

**D1, D2, D3, AND D4 DIGITAL CHANNEL BANKS
AND D5 DIGITAL TERMINAL SYSTEM
APPLICATION ENGINEERING
CARRIER ENGINEERING**

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351-107 for D1, 855-351-108 for D2, 855-351-109 for D3, 855-351-105 for D4, and 855-351-120 for D5.◆

1.02 This practice is reissued to add information on the D5 digital terminal system. Revision arrows are used to emphasize the significant changes.

BACKGROUND

1.03 D1A was the original channel bank for the T1 Carrier System. The terminology, "T1 Carrier System," is no longer appropriate because any of the D-type channel banks may be used with T1 lines. Also, the D1 channel bank or any other channel bank may be used with T1C, T2, or other digital transmission facilities. The original design intent of the D1/T1 system was to provide economical exchange trunk facilities for distances up to 25 miles. However, the rapid growth in the number of systems installed led to a demand for applications not included in the original design intent. Three of the channel banks (D1B, D1C, and D2) were developed in response to this demand. D1B provides 4-state signaling which is needed in some special service applications. D1C is a special channel bank that provides remote operator capability for Traffic Service Position System (TSPS). D2 was developed in response to demand for intertoll capability. D3 was developed to utilize integrated circuits for cost reduction. Since D3 used a different coding format to allow for intertoll capability, D1D was developed to provide D1 end-to-end compatibility with D3. D3 unitized terminal equipment (UTE) was developed to provide for switched maintenance access systems (SMAS). D4 was developed as a 48-channel terminal optimized for 48-channel T1C line facilities. By retaining the basic 24-channel digroup format, D4 can provide efficient access to T1, T1C, and T2 lines.

1.04 ◆A fifth generation digital transmission facility, the D5 digital terminal system, is now available. It is controlled by a microprocessor which automates most maintenance tasks and supervises the operations of up to 20 channel banks. The D5 channel bank contains 96 channels. It can be configured for DS1 and/or DS1C transmission. All channel unit and bank options are electronically set based on option parameters entered in the controller via a local or remote input/output terminal.◆

D-TYPE CHANNEL BANK DESCRIPTIONS

1.05 ◆All D-type channel banks convert between voice frequency (VF) signals and 1.544-Mb/s DS1 pulse code modulated (PCM) bit streams. D4 and D5 can also convert to 3.152-Mb/s DS1C bit streams. Two D4 banks can be connected together to provide a 6.312-Mb/s DS2 bit stream.◆ Fundamentals of PCM techniques are described in Practice 365-010-100. For all D-type channel banks, each channel is sampled 8000 times per second and each sample is then encoded into 7- or 8-bit binary words. When 7-bit words are used, an eighth bit is added for signaling so that each of 24 channels has an 8-bit output. For every $24 \times 8 = 192$ information bits, a synchronization or framing bit is added to provide 193 bits per frame for a digroup (a block of 24 PCM channels). Since there are 8000 samples per second, the output bit rate for a digroup is $8000 \text{ frames/sec} \times 193 \text{ bits/frame} = 1.544 \text{ Mb/s}$. The unique characteristics of the various banks are described in the following paragraphs.

A. D1A Channel Bank

1.06 A D1A channel bank encodes voiceband information into 7-bit words and adds an eighth bit to provide signaling information. The D1A channel bank utilizes a compandor (a compressor-expandor combination) and a linear CODEC (a coder-decoder combination) to convert between voice and PCM. The compandor uses a set of matched diodes which approximates a $\mu = 100$ companding characteristic. In addition to using one of the eight bits of every word for signaling, D1A "robs" the least significant voice information bit when any channel is in the on-hook state. During this supervisory condition, D1A provides only six bits for voice information. This digit robbing is needed for reverive pulse signaling but affects all service since the digit robbing is done in common equipment.

B. D1B Channel Bank

1.07 The D1B channel bank operates as a 24-channel CODEC in exactly the same manner as the D1A except in the way it uses its dedicated signaling digit. The D1B channel bank uses the signaling bit more efficiently by time-sharing it so as to yield the extra signaling states needed for reverive pulsing and foreign exchange channel units without digit robbing.

1.08 D1A channel banks can be converted to D1B by replacing the 4019B and M units with 4019BS and BT units, respectively, and by installing some minor back-of-bay wiring (K option). Option K has been furnished on all bays since 1967. Refer to SD-97070-02 for option K details.

C. D1C Channel Bank

1.09 The D1C channel bank is a special version of D1 used to provide an operator's trunk carrying voice and data between a remote TSPS console position and the TSPS No. 1 basic unit when the distance between them exceeds 4 miles. The circuitry controlling the digit time slot normally assigned to signaling has been modified to permit the transmission of 24-bit data words. D1A, D1B, and D1C channel banks are described in Practice 365-100-100.

D. D1D Channel Bank

1.10 The D1D channel bank operates as a 24-channel PCM CODEC that uses the 7-5/6 bit, 15-segment, $\mu = 255$ nonlinear CODEC, which is also used in D2, D3, D4, and D5 channel banks. In five out of six frames, eight bits are used for voice frequency information. In every sixth frame, the least significant bit position is used for signaling. To obtain the additional signaling states needed for revertive pulsing and some special services, the alternate signaling frames are time shared. An example is that supervision is sent in the sixth frame and revertive pulsing is sent in the twelfth frame. The D1D channel bank may be optioned for loop and external timing and can be used with the digroup terminal (DT) or digital access and cross-connect systems (DACS).

1.11 D1A or D1B, with appropriate bay wiring, can be converted to D1D by replacing 12 common equipment plug-in units. This allows end-to-end use with D3, D4, or D5 channel banks when only D1 channel banks are available.

1.12 The conversion provides the same PCM coding format, companding, and signaling techniques as used in D2 channel banks. However, end-to-end use with D2 channel banks is not recommended because of the different channels/time slot sequences which can cause administrative problems. The D1D channel bank description can be found in Practice 365-116-100.

E. D2 Channel Bank

1.13 The D2 channel bank operates as a 96-channel PCM CODEC. The 96 channels are multiplexed into 4 DS1 signals of 24 channels each. The format is identical to that of D1D channel banks except that the channel numbering assignment is different. See Table A for the different D-type channel bank numbering sequences. The D2 channel bank offers transmission performance suitable for use in intertoll, toll-connecting, direct, and tandem trunks. Practice 365-400-100 describes the D2 channel bank.

F. D3 Channel Bank

1.14 The D3 channel bank superseded the D1 and D2 channel banks. It utilizes the same PCM word and frame formats, companding characteristics, and signaling techniques as the D1D channel bank. The D3 channel bank has options for selecting any of the different channel-to-time-slot numbering assignments shown in Table A. Optional looped and external timing of the D3 channel bank is obtainable. This permits operation with the DT, DACS, and the Digital Data System (DDS). The D3 channel bank offers toll-grade performance and is suitable for use in intertoll, toll-connecting, direct, and tandem trunks. A description of the D3 channel bank is found in Practice 365-150-100.

G. D3B Dataport

1.15 The dataport channel units connect digital data directly to the T-Carrier facility without a separate data multiplexer. To use these channel units, the D3 channel bank must be converted to a D3B channel bank. This includes substituting a new data logic unit (DLU) for the D3 channel bank interface unit (IU). The DLU replaces the IU, performs all of its functions for D3 message channels, and supplies timing to the dataport channel unit[s] installed in the D3B channel bank. Careful consideration is necessary when converting a D3 channel bank for dataport service (i.e., substrate requirements, selection of channel(s), proper channel unit list number, etc.). Refer to Practice 365-150-107 for details on D3B dataport operations and a suggested sequence of tasks for establishing D3 dataport service.

H. D4 Channel Bank

1.16 The D4 channel bank is a 48-channel PCM CODEC, producing DS1, DS1C, or DS2 out-

put(s). The DS1 format of a D4 channel bank is identical to a D3 channel bank. The DS1C and DS2 outputs are obtained by multiplexing the DS1 outputs and adding stuffing and synchronization bits as needed. The output rates and the signal formats are determined by the operational mode of the bank. Figure 1 identifies D4 channel bank PCM operating modes.

1.17 D3, D4, and D5 channel banks have the same options for channel-to-time-slot numbering assignments. These options provide compatibility with all channel banks except D1A, D1B, and D1C. The D4 channel bank also provides local, loop, and external timing options for operation with DDS, DT, or DACS.

1.18 The D4 channel bank offers toll-grade performance and, thus, is suitable for use in intertoll and toll-connecting trunks and in direct and tandem trunks. D4 channel banks are described in Practice 365-170-100.

Timing For D4 Channel Banks

1.19 The D4 channel bank timing options are controlled by office interface units (OIU). The OIU-1 provides loop timing for DACS or DT applications. The OIU-2 provides local, loop, or external timing options for DDS applications. The OIU-3 provides loop timing but is only used with the time assignment speech interpolation (TASI) equipment. The OIU-4 provides the same options as the OIU-2, plus a slip detection feature used with circuit switched digital capability (CSDC) service. When external timing is used, only the OIU-2, List 2 may be used in every bank in the bay. Table B summarizes the limitations for other OIU-2 list numbers.

I. D4 Dataport Operation

1.20 The use of dataport channel units to gain direct digital access to the T-Carrier facility is more economical for end offices that serve a small number of data customers than the use of T1WB4/5 data banks. The D4 channel bank can provide DDS channels on short notice using existing channel bank equipment and dataport channel units. Any T1 line which meets voice quality requirements can qualify for subrate data or 56-kb/s data service using the new 56-KB dataport channel units with error correction. Qualified lines with 10⁻⁶ or better error rates may be used for 56-kb/s dataport service without

error correction. Due to the power supply and heat dissipation requirements, not all 24 channel positions in a digroup should contain dataport units. When using standard dataport channel units, the limits are 6 office channel unit dataport (OCU DP) channel units per digroup or 32 DS0 DP channel units per bank. If new low power dataport channel units are used, 28 OCU DP channel units may be used per bank with no limit per digroup. ♦ If the new 325A power converter unit is used, no bank restrictions exist for the OCU DP low power units. ♦ There are no restrictions in using low powered DS0 DP channel units regardless of which power converter unit is used.

♦J. D5 Channel Banks

1.21 Each D5 bank in the 20-bank D5 system converts individual analog voice frequency circuits and data circuits into multiplexed digital signals for transmission over digital carrier facilities. The D5 bank is compatible with all D-banks (except D1A, D1B, and D1C) and with the digroup terminal (DT), digital interface frame (DIF), digital carrier trunk (DCT), digital access and cross-connect system (DACS), and the digital multiplexers operating at the DS1 or DS1C rate. The D5 bank is also compatible with the DS1C synchronous and asynchronous formats (D4 Modes 1 and 2) and is capable of providing the extended framing (Fe) format. Each D5 bank has 96 channels divided into 4 digroups of 24 channels each.

1.22 The D5 channel bank has five shelves numbered 1 through 5 bottom to top, respectively. Shelf 5 (top shelf) contains the bank common circuit packs. Shelves 1, 2, 3, and 4 correspond to digroups 1, 2, 3, and 4. Each digroup shelf contains its digroup common circuit packs in slots X, Y, and Z (left side) and up to 24 channel units in slots 1 through 24.

1.23 Each digroup can be configured individually for DS1 operation. For DS1C operation, digroups are paired as follows: 1 with 2 and/or 3 with 4. When shelves 1 and 2 are paired for DS1C operation, slot x of shelf 1 contains the FI-1C circuit pack. Slot x of shelf 2 is vacant. When shelves 3 and 4 are paired for DS1C operation, slot x of shelf 3 contains the FI-1C circuit pack. Slot x of shelf 4 is vacant. Table C shows the facility interface circuit pack configuration for each DS rate.

D5 CHANNEL BANK SYNCHRONIZATION

1.24 The D5 system must operate in a synchronous mode; i.e., within the digroup, the transmit PCM and the receive PCM must be timed to the same clock source. Synchronization in D5 takes place at three levels: system, bank, and digroup. The different applications and options are described below and are presented in Table D and Figures 2, 3, 4, 5, and 6.

A. D5 System External Composite Clock

1.25 An external composite clock is always required for the two AEK6 timing interface circuit packs located in the maintenance panel. The AEK6 packs supply timing to each AEK2 bank clock when an AEK4 bank synchronizer is provided in the bank. Two external composite clocks must be supplied to every D5 system (one to each AEK6 pack). The absence of one clock source results in a minor alarm. The absence of both clock sources results in a critical alarm. There are several sources of composite clock which can be used to supply the AEK6 packs. Also, a synchronization distribution expander (SDE) can be used to supply composite clock. The SDE receives its composite clock from the local office timing supply or from an incoming T1 line using a bridging repeater.

B. D5 Bank Timing

1.26 When provisioning a bank using the INSTALL command, there are two option choices for the "BS TYPE=" prompt. They are BS TYPE= NONE or 1. If "NONE" is selected, the AEK2 bank clock's 4 MHz clock will be free running and no bank synchronizer (AEK4) circuit pack is needed. However, if NONE is selected, the far end digroup must be loop-timed to maintain synchronization. This application applies to voice frequency transmission only (no dataports in bank). See Table D. If "1" is selected, the AEK2 bank clock's 4 MHz clock will be timed from an external composite clock source and the far end bank digroups must either be loop timed or synchronized to the same clock source to maintain synchronous operation. In this configuration, a BS-1 AEK4 bank synchronizer circuit pack must be installed in the bank. Regardless of the option selected (NONE or 1), the D5 system timing interface (AEK6) circuit packs must be installed and connected to an external composite clock (CC). For services requiring external clock such as dataport, option "1" must be selected. See Fig. 2.

