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1. General

Introduction

1.01 This document provides telephone company personnel with information on how the 4ESS™ Switch performs its functions. Sufficient information is provided to enable a wide range of users to obtain an overall exposure to the 4ESS Switch. This document is useful to the following personnel:

- Management personnel requiring a broad base of knowledge for office planning and management.
- Operating personnel requiring more detailed information concerning system operation.

This document also supports a wide range of activities such as training, traffic engineering, and system maintenance. The information contained in this document is structured so that a user can obtain either a very high-level description of the system or go into as much detail as is available.

1.02 This document is reissued to include changes to the Expanded Time-Slot Interchange (XTSI) information.

1.03 This document contains an admonishment.

1.04 Lucent Technologies welcomes your comments on this document. Your comments help us improve the quality and usefulness of Lucent Technologies documentation. Please complete and mail or fax (1-336-727-3043) the Feedback Form provided in this document or call the Lucent Technologies Documentation Comment Hot-Line Service, 1-800-334-0404.

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1.06 Every effort is made to ensure that the information in this document is complete and accurate at the time of printing. However, information is subject to change.

1.07 The information contained in this document is organized as follows:

a. Part 1 — **General** describes the purpose, general characteristics, and operational characteristics of the 4ESS Switch.

b. Part 2 — **System Overview** contains a high-level system overview of the 4ESS Switch. This high-level overview identifies the functional areas of the system and, in general terms, describes the operations performed by each area.

c. Part 3 — **Equipment Description—Domestic Offices** identifies 4ESS Switch equipment used in domestic offices. A physical description briefly describes the function of this equipment.

d. Part 4 — **Equipment Description—International Switching Center** identifies the additional 4ESS Switch equipment used in an international switching center. A physical description briefly describes the function of this equipment.

e. Part 5 — **Functional Description—Domestic Offices** contains a functional description of the 4ESS Switch equipment used in a domestic office. Power and power-alarm circuits are included in this part.

f. Part 6 — **Functional Description—International Switching Centers** contains a functional description of the additional 4ESS Switch equipment used in an international switching center.

g. Part 7 — **Call Processing** describes call processing from a hardware point of view. All paths through the system used for switching trunks employing the various signaling methods are identified.

h. Part 8 — **Software** contains a system software overview. This part describes the organization and features of control programs and office data required to operate the system.

i. Part 9 — **Maintenance** describes system maintenance objectives and philosophy.

j. A list of the abbreviations and acronyms used throughout this information is located at the end of this document.

In certain parts of this document, references are made to other Lucent Technologies Practices for additional information. In these instances, refer to the appropriate divisional numerical index to determine the availability of the referenced documents.

1.08 The 4ESS Switch is often considered as a switching network and its controlling processor. This document covers the entire 4ESS Switch complex. It includes discussions of terminal equipment, interface equipment, service and support equipment, and related systems.

FCC WARNING

This equipment generates, uses, and can radiate radio frequency (RF) energy. If not installed and used in accordance with the instructions manual, this RF energy may interfere with radio communications. The equipment has been tested and found to comply with the limits for a Class A computing device pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference when the equipment is operated in a commercial environment. However, operation of this equipment in a residential area is likely to cause interference. In this case, the user, at his own expense, is required to take whatever measures that are necessary to correct the interference.

1.09 This document was developed by the Lucent Technologies Customer Training and Information Products Organization. *Lucent Technologies is the successor to the successor to the business and assets of AT&T Network Systems business unit.*

Purpose

1.10 The 4ESS Switch is a completely electronic, solid-state switching system. The 4ESS Switch was developed for toll and tandem switching applications to be used as a class 1, 2, 3, or 4 office. This system provides a replacement vehicle for existing electromechanical toll, toll tandem, and local tandem offices.

General Characteristics

1.11 The 4ESS Switch is a 4-wire electronic toll or tandem switching system employing a solid-state, time-division/space-division, digital switching network. The 4ESS Switch provides the features available in 4A Crossbar Systems equipped with electronic translator systems. In addition, the 4ESS Switch also provides a significant number of improvements. Among these are increased capacity, improved speed of service, reduced floor space, and full growth capability to maximum capacity. The 4ESS Switch can also serve as an international switching center.

1.12 The 4ESS Switch uses the 1B Processor as its primary controlling processor. The system is fully automated and is controlled by stored computer programs in the 1B Processor. The 1B Processor uses the 3B Computer as an Attached Processor System (APS) for specific functions, such as the storage of file store data. The common network interface (CNI) is also used by the 4ESS Switch. A 4ESS Switch application of the CNI ring is common channel signaling (CCS). In addition to the 1B Processor, CNI ring, and 3B Computer, wired logic signal processors are used to accomplish the repetitive and time-consuming functions associated with service requests, answer detection, digit collection, and digit transmission. These facilities increase the capabilities of the system. Since the switching network contains no electromechanical switching components and is controlled by the high-speed 1B Processor, the 4ESS Switch offers a greatly improved speed of service.

1.13 The 4ESS Switch switching network has a maximum capacity of 107,520 trunk terminations. Approximately 5 percent of these terminations are normally used for service circuits. The system switches 598,000 call attempts per busy hour or 670,000 call attempts (trunk seizures) per peak busy hour. The system can carry a load of 1,700,000 hundred-call-seconds per hour with less than 0.5 percent first trial matching loss. The type of calls processed by a 4ESS Switch office determines the effective capacity of the system within these stated limits. Since offices vary significantly in their individual traffic characteristics, a more meaningful expression of real-time capacity is expressed in terms of the real time required to switch a basic common channel signaling to common channel signaling (CCS-to-CCS) call. This unit of measurement is called an equivalent basic call unit (EBCU). Expressed in this unit of measurement, the peak busy hour call attempts capacity of a 4ESS Switch office is 606,000 EBCUs. The overall factor limiting the size of a 4ESS Switch office is the number of call attempts. Based on current data, the majority of 4ESS Switch offices are projected to reach the real-time limitation (606,000 EBCUs) at a working termination capacity of about 80,000 trunks.

1.14 The 4ESS Switch is designed for both operational and growth flexibility. Only a minimum amount of equipment is required to switch a relatively small number of trunks. Additional equipment and/or software can be readily added to an existing 4ESS Switch office to increase the trunk-handling capability. The system has been designed using integrated circuit technology and other high-technology techniques. These techniques enable the 4ESS Switch to handle a large number of trunks while requiring less floor space than conventional electromechanical systems. A 4ESS Switch can service a number of

trunks equivalent to several electromechanical installations while requiring much less floor space.

1.15 In order to provide reliable call-processing capability, critical 4ESS Switch frames or units are either duplicated or configured so that a failure of any one frame or unit does not seriously affect system operation. Critical system interfaces within the 4ESS Switch are also duplicated so that any problem encountered in transferring signal or control information does not result in a system failure. Individual trunks are not duplicated but are tested on a routine basis. Faulty trunks are identified for repair. Operating capability of 4ESS Switch frames is regularly checked by maintenance software. When detected, malfunctioning frames or units are removed from service. In some instances, a standby frame is switched on line to replace the malfunctioning frame. In other instances, a spare unit is switched on line or the function normally performed by the failed unit is assigned to another unit capable of performing the function. Facilities are provided to monitor overall operation of the 4ESS Switch and to exercise manual control over its operation.

1.16 The individual frames which comprise the 4ESS Switch are designed and constructed using 1A technology and FASTECH® multicomponent telecommunication hardware units. These technologies are based on the use of both integrated circuits and conventional electronic components. Whenever possible, functional circuits are organized on plug-in circuit packs or modules. Functional circuits may be made up of individual components and/or integrated circuits mounted on plug-in circuit packs. These plug- in circuit packs are, in turn, plugged into frame units designed to perform an overall frame function. These units are connected together via intraframe wiring. Any connections which extend beyond a particular frame are brought up to interframe connectors located at the top of each frame. System connections between frames are accomplished using preassembled connectorized cables. System connections that extend beyond the 4ESS Switch equipment are connectorized at the 4ESS Switch equipment end only.

1.17 Use of the preassembled interconnecting cables reduces the amount of time required for equipment installation and simplifies initial system testing. Significant savings are also realized when additional equipment frames are added to an existing office to increase its call-carrying capacity. These prefabricated interconnections make it feasible to interconnect various components of the system at the factory. This enables a 4ESS Switch office to be subjected to preliminary system tests before being shipped for installation. This greatly reduces the on-site testing interval.

1.18 The 1A technology employed in fabrication of 4ESS Switch equipment provides for equipment frames that are 7 feet high rather than the conventional 11-feet-6-inch frames. The 7-feet frames make it easier for operating personnel to work on the equipment. In addition, these 7-feet frames do not require ceilings as high as conventional telephone frames. This provides for additional office space economy when new construction is involved.

1.19 The 4ESS Switch equipment operates satisfactorily in an environment as specified in 760-555-150 and 760-555-151, *Atmospheric Environment for Telephone Equipment Space*. The following information summarizes these requirements:

- Recommended temperature range: 40˚ F to 100˚ F
- Recommended humidity range: 20 percent to 55 percent
- Short term temperature range: 35˚ F to 120˚ F
- Short term humidity range: 20 percent to 80 percent.

Temperature measurements are specified for points 5 feet above floor level at the center of the equipment aisles. Short term limits are defined as 3-day maximum intervals with an annual maximum not to exceed 15 days. The recommended environment for the Circuit Maintenance System (Part 3) is as follows:

- Temperature range: 60˚ F to 80˚ F
- Relative humidity: 40 percent to 60 percent.

Due to equipment density, the amount of heat dissipated by 4ESS Switch equipment is greater than the heat dissipated in a similar area by conventional electromechanical switching devices. For this reason, higher capacity cooling systems are normally required in 4ESS Switch offices.

1.20 The 4ESS Switch office can be tailored to meet the needs of various market situations via the selection of optional features. A summary of all features available with the 4ESS Switch is provided in 234-090-500, *4ESS Switch Feature Handbook*.

Operational Characteristics

1.21 The 4ESS Switch is characterized by many of its unique operational characteristics. Several operational characteristics are described in the following paragraphs.

A. Signaling

General

1.22 The address information that identifies the destination of a particular call is classified according to the method used in transmitting this information between offices. The 4ESS Switch can interface with other switching offices using any of the following basic methods of signaling:

- Multifrequency (MF) signaling
- Dial Pulse (DP) signaling
- Dual Tone Multifrequency (DTMF) signaling
- Common Network Interface (CNI) signaling protocols (CCS7 ISUP, CCITT7 TUP, CCITT7 INUP, Q.931).

1.23 The specific types of signaling supported by the 4ESS Switch include:

- North American multifrequency signaling
- North American decadic dial pulse signaling
- International Telegraph and Telephone Consultative Committee (CCITT) 5 signaling
- CCITT 6 signaling
- Dual-Tone Multifrequency (DTMF) signaling
- Common Network Interface (CNI) signaling protocols.

1.24 The 4ESS Switch office functioning as an international switching center (ISC) is compatible with the major international signaling types. International switching centers are also capable of receiving digits from domestic incoming trunks in two stages. Each type of signaling is briefly described in the following paragraphs.

North American Multifrequency Signaling

1.25 The North American multifrequency signaling (also known as R1-type signaling) uses 2-out-of-6 inband tone combinations to represent the signaling information. The frequencies used are 700, 900, 1100, 1300, 1500, and 1700 Hz. This signaling protocol provides 15 unique signal combinations as follows:

- Signal 1 (700 and 900 Hz) represents the digit 1
- Signal 2 (700 and 1100 Hz) represents the digit 2
- Signal 3 (900 and 1100 Hz) represents the digit 3
- Signal 4 (700 and 1300 Hz) represents the digit 4
- Signal 5 (900 and 1300 Hz) represents the digit 5
- Signal 6 (1100 and 1300 Hz) represents the digit 6
- Signal 7 (700 and 1500 Hz) represents the digit 7

- Signal 8 (900 and 1500 Hz) represents the digit 8
- Signal 9 (1100 and 1500 Hz) represents the digit 9
- Signal 10 (1300 and 1500 Hz) represents the digit 0
- Signal 11 (700 and 1700 Hz) represents the international inward operator signal
- Signal 12 (900 and 1700 Hz) represents the international delay operator signal. In certain special international applications this signal is used to represent the ST (end-of-pulsing) signal
- Signal 13 (1100 and 1700 Hz) represents the KP (start-of-pulsing) and KP1 (international start-of-pulsing) signals
- Signal 14 (1300 and 1700 Hz) represents the KP2 (international start-of-pulsing) signal
- Signal 15 (1500 and 1700 Hz) represents the international ST (end-of-pulsing) signal.

1.26 The 4ESS Switch is capable of receiving or transmitting a maximum of 11 MF digits plus KP (start-of-pulsing) and ST (end-of-pulsing) signals (14 MF digits plus KP, ST, and language digit for international offices) from or to interconnecting offices for each call. The 4ESS Switch equipment can transmit or receive these pulses at a rate of seven or ten pulses per second, depending upon the requirements of the interconnecting offices.

1.27 The 4ESS Switch can delete up to 11 of the incoming MF digits (14 for international offices) and prefix the remaining address digits with up to 6 additional digits.

North American Decadic Dial Pulse Signaling

1.28 For each call, a 4ESS Switch is capable of receiving or transmitting a maximum of 11 DP digits from or to interconnecting offices. The term *decadic* refers to the rate at which the pulses are sent. The 4ESS Switch equipment transmits these pulses at a rate of 10 pulses per second. The digit pulse is a 60-ms on-hook pulse with an off-hook interval of 40-ms. These pulses are received at a rate of up to 12 pulses per second. The 4ESS Switch can delete up to 11 of the incoming DP digits and prefix the remaining address digits with up to 6 additional digits.

CCITT 5 Signaling

1.29 The CCITT 5 signaling is a type of dual frequency supervisory signaling used on international trunks. This signaling conveys supervisory information signals (seizure, start dial, answer, disconnect, and others) consisting of one or two tones (2400-Hz and/or 2600-Hz) in a compelled mode. Special line signaling transceiver plug-ins and support software are required. For address signals (digits), CCITT 5 signaling uses the same combinations of multifrequency tones as domestic signaling but at a faster rate [nominally 10 pulses per second (pps) as compared with 7 pps]. The existing hardware in a 4ESS Switch office is compatible with this type of signaling.

CCITT 6 Signaling

1.30 The CCITT 6 signaling employed in 4ESS Switch international switching centers is similar to the old CCIS signaling used in domestic offices. The signaling information is transmitted on a separate dedicated signaling path. However, the number of digits transmitted and the format for CCITT 6 signaling is unique.

Dual-Tone Multifrequency Signaling

1.31 The 4ESS Switch can be optionally equipped to support dual-tone multifrequency (DTMF) signaling between directly connected private branch exchanges (PBXs) on 4-wire E&M analog and direct T1 digital trunks. The DTMF capability includes 2-way wink-start addressing, generation of dial tone on nonwink-start trunks, and the generation and reception of the full set of DTMF digits. Dual-tone multifrequency signaling (formerly called touch-tone

signaling) is commonly used by local end offices on subscriber loops. Dual-tone multifrequency signaling uses a standardized set of 2-out-of-8 inband tone combinations assigned to 16 unique alpha/numeric digits. The standardized DTMF frequencies are 697, 770, 852, 941, 1209, 1336, 1477, and 1633 Hz.

Common Network Interface Signaling Protocols

1.32 With 4E11 and later generic programs, the 4ESS Switch is equipped to support the Common Network Interface (CNI) ring. Specific signaling and signaling protocols have been developed which use the interface with the CNI ring:

- CCS7 Protocol
- Q.931 Protocol
- CCITT7 TUP
- CCITT7 INUP

Common Channel Signaling

1.33 Common Channel Signaling (CCS) is a digital signaling system in which all address, supervisory, and control data associated with a dedicated group of voice trunks is transmitted over separate signaling paths. The basic minimum configuration for a CCS system includes the following:

- Two stored program control systems (SPCSs)
- Interoffice links dedicated to the signaling path
- Two nodes using the same protocol to provide an interface between the two SPCSs and the signaling path
- Interoffice links dedicated to the voice/data path.

1.34 The CCS systems provide the following advantages over in-band signaling systems:

- Increases call set-up and disconnect speeds
- Reduces post-dialing delay to customers
- Reduces switching equipment holding time
- Transmits additional types of signaling information (routing information, control information, and others)
- Eliminates the need for dedicated signaling circuit hardware for individual voice trunks
- Allows flexibility in transmitting various types of signaling information and network data.

1.35 The 4ESS Switch utilizes the concept of common channel signaling to provide efficient signaling methods for the ever increasing amounts and various types of data being switched. A 4ESS Switch is interconnected to other switching offices by signaling links via signal transfer points (STPs) and CNI ring equipment. The STP and CNI ring equipment supports the Common Channel Signaling 7 (CCS7) protocol.

CCS7 ISUP Protocol

1.36 The CCS7 protocol (commonly referred to as the Integrated Services Digital Network User Part (ISUP) protocol in the 4ESS Switch application) is used to interface the 2STPs with the 4ESS Switch. This interface is made via the CNI ring. The CCS7 protocol can be defined as:

a. Divided into four separate functional layers:

   Layer 1 — Signaling Data Link Message transfer part

   Layer 2 — Signaling Link message transfer part

   Layer 3 — Signaling Network Message transfer part

   Layer 4 — Signaling Connection Control Part.

b. Provides high-speed transmission (56 and 64 kb/s)

c. Provides a variable message format length (up to 256 bytes)

d. Provides destination point code routing for all messages through the network.

Q.931 Protocol

1.37 The Q.931 protocol allows for out-of-band signaling between a PBX on customer premises and the 4ESS Switch. The physical interface between the PBX and network is divided into two types of channels:

a. Bearer Channels (B-Channels)

b. Data Channels (D-Channels).

B-channels are used to carry customer information such as voice, data, video, and others. D-channels are used to carry signaling and control data which manages the information on B-channels. These channels (B and D) have been defined and standardized by the International Telegraph and Telephone Consultative Committee (CCITT) group. A digital data rate of 64 kb/s has been defined as a fundamental building block for both the B- and D-channels. In addition, major interfaces have been defined which consist of one D-channel and a number of B-channels. A primary-rate interface has been standardized by the CCITT group which allows 23 B-channels to be supported by one D-channel (23B + D primary rate). However, at maximum capacity, a D-channel can support up to 40 B-channels.

1.38 Each B-channel provides 64 kb/s clear digital access. In addition to the primary-rate interface (23B + D), B-channels can be accumulated to provide higher data rate channels. As with B- and D-channels, the higher data rate channels have been identified and standardized by the CCITT group. Existing standardized high-data-rate channels are the following:

- 384 kb/s H0 channels
- 1536 kb/s H11 channels
- 1920 kb/s H12 channels (Not used in North America).

The Q.931 out-of-band signaling protocol allows for the exchange of more information and offers the opportunity to provide the customer with many new additional features.

CCITT 7 Telephone User Part (TUP) Protocol

1.39 The international CCITT 7 TUP protocol is used to interface with foreign administration networks to provide the same features as the CCS7 protocol provides for domestic networks and also provides trunk testing capabilities via ATME A tests; telemetry type output via the 3B Computer for International Call Detail Recording (ICDR), and integrated services digital network user part (ISUP) and common channel signaling (CCS) for transit calls within the domestic network.

CCITT 7 International Integrated Services Digital Network User Part

1.40 The international CCITT 7 ISUP (INUP) protocol is used to interface with foreign administration networks to provide the same enhanced signaling capabilities as the CCITT 7 TUP protocol provides for international networks and to extend domestic CCS7 signaling capabilities to international network. The CCITT 7 INUP signaling provides the flexibility for improving and evolving AT&T International Services. The CCITT 7 INUP phase 3 enhances the User-to-User Signaling (UUS) Service 1 and introduces the Connected Line Identification Presentation/Restriction service capabilities.

B. Equal Access

1.41 Equal access (EA) allows end office subscribers to dial the same number of digits to obtain access to any one of several interexchange carriers that were previously chosen by the subscriber. End offices which do not provide equal access signaling are called nonconforming end offices (NCEOs). The current arrangements will continue to be used for NCEOs. Access to tandem toll connecting trunks may be provided by both equal access and traditional access.

1.42 At the end office, equal access is provided by two feature groups called Feature Group B and Feature Group D. Feature Group B provides

access to carrier by dialing 950-0/1XXX (XXX = carrier identification code). Feature Group D provides access to a carrier through presubscribed lines or through an override code (10XXX) (XXX-carrier identification code) prefixed to a 10 digit directory number. An end office that does not support equal access is called a non-conforming end office and is in Feature Group C.

1.43 In order to increase the available carrier identification codes, the carrier identification codes are being expanded from three to four digits. This changes the carrier access codes as follows:

- For Feature Group B, the carrier access code is changed from 950-WXXX to 950-XXXX (Where W = 0/1 and X = 0-9). XXXX is the new carrier identification code. This change was implemented in the 4E15 generic program.
- For Feature Group D, the carrier access code changes to four digits with the 4E18 generic program.

1.44 The 4ESS Switch, acting as an access tandem in the LEC network, accommodates routing based on the 950-XXXX format to a Feature Group B carrier. Automatic Message Accounting (AMA) records include the four digits in the carrier identification code.

1.45 The 4E10 generic program fully supports equal access generated by conforming end offices. Equal access allows provision for automatic number identification (ANI) on every call and provides for addressing international direct distance dialing (IDDD) calls. The ANI can be optionally provided by line class of service, prefix dialed, and/or service access code dialed. The 4ESS Switch must perform digit analysis on the address sequence on each call to determine whether ANI is required to serve the call.

1.46 Equal access is accomplished using MF signaling techniques. The following EA protocol is used for domestic calls.

a. End office/access tandem office seizes toll connecting trunk.

b. The 4ESS Switch returns WINK-START.

c. End office outpulses KP+[II+3/10 digits]+ST+KP+7/10 digits+ST.

d. The 4ESS Switch returns ACKNOWLEDGEMENT-WINK.

The sequence in Step (c) of this paragraph provides an information sequence of two information digits plus a 3- or 10-digit billing number (ANI), followed by an address sequence of 7- or 10-digit called number. The KP and ST represent the standard MF start and stop signals, respectively. When ANI is not required on a call, the information sequence consists only of the KP+ST signals.

1.47 The equal access protocol for outbound international calls to a toll 4ESS Switch provides two stages of signaling as follows:

a. End office/access tandem office seizes toll connecting trunk.

b. The 4ESS Switch returns WINK-START.

c. End office outpulses KP+1NX+XXXX+CCC+ST.

d. The 4ESS Switch returns second WINK-START.

e. End office outpulses KP+[II+3/10 digits] +ST+KP+CC+NN+ST.

f. The 4ESS Switch returns ACKNOWLEDGEMENT-WINK.

1.48 The 4ESS Switch does not receive equal access international calls requiring operator assistance. These calls are routed by conforming end offices to a operator service position system (OSPS). The first stage of an international call consists of 9 digits. The 1NX in Step (c) identifies the call as an international call and is followed by the international carrier identification (XXXX) and country code (CCC). As with the domestic equal access sequence, the information sequence in Step (e) consists only of KP+ST when ANI is not

required on the call. The address sequence in Step (e) provides the destination country code (CC) and national number (NN).

C. Centralized Automatic Message Accounting

1.49 A 4ESS Switch office can provide centralized automatic message accounting (CAMA) service for interfacing class 5 offices where local automatic message accounting is not economically justified. The 4ESS Switch is compatible with offices that employ automatic number identification (ANI) to identify a calling party. In these cases, CAMA data originating at interfacing offices may be applied to the 4ESS Switch via CAMA trunks. The 4ESS Switch can also use operator number identification (ONI) to identify a calling party. When operator number identification is required, the call is routed to a CAMA operator position or to a Operator Service Position System (OSPS) operator. The operator then applies the data to the 4ESS Switch via operator interfaces.

D. Automatic Message Accounting Standard Entries

1.50 Automatic message accounting standard entries (AMASE) enable billing data to be teleprocessed to a revenue accounting office. AMASE provides an alternative approach to the generation of a magnetic tape. The state of an office data assembler (ODA) switch determines whether the billing operation uses the magnetic tape or AMASE method to transfer message accounting data to a revenue accounting office. In the AMASE method, billing data is collected and sent to the accounting office via the Attached Processor System (3B Computer). The interface between the 3B Computer and the accounting office is via either a 4.8 kb/s Direct Distance Dialing (DDD) link or a 9600 b/s or 56 kb/s private line link. The choice between the DDD link or private line link is based on the volume of data to be transferred. Offices having more than 200,000 billable calls-per-day use the 9600 b/s or 56 kb/s private line links.

E. Automatic Message Accounting Recording

1.51 Automatic message accounting (AMA) recording produces an AMA record for various types of calls entering the 4ESS Switch. Call records may be used for billing the caller, access charging, recovery of transport costs from other carriers, or for various other billing or record keeping purposes. The AMA recording function includes the following capabilities:

- Produce an AMA record for any answered call entering the 4ESS Switch using the equal access signaling protocol or direct connect PBX
- Produce an AMA record for international calls
- Optionally generate two AMA records for calls originated via CAMA trunks
- Record test calls initiated outside the interexchange network
- Produce an AMA record for Software Defined Network (SDN) calls
- Produce an AMA record for switched-access Outward Wide Area Telephone Service (OUTWATS) and Inward Wide Area Telephone Service (INWATS) calls
- Generate time change record when time-of-day clock is changed.

F. Call Detail Recording Platform

1.52 The 4E18 generic program supports an Automatic Message Accounting (AMA) adjunct with the Call Detail Recording Platform (CDRP) feature. The CDRP feature provides Small Computer System Interface (SCSI) Interface Nodes (SIN Nodes) on the CNI ring. These SIN Nodes collect 1B processor call data transmitted to the 3B Computer. The data is sent to the SIN Nodes over 3B DMA links and the data blocks are converted into SCSI messages. The SIN Node then forwards these SCSI messages to a Star-Server Computer. The computer collects the data for active calls. As these active calls disconnect, the computer formats the complete data for the calls into AMA and/or

International Call Detail Recording (ICDR) records. The billing records are transmitted to a revenue center. The increased demand for additional billing records is needed to take advantage of the additional call handling capacity of the 1B processor.

G. Basic Digital Switching

1.53 Basic digital switching provides for the transparent switching of 64-kilobit-per-second bandwidth signals through a 4ESS Switch office over a dedicated network of digital trunks. This provides the capabilities necessary to support the Circuit-Switched Digital Capability which provides end-to-end, 56-kb/s, full duplex, Circuit Switched Digital Capability. Two-wire No. 1 and 1A ESS Switch offices serve the Circuit Switched Digital Capability subscribers. In addition, 64 kb/s, 384 kb/s, and 1.5 kb/s clear and restricted data transmission are supported.

1.54 The digital data trunks, used for full-rate data, are two-way dedicated trunks which terminate on digital interface frames (DIF) at the 4ESS Switch and use common channel signaling (CCS) for addressing and supervision. The digital interface use is required for data transmission because the signaling bits of a 64 kb/s T1 channel must be used for data. The digital interface disables the use of the A/B signaling bits and transmits the data as received (no insertion of M-bit). Control of this function is via a ''per-channel, inhibit-signaling'' memory in the digital interface. When the stored bit for a given trunk is a ''one,'' the M-bit is not inserted into the outgoing signaling data (data frame). The miscellaneous trunks used to access and test the digital data trunks (data test access trunks) also require that the insertion of the M-bit be inhibited. Testing is controlled from a trunk work station and an associated Circuit Maintenance System (CMS) or Testing, Operations, Provisioning, and Administration System (TOPAS) input/output terminal.

H. 800 Service (INWATS)

1.55 The 800 Service provides increased routing flexibility to the 800 Services along with additional customer services for both interstate and intrastate inward wide area telephone service (INWATS) offerings. The direct signaling capability of the CCS network is used to access 800 Service data bases to obtain direct distance dialing (DDD) numbers for routing 800 Service calls. The 800 Service data bases are provided by processors at selected signal transfer point sites. The additional customer services made possible via the 800 Service data bases are called 800 Vertical Services. The originating area code of the call is included in the query to the 800 Service data base(s) which returns the appropriate 10-digit telephone number for that area. Thus, service can be provided on a number plan area (NPA) basis. The following are limited examples of 800 Services that can be supported:

a. One advertised 800 number can be used for both interstate and intrastate calls.

b. Customized 800 numbers can be supported such as 800-AIRLINE.

c. When a business moves or changes service, the advertised 800 number does not have to change.

I. Software Defined Network

1.56 The Software Defined Network (SDN) allows analog and/or digital PBX customers to be directly connected to the 4ESS Switch. Various SDN abilities such as customer numbering plan, screening information, and authorization codes are specified by the customer in a network control point data base via a Service Management System terminal on the customers' premises. Calls over the SDN are then routed via the 4ESS Switch toll network as specified by the customer in the Network Control Point (NCP) data base.

J. Special Interface

Inward and Leave-Word Operator Trunks

1.57 The 4ESS Switch can interface with inward trunks and leave-word, one-way, outgoing, MF wink-start, operator trunks. The 4ESS Switch

can interface with inward and leave-word operators on both outpulsing and no-outpulsing type trunks. Auxiliary service operators associated with these trunks assist outward operators in various functions, for example:

a. Verification of line busy

b. Collection of coins (in-band coin collect only)

c. Completion of calls to mobile or marine stations.

In addition, the leave-word operator can complete calls originated at an earlier time by a customer to the toll center associated with the operator.

No. 5 Automatic Call Director Trunk

1.58 The 4ESS Switch can interface with a No. 5 Automatic Call Director Trunk. This trunk is a one-way outgoing trunk requiring no outpulsing. Normally, it does not return an off-hook indication when an operator answers. Because there is no off-hook indication, the automatic call director trunk returns an off-hook wink to the 4ESS Switch as an integrity check. This integrity check must be received at the 4ESS Switch before a subscriber is connected to the trunk.

Emergency Operator Access Circuit

1.59 The emergency access circuit allows an operator to complete calls of an emergency nature to a distant toll-switching point. This ability is used when normal access is not available due to an all-trunks-busy condition. Emergency access is limited to analog trunks. An operator at a type-3 switchboard can bypass the switching system and gain access to a preselected trunk by plugging into an associated switchboard appearance.

800 Service (INWATS) to Automatic Call Distributing Equipment

1.60 The 4ESS Switch can connect incoming 800 Service [inward wide area telephone service (INWATS)] calls directly to a terminating 800 Service customer without going through a class 5 office. The trunks, between the 4ESS Switch office and the automatic call distributing equipment, are one-way outgoing loop or E&M-type trunks. The trunks are on-hook when idle in both directions. When a trunk is seized by a 4ESS Switch, either of two separate and distinct actions can occur. A 215 ±75 ms off-hook, integrity check wink is received from the automatic call distributing equipment for carrier-type trunks. This wink is a carrier verification signal. For metallic facilities, no integrity check wink is used. Both types of trunks are dial-pulse outpulsing trunks. Any of the valid 800 Service digit patterns may be applied to a 4ESS Switch. However, the 4ESS Switch can translate on a maximum of 9 digits to determine routing. The last digit of any incoming 10-digit format is not translated by a 4ESS Switch. Call data is recorded via automatic message accounting entries for all 800 Service calls to automatic call distributing equipment. Call data is recorded independent of and separate from any other automatic message accounting records. This record is made whether or not the call is answered.

Direct PBX Interface

1.61 A customer's analog or digital private branch exchange (PBX) may be directly connected to a 4ESS Switch office. The direct PBX capability enables an interexchange carrier 4ESS Switch to provide a private software defined network (SDN) between several customer PBX locations via the toll switching network. The 4E10 and later generic programs support the direct PBX interface with 2- and 4-wire analog PBX trunks—using class 5 office signaling characteristics and digital PBX T1 trunks using DP or in-band dual tone multifrequency signaling (DTMF) touch-tone.

1.62 Dial pulse and DTMF signaling, dial tone and supervision is provided by a DIF-E1 equipped with DTMF service circuits. Standard 2-wire or 4-wire E&M, or 2-wire dial pulse terminating D4 channel units provide the electrical interface to an analog PBX. A digital PBX is terminated directly via T1 lines to the DIF-E1 complex. Signaling supervision to a digital PBX is provided via the CNI ring using the Q.931 protocol.

K. Timing

1.63 Certain timing criteria have been established to determine the actions to be initiated after certain supervisory signals have been received or transmitted by a 4ESS Switch office.

Permanent Signal

1.64 In a 4ESS Switch office, a permanent signal is defined as a continuous off-hook signal not followed by address information. The permanent signal timing provided is based upon the expected type of signaling on the trunk.

a. Multifrequency (MF): If an incoming MF trunk does not respond with the first MF digit within 5 to 7 seconds after the 4ESS Switch has indicated it is ready to receive MF digits, the incoming trunk is given permanent signal treatment by connecting it to a reorder tone. Incoming operator MF trunks have 15 to 19 seconds to input digits before being given permanent signal treatment.

b. Dial Pulse (DP): If an incoming DP trunk does not respond with the first digit within 12 to 16 seconds after the 4ESS Switch has indicated it is ready to receive dial pulses, the incoming trunk is given permanent signal treatment by connecting it to a reorder tone.

c. Dual Tone Multifrequency (DTMF): If the first DTMF digit is not received on an immediate dial tone start (IDTS) trunk within 15 seconds after the application of dial tone, the incoming trunk will be given permanent signal treatment by connecting it to reorder tone. If the first DTMF digit is not received on a DTMF wink start trunk within 10 seconds after the application of the wink start signal, the incoming trunk is given permanent signal treatment by connecting the incoming trunk to reorder tone.

d. CCITT 5: If an incoming CCITT 5 trunk does not respond with the first MF pulse within 2 seconds after a proceed-to-send signal has been returned to the distant office and the initial seizure tone from the distant office has been turned off, a busy flash signal is sent as the permanent signal treatment.

1.65 After a trunk is given permanent signal treatment, the far-end office determines the time interval until the trunk is disconnected and returned to service. Many step-by-step offices are not capable of timing CAMA trunks with permanent signal treatment and returning them to service. When the 4ESS Switch determines a CAMA trunk from a step-by-step office is given permanent signal treatment, it is recognized as a trunk requiring special treatment. The 4ESS Switch sends a 200-ms wink, followed by a steady on-hook indication and places the trunk in a high-and-wet state. When the step-by-step office receives the off-hook to on-hook transition, it applies dial tone to the loop. The step-by-step office then releases the trunk by going on-hook toward the 4ESS Switch office. The 4ESS Switch office, in turn, restores the trunk to idle. This solves a problem occurring on step-by-step CAMA trunks when a subscriber dials the digit 1 and remains off-hook to prevent his phone from ringing (dial 1 for slumber). Application of this feature must be coordinated with step-by-step offices which do not have a timing-release capability.

Partial Dial

1.66 A partial-dial state exists whenever the 4ESS Switch receives at least one address digit but not all the address digits. Timing is used to detect this type of abnormal condition. As with permanent signal timing, partial dial timing is based upon the expected type of signaling on the trunk.

a. MF: The time interval between the first and last MF digit applied to the 4ESS Switch office on an MF trunk must not exceed 15 seconds. If this interval is exceeded, the incoming MF trunk is given partial dial treatment by connecting it to a reorder tone.

b. DP: With one exception, the time interval between DP digits is monitored to ensure that the interval does not exceed approximately 15 seconds. If this interval is exceeded, the incoming trunk is given partial dial treatment by connecting it to a reorder tone. However, the interval between DP digits 7 and 8 is monitored to determine if this interval exceeds approximately 5

seconds. If this interval is exceeded, it is assumed that no further digits will be applied. If an eighth DP digit is received, the interval between the remaining digits cannot exceed approximately 15 seconds.

c. DTMF: A time interval of 15 seconds must not be exceeded between receipt of the first and last DTMF digit (all digits received) on an incoming DTMF wink start trunk. A time interval of 15 seconds must not be exceeded between the receipt of each DTMF digit on an incoming IDTS trunk. When the time interval is exceeded, the incoming trunk is given partial dial treatment by connecting it to reorder tone.

d. CCITT 5: If an incoming CCITT 5 trunk does not respond with another MF pulse within 5 seconds after the 4ESS Switch has received a previous MF digit, a release-guard signal is sent to the distant office as the partial dial treatment signal.

L. Critical Timing

1.67 When the 4ESS Switch is receiving dial-pulse or dual tone multifrequency (DTMF) information, it is not always possible to determine in advance how many digits will be received. Therefore, the interval between certain digits (for example, the seventh and eighth) is timed to determine when all digits have been received. If no additional digit is received for a period of approximately 5 seconds at a point in the address sequence where all digits might normally have been received, then the reception of digits is assumed to be complete. In some cases (for example, DP-3, -4, -5, or -6 codes), the interval timed is after the third, fourth, or fifth digit. These codes must be specified in a 3-digit type translator.

M. Glare

1.68 A glare situation exists when a two-way trunk is seized for use at the same time by the two switching systems that it interconnects. Different techniques are used to detect and resolve these situations depending on the type of trunk involved. These strategies are described briefly in the following paragraphs for MF, DP, ISUP, Q.931, CCITT6, and CCITT 5 trunks.

MF and DP Trunks

1.69 Two techniques are used in the 4ESS Switch to detect glare on MF and DP trunks. These techniques are the direct trunk scan and the off-hook interval time strategies.

1. **Direct trunk scan** involves checking the state of the selected trunk scan point for an off-hook condition before operating the associated trunk signal distributor point. If on the first attempt to seize a trunk the selected trunk scan point is off- hook, the 4ESS Switch reenters the trunk-hunt sequence. If the second attempt to seize a trunk also finds the selected trunk scan point in an off-hook state, the call is sent to the final-handling sequence. The final-handling sequence terminates calls that result in ineffective attempts.

2. **Off-hook interval time** involves measuring the off-hook time interval of the wink start or the delay-dial/start-dial sequence. A glare condition is initially assumed to exist if the wink-start interval exceeds 350 milliseconds or if the delay-dial/start-dial sequence exceeds 4 seconds.

1.70 The 4ESS Switch has the ability to resolve glare situations by either of two strategies. These strategies are termed *glare noncontrol* and *glare control*.

1. **Glare noncontrol** strategy involves releasing the selected trunk and treating the condition as an incoming seizure. Under this strategy, a different trunk is seized for the call being processed by the 4ESS Switch.

2. The **Glare control** strategy involves maintaining the seizure on the selected trunk in the expectation that the distant office will release the trunk. The particular strategy used by the 4ESS Switch to resolve a glare condition is based on a preset control indicator associated with trunks.

The preset control indicator is part of office translation data and is assigned based on the type of interfacing switching machine. Toll-completing, delay-dial/start-dial trunks, and dial-pulse immediate trunks must have this indicator set so that the 4ESS Switch seizes another trunk, allowing the original trunk to complete an incoming call (glare noncontrol). Since a wink-start or delay-dial time-out can also be an indication of circuit trouble, the 4ESS Switch further tests only the MF trunks in the glare noncontrol area.

Q.931 Trunks

1.71 When a 4ESS Switch office is designated as the controlling office for glare control on a trunk group associated with the Q.931 protocol, the 4ESS Switch always maintains or acquires control of the seizure.

CCITT 6 Trunks

1.72 On international trunks using CCITT 6 signaling, glare is resolved by allowing the office at the control end of a trunk to proceed with the call. The office at the noncontrol end of the trunk releases and reinitiates the call on a different trunk. Normally, an international switching center controls trunks with odd labels within a trunk subgroup. The other end office of the trunk subgroup controls trunks with even labels.

CCITT 5 Trunks

1.73 On international trunks using CCITT 5 signaling, glare is determined when a seizure signal is received in response to a seizure signal initiated by the 4ESS Switch. After 850 ms, the 4ESS Switch turns off its outgoing seizure. Neither office has control, and a number of timing actions follow; this allows the trunk to be idled at both ends before reuse is allowed.

N. Intercept Facilities

1.74 The 4ESS Switch intercept facilities indicate the progress of a particular call or indicate the final status of a call when a particular phase cannot be completed by the system. These intercept facilities consist of reorder and busy tones, recorded announcements, and operator facilities. The announcement facilities in a 4ESS Switch provide up to 20 different announcements. No network terminal hardware engineering is required for announcement and tone facilities. (See discussion in Part 5.) Under some conditions, it is necessary to connect a call to an operator (for example, CAMA operators when ANI failures occur). The 4ESS Switch can route calls to an operator according to a preselected plan for the office. The 4ESS Switch is capable of routing calls to 3CL-type switchboards or their equivalent. It is also capable of operation with the TSPS.

O. Transmission Requirements

1.75 With the 4ESS Switch, a signal is digitally encoded and remains in a digital format through the switching network and while being transmitted via digital carrier facilities interfacing with other 4ESS Switch offices. A specified fixed loss is introduced in the analog portion of the toll-connecting trunk prior to digital encoding and after digital decoding. This is done to meet specified level requirements and overall connection loss for digital toll connections. This approach is referred to as a transmission plan. The essential abilities of this plan are the following:

- A 3-db inserted connection loss (ICL) for toll-connecting trunks
- A 0-db ICL loss for digital intertoll trunks between 4ESS Switch offices
- A minus 3-db conforming transmission level point at all 4ESS Switch toll offices.

P. Traffic Measurements

1.76 A traffic measurement ability is provided to measure the effects of telephone traffic presented to the 4ESS Switch. For engineering purposes, these measurements are required to predict future demand, determine the quantity of equipment needed to meet the future demand, and to verify that present equipage is adequate to meet present demands. For network management, these measurements are used to determine what control actions are necessary to efficiently utilize the

various control strategies. For plant management, these measurements are used to locate and evaluate equipment irregularity and to evaluate the effectiveness of maintenance procedures for the office. Management personnel, responsible for the ineffective machine attempt index, use these measurements to locate the source of ineffective machine attempts and initiate appropriate corrective action. The following paragraphs provide a brief description of the types of data collected as part of traffic measurements.

Trunk Subgroup Measurements

1.77 The standard measurements of incoming attempts, outgoing attempts, overflows, and usage are maintained on all trunk subgroups. In addition, measurements pertaining to network management controls may be maintained on a specified subset of the trunk subgroups. These include such measurements as calls affected by reroutes, cancels, skips, dynamic overload controls, or selective trunk reservation.

Service Circuit, Engineered Memory, and Queue Measurements

1.78 When appropriate, the standard measurement of seizures, usage, overflows, and abandons are maintained on all service circuits, engineered software registers, and associated queues.

Traffic Separations Measurements

1.79 All incoming traffic is split into 128 different incoming classes, and all outgoing traffic is split into 128 different destination classes based on the destination code. Individual measurements of seizures and usage are maintained on the traffic between each incoming class and each destination class. The usage measurement provides a means for evaluating the use of the switching machine by various cross sections of traffic. It will also be an effective network management tool in addition to providing required division-of-revenue and load-distribution data.

Total Office Measurements

1.80 A number of total office counts are maintained. These include network seizures, failures, usage, total incoming calls broken down by signaling type, and total outgoing calls broken down by type of trunk (intertoll versus toll connecting). In addition, measurements are maintained for plant-management purposes on interrupts by type, phases, and equipment outages.

Q. Ineffective Attempt Measurements

1.81 Every origination attempt in the office that fails to reach the waiting-for-answer state passes through a common software control point where the reason for failure is counted. Measurements are maintained that provide a very detailed breakdown of ineffective attempts. Various reports are provided for use by administrative personnel that require ineffective machine attempt data. In addition, provision has been made to segregate each of the ineffective attempt measurements taken by trunk maintenance supervisory group.

R. Network Management

1.82 In order to facilitate efficient traffic flow through the toll network, the 4ESS Switch office maintains interfaces with regional centers and/or the national control center. An interface with the Regional Network Management System (RNMS) or the Engineering and Administrative Data Acquisition System for Network Management (EADAS/NM) may be used to support the management of the hierarchical network. An interface with the Network Management Operations Support (NEMOS) system may be used to support the management of the real time network routing (RTNR) network. These interfaces consist of dedicated data link circuits to coordinate the 4ESS Switch office capabilities with the traffic load on the toll network. Information is transferred over these interfaces to accommodate changes in normal calling patterns (holiday traffic, natural disaster, equipment failure). Network management provides improved control and surveillance functions which ensure that the toll network carries as many

completed calls as possible. Network management surveillance and control capabilities are based upon the extensive 4ESS Switch data base maintained in the 1B Processor memories. Certain network-management functions are implemented automatically, while others can be manually implemented. Manual network-management control is implemented through a two-way, person-machine interface—comprised of cathode-ray tube (CRT), input/output terminals. These terminals display data relevant to network management and permit network-management personnel to initiate controlling operations. Information in the 4ESS Switch data base is also used by network-management control programs to implement automatic network-management functions. Several program-controlled network- management functions are described in the following paragraphs.

Hard-to-Reach Codes

1.83 Three categories of data are maintained to identify hard-to-reach central office codes. These three data categories are as follows:

- Attempts fail to find an outgoing route
- Attempts forwarded to other offices
- Attempts fail to communicate with the destination office.

These three categories of data are maintained on the following areas.

- Each numbering plan area
- The central office codes within the home numbering plan area
- The central office codes for a maximum of six other numbering plan areas.

1.84 Using these statistics, central office codes are identified as hard-to-reach from one or both of two perspectives.

a. First, a hard-to-reach central office code list is calculated on the ratio:

$$\frac{IMA+INA}{IMA+NA}$$

Where:
IMA = Ineffective machine attempts

INA = Ineffective network attempts

NA = All network attempts.

NOTE:
Ineffective machine attempts are defined as attempts which fail to find an outgoing route. Ineffective network attempts are calls which are outpulsed but do not receive answer supervision.

The codes on this list indicate the completing problems for traffic which the office is receiving.

b. Second, a hard-to-reach code list is calculated on the ratio:

$$\frac{IMA+INA}{NA}$$

Where:

IMA = Ineffective machine attempts

INA = Ineffective network attempts

NA = All network attempts.

The codes on this list are those which are encountering completion problems in other parts of the toll network.

Selective Trunk Reservation

1.85 Selective trunk reservation monitors the activity of a trunk subgroup and applies one of two filters to the offered traffic at high levels of trunk subgroup occupancy. As the number of idle trunks in a trunk subgroup falls below a specified threshold, hard-to-reach traffic (which uses this

trunk subgroup as an alternate route) is not permitted access. As a second specified threshold level is passed, only first-routed traffic not destined for hard-to-reach codes is allowed access. Traffic not permitted access to a trunk subgroup is normally canceled but may be transferred to an alternate route.

Call Gapping

1.86 Call gapping control provides for the detection and control of focused overloads caused by expected or unexpected mass calling. Implementation of this control is automatic when preset thresholds entered into the network management display system data base are exceeded. Call gapping limits the call attempts output from the 4ESS Switch which restricts the number of calls completed at the final destination. This control permits only one call per selected number of seconds to be attempted. Any one of thirty-two software-defined values can be selected for the Regional Network Management System. The Engineering and Administrative Data Acquisition System for Network Management (EADAS/NM) only supports 16 software-defined values. Call gapping exhibits the same characteristics as a choke network using trunk direction and code block controls applied to calls. Blocked calls are routed to an appropriate recorded announcement.

Dynamic Non-Hierarchical Routing

1.87 Dynamic nonhierarchical routing (DNHR) provides a more efficient and flexible method of routing calls over the public switched network based on time-varying routing patterns. The following are major considerations in DNHR:

- The use of 1- and 2-link routes between DNHR nodes that are changeable by time-of-day on a prescribed schedule
- Real-time traffic sensitive routing adjustments to improve network service and overload control
- Special network management capabilities for the nonhierarchical routing of calls
- Collection of point-to-point traffic measurements for engineering and selection of minimum cost routes
- Network Management Operations Support System (NEMOS) interface with the 4ESS Switch for transmitting DNHR data to NEMOS and receiving DNHR controls to be activated.

1.88 In a dynamic nonhierarchical network, in-chain or out-of-chain routing concepts do not apply. Calls routed over the DNHR network are routed from the originating toll switch (OTS) directly to the terminating toll switch (TTS), or to the TTS by way of no more than one DNHR ‘‘VIA’’ switch. The 4ESS Switch may function simultaneously as a DNHR OTS, VIA, and TTS node based on the point of call entry into the DNHR network. The routing selection may be modified in relation to the time-of-day and the day-of-week. The reroute control capabilities change when using DNHR. A maximum of 256 reroutes can be in effect for a given 4ESS Switch office. Each reroute can specify a maximum of seven VIA routes, the destination codes to be routed, and the routing data blocks associated with the destinations for which the reroute applies. This DNHR ability is called spray reroute (SPRR). Network management control options for the DNHR SPRR ability include the following:

- Immediate or overflow reroute
- Hard-To-Reach (HTR), non-HTR, and ALL destination code traffic option
- VIA node reroute
- Allow international inbound traffic
- Allow in-chain return (at VIA nodes)
- Trunk subgroup turnoff override
- Reroute Percentage
- Cancel rerouted overflow.

Real-Time Network Routing

1.89 Real-Time Network Routing (RTNR) provides an adaptive, real time method of routing calls over the public switched network. This

method is based on interchanging trunk group status data between switches on a per call basis. RTNR uses direct or two-link paths between switches to complete calls with direct route being first choice in routing a call. The switches determine the traffic load throughout the network and select routes that dynamically and automatically balance the load in the network.

1.90 Calls routed over the RTNR network are routed from the originating switch directly to the terminating switch, or to the terminating switch by way of a via switch. The originating switch determines the terminating switch and method of routing. With 2-link routing, a via switch connects the originating switch to the terminating switch. The originating switch determines the via switch for the call by examining the current status of the network to the terminating switch and setting up the call on the least loaded route.

1.91 The originating switch maintains a list of the trunks that are available to other switches in the network. The originating switch requests a list from the terminating switch showing the status of terminating switch trunks to other switches in the network. The originating switch then compares this list, received from the terminating switch, to the list of switches having access to the originating switch and selects a via switch that has access to the originating and terminating switches.

1.92 The RTNR separates the trunk loading information into six different loading levels. These loading levels are three Lightly Loaded (LL) states (LL1, LL2, and LL3), a Heavily Loaded (HL) state, a Reserved for Direct Traffic state, and an All Busy state. Using bit map lists of these trunk loading states at both the originating switch and terminating switch enables the originating switch to use trunks in the lightest load state in selecting a via switch.

1.93 The originating switch does not actually wait for the response from the terminating switch to the trunk information request before selecting a route for a call. Instead, the most recent trunk information is used to establish the route. The response from the terminating switch is used to update the trunk information at the originating switch for subsequent calls.

1.94 The non-hierarchical network with RTNR provides the following advantages over other routing systems.

- The originating switch knows the approximate availability of trunks in other switches and selects a call completion route that is more likely to succeed, resulting in shorter call setup delays.
- The maximum number of links is reduced allowing faster call setup and removal of some trunks from the network.
- More paths are available between each pair of switches and that increases network redundancy.
- Routing is flexible since the network reacts virtually instantaneously to heavy or unusual call loads and equipment failures.

S. Ineffective Attempt Monitoring

1.95 Ineffective attempt monitoring, incorporated into the 4ESS Switch, utilizes special and multipurpose control programs to monitor system operation. This monitoring function is accomplished by various person-machine interfaces in the 4ESS Switch. Ineffective attempt monitoring does the following:

a. Utilizes extensive check points built into call-processing software. These check points detect ineffective machine attempts, ineffective network attempts, abandons, centralized automatic message accounting irregularities, and retrial conditions.

b. Maintains detailed counts on ineffective machine attempts, abandons, and irregularities on a total office basis.

c. Maintains detailed maintenance-related counts on a trunk maintenance control area basis.

d. Maintains summary machine service reports and machine performance reports for management and operating personnel.

e. Maintains detailed maintenance-related counts on a selective trunk subgroup basis.

f. Provides on-line semiautomatic analysis of ineffective machine attempts and ineffective network attempts for network management (trunk error analysis).

g. Provides on-line automatic analysis of maintenance-related conditions to detect trunk and service circuit failures.

h. Maintains a daily listing of the worst performing trunk subgroups.

i. Provides selective output of maintenance-related, per-call details for manual analysis.

T. Vacant Code Analysis

1.96 The 4ESS Switch is provided with the ability to detect and analyze vacant codes. A vacant code is an unassigned central office code within a defined area code. Vacant code analysis reports only on certain patterns of vacant code failures which have a high probability of indicating problems. In addition to vacant codes, certain routing related failures are also monitored.

U. Integrated Services Digital Network

1.97 The ISDN function provides the 4ESS Switch an enhanced direct connect PBX interface to the Communications Network. The ISDN is based on the CCITT standard Q.931 primary rate interface (PRI) to provide ISDN services. This interface consists of a DS1 transmission facility which has been defined as having 23 B-channels used to carry voice and data. In addition to the 23 B-channels, one D-channel is used to carry all signaling information for the 23 B-channels. However, a D-channel can provide signaling for multiple DS1 facilities. This ability is known as ''non-associated'' signaling. Several ISDN capabilities are as follows:

- Out-of-Band Signaling—Allows out-of-band signaling to be transmitted over the D-channel, thus allowing 64 kb/s restricted or clear transmission to be provided on the B-channels.
- Transmission of message-associated user-to-user information—Allows an ISDN customer to send user-to-user information from customer provided equipment to customer provided equipment.
- Call-by-Call capability—Allows the ISDN customer to combine services over a common set of access and egress facilities.
- Call-Associated Temporary Signaling Connection (TSC)—Provides a user-to-user exchange that is associated with a circuit-switched connection. A call-associated TSC can be established at call setup time or requested after call set up.
- Noncall-Associated Temporary Signaling Connection (TSC)—Provides a user-to-user exchange that is not associated with a circuit-switched connection. A noncall-associated TSC can be established at any time.
- D-channel Backup—Permits a customer continued access to ISDN services in the case of D-channel failures.

2. System Overview

General

2.01 Figure 1 is a high-level functional block diagram of the 4ESS Switch that is divided into the following major functional equipment areas.

a. 1B Processor

b. 3B Computer

c. CNI Ring

d. 1B Processor interface equipment

e. Terminal equipment

f. Terminal interface equipment

g. Switching network

h. Service circuits and trunk test facilities

i. Miscellaneous systems and frames

j. Work centers and support equipment

k. Related systems

l. Network services complex

2.02 The following high-level system description, with the exception of the power distribution system, is oriented toward the functions performed by each equipment area. No attempt is made to identify or discuss the equipment which comprises each area in the following description; however, the equipment is listed in the functional blocks of Figure 1. Parts 3 through 6 of this document are organized according to the same functional equipment areas. The power distribution system is discussed in Part 5.

2.03 Figure 1 illustrates several interfaces which are applicable only when the 4ESS Switch office is integrated into a centralized maintenance environment. These interfaces are discussed under ''Work Centers and Support Equipment''.

1B Processor

2.04 The 1B Processor is a stored program-controlled, real-time, data-processing machine that is a stand-alone subsystem. The 1A Processor is not unique to the 4ESS Switch but the 1B Processor only supports the 4ESS Switch. The 1B Processor is shown double-lined in Figure 1. In its 4ESS Switch application, the stored programs and data (software) in the 1B Processor control the 4ESS Switch switching operations and perform automated operational checks of the equipment on a regular basis.

2.05 The 1B Processor has duplicated frames that use AT&T FASTECH technology with a dense, high performance, standardized interconnection of large circuit packs. The 1B Processor has twice the memory space available with the 1A Processor. The 1B Processor controls switching operations and performs automated operational checks of the 4ESS Switch equipment 2.4 times faster than the 1A Processor. Each 1B frame contains the central control, program store, call store, interface bus, bus driver/receiver, fan, and fuse units.

2.06 The 1A Processor block in Figure 1 consists of the following:

- Duplicated Central Controls
- Semiconductor store frames used as Call Stores and Program Stores
- Semiconductor extended call store (ECS) frame, when required
- Control panels
- Processor Peripheral Interface (PPI) frame

2.07 The functional block of the 1B Processor Complex in Figure 1 consists of the following major areas.

- Duplicated Central Controls (CC)
- Program Stores (PS)
- Call Stores (CS)
- Auxiliary Unit Interface (AUI)
- Scan and Signal Distributor (SSD)
- MCC and Utility Processor (MUP)
- MCC Video Display Terminal (VDT)

2.08 The following equipment is also associated with the 1A and 1B Processors and is considered as being in the 1B Processor community:

- Attached Processor Interface (API)
- Attached Processor System (APS)
- Auxiliary Data System (ADS)
- An input/output frame or input/output processor frame
- Power conversion and distribution equipment.

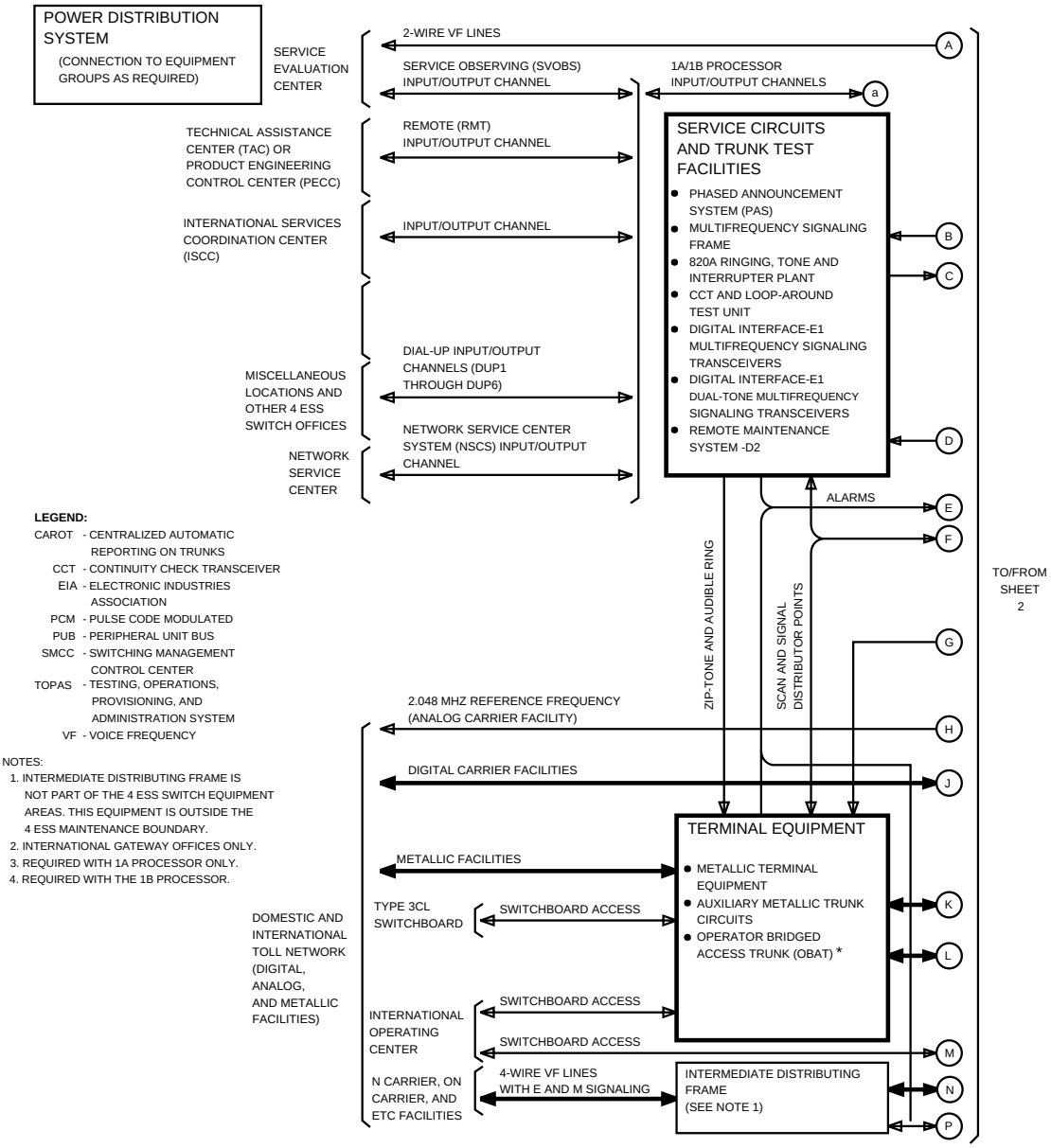


Figure 1. 4ESS Switch Functional Block Diagram (Sheet 1 of 5)

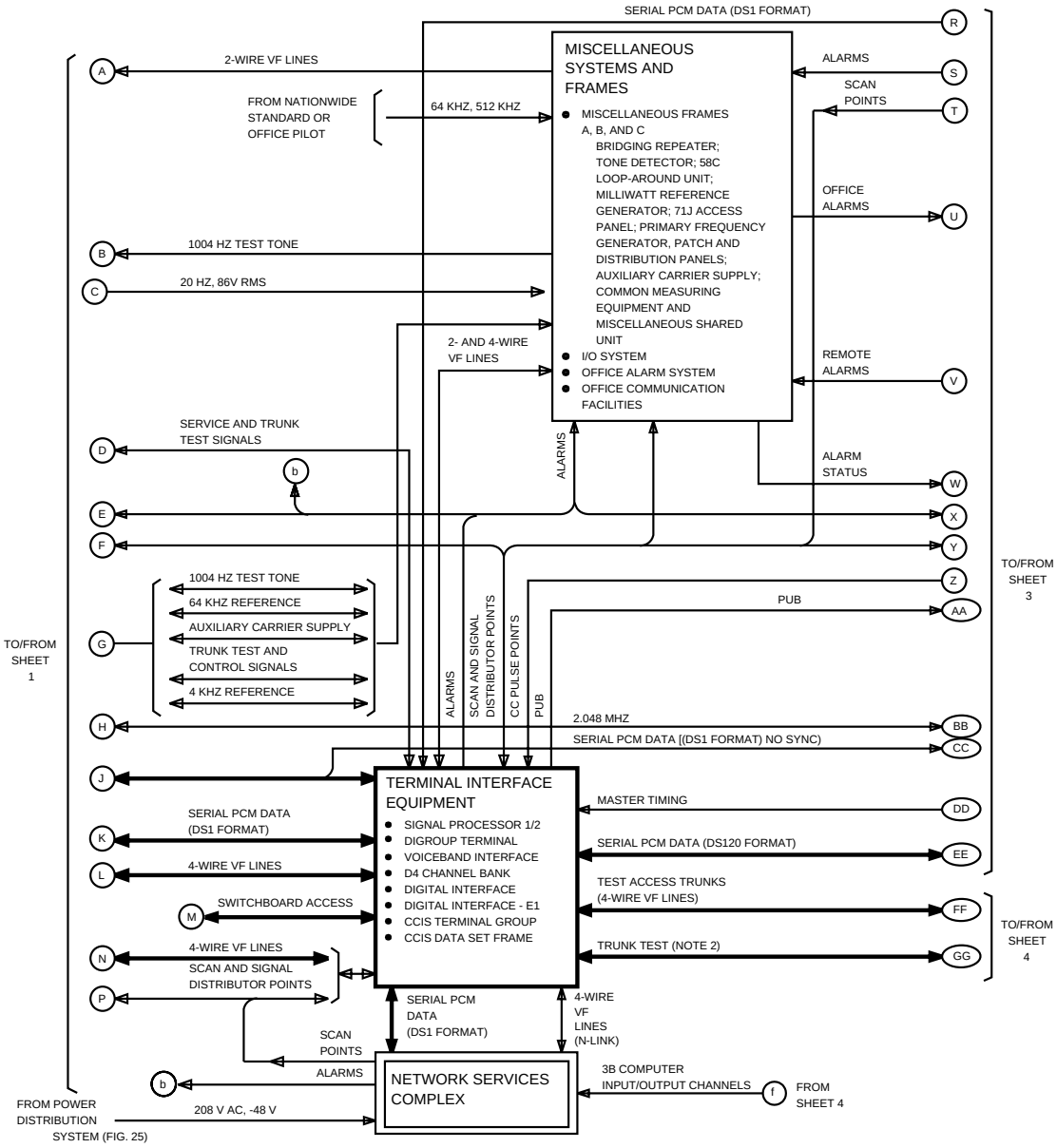


Figure 1. 4ESS Switch Functional Block Diagram (Sheet 2 of 5)

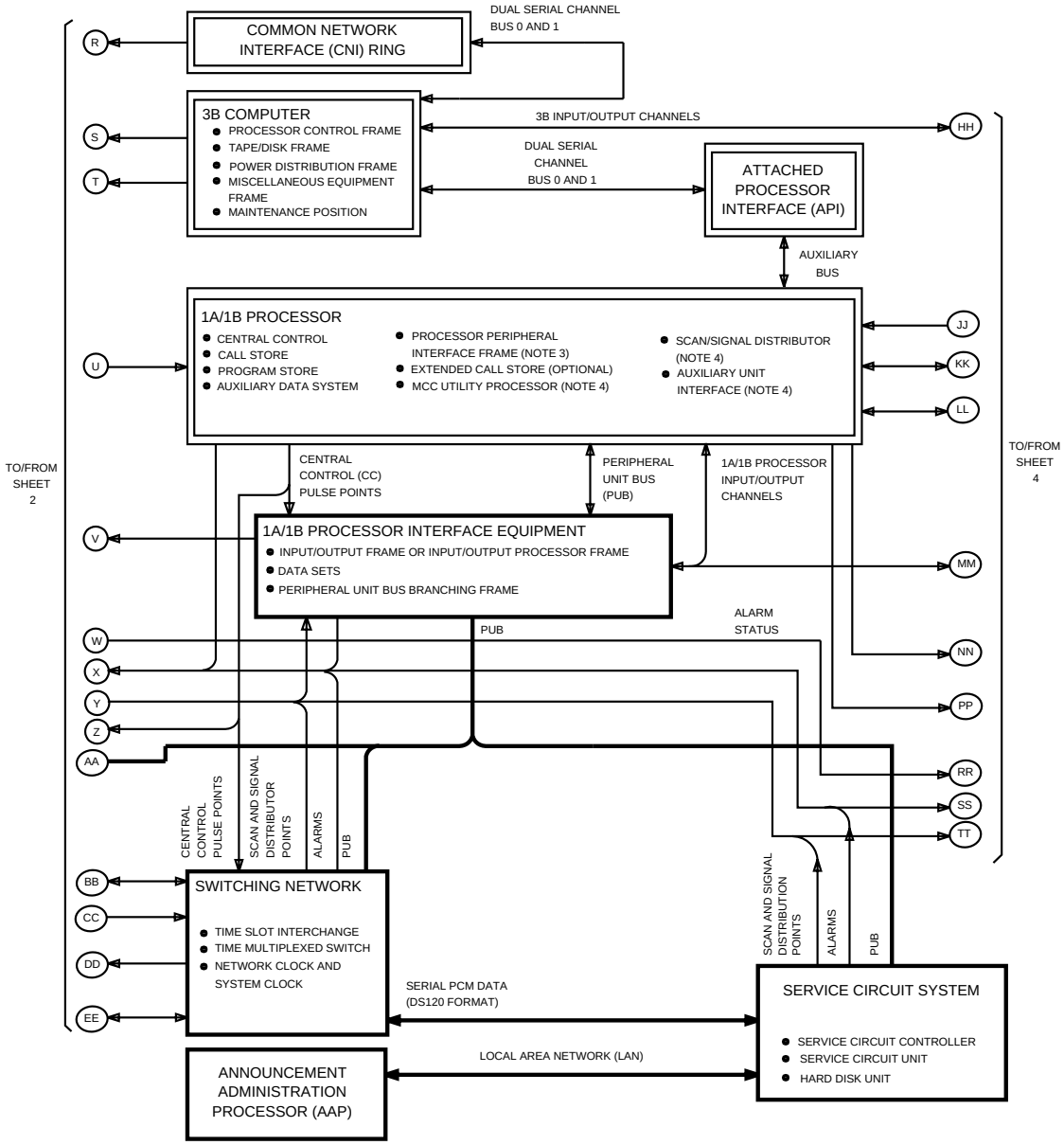


Figure 1. 4ESS Switch Functional Block Diagram (Sheet 3 of 5)

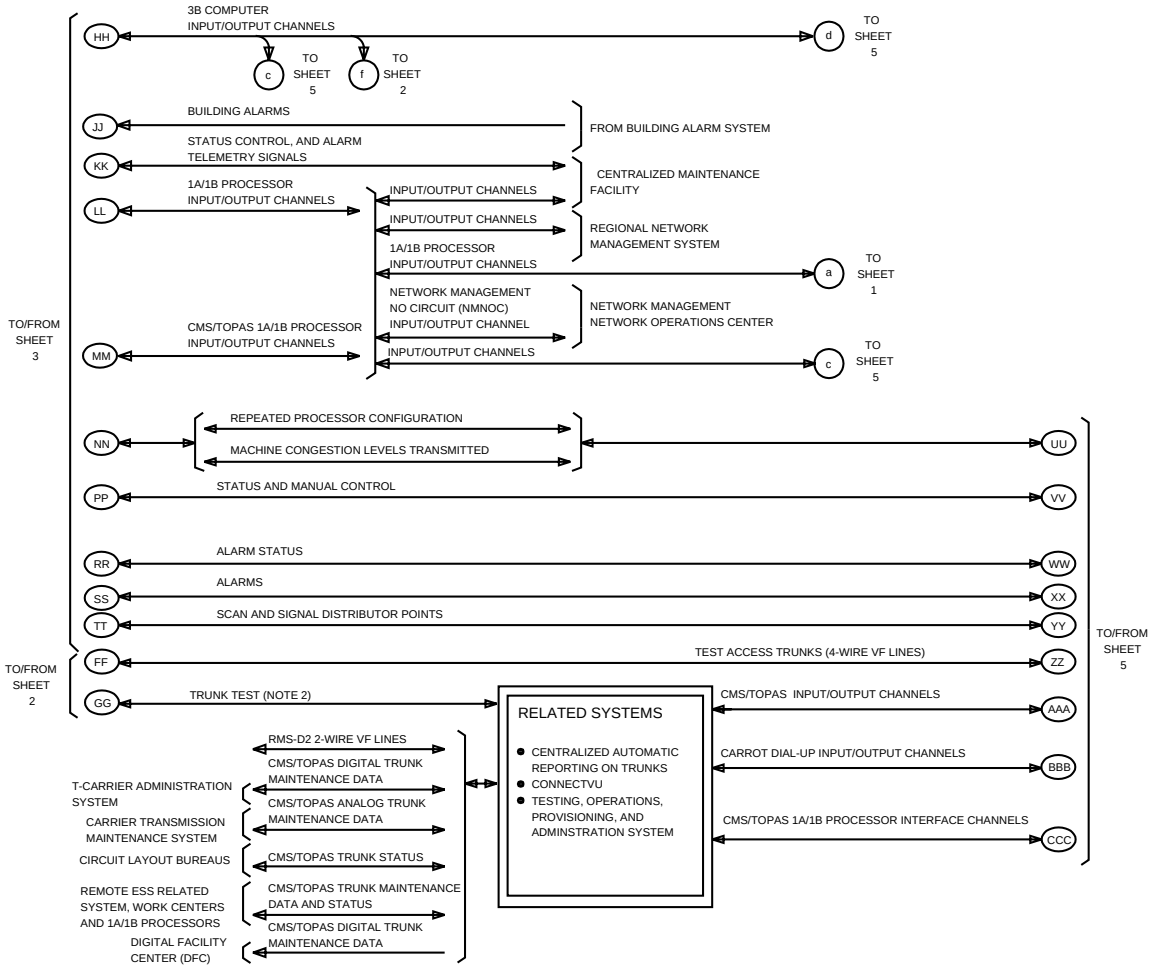


Figure 1. 4ESS Switch Functional Block Diagram (Sheet 4 of 5)

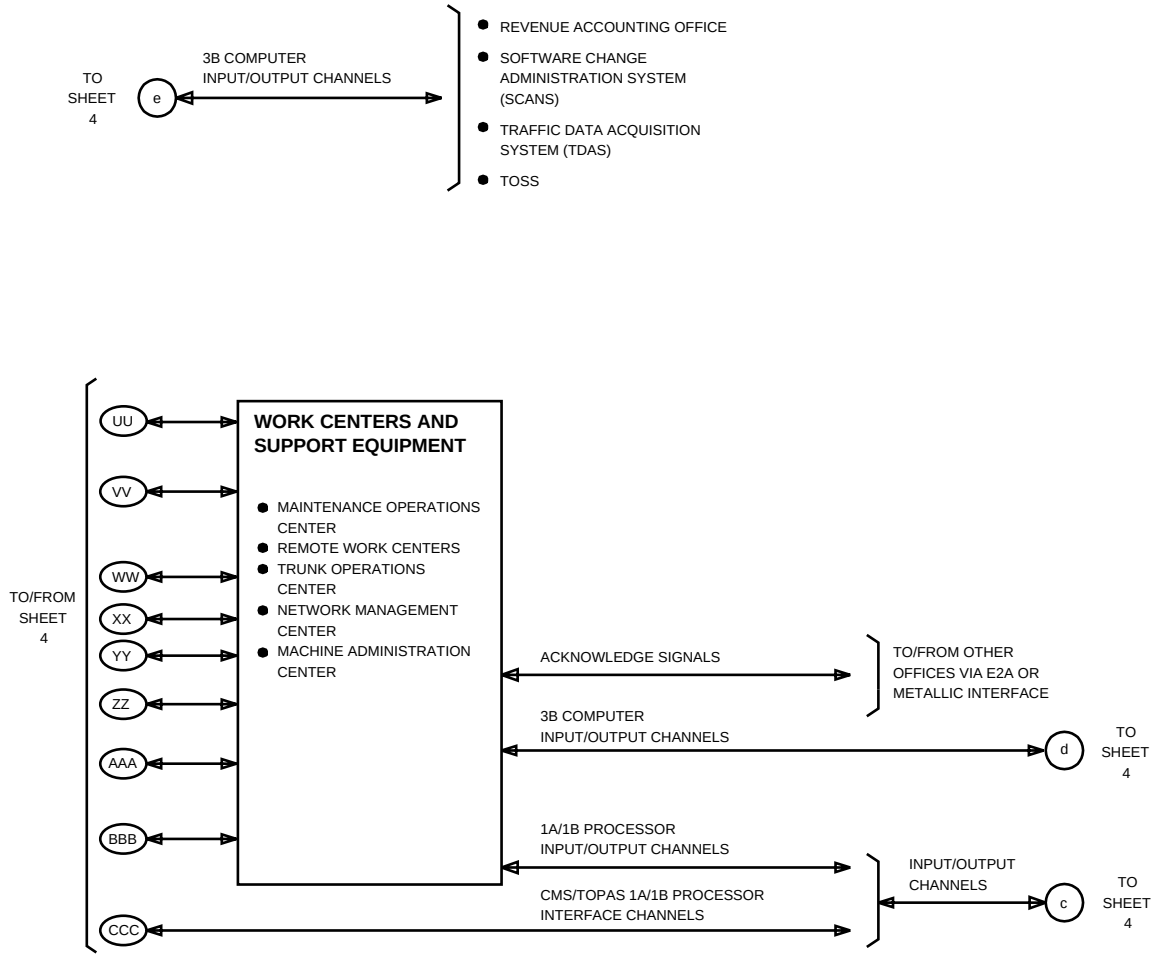


Figure 1. 4ESS Switch Functional Block Diagram (Sheet 5 of 5)

2.09 The 1B Processor software also performs varied system functions such as customer billing, monitoring system operation, initiating diagnostic operations, and compiling management reports. Facilities are provided in several work centers to exercise manual control over the 1B Processor and, consequently, the 4ESS Switch. With the 1A processor, manual control is implemented through indicator lamps and switches located on control panels and through two-way communication via input/output terminals. The 1B Processor uses the Master Control Complex (MCC) video display for manual control and two-way communication via input/output terminals. Manual control is provided to accommodate other than normal operating conditions or to perform maintenance, troubleshooting, or monitoring functions. The 1B processor also has two-way communication via input/output terminals.

2.10 The primary interface between the 1B Processor and the 4ESS Switch equipment is the peripheral unit bus. The peripheral unit bus provides the interface between the 1B Processor and the 4ESS Switch equipment frames which are directly controlled by the 1B Processor. This bus carries information which does the following:

- Identifies the 4ESS Switch equipment which is to be accessed by the 1B Processor
- Directs specific actions to be initiated by the accessed equipment
- Indicates the response by the accessed unit.

2.11 The input/output channels provide a two-way interface between the 1B Processor and input/output terminals located throughout the 4ESS Switch. Input/output channels also provide interfaces to the following:

- A Service Evaluation System which monitors performance of the toll network
- An International Services Coordination Center which monitors the performance of international trunks
- An Engineering and Administrative Data Acquisition System for Network Management Center which provides centralized management surveillance and control of the telephone network
- A Network Service Center System which analyzes call irregularity data as part of a service improvement function
- Remote centralized maintenance facilities
- Other AT&T 4ESS Switches.

3B Computer

2.12 The 3B Computer (Model 20) is a stand-alone computer system which is not unique to the 4ESS Switch. The hardware and software necessary to connect a 3B Computer to a 1B Processor, inclusive of the 3B Computer equipment, is defined as an Attached Processor System (APS). In the 4ESS Switch application, the APS provides disk storage. The increased disk storage capacity provided by the 3B Computer is required by the 4ESS Switch to load 4E7 and later generic programs. Note that the APS is also used for additional functions including the following:

- Network services complex (NSCX) interface
- Automatic message accounting standard entries (AMASE)
- Software Change Administration and Notification System (SCANS) interface
- Traffic Data Administration System (TDAS) interface
- International Call Detail Recording
- CNI applications.
- Service circuit system

2.13 The primary interface between the 1B Processor and the 3B Computer is via a dual serial channel (bus 0 and 1) as shown in Figure 1. Additional input/output channels are provided with the 3B20 in several work centers to display 3B Computer status information and to exercise

manual control over the 3B Computer. Manual control is provided to perform maintenance, troubleshooting, and monitoring functions. The input/output capability of the 3B Computer provides the basic support for interfaces with NSCXs, message accounting facilities, SCANS, TDAS, and others.

3B21D Computer (Attached Processor System)

2.14 The 3B21D computer is a computer that possesses upgrades and additions that makes it a promising replacement for the 3B20D APS. The 3B21D retains the 3B20D architecture and instruction with the following enhanced attributes.

- Faster processor and memory access
- Larger main memory capacity (up to 128 MB of RAM on a single memory board)
- Reduced footprint and lower Cost of Goods (COGs)
- Bit compatible architecture with the 3B20D
- Two open expansion slots for future switch interfaces (for example: LAN, ATM) to enable long-term processing, memory, and input/output expansion
- Circuit pack mounted SCSI pack disk drives, Digital Audio Tape (DAT) SCSI.

CNI Ring

2.15 The CNI ring is a common subsystem designed to interface AT&T 3B Computer controlled switching offices, data bases, and signal transfer points (STPs) with a stored program controlled network. The CNI ring application uses the Interprocess Message Switch (IMS). The IMS includes message-distributing software in the 3B Computer and a system of peripheral microprocessors interconnected by direct memory access hardware and a ring-type busing arrangement to support high-capacity packet switching.

2.16 The CNI ring interfaces are made to the 4ESS Switch via dual serial channels and DS1 trunks. The hardware required to make these interfaces is discussed in the Equipment Description part of this document. Also, a functional description of the CNI ring is discussed in the Functional Description part of this document.

2.17 Two new abilities are available with the introduction of the CNI ring into the 4ESS Switch network.

1. The Common Channel Signaling System 7 and Destination Common Channel Signaling System (CCS7/DCIS) — Allows the 4ESS Switch to replace the interface with the 1STP (1 Signal Transfer Point) network with the 2STP (2 Signal Transfer Point) network. Access to the 2STP network is via two CCS7 nodes on the CNI ring.
2. The Integrated Services Digital Network (ISDN) — Allows customer premises equipment (PBXs, etc) direct access to the AT&T network via out- of-band signaling. This signaling is based on the CCITT recommended Q.931 protocol. Q.931 signaling allows more information to be exchanged between the PBX and the 4ESS Switch. Signaling information is transmitted over D-channels while the user information is transmitted over B-channels.

2.18 The CNI ring processing hardware required to introduce a ring into the 4ESS Switch environment is housed in three basic CNI frames:

- Ring Node Frame
- Digital Facilities Access Frame

Node Types

2.19 The CNI consists of a community of peripheral processors serially interconnected with each other in a dual ring configuration, and a central processor (3B20D Computer) that performs the basic operating duties in a distributive

input/output processing architecture. These peripheral processors are ring nodes that operate as routing or switching devices for data packets or messages. The following are the four ring node types of which the CNI contains:

1. Ring Peripheral Controller Node (RPCN)
2. CCS7 Node (CCS7)
3. Direct Link Node (DLN)
4. D-Channel Node (DCHN)

2.20 Each type of ring node has a number of internal components that are combined to make up the hardware configuration required to provide the specific functions of that node type.

Ring Peripheral Controller Node

2.21 The RPCN provides the communication link between the 3B computer with the CNI ring to provide continuous real-time operation. All network and ring maintenance messages, as well as network traffic measurements and ring measurements, are sent to the 3B Computer via the RPCN node. RPCN also provides the administration, maintenance, and recovery of the ring. An RPCN node pair is required in each CNI ring regardless of its application. The RPCN consists of the following:

- Node Processor (NP)
- Ring Interface (RI)
- 3B Computer Interface (3BI)
- Duplex Dual Serial Bus Selector (DDSBS)

2.22 The NP provides the control for routing the messages around the ring, inserting the messages on the ring, removing messages from the ring, reformatting and error checking the messages, and maintenance functions.

2.23 The RI provides access to the two rings—ring 0 and ring 1—which are directional and propagate data in opposite directions. Each RI has a pair of independent ring access control (RAC) circuits—one for ring 0 (RAC 0) and one for ring 1 (RAC 1)—that guides the message activity on the ring.

2.24 Under normal operation, normal traffic and signaling messages are handled by ring 0; internal maintenance messages are handled by ring 1. In the event of a node failure, each RI has the capacity to loop the data from one ring onto its mate. This isolation mode permits the bypassing of faulty nodes.

2.25 The 3BI establishes the connection between the 16-bit node bus in the NP and the 32-bit Peripheral Bus Interface (PBI) on the DDSBS. The two circuits function as a unit to complete the connection for the 32-bit bus to the Dual Serial Channel (DSCH) of the 3B computer. The 3BI accomplishes the protocol conversion between the two asynchronous buses and contains bidirectional First-In First-Out (FIFO) circuits that provide the ability for each processor to read/write independently.

2.26 The DDSBS performs the conversion between the 32-bit parallel format of the internal PBI bus and the serial format of the 3B computer DSCH. The DDSBS terminates on channel 11 or 12 on the DMA Controller of the DSCH.

CCS7 Node

2.27 The CCS7 nodes connect the signaling network "A-Links" and "E-links" to the ring and control the message flow between the signaling links (SLKs) and the ring. They also perform limited diagnostics out to the Data Service Units (DSUs) in the Digital Facility Access (DFA) frame. A minimum of two CCS7 nodes are arranged on the ring in a duplex mode configuration for every CNI application. The CCS7 node consists of the following:

- Node Processor (NP)
- Ring Interface (RI)

- Link Interface (LI)

2.28 The NP provides the control for routing the message around the ring, inserting the messages on the ring, removing messages from the ring, reformatting and error checking the messages, and maintenance functions.

2.29 The RI provides access to the two rings—ring 0 and ring 1—which are directional and propagate data in opposite directions. Each RI has a pair of independent ring access control (RAC) circuits—one for ring 0 (RAC 0) and one for ring 1 (RAC 1)— that guides the message activity on the ring.

2.30 Under normal operation, normal traffic and signaling messages are handled by ring 0; internal maintenance messages are handled by ring 1. In the event of a node failure, each RI has the capacity to loop the data from one ring onto its mate. This isolation mode permits the bypassing of faulty nodes.

2.31 The LI provides the connection for data transfer between the data link network and the ring, and translates the messages. The type of circuit pack and micronode used is signal link specific rather than application specific like the NP. It also satisfies the Message Transfer Part (MTP) protocol layer requirements for the connection. The LI uses an Intel 8086-2 microprocessor for its CPU. Communication to the node processor is via a dual port RAM memory and to the network via RS-449 interface to a DSU in the DFA frame.

2.32 The capacity of the LI increases with the DSO-A interface feature available with the 4E17 generic program. This optional feature allows a customer to increase the link interface from 56K CCS7 links to 64K CCS7 links by replacing a circuit pack. The LIDO circuit pack required with this feature provides an 8K link interface capacity increase along with additional memory chips that allow fast and easy updating link level problems more efficient. The LIDO circuit pack also eliminates the need for signal conversion by a Data Signaling Unit (DSU)/Channel Signal Unit (CSU).

2.33 The Extended Access Links (E-links) and Full Point Routing features available with the 4E18 generic program allow an alternate routing for data transfer between the data link network and the ring. The E-links improve network performance and provide protection against Signal Transfer Point (STP) failures by providing direct connection to non-home STPs. Network reconfiguration is easier with both A-links and E-links. The CNI has up to three signaling routes to any signaling point. These routes can be either A-link routes or E-link routes.

Direct Link Node

2.34 The DLN transfers signaling messages between the CNI ring and the host computer memory, performs signaling message reformatting, error checking, fault detection, and measurements. The DLN also relieves the 3B computer processor of some signaling message processing to support greater CCS processing capacity.

2.35 In the 4ESS Switch, the DLN stream is sent to the circular buffers (CNIBUF) in the 3B computer, and transferred via Direct Memory Access (DMA) through the Attached Processor Interface (API) to the 1B Processor.

2.36 A DLN pair functions on the ring in a duplex configuration, one in the active mode and the other in standby. The active DLN handles all signaling message traffic between the host processor and the CNI ring. The routing data base is maintained in both the active and standby DLN, allowing the ability to switch between the two should a problem occur. The DLN consists of the following:

- Node Processor (NP)
- Attached Processor (AP)
- Ring Interface (RI)
- 3B Computer Interface (3BI)
- Duplex Dual Serial Bus Selector (DDSBS).

2.37 The NP is the same as described for the RPCN. The NP provides the control for routing the messages around the ring, inserting the messages on the ring, removing messages from the ring, reformatting and error checking the messages, and maintenance functions.

2.38 The AP provides additional processing capacity when translating and reformatting signaling messages with a Motorola 6800 microprocessor. The AP contains one megabyte of main memory and 64K bytes of dual port RAM. The CNI resident software provides the function of translating ISUP routing labels and Q.931 trunk identifiers into Trunk Scanner Numbers (TSNs) for messages going from the ring to the host processor and back. It also maintains routing information and coordinates DLN initialization. The ROM provides the code for memory pump, memory dump, boot diagnostics, and full ring communications.

2.39 The RI is the same as described for RPCN. The RI provides access to the two rings—ring 0 and ring 1—which are directional and propagate data in opposite directions. Each RI has a pair of independent ring access control (RAC) circuits—one for ring 0 (RAC 0) and one for ring 1 (RAC 1)— that guides the message activity on the ring..

2.40 Under normal operation, normal traffic and signaling messages are handled by ring 0; internal maintenance messages are handled by ring 1. In the event of a node failure, each RI has the capacity to loop the data from one ring onto its mate. This isolation mode permits the bypassing of faulty nodes.

2.41 The 3BI is the same as described for RPCN. The 3BI establishes the connection between the 16- bit node bus in the NP and the 32-bit Peripheral Bus Interface (PBI) on the DDSBS. The two circuits function as a unit to complete the connection for the 32-bit bus to the DSCH of the 3B20. The 3BI accomplishes the protocol conversion between the two asynchronous buses and contains bidirectional First-In First-Out (FIFO) circuits that provide the ability for each processor to read/write independently.

2.42 The Duplex Dual Bus Selector (DDSBS) is the same as described for RPCN. The DDSBS performs the conversion between the 32-bit parallel format of the internal PBI bus and the serial format of the 3B20 DSCH. The DDSBS terminates on channel 11 or 12 on the DMA Controller of the DSCH.

D-Channel Node

2.43 The D-Channel Node (DCHN) provides digital connection from Customer Premises Equipment (CPE) to a CNI ring equipped office and terminates messages originating from the CPE. It is used as an interface between the 4ESS Switch and the ISDN network for a Private Branch Exchange (PBX) access using the Q.931 signaling protocol on a T1 carrier system. Up to 8 links between various CPEs and the ring can be supported by one DCHN. This node is used only in the 4ESS Switch and is optional. The functions of the DCHN are as follows:

- Multiple signaling link termination
- Layer 2 protocol support
- Node maintenance
- High speed signaling message transport with flow control between this node and an active DLN.

2.44 The DCHN node consists of the following:

- Node Processor (NP)
- Link Interface (LI)
- Ring Interface (RI)
  (Not required with UN303B or UN304)
- T1 Facility Access (T1FA)
  (One required per shelf)

2.45 The NP provides the control for routing the messages around the ring, inserting the messages on the ring, removing messages from the ring, reformatting and error checking the messages, and maintenance functions.

2.46 The 4E17 generic program provides a D-Channel capacity increase by replacing the TN922 or UN303B NP with an Intel 80836 microprocessor based Integrated Ring Node No. 2 (IRN2) circuit pack. The D-Channel capacity increase feature allows an increase in memory, real-time, and call capacity. The capacity increase and flexibility of the D-Channel node provides the following:

- Sufficient memory for adding additional D-Channel features
- Increase in the simultaneous call capacity per D-Channel
- Node support for larger customers
- Increase in the simultaneous Call Associated Temporary Signaling Connections (CA-TSCs) per D-Channel.

2.47 The RI provides access to the two rings—ring 0 and ring 1—which are directional and propagate data in opposite directions. Each RI has a pair of independent ring access control (RAC) circuits—one for ring 0 (RAC 0) and one for ring 1 (RAC 1)—that guides the message activity on the ring. The IRN/IRN2 incorporates the function of the RIs.

