tellabs

technical manual
76-81251
rev B

practice section 81251

251 24-Channel Digital Echo Canceller System

contents

1. general description

1.01 The 251 24-Channel Digital Echo Canceller System (figure 1) is an adaptive, split-type echo-control system that directly interfaces 1.544-megabit-per-second digital carrier facilities (commonly called *T1* facilities) at the DS-1 level. The 251 System provides individual echo control for all 24 of a T1 facility's voice-frequency (VF) channel circuits and performs comprehensive self-tests on its cancellation circuitry when channels are idle. The 251 can operate as a stand-alone system by monitoring the signaling

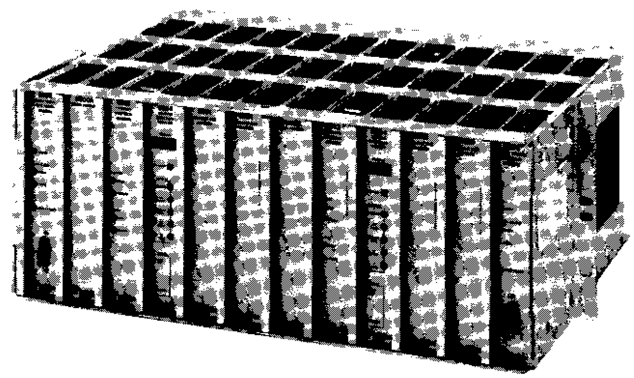


figure 1. 251 24-Channel Digital Echo Canceller System (two Systems shown in same Mounting Assembly)

for channel idle/busy status, or it can be controlled from a manual control panel or from a remote control and status interface that uses a serial data format compatible with EIA standard RS-232-C.

1.02 This Practice section is revised to incorporate the information formerly contained in the 251 Practice Supplement dated 1 June 1983 and also to provide information on two optional modules that allow the 251 System to operate on circuits with a maximum end-path delay of 60ms (instead of 30ms).

1.03 The 251 System is intended for use near the end points of digital carrier facilities characterized by appreciable end-to-end propagation delays. Echoes from the associated near-end voice-frequency channel circuits are effectively cancelled by the 251 System. These echoes are caused by signal reflections at impedance discontinuities and interface points such as 4wire-to-2wire interfaces.

1.04 Because it is a split-type echo canceller system, one 251 is required at each end of the composite circuit, and each System protects the opposite end of the circuit from echoes in return-path channels. The split-type configuration makes the 251 System completely insensitive to transmission delays on intermediate carrier links and therefore allows the System to operate effectively regardless of the duration of these delays. Thus, the 251 System is well suited for a broad range of digital-network applications, including single-hop and double-hop satellite circuits (whose round-trip delays are approximately 600 and 1200ms, respectively) and terrestrial circuits where the transmission characteristics of echo suppressors or via-net-loss (VNL) designs may be undesirable.

1.05 A signal in the receive path of any of the 24 channels served by the 251 System, followed by the signal's echo in the transmit (i.e., return) path, causes the System to begin an adaptation process known as *convergence.* During convergence, a digital signal-processing circuit called a *convolution processor* (one of which is provided for each channel) constructs and stores in memory a mathematical model of the channel's near-end transmission path (terminating set and interconnecting link), and uses this model to compute an echo estimate for the channel. This echo estimate is then subtracted from the transmit-path signal to actually remove the echo from the signal.

1.06 When the transmit-path signal consists of both echo (from the far-end speaker) and near-end speech, the 251 System removes only the echo signal, leaving the speech signal intact for transmission toward the distant end. Thus, parties at both ends can talk simultaneously (this is known as *full-duplex speech* or *doubletalk*) without the choppiness or lockout problems characteristic of echo suppressors. When only the far-end party is talking (one party talking is known as *singletalk*), the transmit signal consists entirely of echo, which the 251 System removes by subtracting the echo estimate from the echo signal. Any residual echo, which is normally a very small amount (typically, less than −40dBm0), is removed by an integral residual suppressor.

1.07 Convergence, the process of initially adapting to a near-end echo path, usually takes less than 200ms (about two or three syllables of speech), depending upon the receive-path (far-end speech) signal level. The 251 System can adapt to any near-end path with a minimum echo return loss (ERL) of 6dB and a maximum end-path echo delay of either 30ms or 60ms, depending upon module selection. After convergence, the 251 System continues to monitor the echo-delay and ERL characteristics of the near-end path. During periods of singletalk, the convolution processor repeatedly updates its mathematical model to match these observed characteristics. Thus, any change in the near-end path, such as a line being switched, will result in a new end-path model to accommodate the changed echo characteristics. As a result, after achieving convergence, the 251 System performs echo cancellation continuously, keeping the transmit path free of echo for the duration of the call.

1.08 Compact in size, an entire 251 System comprises only six Tellabs Type 16 modules (five modules if a tone disabler is not desired) and a prewired mounting assembly, as shown in figure 2. Each of these System components is described briefly below.

1.09 The **6953 Echo Canceller Power Supply and Alarm Module** derives regulated power for all of the System's digital logic circuits from filtered, ground-referenced −44 to −56Vdc (nominal −48Vdc) input. In addition, the 6953 provides local minor alarm indications (via front-panel LED's) as well as relay operation for remote major and minor alarm indications when faults of various types (e.g., loss of power) occur. These alarm indications can be manually terminated by depressing a front-panel *alarm cutoff* pushbutton. Fusing for the System's input power is provided by a 1⅓-ampere GMT-type fuse conveniently located on the module's front panel.

1.10 The **6952 Echo Canceller Network Interface Module**, which is used in applications where maximum end-path delays do not exceed 30ms, provides all required interfacing with the T1 line (at the DS-1 level) and performs all System timing functions (clock generation, framing, and synchronization). If transmit synchronization is lost due to a problem with the transmit-input PCM line, a red *transmit local* LED on the front panel lights. If synchronization is lost at the channel bank whose signals are incoming to the 251 System (in which case the transmit-input line indicates a bit-2 alarm), a yellow *transmit remote* LED lights. A second pair of front-panel LED's provides identical indications for the receive channel. In addition, the 6952 contains the System's integral automatic self-test subsystem for rapid detection and isolation of most System faults. With this subsystem, idle channels are routinely subjected to a test sequence that

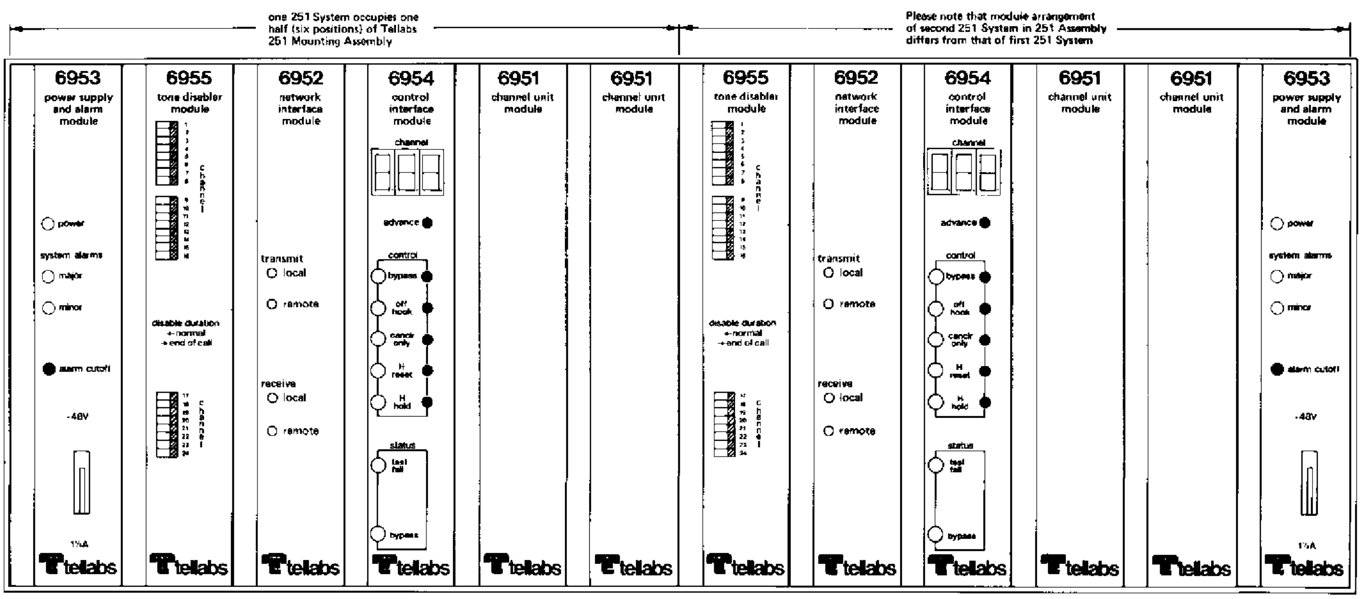


figure 2. Front detail of typical 251 System (Note: Two Systems, each containing the optional 6955 module, are shown in the same 251 Assemby.)

verifies proper operation of their convolution processors and associated circuitry critical to echo cancellation. Any faults discovered result in local alarm indications via an LED display on the System's control interface module. Those fault conditions that disable the System entirely, and those that do not disable the System but require immediate attention nonetheless, also initiate relay operation in the 6953 module for remote alarm indications.

1.11 The **6952A Echo Canceller Network Interface Module** is used in place of the 6952 module in applications where maximum end-path delays are as long as 60ms. The 6952A differs from the 6952 only in certain aspects of its EPROM software that allow the 6952A to operate in conjunction with the 6951A Channel Unit Module (see below). New system automatic-self-test values in the 6952A's EPROM software, for example, ensure rapid detection and isolation of 6951A channel failures.

1.12 The microprocessor-based **6954 Echo Canceller Control Interface Module** controls and monitors a variety of System functions. A complement of six pushbuttons, seven indicator LED's, and an LED window display on the 6954's front panel allows control and status information for the System as a whole and for its individual channels and subsystems to be displayed upon demand; major and minor System alarm indications are displayed automatically. In addition, these pushbuttons and LED's simplify the task of conditioning the 251 System for a particular application by allowing both System and individual-channel operating modes to be programmed into memory from the module's front panel. This memory is nonvolatile, i.e., it retains all stored information in the event of a power loss. Also available via the 6954's front panel is manual override of most automatic System control functions. See paragraphs 2.05 through 2.13 for details.

1.13 The **6951 Echo Canceller Channel Unit Module** contains 12 independent convolution processors and their associated timing-control circuitry. Used in applications where maximum end-path delays do not exceed 30ms, the 6951 performs the actual echo cancellation for 12 of the T1 line's 24 channels. Two 6951 modules are therefore required in every 251 System.

1.14 The **6951A Echo Canceller Channel Unit Module** is designed for use in place of the 6951 module in applications where maximum end-path delays are as long as 60ms. While it is functionally similar to the 6951, the 6951A contains 24 convolution processors arranged in 12 independent pairs, plus their associated timing and control circuitry. Each pair of convolution processors serves 1 of the T1 line's 24 channels, with 1 processor of a pair handling end-path delays of 0 to 30ms and the other handling end-path delays of 30 to 60ms. Thus, as is true of the 6951 module, one 6951A serves 12 channels and, therefore, two 6951A's are required per 251 System.

1.15 The **251 Mounting Assembly** is a Tellabs Type 16 Mounting Shelf that is internally prewired by means of a special printed-circuit backplane. As a result, neither external connections to individual modules nor intermodule connections need be made. Terminals on the backplane are provided for input power and facility input and output connections. Two versions of the 251 Assembly are available: the 251A, which mounts in a 19-inch relay rack, and the 251B, which mounts in a 23-inch relay rack. Each version accommodates 12 modules (two complete 251 Systems) and occupies four mounting spaces (7 vertical inches) in a standard relay rack.

1.16 The 251 Assembly is normally supplied with four Tellabs **80-5078 Central Office Equalizer subassemblies** (two per 251 System) factory-installed on its backplane. These subassemblies provide the proper amount of attenuation to limit the 251 System's transmit-output and receive-output signals (6 volts peak) to no more than 3 volts peak at the DX-1 cross-connect frame when 150 feet (46 meters) or less of cable connects the 251 System to the cross-connect frame. For longer cable runs, two direct-replacement subassemblies that each provide less attenuation than the 80-5078 are available. The Tellabs **9927 CO Equalizer subassembly** is designed for cable runs of 150 to 450 feet (46 to 137 meters), and the Tellabs **9928 CO Equalizer subassembly** is designed for cable runs of 450 to 650 feet (137 to 198 meters).