C. D5 Digroup Timing

1.27 When provisioning a digroup using the PROVISION command, there are two option choices for the "TMG=" prompt. They are TMG= EXT or LP for external or loop. These options apply to the AEK7 (FI-1) or AEK8 (FI-1C) facility interface circuit packs and to the AEK10 digroup formatter circuit pack. See Fig. 2. If "EXT" is selected, that digroup's transmit 4-MHz clock and transmit 1.544 MHz clock will be timed from the AEK2 bank clock. If "LP" is selected, that digroup's transmit 4 MHz clock and transmit 1.544 MHz clock will be timed from the incoming T-line bit stream. Any digroup may be set to "EXT" or "LP" timing independent of the other three digroups.♦

SIGNALING

1.28 Three types of signaling may be used: Common channel interoffice signaling (CCIS), single frequency (SF) signaling, and built-in signaling. With CCIS, the signaling is sent over a separate path from the voice channel. Therefore, only transmission need be considered when using D-type channel banks for trunks with CCIS signaling.

1.29 For SF signaling, D1D, D2, D3, D4, and D5 channel banks are preferable because they perform better when the SF tone is on. Even though tone should not be on during speech, there are occasional SF applications where tone is on. In this case, the D1A and D1B channel banks are noisy.

1.30 Except for D1C, all D-type channel banks generate signaling states by converting trunk or line dc signaling states to data in the bit stream. D1C converts data from the TSPS controller to the signaling states in the channel bank. Signaling compatibility information between specific channel units and connecting circuits must be evaluated for each application. Refer to Practice 179-100-301.

SYSTEM TRANSMISSION LEVELS AND LOSS OPTIONS

1.31 Different transmission levels are used for the various D-type channel banks. Figures 7 and 8 summarize the transmission levels and loss options available for message trunk applications. D1A and D1B cannot be connected to each other nor to any of the other channel banks. On an end-to-end basis, coordination of levels for the other D-type channel banks is achieved by utilizing a "digital milliwatt."

The digital milliwatt is a sequence of code words which, when decoded, will produce a 0-dBm0, 1000-Hz tone at any transmission level point (TLP). For example, a digital milliwatt will produce +7 dBm of power at the D2 +7 TLP decoder output, and will produce +2.5 dBm of power at the D3 +2.5 TLP decoder output. Similarly, 0 dBm0 at an encoder will produce a digital equivalent to the digital milliwatt. For example, either -16 dBm of power at the D2 encoder -16 TLP or -7.5 dBm at the D3 encoder -7.5 TLP will produce a digital equivalent to the digital milliwatt.

1.32 The digital milliwatt thus becomes a standard reference signal, enabling determination of what happens when end-to-end combinations among 2-wire or 4-wire D1D, D2, D3, D4, or D5 are used. For example, consider transmission from a 2-wire D3 at the class 5 end to a 4-wire D4 at a 4A toll. From Fig. 2, a 0-dBm signal at A (the class 5 switch) will reach the D3, -7.5 TLP, L_1 at -7.5 ± 0.05 dBm. Since -7.5 dBm would be encoded to the equivalent of a digital milliwatt, the D4 decoder will decode the signal at the +4 TLP (L_2 of Fig. 2) + 4.0 $\pm 0.05 \pm 0.25$ dBm where

+4.0 is the D4 output for a digital milliwatt

± 0.05 is the variation up to the D3 standard level access

± 0.25 is the variation between the D3 transmit access and the D4 receive access points.

1.33 The D4 channel unit receive gain (see Fig. 7) may be set to produce +7 ± 0.05 dBm at the external standard access level and P_2 will be set to provide the desired receive level for switch B (usually -3 dBm for a toll-connecting trunk). For the opposite direction, the level at the 4A transmit switch (A of Fig. 7) will normally be -2 dBm. The loss of P_1 will be adjusted to attain -16 dBm at the external standard access L_1 . The channel unit transmit gain will be set to obtain -8.5 ± 0.05 dBm. Since -8.5 is encoded into the equivalent of a digital milliwatt, the D3 output at the 2-wire receive access level (L_2 of Fig. 8) will be +2.5 $\pm 0.05 \pm 0.025$ where

+2.5 is the D3 output for a digital milliwatt

± 0.05 is the variation at the D4 transmit access

± 0.25 is the variation between the D4 transmit and the D3 receive access points. The level at

the receiving class 5 switch (B of Fig. 8) will be -5 ± 0.35 dBm. This corresponds to an inserted connection loss of 3 ± 0.35 dB.

BAY ARRANGEMENTS, CABLING, AND POWERING

1.34 Bay arrangements, cabling, and powering of the various D-type channel banks are compared in Fig. 9 and 10 and Tables E and F, respectively.

1.35 The D1 channel banks were originally provided with terminal blocks at the top of the bays to connect office wiring. The voice pairs and E&M leads (six wires per channel) were cabled to the carrier group alarm (CGA) mounted in the miscellaneous relay rack space. From the CGA to an office intermediate distributing frame (IDF), two additional leads, B1 and B2, were added for trunk conditioning (make busy leads) as shown in Fig. 11. A connectorized cable version of the D1 channel bank was provided later to simplify installation.

1.36 The D2 channel banks were originally designed for direct office cabling to connector pins at the back of the channel unit slots; a connectorized cable version was provided later. Eight leads per channel (T, R, T1, R1, E, M, B1, and B2) are cabled from the D2 directly to the IDF. The CGA function is built into the D2 frame. Since these leads are wired directly to channel unit slots in D2, the B1 and B2 leads are utilized to satisfy the need for S, SB, and SG leads for step-by-step sleeve ground. These leads also provide signal battery and signal ground for type II E&M signaling. The T1 and R1 leads provide facilities for A and B leads for 2-wire E&M or for PN1 and PN2 precision network leads except when A, B, PN1, and PN2 are all required. In this case, additional leads are cabled to an extra connector on the 2-wire E&M unit.

1.37 The D3 channel bank originally provided 13 leads per channel (T, R, T1, R1, E, SG, M, SB, S, B1, B2, PN1, and PN2) to the IDF with T1 and R1 leads reusable for A and B leads. Later, PN1 and PN2 were field-wired options since they were rarely used. Both connectorized and bulk cable are used. The CGA function is built into the trunk processing unit and the channel units.

1.38 The D4 channel bank is provided with 10 leads per channel (T, R, T1, R1, E, SG, M, SB, 1, and 2). They are bulk-cabled to the IDF with T1 and R1 leads reusable for A and B leads and with the 1 lead

reusable for the S lead. The PN leads are field-wired options to be provided as needed.

◆**1.39** The D5 channel bank is provided with 10 leads per channel (T, R, T1, R1, E, M, MB(SB), EB(SG), 1, and 2). They are bulk-cabled to the IDF with T1 and R1 leads reusable for A and B leads and with the 1 lead reusable for the S lead.◆

1.40 The 1.544 Mb/s DS1 signal for all D-type channel banks is connected to a DSX-1 cross-connect bay or directly to a T1 office repeater bay (ORB). The maximum cable length is 655 feet from a D-type channel bank to either a DSX-1 or T1 ORB. The 655-foot cable length also applies to the 3.152-Mb/s D4 or D5 cabling to a DSX-1C or T1C ORB.

◆D5 Bay Arrangement Rules

1.41 The following engineering rules are recommended when planning central office floor space for D5 installations.

Rule 1 - For the 11-foot-6-inch bay arrangement, space for one additional bay should be reserved to support the VF/DS0 switch and other enhancements. For the 9- and 7-foot bay arrangements, space for two additional bays should be reserved. One bay is required to support the VF/DS0 switch. The other bay is required to support the facility interface modules (FIM) and other equipment, such as the digital bridge substrate multiplexer and cross-connect, and the packet switch interface.

Rule 2 - There are three options for additional bays as described below:

1. (Preferred) Place additional bays to the left of the system controller bay.
2. Place additional bays to the right of the last channel bank bay.
3. Place additional bays some distance from the phase 1 system. The distance should not exceed 65 cable feet.◆

2. TRANSMISSION PERFORMANCE

2.01 Comparisons are given here of VF transmission characteristics of the various D-type channel banks. D1A, D1B, and D1C channel banks

have approximately the same performance. D2, D3, D4, and D5 channel banks have approximately the same performance. The performance of D1D is like D1A, D1B, and D1C channel banks where the per-channel equipment controls performance [frequency response, SF interference, delay distortion, image impedance, return loss, longitudinal balance, and inserted connection loss (ICL) range]. D1D channel banks perform like D2, D3, D4, and D5 channel banks where the common equipment controls performance (signal-to-distortion, noise in the absence of signal, crosstalk, overload, and tracking). A variety of voiceband transmission performance parameters is compared in the following paragraphs. Comparisons are made of requirements and typical performance.

SIGNAL-TO-DISTORTION RATIO

2.02 Signal-to-distortion can be thought of as a measure of noise in the presence of signal. The distortion of a PCM system consists of the quantization error, which is noise-like, and nonlinear distortion, which is like harmonic distortion. A major improvement in signal-to-distortion exists in D1D, D2, D3, D4, and D5 channel banks relative to D1A and D1B channel banks. This improvement results from the use of 7-5/6 digits rather than 7 and from the use of nonlinear CODECs rather than diode companders. The signal-to-distortion characteristics are compared in Fig. 12.

NOISE IN THE ABSENCE OF SIGNAL

2.03 Noise in the absence of signal is important in voice transmission because it influences judgment of circuit quality. The average noise and the requirements are compared for the various channel banks in Table G. Noise in the absence of signal performance is essentially equivalent for all D-type channel banks. The D1A and B channel banks tend to have a wide variability in noise among channels within a bank. This is sometimes upsetting to maintenance personnel, but the effect on transmission performance is acceptable.

FREQUENCY RESPONSE

2.04 The frequency response of D1 channel banks is a major limitation of their use in intertoll circuits. Figure 13 shows a comparison of typical channel bank performances and intertoll objectives for D-type channel banks.

SF INTERFERENCES

2.05 The objectives for SF interference are intended to limit foldback (inputs with energy at frequencies above 4 kHz reflected back into the voiceband), sidebands around the 8-kHz sampling frequency in the system output, harmonic distortion, and multiple harmonics generated within the quantizing process folding into a single inband frequency. The present objectives for SF interference are:

- (a) For any input frequency from 0 to 12 kHz, the output power at any other single frequency should be less than -28 dBm referred to 0 TLP when the input sinusoid is 0 dBm referred to 0 TLP.
- (b) For an input frequency of 1020 Hz, the output power at any other frequency from 0 to 4 kHz should be less than -40 dBm referred to 0 TLP when the input sinusoid is 0 dBm referred to 0 TLP.

These objectives, which D1D, D2, D3, D4, and D5 channel banks meet, are better than typical D1A, D1B, and D1C channel bank performance by about 3 dB for the first part and by about 10 dB for the second part.

ENVELOPE DELAY

2.06 The objectives for envelope delay are no longer directly established but are included in peak-to-average ratio (PAR) objectives. All D-type channel banks meet PAR objectives of 94 or better. Envelope delay performance comparison of D2 with other D-type channel banks is presented in Fig. 14. The difference is due primarily to the absence of a high-pass (60-Hz rejection) filter in D2 channel banks. The curves are an average among the various channel units. More precise values are presented in Practice 880-100-260.

CROSSTALK

2.07 The present objective for D-type channel banks is that the interchannel near-end or far-end crosstalk coupling loss be such that with 0 dBm of power at the 0 TLP on the disturbing channel in the 0- to 4-kHz band, the power on the disturbed channel should be no worse than -65 dBm referenced to 0 TLP when measured with C-message weighting. All D-type channel banks except D1A, D1B, and D1C

channel banks meet the objective. D1A, D1B, and D1C typically have about -62 dBm of power for the worst case channel combinations.

OVERLOAD

2.08 The overload for all D-type channel banks is at $+3$ dBm0; i.e., the channel banks will begin to clip the tops of sinusoidal inputs whose rms power is $+3$ dBm0. Since sinusoids have a peak-to-rms ratio of 3 dB, the peak instantaneous power which can be transmitted without clipping is $+6$ dBm0.

TRACKING

2.09 Gain deviation as a function of input power is called tracking. The current objectives for tracking are shown in Fig. 15. From 0 to -37 dBm0, the objective is based on control of the overall connection loss for the range of talker volumes normally encountered. Below -37 dBm0, the objective is based on control of echo and noise. Gain at powers below -37 dBm0 can reduce the effectiveness of the loss design for echo control and can increase the amount of noise in the absence of signal. With the exception of the D1A and D1B channel banks with nonhardened compressors, all D-type channel banks meet the objectives. The D1A and D1B channel banks having the old compressors tend to have consistent gain deviation exceeding 0.5 dB at -20 dBm0.

IMAGE IMPEDANCE

2.10 Objectives for image impedance in 2-wire circuits are directly determined by return loss objectives. In 4-wire circuits, another factor is involved: If the drop and line sides at -16 and $+7$ dB TLP are allowed to depart from the nominal value of 600 ohms, an error in overall connection loss may result due to mismatch of line and drop at these points. To control this, objectives for return loss measured against 600 ohms are 28 dB at 1000 Hz and 23 dB at other frequencies from 300 to 3000 Hz. These objectives are met by all D-type channel banks.

RETURN LOSS

2.11 Echo return loss (ERL) and singing return loss (SRL) are difficult to evaluate because the performance in service is highly dependent on connecting equipments. Present objectives for channel units designed with built-in hybrids are that the ERL measures 33 dB or better and the SRL measures 20

dB or better in standard test arrangements shown in Fig. 16. All channel units except D1 satisfy these objectives. In the standard arrangement, the D1 channel units with single-coil hybrids provide only 24-dB ERL and the units with 2-coil hybrids provide only 30-dB ERL. The 24-dB ERL can present problems in toll-connecting applications. For example, when combined with office equipments with an ERL of 26 dB, the single-coil hybrid D1 channel units would provide less than 22-dB ERL. This is the median requirement for toll-connecting trunks. D5 2-wire units contain an automatic balancing network (ABN) which improves the echo and singing return loss performance.

