Meridian 1

Digital Trunk Interface/
Computer-to-PBX Interface
Description

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Introduction

Document overview

This document describes the Digital Trunk Interface (DTI) feature:

— functions

— operations

— associated hardware

Digital Trunk Interface (DTI) is an optional feature and is available on Network enhanced systems equipped with X11 release 5 and later software.

Other documentation

Other Northern Telecom Publications (NTPs) related to DTI are:

— *Digital Trunk Interface/Computer-to-PBX Interface installation and data administration* (553-2811-200)

— *Digital Trunk Interface/Computer-to-PBX Interface maintenance* (553-2811-500)

— *Traffic measurement formats and output* (553-2001-450)

— *Summary of transmission parameters* (553-2201-182)

— *X11 input/output guide* (553-3001-400)

Note: For general reference information on carrier systems and synchronization, see:

• Digital Network Notes, published by Telecom Canada, Ottawa, 1983

• AT&T Technical References 43861 and 41451

• EIA publication PN-1429

Note: Throughout this document, "Meridian 1" refers to Meridian SL-1 machines and Meridian 1 system options, unless otherwise noted.

Digital Trunk Interface feature

The Digital Trunk Interface (DTI) provides the means for transmitting digital voice and data between a Network loop and a DS-1 digital carrier. DTI operates similarly to a channel bank for the carrier side and analog trunks for the Meridian 1 side. It integrates Meridian 1 digital switching capabilities and the most commonly available digital transmission facilities. It digitally processes both the transmission and the reception of Meridian 1 data (mixed voice/data) and voice calls.

DTI interfaces to DS-1/D3 digital carriers, which can use infrared, fiber optics, microwave radio, satellite link, or leased T1 facilities and can connect to:

— another Meridian 1 (see Figure 1) or SL-100

— a non–Meridian 1 system that can use T1 carrier facilities

— a digital Central Office (CO)

Figure 1
Typical Meridian 1 to Meridian 1 communication by means of DTI
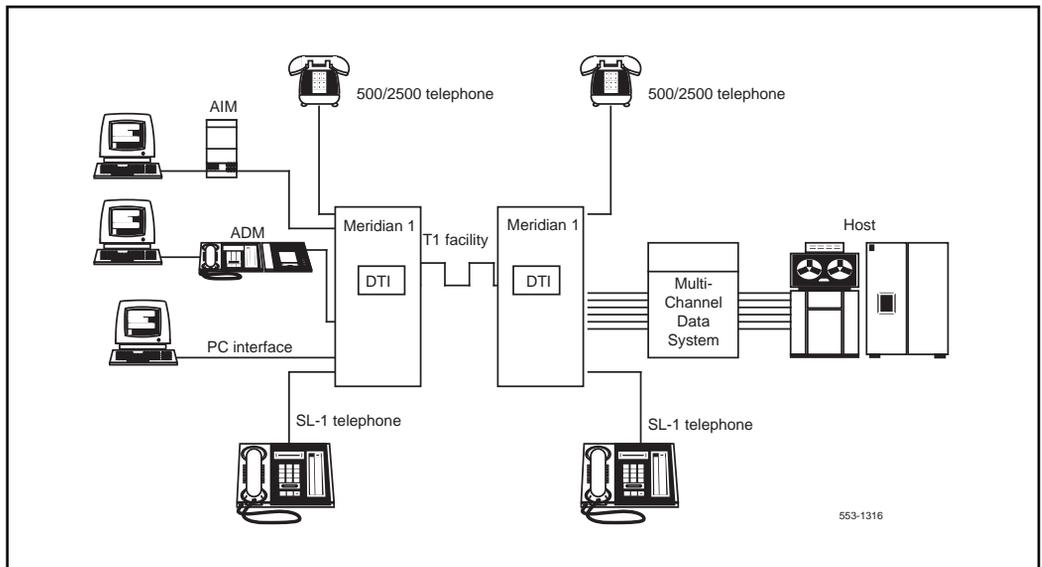
Computer-to-PBX Interface application

The Computer-to-PBX Interface (CPI) is a special application of the DTI feature that uses DTI to connect to a computer vendor-supplied interface residing on the vendor's host computer (see Figure 2).

The CPI application can be used without Clock Control on systems that support X11 software if the Meridian 1–to-Host connection is direct and not over an external network. External networks are applicable only to Meridian 1 systems and require network Clock Controllers.

Figure 2
Typical Meridian 1 to host computer communication by means of CPI
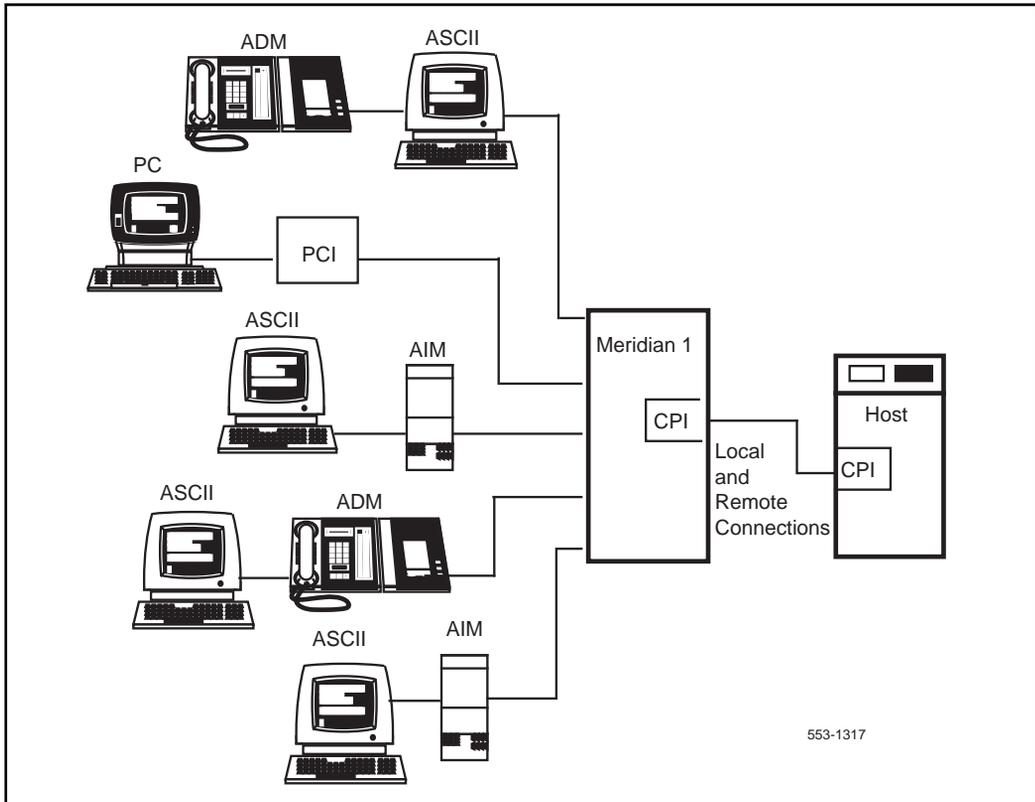
Benefits

DTI enhances Meridian 1 capabilities by:

— extending its capabilities to create all-digital networks

— utilizing North American standard T1 facilities

— providing full compatibility with T1 digital protocol

— providing a single DTI to support the equivalent of 24 trunks

— eliminating the need for channel banks

— eliminating the need for modems on data transmission

— providing a single network that handles both voice and data

— configuring voice and data capacity on an "as needed" basis

— substantially reducing the amount of equipment required to interface 24 data channels to a host computer equipped with Computer-to-PBX Interface (CPI)

North American T1 carrier DS-1 frame organization

The North American T1 carrier operates at 1.544 Mbps using 193-bit frames in DS-1 format. Each frame contains an 8-bit data sample from each of 24 channels, plus 1 framing bit (F-bit), multiplexed into the 125 μs time period provided by the 8 kHz sampling rate. This establishes the basic rate of 1.544 Mbps. Signaling is done on a per channel basis by periodically robbing Bit 8 from certain data samples (see Figure 3).

The framing bit (F-bit) is time-shared to identify both the channel and the signaling frame within a Superframe made up of 12 frames (see Figure 4). Terminal framing (FT) identifies the location of time slot 1, and signaling framing (FS) identifies those frames in which two signaling bits, A and B, are transmitted on a time-shared basis. The least significant bit (Bit 8) in the 6th and 12th frames are the signaling bits in each of the 24 channels.