1.17 External connections to the T1 (DS-1) PCM lines are normally made via wire-wrapping to terminal blocks on the 251 Assembly's backplane. If desired, however, the Assembly can be factory-equipped with two optional Tellabs **80-0121 Twinax Connector Panels** for concentric twinax connection of the T1 (DS-1) PCM lines to the Assembly. Each panel contains four twinax connectors (Trompeter BJ77-type) and serves one of the two Systems the Assembly can accommodate. These panels are mounted on the Assembly backplane via the same standoff posts that secure the CO equalizers; spacers provide the necessary clearance between the panels and the equalizers.

1.18 Although research indicates that voice-band data can be transmitted through echo cancellers without degradation, the 251 System can, if desired, be equipped with an optional **6955 Echo Canceller Tone Disabler Module.** This module is equivalent to tone disablers used in echo suppressors and serves the entire 251 System, providing independent operation for each of the 24 channels. Upon receipt of nominal 2100Hz digital disabling tone in any channel, the 6955 causes all echo cancellation and residual-echo suppression to cease for that channel. Thus, the channel is rendered completely transparent; its transmit-input PCM signals are not processed but simply inserted into the correct time slots in the transmit-output PCM bit stream. DIP switches on the 6955's front panel allow each channel to be individually optioned so that echo cancellation and residual-echo suppression are disabled only while 2100Hz tone is present or are disabled from the time 2100Hz tone is received until the end of the call (even if tone is removed prior to the end of the call).

1.19 For any 251 System that does not require the optional 6955 module, the Issue 2 version of the **6900A Blank Type 16 Module** (Tellabs part number 826900A), which is also optional, can be used in place of the 6955 to fill the empty module position in the 251 Assembly. The 6900A helps to keep foreign matter out of the Assembly and also gives the System a more attractive appearance. In addition, the Issue 2 version of the 6900A can be used to silence external alarms caused by removal of the System's 6953 module from the Assembly. When the Issue 2 6900A is inserted into the module position from which a 6953 has been removed, a projection at the end of the 6900A's "pseudo printed circuit board" opens the cut-through module connector at that module position. This causes both major-alarm and minor-alarm indications to cease. This feature is valuable not only during testing but also during installation of 251 Systems in prewired bays, in which case unwanted alarms can result from module positions not yet equipped.

1.20 For reference purposes, the 251-System components described above are summarized as follows:

★ **251A Mounting Assembly.** Twelve module positions, 19-inch rack mounting, equipped with printed-circuit backplane. Houses two complete 251 Systems and is factory-equipped with four 80-5078 CO Equalizer subassemblies (two per System).

★ **251B Mounting Assembly.** Same as 251A except 23-inch rack mounting.

★ **80-5078 CO Equalizer subassembly** for less than 150 feet (46 meters) of cable. Standard equipment factory-installed on 251 Assembly (four 80-5078's per Assembly).

★ **9927 CO Equalizer subassembly** for 150 to 450 feet (46 to 137 meters) of cable. Optional direct replacement for 80-5078.

★ **9928 CO Equalizer subassembly** for 450 to 650 feet (137 to 198 meters) of cable. Optional direct replacement for 80-5078.

★ **80-0121 Twinax Connector Panels** for concentric twinax connection of T1 (DS-1) PCM lines to 251 Assembly. Optional, factory installed (two per Assembly).

★ **6951 Echo Canceller Channel Unit Module.** Serves 12 channels in applictions where maximum end-path delays do not exceed 30ms (two 6951's required per 251 System).

★ **6951A Echo Canceller Channel Unit Module.** Takes the place of the 6951 and serves 12 channels in applications where maximum end-path delays are as long as 60ms (two 6951A's required per 251 System).

★ **6952 Echo Canceller Network Interface Module.** Used in applications where maximum end-path delays do not exceed 30ms (one required per 251 System).

★ **6952A Echo Canceller Network Interface Module.** Takes the place of the 6952 in applications where maximum end-path delays are as long as 60ms (one required per 251 System).

★ **6953 Echo Canceller Power Supply and Alarm Module.** Operates from nominal −48Vdc input (one 6953 required per 251 System).

★ **6954 Echo Canceller Control Interface Module** (one required per 251 System).

★ **6955 Echo Canceller Tone Disabler Module** (one per 251 System is optional).

★ **Issue 2 6900A Blank Type 16 Module** (one per 251 System is optional when 6955 is not used).

2. application

general

2.01 The 251 24-Channel Digital Echo Canceller System is primarily intended for use on single-hop and double-hop satellite circuits and long terrestrial circuits with T1 (DS-1) end links. In such long-delay circuits, the operating characteristics of conventional echo suppressors may be objectionable, thus necessitating the use of echo cancellers instead. Actually, while the superior performance of the 251 System is most noticeable on long-delay links, its insensitivity to total intermediate delay makes it suitable for nearly all applications involving digital carrier. The 251 System cancels echo by adapting to each near-end echo path it encounters, and it can adapt to any near-end path with an echo return loss (ERL) greater than 6dB and a maximum round-trip delay (measured between the System's receive-output and transmit-input ports) of either 30ms or 60ms, depending upon module selection.

2.02 A typical application of the 251 System is shown in figure 3. The primary cause of echoes received at the far end (B) is the 4wire-to-2wire voice-frequency (VF) interface, i.e., the terminating set, at the near end (A). Signal reflections at this interface are heard as echoes in the corresponding far-end channel. Because it is a split-type echo canceller, the 251 System at the near end actually protects the far-end receive channels from echo, and the far-end 251 System likewise protects the near-end receive channels from echo. This split-type configuration provides effective echo control regardless of the total delay on the intermediate transmission links.

network interface

2.03 The 251 System interfaces the digital network directly at the T1 (or DS-1) level and thus eliminates the need for per-channel echo-control devices on the associated VF circuits. At this interface level, both the transmit and the receive channel of the 251 System accommodate multiplexed input signals in a serial stream at 1.544 megabits per second with segmented μ-255 companded PCM coding. (This is the DS-1 or bipolar alternate-mark-inversion [AMI] signal format.)

2.04 The 251 System typically operates in conjunction with a D-type channel bank or a digital toll switch. In such applications, the 251 System is normally located between a DX-1 cross-connect frame on the side toward the far end (i.e., the satellite side) and another DX-1 frame and the associated channel bank or digital switch on the side toward the near end (i.e., the terrestrial side). An arrangement of this type is shown in figure 4. Cabling between a DX-1 cross-connect frame and a D-type channel bank must be

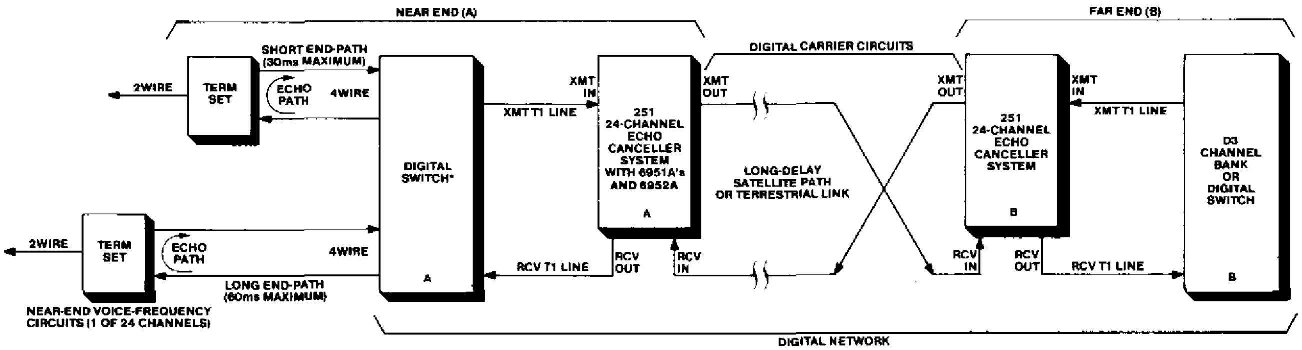


figure 3. Typical application of 251 System

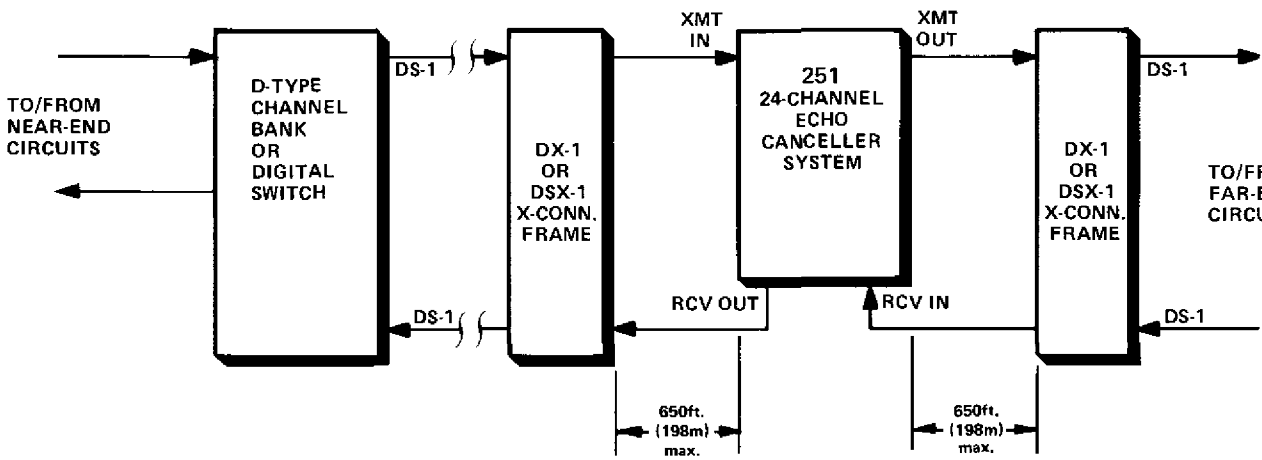


figure 4. Physical connection of 251 System

done with 22-gauge or heavier shielded cable. With 22-gauge cable, maximum permissible distance between the DX-1 cross-connect frame and the 251 System, including intraframe cabling in the DX-1 frame, is 650 feet (198 meters). Where this distance restriction cannot be met, heavier cable should be used. In extreme cases, an intraoffice span (i.e., an intraoffice repeater line) can be used. In all applications, separate input and output cables must be used between DX-1 frames and the 251 System.

system control

2.05 All internal System control functions originate in, and all externally derived System control functions are handled through, the 6954 Control Interface Module. Pushbutton switches and LED's on the 6954's front panel (see figure 2) provide the means for programming both System and individual-channel operating parameters (in effect, optioning the System for its particular application). These codes are stored in a special nonvolatile memory that retains all stored information even if power to the 251 System fails. After the desired operating parameters are programmed, the 6954's pushbuttons and LED's can be used to display the status of these parameters at any time. Specifically, the *channel* LED window and *advance* pushbutton are used to select and display the channel number, and the five *control* and two *status* LED's indicate the selected channel's status. The five pushbuttons associated with the *control* LED's are used to control the indicated functions. Options that can be programmed via the 6954 include (1) selection of the data transfer rate (see paragraph 4.04) for the remote control/status interface port, (2) automatic blanking of the channel display after a 1-minute timeout, (3) assignment of a System unit number for multiple daisy-chained Systems, and (4) selection of one to six consecutive self-test failures before generation of an alarm.

2.06 The 251 System uses the basic D3-channel-bank sequential channel-numbering scheme. With this scheme, the channel number assigned to each of the 24 T1-line (DS-1) time slots is the same as the number of the time slot. Other types of channel banks, however, use different channel-numbering schemes. Table 1 lists the channel-numbering schemes for D1D and D2 as well as D3 channel banks.

2.07 For each of the 251 System's 24 channels, a number of control inputs can be entered externally (i.e., via the 6954's front panel or via a remote control/status interface [see paragraphs 2.11 and 2.12]) to override certain internal control functions normally performed by the 6954 in response to information contained in the transmit-input bit stream. As is true of all user-programmed System parameters, the status of each externally inputted control function can be displayed at any time after the function is initiated. The external control inputs that can be entered for each channel individually to override internal control functions are as follows:

T1-line (DS-1) time slot	251-System and basic D3-bank sequential channel-number assignments (preferred)	D1D channel-number assignment	D2 channel-number assignment
1	1	1	12
2	2	13	13
3	3	2	1
4	4	14	17
5	5	3	5
6	6	15	21
7	7	4	9
8	8	16	15
9	9	5	3
10	10	17	19
11	11	6	7
12	12	18	23
13	13	7	11
14	14	19	14
15	15	8	2
16	16	20	18
17	17	9	6
18	18	21	22
19	19	10	10
20	20	22	16
21	21	11	4
22	22	23	20
23	23	12	8
24	24	24	24

table 1. Channel-number assignments for T1-line (DS-1) time slots

A. **Bypass.** When the *bypass* input is entered, cancellation is disabled; the channel is routed around the processing circuits and placed in the self-test mode. Self-test failures cause the 6953's minor-alarm relay to operate and *minor alarm* LED to light and also cause the 6954's *test fail* LED to light. The *bypass* input also lights the 6954's *control bypass* and *status bypass* LED's.