LONGITUDINAL BALANCE

2.12 The objectives for longitudinal balance and the testing arrangement are shown in Fig. 17. All D-type channel units meet these objectives.

3. D-TYPE CHANNEL BANK SELECTION

3.01 The technical basis for selecting D-type channel banks for specific applications is discussed here. Specific design of circuits should be obtained by using the standard message trunk design system (SMETDS).

INTERTOLL

3.02 All D-type channel banks except D1 are satisfactory for providing intertoll trunks. Intertoll trunks tend to be the most demanding on transmission performance. D1D channel banks fail to meet intertoll objectives for frequency response as do D1A and D1B, which also fail to meet objectives for signal-to-distortion ratio.

3.03 In addition to performance, certain toll maintenance features traditionally have been provided:

- (a) Patch and splitting access at -16 and $+7$ dB TLPs.
- (b) Transmission level adjusting pads between -16 and $+7$ dB TLPs and the switch.
- (c) Adjustment of received levels 0 to $+7$ dBm ± 0.05 dBm.

(d) Provision for circuit connections to special signal processing equipment, such as echo suppressors and delay equalizers.

3.04 Two basic toll environments exist: (1) offices that use the Switched Maintenance Access System (SMAS) and (2) offices that use centralized VF patch bays. The economics and maintenance features of the D3, D4, and D5 channel banks may encourage a third type of environment where maintenance access is at the D-type channel bank. The need for patching individual voice channels is rarely necessary when utilization of a Facility Maintenance Administration Center (FMAC) provides capability for fast restoral of line failures. Hot maintenance banks provide fast restoral of bank failures. Transmission level adjusting pads are available in some E&M channel units to provide loss between the switch and the channel bank. Although -16 and $+7$ dB TLP access is not provided for D3 and D4, the channel access unit provides maintenance access to 0 TLP transmit and receive points with ± 0.05 dB accuracy.

TOLL-CONNECTING

3.05 All D-type channel banks can provide satisfactory toll-connecting trunk performance, but the D1 channel bank does have two problems. First, List 1 revertive pulse and dial pulse channel units use single-coil hybrids which provide marginal transhybrid loss. Second, D1 channel units do not provide adequate loss adjustment when the toll office end is a -2 dB TLP switch. Channel units modified for D1D to DT application may be used but either a 4-dB loss results in lieu of the 3-dB objective or standard maintenance levels at the toll end cannot be retained. *Practice 179-100-301 discusses specific signaling problems encountered with MF signaling between toll-connecting trunks and the 4A toll switches.*

LOCAL DIRECT AND TANDEM

3.06 All D-type channel banks can provide satisfactory operation for local direct or tandem trunks.

INTERTANDEM

3.07 All D-type channel banks are satisfactory for use in intertandem trunks, but D1 channel

banks have no 2-wire channel units to provide the 0.5 or 1.5 dB ICL needed.

NO. 4 ESS™ SWITCH DIGROUP TERMINAL (DT)

3.08 D3, D4, and D5 channel banks were designed to provide tandem, toll-connecting or intertoll trunks terminating in a DT. The features provided in D3, D4, and D5 channel banks to permit efficient use with the DT are as follows:

- Sequential channel numbering,
- Loss options for operation with TP3 testing at the digital switch end, and
- Loop timing option.

Transmission facilities determine three classifications of trunk connecting to digital switch offices as follows (see Fig. 18):

(1) Analog trunks are any trunks that are connected at voice frequency into the voiceband interface frame (VIF) regardless of the facility used (see Note).

Note: If a D-type channel bank and DT are tied together to perform the VIF function, the trunk is then classified as an analog trunk.

(2) Combination trunks have a D-type channel bank at the analog switching office end and a DT at the digital switch end with entirely digital facilities between the ends.

(3) Digital trunks have DTs at both ends with entirely digital facilities.

Treatment of the various D-type channel banks for digital switching applications is covered in the following paragraphs.

A. Loop Timing

3.09 D-type channel banks connecting to a DT, DACS, and DDS in some applications must provide for synchronizing the transmit clock to the receive clock. This is usually done by using loop timing.

3.10 Loop timing is provided in the D1D channel bank by replacing the 4019CN circuit pack with a 4019CW circuit pack and by adding two wires to the bay wiring per SD-97060-01, Fig. 1, Option D.

3.11 Loop timing is provided in the D2 channel bank by replacing circuit pack DM24 (timing generator) with DM71. To incorporate the new network into the system, bay wiring changes must be executed. Refer to SD-99478-01.

3.12 Loop timing is provided on the D3 and D4 channel bank interface units as an option.

3.13 Although loop timing is an available option on D5 channel banks, the external timing (EXT) option should be used. This will synchronize the transmit and receive clocks to each other and also to the 4 ESS switch via the common office timing supply. The loop (LP) timing option is selected when provisioning a digroup using the PROVISION command. See paragraph 3.23 for the D5 digroup PROVISION dialogue.

B. D1 Channel Units (Level and Signaling)

3.14 Since the digital transmission path in a digital switching system requires 6 dB total loss for two toll-connecting trunks switched together compared to 3 dB for a single toll-connecting trunk, a 3-dB pad must be added to the receive side of all D1 channel units used in that application. D1 channel units for use with the DT contain a new 3-dB attenuator which is selectable. The former 0.75-dB optional pad becomes fixed.

3.15 An additional D1 channel unit modification is provided because the DT requires identical signaling in both the A and B channels. Unlike D2 and D3, D1D 2-state channel units originally transmitted signaling only on the A channel while maintaining the signaling state in the B channel in a permanent off-hook condition. The modification, which consists of adding a diode to each channel unit, provides signaling in both channels. The J-codes and

modifications for specific D1 channel units affected are listed below:

CHANNEL UNIT AND J CODE	LIST NO. FOR NO. 4 ESS SWITCH MODIFICATIONS	
	OLD UNIT MODIFIED	NEW UNIT
DPO, J98711J	L4	L5
DPT, J98711K	L5, 8	L6
4W E&M, J98711L	L3	L4
2W E&M, J98711AC	L3	L4
SDPO, J98711AD	L3	L4

C. D3 Attenuators

3.16 Early production D3 dial pulse channel units must have a 50D attenuator instead of a 50B attenuator in the receive direction. This provides -6 dB TLP at the output of the trunk, as compared with -5 dB TLP presently provided for the class 5 office end of toll-connecting trunks. The early production List 4 dial pulse originating (DPO) must be modified to List 4B and the List 5 dial pulse terminating (DPT) must be modified to List 4B. Two-wire E&M and sleeve dial pulse originating (SDPO) channel units include the 50D pad.

SPECIAL SERVICES

3.17 Applications of D-type channel banks for special services (including 2-wire foreign exchange) are covered in Practices 851-300-101 and 855-351-107. Practice 365-010-500 gives useful information on changes and limitations of D-type channel banks for use with voiceband data.

3.18 There are two problems associated with foreign exchange channel units used with the D1A channel bank. FXO and FXS channel units require 2 bits per frame for signaling in a D1A channel bank when either end is on hook. Once the call has been established, the FXS options allow it to lock the bit which signals the on-hook condition out of the signaling circuit. This option frees one signaling bit, thus allowing a total of seven bits for encoding. At the same time it prevents forward disconnect. Only the FXS end can terminate the call. For this reason FX units in D1A channel banks are not recommended for PBX or automatic call distribution systems. The

second problem occurs when D1A foreign exchange units are used in tandem with other systems. The option which allows locking out one signaling bit is not functional unless the far end FXO or FXS channel unit is in a D1A, D1B, or D1D channel bank (Fig. 18). All other D1A tandem configurations have 6-bit encoding. Six-bit encoding does not meet transmission objectives. Therefore, only the configurations shown in Fig. 19 are allowable.

COMPATIBILITY

3.19 Only end-to-end compatibility is described here. Compatibility of channel units with voice-frequency connecting circuits is covered in Practice 179-100-301. Two D-type channel banks or the DT are end-to-end compatible if the DS1 1.544-Mb/s or DS1C 3.152 Mb/s signal from one can be accepted by the other without additional processing at either end. With the exception of D1A, D1B, and D1C, the D-type channel banks have been designed to be end-to-end compatible with each other and with the DT at the DS1 rate. To be end-to-end compatible, the coding, signaling, and digital line format must be the same. These characteristics were discussed in Part 1. Table H lists the compatibility among the various D-type channel banks and the DT. This table covers basic end-to-end compatibility, but for specific applications, other factors that must be considered are:

- Performance—The D1D channel bank is not suitable for intertoll use even when used with D2, D3, D4, D5, or DT at the other end.
- Channel Units—Modified channel units or external E- or F-type signaling units may be required for some applications. This may be checked in the restrictions listed in Practice 365-010-105.

3.20 Other items of concern in end-to-end compatibility are alarms, including carrier group alarms (CGAs). The D1D, D2, D3, D4, and D5 channel banks and the digroup terminal, remote, local, and carrier group alarm operations are compatible. This includes operation with delays in CGA initiation. For example, a DT with a 2.5-second CGA initiate delay is compatible with a D3 channel bank with a 300- μ s CGA initiate delay.

D5 SYSTEM, CHANNEL BANK, AND DIGROUP OPTIONS

3.21 When a system controller is started for the first time, certain system initialization options or parameters must be entered. This is done by the CONFIGURE command. The dialogue for the CONFIGURE command is as follows:

CONTROLLER ID = Example — MVD501

CIU RATE = Enter 300 (Recommended)

CIU PARITY = Enter NONE

T PROV LIMIT = Example — 1.0

3.22 The four parameters of the CONFIGURE command are explained as follows:

CONTROLLER ID: This is the identification of a particular D5 system. Assignment of this identifier is administered by the telephone company. D5 makes no use of it except to include it in all input and output messages. It can contain up to twelve characters and the first character must be alphabetic.

CIU RATE: This is the baud rate for the craft interface unit (CIU). It can be set to 300, 1200, 2400, or 9600. However, it is recommended that the baud rate be set to 300. This prevents having to change the baud rate in order to observe messages during system controller START or RESTART operations.

CIU PARITY: This parameter should be set to NONE.

T PROV LIMIT: This parameter affects the provisioning status when a channel unit is provisioned with the use of a transponder. If the transponder use values set into a channel unit differ from the prescription values by more than the T PROV LIMIT, a CONDITIONAL provisioning status is reported by the system controller. This does not indicate a trouble with transponder provisioning. It does indicate that the prescription values are out of tolerance. This can be a result of inaccurate loop data used to determine the prescription values. If the transponder values do not differ from the prescription values by more than the T PROV LIMIT, a SATISFACTORY status is reported. The

T PROV LIMIT can be used to compare the actual measured transponder provisioning settings to the prescription settings. Therefore, the tolerance may be set as desired. The values that can be entered are 0.0 to 1000.0 in dB.

3.23 Certain options or parameters must be set into the D5 equipment to establish a bank or a digroup. These parameters should be contained on the Work Order Record and Details (WORD) document. The D5 technician obtains the parameter information from the WORD document and inputs it into the D5 system using an input/output terminal. This can be done locally or from a remote location.

3.24 The options for a D5 bank are entered using the INSTALL command. The INSTALL command dialogue is as follows:

LOC = Enter location number (1-20) of bank.
See Fig. 10.

BS TYPE = [1, NONE]

A BS-1 circuit pack is required for external timing. For loop timing, no BS-1 is required. External timing is required for dataport service. Therefore, it is recommended that a BS-1 be installed in each bank and that "1" be selected. In this configuration, external or loop timing can still be selected for any digroup independent of the other digroups.

3.25 The options for a D5 digroup are entered using the PROVISION command. The PROVISION command dialogue is as follows.

LOC = bank (1-20), shelf (1-4). Digroup shelves are numbered 1 through 4, bottom to top, respectively.

LINE = [DS1, DS1C]

EQL = [1, 2, 3, 4, 5]

See Table E.

ZC = [YES, NO]

Zero Code Suppression. (If YES is selected, zero code BSZS is provided.)

If DS1C:

MODE = [1, 2]

Same as D4 Mode 1 or 2. (MODE 1 requires AEK10 Series 2A or later Digroup Formatter.)

TMG = [EXT, LP]

External or Loop.

FE = [YES, NO]

Extended Framing Format. (FE is not available in MODE 1.)

SEQ = [D1, D2, D3]

Channel sampling. Select D3 for D3, D4, or D5 banks.◆

4. ENGINEERING RULES

4.01 The following summary of engineering rules is based on the transmission performance and channel bank selection information presented in Parts 2 and 3.