2.48 Under normal operation, normal traffic and signaling messages are handled by ring 0; internal maintenance messages are handled by ring 1. In the event of a node failure, each RI has the capacity to loop the data from one ring onto its mate. This isolation mode permits the bypassing of faulty nodes.

2.49 The LI provides the connection for data transfer between the data link network and the ring, and translates the messages. The type of circuit pack and microcode used is signal link specific rather than application specific like the NP. It also satisfies the Message Transfer Part (MTP) protocol layer requirements for the connection. The LI uses an Intel 8086-2 microprocessor for its CPU. Communication to the node processor is via a dual port RAM memory and to the PBX Network using the Q.931 protocol.

2.50 The T1FA provides the interface to connect 24 D-Channels to the ring. The T1 carrier system is divided into 23 B-Channels and one D-Channel. The D type is the signaling channel, and the B type is the voice or data channels for the carrier system. One DCHN can support up to 8 links.

2.51 The D-Channels from the PBX are connected to the T1FA via a Trunk Appearance Number (TAN) to TAN connection nailed up in the Time Division Switching Network (TDSN).

Direct Link Node Enhanced (DLNE)

2.52 The DLNE provides the increased signaling traffic requirements for Common Channel Signaling No. 7 (CCS7) and Q.931 signaling in the 4E15 and later generic programs. The current DLN architecture can support up to 2,000 messages per second. These messages include trunk signaling and direct signaling messages. In the 4E15 generic program, DLN is required to support 2,450 messages per second.

2.53 To support the higher message capacity through DLN, a hardware enhancement, DLNE, was added in 4E15. The DLNE increases the capacity of an individual DLN. However, for message flow, the DLNs continue to operate in the one-way mode. The DLNE is required with the 4E16.

2.54 With the DLNE upgrade, the Ring Interface (RI) boards are replaced by an Integrated Ring Node (IRN).

2.55 The DLNE software architecture is the same as in the current DLN. The DLNE nodes are grown as new node types on a 4ESS Switch. Depending on the office needs, either two or four DLNE nodes can be used in an office. The DLNE nodes replace existing DLN nodes one at a time, using the same slots previously occupied by a DLN node. Signaling traffic will be moved from the operational DLNs to DLNEs via a craft command.

Interframe Buffers

2.56 Interframe buffers (IFBs) are used to balance the ring bus transmission media for transmitting messages between ring groups (groups of nodes). There are two types of IFBs, padded (TN1803 pack) and unpadded (TN918 pack) IFBs. Interframe buffers are positioned when entering or exiting a ring group.

2.57 In addition to providing a balanced transmission media between ring groups, the IFBs also provide FIFO buffers to pad the data storage capacity of the ring. This is an important function since the data storage capacity of the ring must be equal to or greater than two times the length of the longest possible message (508 bytes) plus the length of the token (8 bytes). This requirement must be met in order to avoid a message propagation on the ring. Padded IFBs contain 512 bytes of FIFO buffering to compensate for small ring applications.

Digital Facility Access Frame

2.58 The DFA frame provides the interface between the link nodes in the ring node frame and the 4ESS Switch digital transmission facility. This interface is known as a DFA circuit. A DFA circuit is required for each link node connected to a digital signaling link. A fully equipped digital facility access frame can provide ten DFA circuits, thus providing the interface equipment necessary to connect ten link nodes to ten digital signaling links.

2.59 The primary function of the DFA circuit is to convert the RS 449 digital signal format to a bandpass bipolar signal usable by the 4ESS Switch digital transmission facility. The DFA circuit also provides the CNI ring with the ability to transmit messages at 56 kb/s. Digital facility access circuit hardware consists of the following:

- Digital Service Adapter
- Digital Service Unit
- Channel Service Unit.

2.60 The digital service adapter (DSA) provides the circuitry necessary to select the signaling rate (2.8 kb/s, 4.8 kb/s, 9.6 kb/s or 56 kb/s) at which the digital facility access circuit will operate. The DSA consist of a TF5 circuit pack and is associated with one digital service unit and one channel service unit.

2.61 Two versions of the digital service unit (DSU) can be used in a digital facility access circuit:

- 500B DSU
- 502B DSU.

2.62 The 500B DSU provides 56 kb/s signaling for full duplex 4-wire private line operations and for accessing long-haul synchronous transmission facilities. The 500B DSU performs signal processing, test functions, and customer interface functions. The 502B DSU provides 56 kb/s signaling for accessing short-haul nonsynchronous transmission facilities. The 502B DSU is a modified 500B DSU. This modification adds a 112A circuit module to the 500B DSU to alter the synchronization between the DSU and nonsynchronous transmission facility. The 502B DSU performs service terminations, maintenance functions, signal processing, test functions, and customer interface functions.

2.63 The channel service unit (CSU) provides the timing functions for 56 kb/s signaling on full duplex 4-wire private line operations and long haul synchronous transmissions. The 550A CSU also provides maintenance testing capabilities with equalization and loop loss. No CSUs are required for short-haul signaling links to collocated offices.

2.64 The DFA frame may also be equipped with equipment providing an interface between I/O processor signaling links and transmission links to other 4ESS Switches. This interface is provided

by AT&T Paradyne® Model 3511 CSU/DSU circuits. When fully equipped for this function, the DFA frame may provide access for up to 16 links. This is in addition to the link nodes to digital signaling links discussed previously.

Additional Information

2.65 Refer to 234-100-120AC or 234- 100-120, *Common Channel Signaling Systems, Common Network Interface (CNI), System Description Manual*, for detailed information concerning the physical characteristics of the CNI ring.

1B Processor Interface Equipment

2.66 The 1B Processor interface equipment provides a facility to branch the peripheral unit bus to all 4ESS Switch equipment frames requiring access to the bus. This branching facility also provides a loop-around capability which enables the 1B Processor to check the ability of the peripheral unit bus to transfer data accurately.

2.67 The 1B Processor interface equipment can also contain input/output interface equipment. This capability is normally provided because the 1B Processor input/output interface capability is not sufficient to meet the needs of most 4ESS Switch offices. The input/output interface equipment provides 4ESS Switch input/output terminals with access to the 1B Processor via the peripheral unit bus.

2.68 To implement centralized maintenance, a number of 4ESS Switch offices may be linked with a centralized remote maintenance center. The 1B Processor interface equipment provides telemetry circuits required to exchange control, status, and alarm signals between each office and the centralized maintenance center.

2.69 The equipment frames which comprise this functional equipment area also have an alarm interface with the miscellaneous systems and frames equipment group. This interface is used to apply indications of various power-alarm conditions to the office alarm system.

Terminal Equipment

2.70 The terminal equipment provides the interface between metallic trunk facilities in the toll network and the 4ESS Switch. Two-wire and 4-wire voice-frequency (VF) trunks terminating at metallic terminal facilities interface with the 4ESS Switch office through the terminal equipment. signals.

2.71 Terminal equipment frames contain signaling, equalization, and amplification circuits for each trunk. All message traffic interfaces between the terminal equipment and terminal interface equipment are via 4-wire VF trunks (with E&M signaling where required) regardless of the type connection at the toll-network side of the terminal equipment.

2.72 The terminal equipment provides an interface capability with operator-attended, type-3CL switchboards. An operator position may be provided for the following:

- Operator-office trunks associated with the 4ESS Switch office, switchboards, and community dial offices
- Operator number identification associated with centralized automatic message accounting.

A terminal equipment zip-tone input from the service circuits and trunk-test facilities equipment group is provided for switchboard signaling.

2.73 The terminal equipment provides maintenance access to individual metallic trunks. This access is in the form of panels which provide manual jack access to individual trunks at the terminal equipment frames.

2.74 The equipment frames which comprise the terminal equipment area also have an alarm interface with the miscellaneous systems and frames equipment group. This interface is used to

apply indications of various carrier supply and power-alarm conditions to the office alarm system.

2.75 In an international switching center, the terminal equipment also includes equipment which provides the following:

- Message and signaling interfaces for international trunks
- An interface to an operator switchboard in a distant international operating center.

Terminal Interface Equipment

2.76 The overall function of the terminal interface equipment area provides a message traffic interface with the switching network and trunk signaling interface with the 1B Processor. A number of frames with various functions are required to perform the overall terminal interface equipment function. These frames include the following:

a. Equipment which provides an interface between digital carrier equipment and the switching network. Digital carrier signals require no conversion from analog to pulse code modulated format. This equipment performs the following:

   1. Extracts signaling information
   2. Converts the incoming pulse code modulated data to another pulse code modulated format which is compatible with the switching network
   3. Adapts the digital carrier trunk assignment to a grouping compatible with the switching network.

2.77 In international switching centers (ISCs), an interface may also exist between the digital equipment and an operator switchboard in a nearby international operating center. This interface utilizes equipment that performs the following:

a. Processes signaling information and provides a signal interface with the 1B Processor. Signaling information related to analog trunks is handled via an E&M-lead interface with the terminal equipment area. Signaling information associated with trunks employing digital facilities is processed within the terminal interface equipment area.

b. Provides the system with the ability to interface with trunks employing common channel signaling (CCS).

2.78 Most of the frames in this functional equipment area are either directly controlled by or provide information to the 1B Processor. This interface is via the peripheral unit bus. The two-way serial pulse code modulated data interface with the switching network presents service and test signals or message traffic to the switching network. In the reverse direction, this interface carries switched traffic back to the terminal interface equipment for application to appropriate trunks or service circuits.

2.79 The terminal interface equipment interconnections with service circuits and trunk-test facilities provide the switching network with access to trunk-test equipment and tones required in a 4ESS Switch office.

2.80 The equipment frames, which comprise this functional equipment area, also have an alarm and miscellaneous signal interface with the miscellaneous systems and frames equipment group. The alarm interface is used to apply indications of various terminal-interface equipment power-alarm conditions to the office alarm system. The miscellaneous signal interface provides the switching network with access to miscellaneous equipment such as tone detectors, test-tone generators, and loop-around units associated with remote trunk testing.

Switching Network

2.81 The switching network contains the equipment which actually switches traffic from one trunk or service circuit to another. Within

the switching network, a complete physical path never exists between two interconnecting trunks. Instead, the pulse code modulated data which represents message traffic to be switched is entered into a memory associated with the incoming trunk group and the time slot assigned to the specific trunk. At a specific ***time***, this data is applied to the switching network where the data is ***space*** transferred through a time-shared switch. At the output of the switch, this data is transferred to a memory associated with the trunk group and time slot of the outgoing trunk. At a specific ***time,*** this data is forwarded to the terminal interface equipment for application to the appropriate trunk. This transfer path just described is unidirectional. Therefore, two separate paths are established through the switching network in order to interconnect two toll trunks. Equipment which performs the previously described functions is also referred to as the time division network. When required, the switching network is used to connect signaling devices to trunks to detect or send signaling information. The switching network is also used to connect test equipment, announcements, and various tones to trunks when required. The actual transfer paths through the switching network are set up and controlled by the 1B Processor via the peripheral unit bus.

2.82 The equipment frames, which comprise the switching network area, also have an alarm interface with the miscellaneous systems and frames group. This interface is used to apply indications of various switching network power-alarm conditions to the office alarm system.

Service Circuits and Trunk Test Facilities

2.83 The equipment in the service circuits and trunk test facilities group provides varied trunk test and service facilities required in a 4ESS Switch office. These trunk test and service facilities include the following:

- Special services digital interface signaling units
- Dual-tone multifrequency receiver and transmitter units (digital)
- Multifrequency signaling receiver and transmitter units (digital)
- Multifrequency signaling receiver and transmitter units (analog)
- Continuity check equipment (analog)
- Trunk test equipment (digital or analog)
- Recorded announcements (analog)
- Various busy and reorder tones (analog).

When the Service Circuit System (SCS) is available in a 4ESS Switch office equipped with the 4E17 generic program, the primary source of recorded announcements is the SCS. The announcements facility mentioned previously serves as a secondary source for announcements.

2.84 Each facility requires a pulse code modulated (PCM) trunk appearance at the switching network. The analog facilities are connected via 4-wire VF circuits to terminal interface equipment that provide them with PCM trunk appearances at the switching network. Switching network trunk appearances for digital facilities do not require conversion to/from the PCM format by the terminal interface equipment.

2.85 Service circuits and trunk test facilities generate a zip-tone for application to operator switchboards via the terminal equipment. Miscellaneous signals are exchanged with miscellaneous systems and frames equipment. This equipment group also maintains an alarm interface with the miscellaneous systems and frames. This interface is used to apply indications of power-alarm conditions to the office alarm system.

Miscellaneous Systems and Frames

2.86 This equipment group is comprised of various miscellaneous systems required to support 4ESS Switch office operations. These miscellaneous systems include the office alarm

system, office communication system, and input/output system.

2.87 This equipment group also contains miscellaneous test equipment, tone and signal sources, and measuring equipment required by the 4ESS Switch but not specifically related to the function of any other functional equipment group. This equipment group also contains equipment which provides a voice-frequency interface to an external evaluation station which monitors quality of service.

Work Centers and Support Equipment

A. Decentralized Environment

2.88 Each 4ESS Switch office contains work centers for implementing the functions involved with operation, maintenance, and administration of the office. These functions are implemented from various consoles and numerous input/output terminals.

2.89 These consoles and input/output terminals are grouped in areas dedicated to perform specific functions. These areas are referred to as work centers. Collectively, the various consoles and input/output terminals together with other person-machine interface devices are termed system interface devices. Therefore, a work center is a collection of system interface devices necessary to perform specific functions associated with the operation, maintenance, and administration of the office.

2.90 The primary work center interfaces are the status- and manual-control interface and input/output channel interface with the 1B Processor. Status- and manual-control signals terminate at work center consoles. Input/output channels terminate at work center input/output terminals. The 4ESS Switch activities are controlled by applying input signals and control messages to the 1B Processor via these system-interface devices. The work centers also provide system status information to drive status displays at a distant location. Certain work centers also require input/output channel interface with the related systems. Certain work center equipment has an alarm interface with the miscellaneous systems and frames equipment group. This interface is used to apply indications of certain work center conditions to the office alarm system.

B. Centralized Environment

2.91 Certain work center functions for a number of 4ESS Switch offices may be centralized, and the on-site work center structure redefined in order to provide increased economic, operating, maintenance, and administrative efficiencies. When centralized, a different work center structure is defined than that provided in the decentralized environment. Centralization of specific work center functions does not eliminate any of the previously defined work center functions. However, specific functions are reassigned to a centralized facility. Note that in Figure 1, the work center and support-equipment block lists all work centers for both the decentralized and centralized environments.

2.92 Each 4ESS Switch office participating in a centralized work center arrangement interconnects with the centralized facility to provide status, manual control, and input/output channel interfaces. System status- and manual-control signals are exchanged with the centralized facility through remote access and telemetry equipment within the 1B Processor. The input/output channels normally applied to the on-site work center responsible for the transferred functions are applied to the centralized facility. This input/output channel interface between each office and the centralized facility is implemented via office-engineered, multiplexed data links.

Related Systems

2.93 Related systems, such as the Circuit Maintenance System (CMS) or Testing, Operations, Provisioning, and Administration System (TOPAS), are provided to support the 4ESS Switch offices. The related systems apply automated machine aids to the task of trunk testing and maintenance in addition to providing machine-

aided maintenance record keeping and program-controlled trunk maintenance features. The related systems are provided to simplify maintenance of the relatively large number of trunks terminating at a 4ESS Switch office. Related systems are self-contained systems and for this reason are shown double-lined in Figure 1.

2.94 The ConnectVu/CMS or TOPAS systems are provided with their own self-contained miniprocessors. The ConnectVu/CMS or TOPAS provides a computer-supported facility which aids administrative, operations, and maintenance personnel in implementing trunk maintenance. The ConnectVu/CMS or TOPAS processor can be accessed from work center input/output terminals via input/output channels. This processor also has access to the 1B Processor office-dependent data base through an input/output channel interface with the 1B Processor. This processor also exchanges trunk and trunk maintenance data with a Carrier Transmission Maintenance System (CTMS) and with circuit provisioning bureaus at remote locations. The ConnectVu/CMS or TOPAS may support maintenance activities at more than one 4ESS Switch office. When this occurs, the CMS or TOPAS interfaces with the related systems and the 1B Processor at the remote office.

2.95 The 4ESS Switch international switching centers are provided with an additional related system called the Remote Measurement System — Gateway 1 (RMS-G1). The RMS-G1 along with the operational support system Testing, Operations, Provisioning, and Administration System/Circuit Maintenance System-1C (TOPAS/CMS-1C) and 4ESS Switch provides the facility for automated testing of international trunks using International Telegraph and Telephone Consultative Committee (CCITT) 5, CCITT 6, and CCITT 7 signaling. Voiceband tests are conducted on circuits supporting CCITT 5, CCITT 6, and CCITT 7 type signaling. The digital looparound tests are performed only on CCITT 6 and CCITT 7 circuits. There are three types of tests, A, B, and C. Type A test can be scheduled routinely while Type B and C tests are run on a demand basis. The RMS-G1 interfaces with 4ESS Switch terminal equipment to access trunks for maintenance. The RMS-G1 interface with terminal interface equipment provides a means of exchanging signaling and trunk test information with the 1A Processor via the peripheral unit bus.

Network Services Complex

2.96 Network Service Complexes are families of equipment frames that provide teleconferencing and Direct Services Dialing Capability (DSDC) features between two or more physically remote locations over the toll and local telephone networks. There are three NSCX configurations designed to support these features. Each configuration includes common software and firmware that implement common NSCX functions. The NSCX generic program for each type of NSCX consists of the common software combined with the appropriate feature software.

2.97 Each NSCX provides automated caller, customer or operator, interactive abilities for telephone network services. These interactive abilities consist of the following:

- Playing recorded announcements that contain instructions or prompts to callers
- Receiving touch-tone dialed signals that correspond to a chosen service option or a telephone directory number.

2.98 The three NSCX configurations and their uses are as follows:

1. ***Voice-Only or Voice and Analog Graphics Teleconferencing:*** This NSCX is used for customer and/or operator-established conference calls for voice or voice and analog graphics use only. This complex is equipped with two 64-port audio bridges. Each audio bridge combines and distributes the pulse code modulation (PCM) voice samples of speakers on a conference to other participants of the conference. Trunks are assigned to only 60 ports of each audio bridge. Each teleconferencing NSCX is equipped with 120 intraoffice trunks. At least one trunk is reserved for operator access.

Conferences may range in size from 3 to 59 ports— conference legs—per audio bridge. Each audio bridge can support many active conferences simultaneously, provided the total conference legs do not exceed the 59 ports available for service.

2. ***Voice and Data Teleconferencing:*** This NSCX is used for customer and/or operator-assisted calls for voice and/or data use. This complex uses one 64-port audio bridge and one 64-port data bridge—only 60 ports of each bridge are assigned trunks. The audio bridge distributes voice samples; while the data bridge distributes signals from graphic devices to all participants of the conference. The ports on the data bridge may be used for either 4.8 kb/s voiceband data or 56 kb/s Circuit Switched Digital Capability (CSDC) data.
3. ***Direct Services Dialing Capability:*** This NSCX is used to implement DSDC services. The first DSDC service to use this NSCX is the Advanced 800 Service. The Courtesy Response and Call Prompter features use this NSCX.

2.99 Network Service Complexes must be supported by a host stored program-controlled switching (SPCS) system with access to the common channel interoffice signaling (CCIS) system. The 4ESS Switch, equipped with the 4E7 or later generic programs, was used to support the first NSCXs.

2.100 Each NSCX is interfaced to the SPCS system by intraoffice DS1 digital trunks terminated on digital interface frames (DIFs) and a single pair of N-links to CCIS terminal group frames, as shown in Figure 1. In addition, major and minor alarm outputs from each NSCX are connected to the SPCS system office alarm system.

2.101 All NSCX trunks must be terminated on a DIF via a digital signal cross-connect 1 (DSX-1) frame. The voice-only teleconferencing NSCX and voice and data teleconferencing NSCX each requires 120 terminations, five DS1 trunks. Each DSDC NSCX requires 24, 48, or 72 terminations—one, two, or three DS1 trunks. The five DS1 trunks from a single teleconferencing NSCX must be spread over several, as many as five, digital interface units. The DS1 trunks from each of several DSDC NSCXs should be terminated on different DIF frames.

Service Circuit System

2.102 The Service Circuit System (SCS) hardware supports improved announcement and tone detection capabilities in a 4ESS Switch office. The SCS controller and the SCS unit cabinets along with the 4E17 generic program provide the Improved Service Announcement and Information Collection (ISAIC) feature. This feature increases the efficiency of the 4ESS Switch office to play announcements and to collect Dual Tone Multifrequency (DTMF) digit information from customers.

2.103 With the optional Automatic Speech Recognition (ASR) feature on SCS, information collection capabilities become more flexible by allowing recognition of spoken responses such as digits (1, 2, 3, etc.) and simple words ("zero," "yes," "no," etc.). The ASR feature reduces cost by decreasing required attendant services for customers that do not have touch-tone dialing capability.

2.104 The major units of the SCS are the Service Circuit Controller (SCC), Service Circuit Units (SCUs), Hard Disk Unit (HDU), and the Custom Data Service Unit (CDSU). The CDSU is provided only with the ASR feature. These units mount in the SCS controller, SCS unit, and Custom Data Services cabinets with each SCU having at least one associated Hard Disk Unit. The SCC communicates with the 1B Processor over the Peripheral Unit Bus (PUB) and up to 8 SCCs can connect to the PUB. The SCC sends instructions over the extended bus (EB) to the SCU to furnish the announcement playback from disk and provide DTMF detection. The SCUs interface with the switching network over DS120 links with each link serving up to 120 trunks. Pulse Code Modulated

(PCM) data representing announcements and DTMF tones are sent back and forth over these links to the time slot interchange frames in the switching network.

2.105 An announcement administration processor (AAP) performs disk announcement administration for the SCUs. The AAP communicates with the SCUs over a local area network (LAN). A central location performs announcement updates and distributes the updates to each 4ESS Switch via the ISN network. A handset located at the AAP is available for changing the announcements locally.

2.106 The maximum number of SCS complexes in a 4ESS Switch office equipped with the 4E17 generic program is two. The SCS complex requires two cabinets consisting of a Service Circuit System Controller (SCSC) cabinet and a Service Circuit System Unit (SCSU) cabinet. These cabinets are preassembled, wired, and tested at the factory before shipping to the customer.

2.107 The Custom Data Services Cabinet (CDSC) provides the ASR capabilities for the SCS. A CDSC can contain as many as 5 Custom Data Service Units (CDSU). One CDSC (with up to 5 CDSUs) is connected to each SCU with ASR capability. Two DS1 links connect the SCU to each CDSU. (Half of each link is used for ASR, and the other half of each link is used for echo cancellation).

3. Equipment Description—Domestic Offices

General

3.01 This equipment description is organized according to the 4ESS Switch equipment areas defined in Part 2 and shown in Figure 1. The equipment which comprises each of these areas is identified, and a very brief description of each frame is provided. Front-view illustrations and other detailed information concerning the equipment described in this part are provided in the applicable frame-level documents.

3.02 Detailed frame-level documentation can be identified by referring to current issues of 234-000-000, *4ESS Switch, Numerical Index, Division 234*, and 234-000-005, *4ESS Switch, Interdivisional Numerical Index*.

NOTE:
The equipment described in this part is included in domestic and international switching centers. However, equipment unique to an international gateway office is described in Part 4.

3.03 Prefabricated connectorized cables used for interframe connections are a significant factor in developing defined physical equipment groups for 4ESS Switch installations. In most cases, the physical equipment groups are the same as the functional equipment groups identified in Part 2. Any floor-plan variations can exist—provided specific equipment placement is within the maximum limits of prefabricated cable lengths for all interconnections. The arrangement of individual frames within equipment groups such as the 1B Processor, switching network, terminal equipment, and terminal interface equipment groups is more rigidly defined. Although minor variations can occur, factors such as cable length, system timing limitations, and critical power requirements limit the flexibility of frame arrangement.

3.04 Regardless of the size of the 4ESS Switch installation, floor space for a full size 4ESS Switch time division network, supporting 1B Processor, and 3B Computer is dedicated at the time of initial installation. This provides an orderly expansion of a 4ESS Switch office and the advantage of using prefabricated interconnecting cables.

1B Processor

3.05 The 1B Processor is a stored program-controlled, real-time, data-processing machine which controls operation of the 4ESS Switch. It consists of the following:

- 1A Processor:
  - — Duplicated central controls
  - — Semiconductor store frames used as call stores and program stores
  - — Semiconductor extended call store (ECS) frame, when required
  - — Attached Processor Interface (API) frame used as an interface to the Attached Processor System (3B Computer)
  - — An auxiliary tape storage capability
  - — Control panels
  - — Processor Peripheral Interface (PPI) frame
  - — An input/output frame or input/output processor frame
  - — Power conversion and distribution equipment.
- 1B Processor:
  - — Duplicated Central Controls (CC)
  - — Duplicated Program Store (PS) Memory
  - — Duplicated Call Store (CS) Memory
  - — Master Control Complex video terminal
  - — Interface Bus (IFB) and clients
  - — Fans and Fan Controller
  - — Attached Processor Interface (API) frame used as an interface to the APS 3B Computer
  - — An auxiliary tape storage capability
  - — An Input/Output (I/O) frame or I/O processor frame
  - — Power conversion and distribution equipment

3.06 The duplicated central control frames must communicate with all other 1B Processor frames and are placed at the center of the 1B Processor floor plan. The length of the cables between the 1A Processor central control and program and call stores is most critical and must be kept short in order to satisfy timing and bus transmission requirements. The 1B Processor CCs, PSs, and CSs are located internal to the Processor frames. Communication between the 1B Processor CCs, PSs, and CSs is provided by internal buses to the frame and cross-over cables between the two bays.

3.07 When an extended call store (ECS) frame is required in the 1A Processor, the ECS frame is located adjacent to one of the combined call store/program store frames.

3.08 The Peripheral Unit Bus (PUB), Attached Processor Interface (API), Auxiliary Unit Bus (AUB) and Input/Output interface are external connections to the 1B Processor frame. The attached processor interface frame and tape units in the tape frames can be located at a greater distance from the central controls. The 1A Processor peripheral interface frame and input/output frames carry the communications between the central controls and the switching system and associated input/output terminals. The I/O frame interface to the 1B Processor is identical to the interface to the 1A Processor. The 1A Processor PPI frame also contains remote access and telemetry equipment which is required when maintenance and operating functions are remoted to a centralized maintenance facility. These frames are located near the duplicated central controls but at the outer periphery of the 1A Processor floor plan. This is to facilitate the interface with the 4ESS Switch equipment frames and input/output terminals. The PPI frame is not required with the 1B Processor. The 1B Processor provides a

telemetry interface through the MCC and Utility Processor (MUP). The interface to the Master Control Complex (MCC) terminal and the Utility System (US) workstations are also handled by the MUP.

3.09 Refer to 254-200-001, *1A Processor General Description,* or 254-301-001, *1B Processor General Description,* for additional detailed information concerning the physical characteristics and operation of the 1B Processor.

3B Computer

3.10 The 3B Computer is a stand-alone duplex computer system which is not unique to the 4ESS Switch. The following frames and cabinets are required for the 4ESS Switch application of the 3B Computer:

a. Processor Control Frame/Cabinet

b. Tape/Disk Cabinets

c. Power Distribution Frame

d. Miscellaneous Equipment Frame/Cabinet

e. Maintenance Position (Keyboard/display terminal and printer).

f. Attached Processor Interface Frame

g. Common Network Interface Ring Node Cabinet

h. Data Set Frame

i. Digital Facilities Access Frame

3.11 In the 4ESS Switch environment, the 3B Computer is used primarily as a file store replacement feature in the 1B Processor area and is commonly referred to as the Attached Processor System (APS). The greater disk memory capacity provided by the APS is required by all 4ESS Switch offices operating with 4E7 or later generic programs. In addition to a larger disk memory capacity for storing programs and data, the 3B Computer provides the system with additional processor time which can be used to enhance existing or add new 4ESS Switch features. The addition of the 4ESS Switch Common Network Interface (CNI) ring is an example of a new feature utilizing the APS. An enhanced Automatic Message Accounting (AMA) system is another example of how the APS is being used.

3.12 Refer to 234-100-200 and 234-100-201, *Attached Processor System, General System Information, 4ESS Switch Application*, for additional detailed information concerning the physical and operational characteristics of the 3B Computer.

1B Processor Interface Equipment

3.13 The 1B Processor interface equipment area (Figure 1) consists of frames which provide an interface between the 1B Processor and various components of the 4ESS Switch. This equipment also provides various interfaces between the 4ESS Switch and separate maintenance and support facilities.

A. Peripheral Unit Bus Branching (PUBB) Frame J4A005A

3.14 The PUBB frame serves to branch the PUB into a sufficient number of parallel branches to service all the 4ESS Switch equipment. This frame is placed at a location such that the length of the PUB between the 1B Processor, the PUBB frame, the switching network, and the terminal interface equipment is within acceptable limits. Up to four additional PUBB frames are allowed with certain restrictions. These additional frames serve as repeater frames. When provided, the repeater frames serve to expand and extend the peripheral unit bus. The PUBB frame is comprised of two 2-feet-2-inch bays. Each bay consists of eight separate physical subassemblies. Of these eight subassemblies, four are PUBB and loop-around units. In some instances, a frame can be partially equipped with less than four of these branching and loop-around units.

B. Input/Output Frame J5A006A [Discontinued Availability (DA)]

3.15 The input/output frame contains the circuits required to provide the following:

- The input/output channel interface between the 1B Processor central controls and the various input/output terminals provided in the 4ESS Switch office
- The data link interfaces between the 1B Processor central controls and various computer-aided support and monitoring facilities.

3.16 Each input/output frame can accommodate up to 16 separate input/output channels. The input/output frame consists of a single 2-feet-2-inch bay. This input/output frame may be identical to one provided as part of the 1B Processor. Up to three additional input/output frames may be provided in the 4ESS Switch office to supplement the one required in the 1B Processor.

C. Input/Output Processor Frame

3.17 The input/output processor frame is provided in more recent 4ESS Switch offices. The input/output processor frame, like the input/output frame previously described, contains circuits required to provide the input/output channel and data-link interfaces with the 1B Processor central control. The input/output processor frame can accommodate a greater number of input/output channels or data links at a lower cost. The input/output processor frames J5A006C/D are capable of providing a maximum of 32 channels. Each input/output processor frame J5A006C/D consists of a single 2-feet-2-inch bay. This equipment is identical to the input/output processor frame which may be provided in the 1B Processor. This equipment is provided as a 4ESS Switch frame when the office input/output requirements exceed the capabilities of the input/output frame or input/output processor frame provided in the 1B Processor. Up to three input/output processor frames may be provided as part of the 1B Processor interface equipment.

D. Data Sets

3.18 Data sets are required on input/output channel terminals that are located a long distance from the input/output frame or input/output processor frame. Data sets may be the following types:

- 202T
- 202T equipped with 829A, B, or C data auxiliary sets
- 202S
- 208
- 208 equipped with 801C data auxiliary sets
- 208 equipped with 829A, B, or C data auxiliary sets
- 212A
- 212A equipped with 801C data auxiliary sets.

3.19 Data requirements and the type of data sets for input/output channels are unique to each 4ESS Switch installation. When required, the data sets are provided in a framework defined by ED-1B150-70. This framework may also contain data sets related to telemetry functions.

Terminal Equipment

3.20 The terminal equipment area (Figure 1) consists of metallic terminal equipment. This equipment serves as an interface between the 4ESS Switch and metallic facilities in the toll network. Interconnecting wiring between these terminals and main distributing frames is connectorized at the terminal equipment end. Metallic terminal equipment consists of various arrangements of metallic terminal frames and auxiliary metallic trunk circuits. The metallic terminal frames provide manual jack access to individual trunks for maintenance purposes. Auxiliary metallic trunk circuits are not provided with maintenance access.

3.21 The actual number of metallic terminal frames, and auxiliary metallic trunk circuits provided in a 4ESS Switch office is dependent upon variables such as the following:

- The number and types of trunks being serviced
- The type of signaling incorporated on various trunks.

Equipment frames are provided in increments such that the circuit-handling capability of the terminal interface equipment and the terminal equipment are approximately equal.

A. Metallic Terminal Frame J1C015A/C [Discontinued Availability (DA)]

3.22 The metallic terminal frames (MTFs) provide a voice transmission and signaling interface between metallic facilities in the toll network and the 4ESS Switch. These MTFs accept various configurations of balancing networks, 2- and 4-wire amplifiers, and signal converters mounted on plug-in boards. Two different metallic terminal frames are provided for use in the 4ESS Switch. These are metallic terminal frames J1C015A and J1C015C. These frames are single 2-feet-2-inch bay frames. Each frame provides facilities for accepting a maximum of 72 plug-in units of various types to accommodate up to 72 metallic trunks.

3.23 Note that in some offices a miscellaneous equipment frame may be used to accommodate metallic circuits. It may be more economical to use J99338C shelves in place of the metallic terminal frame J1C015C to mount metallic terminal units when only a limited number of circuits need to be supported. These J99338C shelves are mounted in a ''miscellaneous'' equipment frame.

B. Auxiliary Metallic Trunk Circuits

3.24 Auxiliary metallic trunk circuits are provided to interface with operator trunks and auxiliary outgoing trunks. These auxiliary metallic trunk circuits consist of plug-in units that are not compatible with the metallic terminal frame. These plug-in units are mounted in unique equipment shelves. The location of these shelves is a function of individual office design (wherever space is available). The plug-in units contain the various circuits which are required to accommodate the operator and auxiliary outgoing trunks using nonmetallic facilities. These units are described in the metallic terminal frame documents.

Terminal Interface Equipment

3.25 The terminal interface equipment area (Figure 1) consists of equipment frames that provide an interface between the terminal equipment and the 4ESS Switch. In addition, these frames provide an interface between the 4ESS Switch and other functional areas including maintenance and support facilities. Terminal interface equipment includes the following:

- Signal Processor 1 (SP1)
- Signal Processor 2 (SP2)
- Digroup Terminal (DT)
- Digital Interface Frame (DIF)
- Digital Interface Frame - E1 (DIF-E1)
- D4 Channel Bank
- Common Channel Interoffice Signaling (CCIS) Terminal Equipment.

3.26 Equipment arrangements are flexible and are a function of individual office design. Frames are provided in increments such that the circuit-handling capability of the terminal interface equipment and terminal equipment are approximately equal.

A. Signal Processor 1 [Discontinued Availability (DA)]

3.27 The signal processor 1 (SP1) performs the scanning and signal distributing functions for analog trunks (voice, service, and others) terminated on analog carrier facilities, metallic terminal facilities, and others. The SP1 may be provided in either of two production configurations.

The first of these is the initial SP1 production configuration which is provided in earlier 4ESS Switch installations. The second configuration is the SP1 with a combined matrix frame. This second configuration was provided in 4ESS Switch installations that are supported by the 4E2 and later generic program. As far as overall function and external interfaces are concerned, the two SP1 configurations are identical. Either version, when fully equipped, provides a signaling interface for 4080 trunks. The differences in the two configurations are in internal circuit design and physical appearance. The SP1 with a combined matrix frame is a more economical unit. An office can have a mixture of both SP1 configurations. However, any one SP1 configuration, initial or with combined matrix frame, must consist entirely of those frames which comprise that particular configuration. A mixture of SP1 frames within any one particular SP1 configuration is not permitted. A minimum of two SP1s, two SP2s (discussed later), or one SP1 and one SP2 must be provided in each 4ESS Switch office.

Signal Processor 1 (Initial Configuration)

3.28 A fully equipped initial configuration SP1 is made up of the following five separate frames:

- Signal processor 1 control frame (J4A003A)
- Two distributor and scanner matrix frames (J4A003D)
- Two distributor applique frames (J4A003E).

3.29 The minimum equipage for an initial configuration SP1 consists of one fully equipped SP1 control frame (J4A003A), one distributor and scanner matrix frame with fully equipped access circuits, and a distributor applique frame equipped as needed.

3.30 Signal Processor 1 Control Frame (J4A003A): The SP1 control frame contains the SP1 control unit, peripheral unit bus interface circuits, control units for all SP1 frames, and associated power and fuse panels. This frame is comprised of two 2-feet-2-inch bays.

3.31 Distributor and Scanner Matrix Frame (J4A003D): The distributor and scanner matrix frame contains the signal distributor and scan point circuits that interface with the 4ESS Switch equipment frames. This frame is comprised of two 2-feet-2-inch bays. The two bays of this frame are equipped identical.

3.32 Distributor Applique Frame (J4A003E): The distributor applique frame contains the circuits that apply relay-originated control signals to 4ESS Switch equipment frames. This frame is comprised of one 3-feet-3-inch bay.

Signal Processor 1 (With Combined Matrix Frame)

3.33 A fully equipped SP1 with combined matrix frame is made up of the following three separate frames:

- Signal Processor 1 control frame (J4A003G)
- Two combined distributor and scanner matrix frames (J4A003F).

3.34 The minimum equipage for an SP1 with combined matrix frame consists of one fully equipped SP1 control frame (J4A003G) and one combined distributor and scanner matrix frame (J4A003F) equipped as needed.

3.35 Signal Processor 1 Control Frame (J4A003G): This frame contains the same type of equipment as the SP1 control frame provided with the initial configuration SP1. Physically, the J4A003G control frame is similar to the J4A003A control frame previously discussed. The J-codes of the individual units within the frame, circuit pack assignments, and the actual circuit design are different. However, the overall function and appearance are identical.

3.36 Combined Distributor and Scanner Frame (J4A003F): The combined distributor and scanner matrix frame contains the signal distributor and scan point circuits that interface with the 4ESS

Switch equipment frames. This frame is comprised of two 3-feet-3-inch bays.

B. Signal Processor 2 [Discontinued Availability (DA)]

3.37 The Signal Processor 2 (SP2) performs the scanning and signal distributing functions for digital carrier trunks terminated on digroup terminals. An SP2 can interface with up to four digroup terminals for multifrequency signaling and/or dial-pulse signaling and up to twelve additional digroup terminals for common channel signaling. The SP2 can provide a signaling interface for 3840 trunks. The SP2 normally consists of a SP2 control frame only. However, a supplementary matrix frame can be included as part of the SP2 to provide 1024 miscellaneous scan and signal distributor functions.

NOTE:
The supplementary matrix frame is also provided in offices that do not have sufficient SP1s to support the required multifrequency signaling service circuits.

A minimum of two SP2s, two SP1s (previously discussed), or one SP2 and one SP1 must be provided in each 4ESS Switch office.

Signal Processor 2 Control Frame J4A008A

3.38 The SP2 control frame consists of two 3-feet-3-inch bays. The SP2 control unit in this frame can be equipped with either of two types of memory units. When the latest version of memory unit is provided, 9-volt converters are not provided in the frame power converter unit.

Supplementary Matrix Frame J4A008B

3.39 The supplementary matrix frame consists of a single 3-feet-3-inch bay which provides 1024 miscellaneous scan and signal distributor functions.

C. Digroup Terminal Frame J68952A/B [Discontinued Availability (DA)]

3.40 The digroup terminal (DT) frame is provided to terminate digital trunks. The frame contains eight digroup terminal units plus one spare. Each unit can accommodate 120 separate voice channels. This provides the frame with a 960-voice channel capability. A digroup terminal frame complex consisting of four digroup terminal frames and one SP2 can terminate 3840 digital voice channels.

3.41 The digroup terminal frame installed in an office can be either of two types. The digroup terminal J68952A is provided in early 4ESS Switch installations. The digroup terminal J68952B is provided in offices supported by the 4E3 or later generic programs.

3.42 Although different in physical appearance, these two types of frames perform the same function and have the same overall digital trunk capacity. General features of the digroup terminal version J68952B are as follows:

- Lower cost than the J68952A version
- Internal memory units changed
- A lower number of power converters is provided in the frame and converters used are of a higher current rating
- Revised circuit design has reduced the total number of circuit packs in the frame.

Both types of digroup terminal frames are comprised of two 2-feet-2-inch bays.

D. Digital Interface Frame J68960A [Discontinued Availability (DA)]

3.43 The J68960A digital interface frame (DIF) provides an interface between T1 digital trunks (DS1 format) and the time division network (DS120 format). The DIF can only provide the E&M (dial-pulse) supervision and signaling function for T1 trunks. However, the supervision and signaling function can be inhibited on a per-channel basis for common channel signaling T1 trunks terminated on

the DIF. This allows the DIF to terminate Circuit Switched Digital Capability (DSDC) trunks from end offices which use the T1 signaling bits as data bits to provide 56-kilobit end-to-end digital capabilities. In function, each DIF complex is equivalent to a DT/SP2 complex (four DTs and SP2) without the SP2 supplementary matrix frame. Each fully equipped DIF complex (three 3-feet-3-inch bays) is thus capable of terminating 3840 digital trunks. The maximum DIF frame lineup should be limited to four DIFs (39 feet) in order to avoid cable rack lineup congestion.

3.44 A combined total of 32 DIFs, SP1s, and SP2s can be installed in a 4ESS Switch office. The actual number of DIFs, SP1s, and SP2s provided in an office is dependent on the following:

- The mixture of analog, metallic, and digital trunks served by the office
- Utilization of common channel signaling (CCS).

E. Digital Interface-E1 J5X059B

3.45 The J5X059B digital interface frame (DIF-E1) was introduced with the 4E8 generic program as a direct replacement for the J68960A DIF frame. The DIF-E1 can be fully equipped to terminate 3840 E&M and/or common channel signaling T1 digital trunks. A special configuration using E&M channel units in D4 channel banks is provided for interfacing CCITT 5 trunks to the DIF-E1. In this special application, each trunk uses two terminations on the DIF-E1. These two terminations appear as independent trunks to the DIF-E1 and are linked only by software in the office data base. The maximum DIF frame lineup should be limited to four DIF complexes (39 feet) in order to avoid cable rack lineup congestion.

3.46 With 4E9 generic program, the DIF-E1 can be equipped with four multifrequency (MF) digital interface service units (DISUs) that provide a total of 64 MF service circuit trunk appearances directly to the switching network. This feature may be used to replace the analog MF transmitters and receivers, signal processor matrix, and associated analog-MF to digital-MF conversion. The E&M and per-channel inhibit signaling (PCIS) bits are used to control the digital MF transmitters and receivers. The MF DISUs are also designed to generate the 480-Hz operator tone source required for use on operator trunks.

3.47 With 4E10 generic program, the DIF-E1 can be equipped to support dual-tone multifrequency (DTMF) (touch-tone) signaling and special services signaling features. The DTMF signaling capability is required to enable the 4ESS Switch to transmit and receive touch-tone addressing from Private Branch Exchanges (PBXs) on 2- or 4-wire E&M analog and direct T1 digital trunks. A DIF-E1 complex can be equipped with either the four MF DISUs described in the previous paragraph or with four DTMF DISUs. As with the MF DISUs, a DIF-E1 complex equipped with four DTMF DISUs provides 64 DTMF service circuit trunk appearances to the switching network. The DTMF DISU capability includes two-way wink-start addressing, generation of dial tone on nonwink-start trunks, and the reception of the full set of 16 DTMF digits. The special services interface digital interface unit (DIU) requires five circuit packs in place of regular DS-1 DIUs. A special services interface is similar to a regular DS-1 interface in its function, except that it can perform special handling of line signaling information for each of the PCM channels it interfaces. The incoming and outgoing signaling bits (Ma, Mb, Ea and Eb) are manipulated on a per-channel basis to provide four states of supervisory signaling on CSDC trunks. Either regular MF, equal access protocol, or DTMF may be used on these trunks for address signaling.

F. D4 Channel Bank J98726

3.48 The D4 channel banks can be mounted in single 2-feet-2-inch bay frames which are 11-feet-6-inches, 9-feet-7-inches, or 4-feet-5-inches in height. The D4 channel banks can also be mounted in a miscellaneous fashion with other equipment. In the 4ESS Switch application, it is recommended that D4 channel banks be mounted in single 2-feet-2-inch bay frames which are 7 feet in height. This framework can be equipped with a maximum of four D4 channel banks; however, when equipped with a communications panel (ED-

3C660), only three D4 channel banks may be equipped in a frame.

3.49 In the 4ESS Switch application, the D4 channel banks are used to interface analog service circuits, certain metallic trunks, and N-Carrier facilities with either digroup terminals or digital interface frames, which would otherwise require an interface with the voiceband interface frame and SP1 universal matrix points. A D4 channel bank, in conjunction with a LT-1 connector/LT-2 digital transmultiplexer, is a more cost effective means of interfacing analog circuits to the 4ESS Switch than the VIF/SP1 arrangement. However, the SP1 may still be used to provide miscellaneous scan and signal distributor points.

G. Common Channel Interoffice Signaling (CCIS) Terminal Equipment

CCIS Terminal Group Basic Frame J4A009A [Discontinued Availability (DA)]

3.50 The CCIS terminal group basic frame terminates the CCIS signaling links connected to the office and serves as an interface between these data links and the 1B Processor. The frame contains six CCIS terminals. Two supplementary frames can be added to this basic frame to provide a total frame capacity of 16 CCIS terminals. Also, a maximum of 16 frames can be provided in a 4ESS Switch office. Depending on expected CCIS trunking and projected growth, two basic frames must be provided before adding supplementary frames. The basic frame is comprised of two 2-feet-2-inch bays.

CCIS Terminal Group Supplementary Frame J4A009B [Discontinued Availability (DA)]

3.51 This frame extends the capability of the CCIS basic frame. This frame contains five CCIS terminals. When required, one supplementary frame is added to each side of the basic frame. This frame consists of a single 2-feet-2-inch bay.

CCIS Data Set Frame J99399A [Discontinued Availability (DA)]

3.52 The CCIS data set frame provides data set equipage for implementing 4800-bit-per-second CCIS signaling links. Each frame supports a maximum of 16 links (two data set units, each equipped with eight 2048A data sets). The frame is comprised of a single 2-feet-2-inch bay which is 7 feet in height. When the CCIS data set frame is used, changes in CCIS terminal group equipage are required. The 201D data sets are replaced with a terminal modem interface (J99360CB), data encryption, and dc-to-dc converter circuits. The increase in the data rate also requires that the terminal buffer be increased in size.

Switching Network

3.53 The switching network area (Figure 1) contains the equipment through which pulse code modulated (PCM) data is transferred from one trunk to another. The switching network also contains timing equipment which generates the precise timing signals required to switch traffic. The switching network equipment area consists of the time slot interchange (TSI) or the expanded time slot interchange (XTSI), the time multiplexed switching (TMS), and the network clock frames. In offices provided with the initial version of the TSI frame and the initial version of the TMS frame, a fully equipped switching network contains 64 TSI frames, 8 TMS frames, and 1 network clock frame. Depending on the dimensions of the area provided for the switching network, equipment can be arranged in rows of 5, 6, or 7 TSI frames per row. Appropriate adjustments are made in both the number of TMS frames in a row and the total number of rows. In offices provided with the modified design TSI frame and modified design TMS frame, a fully equipped switching network contains 32 TSI frames, 4 TMS frames, and 1 network clock frame. An office fully equipped with the expanded time slot interchange feature contains 64 XTSI cabinets that support 32 XTSI equipment arrangements, 4 TMS frames, and 1 network clock frame. With the 4E21 generic

program, all 4ESS Switch offices require four TMS frame capability.

A. Time Slot Interchange Frame J4A001A/B

3.54 The TSI frames provide the first and fourth stages of switching for the 4-stage switching network. The TSI frames may be either of two general configurations. For this discussion, the TSI frames are identified as the initial configuration and the modified design. In addition, the initial configuration can be either of two versions. Details are in subsequent paragraphs.

Initial Configuration TSI Frame J4A001A [Discontinued Availability (DA)]

3.55 Each initial configuration TSI frame has the capacity to handle 1680 separate voice and service circuits. There can be a maximum of 64 TSI frames in any one 4ESS Switch office. These 64 frames can accommodate 107,520 trunks. Initial configuration TSI frames installed in an office can be either of two versions. The TSI frame J4A001A-1 was provided in earlier 4ESS Switch installations. The TSI frame J4A001A-2 was provided in later 4ESS Switch installations. Offices may have a mix of these two types of TSI frames. Although different in physical appearance, these two frame types perform the same function. General features of the J4A001A-2 version of the TSI frame are as follows:

- Lower cost than the J4A001A-1 version.
- Internal memories no longer require +9 V power.
- Frame not equipped with +9 V dc-to-dc power converters or +9 V fuses.

The J-codes for some units in these frames are different. Both initial configuration TSI frames are comprised of two 3-feet-3-inch bays.

Modified Design TSI Frame J4A001B

3.56 Each modified design TSI frame has the capacity to handle 3360 separate voice and service circuits. This is twice the capacity of the initial configuration TSI. The switching network can contain a maximum of 32 modified TSI frames. These 32 frames can accommodate 107,520 trunks. The modified design TSI frame is comprised of two 3-feet-3-inch bays.

B. Expanded Time Slot Interchange Cabinet J4A034A-1

3.57 The expanded time slot interchange (XTSI) is a 4ESS Switch peripheral that can coexist with installed DIFs and TSIs or can replace existing TSIs for switch termination growth. It provides the first and fourth stages of switching for the 4-stage switching network. Each XTSI has the capacity to handle 4032 separate voice and service circuits. A fully equipped 4ESS Switch contains a maximum of 32 XTSIs with 64 XTSI cabinets. These 64 cabinets can accommodate 129,024 trunks. The XTSI cabinets consist of main cabinets and growth cabinets. The cabinets are standard 6-foot switching cabinets that are 2-feet 6-inches wide. The XTSI reduces termination costs and improves the reliability of the switching network.

C. Time Multiplexed Switching Frame J4A002A/B

Initial Configuration TMS Frame J4A002A (DA)

3.58 The TMS frames provide the second and third stages of switching for the 4-stage switching network. The TMS frames are fully duplicated to provide reliable switching. A 4ESS Switch office can be equipped with two or four duplicated frames and is referred to as a 2- or 4-TMS office, respectively. It is possible to have a 1-TMS office to support small toll offices but not possible to have a 3-TMS office. A 4ESS Switch office can be initially equipped with two duplicated TMS frames and then grown to a larger size as additional trunks are required. In addition, the duplicated TMS frames can be partially equipped as required to provide for greater economy and growth flexibility.

3.59 Each TMS frame is comprised of two 2-feet-2- inch bays. The TMS frames may be provided in either of two configurations. The TMS frame J4A002A-1 is provided in earlier 4ESS Switch installations. The TMS frame J4A002A-2 is a newer design and is provided in later 4ESS Switch installations. Functionally, these two frames are identical. The units provided in the newer frame are designed to function without the need for 9 Volt DC power. When required, these newer units can be used in the older frame. The new frame is not equipped with +9 Volt converters. In addition, the newer frame is equipped with fewer (but higher current rating) -3 Volt DC converters.

Modified Design Time Multiplexed Switching Frame J4A002B-1

3.60 The modified design TMS frame, introduced with the 4E5 generic program, consists of two 3-feet-3-inch bays and contains a mated TMS pair (two TMS circuits). This TMS design is functionally equivalent to a ***pair*** of the earlier production J4A002A-2 or J4A002A-1 TMS frames.

3.61 The J4A002B-1 TMS frame eliminates the ''mate-frame concept'' required by these previous designs. A fully equipped switching network (eight TMS circuits) consists of four J4A002B-1 TMS frames for the second and third stages of switching. This modification requires less floor space than the previous version of TMS frames.

3.62 The maximum equipage of eight TMS circuits may also be provided by a combination of J4A002A-1, J4A002A-2, and J4A002B-1 TMS frames. Each bay of TMS frame J4A002B-1 is completely separate (hardware-independent) from the mate bay and contains a peripheral unit bus access unit, controller, switch units, and power circuits.

D. Network Clock Frame J4A004A

3.63 The network clock frame provides timing signals for the switching network and timing signals that synchronize the terminal interface equipment with the switching network. The network clock frame also provides system timing data that may be read by the 1B Processor. The network clock frame (J4A004A-1 and -2) is comprised of two 3-feet-3-inch bays. Each bay contains a complete clock circuit. The J4A004A-2 network clock frame, introduced with the 4E5 generic program, can automatically synchronize the network clocks of digitally interconnected offices to a common reference signal. The reference signal may be either the pulse code modulated data in DS1 format (T1 Carrier) or the AT&T Reference Frequency (2.048 MHz) which is being phased out domestically.

Service Circuits and Trunk Test Facilities

3.64 Service circuits and trunk test facilities (Figure 1) equipment provide trunk service and trunk test equipment required in a 4ESS Switch office. The following paragraphs identify and describe this equipment.

A. Remote Office Test Line Frame J4A007A (DA)

3.65 The remote office test line (ROTL) frame provides the necessary circuits to enable Centralized Automatic Reporting on Trunks 2 or a remote manual facility to conduct tests on trunks. The ROTL frame is not required in offices equipped with the Remote Measurement System-D2 (RMS-D2) introduced with the 4E10 generic program.

3.66 The ROTL frame consists of a single 2-feet-2-inch bay. The frame can contain either two ROTL units or one ROTL unit and one or two 105-type test-line responder units along with assorted power and alarm circuits. The ROTL frame is normally located near the voiceband interface frames in the overall 4ESS Switch floor plan.

B. Service Circuit System

3.67 The Service Circuit System (SCS) is a 4ESS Switch peripheral unit that provides general purpose service ports for use by features needing to play announcements and collect Dual Tone

Multifrequency (DTMF) digit information from customers.

3.68 The SCS, introduced in the 4E17 generic program, provides the primary source for announcements in the 4ESS Switch office. The SCS allows for either a maximum capacity of 420 megabytes total announcement storage or 1.6 gigabytes total announcement storage. The SCS is housed in two 6-feet high, 30-inch wide, and 24-inch deep cabinets. The SCS hardware includes three major unit types: the duplexed Service Circuit Controller (SCC), the Service Circuit Unit (SCU), and the Hard Disk Unit (HDU).

3.69 The HDU provides the announcement storage capacity for the SCS. Each pair of hard-disk circuit packs, using the TN1672 hard-disk circuit packs, can store up to 93,000 announcement seconds (approximately). Each pair of hard-disk circuit packs, using the TN1972 hard-disk circuit packs, can store up to 478,000 announcement seconds (approximately). Each pair of hard-disk circuit packs, using the TN4000 hard-disk circuit packs, can store up to 956,000 announcement seconds (approximately).

3.70 The SCS is discussed in more detail later. With the 4E20 generic program, the optional Automatic Speech Recognition (ASR) feature on the SCS allows speech recognition functions to enhance SCS information collection capabilities. The hardware for the ASR feature consist of Custom Data Service Units (CDSU) housed in a Custom Data Services Cabinet (CDSC).

3.71 A detailed description of the 4ESS Switch SCS is contained in 234-100-130, *Service Circuit System, Description*.

C. Phased Announcement System

3.72 The phased announcement system (PAS) is a solid-state recorded announcement frame which provides ''phased'' recorded messages required in the 4ESS Switch office. The PAS has a maximum capacity of 20 recorded spoken messages that are up to 12 seconds in length. These messages are used to inform the calling party of why a call was not completed and the action to be taken. The PAS is comprised of modular hardware items that are housed in a 7-feet high, 2-feet-2-inch wide, 4ESS Switch frame. The PAS modular hardware includes an interface panel, card cage A, card cage B, and a control unit. Communication between the PAS and the 4ESS Switch is accomplished via connectorized cables which allow the transfer of ''phased'' audio messages through the multifrequency signaling frame to a voiceband interface unit (VIU) or D4 channel bank. With the SCS available in a 4ESS Switch office equipped with the 4E17 generic program, the primary source of recorded announcements is the SCS discussed in the previous paragraphs. The PAS becomes the secondary source of announcements.

3.73 Refer to 234-110-160, *Phased Announcement System, Description, 4ESS Switch*, for additional detailed physical information.

D. 820A Ringing, Tone, and Interrupter Plant J87822A

3.74 The 820A ringing, tone, and interrupter plant provides the various ringing and tone signals required in the 4ESS Switch office. This frame consists of a 2-feet-2-inch bay.

E. Multifrequency Signaling Frame J99353A [Discontinued Availability]

3.75 The multifrequency signaling frame provides the 4ESS Switch office with a multifrequency signaling capability. The frame may include a multifrequency test circuit. This frame also contains a number of terminal strips used by other service circuits, trunk test facilities equipment, some miscellaneous equipment, and terminal interface equipment. These terminal strips and the interframe connectors on this frame are used to convert from point-to-point wiring to connectorized cables. This facility is provided so that equipment which is not unique to a 4ESS Switch office can interface with frames which require connectorized

cables. The multifrequency signaling frame is comprised of a single 2-feet-2-inch bay.

3.76 In some offices, a pseudo multifrequency signaling frame (standard ED-1B150-70 framework) consisting of terminal strips and connectors may be used to provide the conversion from point-to-point wiring to connectorized cables. The pseudo multifrequency signaling frames are numbered starting with number 40. Each pseudo multifrequency signaling frame can support a maximum of 360 circuits (three groups of 120 circuits designated A, B, and C).

F. Continuity Check Transceiver and Loop-Around Test Unit

3.77 The continuity check transceiver and loop-around test unit is used to check the continuity of trunks during call setup. The number of trunks accommodated by a continuity check transceiver unit is a function of office design. Two types of transceiver units are available. One type contains eight transceivers plus two loop-around test circuits (J4A010AE). The other type contains up to 12 transceivers (J4A010AC). A maximum of two of each type of transceiver unit may be mounted in miscellaneous frame A. Sixteen additional transceiver units (192 circuits) may be mounted in miscellaneous frame C.

Miscellaneous Systems and Frames

3.78 Miscellaneous system and frame equipment (Figure 1) provides various abilities required to support a 4ESS Switch office. The equipment and systems are grouped under this category, because they are not closely related to the other equipment groups which comprise the 4ESS Switch. The following paragraphs identify and describe this equipment and office systems.

A. Input/Output System

3.79 The input/output system provides system operating and maintenance personnel with a means of communicating with the 1B Processor, 3B Computer, network services complexes, and the Circuit Maintenance System (CMS) or Testing, Operations, Provisioning, and Administration System (TOPAS). The primary input/output system for the administration, maintenance, and control of a 4ESS Switch is the 1B Processor input/output system. This input/output system also provides the following:

- Date exchange between the 1B Processor and ConnectVu/CMS or TOPAS.
- Data exchange between the 1B Processor and external support and monitoring facilities
- Data exchange between 1B processors.

3.80 Input/output capabilities are provided through a number of software-defined input/output channels. Access to these channels is implemented using a number of input/output terminals which are located in the various work centers in the 4ESS Switch office.

3.81 The input/output terminals used in the various 4ESS Switch work centers include the following types of devices:

a. **DECWRITER† II Keyboard Send and Receiver Terminal:** The LA36-CA *DECWRITER II* terminal consists of a keyboard and tractor-feed printer. This terminal is used to interface with the Circuit Maintenance System (CMS) or TOPAS.

b. **VT100‡ Keyboard/Display Terminal:** The *VT100* terminal is used to interface with the various network maintenance center minicomputers which are part of the centralized work center arrangements.

c. **Advanced Interactive Maintenance System (AIMS):** The *AIMS* is an easy-to-use intelligent workstation. The split screen dual-channel monitor allows simultaneous monitoring of two input/output channels. The data logging capability can replace ROP paper with a PC hard disk or floppy disk. AIMS allows users to program series of

† DECWRITER is a trademark of Digital Equipment Corporation

commands into a function key. AIMS is capable of filtering selected messages from the switch to a file and recalling or updating previously activated commands.

3.82 Additional information concerning the various input/output terminal devices is provided in 234-100-021, *Input/Output System Description*.

B. Office Alarm System

3.83 The office alarm system provides a means of alerting operating and maintenance personnel to trouble conditions using audible and visual alarms. The 4ESS Switch office is divided into a number of alarm grid areas (maximum of 15). All equipment in a particular grid area is the responsibility of a work center. However, a work center may be responsible for more than one alarm grid area. The office alarm system senses alarm conditions generated within various 4ESS Switch equipment frames. When an alarm condition is detected by the office alarm system, audible and visual alarms are activated and appropriate teletypewriter messages are output at the appropriate work center(s).

3.84 The frame-mounted equipment which comprises the office alarm system (exclusive of audible and visual alarm panels) is mounted in miscellaneous frames A and B. Frame-mounted, office-alarm, grid equipment for each office alarm grid is comprised of the following units:

- One alarm grid control unit J4A012AA
- One power-alarm control J4A012AB
- One alarm transfer control J4A012AD
- One manual alarm grouping control unit J4A012AE
- One fuse panel J4A012AF
- Aisle pilot control units J4A012AC.

3.85 One such equipment grouping is mounted in miscellaneous frame A. Two such equipment groupings may be mounted in miscellaneous frame B. In a 4ESS Switch office divided into the maximum allowable 15 alarm grid areas, the maximum of 7 miscellaneous B-frames must be provided.

C. Office Communication Facilities

3.86 The office-communication facilities provide office personnel access to the input/output system and a means for voice communications within the office and with distant offices. Access to the input/output system is provided through two belt-line channels which run throughout a 4ESS Switch office. Jack access is provided to these buses at various equipment frames throughout the office. These jacks, designated TTY A and TTY B, are part of telephone and TTY jack unit assembly panels mounted on the frames. The jack panels also contain a TEL jack which provides frame-to-frame voice communication within an office. Conventional telephone circuits provide voice-communication facilities with other offices. The unitized terminal equipment frames and metallic terminal frames are equipped with an additional communications panel. This panel contains keysets, order wire access, and ConnectVu/CMS or TOPAS access jacks. Similar voice-communication facilities are provided at the 51A test positions and remote maintenance system - D2 (RMS-D2).

D. Miscellaneous Frame A J4A010A

3.87 Miscellaneous frame A is provided merely as a facility on which to mount the following:

- Two required continuity check transceiver and loop-around test units
- Two optional continuity check transceivers (without loop-around test capability)
- Frame-mounted, office alarm grid equipment for an office alarm grid

‡ VT100 is a trademark of Digital Equipment Corporation

- An AC power distribution unit.

3.88 One miscellaneous frame A is required in a 4ESS Switch office. Miscellaneous frame A consists of a single 2-feet-2-inch bay. The equipment housed in the frame is part of the service and trunk test facilities equipment group previously described in this part. Only the office alarm system equipment is part of the miscellaneous systems and frames equipment group as identified in Figure 1.

E. Miscellaneous Frame B J4A010B

3.89 Miscellaneous frame B consists of a single, 2-feet-2-inch bay. The frame contains frame-mounted, office-alarm, grid equipment for either one or two office alarm grids. Depending on the configuration of the office alarm system, a maximum of seven fully equipped frames may be provided in a 4ESS Switch office.

F. Miscellaneous Frame C J4A010C

3.90 Miscellaneous frame C is 7-feet and comprised of a single 2-feet-2-inch bay. A 4ESS Switch office can be equipped with one miscellaneous frame C in order to provide additional common-channel-signaling (CCS), continuity-check, transceiver (CCT) units (J4A010AC) to those units equipped in miscellaneous frame A. The minimum equipage of miscellaneous frame C is one CCT unit (CCT04). A maximum of 16 CCT units (192 CCT circuits) can be equipped in miscellaneous frame C. The CCS equipment is part of the service circuit and trunk test facilities equipment group previously described in this part.

G. Miscellaneous Trunk Test and Support Equipment

3.91 Miscellaneous trunk test and support equipment is mounted in a number of single 2-feet-2-inch bay frames. These frames are provided to mount miscellaneous equipment required throughout a 4ESS Switch office. The type and quantity of miscellaneous trunk test and support equipment required in any 4ESS Switch office are dependent upon office size and facilities provided in that office. This equipment is identified and discussed in Parts 4 and 5. Physical descriptive information on this miscellaneous equipment is provided in 234-110-140, *Miscellaneous Trunk Test and Support Equipment—Description and Theory*.

Work Centers and Support Equipment

3.92 The 4ESS Switch operation, maintenance, and administration are implemented from several consoles and numerous input/output terminals which interface with the 4ESS Switch. These consoles and input/output terminals are grouped in areas dedicated to perform specific functions. These areas are referred to as work centers (Figure 1). In some offices, the functions and responsibilities of certain work centers may be combined. Depending on whether an office is participating in a centralized work center environment or decentralized environment also effects the work center assigned functions and responsibilities. For these reasons, the work centers encountered in actual offices may be grouped differently and functions assigned that differ from the typical work centers described in the following paragraphs.

3.93 The basic work center structure in a decentralized environment includes the following work centers:

- Maintenance Operations Center (MOC)
- Terminal Equipment Center (TEC)
- Trunk Operations Center (TOC)
- Machine Administration Center (MAC)
- Network Management Center (NMC).

3.94 When work center functions are centralized, a different work center structure is defined. Centralization of specific work center functions for a number of 4ESS Switch offices involves the reassignment of functions to a centralized facility and a redefinition of the on-site work center responsibilities. Note that the network management

function for a 4ESS Switch is centralized at a Regional Network Management System (RNMS) or the Engineering and Administrative Data Acquisition System for Network Management (EADAS/NM). The work center structure in a centralized environment includes the following:

- Maintenance Operations Center—Centralized Arrangement
- Network Maintenance Center
- Remote Network Administration Center (RNAC)
- Remote Network Operations Center (RNOC).

3.95 Each of the previously-defined work centers is described in the following paragraphs. Again, these descriptions are typical. The actual organization and function of the work centers encountered in an office differ from these typical descriptions because of variables such as the following:

- Office size
- Existence of joint-equipment ownership
- Basic type of company operation
- Implementation of centralized work center functions.

A. Maintenance Operations Center

3.96 The Maintenance Operations Center (MOC) provides a facility to control the 1B Processor, 3B Computer, network services complexes, switching network, and all equipment controlled by the 1B Processor. The MOC contains the master control console and input/output terminals for communicating with the 1A Processor. The MCC video terminal is used to control the 1B Processor. Input/output terminals are also provided for communicating with the 3B Computer and network services complexes, as applicable. Detailed information concerning the MOC operations is provided in 234-105-015, *MOC Operating Guidelines*. Also refer to 234-105-000, *MOC System Interface Devices*, for information concerning the input/output devices.

Master Control Console

3.97 The master control console (MCC) is a sit-down control and display console which provides operating and maintenance personnel with visual displays of system performance. Three separate panels on this console also provide for limited manual control of the system. Two control panels mounted on the right side of the console panel enclosure are provided for specific control of the 1A Processor. These two panels are considered part of the 1A Processor and are described in 254-200-001, *1A Processor General Description,*. These panels are replaced by pages on the video display terminal in the 1B processor.

3.98 The desk portion of the MCC is 78.5 inches long, 28 inches high, and 24 inches deep. Six internal access doors are provided at the rear of the console. A rectangular opening located at the center-rear of the bottom desk panel provides routing access of all interface cables into the MCC. The desk portion of the console is equipped with conventional telephone facilities. Also, a telephone jack panel enables personnel to use hands-free operation of the telephone. This jack panel also provides access to the office communication facilities.

3.99 The console panel enclosure is mounted above the desk top on the right side of the desk. It is 49.5 inches wide, 23.5 inches high, and 6.5 inches deep. Four doors are provided at the rear for internal access. Interface cables are routed through hollow supports at each end of the enclosure. The enclosure can be considered as two bays. The left bay contains the 4ESS Switch system status panel. The right bay contains the 1A Processor panels.

3.100 The MCC Video Display Terminal is a computer terminal that is required with the 1B processor to provide control and display functions to technicians either at the switch or at a remote site. The MCC terminal is a replacement for the Master Control Console used with the 1A

Processor. Control refers to the ability to change the state of the 1B Processor or 4ESS Switch components, ranging from causing an indicator to be turned on or off, to forcing a processor reconfiguration. Display refers to the functions involved in providing status indications to the maintenance technicians through the use of various video display features. The MCC Video Display Terminal is described in detail in 254-301-001, *1B Processor General Description*.

Input/Output Terminals

3.101 Manual control of the system can be implemented using predefined messages that can be input to the 1B Processor, 3B Computer, and network services complexes (as applicable) on various input/output terminals. Messages output on these terminals are also an effective means of monitoring system status.

3.102 Any of several types of input/output terminals may be provided in the MOC. These may be any of several configurations of the ***DATASPEED 40*** terminal. The MOC is also provided with a mobile version of the ***DATASPEED 40*** terminal. Either a magnetic tape ***DATASPEED*** terminal or a ***COMM-STOR II*** communications storage unit is provided to input maintenance data or record test results on selected MOC input/output data channels.

B. Terminal Equipment Center

3.103 The Terminal Equipment Center (TEC) provides a facility to implement circuit-order work on trunks, terminal equipment, and service circuits. The TEC is normally located near the toll terminal equipment. In large offices, the TEC may be subdivided into several areas called TEC control areas. The TEC contains input/output terminals used to communicate with both the 1B Processor and the Circuit Maintenance System (CMS) or TOPAS. Refer to 234-104- 000, *TEC System Interface Devices,* for information concerning the input/output interfaces.

3.104 The input/output terminals used in the TEC are both fixed and mobile devices. The mobile devices enable TEC personnel to access the input/output system from several points throughout the office. These devices may be any of several configurations of the *DATASPEED 40* terminal.

C. Trunk Operations Center

3.105 The Trunk Operations Center (TOC) provides a facility to implement trunk maintenance. In large 4ESS Switch offices, the TOC may be divided into as many as ten separate areas called TOC test-control areas. However, if a large number of TEC control areas are provided, the maximum number of TOC test-control areas might be restricted to a lesser number. Each TOC test-control area consists of one control position and up to nine test positions. In offices which use 51A test positions for trunk testing, the TOC contains a number of 51A test positions and also a number of input/output terminals to communicate with both the 1B Processor and the Circuit Maintenance System (CMS) or the Testing, Operations, Provisioning, and Administration System (TOPAS). A miscellaneous common equipment frame which contains 51A test position related circuits is described in subsequent paragraphs. This equipment is described as part of the TOC because of its functional relationship to the 51A test position. The 4E10 generic program supports the replacement of 51A test positions and associated test equipment with the Remote Maintenance System-D2 (RMS-D2). When equipped with the RMS-D2, the TOC contains a number of trunk work stations which use an input/output terminal for communications with the ConnectVu/CMS or TOPAS. Detailed information concerning TOC operations is provided in 234-103-015, *TOC Operating Guidelines*. Also refer to 234-103-000, *TOC System Interface Devices*, for information concerning the input/output devices.

51A Test Position [Discontinued Availability (DA)]

3.106 The 51A test position provides operating and maintenance personnel with a means of performing trunk maintenance operations on domestic trunks and R1 type international trunks. The 51A test position is a sit-down console which provides personnel with convenient access to controls and indicators required to implement trunk maintenance. The console is configured to accept interconnecting cables from under the floor.

3.107 The console-desk unit contains control circuits, miscellaneous telephone circuits, and test-access trunks. A CRT display unit and a test turret are mounted on the desk top. The CRT display unit, mounted at the left of the desk top, is a *DATASPEED 40* terminal which connects to the Circuit Maintenance System (CMS) or the Testing, Operations, Provisioning, and Administration System (TOPAS). The test turret, mounted at the right of the desk top, contains the key and lamp panel and test equipment required for manual trunk testing. In international gateway offices, the 51A test position coexists with the 51A L6 test position. The 51A L6 test position is provided to test international trunks and is described in Part 4.

Miscellaneous Common Equipment Frame

3.108 The miscellaneous common equipment frame consists of a single 2-feet-2-inch bay and contains common equipment for the transmission measuring system and echo suppressor measuring system in the 51A test position. This frame contains a flashing unit, milliwatt reference generator J94071G, and associated distribution panel J94071J—required by the 51A test position. The reference generator provides 404- Hz, 1004-Hz, 2600-Hz, and 2804-Hz signals used for level, gain, and frequency tests. The distribution panel routes these reference signals to the 51A test positions.

3.109 The miscellaneous common equipment frame serves up to ten 51A test positions and must be located within 250 cable feet of the most distant test position. If more than ten 51A test positions are installed in a 4 ESS Switch office, additional miscellaneous common equipment frames are required.

Remote Measurement System-D2

3.110 The 4E10 generic program supports the replacement of the existing analog trunk test equipment (51A test positions and remote office test line frames) with the Remote Measurement System-D2 (RMS-D2). The RMS-D2 is a self-diagnosing, modularly incremental digital test system. It is designed to serve as the primary trunk transmission measurement unit for the 4ESS Switch. The RMS-D2 uses T1 digital trunks to interface the 4ESS Switch and digital signal processing techniques to perform a wide variety of transmission and signaling tests on analog and digital trunks. Communications between the RMS-D2 and the 1B Processor is provided by a 4800-baud input/output channel data link.

3.111 The RMS-D2 provides support for installation and maintenance testing of 4ESS Switch trunks by users physically remote from the circuit under test. Testing capabilities are invoked via intelligent terminal systems such as the central trunk test unit (CTTU), centralized automatic reporting on trunks (CAROT) at network maintenance centers and the CMS or TOPAS trunk operations center. The RMS-D2 also provides local digital and analog test access for portable test equipment.

3.112 Each 4ESS Switch office is equipped with two RMS-D2 units which are directed via data links or ports from a remote controller. Physically, the RMS-D2 is a stand-alone unit and is installed in the office as a factory-wired and tested frame. A small PBX is also required to interface a voiceband link between the RMS-D2 and trunk work stations and/or other dial-in users. The PBX provides the call setup and conferencing capabilities needed to support the voice frequency testing and control features invoked at the RMS-D2 by the trunk work stations or dial-in users. Data terminals serving the trunk work station are connected to the ConnectVu/CMS or TOPAS. The ConnectVu/CMS or TOPAS interfaces the RMS-D2

equipment and the 1B Processor via separate data links.

D. Machine Administration Center

3.113 The Machine Administration Center (MAC) provides a facility for circuit-order administration, recent-change operations, and traffic measurements. The MAC contains input/output terminals used to communicate with both the 1B Processor and the CMS or the Testing, Operations, Provisioning, and Administration System (TOPAS). Detailed information concerning the MAC operations is provided in 234-102-015, *MAC Operating Guidelines*. Also refer to 234-102-000, *MAC System Interface Devices*, for information.

3.114 Any of several types of input/output terminals may be provided in the MAC. These may be any of several configurations of the ***DATASPEED 40*** terminal. Either a ***DATASPEED*** magnetic tape terminal or ***COMM-STOR II*** communications storage unit may be provided to input recent change data.

E. Network Management Center

3.115 The Network Management Center (NMC) provides a facility through which overall operation of the 4ESS Switch interfacing toll network can be monitored. The NMC contains wall-mounted and/or console-mounted network-management display and input/output terminals used to communicate with the 1B processor. The network management display control frame and the network management display telemetry frame are described in subsequent paragraphs. These frames are described here because of their functional relationship to the NMC. Any of several types of input/output terminals may be provided in the NMC. These may be any of several configurations of ***DATASPEED 40*** terminal. Either a ***DATASPEED 40*** magnetic tape terminal or ***COMM-STOR II*** communications storage unit may also be included in the NMC. Detailed information concerning the NMC operations is provided in 234-101-015, *NMC Operating Guidelines*. Also refer to 234-101-000, *NMC System Interface Devices*, for information concerning the input/output devices.

F. Maintenance Operations Center — Centralized Arrangement

3.116 The centralized arrangement of the Maintenance Operations Center (MOC) provides the on-site MOC and TEC work functions. The MOC is the support and backup facility for the centralized work center facilities and can be self-supporting. Like the MOC previously described, the centralized arrangement of the MOC contains a master control console and input/output terminals for communicating with the 1B Processor. Input/output terminals are also provided for communicating with the 3B Computer and network services complexes, as applicable. An input/output device interface with the centralized maintenance facility minicomputer provides the MOC with access to automated centralized maintenance aids.

G. Network Maintenance Center

3.117 A Network Maintenance Center performs switching maintenance surveillance, control, and analysis functions for a number of 4ESS Switch offices. Each network maintenance center consists of one or more No. 2 Switching Control Center Systems (No. 2 SCCSs) and certain input/output devices. Certain of these input/output devices are dedicated to each served office while others are shared among all served offices.

3.118 Each No. 2 SCCS is a minicomputer-based system that monitors and controls a number of stored program-controlled offices like the 4ESS Switch. Refer to 190-110-110, *No. 2 SCCS Common Application, Description*, for a complete description of the No. 2 SCCS equipment. The network maintenance center system interface devices are described in 234-106-000, *System Interface Devices*.

Related Systems

3.119 The Circuit Maintenance System (CMS) or TOPAS related systems may be provided to support 4ESS Switch maintenance and administration activities.

A. Testing, Operations, Provisioning, and Administration System

3.120 The Testing, Operations, Provisioning, and Administration System (TOPAS) is a mechanized, automated, related system that provides provisioning and maintenance support for the 4ESS Switch. The TOPAS database contains all trunking information available to the NOW platform. Each TOPAS system uses a commercial central processing unit (CPU) with associated peripheral equipment. The TOPAS system provides operational, administrative and maintenance (OA&M) functions such as optical back-ups, disk mirroring, and have fail-over capabilities to a back-up processor. The CPU's are organized in a duplex, triplex, and quadplex configuration that include TOPAS, Network Services Automator (NSA), and Data Acquisition and Administration System (DAAS). Two, three or four CPU's are linked together; one is in a back-up status while the others are active.

B. Circuit Maintenance System

3.121 The Circuit Maintenance System (CMS) is a dual-processor system that uses commercially available minicomputers with associated peripheral equipment. This equipment provides operating personnel in the various work centers at one or more 4ESS Switch installations with an operations support facility. An interface with the 1B Processor provides the CMS processors with access to the 4ESS Switch operational features and the 1B Processor data bases.

3.122 The CMS system and certain input/output terminals are located in an area called the CMS Maintenance Center (CMSMC). This maintenance center is provided only to monitor operation of the CMS. The input/output terminals in the CMSMC are used to access CMS control software, monitor, and to control each of the dual CMS processors. The CMS operations-support features are implemented from input/output terminals assigned to CMS control areas in the various 4ESS Switch work centers. The actual number of control accesses assigned in the various work centers and the actual number of input/output terminals in each control area are dependent upon the specific requirements of each 4ESS Switch office. Refer to the *234-108-042, CMSMC System Interface Devices* for information concerning the person-machine interface devices provided by the CMSMC.

Network Services Complex

3.123 A network services complex (NSCX) contains the equipment necessary to support the teleconferencing customer service. This equipment is not unique to the 4ESS Switch and can be equipped at any stored program-controlled system serving as an action control point. The equipment configuration of a specific network services complex varies depending on the network service feature being supported. The network services complex equipment frames include the following:

- Network services frame J4A017A-1
- Audio bridge frame J4A017B-1
- Data bridge frame J4A017C-1
- Direct services dialing frame J4A017D-1
- Modem link frame J4A017E-1
- Network Services Frame J4A017G (DSD7 generic or later)
- Disk and Tone Receiver Frame J4A017H (DSD7 generic or later)
- Moving head disk frame J1C131B-1
- Power distribution frame J86334B/C-1.

3.124 The following three equipment configurations of network services complex may be equipped at the host stored program-controlled system:

- Audio only teleconferencing network services complex
- Audio with data teleconferencing network services complex
- Direct services dialing capability network services complex.

3.125 The maximum number of teleconferencing network services complexes that can be equipped in a 4ESS Switch is 28.

3.126 Refer to 256-041-100, *Network Services Complex, Description*, for additional detailed information concerning the physical and operational characteristics of the NSCX.

Service Circuit System

3.127 The Service Circuit System (SCS) hardware and the 4E17 generic program provide the 4ESS Switch with a cost effective method of supporting services requiring increased interaction between the network and the customer for announcement and collection capabilities. The optional Automatic Speech Recognition (ASR) feature on the SCS, available with the 4E20 generic program, allows speech recognition functions to enhance SCS information collection capabilities.

3.128 The SCS hardware consists of Service Circuit Controllers (SCC) and several Service Circuit Units (SCU). Each SCS provides one duplex SCC and up to 16 SCUs with 120 ports on each SCU. The SCCs connect to the SCUs over an optical Extended Bus (EB). An adjunct Announcement Administration Processor (AAP) provides announcement administration for each SCU's database over a dedicated Local Area Network (LAN).

3.129 Two different cabinets house the SCS hardware. The SCC cabinet contains the duplex SCC's and a single SCU with up to four disk pair units. The second cabinet is the SCS unit cabinet that has up to four SCUs, each with a single disk pair. Both cabinets are 6 feet high, 30 inches wide, and 24 inches deep.

3.130 The power control switches on the SCS power units contain the following five buttons:

- Request Out-of Service (ROS)
- Power On (ON)
- Power Off (OFF)
- Manual Override (MOR)
- Lamp Test (LT).

3.131 There are five lamps associated with the power control switches on the SCS power units. These lamps are:

- Out-of Service (OS)
- Power Status (OFF)
- Power Fail (PF)
- Fuse Alarm (FA)
- Acknowledgement (ACK).

3.132 The duplex SCC is a two-shelf unit consisting of two identical controllers. Each controller occupies a single shelf that houses the control, memory, Peripheral Unit Bus (PUB) interface, EB interface and power circuit packs.

3.133 The SCU is located above the fan assembly shelf in the controller cabinet. The SCU is a single unit with one shelf of circuit packs. The four hard disk units (HDUs) that store announcements for the SCU are located on the two lower shelves of the controller cabinet. Only one HDU is required. Each of the four SCUs in the unit cabinet uses a single HDU and the four HDUs are located on the lower two shelves of the cabinet. A HDU only requires half a shelf in this cabinet.

3.134 The Announcement Administration Processor (AAP) is a Star Server® computer that provides announcement administration. The AAP receives and buffers updates to the announcements and sends the announcement data to the SCUs. The AAP is an adjunct unit that communicates with the SCUs over a dedicated LAN. Refer to 201-525-010, *Improved Service Announcement and Information Collection (ISAIC), Description*, for additional detailed information concerning the physical and operational characteristics of the AAP.

3.135 The optional ASR feature Custom Data Services Cabinet (CDSC) connects to an SCU to perform special signal processing functions. The cabinet contains up to five Custom Data Service Units (CDSUs). Each CDSU performs speech recognition for 24 channels. The CDSC houses the following equipment.

- One Fuse and Filter Panel
- Up to 5 CDSUs
- One Smart Hub (not in every CDSC; only 1 required for each set of 8 CDSCs).

3.136 Each CDSU is a single unit occupying one shelf of the CDSC. A CDSU consists of the following:

- One 486 Processor Card
- One Hard Disk Drive
- One Ethernet LAN Interface Card
- One SVGA Card
- One SCSI Card
- Twelve AYC50 Speech Processing Cards
- Two T1 Interface Cards
- One Control Module
- One Power Module
- Three Fans.

3.137 Refer to 234-100-130, *Service Circuit System, Description*, for additional detailed information concerning the physical and operational characteristics of the SCS.

4. Equipment Description—International Switching Centers

General

4.01 This part contains a description of the equipment provided in a 4ESS Switch international switching center (ISC). Note that the equipment described in Part 3 is also provided in 4ESS Switch International Switching Centers. Part 4 is organized according to the same functional areas as defined in Part 2. These functional equipment areas are shown in Figure 1. Equipment unique to an international switching center is identified by an asterisk (*) in Figure 1. The type of information presented is identical to Part 3. Front-view illustrations and other detailed information concerning the equipment described in this part are provided in the applicable frame-level documents.

4.02 As with domestic equipment, detailed frame-level documentation can be identified by referring to current issues of 234-000-000, *4ESS Switch, Numerical Index, Division 234* and 234-000-005, *4ESS Switch, Interdivisional Numerical Index*.

1A Processor

4.03 Only the information in Part 3 is required.

3B Computer

4.04 Only the information in Part 3 is required.

1A Processor Interface Equipment

4.05 Only the information in Part 3 is required.

Terminal Equipment

4.06 In addition to the equipment described in Part 3, the following equipment is required in 4ESS Switch international switching centers.

A. International Operator Bridged Access Interoffice Trunk

4.07 The international operator bridged access trunk (OBAT) provides a means for an operator at a remote international operating center to access trunks to provide customer assistance. The OBAT equipment is mounted in OBAT frame J1C015F. The OBAT frame is comprised of a single 2-feet-2-inch bay. A fully equipped frame can provide access for 72 trunks (36 A-trunks and 36 B-trunks). (An A-trunk and a B-trunk are required to service a customer.) In addition to the OBAT circuits, the OBAT frame contains a supporting maintenance-communications panel, a power-distribution panel, and terminal strips.

Switching Network

4.08 Only the information in Part 3 is required.

Service Circuits and Trunk Test Facilities

A. Remote Office Test Line Frame J4A007A

4.09 Only the information in Part 3 is required.

B. Phased Announcement System (PAS)

4.10 Only the information in Part 3 is required.

C. 820A Ringing, Tone, and Interrupter Plant J87822A

4.11 Only the information in Part 3 is required.

D. Multifrequency Signaling Frame J99353A

4.12 Only the information in Part 3 is required.

E. Continuity Check Transceiver and Loop-Around Test Unit

4.13 Only the information in Part 3 is required.

Digital Services Interface Equipment

4.14 Only the information in Part 3 is required.

Miscellaneous Systems and Frames

4.15 Only the information in Part 3 is required.

Work Centers and Support Equipment

A. Maintenance Operations Center

4.16 Only the information in Part 3 is required.

B. Terminal Equipment Center

4.17 Only the information in Part 3 is required.

C. Trunk Operations Center

4.18 In addition to the equipment described in Part 3, the Trunk Operations Center in an international switching center requires a 51A L6 test position.

51A L6 Test Position

4.19 The 51A L6 test position provides operating and maintenance personnel with a means of performing trunk maintenance operations on international and transit trunks using CCITT 5 and CCITT 6 signaling. The 51A L6 test position is similar to the 51A test position discussed in Part 3. However, the key and lamp panel and the test equipment mounted on the 51A L6 test position is provided to test CCITT 5 and CCITT 6 signaling trunks. In addition to the CCITT 5 and CCITT 6

trunk test capability, the 51A L6 test position retains many of the original 51A test position features and can also be used for maintenance on domestic and international R1-type trunks.

4.20 Support equipment for the 51A L6 test position is not mounted in a dedicated common equipment frame as it is for the 51A test position. Common equipment for the 51A L6 test position is mounted in miscellaneous trunk test and support equipment frames in the office. This 51A L6 test position support equipment consists of an echo suppressor test set, a flashing unit, and a 71G precision tone generator (with 2400-Hz tone) and distribution networks.

D. Machine Administration Center

4.21 Only the information in Part 3 is required.

E. Network Management Center

4.22 Only the information in Part 3 is required.

F. Maintenance Operations Center—Centralized Arrangement

4.23 Only the information in Part 3 is required.

G. Network Maintenance Center

4.24 Only the information in Part 3 is required.

Related Systems

A. Circuit Maintenance System

4.25 Only the information in Part 3 is required.

B. Centralized Automatic Reporting on Trunks 2

4.26 Only the information in Part 3 is required.

C. Remote Measurement System - Gateway 1

4.27 The RMS-G1 equipment provides operating and maintenance personnel in various 4ESS Switch work centers with a means to automatically test international trunks. Various international trunk tests are initiated and controlled, and the results are monitored under control of the RMS-G1.

4.28 The RMS-G1 hardware consist of a Digital Test Unit (DTU) and the G1 Driver. The G1 Driver is an AT&T 6386E Work Group Station that connects to the RMS-G1 DTU via an X.25 link. Routine and demand test commands in addition to maintenance commands are sent to the RMS-G1 DTU via this link.

4.29 The RMS-G1 DTU is a stand-alone (5ESS® Switch) type equipment cabinet that contains *six directors, five responders, a Local Test Port,* and associated control circuits.

a. Each *director* requires two channels of the DS-1 facility to the 4ESS Switch. One channel per director (E&M signaling channel) initiates voiceband transmission tests. The other director channel (clear signaling channel) initiates digital transmission tests.

b. Each *responder* requires two channels of the DS-1 facility to the 4ESS Switch. One channel per responder (E&M signaling channel) terminates voiceband transmission tests. The other responder channel (clear signaling channel) terminates digital transmission tests.

c. The *Local Test Position* (LTP) circuit pack requires two channels (E&M signaling) on the DS-1 facility to the 4ESS Switch. A local Test Port Panel (LTPP) provides local access. An Advanced Measurement Processor and a Voice Service Remote Test Port (VSRTP) along with a Local Test Port are used for voiceband and voiceband data parameter tests from the Local Terminal.

Network Services Complex

4.30 Only the information in Part 3 is required.

CNI Ring

4.31 Only the information in Part 3 is required.

5. Functional Description—Domestic Offices

General

5.01 This functional description is organized according to the 4ESS Switch equipment areas defined in Part 2. A functional description is provided for each defined equipment area. These descriptions address equipment directly related to call processing, system power, and power-related alarm circuits. Figure 1 shows the equipment areas which comprise a 4ESS Switch; internal interfaces, excluding power and alarm interfaces; and interfaces with equipment external to the 4ESS Switch. Lower level functional block diagrams are referenced from this diagram for the equipment areas that required a more detailed level of coverage. Equipment, which is unique to international switching centers, is identified by an asterisk (*) on the figures. The international unique equipment and associated interfaces are discussed in Part 6.

5.02 Figure 1 illustrates the equipment, work centers, and related systems that can be provided in a typical 4ESS Switch office. The actual equipment provided in any one office can vary according to the maintenance features desired, number and type of toll trunks serviced, and the method of signaling employed. For example:

- Related systems may not be provided
- Functions of work centers may be combined
- Common channel signaling (CCS) protocols (CCS7, CCITT 7, and others) may not be provided
- In a completely digital office, analog terminal equipment and Signal Processor 1 are not provided
- The office may or may not participate in centralized maintenance.