B. **Off Hook.** When the *off hook* input is entered, the channel is placed in a permanent busy condition. Continuous echo cancellation takes place, and self-testing is inhibited. Also, any existing *test fail* and *minor alarm* indications for the channel are cleared.

C. **Bypass plus Off Hook.** When a *bypass* and an *off hook* input are entered simultaneously, the channel is completely removed from service. It is routed around the processing circuits, and the *test fail* and *minor alarm* indications for the channel are cleared and inhibited.

D. **Canceller Only.** When the *canceller only* input is entered, the channel's residual suppressor is disabled but its cancellation circuitry remains active.
Note: *If self-testing is taking place at the time the* canceller only *input is entered, self-test failure occurs and the 6954's* test fail *LED lights because the residual suppressor is checked by self-test.*

E. **H Reset.** When the *H reset* input is entered, the H register (which stores the mathematical model of the end-path impluse response) is zeroed, effectively disabling echo cancellation for the channel. The *H reset* input also lights the 6954's *status bypass* LED.
Note: *If self-testing is taking place at the time the* H reset *input is entered, self-test failure occurs and the 6954's* test fail *LED lights because cancellation is disabled by the* H reset *input.*

F. **H Hold.** When the *H hold* input is entered, updates are inhibited so that the H register is forced to hold its current contents. The channel's echo-cancellation circuitry and residual suppressor still operate normally, but the channel's convolution processor(s) is prevented from adapting to changes in the end path.
Note: *If self-testing is taking place at the time the* H hold *input is entered, self-test failure occurs and the 6954's* test fail *LED lights because adaptation is disabled by the* H hold *input.*

2.08 For each channel, additional status information derived from the 6954 module's internal control circuits can also be displayed at any time via the 6954's *status* LED's. This information consists of the following:

A. Channel's failure of self-test and subsequent removal of the channel from service (*status test fail* LED lighted).

B. Channel's echo cancellation disabled for any of the following reasons (*status bypass* LED lighted):
   (1) The channel is bypassed.
   (2) The *H reset* control input is activated for the channel.
   (3) The channel is idle (on-hook) and therefore has been automatically placed in the self-test mode.
   (4) A tone-generated data-disable condition is detected by the 6955 module, thus causing the 6954 module to automatically generate an *H reset* control input for the channel.

2.09 When operating as a stand-alone unit, the 251 System monitors the channel-associated signaling in the frame-6 and frame-12 signaling bits of both the transmit and receive digital lines to determine the busy/idle status of each channel. If desired (or if channel-associated signaling is not present), the channel busy/idle status can be provided externally through the remote control/status interface, typically from a processor-controlled toll switch (see paragraphs 2.11 through 2.13).

2.10 For details on local configuration and status-monitoring via the 6954 module's controls and indicators, refer to section 4 of this Practice, *local system control.*

remote control/status interface

2.11 The 251 System can, if desired, be controlled from a remote location via a remote control/status interface that uses a serial data format compatible with EIA standard RS-232-C. The 251 System itself is data terminal equipment (DTE), and the signals it provides are suitable for serial interface with either data communication equipment (DCE) or, if a null-modem adapter is provided, with other DTE. All channel-related control functions and status indications available via the 6954 module's front-panel switches and LED displays are also available via the remote control/status interface.

2.12 Figure 5 shows four possible remote control/status interface configurations. In configuration **a**, the control center is close enough to the 251 System to allow a direct RS-232-C connection. The maximum

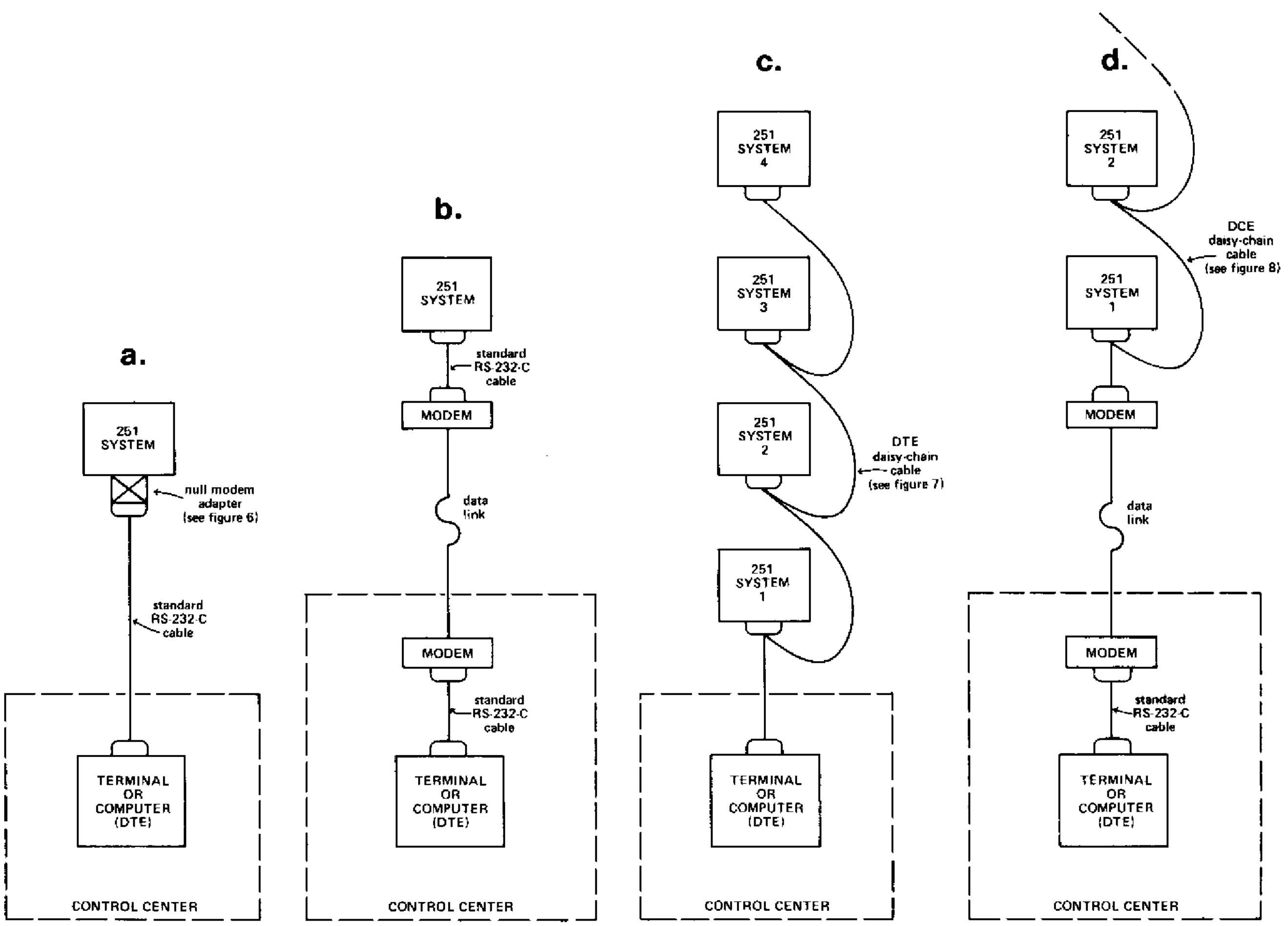


figure 5. Four remote control/status interface configurations

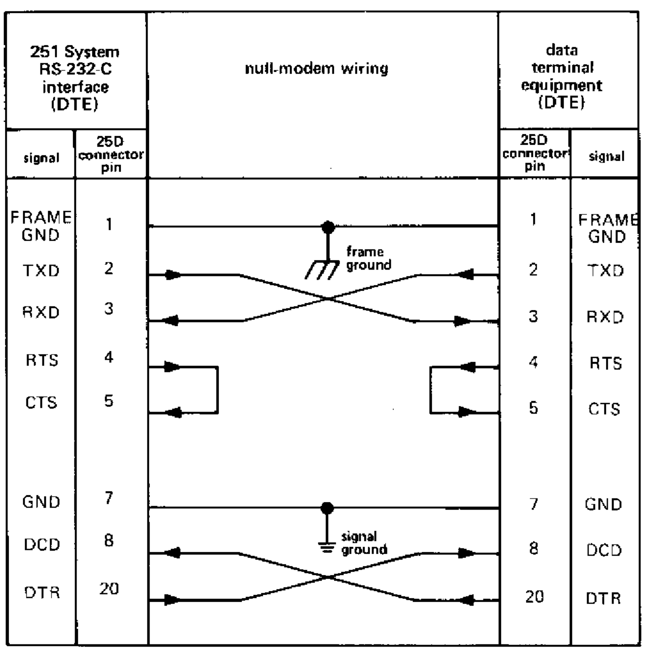


figure 6. Null-modem wiring for connection to DTE

recommended range for a direct RS-232-C connection is 50 feet. A null-modem adapter, the wiring of which is shown in figure 6, interfaces the 251 System (DTE) with the control-center terminal or computer. In configuration **b**, two modems and a private data link are used to link the 251 System to a control center located beyond the range of a direct RS-232-C connection. In configuration **c**, four 251 Systems are interfaced with the control center via a DTE daisy-chain cable (figure 7). As in configuration **a**, the range of the direct daisy-chained connection is 50 feet. In configuration **d**, the 251 Systems are interfaced with the control center via a DCE daisy-chain cable (figure 8), two modems, and a private data link. Contact Tellabs' Applications Engineering Group at our U.S. or Canadian headquarters or at your Tellabs Regional Office for details on other special interface configurations.

2.13 For details on the remote control/status interface protocol and on remote configuration and status-monitoring procedures, refer to section 5 of this Practice, *remote system control.*

automatic self-test

2.14 The 251 System's self-test subsystem automatically verifies proper operation of each channel's convolution processor (and associated support circuits), doubletalk detector, and update control circuits. The self-test sequence is initiated by the 6954 Control Interface Module, which scans each channel at regular 36ms intervals for on-hook/off-hook status. On-hook (idle) channels are marked available for test, and this information is passed to the 6952 or 6952A Network Interface Module, which contains the self-