1. Use D3 or D4 channel banks for any 2-wire or 4-wire application.
- ◆ 2. Use D5 channel banks for any 2-wire or 4-wire application where an applicable D5 channel unit exists. Some applications where no D5 channel units currently exist are revertive pulse, 2-wire duplex, ringdown, and program.
3. Use D3 or D4 unitized terminal equipment banks where switched maintenance access system (SMAS) is required. Also use any D5 bank where SMAS is required.◆
4. Use D2 channel banks for any 2-wire or 4-wire application except those requiring special service channel units not available for D2, 60-Hz suppression, or DDS external timing.
5. Use D1A, D1B, or D1D channel banks in previously installed shop-wired bays to provide economical, direct, local tandem, or toll-connecting exchange trunk facilities. Do not use List 1 DP and RP channel units for toll-connecting trunk applications.
6. Use D1D channel banks to terminate a D3, D4, or D5 circuit in an existing D1 bay, or to upgrade D1 channel bank performance.
7. Use D1B instead of D1A channel banks when special service applications require 4-state signaling.
8. Use D1C channel banks to provide remote operator capability for TSPS.
9. Refer to Table E for channel bank cable limitations and equalizer requirements.
10. D1 channel banks, including D1D, are not recommended for intertoll trunks.
11. For special services, a wide range of special channel units has been developed for D1, D3, or D4 channel banks. These applications are covered in Practices 851-300-155, 855-351-105, 855-351-107, and 855-351-109. ◆Generic channel units have been developed for the D5 system. Currently, six generic channel units provide 24 separate message and special service applications. These applications are covered in Practice 855-351-120.◆
12. There are five acceptable methods of connecting carrier channels back-to-back:
 - (a) Use external office equipment to provide loss pads and pulse link repeaters (pulse link repeaters are not needed for transmission only applications) to connect standard 4-wire E&M channel units. This is applicable to any back-to-back carrier combination.
 - (b) Directly connect channel units with E&M capability and built-in pads (D2 E&M units, selected D3, D4, and D5 units, and F-type signaling).
 - (c) Connect pulse link repeater (PLR) type channel units (available for D1, D3, D4, and D5 channel banks and F-type signaling) to standard E&M D-type channel units or SF signaling units.

(d) Directly connect among D1, D3, D4, and D5 channel banks by using tandem channel units which provide back-to-back 2- or 3-state signaling.

(e) Directly connect among D1, D3, D4, and D5 transmission only channel units.

13. D3, D4, and D5 channel banks are preferred to provide tandem, toll-connecting, or intertoll trunks terminating in a digroup terminal. D2 channel banks may be used. D1D channel banks may be used except for intertoll.
14. D1D, D2, D3, D4, or D5 channel banks can be used with any other D-type channel bank except D1A, D1B, and D1C. D2 is not recommended for use with D1D because the channel numbering is different.
15. Refer to Table F for -48V power requirements.
16. For signaling capabilities and limitations and trunk compatibility, refer to Practice 179-100-301.
17. Refer to Fig. 9 and 10 for channel bank bay arrangements.

5. CIRCUIT OPTIONS FOR CHANNEL UNITS

5.01 Each D-type channel bank has its own list of plug-in channel units. The D-type channel banks may use an intermix of channel unit types as needed to perform specific requirements of the connecting circuits. The available channel units include switched message trunk and special service units. Detailed descriptions of the channel units are included in the following practices:

PRACTICE	TYPE
365-100-110	
365-400-104	
365-150-101	
365-170-101	
365-190-105	

PRACTICE	TYPE
365-190-110	D5.
5.02	D1 channel banks use channel units of the J98711 series. Channel unit option and transmission level adjustment information is provided in Practices 365-115-500 and 855-351-107.
5.03	D2 channel banks use channel units of the J98714 series. Channel unit option and transmission level adjustment information is provided in Practices 365-400-107 and 855-351-108.
5.04	D3 channel banks use channel units of the J98718 series. Channel unit option and transmission level adjustment information is provided in Practices 365-150-503 and 855-351-109.
5.05	D4 channel banks use channel units in the J98726 series. Channel unit option and transmission level adjustment information is provided in Practices 365-170-000 (TOP) and 855-351-105.
5.06	D5 channel banks use generic channel units to provide for most message and special service applications. Also, two dataport units are available. One provides all OCU functions and one provides all DS0 functions. D5 channel unit option and transmission level adjustment information is provided in Practice 855-351-120.

6. MAINTENANCE AND TESTING

6.01 Maintenance of D-type channel banks includes initial lineup and testing, routine testing, reading and resetting CGA registers, and trouble clearing. All D-type channel banks have 4-wire splitting access to transmit and receive paths as described in Part 1. These channel banks also have bridging and access to T and R or E&M leads.

6.02 In general, little in-service maintenance is required on any D-type channel bank. Routine tests for D1 or D2 channel banks are performed at 3- to 12-month intervals. D3, D4, and D5 channel banks require no routine testing. "Hot" spares should be made available for rapid replacement of failed plug-in units. The testing facilities for each type of channel bank are listed in the following paragraphs.

6.03 Testing facilities for the *D1 channel bank* are:

- (a) Four plug-in test boards are provided to assist in lineup, maintenance, and trouble-locating procedures.
- (b) The J94748A encoder bias digital test set may be used for in-service or out-of-service adjustment of the encoder bias of D1A, D1B, or D1C channel banks.
- (c) The J98711M matching network, which is ordered separately and provided for up to every fourth bay (typically every bay), is employed in connection with the 4-wire test jacks to match impedances and provide proper test power levels.
- (d) Pin jacks are provided on the right-hand side of each channel bank to permit checking power supply voltages supplied to the channel bank.
- (e) Pin jacks are provided on the various common equipment plug-in units with functions which vary from unit to unit.
- (f) A hot maintenance bank should be provided for 15 or more channel banks.
- (g) The D1 J98711AG channel signaling test unit and ED-3C447 channel unit extender are available for testing banks.

6.04 Testing facilities for the *D2 channel bank* are:

- (a) E&M leads are provided on patching jacks on E&M channel units.
- (b) 2-wire splitting jacks are provided on the dial pulse and revertive pulse channel units.
- (c) Test point jack access to the network build-out capacitors (NBOC) is provided on all 2-wire channel units.
- (d) Six testing circuit packs are available for insertion in the test shelf to be used in lineup, maintenance, and trouble-locating procedures.

6.05 Testing facilities for the *D3 channel bank* are:

- (a) Hot spare and maintenance panel test capabilities. Included in the maintenance panel is the channel access unit (CAU) used in connection with the 4-wire test jacks to provide proper test power level. The CAU may also be available in portable form.
- (b) Pin jacks provided on the power converter permit checking of input and output voltages.
- (c) Pin jacks on alarm control and receive units permit single-end testing of alarm functions.
- (d) Input jacks on some interface units accept test signals from the code generator to test the receive portions of the bank. When jacks are not provided, the code generator may be inserted in the interface unit slot.
- (e) The D3 J98718BR channel test unit and ED-3C424 channel unit extender are available for testing banks.
- (f) The D3 channel bank portable bay is available to assist in providing new service, temporary service, or rapid service restoration.

6.06 Testing facilities for the *D4 channel bank* are:

- (a) The card jack on each channel unit provides 4-wire splitting access and also provides splitting access at the 2-wire point and to E&M leads where appropriate.
- (b) A portable CAU is used in connection with the card jack 4-wire splitting access to provide proper test power levels.
- (c) Pin jacks provided on the power converter permit checking the output voltages.
- (d) Pin jacks provided on the power distribution unit permit checking the input voltages.
- (e) Controls on plug-in units permit looping of the bank by internal test tone generation and a test sampling sequence.

- (f) Indicators on plug-in units show alarm status, looping status, and a count of the number of trunk processing operations.
- (g) The J98726MH signaling path test set is a plug-in test unit provided on a one-per-office basis for initial tests and trouble isolation.
- (h) The J98726M D4 maintenance bank is provided on a one-per-office basis. It is used as a source of monitored spare plug-ins for trouble isolation and restoration in D4 channel banks. The D4 maintenance bank also provides for both transmission and signal testing of channel unit integrity.
- (i) Four voltage indicator and simulator plug-ins, a channel unit extender, and a connector extender are also available.

6.07 Testing operations for the *D5 channel banks* are divided into three categories: automatic testing, technician initiated system controller testing, and technician manual testing at the maintenance panel.

6.08 Automatic testing by the system controller is a continuous operation. This involves constant monitoring of the provisioning settings in all channel units and common units for changes in the original settings. If the provisioning settings change, a minor alarm is generated unless the settings are automatically corrected by the controller. If the line signal or digroup common equipment fails, a major alarm is generated and an automatic fast loopback occurs. The controller will then identify the location of the failure-bank/digroup or line facility.

6.09 The system controller can perform various diagnostic routines when a technician enters a DIAGNOSE command at the CIU. The diagnostics performed depend on the equipment locations entered at the CIU. For example, a DIAGNOSE channel unit location tests the channel unit net loss, gain tracking, 0 and -40 TLP distortion, idle circuit noise, equalizer slope, and automatic balance network (ABN) training (if applicable).

6.10 Manual test access, either digital or metallic, is available to each channel. A channel to be tested can be processed by the system controller for manual test access at the test access jacks on the maintenance panel.

6.11 Manual metallic testing allows the technician to test at the METALLIC test jacks on the maintenance panel for the proper signaling and transmission parameters to and from the drop facility. Manual digital or transmission level point (TLP) testing allows the technician to test the digital output signal of a channel unit at the digital test jacks on the maintenance panel. However, the digital output signal to be tested is first converted by the system controller to an analog signal and then accessed at the maintenance panel for testing. This allows the use of existing analog test equipment to, in effect, test the digital signal.

7. REFERENCES

7.01 The following is a list of documents relating to the D-type channel banks.

PRACTICE	TITLE
103-494-111	J99403TA Transponder—Description and Operation
179-100-301	T1 Carrier Signaling and Transmission System Compatibility Information
365-010-100	Type T1 Carrier System—Overall System—General Description
365-010-105	D-Type Channel Units—Application Information
365-010-500	D-Type Channel Banks—Voiceband Data Considerations and Trouble Location
365-100-100	D1A, D1B, and D1C Channel Banks—General Description
365-100-110	D1 Channel Bank—Channel Units—Description
365-115-500	D1-Type Channel Units—Tests and Adjustments
365-116-100	D1D Channel Bank—Description
365-150-100	D3 Channel Bank—General Description

PRACTICE	TITLE	PRACTICE	TITLE
365-150-107	D3B Channel Bank—Dataport Operation—Description, Installation, and Tests	801-505-155	J98726 D4 Channel Bank Equipment for Use With Digital Transmission Equipment
365-150-101	D3 Channel Units—Description		
365-150-503	D3 Channel Units—Option and Pad Selection	801-505-159	D5 J Specification
365-170-000	D4 Channel Bank—TOP		
365-170-100	D4 Channel Bank—Description	851-300-101	Standard Design of Switched Special Services Circuits— Transmission and Signaling, General
365-170-101	D4 Channel Units—Description		
365-190-000	D5 Digital Terminal System (TOP)	851-300-155	Standard Design of Switched Special Services Circuits— Application of Digital Carrier System— Using D-Type Channel Banks
365-190-100	D5 Digital Terminal System— Description		
365-190-105	D5 Generic Channel Units—Description	855-351-105	D4 Channel Units—Application Engineering
365-190-110	D5 Dataport Channel Units—Description		
365-400-100	D2 Channel Bank—General Description	855-351-107	D1 Channel Units—Application Engineering
365-400-104	D2 Channel Units—Description	855-351-108	D2 Channel Units—Application Engineering
365-400-107	D2 Channel Units—Option and Pad Selection		
801-505-150	J98711 D1 Channel Bank Equipment for Use With T1 Carrier	855-351-109	D3 Channel Units—Application Engineering
801-505-152	J98714 D2 Channel Bank Equipment for Use With Digital Transmission Systems	855-351-120	D5 Channel Units—Application Engineering
801-505-153	J98718 D3 Channel Bank Equipment for Use With Digital Transmission Equipment	880-100-260	Envelope Delay of T1 Carrier Facilities.

♦TABLE A♦			
TIME SLOT NUMBERING ASSIGNMENTS			
TIME SLOTS	ASSIGNED CHANNEL NUMBER		
	D1 CHANNEL BANK	D2 CHANNEL BANK	D3, D4, AND D5 CHANNEL BANKS
1	1	12	1
2	13	13	2
3	2	1	3
4	14	17	4
5	3	5	5
6	15	21	6
7	4	9	7
8	16	15	8
9	5	3	9
10	17	19	10
11	6	7	11
12	18	23	12
13	7	11	13
14	19	14	14
15	8	2	15
16	20	18	16
17	9	6	17
18	21	22	18
19	10	10	19
20	22	16	20
21	11	4	21
22	23	20	22
23	12	8	23
24	24	24	24

TABLE B		
D4 CHANNEL BANK OIU-2 LIMITATIONS PER BAY (NOTE)		
OIU-2 VERSION		
L1	L1 MOD A	L2
1	0	Up to 5
0	1	Up to 5
0	2	Up to 4
0	3	Up to 3
0	0	Up to 6

Note: To determine allowable combinations per bay, read across.

TABLE C		
D5 FACILITY INTERFACE CIRCUIT PACK CONFIGURATION — DS RATE		
BANK DIGROUP OR SHELF/SLOT	FACILITY INTERFACE CIRCUIT PACK	
	DS1 RATE	DS1C RATE (NOTE)
4/X	FI-1	Vacant
3/X	FI-1	FI-1C
2/X	FI-1	Vacant
1/X	FI-1	FI-1C

Note: For DS1C operation, digroups are paired as follows: 1 with 2 and/or 3 with 4.

◆TABLE D◆							
D5 SYSTEM SYNCHRONIZATION OPTIONS							
SPECIAL SERVICES CONDITIONS	CENTRAL OFFICE A			CENTRAL OFFICE B			
	SYSTEM EXTERNAL CLOCK	BANK OPTIONS	DIGROUP OPTIONS	SYSTEM EXTERNAL CLOCK	BANK OPTIONS	DIGROUP OPTIONS	
Without dataport	Any CC	None	EXT	Any CC	1	LP	
	Any CC	1	EXT	Any CC	1	LP	
With Dataport	Non-DDS Network	Any CC	1	EXT	T1 Line	1	EXT
	DDS Network	DDS Clock	1	EXT	DDS Clock	1	EXT
	DDS Network	DDS Clock	1	EXT	T1 Line	1	EXT

Any CC = Any composite clock source — DDS source, ESS, DACS, T1 line via bridging repeater, and other sources

DDS Clock = Nodal timing supply or equivalent per DDS synchronization plan

T1 Line = T1 line associated with the common master timing source (supplied in CO A). Clock signal derived from T1 line via bridging repeaters must use synchronization distribution expander (SDE).