Figure 3
DS-1 frame format

Figure 3 — DS-1 frame format

Figure 4
Framing format
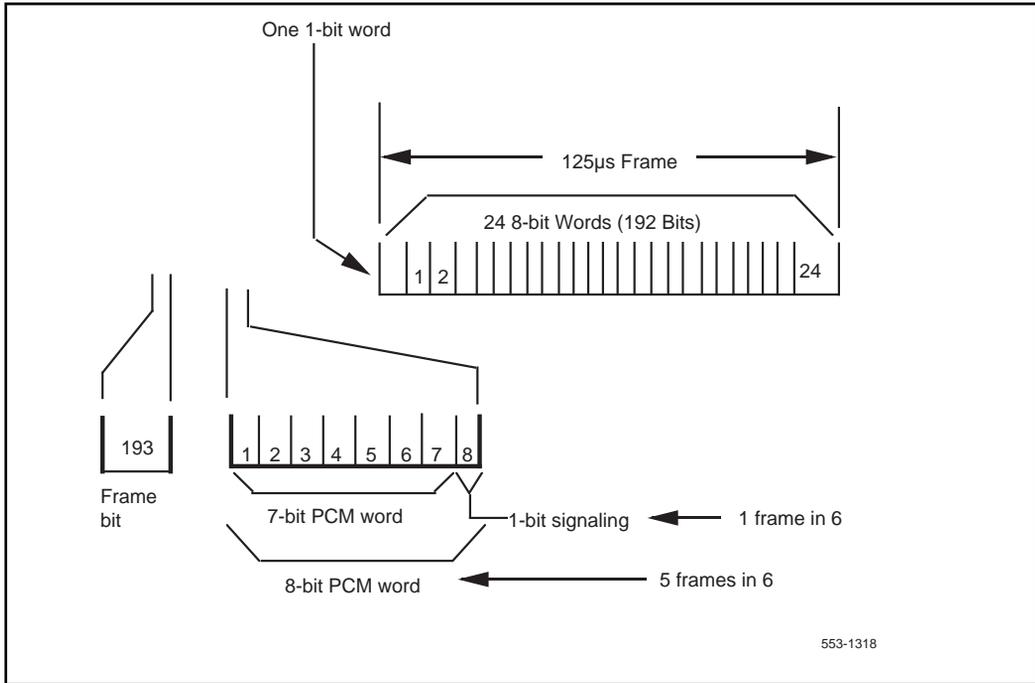
Figure 4 — Framing format
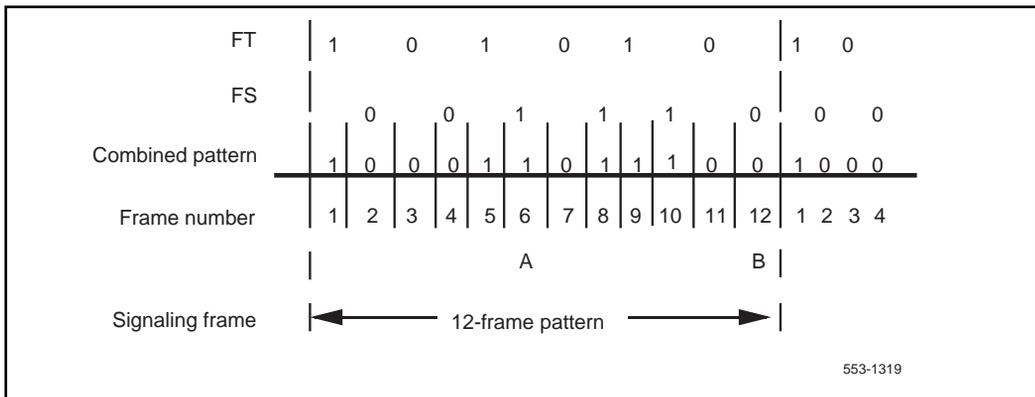
B8ZS line coding method

With the increasing demand for higher bandwidths in data transmission, the use of the eighth bit of every channel in every frame of the DS-1 signal has proved to be expensive. The Binary 8 Zero Substitution (B8ZS) line coding method replaces a string of eight zeros with a standard pattern. This pattern has two intentionally added bipolar violations in the signal. At the receiving end, the detected pattern is replaced by the string of eight zeros.

This technique, coupled with the Extended Superframe (ESF) format, increases the data rate from a maximum of 56 kilobits per second to the full 64 kbps if in-band signaling is replaced with out-band signalling. A typical use is with ISDN Signaling Link, described in *ISDN Primary Rate Interface description and administration* (553-2901-100).

Extended Superframe format

The Extended Superframe (ESF) format consists of 24 frames. The 8 kbps framing bit (F-bit) channel is divided into three separate channels:

Channel 1 Framing Pattern Sequence (FPS)—beginning with frame 4 or ESF bit 579, the framing bit of every fourth frame forms FPS 001011, which is used to determine the mainframe, Superframe, and robbed bit signaling synchronization. This sequence is a 2 kbps channel.

Channel 2 Facility Data Link (FDL)—This is a 4 kbps channel. The QPC720 uses FDL to convey remote alarm information or to transmit all ones, as selected in service change.

Channel 3 Cyclic Redundancy Check (CRC)—The CRC sequence is a 2 kbps channel that carries the CRC-6 code. CRC indicates one or more bit errors in a block, or bits from the received bit stream. CRC can be used as an end-to-end bit error rate indicator.

The assignments of the F-bit and the A, B, C, and D bits are shown in Table 1.

Table 1
Extended Superframe format (Part 1 of 2)

Frame number	Bit number	F-bit			Robbed bit signaling
		Assignments			
		FPS	FDL	CRC	
1	0	—	m	—	
2	193	—	—	CB1	
3	386	—	m	—	
4	579	0	—	—	
5	772	—	m	—	
6	965	—	—	CB2	A
7	1158	—	m	—	
8	1351	0	—	—	
9	1544	—	m	—	
10	1737	—	—	CB3	
11	1930	—	m	—	
12	2123	1	—	—	B
13	2316	—	m	—	
14	2509	—	—	CB4	
15	2702	—	m	—	
16	2895	0	—	—	
17	3088	—	m	—	
18	3281	—	—	CB5	C
19	3474	—	m	—	

Table 1
Extended Superframe format (Part 2 of 2)

Frame number	Bit number	FPS	FDL	CRC	Robbed bit signaling
		F-bit			**Robbed bit signaling**
		Assignments			
		FPS	**FDL**	**CRC**	
20	3667	1	—	—	
21	3860	—	m	—	
22	4053	—	—	CB6	
23	4246	—	m	—	
24	4439	1	—	—	D

Functions

Digital Trunk Interface

The QPC472/QPC720 Digital Trunk Interface (DTI) card is the interface between any selected channel of the 32-channel, 2.048 Mbps bit stream on the associated Meridian 1 Network loop and a DS-1, 24-channel, 1.544 Mbps, bipolar carrier terminal.

DTI software

The DTI software module performs the following procedures in supporting the DTI feature:

— processes messages from the DTI hardware

— handles transmission loss pad settings

— handles Echo Canceller control

— processes online performance monitoring functions of the DTI

— inserts and translates call types (voice or data)

— converts a DTI Terminal Number (TN) to an equivalent loop and channel or a loop and channel to an equivalent TN

— periodically checks the Clock Controller (CC)

— switches the reference clock from primary to secondary source if unable to track on primary

— switches the reference clock from secondary to free run if unable to track on secondary

— updates the tracking of the Clock Controller after a change of primary or secondary reference source, or after sysload

Meridian 1/DS-1 conversion

Flexible mapping of 30 network time slots into 24 DS-1 channels (conversion from bit-interleaved to byte-interleaved format) and vice versa is performed by the DTI.

Idle, unequipped, or disabled DS-1 channel states

For each DS-1 channel that is idle or not configured, DTI hardware transmits "idle" (7F hexadecimal) or "unassigned" (FF hexadecimal) Pulse Code Modulation (PCM) codes respectively during the voice/data time slots. The DTI hardware and software data blocks are initialized to the appropriate idle or disabled state after system configuration, or following service change, and after every initialization. Other DS-1 systems receiving these signals interpret them as idle and unassigned, respectively.

Processing of A & B signaling bits

The DTI software sets the transmitted A & B bits to represent the appropriate signals for the trunk being supported. It also interprets the received A & B bit states as appropriate signaling states for that trunk.

Control of pad switching

The DTI inserts digital pads for both transmit and receive directions on a per channel basis, to achieve the desirable port-to-port transmission loss values. DTI channels are classmarked for different trunk types for pad-setting and signaling purposes.