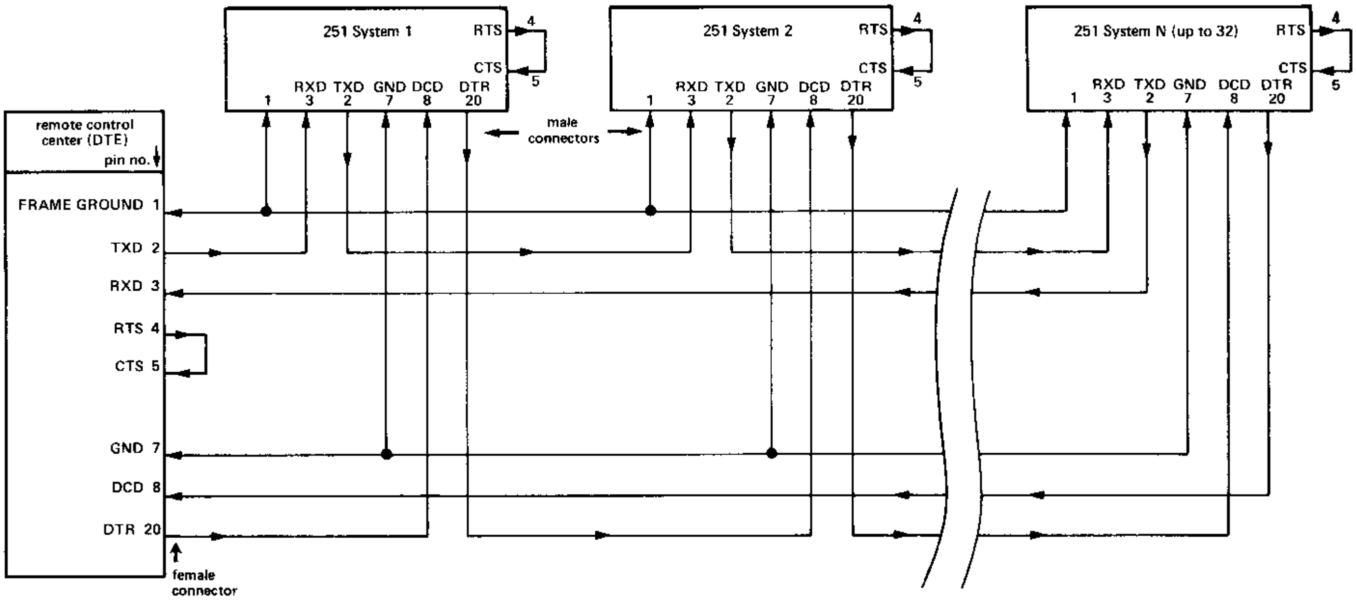


figure 7. Daisy-chain connection of multiple 251 Systems to DTE

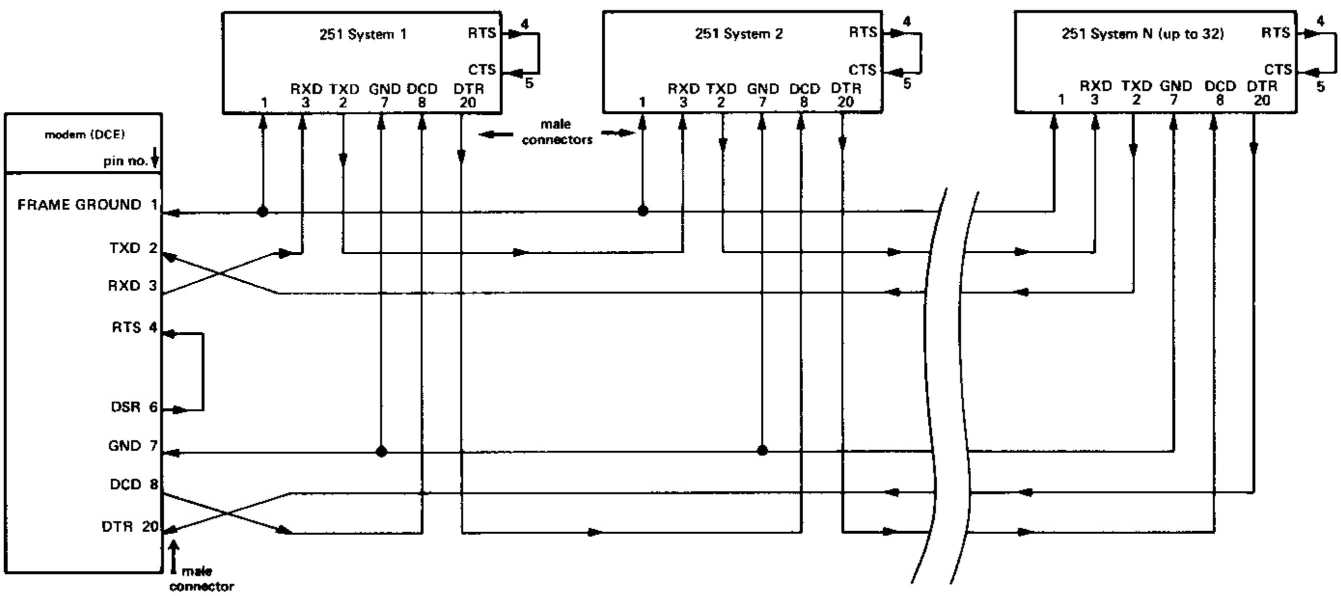


figure 8. Daisy-chain connection of multiple 251 Systems to DCE

test circuitry and performs the actual testing. The testing sequence, which takes approximately 750 milliseconds per channel, is halted for any channel that goes off-hook during testing, while on-hook channels continue under test until the end of the test sequence. Test results are reported for only those channels that have undergone the entire test sequence. Any channel that repeatedly fails a self-test activates a minor alarm (see paragraphs 2.15 and 2.16) and causes a channel alarm code to appear in the LED display on the 6954 module.

alarms

2.15 When fault conditions are detected by the 251 System, they are automatically classified as minor or major, depending upon their effect on the System. Both classes of alarms result in similar alarm indications: lighting of the *system alarms minor* or *major* LED on the front panel of the 6953 Power Supply and Alarm Module and lighting of the *channel* LED display (indicating the affected channel) and appropriate *status* LED's on the front panel of the 6954 Control Interface Module. In addition, each of the two alarm classes has two dedicated pairs of form-C relay contacts, both of which provide a closure for an external indication (audible, visible, or both) when an alarm occurs.

2.16 Minor alarms are generated upon failures of single channels. In addition to initiating the aforementioned LED indications and minor-alarm relay-contact operation, failure of a single channel causes the 251 System to bypass that channel so that transmission can still take place over the channel, albeit with possible echo.

2.17 Major alarms comprise the following:

A. Loss of remote transmit or receive frame synchronization (yellow *transmit remote* or *receive* on 6952 or 6952A module lighted). If frame synchronization cannot be achieved in 3ms or less, the aforementioned LED indications on the 6953 and 6954 modules are provided and major-alarm relay-contact closure takes place. Also, the entire 251 System is bypassed so that transmission can still take place over all 24 channels, albeit with possible echo.

B. Loss of remote transmit or receive frame synchronization (yellow *transmit remote* or *receive remote* LED on 6952 or 6952A module lighted). If remote frame synchronization cannot be achieved in the amount of time allotted, i.e., if a bit-2 alarm from the channel bank on the transmit-input or receive-input line is detected, the aforementioned LED indications on the 6953 and 6954 modules are provided and major-alarm relay-contact closure takes place. Also, the entire 251 System is bypassed so that transmission can still take place over all 24 channels, albeit with possible echo.

C. Failure of 251-Assembly input power, failure of the 6953's power supply, or blowing of the 6953's input-power fuse. If input power to the 251 Assembly fails, if the 6953's power supply fails entirely or cannot maintain System power within its regulated limits, or if the 6953's front-panel 1⅓-ampere fuse blows, the *power* LED on the 6953 goes off and major-alarm relay-contact closure takes place. (No other LED indications are provided.)

D. Failure of the 6954's microprocessor system. If the 6954's microprocessor system fails, the aforementioned LED indications on the 6953 and 6954 modules are provided and major-alarm relay-contact closure takes place. Also, the entire 251 System is bypassed so that transmission can still take place over all 24 channels, albeit with possible echo.

2.18 When either a minor or major alarm **not caused by a power failure, a blown fuse, or removal of the 6953 from its module position** occurs, momentarily depressing the *alarm cutoff* pushbutton on the 6953's front panel restores the corresponding alarm relay to its normal state, thereby causing the external alarm indications to cease. Although depressing the 6953's *alarm cutoff* pushbutton clears all external alarm indications, local alarm indications (the lighted *system alarms major* or *minor* LED on the 6953 and the lighted LED display on the 6954) remain until the fault is cleared.

2.19 When an alarm caused by failure of input power to the 251 Assembly, failure of the 6953's power supply, blowing of the 6953's input-power fuse, or removal of the 6953 from its module position occurs, the alarm indications can only be cleared by locating and correcting the problem.

tone disabler option

2.20 Should disabling of any of the 251 System's channels during voice-band data transmission be deemed necessary, the System can be equipped with an optional 6955 Echo Canceller Tone Disabler Module. This single module serves the entire System, providing independent operation for each channel. Upon detection in a channel of digital 2010 to 2240Hz disabling tone (at a level greater than −36dBm0) in either or both directions of transmission, the module disables that channel's echo-cancellation circuitry and residual suppressor so that the channel is completely transparent to all transmission. A guard band is used to prevent false operation of the 6955 module by speech signals. Three 8-position DIP switches on the 6955's front panel allow each channel to be individually optioned so that disabling occurs only while tone is present or so that disabling lasts from the time tone is detected until the end of the call (even if tone is removed prior to the end of the call).

3. installation

inspection

3.01 Each component of the 251 24-Channel Echo Canceller System, i.e., all five modules (six if the 6955 is used) and the 251 Mounting Assembly, should be visually inspected upon arrival to find possible damage incurred during shipment. If damage is noted, a claim should immediately be filed with the carrier. If stored, both the modules and the assembly should be inspected again prior to installation.

mounting of 251 Assembly

3.02 The 251A Mounting Assembly mounts in a standard 19-inch relay rack, and the 251B Mounting Assembly mounts in a standard 23-inch relay rack. Each version of the 251 Assembly occupies 7 inches of vertical rack space. Ensure that the 251 Assembly is securely mounted before proceeding to *central office equalizers* and *installer connections* below.

central office equalizers

3.03 The 251 Assembly is normally shipped with four Tellabs 80-5078 Central Office Equalizer subassemblies (one for the transmit output line and one for the receive output line of each of the two Systems that the Assembly can house) factory-installed on the Assembly's backplane. To replace any of these equalizers (e.g., if a Tellabs 9927 CO Equalizer subassembly [for 150 to 450 feet of cable between the System and the DX-1 cross-connect frame] or a Tellabs 9928 CO Equalizer subassembly [for more than 450 feet of cable between the System and the DX-1 cross-connect frame] is to be used in place of an 80-5078 subassembly), proceed as follows:

A. Remove and save the two Phillips-head screws that secure the subassembly to its standoff posts on the backplane. (If your 251 Assembly is equipped with optional Tellabs 80-0121 Twinax Connector Panels, remove and save the four Phillips-head screws that secure the twinax connector panel covering the subassembly to be replaced. Then remove and save not only the panel itself but also the four spacers between the panel and the subassemblies below it.)

B. Unplug the subassembly to be replaced from its five-pin connector (*P4, P5, P10,* or *P11*).

C. Plug the new subassembly into the five-pin connector.

D. Secure the new subassembly to its standoff posts with the two Phillips-head screws. (If your 251 Assembly is equipped with twinax connector panels, replace the four spacers between the two subassemblies and the twinax connector panel that was removed, reinstall the panel over the subassemblies, and secure the panel and subassemblies with the four Phillips-head screws.)

installer connections (general)

3.04 Because the 251 Assembly is prewired and equipped with a printed-circuit backplane, neither external connections to individual modules nor intermodule connections need be made. The only mandatory external connections to each 251 System in a 251 Assembly are as follows:

A. Eight facility (signal) connections, consisting of one tip and one ring connection for each of the four input/output cables accessing the System. Unless the 251 Assembly is equipped with optional twinax connector panels (see paragraph 3.10), these connections are made via wire-wrapping to four clearly labeled three-pin terminal blocks on the Assembly's backplane.

B. Input battery and ground connections, which are made with 16AWG or heavier wire to screw-type terminals on a three-position barrier strip on the Assembly's backplane.

3.05 Optional external connections to each 251 System in a 251 Assembly comprise the following:

A. One cable-shield connection for each of the four facility (signal) input/output cables. Unless the 251 Assembly is equipped with optional twinax connector panels (see paragraph 3.10), these are made via wire-wrapping to the same three-pin terminal blocks used for facility (signal) connections.

B. Input-power frame ground. This connection is made with 16AWG or heavier wire to the same three-position barrier strip used for input battery and ground connections.

C. Connections for external minor-alarm indications. These connections are made via wire-wrapping to a six-pin terminal block on the 251 Assembly's backplane. (Two sets of minor-alarm relay contacts are provided, and three pins are used for each set.)

D. Connections for external major-alarm indications. These connections are made via wire-wrapping to a six-pin terminal block on the 251 Assembly's backplane. (Two sets of major-alarm relay contacts are provided, and three pins are used for each set.)

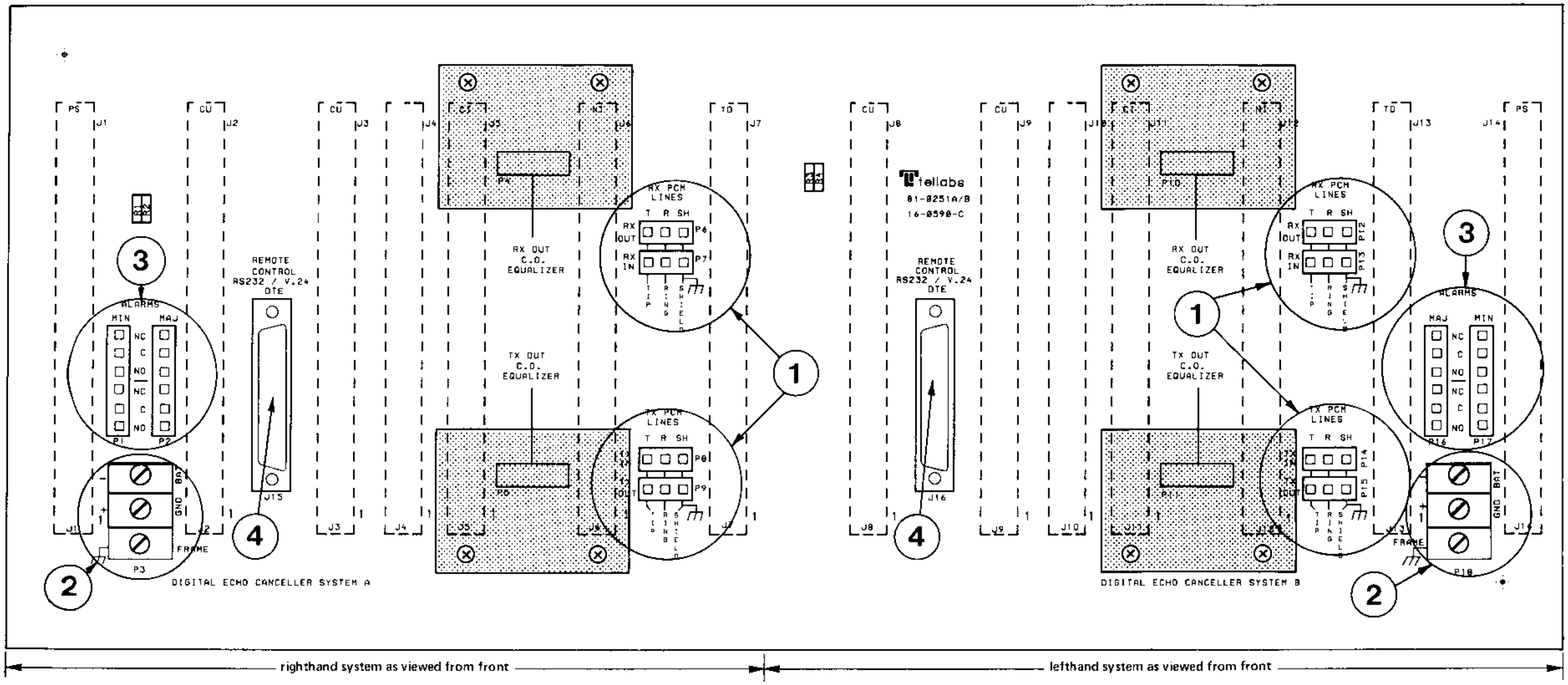
E. Remote control/status interface connections. These connections are made via a 25-pin female D-subminiature connector arranged for RS-232-C serial interface and located on the 251 Assembly's backplane.