♦TABLE E♦			
CABLE LIMITATIONS AND EQUALIZER REQUIREMENTS			
CHANNEL BANK	CABLE TO	CABLE LENGTH (FT)	EQUALIZER
D1A, D1B D1C, and D1D	DSX-1 or ORB Bay Cross-Connect	0 - 150	6-dB Pad (ED-97079-30, G6)
		150 - 450	358A
		450 - 655	358B
D2	DSX-1 or ORB Bay Cross-Connect	0 - 150	ED-1C318-30, G1
		150 - 450	ED-1C318-30, G2
		450 - 655	ED-1C318-30, G3
D3 (A, B, C, and UTE Bays)	DSX-1 or ORB Bay Cross-Connect	0 - 150	ED-97079-30, G6
		150 - 450	358D
		450 - 655*	358E
D3 (J, K, and L Bays)	DSX-1 or ORB Bay Cross-Connect	0 - 220	988A, "A" Strap‡
		220 - 440	988A, "B" Strap
		440 - 655*	988A, "C" Strap
D4 Modes 1, 2, and 3	DSX-1 DSX-1C T1 or T1C ORB Bay Cross-Connect	0 - 133	ED-3C655-30, G1 or -31, G6
		133 - 267	ED-3C655-30, G2
		267 - 400	ED-3C655-30, G3
		400 - 533	ED-3C655-30, G4
		533 - 655	ED-3C655-30, G5
D4 Mode 3	DSX-1 or ORB Bay Cross-Connect	0 - 220	ED-3C585-30, G1
		220 - 440	ED-2C585-30, G2
		440 - 655*	ED-3C585-30, G3
D4 Mode 4	DSX-2 ORB Bay Cross-Connect	0 - 90	ED-3C656-30, G1
		90 - 250	ED-3C656-30, G2
		250 - 410	ED-3C656-30, G3
		410 - 570	ED-3C656-30, G4
		570 - 730	ED-3C656-30, G5
		730 - 890	ED-3C656-30, G6
890 - 1050	ED-3C656-30, G7		
D4 Mode 4A	DSX-2 or ORB Bay Cross-Connect	25	ED-3C656-30, G7
D5†	DSX-1 DSX-1C ORB Bay Cross-Connect	0 - 133	Select 1
		134 - 266	Select 2
		267 - 399	Select 3
		400 - 532	Select 4
		533 - 655*	Select 5

* Maximum cable length is 750 feet when connections from bay cross-connect to span cross-connect are in the same or adjacent ORB.

† D5 equalizers are contained in the digroup facility interface (FI) circuit packs. They are electronically selected by the system controller when a number 1, 2, 3, 4, or 5 is entered into a D5 input/output terminal during digroup provisioning. Selection between DS1 or DS1C equalizers is automatic since a digroup will have the FI circuit pack corresponding to the line rate.

‡ This equalizer is factory installed in the D-type channel bank.

♦TABLE F♦	
TYPICAL AVERAGE POWER DRAINS	
CHANNEL BANK	WATTS PER DIGROUP
D1	175
D2	175
D3	40*
D4	23
D5	35

* Early production D3 power drain is 60 watts per digroup

♦TABLE G♦		
NOISE IN ABSENCE OF SIGNAL		
CHANNEL BANK	NOISE IN DBRNC 0	
	TYPICAL	LIMIT
D1A	15	28
D1B	15	28
D1C	15	28
D1D	16	26
D2	18	28
D3	16	25
D4	16	25
D5	16	30

TABLE H										
END-TO-END D-TYPE CHANNEL BANK AND DIGROUP TERMINAL (DT) COMPATIBILITY										
	D1A	D1B	D1C	D1D	D2	D3	D4 MODE 2, 3, or 4	D4 MODE 1	DT	D5
D1A	X									
D1B		X								
D1C			X							
D1D				X	X*†	X†	X†		X†	X
D2				X*†	X	X†	X†		X	X
D3				X†	X†	X	X		X†	X
D4 Mode 2, 3, or 4				X†	X†	X	X		X	X
D4 Mode 1								X		X
DT				X†			X		X	X
D5				X	X	X	X	X‡	X	X

* Compatible, but not recommended (time slot numbering not same).
† Compatible, but modified channel units required in some cases.
‡ Mode 1 requires AEK10 Series 2A or later digroup formatter.

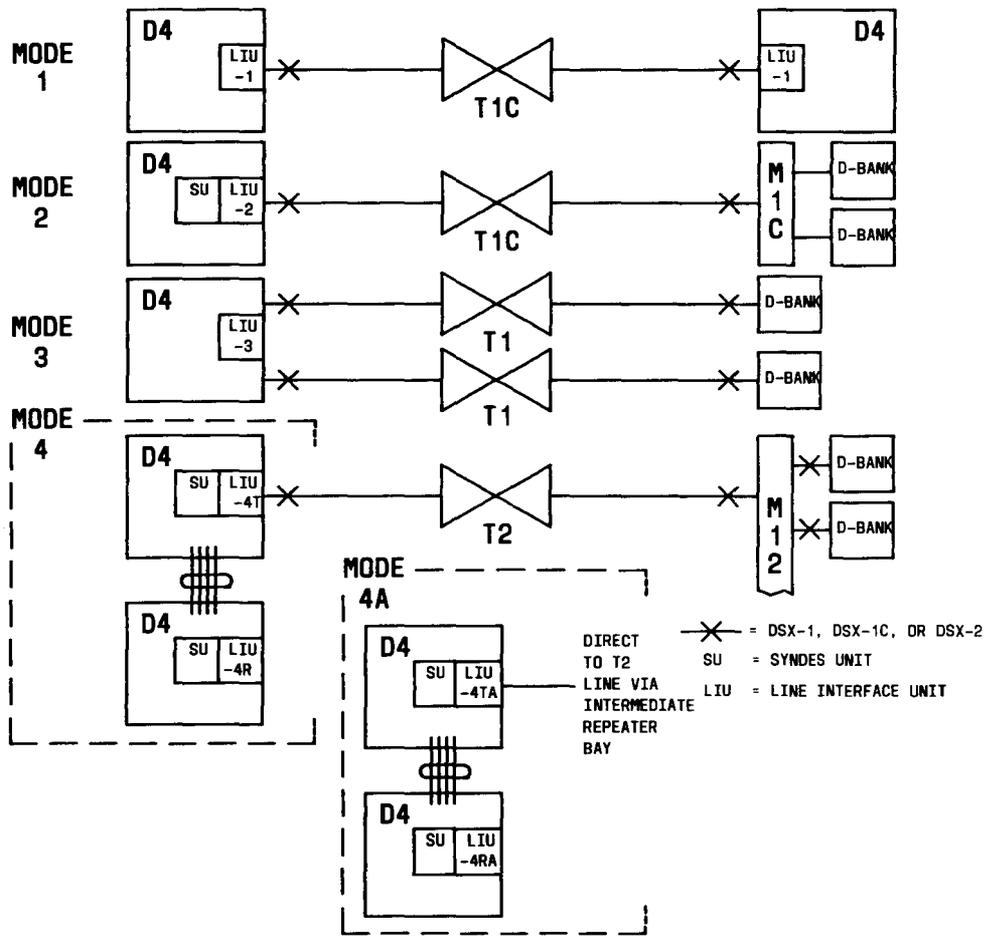
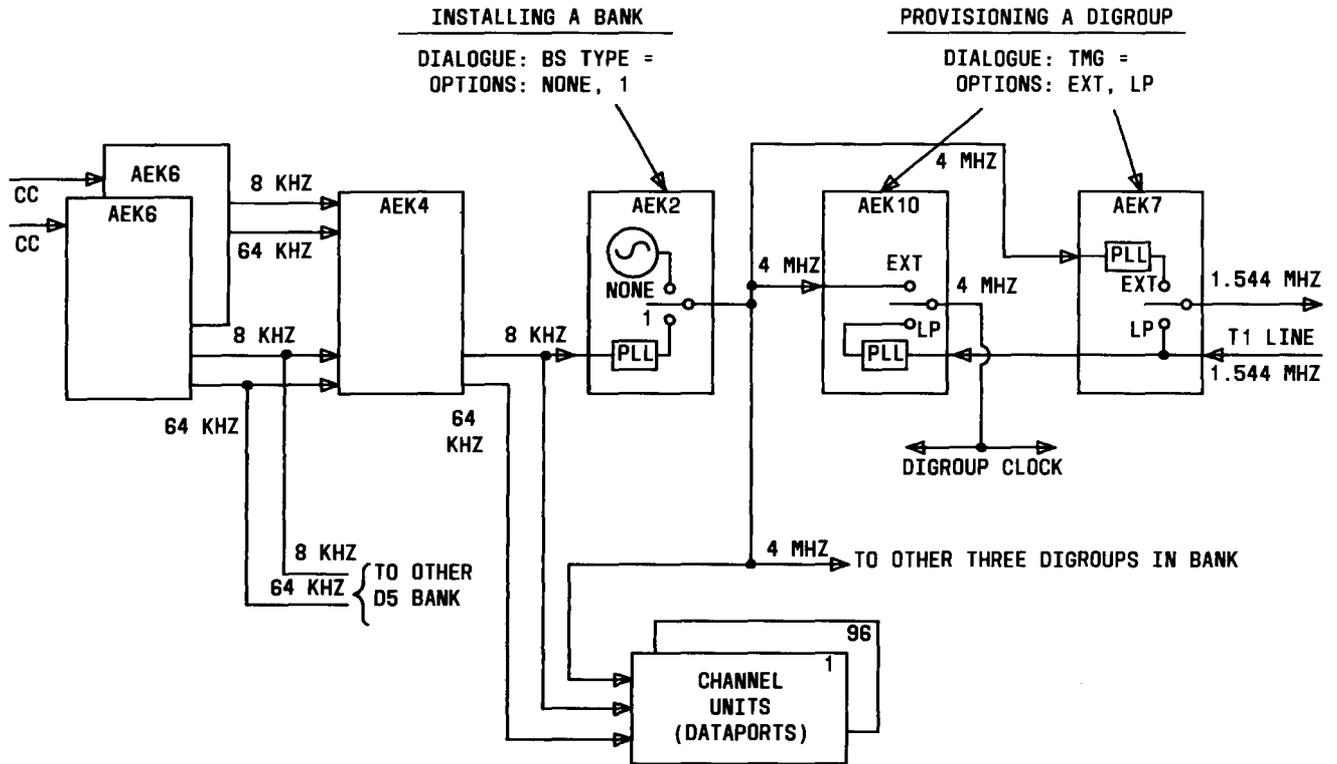
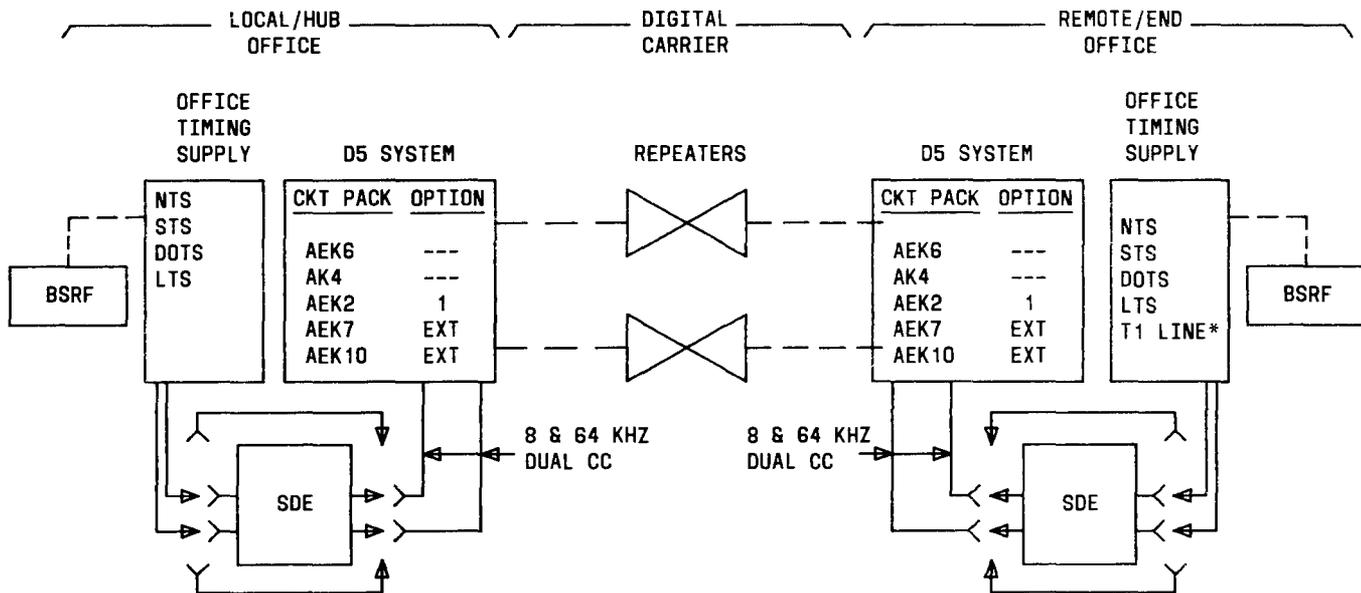


Fig. 1—D4 PCM Bank Operating Modes



- ABBREVIATIONS**
- CC COMPOSITE CLOCK
 - PLL PHASE LOCK LOOP
 - AEK2 BANK CLOCK
 - AEK4 BANK SYNC
 - AEK6 TIMING INTERFACE
 - AEK7 FACILITY INTERFACE
 - AEK10 DIGROUP FORMATTER