Meridian 1 data protocol converter

The Meridian 1 data protocol, which uses 8 bits for data, is not compatible with DS-1 protocol. Transmission on DS-1 facilities requires a "ones" density not compatible with data. Also, if A & B bits are processed on the link, the least significant bit of the 8-bit Pulse Code Modulation (PCM) word in the signaling frames is used for A & B signaling. For this reason, protocol conversion is provided to originating and terminating data messages on a per call basis at the originating and terminating DTIs. After trunk, line, and address signaling is complete and a path has been established between the two data terminals, the protocol converter is switched in until the call is disconnected.

Echo Canceller control

Echo Cancellers are required for satellite applications only. The DTI software controls external Echo Cancellers on a per channel basis by means of an RS232-C link. The Echo Canceller usually remains enabled. For data calls however, the DTI hardware disables the Echo Canceller. When the Meridian 1 is connected to another switching node equipped with Echo Cancellers that do not provide per call control, specific time slots can be permanently marked as data only.

Maintenance functions

The DTI performs maintenance functions related to the DS-1/D3 format link, including monitoring and reporting. It also does a self-check.

Data transmission and reception

DTI transmits and receives bipolar return-to-zero data at DS-1/D3 signal levels. Zero code suppression is normally in effect but may be inhibited as required by DTI software.

Controlled slips

DTI deletes or repeats frames of information from time to time in the receive Pulse Code Modulation (PCM) direction to allow for signals that may be running at a slightly different bit rate to the DTI (that is, controlled by the transmitting system clock).

Clock Controller synchronization

Digital communication requires accurate timing alignment of digital signals so that data is interleaved into or extracted from the appropriate timeslots during multiplexing and demultiplexing operations. Frame synchronization can be attained by having all switches and transmission facilities in a network controlled by clocks of the same frequency. This is achieved by having all nodes (switches) in a network locked to a primary frequency source (a master clock).

Synchronization criteria

North American digital network nodes are synchronized using a priority master-slave method. Digital nodes are ranked in categories (AT&T Strata 1 to 4 or Bell Canada Node Category A to E). Each node is synchronized to the highest ranking node in its vicinity with which it has a direct digital link.

The Clock Controller (CC) meets AT&T Stratum 3 and Bell Canada Node Category D synchronization criteria. The clock has a drift rate of less than one part in 10^9 per day when the clock is in free running mode.

Clock Control

The clock synchronization subsystem for DTI is provided by a single card on single CPU systems or a duplicated pair of Clock Controller (CC) cards on dual CPU systems. On dual CPU systems, only one CC is active at any given time. The disabled clock serves as a standby to the first.

When the clock subsystem is synchronized to an external clock source through a specific DTI defined as a reference clock source, it is said to run in Tracking Mode. When no reference source is defined, or when the clock subsystem is not locked onto the external clock source, it is in Non-Tracking Mode and running free. In this case, there is no synchronization between the Meridian 1 and the external network. Where more than one DTI loop exists, primary and secondary reference clock sources can be defined for Tracking Mode operation.

The active CC in the subsystem performs the following functions:

— synchronizes to a primary or secondary reference clock (in Tracking Mode)

— supplies Meridian 1 with a clock

Tracking supervision

Meridian 1 software periodically (every 15 minutes) monitors the Clock Controller (CC) status. If the CC is unable to track the reference source, Meridian 1 sends a message to the system terminal. If automatic switching is defined in the CC data block, the Meridian 1 switches as follows:

Unable to track on	Switch CC to
Primary	Secondary
Secondary	Free-run

Meridian 1 performs the same operation if a DTI that is a primary or secondary reference clock source is placed out of service.

Bit error rates

Bit error rate monitoring detects errors in transmission. There are two methods of bit error rate monitoring, bipolar violation (BPV) tracking and cyclic redundancy check (CRC). The method used depends on the framing format (D2, D3, D4, or Extended Superframe [ESF]). Framing format is defined in LD17 prompt DLOP.

Bipolar violation (BPV) In a bipolar pulse stream, pulses alternate in polarity. If, after transmission, two pulses of the same polarity are received in succession (this could be caused by an electrical disturbance, such as noise), a bipolar violation has occurred.

Cyclic redundancy check (CRC) The primary difference between Bipolar Violations (BPV) and CRC is that BPVs indicate errors on the local span, while CRC indicates errors on an end-to-end span. For example, on a satellite link, BPV only detects errors in the span between the Meridian 1 and the satellite connection. Since CRC travels between the entire span, it indicates end-to-end bit error rate. In DTI with ESF, bit error rate checking is done as CRC; however, the BPV counter is incremented.

Frame slip

Digital signals must have accurate clock synchronization for data to be entered into or taken from the appropriate timeslot during multiplexing and demultiplexing operations. Frame slip monitoring detects frame deletion and repetition errors in clock synchronization.

Frame alignment

Loss of frame alignment monitoring detects out-of-frame conditions on the DS-1 bit stream.

Loss of frame alignment thresholds DTI hardware detects out-of-frame conditions. The midnight routines print the number of loss of frame alignment occurrences and clear the counters.

There are three frame alignment thresholds set in LD73. When a maintenance or out of service threshold is reached, a data terminal allowed (DTA) message is output:

— DTA019: Frame alignment maintenance limit.

— DTA020: Frame alignment out of service limit.

If a loss of frame alignment condition persists for three seconds, the affected DTI loop is taken out of service and a red alarm is raised. If the loss of frame alignment condition clears for at least 15 seconds, the DTI is automatically restored to service. The following data terminal allowed (DTA) message is generated:

— DTA021: Loss of frame alignment has persisted for 3 seconds.

Clock distribution

Multi-group mode (XN and XT) Each Clock Controller (CC) continuously drives the following signals to the IGS cards:

— M8 (8 MHz system clock)

— MFS (4 kHz sync pulse)

— CLKEN (clock enable active/disabled)

Single- or half-group mode (N, NT, and RT) Each CC continuously drives the following signals to PS cards:

— M8XB (8 MHz system clock)

— MFSB (4 kHz sync pulse)

Half-group mode (MS, ST) The optional single CC operates in the half-group mode and supplies the clock. Should the clock fail, there is no switchover, and the PS card provides the clock.

Clock switchover

Each of the two CC cards monitors the other for clock failure and responds to switchover requests from its twin or from the CPU.

Phase locked loop

CC synchronization is achieved by phase locking to a 4 kHz clock derived from the 1.544 MHz reference source selected by the CPU. If the reference clock is lost, the CCs run free.

Automatic clock recovery

An option for automatic clock recovery can be selected in LD60 with the command EREF.

A DTI loop is disabled when it enters a red alarm (local) condition. If the red alarm is cleared, the loop is enabled automatically. When the loop is enabled, clock tracking is restored with the following conditions:

— If the loop is assigned as the primary reference clock but the CC is tracking on the secondary reference or in free run mode, it is restored to tracking on primary.

— If the loop is assigned as the secondary reference clock but the CC is in free run mode, it is restored to tracking on secondary.

If the 15-minute clock check indicates the system is in free run mode:

— Tracking is restored to the primary reference clock if defined.

— If the primary reference is disabled or in red alarm, (local) tracking is restored to the secondary reference clock if defined.

If the EREF option is selected in LD60, tracking on the primary or secondary reference clock is automatically switched in the following manner:

— If software is unable to track on the assigned primary reference clock, it switches to the secondary reference clock and sends appropriate DTC maintenance messages.

— If software is unable to track on the assigned secondary reference clock, it switches to free run.

Feature operation

DTI emulates both analog trunks and digital channel banks, while acting as an interface between Meridian 1 and digital transmission lines. DTI outputs digital signals at DS-1 level in either D2 or D3 format and with X11 release 11 or later software in D4 or ESF formats. The appropriate trunk signaling, basic trunk states, timing, and trunk processing are the same as the analog processes.

Interface functions are handled by DTI software:

— input/output messages

— pad setting

— Echo Canceller control

— data call recognition

— data call signaling to the next switch

These functions are under control of the trunk and DTI software modules. DTI supports both dual tone multifrequency (DTMF) and dial pulse address signaling (the traffic provisioning ratio for DTMF is the same as provided for analog trunks).

Voice call processing

A general description of voice call processing is given in the following paragraphs.

Idle condition A digital trunk (DTI channel) must be idle to be available for outgoing calls. Idle state indications are different for different trunk types. These are handled automatically by DTI. When a trunk (channel) is idle, the DTI, under control of the CPU, sends idle PCM code (7F hexadecimal) on the voice/data timeslot of the idle channel.