3.06 Because the 251 Assembly can house two separate and independent 251 Systems, the Assembly's backplane contains two input-power barrier strips, two sets of wire-wrapping terminal blocks for facility (signal), minor-alarm, and major-alarm connections, and two 25-pin female RS-232-C connectors. These items are shown in figure 9, and all mandatory and optional connections to a single 251 System are summarized in table 2. Detailed wiring instructions and a complete wiring table for both systems in a 251 Assembly **not equipped with twinax connector panels** follow in paragraphs 3.07 through 3.09. If your 251 Assembly is equipped with twinax connector panels, make all connections **except** facility (signal) connections and cable-shield connections as directed in paragraphs 3.07 through 3.09; then proceed to paragraph 3.10.

Note: *Before making any connections to the 251 Mounting Assembly, ensure that power is* **off** *and modules are* **removed.** *Modules should be inserted into their Assembly positions only* **after** *all wiring is completed. For easy reference during the wiring procedure, table 3 lists each individual connection (both mandatory and optional) for each of the two 251 Systems that can be housed in a 251 Assembly. A checklist in the table's rightmost column can be filled out*

mandatory connections:
power inputs: −BAT (−44 to −56Vdc, filtered, positive ground referenced) +GND (input ground [0Vdc])
T1 lines (DS-1 message signals) (see note 1): RCV IN T&R (receive input from far end) RCV OUT T&R (receive output to near end) XMT IN T&R (transmit input from near end) XMT OUT T&R (processed transmit output to far end)
optional connections:
power inputs: FRAME GROUND
T1 lines (DS-1 message signals) (see note 1): RCV IN SH (receive input cable shield) RCV OUT SH (receive output cable shield) XMT IN SH (transmit input cable shield) XMT OUT SH (transmit output cable shield)
alarm outputs: MINOR ALARM (*Two* form-C sets of minor-alarm relay contacts are available) MAJOR ALARM (*Two* form-C sets of major-alarm relay contacts are available.)
remote control/status interface connections (made via 25-pin D-subminiature RS-232-C/V.24 connector) (see note 2): FRAME GROUND TXD (transmit data output) RXD (receive data input) RTS (request to send) CTS (clear to send) GND (signal ground) DCD (data carrier detect) DTR (data terminal ready)
Note 1: *These connections can be made either directly to the 251-Assembly backplane via wire-wrapping or to an optional Tellabs 80-0121 Twinax Connector Panel via appropriate cables.* **Note 2:** *The 251 System's remote control/status interface signals are compatible with EIA standard RS-232-C electrical characteristics and are thus suitable for serial interface with data communication equipment.*

table 2. Summary of mandatory and optional external connections to 251 System (made via 251-Assembly backplane)



INSTALLER CONNECTIONS:	FOR EACH SYSTEM:	CONNECTION TYPE:
1 DS-1 1.544Mbps PCM lines	4 pairs (shield for each pair optional)	wire-wrapping
2 input power	nominal −48Vdc, positive ground (frame ground optional)	screw-type (16 to 12AWG wire with or without spade lugs)
3 optional external alarm indications (NC-to-C closure indicates alarm; empty assembly gives both major and minor alarm indications)	2 sets of contacts for major alarm, 2 sets of contacts for minor alarm	wire-wrapping
4 optional RS-232-C remote control/status interface	one connectorized cable with 25-pin male D-subminiature RS-232-C connector on cable	25-pin female D-subminiature RS-232-C connector on assembly

figure 9. 251 Assembly backplane with installer connections indicated

(by checking the appropriate boxes) either prior to wiring to indicate the required connections for a particular application or as wiring is being done to provide a record for future reference.

input-power connections

3.07 Input-power connections to each 251 System in the 251 Assembly must be made with 16AWG or heavier wire. The screw terminals on the three-position input-power barrier strips accept 16 to 12AWG wire directly; wire terminated in appropriately sized spade lugs can also be used. Make the input-power connections to the 251 Assembly as follows:

for righthand system (as viewed from front of assembly):

A. Connect filtered, positive-ground-referenced −44 to −56Vdc input power to the *−BAT* terminal on

system	section of system	connection		barrier strip, terminal block, or connector no.	terminal or pin designation or no.	check-list
righthand (as viewed from **front** of 251 Assembly)	power inputs	input battery (−44 to −56Vdc, filtered, positive ground referenced)		P3	−BAT	
		input ground (positive)		P3	+GND	
		frame ground*		P3	FRAME	
	T1 lines (DS-1 message signals)	receive input from far end	tip	P7	RX IN T (TIP)	
			ring	P7	RX IN R (RING)	
			shield*	P7	RX IN SH (SHIELD)	
		receive output to near end	tip	P6	RX OUT T (TIP)	
			ring	P6	RX OUT R (RING)	
			shield*	P6	RX OUT SH (SHIELD)	
		transmit input from near end	tip	P8	TX IN T (TIP)	
			ring	P8	TX IN R (RING)	
			shield*	P8	TX IN SH (SHIELD)	
		processed transmit output to far end	tip	P9	TX OUT T (TIP)	
			ring	P9	TX OUT R (RING)	
			shield*	P9	TX OUT SH (SHIELD)	
	minor alarm outputs	first set of relay contacts*	normally closed	P1 (upper three pins)	MIN NC	
			common		MIN C	
			normally open		MIN NO	
		second set of relay contacts*	normally closed	P1 (lower three pins)	MIN NC	
			common		MIN C	
			normally open		MIN NO	
	major alarm outputs	first set of relay contacts*	normally closed	P2 (upper three pins)	MAJ NC	
			common		MAJ C	
			normally open		MAJ NO	
		second set of relay contacts*	normally closed	P2 (lower three pins)	MAJ NC	
			common		MAJ C	
			normally open		MAJ NO	
	remote control/status interface*†	FRAME GROUND		25-pin connector J15 (REMOTE CONTROL RS-232/V.24 DTE)	1	
		TXD (transmit data output)			2	
		RXD (receive data input)			3	
		RTS (request to send)			4	
		CTS (clear to send)			5	
		GND (signal ground)			7	
		DCD (data carrier detect)			8	
		DTR (data terminal ready)			20	
					pin numbers on connector J15 listed for reference only	

continued on next page

table 3. Wiring table: external connections to 251 Assembly backplane for righthand and lefthand 251 Systems in Assembly

system	section of system	connection		barrier strip, terminal block, or connector no.	terminal or pin designation or no.	check-list
lefthand (as viewed from **front** of 251 Assembly)	power inputs	input battery (−44 to −56Vdc, filtered, positive ground referenced)		P18	−BAT	
		input ground (positive)		P18	+GND	
		frame ground*		P18	FRAME	
	T1 lines (DS-1 message signals)	receive input from far end	tip	P13	RX IN T (TIP)	
			ring	P13	RX IN R (RING)	
			shield*	P13	RX IN SH (SHIELD)	
		receive output to near end	tip	P12	RX OUT T (TIP)	
			ring	P12	RX OUT R (RING)	
			shield*	P12	RX OUT SH (SHIELD)	
		transmit input from near end	tip	P14	TX IN T (TIP)	
			ring	P14	TX IN R (RING)	
			shield*	P14	TX IN SH (SHIELD)	
		processed transmit output to far end	tip	P15	TX OUT T (TIP)	
			ring	P15	TX OUT R (RING)	
			shield*	P15	TX OUT SH (SHIELD)	
	minor alarm outputs	first set of relay contacts*	normally closed	P17 (upper three pins)	MIN NC	
			common		MIN C	
			normally open		MIN NO	
		second set of relay contacts*	normally closed	P17 (lower three pins)	MIN NC	
			common		MIN C	
			normally open		MIN NO	
	major alarm outputs	first set of relay contacts*	normally closed	P16 (upper three pins)	MAJ NC	
			common		MAJ C	
			normally open		MAJ NO	
		second set of relay contacts*	normally closed	P16 (lower three pins)	MAJ NC	
			common		MAJ C	
			normally open		MAJ NO	
	remote control/status interface*†	FRAME GROUND TXD (transmit data output) RXD (receive data input) RTS (request to send) CTS (clear to send) GND (signal ground) DCD (data carrier detect) DTR (data terminal ready)		25-pin connector J16 (REMOTE CONTROL RS-232/V.24 DTE)	1 2 3 4 5 7 8 20 pin numbers on connector J16 listed for reference only	

*This connection or group of connections is optional.

†The 251 System's remote control/status interface signals are compatible with EIA standard RS-232-C electrical characteristics and are thus suitable for serial interface with data communication equipment (DCE).

table 3. Wiring table: external connections to 251 Assembly backplane for righthand and lefthand 251 Systems in Assembly

barrier strip *P3* (located at the lower lefthand corner of the assembly as viewed from the back).

B. Connect positive ground to the *+GND* terminal on barrier strip *P3*.

C. Connect optional frame ground (if used) to the *FRAME* terminal on barrier strip *P3*.

for lefthand system (as viewed from front of assembly):

D. Repeat steps A through C but make connections to barrier strip *P18* (located at the lower righthand corner of the assembly as viewed from the back) instead of *P3*.

facility (signal) connections (without twinax connector panels)

3.08 For each of the two systems the 251 Assembly can house, four three-pin terminal blocks are provided on the Assembly's backplane for connection to the 1.544Mbps, 100-ohm PCM lines. Connections between the Assembly and the DX-1 cross-connect frame should be made with 22AWG twisted-pair shielded cable. Separate receive input, receive output, transmit input, and transmit output cables are recommended. If cables containing multiple twisted pairs with a common shield are used, ensure that the transmit input (TX IN) and receive input (RX IN) pairs are in a different cable than the transmit output (TX OUT) and receive output (RX OUT) pairs. This will prevent crosstalk between the high-level (3 to 6V peak) regenerated output signals from the system and the low-level (1.5 to 3V peak) input signals. Depending upon the CO equalizers used (see paragraph 3.03), the maximum permissible length of 22AWG cable between the Assembly and the DX-1 cross-connect frame is 650 feet (198 meters). If this distance restriction cannot be met, heavier cable must be used. In extreme cases, an intraoffice span (i.e., an intraoffice repeater line) can be used. Make the facility (signal) connections (by wire-wrapping) as follows:

Note: *To accommodate a wide range of office installation methods, the* **SHIELD** *wire-wrapping pins on PCM-line terminal blocks* **P6** *through* **P9** *and* **P12** *through* **P15** *are provided as tie points only. These pins are* **not** *connected to frame ground (as might be assumed due to the frame-ground symbol on the 251-Assembly backplane adjacent to those pins). This symbol merely indicates that grounding connections may be made, if desired, by connecting jumpers from the* **SHIELD** *wire-wrapping pins to the* **FRAME** *(frame ground) terminals on terminal strips* **P3** *and* **P18**. *The only prewired connections to the* **SHIELD** *pins are as follows:*

RX OUT SH *on* **P6** *to* **RX IN SH** *on* **P7**
TX IN SH *on* **P8** *to* **TX OUT SH** *on* **P9**
RX OUT SH *on* **P12** *to* **RX IN SH** *on* **P13**
TX IN SH *on* **P14** *to* **TX OUT SH** *on* **P15**

for righthand system (as viewed from front of assembly):

A. Connect the receive input tip lead to pin *RX IN T* and the receive input ring lead to pin *RX IN R* of terminal block *P7*.