5.03 In Figure 1, internal and external interfaces that carry switched message traffic and the peripheral unit bus are shown heavy lined. The remaining signaling, timing, control, miscellaneous, maintenance, and input/output interfaces are shown using normal weight lines.

4ESS™ Switch

5.04 The external 4ESS Switch interfaces consist of the following:

- Trunk test and status data
- System status data
- Network management information
- Dynamic overload control signals
- Toll trunks
- Status signals.

5.05 In-effect notices may be applied to circuit provisioning bureaus to keep these bureaus informed of the current configuration of the 4ESS Switch office. Trunk-test data may be exchanged with a carrier transmission maintenance system in an interfacing transmission systems center. This data exchange is used whenever necessary to assist isolation of trunk malfunctions to either the 4ESS Switch terminal equipment or interfacing carrier systems. Dynamic overload control signals sent to the 4ESS Switch identify interconnected offices which are operating at various levels of capacity that can or cannot accept additional switched traffic from the 4ESS Switch network. Dynamic overload control signals are sent to interconnected offices when the 4ESS Switch toll office is operating at various levels of capacity and can accept little or no additional incoming traffic for switching. Status signals are sent to remote areas which are equipped with console or wall units to

monitor status of the 4ESS Switch network. Various interfaces with external monitoring systems are also provided. These interfaces allow the following:

- Permit evaluation of service
- Permit monitoring of overall system status
- Enable high-level network management centers to monitor and evaluate overall office performance within the toll network.

5.06 Toll trunks comprise the major external interface for the system. These trunks carry the voice and data signals which are switched by the 4ESS Switch. A small percentage of these trunks are nonmessage circuits and are reserved for maintenance and interoffice signaling purposes.

5.07 Trunks employing digital facilities are applied to the 4ESS Switch office through the digroup terminal or digital interface in the terminal interface equipment. The digroup terminal and digital interface provide a direct interface between DS1 formatted T1 carrier systems and the time slot interchange (DS120 format) in the switching network. The digroup terminal contains circuits which detect and insert supervisory and dial-pulse signals under control of the signal processor 2. On digital carrier trunks which employ multifrequency signaling or dial-pulse signaling, trunk-supervisory signals are detected by the signal processor 2. This is accomplished by monitoring data transferred over a digital link between the digroup terminal and the signal processor 2. On trunks employing dial-pulse signaling, digits received are also detected by the signal processor 2. As with analog trunks, digital carrier trunks employing MF signaling are connected to a multifrequency receiver or transmitter for digit collection or generation. Signaling for digital trunks employing CCS is processed through the CNI ring. The signal processor 2 provides functions similar to the signal processor 1 but for digital carrier trunks. The signal processor 2 is provided only in offices equipped with digroup terminals. The 4ESS Switch offices that interface with only digital carrier trunks do not contain a signal processor 1. In these instances, the signal processor 2 is provided with a supplementary matrix frame which provides the miscellaneous signal distributor and scan points which connect to various 4ESS Switch equipment frames. The digital interface is the functional equivalent of the digroup terminal and signal processor 2, less the supplementary matrix frame (miscellaneous points) function.

5.08 After switching, outgoing calls are handled in a similar manner. The 1B Processor transmits digits to be outpulsed to the signal processor. Depending upon transmission facilities and the type of signaling employed, the signal processor 1 or signal processor 2 applies the digits to the following:

a. The terminal equipment or intermediate distributing frame via signal distributor points: These points, in turn, control the M-leads which drive the trunk signaling unit.

b. The digroup terminal via the digroup terminal-signal processor 2 data link

c. An analog multifrequency transmitter via signal-distributor points: The transmitter generates appropriate tones which are applied to the designated trunk through the switching network.

d. In the case of trunks employing common channel signaling, data relating to the outgoing call is applied directly to the CNI ring via the 3B Computer and forwarded to the appropriate destination via the common channel signaling network.

5.09 Traffic applied to the 4ESS Switch via the various metallic and analog trunks is comprised of analog or voice-frequency signals. However, the 4ESS Switch switching network is designed to accept only digital signals. A voiceband interface contains circuits that convert voice frequency signals to pulse code modulated (PCM) digital signals for application to the switching network. The voiceband interface converts digital signals from the switching network to voice-frequency signals for application to appropriate trunks. In addition, the voiceband interface accepts and converts voice-frequency signals from a number of trunks to digital signals. The signals from

many separate voice frequency trunks is assigned to serial time slots and applied to the switching network via coaxial cable. The digital signals from the switching network is applied to the voiceband interface via coaxial cable. These signals are separated according to the assigned time slots, converted to voice frequency, and applied to the appropriate voice frequency trunks.

5.10 The 4ESS Switch switching network is comprised of the time slot interchange/expanded time slot interchange, time multiplexed switch, and network clock and system clock. The time slot interchange/expanded time slot interchange and the time multiplexed switch together form a 4-stage network through which data is transferred both in time and space across the network. The network clock and system clock provide the precise timing signals required to control the network. The time slot interchange/expanded time slot interchange provides the first and fourth stage of switching plus other related functions. The time multiplexed switch provides the second and third stages of switching. Details of these frames and their assigned functions are presented later in this part.

1B Processor

5.11 The 1B Processor is a stored, program-controlled, data processor capable of controlling a complex switching system. The 1A Processor hardware is designed to support more than one type of switching system. The 1B Processor only supports the 4ESS Switch. However, the control programs and office data structure which are loaded into the 1B Processor are application-dependent. The control programs loaded into the 1B Processor in the 4ESS Switch application are specifically designed to control the 1B Processor in a 4ESS Switch environment. These programs control the operation of the 1B Processor and 4ESS Switch, and control operating, monitoring, and maintenance activities for the entire system. The 1B Processor is a completely self-contained subsystem. However, Master Control Console (MCC) panels, located in the 4ESS Switch Maintenance Operations Center, control the 1A Processor. These panels provide operating personnel with a means of monitoring 1A Processor operation and exercising manual control over the 1A Processor. Indirectly, this also provides a means of monitoring and controlling the 4ESS Switch. These panels are located on the master control console adjacent to a 4ESS Switch indicator panel which provides indications of the 4ESS Switch operating status. These panels together provide a single point to comprehensively monitor complete system operation. A terminal interface, the MCC and Utility Processor (MUP), provides the similar capabilities for the 1B Processor through a video display terminal.

5.12 As with 4ESS Switch equipment frames, 1B Processor frames are either duplicated or configured so that failure of any one frame will not drastically reduce 4ESS Switch capabilities. Internal and external interfaces are also duplicated so that any problem encountered in transferring data either within the 1B Processor or to external 4ESS Switch peripheral equipment will not result in a system failure. The 1B Processor frames are diagnosed by maintenance software on a regular basis. Malfunctioning frames detected during this diagnosis are removed from service. In some instances, standby frames are switched on-line to replace the malfunctioning frames. In other instances, the function normally performed by the failed unit is assigned to another operating unit capable of performing the function.

A. 1B Processor Equipment

5.13 The primary control equipment in the 1B Processor is the central control. The central control interfaces with all other 1B Processor equipment and performs the processing functions in the 1B Processor. Under program control, the central control uses all 1B Processor equipment, as required, to ensure calls are switched in an accurate and reliable manner. The central control also executes program-controlled maintenance routines which check the operation of the 1B Processor and 4ESS Switch.

5.14 The 1B Processor contains semiconductor memory that is used for two specific purposes. These are program store and call store. ***Program store*** is used for the storage of infrequently changed data. This information primarily is program instructions. However, data related to the configuration of the particular 4ESS Switch office, which is rarely changed, is also stored in program store. The Program Store Expansion (PSE) feature, available with the 4E21 generic program, supports hardware growth in the 4E22 generic program for the PSE feature. The PSE feature converts 1 mega word (Mw) of call store memory to program store memory. The increase in program store memory from a maximum of 2 Mw's to approximately 3 Mw's allows for growth of programs to support customer feature request. ***Call store*** is used for the storage of frequently changed data related to call processing. This information includes but is not limited to the following:

- Status of trunks and the switching network
- Records of switching network configurations for each call in progress
- Digits received and digits to be outpulsed
- Office translation update data
- Maintenance data related to programmed-diagnostic tests
- An Extended Call Store (ECS) feature, if required.

5.15 Call store also contains some semipermanent office-dependent data and an emergency system recovery program. The data consists of trunk and routing data and office-engineered data (for example, unit type data). The emergency recovery program is used to establish a working system in the event of a program store failure.

5.16 The 1B Processor has access to two auxiliary unit communities which provide the 1B Processor with auxiliary memory; these are the APS (3B Computer) and Auxiliary Data System. The APS provides the central control with a magnetic disk memory. The APS serves as a backup memory for program store and portions of call store in addition to storage for infrequently used programs and data. The Auxiliary Data System provides the CC with a magnetic tape storage and data retrieval capability. The magnetic tape facility is used for system reinitialization, memory dumps, message accounting, program updating, and general data-handling capabilities.

5.17 The 1B Processor contains an input/output frame or input/output processor frame which serves as the interface between the central control and input/output terminals in the 4ESS Switch work centers. These terminals are used to input control messages to the central control. They are also used to output responses and status messages from the central control. Input/output channels also provide 2-way access between the 1B Processor and processors in other maintenance support and data-gathering systems. Currently, this type interface is used by the Circuit Maintenance System, the Service Evaluation System, the Engineering and Administrative Data Acquisition System for Network Management (EADAS/NM), and a centralized maintenance facility. If the number of input/output channels accommodated by the 1B Processor input/output frame or input/output processor are insufficient to meet the requirements of a 4ESS Switch office, facilities are provided to add additional input/output frames or processors as part of the 4ESS Switch equipment. The I/O frame may also provide the interface between 1B processors in different 4ESS Switches.

5.18 With the exception of input/output channels and the 3B Computer interface, all 1A Processor external interfaces pass through a processor peripheral interface frame which is included in the 1A Processor. Since the 1A Processor may be used with several switching systems, this frame is included in the 1A Processor to provide a common point of connection for any using system. In the 4ESS Switch application, this frame is used to physically mount several logic circuits which are considered part of the 4ESS Switch master control console. In the 1B architecture, the PPI MCC and telemetry capabilities are replaced by the MUP.

5.19 Internal and external 4ESS Switch interfaces associated with the centralized maintenance ability also pass through the processor peripheral interface frame. In 4ESS Switch offices which are controlled and monitored from a centralized maintenance facility, designated as remote offices, the processor peripheral interface frame contains remote access interface and telemetry equipment. This equipment receives inputs from:

- The office alarm system and miscellaneous building alarm systems
- Frame-mounted master control console status and control circuits.

5.20 The various status, control, and alarm signals are converted to telemetry data and are applied to a centralized maintenance facility.

B. Interface

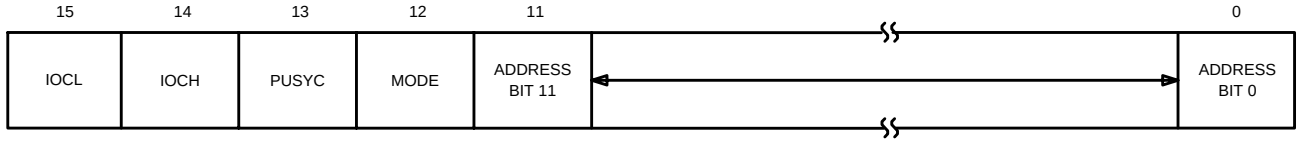
5.21 The primary interface between the 1B Processor subsystem and the 4ESS Switch equipment is the peripheral unit bus. The peripheral unit bus is comprised of several functional components.

a. **Peripheral Unit Enable Address Bus:** In the 4ESS Switch application, this portion of the peripheral unit bus consists of 16 data and control bits. Figure 2 is a pictorial representation of the information carried on this bus. These data and control bits are generated at the 1B Processor central control and are applied to the 4ESS Switch equipment frames. Generally speaking, information transmitted on this portion of the peripheral unit bus identifies specific 4ESS Switch equipment selected for access by the 1B Processor central control. Specific functions of individual enable address bus bits are discussed in individual frame theory documents.

b. **Peripheral Unit Write Bus:** This portion of the peripheral unit bus consists of 40 data bits. Figure 3 is a pictorial representation of the information carried on this bus. These data bits are generated at the 1B Processor central control and are applied to 4ESS Switch equipment frames. Information transmitted on this portion of the bus represents various instructions and/or data to be applied to the addressed 4ESS Switch equipment. Specific functions of various write bus bits are discussed in individual frame theory documents.

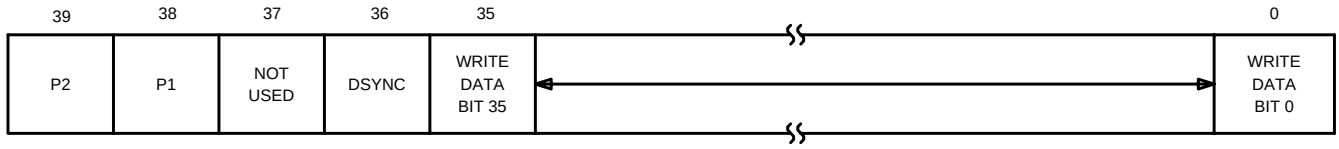
c. **Peripheral Unit Reply Bus:** This portion of the peripheral unit bus consists of 32 data bits. Figure 4 is a pictorial representation of the information carried on this bus. These data bits are generated by addressed 4ESS Switch equipment frames and are transmitted to the 1B Processor central control. Information carried on this bus consists of reply data sent to the 1B Processor as a result of some control pulse or equipment instruction. Specific functions of various reply bits are discussed in individual frame theory documents.

d. **Peripheral Unit Control Bus:** This portion of the peripheral unit bus consists of eight control bits. Figure 5 is a pictorial representation of the information carried on this bus. The control bits are generated at the 1B Processor central control and are applied to 4ESS Switch equipment frames. These control bits initiate or control specific operations in frames to which they are applied. Specific functions of various control bits are discussed in individual frame theory documents.



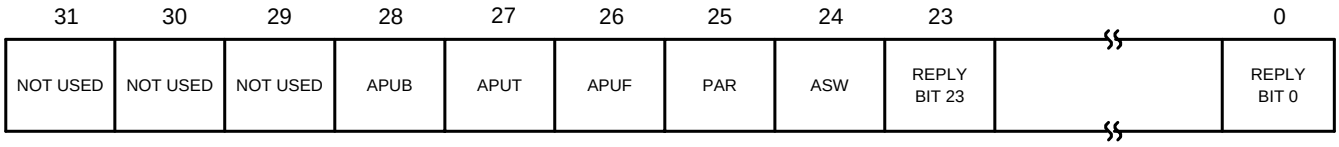
LEGEND:
IOCH - INPUT/OUTPUT CLOCK HIGH
IOCL - INPUT/OUTPUT CLOCK LOW
PUSYC - SYNC PULSE FOR OSCILLOSCOPE

Figure 2. Peripheral Unit Enable Address Bus



LEGEND:
P1 - ODD PARITY COMPUTED FOR BITS 1, 3, 5, 7, 9 AND 11 OF ENABLE ADDRESS BUS AND ODD BITS 1 THROUGH 35 OF WRITE BUS
P2 - ODD PARITY COMPUTED FOR BITS 0, 2, 4, 6, 8 AND 10 OF ENABLE ADDRESS BUS AND EVEN BITS 0 THROUGH 34 OF WRITE BUS
DSYNC - DIAGNOSTIC SYNC PULSE

Figure 3. Peripheral Unit Write Bus



LEGEND:
APUB - AUTONOMOUS PERIPHERAL UNIT BASE LEVEL
APUF - AUTONOMOUS PERIPHERAL UNIT FAILURE
APUT - AUTONOMOUS PERIPHERAL UNIT TROUBLE
ASW - ALL SEEMS WELL
PAR - ANSWER PARITY

Figure 4. Peripheral Unit Reply Bus

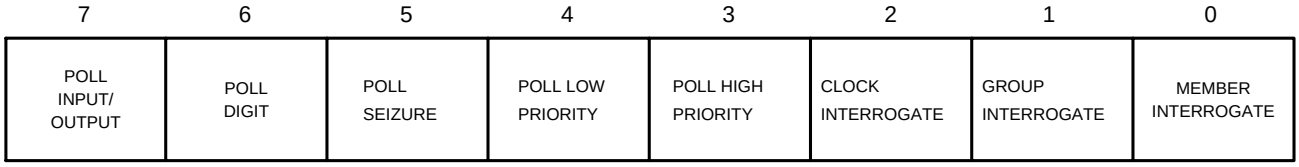


Figure 5. Peripheral Unit Control Bus

5.22 The peripheral unit bus is fully duplicated. The duplicated bus is referred to as bus 0 and bus 1. The 4ESS Switch frames connected to the peripheral unit bus can communicate with the 1B Processor on either bus 0 or bus 1. Bus-select circuits in each 4ESS Switch equipment frame determine which bus a frame uses to communicate with the 1B Processor. These bus-select circuits are controlled by the 1B Processor central control. Bus-control circuits in the central control determine whether the central control communicates with the 4ESS Switch equipment on bus 0, bus 1, or both buses. The bus or buses used by the 1B Processor and by various 4ESS Switch frames are referred to as the operating configuration. The 1B Processor can also communicate with different 4ESS Switch frames using alternate buses. The 1B Processor control programs automatically monitor and control this operating configuration.

5.23 All 4ESS Switch equipment connected to the peripheral unit bus simultaneously receives any data transmitted on the peripheral unit bus. The method used to access specific equipment is referred to as coded enabling. With some exceptions (network clock circuit, voiceband interface frame, digroup terminal), all 4ESS Switch equipment connected to the peripheral unit bus is assigned a unique code called K-code. When the central control accesses a particular unit, the K-code assigned to that unit is transmitted on the peripheral unit enable address bus. Only the unit whose assigned K-code matches the K-code transmitted responds to the central control access. Units whose assigned K-code does not match the transmitted K-code do not respond.

5.24 The peripheral unit bus may also be used by the 1B Processor to communicate with 4ESS Switch equipment using a method known as polling. Polling is used by the central control to obtain status data from up to 24 separate units of the same type. During polling, the central controls apply a control or maintenance interrogation pulse to 4ESS Switch units via the peripheral unit control bus. The 4ESS Switch units, wired to process the particular control bit, respond by transmitting a single status bit on an assigned bit position of the peripheral unit reply bus. The central controls monitor the reply bus to determine the particular status of each of the polled 4ESS Switch units. This status data may typically represent a request for service condition, a full buffer, or any number of conditions which might be represented by the status of a single bit.

5.25 The 1B Processor central control also communicates with selected 4ESS Switch equipment using pulse points. These pulse points consist of specific control pulses generated under software control by the central control. These control pulses are applied to designated frames to initiate or control specific operations within that frame. As illustrated in Figure 1, these control pulses are applied to the peripheral unit bus branching frame, SP1 and/or SP2 (base signal processors 0 and 1), the IO frame, and the network clock and system clock.

5.26 The 4ESS Switch equipment is not capable of initiating data transfers or directly controlling operation of the 1B Processor. Instead, system-control programs stored in the 1B

Processor memories cause the processor to monitor the contents of various status registers in selected 4ESS Switch equipment. Program-controlled analysis of these data words causes the 1B Processor to request data from selected units. The data input from 4ESS Switch equipment is used by the 1B Processor to generate appropriate system control instructions.

5.27 The 1A Processor also has a status- and manual-control interface with the master control console. At the MCC, this interface terminates at the 1A Processor control panels or 1B Processor video display terminal described previously in this part.

5.28 The 1A Processor applies a control signal to the Network Management Center when operating conditions make it impractical for the 4ESS Switch to accept additional traffic. This signal is forwarded to the connecting offices as an indication of the overload condition. The control signal is also forwarded to display equipment in the Network Management Center to notify network management personnel of the overload condition. This feature is removed with the 4E18/4E19 generic program.

5.29 A complete description of the 1B Processor can be found in 254-200-001, *1A Processor General Description,* or 254-301-001, *1B Processor General Description*.

3B Computer

5.30 The 3B Computer, commonly referred to as the attached Processor System (APS) in the 4ESS Switch environment, is feature oriented; that is, the 3B Computer is used as an adjunct processor by the 1B Processor to support specific functions. The APS was primarily implemented to replace the 1A file store. The APS expands the directly addressable disk storage capacity available to the 1B Processor from 5,120,000 data words to 8,388,608 data words (33.5 megabytes). This directly addressable area of the 3B Computer disk storage is called the 1A_File. The 3B Computer disk system also provides the ability to use expandable 3B Computer file structures that are accessible to the 1B Processor via the 3B Computer disk file management system. With the 4E16 generic program, the 3B Computer disk drives are replaced with Small Computer Interface System (SCSI) disk drives. The SCSI disk drives provide a more reliable, economical, and expandable disk storage area. This area of disk storage is called the 3B Computer_File, and addressing within the 3B Computer_File is on a file-path-name word-offset basis.

5.31 The input/output ability of the 3B Computer supports several optional data link interfaces with remote facilities. These interfaces are equipped with various interface devices and private and/or switched data links as required by the specific application. The following optional 4ESS Switch features and remote facilities may be interfaced to the 3B Computer input/output channels:

- Network Maintenance Center interface
- Maintenance and surveillance interface to Network Services Complexes (NSCXs)
- Operations Network Administration Center (ONAC) interface
- Teleconferencing Operator Support System (TOSS) interface
- Interface to a Regional Accounting Office (RAO) for teleprocessing Automatic Message Accounting Standard Entries (AMASE) data
- Software Change Administration and Notification System (SCANS) interface
- Traffic Data Acquisition System (TDAS) interface
- Network Management Operations Support (NEMOS) system interface.

5.32 Refer to 234-100-200 and 234-100-201, *Attached Processor System, General System Information, 4ESS Switch Application,* for detailed information concerning the 4ESS Switch application of the 3B Computer. A complete

description of the 3B Computer is provided in 254-301-005, *3B Computer, General Description.*

1B Processor Interface Equipment

5.33 As illustrated in Figures 1 and 6, and briefly discussed in Part 3 of the document, the 1B Processor interface equipment is comprised of a peripheral unit bus branching frame and one or more input/output frames, **or** an input/output processor, **or** a mixture of the two. Associated data sets are also included in this equipment group. This equipment is discussed in the following paragraphs. Also shown in Figure 6 are the power input requirements for the 1B Processor interface equipment. The 4ESS Switch power distribution is discussed later in this part.

A. Peripheral Unit Bus Branching Frame J4A005A

5.34 The peripheral unit bus branching frame (Figure 6) is the first point of connection for the peripheral unit bus as it leaves the 1B Processor. The peripheral unit bus branching frame can expand the peripheral unit bus into a maximum of 16 parallel-connected branches for each duplicated bus.

5.35 The two bays of the peripheral unit bus branching frame are designated bay 0 and bay 1. Bay 0 branches peripheral unit bus 0 and bay 1 branches bus 1. Since each bay is provided with a separate power source, this duplicate bay arrangement provides redundancy. A failure in any one bay would still enable the system to operate with the other bay and corresponding bus.

5.36 In addition to circuits which branch the peripheral unit bus and serve as an interface between the 1B Processor and the 4ESS Switch equipment frames, the peripheral unit bus branching frame also provides a loop-around ability. This loop-around ability enables the 1B Processor central control to verify data carried on the peripheral unit bus as far as the peripheral unit bus branching frame. When the loop-around circuits are enabled, the central controls transmit data on the peripheral unit bus and the peripheral unit bus branching frame returns this data to the central control for verification. The loop-around circuits receive data on the peripheral unit enable address, write, and control bus and return the data in predefined bit patterns on the peripheral unit reply bus. The loop-around function is enabled, and bit patterns are selected according to central control pulse points applied to the branching frame. The loop-around ability is provided on both peripheral unit bus 0 and bus 1. However, data cannot be looped around from bus 0 to bus 1 or vice versa.

5.37 Although not shown in Figures 1 and 6, up to four additional peripheral unit bus branching frames may be provided in the 4ESS Switch terminal interface equipment area. These frames may be provided, with certain restrictions, to either extend the length of the peripheral unit bus or to increase the number of branches to the peripheral unit bus. When provided, these additional frames function similarly to the peripheral unit bus branching frame in the 1B Processor interface equipment area.

B. Input/Output Frame J5A006A [Discontinued Availability (DA)]

5.38 In addition to the one I/O frame provided in the 1B Processor, up to three additional I/O frames may be installed as 4ESS Switch equipment. These additional frames increase the number of I/O channels available to a maximum of 64. These I/O frames are identical to the frame provided within the 1B Processor. These frames serve as an interface between the central control and I/O terminals in the work centers. Depending on the particular I/O channel assignment, these frames may also interface with external monitoring, maintenance, and evaluation facilities.

5.39 The input/output frame consists of two identical input/output unit selectors. Each of the selectors interfaces with a maximum of eight input/output unit controllers. Each controller is assigned to a software-defined input/output channel. Each controller can accommodate up to three terminals which are used for transferring the

same information. Each input/output unit selector is assigned its own unique K-code. The 1B Processor central controls can access the input/output unit selectors using peripheral unit instructions transmitted on the peripheral unit write bus 0 or bus 1. The appropriate K-code must be transmitted on the corresponding peripheral unit enable address bus before the input/output unit selectors will process any peripheral unit orders.

5.40 In addition to specifying an input/output instruction and identifying the applicable input/output unit selector, the K-code also identifies the input/output unit controller to be accessed. The enabled selector decodes the peripheral unit instruction and accesses the specified controller. The controller, in turn, forwards output data to the respective input/output terminal. The output from the controller conforms to the Electronic Industries Association (EIA) interface standard. The controller is able to interface directly with input/output terminals that are within 200 cable feet of the controller. Connections to data sets must be made if the distance exceeds 200 cable feet or if the terminal is not compatible with an EIA interface standard. When data sets are used, the data sets at the 4ESS Switch end must be within 50 cable feet of the controller.

5.41 At regular intervals, the CC poll the I/O unit controllers to search for service requests. When detected, the central controls generate appropriate peripheral unit instructions to read this data via the peripheral unit reply bus. This data can be obtained on bus 0, bus 1, or both.

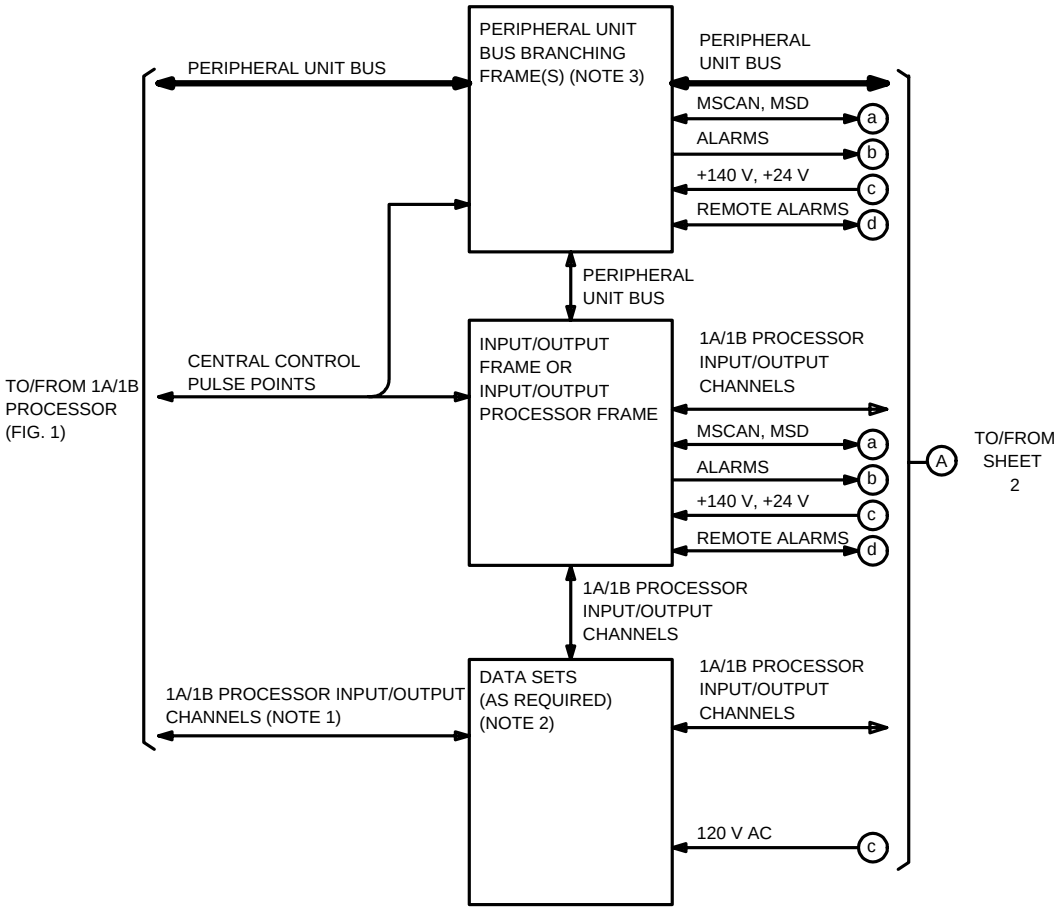
5.42 The input/output frame consists of two input/output unit selectors and their associated input/output unit controllers. In the event of a failure of any selector or controller, sufficient hardware redundancy is provided through the remaining selectors or controllers to permit data to be effectively input or output. The software-assigned input/output channels are appropriately configured to provide this flexibility. Power distribution within the frame is configured so that a complete frame failure is unlikely.

C. Input/Output Processor Frame J5A006C [Discontinued Availability (DA)]

5.43 As with the input/output frame, an IOP frame may be provided in the 4ESS Switch equipment area when the input/output ability of the 1B Processor is not sufficient to meet the requirements of a 4ESS Switch. The IOP is identical to the one which may be provided as part of the 1B Processor. The purpose of the input/output processor frame, like the input/output frame, is to provide an interface between the 1B Processor CC and 4ESS Switch work centers and external maintenance, monitoring, and evaluation facilities.

5.44 The fully equipped input/output processor frame consists of two identical input/output processors. Each input/output processor consists of a direct memory access controller and either one or two microprocessor communities. Each microprocessor community consists of a microprocessor and from one to eight line interface units. Functionally, a direct memory access controller and its associated microprocessors are the equivalent of an input/output unit selector. Each of the line interface units is the equivalent of an input/output unit controller. Thus, each of the two input/output processors equipped in the frame may support up to 16 input/output channels, double the capacity of the input/output frame. In addition, the data rate of each of these channels is under software control and can be changed as required to any one of the following: 110, 1200, 1800, 2400, 4800, or 9600 bits per second.

NOTE:
Changes in channel data rate may also require changes in line interface unit equipage.



NOTES:

1. INPUT/OUTPUT CHANNELS ARE ASSIGNED TO INPUT/OUTPUT FRAME OR INPUT/OUTPUT PROCESSOR FRAME IN THE 1A PROCESSOR WHICH REQUIRE DATA SETS.
2. THE EQUIPAGE OF DATA SETS IS OFFICE ENGINEERED.
3. A MAXIMUM OF FOUR ADDITIONAL PERIPHERAL UNIT BUS BRANCHING FRAMES MAY BE USED TO EXTEND THE LENGTH OF A BUS BRANCH OR TO INCREASE THE NUMBER OF BUS BRANCHES. THESE FRAMES ARE NOT INDIVIDUALLY SHOWN IN THIS FIGURE.

LEGEND:

MSCAN - MISCELLANEOUS SCAN POINNS

MSD - MISCELLANEOUS SIGNAL DISTRIBUTOR POINTS

Figure 6. 1B Processor Interface Equipment—Functional Block Diagram (Sheet 1 of 2)

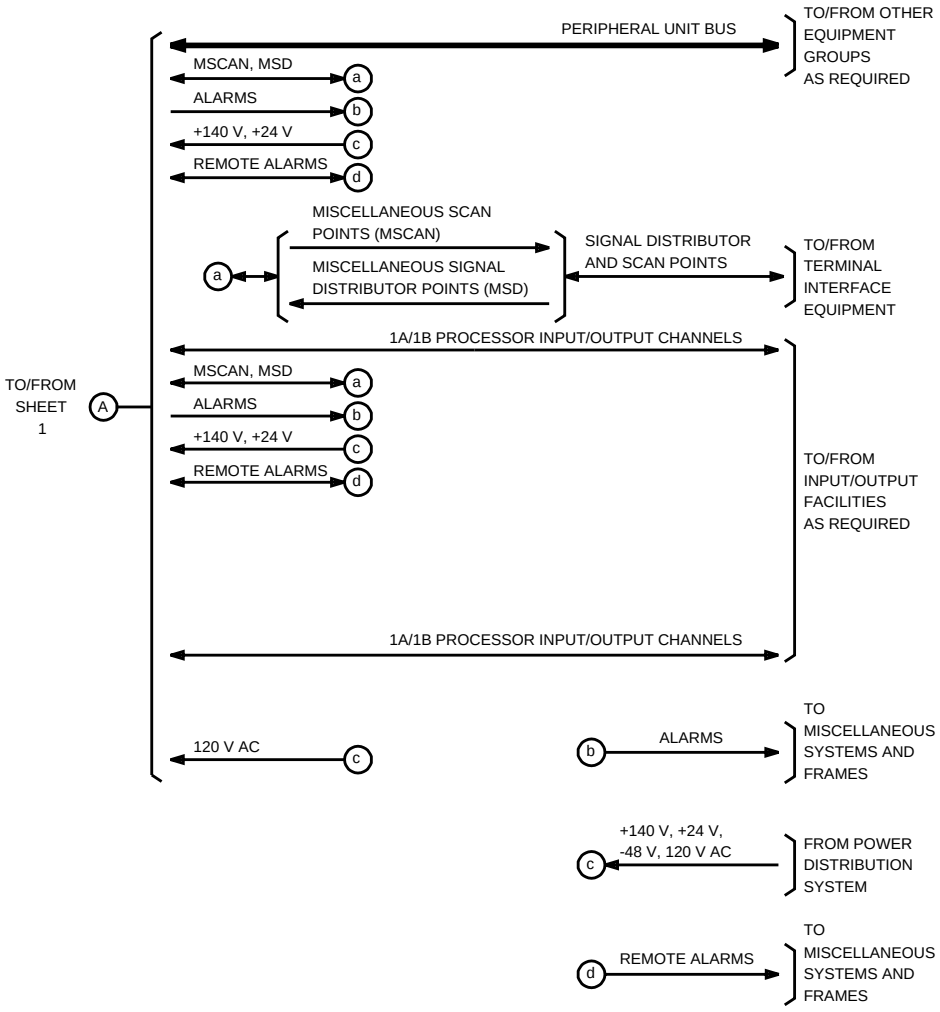


Figure 6. 1B Processor Interface Equipment—Functional Block Diagram (Sheet 2 of 2)

Each of the channels in a fully equipped frame (32 channels) may be operated at 1200 bits per second. A given channel in a community may be operated at a higher speed than 1200 bits per second; however, a corresponding decrease is required in the maximum number of channels such that the community total capacity does not exceed 19,200 bits per second. For example, a community may have a maximum of 8 channels operating at 2400 bits per second without decreasing the number of channels.

5.45 Overall function and interfaces of the input/output processor frame are similar to the input/output frame. The polling scheme and K-code identification of various input/output channels, briefly described for the input/output frame, applies to the input/output processor frame. However, within the input/output processor frame, the input/output data and control signal exchanges are processed by a stored program microprocessor rather than the hard-wired logic of the input/output unit selector and input/output controller in the input/output frame. This software-controlled microprocessor provides the input/output processor with a large degree of flexibility. The input/output processor can meet the changing data set and input/output terminal requirements through microprocessor software changes and line interface unit circuit pack substitutions. The input/output processor is able to interface with input/output terminals that are within 500 cable feet. Connections to data sets must be made if the distance exceeds 500 cable feet or when the terminal is not compatible with the EIA interface. When data sets are used at the 4ESS Switch end, the data sets must be within 50 cable feet of the input/output processor frame.

5.46 Input/output processor redundancy is provided through the duplicated microprocessor and line interface unit communities. Assignment of critical system input/output channels to separate input/output processors ensures person-machine access to the system in the event of failure of either unit. Power is applied to the frame from duplicate power buses to protect against power failure.

D. Input/Output Processor Frame J5A006D

5.47 This version of the IO processor frame may be provided in the 4ESS Switch equipment area (1B Processor interface equipment) when the IO ability of the 1B Processor is not sufficient to meet the requirements of a 4ESS Switch office. This equipment is identical to the IO processor frame which may be provided as part of the 1B Processor. The purpose of the IO processor frame (J5A006D), like the previously described IO frame and IO processor frame, is to provide an interface between the 1B Processor central control and 4ESS Switch work centers (including external centers and facilities). The IO processor frame may also provide an interface to other 1B processors (in AT&T switches). Data sets are used to provide IO interfaces with external maintenance, monitoring, and evaluation facilities, as required.

5.48 A fully equipped input/output processor frame consists of two input/output processors. Each input/output processor consists of an input/output processor logic unit (J5A006DB) and either a 1B input/output growth unit (J5A006CE) or a 3B Computer input/output processor growth unit (J1C130BB). The input/output processor logic unit, 1B growth unit, and 3B Computer growth unit are each able to provide eight input/output channels. When equipped with two 1B growth units, the frame is equivalent to the previously described input/output processor frame (J5A006C). The maximum equipage (32 channels), using the 1B growth units, is realized when average operating speeds per channel are not greater than 2400 bits per second. The input/output processor frame equipped with 3B Computer growth units differs in this regard. Each of the eight input/output channels provided by the 3B Computer growth unit may be operated at a maximum rate of 56,000 bits per second. This high maximum rate per channel is made possible in the 3B computer growth unit since each channel is driven by a dedicated peripheral controller (microprocessor). The maximum capacity of each peripheral controller is 56,000 bits per second.

5.49 The overall function and interfaces of the J5A006D input/output processor frame are similar to that described for the J5A006C frame. The additional high-speed, input/output abilities—provided by the J5A006D input/output processor—are described in 234-100-021, *Input/Output System Description*.

E. Data Sets

5.50 Data sets are used to extend the range of signaling between the input/output frames and input/output terminals. Data sets must be used on input/output channels any time the transmission path between the input/output frame and an input/output terminal exceeds 200 feet or 500 feet in the case of the input/output processor frame. When data sets are used, the data sets at the 4ESS Switch end must be within 50 cable feet of the input/output (processor) frame. When data sets are used for TN82 channels, the data sets may be up to 200 cable feet from the input/output (processor) frame.

5.51 The data sets accept data and control signals from the input/output frame in an EIA interface standard format. These signals are converted to modulated tones. These tones are transmitted over a 2-wire or 4-wire interface, depending on the type of channel and data set used, to another data set mounted on or near the input/output terminal. Here the tones are converted to EIA signals, and they are applied to the input/output terminal.

5.52 Data sets are also used in the input/output channel and telemetry links between remote and local offices participating in a centralized maintenance network. The number of data sets required to implement the input/output system and telemetry data interfaces of a centralized work center environment is held to a minimum by the use of multiplexers/demultiplexers. Groupings of up to eight 1200-baud channels are multiplexed into one 9600-baud data link. The assignment of channels to a given multiplexed data link is office engineered. However, different multiplexed data links must be assigned for a given channel and the corresponding backup channel. The type of equipment used to implement the concentration of data among the various offices and a centralized facility is also office engineered.

Terminal Equipment

5.53 As illustrated in Figures 1 and 7 and briefly discussed in Part 3, the terminal equipment is comprised of metallic terminal frames, auxiliary metallic trunk circuits, and various types of unitized terminal equipment frames. This equipment provides the interface between the analog carrier and metallic facilities in the toll network and 4ESS Switch. The following paragraphs describe the terminal equipment. Although not considered part of the terminal equipment, an interface with an intermediate distributing frame, shown in Figure 1, is also discussed.

A. Metallic Terminal Frame [Discontinued Availability (DA)

5.54 The metallic terminal frame (MTF) contains analog circuits that provide a transmission interface with 2-wire and 4-wire metallic facilities. Each MTF provides facilities for accepting a maximum of 72 metallic terminal plug-in units, each capable of accommodating one metallic trunk. These plug-in units may be any of several different types to provide compatibility with a specific type of metallic circuit. These plug-in units provide signal conversion, equalization, hybrids, trunk maintenance access, and amplification or pads as required for each trunk. Trunks equipped for dial-pulse signaling or multifrequency signaling can be accommodated. The metallic terminal frame also accommodates remote office test-line frame interfaces with class 5 offices.

5.55 Figure 7 illustrates the MTF interfaces within and external to the 4ESS Switch. The primary interfaces are with the VF metallic facility, the voiceband interface, and with the signal processor 1 through universal scan and signal distributor points. The MTFs accept 2-wire and 4-wire VF transmission and signaling lines which connect to the metallic facility. The metallic terminal units provide a 4-wire VF line output with looped

E&M signaling for all metallic trunks. The 4-wire VF lines are connected to the voiceband interface. The E&M signaling leads are connected to the signal processor via universal signal distributor and scan points. This signal distributor (M-lead) and scan point (E-lead) interface enables the signal processor to receive and transmit the following signals:

a. Supervisory signals for multifrequency signaling trunks

b. Supervisory and dial-pulse signals for dial-pulse signaling trunks.

5.56 The E-leads convey incoming trunk signals to the signal processor 1 via universal scan points. The M-leads convey outgoing signaling information from the signal processor 1 to metallic circuits. The signaling is accomplished by closing or opening the looped scan or signal distributor points as an indication of off-hook or on-hook status. Metallic terminal plug-in units can also be used to accommodate trunks employing common channel signaling signaling. In these instances, the E&M signaling leads are not used.

LEGEND:

CCITT	INTERNATIONAL TELEGRAPH AND TELEPHONE CONSULTIVE COMMITTEE
VF	VOICE FREQUENCY
MSCAN	MISCELLANEOUS SCAN POINTS
MSD	MISCELLANEOUS SIGNAL DISTRIBUTOR POINTS
PCM	PULSE CODE MODULATED
USCAN	UNIVERSAL SCAN POINTS
USD	UNIVERSAL SIGNAL DISTRIBUTOR POINTS

NOTES:
1. INTERFACE IS FOR REMOTE CENTRALIZED AUTOMATIC MESSAGE ACCOUNTING (CAMA) OPERATOR POSITION AND IS VIA ANALOG FACILITY.
2. INTERNATIONAL GATEWAY OFFICES, ONLY

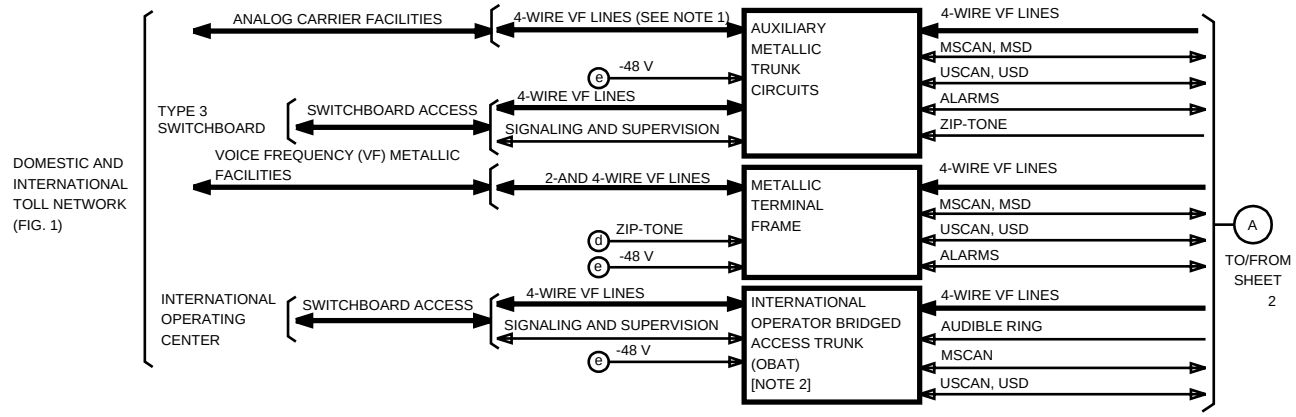


Figure 7. Terminal Equipment—Functional Block Diagram (Sheet 1 of 2)

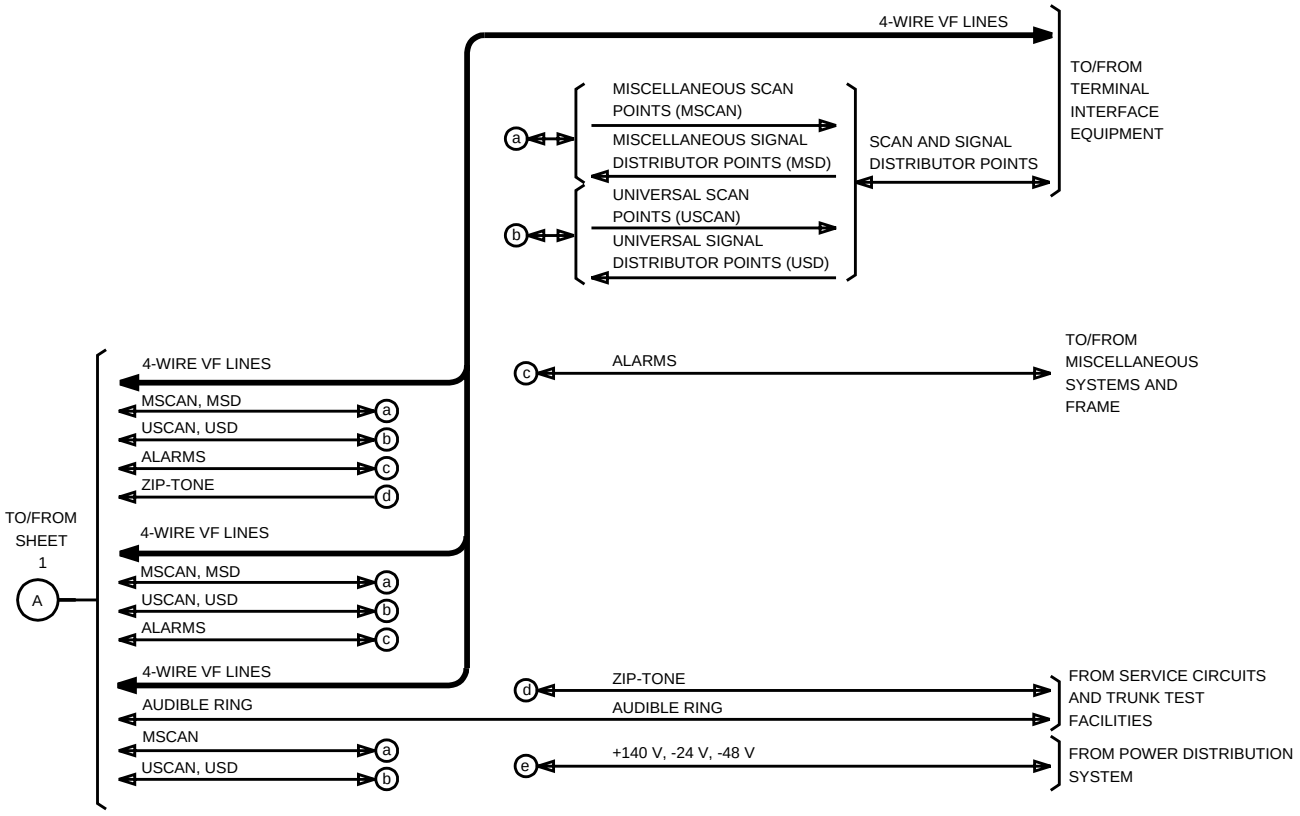


Figure 7. Terminal Equipment—Functional Block Diagram (Sheet 2 of 2)

5.57 The MTFs also interface with the 820A ringing, tone, and interrupter plant. This interface provides the MTF with a zip-tone signal. The zip-tone provides an audible signal which is applied to CAMA and TSPS operator positions. Application of the zip-tone and ring-forward signals—generated by certain type metallic terminal units—is controlled by a miscellaneous signal distributor and scan point interface with the signal processor 1.

5.58 The MTFs provide a means of manually accessing each trunk for maintenance purposes at the frame through a manual cord-reel access panel.

5.59 Also shown in Figure 7 are the power input requirements for the MTF. Each frame requires –48 V from the power distribution system. The 4ESS Switch power distribution is discussed later in this part.

B. Auxiliary Metallic Trunk Circuits

5.60 The auxiliary metallic trunk circuit interfaces, as illustrated in Figure 7, are similar to those provided for the metallic terminal frames. The functions of these auxiliary trunk circuits are also similar to those described for the metallic terminal frames previously discussed. However, these auxiliary circuits provide an interface for the following:

a. A type-3 switchboard located in the vicinity of and connected to the 4ESS Switch via metallic facilities. The metallic facilities connecting to this switchboard may be alternately used as follows:

   1. An emergency operator-access circuit.
   2. An incoming operator-office trunk from a community dial office.
   3. An outgoing trunk from the 4ESS Switch.

b. A remote CAMA operator position interconnected via an analog carrier facility.

5.61 Auxiliary circuits are required to accomplish the interface because of the physical size of the metallic terminal units. The auxiliary metallic terminal unit interfaces listed in (a) and (b) are not compatible with the metallic terminal frame.

5.62 The auxiliary metallic trunk circuits do not provide manual maintenance access to trunks. Maintenance access must be provided from a distributing frame external to the 4ESS Switch equipment. However, maintenance access cannot be provided to E&M signaling leads.

5.63 Also shown in Figure 7 are the power-input requirements for the auxiliary metallic trunk circuits. Like the MTF previously discussed, these circuits require –48 V from the power distribution system. The 4ESS Switch power distribution is discussed later in this part.

Terminal Interface Equipment

5.64 As illustrated in Figures 1 and 8 and briefly discussed in Part 3, the terminal interface equipment is comprised of the following:

- Digroup terminal
- Signal processor 1
- Signal processor 2
- Digital interface frame
- D4 channel banks
- CCIS terminal group

5.65 The preceding equipment performs three major functions.

1. The first function is to provide a message traffic interface with the digital switching network. This function is performed by the voiceband interface and D4 channel banks for analog signals and the digroup terminal for digital signals.
2. The second function is to provide a trunk control and signaling interface with the 1B Processor. This is performed by the SP1, SP2, and the digital interface.
3. The third function of the terminal interface equipment is digital echo suppression. This is performed by the EST. The function performed by specific terminal interface equipment is described in the following paragraphs.

A. Digroup Terminal [Discontinued Availability (DA)]

5.66 The digroup terminal (DT) frame is illustrated in Figure 8 as a single block. In actual practice, the digroup terminal block represents as many digroup terminal frames as are required to accommodate the digital trunks interfacing with a 4ESS Switch office. The digroup terminal may be either the initial configuration or the cost-reduced version, discussed in Part 3.

5.67 The digroup terminal accepts digital signals, destined for the switching network, from digital carrier equipment outside the 4ESS Switch office and the D4 channel bank inside the 4ESS Switch office. The digroup terminal can interface with D1, D2, D3, and D4 carrier equipment. The digroup terminal is not compatible with D1 carrier equipment. In Figure 8, the digital carrier interface is designated PCM data (DS1 format). Message and signaling traffic carried on these lines is in a DS1 PCM format. This format, however, is not

compatible with the 4ESS Switch switching network. The digroup terminal converts the DS1 format PCM data to the 4ESS Switch DS120 format. This data is then applied to the echo suppressor terminal and/or the time slot interchange. In the reverse direction, the digroup terminal accepts DS120 digital information from these frames and converts it to the DS1 format for application to the digital carrier equipment.

5.68 A fully equipped digroup terminal frame can accommodate 960 digital trunks. These 960 trunks are processed by 8 separate digroup terminal units which accept 120 trunks each. At the digital carrier equipment side of the digroup terminal units, these 120 trunks are carried on 5 cable pairs. Each cable pair is associated with one D-channel bank. Separate cable pairs are used to carry trunk data in each direction between the digroup terminal unit and the digital carrier equipment. Data carried on these cable pairs is in the DS1 format. In this format, data for 24 trunks is encoded into 24 time slots in one 125-µs data frame as opposed to 128 time slots in the DS120 format. Each digroup terminal unit converts the data on five DS1 format input cable pairs from serial format to a 120-trunk data parallel format. This data is then converted to the serial DS120 format. This data is identical to the VIF output and is applied to the echo suppressor terminal or time slot interchange on a unidirectional DS120 formatted output coaxial cable. In the reverse direction, DS120 formatted PCM data is applied to the digroup terminal units on input coaxial cables from the echo suppressor terminal or time slot interchange. This data is appropriately reformatted by each digroup terminal unit and is applied to the five DS1 format output cables for transfer to the digital carrier equipment. Any specific time slot on a digroup terminal DS120 input and output cable is directly related to a digital trunk.

5.69 In the previously discussed aspects of the digroup terminal, the digroup terminal is similar to the voiceband interface in that it converts trunk inputs to a format compatible with the 4ESS Switch switching network. However, digroup terminal functions are complicated by the fact that signaling detection and insertion must also be performed at the digroup terminal. On trunks equipped for dial-pulse signaling, the digroup terminal:

- Senses supervisory signals and incoming digits for incoming calls
- Generates supervisory signals and digit pulses for outgoing calls.

5.70 This is accomplished by sensing or inserting digital information into the DS1 format signal at the appropriate time. On trunks equipped for multifrequency signaling, the digroup terminal senses supervisory signals for incoming calls and generates supervisory signals for outgoing calls.

5.71 This signaling information is applied to or received from the signal processor 2 which is controlled by the 1B Processor. The interface between the digroup terminal and the signal processor 2 is accomplished via a two-way digital data link between these units. This data link serves the same function as the universal signal distributor and scan point/E&M lead interfaces between the terminal equipment and the signal processor 1. The digital data link is also used to transfer alarm indications from the digroup terminal to the signal processor 2. For example, circuits within the digroup terminal monitor the DS1 PCM lines applied from the digital carrier equipment. Indications of failures are forwarded to the signal processor 2 for application to the 1B Processor. The 1B Processor, in turn, causes appropriate diagnostic messages to be output on designated work center input/output terminals. Other T1 carrier degradations such as bipolar variations, out of frame, and slip are similarly detected and notification is sent to an appropriate work center(s).

5.72 Each digroup terminal frame receives timing signals from its interfacing time slot interchange frame (or echo suppressor terminal where applicable). These timing signals are used in the generation of PCM data and are used to synchronize the transfer of PCM data between these units.

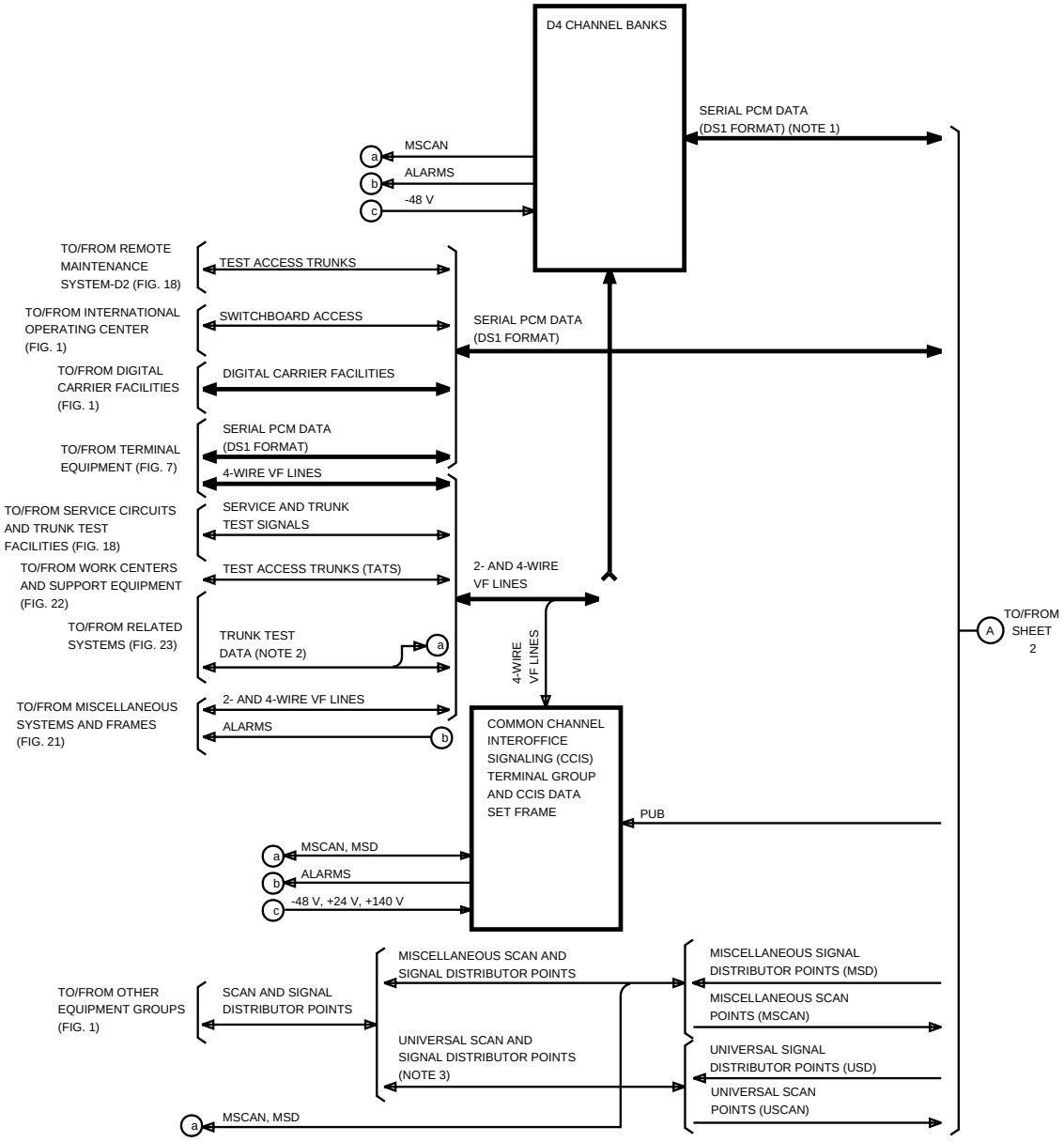


Figure 8. Terminal Interface Equipment—Functional Block Diagram (Sheet 1 of 3)

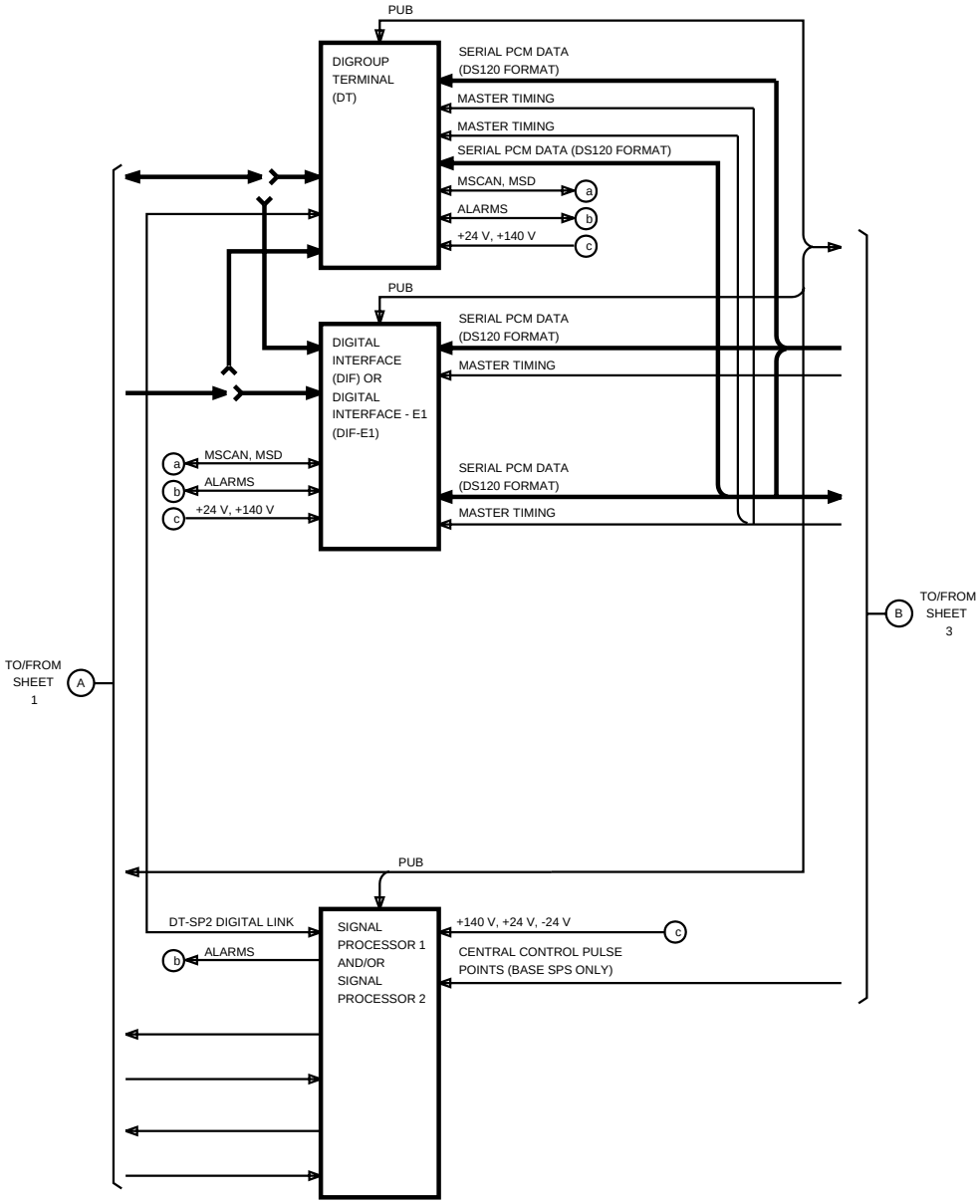
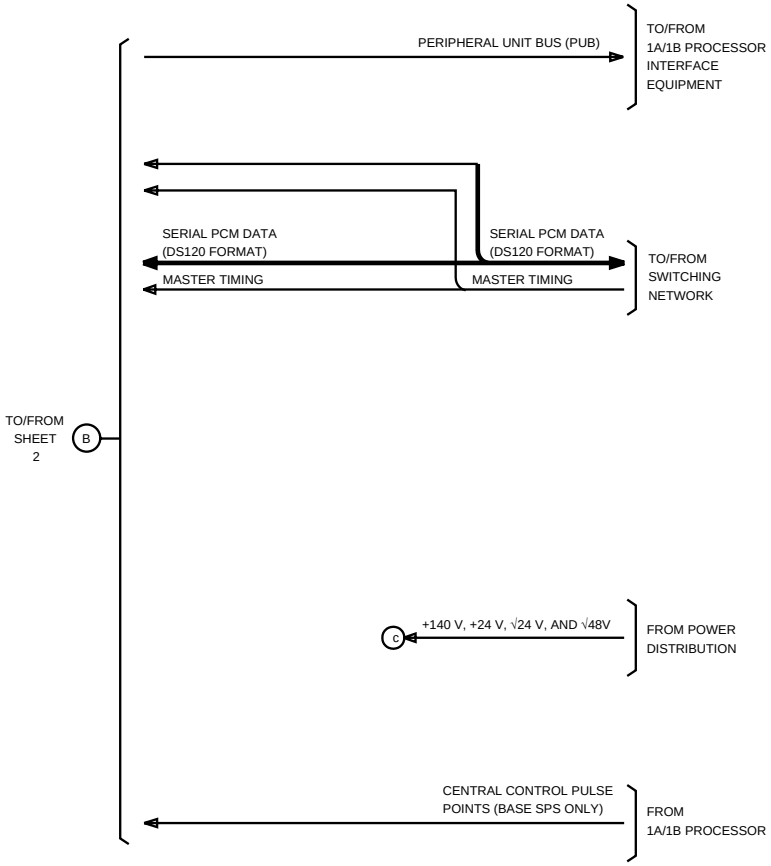


Figure 8. Terminal Interface Equipment—Functional Block Diagram (Sheet 2 of 3)



NOTES:

1. INTERFACE BETWEEN THE D4 CHANNEL BANKS AND EITHER DIGROUP TERMINAL OR DIGITAL INTERFACE IS VIA A DIGITAL CROSS-CONNECT FRAME (DSX).
2. INTERNATIONAL GATEWAY OFFICES, ONLY.
3. IN ALL DIGITAL OFFICES WHERE VIFS ARE ELIMINATED VIA LT1/2 OR D4 CHANNEL BANKS, UNIVERSAL SCAN AND SIGNAL DISTRIBUTOR POINTS ARE NOT APPLICABLE.

LEGEND:

MSCAN - MISCELLANEOUS SCAN POINT
MSD - MISCELLANEOUS SIGNAL DISTRIBUTOR POINT
PCM - PULSE CODE MODULATED
PUB - PERIPHERAL UNIT BUS
TAT - TEST ACCESS TRUNK
USCAN - UNIVERSAL SCAN POINT
USD - UNIVERSAL SIGNAL DISTRIBUTOR POINT
VF - VOICE FREQUENCY

Figure 8. Terminal Interface Equipment—Functional Block Diagram (Sheet 3 of 3)

5.73 Redundancy in the digroup terminal frames is provided by a spare digroup terminal unit. Outputs and various categories of operation of each digroup terminal unit are continuously monitored. Detection of a fault condition in any on-line digroup terminal unit causes the spare digroup terminal unit to be switched on-line to assume its function. Data identifying this trouble condition is applied to the signal processor 2 via the digital data link previously discussed. The signal processor 2 alerts the 1B Processor to the alarm condition. The digroup terminal units, in each digroup terminal frame, operate under the control of a digroup terminal controller. In each digroup terminal frame, the digroup terminal controllers are duplicated. Each controller is provided with access to the two-way digital data link with the signal processor 2. In the event of a malfunction of the active controller, the standby controller is switched on-line to assume its function. Appropriate alarm indications are applied to the signal processor 2. These features provide each digroup terminal frame with a large measure of redundancy.

5.74 Also shown in Figure 8 are the power input requirements for the digroup terminal frame. Each frame requires +140 V and +24 V from the power distribution system. The 4ESS Switch power distribution is discussed later in this part.

B. Signal Processor 1 [Discontinued Availability (DA)]

5.75 The signal processor 1 (SP1) is illustrated in Figure 8 in combination with the signal processor 2 (SP2) as a single block. This is done because of the similarity of functions of these two units. Note that SP1s are not provided in 4ESS Switch offices which service digital trunks exclusively. As discussed in Part 3, an SP1 is comprised of a number of different frames. In actual practice, there are as many SP1s (maximum of 32 SP1s, SP2s, pseudo-signal processors, and digital interface frames combined) as required by a particular 4ESS Switch office; see note. The SP1 may be either the initial configuration or an SP1 with a combined matrix frame, described in Part 3.

NOTE:
Pseudo-signal processors are groups of universal points that exist in software (memory) to support non-E&M facilities.

5.76 The SP1s interface with most 4ESS Switch equipment through universal and/or miscellaneous signal distributor and scan points. Scan points are simply a monitoring facility through which the SP1 accepts various inputs from 4ESS Switch equipment. These scan points consist of individual inputs which monitor various conditions indicated by a relay contact opening or closing, a set or reset flip-flop, switch position, fuse alarm, and others. Through hardware assignment, the status of each scan point is associated with a known function. The SP1 continuously monitors or scans all the scan point signals to detect any changes in state. This scan point data is assembled into data words and is held for transfer to the 1B Processor. The SP1 cannot initiate any data transfers to the 1B Processor. Control software causes the 1B Processor to read scan point data words at regular intervals. The 1B Processor compares these data words with those previously obtained to detect any changes in scan point status. The 1B Processor initiates software-controlled actions, depending on scan point status changes.

5.77 Signal distributor points are a control facility through which the signal processor can apply control signals to various 4ESS Switch equipment. Signal distributor points consist of individual relay outputs which are applied to 4ESS Switch equipment to initiate or control specific functions. These control signals can be either a level change type of signal generated by a relay contact closing or opening; or they can be control pulses used to control logic circuits. The signal distributor points are generated according to data received from the 1B Processor. Control data words are decoded and applied to appropriate circuits that generate relay signal distributor points or pulse signal distributor points.

5.78 The prime SP1 function is to provide the 1B Processor with access to trunk signaling circuits. This is accomplished for the most part through the use of universal signal distributor and scan points. Universal signal distributor and scan points are employed for supervisory and dial-pulse signaling for analog and metallic trunks. Miscellaneous signal distributor and scan points are employed for multifrequency signaling. In addition to certain signaling functions previously described, miscellaneous signal distributor and scan points enable the SP1 to perform various maintenance, control, and monitoring functions throughout the 4ESS Switch office. The time-consuming, repetitive activities associated with miscellaneous and signaling functions are performed autonomously by the SP1. They are, however, under a degree of 1B Processor control. Assigning the time-consuming aspect of these functions to the SP1 frees the 1B Processor to perform more complex system functions.

5.79 With 4080 universal scan points and 4080 universal signal distributor points, each fully equipped SP1 is capable of interfacing with signaling units for 4080 analog and metallic trunks. In addition, each SP1 can service additional signaling, maintenance, control, and monitoring circuits through 2048 miscellaneous scan points and 2048 miscellaneous signal distributor points. In each SP1, a number of miscellaneous signal distributor and scan points are reserved to accommodate a total of 32 multifrequency receivers and multifrequency transmitters.

5.80 The various matrices and associated circuits in the SP1 which monitor the scan points and are involved in generation of signal distributor points are controlled by an internal SP1 controller. This controller is duplicated to provide a measure of redundancy for SP1 operations. The circuits directly involved with scan point monitoring and signal distributor generation are not duplicated. However, critical 4ESS Switch system functions which require signal distributor pulse point interfaces are provided with these connections from two independent SP1s. Scan points and relay applied signal distributor points could be duplicated in the same manner.

5.81 The number of signal distributor points, provided in each of the SP1s, makes it appear unlikely that the 1B Processor could generate and analyze the numerous data words associated with signal distributor control and scan point monitoring. However, control software and the extremely short operating cycle of the 1B Processor (700 ns) make this possible and, in addition, enable the 1B Processor to control the other terminal interface and the switching network equipment.

5.82 The SP1 interfaces with the 1B Processor via the peripheral unit bus. The SP1 is connected to all four parts of the bus. In addition, two SP1s designated as base SPs are accessed directly by the 1B Processor central control via pulse points. The base SPs may be either two SP1s, an SP1 and SP2, or two SP2s. These central control pulse points provide a means for the 1B Processor to communicate with the base SPs for maintenance purposes when normal peripheral unit bus communication proves unreliable. Maintenance access to other SP1s and SP2s is provided through miscellaneous signal distributor points from both base SPs. These signal distributor points are controlled by normal peripheral unit bus communication between the 1B Processor and the base SPs. The base SPs are different from other SPs by providing the miscellaneous signal distributor and scan point connections associated with power control switches for all 4ESS Switch equipment outside the 1B Processor. Signal distributor and scan point access of the base SPs is provided through connection between the two base SPs.

5.83 Also shown in Figure 8 are the power input requirements for the signal processor 1. Each signal processor 1 requires +140 V, +24 V, and –24 V. The 4ESS Switch power distribution is discussed later in this part.

C. Signal Processor 2 [Discontinued Availability (DA)]

5.84 The system functions of the signal processor 2 (SP2) are similar to the SP1 previously discussed. However, the SP2 provides these functions for digital carrier trunks only. The SP2 presents supervisory and dial-pulse signaling for these trunks to the 1B Processor in a format identical to the SP1. This enables the same 1B Processor call-processing programs to accommodate signaling from trunks employing digital or analog facilities.

5.85 The SP2 does not use universal signal distributor and scan points for its signaling interface with digital trunks. This signaling interface is accomplished by a high-speed, two-way digital data link between the digroup terminal and the SP2. Trunk signaling and status data applied to the SP2 via the data link is stored in SP2 controller memories. The SP2 controller reformats the signaling data into data words that are held for access by the 1B Processor. Data words applied to the SP2 by the 1B Processor are decoded in the controller and are applied to the digroup terminal as trunk signaling control data via the data link. This data link is also used to exchange data relating to maintenance, control, and monitoring functions.

5.86 In Figure 8, the SP2 is shown as a single block in combination with the SP1. In actual practice, the SP2 block represents as many SP2s (maximum 32 SP1s, SP2s, pseudo-signal processors, and digital interface frames combined) as are required by a 4ESS Switch office. Each SP2 can accommodate signaling circuits for 3840 trunks. This is equivalent to four digroup terminals. Each SP2 also processes the maintenance, control, and monitoring data for these four digroup terminals. In addition, each SP2 can process the maintenance, control, and monitoring (only) data for 12 additional digroup terminals. However, these 12 digroup terminals must be assigned to trunks exclusively equipped for common channel signaling. This total capacity of the SP2 to support 16 digroup terminals is restricted in order to meet the reliability objectives of the 4ESS Switch. Since the largest cluster of trunks on which peripherals are engineered is 10,700 circuits, no more than 11 digroup terminals can be assigned to an SP2. Small office installations may choose to further restrict the number of digroup terminals connected to an SP2 to nine digroup terminals.

5.87 In 4ESS Switch offices which interface entirely with digital carrier trunks, no SP1s are provided. In these instances, an appropriate number of SP2s are equipped with supplementary matrix frames. These supplementary frames provide the 1024 miscellaneous signal distributor and 1024 scan points required to provide the maintenance, control, monitoring, and signaling functions normally provided by the SP1.

5.88 As previously discussed, the digroup terminal data link is connected to the SP2 controller. This controller is duplicated, and both controllers have access to the digroup terminal data link. This provides complete redundancy for the SP2. In the event the active (on-line) controller malfunctions, the standby controller is switched on-line to assume normal functions. The 1B Processor:

- Detects this change by analysis of data words received from SP2.
- Notifies the office alarm system via an SP1 miscellaneous signal distributor point.
- Causes an appropriate message to be output on an input/output terminal(s) at a designated work center.

5.89 Circuits in the supplementary matrix frame, when provided, are not duplicated. However, as in the SP1, critical 4ESS Switch system functions that require signal distributor or scan point connections are provided with these signals from two independent supplementary matrix frames. In addition, all signal distributor points that consist of control pulses are duplicated.

5.90 The SP2 controllers are both accessed by the 1B Processor via the peripheral unit bus. The SP2 is connected to all four parts of this bus.

In addition, when an SP2 is designated as a base SP, it is also accessed directly by the 1B Processor central controls by pulse points. When an SP2 is designated as a base SP, the base SP functions, previously described, also apply to the SP2.

5.91 Also shown in Figure 8 are the power input requirements for the signal processor 2. Each signal processor 2 requires +140 V, +24 V, and –24 V. The 4ESS Switch power distribution is discussed later in this part.

D. Digital Interface Frame [Discontinued Availability (DA)]

5.92 The digital interface frame (DIF) is illustrated in Figure 8 as a single functional block. In actual practice, this DIF block represents as many DIFs as required by a particular 4ESS Switch office for interfacing with digital (T1) circuits. Since the DIF has the same peripheral unit identification as the signal processor 1 (SP1) and signal processor 2 (SP2), the total number of SP1s, pseudo-signal processors, SP2s, and digital interface frames cannot exceed 32. See Note. In addition, the digital interface cannot presently be used as a base signal processor—assigned member numbers 0 or 1.

NOTE:
Pseudo-signal processors are groups of universal points which exist only in software (memory) for the support of non-E&M facilities.

5.93 Each fully equipped DIF is capable of terminating 3840 digital circuits (32 by 120). This is equivalent, in function, to a digroup terminal/signal processor 2 complex, four DTs and SP2, excluding the miscellaneous scan and signal distributor point function provided by the supplementary matrix frame. Each fully equipped DIF contains a duplicated digital interface controller and peripheral unit bus interface along with 34 digital interface units. Two of these units are spares, 1 switchable spare per each 16 digital interface units. Each digital interface unit serves 5 digroups (T1 lines) which equates to 120 trunks (circuits).

5.94 The DIF converts digital signals in pulse code modulated DS1 format received from the LT-1 connector, LT-2 transmultiplexer, D1D, D2, D3, and D4 carrier equipment to the 4ESS Switch switching network DS120 format. This data is then applied to either the echo suppressor terminal or the time slot interchange (J4A001B).

5.95 In the reverse direction, the DIF accepts DS120 digital information from the switching network and converts it to the DS1 format for application to the appropriate digital carrier equipment. Connections to the digital carrier equipment, which is outside the 4ESS Switch maintenance boundary, as well as the D4 channel bank equipment, used for miscellaneous trunks and service circuits, are via a digital signal cross-connect (DSX) frame.

5.96 Each DIF receives timing signals from the interfacing time slot interchange or echo suppressor terminal. These master timing links are used in the generation of the pulse code modulated data and to synchronize the transfer of data between the DIF and the switching network. As previously stated, the DIF must connect to the time slot interchange (J4A001B) in the switching network. This requirement is imposed by the structure of the maintenance software.

5.97 Also shown in Figure 8 are the power input requirements for the DIF. Each DIF requires +140 V and +24 V from the power distribution system. The 4ESS Switch power distribution is discussed later in this part.

E. Digital Interface Frame-E1

5.98 The digital interface frame-E1 (DIF-E1) is illustrated in Figure 8 as a single functional block. In actual practice, this DIF-E1 block represents as many DIF-E1s as are required by a particular 4ESS Switch office for interfacing with digital (T1) circuits. Since the DIF-E1 has the same peripheral unit identification as the signal processor 1 (SP1) and signal processor 2 (SP2), the total number of SP1s, pseudo-signal processors, SP2s, and digital interface frames cannot exceed 32. A DIF-E1 providing the multifrequency signaling or

dual tone multifrequency signaling function can only be assigned member numbers in the range from 2 through 23 (See Note). In addition, the digital interface cannot be used as a base signal processor (assigned member numbers 0 and 1).

NOTE:
Pseudo-signal processors are groups of universal points which exist only in software (memory) for the support of non-E&M facilities.

5.99 Each fully equipped DIF-E1 is capable of terminating 3840 non-CCITT 5 trunks or 1920 CCITT 5 trunks. Each fully equipped DIF-E1 contains a duplicated digital interface controller and peripheral unit bus interface along with 34 digital interface units. Two of these units are spares—1 switchable spare per each 16 digital interface units. Each digital interface unit serves 5 digroups (T1 lines) which equates to 120 trunks (circuits). Thus, each fully equipped frame can support 3840 non-CCITT 5 circuits (32 by 120).

5.100 The DIF-E1 converts digital signals in pulse code modulated DS1 format received from other digital switches, D1D, D2, D3, and D4 carrier equipment to the 4ESS Switch switching network DS120 format. This data is then applied to either the echo suppressor terminal or the time slot interchange (J4A001B).

5.101 In the reverse direction, the DIF-E1 accepts DS120 digital information from the switching network and converts it to the DS1 format for application to the appropriate digital carrier equipment. Connections to the digital carrier equipment (which is outside the 4ESS Switch maintenance boundary) as well as the D4 channel bank equipment (used for miscellaneous trunks and service circuits) are via a digital signal cross-connect (DSX) frame.

5.102 Each DIF-E1 receives timing signals from the interfacing time slot interchange (or echo suppressor terminal). These master timing links are used in the generation of the pulse code modulated data and to synchronize the transfer of data between the DIF-E1 and the switching network. As previously stated, the DIF-E1 must connect to the time slot interchange (J4A001B) in the switching network. This requirement is imposed by the structure of the maintenance software.

5.103 Also shown in Figure 8 are the power input requirements for the DIF-E1. Each DIF-E1 requires +140 V and +24 V from the power distribution system. The 4ESS Switch power distribution is discussed later in this part.

5.104 With 4E9 generic program, the DIF-E1 can be equipped with four multifrequency (MF) digital interface service units (DISUs) that provide a total of 64 MF service circuit trunk appearances directly to the switching network. This feature may be used to replace the analog MF transmitters and receivers, signal processor matrix, and associated analog-MF to digital-MF conversion. The E&M and per-channel inhibit signaling (PCIS) bits, normally used in the DIF-E1 with E&M and common channel signaling trunks, are used to control the digital MF transmitters and receivers. The MF DISUs are also designed to generate the 480-Hz operator tone source required for use on operator trunks.

5.105 With the 4E10 generic program, the DIF-E1 can be equipped to support dual-tone multifrequency (DTMF) (touch-tone) signaling and special services signaling features. The DTMF signaling ability is required to enable the 4ESS Switch to transmit and receive touch-tone addressing from Private Branch Exchanges (PBXs) on 4-wire E&M analog and direct T1 digital trunks. A DIF-E1 complex can be equipped with either the four MF DISUs described in the previous paragraph, or with four DTMF DISUs. As with the MF DISUs, a DIF-E1 complex equipped with four DTMF DISUs provide 64 DTMF service circuit trunk appearances to the switching network. The DTMF DISU abilities include two-way wink-start addressing, generation of dial tone on nonwink-start trunks, and the reception of the full set of 16 DTMF digits. The special services interface digital interface unit (DIU) requires five circuit packs in place of regular DS-1 DIUs. A special services interface is similar to a regular DS-1 interface in its function, except that it can perform special handling

of line signaling information for each of the PCM channels it interfaces. The incoming and outgoing signaling bits (Ma, Mb, Ea and Eb) are manipulated on a per-channel basis to provide four states of line signaling information.

5.106 With the 4E11 generic program, the DIF-E1 can interface T1 lines with 64 clear channel capability (64CCC) in both the superframe and expanded superframe formats. The per call control (PCC) feature, available with the 4E14 generic program, allows for enabling/disabling echo cancelers and A/μ-law converters on a per call basis.

F. D4 Channel Bank

5.107 The D4 channel bank is illustrated in Figure 8 as a single functional block. In actual practice, this block represents as many D4 channel banks as are required by a particular 4ESS Switch office for interfacing analog service circuits, certain metallic trunks, and N-Carrier facilities with either digroup terminals or the digital interface frame.

5.108 Each D4 channel bank in the 4ESS Switch application is operated in Mode 3. In this mode of operation, each D4 channel bank provides two separate digroups for connection as two separate DS1 bit streams with either the digital interface or digroup terminal. For reasons of reliability, no more than 24 multifrequency transmitters, 24 multifrequency receivers, or 12 continuity check transceivers (plug- ins) may be assigned to a given D4 channel bank. As noted in Figure 8, the interface between either the digroup terminal or the digital interface and the D4 channel banks is via the digital signal cross-connect (DSX) frame. In addition, the connection of certain miscellaneous trunk test and support equipment to the D4 channel banks is via terminal strips in the multifrequency signaling frame.

5.109 Also shown in Figure 8 are the power input requirements for the D4 channel banks. Each D4 channel bank requires -48 V from the power distribution system. The 4ESS Switch power distribution is discussed later in this part. The alarm and miscellaneous scan point connections are for reporting hardware (fuse) failures to the office alarm system and software, respectively.

G. CCIS Terminal Group

5.110 The CCIS system is used for exchanging information between switching systems over a network of signaling links. The CCIS terminal group provides a signaling facility in which all signaling information associated with a designated group of trunks is exchanged between offices via a common signaling link. Signaling information is exchanged between CCIS terminal groups located at both ends of a signaling link. The CCIS ability is limited in use to processor-equipped switching offices.

5.111 In addition to the CCIS terminal group, the 4ESS Switch CCIS equipment involves the use of CCIS continuity check transceivers (discussed elsewhere in Part 5). In Figure 8, the CCIS terminal group is illustrated as a single block. In actual practice, the CCIS terminal group represents as many CCIS terminal group frames as are required by a particular 4ESS Switch office. However, the maximum number of CCIS terminal group frames cannot exceed 16. A fully equipped terminal group frame with associated supplementary frames contains a duplicated terminal access controller and a maximum of 16 CCIS terminal units and associated modulator-demodulator units. Each terminal unit and associated modulator demodulator provides one signaling path. Therefore, 16 fully-equipped terminal group frames provide a maximum of 256 CCIS signaling paths. The CCIS terminal units and associated signaling links are assigned in pairs (See Figure 90).

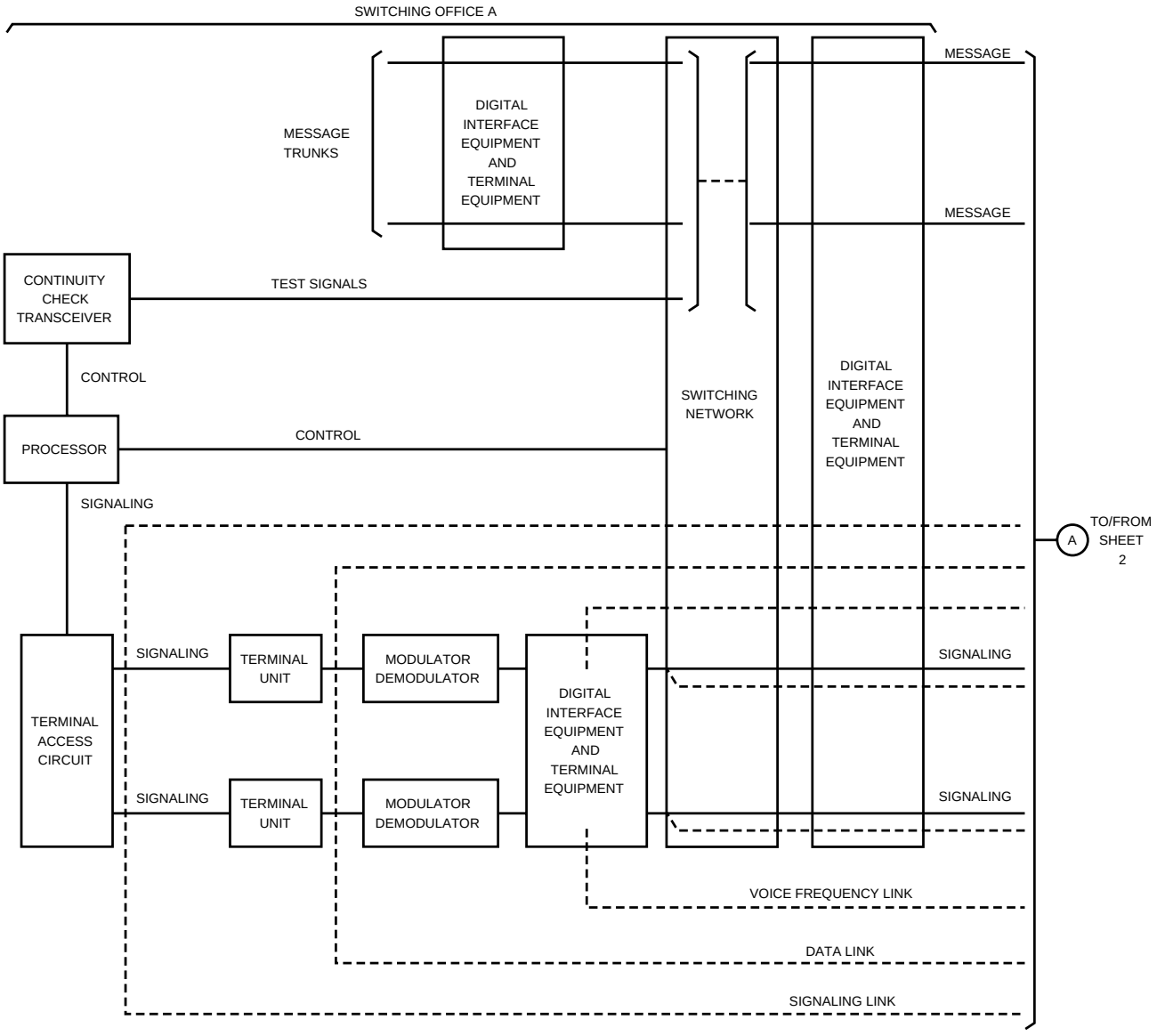


Figure 9. Common Channel Signaling (CCS) System—Typical Interoffice Connections (Sheet 1 of 2)

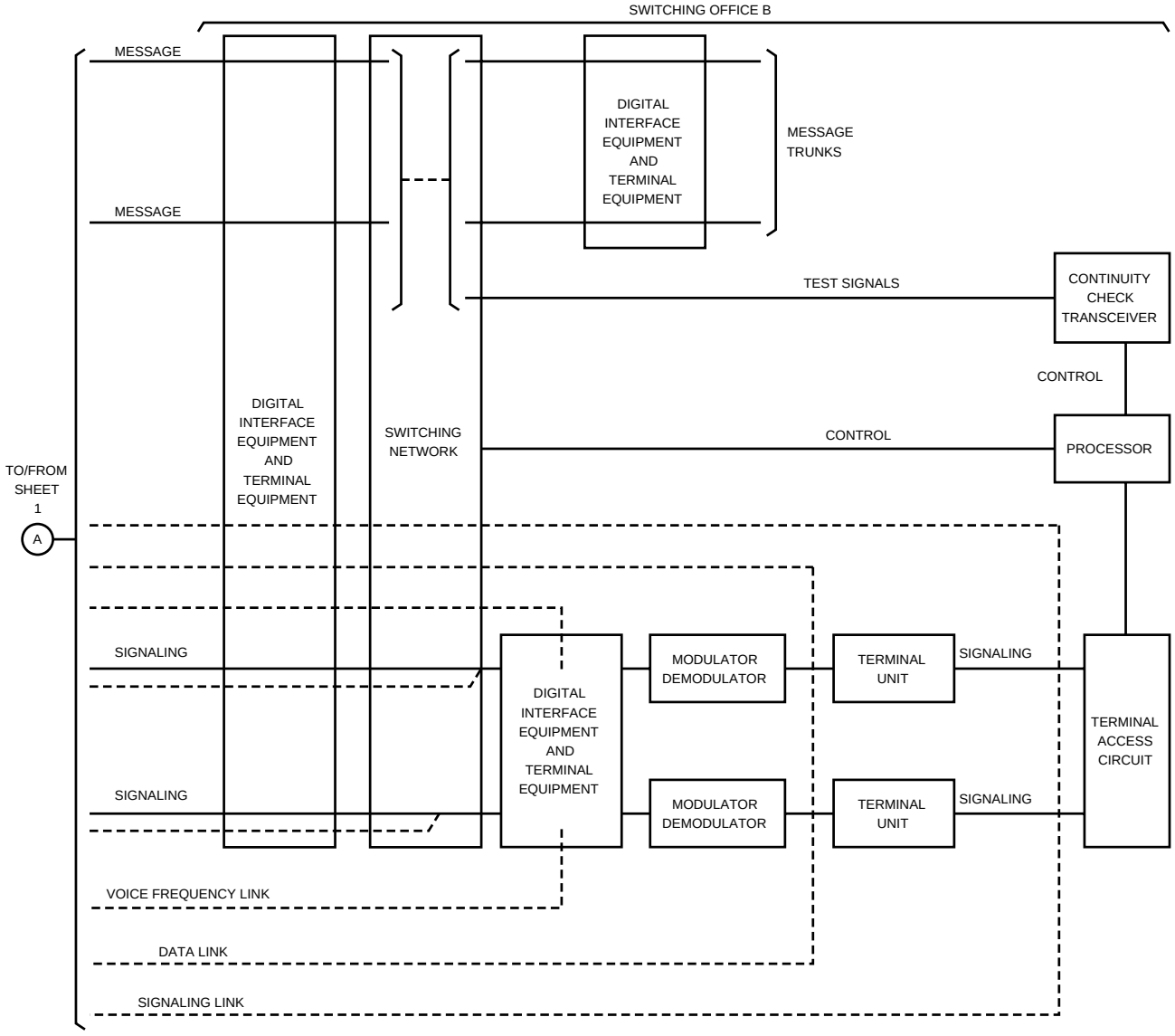


Figure 9. Common Channel Signaling (CCS) System—Typical Interoffice Connections (Sheet 2 of 2)

5.112 When operating at 2400 bits per second, each terminal unit pair can process signaling data for up to 2250 message trunks. However, each terminal unit in the pair processes signaling data for 1125 message trunks. In the event of a failure of one terminal unit or signaling path of the pair, the associated terminal unit and signaling path processes the signaling data for all 2250 message trunks. When operating at 4800 bits per second, each terminal unit pair can process signaling data

for up to 4500 message trunks. Again, each unit of the pair normally processes half of the signaling data (2250 message trunks) but can process all the signaling data for 4500 message trunks. Terminals which are paired are normally serviced from separate terminal groups.