Outgoing calls

Trunk seizure When a caller dials a digital trunk route, the digit processor selects an idle trunk (a DTI channel) associated with the dialed route and sends seizure and pad control messages to the DTI hardware.

Note: The route consists of digital trunks only. Analog and digital trunks are not mixed in a route, but a DTI loop can have 24 routes.

The DTI hardware sets the proper digital pads, using A & B bit signaling, and sends an "off hook" message that is detected at the far end as a change of state. When it is ready to receive, the far end trunk (depending on its supervisory mode) informs the DTI by sending the appropriate A & B bit signal. After receiving this message, the DTI sends a seizure message to the far end. This is equivalent to an analog trunk closing the loop and must be done within 210 ms to avoid false signaling. The Echo Canceller, if equipped, remains enabled.

Outpulsing After receiving the seizure signal, or after an appropriate timing interval, the far end sends dial tone to the Meridian 1 and waits to receive dual tone multifrequency (DTMF) or dial pulse (DP) address signaling, depending on the type of trunk (in the case of DTMF, digitized DTMF frequencies are transmitted on the active channels). The calling party dials the destination number. The Tone and Digit Switch (TDS) generates the pulses and timing on an enabled network voice timeslot. The DTI extracts this information and transmits DS-1 A & B bits to the far end in the appropriate signaling frame.

Answer When the far end receives the address signals, the call is routed to the dialed destination. If the called party answers, the far end returns an A & B bit answer signal to the DTI. DTI, in turn, notifies the CPU and a speech path is cut through.

Release Guard and disconnect supervision timing and idling of the trunk are the same in operation as those of the analog trunk. After receiving a release message from the CPU, the DTI sends a release message (idle state) to the far end by means of A & B signaling bits. When the CPU sends the idle trunk message to the DTI, it starts sending the Idle PCM code on nonsignaling frames on the idle channel.

Glare When a glare condition occurs (both ends of the same trunk attempt seizure at the same time), priority is given to the incoming call. In this case, the operation is the same as that of an analog trunk.

Incoming calls

Trunk seizure When the DTI hardware detects an A & B bit change of state on an idle DTI channel, it notifies the CPU. The CPU interprets the A & B bit state and takes the following action:

— **Central Office trunk** The CPU tells the DTI hardware to set up digital pads. It also alerts the Attendant or Night Station Directory Number (DN) (except on Direct Inward System Access [DISA] trunks).

— **TIE or Direct Inward Dialing trunks** The CPU attaches the Digitone receiver (DTR) in the case of dual tone multifrequency (DTMF) trunks, or interprets the A & B bits for the destination address in the case of dial pulse (DP) trunks. The address signals are processed by the digit processor and the called party is alerted. The CPU tells the DTI to set up digital pads for the call.

Answer When the call is answered, Meridian 1 software sends the appropriate answer message to the DTI. The DTI informs the far end and cuts through a speech path.

Release Guard and disconnect supervision timing and idling of the trunk are the same in operation as those of an analog trunk. DTI relays the release message for the CPU (idle state) to the far end by means of A & B signaling bits. When the CPU sends the idle trunk message, the DTI starts sending the Idle PCM code on nonsignaling frames on the idle channel.

Data call processing

Trunk timing and trunk transition used to set up data calls are similar to those used to set up voice calls with the following exceptions.

Mixed voice/data

When data calls using a route with mixed voice/data assignments are switched through a private network, intermediate switches must be signaled during call setup. This is done to ensure that:

— the tandem connection is made to digital facilities if Automated Modem Pooling is not provided

— the digital pads are not applied

— the Echo Cancellers are disabled on the data connections

This signaling is achieved by using the special address prefix or an equivalent format such as Electronic Switched Network (ESN) "call type" network signaling. Signaling on DTI for Standard (STD) and ESN trunk group option (shown in Table 2) is defined in LD16 in response to the SIGO (signaling arrangement) prompt.

Table 2
Network signaling on DTI

Trunk group	Call type	Digit	Sub-call type	Digit
Option (SIGO)				
STD	SIG STD VOICE	1		
	SIG STD DATA	2		
ESN5*	SIG DTI DATA	7	DTI CCBQ ALLOW #	1
			DTI STD NCOS #	2
			DTI STD TCOS +	3
			DTI SAT CCBQ #	4
			DTI SAT NCOS #	5
			DTI SAT TCOS +	6
* Call types 1-6 are treated as voice call. They have the same meanings as in ESN2 ESN3.				
# Followed by a 2-digit NCOS				
+ Followed by a 2-digit TCOS				

Voice calls only

When voice calls are switched through a private network on a voice calls only (VCE) route, special Electronic Switched Network (ESN) signaling is not required. Digital pads are applied as required, and Echo Cancellers are permanently enabled.

Data calls only

When data calls are switched through a private network on a data calls only (DTA) route, special Electronic Switched Network (ESN) signaling is not required. Digital pads are not applied and Echo Cancellers are permanently enabled.

Data call limitations

Analog and digital calls cannot be mixed in the same route. However, in cases where an analog facility runs parallel to a digital link, voice calls from the analog route are allowed to overflow onto the digital route and vice versa. Digital data calls do not overflow onto analog routes.

To prevent the inadvertent generation of false yellow alarms on a digital trunk loop, the number of data calls allowed on a digital trunk loop is limited to a value that is configured on a loop basis. This is done in LD17 in response to the DLOP (digital trunk loop) prompt. The range of possible values for a maximum number of data calls is 0 to 24. The default value is 24. False yellow alarms can be caused by high-speed synchronous data being present on *all* channels for an extended period of time. If this special condition is a provisioning criterion, consult your Northern Telecom sales engineer.

Recognition of data calls

Outgoing calls A bit in the terminal block identifies whether the call is from a voice or a data terminal.

Incoming calls Incoming calls are identified by their special call type or route type (that is, dedicated for voice or data usage).

Digital connectivity

Digital data routes must be engineered so that end-to-end connectivity is provided. Intermediate switches must route data calls over digital trunks and must not insert pads or Echo Cancellers. (Call identity digits are not stripped unless the succeeding loop has dedicated voice or data channels.)

Digital pad control

DTI software instructs its hardware to switch off digital pads for a particular channel when a digital data call is initiated for that channel. This is done to maintain bit integrity on such calls.

The DTI software inserts digital pads for both transmit and receive directions (on a per channel basis) to achieve the desirable port-to-port transmission loss values for each type of connection as identified by the Channel Classmarks.

Note: The net loss of a particular overall port-to-port connection is the combination of this DTI pad loss *and* the pad loss of the connecting analog line. All of the various insertion loss specifications for DTI overall port-to-port losses are listed in *Summary of transmission parameters* (553-2201-182) and conform to the EIA document PN-1429.

DTI/CPI Channel Classmarks

Channel Classmarks (see Table 3) are used for different types of connections for signaling and pad-setting purposes. Digital pad values are assigned for the appropriate timeslot (in accordance with the Pad Switching Table) during call processing when both the near and far end ports are known. When both ports of a connection are digital, only one port is assigned a pad value. The other port is automatically assumed to be zero.

Table 3
DTI Channel Classmarks

Number	Class	Explanation
1	ONS	Line interface/on premise line
2	OPS	Line interface/off premise line
3	ATT	Analog trunk interface/analog TIE trunk
4	AOT	Analog trunk interface/analog satellite PBX TIE trunk when PBX includes OPX telephones
5	SCTT	Digital trunk interface/combination satellite PBX TIE trunk
6	DTT	Digital trunk interface/digital or combination TIE trunk
7	ACO	Analog trunk interface/analog CO trunk
8	DCO	Digital trunk interface/digital or combination CO trunk
9	ATO	Analog trunk interface/analog toll office trunk
10	DTO	Digital trunk interface/digital or combination toll office trunk
11	SDTT	Digital trunk interface/digital satellite PBX TIE trunk
12	SATT	Analog trunk interface/analog satellite PBX TIE trunk

Echo Canceller

DTI hardware, under control of DTI software, disables the Echo Canceller on a per channel basis on data calls over satellite. If the Echo Canceller cannot be controlled dynamically (that is, on a per call basis), some channels should be set to voice calls only and some to data calls only. Echo cancellation should then be manually removed for the data calls only channels.