B. Connect the receive input cable shield (if present) to pin *RX IN SH* of terminal block *P7*.

C. Connect the receive output tip lead to pin *RX OUT T* and the receive output ring lead to pin *RX OUT R* of terminal block *P6*.

D. Connect the receive output cable shield (if present) to pin *RX OUT SH* of terminal block *P6*.

E. Connect the transmit input tip lead to pin *TX IN T* and the transmit input ring lead to pin *TX IN R* of terminal block *P8*.

F. Connect the transmit input cable shield (if present) to pin *TX IN SH* of terminal block *P8*.

G. Connect the transmit output tip lead to pin *TX OUT T* and the transmit output ring lead to pin *TX OUT R* of terminal block *P9*.

H. Connect the transmit output cable shield (if present) to pin *TX OUT SH* of terminal block *P9*.

for lefthand system (as viewed from front of assembly):

I. Connect the receive input tip lead to pin *RX IN T* and the receive input ring lead to pin *RX IN R* of terminal block *P13*.

J. Connect the receive input cable shield (if present) to pin *RX IN SH* of terminal block *P13*.

K. Connect the receive output tip lead to pin *RX OUT T* and the receive output ring lead to pin *RX OUT R* of terminal block *P12*.

L. Connect the receive output cable shield (if present) to pin *RX OUT SH* of terminal block *P12*.

M. Connect the transmit input tip lead to pin *TX IN T* and the transmit input ring lead to pin *TX IN R* of terminal block *P14*.

N. Connect the transmit input cable shield (if present) to pin *TX IN SH* of terminal block *P14*.

O. Connect the transmit output tip lead to pin *TX OUT T* and the transmit output ring lead to pin *TX OUT R* of terminal block *P15*.

P. Connect the transmit output cable shield (if present) to pin *TX OUT SH* of terminal block *P15*.

alarm connections

3.09 For each of the two systems that can be housed in a 251 Assembly, two sets of minor-alarm and two sets of major-alarm relay contacts are provided for external alarm indications. Each set of relay contacts consists of a normally closed (NC) contact, a common (C) contact, and a normally open (NO) contact. Normal conditions are indicated by a closure between the NO and C contacts, and alarm conditions are indicated by a closure between the NC and C contacts. If external alarm indications are desired, make the connections (by wire-wrapping) as follows:

Note: *Before the 6953 Power Supply and Alarm Module for a 251 System is inserted into its assembly position, alarms will be indicated by all four sets of alarm contacts for that system.*

for righthand system (as viewed from front of assembly):

A. For external minor-alarm indications, make the appropriate alarm-device connections to one or both sets of NC, C, and NO pins on *ALARMS MIN* terminal block *P1*.

B. For external major-alarm indications, make the appropriate alarm-device connections to one or both sets of NC, C, and NO pins on *ALARMS MAJ* terminal block *P2*.

for lefthand system (as viewed from front of assembly):

C. For external minor-alarm indications, make the appropriate alarm-device connections to one or both sets of NC, C, and NO pins on *ALARMS MIN* terminal block *P17*.
D. For external major-alarm indications, make the appropriate alarm-device connections to one or both sets of NC, C, and NO pins on *ALARMS MAJ* terminal block *P16*.

facility (signal) connctions via optional twinax connector panels

3.10 For 251 Assemblies whose backplanes are equipped with the optional 80-0121 Twinax Connector Panels (two per Assembly), T1 (DS-1) PCM facility connections to each System are quickly and easily made via the four concentric twinax connectors on the appropriate panel (see figures 10 and 11). Make these connections as follows:

for righthand system (as viewed from front of assembly:

A. Connect the receive input twinax cable to connector *J1* (*RX IN*) on the twinax connector panel for *DIGITAL ECHO CANCELLER SYSTEM A.* This panel is located to the immediate left of three-pin terminal blocks *P6* through *P9* as viewed from the **rear** of the assembly.
B. Connect the receive output twinax cable to connector *J2* (*RX OUT*) on the twinax connector panel for *DIGITAL ECHO CANCELLER SYSTEM A.*
C. Connect the transmit input twinax cable to connector *J3* (*TX IN*) on the twinax connector panel for *DIGITAL ECHO CANCELLER SYSTEM A.*
D. Connect the transmit output twinax cable to connector *J4* (*TX OUT*) on the twinax connector panel for *DIGITAL ECHO CANCELLER SYSTEM A.*

for lefthand system (as viewed from front of assembly):

E. Connect the receive input twinax cable to connector *J1* (*RX IN*) on the twinax connector panel for *DIGITAL ECHO CANCELLER SYSTEM B.* This panel is located to the immediate left of three-pin terminal blocks *P12* through *P15* as viewed from the **rear** of the Assembly.
F. Connect the receive output twinax cable to connector *J2* (*RX OUT*) on the twinax connector panel for *DIGITAL ECHO CANCELLER SYSTEM B.*
G. Connect the transmit input twinax cable to connector *J3* (*TX IN*) on the twinax connector panel for *DIGITAL ECHO CANCELLER SYSTEM B.*
H. Connect the transmit output twinax cable to connector *J4* (*TX OUT*) on the twinax connector panel for *DIGITAL ECHO CANCELLER SYSTEM B.*

remote control/status interface connections (general)

3.11 Each of the two 251 Systems in a 251 Assembly can be optionally controlled via an RS-232-C serial interface. This is accomplished via one 25-pin female D-subminiature connector for each System on the 251 Assembly's backplane. In addition, the 251 System is designed so that up to 32 systems can be "daisy-chained" together on the same cable, thereby minimizing the number of RS-232-C ports required to control a large number of 251 Systems. Make the

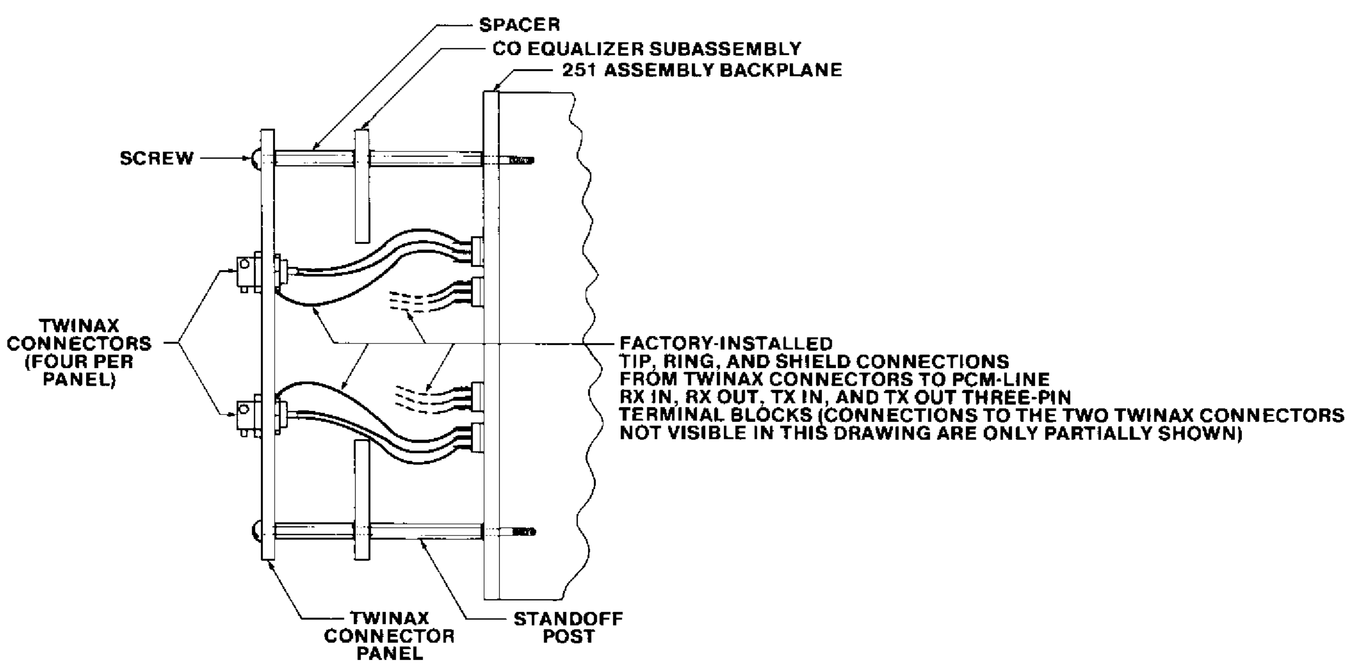


figure 10. Side view of 80-0121 Twinax Connector Panel showing its installation over CO equalizer subassemblies on 251 Assembly backplane

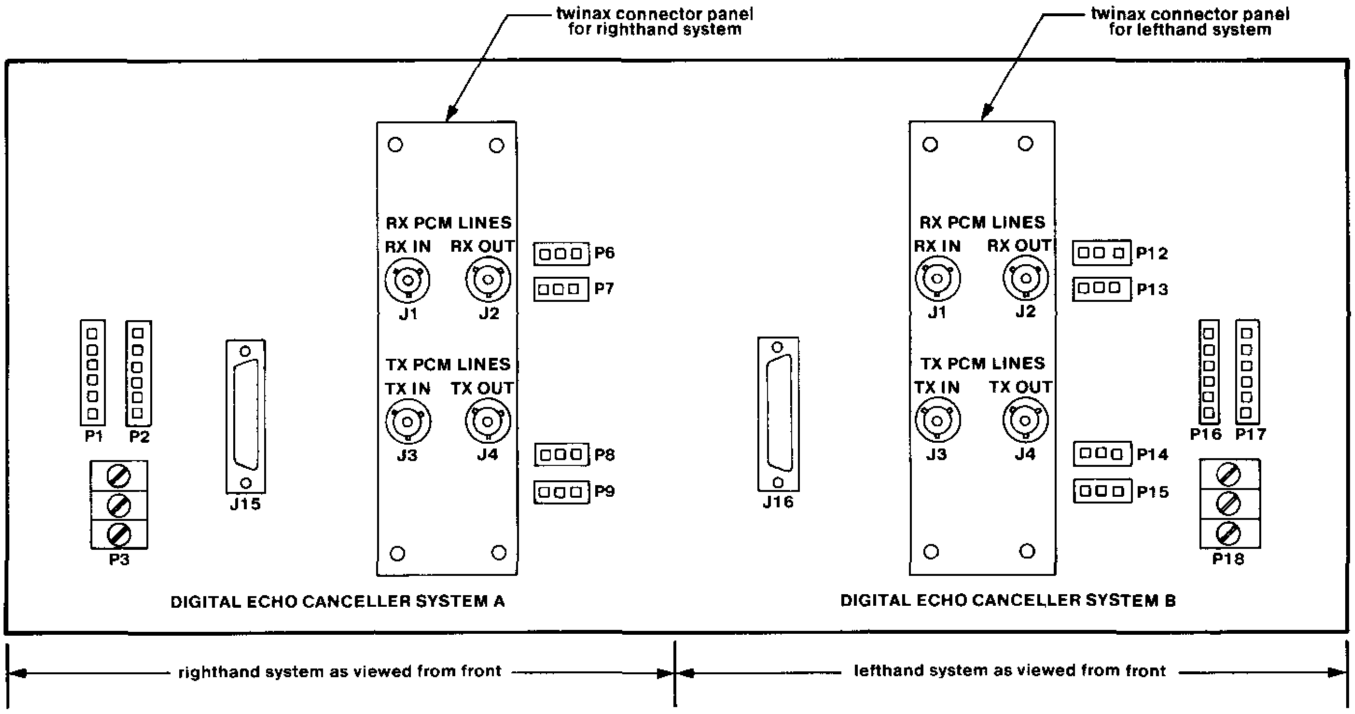


figure 11. 251 Assembly backplane with optional 80-0121 Twinax Connector Panels (for simplicity, some backplane details and designations are omitted and presence of CO equalizer subassemblies under connector panels is not indicated)

remote control/status interface connections to the 251 Assembly as follows:

Note 1: *Should you require detailed information on single-system and multiple-system (daisy-chain) connections, such information follows these basic instructions.*

Note 2: *For connection to data terminal equipment (DTE), the cable must contain a null-modem adapter. See paragraph 3.13.*

for righthand system (as viewed from front of assembly):

A. Plug an appropriate 25-pin male D-subminiature connector from the data communication equipment (DCE) or data terminal equipment (DTE) into *REMOTE CONTROL RS232/V.24 DTE* connector *J15* on the 251 Assembly's backplane.

for lefthand system (as viewed from front of assembly):

B. Plug an appropriate 25-pin male D-subminiature connector from the data communications equipment (DCE) or data terminal equipment (DTE) into *REMOTE CONTROL RS232/V.24 DTE* connector *J16* on the 251 Assembly's backplane.

remote control/status interface connections for single 251 System

3.12 **Connection to DCE.** The 251 System contains the necessary interface circuits for connections to a customer's data communication equipment (DCE). These connections, along with their circuit designations and corresponding pin numbers on each of the 251 Assembly's 25-pin female *REMOTE CONTROL RS232/V.24 DTE* connectors, are listed in table 4.

connection (signal)	EIA RS-232-C circuit designation	CCITT V.24 circuit designation	251-Assembly RS-232-C 25D connector pin no.
protective ground (frame or earth)	AA	101	1
transmitted data (TXD)	BA	103	2
received data (RXD)	BB	104	3
request to send (RTS)	CA	105	4
clear to send (CTS)	CB	106	5
signal ground (common return)	AB	102	7
received line signal detector (DCD)	CF	109	8
data terminal ready (DTR)	CD	108.2	20

table 4. RS-232-C interface connector pin assignments

Connection names and abbreviations are in accordance with EIA standard RS-232-C. Pin numbers not listed have no connections.