Fig. 2—D5 Timing Options

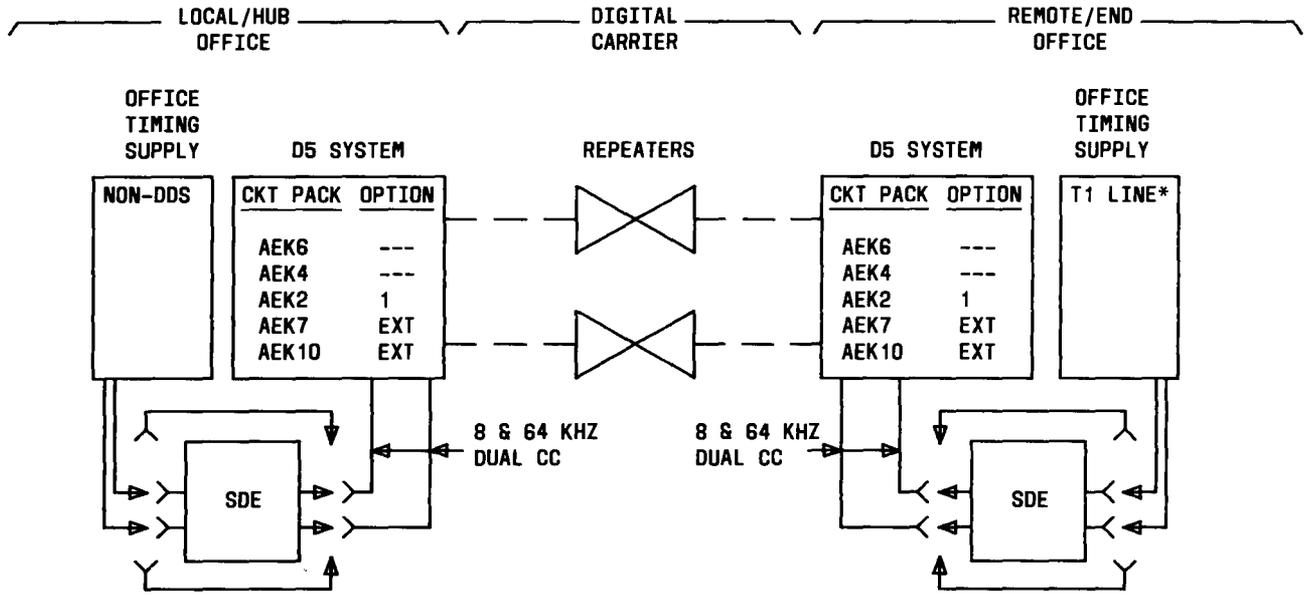


* T1 LINE VIA BRIDGING REPEATERS.
T1 LINE MUST ORIGINATE
TIMING FROM COMMON LOCAL/HUB
OFFICE TIMING SUPPLY

ABBREVIATIONS

BSRF = BELL SYSTEM REFERENCE FREQUENCY
NTS = NODAL TIMING SUPPLY
STS = SECONDARY TIMING SUPPLY
DOTS = DIGITAL OFFICE TIMING SUPPLY
LTS = LOCAL TIMING SUPPLY
CC = COMPOSITE CLOCK
SDE = SYNCHRONIZATION DISTRIBUTION EXPANDER

Fig. 3—Dataport — DDS Timing (Recommended)

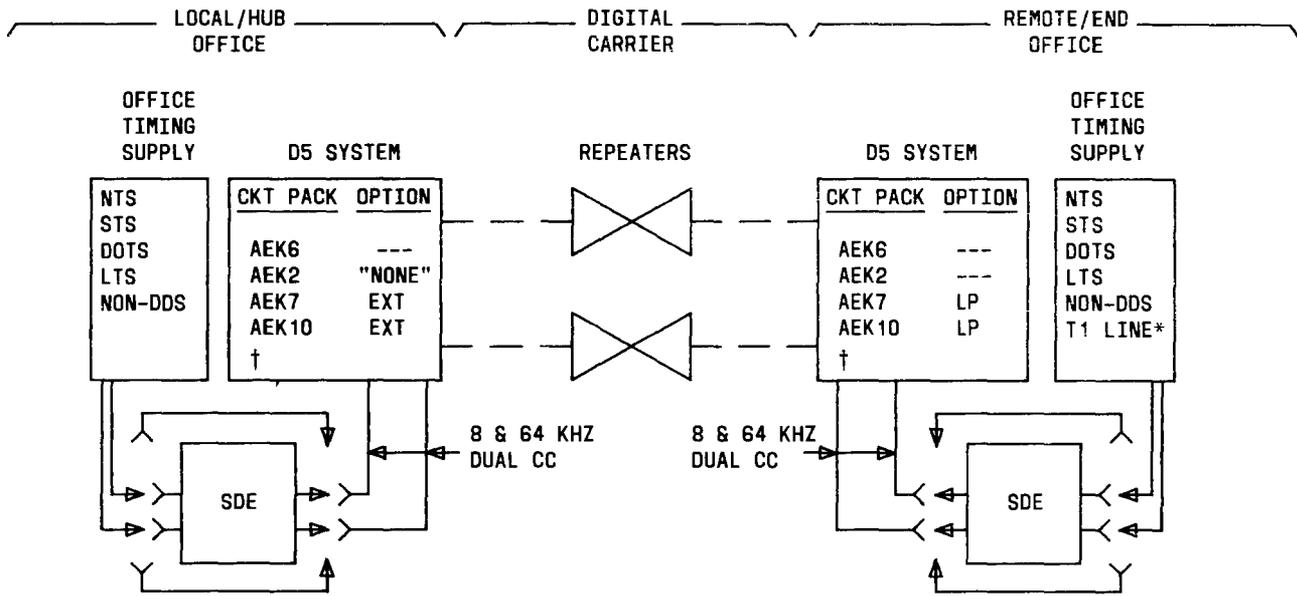


*T1 LINE VIA BRIDGING REPEATERS.
T1 LINE MUST ORIGINATE TIMING
FROM COMMON HUB/LOCAL OFFICE
TIMING SUPPLY

ABBREVIATIONS

SDE = SYNCHRONIZATION DISTRIBUTION EXPANDER
CC = COMPOSITE CLOCK
DDS = DIGITAL DATA SYSTEM

Fig. 4—Dataport — Non-DDS Timing

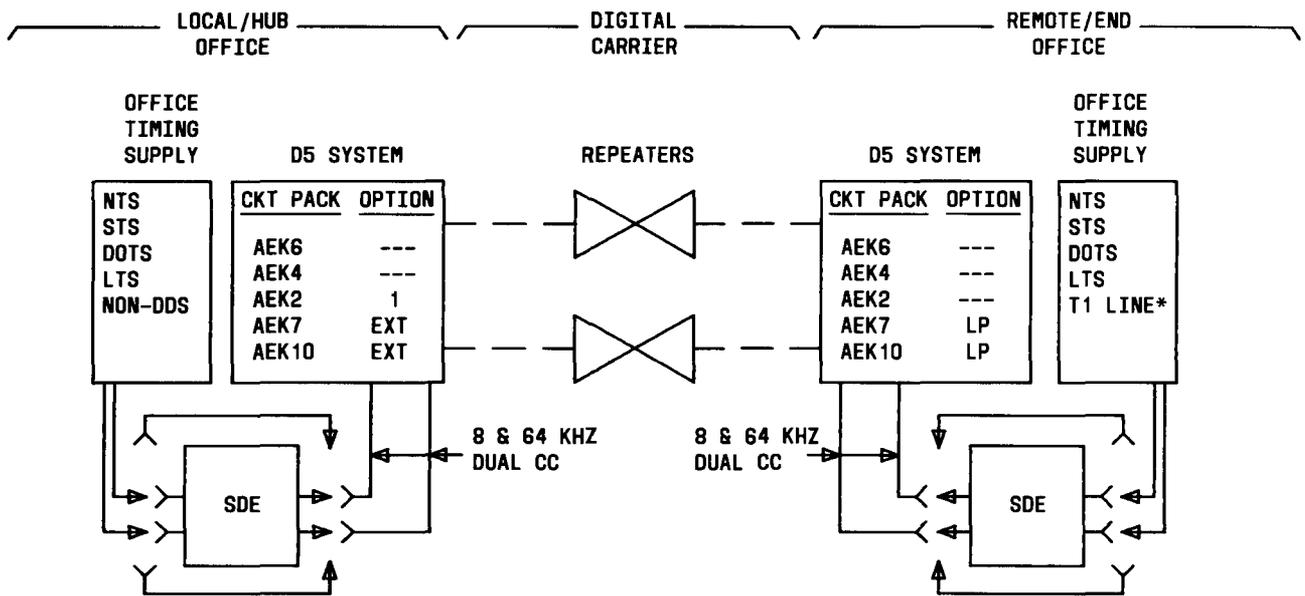


* T1 LINE VIA BRIDGING REPEATERS.
 † AEK4 NOT REQUIRED

ABBREVIATIONS

- NTS = NODAL TIMING SUPPLY
- STS = SECONDARY TIMING SUPPLY
- DOTS = DIGITAL OFFICE TIMING SUPPLY
- LTS = LOCAL TIMING SUPPLY
- SDE = SYNCHRONIZATION DISTRIBUTION EXPANDER
- CC = COMPOSITE CLOCK
- DDS = DIGITAL DATA SYSTEM

Fig. 5—Voice Frequency Free-Running and Digroup Loopback

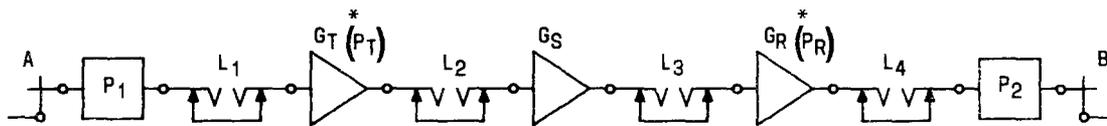


*T1 LINE VIA BRIDGING REPEATERS.

ABBREVIATIONS

- NTS = NODAL TIMING SUPPLY
- STS = SECONDARY TIMING SUPPLY
- DOTS = DIGITAL OFFICE TIMING SUPPLY
- LTS = LOCAL TIMING SUPPLY
- SDE = SYNCHRONIZATION DISTRIBUTION EXPANDER
- CC = COMPOSITE CLOCK
- DDS = DIGITAL DATA SYSTEM

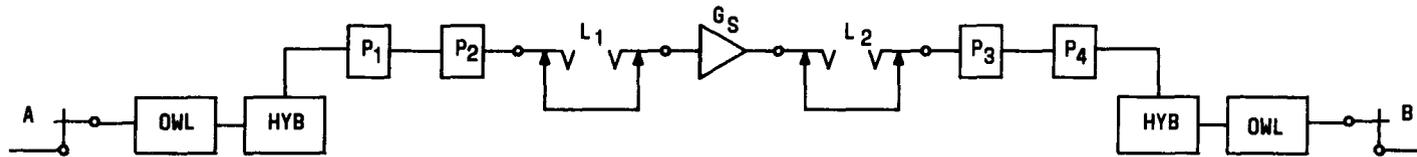
Fig. 6—Voice Frequency External Timing and Digroup Loopback



ITEM \ BANK		D1A, B	D1D	D2	D3	D4 AND D5
TRMT SWITCH LEVEL (dB TLP)	A	0, -2, OR -3	0, -2, OR -3	0, -2, OR -3	0, -2, OR -3	0, -2, OR -3
EXTERNAL EQPT. & WIRING LOSS	P1	13 TO 17 dB	13 TO 17 dB	0 TO 16 dB	13 TO 17.5 dB	13 TO 17.5 dB
EXTERNAL STANDARD LEVEL ACCESS	L1	-16 dB TLP	-16 dB TLP	-16 dB TLP BUILT IN	-16 dB TLP	-16 dB TLP
CHANNEL UNIT TRMT GAIN OR LOSS	G _T (P _T)	6.75 TO 8.35 dB GAIN	6.75 TO 8.35 dB GAIN	0 TO 16.5 dB LOSS	8.5 TO 10 dB GAIN	7.5 TO 9 dB GAIN
INTERNAL STANDARD LEVEL ACCESS	L2	-9.25 dB TLP (2500Ω, UNBAL)	-9.25 dB TLP (2500Ω, UNBAL)	-16 dB TLP (600Ω, BAL)	-7.5 dB TLP (600Ω, UNBAL)	-8.5 dB TLP (600Ω, UNBAL)
SYSTEM GAIN	G _S	12 dB	11.75 dB	23 dB	10 dB	12.5 dB
INTERNAL STANDARD LEVEL ACCESS	L3	+2.75 dB TLP (2500Ω, UNBAL)	+2.5 dB TLP (2500Ω, UNBAL)	+7 dB TLP (600Ω, BAL)	+2.5 dB TLP (600Ω, UNBAL)	+4 dB TLP (600Ω, UNBAL)
CHANNEL UNIT RCV GAIN OR LOSS	G _R (P _R)	4.25 TO 6.05 dB GAIN	4.25 TO 6.05 dB GAIN	0 TO 16.5 dB LOSS	4.5 TO 6.0 dB GAIN	3 TO 4.5 dB GAIN
EXTERNAL STANDARD LEVEL ACCESS	L4	+7 dB TLP	+7 dB TLP	+7 dB TLP BUILT IN	+7 dB TLP	+7 dB TLP
EXTERNAL EQPT. & WIRING LOSS	P2	7 TO 15 dB	7 TO 15 dB	0 TO 15 dB	7 TO 15 dB	7 TO 15 dB
RCV SWITCH LEVEL (dB TLP)	B	0 TO -8	0 TO -8	0 TO -8	0 TO -8	0 TO -8