Tandem switches

A Meridian 1, acting as a tandem switch, can perform the following tasks on data calls:

— recognize the special call type for data calls

— absorb the prefix if necessary

— route data calls to the appropriate trunks

— suppress digital pads

— disable Echo Cancellers

— if necessary, insert and send special call type prefix to the next switch down the line

In certain cases, one or more of these requirements may not be needed. This depends on the signaling and transmission requirements of the tandem.

Trunk supervision

Trunk supervision signaling is dependent on the trunk type being emulated by the DTI.

Computer-to-PBX Interface application

The Computer-to-PBX Interface (CPI) uses DTI as a multiplex interface between Meridian 1 and a host computer. The operation of DTI when used in a CPI application is the same as for other applications. However, the following considerations must be made:

Channel assignments The DTI channels associated with CPI are classmarked Data Only and must be configured in one of the following ways:

— one-way TIE trunks arranged for manual outgoing service

— two-way TIE trunks arranged for manual outgoing and incoming service

— two-way TIE trunks arranged for manual outgoing and wink-start incoming service

Remote (yellow) alarms Remote (yellow) alarm recognition and transmission are disabled in the DTI and are not provided at the host computer interface.

Echo Cancellers Echo Cancellers must be disabled or removed.

Synchronization If the transmission facilities require the Meridian 1 to be synchronized with the digital network, then the Clock Controllers must be used as DTI applications.

Note: Clock Controllers are not required for the CPI application (except if the connecting facility is repeatered and requires synchronization).

Public Switched Data Service

The Meridian 1 Public Switched Data Service (PSDS) is a digital data feature that provides a pure 56 kbps data call between the following:

— a Meridian 1 and the Central Office (CO)

— a tandem call from an SL-100 to a Meridian 1

— a Meridian 1 and other Public Switched Data Service–compatible switches. See Figure 5.

Figure 5
Public Switched Data Service between Meridian 1 and Central Office
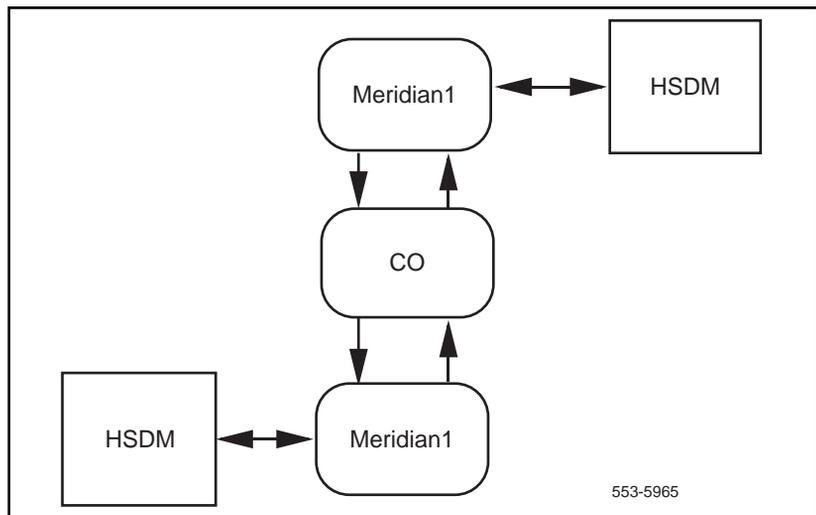
Note: For information on how to implement this feature, refer to *X11 features and services* (553-3001-305) and *X11 input/output guide* (553-3001-400).

The customer can install a T1 link to different vendors and use the Meridian 1 data unit to initiate or receive a 56 kilobit digital data call. The digital data call then transports across the vendor's digital network to another Meridian 1 or SL-100.

The Public Switched Data Service (PSDS) supports DTI trunks, TIE and Direct Inward Dial (DID)/Direct Outward Dial (DOD) trunks, and Electronic TIE Network–compatible signaling (ETN).

Operation

The data selection (DSEL) in the route data block can be defined as voice calls only (VCE), data calls only (DTA), or voice or data calls (VOD). The call can be defined as voice calls, regular data calls, or Public Switched Data Service (PSDS) calls. Refer to *X11 input/output guide* (553-3001-400) to configure the route data block.

For direct access, the user dials the regular seven- or ten-digit Directory Number (DN). The translation selects the TIE or Direct Inward Dial (DID)/Direct Outward Dial (DOD) DTI trunks. If the normal public access trunks are analog trunks, the data DN needs to be separated into an Electronic Switched Network (ESN) Special Number so the user can access the digital DTI facility.

For special route access, the user dials a route access code after hearing a dial tone. All the trunks in that route are one of TIE or DID/DOD DTI trunks.

Configurations

End to End DTI network For all Meridian 1 Networks (Point to Point), users can access the existing data facility in the Meridian 1 to support data calls, or they can select the Switched 56 data mode. For mixed vendors private network, users can select only the Public Switched Data Service mode.

Receiving data calls

A call can be answered either automatically (by a switch located inside the data module) or manually (by pressing the data Directory Number [DN] key on the data module).

Public Switched Data Service (PSDS) call on Primary Rate Interface The following routes are possible using this feature on Primary Rate Interface (PRI):

— **Point to point access** For point to point access of TIE trunks, the software can be modified to handle the requirements of this feature.

— **Tandem call** For tandem access, additional information on this feature is needed, or the data call can be defined as a voice call.

— **DID/FX/WATS/Accunet** The Meridian 1 supports PSDS data calls to these trunk types.

— **Public Network Hopoff** Signaling informs the tandem switch about the PSDS data call.

Equipment

Required firmware

To implement the Binary 8 Zero Substitution (B8ZS) feature requires CPU ROM firmware that is compatible with X11 release 19 software.

Installation-dependent hardware

The following hardware may be required, depending upon the specific installation:

— Echo Canceller

A Tellabs 24 Channel Echo Canceller, or the equivalent, should be used for echo cancellation on DTI voice calls over satellite only.

— Channel Service Unit

Depending on local or national regulations (for example, Part 68 of FCC regulations), connections to registered common carrier trunks may require that Network Channel Terminating Equipment (NCTE) be provided at the demarcation point. Digilink, Verilink, or similar Channel Service Units (CSUs) can be used.

— Test equipment

A Thor Error Counter, or equivalent, should be used for testing bipolar violations (BPV) on DTI circuits.

Required hardware

To implement the DTI feature, Meridian 1 uses:

— QPC472 Digital Trunk Interface or QPC720 Primary Rate Interface (PRI)

The DTI card or PRI card is associated with a Meridian 1 Network loop and forms the interface between the loop and a DS-1 24-channel 1.544 Mbps bipolar carrier terminal.

Note 1: DTI loops that use the Binary 8 Zero Substitution (B8ZS) feature must be QPC720 packs or equivalents.

Note 2: This feature applies to the 1.544 Mbps DTI only. DTI2/PRI2 is not supported.

DTI card location Each DTI card occupies two adjacent slots of a CPU shelf or a Network shelf. The specific location depends on the:

- machine type

- mode of operation

- availability of space

As many as six DTI cards can be plugged into a spare Network shelf along with a power converter card.

— QPC471 or QPC775 Clock Controller (CC)

Clock Controllers are required when the Meridian 1 is synchronized to an external source clock, such as AT&T Stratum 3 (all DTI applications and CPI applications where the host and CPI are remote and require a repeatered facility). The CC generates and distributes clock signals to the system.

Note 1: The QPC775 Clock Controller card is currently only available in Canada and the international market.

Note 2: The QPC471 and QPC775 Clock Controllers cannot be intermixed in one system.

Note 3: For the CPI application, in most cases a Clock Controller is not required.

Note 4: Option 81 systems require QPC471 vintage H or later.

QPC472 and QPC720 hardware description

Physical description

The QPC472 and QPC720 cards consist of two PCBs arranged into a single assembly in a mother/daughter configuration. The Network Interface (NI) PCB serves as the motherboard. It connects through a 60-pin ribbon cable to the Carrier Interface (CI) PCB daughterboard.

Note 1: QPC472 card's daughterboard is the QPC473.

Note 2: QPC720 card's daughterboard is the QPC752.

The DTI card draws power through the backplane connector of the Network Interface (NI). NI faceplate mounted connectors J1 and J2 extend through the faceplate and connect by cable to the Clock Controller when the DTI card is used as a reference clock source. J3 connects by cable to the Network loop.

Because of its power requirements, a QPC472 or QPC720 card must be plugged into a network or CPU backplane.

QPC472 J4 and J5 Extending through the faceplate from the daughterboard are connectors J4 and J5. J4 connects by cable to the Echo Canceller. J5 connects by cable to the T1 trunk.

See Figure 6 for card faceplate jacks and LED locations.