3.13 **Connection to DTE.** The 251 System, which itself is data terminal equipment (DTE), requires a null modem for connection to other (e.g., a customer's) DTE. The required null-modem wiring is shown in figure 6 in section 2 of this Practice.

remote control/status interface connection of multiple 251 Systems

3.14 A special *daisy-chain* cable with multiple 25-pin male RS-232-C connectors is required for remote control/status interface connection of multiple 251 Systems. Up to 32 Systems can be controlled via a single RS-232-C serial link. There are two types of daisy-chain cable: DTE and DCE. The DTE daisy-chain cable (see figure 7 in section 2 of this Practice) interfaces the daisy-chained 251 Systems with DTE; this type of cable contains an integral null modem adapter. The DCE daisy-chain cable (see figure 8 in section 2 of this Practice) interfaces the daisy-chained 251 Systems with DCE. The DCE and DTE daisy-chain cables can themselves be daisy-chained if appropriate connectors and/or adapters are used.

Note: *If the 6954 Control Interface Module of any 251 System in a daisy-chain arrangement is removed, shorting contacts in the 251 Assembly close to bypass that 251 System in the daisy chain. These shorting contacts are provided for the RXD-to-TXD and DCD-to-DTR connections on the 251 Assembly's 25-pin female RS-232-C connectors.*

module insertion

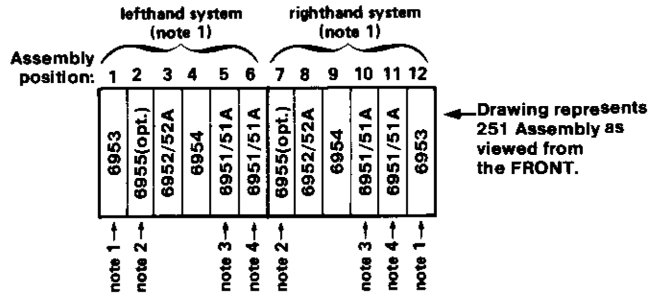
Caution: *Before inserting any modules into the 251 Assembly, remove the 1⅓-ampere GMT-type fuse from the fuse holder on the front panel of each of the two 6953 Power Supply and Alarm Modules to be installed in the Assembly.*

3.15 A single 251 System is housed in one half (six module positions)of the 251 Mounting Assembly. Thus, one Assembly can house two complete 251 Systems, one in module positions 1 through 6 and the other in module positions 7 through 12. Each module of the 251 System plugs physically and electrically into a connector at the rear of its Assembly position, and each Assembly position is dedicated with respect to the particular module that it houses. Module-position assignments are clearly indicated on the Assembly. Figure 12 shows the mandatory module arrangements for both Systems in a 251 Assembly. **Please observe that the module arrangement is different for each of the two Systems because the 6953 modules occupy the first and twelfth module positions in the Assembly** rather than the first and seventh. This arrangement (power supplies at opposite ends of the Assembly) results in better heat dissipation for longer component life. Insert the modules for each 251 System into the Assembly as follows:

A. Ensure that the front-panel GMT-type fuse is removed from each 6953 Power Supply and Alarm Module to be used in the 251 Assembly.

B. Insert each 6953 module into its proper Assembly position (position 1 for the lefthand System, position 12 for the righthand System). (By inserting the 6953 modules first, the chance of installing other modules in the wrong positions is reduced.)

C. For each System in the Assembly, insert the remaining modules into their proper Assembly positions as shown in figure 12.



Notes:
1. Please be aware that the module arrangement is different for each System in the Assembly and that the 6953 modules occupy the Assembly's **first** and **twelfth** module positions.
2. The 6955 is optional; the 6900A Blank Type 16 Module (also optional) can be used to fill the empty module position if the 6955 is not needed.
3. These 6951's or 6951A's serve channels 1 through 12 of their respective Systems.
4. These 6951's or 6951A's serve channels 13 through 24 of their respective Systems.

figure 12. 251-System module arrangement for both Systems in a 251 Assembly

D. Doublecheck that all modules are installed in their correct positions and firmly seated in their connectors.

E. Apply power to each 251 System in the Assembly by reinserting the GMT-type fuse into its holder on the front panel of the system's 6953 module.

Caution: *Before inserting a 6953 module into or removing a 6953 module from its position in the 251 Assembly,* **be certain to remove the 6953's front-panel fuse** *so that power is not applied to the System during the module's insertion or removal. All other modules may be safely inserted into or removed from the 251 Assembly with power applied to the System. This means that 6951 or 6951A Channel Unit Modules and the 6954 Control Interface Module can be replaced without interrupting transmission on the transmit and receive T1 (DS-1) PCM lines. Only the 6953 Power Supply and Alarm Module and the 6952 or 6952A Network Interface Module need be operating for transmission continuity to exist through the 251 System.*

initial power-on sequence

3.16 When a 251 System is initially connected to its nominal −48Vdc power source, the 6953's *power* LED should light steadily, and all *control* and *status* LED's on the 6954 as well as the *major alarm* LED on the 6953 should light briefly and then go off. In addition, the numbers *8.8.8.* should appear briefly in the 6954's *channel* LED display; the display should then go blank. On the 6952 or 6952A module, all four

LED's should also light. The two red *local* LED's should go off after a few seconds; the two yellow *remote* LED's may, however, remain lighted for up to approximately 18 seconds before going off. If one or both of the 6952's or 6952A's red *local* LED's remain lighted for more than approximately 18 seconds, refer to section 9 of this Practice for testing and troubleshooting information. If a two-digit channel number (with each digit followed by a decimal point) remains in the 6954's *channel* LED display and/or if any of the 6954's *control* or *status* LED's remain lighted after the System is initially powered up, proceed as follows:

A. Wait 20 seconds. If the *channel* display does not clear and the other LED's do not go off automatically, proceed to step B.
B. Momentarily depress the *advance* pushbutton once. The *channel* display should indicate *00* and all lighted *control* LED's should go off. If any *control* LED remains on, momentarily depress its corresponding *control* pushbutton to turn it off. Proceed to step C.
C. Momentarily depress the *advance* pushbutton 24 times to advance the channel numbers from *01* through *24*. When *24* is displayed, momentarily depress the *advance* pushbutton one more time. The channel display should go blank. If it does not, and/or if any *control* LED's cannot be turned off, refer to section 9 of this Practice for testing and troubleshooting information.

self-test checkout

3.17 If the *channel* LED display and all *control* LED's on the 6954 module go off after lighting briefly upon initial power-up or after the above steps are performed, all 24 channels of the 251 System pass the automatic self-testing routine. To verify that the self-test program functions properly, proceed as follows:

A. Depress the 6954's *advance* pushbutton to select any desired channel (as indicated in the *channel* LED display).
B. Momentarily depress the 6954's *bypass* pushbutton. The *bypass* LED should light and remain on.
C. Momentarily depress the 6954's *H reset* pushbutton. The *H reset* LED should light and remain on. After a delay of approximately 1 minute, the 6954's *test fail* LED and the 6953's *minor alarm* LED should both light.
D. Momentarily depress the 6954's *H reset* pushbutton once again. The *H reset* LED should go off immediately, and the 6954's *test fail* LED and the 6953's *minor alarm* LED should go off after a maximum delay of approximately 18 seconds. If any of these three LED's remain lighted, refer to section 9 of this Practice for testing and troubleshooting information.
E. Depress the 6954's *bypass* pushbutton once again to take the System out of the bypass mode (the *bypass* LED should go off).

4. local system control

4.01 Pushbutton switches and LED's on the 6954 Control Interface Module's front panel (figure 2) provide the means for programming both System and individual-channel operating parameters. The selected parameters are stored in a special nonvolatile memory that retains all stored information even if power to the 251 System is removed or fails. This section describes the procedures for programming System and individual-channel operating parameters via the 6954 module's front panel. Refer to paragraphs 2.05 through 2.07 for brief descriptions of the functions of the 6954's front-panel pushbuttons and displays.

system operating parameters

4.02 The following System operating parameters can be programmed via the 6954 module's front panel: (1) data-transfer rate for the RS-232-C remote control/status interface port, (2) display timeout, (3) System unit number, and (4) number of consecutive self-test failures before an alarm indication. Paragraphs 4.03 through 4.08 contain the procedures for programming these System operating parameters. The 251 System is shipped from Tellabs with its parameters factory-programmed as indicated in table 5.

Note. *In each of the procedures below, it is assumed that only one System operating parameter is being programmed. If more than one parameter is being programmed, refer to paragraph 4.08.*

parameter	selection	6954 *channel* display indication
data-transfer rate for RS-232-C remote control/ interface port	300bps	103
6954 *channel* display and LED timeout	timeout in effect	201
System unit number	1	301
number of self-test failures before alarm	3	403

table 5. Factory-programmed (at time of shipment from Tellabs) 251-System parameters

4.03 **Resetting the 6954 Control Interface Module.** The following procedures require that the 6954 module's front-panel *channel* display be blank before beginning the procedure. To reset the 6954 module to this state, proceed as follows:

A. If a two-digit number (see note) is displayed in the 6954 module's front-panel *channel* display, depress the front-panel *advance* pushbutton until the *channel* display goes blank. Holding the *advance* pushbutton depressed causes the displayed number to be incremented approximately 4 times per second. After *24* is displayed, the next increment blanks the display. Resetting is then complete.
Note: *A two-digit number with a decimal point to the right of each number indicates a self-test failure. It is not necessary to clear such indications before proceeding with the following procedures. Procedures for clearing self-test failures are included in section 9 of this Practice.*
B. If a three-digit number is displayed in the *channel* display, hold the *H hold* pushbutton depressed while

you momentarily depress the *advance* pushbutton once. Repeat this until the *channel* display goes blank. Resetting is then complete.

4.04 **Data-Transfer Rate for Remote Control/ Status Interface Port.** To program the data-transfer rate for the RS-232-C remote control/status interface port, proceed as follows:

A. Reset the 6954 module as described in paragraph 4.03.
B. While holding the *H hold* pushbutton depressed, momentarily depress the *advance* pushbutton once. Then release the *H hold* pushbutton. A three-digit number with a *1* in the leftmost position should appear in the *channel* display. The *1* denotes the first System operating parameter.
C. Determine the desired data-transfer rate for the remote control/status interface port. Then refer to table 6 to determine the corresponding *channel* display contents.

data-transfer rate (bits per second)	6954 *channel* display indication
300	103
600	106
1200	112
2400	124
4800	148
9600	196

table 6. Data-transfer-rate programming for remote control/status interface port

D. If the *channel* display contents corresponding to the desired rate (in bps) are already present in the *channel* display, proceed directly to step E. Otherwise, depress the *advance* pushbutton to advance to the next rate. Repeat this until the desired *channel* display contents appear.
E. Reset the 6954 module as described in paragraph 4.03B.

4.05 **Display Timeout.** The 6954 module can be configured so that its LED's turn off approximately 1 minute after the last *control* pushbutton is depressed. To enable or disable this feature, proceed as follows:

A. Reset the 6954 module as described in paragraph 4.03.
B. While holding the *H hold* pushbutton depressed, momentarily depress the *advance* pushbutton twice. Then release the *H hold* pushbutton. A three-digit number with a *2* in the leftmost position should appear in the *channel* display. The *2* denotes the second System operating parameter.
C. If the *channel* display contents are *201*, display timeout is enabled; if the *channel* display contents are *202*, display timeout is disabled. Depress the *advance* pushbutton until the desired contents appear in the *channel* display (each time the *advance* pushbutton is depressed, the alternate contents appear).
D. Reset the 6954 module as described in paragraph 4.03B.