5.113 The CCIS terminal access controllers have a direct interface with the 1B Processor via the peripheral unit bus. The terminal access controllers interface with the enable address, write, and reply buses. They do not interface with the peripheral unit control bus. The CCIS terminal access controllers also have an indirect interface with the 1B Processor via miscellaneous signal distributor points and scan points. Scan points are used to notify the 1B Processor that incoming CCIS data is available for processing. Signal distributor points provide the 1B Processor with maintenance access to a faulty terminal unit. As shown in Figure 9, the 4-wire VF line connections to the voiceband interface provide the facilities through which the CCIS terminals are connected to the switching network.

5.114 In offices equipped with a digital interface frame, these 4-wire VF lines connect to D4 channel banks which interface with either the digital interface frame or digroup terminals for connection to the switching network. Each CCIS signaling path is subdivided into the following links:

- Overall CCIS signaling link
- CCIS data link
- CCIS voice-frequency link.

The voice-frequency link is considered as the equipment and interconnections that carry analog signals between the CCIS terminal modulator-demodulators. The CCIS data link consists of the voice-frequency link plus the modulator-demodulator units and includes the digital inputs to the modulator-demodulators. The entire signaling link consists of the data link plus the CCIS terminal units. These links are illustrated in Figure 9 with dashed enclosures.

5.115 The CCIS signals transferred between CCIS terminals are digital bit streams converted to analog tones by either the terminal unit modulator demodulators (2400 bits per second) or by the CCIS data set frame modulators-demodulators (4800 bit-per-second data sets). Encrypted 4800 bit per second interfaces between offices may be provided with the 4E6 and later generic issues. These encrypted interfaces require the addition of the CCIS data set frame and circuit pack changes in the terminal group frame. These two-way signals are carried between offices via 4-wire circuits. These circuits are dedicated to carrying CCIS signals and are connected to either the CCIS terminal unit or CCIS data set frame modulator-demodulator units via the switching network. In the 4ESS Switch, appropriate information entered into office translation data in 1B Processor memory causes the switching network to continuously connect these CCIS signaling circuits to the CCIS terminal modulator- demodulator units.

Software can designate an alternate predefined path, as shown in Figure 9, to be selected when the primary path is suspect.

5.116 Incoming analog signaling data is applied to the modulator-demodulator associated with a terminal unit for conversion to digital. This digital signaling undergoes validity checks and is converted from a serial to parallel format in the terminal unit before being sequenced for application to the 1B Processor. When validity checks prove satisfactory, an acknowledgment signal is returned to the originating office via the same data link.

5.117 In the reverse direction, CCIS signaling information generated by the 1B Processor is applied to the CCIS terminal unit. This information is converted to serial format, combined with validity check data, and is applied to the associated modulator-demodulator for conversion prior to transmission to the distant office. The signaling data exchanged over the signaling link includes the supervisory and call-identification data required by the 1B Processor to control the connecting or disconnecting of designated voice

trunks. Synchronizing data is also exchanged between terminal units via the signaling link.

5.118 The simplest and most direct form of CCIS is to provide a direct signaling link between the processors of all CCIS-equipped switching offices having interconnecting trunks. Figure 9 illustrates a typical direct interconnection using analog facilities between offices. Digital facilities can also be used. Since the signaling link is associated with a specific trunk group, this type of CCIS interconnection is known as associated signaling. However, in most cases, CCIS is provided via a signaling network as shown in Figure 10.

5.119 The nation is divided into ten signaling regions which have been chosen to correspond to the existing regions of the direct distance dialing hierarchy. All CCIS-equipped switching offices within a switching region concentrate the signaling traffic for all their CCIS trunks on a few access links (A-links). These A-links interface with a pair of CCIS message concentrators in the region called signal transfer points (STPs). The A-links are provided in fully redundant pairs: one A-link pair to each of the two STPs in the region. Between regions, one or more bridge links (B-links) connect each STP to all the STPs in the other regions. Each STP is connected to its mate STP in the region by cross links (C-links). These links provide alternate routing within the signaling network. Extension links (E-links) may be provided to interconnect a switching office in one region with an STP in another region. These E-links are provided where heavy traffic routing is anticipated. Fully associated links (F-links) may also be provided where heavy CCIS traffic between two switching offices justifies this dedicated link.

5.120 Duplicate STPs within each region and the various types of interconnecting links in the signaling network provide a large degree of redundancy. These duplicate STPs provide for reliable operation in case of equipment failure. Additional redundancy is achieved by providing A-links from each switching office to both STPs in the region. Greater redundancy and reliability is accomplished by providing duplicate voice-frequency links to each A-link and E-link. These duplicated voice-frequency links are assigned diverse routes whenever possible. In the event of a failure or high error rate on the regular voice-frequency link, the reserve voice-frequency link is automatically switched into the signaling link under control of the 1B Processor.

5.121 Prior to the 4E3 generic program, CCIS signaling links were provided in groups of four. With the introduction of the 4E3 and later generic programs, these groups of four, although recommended, can be reduced. Additional software is provided to insure adequate reliability with only two signaling links.

5.122 Also shown in Figure 8 are the power input requirements for the CCIS terminal group. Each frame requires +140 V and +24 V from the power distribution system. The 4ESS Switch power distribution is discussed later in this part.

Switching Network

5.123 As illustrated in Figures 1, 11, and 12 and briefly discussed in Part 3, the switching network is comprised of the following equipment:

- Time slot interchange
- Expanded time slot interchange
- Time multiplexed switch
- Network clock and system clock.

5.124 The time multiplexed switch and time slot interchange frames/expanded time-slot interchange cabinets actually perform the switching function. Combined, these frames/cabinets are referred to as the time division network. The network clock and system clock is considered part of the switching network because of its functional association and interfaces with time division network equipment. The time division network accepts the incoming traffic data presented in DS120 and DS3 format on numerous coaxial cables. The incoming data is switched in four stages to an outgoing DS120 or DS0 coaxial cable while also being repositioned in time to the time slot associated with the outgoing trunk. The

network clock and system clock generates the precise timing signals required to control these operations. The time division network is synchronized to operate on a 125-µs cycle with 128 precise time slots in each cycle.

5.125 Figure 13 is a greatly simplified block diagram of the time division network equipment showing time slot interchange equipment. This illustration also shows the interconnections with terminal interface equipment. Figure 13 illustrates the maximum size of a time division network that can be provided in a 4ESS Switch office. Normally, only the required amount of equipment is provided during an initial installation. The office can then be expanded to this maximum configuration. Note that in actual practice the interconnections between the time multiplexed switch and the receive and transmit portions of the time slot interchange are not connected in the straightforward manner as illustrated in Figure 13. Instead, they are interconnected in a complex pattern which actually simplifies selection of a switched path through the network. The major functions performed at various points in the time division network are indicated in Figure 13. These functions are discussed in the following paragraphs.

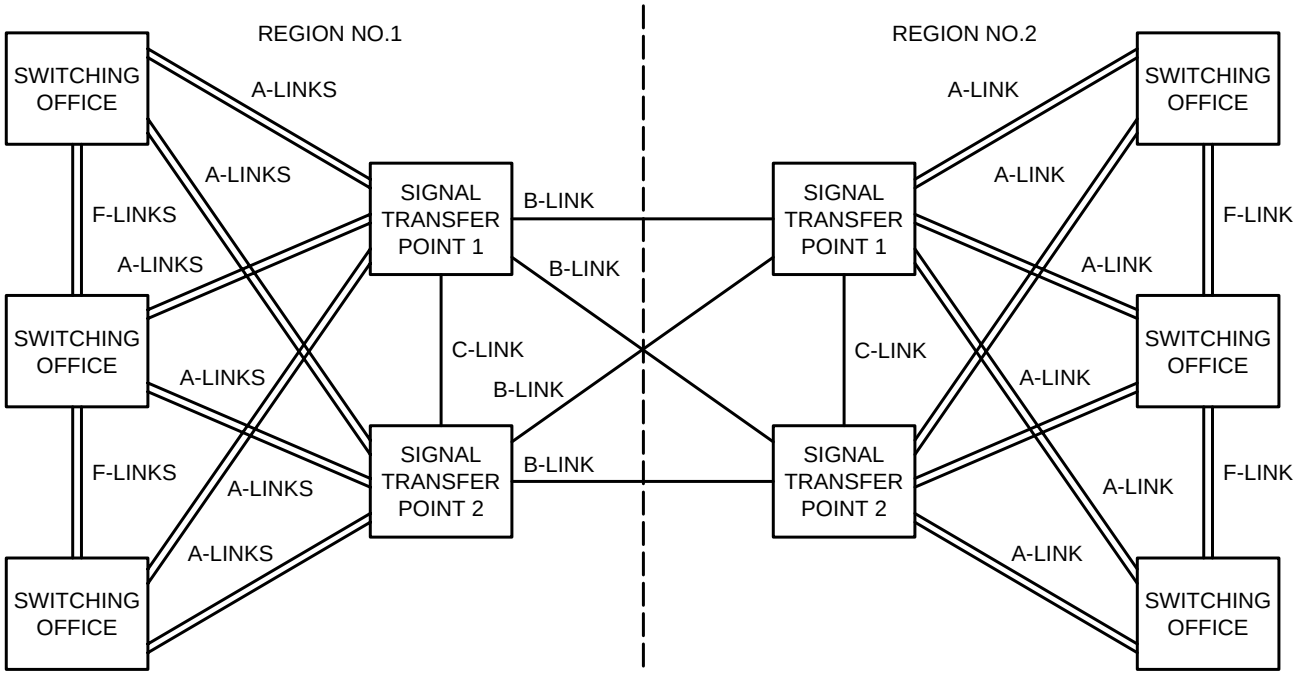


Figure 10. Common Channel Signaling (CCS) Network

A. Time Slot Interchange

5.126 The time slot interchange (TSI) is shown as a single block in Figure 11. In actual practice, the TSI is comprised of as many frames as are required to accommodate the trunks and service circuits required in a 4 ESS Switch office. As discussed in Part 3, the TSI frames can be either the initial configuration TSI frames or the modified design TSI frames. The primary functional element of either TSI frame is the switching and permuting circuit. Each initial configuration TSI frame contains two switching and permuting circuit pairs. Each cost-reduced TSI frame contains four switching and permuting circuit pairs. One switching and permuting circuit of each pair is designated as active, and the other switching and permuting circuit is designated standby. The standby unit is designated active in the event of a failure of the active unit.

5.127 Each switching and permuting circuit can accommodate 840 trunks and service circuits which are applied through seven DS120 coaxial cable pairs from each digroup terminal, voiceband interface, or echo suppressor terminal. Note that the digroup terminal DS120 interface consists of eight coaxial cable pairs. The eighth cable pair from the digroup terminal is routed to a separate TSI frame which accommodates the eighth cable pair from seven separate digroup terminals. A fully equipped 4ESS Switch office can contain up to 128 switching and permuting circuit pairs—active switching and permuting circuits 0 through 127 shown in Figure 13. These 128 switching and permuting circuits can be mounted either in 64 initial configuration TSI frames or 32 modified design TSI frames. The 128 active switching and permuting circuits in a fully equipped office enable the 4ESS Switch to provide switching terminations for 107,520 trunks and service circuits.

5.128 Each switching and permuting circuit is comprised of two parts: a receive portion and a transmit portion. These are illustrated in Figure 13. The receive portion accepts inputs from the voiceband interface frames, digroup terminal frames, and echo suppressor terminals. These inputs are applied via seven DS120 PCM data coaxial cables. As described earlier, these DS120 cables each carry data words for 120 trunks and 8 nontraffic words. The receive portion of the switching and permuting circuit performs the following functions:

- Time buffering
- Deloading
- Decorrelating
- First-stage switching and time slot interchanging.

5.129 The resulting output signals are applied to the time multiplexed switch for the second- and third-stage switching. The output of the time multiplexed switch is applied to the output portion (transmit portion) of a TSI switching and permuting circuit. The output portion performs the following functions:

- Fourth-stage switching and time slot interchanging
- Reloading
- Recorrelation.

5.130 The resulting output from each TSI switching and permuting circuit is applied to the same voiceband interface frame, digroup terminal frame, or echo suppressor terminal connected to the input portion of the TSI.

5.131 The first operation performed on the PCM data applied to the TSI is time buffering. The terminal interface equipment which generates the DS120 PCM data is synchronized by timing signals originating at the network and system clock. When generated at the voiceband interface or digroup terminal, PCM data is in frame synchronism. In other words, time slot 0 data is generated in all voiceband interface frames and digroup terminals at the same instant. However, due to minor differences in cable length and the fact that some PCM data is routed through an echo suppressor terminal, the DS120 data is no longer frame synchronized at the TSI. The maximum variation between frames is seven or eight time slots. The time division network, however, is designed to

process similar time slots at the same time. This means that time slot 0 data on all inputs must be presented to the time division network at the same instant. Therefore, the TSI input circuits briefly store PCM data as required—up to 125 μs or one frame—in order to establish frame synchronism.

5.132 The second TSI operation performed on PCM data is deloading. Deloading is a means of distributing the total traffic load on the switching network. In this application, deloading increases the number of switched paths available through the TSI to the time multiplexed switch. This provides lighter loading on each path and makes it less likely that blocking will occur. This is done in order to maintain the call-blocking characteristics of the system within acceptable limits. A *blocked call* is defined as a call for which the system cannot provide a complete switched path through the network. In other switching systems, deloading is a traffic-engineering function. Some of the switching equipment trunk terminations available for use are simply not assigned. In the 4ESS Switch, the deloading function is inherent in the TSI design. The basic design of a fully equipped TSI can theoretically accommodate 122,880 trunk terminations—960 trunks per each of 128 switching and permuting circuits. However, the actual design, as implemented in 4ESS Switch, accommodates a total of 107,520 trunk terminations in a fully equipped system—840 trunks per switching and permuting circuit. There is a 120-trunk ability within each switching and permuting circuit simply not available for connection. The TSI deloading is discussed further in a subsequent paragraph.

5.133 The third TSI operation performed on incoming PCM data is decorrelation. Decorrelation protects the network against concentrated traffic arriving on many trunks assigned to the same DS120 PCM cable. Decorrelation enables the trunks associated with a DS120 PCM cable to be distributed across the time division network. This reduces the requirement for load balancing while maintaining low blocking under most traffic conditions. Without decorrelation, an unusually high traffic condition on any one DS120 PCM cable input to the TSI could result in an unacceptable blocking level for calls processed in that portion of the network. In the 4ESS Switch, decorrelation is accomplished by mixing the trunk data applied on the input DS120 PCM lines and distributing this data across the output lines. Decorrelation is discussed further in the following paragraph.

5.134 Figure 14 is a greatly simplified diagram of the receive portion of 1 of the 128 TSI switching and permuting circuits. Each of the A and B buffer memories illustrated in this diagram has a storage capacity of 128 data words, or 1 data word for each time slot. The data carried on each input cable is applied to buffer memory A0 through A6 as shown. The eighth input buffer memory, designated A7, is unused. In effect, this memory contains null traffic words. As PCM data is applied to the TSI, the trunk data in each time slot is entered into one of the 128 memory data locations. The data words are temporarily held in the "A" memories to provide the time buffering function. The trunk data words are sequentially gated to the decorrelating and deloading circuit. This circuit distributes the **trunk data words** from the seven input buffer memories (A0 through A6) to eight output buffer memories designated B0 through B7. Since input buffer memory A7 contains no trunk data, this circuit effectively distributes 7 inputs containing data for 840 trunks across 8 outputs. This distribution constitutes the deloading function. During this distribution, the deloading and decorrelating circuit mixes the trunk data words present in various time slots. The 128 data words in each buffer memory A, null words in the case of memory A7, are evenly distributed to all output buffer memories according to a precise pattern. In other words, 16 trunk data and nonmessage words from each of the 8 input buffer memories are applied to each output buffer memory. Each output buffer memory contains 128 data words, 16 from each of the input buffer memories. This constitutes the decorrelating function. At this point, each of the 128-word output buffer memories contains 105 trunk data words and 23 nonmessage words. The contents of each of these buffer memories are updated once during each 125-μs DS120 data frame.

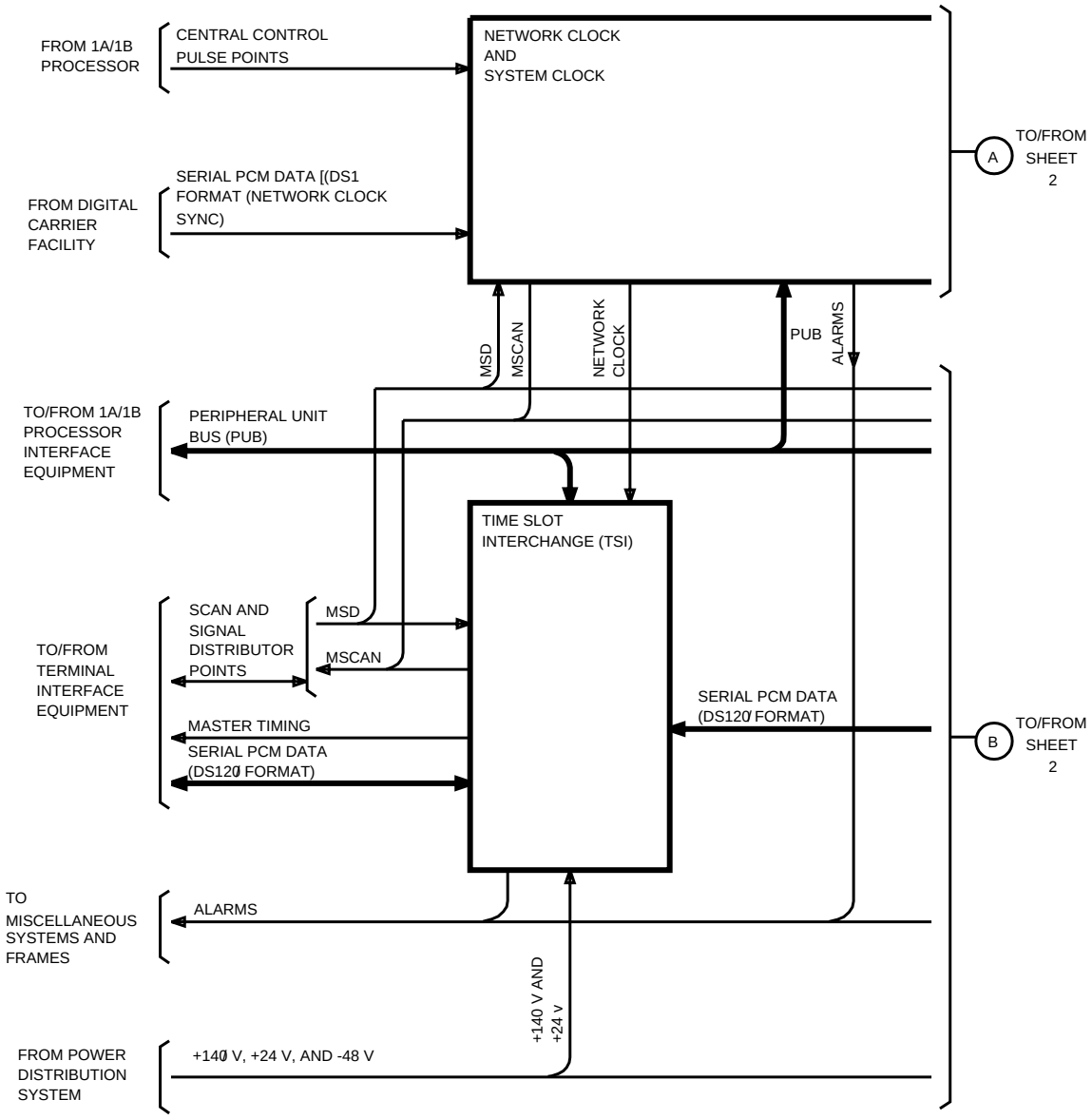


Figure 11. Switching Network—Functional Block Diagram (Sheet 1 of 2)

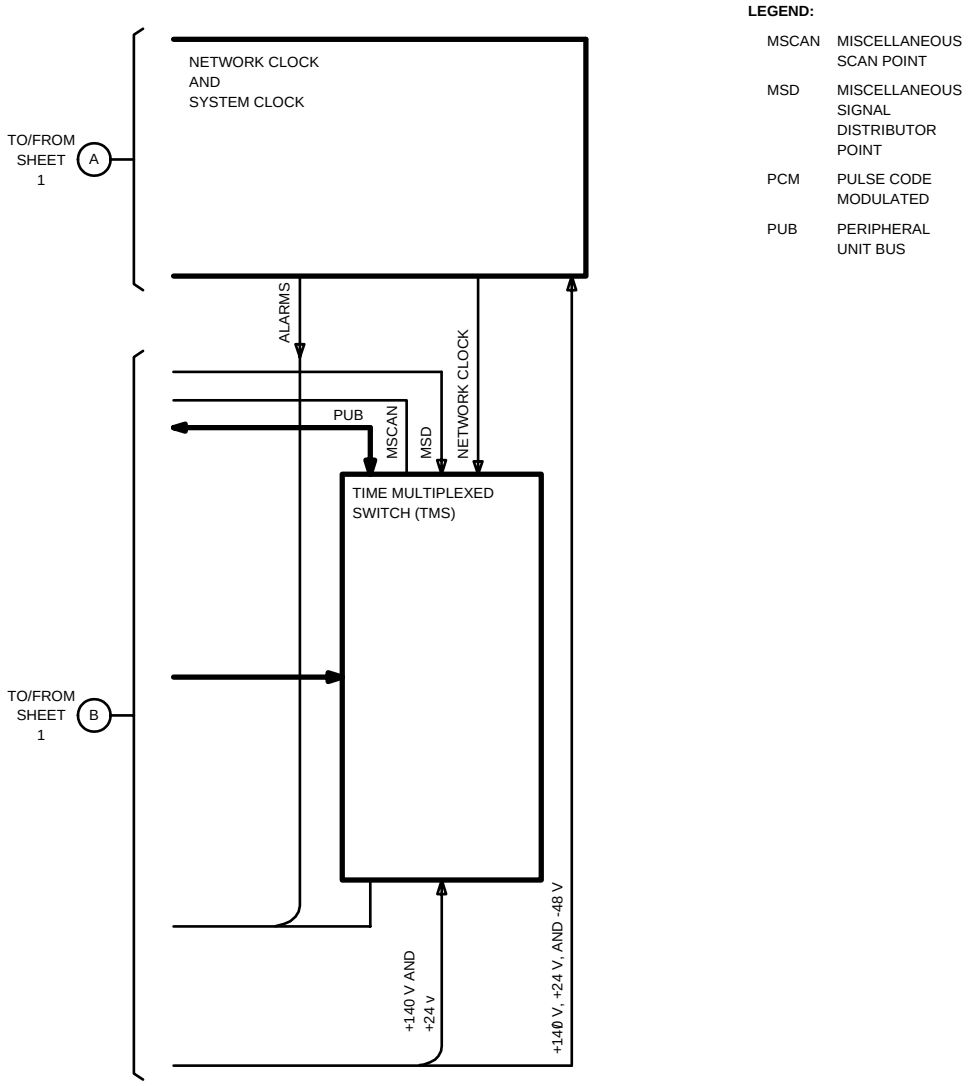


Figure 11. Switching Network—Functional Block Diagram (Sheet 2 of 2)

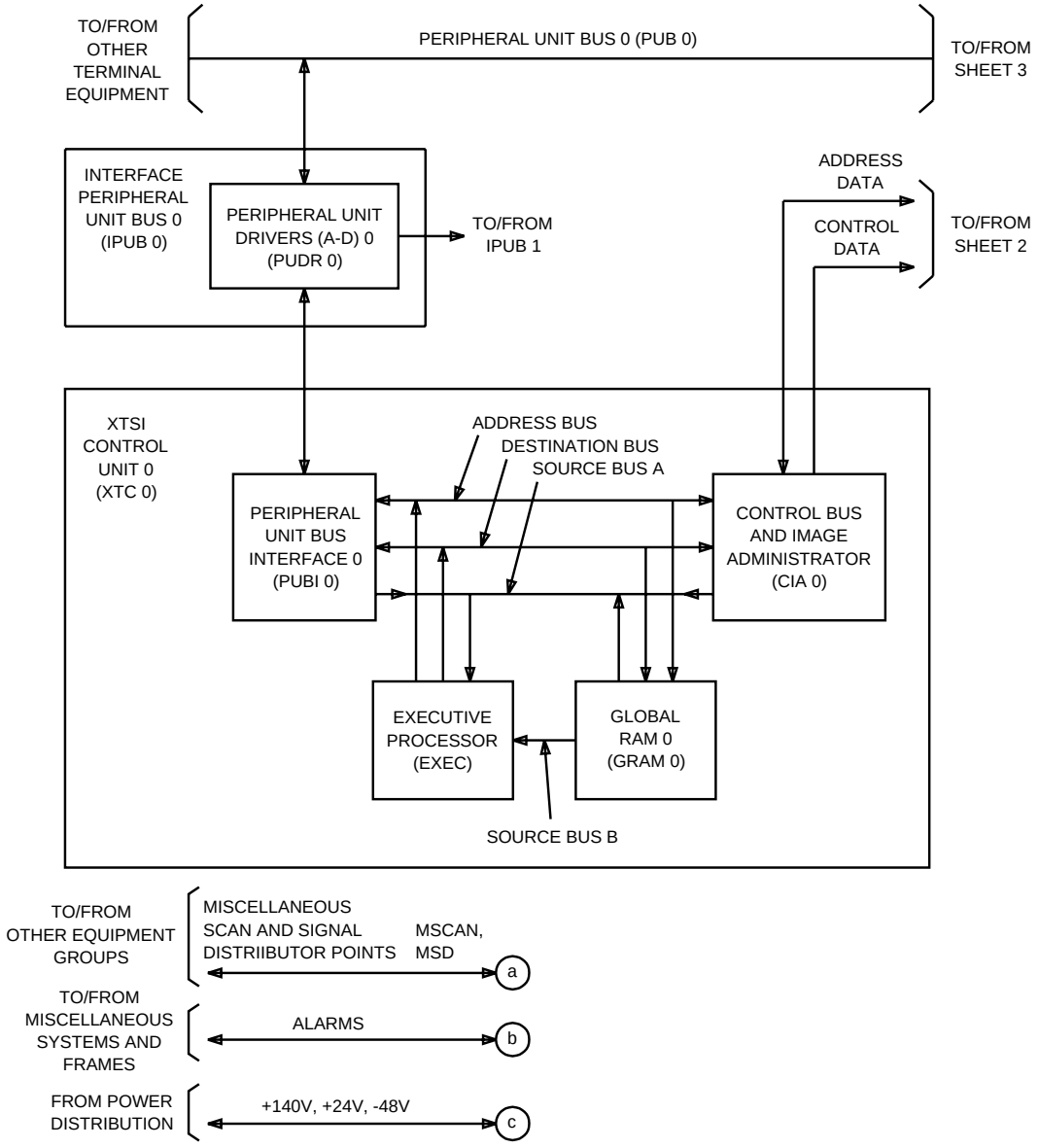


Figure 12. Expanded Time Slot Interchange—Functional Block Diagram (Sheet 1 of 3)

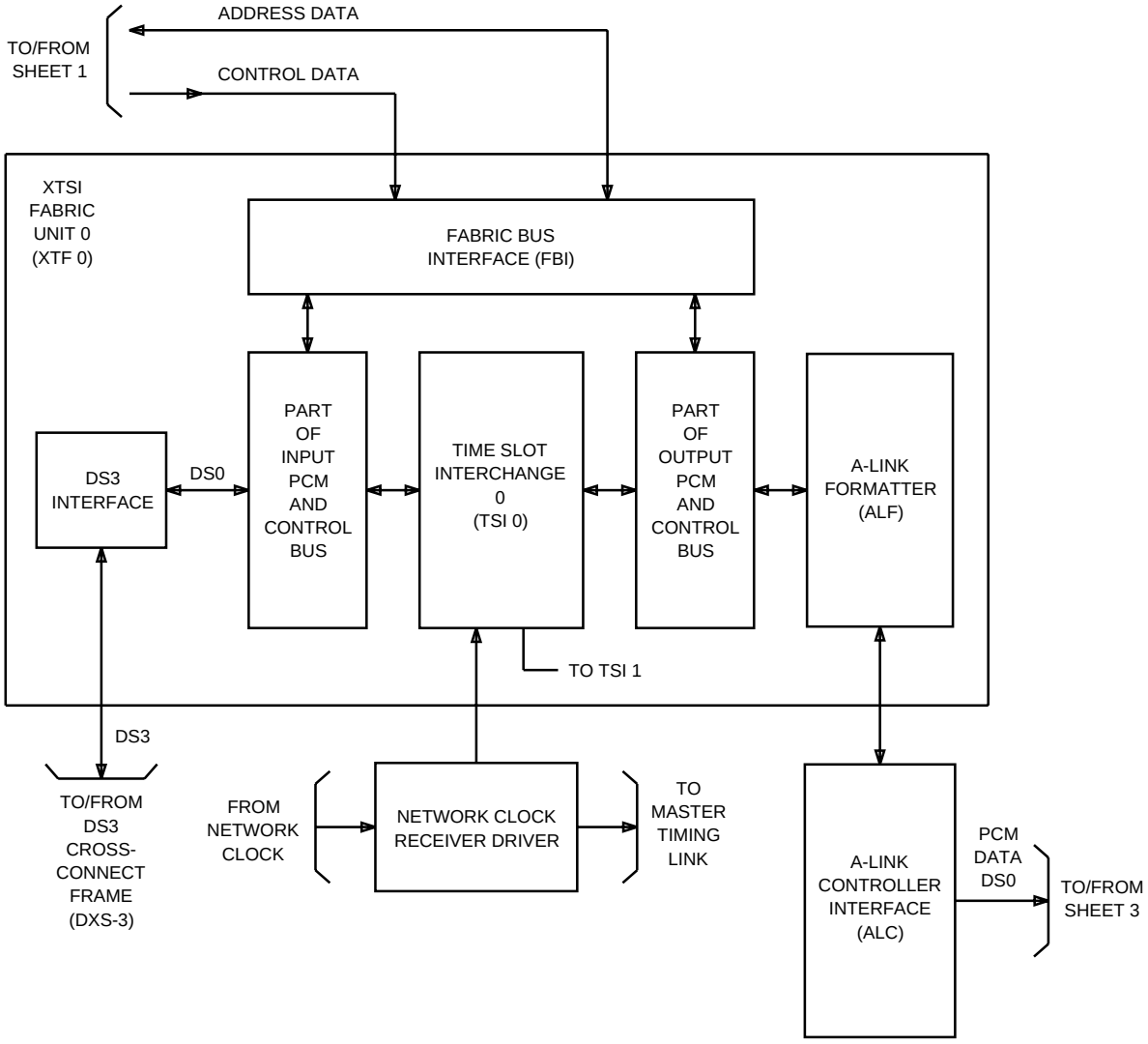


Figure 12. Expanded Time Slot Interchange—Functional Block Diagram (Sheet 2 of 3)

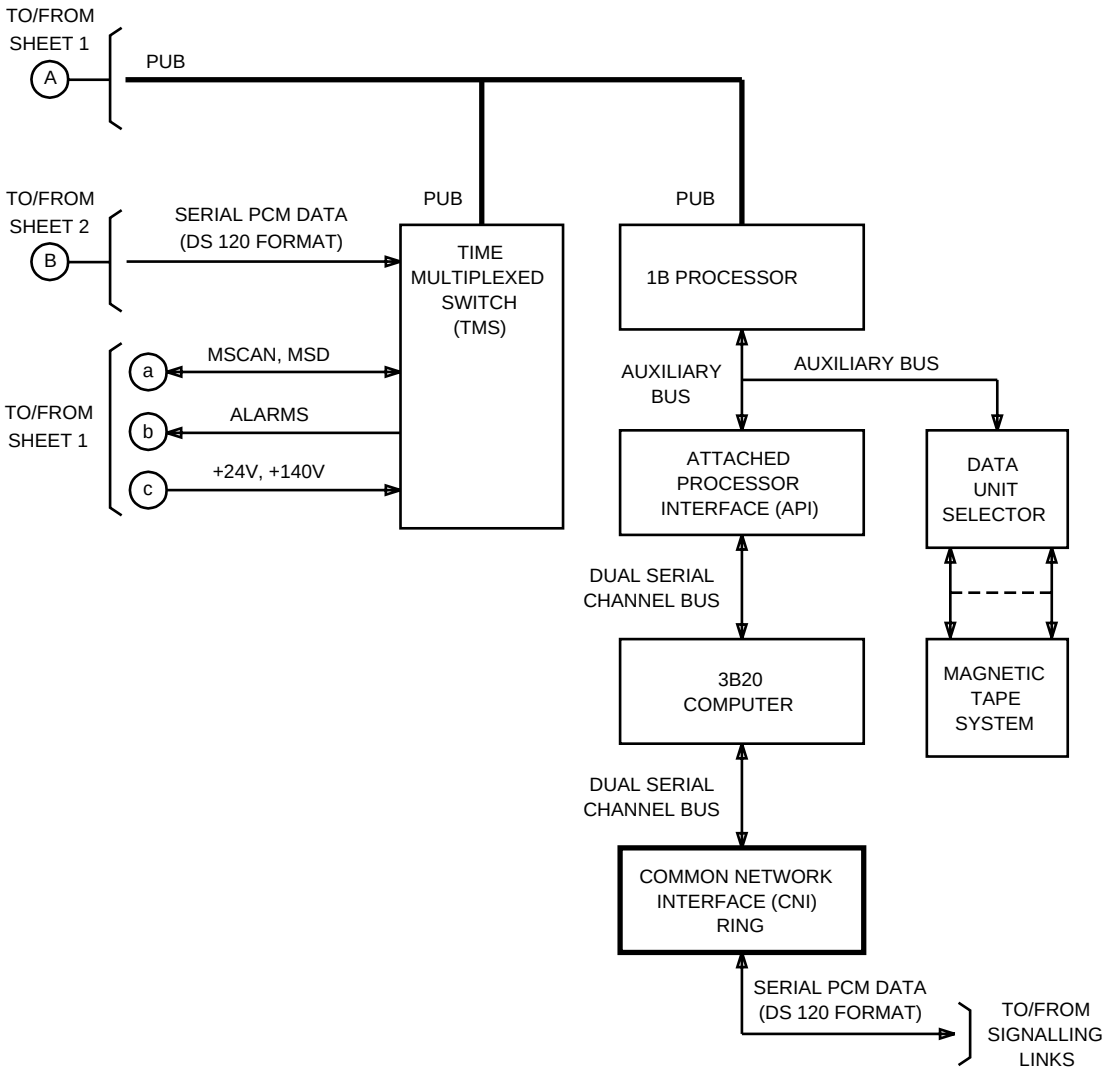


Figure 12. Expanded Time Slot Interchange—Functional Block Diagram (Sheet 3 of 3)

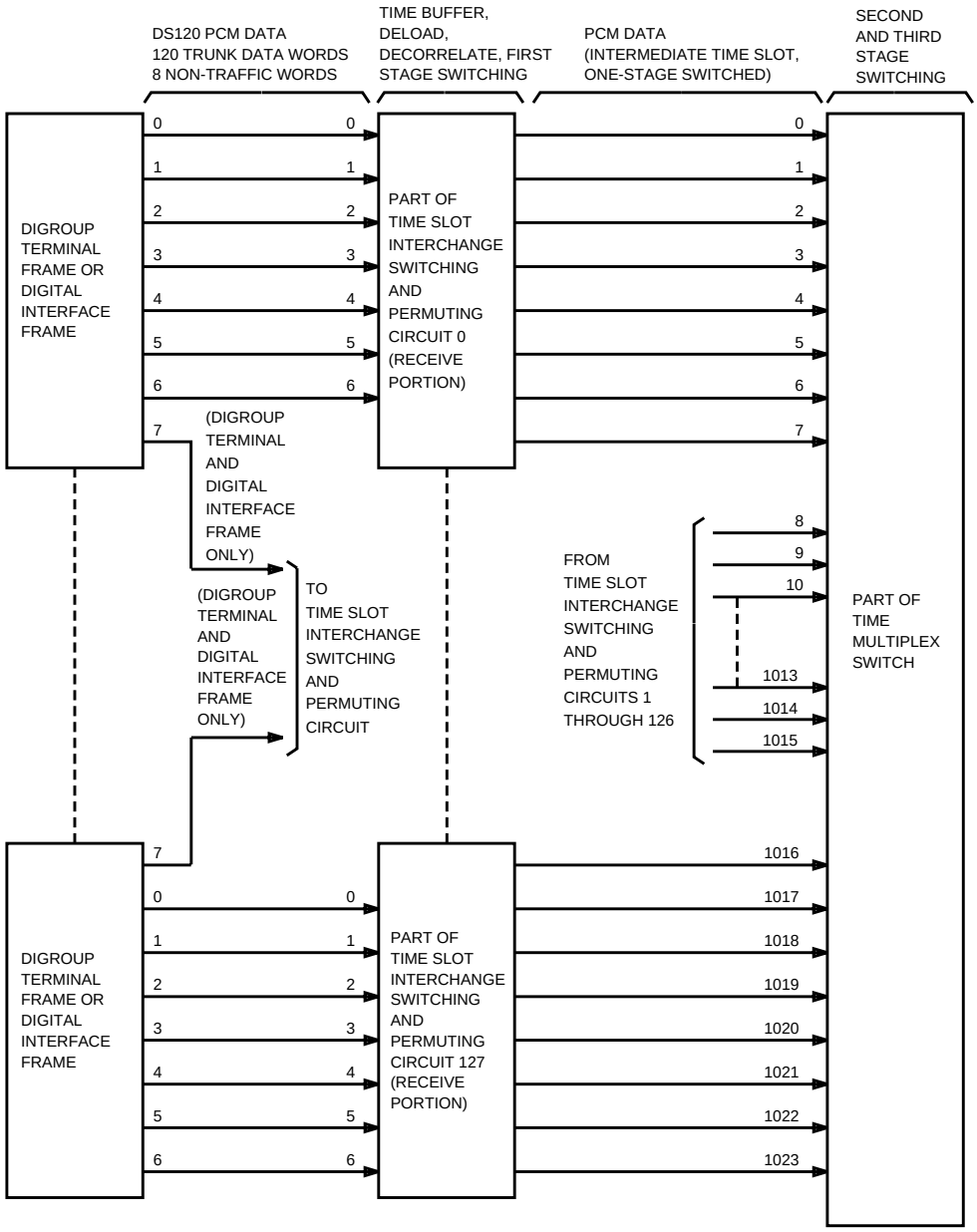


Figure 13. Time Division Network (Fully Equipped)—Simplified Diagram (Sheet 1 of 2)

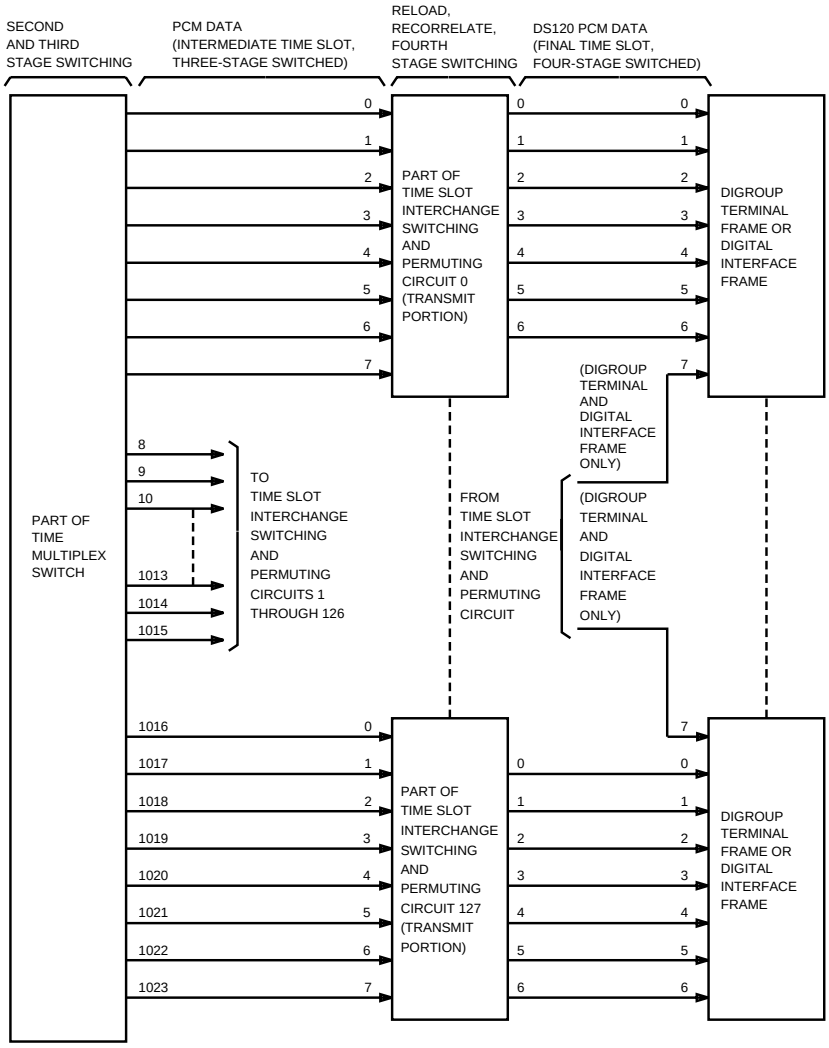


Figure 13. Time Division Network (Fully Equipped)—Simplified Diagram (Sheet 2 of 2)

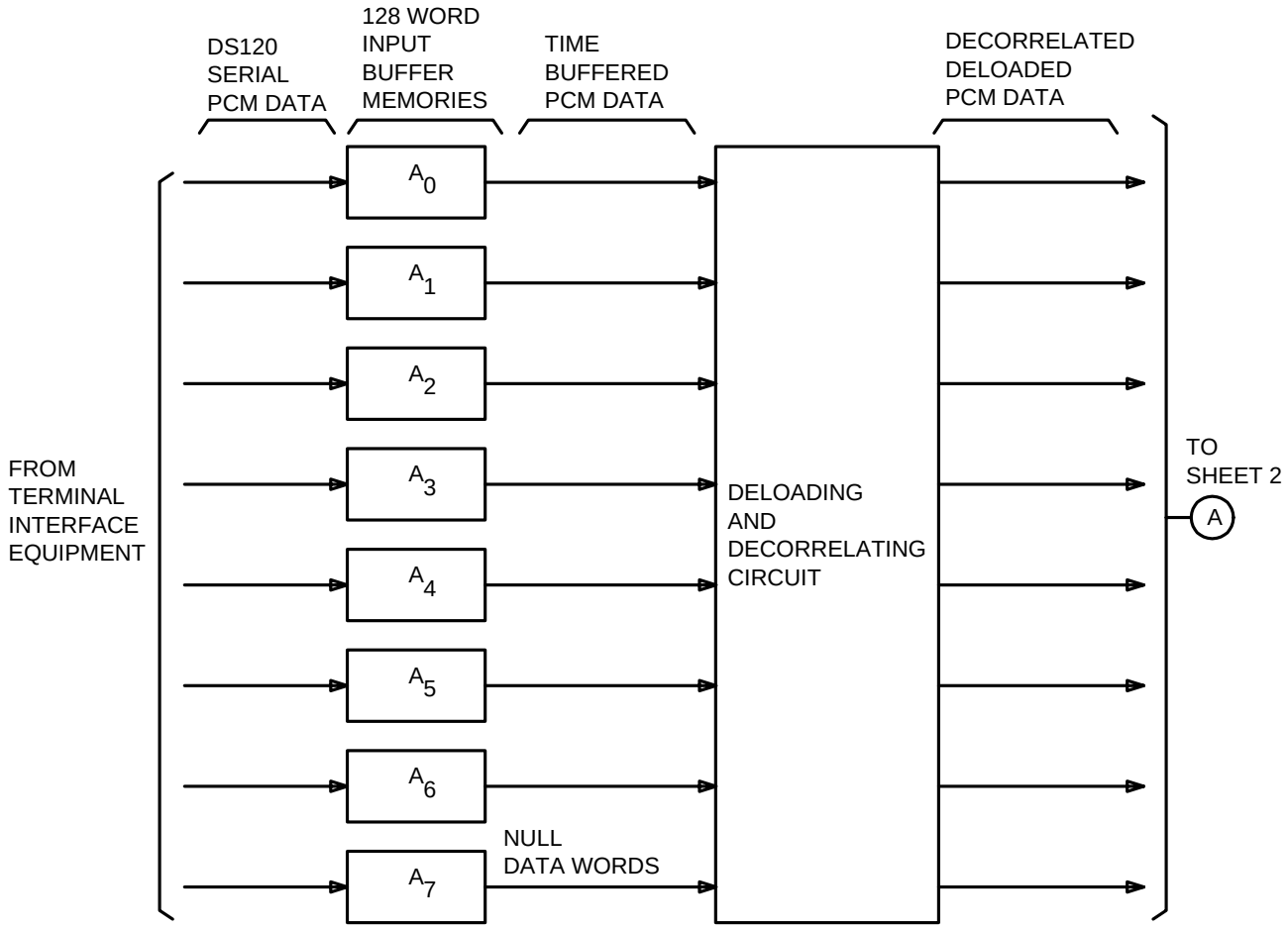


Figure 14. Switching and Permuting Circuit (Receive Portion)—Simplified Diagram (Sheet 1 of 2)

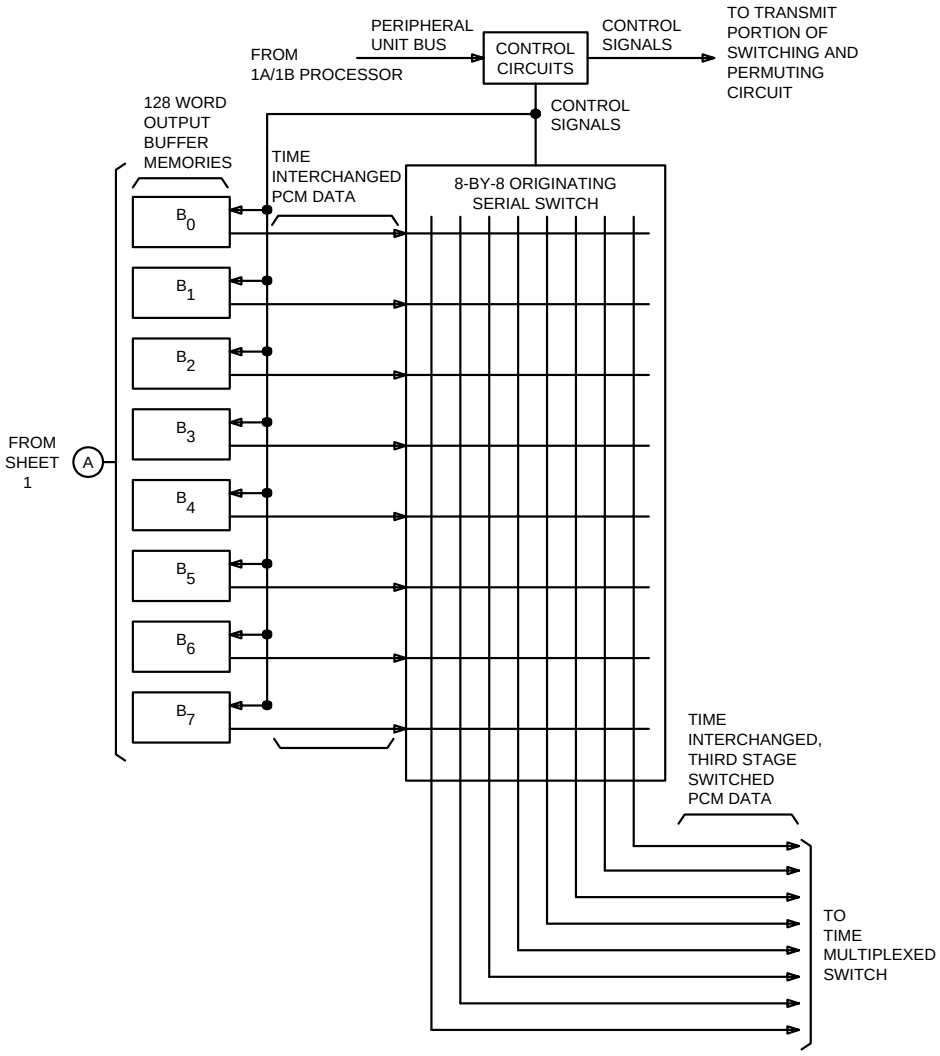


Figure 14. Switching and Permuting Circuit (Receive Portion)—Simplified Diagram (Sheet 2 of 2)

5.135 The fourth function performed by the receive portion of a TSI switching and permuting circuit is first-stage, space-division switching. The first-stage switch, operating in conjunction with the output buffer memories, also repositions trunk data to a different time slot. As illustrated in Figure 14, this first-stage switch consists of an 8-by-8 integrated circuit matrix. One of the output buffer memories connects to each input level of the switch.

5.136 Each output buffer memory contains PCM data words for 105 trunks. The 23 nonmessage words require no further consideration in a system-level discussion. The output buffer memories select the specific trunk data word to be applied to the first-stage switch.

5.137 The 8-by-8 originating serial switch and the output buffer memories operate as directed by associated control circuits. These control circuits receive switching instructions from the 1B Processor via the peripheral unit bus. Generation of these instructions within the 1B Processor is controlled by the path-hunt subset of call-processing programs. These instructions contain sufficient data to select an identified path through the switch at a specified time. These control circuits also control the transmit portion of the switching and permuting circuits.

5.138 As directed by the control circuits the following is performed:

a. Specific noninterfering paths are set up through the 8-by-8 switch during each time slot.

b. Any one or none of the trunk data words residing in an output buffer memory may be applied to a corresponding switch input level.

The result is that any designated trunk data word(s) applied to a switch input level can be space switched to any one of the eight output levels. In addition, this transfer probably, but not necessarily, occurs at some time slot other than the one assigned to the trunk data word(s) being switched. For example, a trunk data word residing in an output buffer memory B0 data location associated with time slot 92 could be transferred to switch output level 6 at time slot 14. This effectively repositions the trunk data word to time slot 14. This trunk data is also switched from input level 0 to output level 6. The output levels of this first-stage switch are applied to the time multiplexed switch.

5.139 Figure 15 is a greatly simplified diagram of the transmit portion of one TSI switching and permuting circuit. Like the "A" and "B" buffer memories, the C-buffer memories also have a storage capacity of 128 data words—one data word for each time slot. Data words sequentially output from the receive switching and permuting circuit, originating serial switch, via the 2-stage time multiplexed switch are applied to the 8-by-8 terminating serial switch. This switch provides the fourth stage of space switching in the time division network. This switch, operating in conjunction with the C-buffer memories, again repositions data to another time slot. The 8-by-8 serial switch and the C-buffer memories operate as directed by switching and permuting control circuits. These control circuits are illustrated in Figure 14 and were previously discussed. During each time slot, the control circuits cause the 8-by-8 switch to set up noninterfering paths from designated input levels to designated output levels. Trunk data words are moved across the switch and are applied to the C-buffer memories. The control circuits identify the time slot assigned word in which the trunk data word is to be entered. This effectively repositions the trunk data time slot for the second time. In the example presented in the previous paragraph, a trunk data word associated with time slot 92 was transferred to an intermediate time slot (time slot 14) for transfer through the switching network. When applied to the C-buffer memory, this time slot 92 trunk data word is entered into a data location associated with the time slot assigned to the outgoing trunk. The trunk data words are sequentially gated out of the C-buffer memories at their new time slots.

5.140 Data output from the C-buffer memories is applied to the reloading and recorrelating circuit. This circuit reloads the data from eight inputs to seven outputs and recorrelates time-slot

data. The recorrelating pattern is the exact opposite of the decorrelating pattern, and each trunk data word is restored to its proper time slot. The data output from the reloading and recorrelating circuit is applied to the switching and permuting circuit output circuit. This circuit applies trunk data words to terminal interface equipment as DS120 PCM data. This data is, in turn, applied to appropriate outgoing trunks or service circuits. In summary, trunk data words present at the output of the TSI switching and permuting circuit have completed the following:

- Time buffering
- Deloading and decorrelating
- One stage of space switching and repositioning to an intermediate time slot
- Two stages of space switching in the time multiplexed switch
- A final stage of space switching and repositioning to a final time slot
- Reloading and recorrelating.

5.141 As illustrated in Figure 11, the TSI interfaces with several different types of equipment in the 4ESS Switch. The PCM data interfaces have been adequately described in the previous paragraphs. The peripheral unit bus interface enables the 1B Processor to control and monitor switching and maintenance activities within the TSI. All four components of the peripheral unit bus connect to the TSI. The TSI receives timing signals from the network clock and system clock. These signals are required to synchronize the time-shared switching activities within the TSI. These timing signals are forwarded, by each TSI frame, to the terminal interface equipment interfacing with that frame. This is required to synchronize the transfer of PCM data between these units. The TSI also receives miscellaneous signal distributor points from the signal processor 1 or signal processor 2. These signal distributor points provide the 1B Processor with maintenance and diagnostic access to the TSI through a signal processor.

5.142 As previously discussed, the switching and permuting circuit is the primary functional element in the TSI. A malfunction within this unit could conceivably affect the operation of 840 trunks. The switching and permuting circuits are duplicated to eliminate this possibility. Input signals are applied to both switching and permuting circuits. The active circuit is in bay 0, and the standby circuit is in bay 1 or vice versa. An output selection circuit enables the output from the active circuit. In case of a malfunction, the output circuit selects the standby unit which is then designated active. Outputs of both circuits are monitored continuously. Any detected errors are reported to the 1B Processor. Each switching and permuting circuit pair is provided with one peripheral unit bus interface circuit and one timing and control circuit. Sufficient redundancy is built into these units to provide for continuous operation in the event of a malfunction.

5.143 Also shown in Figure 11 are the power input requirements for the TSI. Each TSI frame requires +140 V and +24 V from the power distribution system. The 4ESS Switch power distribution is discussed later in this part.

B. Expanded Time Slot Interchange

5.144 A controller is the primary functional element of the XTSI. Two controllers are located in each XTSI cabinet. Each controller contains a control function (XTC) and a fabric switching function (XTF). A functional block diagram of the Expanded Time Slot Interchange (XTSI) is shown in Figure 12.

5.145 The XTC transmits or receives control information via either peripheral unit bus (PUB) through the IPUB0 and IPUB1 interfaces. The XTC has a 64K word local memory to store state information and a 256K word global memory to store data tables. A 32 bit, three bus, custom microprogrammed controller accepts commands from these interfaces, checks validity, and passes messages to the XTF to set up calls and perform maintenance functions.

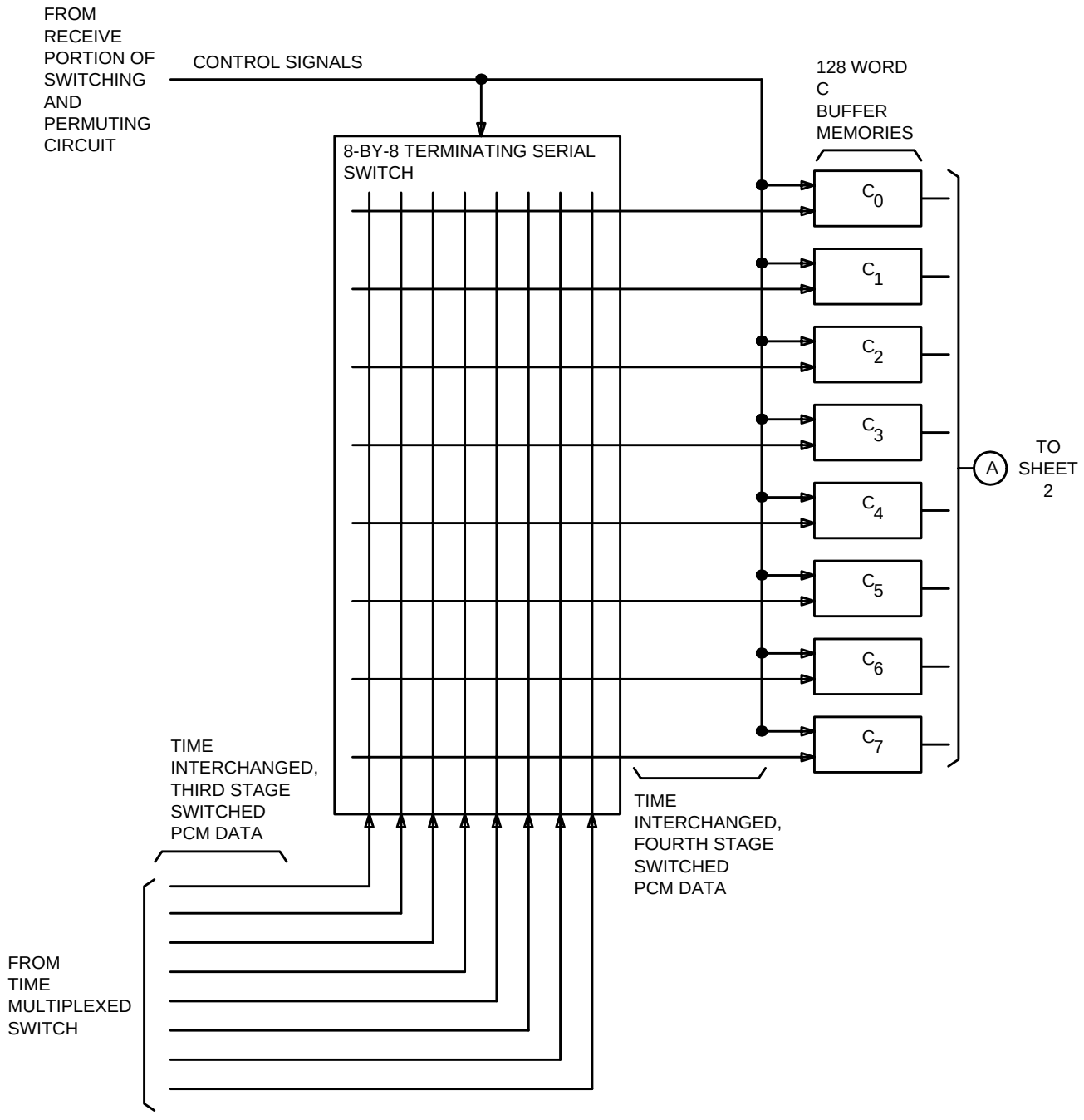


Figure 15. Switching and Permuting Circuit (Transmit Portion)—Simplified Diagram (Sheet 1 of 2)

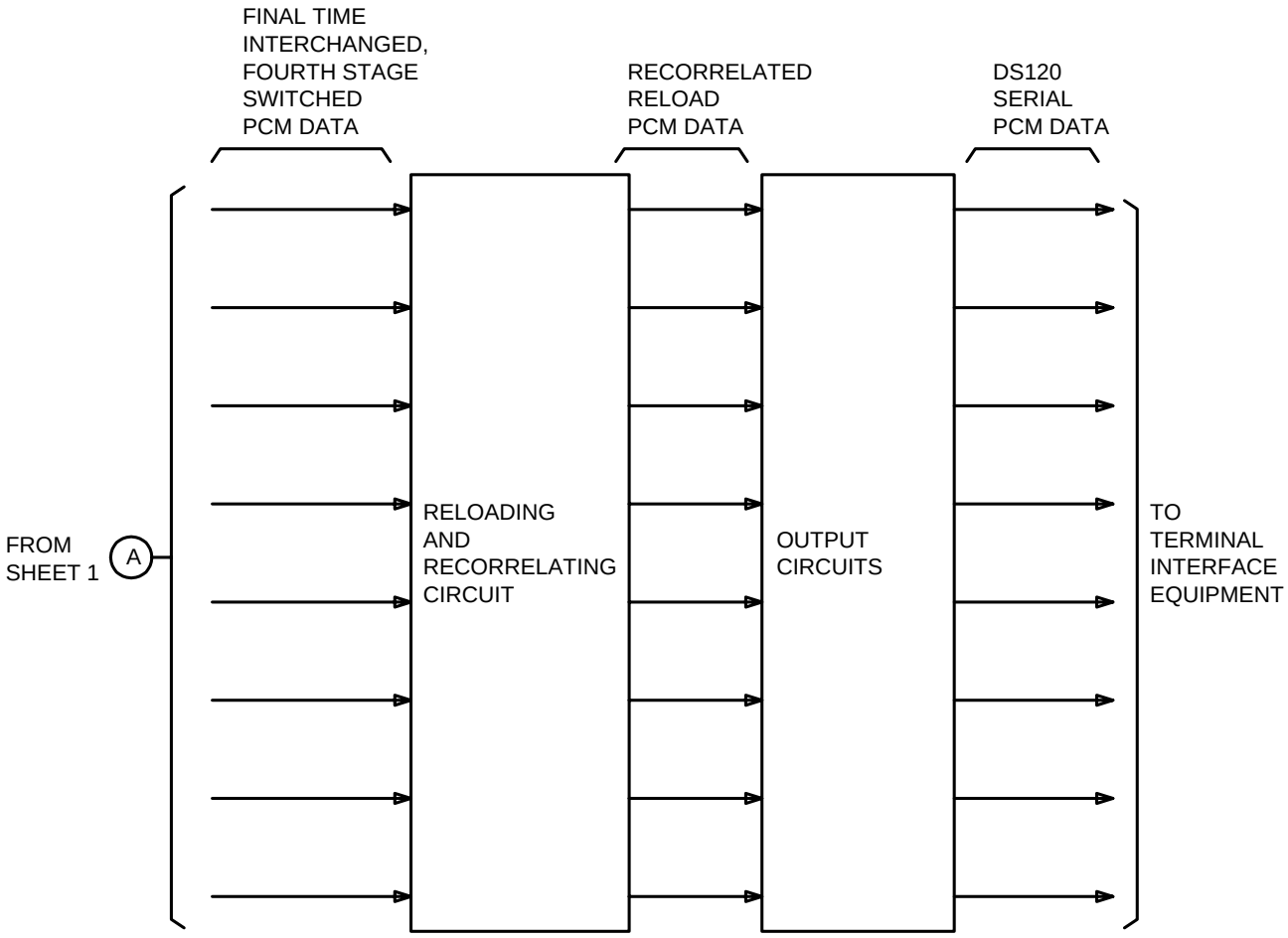


Figure 15. Switching and Permuting Circuit (Transmit Portion)—Simplified Diagram (Sheet 2 of 2)

5.146 The XTF has four, double buffered 4096 Time Slot Interchanges (TSI) that perform the time switching functions. Each TSI can switch any one of 4096 input time-slots to any or all of the 4096 output time-slots. Each TSI, along with the associated input and output pulse coded modulated (PCM) busses, is referred to as a switching and permuting circuit (SPC)in the XTF. Four switching and permuting circuits that support 16,384 time-slots are located in each XTSI cabinet. The XTSI provides an additional 8192 time slots that can be used for new switching features. *One switching and permuting circuit of each pair is designated as* **active***, and the other switching and permuting circuit that is designated* **standby** *is designated* **active** *if the active unit fails.*

5.147 Two A-link formatters (ALFs) occupy dedicated client positions on the PCM bus system and access the 4096 time-slots via the PCM bus. These A-link formatters are cross-coupled to a duplicated set of A-link controller (ALC) interfaces that interface the time multiplex switch (TMS). The A-Links lead from the ALC to the TMS and A'-Links connect the TMS to the ALC. Each A-Link has 128 time-slots on a single coaxial cable so that 4096 time-slots between the XTSI and TMSs require 32 A-Links and 32 A'-Links. Since these links are duplicated, a total of 128 coaxial cables connect to each XTSI cabinet.

5.148 The 4ESS Switch call processing software determines when a network path is required through an XTSI. The software sends an order over the PUB to modify the control structures in the XTSI. A unique address identifies a particular XTSI. The peripheral unit driver (PUDR) packs receive the call set-up message and send the message to the PUBI packs for partial decoding.

5.149 The PUBI circuit pack generates an interrupt signal to the EXEC processor in the XTC. The EXEC processor jumps to an interrupt routine to handle the PUB orders. The processor then completes the decoding of the message and determines the operation required of the XTF unit. A control message is sent to the XTF unit over the control bus. The fabric bus interface (FBI) circuit pack in the XTF unit receives these instructions in the form of register reads and writes from the control bus and distributes them to all of the XTF circuit packs.

5.150 The EXEC processor initiates several of these operation instructions to establish the PCM path to a particular time-slot on the PCM bus and to cause the TSI to correctly translate the input time-slot to the output time-slot. Operation instructions also configure the A-link and DS3 interface circuit packs. An on-board processor on the DS3 circuit pack manages the maintenance of the PCM paths through the interface circuit packs. The EXEC processor sends an All Seems Well (ASW) signal to the 1B processor upon completion of the call set up operations in the XTF unit.

5.151 With the XTSI, four PCM buses connect a single TSI circuit pack to other client circuit packs. These client circuit packs are the A-link clients and the protection switch clients (PSC) that include the DS3 circuit packs. Formatting and interfacing logic in these packs allow connection to all XTSI external sources. The PCM buses that connect these clients to the TSI pack are shared and provide resources called time slots. The customer interface side of the PSC clients provide resources called channels.

5.152 The single TSI complex associated with each switching and permuting circuit has no hardware differentiation between a receive TSI and a transmit TSI. The four SPCs terminate 1008 customer channels and 1024 TMS time slots. All inputs to the XTSI (inputs from transmission facilities and from the TMS) connect to the input of the TSI. All outputs from the XTSI are generated in the TSI. There is no decorrelator or recorrelator per SPC with the XTSI. A mapping RAM controls the association of specific input PCM bus time-slots with specific buffer memory locations; another mapping RAM controls the association of specific time slot memory locations with output PCM bus time slots. The XTSI supports the DS3 transmission facilities. The basic XTSI configuration includes up to six DS3 interfaces along with two spare protection switch client positions and 32 A-links. Two DS3 protection switch client groups are available with the XTSI.

Each protection switch group consists of three active DS3 protection-switch client circuit packs and one protection switch spare circuit pack. When an active DS3 protection switch client fails, the DS3 line associated with the defective DS3 protection switch client position is switched to the spare protection switch client position for that group. The six DS3 lines terminate up to 4032 trunks. The DS3 interface operates at 44.736 Mb/s and provides a high speed interface that reduces cable congestion and improves termination cost for the 4ESS Switch. The DS3 line provides 28 DS1 signals on a a single pair of coaxial cables. Each DS1 signal allows 24 DS0 signals on a single pair of wires; so, the capacity of a DS3 line is $28 \times 24 =$ 672 trunk terminations. The XTSI cabinet requires only 48-volt power. Battery plants supply this power from the power distribution system. The 4ESS Switch power distribution is discussed later in this part. A maximum of 30 power groups are located in the XTSI cabinet. The six main power groups are the two peripheral unit bus interfaces, the two A-Link interfaces, and the two XTSI controllers (XTC and XTF). Each of the 24 Protection Switch Client (PSC) pack positions has a power group. Scan and signal distribute (SD) interfaces monitor the XTC, XTF, IPUB, and A-Link interface power groups. With the XTSI, Pseudo Scan/SD connections control the PSC positions and the ALCs. These 24 PSSD connections are provided by the fabric bus interface (FBI) circuit pack in the XTF controller.

5.153 Refer to 234-310-034, *Expanded Time Slot Interchange, Description*, for additional detailed information concerning the physical and operational characteristics of the XTSI.

C. Time Multiplexed Switch

5.154 In Figures 1, 11, 12 and 13 the time multiplexed switch (TMS) is shown as a single block. The TMS block represents one, two, or four duplicated switch grids as determined by the size of the 4ESS Switch installation. An office can initially be equipped with something less than four complete TMS switch grids. The number of TMS frames can increase to the preestablished levels as required. As discussed in Part 3, the TMS frame can be either of two configurations. The function of either configuration is the same, and a mixture of TMS frames can exist in an office.

5.155 Figure 16 is a greatly simplified block diagram of a fully equipped TMS. Each TMS switch grid is comprised of 16 switch units. These 16 switch units in each grid contain a total of thirty-two 16-by-16 integrated circuit matrices. These matrices are interconnected to form a 2-stage 256-by-256 switch array which is called a grid. In a fully equipped 4ESS Switch, four grids are provided. The stage-1 TMS switch provides the second stage of switching in the time division network. [The time slot interchange receive portion (Figure 13) provides the first stage.] The stage-2 TMS switch provides the third stage of switching in the time division network.

5.156 Note that the interconnections between the stage-1 and stage-2 switches as shown in Figure 16 are also greatly simplified. Actually, the output levels of stage-1 are connected to stage-2 input levels in a complex pattern. The interconnection pattern in conjunction with the time slot interchange/TMS interconnection pattern was chosen to simplify the call-processing software task of establishing the required noninterfering paths through the time division network.

5.157 The TMS stage-1 switch receives trunk-data words from the first-stage switches in the time slot interchange switching and permuting circuits (Figure 13). As the switching and permuting circuit configuration changes from time slot to time slot, the trunk-data words applied to the stage-1 switch change from one time slot to another. For each specific call to be switched, the TMS control circuits receive switching instructions from the 1B Processor via the peripheral unit bus. These switching instructions correspond with the instructions applied to the switching and permuting circuit control circuit. During any one time slot, the configuration of the TMS stage-1 and stage-2 switches is changed to switch trunk-data words received from the switching and permuting circuit. Trunk-data words are switched to the appropriate switching and permuting circuits (transmit portions) associated with outgoing trunk data. The TMS is

accessed by all active switching and permuting circuits and changes its switched connections from time slot to time slot. During a 125-µs frame, the TMS is reconfigured 128 times. With 1024 input levels and 1024 output levels, the TMS effectively provides a 131,072-by-131,072 switch matrix. Because the TSI, through its deloading function, applies 105 trunk-data words to the B-buffer memories during each 128 time slots, the TMS is more appropriately considered as a 107,520-by-107,520 switching network. This establishes the maximum number of toll trunks and service circuits that can be accommodated by a fully equipped 4ESS Switch. All 131,072 paths through the TMS are available for switching traffic.

5.158 Figure 11 illustrates the TMS interfaces with other 4ESS Switch equipment. The PCM data interfaces with the time slot interchange have been discussed in previous paragraphs. The peripheral unit bus interface enables the 1B Processor to control and monitor switching and maintenance activities within the TMS. All four components of the peripheral unit bus connect to the TMS. The TMS receives timing signals from the network clock and system clock. These signals are required to synchronize time-shared switching functions within the TMS. These timing signals also synchronize the TMS with the time slot interchange. The TMS also receives miscellaneous signal distributor points from the signal processor 1 or signal processor 2. These signal distributor points provide the 1B Processor with maintenance and diagnostic access to the TMS through a signal processor.

5.159 Each individual TMS frame is comprised of one 256-by-256 two-stage switch. Four such frames are required to provide a fully equipped TMS. Obviously, a failure in any one TMS frame could seriously impair the ability of the 4ESS Switch to handle switched traffic by reducing the number of available paths through the network. In a 1-TMS office, TMS frame pair failure could stop all 4ESS Switch switching activity. For this reason, all TMS frames are completely duplicated. This provides four TMS frame pairs in a fully equipped office. One frame is designated active and the other is standby. Outputs of both TMS frames are monitored. The 1B Processor implements changes as necessary to ensure a valid unit is designated active. Duplication of time slot interchange switching and permuting circuits, TMS frames, and a means of interconnecting active units provide continuous operation during all but multiple equipment failures.

5.160 Also shown in Figure 11 are the power input requirements for the TMS. Each frame requires +140 V and +24 V from the power distribution system. The 4ESS Switch power distribution is discussed later.

D. Time Division Network

5.161 In previous paragraphs, the functions of the time slot interchange and the time multiplexed switch frames have been discussed independently. The functions of these two frames which comprise the time division network (TDNET) are closely related. In order to completely understand the switching function performed by the 4ESS Switch, the combined functions of these frames must be described. The following paragraphs, supported by Figure 17, provide this description. Figure 17 also shows some typical interfaces with terminal interface equipment. These interfaces are included to tie discussions of terminal interface equipment and the TDNET together. The time-slot assignments shown in Figure 17 are arbitrary and are included only to clarify the discussion. There is no intent to show actual relationships between trunk connections on the terminal interface equipment inputs and time-slot assignments on the outputs.

5.162 Figure 17 illustrates a call applied to a 4ESS Switch office on a digital trunk designated trunk A. This call is connected through the network to an analog trunk designated trunk B. For purposes of this discussion, assume trunk A is assigned to time slot 112 on its digroup terminal unit coaxial cables. Trunk B is assigned to time slot 42 on its voiceband interface unit. In order for trunk A to communicate with trunk B, the TDNET must transfer data from the digroup terminal unit cable to the voiceband interface unit cable. The TDNET must also reposition this data from time slot 112 to

time slot 42. Since this path through the TDNET is unidirectional, the network also sets up a second similar path to enable trunk B to communicate with trunk A.

5.163 Signaling data detected and applied to the 1B Processor identifies the two trunks to be interconnected. In the TDNET, the term interconnect is different than in other switching systems. A complete physical path from trunk A to trunk B never exists. Instead trunk-data words representing traffic to be switched are transferred through the network. The path-hunt programs deal with both time and space parameters. As previously discussed, the TDNET is reconfigured during each time slot. Also, during any one time slot, a number of different paths can be established through the TDNET. The 1B Processor control programs, known as path-hunt programs, examine the switching network configuration during each time slot. These programs locate a noninterfering path through the network to interconnect these two trunks. The path-hunt programs compensate for the fixed decorrelation/recorrelation patterns in their search for an acceptable path through the network. When a path is located, the 1B Processor applies appropriate instructions to the control circuits in the time slot interchange switching and permuting circuits and in the time multiplexed switch. These instructions specify the path to be established and identify the time slot in which the path is to be completed. In addition to applying this control information to control circuits in the TDNET, this data is also stored in 1B Processor memories as a backup. Once path-hunt programs apply control information to the TDNET, no further action is required by the 1B Processor to maintain the connection. The TDNET autonomously sets up the identified path each time the specified time slot occurs. The 1B Processor only notifies the TDNET when the call is to be disconnected.

5.164 In Figure 17, the two paths to be established through the TDNET are trunk A transmit to trunk B receive and trunk B transmit to trunk A receive. These two paths are mirror images of each other. The pattern of interconnections between the time slot interchange and the time multiplexed switch and between the stage-1 and stage-2 time-multiplexed switches makes this mirror arrangement feasible. The use of the mirror-image scheme permits both paths through the TDNET to be determined simultaneously by path-hunt programs. This reduces the amount of time required by the 1B Processor to establish both paths through the network. Mirror-image paths cannot be used when two trunks to be interconnected are processed by the same output buffer B memory. (See Figure 14.) In these instances, two path hunts are required to establish two unique paths through the TDNET.

5.165 In Figure 17, the trunk A data is applied to input buffer memory A during time slot 112. After deloading and decorrelation, the trunk A data word is written into output buffer memory B . The path-hunt programs locate a path through the network and identify an intermediate time slot when the transfer takes place. The 1B Processor generates the required instructions and applies the required information to the time multiplexed switch and to the two time slot interchanges associated with the transfer. At the intermediate time slot (example time slot N in Figure 17), the trunk A data word is:

a. Connected through the receive time slot interchange switch (first-stage TDNET switch) to a specified output level (level 3 in Figure 17).

b. Applied to input level X on the first-stage time multiplexed switch.

c. Connected through the first- and second-stage time multiplexed switch (second- and third-stage TDNET switch) to output level Y.

d. Applied to input level 7 of the transmit time slot interchange switch (fourth-stage TDNET switch).

e. Connected through this switch to a specified output level (level 5 in Figure 17).

f. Written into output buffer memory C in a word location associated with time slot 42.

5.166 The trunk A data word is held in output buffer memory C until time slot 42 occurs. At time slot 42, the trunk A data word is reloaded,

recorrelated, (to output 3 in Figure 17), and applied to the terminal interface equipment. Trunk B data words are simultaneously being passed through the network over a mirror-image path. These exchanges occur 8000 times each second until the 1B Processor notifies the TDNET to disconnect the call. Data transferred through the network may be delayed up to something less than three 125-μs data frames. This delay is dependent upon input and output time slots involved and the intermediate switching time slot assigned.

E. Network Clock and System Clock

5.167 The network clock and system clock illustrated in Figure 11 are contained in the network clock frame. The network clock provides precise timing signals required to control the switching network. The system clock also generates timing data which can be read by the 1B Processor as directed by control programs. This feature enables the 1B Processor to synchronize its internal clock in the event of a malfunction.

5.168 The network clock frame is accessed by all four portions of the peripheral unit bus. The system clock uses the enable address, write, and reply buses. The 1B Processor uses these buses to obtain timing data for internal timing verification. The network clock uses only the control bus and reply bus portion. In addition, the network clock is accessed via central control pulse points to initiate and control specific functions. The 1B Processor can access the network clock and system clock via signal processor miscellaneous signal distributor points for maintenance purposes.

5.169 The network clock frame is comprised of two identical bays. One bay provides timing signals for one set of duplicated TDNET equipment. The other bay provides timing signals for the other set. Each bay also contains duplicated oscillator units for additional redundancy. The duplicated oscillator units consist of four 39B crystal oscillators or four disciplined rubidium oscillators (DROs) that operate at a frequency of 16.384 MHz.

5.170 For offices participating in the switched digital network, the network clock frame in each office is equipped with a synchronization unit. This network consists of network engineering defined groups of digitally interconnected switching systems, offices, that require synchronization in order to control the flow of digital data across the network better. Operating digital switching systems at a common, synchronized, clock rate is necessary to control slips in time and, hence, minimize the loss of data transmitted between offices over digital (T1-Carrier) facilities. Offices in the switched digital network are grouped with one office in each group designated as the ‘‘master’’ office. The ‘‘master’’ office in each group is synchronized to the AT&T Reference Frequency (2.048 MHz) transmitted via dedicated L-Carrier facilities from Hillsboro, Missouri. The other offices in a group are synchronized and slaved to the ‘‘master’’ office via the serial pulse code modulated data (DS1 format) interface with the synchronization unit. This T1-Carrier facility interface may be either a direct trunk connection with the ‘‘master’’ office or via another office in the group served by the ‘‘master’’ office. The number of groups, the number of offices in a group, and the manner in which they interconnect for primary and alternate synchronization links are network engineered. Software monitors the performance of the synchronized network and reports any slips.

5.171 Also shown in Figure 11 are the power input requirements for the network clock frame. This frame requires +140 V, +24 V, and –24 V from the power distribution system. The 4ESS Switch power distribution is discussed later in this part.

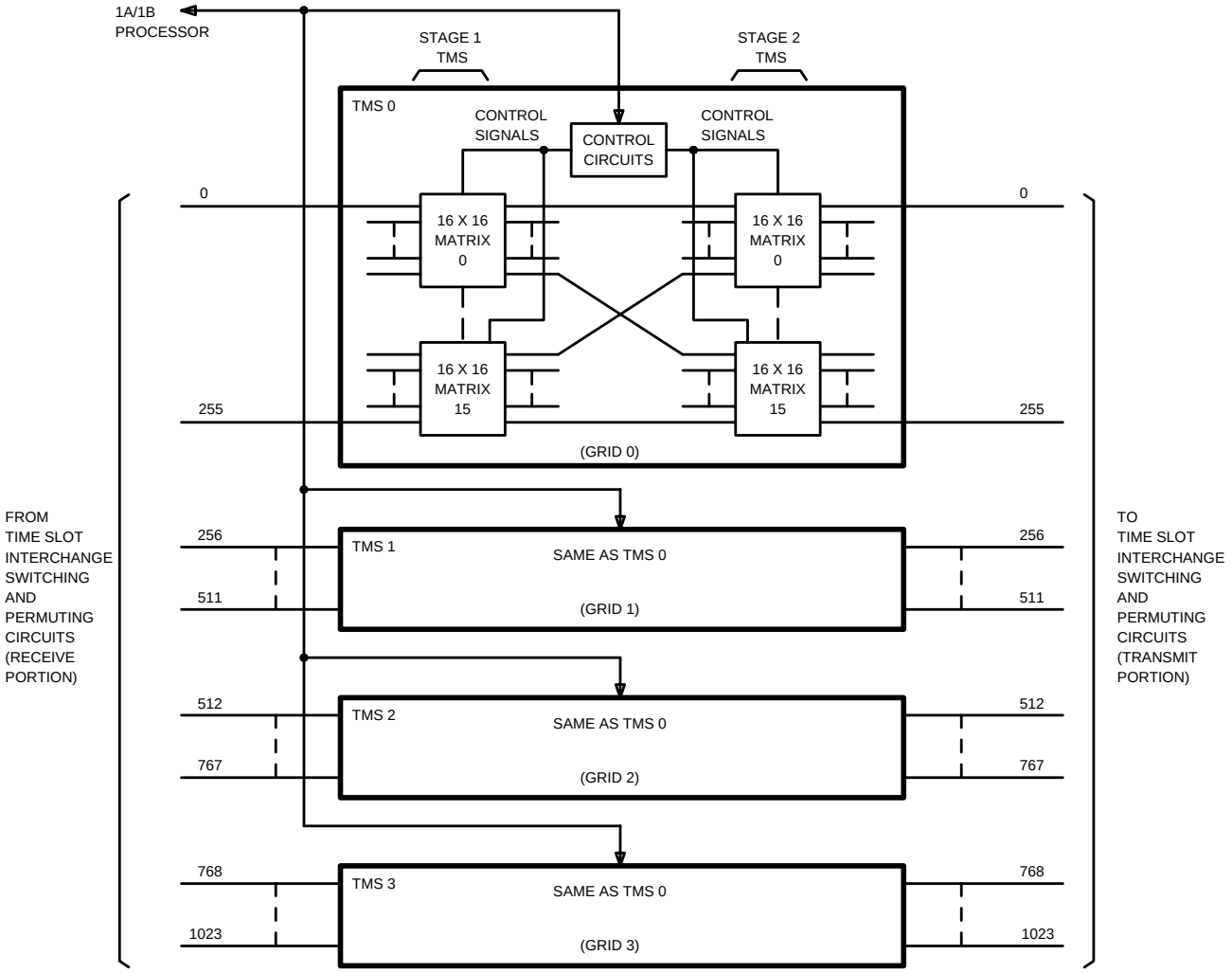


Figure 16. Time Multiplexed Switch (Fully Equipped)—Simplified Diagram

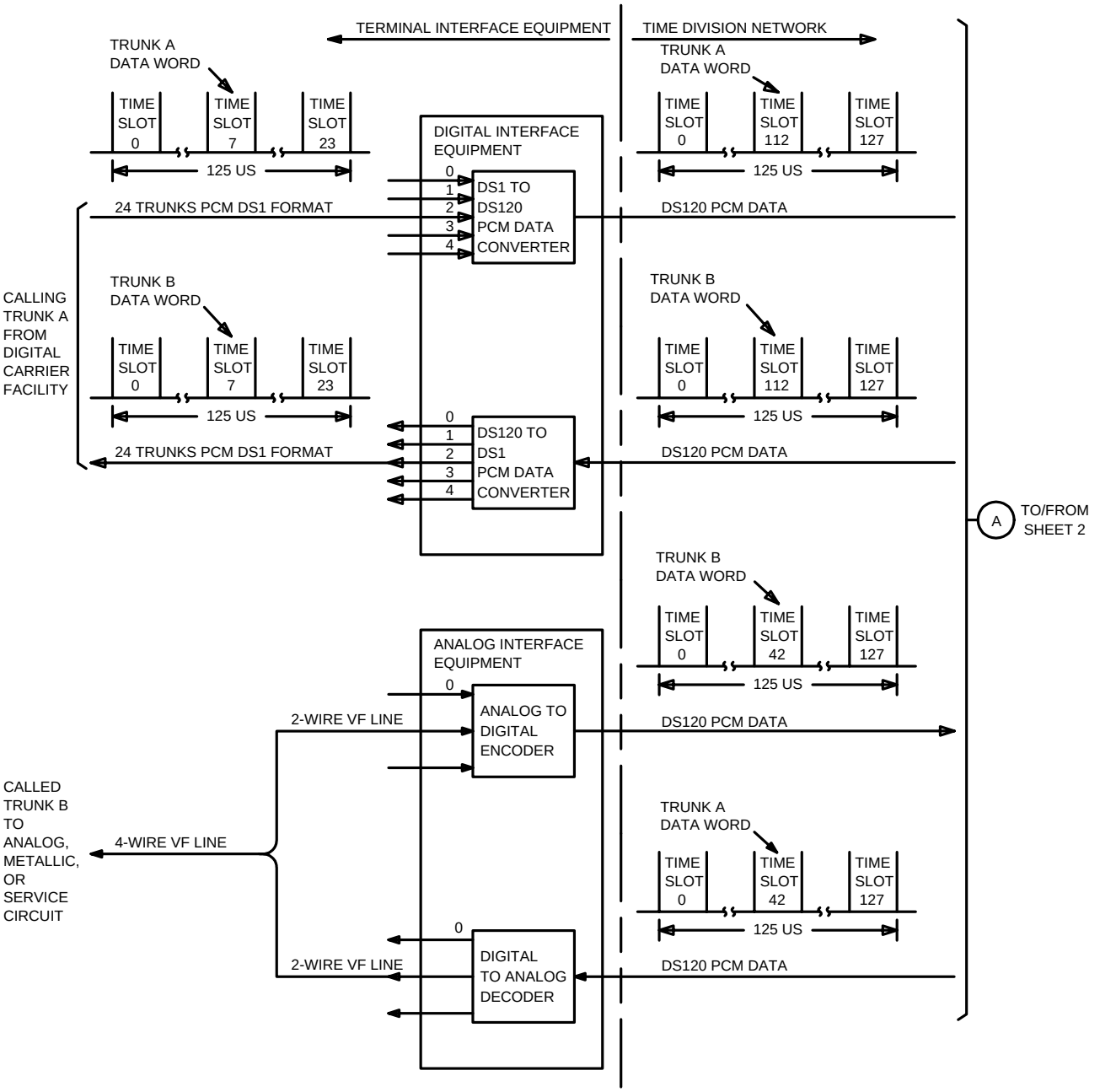


Figure 17. Time Division Switching—Simplified Diagram (Sheet 1 of 3)

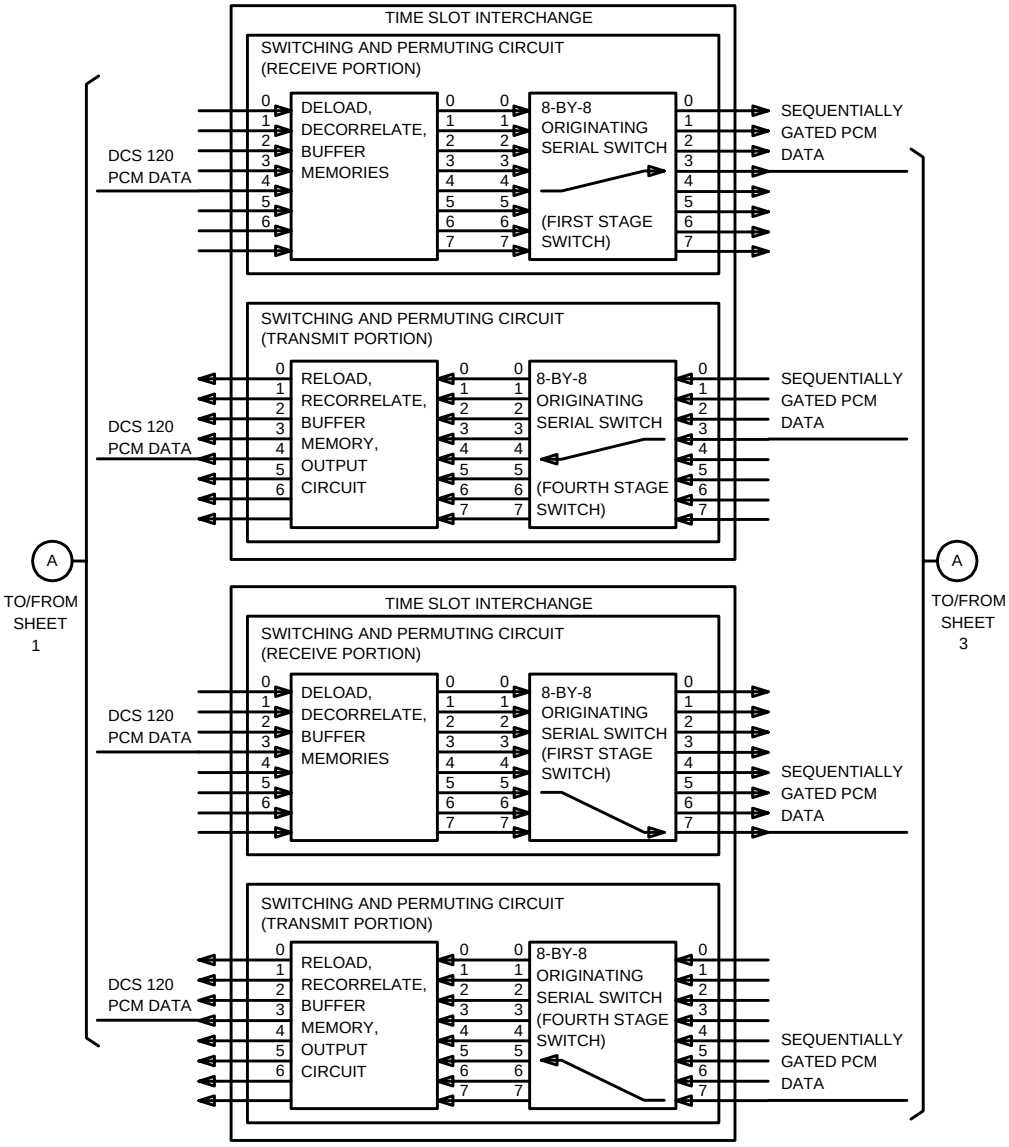
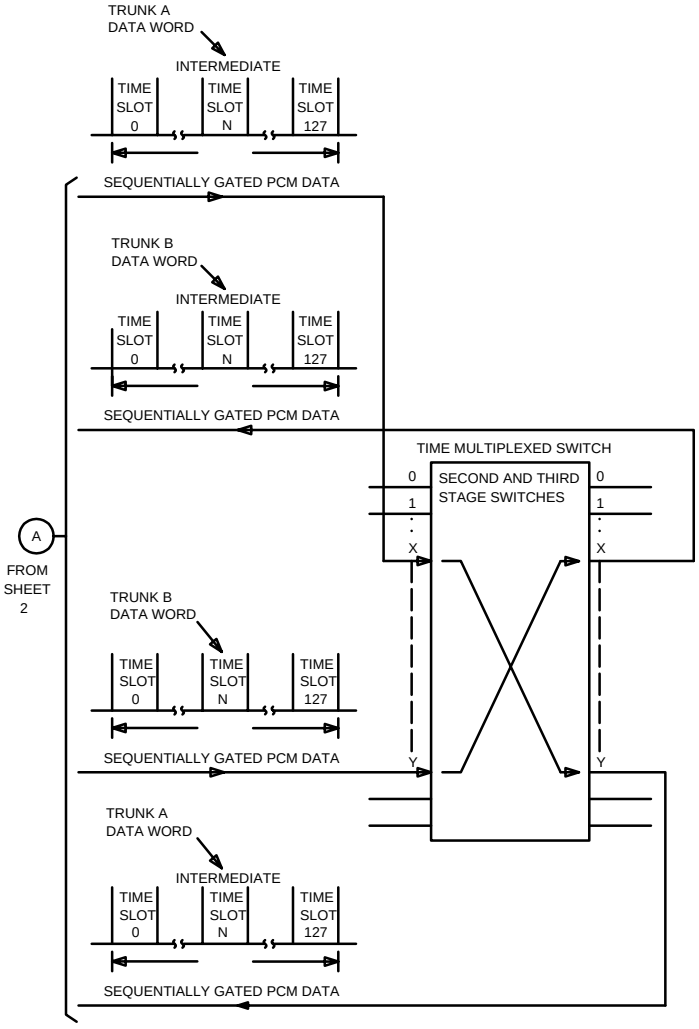


Figure 17. Time Division Switching—Simplified Diagram (Sheet 2 of 3)



NOTE:
TIME SLOT ASSIGNMENTS AND SWITCH LEVEL CONNECTIONS ARE ARBITRARY AND ARE ONLY INTENDED TO ILLUSTRATE GENERAL PROCEDURES AND NOT SPECIFIC DETAILS.