QPC720 J4, J5, and J6 Extending through the faceplate from the daughterboard are connectors J4, J5, and J6. J4 connects by cable to the T1 trunk. J5 is not used in DTI/CPI applications. J6 connects by cable to the Echo Canceller.

Figure 6
QPC472/QPC720 faceplate jacks and LEDs

DIS:	Card disabled
ACT:	Line active
RED:	Red alarm
YEL:	Yellow alarm
LBK:	Loopback test
RCV MON	An access point to the regenerated DS-1 signal from the external network
XMT MON	An access point to the DS-1 signal being transmitted by the DTI assembly
J1/J2: (Ref 1 & 2)	Buffered recovered clocks derived from the external carrier facilities
J4: (T1)	T1 interface to the external digital carrier
J5: (DCHI)	Not used in DTI
J3: (Loop)	Standard 18-pair connector to the Meridian 1 network loop
J6: (RS-232)	Interface to Echo Canceller (needed only with satellite transmission)

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Faceplate LEDs

QPC472 The LEDs on the QPC472 faceplate indicate the following states:

FLR   DTI failed or is disabled if ON

ACT   DTI active if ON

RALM   DTI local (red) alarm

YALM   DTI remote (yellow) alarm

LP BK   DTI in loopback test state if ON

QPC720 The LEDs on the QPC720 faceplate indicate the following states:

DIS   DTI failed or is disabled if ON

ACT   DTI active if ON

RED   DTI local (red) alarm

YEL   DTI remote (yellow) alarm

LBK   DTI in loopback test state if ON

Transmission equalizer switch

Making appropriate DIP switch settings on the Carrier Interface (CI) (daughterboard) card of the DTI card achieves transmission equalization. Transmission equalization is needed to compensate for cable-induced amplitude and phase distortions.

QPC472 card The DIP switch is located on the QPC473 daughterboard and is labeled SW1. The switch consists of eight poles. Poles one through seven are used for DTI applications.

QPC720 card The DIP switch is located on the QPC752 daughterboard and is labeled SW2. The switch consists of seven poles. All seven poles are used for DTI applications.

See Figure 7 and refer to Tables 4 and 5 for DIP switch locations and settings.
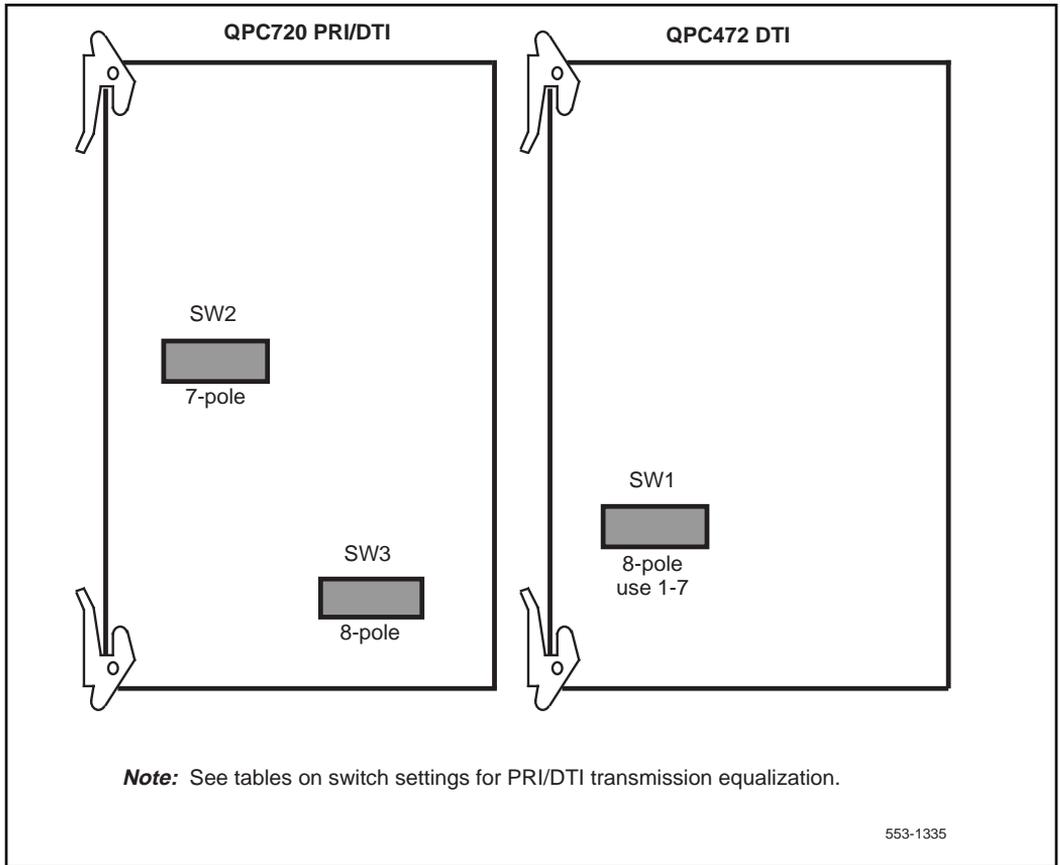
Table 4
QPC472 transmission equalization switch settings for DTI

Switch settings (transmission equalization)	To repeatered facility	To cross-connect point
5 on	0 - 45 m (0 - 150 ft)	0 - 15 m (0 - 55 ft)
2, 4, 6, on	45 - 135 m (150 - 450 ft)	15 - 100 m (56 - 355 ft)
1, 3, 7, on	135 - 225 m (450 - 750 ft)	100 - 200 m (355 - 655 ft)
Note: All switch positions should be OFF except those under the "switch settings" column.		

Table 5
QPC720 transmission equalization SW2 switch settings for PRI/DTI

Switch S2 settings	To repeatered facility	To cross-connect point
5 on	0 - 45 m (0 - 150 ft)	0 - 30 m (0 - 100 ft)
2, 4, 6 on	46 - 135 m (151 - 450 ft)	31 - 100 m (101 - 355 ft)
1, 3, 7 on	136 - 225 m (451 - 750 ft)	101 - 200 m (356 - 655 ft)

Switch 3 options for PRI/DTI with ESF
 	
    SW3-1   on   =   extended superframe format (ESF)
    SW3-2   off   =   superframe format (SF)
             on   =   B8ZS line encoding
             off   =   AM1 line encoding
    SW3-3   on   =   facility data link (FDL) yellow alarm method
             off = Digit 2 yellow alarm method		

Note 1: All positions on S2 (location B22) are OFF except as shown under the column labeled "Switch S2 settings." The 8-pole SW3 (location E37) positions are OFF except as shown for "Switch 3 options for PRI/DTI with ESF."		
Note 2: For D2, D3, or D4 framing formats (superframe formats), set all SW3 options to OFF.		

Figure 7
QPC472/QPC720 DIP switch locations and settings

QPC720 PRI/DTI

QPC472 DTI

SW2

7-pole

SW3

8-pole

SW1

8-pole
use 1-7

Note: See tables on switch settings for PRI/DTI transmission equalization.

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Faceplate connectors

J1, J2 reference clock The DTI card is equipped with two 9-pin PCB
mounted connectors designated J1 and J2. If the DTI is defined as the primary
reference clock source, DTI connector J1 is cabled to CC0 connector J2 and
DTI connector J2 is cabled to CC1 connector J2. If the DTI is defined as the
secondary reference clock source, DTI connector J1 is cabled to CC0
connector J1 and DTI connector J2 is cabled to CC1 connector J1.

J3 Network Loop The 36-pin DTI connector J3 is cabled to the 36-pin
connector (even or odd) of its assigned Network loop.

QPC472 J4/QPC720 J6 Echo Canceller The DTI/Echo Canceller controller
interface is made through the 15-pin female connector. The DTI is a data
terminal equipment (DTE) RS-232 interface. Its pin assignments and
interconnections are shown in Table 6.

Table 6
DTI/Echo Canceller RS-232-C interface pin assignments

Signal	EIA RS-232-C circuit designation	Echo Canceller pin	DTI pin
Transmitted Data (TXD)	BA	5	2
Received Data (RXD)	BB	2	3
Request to Send (RTS)	CC	—	4
Clear to Send (CTS)	CB	—	5
Signal Ground (common return)	AB	10	7
Received Line Signal Detector (DCD)	CF	1	8
Data Terminal Ready (DTR)	CD	4	20

QPC472 J5/QPC720 J4 Carrier Interface The DTI interface to the carrier, by means of the Echo Canceller (if required), is made through the 15-pin connector. The pinouts at the DTI end are shown in Table 7.