*D2 HAS PADS RATHER THAN GAIN

◆Fig. 7—D-Type Channel Bank 4-Wire Trunk Level Diagram◆

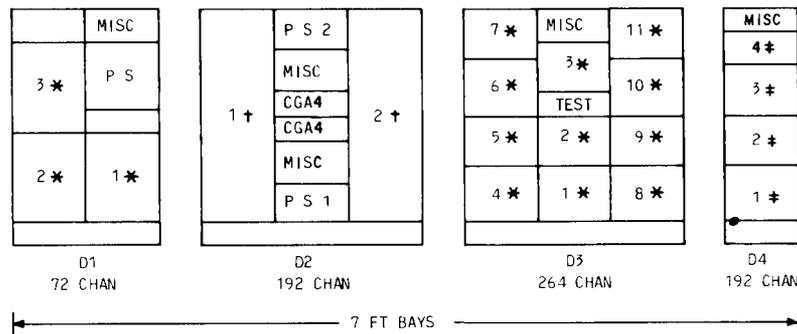
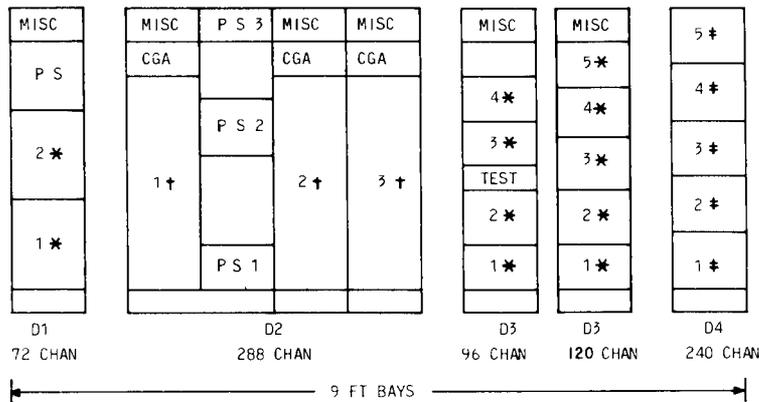
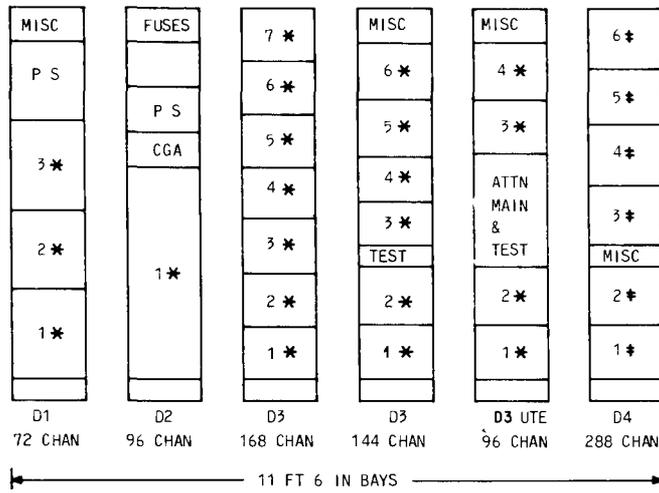


ITEM	BANK	D1A, B	D1D	D2	D3	D4 AND D5
TRANSMIT SWITCH LEVEL (dB TLP)	A	0	0	0, -2, OR -3	0 OR -2	0, -2, OR -3
EXTERNAL EQUIPMENT AND WIRING LOSS	OWL	0 TO 1 dB	0 TO 1 dB	0 TO 1.5 dB	0 TO 1.5 dB	0 TO 1.5 dB
HYBRID LOSS	HYB	4 dB	4 dB	4.9 dB	4 dB	4 dB
OFFICE LOSS BUILD OUT	P ₁	0 OR 0.5 dB	0 OR 0.5 dB	COMBINED WITH P ₂	0 TO 1.5 dB IN 0.1 dB STEPS	COMBINED WITH P ₂
TRANSMIT LEVEL ADJUST	P ₂	4.5 dB	4.5 dB	0 TO 16.5 dB IN 0.1 dB STEPS	1, 2, OR 3 dB*	0 TO 6.3 dB IN 0.1 dB STEPS
MAINTENANCE ACCESS LEVEL	L ₁	-9.25 ± 0.25 dB	-9.25 ± 0.25 dB	-16 ± 0.05 dB	-7.5 ± 0.05 dB	-8.5 ± 0.05 dB
SYSTEM GAIN	G _S	12 dB	11.75 dB	23 dB	10 ± 0.25 dB	12.5 ± 0.25 dB
MAINTENANCE ACCESS LEVEL	L ₂	+2.75 ± 0.25 dB	+2.5 ± 0.25 dB	+7 ± 0.05 dB	+2.5 ± 0.30 dB	+4 ± 0.30 dB
CIRCUIT LOSS ADJUST	P ₃	0 OR 0.75 dB (0.75 OR 3.75 dB)	0 OR 0.75 dB (0.75 OR 3.75 dB)	0 TO 16.5 dB IN 0.1 dB STEPS	1, 2, OR 3 dB*	0 TO 6.3 dB IN 0.1 dB STEPS
OFFICE LOSS BUILD OUT	P ₄	0 OR 0.5 dB	0 OR 0.5 dB	COMBINED WITH P ₃	0 OR 1.5 dB IN 0.1 dB STEPS	COMBINED WITH P ₃
HYBRID LOSS	HYB	4 dB	4 dB	4.9 dB	4 dB	4 dB
EXTERNAL EQUIPMENT AND WIRING LOSS	OWL	0 TO 1 dB	0 TO 1 dB	0 TO 1.5 dB	0 TO 1.5 dB	0 TO 1.5 dB
RECEIVE SWITCH LEVEL (dB TLP)	B	-2 OR -2.75 ± 0.5 dB (-2.75 OR -5.75 ± 0.5 dB)	-2.25 OR -3 ± 0.5 dB (-3 OR -6 ± 0.5 dB)	2.1 - 14.4 ± 0.1 dB IN 0.1 dB STEPS	-3, -4, OR -6 ± 0.35 dB	1.5 TO -6.3 ± 0.35 dB IN 0.1 dB STEPS

* SOME VERSIONS OF D3 HAVE 0 TO 6.3 dB IN 0.1 dB STEPS.

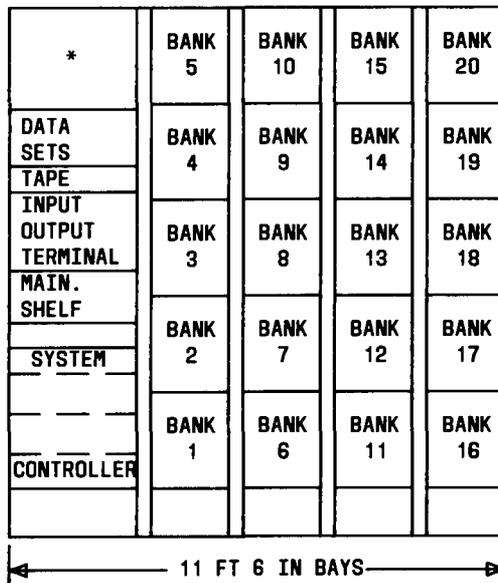
NOTE: VALUES IN () ARE FOR CHANNEL UNITS MODIFIED FOR NO. 4 ESS

◆Fig. 8—D-Type Channel Bank 2-Wire Trunk Level Diagram◆



- * COMMON EQUIPMENT AND CHANNEL UNITS FOR A 24-CHANNEL BANK
- † COMMON EQUIPMENT AND CHANNEL UNITS FOR A 96-CHANNEL BANK
- ‡ COMMON EQUIPMENT AND CHANNEL UNITS FOR A 48-CHANNEL BANK

Fig. 9—D1, D2, D3, and D4 Channel Bank Bay Arrangement



* SYSTEM CONTROLLER BAY IS ON LEFT SIDE OF 20-BANK BAY SYSTEM FOR ALL BAY SIZES: 11 FT, 9 FT, AND 7 FT. IT IS CONFIGURED THE SAME WAY FOR ALL BAY SIZES.

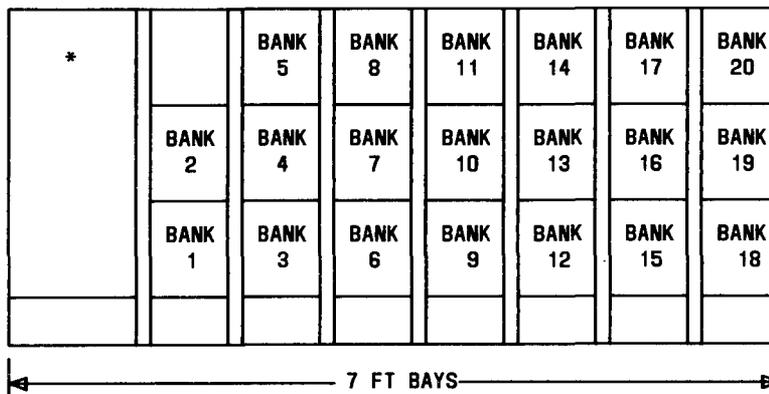
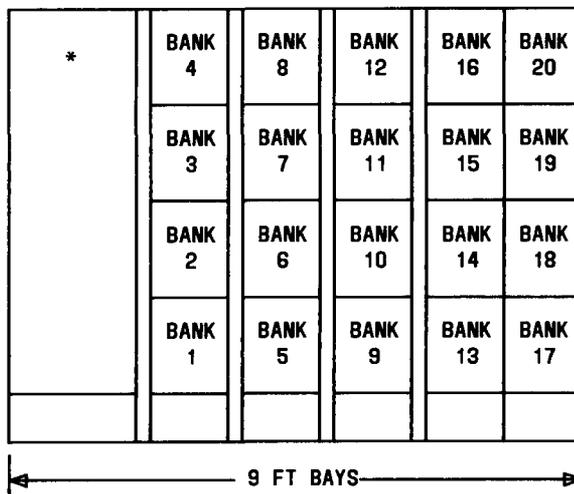