Figure 17. Time Division Switching—Simplified Diagram (Sheet 3 of 3)

Service Circuits and Trunk Test Facilities

5.172 The service circuits and trunk test facilities are as follows, discussed briefly in Part 3, and illustrated in Figures 1 and 18.

- Remote office test line frame
- Phased announcement system
- 820A Ringing, tone, and interrupter plant
- Multifrequency signaling frame
- Continuity check transceiver
- Digital interface frame DIF-E1 (MF) and DIF-E1 (DTMF)
- Service Circuit System (SCS)
- Remote Measurement System-D2 (RMS-D2).

5.173 The 4ESS Switch office equipment in this functional group provides tones, recorded announcements, signaling, and trunk test. With the exception of the SCS, DIF-E1 (MF), DIF-E1 (DTMF), and RMS-D2, all the equipment in this functional group interfaces with the voiceband interface or the D4 channel bank in the terminal interface equipment area. Through the terminal interface equipment, the service and trunk test equipment is connected to the switching network for application to various points throughout the office. The SCS, DIF-E1 MF, and DTMF service circuits interface the switching network directly via DS120 lines. The RMS-D2 interfaces the switching network via a DIF frame. The remote office test line frame is not required when the office is equipped with the RMS-D2 (4E10 generic program).

A. Multifrequency Signaling Frame [Discontinued Availability (DA)]

5.174 The multifrequency signaling frame is shown in Figure 18 as a single block.

The actual number of multifrequency signaling frames provided in a 4ESS Switch office is dependent on the number of multifrequency signaling trunks terminating at a 4ESS Switch office and the anticipated usage of these trunks.

5.175 Each frame can contain a maximum of 32 MF transmitters and 32 MF receivers. In addition, the first two multifrequency signaling frames provided in an office also contain MF signaling test units.

NOTE:
Each multifrequency signaling frame can be equipped with a terminal strip to which several common system frames connect. This terminal strip and the frame connectors are used to convert from point-to-point wiring provided in common system frames to connectorized cables which are used for voiceband interface, D4 channel bank, and signal processor connections. Common system frames which convert in this manner are the phased announcement system; 820A ringing, tone, and interrupter plant, and the remote office test line frame. In Figure 18, however, these frames are shown connecting directly to terminal interface equipment. As described in Part 3, a pseudo-multifrequency signal frame may be used solely for the conversion of point-to-point wiring.

5.176 Multifrequency receivers are used to detect signaling information for incoming calls on trunks employing multifrequency signaling. These units are also compatible with the multifrequency signaling used in conjunction with CCITT 5 signaling trunks in 4ESS Switch international switching centers. A receiver is connected to a specified trunk via the switching network. Incoming multifrequency signals are detected by the receiver, and the resulting digits are applied to the signal processor 1 or signal processor 2 via miscellaneous scan points.

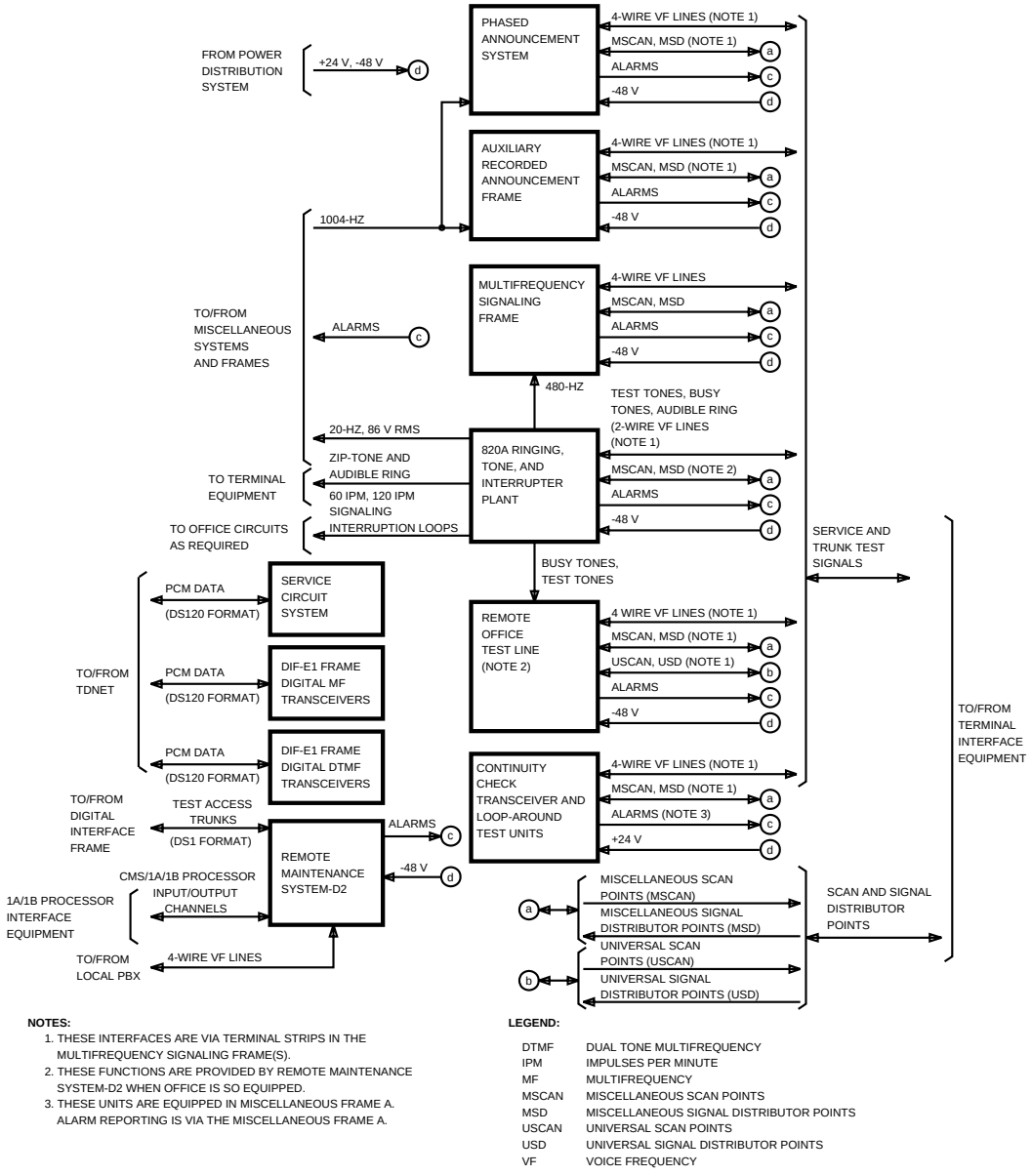


Figure 18. Service Circuits and Trunk Test Facilities—Functional Block Diagram

5.177 Multifrequency transmitters are used to outpulse multifrequency signaling information for outgoing calls on trunks employing multifrequency signaling. These units are also compatible with the multifrequency signaling used in conjunction with CCITT 5 signaling trunks in 4ESS Switch international switching centers. A transmitter is connected to a specified trunk via the switching network. Outgoing signaling information is applied to the transmitter by the signal processor 1 and/or signal processor 2 via miscellaneous signal distributor points.

5.178 Multifrequency signaling test units are provided to test the multifrequency receivers and transmitters. A test unit is connected to a specified receiver or transmitter through the switching network. Specific tests are initiated by the 1B Processor operating through a signal processor using miscellaneous signal distributor points. Test results are returned to the signal processor 1 and 1B Processor via miscellaneous scan points and the peripheral unit bus.

5.179 The 480-Hz signal applied to the multifrequency signaling frame is applied to tone-return circuits in the frame and is provided only in an office that is equipped to handle international calls. The tone-return circuits, controlled by the 1B Processor through the signal processor 1, send order tones to operators. These order tones advise the operators at non-TSPS locations to start the second stage of MF pulsing on international calls.

5.180 Also shown in Figure 18 are the power input requirements for a multifrequency signaling frame. Each frame requires –48 V from the power distribution system. The 4ESS Switch power distribution is discussed later in this part. The alarm and miscellaneous scan-point interface are for reporting hardware (fuse) failures to the office alarm system and software, respectively.

B. DIF-E1 (MF) and DIF-E1 (DTMF)

5.181 With 4E9 generic program, the DIF-E1 can be equipped with four multifrequency (MF) digital interface service units (DISUs) that provide a total of 64 MF service circuit trunk appearances directly to the switching network. This feature may be used to replace the analog MF transmitters and receivers, signal processor matrix, and associated analog-MF to digital-MF conversion. The E&M and per-channel inhibit signaling (PCIS) bits, normally used in the DIF-E1 with E&M and common channel signaling trunks, are used to control the digital MF transmitters and receivers. The MF DISUs are also designed to generate the 480-Hz operator tone source required for use on operator trunks.

5.182 With 4E10 generic program, the DIF-E1 can be equipped to support dual-tone multifrequency (DTMF) (touch-tone) signaling. The DTMF signaling ability is required to enable the 4ESS Switch to transmit and receive touch-tone addressing from Private Branch Exchanges (PBXs) on 4-wire E&M analog and direct T1 digital trunks. A DIF-E1 complex can be equipped with either the four MF DISUs, described in the previous paragraph, or with four DTMF DISUs. As with the MF DISUs, a DIF-E1 complex equipped with four DTMF DISUs provides 64 DTMF service circuit trunk appearances to the switching network. The DTMF DISU abilities include two-way wink-start addressing, generation of dial tone on nonwink-start trunks, and the reception of the full set of 16 DTMF digits.

C. Phased Announcement System

5.183 The phased announcement system (PAS) is a solid-state recorded announcement frame which provides the 4ESS Switch with a series of recorded announcements to be connected to incompleted calls. These announcements indicate why the call was not completed and what action should be taken. The PAS is comprised of two basic modules:

- Record module
- Playback module.

If the Service Circuit System (SCS) is available in 4ESS Switch offices equipped with the 4E17 or later generic program, the primary source for

announcements is the SCS; the PAS is the secondary source of announcements.

5.184 The three main functions of the PAS record module are to perform, supervise, and monitor a record session. The module consists of audio filtering, analog-to-digital conversion, and digital storage circuitry. It processes and supervises record sessions from either a dedicated telephone or from a tape recorder. The record sessions are digitized and processed for eventual storage in one of the playback modules. The record module communicates with the playback modules via I/O channels.

5.185 The PAS playback module contains the circuitry necessary to play back a single unique message/announcement. During playback, four phases of the announcement are transmitted to the switching network. Each playback module contains sufficient semiconductor memory for retaining 12 seconds of announcement and the circuitry for outputting four identical versions of the announcement preceded by 4 seconds of silence. The playback module communicates with the record module via I/O channels.

5.186 The recorded announcements are applied to either the voiceband interface for conversion to digital form and application to the switching network or to a D4 channel bank. When announcements are applied to a D4 channel bank, connection to the switching network is via either the digital interface or digroup terminal. Each message is also returned from the switching network and is applied to the phased announcement system. The frame monitors this signal to ensure adequate level signals are being applied to the network. Certain time division network equipment is dedicated for the specific purpose of multiplying the recorded announcements as required for connection to many different trunks simultaneously. This announcement fan-out procedure is described in the following paragraphs.

5.187 The phased announcement system has a miscellaneous signal distributor and scan point interface with the signal processor 1 or signal processor 2. These points are used to monitor operation of the system as well as individual recorded channels. Maintenance activities both on a frame level as well as on an individual channel basis are controlled by these points. The phased announcement system also receives a 1004-Hz signal from the miscellaneous systems and frames area. This signal is merely made available to operating personnel for testing activities at the frame.

5.188 The function of the phased announcement system is not critical to the operation of the 4ESS Switch office. Normally, there are no redundancy provisions to provide continuous service in the event of a phased announcement system failure. However, if desired, redundancy can be provided by including two separate phased announcement systems in an office.

5.189 Figure 19 illustrates the method involved in using the time division network in multiplying the recorded messages for simultaneous application to many trunks. This same procedure is used for multiplication fan-out of various tones generated by the ringing, tone, and interrupter plant and test tones originating from miscellaneous equipment. The following is a description of the processing of a single message or tone. In actual practice, this procedure occurs simultaneously for all messages and tones. As shown in Figure 19, a recorded announcement or tone is applied to an analog-to-digital converter in a voiceband interface unit. In offices equipped with a digital interface, a recorded announcement or tone is applied to the switching network via a D4 channel bank connection to either a digroup terminal or digital interface frame. The resulting output is applied to a time slot interchange switching and permuting circuit, receive, and is processed in a manner identical to that described earlier.

5.190 The receive portion output of the switching and permuting circuit is applied to the time multiplexed switch. The time multiplexed switch connects this signal over a semipermanent or ‘‘nailed-up’’ connection in order to continuously apply the signal to the transmit portion of a unique switching and permuting circuit. Electrically, this switching and permuting circuit is identical to all

others. What makes it unique is its functional application within the system. This switching and permuting circuit is dedicated to the task of multiplying recorded announcements and tones and receives unique instructions from the 1B Processor.

5.191 The recorded announcement or tone data word is applied to the 8-by-8 switch in the transmit portion of the dedicated time slot interchange. This switch and associated output C buffer memories (Figure 15) are configured by the 1B Processor so that the data word is written into a location in each of the eight C buffer memories. After reloading and recorrelating, the data word appears in eight consecutive time slots on one of the seven output cables. These output cables are directly connected to the seven inputs of the receive portion of the dedicated switching and permuting circuit. In the receive portion of the dedicated switching and permuting circuit, the eight copies of the message word are deloaded and decorrelated (Figure 15) and applied to the output B-buffer memories. At this point, a copy of the message word is written into one location in each of the eight output buffer B memories. As directed by the 1B Processor, the receive circuit can output this word during any one or as many as 120 time slots on any one or all eight outputs of the 8-by-8 switch.

5.192 The outputs of the dedicated receive circuit are applied to the time multiplexed switch. As directed by the 1B Processor, one message data word is connected through a semipermanent ‘‘nailed-up’’ connection back to a transmit switching and permuting circuit and voiceband interface unit for application to the originating frame. The phased announcement system and ringing, tone, and interrupter plant monitor appropriate signals to ensure that they are available to the network.

5.193 Additional message data words are connected through the time multiplexed switch via normal switched connections for application to toll trunks as required. This multiplication technique enables over 800 toll trunks to be simultaneously connected to a given message or mix of messages—one message per trunk.

5.194 Also shown in Figure 18 are the power input requirements for a phased announcement system. Each frame requires -48 V from the power distribution system. The 4ESS Switch power distribution is discussed later in this part. The alarm and a miscellaneous scan point interface are for reporting hardware (fuse) failures to the office alarm system and software, respectively.

D. 820A Ringing, Tone, and Interrupter Plant

5.195 The ringing, tone, and interrupter plant provides the 4ESS Switch office with various ringing, tone, and interrupt signals. These signals consist of audible ringing signals, 60- and 120-interrupts-per-minute busy or reorder tones, a 1004-Hz test tone, and a 2225-Hz test progress tone. These tones are applied to the switching network via the voiceband interface frame. The switching network, as directed by the 1B Processor, connects tones to appropriate trunks as required. The switching network also multiplies, fans out, the tones so that they can be applied to a large number of trunks when required. This procedure is identical to that employed for the recorded announcement frame previously discussed. The switching network and terminal interface equipment are employed to return the individual tones to the ringing and tone plant. These signals are monitored to ensure adequate signal level tones are available.

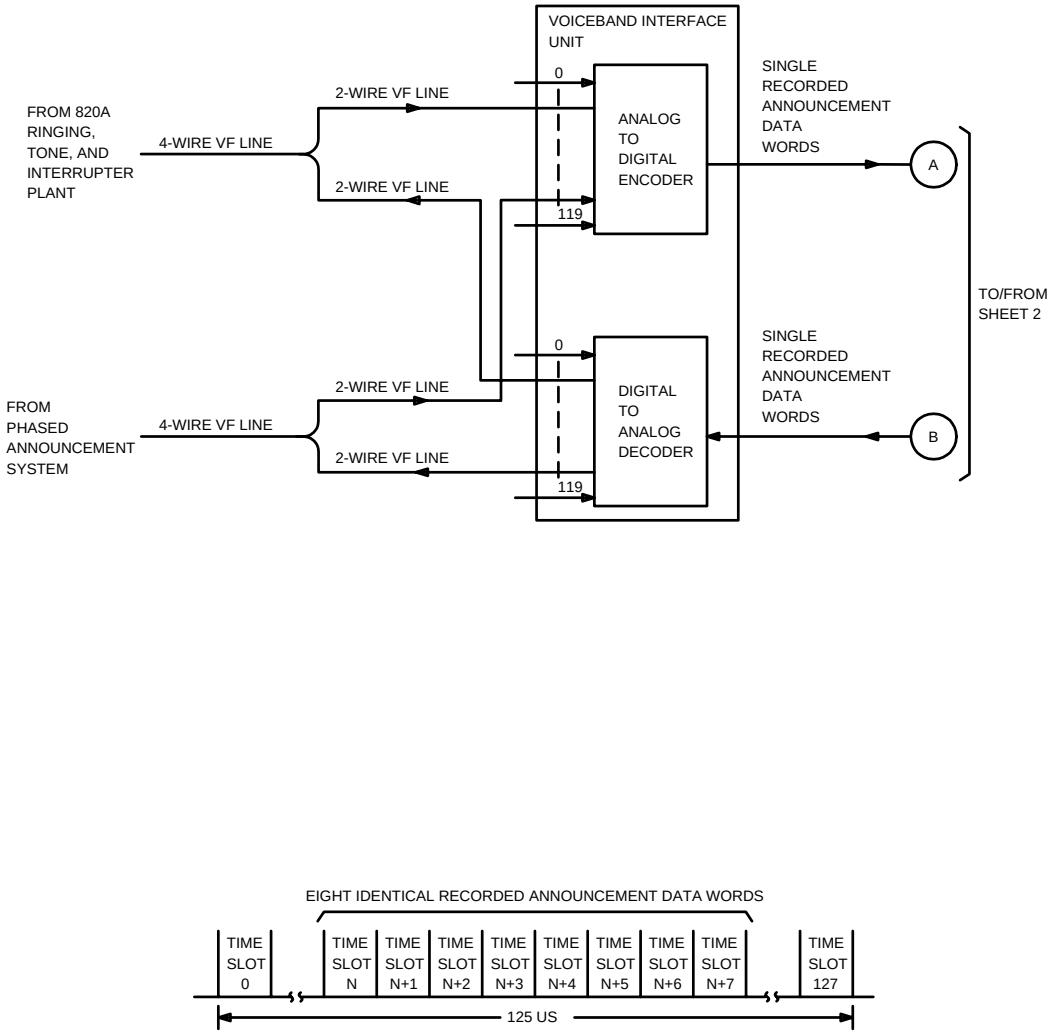


Figure 19. Recorded Announcement Distribution—Simplified Diagram (Sheet 1 of 4)

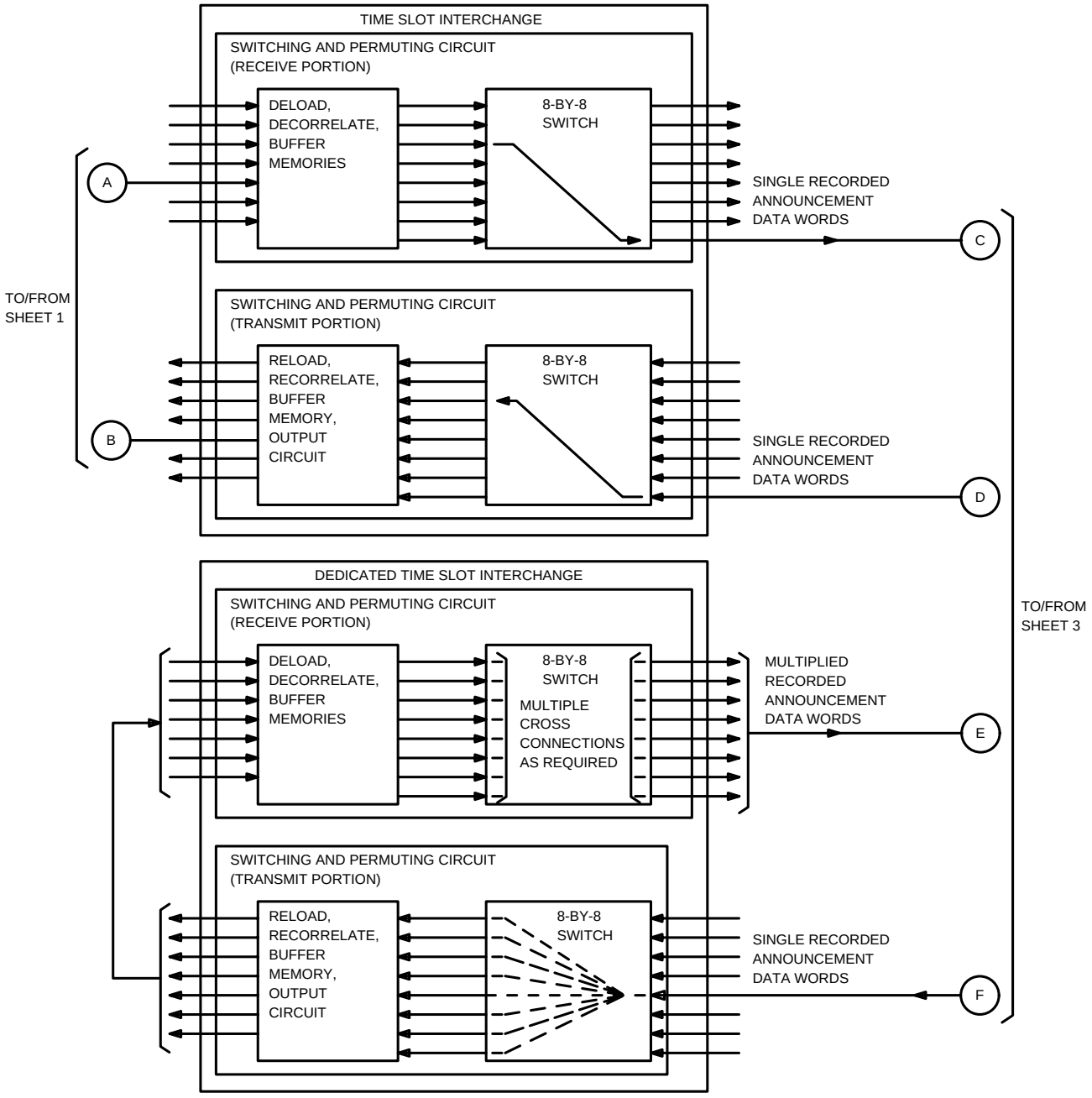


Figure 19. Recorded Announcement Distribution— Simplified Diagram (Sheet 2 of 4)

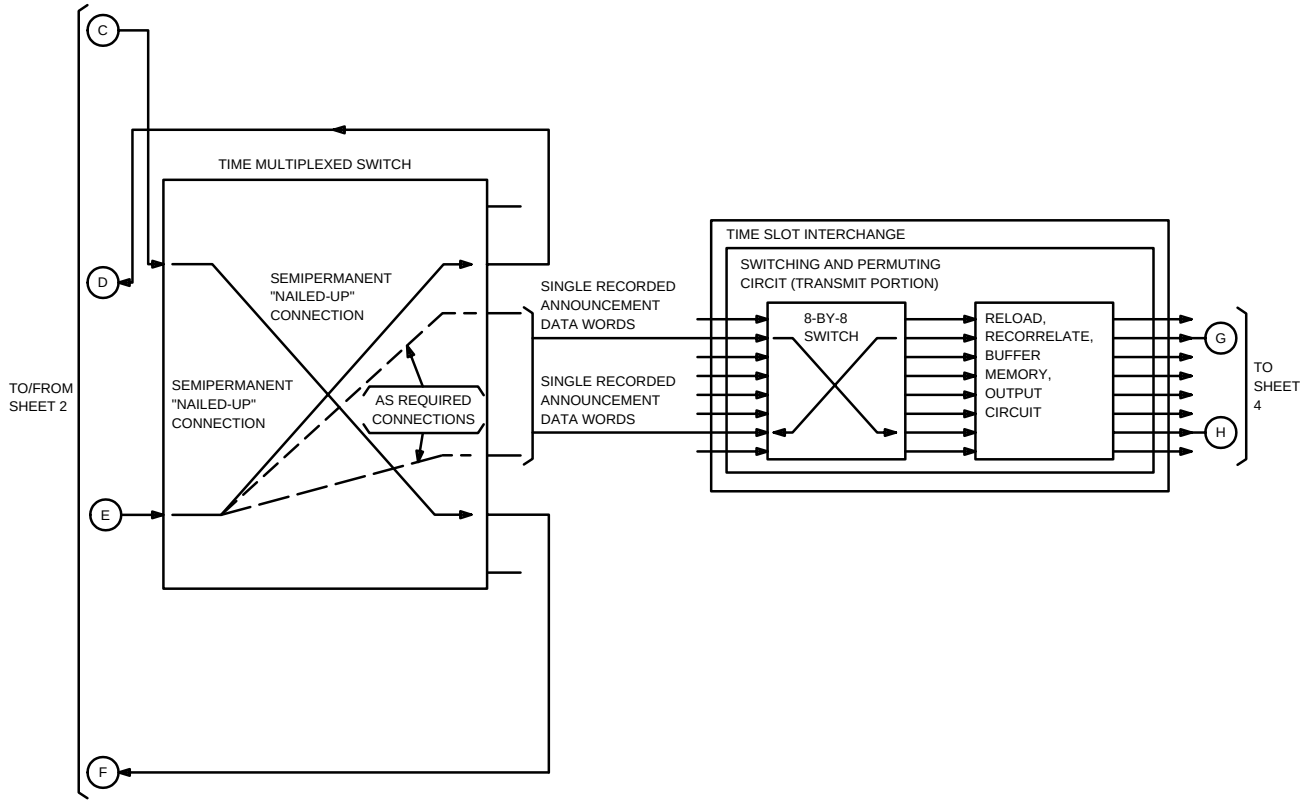


Figure 19. Recorded Announcement Distribution— Simplified Diagram (Sheet 3 of 4)

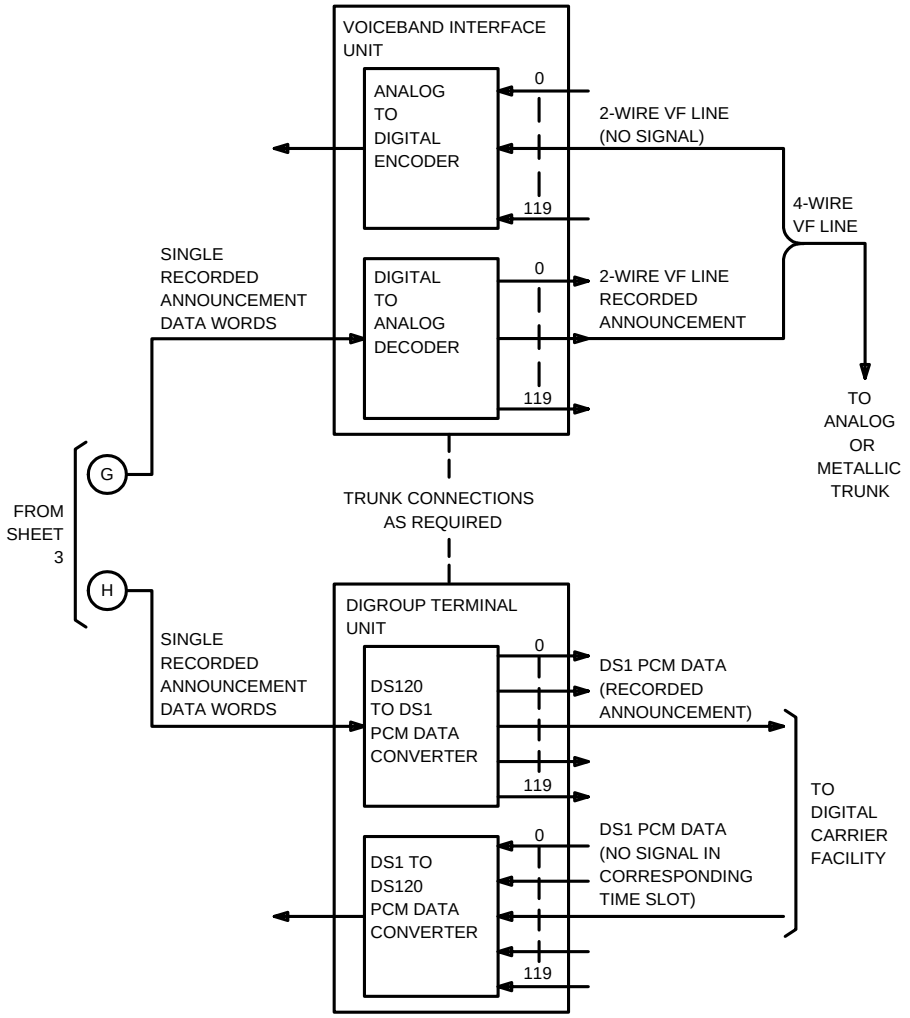


Figure 19. Recorded Announcement Distribution— Simplified Diagram (Sheet 4 of 4)

5.196 The ringing, tone, and interrupter plant also provides 60- and 120-interrupts-per-minute loops for use by equipment external to the 4ESS Switch. The following is also provided by the tone plant:

- A 20-Hz signal to the office alarm system to operate audible alarms
- A 480-Hz signal to the multifrequency signaling frame for use in international calling
- A zip-tone signal which is applied to metallic and auxiliary metallic circuits for use in operator signaling.

5.197 The tone plant also interfaces with the signal processor 1 or signal processor 2 via miscellaneous signal distributor and scan points. Scan points are used to apply alarm indications to the 1B Processor via the signal processor 1 or 2. Signal distributor points enable the 1B Processor to initiate internal frame tests. Hardware (fuse) failures are reported to the office alarm system via the alarm interface shown in Figure 18.

5.198 Also shown in Figure 18 are the power input requirements for the 820A ringing, tone, and interrupter plant. The frame requires –48 V from the power distribution system. The 4ESS Switch power distribution is discussed later in this part.

E. Remote Office Test Line Frame

5.199 When equipped with 4E10 or later generic programs, the 4ESS Switch may be equipped with the Remote Measurement System-D2 (RMS-D2). This trunk test and measurement system provides all the functions of the remote office test line (ROTL) frame described in the following paragraphs. The ROTL frame provides access for either the Centralized Automatic Reporting on Trunks (CAROT) 2 System or a remote manual location to conduct transmission tests on trunks connected to the 4ESS Switch office. These transmission tests may be implemented only on domestic trunks or international trunks using R1-type signaling. The ROTL frame (Figure 18) may also provide 105-type test line features for termination of test calls originating at other offices. The ROTL frame is provided with 4-wire trunk appearances through its connection with the terminal interface equipment. Remote locations access the 105-type test line responder unit in the ROTL frame via toll trunks and the switching network. The 1B Processor connects trunks awaiting 105-type test line responder unit access to a test progress tone. As these trunks are connected to the responder unit for testing, the 1B Processor removes the test progress tone. The ROTL and 105- type test line are controlled by 1B Processor software. This software is discussed in Part 8 and Part 9.

5.200 The ROTL frame receives various busy and test tones from the ringing, tone, and interrupter plant. The ROTL frame applies these signals as directed to the trunk under test. The 1B Processor can control the configuration of the ROTL and can control certain trunk tests through the use of signal processor 1 or signal processor 2 signal distributor points. The 1B Processor can also monitor operating status of the ROTL and can monitor test results through signal processor 1 or 2 scan points.

5.201 Also shown in Figure 18 are the power input requirements for a ROTL frame. The ROTL frame requires –48 V from the power distribution system. The 4ESS Switch power distribution is discussed later in this part. The alarm and a miscellaneous scan point interface are used to report hardware (fuse) failures to the office alarm system and software, respectively.

F. Continuity Check Transceiver

5.202 The continuity check transceiver unit is shown as a single block in Figure 18. In actual practice, there may be as many as 40 continuity check transceivers equipped as part of miscellaneous frame A. Up to 192 additional continuity check transceiver circuits (16 CCT units) can be provided in miscellaneous frame C if more capacity is required. Prior to each call, the transceivers are used to check the continuity and signal loss of message trunks employing CCS to determine their acceptability for voice

communication between two offices. The continuity tests are required because the signaling information for CCS trunks is separate from the message trunks. Therefore, conventional signal exchanges do not verify the acceptability of the common channel signaling message trunk prior to its use as a talking path. Continuity checks are made on trunks employing CCS for outgoing calls only. On 4-wire trunks, continuity checks consist of transmitting a fixed level 2010-Hz tone on a trunk and detecting the tone on the return path of the trunk which has been looped at the far end. On 2-wire trunks, continuity checks consist of transmitting a fixed level 1780-Hz tone on a trunk. A CCT connected to the trunk at the far end returns a 2010-Hz signal upon receipt of the 1780-Hz tone. Upon receipt of the returned 2010-Hz signal, the originating office performs various level checks to verify trunk acceptability. A trunk is considered acceptable when the loss of the looped trunk is within specified limits.

5.203 The CCTs are connected to trunks through the switching network as needed. The tests are controlled by and results returned to the 1B Processor via the miscellaneous signal distributor and scan point interface with the SP1 or SP2. Trunks handling incoming CCS traffic are tested using continuity check transceivers at the far-end office. The near-end office loops the 4-wire trunk to support the test.

5.204 Also shown in Figure 18 are the power input requirements for the continuity check transceiver units. As noted in Figure 18, this equipment is mounted in miscellaneous frame A. Each unit requires +24 V from the power distribution system. Alarm reporting is via the miscellaneous frame A. Any additional CCT units require the same interfaces; however, these interfaces are office engineered. The 4ESS Switch power distribution is discussed later in this part.

G. Digital Interface-E1 (MF)

5.205 With 4E9 generic program, the DIF-E1 can be equipped with four multifrequency (MF) digital interface service units (DISUs) that provide a total of 64 MF service circuit trunk appearances directly to the switching network. This feature may be used to replace the analog MF transmitters and receivers, signal processor matrix, and associated analog-MF to digital-MF conversion. The E&M and per-channel inhibit signaling (PCIS) bits, normally used in the DIF-E1 with E&M and common channel signaling trunks, are used to control the digital MF transmitters and receivers. The MF DISUs are also designed to generate the 480-Hz operator tone source required for use on operator trunks.

H. Digital Interface-E1 (DTMF)

5.206 With 4E10 generic program, the DIF-E1 can be equipped to support dual-tone multifrequency (DTMF), touch-tone, signaling and special-services signaling features. The DTMF signaling ability is required to enable the 4ESS Switch to transmit and receive touch-tone addressing from Private Branch Exchanges (PBXs) on 4-wire E&M analog and direct T1 digital trunks. A DIF-E1 complex can be equipped with either the four MF DISUs, described in the previous paragraph, or with four DTMF DISUs. As with the MF DISUs, a DIF-E1 complex equipped with four DTMF DISUs provides 64 DTMF service circuit trunk appearances to the switching network. The DTMF DISU abilities include two-way wink-start addressing, generation of dial tone on nonwink-start trunks, and the reception of the full set of 16 DTMF digits.

I. Remote Measurement System-D2

5.207 The 4E10 generic program supports the replacement of the existing analog trunk test equipment, 51A test positions and ROTL frames,

with the Remote Measurement System-D2 (RMS-D2). The RMS-D2 is a self-diagnosing, modularly incremental digital test system. It is designed to serve as the primary trunk transmission measurement unit for the 4ESS Switch. The RMS-D2 uses T1 digital trunks to interface the 4ESS Switch and digital signal processing techniques to perform a wide variety of transmission and signaling tests on analog and digital trunks. Communications between the RMS -D2 and the 1B Processor is provided by a 4800-baud input/output channel data link.

5.208 The RMS-D2 provides support of installation and maintenance testing of 4ESS Switch trunks for users physically remote from the circuit under test through digital and diagnostic access. These abilities may be invoked via intelligent terminal systems such as the central trunk test unit (CTTU) and centralized automatic reporting on trunks (CAROT) at network maintenance centers and the ConnectVu/CMS or TOPAS trunk operations center. The RMS-D2 also provides local digital and analog test access for portable test equipment.

5.209 The 4ESS Switch office is equipped with two RMS-D2 digital test units. Physically, the RMS-D2 is a stand-alone unit and is installed in the office as a factory-wired and tested frame. A small PBX is also required to interface a voiceband link between the RMS-D2 and trunk work stations and/or other dial-in users. The PBX provides the call setup and conferencing abilities needed to support the voice frequency testing and control features invoked at the RMS-D2 by the trunk work stations or dial-in users. Data terminals serving the trunk work station are connected to the ConnectVu/CMS or TOPAS. Via separate data links, the ConnectVu/CMS or TOPAS interfaces the RMS-D2 equipment and the 1B Processor.

J. Service Circuit System

5.210 With the 4E17 generic program, the service circuit system (SCS) enhances the 4ESS Switch abilities to provide announcements and tones and collect call information. The SCS allows the 4ESS Switch to play announcements to the calling party and the called party in addition to collecting information from both parties. The optional ASR feature available with the 4E20 generic program enhances the information collection function by allowing speech recognition capabilities to interact with a call instead of digits entered by using the telephone keypad. The SCS hardware includes three major unit types and the optional ARS units:

1. The duplexed SCC that connects to each SCU over an optical EB
2. The Service Circuit Unit (SCU)
3. The Hard Disk Unit (HDU).
4. The Custom Data Services Unit (CDSU) that allows speech recognition capabilities for the SCU DS-120 channels.

Service Circuit Controller (SCC)

5.211 The SCC sends messages between the 1B Processor and the SCU by translating these messages from one format to another and manipulating control registers. Each duplex SCC supports a maximum of 16 SCUs.

Service Circuit Unit (SCU)

5.212 The SCU processor receives and decodes messages from the SCC and manipulates control registers to play announcements and tones and to collect information. A bidirectional DS120 link allows each SCU to interface the 4ESS Switch switching network.

Custom Data Services Unit (CDSU)

5.213 The CDSU performs special signal processing functions to allow automatic speech recognition (ASR) for 24 channels. Two DS 1 links from each CDSU connect to the SCU.

Miscellaneous Systems and Frames

5.214 Miscellaneous systems and frames (Figure 20) provide various abilities required to operate a 4ESS Switch office. Equipment and systems included in this equipment group are not

functionally related to each other or other 4ESS Switch equipment areas. Their functions, however, are vital to office operation. Of all the various equipment included in this category, the input/output system, office communications system, miscellaneous frame A, and miscellaneous frame B are not shown in Figure 20. This equipment is, however, discussed in the following paragraphs.

A. Input/Output System

5.215 The overall input/output system for a 4ESS Switch includes the input/output system abilities of the 1B Processor, 3B Computer, Circuit Maintenance System (CMS), Testing, Operations, Provisioning, and Administration System (TOPAS), and any other interfacing systems and centers, as applicable. The overall input/output abilities of a 4ESS Switch provide the primary means of transferring administrative, maintenance, and control data between a central processor and either input/output devices—in the case of person-machine interfaces—or other central processors—in the case of machine-to-machine interfaces. The input/output system is thus the primary means of implementing administration, maintenance, and control functions for the 4ESS Switch from a number of decentralized and/or centralized work centers. The input/output interfaces associated with a 4ESS Switch office are identified in Figure 1.

5.216 The primary input/output system of a 4ESS Switch office is the 1B Processor input/output system. Another input/output system is provided by the 3B Computer. The 1B Processor and 3B Computer input/output systems are completely independent. The administration, maintenance, and control of each of these two processors is provided on a stand-alone basis. A collocated or remote ConnectVu/CMS or TOPAS is also required to support the administration and maintenance of all 4ESS Switch interoffice trunks. The input/output facilities of the ConnectVu/CMS or TOPAS processor are interfaced to the 1B Processor and to input/output devices located in specific 4ESS Switch work centers.

5.217 The external centers and systems interface with a 4ESS Switch via certain 1B Processor and ConnectVu/CMS or TOPAS input/output channels. These external centers and systems are identified and briefly discussed in Part 9. Refer to 234-100-021, *Input/Output System Description,* for more specific information on the overall 4ESS Switch input/output system.

B. Office Alarm System

5.218 The office alarm system provides audible and visual alarms to alert operating personnel when various fault conditions are detected in the 4 ESS Switch equipment frames. Building alarms can also be applied to the office alarm system. The office alarm system also can selectively accept and/or transfer alarm signals from or to alarm systems outside the 4ESS Switch office. This remote alarm transfer is implemented by the 1B Processor via signal processor 1 miscellaneous signal distributor points. The function is controlled by a switch on the master control console.

5.219 A 4ESS Switch office is divided into a number of alarm grid areas, 15 is maximum. Various work centers are assigned monitoring responsibility for the alarm grid areas. Actual equipment included in an alarm grid and the specific work center assigned the monitoring responsibility are defined in general terms. However, a degree of flexibility is permitted during office design. Equipment alarm signals are routed from each equipment frame to an appropriate alarm grid in the office alarm system. These alarm signals, referred to as hardware alarms, are directly related to power conditions (see Power and Power-Related Alarm Circuits later in this part). Receipt of an alarm signal causes an appropriate audible and/or visual alarm to be activated. The 1B Processor is notified of alarm conditions over a miscellaneous scan point interface through the signal processor 1 or signal processor 2. As directed by control software, the 1B Processor analyzes these alarm indications. The 1B Processor causes detailed messages relevant to the alarm condition to be output at the assigned work center. Additional miscellaneous scan points

relating to equipment malfunctions are applied to the signal processor 1 or signal processor 2 directly from the various 4ESS Switch equipment frames. This type alarm is referred to as a software alarm. Upon detection of such an alarm condition, the 1B Processor outputs detailed messages at the responsible work center. When appropriate, the 1B Processor signals the office alarm system through signal processor 1 miscellaneous signal distributor points to actuate audible and/or visual alarms.

5.220 The office alarm system receives a 20-Hz 86 V RMS signal from the ringing, tone, and interrupter plant. The signal is used to drive audible alarms associated with the office alarm system.

5.221 Also shown in Figure 20 are the input power requirements for the office alarm system. The office alarm system requires –48 V from the power distribution system. As noted in Figure 20, power and alarm interfaces are via miscellaneous frame A. The 4ESS Switch power distribution is discussed later in this part.

C. Office Communication Facilities

5.222 The office communication facilities provide a means of voice communication within the 4ESS Switch office and with distant offices. The office communication facilities also provide several points of access to the input/output system via the belt-line input/output channels. These access points are provided for use by mobile input/output terminals which are part of the Terminal Equipment Center function. The office communications system consists of the following:

- Conventional telephone facilities
- Dedicated lines (order wires and ringdown trunks) within the office or to external offices
- Tandem access trunks
- Frame-to-frame, voice-communications circuits
- Data communication circuits routed to various 4ESS Switch equipment frames which provide belt-line remote access to the input/output system.

5.223 Conventional telephone facilities are provided on the unitized terminal equipment, metallic terminal frame, and trunk test positions in addition to consoles throughout the office.

D. Miscellaneous Frame A

5.224 This frame is not directly shown in Figures 1 and 20. Frame A contains the continuity check transceivers and frame-mounted equipment required to support one alarm grid of the office alarm system. The continuity check transceivers and the office alarm system are shown in Figure 20. Miscellaneous frame A also contains an AC power distribution unit. See Part 5.

E. Miscellaneous Frame B

5.225 This frame (not directly shown in Figures 1 and 20) is part of the office alarm system, Figure 20. Frame B contains frame-mounted equipment required to support one or two alarm grids of the office alarm system.

F. Miscellaneous Frame C

5.226 Miscellaneous frame C (not shown in Figures 1 and 20) contains CCTs which are covered as part of the service circuit and trunk test facilities equipment group.

G. Miscellaneous Trunk Test and Support Equipment

5.227 Miscellaneous trunk test and support equipment is provided as required to support a variety of miscellaneous functions. The equipment which comprise this category is shown in Figure 20. Additional miscellaneous trunk test and support equipment, discussed in Part 6, is required to support the 51A L6 test position in international switching centers.

5.228 Also shown in Figure 20 are the power input requirements and alarm interface for the miscellaneous trunk test and support equipment. The alarm and associated miscellaneous scan point interfaces, Figure 20, are office-dependent.

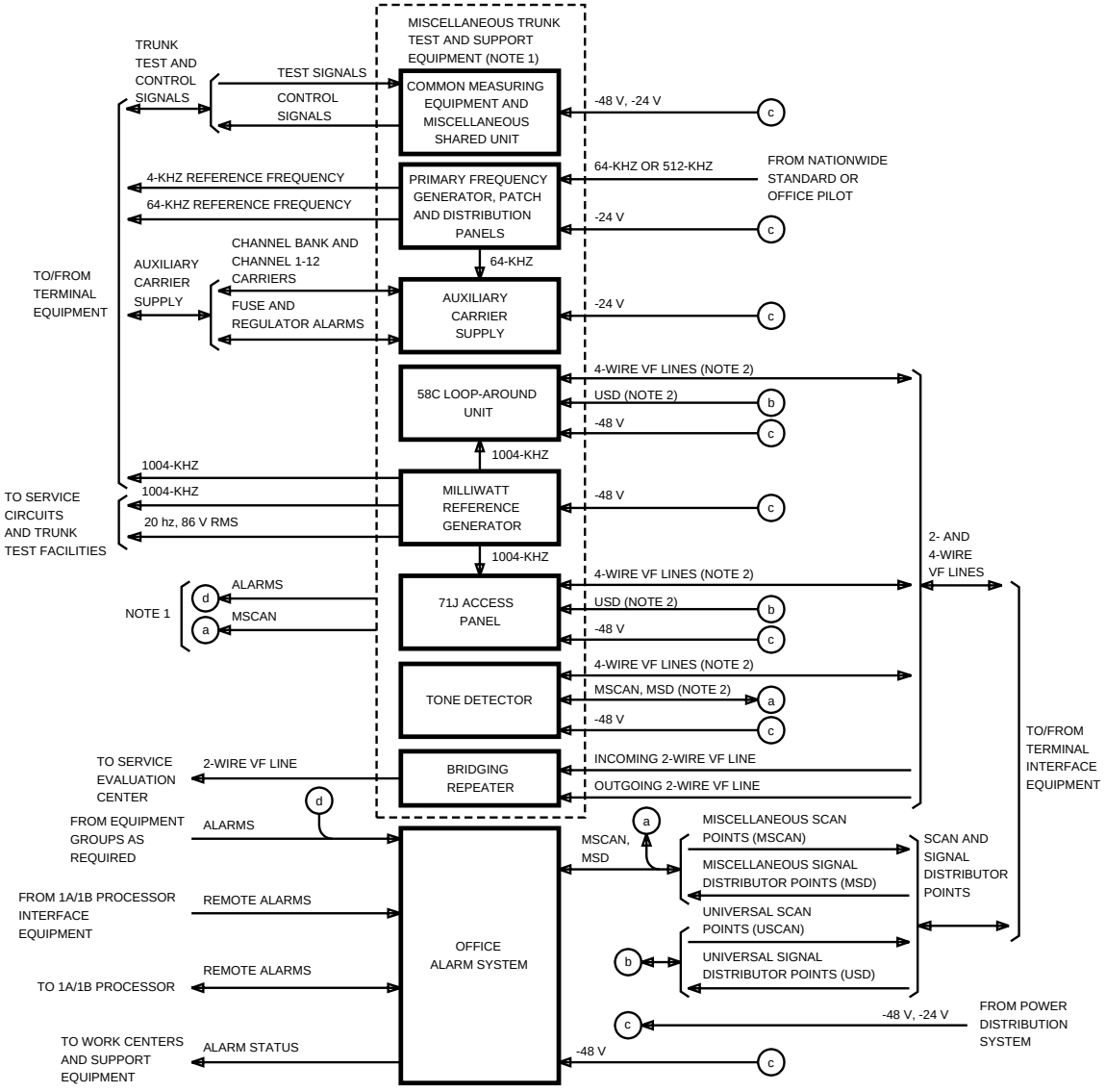


Figure 20. Miscellaneous Systems and Frames—Functional Block Diagram (Sheet 1 of 2)

LEGEND:

MSCAN - MISCELLANEOUS SCANPOINTS
MSD - MISCELLANEOUS SIGNAL DISTRIBUTOR POINTS
USCAN - UNIVERSAL SCAN POINTS
USD - UNIVERSAL SIGNAL DISTRIBUTOR POINTS
VF - VOICE FREQUENCY

NOTES:

1. THIS EQUIPMENT IS MOUNTED IN AN OFFICE ENGINEERED MISCELLANEOUS FRAME(S). OFFICE ALARM AND ASSOCIATED MISCELLANEOUS SCAN POINT INTERFACES ARE OFFICE DEPENDENT.
2. THESE INTERFACES ARE VIA TERMINAL STRIPS IN THE MULTIFREQUENCY SIGNALING FRAME(S).

Figure 20. Miscellaneous Systems and Frames—Functional Block Diagram (Sheet 2 of 2)

Primary Frequency Generator, Patch, and Distribution Panels

5.229 The primary frequency generator provides a 64-kHz signal to the unitized terminal equipment and auxiliary carrier supply, when provided. This 64-kHz signal is used in the generation of signals required to process analog carrier signals. The primary frequency generator also outputs 4-, 128-, and 512-kHz signals. These signals are terminated or are used for various office-dependent purposes. The primary frequency generator is synchronized to a 64- or 512-kHz reference supplied from a national or office-frequency standard. A series of patch and distributor panels make various output signals available for permanent or temporary connection, as required. These panels also maintain specified signal levels and provide impedance matching.

Auxiliary Carrier Supply

5.230 This carrier supply is provided, in certain instances, to backup the carrier supply in the A6 unitized terminal equipment frames.

Common Measuring Equipment and Miscellaneous Shared Unit

5.231 Common measuring equipment and miscellaneous shared unit are provided to monitor certain signals used in the conversion of analog carrier signals in the unitized terminal equipment frames. The parameters—frequency, signal level, noise level—of signals monitored are presented on visual displays located in the office.

Milliwatt Reference Generator

5.232 The milliwatt reference generator provides fixed level 1004-Hz test tones for use throughout the 4ESS Switch office. Various applications of these test tones are covered in destination equipment discussions.

71J Access Panel

5.233 The 71J access panel provides a means of attenuating a 1004-Hz test tone which is applied to the switching network for the purpose of providing a test tone to trunks. The 1004-Hz signal is obtained from either of two milliwatt reference

generators. The selected 1004-Hz signal can be applied to the switching network through either of two access panel attenuator networks. A universal signal distributor point applied from the signal processor 1 selects the network from which the test tone is obtained. The switching network multiplies the test tone so that it can be applied to a large number of trunks when required. The procedure involved is identical to that employed for the recorded announcement frame. One of the multiplied test tones available at the output of the switching network is returned to the access panel for monitoring purposes [similar to recorded announcement frame (Figure 19)].

58C Loop-Around Unit

5.234 The 58C loop-around unit (part of the 108-type test line) is to support other echo suppressor measuring system equipment which is located in other switching offices. The loop-around unit is applied to the switching network through the voiceband interface. Through the switching network, this unit can connect a test facility trunk to a trunk to be tested from a far-end office. The loop-around unit can also connect a 1004-Hz test tone to the trunk under test and can perform certain filtering operations. These functions are controlled by the 1B Processor through the signal processor 1 universal signal distributor interface.

Tone Detector

5.235 This common systems tone detector is to support various operational test activities originating within the office or from a far-end office. The tone detector is connected to trunks under test through the voiceband interface and the switching network. The tone detector is controlled by the 1B Processor through a signal processor 1 or signal processor 2 miscellaneous signal distributor point interface. The results of various tone monitoring activities are returned to the 1B Processor over a miscellaneous scan point interface.

Bridging Repeater

5.236 A three-way, 4-wire bridging repeater provides a means for the Service Evaluation System to monitor calls being processed by the 4ESS Switch. The bridging repeater presents two trunk circuits to the switching network. These trunk circuits are connected to the incoming and outgoing trunk talking paths of a selected call. Through the bridging repeater, they provide listen-only capability to selected calls. The output of the bridging repeater is connected to a private line transmission facility leading to the remote Service Evaluation System (Part 9).

Work Centers and Support Equipment

5.237 As discussed in Part 3, work centers are provided as the primary means of defining and performing activities involved with the operation, maintenance, and administration of a 4ESS Switch office. Various control and maintenance activities coordinated and performed through 4ESS Switch work centers are based on system software-defined, I/O channels. In addition to I/O terminals, some work centers contain consoles or other display equipment that provide a one- or two-way interface with the system. The functions monitored and controlled by this equipment are related to the software-controlled functions of the input/output channels assigned to the corresponding work center.

5.238 These descriptions are typical and may differ, for the reasons explained in Part 3, from the actual work centers encountered in an office. Figures 1 and 21 are based on the 4ESS Switch work centers defined in Part 3.

5.239 Work centers are directly involved in all maintenance activities. Part 9 contains additional work center information directly related to maintenance activities.

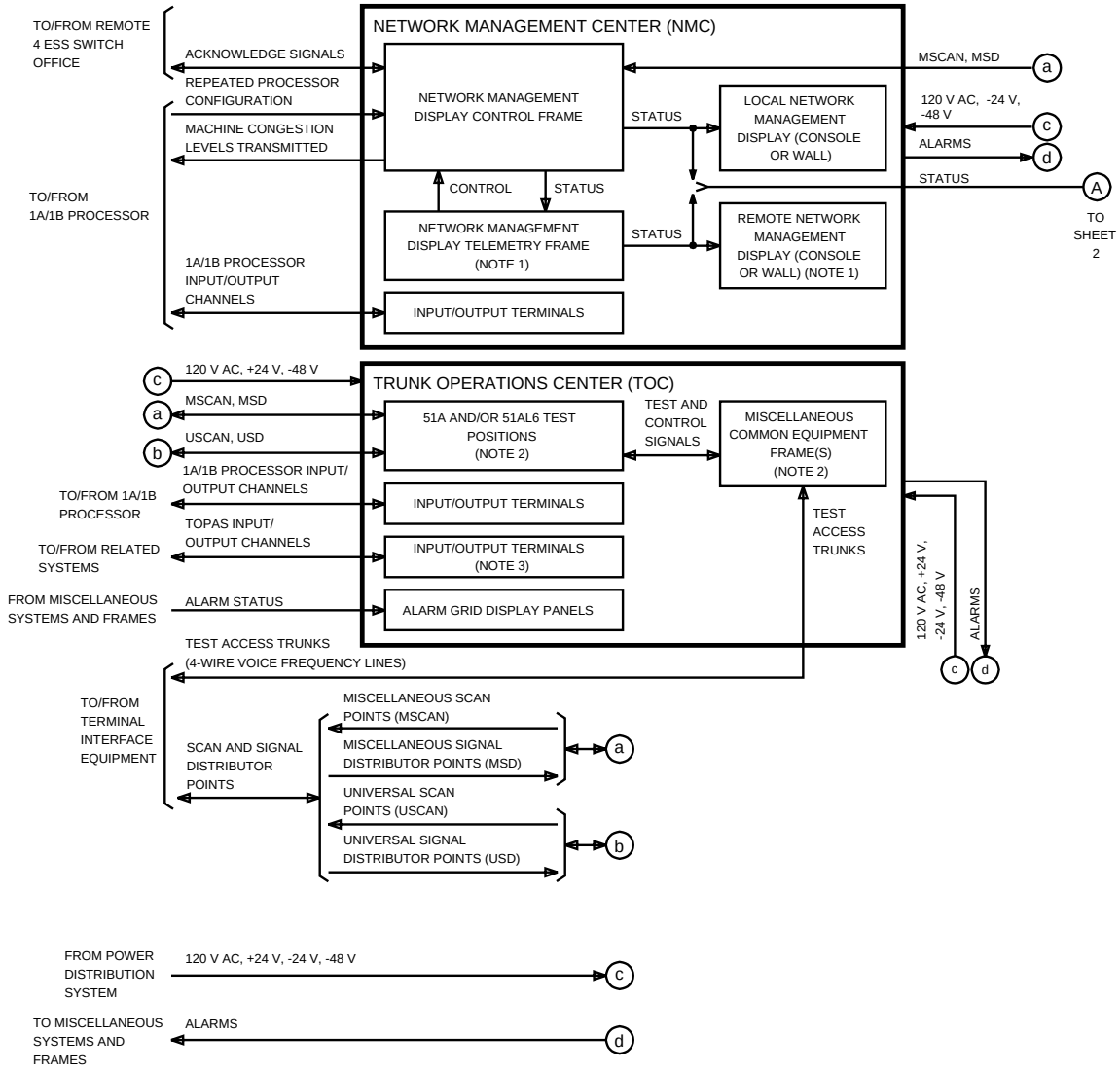


Figure 21. Work Centers and Support Equipment— Functional Block Diagram (Sheet 1 of 3)

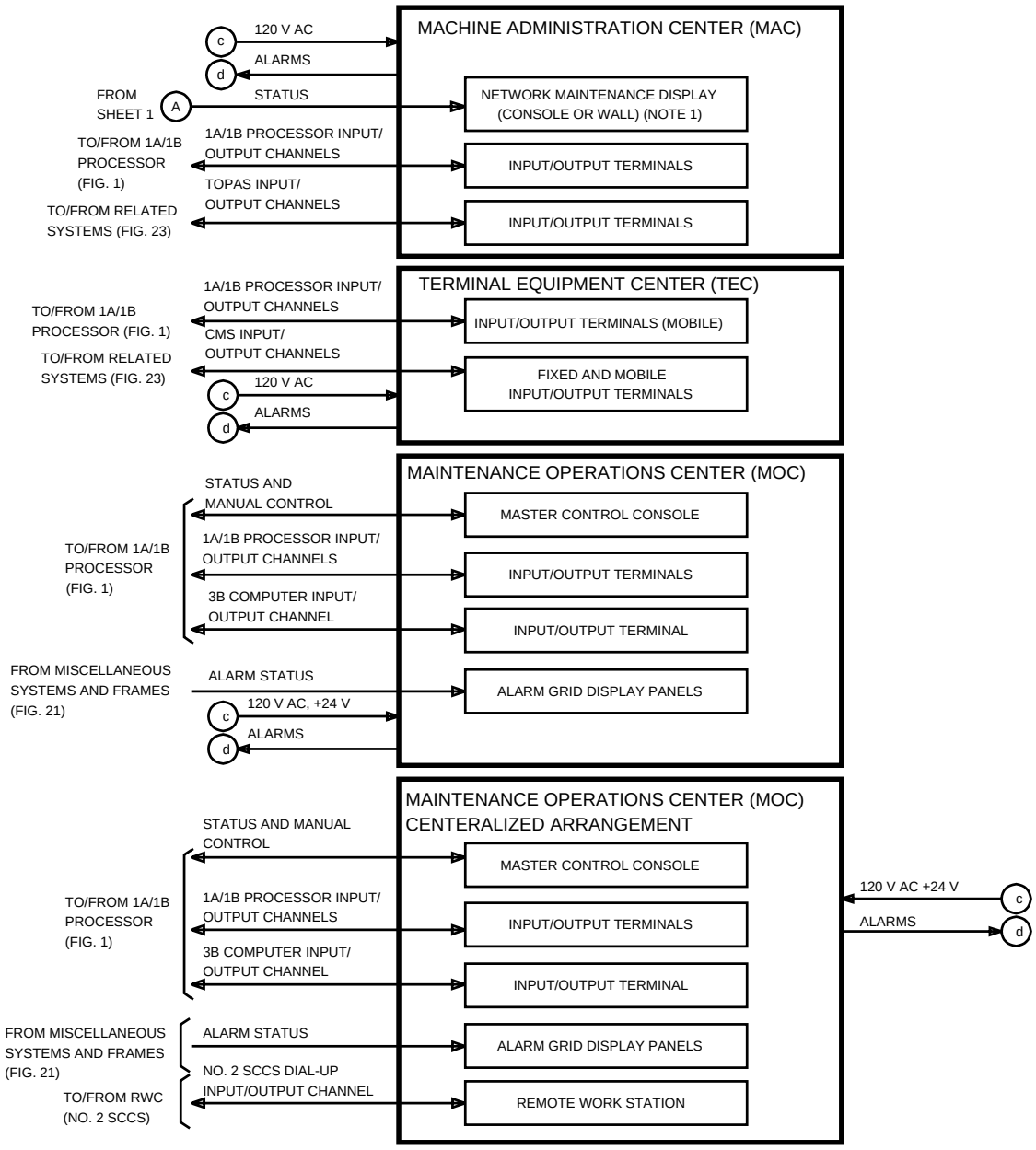
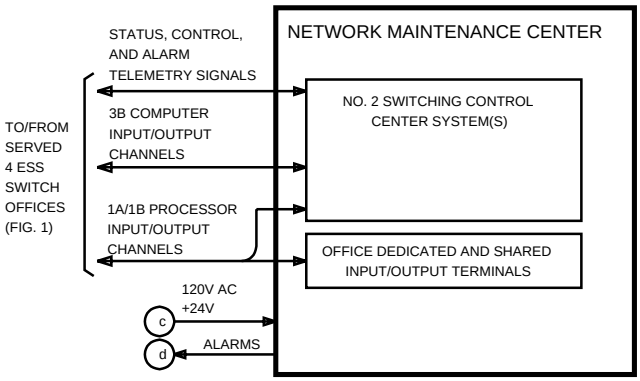


Figure 21. Work Centers and Support Equipment— Functional Block Diagram (Sheet 2 of 3)



NOTES:

1. THE NETWORK MANAGEMENT DISPLAY TELEMETRY FRAME IS AN OPTIONAL FRAME. THIS FRAME IS PROVIDED WHEN THE DISTANCE BETWEEN THE NETWORK MANAGEMENT CONTROL FRAME AND THE NETWORK MANAGEMENT DISPLAY (CONSOLE OR WALL) EXCEEDS 500 CABLE FEET.

2. THE 51AL6 TEST POSITION IS INSTALLED IN 4 ESS SWITCH INTERNATIONAL SWITCHING CENTERS ONLY. SUPPORT EQUIPMENT FOR THE 51AL6 TEST POSITION IS MOUNTED IN OFFICE ENGINEERED MISCELLANEOUS FRAME. SUPPORT EQUIPMENT FOR 51A TEST POSITIONS IS MOUNTED IN A DEDICATED MISCELLANEOUS COMMON EQUIPMENT FRAME WHICH CAN SUPPORT A MAXIMUM OF TEN 51A TEST POSITIONS PER CONTROL AREA.

3. WHEN OFFICE IS EQUIPPED WITH THE REMOTE MAINTENANCE SYSTEM-D2, THE TOC TRUNK WORK STATIONS CONSIST ONLY OF CMS/TOPAS INPUT/OUTPUT TERMINALS AND TELEPHONE SETS.

LEGEND:

MSCAN - MISCELLANEOUS SCAN POINTS
MSD - MISCELLANEOUS SIGNAL DISTRIBUTOR POINTS
TOPAS - TESTING, OPERATIONS, PROVISIONING, AND ADMINISTRATION SYSTEM
USCAN - UNIVERSAL SCAN POINTS
USD - UNIVERSAL SIGNAL DISTRIBUTOR POINTS

Figure 21. Work Centers and Support Equipment— Functional Block Diagram (Sheet 3 of 3)

A. Maintenance Operations Center

5.240 A number of Maintenance Operations Center (MOC) system interface devices are provided to perform the following functions in support of the 1B Processor, time division network, and common control terminal equipment—terminal equipment which connects to the 1B Processor:

- Surveillance of system status
- Control of the system for testing, repair, and equipment configuration
- Analysis of system performance
- Acceptance
- Growth coordination
- Routine maintenance
- Repair.

5.241 Refer to 234-105-000, *MOC System Interface Devices,* for information concerning the input/output interfaces.

5.242 The 4ESS Switch Master Control Console contains indicators which provide general indications of the 1B Processor and overall system performance. Controls on the console provide a means of exercising manual control over the basic system functions through the 1A Processor.

Entering Pokes (commands) on the video display terminal keyboard provides similar capabilities for the 1B processor.

5.243 Several input/output (I/O) channels terminate at data terminals in the MOC. The combined functions of these input/output channels are a significant factor in the definition of the MOC. These I/O channels and assigned functions are discussed in 234-100-021, *Input/Output System Description*. As illustrated in Figure 21, MOC I/O channels interface with the 1B Processor and 3B Computers. The 1B Processor channels and associated terminals provide a more comprehensive system control than the master control console. The 1B Processor uses these channels to output detailed error and status messages to support visual and audible indicators and alarms.

B. Terminal Equipment Center

5.244 Terminal Equipment Center (TEC) system interface devices are provided to perform the following 4ESS Switch office functions:

- Acceptance
- Growth coordination
- Routine maintenance
- Repair
- Circuit order implementation.

5.245 Refer to 234-104-000, *TEC System Interface Devices*, for input/output interfaces information.

5.246 In large 4ESS Switch offices, the TEC may be subdivided into several TEC control areas. Each control area can contain up to ten ports of TEC input/output channels. One port is designated as a control port and consists of a desk and hard-copy printer, and a *DATASPEED 40* terminal. The remaining ports consist of mobile *DATASPEED 40* terminals. The TEC is assigned specific ConnectVu/CMS or TOPAS and 1B Processor input/output channels in order to fulfill its functions. One of these is a belt-line channel. This channel enables TEC personnel to communicate with the 1B Processor from various points throughout the equipment operating area of the office. The input/output interface with the CMS or TOPAS provides a convenient access to many maintenance features for trunks terminating in the 4ESS Switch office. These input/output channel interfaces are illustrated in Figure 21.

C. Trunk Operations Center (TOC)

5.247 The TOC has system interface devices which are used to perform the following functions:

- Trunk status control
- Testing and sectionalizing trunk failures
- Trunk repair coordination
- Routine trunk testing
- Trunk performance analysis
- End-to-end circuit order testing and turnup
- Service improvement work related to ineffective attempts.

5.248 These functions are implemented by a combination of manual and automatic methods using tools such as the ConnectVu/CMS or TOPAS. Detailed information concerning the TOC operations is provided in 234-103-015, *TOC Operating Guidelines*. Also refer to 234-103-000, *TOC System Interface Devices,* for information concerning the input/output interfaces.

5.249 The following paragraphs describe the TOC equipped with 51A test positions. The 4E10 generic program supports the optional replacement of 51A test positions and associated analog test equipment with the Remote Measurement System-D2 (RMS-D2). The RMS-D2 is designed to serve as the primary trunk transmission measurement system for the 4ESS Switch equipped with 4E10 or later generic programs. The RMS-D2 provides all TOC functions currently provided via the 51A test position. The RMS-D2 generates and measures test signals in response to commands entered interactively via input/output terminals serving TOC

trunk work stations. The RMS-D2 also provides new bit-error analysis test functions required to support Circuit Switch Digital Capability (CSDC) services. Unlike the 51A test position, each TOC trunk work station consists only of an input/output terminal linked to the RMS-D2 via the associated Circuit Maintenance System (CMS) or Testing, Operations, Provisioning, and Administration System (TOPAS), and a two-way telephone set and monitor-only speaker linked to the RMS-D2 via two voiceband links.

5.250 The TOC is subdivided into TOC control areas. Each control area consists of one control position and up to nine test positions. Each test position consists of a 51A test position and includes an input/output terminal which provides access to the ConnectVu/CMS or TOPAS. The control position has responsibility for all positions within the control area. Through ConnectVu/CMS or TOPAS, the control position can monitor work flow, redistribute work loads, and obtain administrative reports.

5.251 Each control area is provided with two additional input/output channels and associated terminals. As illustrated in Figure 21, these channels provide access to the 1B Processor and ConnectVu/CMS or TOPAS. The CMS or TOPAS channel uses a receive-only printer. The 1B Processor channels are used to input various data concerning trunk operating status. Trunk trouble data can be output via these channels. A complete description of the TOC input/output channels is provided in 234-100-021, *Input/Output System Description*.

5.252 The 51A test position is used to initiate access and perform various tests on trunks connected to a 4ESS Switch office. The trunks can be accessed through the switching network via the terminal interface equipment. Each 51A test position is provided with three test-access trunks. These test-access trunks connect to the voiceband interface frame or D4 channel bank and appear as incoming wink-start, MF-pulsing trunks to the 4ESS Switch. All three test-access trunks can receive 101-type calls to the 4ESS Switch. Two of these test-access trunks, designated TAT0 and TAT1, can be used to monitor or access toll trunks for testing purposes at the 51A test position. The third test-access trunk, designated TAT2, is provided exclusively for 101-type calls. In this type of operation, the trunk to be monitored or split is identified at the input/output terminal or at the 51A test position. Data is entered via this terminal to activate a designated trunk in the ConnectVu/CMS or TOPAS and connect this trunk to a 51A test position test access trunk. The ConnectVu/CMS or TOPAS communicates with the 1B Processor via dedicated input/output channels and forwards trunk test identification data to the 1B Processor. The 1B Processor, in turn, configures the switching network to connect the identified trunk to the 51A test position test access trunk. This provides the 51A test position with maintenance access to trunks. When testing trunks in this manner, the 1B Processor also applies maintenance status information, concerning the trunk under test, to the 51A test position via signal processor 1 miscellaneous signal distributor points. This information is presented to the 51A test position via a test position lamp panel. Miscellaneous scan points are used to implement trunk test functions involving the 1B Processor. Through the use of a multifrequency signaling outpulsing ability, the 51A test position operator can use the two test-access trunks to access distant offices. In this mode of operation, the test-access trunks are used for voice-communication purposes to coordinate test activities. The universal signal distributor and scan point interface with the signal processor 1 provides a supervisory signal interface to support the multifrequency outpulsing ability.

5.253 The 51A test position also interfaces with a miscellaneous common equipment frame as shown in Figure 21. This frame contains various signal and tone generating equipment used to support various 51A test position trunk tests. The miscellaneous common equipment frame also contains equipment associated with transmission measuring and echo suppressor measuring systems.

D. Machine Administration Center

5.254 The Machine Administration Center (MAC) is

provided with system interface devices for implementing the general administration of a 4ESS Switch office. These administration abilities include the following:

- Preparation of office data assembler input forms for initial office assignment
- Completion of circuit order requests received from the circuit provisioning bureau
- Assumption of administration and data base coordination responsibilities for these support systems
- Assumption of overall responsibility for successful entry of recent change messages
- Monitoring of automatic and implementation of manual rollback, roll-forward, and reinitialization procedures which are required as a result of system interrupts
- Administration of traffic and plant measurements and route data to appropriate users
- Collection of various operating data and distribute reports to 4ESS Switch operating groups
- Planning, scheduling, and coordinating system growth with minimum adverse impact on system operation
- Ensuring 4ESS Switch equipment is being used efficiently
- Monitoring availability, adequacy, and quality of recorded announcements.

5.255 Detailed information concerning the MAC operations is provided in 234-102-015, *MAC Operating Guidelines*. Also refer to 234-102-000, *MAC System Interface Devices,* for information concerning the input/output interfaces.

5.256 The MAC is assigned specific ConnectVu/CMS or TOPAS and 1B Processor input/output channels in order to fulfill its assigned responsibilities. The 1B Processor interface is used for recent change operations and traffic measurements. The ConnectVu/CMS or TOPAS interface is used to implement circuit order administration. The MAC functions also require access to information presented on the network management display console or wall unit. When the Network Management Center (NMC) and the MAC are located in the same room, personnel from both work centers can use the NMC console or wall unit. When these two work centers are not located in the same area, the MAC is provided with a separate network management display console or wall unit. A complete description of the input/output channels assigned to the MAC is provided in 234-100-021, *Input/Output System Description*.

E. Network Management Center

5.257 The Network Management Center (NMC) is provided with system interface devices which are used to perform the following functions:

- Monitor the interfacing toll network for existing or potential problems
- Investigate network trouble
- Exercise manual control over routing of calls
- Perform network management functions.

5.258 Selected NMC abilities can be temporarily transferred to other work centers. In some 4ESS Switch offices, some or all of the NMC functions are permanently assigned to another work center. The NMC is normally centered around a network management display console and/or wall unit. The NMC is also provided with 1B Processor input/output channels and associated terminals to access the 1B Processor data base. The 1B Processor data base is accessed to investigate troubles and control the routing of calls. Detailed information concerning the NMC operations is provided in 234-101-015, *NMC Operating Guidelines*. Also refer to 234-101-000, *NMC System Interface Devices*, for information concerning the NMC input/output devices.

5.259 In Figure 21 and as discussed throughout this document, the NMC includes the network management display control frame and the network management display telemetry frame. These frames are not actually part of the NMC. However, because of their close functional

relationship with the NMC, these frames are included for descriptive purposes. In 4 ESS Switch offices, which are not provided with a separate NMC, the network management display control frame and the optional network management display telemetry frame are furnished to provide display interfaces as required by the 4ESS Switch.

5.260 The network management display console and wall unit provide a means of alerting network management personnel to possible trouble conditions. The console and wall unit contain lamp indicators, numeric indicators, and an audible alarm to achieve this function. The console and wall unit receive their input from the network management display control frame. The display devices must be located within 500 cable feet of this frame. Telemetry and remote distribution units in the network management display telemetry frame are required if this distance is exceeded.

5.261 The network management display control frame contains the circuits which control both the local and remote display devices. These display control circuits receive their input from the 1B Processor via the miscellaneous signal distributor interface with the signal processor 1 or 2. These display control circuits are only capable of driving console or wall unit displays located within 500 cable feet of the network management display control frame. When this distance is exceeded, the display control signals are routed to the network management display telemetry frame via a telemetry circuit. The telemetry frame contains circuits which can convert these signals and drive the console and/or wall unit. The network management display control frame can also send status signals to remote telemetry units for application to display devices at distant offices.

5.262 The network management display control frame also contains a number of dynamic overload control transceivers. These transceivers serve as an interface for dynamic overload control and associated acknowledge signals exchanged between the 1A Processor and distant offices. Dynamic overload control signals indicate various levels of machine congestion and are used by switching offices to monitor the traffic-handling ability of interconnecting offices. Various levels of dynamic overload control signals are discussed in greater detail in Part 8. With the 4E18 generic program, these transceivers are removed and the network management capability to transmit, receive, and respond to dynamic overload control signals for multifrequency (MF) and dial-pulse (DP) signaling types is removed.

5.263 Within the dynamic overload transceiver, dynamic overload control signals are generated as a result of input from the 1A Processor. These inputs are applied via miscellaneous signal distributor points which reflect current traffic levels and remaining traffic-handling ability. If the 1A Processor experiences serious difficulty, the 1A Processor generates a repeated processor configuration signal. When applied to the network management display and control frame, this signal causes the highest level dynamic overload control signal to be sent to the interconnecting offices. This dynamic overload control signal causes the interconnecting offices to route traffic around the 4ESS Switch office. In the event of a total 1A Processor malfunction, the highest level dynamic overload control signal can be initiated manually at the network management display and control frame. When the highest level dynamic overload control signal is sent to an interconnecting office, the network management display control frame applies a machine congestion transmitted signal to the 1A Processor to indicate this condition. The 1A Processor, in turn, causes an appropriate lamp on the master control console to light. Dynamic overload control acknowledge signals from interconnecting offices are applied to the network management display control frame. Acknowledge signals are detected by the 1B Processor through miscellaneous scan points.

5.264 The dynamic overload control transceivers also receive dynamic overload control signals from interconnecting offices. These signals indicate various stages of machine congestion for offices that interface with the 4ESS Switch. These signals are applied to the 1A Processor via the signal processor miscellaneous scan point interface. The 1A Processor acknowledges these dynamic overload control signals via the

miscellaneous signal distributor interface with the network management display and control frame. The frame, in turn, applies acknowledge signals to the appropriate interconnecting office(s). The NMC operating personnel are appraised of various incoming and outgoing dynamic overload control signals via the console or wall unit or via the NMC input/output channels.

F. Maintenance Operations Center—Centralized Arrangement

5.265 The centralized arrangement of the Maintenance Operations Center (MOC) provides the on-site MOC and TEC work functions. The MOC is the support and backup facility for the centralized work center facilities and can be self-supporting. Like the MOC previously described, the centralized arrangement of the MOC contains a master control console used to control the 1A Processor. The MCC video terminal is used to control the 1B Processor. Input/output terminals are also provided for communicating with the 3B Computer and network services complexes, as applicable. An input/output device interface with the centralized maintenance facility minicomputer provides the MOC with access to automated centralized maintenance aids.

G. Network Maintenance Center

5.266 A Network Maintenance Center can perform switching maintenance surveillance, control, and analysis functions for a number of 4ESS Switch offices. Each network maintenance center consists of one or more No. 2 Switching Control Center Systems (SCCSs) and certain input/output devices. Certain of these input/output devices are dedicated to each served office—while others are shared among all served offices. Refer to 234-106-000, *System Interface Devices,* for information concerning the input/output devices provided by the network maintenance center.

5.267 Each No. 2 SCCS is a minicomputer-based system that can monitor and control a number of stored program-controlled offices like the 4ESS Switch. Specific input/output channels and telemetry data are interfaced between each of the served offices and the network maintenance center. This system provides computer-aided analysis of the input/output messages received from the served offices. Refer to 190-110-110, *No. 2 SCCS Common Application, Description*, for a description of the No. 2 SCCS equipment.

Related Systems

5.268 The following are three related systems which apply automated machine aids to the task of trunk testing and maintenance and can be integrated into a domestic 4ESS Switch office.

- Circuit Maintenance System.
- Testing, Operations, Provisioning, and Administration System (TOPAS)
- Centralized Automatic Reporting on Trunks-2.

5.269 These systems and their interfaces, both internal and external to the 4ESS Switch, are described in subsequent paragraphs as shown in Figure 22. Another related system is provided in international switching centers. This system is described in Part 6.

A. Circuit Maintenance System

5.270 The Circuit Maintenance System (CMS) is a self-contained related system which is comprised of commercially available minicomputers and associated peripheral equipment. The CMS includes two independent processors. One functions as an active or primary processor while the other processor provides redundancy. The main memory is provided by magnetic disk. The CMS also has a magnetic tape ability which can be used as a main memory backup as well as a

means of inputting new data. The CMS provides processor controlled test, administrative, and maintenance features which simplify 4ESS Switch trunk maintenance. The 4ESS Switch work center personnel can access the CMS via a number of software-defined input/output channels. Through use of the CMS:

- Circuit maintenance operations are simplified, thereby, reducing errors
- Efficiency and productivity are increased through the use of improved maintenance abilities
- Maintenance costs are reduced by increased automation.

5.271 The CMS can support maintenance activities for up to six 4ESS Switch offices. The CMS may or may not be collocated at a 4ESS Switch office.

5.272 All CMS input/output channel interfaces with other equipment are illustrated in Figure 22. Some of these input/output channels and associated input/output terminals provide an operating personnel machine interface between 4ESS Switch work centers and the CMS processor. The CMS is accessed by personnel in the various work centers of 4ESS Switch offices. Typical CMS use of these interfaces is to output failure messages to input/output terminals in the work centers. Other input/output channels provide machine-to-machine interfaces with other processor-oriented equipment. These machine-to-machine, input/output channels are also known as data links. These data links interface the CMS with other maintenance and off-line processors.

5.273 The CMS has a data link with associated 4ESS Switch 1B Processors. This interface provides the CMS with access to office data in 1B Processor memory. The interface also permits the 1B Processor to access the CMS to output maintenance-related data. Typical uses of this interface are as follows:

a. Maintenance status of trunks are identified, and an overview of trunks experiencing various difficulties is provided.

b. 4ESS Switch detected trunk failures to the CMS are reported by the 1B Processor. The CMS in turn, creates outage tickets for reported failures and enters the tickets on an appropriate TOC worklist.

c. Operating personnel, through CMS, can initiate various tests which are exercised under control of the 1B Processor.

d. Trunks that require maintenance are removed from service by operating personnel and are then returned to service when problems are eliminated.

e. Test access to a trunk is gained via the switching network by operating personnel.

f. Operating personnel identify the trunks involved in a switch connection. In addition, disconnect can be inhibited until testing is complete.

g. Operating personnel control 4ESS Switch equipment to assist trunk troubleshooting.

5.274 The CMS interfaces with the following off-line and maintenance processors to obtain its data base and to provide data to circuit provision and results analysis systems.

- Carrier Transmission Maintenance System
- Circuit Provisioning Bureau
- Circuit Assignment and Records Transfer System
- Trunk Service Results Plan
- Installation Test System
- Office Data Assembler.

5.275 These interfaces are briefly discussed in subsequent paragraphs.

a. **Carrier Transmission Maintenance System (CTMS):** This data link enables operating personnel to initiate tests for the purpose of putting circuit troubles into sections. If a circuit problem is due to a condition within the office, operating personnel can use CMS to assign the trouble to an appropriate work center.

b. **T-Carrier Administration System (TCAS):** This data link provides a means to obtain status information concerning trunks interfacing with the 4ESS Switch through T-Carrier systems.

c. **Circuit Provisioning Bureau:** The CMS interfaces may be either data link, magnetic tape, or manual input. This interface is used to input data relating to trunk configuration and interconnections with other offices. The type of interface used is dependent on the location and management responsibility of the circuit provisioning bureau.

d. **Digital Facility Center (DFC):** This optional data link terminates on a receive-only printer which provides digital trunk status information to local digital facility maintenance groups—within the same building as the 4ESS Switch office.

e. **Analog Facility Center (AFC):** This optional data link terminates on a receive-only printer which provides analog trunk status information to local analog facility maintenance groups—within the same building as the 4ESS Switch office.

f. **Circuit Assignment and Records Transfer System (CARTS):** This interface is via magnetic tape. CARTS provides the data used to initially load the CMS equipment files.

g. **Trunk Service Results Plan (TSRP):** This interface is used to transmit CMS outage ticket records for use by the TSRP. This data is transmitted daily via a direct dialed rather than dedicated data link.

h. **Installation Test System (ITS)—1A Processor Only:** During the office precutover interval, the 4ESS Switch system generic program is not available. However, the ITS provides a version of the generic program. Through the 1A Processor interface, operating personnel can set up no-outpulse connections, reconfigure voiceband interface units, and monitor and change the status of scan and signal distributor points. The ITS is also able to output messages to operating personnel via input/output terminals.

i. **Installation Test System (ITS)—1A Processor Only:** During the office precutover interval, the 4ESS Switch system generic program is not available. However, the ITS provides a version of the generic program. Through the 1A Processor interface, operating personnel can set up no-outpulse connections, reconfigure voiceband interface units, and monitor and change the status of scan and signal distributor points. The ITS is also able to output messages to operating personnel via input/output terminals.

j. **Office Data Assembler (ODA):** Through this magnetic tape interface, the CMS provides some data required by the ODA to generate the 4ESS Switch office data base. The CMS also provides documentation which describes data on the tape. The CMS load tape is transmitted to the ODA before initial cutover and prior to cutover of major growth increments.

5.276 Input/output device terminals, not illustrated in Figure 22, provide an operating personnel machine interface which is used to monitor and control operation and maintenance of the CMS. These input/output devices are located in the CMS maintenance center. They cannot be used for any trunk maintenance-related activity.

5.277 Additional information concerning the CMS is contained in 234-108-040, *CMS General Description*.

B. Testing, Operations, Provisioning, and Administration System

5.278 The Testing, Operations, Provisioning, and Administration System (TOPAS) is a mechanized, automated, related system that provides provisioning and maintenance support for the 4ESS Switch. The TOPAS database contains all trunking information available to the NOW platform. Each TOPAS system uses a commercial

central processing unit (CPU) with associated peripheral equipment. The TOPAS system provides operational, administrative and maintenance (OA&M) functions such as optical back-ups, disk mirroring, and have fail-over capabilities to a back-up processor. The CPU's are organized in a duplex, triplex, and quadplex configuration that include TOPAS, Network Services Automator (NSA), and Data Acquisition and Administration System (DAAS). Two, three or four CPU's are linked together; one is in a back-up status while the others are active.

5.279 The TOPAS can support maintenance activities for ten 4ESS Switch offices and may or may not be collocated at a 4ESS Switch office. All TOPAS input/output-channel interfaces with other equipment are illustrated in Figure 22.