Table 7
DTI/QPC472 J5/QPC720 J4 Carrier Interface pinouts

Pin	Signal	Pin	Signal
1	XTIP	3	RTIP
9	XRING	11	RRING
2	GRD	4	GRD

Note: See *Digital Trunk Interface/Computer-to-PBX Interface installation and data administration* (553-2811-200) for DTI cabling details.

QPC471 and QPC775 Clock Controllers

The QPC471 and QPC775 Clock Controller (CC) cards provide Stratum 3 clocking to an external facility and can therefore control synchronization. It can also synchronize the Meridian 1 Network to an external source clock and generate and distribute a clock signal to the system.

The Meridian 1 accepts several vintages of the QPC471. The QPC471H is required for option 81.

The QPC775A (currently available in Canada only) CC card is compatible with the N, NT, XN, XT, MS, ST, and RT machine types.

Note: The QPC471 and QPC775 cannot be intermixed in one system.

The CC is contained on a 12.5 in. (32 cm) by 10 in. (25 cm) printed card. The CC connects with other circuits through a 120-pin backplane connector (P1) and through two 9-pin PCB-mounted connectors, J1 and J2. J1 and J2 extend through the faceplate and through a 50-pin faceplate mounted connector, J3. An Enable/Disable switch and LED are also located on the CC faceplate.

Clock Controller Enable/Disable switch and indicator

When the Enable/Disable switch has been used to disable the CC, the LED is turned on and the CC does not distribute clock signals. CC Enable and Disable are also under CPU control and that of the DTI hardware diagnostic, LD60.

Clock Controller card location CC cards are located as follows:

— XN: CPU shelf

— XT: CPU/MEM shelf slot 14 or 15

— N, RT: Network shelf slot 13

— MS: CE shelf slot 9

— ST, STE: Common equipment (CE) shelf slots 5 through 8 or 10 through 12

— NT: Network shelf 0 (half group) slot 13; Network shelf 1 (single group) slot 2

— 21, 21E: CE/peripheral equipment (PE) Network slots 4 through 7

— 51: CPU/Network slot 9

For dual CPU systems, two CC cards are required (one for each CPU), in the following locations:

— 61: CPU/Network slot 9

— 71: CPU slot 14

— 81: Core slot 6 (requires QPC471 vintage H)

Depending on the configuration of the Meridian 1, DTI and CC cards are arranged differently. Note that only the first two DTI cards are connected to the CCs. All other DTI cards are connected only to Network cards. This is because the Meridian 1 either slaves to the carrier clocking by means of the Stratum 3 level CC or provides clock to the carrier.

In dual CPU systems, CC redundancy is provided for each CPU. Northern Telecom recommends that dual CPU systems operate with CCs of the same vintage. In addition, any two, but only two, DTI cards are connected to the CC cards for further backup. If one T1 link fails, the second DTI card can provide clocking to the CC cards. Any additional DTI cards receive clocking by means of the Network Signaling bus. Figures 8 through 10 depict some typical arrangements.
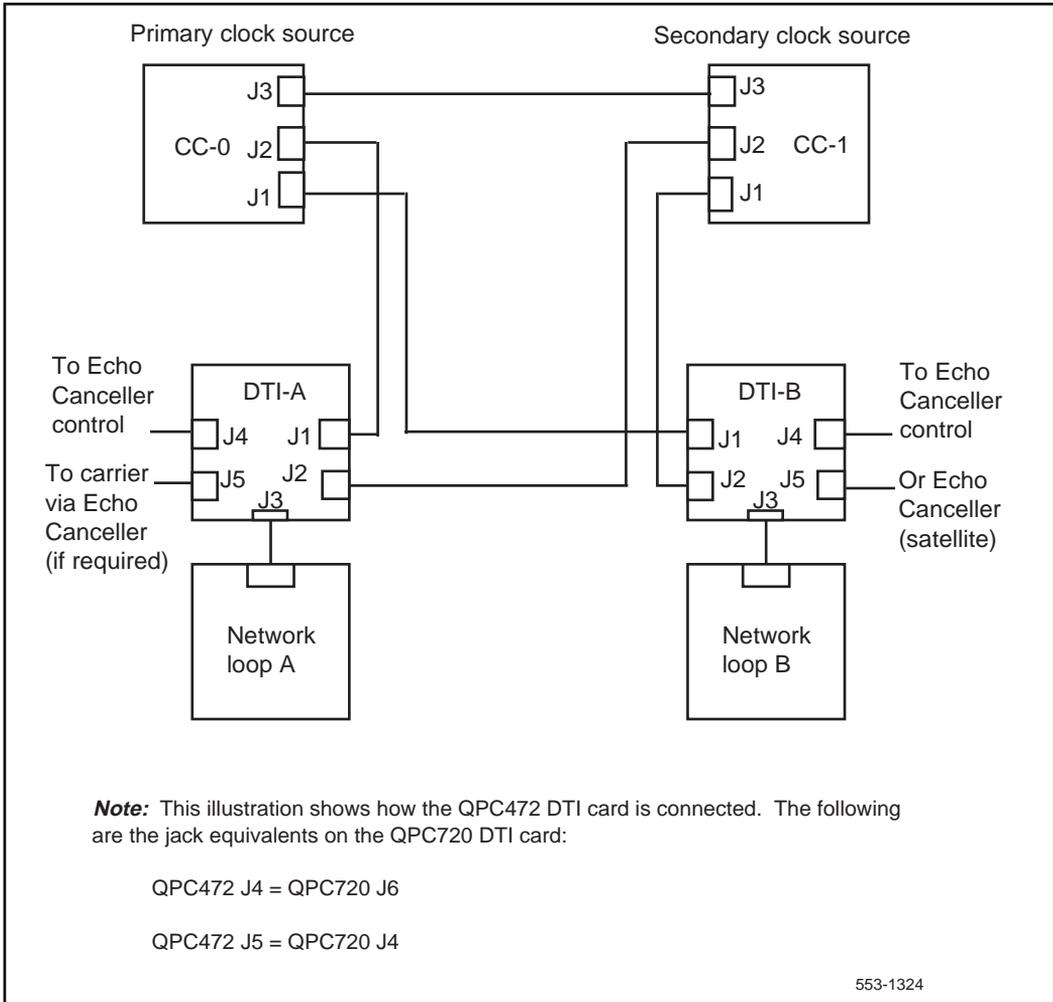
Figure 8
XN and XT multi-group operation

Primary clock source

Secondary clock source

CC-0   J3 J2 J1

J3 J2 J1   CC-1

J11   J12

Junctor Board

To Echo Canceller control

DTI-A   J4   J1

DTI-B   J1   J4

To Echo Canceller control

To carrier via Echo Canceller (if required)

J5   J2   J3

J2   J5   J3

Or Echo Canceller (satellite)

Network loop A

Network loop B

Note: This illustration shows how the QPC472 DTI card is connected. The following are the jack equivalents on the QPC720 DTI card:

QPC472 J4 = QPC720 J6

QPC472 J5 = QPC720 J4

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Figure 9
N and NT single-group operation

Primary clock source

Secondary clock source

J3

J3

CC-0 J2

J2 CC-1

J1

J1

To Echo
Canceller
control

DTI-A

J4   J1

To Echo
Canceller
control

To carrier
via Echo
Canceller
(if required)

J5   J2
J3

DTI-B

J1   J4

J2   J5
J3

Or Echo
Canceller
(satellite)

Network
loop A

Network
loop B

Note: This illustration shows how the QPC472 DTI card is connected. The following
are the jack equivalents on the QPC720 DTI card:

QPC472 J4 = QPC720 J6

QPC472 J5 = QPC720 J4

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Figure 10
N, NT, MS, ST, and RT half-group operation

Note: This illustration shows how the QPC472 DTI card is connected. The following are the jack equivalents on the QPC720 DTI card:

QPC472 J4 = QPC720 J6

QPC472 J5 = QPC720 J4

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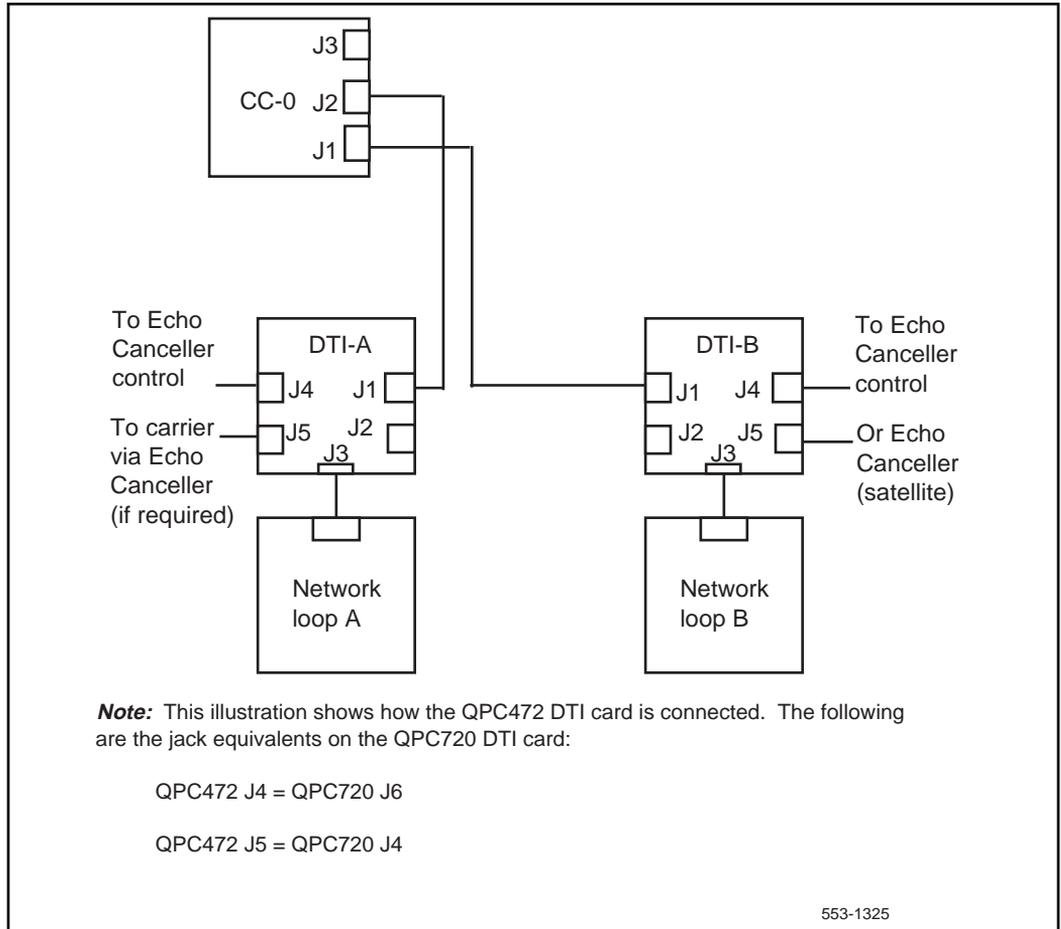
Clock Controller switch settings

Switch settings for the Clock Controller are shown in Tables 8 and 9.

Table 8
QPC471 vintages A through G Clock Controller switch settings

Vintage	Switch	MS	ST, STE, 21A, 21	N, NT, RT, 51, 61	XN, XT, 71, 81
QPC471A	SW2	not applicable	not applicable	ON	OFF
QPC471B through G	SW1	ON	ON	ON	OFF
	SW2	ON	OFF	OFF	OFF
	Jumper F38	TP9-TP10	TP8-TP9	TP8-TP9	TP8-TP9
	Jumper G38	TP12-TP13	TP11-TP12	TP11-TP12	TP11-TP12
QPC775	SW2	ON	ON	ON	OFF
	SW3	ON	OFF	OFF	OFF
	SW4(1, 2)	OFF	ON	ON	ON
Note 1: ON means 1 or CLOSED					
Note 2: OFF means 0 or OPEN.					
Note 3: The QPC775 Clock Controller card is currently available in Canada only.					

Table 9
QPC471 vintage H Clock Controller switch settings

System	SW1				SW2				SW4			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
ST, STE, 21A, 21, 21E	on	on	on	on	off	off	off	off	off	off	off	off
MS, SN	on	on	on	on	on	on	on	on	off	off	off	off
RT, N, NT, 51, 61	on	on	on	on	off	off	off	off	off	on	*	*
XN, XT, 71, 81	off	off	off	off	off	off	off	off	off	on	*	*
Cable length between the J3 faceplace connectors:												
0 - 4.3 m (0 - 14 ft)									off	off		
4.6 - 6.1 m (15 - 20 ft)									off	on		
6.4 - 10.1 m (21 - 33 ft)									on	off		
10.4 - 15.2 m (34 - 50 ft)									on	on		
* If there is only one clock controller card in the system, set to OFF. If there are two clock controller cards, set to match the cable length between the J3 faceplate connectors. Determine the total cable length (no single cable can exceed 25 ft) between the J3 connectors. Both cards must have the same setting.												

Clocks per system

The number of clocks used with the DTI is dependent on the Meridian 1
Network Group configuration. Table 10 shows clocks required per system.

Table 10
Meridian 1 system clock requirements

Number of CC	Network Group	Meridian 1 type
2 (QPC471)	Multi-Group	XN, XT, 71
2 (QPC471)	Single-Group	N, NT, 61
1 (QPC471)	Half-Group	N, NT, RT, 51
1 (QPC471)	Half-Group	MS, ST, STE, 21, 21E
2 (QPC471H)	Multi-Group	81

Clock Controller interconnections

Backplane interface The CC interconnects with the CPU bus by means of
the 120-pin backplane connector (P1).

Faceplate connectors The CC card is equipped with two 9-pin
PCB-mounted connectors, designated J1 and J2. Connector J1 is associated
with the DTI unit that is selected as the secondary reference clock source. J2
is associated with the DTI unit that is selected as the primary reference clock
source. The CC is also equipped with a 50-pin, faceplate-mounted connector,
designated J3. It is connected to the junctor board in Multi-Group mode, or
directly to the other CC when Single-Group mode is used.

> *Note:* CC cabling details are described in *Digital Trunk
> Interface/Computer-to-PBX Interface installation and data
> administration* (553-2811-200).

Interfacing with common carriers

The DTI provides an interface to the DS-1/D3 line either directly or by means of channel banks or office repeater. In accordance with FCC regulations (FCC 68), connections to registered common carrier trunks require that Network Channel Terminating Equipment (NCTE) —such as the NT QRY551 Channel Service Unit (CSU)—be provided at the demarcation point as long as the facility uses cable. (Microwave, fiber, infrared, and direct satellite connections do not require NCTE equipment.)

Echo Canceller interface

The DTI provides both a T1 line interface and a control interface to a remotely controlled Echo Canceller. The control interface is a serial link with a signal format compatible with EIA standard RS-232-C. Both the DTI and the Echo Canceller act as data terminal equipment (DTE). Installation of the Echo Canceller is covered in the manufacturer's documentation; however, the following guidelines outline the requirements for operation with DTI.

Physical interface The DTI/Echo Canceller interface is made through a 15-pin D-type connector at the DTI end. See Table 11.

Table 11
DTI/Echo Canceller interface

Interface protocol	Serial link protocol
Mode	asynchronous
Data transfer rate	4800 baud
Duplex	full
Received characters echoed	yes
Parity	even
Start bits	1
Data bits	7
Stop bits	1

Command protocol All remote control commands consist of a sequence of four 7-bit ASCII characters as shown in Table 12.

Table 12
Command protocol

Character	Description
1	System Unit Number (1)
2 & 3	Channel number being controlled (1-24)
4	Command Key (see Table 13)

There are two types of commands:

— **Control** Causes reconfiguration of the specified channel. The Echo Canceller must return an ACK (06 Hex) if the command is legal or a NACK (15 Hex) if the command is illegal.

— **Status** Monitors the existing configuration. The Echo Canceller must return a three-character response, the first two characters of which are the channel number. The third character is P (pass) or F (fail).

Table 13
Echo Canceller command keys

Command type	Command	On		Off	
		ASCII	Hex	ASCII	Hex
Control	bypass (Notes 1 & 3)	B	42	A	41
	off hook (Notes 2 & 3)	N	4E	O	4F
	canceller only (Note 4)	C	43	D	44
Status	self-test result (Notes 1 & 2)	T	54	—	—

Note 1: Echo cancellation is disabled when input is ON. Echo cancellation is active when the device performs a self-test.

Note 2: Continuous echo cancellation takes place and self-testing is inhibited when input is ON.

Note 3: When Bypass and Off Hook are entered simultaneously, the channel is removed from echo cancellation service.

Note 4: Residual suppressor is disabled but cancellation circuitry remains active.

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