Fig. 10—D5 Channel Bank Bay Arrangement

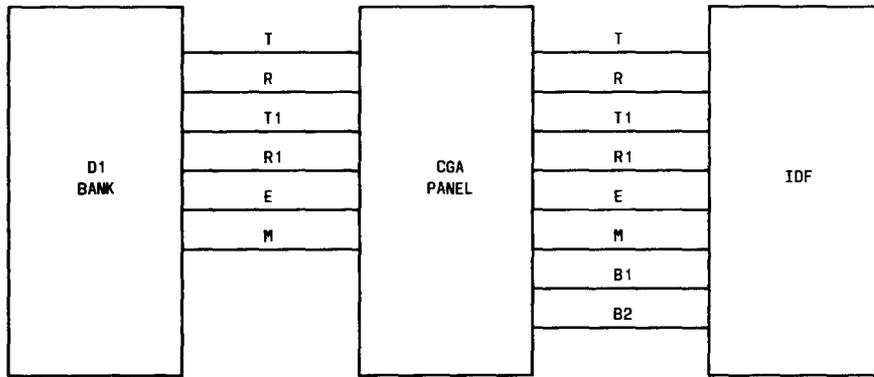
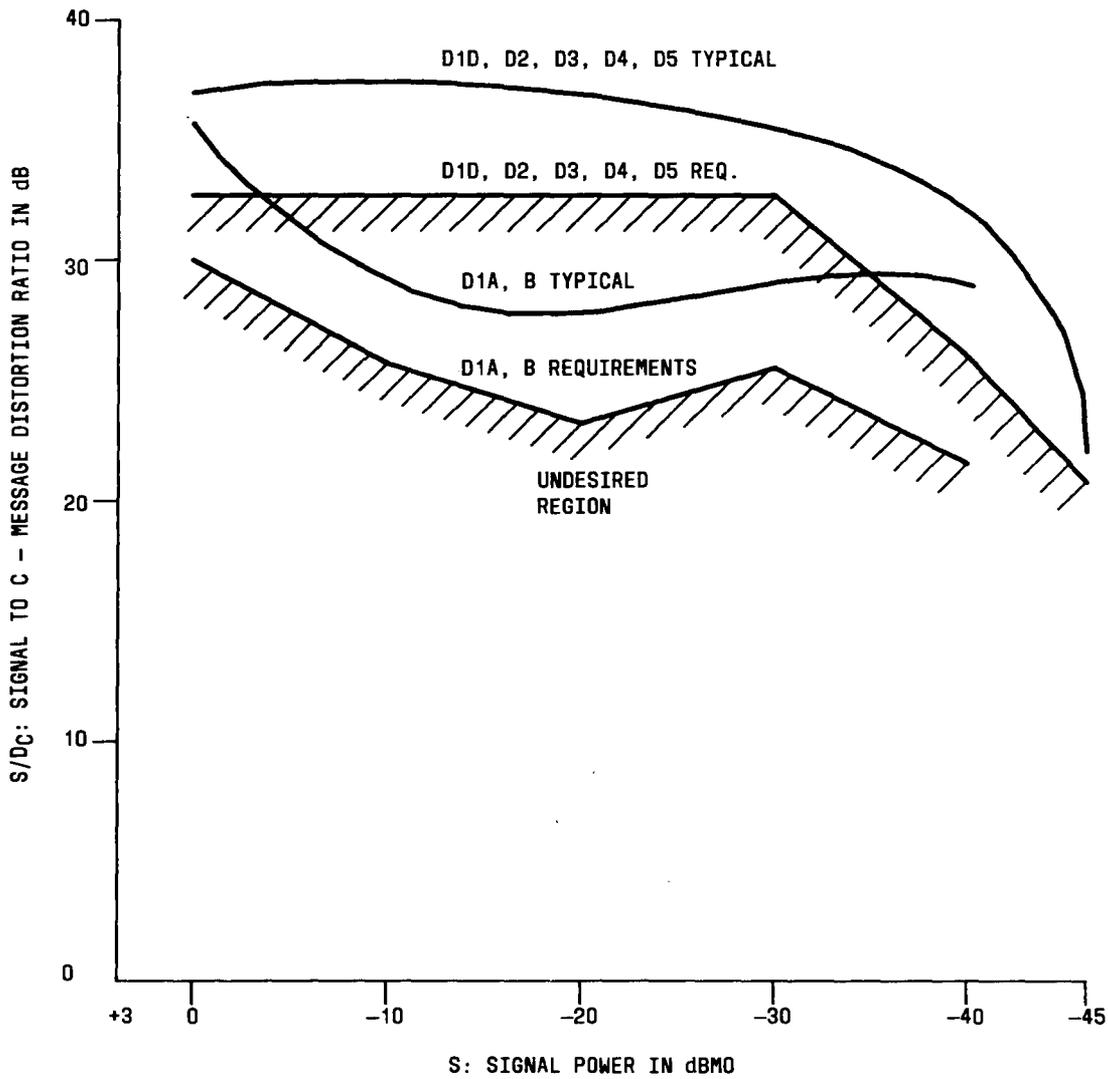
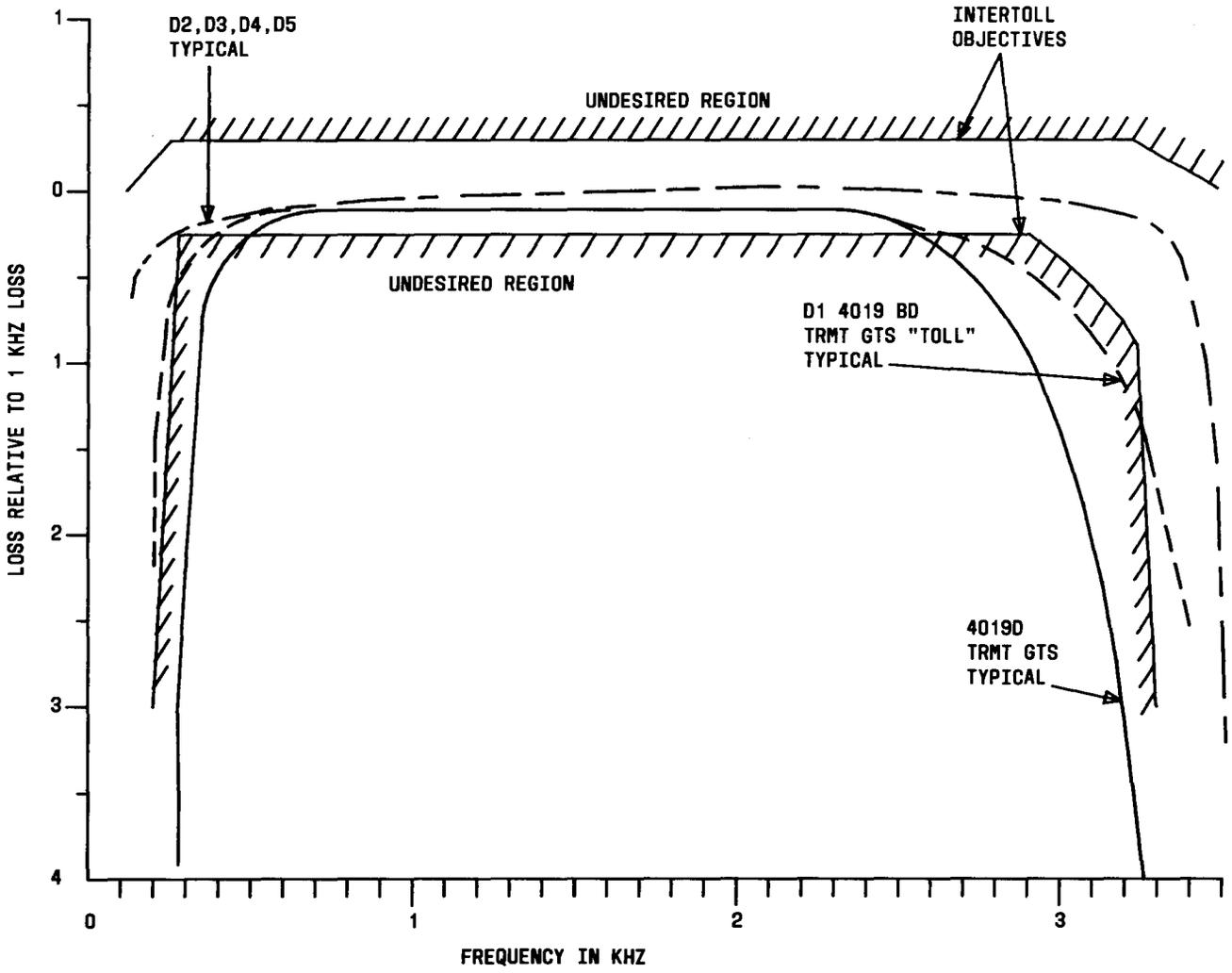


Fig. 11—D1 Channel Bank Channel Cabling



◆Fig. 12—Signal-to-Distortion Characteristics◆



◆Fig. 13—Frequency Response◆

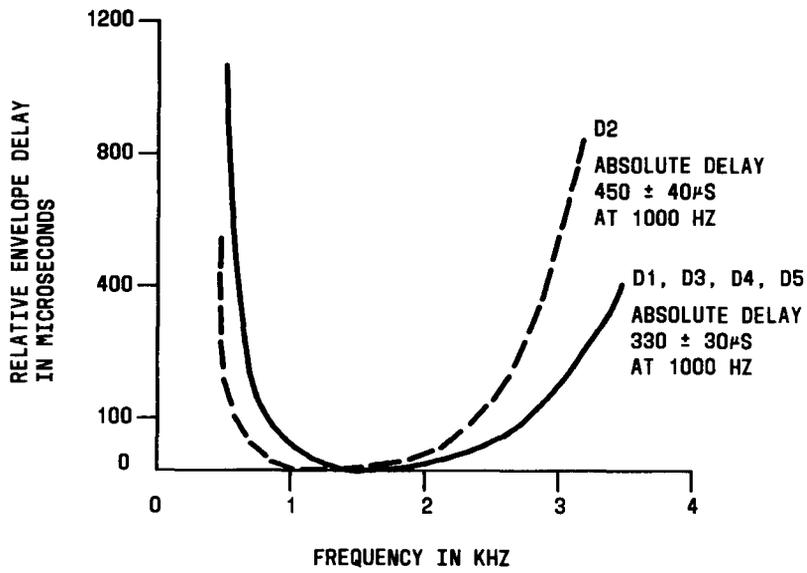


Fig. 14—Envelope Delay

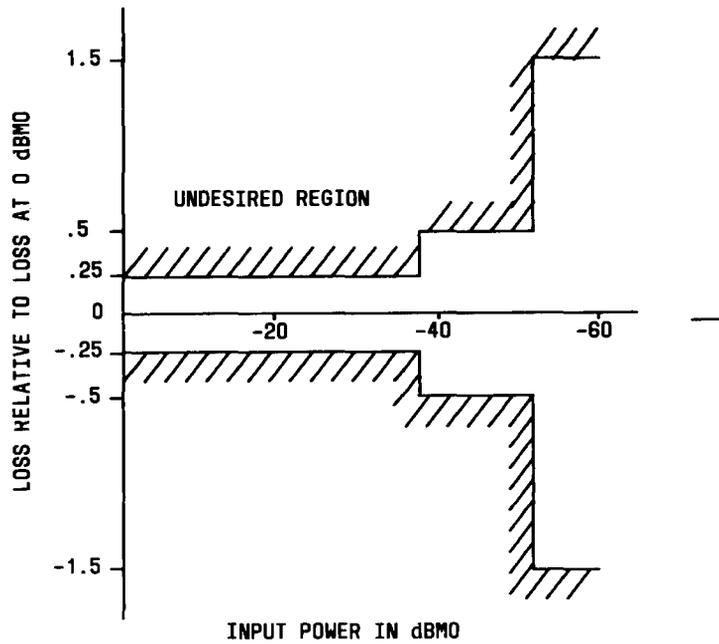
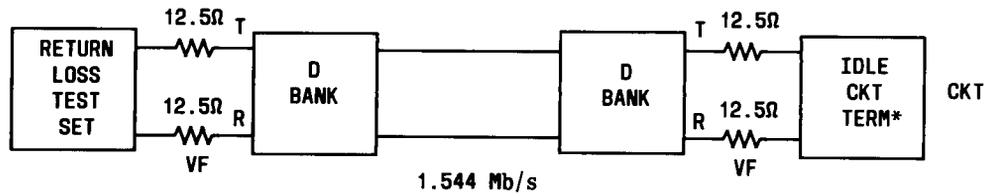


Fig. 15—Tracking



* 900Ω, 2μf OR OTHER TERMINATIONS APPROPRIATE TO CHANNEL UNDER TEST

Fig. 16—Return Loss Test

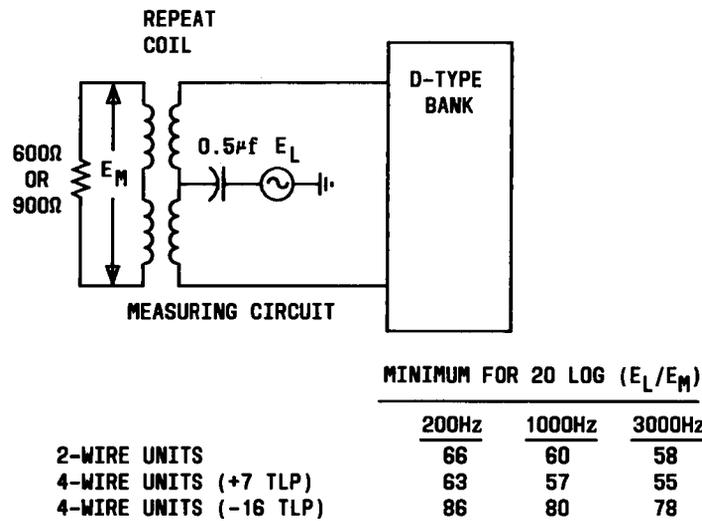
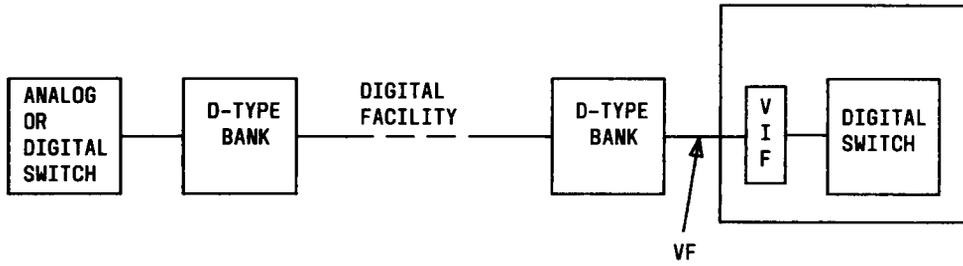


Fig. 17—Longitudinal Balance Objectives



D-TYPE BANKS IN ANALOG TRUNKS TO NO. 4 ESS SWITCH



D-TYPE BANK IN COMBINATION TRUNK TO DIGROUP TERMINAL



NO D-TYPE BANK IN DIGITAL TRUNK TO DIGROUP TERMINAL

◆Fig. 18—No. 4 ESS Switch◆

tpa613474

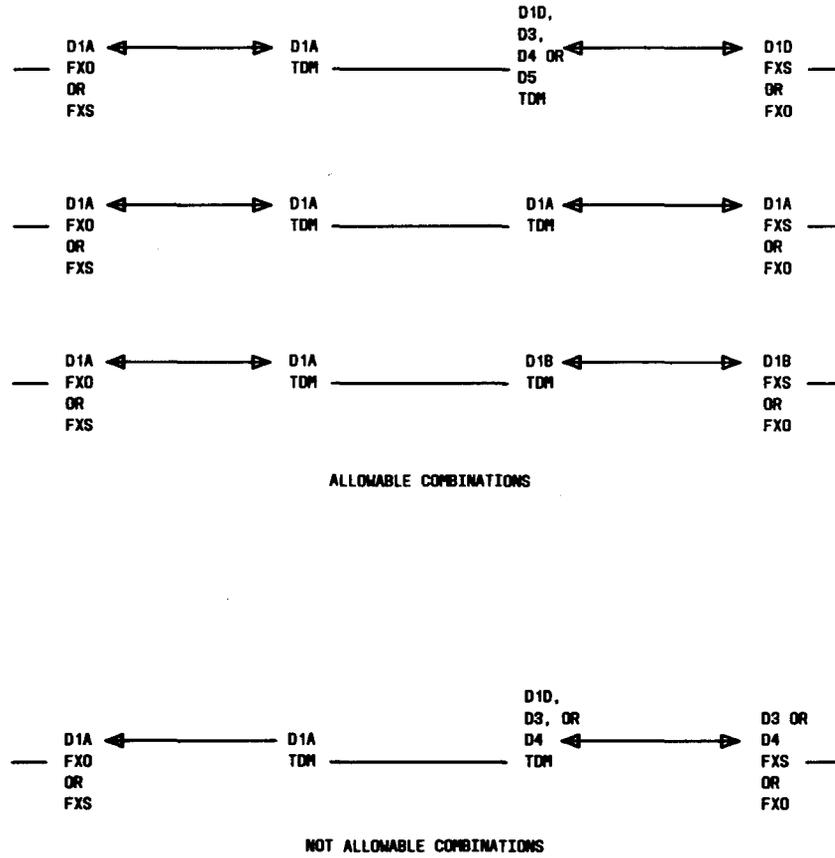


Fig. 19—Allowable D1A-TDM Combinations