5.280 The TOPAS interfaces a packet internal network (PINET) that provides access to the 3B Attached Processor System (APS) in the 4ESS Switch. This interface provides the TOPAS with access to office data available to the 3B APS from the 1B processor memory. The interface also permits the 3B APS to access the TOPAS to output maintenance-related data. TOPAS uses this interface to provide the following functions:

- Report generation
- Automatic trunk assignments
- In-service/out-of-service trunk control
- Complete in-service 4ESS equipment data base
- Circuit order processing
- Provisioning work management
- Provisioning work management
- In Service display data
- Automatic termination selection
- Full and partial downloads of 4ESS equipment data and limited equipment update capabilities.

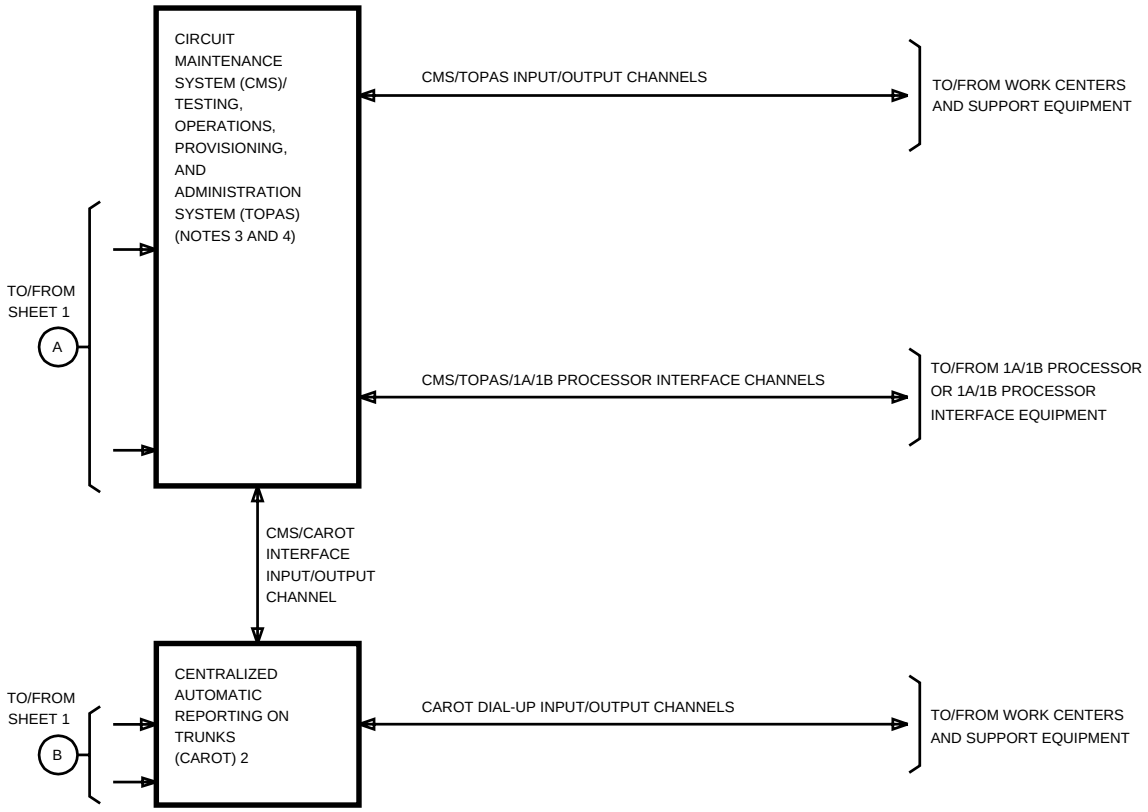
5.281 TOPAS uses CMS2 and CMS4 channels that are accessed via Datakit® to provide the following functions:

- Autonomous message handling from the 4ESS
- Manual/demand/automatic testing.

C. RMS-D2

5.282 The RMS-D2 is a modular digital test unit that serves as the primary trunk transmission measurement system for the 4ESS Switch. The RMS-D2 uses trunk accesses at the DS-1 (digital signal at the first level) to perform many operational, transmission, and signaling tests on the analog and digital trunks. Testing resources are located within the RMS-D2, while circuit access and circuit diagnostic routines are obtained through CMS-1 (Circuit Maintenance System-1) and the 4ESS Switch.

5.283 The RMS-D2 allows users, physically remote from the trunk under test (TUT), to perform installation and maintenance testing on trunks of 4 ESS Switches. The RMS-D2 testing capabilities are invoked via intelligent terminal systems such as the trunk work stations (TWSs) in Trunk Operations Center (TOC) of a CMS-1 and Centralized Automatic Reporting on Trunks (CAROT). The RMS-D2 system interfaces with CMS-1 (generic program 10 and later) which provides an integrated TWS arrangement. Five TWSs connect to each RMS-D2.



NOTES:

1. CMS INPUT/OUTPUT CHANNEL INTERFACES WITH AFC AND DFC TERMINATE ON RECEIVE ONLY PRINTERS. THESE OPTIONAL CHANNELS ARE FOR THE SUPPORT OF FACILITY MAINTENANCE GROUPS LOCATED IN THE SAME BUILDING AS THE APPLICABLE 4 ESS SWITCH OFFICE.
2. INTERNATIONAL GATEWAY OFFICES, ONLY.
3. INPUT/OUTPUT CHANNELS ARE EQUIPPED WITH DATA SETS AS REQUIRED.
4. CMS MAY SERVE A MAXIMUM OF SIX OFFICES. TOPAS MAY SERVE UP TO TEN OFFICES

LEGEND:

AFC	ANALOG FACILITY CENTER
ATME	AUTOMATIC TRANSMISSION MEASURING EQUIPMENT
CAROT	CENTRALIZED AUTOMATIC REPORTING ON TRUNKS
CMS	CIRCUIT MAINTENANCE SYSTEM
DFC	DIGITAL FACILITY CENTER
TOPAS	TESTING, OPERATIONS, PROVISIONING, AND ADMINISTRATION SYSTEM
VF	VOICE FREQUENCY

Figure 22. Related Systems—Functional Block Diagram (Sheet 1 of 2)

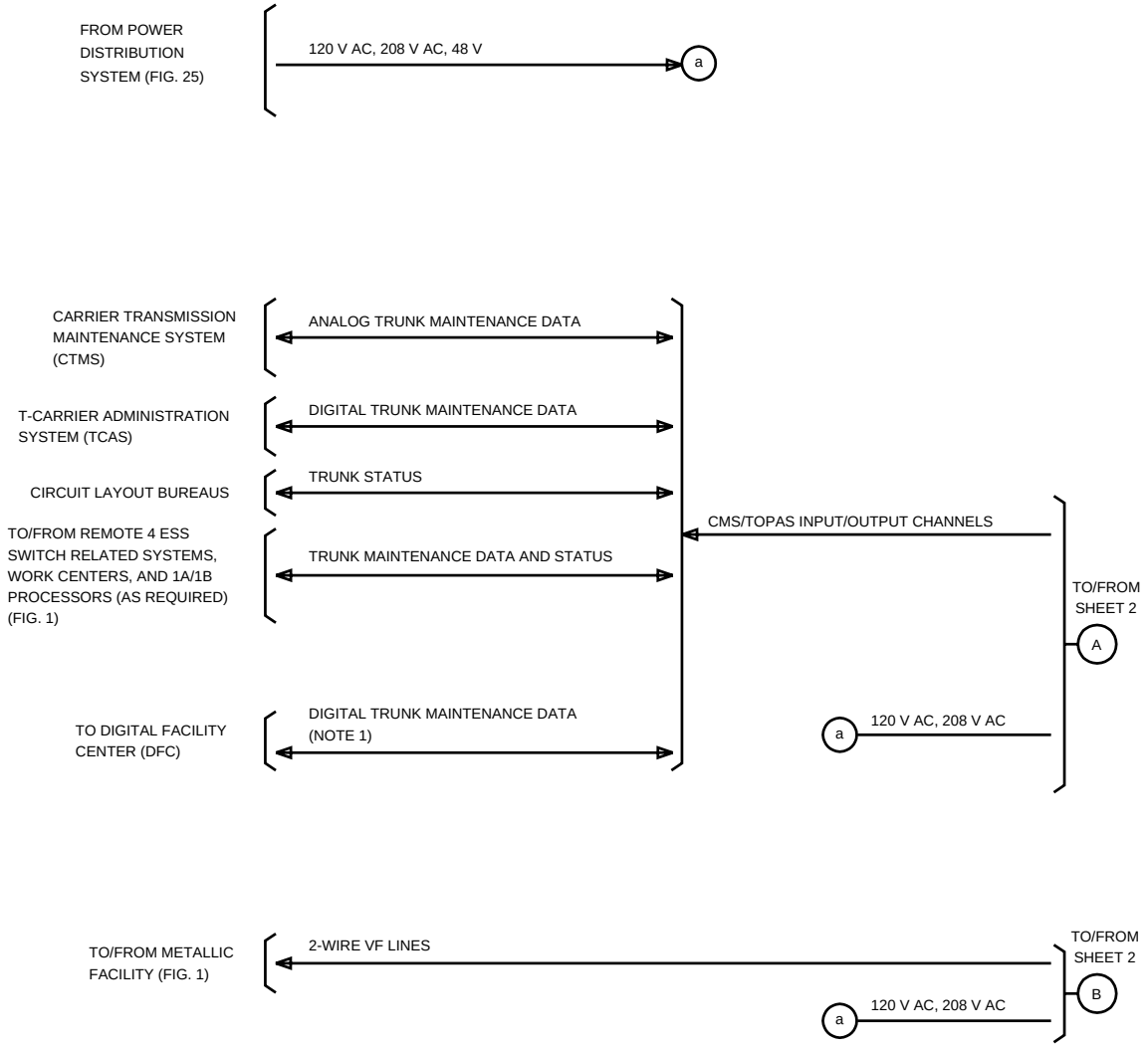


Figure 22. Related Systems—Functional Block Diagram (Sheet 2 of 2)

5.284 Additionally, the RMS-D2 allows local trunk access and testing — via an LTP panel and a local access terminal. Local testing with the LTP panel allows the performance of analog and digital measurements by using external test equipment. Testing via the LTP panel is described in Part 5. The local access terminal also provides voiceband data testing, voiceband testing, and digital services testing **with** the AMP, EVSRTP, and DSRTP resources, but **without** the need for an LTP panel. Testing via the local access terminal is described in Part 4.

5.285 Offices supporting 4ESS Switches normally have two RMS-D2s. This arrangement can handle the testing requirements of a fully loaded (80,000 circuits) 4ESS Switch.

Network Services Complex

5.286 When a network services complex is equipped at a 4ESS Switch, the interfaces are as shown in Figure 1. These interfaces include:

a. Up to five DS1 lines, 120 circuits maximum, per each network services complex provide an interface with the host switching network. Each direct services dialing ability (DSDC) network services complex requires only one DS1 line.

b. Two N-links between the CCS terminal group and each network services complex provide the control interface with the 1B Processor—host stored program-controlled system. Each N-link consists of a 4-wire voice frequency line between a 4ESS Switch CCS terminal group and an N-link controller in a network services complex.

c. One I/O channel from each network services complex terminates on an Attached Processor System I/O processor port. All network services complexes are thus accessible from a single I/O terminal in the Maintenance Operations Center. An I/O port is also available at each network services complex for connecting a mobile I/O terminal (not shown in Figure 1).

d. One miscellaneous scan point from the office-dependent alarm category is assigned to the network services frame to report software-generated major alarms. Details of the software major alarms are output to the associated network services complex data terminal. Hardware/software major and hardware minor alarms are connected to the office alarm system which provides the appropriate audible and visual alarm indications.

e. Each network services complex requires –48 V which is distributed to the various frames of the complex by a power distribution frame J86334B/C. The type of power distribution frame used depends on whether power is being supplied by a battery plant, J86334B is required, or a converter plant, J86334C is required. A maximum of eight complexes, four on each of two power buses, can be powered from a single power distribution frame; however, for reasons of reliability, no more than two complexes providing the same service features are powered from the same power distribution frame. The moving head disk frame also requires 208 V AC essential power.

5.287 Refer to 234-100-205, *Network Services Complex, 4ESS Switch Application*, for a complete description of the network service complex equipment.

Service Circuit System (SCS)

A. General

5.288 The Improved Service Announcement and Information Collection (ISAIC) feature improves the announcement/tone receiver capabilities of the 4ESS Switch. The 4E17 generic program and the Service Circuit System (SCS) hardware provide the ISAIC feature. This feature gives the 4ESS Switch a cost effective method of supporting services that require more interaction between the network and the customer. The Automatic Speech Recognition (ASR) feature of

SCS, available with 4E20 generic program, further enhances the interaction between the network and the customer.

5.289 The Service Circuit System (SCS) functional block diagram is shown in Figure 23. The SCS hardware consists of service circuit controllers (SCC) and several service circuit units (SCU). The service circuit controllers connect to each service circuit unit over an optical extended bus (EB). The optional Custom Data Services Unit (CDSU) connects to the SCU over DS 1 channel interfaces to provide the ASR feature. An adjunct announcement administration processor (AAP) provides announcement administration for the database of each SCU over a dedicated Local Area Network (LAN).

5.290 The SCS controller and the SCS unit cabinets house the SCS hardware. The SCC cabinet contains the duplex service circuit controllers and a single service circuit unit with up to four disk pairs. The second cabinet is the SCS unit cabinet that contains up to four SCUs, each with a single disk pair. The optional Custom Data Services cabinet houses up to five CDSU modules.

5.291 A SCS is fully compatible with database applications requiring recorded announcements.

B. Service Circuit Controller (SCC)

5.292 The service circuit controller processes messages between the 1B Processor and a maximum of 16 SCUs. Messages from the 1B processor travel the PUB to the SCC which processes high level maintenance functions for the SCUs as well as message routing and buffering functions. A large memory stores tables and buffers messages.

5.293 The duplex SCC is a two-shelf unit consisting of two identical controllers. Each controller occupies a single shelf that houses the control, memory, PUB interface, EB interface and power circuit packs. A single backplane is provided for both shelves.

C. Service Circuit Unit (SCU)

5.294 The service circuit unit (SCU) receives messages from the SCC, alerts the SCU processor to decode the messages, and sets the control registers to respond to these messages. The SCU is a single unit with one shelf of circuit packs.

5.295 A DS120 trunking interface on each SCU supports up to 120 interactive ports for playing announcements and receiving Dual Tone Multi-Frequency (DTMF) digits that can be used to interrupt the announcement. Each SCU supports up to 65,535 unique announcements used in many applications ranging from short digit playback to longer announcements for music-on-hold type applications. The announcements vary in length from 0.5 to 260 seconds. The following are additional capabilities of each SCU.

- Eight maintenance channels
- Up to 1,500,000 seconds of storage (disk based)
- Queuing up to 32 announcements together to provide up to 2 hours of announcements
- Storing short and frequently used announcements in the 1000 seconds of RAM based announcement storage to improve response time
- Announcements that are interruptible by the customer
- Announcements that are played continuously.

5.296 If the message from the SCC specifies speech recognition collection (associated with the ASR feature), a circuit pack in the SCU routes PCM encoded data over a DS1 (T1) interface channel to an adjunct Custom Data Services (CDSC) cabinet. This cabinet performs the speech recognition function.

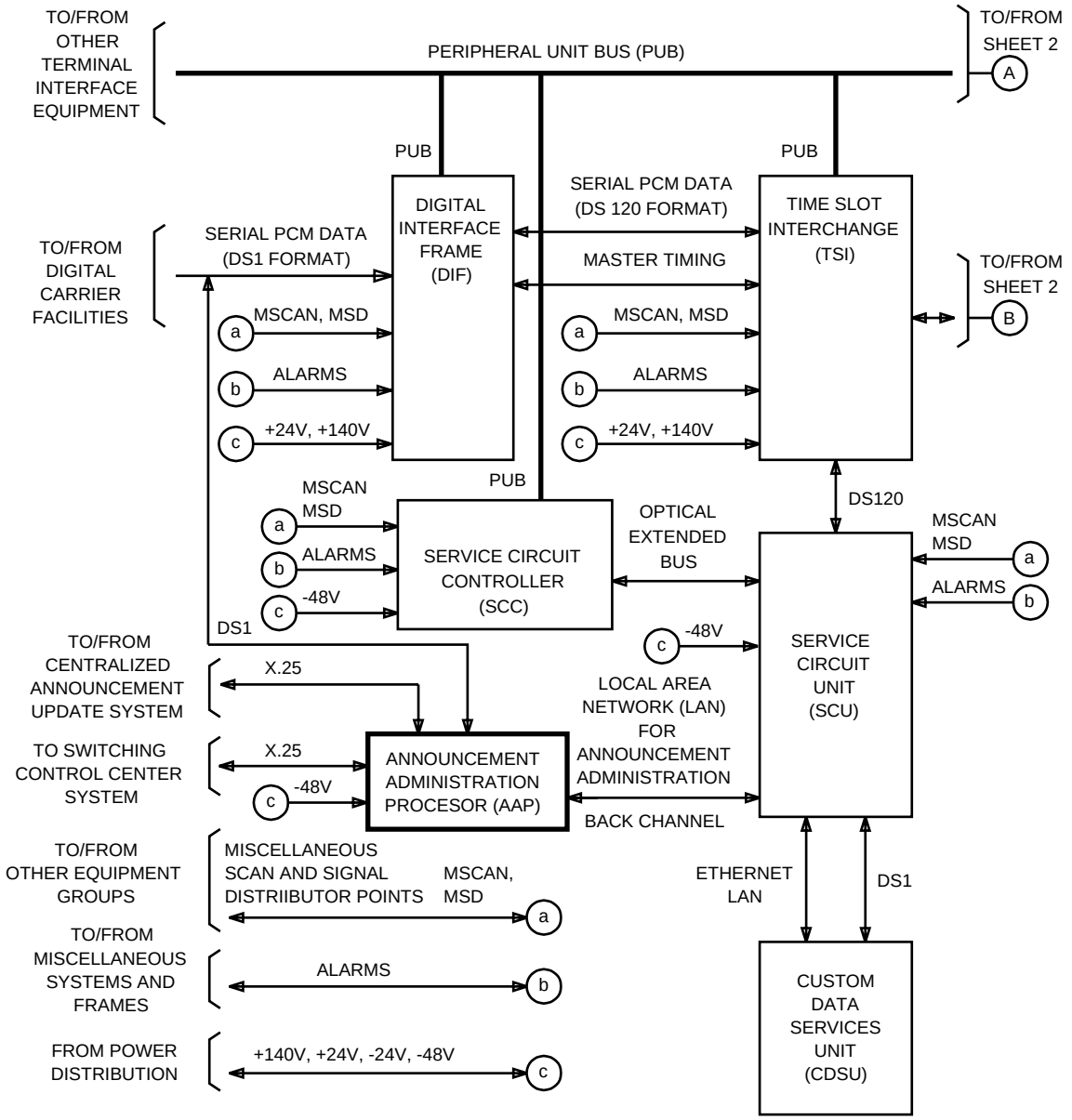


Figure 23. Service Circuit System — Functional Block Diagram (Sheet 1 of 2)

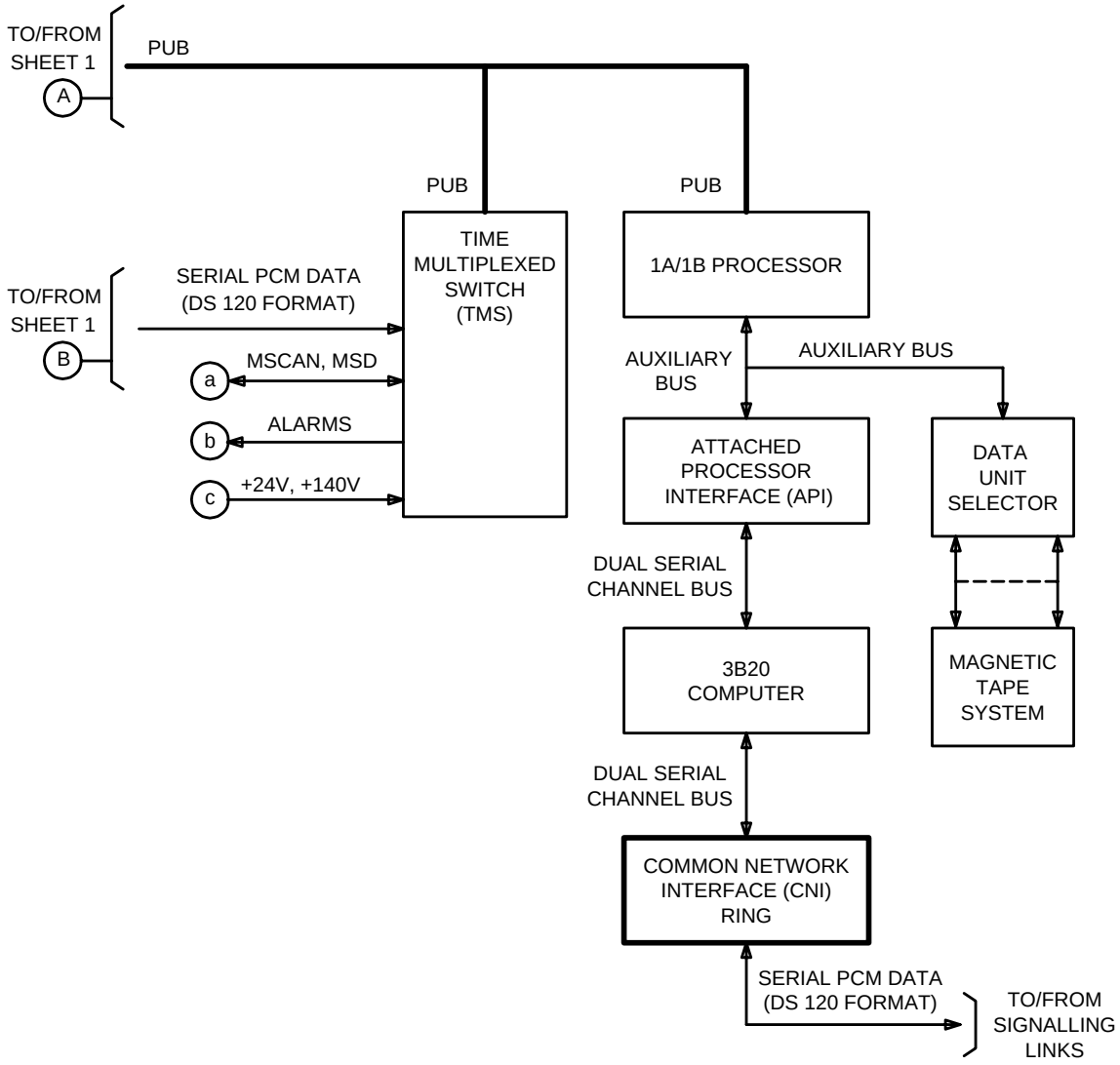


Figure 23. Service Circuit System — Functional Block Diagram (Sheet 2 of 2)

D. Custom Data Services Unit (CDSU)

5.297 The optional Custom Data Services Unit (CDSU) provides Automatic Speech Recognition (ASR) capabilities for the DS-120 channels associated with a SCU. A CDSC cabinet houses up to five CDSUs. All CDSUs within the same CDSC connect to the same SCU. Each CDSU provides ASR capabilities for 24 DS-120 channels. A CDSU consists of the following:

- One 486 Processor Card
- One Hard Disk Drive
- One Ethernet LAN Interface Card
- One SVGA Card
- One SCSI Card
- Twelve AYC50 Speech Processing Cards
- Two T1 Interface Cards
- One Control Module
- One Power Module
- Three fans.

5.298 An ethernet LAN interface routes control and speech recognition messages between the CDSC and the SCU. If an announcement playback request appears on the channel at the same time, echo cancellation on the incoming speech produces reliable speech recognition. The SCU sends the PCM encoded announcement directly to the CDSC over a second DS1 (T1) channel. The CDSC performs the echo cancellation and returns the announcement playback data back to the SCU. The SCU then routes the announcement playback data to the DS-120 interface.

E. Hard Disk Unit (HDU)

5.299 Each HDU supports two matched Hard Disk pairs and a power controller. Each hard disk pair provides announcement storage for the SCS in addition to system files. Each pair of hard disk circuit packs using the TN1672 hard disk circuit packs can store up to 93,000 announcement seconds (approximately). Each pair of hard disk circuit packs using the TN1972 hard disk circuit packs can store up to 478,000 announcement seconds (approximately). Each pair of hard disk circuit packs using the TN4000 hard disk circuit packs can store up to 956,000 announcement seconds (approximately). Each SCU connects to at least one HDU with up to a maximum of four disk pairs connected to a SCU. The two lower shelves of the SCS cabinets house the HDU hardware.

F. Announcement Administration Processor

5.300 The Announcement Administration Processor (AAP) provides announcement administration. The AAP receives and buffers updates to the announcements and sends the announcement data to the SCUs. The AAP is an adjunct unit that communicates with the SCUs over a dedicated Local Area Network (LAN).

G. Service Circuit System (SCS) Interface

5.301 A SCS complex uses buses and networks to make the following interfaces with the 4ESS Switch.

a. The duplicated ***Peripheral Unit Bus*** (PUB) that allows the SCS to communicate with the 4ESS Switch Central Control (CC).

b. A ***bidirectional DS-120 link*** that connects each SCU to a pair of time slot buses in the Time Slot Interface (TSI) frame. Pulse code modulated (PCM) data is transferred from and to the TSI over the DS-120 link per SCU.

c. ***Scan and Signal Distribution (SD) points*** that monitor and control individual power switches as well as basic maintenance functions.

d. ***Pulse points*** that are used for basic maintenance functions.

e. A ***local area network*** (LAN) that connects each SCU to the Announcement Administration Processor (AAP). The AAP receives and buffers updates to the

announcement data and sends announcement data to the appropriate SCU.

f. The ***ISDN network*** that allows the AAP to connect to the Central Announcement Update facility.

5.302 Refer to 234-100-130, *Service Circuit System, Description*, for a complete discussion of the Service Circuit System equipment.

CNI Ring

5.303 The CNI ring is a common subsystem which interfaces with the 4ESS Switch via the 3B20 Computer, attached processor system. This interface enhances the ability of the switch to handle the increasing amount and different types of data being switched by the network. These abilities are made possible by the various CNI hardware and software. The CNI application software is added to the 4ESS Switch 3B computer (APS) generic package. The CNI application software provides specific instructions to perform functions applicable to the 4ESS Switch application. This software can be broken down into two layers:

- Common Network Interface (CNI)
- Interprocess Message Switch (IMS).

5.304 Common Network Interface (CNI) software controls the links and link interface hardware that enables messages/data to enter and exit the ring. Interprocess Message Switch (IMS) software is responsible for maintaining the ring hardware. The IMS software provides ring circuitry diagnostics, ring hardware removal/restoral software, software instructions to ''blindly'' move message/data around the ring, and software to allow communications between the CNI ring and 4ESS Switch 3B Computer (APS) through the ring peripheral control node (RPCN).

5.305 In addition to the basic 3B Computer (APS) generic package and CNI application software, two databases are maintained to provide office-dependent data and application-dependent data. These databases are the Equipment Configuration data (ECD) database and Application Equipment Configuration data (APPECD) database, respectively.

5.306 The ECD database provides the basic 3B Computer (APS) hardware information required for the DMERT/RTR operating system. This information is used only when the 3B Computer is hosted in the minimum configuration, and it is necessary to recover the processor in order to run diagnostics. Under normal conditions, the 3B Computer uses the APPECD database. The APPECD database is delivered as part of the CNI application software and is essential to the operation of the system. This database contains a set of related data tables that contains equipage and option information for the CNI ring hardware. Whenever equipment/options are altered—added, deleted, changed, and others—the APPECD database must be updated to reflect the changes.

5.307 The 4ESS Switch 3B Computer (APS) maintains the CNI ring software and control the processing of data handled by the CNI ring. Most CNI ring hardware is micro-processor driven. This hardware design allows the 3B Computer to be free from most CNI ring processing to perform other designated functions.

5.308 A message entering the CNI system may enter via a digital signaling link (56 kb/s or 64 kb/s if the optional DSO interface feature is provided with the 4E17 generic program), D-channel (64 kb/s), or analog signaling link (4.8 kb/s). Digital signaling links (56 kb/s) gain access to the system by being connected to the digital facility access (DFA) cabinet. Digital signaling links (64 kb/s) connect directly to the CNI system from the D4 channel banks. Analog signaling links gain access to the system by being connected to the Analog Facilities Access (AFA) cabinet. In this discussion of processing a message through the CNI system, a digital signaling link is used.

5.309 A message entering the CNI system via a 56 kb/s digital signaling link connects to the digital facility access (DFA) cabinet. The DFA cabinet provides the circuitry necessary to make

signal level translations and provide loopbacks for signaling link maintenance access. The DFA cabinet circuitry also converts the incoming digital signal to a digital form usable by the CNI ring hardware. A message entering the CNI system via a 64 kb/s digital signaling link is in a digital form usable by the CNI ring hardware.

5.310 The reformatted digital signal is then transferred to an assigned incoming link node (LN) in the ring node (RN) cabinet. A link node can be broken down into three functional areas:

- Link interface
- Node processor
- Ring access circuit.

5.311 During CNI system initialization, each node processor in the LN is downloaded with code from the 3B Computer (APS). This allows each link node the ability to perform specific autonomous processing functions. Upon receiving the reformatted digital signal, the incoming link node independently translates each message as it arrives at the node processor. The node processor, via downloaded code, determines the destination link node and assigns a header to the message containing the destination address. In addition to the destination address, the assigned header also contains the incoming link node address and length of the original message. The length of a message is important to the CNI ring hardware because messages are serially inserted on the ring in a byte-by-byte format. As a message is being inserted on the ring, no other link node is permitted to insert a message. All messages, operational-type and maintenance-type, are assigned headers.

5.312 When the incoming link node is ready to insert a message on the ring, it waits for the ring token and unassigned destination address in its header. This unassigned destination address causes the token to continue to travel around the ring. The function of the token is to keep link nodes from simultaneously inserting messages on the ring. Before a link node can insert a message, it waits for the token to arrive at the output of the previous link node. At this point, the node processor of the incoming LN delays the token while the message is inserted on the ring. Under normal conditions, CNI ring 0 is used for operational-type messages and CNI ring 1 is used for maintenance-type messages.

5.313 After the message has been inserted on the ring, the message is passed to the next node [link node, ring peripheral control node (RPCN), direct link node (DLN), and others] and the destination address is read to determine if there is a match. If there is no address match, the message is passed serially to the next node on the ring. This process continues until the message reaches the node with a matching destination address. When the message reaches the node with a matching address, the node permits the message to be copied into its node processors first-in/first-out (FIFO) memory.

5.314 The node processor determines, via downloaded code, if the message requires additional processing or if the message is ready to be transmitted to the DFA frame circuitry assigned to the node. If the message requires additional processing, the message is processed by the 3B Computer (APS) using stored application database translations or by the direct link node— attached processor (DLN-AP) circuitry in the DLN. Access to the 3B Computer (APS) is provided via the RPCN or the DLN. Both the RPCN and DLN contain a node processor, ring interface, 3B interface circuitry, and a DLN-AP.

5.315 A message containing the RPCN destination address is sent to the 3B Computer (APS) for additional processing. A message containing the DLN destination address is directed to the DLN-AP circuitry. The DLN-AP circuitry contains dual-port random access memory (DPRAM) that is used to store application specific software that allows the DLN to perform specific signal message processing. With the 4E18 generic program, the DPRAM can be increased to 80 MB of memory that is available for new or expanded applications requiring more than 16 MB of memory. The DLN-AP circuitry along with the ability of the DLN to interface with the 3B Computer allows the DLN

to aid the 1B Processor in processing messages. While a message is being processed on the DLN-AP, the token continues to travel around the ring.

5.316 When the 3B Computer (APS) or DLN-AP needs to send a message on the ring, it seeks the token via the RPCN or DLN node processor. When the token arrives at the preceding node, the token is stopped, and the message is inserted on the ring. The message serially travels around the ring from node to node until the destination address is matched. Upon matching the destination address, The outgoing message is moved from the ring to the destination link node.

5.317 The destination link node now transfers the outgoing message to the DFA cabinet. Again, the DFA cabinet circuitry converts the outgoing digital message to a digital format usable by the DFA cabinet signaling links. The 4E18 generic program provides an Extended Access Link (E-link) as an alternative route to the primary A-links for the data transfer between the the 4ESS Switch and the data link network. If the DSO interface feature is used, the outgoing message is converted to a usable format in the link interface and transferred directly to the D4 channel bank equipment. In this discussion of processing a message through the CNI system, a digital signaling link and associated equipment was used. However, analog signaling links and associated equipment can be used.

5.318 Refer to 234-100-120 or 234-100-120AC, *Common Channel Signaling Systems, Common Network Interface (CNI), System Description Manual*, for additional detailed CNI ring information.

Power and Power-Related Alarm Circuits

5.319 Up to this point, functional descriptive information has been organized according to the equipment areas originally defined in Part 2. However, a discussion of 4ESS Switch power, ground, and alarm circuits is required to complete this functional description. The remaining paragraphs in Part 5 contain a general system level power discussion.

NOTE:
This power and power-related alarm circuit discussion applies to both domestic offices and international switching centers.

5.320 Additional details concerning 1B Processor power circuits, power-related alarm circuits, and grounding methods are contained in 254-200-001, *1A Processor General Description,* or 254-301-001, *1B Processor General Description*.

A. Power Input

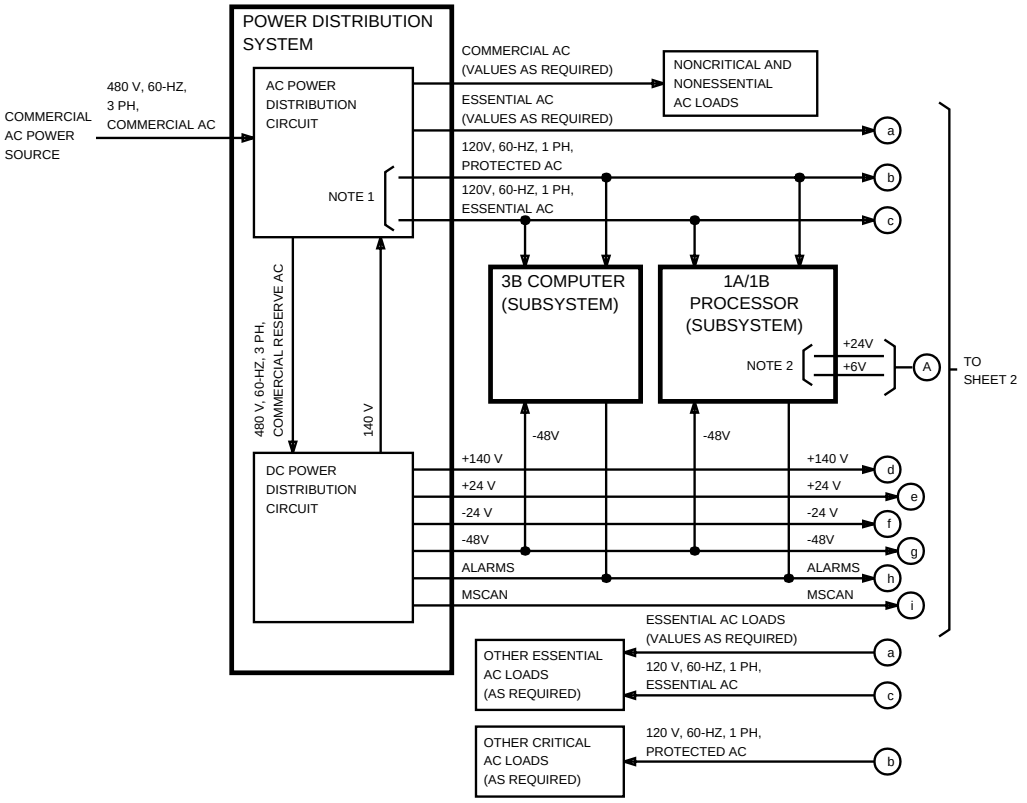
5.321 The 4ESS Switch power and power-related alarm circuits are illustrated in Figure 24. The normal source for the system is 208 V, 240 V, or 480 V, 60-Hz, 3-phase commercial AC power. Reserve AC power is provided by engine-driven alternators which supply 208 V, 240 V, or 480 V, 60-Hz, 3-phase AC power when commercial AC power is lost. In Figure 24 only 480 V, 60-Hz, 3-phase commercial AC power is shown applied to the AC power distribution circuit. Reserve AC power is applied in a similar fashion.

B. AC Power Distribution

5.322 The AC power distribution circuit illustrated in Figure 24 provides the following three categories of AC power to the system AC loads.

a. **Commercial AC power** is supplied to all AC loads that can tolerate long-term power interruptions with no degradation to call processing. Various commercial AC voltages required by the system are derived only from the 480 V commercial AC input.

b. **Essential AC power** is supplied to all system AC loads essential to call processing but can tolerate short-term power interruptions. The required AC values are derived from the commercial or reserve AC source, whichever is supplying power to the system.



NOTES:

1. THE 120 V, 60-HZ, 1 PH, PROTECTED AC AND PART OF THE 120 V, 60-HZ, 1 PH, ESSENTIAL AC POWER FEEDERS ARE INDIVIDUALLY FUSED AND ALARMED IN THE DC POWER DISTRIBUTION UNIT MOUNTED IN MISCELLANEOUS FRAME A. OTHER AC ESSENTIAL AC POWER FEEDERS ARE DISTRIBUTED VIA CONVENTIONAL AC POWER DISTRIBUTION EQUIPMENT.
2. DC POWER TO THE MASTER CONTROL CONSOLE IS SUPPLIED BY THE PROCESSOR PERIPHERAL INTERFACE FRAME OF THE 1A PROCESSOR.
3. MISCELLANEOUS SCAN AND MISCELLANEOUS SIGNAL DISTRIBUTOR POINTS ARE CONTROLLED AT THE SIGNAL PROCESSOR BY THE 1A/1B PROCESSOR (CENTRAL CONTROL) VIA THE PERIPHERAL UNIT BUS (NOT SHOWN).
4. THESE FRAMES MUST BE LOCATED IN THE TRANSMISSION EQUIPMENT AREA FOR CONNECTION TO THE PROPER GROUND PLANE. THESE FRAMES MUST NOT BE CONNECTED TO THE 1A/1B PROCESSOR OR NETWORK GROUND PLANES.
5. ALARM AND ASSOCIATED MISCELLANEOUS SCAN POINT CONNECTIONS FOR THE MISCELLANEOUS TRUNK TEST AND SUPPORT EQUIPMENT ARE OFFICE ENGINEERED. SCAN POINTS ARE ASSIGNED FROM THE OFFICE-DEPENDENT CATEGORY.
6. INTERNATIONAL SWITCHING CENTERS ONLY.

LEGEND:

AFT	ANALOG FACILITY TERMINAL
CCIS	COMMON CHANNEL INTEROFFICE SIGNALING
CCITT	CONSULTATIVE COMMITTEE FOR INTERNATIONAL TELEGRAPH AND TELEPHONE
MSCAN	MISCELLANEOUS SCAN POINTS
MSD	MISCELLANEOUS SIGNAL DISTRIBUTOR POINTS
PH	PHASE

Figure 24. 4ESS Switch Power and Power-Related Alarm Circuits (Sheet 1 of 5)

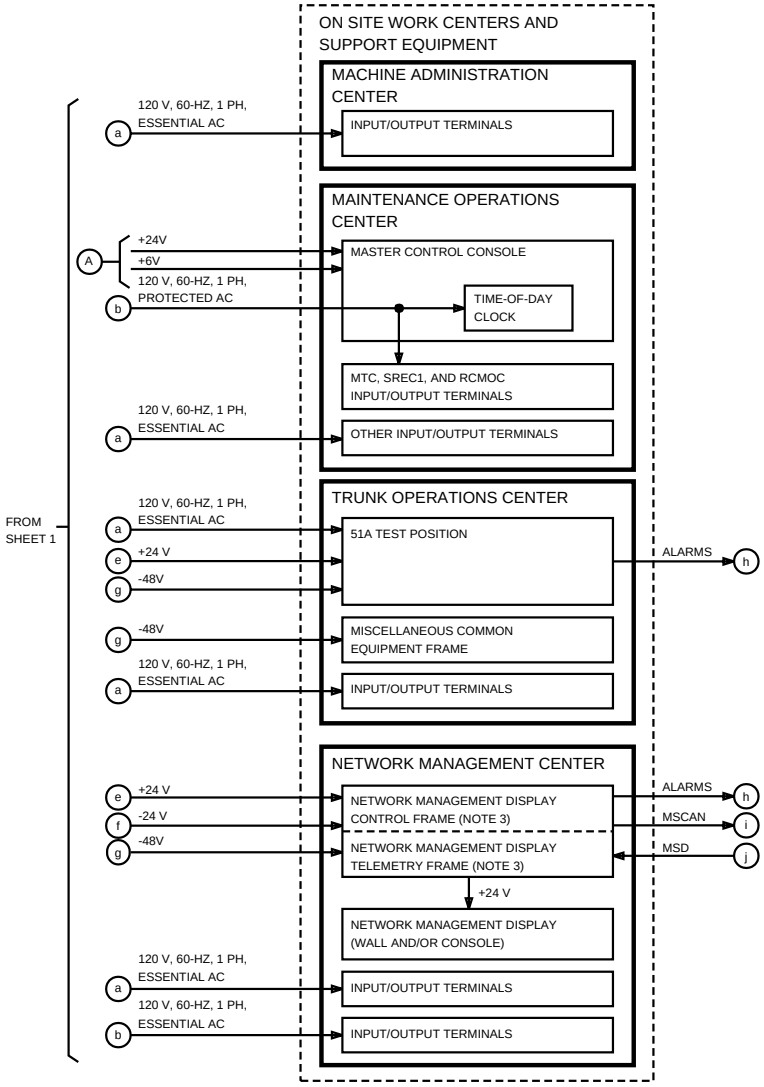


Figure 24. 4ESS Switch Power and Power-Related Alarm Circuits (Sheet 2 of 5)

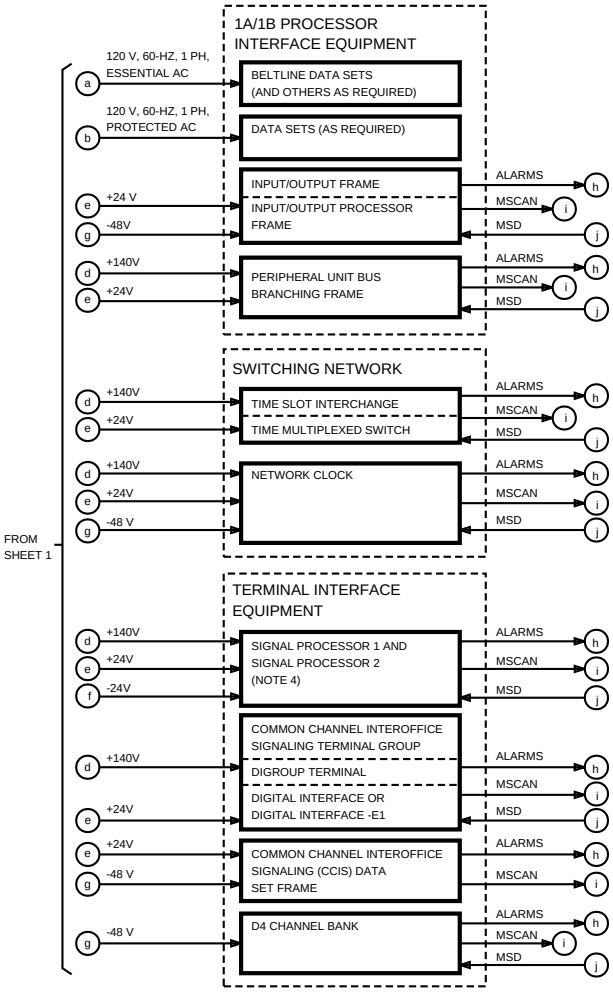


Figure 24. 4ESS Switch Power and Power-Related Alarm Circuits (Sheet 3 of 5)

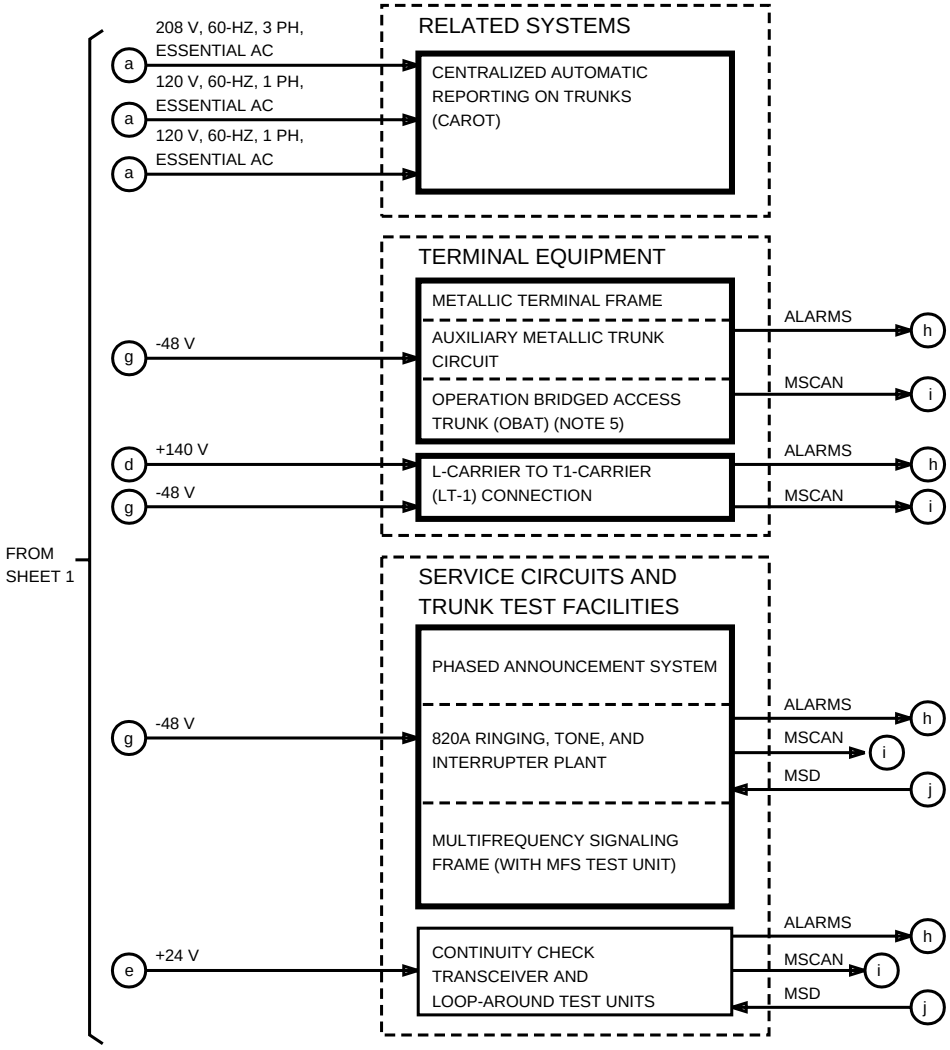


Figure 24. 4ESS Switch Power and Power-Related Alarm Circuits (Sheet 4 of 5)

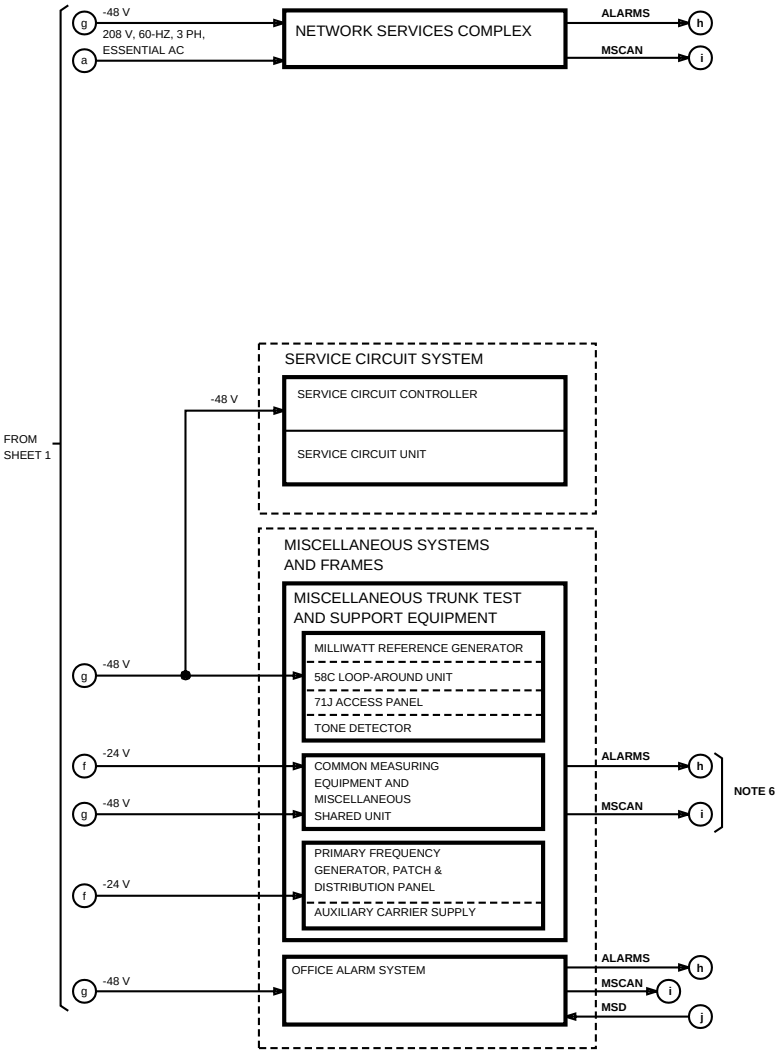


Figure 24. 4ESS Switch Power and Power-Related Alarm Circuits (Sheet 5 of 5)

c. **Protected AC power** is supplied to all AC loads critical to call processing which require uninterrupted power. Protected AC power is 120 V 60-Hz, single-phase AC power. Under normal operating conditions, protected AC power is derived from the commercial AC power source. When commercial AC power is interrupted, protected AC power is provided by a DC-to-AC inverter.

5.323 The distribution of AC power is illustrated in Figure 24. All protected AC feeders and some of the 120 V 60-Hz, single-phase, essential AC power feeders are individually fused and alarmed in an AC power distribution unit located in miscellaneous frame A. This unit provides spare protected and essential feeders. These feeders are assigned or reserved for future growth as dictated by individual office requirements. Other essential and commercial AC power feeders utilize standard office power distribution equipment.

C. DC Power Distribution

5.324 Primary DC power for the 4ESS Switch office installations prior to 1992 is +140 V supplied by a 140 V battery plant. This battery plant is included as part of the DC power distribution circuit illustrated in Figure 24. Plant rectifiers convert 480 V commercial, 208 V commercial, or reserve AC power to 140 V DC. Plant batteries are permanently connected to the 140 V DC rectifier output and provide 140 V DC power when the commercial or reserve AC power input to the system is lost. This 140 V DC also supplies power to the DC-to-AC inverter which provides protected AC power for the system. Power distribution system bulk converter plants convert the 140 V DC to –48 V, 24 V, and –24 V DC required by certain equipment frames. Some bulk converter plants convert –48 V to 24 V. These bulk converters are physically located throughout the system near the frames which they supply. Placement of these converters throughout the office keeps low-voltage, high-current, power bus lengths to a minimum. This method of DC power distribution permits use of more economical bus material for distribution of higher voltage, lower current power throughout the office.

5.325 As illustrated in Figure 24, certain frames are provided with 140 V DC in addition to lower power levels provided by the bulk converter plant. These frames are unique to the 4ESS Switch. The frames contain DC-to-DC converters which supply well regulated low-level voltages other than -48 V, 24 V, and –24 V DC required within the frame. The following 4ESS Switch frames **are not** powered from 140 V DC.

a. Input/output frame

b. Input/output processor frame

c. Miscellaneous frame A

d. Miscellaneous frame B

e. Miscellaneous trunk test and support equipment frames

f. Network management display control frame

g. Network management display receiver frame.

5.326 The subassemblies, which are mounted in these frames, may or may not be unique to the 4ESS Switch and require only the DC power levels provided by the bulk converter plants. The remaining 4ESS Switch frames, which do not receive 140 V DC, are common system frames—miscellaneous common equipment frame, remote office test line frame, recorded announcement frame, and others—require only lower-level dc voltages.

5.327 The 4ESS Switch DC power distribution system connects the equipment frames to the power buses in a manner that assures adequate power is always supplied to critical frames. This provides continuous call processing and system operation in the event of a major power component failure.

5.328 Dual –48 V and +24 V Battery Plants and a single 415 plant for 140 V power requirements furnish the DC power for recent 4ESS Switch offices. Dedicated A and B bus power distribution (PD) frames distribute the –48 V and +24 V power to the 4ESS frames. The 140 V power is supplied over A and B busses to the Area

Bus Centers (ABCS). Distribution of the 140 V power from the ABCs is through A and B busses to the 4ESS frames. Input to each DC battery plant is either 208 Volt or 480 Volt essential power. One AC distribution bay is provided with each +24 V and −48 V plant to furnish AC power to the rectifiers.

D. Power Control

5.329 Control of AC and DC power feeders from the power distribution system is entirely manual. Power is applied to the distribution buses by manual operation of circuit breakers and the installation of fuses at power distribution equipment. Power is removed from the buses in a similar manner either by manual operation or by operation of these protection devices due to an overcurrent condition. The two −48 V and two +24 V battery plants are designated as Plant A and Plant B. Plant A uses red distribution cables and controls that are marked Plant A. Plant B utilizes blue distribution cables with controls being marked Plant B. The DC power cabling from Plant A (red cables) and Plant B (blue cables) to their respective PD frames use separate cable racks with a minimum separation of 6 feet between racks at all time.

5.330 Control of AC and DC power within common system frames and noncritical 4ESS Switch unique frames is also accomplished via manual operation of switches, circuit breakers, and fuses. Inadvertent application or removal of power to a common system frame does not seriously impair the call-processing ability of the system. For this reason, common system frames have no power monitor or control interfaces with the 1B Processor. The DC-to-DC converters within these frames are equipped with output monitors that shut down the converters upon detection of a faulty output. Common system frames have a power-related alarm interface with the office alarm system. Appropriate alarms are activated in the event of a power malfunction in a common system frame.

5.331 The 4ESS Switch unique frames which perform critical system functions are provided with a power monitor and control interface with the 1B Processor. This is required because an inadvertent application or removal of power from a critical frame without prior 1B Processor preparation could adversely affect overall system performance. This power control and monitor interface is provided via miscellaneous signal distributor and scan point connections with the signal processor 1 or signal processor 2. A special power switch assembly provided on critical frames enables operating personnel to notify 1B Processor control programs that a change in power status is desired. Indicator lamps on this switch assembly enable the 1B Processor to signal approval to make the change. Specifically, the power switch assembly and associated circuits provide the following:

- A visual status display by power switch lamps
- A manual power-up and power-down ability without introducing erroneous signals into the system
- The means to manually request that the program remove the frame or subassembly from service
- An automatic power-down capability when a power fault is a potential threat to service
- The means to perform a power alarm test under manual or program control.

5.332 All 1B Processor frames are equipped with similar power monitor and control circuits. However, the 1B Processor, power-related, signal distributor and scan points are processed within the 1B Processor.

E. Alarm Circuits

5.333 The AC power feeders, in general, are alarmed only within the power distribution system (Figure 24). An AC power-related alarm results from a blown fuse, tripped circuit breaker, loss of commercial AC power, or an alternator malfunction. A DC power-related alarm in the power distribution system results from a blown fuse, tripped circuit breaker, a rectifier fault, or a bulk converter plant malfunction. These alarm

indications are forwarded to the office alarm system and to the signal processor 1 as indicated in Figure 24.

5.334 Two categories of power-related alarms can be generated by frames used in the 4ESS Switch. These are major alarms and minor alarms. A major alarm is generated when a power failure presents an immediate or potential threat to system operation. A minor alarm is generated when a power failure occurs but presents no immediate or potential threat to system operation. These alarm signals are applied to the office alarm system which, in turn, activates appropriate visual and/or audible alarms. A miscellaneous scan point interface with the signal processor 1 or signal processor 2 enables the 1B Processor to monitor all power alarms. The 1B Processor can output appropriate messages to work centers assigned having responsibility for the equipment generating the alarm.

5.335 The power switch assembly and associated circuits on critical 4ESS Switch frames provide these frames with a manual or program-controlled power alarm test ability. The manual power alarm test is initiated by a switch on the power switch assembly. This test activates the various power alarm lamps provided on converters in the frame. The program-controlled power alarm test is initiated via signal distributor points from the signal processor. The results of the test are monitored by the 1B Processor via signal processor scan points. Alarms generated during the power alarm test are not applied to the office alarm system. Noncritical 4ESS Switch unique frames and common system frames are not provided with a power alarm test ability.

F. Protective Grounding System

5.336 The 4ESS Switch unique frames and the 1B Processor subsystem frames contain electronic circuits that cannot tolerate power transients and noise that are tolerable in electromechanical circuits. To eliminate stray currents generated outside these frames, the frames and the associated DC power distribution frames are bonded into a ground plane that is isolated except for a single point. This grounding system is described in 803-500-410 *Protective Ground System, Equipment*. Grounding of other frames and equipment and the associated DC power distribution frames are described in 802-001-180 *Protective Ground System* and 803-500-150 *Grounding Practices, Telecommunication System Grounding in New Buildings Having Digital and/or Analog Telecommunication Equipment, General Equipment Requirements and Engineering Information.* The protective grounding system for the overall system is not depicted in Figure 24 but is described in appropriate 4ESS Switch and 1B Processor documents.

6. Functional Description—International Switching Centers

General

6.01 This part contains a functional description of 4ESS Switch equipment which is found **only in international switching centers.** Note that the equipment described in Part 5 is also found in international switching centers. The functional description in this part is organized according to the same major equipment areas identified in Part 5. Only the international switching center unique equipment applicable under each heading is discussed in this part.

6.02 This part does not contain a system block diagram dedicated specifically to international switching center (ISC) offices. The functional descriptions presented in this part are supported by Figure 1, which is a functional block diagram of the 4ESS Switch. Equipment unique to an international switching center is identified by an asterisk (*) in Figure 1 and in the applicable lower level equipment group functional diagrams referenced in Figure 1.

6.03 Unique equipment is required in a 4ESS Switch international switching center primarily to accommodate the different signaling required on international trunks. The signaling on international trunks is referred to as CCITT 5 and CCITT 6 signaling. These types of signaling require the exchange of supervisory signals which are not required in domestic-type signaling.

a. The CCITT 5 line signaling uses single- and dual-frequency signals (2400 and 2600 Hz) to convey supervisory information. Signaling tones have different meanings depending on the direction of signaling and when in the call setup sequence the signal occurs. Multifrequency signaling is used in conjunction with CCITT 5 line signaling to pass digits. This multifrequency signaling uses six separate signaling tones in paired combinations. These paired tones are the same as those used for domestic signaling but are of a shorter duration. These tones can be decoded or generated by existing multifrequency receivers and generators.

b. From an equipment point of view, the CCITT 6 signaling is similar to the old domestic CCIS signaling. However, the format and type of signaling data exchanged in CCITT 6 signaling is different. In international switching centers, several additional memory packs are required to accommodate the different format. However, from an office point of view, the primary difference is software-oriented.

4ESS™ Switch

6.04 The general system operation discussion and description of external interfaces contained in Part 5 is also applicable to international switching centers.

1A Processor

6.05 Only the information in Part 5 is required.

3B Computer

6.06 Only the information in Part 5 is required.

1A Processor Interface Equipment

6.07 Only the information in Part 5 is required.

Terminal Equipment

6.08 The following paragraphs describe only the additional terminal equipment which is required in 4ESS Switch international switching centers.

A. International Operator Bridged Access Interoffice Trunk

6.09 The international operator bridged access trunk (OBAT) provides an interface between domestic and international trunks and 2-wire 3C/3CL switchboards at international operating centers. This interface is provided for those international calls that require operator assistance. The OBAT interface is used when the international operating center is located a far distance from the international switching center. When the international operating center and 4ESS Switch are near one another or are collocated, this interface is provided via digital facilities.

6.10 The OBAT consists of a three-way bridge circuit which provides impedance matching and amplification required to interconnect the international operating center and the 4ESS Switch domestic and international trunks. Each OBAT circuit provides a 4-wire interface between the international operating center and the 4ESS Switch international switching center. Conversion from 4-wire to 2-wire occurs at the international operating center prior to connection to the switchboard.

6.11 Figure 7 illustrates the OBAT interfaces when incorporated in a 4ESS Switch international gateway office. Each individual OBAT circuit provides a 2-trunk interface with the toll

network via the voiceband interface and switching network. Either trunk can be connected to a domestic or international trunk depending on the digits pulsed to the OBAT by the signal processor. The OBAT connects these trunks to the international operating center through a bridge. This bridge enables an international operating center switchboard operator to provide required assistance. The bridge removes the operator from the circuit upon completion of the call. However, a signaling and supervision interface provides the means for the operator to selectively gain monitor access or talk and monitor access to the circuit.

6.12 The universal signal distributor points and universal scan points provide a looped E&M signaling interface with the 4ESS Switch signal processor. Audible ring, received from the ringing and tone plant, is applied to the originating trunk while waiting for answer by the international operator.

Terminal Interface Equipment

6.13 The information contained in Part 5 also applies to international switching centers. The following paragraphs, however, discuss some minor differences that exist in terminal interface equipment (Figure 8) in international switching centers.

A. Digroup Terminal

6.14 In international switching centers, a T-Carrier interface may be provided between the digroup terminal and an international operating center. This interface is used to interconnect the international switching center with operator consoles at a nearby international operating center. Appropriate digital/analog conversion equipment is provided in the international operating center. Note that this interface is only provided when the international operating center is located near the 4ESS Switch. When the international operating center is located some distance from the 4ESS Switch, this interface is provided through an international operator bridged access interoffice trunk in the terminal equipment area.

B. Signal Processor

6.15 In a 4ESS Switch international switching center, the signal processor interfaces with operator positions in an international operating center. This interface consists of a number of miscellaneous scan points and a miscellaneous signal distributor point. The miscellaneous scan points enable the international operating center to control the amount of traffic applied to each individual operator position. The miscellaneous signal distributor point provides a supervisory signal exchange capability. The signal processor can use the miscellaneous signal distributor point to notify the international operating center that all scan points have been read. The signal distributor can also be used to request updated data from the international operating center on the various miscellaneous scan points.

C. Common Channel Signaling (CCS) Terminal Group

6.16 In a 4ESS Switch international switching center, CCITT 6 signaling is processed using additional memory units in the common channel signaling (CCS) terminal group.

Switching Network

6.17 Only the information in Part 5 is required.

Service Circuits and Trunk Test Facilities

6.18 In addition to the information presented in Part 5, the following minor differences apply to international switching centers.

A. Auxiliary Phased Announcement System

6.19 The number of recorded messages required in an international gateway office exceeds the capability of the basic phased announcement system. The auxiliary phased announcement system merely extends the ability of the basic

phased announcement system. Messages are recorded in the same manner as on the basic phased announcement system. In addition, the functions of the auxiliary phased announcement system is identical to the system discussed in Part 5 and illustrated in Figure 18.

B. 820A Ringing, Tone, and Interrupter Plant

6.20 In international switching centers, the ringing and tone plant applies an audible ring signal to the international operator bridged access interoffice trunk.

Digital Services Interface Equipment

6.21 Only the information in Part 5 is required.

Miscellaneous Systems and Frames

A. Input/Output System

6.22 Only the information in Part 5 is required.

B. Office Alarm System

6.23 Only the information in Part 5 is required.

C. Office Communication Facilities

6.24 Only the information in Part 5 is required.

D. Miscellaneous Frame A

6.25 Only the information in Part 5 is required.

E. Miscellaneous Frame B

6.26 Only the information in Part 5 is required.

F. Miscellaneous Frame C

6.27 Only the information in Part 5 is required.

G. Miscellaneous Trunk Test and Support Equipment

6.28 In addition to the miscellaneous trunk test and support equipment described in Part 5, the following equipment is required to support the 51A L6 test position in international switching centers.

Flashing Unit

6.29 The flashing unit provides DC power interrupted at a rate of 60 and 120 times per minute. This pulsed DC power is applied to selected 51A L6 test position lamps to provide flashing indications.

71G Precision Tone Generator

6.30 The 71G precision tone generator provides an accurate 1004-Hz tone. This tone is used for trunk test purposes at the 51A L6 test position.

Distribution Networks

6.31 The distribution networks provide impedance matching for the 1004-Hz test tone between the 71G precision tone generator and points of use in the 51A L6 test positions. The 1004-Hz test tone is provided to the points of use in the 51A L6 test position at a level of –10 dB.

Work Centers and Support Equipment

6.32 The information contained in Part 5 also applies to the 4ESS Switch international switching centers. However, differences do exist in trunk operating center functions and network management center functions in international switching centers.

6.33 As discussed in Part 5, work centers are provided as the primary means of defining and performing activities involved with the operation, maintenance, and administration of a 4ESS Switch office. Various control and maintenance activities coordinated and performed through 4ESS Switch work centers are based on system software-defined, input/output channels. In

addition to input/output terminals, some work centers contain consoles or other display equipment which provide a one- or two-way interface with the system. The functions monitored and controlled by this equipment are related to the software-controlled functions of the input/output channels assigned to the corresponding work center.

6.34 This part is a parallel organization of Part 5. Again, these descriptions are typical and may differ from the actual work centers in an office for the reasons explained in Part 3.

6.35 Work centers are directly involved in all maintenance activities. Part 9 contains additional work center information directly related to maintenance activities.

A. Maintenance Operations Center

6.36 Only the information in Part 5 is required.

B. Terminal Equipment Center

6.37 Only the information in Part 5 is required.

C. Trunk Operations Center

6.38 The Trunk Operations Center (TOC) function and organization in an international switching center are similar to a domestic office (Part 5). As in domestic offices, TOC personnel have access to trunk maintenance facilities such as ConnectVu/CMS or TOPAS. Other differences are discussed in subsequent paragraphs.

6.39 In international gateway offices, a 51A L6 test position is provided for performing maintenance operations on international and transit trunks using CCITT 5 and CCITT 6 signaling. The functions of the 51A L6 test position are similar to the 51A test position provided in domestic offices. However, the test equipment provided on the 51A L6 test position is compatible with CCITT 5 and CCITT 6 trunks. This test equipment includes a modified transmission measuring system, an echo measuring test set, and an optional impulse noise measuring set identical to the one provided in the 51A test position. The 51A L6 test position can also be used to perform maintenance checks on trunks employing domestic-type signaling when required. However, the TOC in international switching centers may contain a mix of trunk test positions.

6.40 The TOC devices in international switching centers provide functions relevant to trunk testing that are not required in domestic offices. On domestic trunks, when a trunk malfunction is detected, a trouble report is automatically entered into the ConnectVu/CMS or TOPAS. On CCITT 5 and CCITT 6 international trunks, automated trunk testing is performed by the Remote Measurement System - Gateway 1 (RMS-G1). An international trunk malfunction detected and reported by the RMS-G1 System must be manually entered into the ConnectVu/CMS or TOPAS by TOC operating personnel.

D. Machine Administration Center

6.41 Only the information in Part 5 is required.

E. Network Management Center

6.42 The equipment and overall functions of a Network Management Center (NMC) in an international office is the same as in a domestic office.

F. Maintenance Operations Center—Centralized Arrangement

6.43 Only the information in Part 5 is required.

G. Network Maintenance Center

6.44 Only the information in Part 5 is required.

Related Systems

A. Circuit Maintenance System

6.45 Only the information in Part 5 is required.

B. Centralized Automatic Reporting on Trunks 2

6.46 Only the information in Part 5 is required.

C. Remote Measurement System - Gateway 1

6.47 The Remote Measurement System - Gateway 1 (RMS-G1) related system provides 4ESS Switch international switching centers with an automated means of performing signaling and transmission tests on international trunks employing CCITT 5, CCITT 6, and CCITT 7 signaling. The RMS-G1 related system is comprised of six directors, five responders, and associated input/output devices. The RMS-G1, upon receiving a request message from the TOPAS/CMS-1C, signals the 4ESS Switch to connect the Trunk Under Test (TUT) to the RMS-G1 test access transmission path. After the connection is established, the RMS-G1 directs the transmission test using the transmission path as an access to the test trunk. Upon completion of the test, the RMS-G1 requests the 4ESS Switch to remove the connection. The RMS-G1 sends the test results to the TOPAS/CMS-C1 for reporting. After the local 4ESS Switch connects the transmission path for far-end directed transmission tests, the RMS-G1 responds to an incoming trunk call connected to the transmission path by conducting the transmission tests directed by the far end and sending the results back to the far end. After the tests are completed, the far end requests the local 4ESS Switch to remove the connection.

6.48 Figure 22 illustrates the RMS-G1 interfaces within a 4ESS Switch international switching center. These interfaces are standard DS-1 facilities between 4ESS Digital Interface Frame (DIF) Digital Interface Unit (DIU) circuit pack and the RMS-G1 DIU. The control link between the RMS-G1 and the 4ESS Switch terminates on the Office Interface Module at the RMS-G1 end and the 1A I/O Port at the 4ESS end. The interfaces with the DIF provide the RMS-G1 with the required access to international trunks through the switching network. The control link interface provides a communication path between the TOPAS/CMS-1C, the RMS-G1 and the 4ESS Switch control software. The 4ESS Switch software is notified of a RMS-G1 initiated test via a TOPAS/CMS-1C message. The 4ESS Switch software selects a path through the switching network to connect the RMS-G1 to the designated trunk under test. The control software also initiates appropriate signaling to the far-end office to direct that office to connect the trunk under test to the RMS-G1 at that office. Signaling tests are controlled by 4ESS Switch software while transmission tests are controlled by the RMS-G1 director. Test results of signaling tests are sent to TOPAS/CMS-1C or RMS-G1, depending on the initial request. When the 4ESS Switch receives far end request for tests, the incoming trunk under test is connected to either the transmission path connected to the RMS-G1, a digital loopback test line, or to the test function of the 4ESS Switch.

D. RMS-D2

6.49 The RMS-D2 is a modular digital test unit that serves as the primary trunk transmission measurement system for the 4ESS Switch. The RMS-D2 uses trunk accesses at the DS-1 (digital signal at the first level) to perform many operational, transmission, and signaling tests on the analog and digital trunks. Testing resources are located within the RMS-D2, while circuit access and circuit diagnostic routines are obtained through CMS-1 (Circuit Maintenance System-1) and the 4ESS Switch.

6.50 The RMS-D2 allows users physically remote from the trunk under test (TUT) to perform installation and maintenance testing on trunks of 4 ESS Switches. The RMS-D2 testing capabilities are invoked via intelligent terminal systems such as the trunk work stations (TWSs) in Trunk Operations Center (TOC) of a CMS-1 and Centralized Automatic Reporting on Trunks (CAROT). The RMS-D2 system interfaces with CMS-1 (generic program 10 and later) which provides an integrated TWS arrangement. Five TWSs connect to each RMS-D2.

6.51 Additionally, the RMS-D2 allows local trunk access and testing — via an LTP panel and a local access terminal. Local testing with the LTP panel allows the performance of analog and digital measurements by using external test equipment. Testing via the LTP panel is described in Part 5. The local access terminal also provides voiceband data testing, voiceband testing, and digital services testing **with** the AMP, EVSRTP, and DSRTP resources, but **without** the need for an LTP panel. Testing via the local access terminal is described in Part 4.

6.52 Offices supporting 4ESS Switches normally have two RMS-D2s. This arrangement can handle the testing requirements of a fully loaded (80,000 circuits) 4ESS Switch.

Network Services Complex

6.53 Only the information in Part 5 is required.

CNI Ring

6.54 Only the information in Part 5 is required.

Power and Power-Related Alarms

6.55 Only the information in Part 5 is required.

7. Call Processing

General

7.01 Call processing in the 4ESS Switch is controlled by programs stored in 1B Processor memories. Specific call-processing programs made active for any particular call are determined by the information received by the 1B Processor from trunk signaling circuits. Various aspects of call-processing programs, such as path hunt (Part 5 switching network discussions), are discussed elsewhere in the document. Part 8 contains additional information concerning call-processing software.

7.02 The following call-processing discussion is hardware-oriented. In the following paragraphs, typical calls are traced through the 4ESS Switch office from a trunk carrying an incoming call to a trunk selected to carry the outgoing call. The equipment actively involved in processing the calls and the relative operating sequences are discussed. These discussions are general in nature. Details of system operations such as message accounting, application of audible ring, etc, are not covered. Also, various supervisory signal exchanges which are dependent upon the configuration of connecting offices are not discussed.

7.03 Incoming and outgoing calls employing different signaling methods are discussed separately. In the following discussions, the sequence of events and equipment involved in processing a call through the system to the output of the switching networks are covered under incoming call descriptions. This is illustrated in Figures 25, 26, and 27 as PCM data output from the TSI. This output is referenced to an outgoing trunk. As illustrated in Figures 28, 29, and 30, outgoing call descriptions cover active interfaces and equipment involved in applying message and signaling information from the output of the time slot interchange to a selected trunk. Incoming call and outgoing call descriptions are compatible so that an incoming call, using any signaling, can be traced through the office and applied to a destination trunk, regardless of outgoing signaling. Examples for various types of call-processing activities discussed are as follows:

- Dial-pulse incoming call
- Multifrequency/Dual Tone Multifrequency signaling incoming call
- Common channel signaling (CCS) incoming call with digital echo suppression
- Dial-pulse outgoing call

- Multifrequency/Dual Tone Multifrequency signaling outgoing call
- Common channel signaling (CCS) outgoing call.

7.04 Several of these call-processing descriptions can also be applied to international call processing. In addition to call processing, a discussion of connections to reorder tones and recorded messages is included.

7.05 Each of these previously identified call-processing descriptions is supported by a block diagram. Through the use of heavy lines, these diagrams indicate equipment involved in processing that type of call. Heavy lines also indicate the message traffic and signaling interfaces active for the call.

NOTE:
Note that these diagrams do not attempt to illustrate all 4ESS Switch equipment and interfaces. Only those relevant to the particular call-processing discussion should be considered.

Use of this type diagram provides a correlation between the functional description in Part 5 and the call-processing discussions.

A. Dial-Pulse Incoming Call

7.06 Figure 25 illustrates the equipment and interfaces involved in processing an incoming call on a domestic metallic trunk employing dial-pulse signaling. The incoming call is applied to a metallic terminal frame from the VF metallic facility. The off-hook indication is detected at the metallic terminal frame and is applied to the signal processor 1 via universal scan points and from there to the 1B Processor via the peripheral unit bus.

7.07 The 1B Processor obtains pertinent data concerning the active incoming trunk from office translation data stored in memory. After examining this data, the 1B Processor directs the signal processor 1 to initiate the required supervisory signal exchanges and collect incoming digits. This exchange occurs via universal signal distributor and scan points (E&M leads). Digits received are applied to the signal processor 1 via universal scan points.

7.08 The 1B Processor reads these digits to identify the destination of the incoming call. Call-processing programs use this information to identify the destination office or to identify another toll office which can route the call to its eventual destination. Once the destination office is identified, control programs examine the office data to locate an idle trunk connecting to that office. These programs then search for and identify a path through the time division network to connect the incoming trunk to the trunk connecting to the destination office.

7.09 The 1B Processor applies path identification data to the time division network via the peripheral unit bus. This data causes the incoming trunks to be connected to the selected outgoing trunk. The 1B Processor also identifies the type of signaling employed on the trunk selected to handle outgoing traffic and initiates appropriate signaling and digit transmission. The steps involved in processing various outgoing calls are discussed later.

B. Multifrequency/Dual Tone Multifrequency Signaling Incoming Call

7.10 Figure 26 illustrates the equipment and interfaces involved in processing an incoming call on a digital carrier trunk employing multifrequency/dual tone multifrequency signaling. The incoming call is applied to a digroup terminal frame from the T1 digital carrier facility. The off-hook indication is detected at the digroup terminal. This indication is routed to the signal processor 2 via the interconnecting DT-SP2 digital link. The signal processor 2, in turn, makes data indicating the off-hook condition available to the 1B Processor.

7.11 The 1B Processor obtains pertinent data concerning the active incoming trunk from office translation data stored in memory. In the illustrated example, the office translation data stored in the 1B Processor identifies the trunk as one employing multifrequency signaling. Control programs locate an appropriate path through the time division network and connect a multifrequency receiver to the incoming trunk.

7.12 The 1B Processor then directs the signal processor 2 to initiate the required supervisory signal exchanges. The calling office then applies incoming multifrequency digits to the 4ESS Switch office. The multifrequency signal information is routed through the digroup terminal and is switched through the time division network via the selected path to a multifrequency receiver trunk appearance on the voiceband interface. The voiceband interface converts these multifrequency signaling data words to analog signals and applies them to the multifrequency receiver which decodes the incoming multifrequency digits.

7.13 Decoded digits from the multifrequency receiver are detected by the signal processor 1 via miscellaneous scan points. The 1B Processor reads these digits via the peripheral unit bus and determines the destination of the incoming call. The 1B Processor also causes the time division network to disconnect the multifrequency receiver from the incoming trunk.

7.14 Call-processing programs examine the collected digits to identify the destination office or to identify another toll office which can route the call to its eventual destination. Once the destination office is identified, control programs examine the office data to locate an idle trunk connecting to that office. These programs then search for and identify a path through the time division network to the trunk connecting to the destination office.

7.15 The 1B Processor applies this path identification data to the time division network via the peripheral unit bus. The time division network uses this data to reserve a connection between the incoming and outgoing trunk. The 1B Processor also identifies the type of signaling employed on the trunk selected to handle outgoing traffic and initiate appropriate signaling and digit transmission. The steps involved in processing various outgoing calls are discussed later.

C. Common Channel Signaling (CCS) Incoming Call

7.16 Figure 27 illustrates the equipment and interfaces involved in processing an incoming call on a digital trunk employing CCS. The example illustrated in Figure 27 is based upon the following assumptions:

a. The incoming call is applied to digital interface equipment from a digital carrier facility.

b. The message trunk requires digital echo suppression.

7.17 Common channel signaling (CCS) data identifying incoming message traffic is transmitted to the 4ESS Switch office over the common channel signaling network via applicable common network interface (CNI) rings. Applicable data for the associated CCS incoming call is identified and removed from the CNI ring via CCS7 link nodes. The CCS data is then applied to the 1B Processor through the 3B Computer. Translation data required to set up identified message trunks is a part of the office translation database stored in the 3B Computer and 1B Processor.

7.18 Common channel signaling data identifies the trunk on which traffic is to be applied and contains the digits which identify the destination of the call. This information is applied to the 1B Processor through the 3B Computer. The 1B Processor establishes a path through the time division network to loopback the incoming message trunk. This is done to enable the far-end office to perform a continuity check on the message trunk.

7.19 The 1B Processor control programs process the incoming digits to identify the destination office or another toll office which can route the call to its eventual destination. Once this office is

identified, the office data base is examined to locate an idle trunk connecting to that office. Control programs then search for and identify a path through the time division network to interconnect these two trunks.

7.20 The 1B Processor applies this path identification data to the time division network via the peripheral unit bus. The time division network uses this data to establish a connection between the incoming and outgoing trunk. Referring to office translation data, the 1B Processor identifies the type of signaling employed on the trunk selected to handle outgoing traffic and initiates appropriate signaling and digit transmission.

7.21 If the selected outgoing trunk employs multifrequency signaling, multifrequency digit outpulsing is started immediately. However, the last digit is not outpulsed unless continuity checks on the incoming trunk are valid. In this particular example, the office translation data pertaining to the incoming trunk also specifies that digital echo suppression is required. The 1B Processor applies appropriate control data to the echo suppressor terminal to implement the specified mode of echo suppression on the designated trunk. The steps involved in processing various outgoing calls are discussed in the following paragraphs.

D. Dial-Pulse Outgoing Call

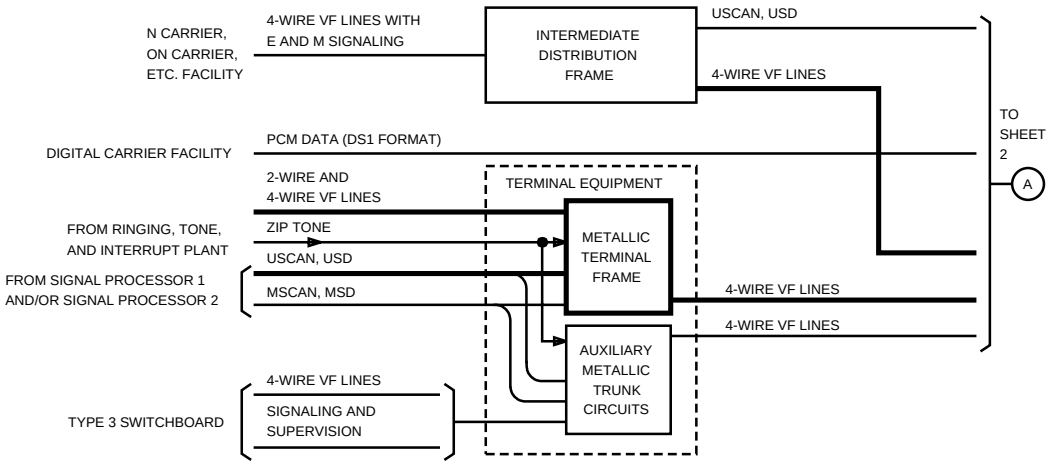
7.22 Information previously applied to the 1B Processor as incoming call data, regardless of signaling method employed, provides the 1B Processor with information required to locate an appropriate idle outgoing trunk. Control programs check the office translation data to obtain information concerning the trunk selected. In this particular example, illustrated in Figure 28, the selected trunk is a digital carrier trunk. Translation data in 1B Processor memory indicates the trunk employs dial-pulse signaling. Translation data also indicates the type of supervisory signal exchange required on the selected trunk.

7.23 The 1B Processor directs the signal processor 2 to initiate the appropriate supervisory communication. This is accomplished via the DT-SP2 interface between the signal processor 2 and the digroup terminal. When supervisory signals indicate the receiving office is ready to accept digits, the 1B Processor directs the signal processor 2 to apply outgoing digits to the digroup terminal. The outgoing digits are applied to the trunk by the digroup terminal. As mentioned in description of incoming calls, the message path through the 4ESS Switch is established as soon as the 1B Processor identifies a path through the time division network. When all digits have been outpulsed, the called office responds with audible ring, busy or reorder tone, or a recorded message as appropriate.

E. Multifrequency/Dual Tone Multifrequency Signaling Outgoing Call

7.24 Information previously applied to the 1B Processor as incoming call data, regardless of signaling method employed, provides the 1B Processor with information required to locate an appropriate idle outgoing trunk. Control programs check the office translation data to obtain information concerning the trunk selected. In this particular example, illustrated in Figure 29, the selected trunk is an N-Carrier or ON Carrier, and others, analog trunk.

7.25 Translation data in 1B Processor memory indicates the selected trunk employs multifrequency/dual tone multifrequency signaling. Translation data also indicates the type of supervisory signal exchanges required on the selected trunk. This discussion could also apply to an outgoing call on an international trunk using CCITT 5 signaling. In that case, the office interface would be through a CCITT 5 unitized analog facility terminal rather than the intermediate distribution frame as shown in Figure 29.



NOTE: UNLESS OTHERWISE INDICATED, ALL SIGNAL FLOW IS BIDIRECTIONAL

LEGEND:

CC - CENTRAL CONTROL
CCIS - COMMON CHANNEL INTEROFFICE SIGNALING
IO - INPUT/OUTPUT
MSCAN - MISCELLANEOUS SCAN POINT
MSD - MISCELLANEOUS SIGNAL DISTRIBUTOR POINT
PCM - PULSE CODE MODULATED
PUB - PERIPHERAL UNIT BUS
USCAN - UNIVERSAL SCAN POINT
USD - UNIVERSAL SIGNAL DISTRIBUTOR POINT
VF - VOICE FREQUENCY

Figure 25. Call Processing, Dial-Pulse Incoming Call (Sheet 1 of 4)

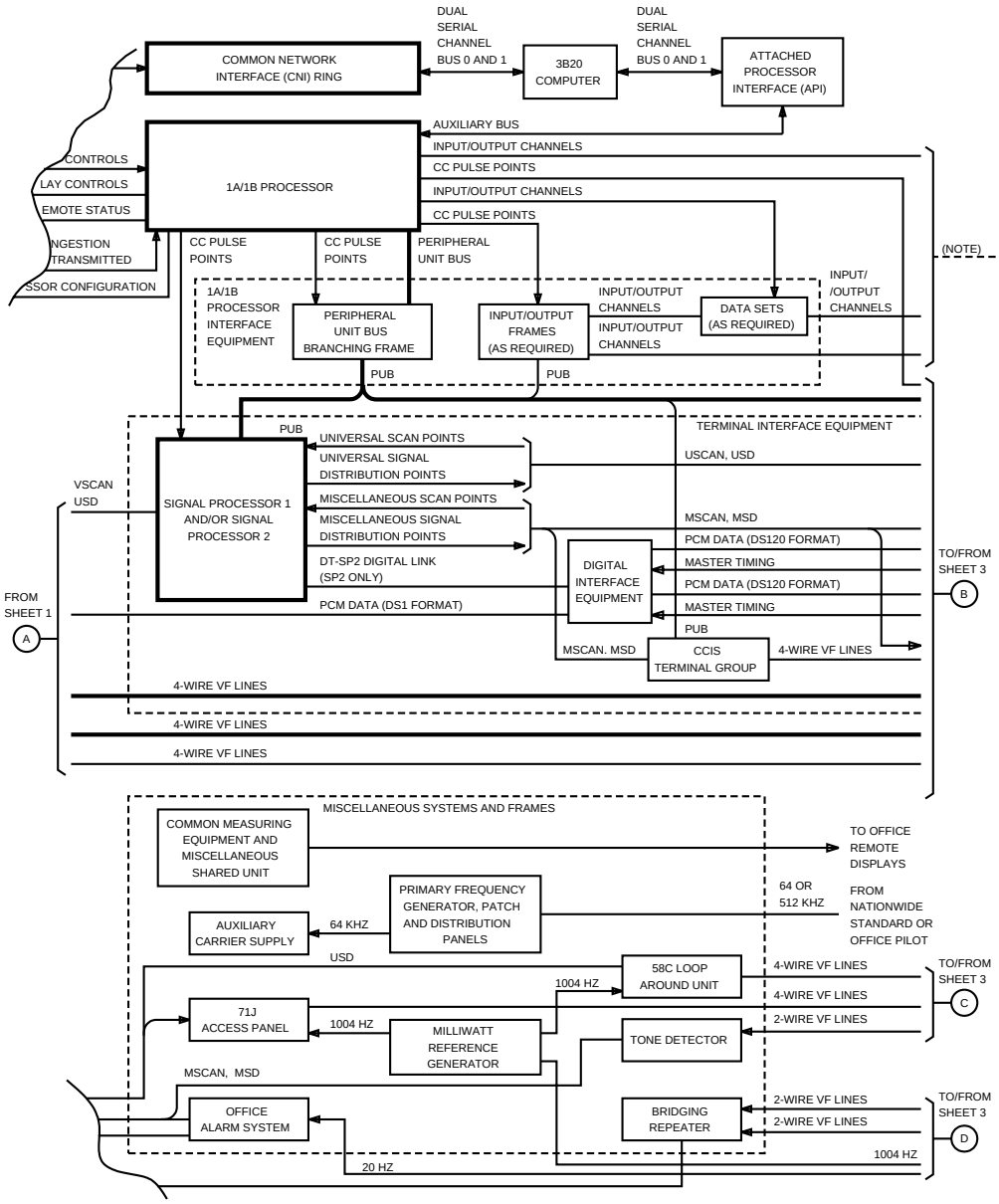


Figure 25. Call Processing, Dial-Pulse Incoming Call (Sheet 2 of 4)

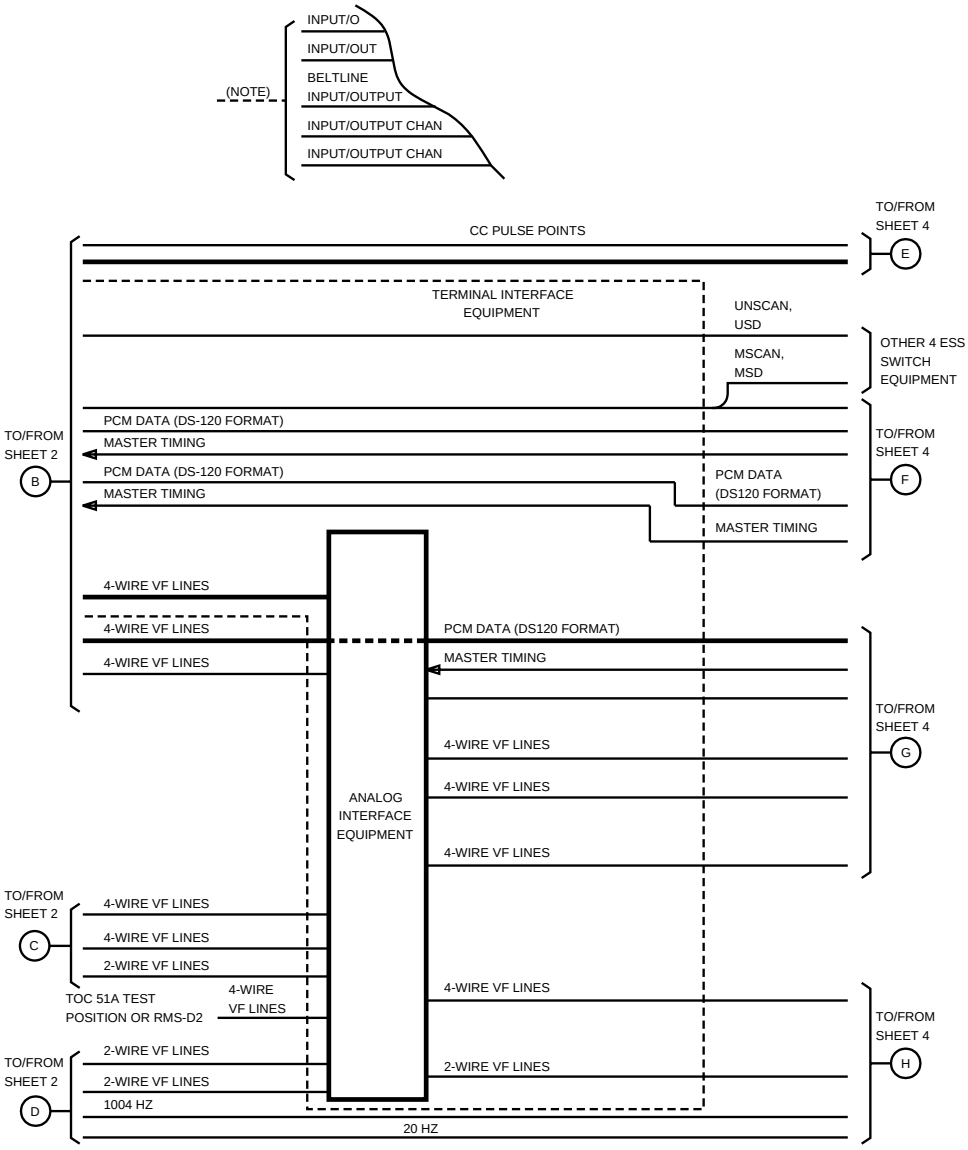


Figure 25. Call Processing, Dial-Pulse Incoming Call (Sheet 3 of 4)

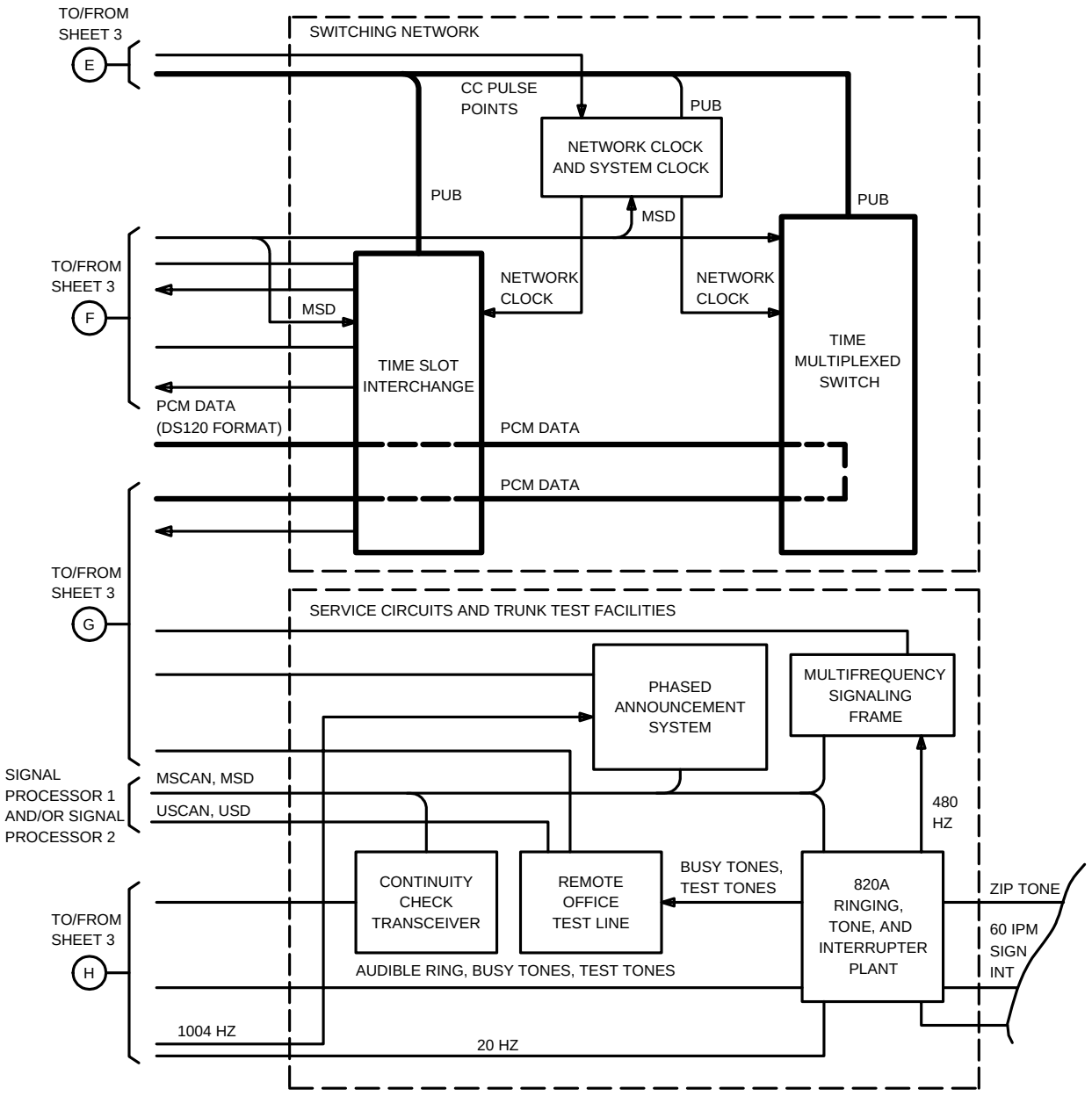
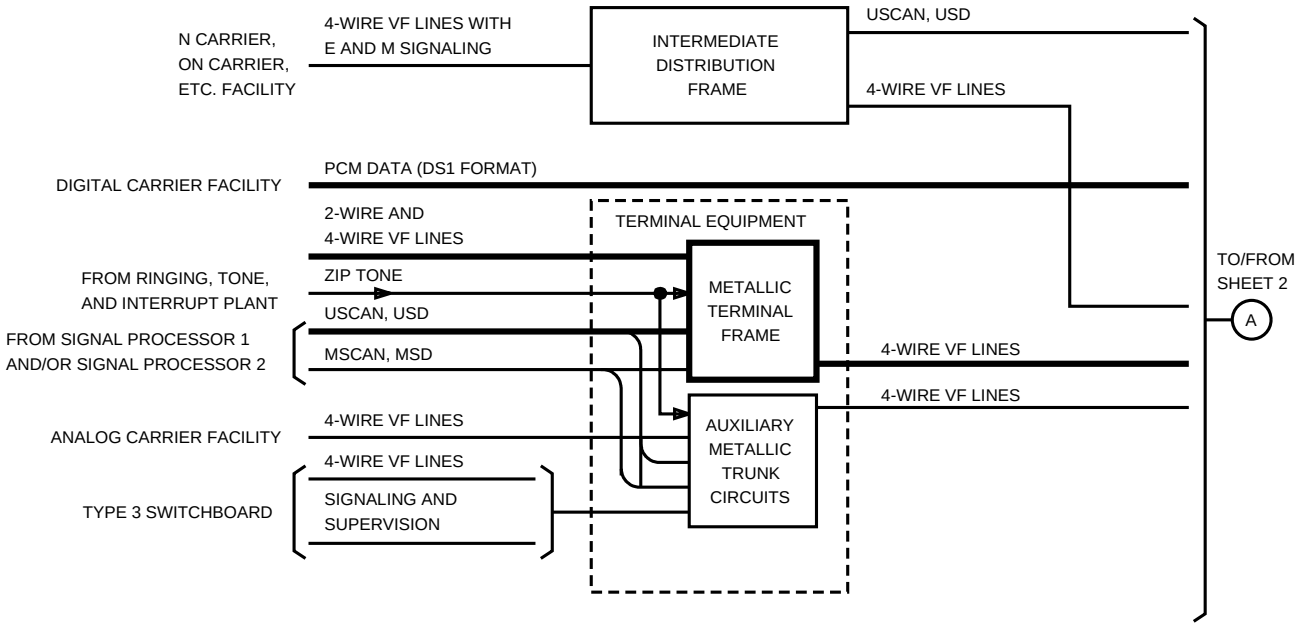


Figure 25. Call Processing, Dial-Pulse Incoming Call (Sheet 4 of 4)



NOTE: UNLESS OTHERWISE INDICATED, ALL SIGNAL FLOW IS BIDIRECTIONAL

LEGEND:

CC - CENTRAL CONTROL
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MSD - MISCELLANEOUS SIGNAL DISTRIBUTOR POINT
PCM - PULSE CODE MODULATED
PUB - PERIPHERAL UNIT BUS
USCAN - UNIVERSAL SCAN POINT
USD - UNIVERSAL SIGNAL DISTRIBUTOR POINT
VF - VOICE FREQUENCY

Figure 26. Call Processing, Multifrequency/Dual Tone Multifrequency Signaling Incoming Call (Sheet 1 of 4)

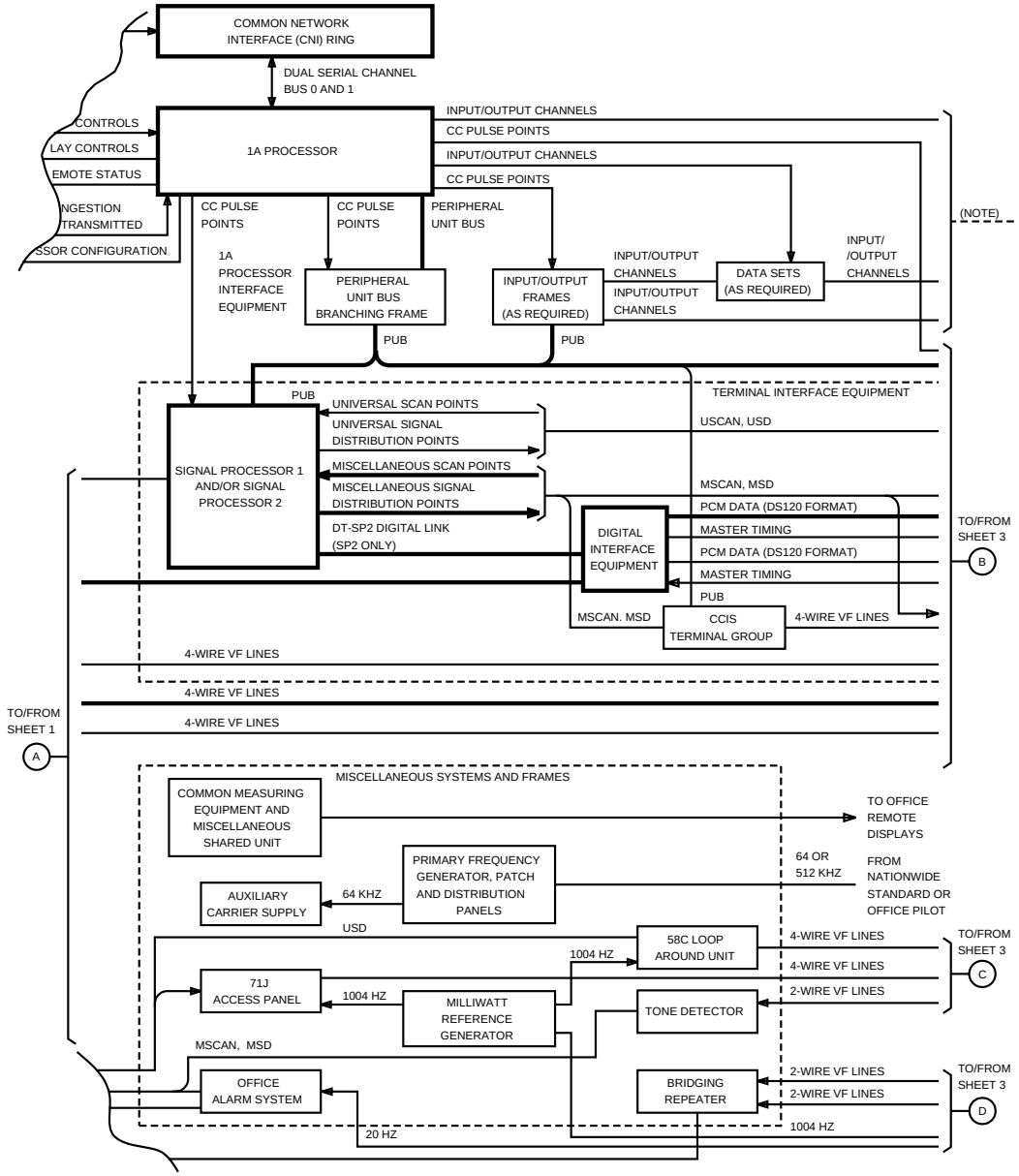


Figure 26. Call Processing, Multifrequency/Dual Tone Multifrequency Signaling Incoming Call (Sheet 2 of 4)

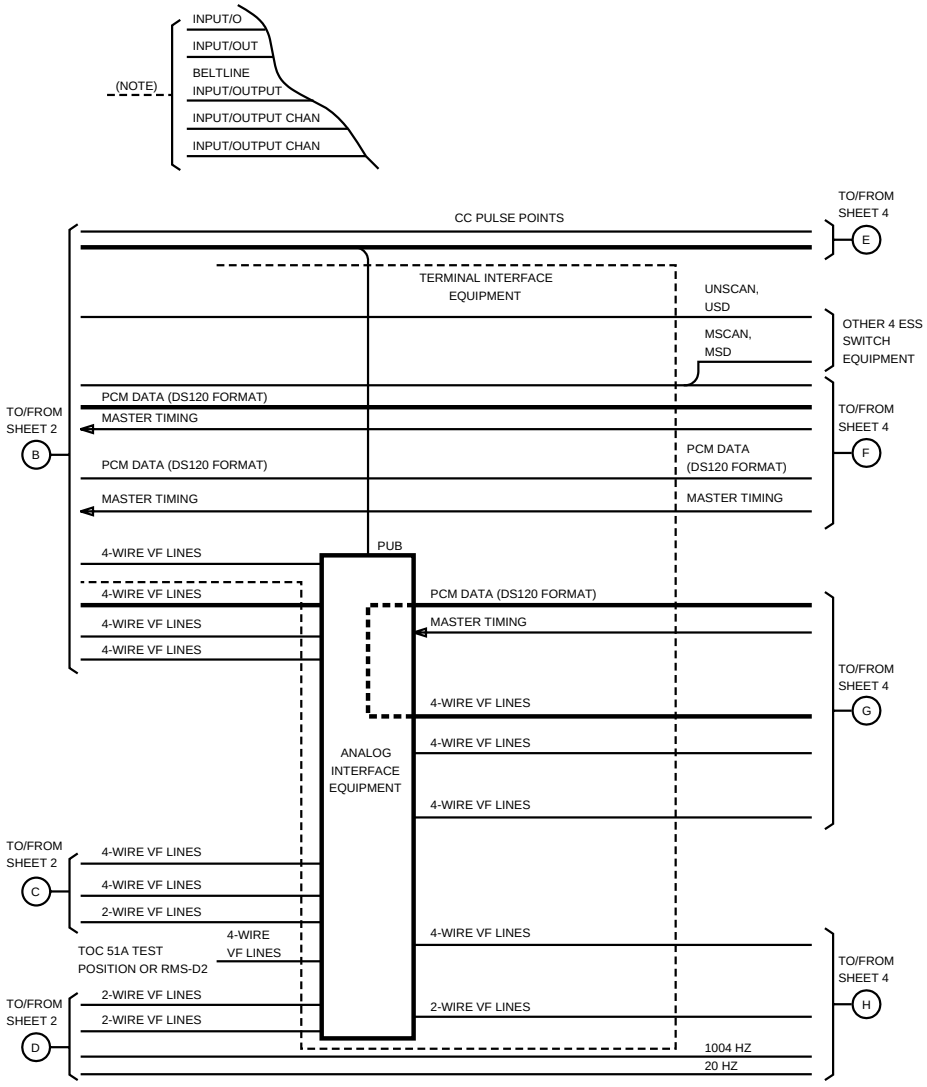


Figure 26. Call Processing, Multifrequency/Dual Tone Multifrequency Signaling Incoming Call (Sheet 3 of 4)

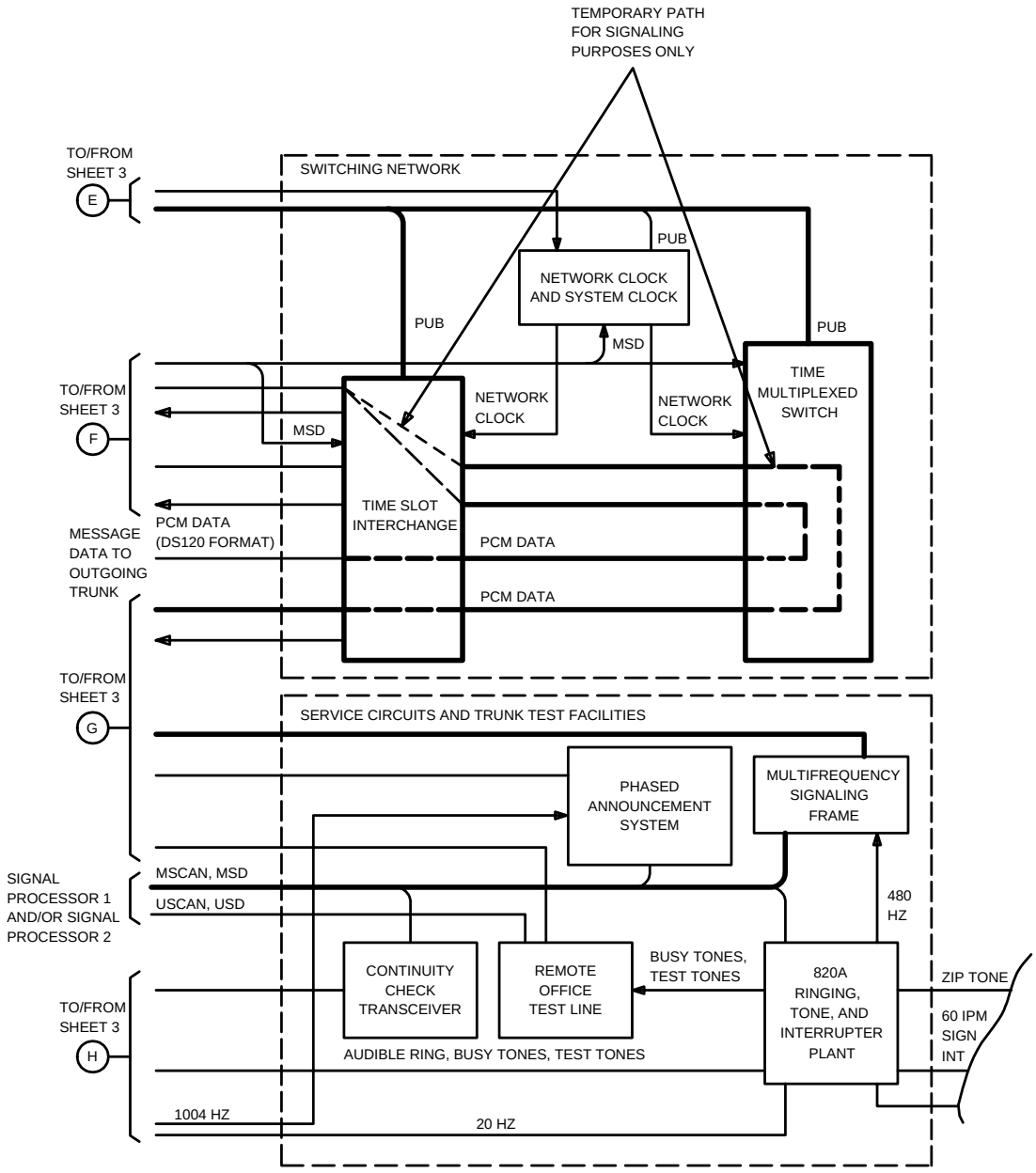


Figure 26. Call Processing, Multifrequency/Dual Tone Multifrequency Signaling Incoming Call (Sheet 4 of 4)

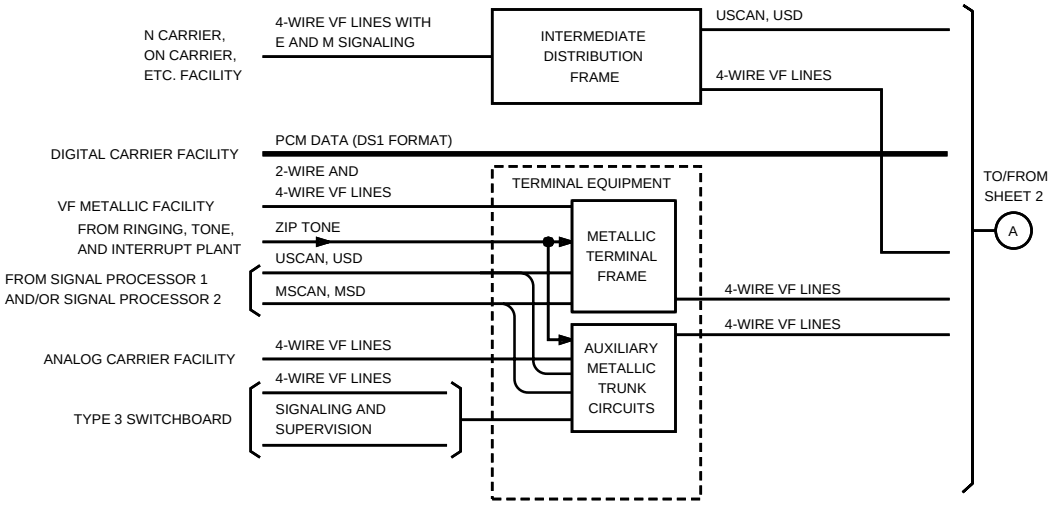


Figure 27. Call Processing, Common Channel Signaling (CCS) Incoming Call (Sheet 2 of 4)

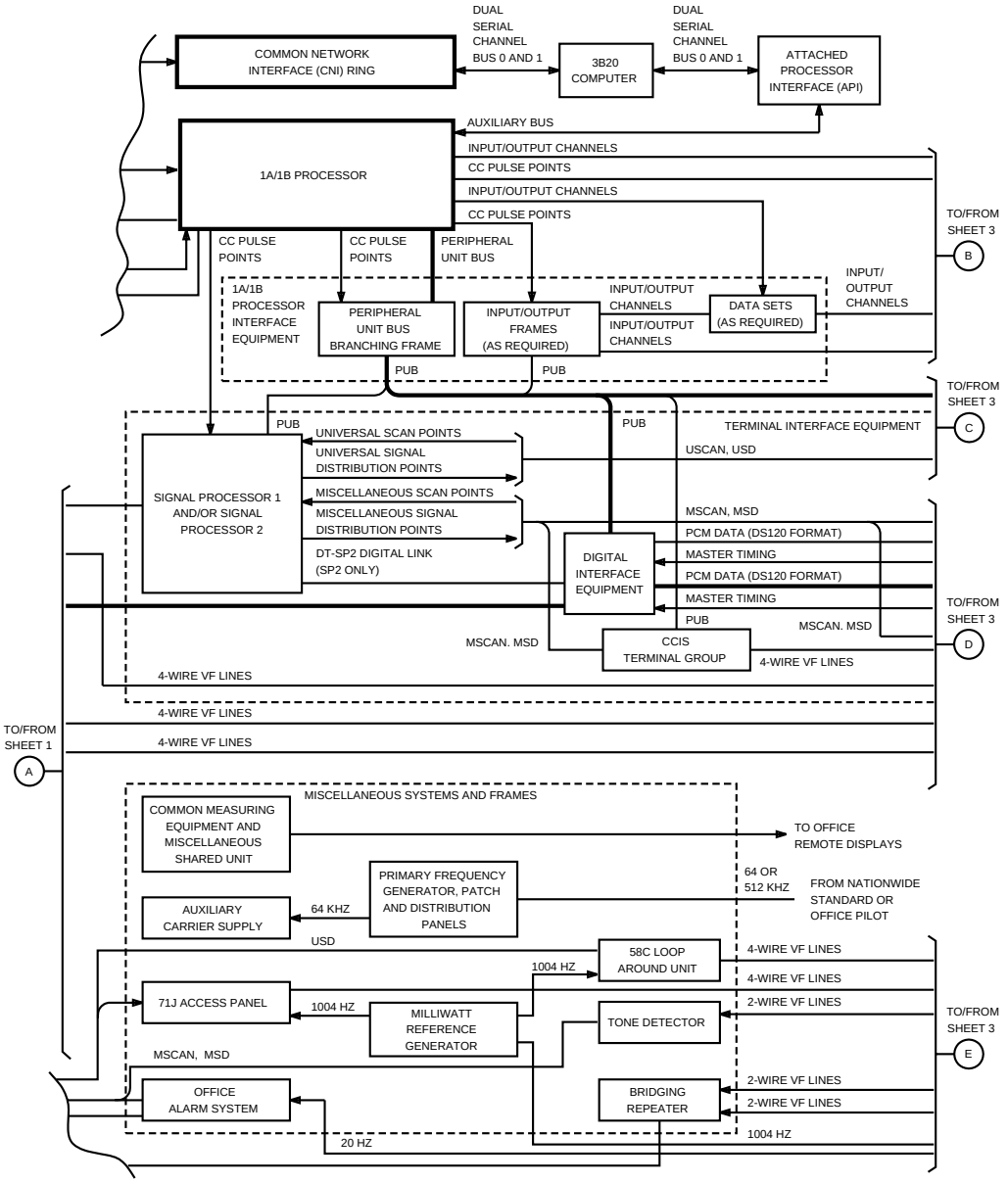


Figure 27. Call Processing, Common Channel Signaling (CCS) Incoming Call (Sheet 2 of 4)

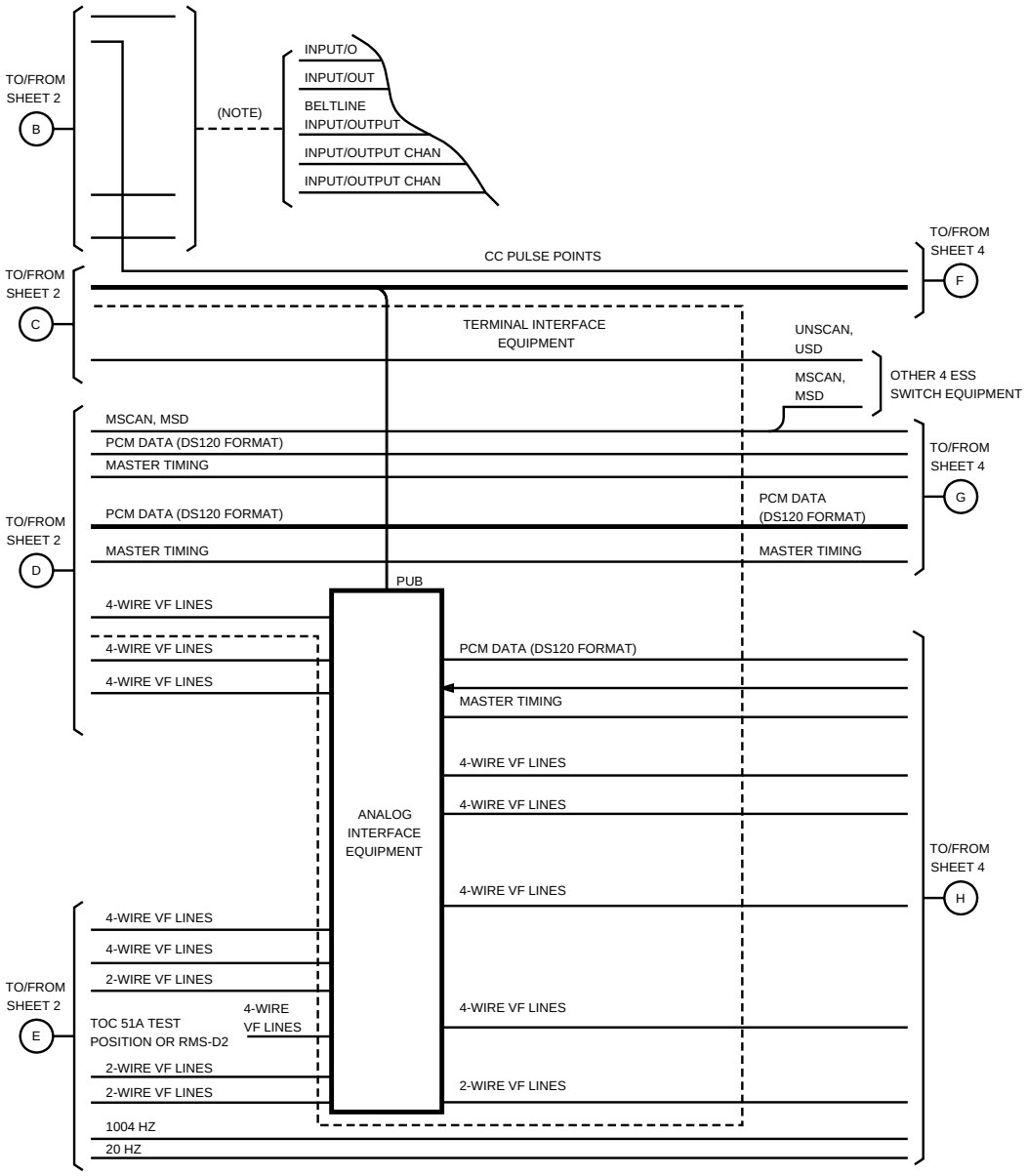
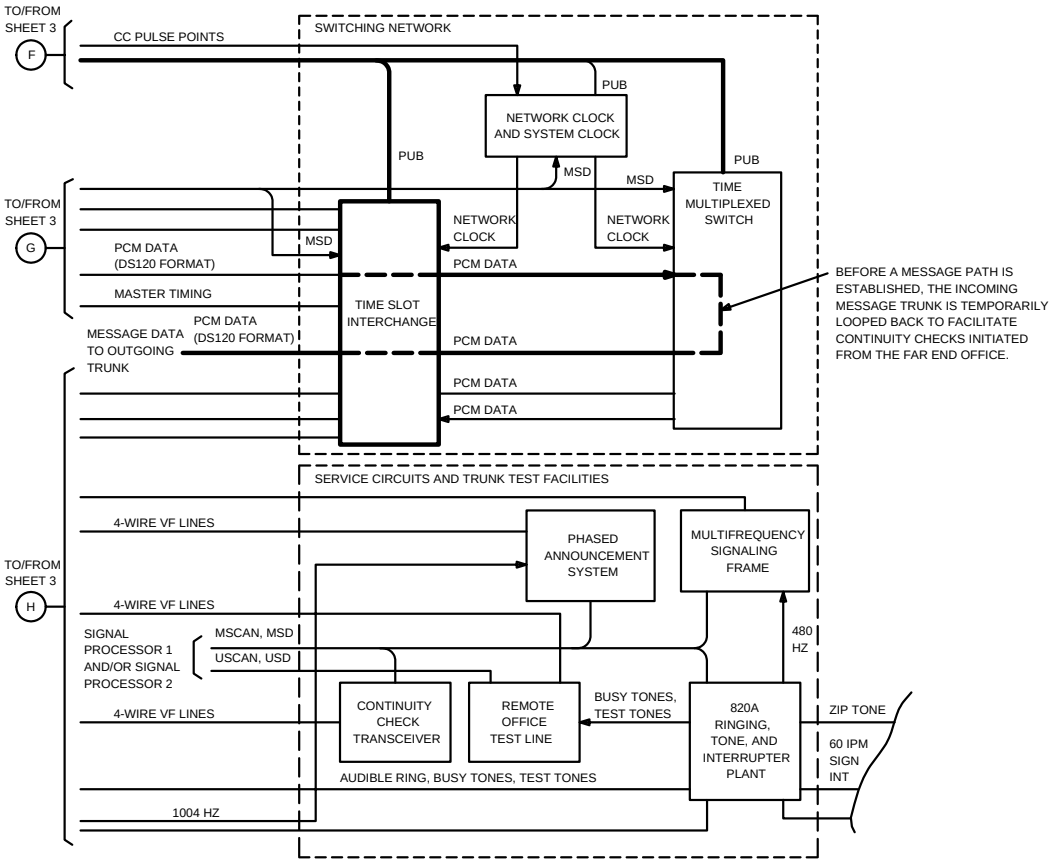


Figure 27. Call Processing, Common Channel Signaling (CCS) Incoming Call (Sheet 3 of 4)



NOTE: UNLESS OTHERWISE INDICATED, ALL SIGNAL FLOW IS BIDIRECTIONAL

LEGEND:

CC - CENTRAL CONTROL
CCIS - COMMON CHANNEL INTEROFFICE SIGNALING
IO - INPUT/OUTPUT
MSCAN - MISCELLANEOUS SCAN POINT
MSD - MISCELLANEOUS SIGNAL DISTRIBUTOR POINT
PCM - PULSE CODE MODULATED
PUB - PERIPHERAL UNIT BUS
USCAN - UNIVERSAL SCAN POINT
USD - UNIVERSAL SIGNAL DISTRIBUTOR POINT
VF - VOICE FREQUENCY

Figure 27. Call Processing, Common Channel Signaling (CCS) Incoming Call (Sheet 4 of 4)

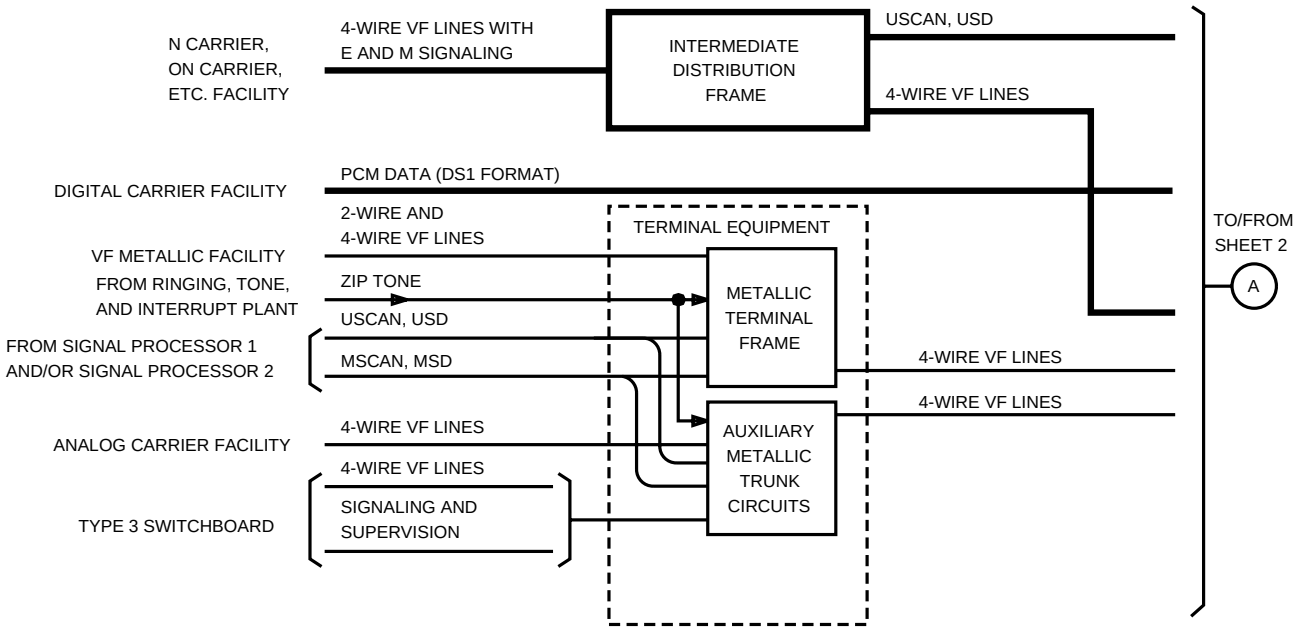


Figure 28. Call Processing, Dial-Pulse Outgoing Call (Sheet 1 of 4)

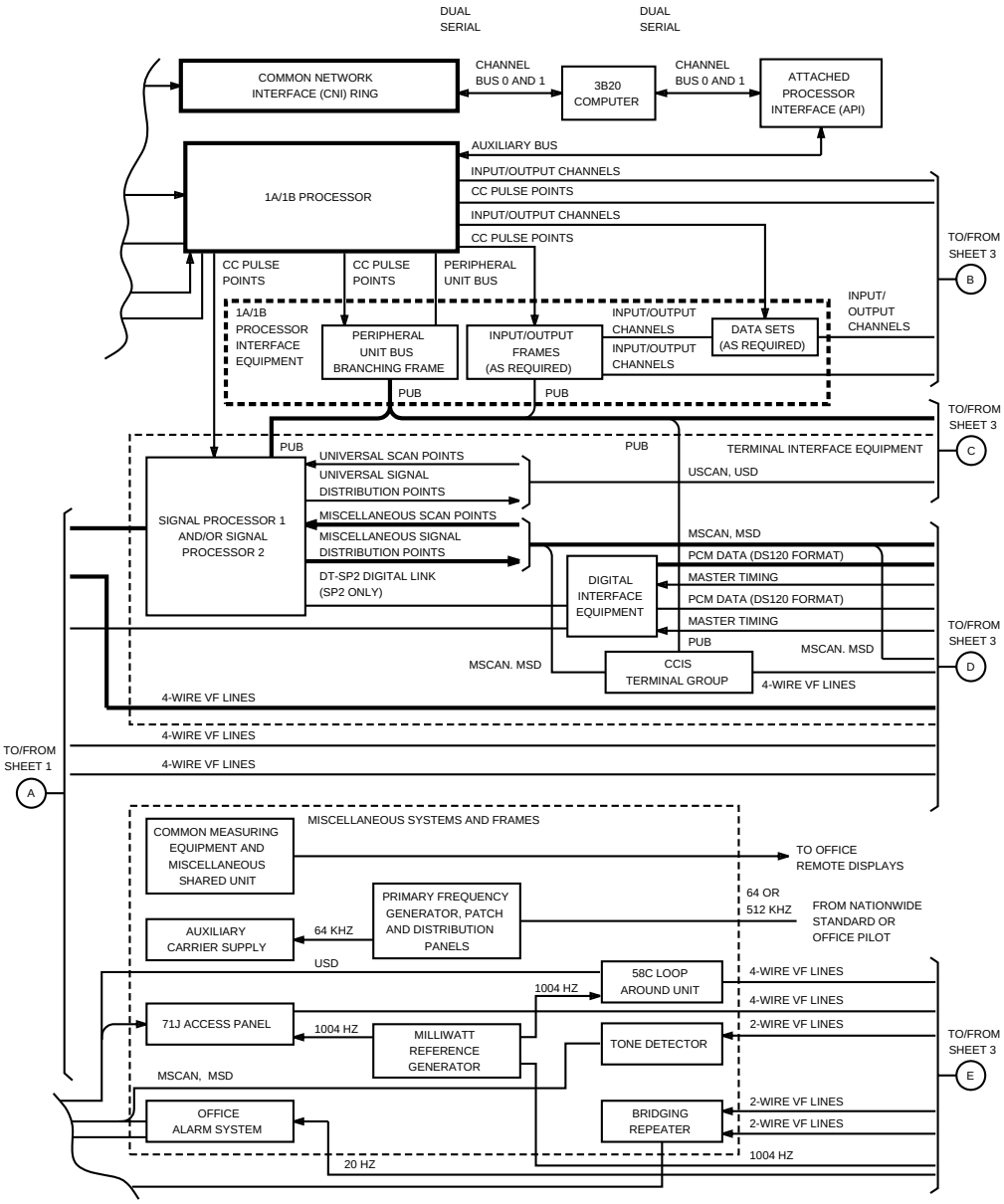


Figure 28. Call Processing, Dial-Pulse Outgoing Call (Sheet 2 of 4)

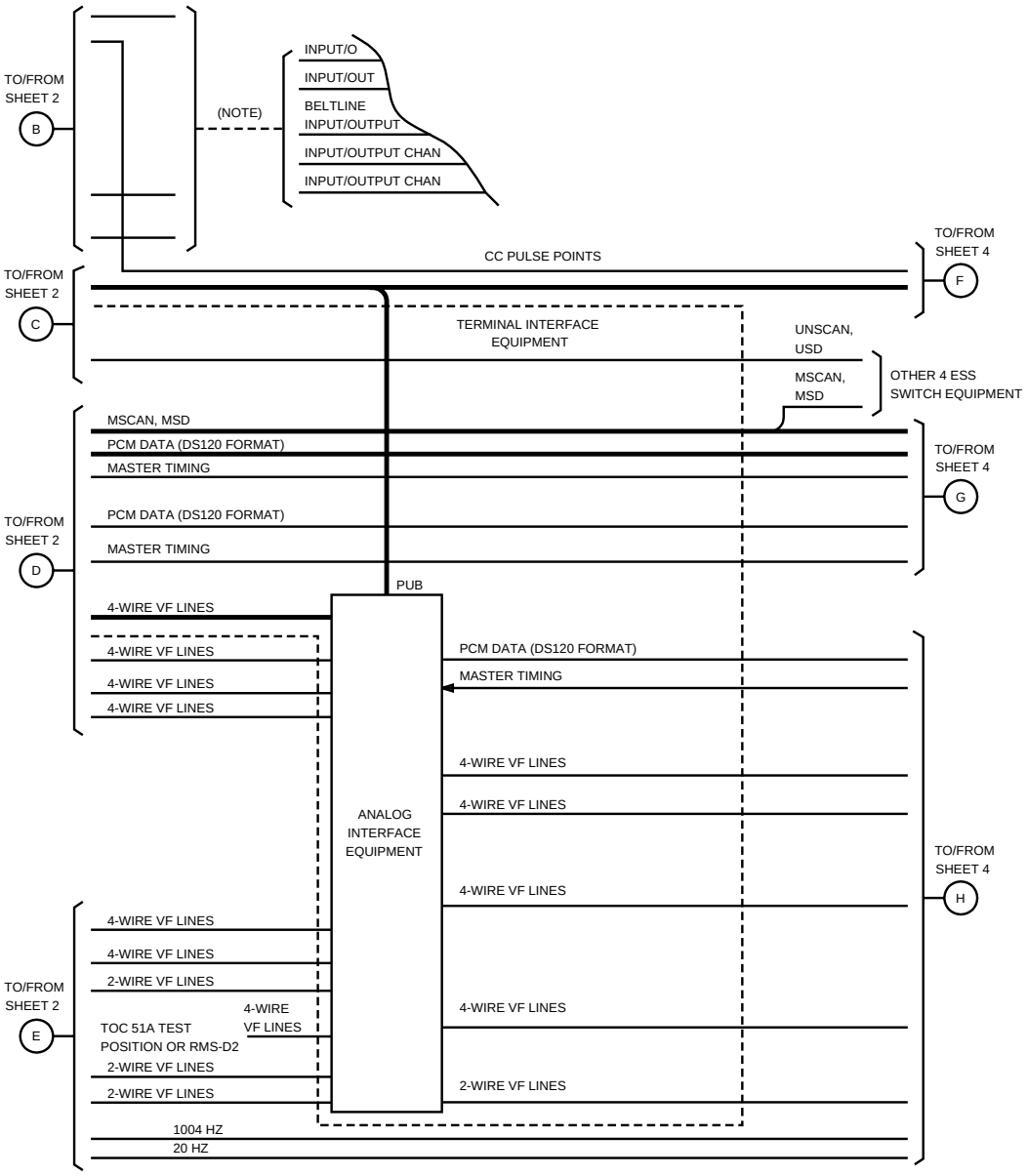


Figure 28. Call Processing, Dial-Pulse Outgoing Call (Sheet 3 of 4)

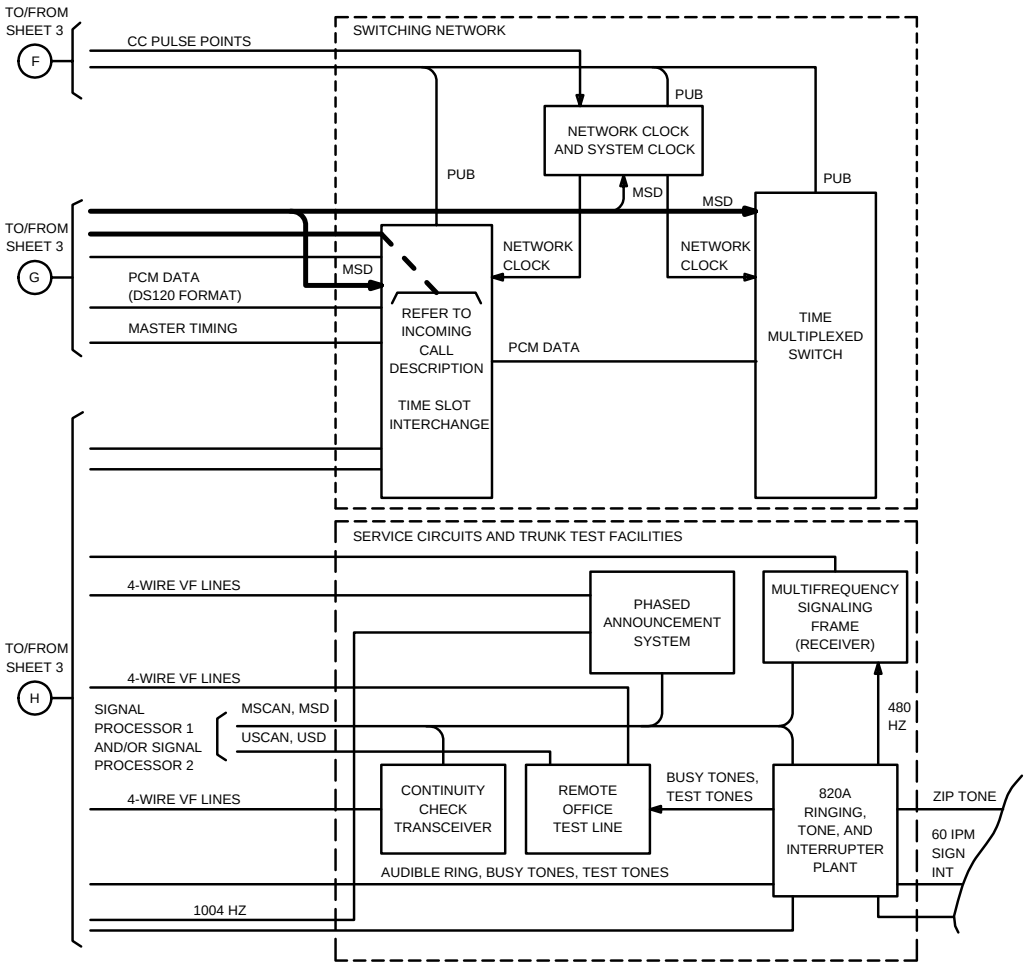


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Figure 28. Call Processing, Dial-Pulse Outgoing Call (Sheet 4 of 4)

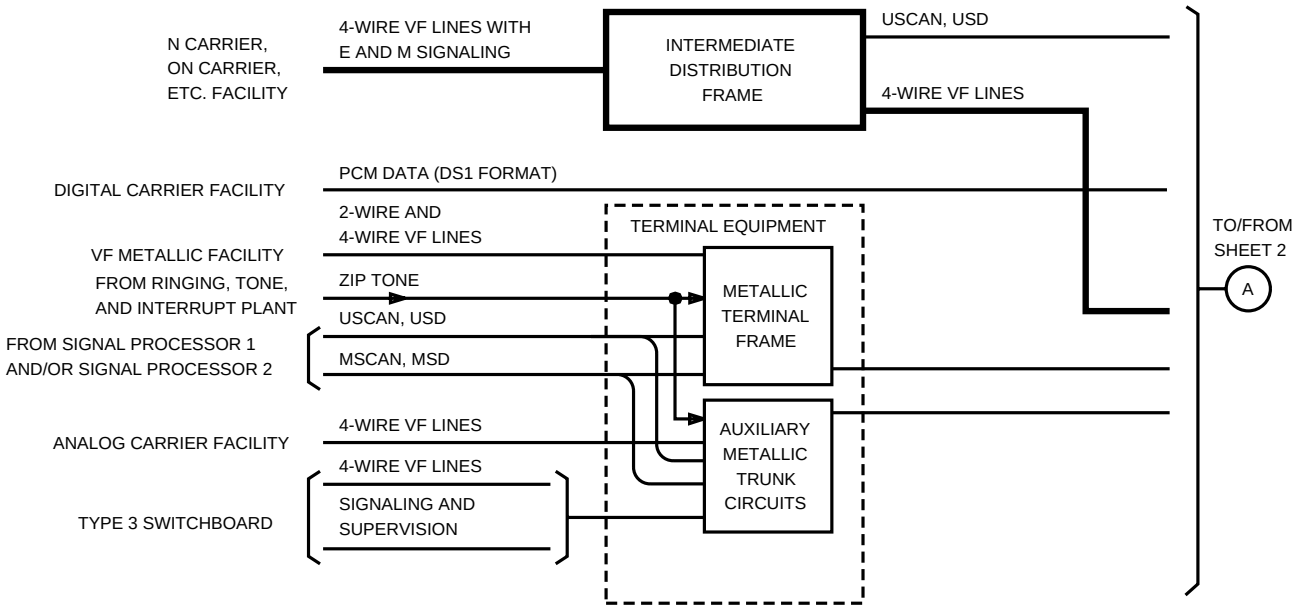

Figure 29. Call Processing, Multifrequency/Dual Tone Multifrequency Signaling Outgoing Call (Sheet 1 of 4)

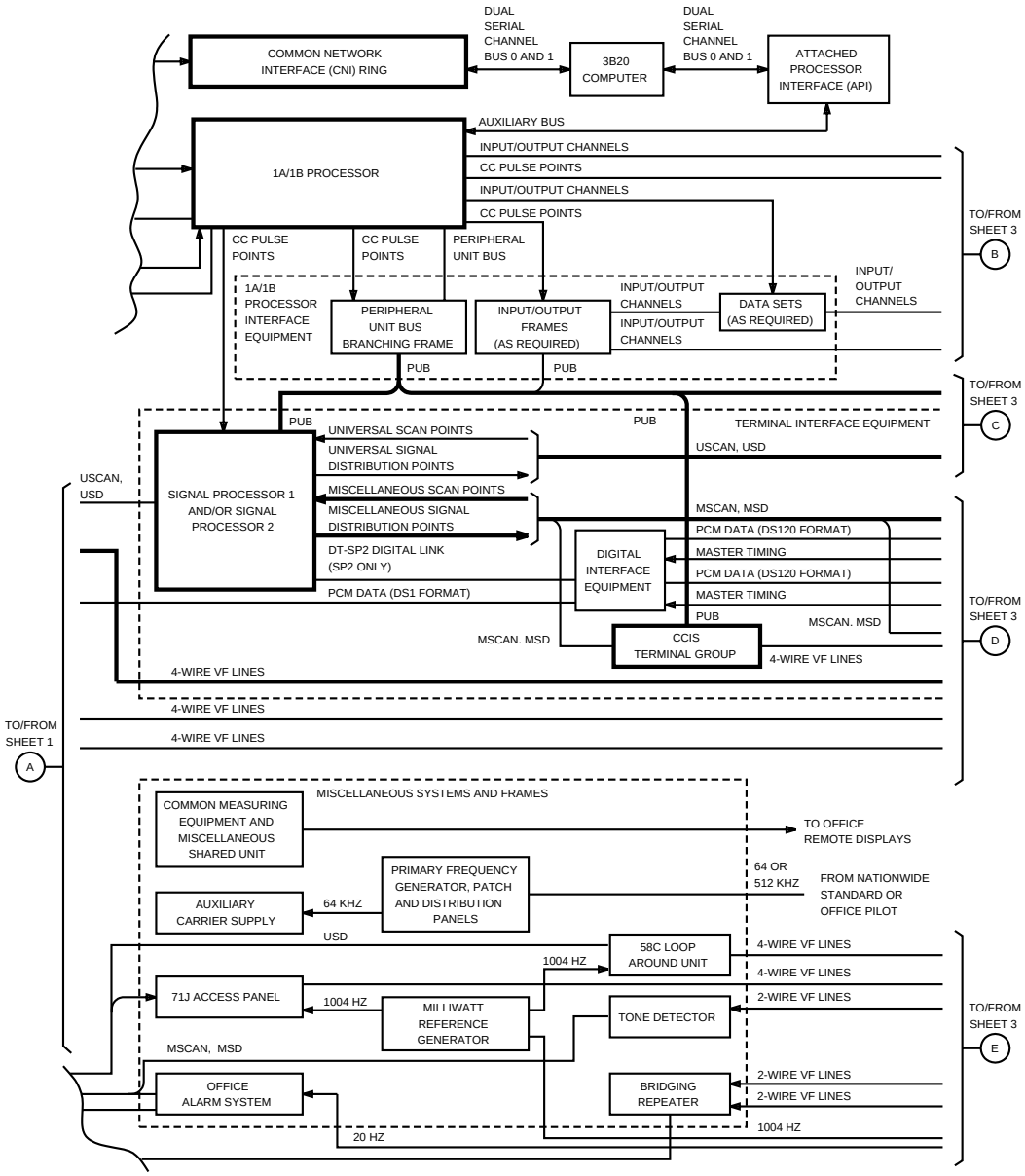

Figure 29. Call Processing, Multifrequency/Dual Tone Multifrequency Signaling Outgoing Call (Sheet 2 of 4)

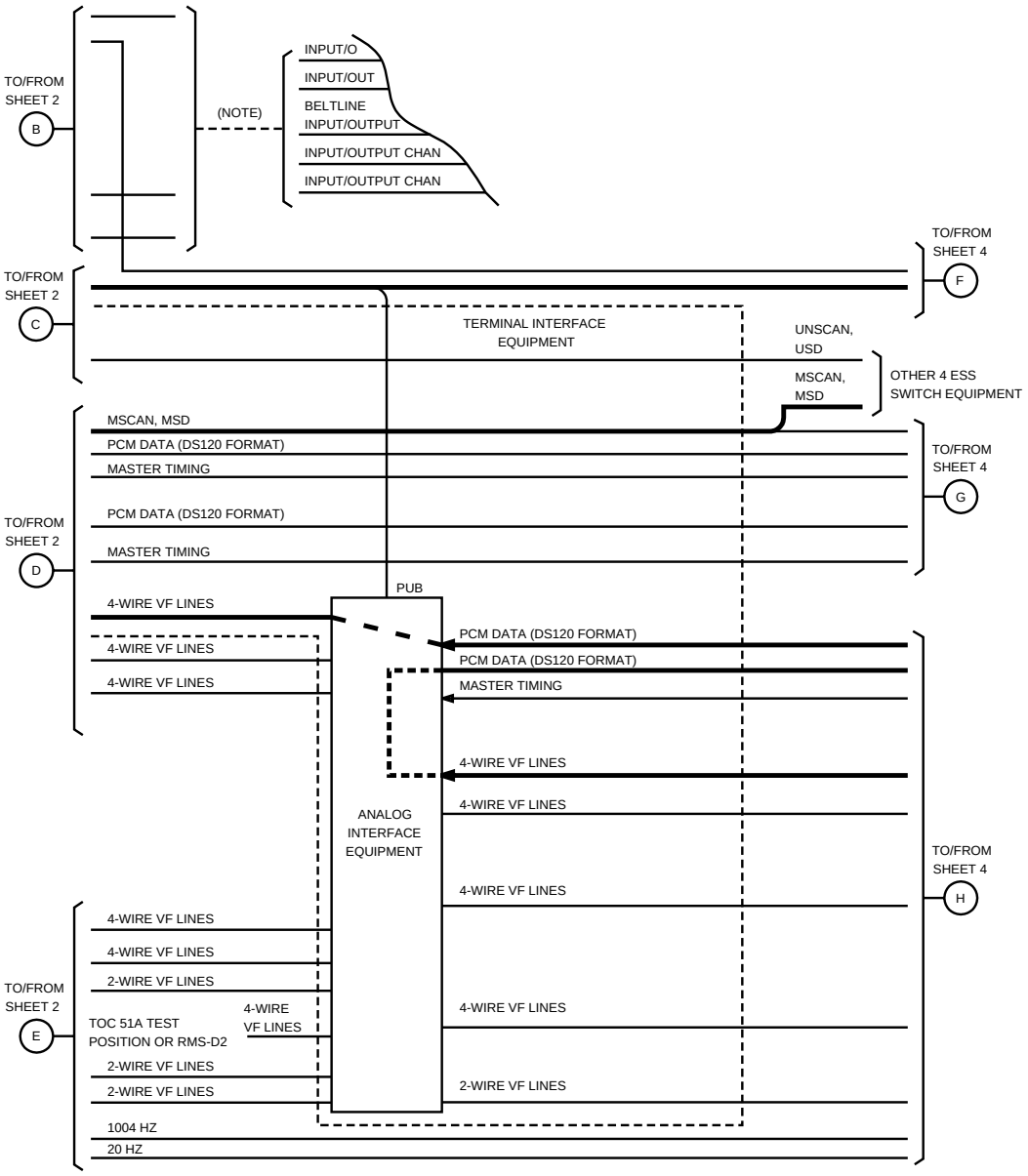

Figure 29. Call Processing, Multifrequency/Dual Tone Multifrequency Signaling Outgoing Call (Sheet 3 of 4)

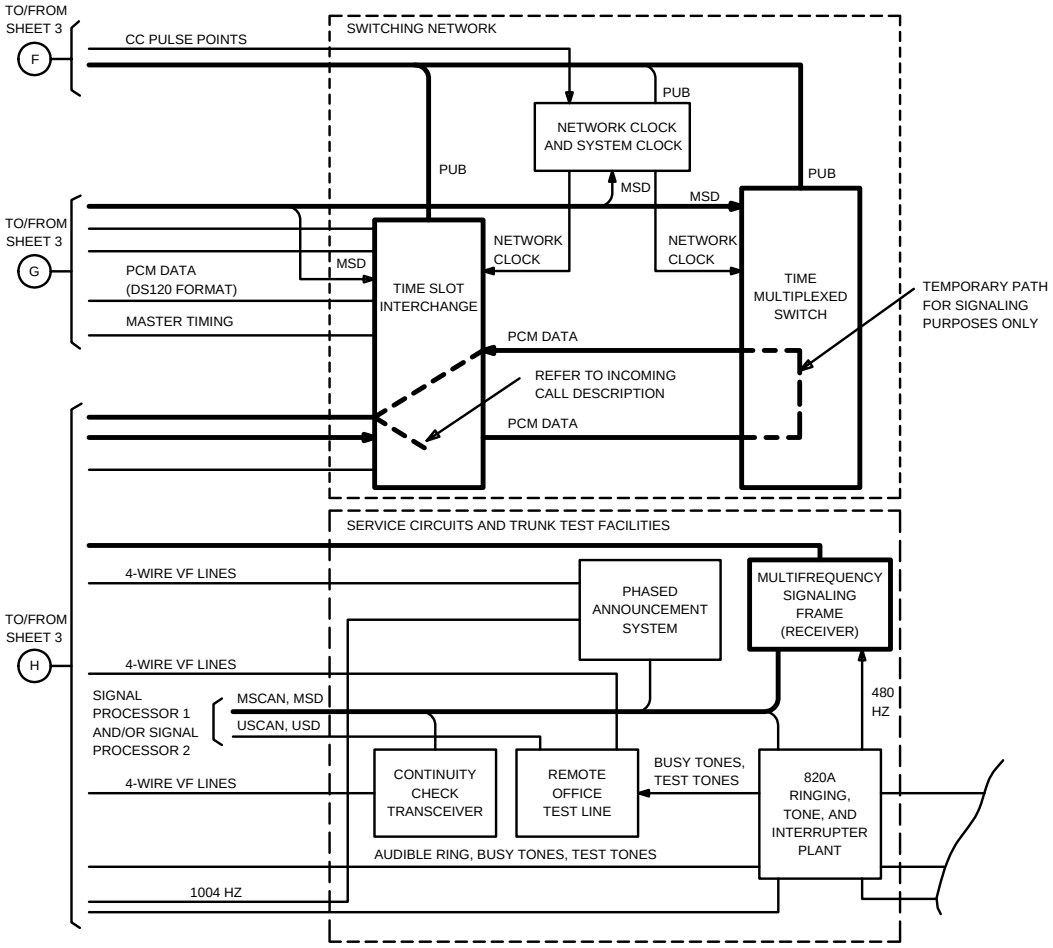

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Figure 29. Call Processing, Multifrequency/Dual Tone Multifrequency Signaling Outgoing Call (Sheet 4 of 4)

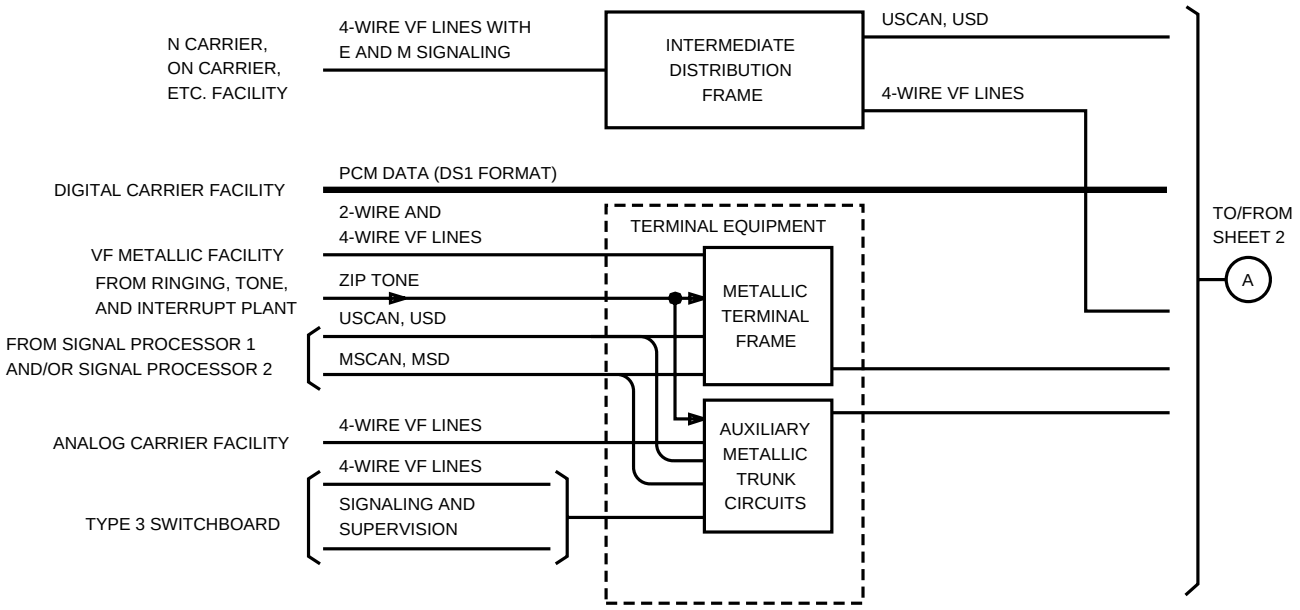

Figure 30. Call Processing, Common Channel Signaling (CCS) Outgoing Call (Sheet 1 of 4)

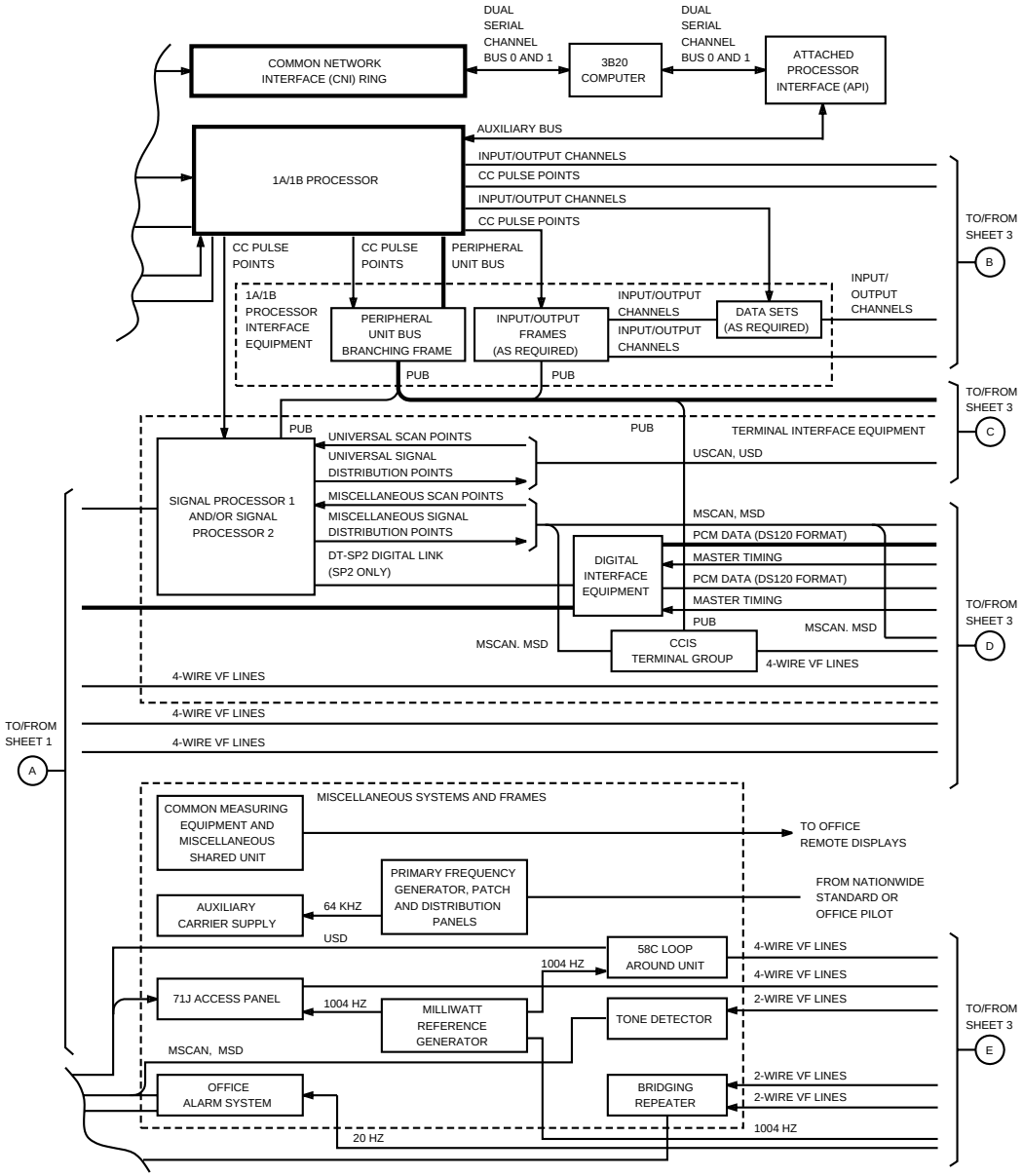

Figure 30. Call Processing, Common Channel Signaling (CCS) Outgoing Call (Sheet 2 of 4)

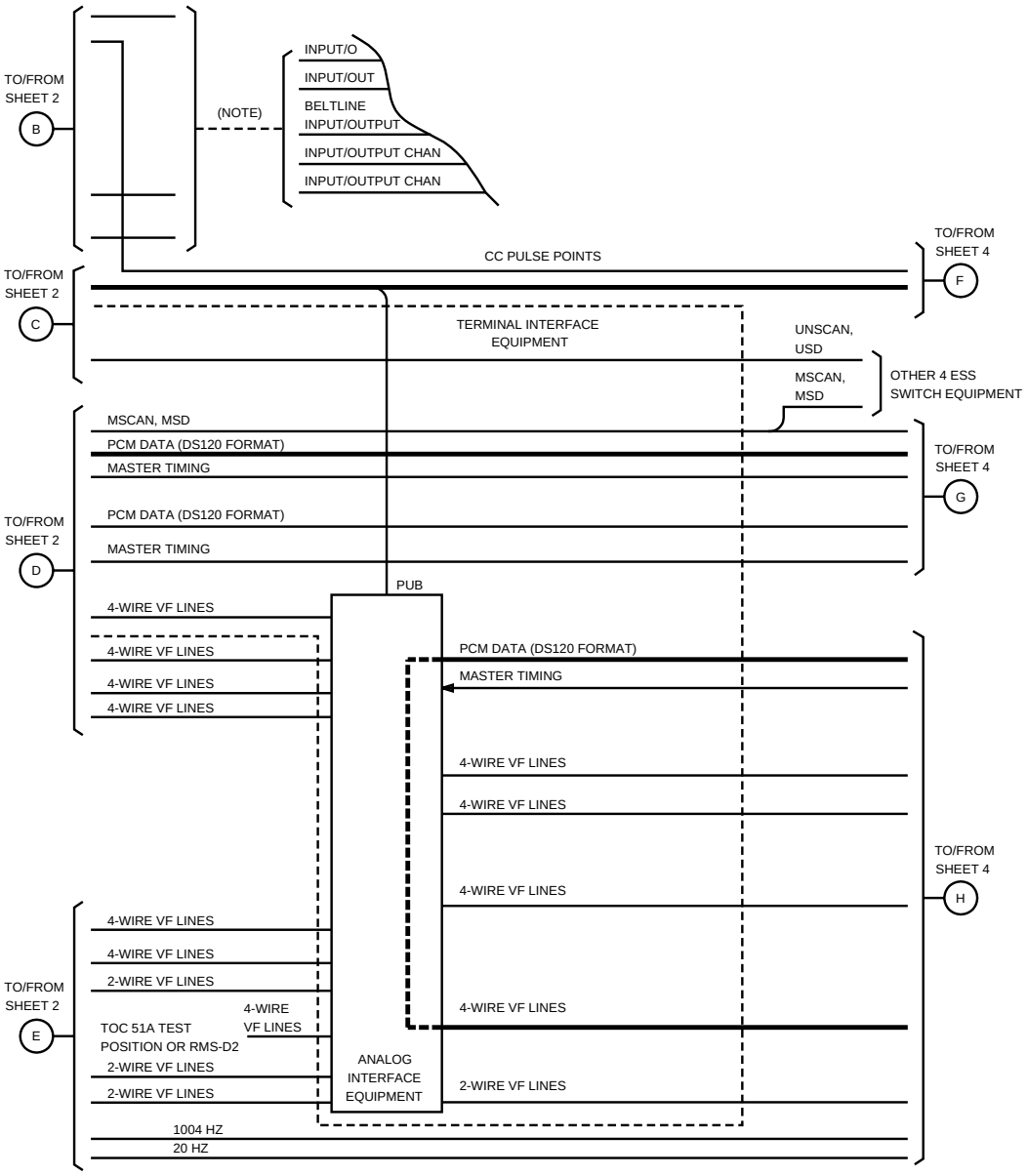

Figure 30. Call Processing, Common Channel Signaling (CCS) Outgoing Call (Sheet 3 of 4)

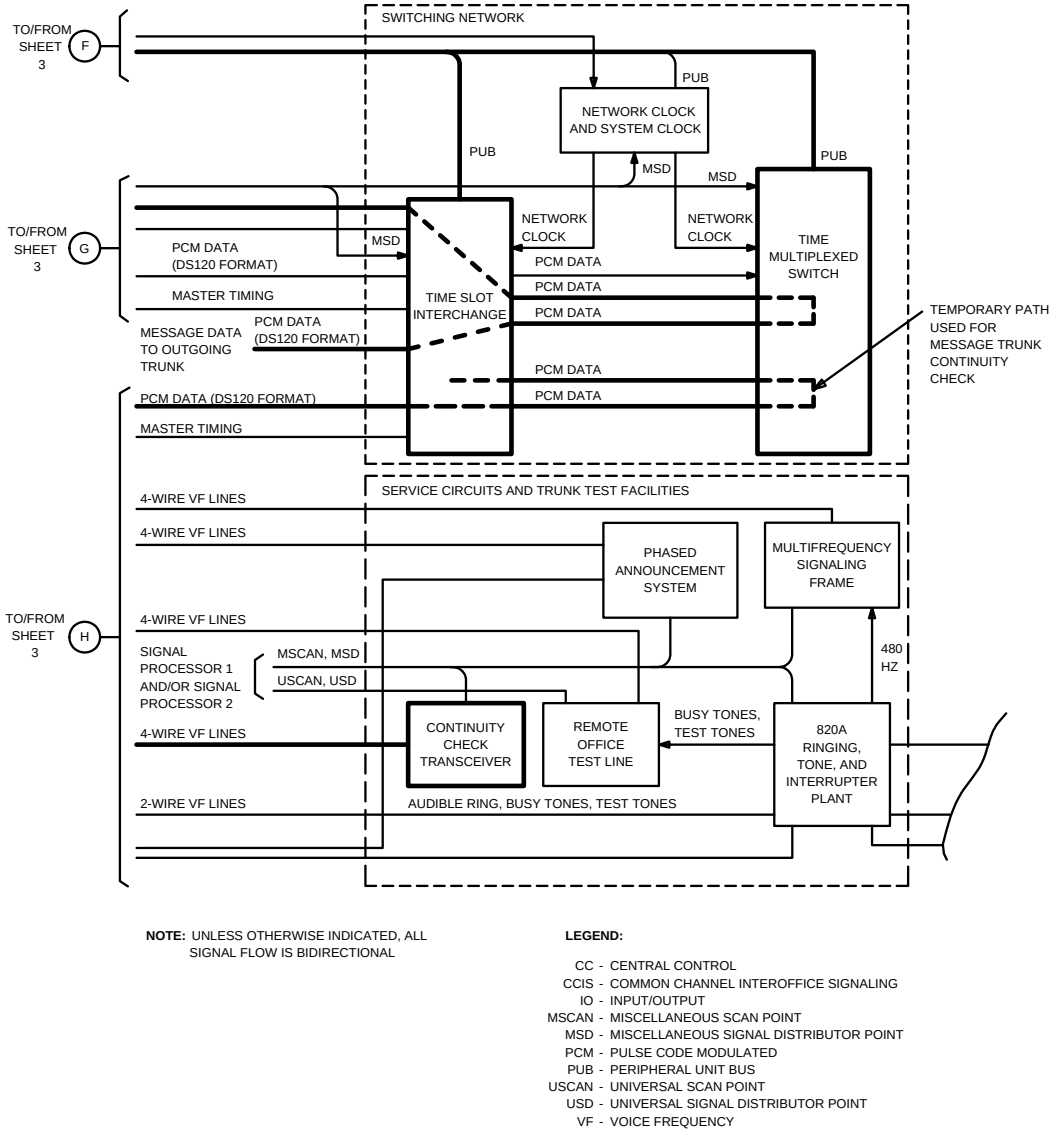

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Figure 30. Call Processing, Common Channel Signaling (CCS) Outgoing Call (Sheet 4 of 4)

7.26 The 1B Processor directs the signal processor 1 to initiate the appropriate supervisory communication. This is accomplished via the universal signal distributor and scan point interface between the intermediate distributing frame and the signal processor 1. When supervisory signals indicate the receiving office is ready to accept digits, the 1B Processor locates and establishes a temporary path through the time division network. This temporary path connects a multifrequency transmitter to the trunk selected to carry the outgoing call.

7.27 The signal processor 1 applies digits to be transmitted to the multifrequency transmitter via the miscellaneous signal distributor interface between these units. The multifrequency transmitter converts these digits to multifrequency signals and applies them to the outgoing trunk through the switching network. When all digits have been transmitted, the signal processor 1 notifies the 1B Processor.

7.28 The 1B Processor, in turn, disconnects the multifrequency transmitter by discontinuing the temporary path through the time division network. As mentioned in descriptions of incoming calls, the message path through the 4ESS Switch is established as soon as the 1B Processor identifies a path through the time division network. When all digits have been outpulsed, the called office responds with audible ring, busy tone, reorder tone, or a recorded message as appropriate.

F. Common Channel Signaling (CCS) Outgoing Call

7.29 Information previously applied to the 1B Processor as incoming call data, regardless of signaling method employed, provides the 1B Processor with information required to locate an appropriate idle outgoing trunk. Control programs check the office translation data to obtain information concerning the trunk selected. In this particular example, illustrated in Figure 30, the selected trunk is a digital trunk accommodated by digital interface equipment. Translation data in 1B Processor memory would indicate that the selected trunk employs CCS.

7.30 Upon recognizing the outgoing trunk as one employing common channel signaling, the 1B Processor establishes a temporary path through the time division network. This temporary path connects a continuity check transceiver to the outgoing trunk to verify the trunk is acceptable for voice transmission. The 1B Processor controls the test from the near end via the miscellaneous signal distributor and scan point interface between the continuity check transceiver and the signal processor 1.

7.31 The 1B Processor also directs the 3B Computer to send data concerning the trunk test to the far-end office over the CCS network. Translation data required to establish this connection is part of the office data base stored in 1B Processor and 3B Computer memory.

7.32 Upon successful completion of the message trunk test, the 1B Processor disconnects the continuity check transceiver from the message trunk by removing the temporary path through the network. At the beginning of the message trunk test, the 1B Processor forwards signaling data to the far-end office via the CCS network. This data identifies the trunk over which the call is transmitted and contains the digits which identify the destination of the call.

7.33 As mentioned in descriptions of incoming calls, the message path through the 4ESS Switch is established as soon as the 1B Processor identifies a path through the time division network. When all digits have been outpulsed, the called office responds with audible ring, busy or reorder tone, or a recorded message as appropriate.

G. Reorder Tones and Recorded Messages

7.34 The call-processing discussion in A through F of this part is based upon the assumption that a call is either completed or the destination office returns a busy signal, reorder tone, or

recorded message. However, the 4ESS Switch office can also connect an incoming call to a 120-interrupt-per-minute reorder tone or to a recorded message. A reorder tone or recorded message can be connected to an incoming call for a variety of reasons which are determined by office-dependent data stored in 1B Processor memory.

7.35 Figure 31 illustrates the equipment and interfaces involved when a call is not completed for some reason and is connected to a recorded message or reorder tone. In the illustrated example, a call is applied to the 4 ESS Switch auxiliary metallic trunk circuits from an analog carrier facility. This example trunk employs dial-pulse signaling. The method of transferring signal information is identical to that previously described for a typical dial-pulse incoming call. In this example, however, the 1B Processor for some reason cannot locate an idle trunk leading to the destination office. The 1B Processor identifies the reason for not being able to complete the call and selects a reorder tone or recorded message to apply to the incoming trunk. A path is established through the time division network to connect the trunk to the selected tone or message.

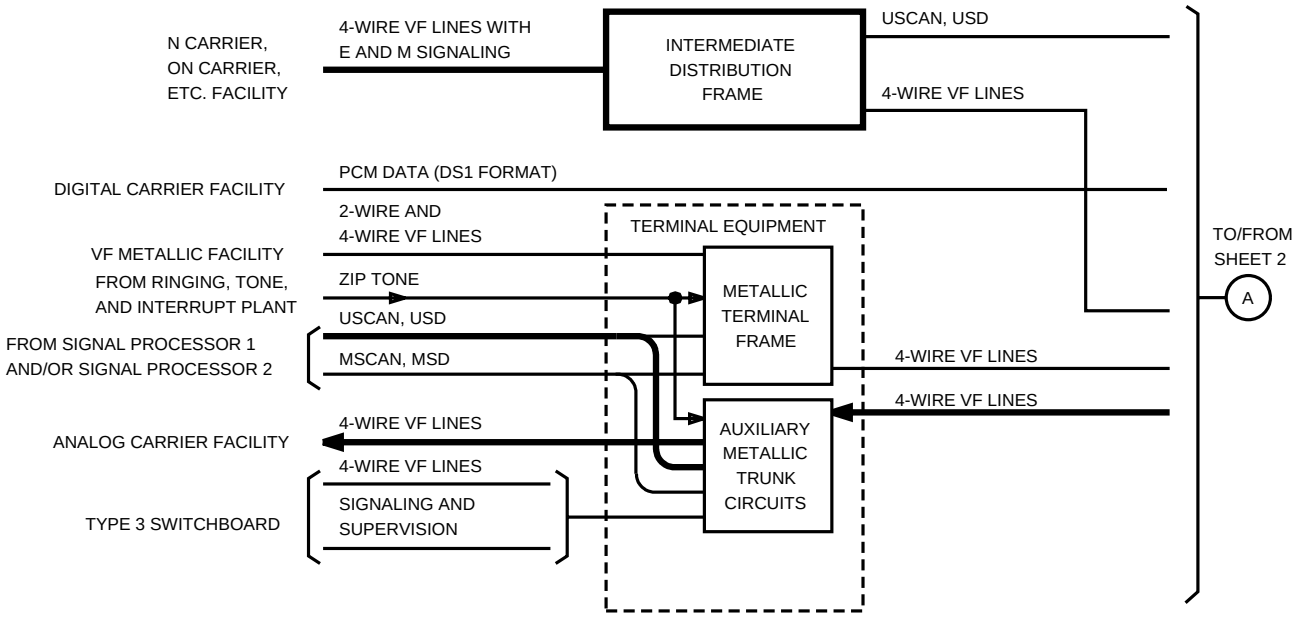

Figure 31. Call Processing, Reorder Tones, and Recorded Messages (Sheet 1 of 4)

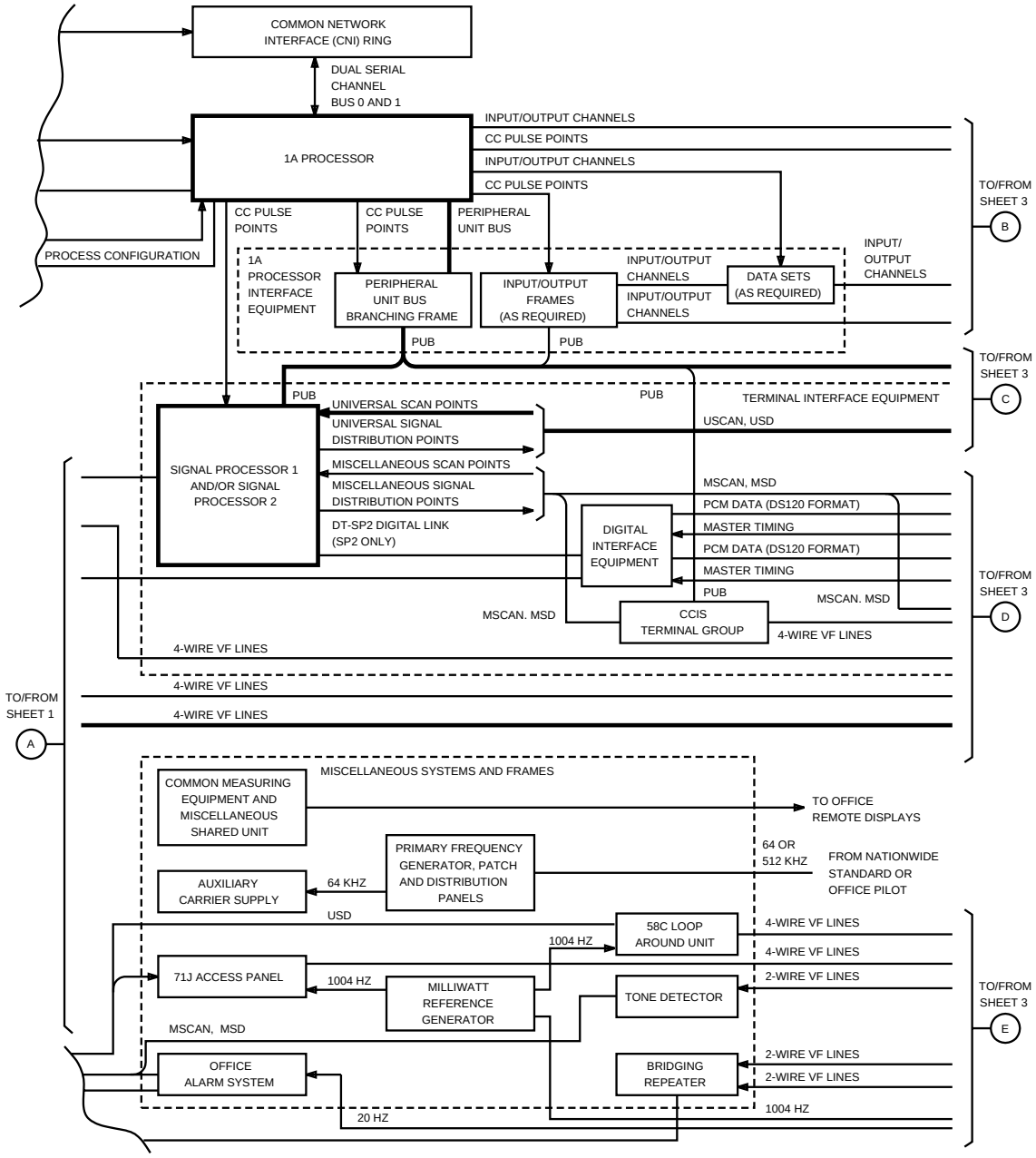

Figure 31. Call Processing, Reorder Tones, and Recorded Messages (Sheet 2 of 4)

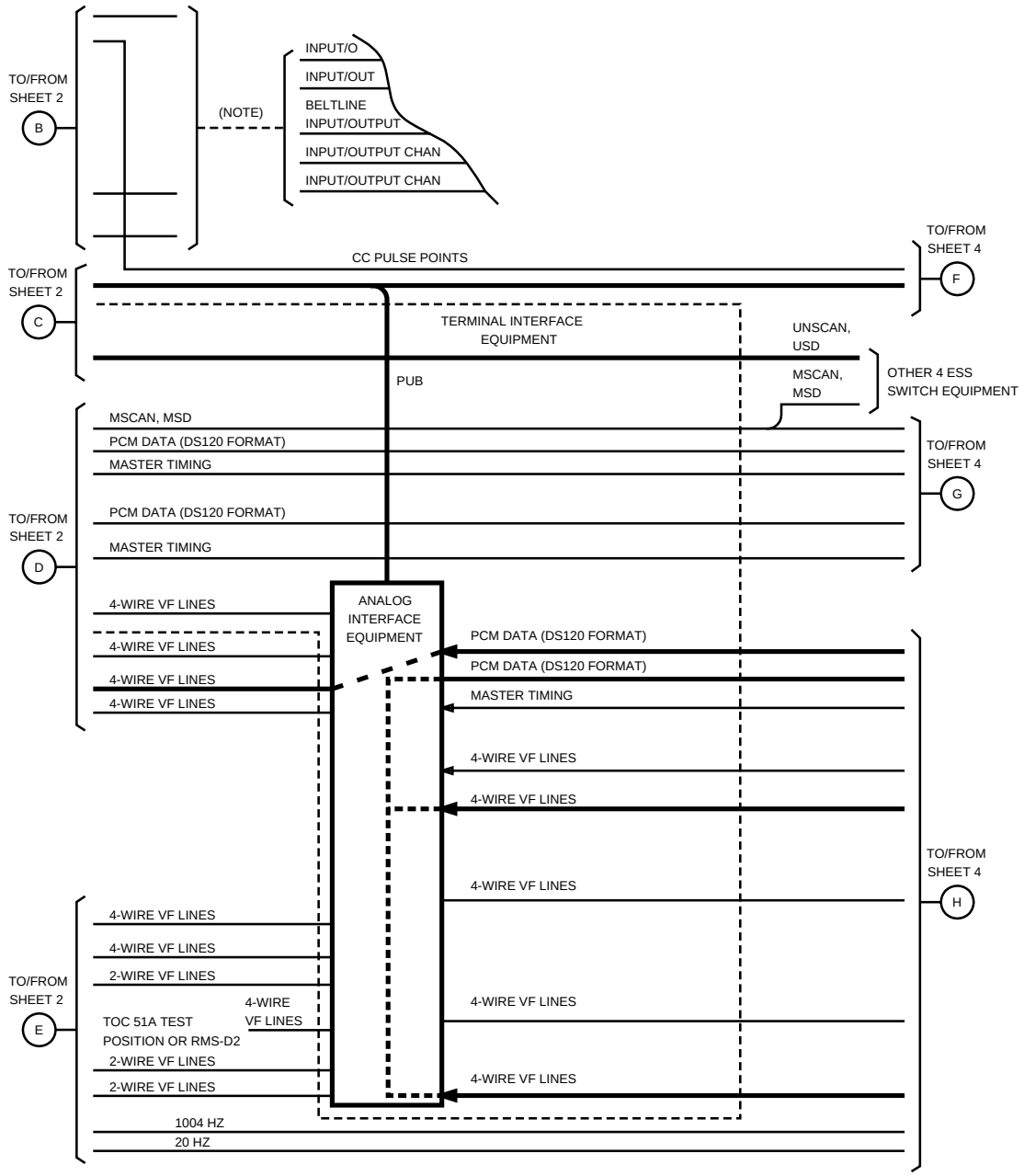

Figure 31. Call Processing, Reorder Tones, and Recorded Messages (Sheet 3 of 4)

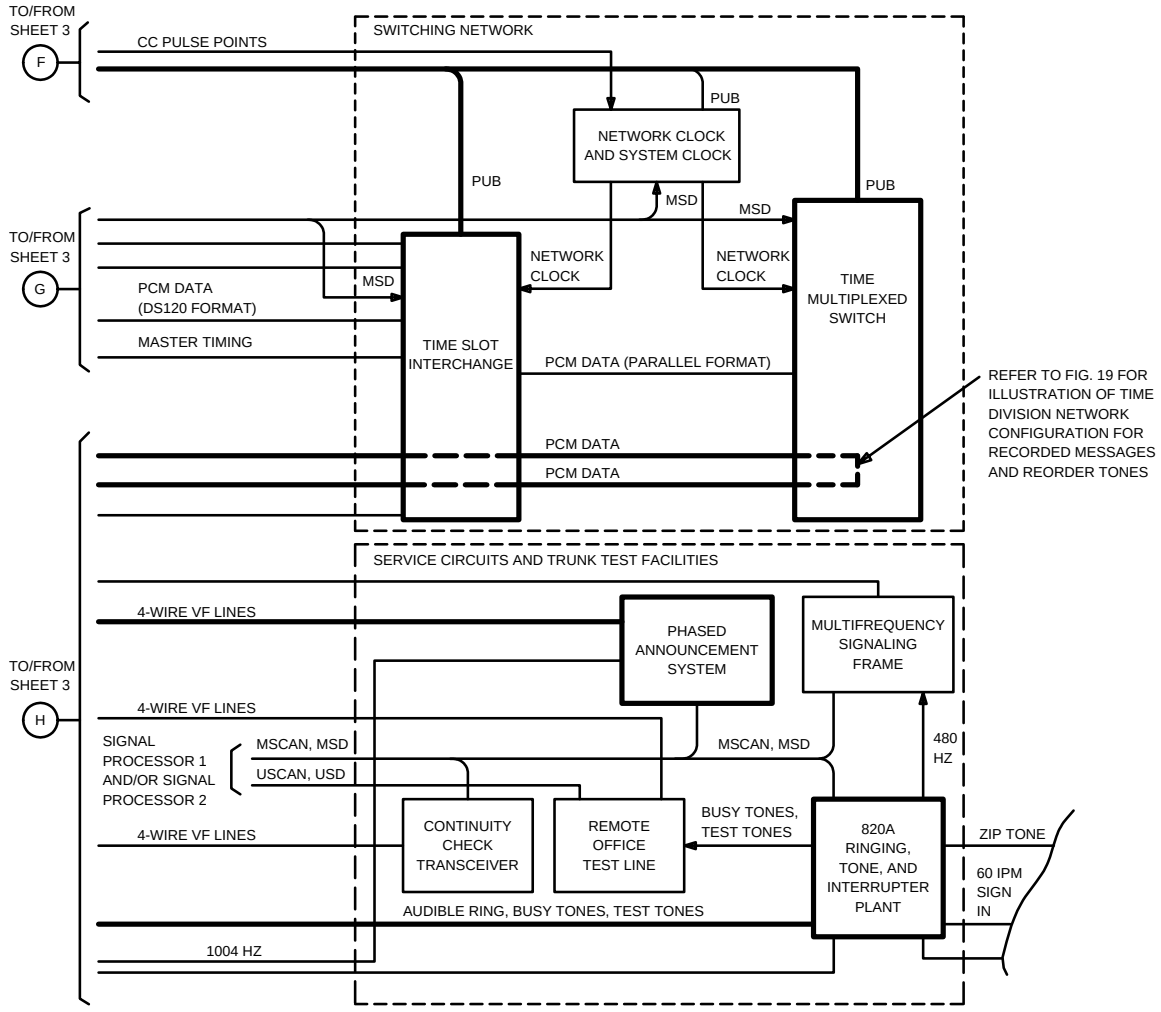

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Figure 31. Call Processing, Reorder Tones, and Recorded Messages (Sheet 4 of 4)

8. Software

General

8.01 Operation, maintenance, and administration of the 4ESS Switch are, to varying extents, controlled by software programs stored in the 1B Processor. These programs are commonly referred to as the 4ESS Switch generic program. The 4ESS Switch generic program is comprised of two major program categories. These are operational programs and interrupt recovery programs.

8.02 Operational programs are programs that are initiated by task and task-dispenser routines. The operational program category consists of the following program types:

a. Executive control

b. Software integrity

c. Network management

d. Call processing

e. Input/output

f. Maintenance control

g. Trunk maintenance

h. Traffic and plant measurement

i. Recent change and verification

j. Library programs.

8.03 Interrupt recovery programs are initiated in response to an interrupt by a hard-wired transfer to the appropriate software program(s). The interrupt recovery program category consists of these program types:

a. System interrupt recovery

b. Fault recovery

c. Maintenance restart

d. Maintenance restart software update.

8.04 Similar generic programs are provided in all 4ESS Switch offices. As new versions are available, generic programs in existing offices are updated to the newest version. The office data base provided in a 4ESS Switch office is unique to each installation. This data base provides the interface between the 4ESS Switch generic program and the physical office.

8.05 The control programs and office data base are described in this part. Refer to 234-180-002, *System Software Overview, Software Description*, for system level information. Additional information concerning maintenance software is provided in Part 9.

Executive Control

8.06 Executive control programs are responsible for the orderly scheduling and execution of the various programs which control the 4ESS Switch. Two levels of executive control are provided. These are base level and interject level. Base-level executive control activates task and task-dispenser programs which must be scheduled for execution at least once every base-level cycle. Scheduling is accomplished either directly or indirectly:

- ***Directly*** by transferring program control to the task program that is to be executed
- ***Indirectly*** by transferring program control to a task-dispenser program which, in turn, schedules the programs that are to be executed.

8.07 Every 3 ms, base-level programs check the status of the interject request flip-flop to determine the need to execute interject level (high priority) work. Base-level programs which require more than 3 ms for completion are segmented so that the 3-ms interval is not exceeded. Every 10 ms, a hardware clock sets the interject request flip-flop. Thus, every 10 ms + or –3 ms, program control is transferred to the interject-level executive control program. This program schedules task and task-dispenser programs in the same manner as the base-level executive control program. When all

interject-level work has been completed, the interject level executive control program also schedules the input/output buffer program if it has not been executed within the last 60 ms. The input/output buffer program controls input and output of messages from the various input/output terminals in the work centers.

8.08 The decision of which programs should be executed or should not be executed is made by an overload control program. The need for overload control is determined by the software integrity programs. The executive control programs interrogate the overload control program and schedule the task and task-dispenser programs accordingly. The overload control program does not entirely inhibit the scheduling of any base-level or interject-level program. Certain tasks are inhibited or executed on every other base cycle or every third cycle until the overload condition no longer exists.

Software Integrity

A. General

8.09 Software integrity programs determine the appropriate control actions needed when errors are detected in the system. The various software integrity programs are controlled by a software integrity control program. Software integrity programs perform several general functions related to the task of monitoring an operating system. These general functions are discussed in the following paragraphs.

B. Monitor Programs

8.10 Software integrity monitor programs monitor the sanity of the software system. These programs perform various operations to verify that call-processing tasks can be executed in the proper sequence and within acceptable time limits. These monitor programs perform the following:

a. Monitor various system activities and collect data to update 4ESS Switch displays on the Maintenance Operations Center master control console.

b. Monitor the transfer of program control from program to program. Records are maintained and checked to ensure various control programs are being called at the proper frequency.

C. Overload Control Program

8.11 An overload control program monitors system congestion and initiates appropriate controls. This program can also administer deference certain tasks. The overload program monitors the offered load of each type of call, software resource usage, and the number of idle call registers and multifrequency signaling equipment. The overload program uses this information to initiate action to relieve software and machine congestion. Typically, these actions might include the following:

- Allocating less time to software tasks which can be deferred.
- Canceling voice path assurance tests on a certain percentage of outgoing common channel signaling calls.
- Requesting connecting offices to restrict the amount of traffic sent to the 4ESS Switch.

D. Initialization Programs

8.12 Software-initialization programs remove erroneous data from the system by restoring portions of 1B Processor memory to an initial state. Four progressively comprehensive phases of initialization are provided; phase 1 being the least drastic, and phase 4 being a total reinitialization of system memory. Phases 1, 2, and 3 can be automatically or manually activated; phase 4 can only be activated manually. A zero-start phase of initialization is also available. This is the same as a phase 4, but it is preceded by a manual initialization of disk storage from tape.

8.13 Phase 1 assumes a valid hardware configuration. Phases 2, 3, and 4 are not executed until the call store, program store, and

peripheral interrupt recovery programs are run. In addition, interconnecting offices are requested to stop routing traffic to the 4ESS Switch. When the particular phase is complete (phase 2, 3, or 4), interconnecting offices are requested to limit the offered load to a level that has the best chance of completion. Calls that are in a stable state,—have a network connection between two trunks or a path between a trunk and a recorded announcement or reorder tone—are preserved during phases 1, 2, and 3. Phase 4 idles all trunk-related memory; no calls are saved.

8.14 When any phase of initialization is requested, all parameter and translation data changes in progress are rolled back to an insensitive state. Maintenance interrupts are also inhibited (pested). Upon completion of a phase, program control is passed to a maintenance restart program for the purpose of resetting pests, updating the program sanity timer, and handling initialization, if required, of the executive control before returning to the base-level cycle.

E. Audit System Programs

8.15 Audit programs validate information stored in 1B Processor memory. These programs compare the various memory structures against a set of rules or standards for the use of memory. Memory usage that does not conform to these standards is subject to failing an audit check and being put into a safe or audit state. The processing system does not honor a request to perform processing using any area of memory in the audit state. Failing memory structures are set to a valid state by the audit programs.

8.16 All requests for audits are processed by a software integrity control program. This program reads the audit history maintained by the audit programs and determines whether to honor the audit request or to escalate to a phase 1 initialization. This process protects the software system from additional memory mutilation and failures resulting from repeated defensive checks.

F. Software Integrity Control Program

8.17 System control is passed to the software integrity control program once during each base-level cycle. This program also assumes control as directed by call processing, maintenance control, and interrupt recovery programs. Primarily, the software integrity control program determines the appropriate control actions needed when errors or congestion are detected in the system. The software integrity control program functions also include the following:

- Performs administration of the software integrity programs
- Provides a common interface for base-level software integrity programs and the rest of the software system
- Schedules software integrity programs
- Retains a history of all the errors detected which generated phases of initialization.

8.18 As administrator of the software integrity programs, the control program has access to reports of all errors detected by these programs. The control program compares software errors before initiating appropriate control actions. The error history and audit history are also used in decision-making to avoid redundant control actions, to identify error patterns, and to control an escalating corrective sequence.

8.19 As common interface for the integrity programs, the control program receives all reports of detected errors from the rest of the software system. The control program also receives and analyzes requests for specific phases of initialization and demands audits from operational and maintenance programs. If the control program determines that a phase or an audit(s) is needed, system control is passed to appropriated programs. All system demand audit and initialization requests are received by the control program in order to have a complete picture of the state of the system for use in decision-making.

8.20 The control program can activate any controls provided by the integrity programs—audits, phases of initialization, overload controls. In most cases, the control program can determine the true problem when an overload condition and an error have similar symptoms. If this distinction cannot be made, the control program initiates the least drastic control action of those under consideration.

Network Management

A. General

8.21 Network management programs expedite the flow of message traffic through the toll network. The primary objective is to have the toll network carry as many completed calls as possible, thus making maximum use of the toll network facilities. Network management programs monitor trunks for congestion, automatically institute certain controls, and provide data for use by network management personnel in manual control activation.

B. Network Management Display

8.22 Network management display software provides a means for network management personnel to access the 4ESS Switch data base to monitor the network and solve network congestion problems. Network management display software provides two basic functions—interrogation and control. The *interrogation function* provides the means to identify and investigate a network problem. The *control function* provides a means of applying corrective controls. The network management display software provides the interrogation and control functions through a set of network management displays. These displays can be accessed through CRT terminals on the network management input/output channels. The network management displays are organized into separate pages. Each page contains a functionally-related set of raw or pre-processed data.

8.23 A standard set of display pages independent from the generic program is provided with each 4ESS Switch installation. These display pages are divided into three categories. These are domestic, international, and common display pages. Each display page provides a coordinated set of data dealing with some aspect of international and/or domestic network performance. Data establishing the various display pages for an individual office is generated by the network management display page assembler. This assembler is an off-line, data-processing system and is used to organize data related to the required displays. This data is then entered into the 4ESS Switch 1B Processor memory, independent of the generic program. This off-line assembler and on-line software is also used to define on-site operational reports.

C. Network Management Control

8.24 Network management controls may be initiated manually or automatically by control software. Whether manually or automatically initiated, all network management controls are executed under the direction of control software.

Manually-Initiated Controls

8.25 Manual control is initiated by entering specific messages or data on the network management input/output terminals. This interface is via the network management display pages. These manually initiated network management controls are:

a. Call Gapping

b. Cancel-to

c. Skip

d. Reroute

e. Cancel-from

f. International hard-to-reach.

These manual controls are briefly discussed in subsequent paragraphs.

Calling Gapping

8.26 The call gapping control can be simultaneously activated on up to 64 digit codes. A digit code ranges from 1 to 12 digits. The gap control, intervals are listed in Table A, limits the outgoing attempt rate to 1 of 32 possible rates as specified in the network management data base. The implementation of this control is automatic when previously defined thresholds in the network management data base are exceeded. The implementation of this control is automatic when previously defined thresholds in the network management data base are exceeded.

8.27 The first call, which arrives after the expiration of the selected gap interval, is forwarded (attempted) and the gap-interval timer restarted. All calls which arrive before the time-out of the gap interval are routed to an appropriate recorded announcement as specified in the network management data base. This control is also used as part of the mass announcement digital service feature in order to implement cut-through of a number of calls per hour for special treatment.

Cancel-to Control

8.28 The cancel-to manual control provides the means to inhibit a trunk subgroup from being searched for idle trunks. A call encountering this control is routed to a no-circuit or equivalent type termination. Cancel-to can be applied to a maximum of 511 trunk subgroups.

Skip Control

8.29 The skip manual control provides the means to inhibit a trunk subgroup from being searched for an idle trunk. Calls encountering this control on a trunk subgroup skip to the next trunk subgroup in the routing data block. If the next trunk subgroup has a reroute control designated, the call is rerouted.

Reroute Control

8.30 The reroute manual control provides the means to hunt for an idle trunk in a specified trunk subgroup which is not in the in-chain routing data block. This occurs when a call encounters an overflow condition. An overflow condition in the manually specified trunk subgroup causes a return to the in-chain routing data block to hunt the next trunk subgroup. A maximum of 256 reroutes can be in effect for a given 4ESS Switch office.

Table A. Call-Gapping Intervals

Gap Interval (Seconds)	Maximum Calls (Per Hour)	Gap Number (Index)
OFF	—	0
0	NO CALLS BLOCKED	1
0.1	36000	2
0.12	30000	16
0.14	25704	17
0.16	22500	18
0.18	19992	19
0.2	18000	20
0.25	14400	3
0.36	9996	21
0.5	7200	4
0.6	6000	22
0.75	4800	23
1.0	3600	5
1.6	2244	24
3	1200	6
6	600	7
9	396	8
12	300	25
15	240	9
20	180	26
30	120	10
45	72	27
60	60	11
75	48	28
100	36	29
120	30	12
150	24	30
300	12	13
450	7.2	31
600	6.0	14
∞	ALL CALLS BLOCKED	15

Cancel-From Control

8.31 The cancel-from manual control provides the means of inhibiting a call from hunting for an idle trunk on any other trunk subgroup after encountering an overflow condition. Calls

encountering this control are routed to a no-circuit or equivalent type of termination. Cancel-from control can be placed on a maximum of 511 trunk subgroups.

International Manual Hard-to-Reach

8.32 The international hard-to-reach manual control provides a means to:

- Designate trunks as hard-to-reach.
- Inhibit trunks from automatically being designated hard-to-reach.

This control can be implemented only on an international code. It cannot be implemented on individual trunk subgroups. This control cannot be used to override trunks that already have been automatically designated hard-to-reach.

Software-Initiated Controls

8.33 Software-initiated network management controls are applied during the translation and path-hunting sequences of call processing and are an integral part of the call-processing logic sequences. Software-initiated network management controls are the following:

- Selective trunk reservation.
- International automatic hard-to-reach.
- Selective Incoming Load Control.

These software-initiated controls are briefly discussed in subsequent paragraphs.

Selective Trunk Reservation

8.34 Selective trunk reservation (STR) may be activated on up to 511 trunk subgroups simultaneously. The STR provides the means to dynamically sense congestion of outgoing trunk subgroups on a call-by-call basis. The STR also identifies the trunk subgroup in the routing chain that is monitored. Dynamic congestion is sensed by comparing the number of idle trunks in a subgroup to thresholds defined by the network manager. These thresholds which initiate STR control can be changed via the network management displays. In addition, an override ability is provided to exclude selected trunk subgroups.

8.35 The STR involves different response patterns for four categories of trunk subgroups. The classes of traffic controlled by STR are as follows:

- Alternate routed and hard-to-reach specified.
- First-choice routed and hard-to-reach specified.
- Alternate routed and not hard-to-reach specified.
- First-choice routed and not hard-to-reach specified.

8.36 Depending on the results of the number of idle trunks to threshold comparisons, a selective reservation level (SRL) 1 or SRL 2 control is activated. The SRL 1 provides control on a greater number of trunks than SRL 2. The controls applied to trunk subgroups on which an SRL has been implemented are dependent upon the following two factors.

- The manual control (reroute, skip, cancel) designated for the trunk subgroup.
- The percentage of traffic controlled for that trunk subgroup category for the particular SRL selected.

International Automatic Hard-to-Reach

8.37 The international automatic hard-to-reach control designates specific international codes as hard-to-reach. This determination is made relative to thresholds which are manually input to the system via display pages. There is no restriction as to the number of international codes which may be designated hard-to-reach.

Selective Incoming Load Control

8.38 Selective incoming load control (SILC) is an automatic control that allows a switch to reject traffic from specific trunk subgroups whenever the switch reaches a predefined machine

congestion level. There are two congestion levels for each switch. When the first congestion level is reached, a predetermined percentage of traffic on specified trunk subgroups is blocked. If the overload condition continues and the second level is reached, a greater percentage of traffic is blocked.

Call Processing

A. General

8.39 Call-processing programs control all phases of processing calls through a 4ESS Switch office. The major functions performed by these programs are as follows:

- Detection of originations
- Reception of digits
- Setup of network connections
- Digital echo suppressor control
- Outpulsing digits
- Disconnection of network connections
- Handling of abnormal and failure conditions
- Collection of billing information, if required
- Processing requests from Service Evaluation System.

8.40 There are six major categories of programs which are employed to process calls applied to the system. Another category of call-processing programs is provided to collect billing information on toll calls for interconnecting class 5 offices that do not have automatic message accounting facilities. These categories of call-processing programs are discussed in subsequent paragraphs. The office data base, which serves an important function in call-processing activities, is discussed later.

B. Main Call Programs

8.41 Task-dispenser routines provide the stimulus for executing task routines and other call-processing programs. The task dispensers are scheduled by executive control programs. Task routines are primarily responsible for processing multifrequency, DTMF, dial pulse, and CCITT 5 signaling calls. These routines respond to call stimuli by performing the actions required to advance the state of a call from the incoming state, through the outgoing state, to the stable state. The actions taken are determined by the stimulus received and the current state of the call. The stimuli for MF, DTMF, DP, and CCITT 5 calls consist of externally generated reports via the signal processor 1 or signal processor 2, such as seizure, digits, off-hook, on-hook, stop dial, and others, and software-generated reports, such as timing and queuing reports. Most stimuli to the task routines are from the task dispensers; however, other programs also transfer control to these routines. Task routines are also responsible for processing portions of centralized automatic message accounting data.

8.42 Final handling routines are responsible for terminating calls that result in ineffective attempts. Calls that reach the waiting-for-answer state are considered normal with respect to the following routines.

a. Take control of all calls which have encountered a failure condition

b. Idle hardware, software, and service facilities being used by calls encountering failures

c. Connect incoming trunks to the appropriate announcements or tones, or send the appropriate failure messages

d. Time trunks connected to announcements and disconnect the trunks after a certain time if they have not disconnected

e. Request trunk maintenance routines for the purpose of collecting call failure data

f. Check the software integrity of ineffective attempt calls and transfer control to the audit programs if inconsistencies are found.

C. Common Channel Signaling (CCS) Programs

8.43 Common channel signaling programs, like the main call programs, consist of task dispenser and task routines scheduled by executive control. These programs perform a polling operation to determine if a common channel signaling terminal has a buffered message. When such a terminal is identified, it is accessed to retrieve the waiting message. Each message is processed by an appropriate common channel signaling task program which will advance the call state as required and return to the task dispenser. The common channel signaling call-processing actions include the following:

a. Extracting the digits from address messages and passing them to the digit reception program for analysis

b. Calling the appropriate translation routines to determine routing information

c. Performing the appropriate incoming and outgoing continuity checks

d. Making the appropriate network connections between continuity check transceivers, incoming trunks, and outgoing trunks (via the network program)

e. Formulating and transmitting common channel signaling messages for outgoing common channel signaling calls

f. Selectively returning address complete messages or unsuccessful backward call setup messages for incomplete calls. This causes completion of voice circuit connections at preceding offices and permits the return of 4ESS Switch office emergency or special recorded announcements.

g. Reattempting calls that fail because a network path cannot be found between incoming and outgoing trunks

h. Reattempting calls that fail because of malfunctioning signaling links.

8.44 The actual processing of common channel signaling calls varies due to the different type and format of signaling exchanges used.

D. Digit Reception Program

8.45 The digit reception program recognizes and analyzes digits arriving from incoming trunks. This program determines digit legibility and routing data, call destination and the number of digits to be outpulsed, based on translation data. Program control is passed to this program by the main call program task dispenser for analysis of multifrequency and dial-pulse digits. The common channel signaling program task dispensers transfer control to the program for analysis of common channel signaling digits. After the successful completion of code-blocking checks (network management function), the digit reception program compares the number of digits received with the number of digits expected. The digit reception program also checks for an international routing code to determine if 2-stage digit reception is required. The digit reception program then transfers program control along with routing data to the appropriate call-processing program based on the type of call (that is, CAMA, main call, or 2-stage). The failure of any checks initiated by the digit reception programs results in a transfer of program control to an appropriate portion of the main call program for termination.

E. Two-Stage Digit Reception

8.46 Two-stage programs control supervisory signal exchanges between the incoming domestic trunk and the 4ESS Switch. This is accomplished after the digit reception program detects an incoming international routing code. Two-stage programs initiate action to connect a multifrequency receiver to the incoming trunk, if not already connected. If necessary, the MF receiver international signal distributor point is operated to alert a domestic operator to begin the second stage of outpulsing. The incoming trunk is then used to pass forward the outgoing MF international digits. After the incoming digits are detected, software control is returned to digit reception programs. This feature is provided to enable switching machines,

between the international direct distance dialing office and the 4ESS Switch international switching center, which are not capable of recognizing 14-digit codes to forward 14-digit international codes to the international switching center.

F. Centralized Automatic Message Accounting Program

8.47 Automatic message accounting (AMA) programs collect and store toll billing data on the AMA calls originated by local offices served by the 4ESS Switch office. The billing data includes the calling number, the called number, the answer time, the disconnect time, plus other information concerning the type of toll call needed by the accounting center to correctly bill a call. In addition to collecting and storing toll billing data, the AMA program provides the ability to collect and store AMA data on calls for which AMA records are not usually made, —information calls and incorporated calls that originate on AMA trunks. This program is based on the generation of one AMA record for each call. Data is collected at various points in the call and stored in a stable call accumulation register (SCAR) which is linked to the incoming trunk register. If the magnetic tape method has been selected, larger blocks of messages are transferred to the Auxiliary Data System magnetic tapes. This program also writes the necessary control labels on the magnetic tape which allows the electronic data processing center to properly analyze the call data. If the automatic message accounting standard entries (AMASE) feature has been selected, billing information may be optionally teleprocessed to the regional accounting office via an Attached Processor System input/output channel or recorded on a 3B Computer magnetic tape for subsequent transport to the regional accounting office.

G. Call Detail Recording

8.48 Call detail recording programs are provided to record call and trunk usage information at 4ESS Switch international switching centers. International call data is recorded on the Attached Processor System (APS) disk file system. All international calls processed by the international switching center are recorded and subsequently teleprocessed via data link to the Overseas Data Processing Center in Atlanta. Additionally, an international trunk subgroup study list, administered via an input/output terminal, may be maintained by a 4ESS Switch international switching center.

H. Network Programs

8.49 Network or path-hunt programs are responsible for setting up and taking down paths through the time division network. Network program functions include the following functions:

a. Determining the connection type to be either interswitch, intraswitch, or intrabuffer

b. Hunting available network paths through use of the network maps (the time slot maps, the A-link maps, and the B-link maps)

c. Updating busy/idle bits of network maps

d. Recording path information in appropriate memory(s)

e. Issuing a fixed sequence of orders for connections and disconnections (abandons) concerning the applicable network action desired

8.50 The following are path types administered by the network programs:

a. Connections and disconnections (abandons) for a normal connection

b. Partial connections for a path reservation followed by either a completed connection or erasure of the partial connection

c. Self-connection loops and abandons for use by common channel signaling

d. One-way connections for monitoring purposes and subsequent abandons

e. Recorded announcement and tone dispersement connections for final handling of call irregularities. These connections comprise two routines for connections and two routines for disconnections (abandons). These routines are as follows:

1. ''Nailed-up'' connections and abandons. The nailed-up connection is set up by the initialization program and never taken down.
2. Broadcast connections and disconnections.

Input/Output

8.51 In general, the function of the 4ESS Switch input/output programs is to process machine/machine and person/machine data-transfer requests. The 4ESS Switch input/output programs include:

- Disk administration program
- Tape administration program
- Input/output programs.

8.52 Machine/machine data-transfer requests are processed by the disk administration and tape administration programs. These programs are responsible for interfacing the 3B Computer (APS) and Auxiliary Data System communities, respectively, with programs that either need to retrieve data from or store data in the appropriate equipment. Person/machine data-transfer requests are processed by the input/output programs. These programs are responsible for interfacing the input/output terminals with client software programs. This interface is accomplished through a set of generic defined input/output messages. Operating personnel can create or change output messages independent of generic changes.

Maintenance Control

8.53 The 4ESS Switch maintenance control program is the major maintenance administration vehicle in the 4ESS Switch. The program operates in conjunction with the common 1B Processor maintenance control program. The 4ESS Switch maintenance control program provides the scheduling and supervisory functions deferrable for base-level maintenance programs with the exception of trunk maintenance programs and audit programs.

8.54 Some maintenance programs are critical and must be run immediately on interrupt level in order to recover system processing capability. However, execution of most maintenance programs can be deferred to a later time and interleaved with other base-level programs. The maintenance control program is concerned with these deferrable maintenance programs, that is, diagnostic control programs. Normally, programs run as maintenance control program clients deal with maintenance of the system, but maintenance control programs also control other types of programs. These include generic utility, general purpose library, and system update programs. Part 9 of this document contains additional information on maintenance software.

Trunk Maintenance

A. General

8.55 Trunk maintenance programs are comprised of the following types of programs:

- Trunk maintenance administration program
- Trunk error analysis program
- Service circuit programs
- 51A test position test program
- RMS-G1 programs
- Operational and transmission trunk test programs
- Carrier group alarm program
- Common channel signaling link security programs
- Vacant code analysis programs.

The general functions of these programs are described in subsequent paragraphs.

B. Trunk Maintenance Administration Program

8.56 The trunk maintenance administration program controls the operation of the other

trunk and service circuit maintenance programs. It also provides the interfaces with the executive control, call processing, software integrity, interrupt recovery, network management, input/output, and traffic and plant measurement software and the office data base. Trunk maintenance administration program responsibilities include the following:

- Administration of trunk maintenance status
- Trunk maintenance scheduling
- Collection of trunk status information
- Analysis of unswitched calls.

8.57 The trunk maintenance administration program also provides routines to perform functions that are common to the other trunk maintenance programs—supplementary task dispenser, ring- forward detection, and trunk register linkage routines.

C. Trunk Error Analysis Program

8.58 The trunk error analysis program performs the following:

a. Records certain trouble-indicative call irregularities

b. Analyzes trouble-indicative call irregularities.

c. Compiles a list of the trunk subgroups that are observed to have had the worst performance on a daily basis and on demand.

d. Provides a real-time trunk trouble report on trunks and trunk-related circuits which exhibit poor performance and are believed to require maintenance. Gross offenders are automatically removed from service in an outgoing direction.

8.59 The trunk error analysis program is scheduled by the trunk maintenance administration program which also handles inputs and outputs of the trunk error analysis program.

8.60 The recording and analyzing of trunk failure data is accomplished through the use of a statistical filtering process and a long-term error analysis table in conjunction with the performance record of each trunk subgroup. Therefore, a trunk must exhibit poor performance relative to its group before it is included in a report. The trunk error analysis program also uses the trunk subgroup performance record to compile a list of subgroups with the worst performance record—Daily Worst Trunk Subgroup List—as compared to other trunk subgroups in the same attempt range.

8.61 Two stages of filtering are used to minimize the storage requirements. The first stage filter is located in the trunk register and is administered by the trunk maintenance administration program. The second stage filter is located in an engineered storage area and is administered by the trunk error analysis program. Trunks which fail both filters are placed in the long-term error analysis table administered by the trunk error analysis program. Long-term error analysis is the process of counting call success and failure reports on a per-trunk basis. This count is used as a sample to compare against the performance of the trunk subgroup for that trunk. Trunks which perform significantly worse than their trunk subgroup are said to have failed the long-term error analysis. Trunk error analysis is performed on all trunks and appropriate service circuits.

D. Service Circuit Programs

8.62 The service circuit programs contain functions dealing with the monitoring, control initialization, auditing, and testing of service circuits used in the 4ESS Switch. These programs include the following:

- Service circuit test program (control program, data tables, and task subroutines)
- Recorded announcement machine control, audit, and initialization software
- 820A ringing, tone, and interrupter plant control audit, and initialization software

- Multifrequency signaling frame monitor and control software
- Continuity check transceiver.

E. 51A and 51A L6 Test Position Programs

8.63 The purpose of the test position test programs is to administer the operation of the test position test access trunks. All test access trunk calls are controlled by the test position test program. Call originations on a test access trunk are achieved as follows:

a. An input/output message originated at the test position input/output terminal. Data obtained from this message is applied to the 1B Processor via the Circuit Maintenance System (CMS) or Testing, Operations, Provisioning, and Administration System (TOPAS).

b. Going off-hook to the test access trunk.

Terminations come from the following:

a. Incoming 101-type test calls (operating personnel-to-operating personnel calls)

b. Transfers of 101-type test calls from one test position to another.

8.64 The test position test program execution is accomplished with frequent transfers of program control between the test position test program and the trunk maintenance administration program. Many of the tasks performed by the test position test program are dispensed from the trunk maintenance administration program. Upon completion of the task, control is usually returned to the trunk maintenance administration program. Service routines provide functions, such as trunk idling, outpulsing, and ring forward. The network connections and disconnections required for trunk testing are performed via the network program. The data required to make the network connections is derived from translations via the translations program.

8.65 A similar software package exists for administration of the 51A L6 test position in international switching centers. The 51A L6 test position program contains additional software to provide key and lamp control for international trunk testing.

F. RMS-G1 Programs

8.66 The RMS-G1 consists of hardware directors (A) and responders (A), a local test panel, and associated RMS-G1 support software. Additional 4ESS Switch software is provided to support international trunk transmission tests performed by the RMS-G1. The RMS-G1 trunk transmission tests can be initiated on demand by operating personnel or automatically according to an RMS-G1 programmed schedule.

8.67 The 4ESS Switch generic program contains RMS-G1 related software that support trunk signaling tests. These software-controlled signaling tests can be initiated in either of three ways as follows:

- Operating personnel request via 4ESS Switch input/output terminal
- Software request initiated by detected trunk failure
- When requested by the RMS-G1 software via a director (A).

G. Operational and Transmission Trunk Test Programs

8.68 Operational test programs are used to test the operational capabilities of trunk circuits from the terminating end of a trunk. The 1B Processor resident operational test programs test toward operational test lines which provide access to the trunk circuitry at the far-end office. Tests can be run on either an automatic routine or demand basis. Transmission test programs are used to measure the transmission characteristics of trunks by using the remote office test line frame hardware.

H. Carrier Group Alarm Program

8.69 The transmission facilities that interconnect switching systems may use carrier systems. The carrier group alarm is a monitoring arrangement that determines if the carrier equipment is operating properly. However, this carrier group alarm is used only when the carrier system is equipped with the carrier failure alarm feature. The carrier group alarm program performs the following functions:

a. Removes trunks of failing carriers and voiceband interface units from service or restores trunks to service upon return of failing analog/digital carriers or voiceband interface unit restoral

b. Tests carrier group alarm facilities

c. Initiates a sequence of tests which check for the existence of a common channel signaling network failure

d. Disables and restores carrier group alarm facilities.

e. Provides input/output messages which notify maintenance personnel of failures, restorals, disabled carrier group alarms and carrier group alarm facilities in a test state.

8.70 The 4ESS Switch call-processing software examines the state of the carrier group alarm indicators and activates appropriate alarm signals when a carrier failure occurs. Input/output messages also identify which carrier group has failed. The alarm condition detected at the unitized terminal equipment and digroup terminal is caused by loss of carrier frequency or carrier pilot. In addition, a digroup terminal alarm can be initiated by faulty carrier framing for a critical time interval. The appropriate trouble lamps, alarms, and contacts are activated, and the far-end terminal is informed of the alarm condition.

8.71 Upon recognition of an alarm point failure, the carrier group alarm program performs the following:

- Disconnects talking connections
- Terminates customer billing
- Places affected trunks out-of-service.

When normal system operation is resumed for a predetermined time interval, the alarm circuit is reset and trunks are returned to service.

I. Common Channel Signaling Link Security Programs

8.72 The common channel signaling link security programs monitor and administer the use of common channel signaling facilities. These programs also provide automatically and manually initiated procedures to maintain and restore signaling in the event of a failure. The link security programs provide the following:

- Status information to the call-processing programs for the transmission of common channel signaling (CCS) messages.
- The means to implement network management control of the common channel signaling facilities.

J. Vacant Code Analysis Programs

8.73 Vacant code analysis programs monitor the incoming digits for calls being processed. Routing-related failures are analyzed and reports are generated for those cases which have a high probability of indicating problems. Customer misdials and other normal events are filtered out by a 2-stage filtering process and are not reported. Those events which lead to a connectable condition (for example, routing error) are reported. In addition to vacant codes, vacant code analysis software analyzes other similar routing related irregularities, such as:

a. **Misdirected CAMA:** Called numbers are checked to assure they are permitted numbers for a customer to dial directly.

b. **Unauthorized CAMA:** The calling number is checked on CAMA incoming trunks to ensure the number is expected on that particular trunk group. This is a protection

against fraud when using operator numbering identification. This feature provides a defensive check when automatic number identification is used.

c. **Originating 800 SERVICE (INWATS) Not Allowed:** This feature ensures incoming calls are not accepted from areas for which the 4ESS is not prepared to calculate an originating INWATS zonal band.

d. **INWATS Band Exceeded:** This failure blocks calls to an INWATS number that originate from an area farther away than INWATS subscriber has contracted.

e. **Subsequent Office Routing Failure Only:** Calls receive a report of subsequent office failure while the digits are still available for analysis.

Traffic and Plant Measurement

8.74 The traffic and plant measurement programs are responsible for obtaining measurement data, administering the traffic and plant measurement data bases, and generating the various traffic and plant measurement reports. Most 4ESS Switch software programs adjust peg, occupancy, and idle counters (registers) in the process of their execution. Periodically, the contents of these registers are read by data collection routines which compile the traffic and plant measurement databases. Measurement data output routines assemble the various traffic and plant measurement reports from the databases.

8.75 Traffic measurement reports reflect the effects of the traffic presented to the switching system. These reports are used by engineering personnel to verify that existing equipage is adequate for present needs, to predict future demands, and to determine the quantity of equipment required to meet future demands. For network management, these reports are used to determine the control actions necessary to efficiently utilize the nationwide network and to evaluate the effects of the various control strategies. Plant management uses traffic measurement reports to locate equipment irregularities and evaluate the effectiveness of office maintenance procedures.

8.76 Plant measurement reports reflect the effects of maintenance in relation to the service provided to the customer. The overall condition of the switching system can be determined and compared to other toll switching systems using these reports. Available traffic and plant measurement reports are identified in Part 9.

Per-Call Control (PCC) and 2-Tier Dynamic Load Control (DLC)

8.77 With PCC, alternate voice and data calls can be routed on the same trunk circuits, eliminating separate voice and data networks. This ability is applicable in the Integrated Services Digital Network (ISDN) environment, where individual trunk subgroups (TSGs) may carry voice and data traffic.

8.78 The DLC is used to control the amount of traffic offered to TSGs. For PCC, there are two levels of DLC. The first level DLC (DLC-1) controls data traffic. While DLC-1 is active, no additional data traffic is offered to associated TSGs. The second level DLC (DLC-2) controls all traffic. While DLC-2 is active, all new originating traffic is kept off the associated TSGs.

PCC Operation

NOTE:
Only TSGs with ISUP, INUP, or TUP signaling can be established with PCC control. This restriction is a function of ODA and recent changes, which provide the mechanism for defining TSGs.

8.79 To obtain a clear channel circuit for routing a data call, the 4ESS Digital Interface Frame (DIF) sends a 64 Clear Channel Request PCC message to the Advanced Switching Signaling and Echo Canceling Terminal (ASSET). ASSET receives the message and passes it to the Digital

Circuit Multiplication System (DCMS); and while doing so, ASSET disables the echo converters associated with the circuit. The DCMS receives the PCC message from ASSET and allocates a clear channel circuit for the duration of the call. When the call is over, the DIF sends a Clear Channel Release PCC message to the ASSET. The ASSET receives the message and enables the echo cancelers and law converters associated with the call and passes the PCC message to the DCMS. The DCMS releases the clear channel, and the circuit is available for another call.

DLC Operation

8.80 The DLC is provided by the existing TASI-E DLC, which has been modified to provide two levels of DLC (2-tier DLC) for PCC TSGs.

8.81 The first tier level, TASI-E DLC, uses five miscellaneous Signaling Points (SPs) to control traffic offered to associated TSGs. Each SP point may have its own list of TSGs. A maximum of 20 TSGs per TASI-E unit is allowed.

8.82 The second tier, TASI-E DLC, uses only two SPs to control traffic over associated TSGs. The SPs retain TASI-E nomenclature and are referred to as Clique 0 and Clique 1. The SP for Clique 0 controls data traffic, and the SP for Clique 1 controls all traffic. There is only one list of TSGs, and it must be assigned to Clique 0.

Recent Change and Verification

8.83 Recent change software provides a means to change translations information in the office data base. The recent change software is accessed, and recent change data is entered into the data base via several input/output channels. These input/output channels are assigned to the Maintenance Operations Center and the Machine Administration Center. Recent change information is entered into the system in three stages. These are buffer, test, and activate. Using these three recent change stages, data can be entered, verified, checked for functional accuracy, and actually placed on-line.

8.84 The recent change software is capable of rolling back old translation data. As recent change data is entered into memory, a rollback copy is created in another area of memory. This rollback area contains the old translation data being replaced by the recent change. The following two types of rollback are provided:

- Type-1 rollback is applicable only to a recent change that is actively being processed. It provides for reinitializing the office data to its original state whenever an interrupt or memory initialization phase is triggered while a recent change is being processed. This is necessary to prevent the partial update of recent change.
- Type-2 rollback provides for the reinsertion of the original data that was modified by the recent change messages. As each recent change message is updated into the database, the address and original contents of each word modified are stored in the rollback translator (that is, each new recent change will overwrite the data for the oldest recent change in the rollback translator). The recent change messages can only be rolled back in the reverse order of their insertion. Type-2 rollback can only be activated manually in conjunction with a phase 2 or higher system initialization.

8.85 A roll-forward ability is also included in the recent change software. The roll-forward capability provides a means of reentering recent change data after a rollback or complete reinitialization has occurred. In order to implement roll-forward, a cassette tape copy is made of every recent change that is put into the test mode. Using the cassette tape copy as input, the messages may be resubmitted to the memory, buffered, and then placed into the test mode and activated in any order desired.

8.86 Verification software provides a means for retrieving information stored in the 1B Processor memories. Verification is implemented through the use of special messages input on various input/output channels. These messages

enable operating personnel to verify recent change information and translations data.

Library Programs

8.87 Library programs provide the 4ESS Switch with a means to access nonessential software. Infrequently used software is stored on magnetic tape. When required, these programs are entered into a spare program store. From there, the programs are exercised as part of the generic software package. This feature provides for more efficient use of program store. Software whose desirability has been proven, but which cannot economically be entered in program store on a permanent basis, is made available to operating and maintenance personnel.

Interrupt Recovery Software

8.88 The 4ESS Switch interrupt recovery programs are initiated by hardware sequencers. The hardware interrupt sequencers in the 1B Processor central control complex may be triggered manually from the MCC or automatically by hardware. When directed by an interrupt sequencer, program control is transferred to an appropriate entry point in the system interrupt recovery program. The entry point selected depends on the hardware-controlled (wired) address specified by the interrupt sequencer. The system interrupt recovery program stores a basic set of data that may be useful for determining the cause of the interrupt and for restarting base-level processing after interrupt recovery. This data is stored at memory locations (interrupt bins) that are assigned to each interrupt level.

8.89 After the system-interrupt-recovery program has stored the required data in an appropriate interrupt bin, program control is transferred to an associated interrupt-filter program. This program determines the primary source of the interrupt and the units involved. After the basic source of the interrupt is resolved, fault recovery programs are entered.

8.90 The fault recovery programs are designed to isolate faulty units or subsystems rather than to identify replaceable components. These programs recognize and isolate most call-affecting faults during a single interrupt interval. The basic techniques of the fault recovery strategy are centered around rapid resolution of problems and quick return to normal system operation. Fault recovery programs verify their actions with the error-analysis programs which maintain a history of interrupts and associated data. In addition to the basic function of maintaining a history of interrupts and associated data, peripheral unit error-analysis programs may modify the action of the peripheral unit fault recovery programs. This occurs if the data indicates that recent interrupts of that particular type have occurred and a modification of the basic strategy is needed. A common systems error-analysis program provides a long-term (disk) data storage and retrieval system. This program does not modify processor interrupt actions.

8.91 After the fault recovery programs have selected a working configuration of hardware, the programs must perform several ‘‘housekeeping’’ tasks. These tasks include setting appropriate flags that cause diagnostics and other deferrable testing to be scheduled during base level after the system has returned to call-processing. Also, the fault recovery programs must record the actions taken in the appropriate error analysis data history.

8.92 Finally, the fault recovery programs initiate output messages to operating personnel which identify actions taken. If several interrupts have failed to resolve a persistent problem, the output messages may be utilized to supplement automatic error analysis. The operating personnel may analyze the output messages and manually select a working hardware configuration.

8.93 After the fault recovery programs have taken the basic recovery action, program control is transferred to a maintenance restart program. This program then performs several additional functions based on the highest interrupt encountered during an interrupt interval. Multiple interrupts may occur during an interrupt interval. In this case, the lower

level interrupts are recorded but not analyzed. The maintenance restart program, using system interrupt recovery stored data, restores or initializes system registers, including central control pests, as appropriate. Maintenance also sets flags for the appropriate audits to be scheduled on base level after the return to normal processing.

8.94 Program control is then transferred to the maintenance restart software update program which performs an initialization function for software. This program has the following responsibilities:

- Resetting pest controls for peripheral units
- Updating the software clock
- Initialization of executive control as required prior to the return to normal processing
- Requesting a system phase to be run.

8.95 Finally, the maintenance restart software update program places its output data in a buffer and selects one of the following basic options for the return mechanism:

a. Unwind and re-execute the interrupted instruction. This option is used only for interrupts lower than C-level. This option is the most common return. The maintenance restart program may alter this decision based on either the instruction type or on errors detected in automatic interrupt data storage.

b. Roll back to a safe point in the interrupted program. This option is used if more than one interrupt has occurred during the interrupt interval, if a windable instruction such as an execute was the interrupted instruction, or if the interrupt was an out-of-range failure.

c. Return to a reference point, which is either the beginning of the base-level cycle or to the beginning of the interject task schedule. This option is used after certain levels of interrupts or after any interrupt lasting longer than 10 ms.

8.96 After the maintenance restart software update program has selected the method of return to normal program control, program control is transferred to the maintenance restart program. Maintenance restart initiates the output of input/output messages relevant to the particular interrupt. Maintenance restart then transfers program control to normal processing as designated by the maintenance restart software update program.

Office Data Base

8.97 The office database consists of parameter and translation data. Parameter data specifies the starting addresses and number of call registers in the office and the various threshold values. Translation data specifies the characteristics, interrelationships, and assignments of trunk subgroup trunks, routing data and hardware equipage. Translation data ties the generic program and the physical configuration of an office together.

8.98 During office planning, initial office data is entered on forms designed for input to the office data assembler. The office data assembler is an off-line, data-processing system used to generate the translation and parameter data for each 4ESS Switch. Parameter data is relatively constant and changes cannot be made without a separate off-line run of the office data assembler. Translation data requires frequent changes, such as the following:

- Addition or deletion of trunks
- New or changed routing data
- Office equipment growth information.

8.99 Translation data is initially created with sufficient flexibility to accommodate changes and growth over an approximate 2-year interval. During this interval, changes can be incorporated using recent change and verification software. When translation data can no longer accommodate changes and additions, a new translation structure must be created using the office data assembler.

Whenever a new generic program is retrofitted in an office, a new office database may be required.

8.100 The operation of the 4ESS Switch, in particular, call-processing, is dependent on the integrity of the office database. Therefore, a means to re-initialize the database to a known valid state and reinstate recent changes is provided. This scheme, referred to as rollback-roll forward, is implemented when database integrity is questioned. Recent change software provides the rollback-rollforward ability. In the event the database is severely mutilated, a complete reinitialization may be implemented. Periodically, the contents of the office database are dumped onto magnetic tape. In the event that the on-line database gets mutilated, this tape serves as a backup. In addition to restoring the data that was mutilated, resorting to the tape-backup also removes all history of recent change activity subsequent to the tape dump. The rollforward procedure can then be used to reinstate lost recent changes. This magnetic tape can also serve as an input to the office data assembler when a new database is created to support growth or a new generic program retrofit.

9. Maintenance

General

9.01 The overall objective of 4ESS Switch maintenance is to ensure the integrity of call-processing and service quality during normal and error/fault conditions. In order to achieve this objective in an efficient and effective manner, 4ESS Switch operation, maintenance, and administrative functions are implemented through work centers. Supporting the work centers are various automatic, semiautomatic, and manual hardware and software maintenance facilities which, in conjunction with a supporting documentation program, supports the operation and maintenance of the complex. These various facilities are also employed for maintenance of trunk and service circuits which interface with each 4ESS Switch office.

9.02 In general, maintenance includes preventive or routine maintenance tasks and repair or corrective maintenance tasks. For the most part, routine maintenance in the 4ESS Switch is performed automatically via scheduled software programs; the remaining routine maintenance tasks are semiautomatically and manually performed as listed on routine task lists of Task Oriented Practices (TOP) documentation. All routine maintenance requirements are listed on equipment test lists. Corrective maintenance (trouble-clearing) is also highly automated in the 4ESS Switch via automatically and manually-initiated software programs. These programs perform the corrective maintenance functions of the following:

- Trouble detection
- Trouble verification
- Service protection
- Trouble isolation
- Repair verification
- Restoral of equipment to service.

9.03 Operating personnel are aided in the performance of most corrective maintenance via distinctive and descriptive output messages. These messages include trouble-locating information such as lists of circuit packs to be replaced. Trouble-indicator lists, which provide access to TOP documentation based on initial trouble indications, also aid operating personnel in the performance of corrective maintenance.

NOTE:
Whether routine or corrective in nature, maintenance of the 4ESS Switch is approached on a noninterference basis with respect to the integrity of service and call processing.

Work Centers

9.04 Operation, maintenance, and administrative functions of the 4ESS Switch complex are implemented through work centers. Each work center may have specific functions/responsibilities which overlap with other work center functions to the extent necessary to provide the interfaces required to support the operation and maintenance of the office. The functions of the various work centers are applicable to all 4ESS Switch offices; however, the office size, equipment ownership, centralization of work center functions, and local administrative policies and procedures determine whether the work centers exist as separate and distinct areas or if the functions are combined. The 4ESS Switch work functions are grouped broadly into the following categories:

a. Equipment maintenance functions

    1. Switching equipment maintenance
    2. Terminal equipment maintenance

b. Maintenance coordination and control functions

    1. Toll switching control
    2. Trunk maintenance control

c. Network control

    1. Network management control
    2. Restoration control

d. Office administration

    1. Machine administration
    2. Circuit provision.

9.05 Software-defined, input/output channel functions are the primary consideration in assigning work center functions and responsibilities. Many of these input/output channels are used for both maintenance and administrative functions. A complete description of the 1B Processor and Circuit Maintenance System input/output channels, used to implement the various work center functions, is provided in 234-100-021, *Input/Output System Description*.

9.06 Although individual managers may determine the assignment of responsibilities within a given office, the basic design of the work center concept must be followed. This is necessary because certain input/output channels are assigned certain functions by the stored program control. For example, within a given office, the Terminal Equipment Center (TEC) and the Maintenance Operations Center (MOC) may be combined physically; but, the required input/output channels and devices for each work center must be provided.

9.07 Although not considered a 4ESS Switch work center, an office may be provided with a Circuit Maintenance System Maintenance Center (CMSMC). The CMS can support several 4ESS Switch offices. One of these offices will be provided with a CMSMC. The CMSMC is provided as a central point to coordinate operation and maintenance of the CMS.

Maintenance Facilities

9.08 The work centers are supported by various automatic, semiautomatic, and manual hardware and software maintenance facilities. These facilities, in conjunction with a supporting documentation program, provide for the operation and maintenance of the office. These facilities are:

- Related systems
- Input/output system
- Maintenance software
- Manual control
- Alerting
- Maintenance documentation
- Voice communications

- Tools and test equipment
- External monitoring.

A. Related Systems

9.09 Related systems include the following:

- ConnectVu/CMS or TOPAS
- RMS-G1.

The primary function of the related systems concerns the performance of trunk maintenance. The ConnectVu/CMS or TOPAS also functions as an administrative tool in the 4ESS Switch. The maintenance-related aspects of these related systems are discussed in subsequent paragraphs. Additional information concerning these related systems is contained elsewhere in this document.

Circuit Maintenance System

9.10 The Circuit Maintenance System (CMS) is a dual processor minicomputer system. These processors are referred to as the front-end processor and the backup processor. The front-end processor handles circuit maintenance data, including the following operational functions:

a. Establishes and maintains a work list for each 51A test position or trunk test position

b. Provides trouble ticket information

c. Provides the ability to perform operational and transmission tests on a demand basis via the 1B Processor

d. Provides dispatch information

e. Provides an interface for the 1B Processor to connect trunks to 51A test positions or Remote Measurement System-D2 via the switching network

f. Provides an interface with the 1B Processor, the Carrier Transmission Maintenance System (CTMS), and the T-Carrier Administration System (TCAS)

NOTE:
The CTMS is associated with testing and maintenance of line multiplex and master group multiplex broadband equipment. The TCAS is provided to facilitate maintenance on T-Carrier transmission equipment. In conjunction with CMS, the CTMS and the TCAS are used for trunk trouble sectionalization.

g. Provides status information

h. Provides printout of trunks referred to the repair locations

i. Provides file administration

j. Provides system status of trunks

k. Provides administrative functions.

The backup processor acts as backup to the circuit maintenance processor.

Remote Measurement System RMS-G1

9.11 The RMS-G1 is provided in international switching centers only. It is used for testing of international trunks using CCITT 5, CCITT 6, and CCITT 7 signaling. The RMS-G1 hardware and software and supporting 4ESS Switch generic software provide a means of performing scheduled and demand signaling and transmission tests on international tests. The RMS-G1 responds to transmission tests at far-end offices. Transmission test and signaling test results are transmitted to the TOPAS/CMS-1C for reporting.

B. Input/Output System

9.12 The 1B Processor input/output system is the primary maintenance tool (person/machine interface) in the 4ESS Switch for effecting control, monitoring, testing, and repair of the office. This system is designed to operate with various configurations of input/output terminals. The 1B Processor and ConnectVu/CMS or TOPAS communicate with their respective input/output devices and vice versa via input/output unit selectors and input/output unit controllers. The input/output system is described in Parts 3 and 5 of this document.

C. Maintenance Software

General

9.13 The first line of defense for the 1B Processor, switching network, 1B Processor interface, and terminal interface equipment is the automatic fault detection and control mechanisms provided by maintenance software. The existence of problems is reported to the system via program interrupts or integrity check failures. Appropriate corrective actions are automatically initiated to restore service. The primary tools used are:

- Fault recovery programs
- Error analysis programs
- Processor recovery system
- Program recovery system.

9.14 Software diagnostic programs are the primary tools for testing and repair of the various 4ESS Switch frames or equipment. Diagnostic programs are normally stored in Attached Processor System. These programs comprise data table-driven tests which apply predefined inputs to a unit under test, compare the resulting output(s) from the unit with known correct outputs, and relate the failure pattern to a particular fault in the unit. Diagnostic results are correlated and made available to operating personnel via messages output on input/output trunks. These messages are in the form of repair information if a test fails, or in the form of an all-tests-passed message if the results match expected test results.

9.15 Diagnostic programs can be requested automatically by fault recovery programs, routine exercise programs, or error analysis programs. Diagnostic programs can also be requested manually via input/output terminal messages or via frame-level control (power switch). Manually initiated diagnostics (demand testing) via input/output terminal input message(s) perform the following:

a. Routine testing of maintenance detection and control logic not tested automatically

b. Repairs of a unit known to be faulted or suspect of failure

c. Verification repair

d. Growth testing.

Frame power switch-initiated testing is for repair verification and service restoral. The applicable diagnostic is requested any time a frame or unit is powered up. If all tests pass, the frame or unit is restored to service unless previously removed from service via an input/output terminal input message.

9.16 Certain fault recovery programs can be manually initiated via input/output terminal input messages to perform routine testing.

Fault Recovery Programs

9.17 The fault recovery program verifies that an error exists. This program isolates the faulty equipment from the operational system and restores the system operational capabilities following the occurrence of an equipment failure. To accomplish this, the hardware has the following types of built-in error detection mechanisms:

a. Matching in duplex operations

b. The use of various forms of parity error check codes in communications between the 1B Processor central controls, call stores, program stores, attached processor system, auxiliary data units, and the 4ESS Switch peripheral units

c. The use of all-seems-well signaling between subsystems

d. Unique error detectors for internal self-checking of memory, parity, sanity, and others.

9.18 Fault recovery programs interrogate system hardware at regular intervals to determine whether a trouble which warrants a maintenance response has occurred. When a system unit indicates a problem has occurred, software tables are used to determine the appropriate action to identify the unit—member number and unit number. Once identified, fault recovery software relevant to that particular unit is made active to further analyze the unit. If the fault recovery cannot verify the existence of an error, error analysis is

updated. If the error is verified and duplicated, the condition is considered as a fault.

9.19 The fault recovery programs are activated by a program interrupt mechanism which transfers program control to the appropriate fault recovery program when any of the hardware detectors are triggered. By a process of reconfiguration retrial, deductive logic, and some actual hardware testing, the fault recovery programs can isolate a faulty unit and, utilizing the redundancy built into the system, restore operating capability and return control to the normal system programs. Elapsed time for the various recovery processes can be expected to lie in the range of 5 to 50 ms when no core memory updating is required, and as great as 400 to 800 ms per call store or program store when a reload from the file store is required.

Error Analysis Programs

9.20 When faults occur one at a time and react consistently under test, the fault recovery program normally isolates the problem on a single stimulus (interrupt). On occasion, however, intermittent, marginal, or multiple faults can occur which go beyond the scope of the fault recovery program strategy. To cope with these problems, a higher level fault resolution strategy is used. The process is called error analysis.

9.21 Error analysis programs resolve marginal faults to an isolatable and repairable entity. To achieve this, the configuration of the units that may be involved is systematically modified. When a series of interrupts occur due to some error condition, the error analysis program saves the configuration of the units. After analyzing the configuration, the error analysis program alters it in such a manner that another interrupt provides an additional degree of resolution. This process is repeated until the fault is isolated. Multiple faults are identified when the error analysis process implicates more than one unit and the resolution ''bottoms out''—no further resolution is achieved.

9.22 The error analysis programs have the ability to remember the various configurations involved in a series of interrupts. In addition, the programs are able to remember their place in a particular interrupt sequence so that on the next interrupt the programs can take the next step in the isolation process. Error analysis data is saved or ''remembered'' in tables such that a common control program is used by all unit types.

9.23 Error analysis fills the large gray area between the simple straightforward fault that is easily resolved, diagnosed, and repaired and the difficult fault which, without error analysis, would result in continued system hardware reconfiguration and possible program and memory reinitialization.

Processor Recovery System

9.24 A special system of automatic detection and control logic is used to ensure processor sanity. This logic is used on processor clock failures or certain troubles in either the hardware or program systems which cause the processor to lose program execution sanity. A set of hardware monitors automatically trigger a sequence of control actions to reconfigure and recover the processor. This emergency action is stimulated by the processor configuration logic in the central controls.

Program Recovery System

9.25 The loss of processing sanity may be due to software problems as well as hardware troubles previously noted. There are cases where the processing capability can be partially or even totally lost, yet the processor configuration monitors do not sense the trouble. This void is filled by a system integrity control program interfacing with a large number of specialty programs which oversee and ensure processing viability. By a system of detection and correction programs, the generic program, data, and transient call memory are audited for mutilation or inconsistencies. Corrective action may be taken, ranging from localized memory updating to complete system program and memory regeneration. The integrity monitor

programs—test call-processing— verify that all call-processing tasks are being executed in the proper sequence and within reasonable time intervals . Deviations from the expected norm results in corrective action.

Demand Testing

9.26 Demand testing in the 4ESS Switch is manually initiated via input/output devices and individual frame control panels. Requests from frame control panels result in only the normal set of diagnostic tests being executed (no options). Flexibility in requesting a specific test, types of output data, number of passes, and others, is provided via the input/output system. The primary input messages for requesting a diagnostic test where applicable are DGN (diagnose), EX (exercise), and RST (restore). Detailed information regarding these messages is provided in the input message manual; a brief description is as follows:

DGN — Basic diagnostic request verb

EX — Interactive diagnostic execution verb

RST — Conditionally restores an equipment to service which includes initiating the appropriate diagnostic

TEST — Fault recovery and routine exercise programs.

Routine Tests

9.27 A routine test or exercise can consist of a specific subset of tests from a complete diagnostic, a partial diagnostic, or a test that is independent of the normal diagnostic such as contained in a faulty recovery program or unique demand diagnostic test. The extent and frequency of a routine test is primarily determined by the type of hardware being tested, reconfiguration complexities, and the sensitivity of the system to the various unit types being removed from service for testing.

9.28 Routine tests are run hourly, daily, weekly, and other times, as specified on equipment test lists and are either initiated manually via input/output terminal input messages or automatically initiated under program control. Routine tests are normally run during low system traffic periods.

Interactive Diagnostic

9.29 The interactive test mode is a special manually initiated test facility which enables operating personnel to solve the more subtle types of problems. Interactive diagnostics address the same diagnostic test programs as previously discussed; however, input messages used with the EX verb provide several options not available with the DGN verb. These options permit the actions of pause at a test, advance to a test point, step through a number of instructions, and loop through a number of instructions or tests.

Trouble-Locating Procedure Programs

9.30 Trouble-locating procedure programs generate a pack list which is an important maintenance tool. Operating personnel can use this pack list to assist in the repair of faulty equipment. The pack list identifies equipment most likely to have caused a malfunction. Although referred to as a pack list, the list may identify equipment other than circuit packs. The pack list identifies the frame, unit, and equipment location within the frame where the suspected faulty component or components are located. The pack list also identifies the schematic diagram, functional schematic, and symbol number of the listed components. The equipment identifying code is also included. A weighted code is applied to each component on the pack list to identify the component most probably causing the trouble.

9.31 The trouble locating procedure programs analyze raw data generated by failing software-controlled diagnostic tests. These trouble-locating programs generate trouble-locating summary data and temporarily enter this data into disk memory. A trouble-locating data base tape, normally mounted on a tape unit, contains pack list data. This data is organized in groups with each group containing all the pack list data for a particular unit or frame type. Using input provided by the failed diagnostic, the trouble-locating programs locate the appropriate data group on the

trouble-locating tape. Once located, the trouble-locating programs process the trouble-locating summary data from disk and the trouble-locating data from tape. The result of this processing operation is a list, pack list, of probable malfunctioning units causing the trouble.

Service Degradation Report Software

9.32 Service degradation report software provides a means of notifying office personnel in the Maintenance Operations Center of a loss in 4ESS Switch call-processing. Service degradation is defined as a hardware failure resulting in loss of service to more than 128 trunks. The following are conditions currently reported as service degrading:

- Most duplex-failed frames
- Out-of-service subunits which are not replaced by a protection switch unit.

9.33 A visual indication of service degradation is presented on the master control console. Detailed service degradation reports can be output on Maintenance Operations Center input/output channels on request. Service degradation data is also made available to plant measurement software. This allows measurement of the time interval that equipment is in a failed condition.

D. Manual Control

General

9.34 The following manual control facilities provide a backup for the automatic control systems:

- Master control console
- Input/output system
- 51A test position(s)
- Local control.

Master Control Console

9.35 The master control console (1A Processor) and master control complex (1B Processor) are the primary control and display person/machine interface of the 4ESS Switch for the equipment under the control of the Maintenance Operations Center. The console is used to display hardware active/standby configuration and software status, test results, and system performance. The console also provides the ability to manually request additional status information and to control system reconfiguration should the automatic recovery systems fail.

Input/Output System

9.36 The input/output system provides the most comprehensive person/machine interface in the 4ESS Switch. It enables operating personnel to control system operation via numerous input messages which are recognized by control software. The input/output system also provides a means to output data for the purpose of reconfiguration actions, testing, and monitoring of the system. Additional information concerning the input/output system is presented in Parts 4, 6, and 7 of this document.

51A and 51A L6 Test Positions

9.37 The trunk test position(s) provides the primary Trunk Operations Center interface for manual and semiautomatic trunk testing. The 51A test positions can test only domestic trunks. The 51A L6 test positions are provided in international switching centers only. Although they can test domestic trunks, the 51A L6 test positions are provided primarily for testing international trunks. Refer to Parts 5 and 6 for additional information regarding the trunk test position(s).

NOTE:
With 4E10 generic program, 51A and 51A L6 test position functions may be provided by the Remote Measurement System-D2 (RMS-D2). When equipped with the RMS-D2, the trunk work station provides the primary Trunk Operations Center interface for manual and semiautomatic trunk testing.

Local Control

9.38 Manual control at the individual frames is provided by local control panels mounted on

the equipment. A scan-monitoring procedure is used to periodically scan the state of these controls and to detect and react to manual requests and state changes. Diagnostic requests and requests to remove units from service are the primary manually initiated functions that can be directed from these local controls. Frame status and pass/fail diagnostic results are displayed on the lamps located on the frame control panels. Failing diagnostic results should be compared with input/output terminal output messages for details of the failure. The pass/fail lamp indicators should not be relied on when engaged in a repair activity. Out-of-service control for maintenance-related actions will generally be via an input/output terminal.

9.39 Manual access panels, multipin access connectors, and communication panels are also provided on certain unitized terminal equipment frames and metallic terminal frames for the purpose of local testing and monitoring.

E. Alerting

9.40 The 4ESS Switch office alarm system coordinates all the areas of maintenance responsibility within the office via a standard set of audible and visual alarms. Flexibility is provided by partitioning the office on an area basis with each area having a separate alarm circuit. These circuits are controlled by the alarm control program which provides the ability to group and/or transfer alarms among the areas. The objectives of the 4ESS Switch office alarm system are to notify the 4ESS Switch equipment of trouble conditions, to alert operating personnel to the occurrence of trouble conditions, and to direct operating personnel to the affected hardware equipment or software and/or hardware system problem.

9.41 The following are the basic characteristics of the 4ESS Switch office alarm system:

a. Audible and visual alarms which are consistent with AT&T standards

b. Alarms which are common in meaning throughout the office

c. Distinctive and descriptive output messages provided to the appropriate areas of responsibility for each alarm

d. Independent alarm control circuits under program control serving each area. These circuits provide the ability to group and/or transfer alarms as office needs dictate.

Nonalarmed printouts are also provided to alert operating personnel to the status of the office.

F. Maintenance Documentation

9.42 Several types of documentation support the previously described maintenance facilities. This includes procedural documents, operational guidelines, equipment description and theory manuals, software descriptions, support data, and office records. The principle procedural documents are Task Oriented Practices (TOP) which provide coverage of routine, acceptance, company order, and trouble-clearing tasks. Support data includes diagnostic, software, listings and the input/output message manuals. Office records include a collection of forms, tabulations of equipment records, spare parts inventories, work force assignments, plus many trunk, routing, and network management records.

G. Voice Communications

9.43 Operating personnel in the Maintenance Operations Center have a major responsibility in solving problems in cooperation with personnel in other work centers, in other switching offices, and at local equipment frames. Telephone communication facilities with various abilities are provided in the Maintenance Operations Center to coordinate these activities. The basic device at the master control console is a *CALL DIRECTOR* telephone which has the following features:

- Touch-tone telephone
- Audible and visual alerting devices to signal the presence of incoming calls
- A speaker phone
- The ability to connect to an operator-type headset
- The ability to hold calls and add on lines for a three-way conference connection
- Access to all the maintenance centers in the office.

9.44 Voice communications facilities are provided in all other work centers as well as in the Maintenance Operations Center. The other centers in the office do not require the extensive facilities provided in the Maintenance Operations Center. The trunk test positions in the Trunk Operations Center are provided with 101-type test lines. Also within the office, operating personnel in the equipment area can talk with other operating personnel in the equipment area or in the Maintenance Operations Center and Trunk Operations Center via the interframe voice communications circuit. This frame telephone circuit has appearances on both front and rear sides of the equipment aisles. Certain frames, such as the A6 unitized terminal equipment frames and metallic terminal frames, have built-in communication panels which also have access to the interframe voice communication circuit.

H. Tools and Test Equipment

9.45 Many types of tools and test equipment are needed to support the testing and repair activities of the maintenance force. Two broad categories of test equipment can be identified.

a. General use equipment such as scopes and probes, voltmeters, frame telephone headsets, tools, and others.

b. Special use equipment which is unit type or frame oriented, such as bus pulsers, file store clock writer, plug-in matcher packs, miscellaneous transmission test equipment, and others.

A list of test equipment from both categories is given in 820-740-150, *J4A000 4ESS Summarizing Specification*.

I. Traffic and Plant Measurement Reports

General

9.46 Traffic measurements are concerned with the effects of the telephone traffic presented to the switching system. Plant measurements are concerned with relating the effects of the maintenance condition of the 4ESS Switch to the service provided to customers. Separate measurements are maintained for domestic and international traffic. However, international measurements are equivalent to those taken in a domestic office. Note that regarding traffic and plant measurements, international trunks are defined as only those trunks using CCITT 5 and CCITT 6 signaling. Data concerning international trunks using domestic type signaling is recorded as a domestic trunk.

9.47 On-site Operations Reports, generated by the 4ESS Switch, enable the machine administrator to extract hard copy reports of operational data accumulated over extended time intervals. These reports are available on a scheduled and/or demand basis. The Onsite Operations Reports represent a summary of data available from traffic and plant measurements. Separate data is provided for international versus domestic trunks.

9.48 The software related to Onsite Operations Reports is incorporated into the network management display paging system. In this configuration, new reports can be defined or existing reports can be modified for a particular installation. These changes can be made independent of generic changes. This procedure is similar to changing or adding a new network management display page. However, in the case of Onsite Operations Reports, data is compiled to

access the traffic measurement data base to display a unique report. The standard Onsite Operations Reports are defined in subsequent paragraphs. Data contained in these reports provide administration and maintenance personnel with a means to do the following:

- Recognize and locate equipment irregularities
- Evaluate the effectiveness of the office maintenance procedures
- Evaluate the quality of service provided by the 4ESS Switch
- Determine the maintenance condition of the office and compare the condition to other offices.

These reports also provide a data source for engineering the office.

Machine Service Report

9.49 The Machine Service Report documents the quality of service provided by a 4ESS Switch. The Machine Service Report presents data relating only to problems which affect service—those that can be seen by the customer. This report includes the quantities and kinds of ineffective attempts in addition to other service irregularities.

Machine Performance Report

9.50 The Machine Performance Report documents all machine troubles whether or not they affect service. This is done because the usual service measurements reported by the Machine Service Report do not relate directly to the performance of the most critical elements in the system. Because of the high redundancy provided for these critical elements, elements are transferred to the customer. Due to a hierarchy placed on service measured by the Machine Service Report, actual performance of critical elements may be de-emphasized. This could lead to gradual degradation of service and eventually to severe service impairments. The Machine Performance Report includes data on all 4ESS Switch equipment that interfaces with system maintenance software. This report contains both trunk and switching-related information.

Machine Load and Service Summary

9.51 The machine load and service summary is an overall machine status report. It is used by the traffic engineer as a data source for engineering the office and for monitoring office performance on an ongoing basis. This report is used by the machine administrator to assure that the service provided by the office is at or above the objective level. The summary report can be used to analyze general machine problems and identify particular trouble causing components or areas. Machine load and service summary data consists of assignment data such as installed quantities, working quantities, capabilities, and assignments used primarily by the engineer. Additional data consists of dynamic traffic counts and calculated quantities that together represent the load on the equipment.

Load Service Report

9.52 The Load Service Report contains data concerning eight different items. This report identifies the following:

- 15 high days of the year
- average of the 10 highest days
- average of each of the 12 months
- 3 busiest months
- An average of the 3 busiest months.

Load Distribution Report

9.53 The Load Distribution Report is a busy hour determination report. It shows the busy hour for eight different items. This report can be printed each day or after 5 consecutive days' accumulation. When accumulated for 5 days, the data is collected during time-consistent intervals and averaged to yield a 5-day average report.

Network Switching Performance Measurement Plan

9.54 This plan provides an office report that is designed to measure the level (index) of network switching performance as viewed by the 4ESS Switch. The plan is based on data that is readily available in other traffic and plant measurement reports and network management presentations. Separate reports are provided for domestic and international service at international switching centers. The following are the principle parts of the plan:

- Switching service
- Billing service
- Performance indicators
- Base counts
- Administration.

User-Defined Reports

9.55 User-Defined Reports provide a means to extract user-formatted reports from the 4ESS Switch data base. These reports are in addition to the Onsite Operational Reports previously discussed. Up to 23 User-Defined Reports can be output. Data can be collected at quarter-hour intervals for a period of up to one week. Any report may be output at any specified quarter-hour on any designated I/O channel.

J. External Related Centers and Systems

Regional Network Management System for Network Management

9.56 The 4ESS Switch interfaces with a Regional Network Management System (RNMS) [formerly an Engineering and Administrative Data Acquisition System for Network Management (EADAS/NM)]. The EADAS/NM is a computerized system which provides centralized real-time surveillance and control of the hierarchical switching network. This monitoring and control function is provided for all levels of switching hierarchy from regional centers to selected end offices within predefined segments of the network.

The EADAS/NM uses a minicomputer and associated peripheral equipment which provide the following functions:

- Real-time surveillance of switching machine and trunk group interaction
- A computer-driven, network exception display system which is activated when predefined thresholds are exceeded
- Centralized remote network management control capability.

9.57 The 4ESS Switch interfaces with RNMS via an input/output channel. The RNMS minicomputer acquires the following types of data via this input/output channel:

- Data reflecting the status of the indicators on the network management display in the Network Management Center
- Trunk subgroup data
- Hard-to-reach code status
- Machine performance data
- Control status data
- Trunk subgroup register assignment data.

9.58 In addition to the input/output channel interface between the 4ESS Switch 1B Processor and the RNMS minicomputer, two NMC input/output channels are remoted to RNMS. The network management display terminal channel provides RNMS personnel with access to the data and control display pages available to the 4 ESS Switch NMC personnel. A network management exception printer channel presents RNMS personnel with the data being output on the network management printer in the 4ESS Switch NMC.

NOTE:
The 4ESS Switch also interfaces with the Network Management Operations Support (NEMOS) system to provide network management of the dynamic nonhierarchical routing (DNHR) network. This interface is similar to the RNMS interface and provides

similar control and report functions for the DNHR network.

Carrier Transmission Maintenance System

9.59 The Carrier Transmission Maintenance System (CTMS) provides maintenance personnel with a means to perform automated in-service tests on radio and coaxial carrier facilities. These automated procedures replace manual routine measurements. The CTMS also provides a means to isolate and identify carrier and trunk problems. A data interface exists between the ConnectVu/CMS or TOPAS in a 4ESS Switch office and a CTMS in a transmission systems center. The 4ESS Switch trunk maintenance personnel can use this interface to sectionalize a trunk to locate a trouble. The CTMS can provide measurement results from carrier access points. Trunk maintenance personnel can also verify circuit order activity by requesting special measurements via the CTMS.

T-Carrier Administration System

9.60 The T-Carrier Administration System (TCAS) is a combination of computer-based equipment and central office equipment. The TCAS provides a means of performing automated centralized administration and maintenance of digital networks. The TCAS interfaces with a 4ESS Switch via the ConnectVu/CMS or TOPAS. The function of TCAS is similar to the CTMS previously described. However, TCAS is concerned with digital equipment only.

No. 2 Service Evaluation System (No. 2 SES)

9.61 The No. 2 SES takes measurements and matches them against known patterns (ringing, voice, tone, and others). The Service Evaluation System generates various service evaluation reports which are returned to the 4ESS Switch.

9.62 Evaluation of network performance occurs during the call setup phase and during the initial stages of conversation. Call observations are initiated by the Service Evaluation System. A message sent to the 4ESS Switch by the Service Evaluation System via a dedicated data link initiates a call observation. The 4ESS Switch selects the next call which reaches the stage where all digits of the called number have been received.

9.63 The incoming trunk is one-way connected to the No. 2 SES. This permits monitoring of the originating subscriber during call set up. After digit outpulsing is complete, a one-way connection is made to the outgoing trunk. These two connections permit the No. 2 SES to monitor quality of the connection and any call irregularities, tones, or announcements. The No. 2 SES monitors any tones or announcements applied to the incoming trunk by the 4ESS Switch. These and other nonaudible events are returned to the Service Evaluation System via the dedicated data link. This data includes:

- A seizure signal which indicates a new call is available for evaluation
- Called number digits
- Circuit identification number of the incoming trunk, on request
- Called party on-hook and off-hook status
- Call disposition signals which originate at the 4ESS Switch
- Trunk disconnect (incoming trunk on-hook)
- Call class flag (POTS, NON-POTS, INT'1, DED egress SDN, GSDN, INT'1 2-Stage, INT'1 EA, INT'1 intertoll 800, PAS, MAS)
- Final handling treatment (60 IMP, 120 IMP, NCA, VCA, RDA, IVC, INC, I&F, EA1-4, NCD, SP 1-4, NCC, NWC, OOB, HAW, ARG, CBK)
- Network services frame connect and disconnect.

9.64 The 4ESS Switch software selects any call on incoming trunks from equal or higher level offices as candidates for service observation. This is done to ensure that a high percentage of calls attempting to complete to lower level offices are selected. However, data calls in excess of 56kbs are excluded from the observation. Implementation of this feature allows the 4ESS Switch to connect one call at a time to the Service Evaluation System. Call selection is a random process. There is no provision to monitor calls on a preselected trunk.

Network Service Center System

9.65 The Network Service Center System is an optional interface of the 4ESS Switch via a 1200 bit per second, asynchronous, full duplex, 1B Processor input/output channel. Call irregularity data is collected by the 4ESS Switch and transmitted to the Network Service Center System in response to office data traps specified by the Network Service Center System. The Network Service Center System initiates data traps, modifies existing traps, stops and inhibits traps, and sets data sampling rates via input messages to the 4ESS Switch. The Network Service Center System stores the requested data and analyzes it as part of a service improvement function to detect far-end and facility problems which are not readily traceable with local maintenance tools.

International Services Coordination Center

9.66 The International Services Coordination Center (ISCC) is an optional interface of the 4ESS Switch via a 1200 bit per second, asynchronous, full duplex, 1B Processor irregularity data as part of the service improvement function in determining international traffic distribution, foreign network penetration, and information about incomplete calls.

Trunk Maintenance

9.67 The basic objective of domestic and international trunk maintenance is to maximize the number of trunks in service and the number of trunks performing properly. To meet this objective, the following trouble detection strategies are used:

- Trunk state control
- Per-call trunk testing
- Routine testing.

Another aspect of trunk maintenance is circuit order work; installing, testing, and turning new trunks up for service.

A. Trunk State Control

9.68 The 1B Processor trunk maintenance software maintains records concerning the in-service/out-of-service status of trunks. When a trunk is removed from service, an output message is directed to the responsible Trunk Operations Center control area. When the status of a trunk changes, the trunk out-of-service list maintained on disk is updated. Trunks are automatically removed from service for equipment failures such as duplex time slot interchange or signal processor 1 failures and voiceband interface unit failures with no protection switch.

B. Per-Call Trunk Testing

9.69 Per-call trunk and service circuit testing is the process of recognizing per-call failures, ineffective machine attempts and call set up irregularities. This testing also involves taking the appropriate actions to identify the faulty trunks and service circuits involved for circuits which **are not** equipped with software carrier group alarm treatment. Per-call trunk and service circuit testing is the function of the 1B Processor in response to per-call failures involving a given circuit. Typically, the first per-call failure results in the outgoing call being routed over another trunk and the associated per-call failure data being stored in memory. If another per-call failure occurs during the next three

calls attempting to access the same trunk, either an operational trunk test is executed or the circuit is subjected to further error analysis dependent on the type of per-call failure that occurred and the service circuit involved. If the operational trunk test fails, the trouble is verified. The circuit is then removed from service and a trouble report is sent to the ConnectVu/CMS or TOPAS. The remainder of the maintenance process is the responsibility of the Trunk Operations Center and the appropriate repair center. If the operational trunk test passes, no notification is given, but further error analysis occurs. If this analysis indicates a trouble, appropriate trouble reports are issued.

C. Routine Trunk Testing

9.70 Routine trunk testing consists of operational and transmission tests executed under the control of 4ESS Switch generic program and RMS-G1. Routine tests are run automatically on all trunks and service circuits in the office for which tests are available. The frequency of automatically-initiated routine operational trunk testing is limited automatically by system load and manually by scheduling via teletypewriter input. Operational and transmission trunk tests automatically requested for the purpose of routine testing are lower in priority than those which are automatically and manually requested for the purpose of error/fault detection. The 4ESS Switch also provides operational and transmission test lines to support trunk tests initiated from far-end offices. The RMS-G1 can initiate tests on international trunks and can support international trunk tests initiated at far-end offices.

D. Circuit Order Process

9.71 Circuit orders originate in the operating company circuit provision bureau and enter the 4ESS Switch environment in the form of paper records, magnetic tape, or via data link. Circuit orders entering the system in the form of paper records are inputted to the CMS or TOPAS and 1B Processor from the Machine Administration Center. Circuit orders entering the system in the form of magnetic tape or via data link are inputted directly to the ConnectVu/CMS or TOPAS. The ConnectVu/CMS or TOPAS forwards circuit orders to the Machine Administration Center for terminal equipment assignments and initial input to the recent change process.

9.72 The ConnectVu/CMS or TOPAS generates circuit order work lists which are sent to the Terminal Equipment Center and Trunk Operations Center for implementation of the circuit orders. The ConnectVu/CMS or TOPAS then updates the database for the per-circuit type data.

9.73 When the Terminal Equipment Center personnel have completed the equipment-related tasks—installation of circuit packs, setting pads, and the others—the Trunk Operations Center performs end-to-end circuit order trunk testing. Subsequent to the successful completion of these tests, the new trunks are turned up for service by the Trunk Operations Center. The ConnectVu/CMS or TOPAS notifies the Machine Administration Center of the turnup and an ''in effect'' notice is returned to the circuit provision bureau.

E. Operational and Transmission Testing

9.74 Operational and transmission tests of trunks are executed under the control of 4ESS Switch. For domestic trunks, these tests are accomplished by seizing a trunk at the originating end office and outpulsing the directory number of a test line located in the office at the terminating end of the trunk. Test equipment, if required, is then connected to the originating end of the trunk, and the trunk test is executed under software or 1B Processor control. Various types of operational and transmission test lines are used to test a trunk. Each of these test lines is identified in subsequent paragraphs. Detailed information regarding operational and transmission test lines is provided in 234-110-094, *Operational and Transmission Test Lines*.

Operational Test Lines

9.75 Operational test lines are used to routinely test the operational abilities of a trunk and

basically test the trunk circuitry at the terminating end of the trunk. The 1B Processor tests toward these types of test lines. The primary purpose of these test lines is to permit trouble detection tests to be performed in order to attempt to identify the specific problem in the far-end trunk circuit. Operational tests are originated by the 4ESS Switch to the following types of test lines:

- Synchronous test line
- Phase II Centrex synchronous test line
- Phase III Centrex synchronous test line
- Step-by-step test lines
- 103-type test line.

9.76 The 4ESS Switch terminates the 103-type and synchronous test lines to support operational tests originated by far-end offices.

Transmission Test Lines

9.77 Automatic routine and demand transmission testing can be executed under the control of far-end offices to 4ESS Switch trunk test lines. Transmission tests are used to measure the transmission characteristics of trunks—loss, noise, echo, and distortion. The transmission test lines provided by the 4ESS Switch are as follows:

- 100-type test line
- 101-type test line
- 102-type test line
- 104-type test line
- 105-type test line
- 108-type test line
- 109-type test line
- 606-type test line

Abbreviations and Acronyms

3

3B
AT&T 3B20D Computer

3BI
3B Interface

A

AAP
Announcement Administration Processor

AFA
Analog Facility Access

AFC
Analog Facility Center

ALM
Alarm

ALC
A-Link Controller

ALF
A-Link Formatter

ASW
All Seems Well

AMA
Automatic Message Accounting

AMASE
Automatic Message Accounting Standard Entries

ANI
Automatic Number Identification

API
Attached Processor Interface

APN
Action Point Number

APPECD
Application Equipment Configuration Database

APS
Attached Processor System

ASR
Automatic Speech Recognition

ATME
Automatic Transmission Measuring Equipment

AUI
Auxiliary Unit Interface

B

BISO
Begin Isolation

C

C-Links
Cross Links

CAMA
Centralized Automatic Message Accounting

CAROT-2
Centralized Automatic Reporting on Trunks-2

CARTS
Circuit Assignment and Records Transfer System

CC
Country Code

CCC
Carrier Identification and Country Code

CCIS
Common Channel Interoffice Signaling

CCITT
International Telegraph and Telephone Consultative Committee

CCS
Common Channel Signaling

CCS7
Common Channel Signaling System 7

CCT
Continuity Check Transceiver

CDSC
Custom Data Services Cabinet

CDSU
Custom Data Service Unit

CMS
Circuit Maintenance System

CMSMC
Circuit Maintenance System Maintenance Center

CNAC
CCIS National Administration Center

CNI
Common Network Interface

CPU
Central Processing Unit

CRO
Cancel Rerouted Overflow

CRT
Cathode Ray Tube

CSDC
Circuit Switched Digital Capability

CSU
Channel Service Unit

CTMS
Carrier Transmission Maintenance System

CTTU
Central Trunk Test Unit

D

DATS
Digital Access Time Slot Selector

DCIS
Destination Common Channel Signaling System

DCMS
Digital Circuit Multiplication System

DDD
Direct Distance Dialing

DDSBS
Duplex Dual Serial Bus Selector

DFA
Digital Facility Access

DFC
Digital Facility Center

DIF
Digital Interface Frame

DIF-E1
Digital Interface Frame-E1

DIF-E1 (DTMF)
Digital Interface Frame DIF-E1(DTMF)

DIF-E1 (MF)
Digital Interface Frame DIF-E1(MF)

DISU
Digital Interface Service Units

DIU
Digital Interface Unit

DLC
Dynamic Load Control

DLN
Direct Link Node

DMA
Direct Memory Access

DMAC
Direct Memory Access Controller

DMERT
Duplex Multienvironmental Real-Time Operating System

DNHR
Dynamic Non-Hierarchical Routing

DP
Dial Pulsing

DRAM
Dual Port Random Access Memory

DRO
Disciplined Rubidium Oscillator

DSA
Digital Service Adapter

DSCH
Dual Serial Channel

DSDC
Direct Services Dialing Capability

DS3
Digital Signal Level 3

DSU
Digital Service Unit

DSX
Digital Signal Cross Connect

DT
Digroup Terminal

DTMF
Dual Tone Multifrequency

E

E-Links
Extension Links

EADAS/NM
Engineering and Administrative Data Acquisition System for Network Management

EAI
Emergency Action Interface

EB
Extended Bus

EBCU
Equivalent Basic Calling Unit

ECD
Equipment Configuration Data

ECS
Extended Call Store

EDAS
Engineering Data Acquisition System

EIA
Electronic Industries Association

EISO
End Isolation

EKCODE
Extended Address Enable Code

EST
Echo Suppressor Terminal

ETS
Electronic Translator System

EXEC
Executive Processor Pack

F

F-Link
Fully Associated Links

FETL
Far End Test Line

FIFO
First In First Out

H

HDU
Hard Disk Unit

HTR
Hard-to-Reach

I

IAM
Initial Address Message

ICDR
International Call Detail Recording

ICL
Inserted Connection Loss

IDDD
International Direct Distance Dialing

IDTS
Immediate Dial Tone Start

IFB
Interframe Buffer

IMS
Interprocessor Message Switch

INUP
International Network User Part

INWATS
Inward Wide Area Telephone Service

IOP
Input/Output Processor

IRN
Integrated Ring Node

IRR
Immediate Reroute

ISAIC
Improved Service Announcement and Information Collection

ISC
International Switching Center

ISCC
International Services Coordination Center

ISDN
Integrated Services Digital Network

ISUP
Integrated Services Digital Network User Part

ITS
Installation Test System

IUN
IMS User Node

IPUB
Interface to Peripheral Unit Bus

K

KCODE
Address Enable Code

L

LAN
Local Area Network

LI
Link Interface

LIFO
Last In First Out

LN
Link Node

LT-1
L-Carrier to T1-Carrier

M

MAC
Machine Administration Center

MC
Machine Congestion

MCC
Master Control Console (1A Processor) or Master Control Complex (1B Processor)

MCRT
Maintenance Cathode-Ray Tube

MF
Multifrequency

MFS
Multifrequency Signaling

MHD
Moving Head Disk

MOC
Maintenance Operations Center

MROP
Maintenance Read-Only Printer

MTF
Metallic Terminal Frame

MUP
Maintenance Utility Processor

N

NCEO
Nonconforming End Office

NCP
Network Control Point

NEMOS
Network Management Operations Support

NMC
Network Management Center

NN
National Number

NP
Node Processor

NPA
Number Plan Area

NSC
Network Services Complex

O

OBAT
Operator Bridged Access Trunk

ODA
Office Data Assembler

ONAC
Operations Network Administration Center

ONI
Operator Number Identification

OOS
Out of Service

OSO
Originating Screening Office

OSPS
Operator Services Position System

OTS
Operating Toll Switch

P

PAS
Phased Announcement System

PBX
Private Branch Exchange

PCC
Per Call Control

PCIS
Per Channel Inhibit Signaling

PCM
Pulse Code Modulated

PICO
Padded Input Output

PIFB
Padded Intraframe Buffer

POTS
Plain Old Telephone Service

PR
Program Listing

PRI
Primary Rate Interface

PRM
Processor Recovery Message

PSC
Protection Switched Client

PSE
Program Store Expansion

PUB
Peripheral Unit Bus

PUDR
Peripheral Unit Driver-Receiver

R

RAM
Random Access Memory

RAO
Regional Accounting Office

RF
Radio Frequency

RMS-D2
Remote Measurement System-D2

RN
Ring Node

RNAC
Remote Network Administration Center

RNF
Ring Node Frame

RNMS
Regional Network Management System

RNOC
Remote Network Operations Center

ROM
Read-Only Memory

ROTL
Remote Office Test Line

RPC
Ring Peripheral Controller

RPCN
Ring Peripheral Controller Node

S

SCANS
Software Change Administration and Notification System

SCAR
Stable Call Accumulation Register

SCC
Service Circuit Controller

SCCS
Switching Control Center System

SCS
Service Circuit System

SCSC
Service Circuit System Controller

SCSU
Service Circuit System Unit

SCU
Service Circuit Unit

SDN
Software Defined Network

SDOC
Selective Dynamic Overload Control

SLK
Signaling Link

SMCC
Switching Management Control Center

SP
Signal Processor

SPC
Switching and Permuting Circuit

SPCS
Stored Program Controlled System

SPRR
Spray Reroute

SRL
Selective Reservation Level

STP
Signal Transfer Point

STR
Selective Trunk Reservation

T

TASI
Time Assignment Speech Interpolation

TCAS
T-Carrier Administration System

TDAS
Traffic Data Acquisition System

TDNET
Time Division Network

TEC
Terminal Equipment Center

TMS
Time Multiplexed Switching

TOC
Trunk Operations Center

TOP
Task Oriented Practices

TOPAS
Testing, Operations, Provisioning, and Administration System

TOSS
Teleconferencing Operator Support System

TSC
Temporary Signaling Connection

TSI
Time Slot Interchange

TSPS
Traffic Operator Position System

TSPS
Traffic Service Position System

TSRP
Trunk Service Results Plan

TTS
Terminating Toll Switch

TUP
Telephone User Part

TUT
Trunk Under Test

TWS
Trunk Work Stations

U

UTE
Unitized Terminal Equipment

V

VF
Voice Frequency

VFL
Voice Frequency Link

VFLA
Voice Frequency Link Access

VIF
Voiceband Interface Frame

VIU
Voiceband Interface Unit

X

X.25
Processor Assembled Data Message Protocol

XTC
XTSI Controller

XTF
XTSI Formattor

XTSI
Expanded Time Slot Interchange

XXX
International Carrier Identification

How Are We Doing?

Document Title: ***4ESS***™ Switch General Description

Document No.: 234-100-000 Issue 18 Date: March 1999

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