4.06 **System Unit Number.** When the System is to be programmed or monitored via the remote control/ status interface, a System unit number (1 to 32) is sent to address the desired System (recall that multiple Systems can be interfaced to one remote interface serial link). To assign a System unit number, proceed as follows:

A. Reset the 6954 module as described in paragraph 4.03.
B. While holding the *H hold* pushbutton depressed, momentarily depress the *advance* pushbutton three times. Then release the *H hold* pushbutton. A three-digit number with a *3* in the leftmost position should appear in the *channel* display. The *3* denotes the third System operating parameter.
C. Depress the *advance* pushbutton until the desired System unit number (01 to 32) appears in the two rightmost digits of the *channel* display. Holding the *advance* pushbutton depressed causes the displayed number to be incremented approximately 4 times per second.
   Note: *For multiple Systems daisy-chained to a single remote control/status interface link, each System must be assigned a unique System unit number.*
D. Reset the 6954 module as described in paragraph 4.03B.

4.07 **Number of Self-Test Failures for Alarm.** The System can be programmed to generate an alarm after a specified number (one to six) of consecutive self-test failures. (For most applications, two failures is an adequate number.) To program the number of consecutive self-test failures required before an alarm is generated, proceed as follows:

A. Reset the 6954 module as described in paragraph 4.03B.
B. While holding the *H hold* pushbutton depressed, momentarily depress the *advance* pushbutton four times. Then release the *H hold* pushbutton. A three-digit number with a *4* in the leftmost position should appear in the channel display. The *4* denotes the fourth System operating parameter.
C. Depress the *advance* pushbutton until the desired number of consecutive self-test failures before an alarm appears in the rightmost digit of the *channel* display. Holding the *advance* pushbutton depressed causes the displayed number to be incremented approximately 4 times per second.
D. Reset the 6954 module as described in paragraph 4.03B.

4.08 **Programming Multiple System Operating Parameters.** In each of the preceding procedures for programming System operating parameters, it is assumed that only one parameter is being programmed. If more than one parameter is being programmed, it is not necessary to reset the 6954 module (as described in paragraph 4.03B) after each parameter is programmed. After programming one parameter, hold the *H hold* pushbutton depressed and momentarily depress the *advance* pushbutton until the leftmost digit of the *channel* display advances to the number corresponding to the next parameter to be programmed. Then release the *H hold* pushbutton. After all desired parameters have been programmed, reset the 6954 module as described in paragraph 4.03B.

channel operating parameters

4.09 The following operating parameters can be programmed individually for each channel via the 6954 module's front panel: (1) *bypass*, (2) *off hook*, (3) *canceller only*, (4) *H reset*, and (5) *H hold*. Refer to paragraph 2.07 for descriptions of these parameters. Associated with each of the channel operating parameters is a *control* pushbutton used to enable or disable the parameter and a *control* LED that indicates the status of the parameter.

4.10 In addition to the *control* LED's, two *status* LED's are provided on the 6954 module's front panel. The *status test fail* LED lights when a channel fails self-testing; refer to section 9 of this Practice for details on interpreting the status of this LED and the *channel* display. The *status bypass* LED lights when the channel whose number is displayed in the *channel* display is effectively bypassed. It is important to recognize the difference between the *control bypass* and *status bypass* LED's. The *control bypass* LED lights only when a channel is bypassed by selecting the corresponding *control bypass* parameter. The *status bypass* LED lights when a channel is effectively bypassed. A channel is effectively bypassed under any of the following conditions:

A. The channel is on-hook.
B. The channel's *control bypass* parameter is selected.
C. The channel's *H reset* parameter is selected.
D. The channel is bypassed upon receipt of data-disable tone.

4.11 To examine or to program channel parameters, proceed as follows:

A. Reset the 6954 module as described in paragraph 4.03.
B. Depress the *advance* pushbutton until the desired channel number appears in the *channel* display. Holding the *advance* pushbutton depressed causes the displayed number to be incremented approximately 4 times per second. If the programming is to be performed simultaneously on all channels, select channel number *00*. After the desired channel number is displayed in the *channel* display, the *control* and *status* LED's indicate the existing programming and status for the channel. A lighted *control* LED indicates that the corresponding parameter is selected.
C. To select a parameter, depress the corresponding *control* pushbutton once. To cancel a selected parameter, depress the pushbutton a second time.
D. Repeat steps B and C for any other channels to be programmed.
E. Reset the 6954 module as described in paragraph 4.03A.

5. remote system control

5.01 The 251 System can, if desired, be controlled from a remote location via a remote control/status interface that uses a serial data format compatible with EIA standard RS-232-C. All channel-related control functions and status indications available via the 6954 Control Interface Module's front-panel pushbuttons and LED's are also available via the remote control/status interface. This section describes the protocol for remote system control. Refer to paragraphs 2.11 through 2.13 for typical remote interface configurations.

remote interface protocol

5.02 **Serial Link Protocol.** The remote interface serial link is an RS-232-C full-duplex asynchronous link that uses seven-bit ASCII characters with one start bit, one stop bit, and one even-parity bit. Serial link speed can be 300, 600, 1200, 2400, 4800, or 9600bps; the selected speed must be programmed into the 6954 module (see paragraph 4.04). The 251 System echoes all characters received; therefore, the controlling terminal or computer should be configured for remote echoplex operation.

5.03 **Command Protocol.** All remote-control commands consist of a sequence of four ASCII characters. The first character sent is the ASCII-encoded System unit number of the System to be controlled. Table 7 lists the ASCII characters corresponding to each System unit number. System unit numbers are assigned via the 6954 module's front-panel controls (see paragraph 4.06). For example, if System unit 2Ø is to be the target of a remote-control command, the first character of the four-character sequence would be a *t*. The second and third characters sent are the channel number of the channel to be controlled. For example, if channel 7 is to be controlled, the second character of the four-character sequence would be *Ø* and the third character would be *7*. The fourth character sent is the command key; command keys are listed in table 8 and described further in paragraphs 5.05 through 5.11.

System unit number	ASCII	hex	System unit number	ASCII	hex
1	a	61	17	q	71
2	b	62	18	r	72
3	c	63	19	s	73
4	d	64	2Ø	t	74
5	e	65	21	u	75
6	f	66	22	v	76
7	g	67	23	w	77
8	h	68	24	x	78
9	i	69	25	y	79
10	j	6A	26	z	7A
11	k	6B	27	{	7B
12	l	6C	28	|	7C
13	m	6D	29	}	7D
14	n	6E	3Ø	~	7E
15	o	6F	31	DEL	7F
16	p	7Ø	32	`	6Ø

table 7. System unit number codes

5.04 Remote commands are of two types: control commands and status-request commands. Control commands cause reconfiguration of the specified channel. Status-request commands simply monitor the existing configuration. When a control command is sent, the targeted 251 System returns an *ACK* character (Ø6 hexadecimal) if the command is legal or a *NAK* character (15 hex) if the command is illegal. Neither an *ACK* nor a *NAK* is returned in response to status commands; only the status information is returned.

remote control commands

5.05 **Control Commands.** Table 8 lists the remote interface control commands. The *bypass*, *off hook*, *canceller only*, *H reset*, and *H hold* commands are equivalent to the functions controlled by the 6954 module's front-panel *control* pushbuttons. For example, if the *canceller only* parameter is to be selected, the required command is *C*. If the *canceller only* parameter selection is to be cancelled, the required command is *D*.

5.06 The *CCS off hook* and *CCS on hook* commands are provided to allow a common-channel signaling (CCS) processor to override the normal T1 signaling. The *CCS off hook* command (*U* character) forces an off-hook condition, and the *CCS on hook* command (*W* character) forces an on-hook condition; both conditions remain in effect until cancelled with a *V* character, which restores the channel busy/idle status control to the signaling bits.

5.07 **Status Commands.** Table 8 lists the remote interface status commands. The *channel status* command (*S* character) provides a means of effectively reading the 6954 module's front-panel LED's. When

command type	command	ON*	OFF*
control commands	bypass**	B (42)	A (41)
	off hook**	N (4E)	O (4F)
	canceller only**	C (43)	D (44)
	H reset**	R (52)	Q (51)
	H hold**	H (48)	I (49)
	CCS off hook	U (55)	V (56)
	CCS on hook	W (57)	V (56)
status commands	channel status	S (53)	–
	self-test result	T (54)	–
	bypass status (all channels)	E (45)	–
	T1 signaling status (all channels)	J (4A)	–
	CCS status	Y (59)	–

**The command keys are in ASCII; hexadecimal equivalents are given in parentheses.*
***This command is equivalent to the 6954 module's corresponding* **control** *pushbutton.*

table 8. Remote interface command keys

the *S* command is entered, the targeted 251 System first returns the System unit number and channel number (using the protocol described in paragraph 5.03). The 251 System then returns two hex-coded characters that contain the status information. To interpret this information, first take the first character as a hex digit, convert it to binary, and map it into the high-order four bits of the bit map in figure 11. Then take the second character as a hex digit, convert it to binary, and map it into the low-order four bits of the bit map in figure 11. For example, if the status characters are *D* followed by *1*, the bit map is *11Ø1ØØØ1*. Figure 11 shows the bit definitions for the bit map. Logic 1 indicates that the corresponding 6954 front-panel LED is lighted; logic Ø indicates that it is off.

5.08 The *self-test result* command (*T* character) provides a means of determining whether a channel passes self-testing. When the *T* command is entered with a channel specified, the 251 System first returns the System unit number and channel number (using the protocol described in paragraph 5.03). The 251 System then returns a *P* character if the channel passes self-testing or an *F* character if the channel fails self-testing. If the *T* command is entered with channel ØØ specified, the 251 System returns, instead of a single *P* or *F* character, six hex-coded characters that contain the self-test status for **all** channels. To interpret this information, take the first character as a hex digit, convert it to binary, and map it into the first character position in the bit map in figure 12. Then, using the appropriate character positions, repeat this for the remaining five characters. The correspondence between bit position and channel number is shown in the figure. A logic 1 indicates a self-test failure; a logic Ø indicates a self-test pass.

first hex-coded character (high-order four bits)				second hex-coded character (low-order four bits)			
bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit Ø
status bypass	control bypass	off-hook	canclr only	H reset	H hold	–	test fail

logic 1 = ON logic Ø = OFF

figure 11. Bit map for channel status (S) command

5.09 The *bypass status* command (*E* character) provides a means of determining whether channels are effectively bypassed. When the *E* command is entered (channel number ØØ must be specified), the 251 System first returns the System unit number and channel number (using the protocol described in paragraph 5.03). The 251 System then returns six hex-coded characters that contain the bypass status for all channels. To interpret this information, take the first character as a hex digit, convert it to binary, and map it into the first character position in the bit map in figure 12. Then, using the appropriate character positions, repeat this for the remaining five characters. The correspondence between bit position and channel number is shown in the figure. A logic 1 indicates that the channel is effectively bypassed; a logic Ø indicates that it is not bypassed.

	first hex-coded character				second hex-coded character				third hex-coded character				fourth hex-coded character				fifth hex-coded character				sixth hex-coded character			
bit position	23	22	21	2Ø	19	18	17	16	15	14	13	12	11	1Ø	9	8	7	6	5	4	3	2	1	Ø
channel number	4	3	2	1	8	7	6	5	12	11	1Ø	9	16	15	14	13	2Ø	19	18	17	24	23	22	21

logic 1 = self-test failure, bypass, or off-hook
logic Ø = self-test pass, no bypass, or on-hook

figure 12. Bit map for self-test status (T), bypass status (E), and T1 signaling status (J) commands

5.10 The *T1 signaling status* command (*J* character) provides a means of determining channels' on-hook/off-hook status. When the *J* command is entered (channel ØØ must be specified), the 251 System first returns the System unit number and channel number (using the protocol described in paragraph 5.03). The 251 System then returns six hex-coded characters that contain the on-hook/off-hook status for **all** channels. To interpret this information, take the first character as a hex digit, convert it to binary, and map it into the first character position in the bit map in figure 12. Then, using the appropriate character positions, repeat this for the next five characters. The correspondence between bit position and channel number is shown in the figure. A logic 1 indicates that the channel is off-hook; a logic Ø indicates that it is on-hook.

5.11 The *CCS status* command (*Y* character) provides a means of determining whether the T1 signaling is overridden by a *CCS off hook* (*U*) or *CCS on hook* (*W*) command. When the *Y* command is entered, the 251 System first returns the System unit number and channel number (using the protocol described in paragraph 5.03). The 251 System then returns a single ASCII character to indicate the CCS status, as follows:

L: indicates that *CCS on hook* is in effect.
M: indicates that *CCS off hook* is in effect.
E: indicates that both *CCS on hook* and *CCS off hook* are off; T1 signaling is in effect.

command examples

5.12 To illustrate command usage, the following three examples are provided:

Example 1: To force channel 12 of System unit 5 off-hook, send the following characters in the order given: *e, 1, 2, N*. The 251 System returns an *ACK* character (Ø6 hex).

Example 2: To read channel status for channel 8 of System unit 17, send the following characters in the order given: *q, Ø, 8, S*. The 251 System returns the following characters: *q, Ø, 8, D, 1*. The corresponding status bit map is *11Ø1ØØØ1*, indicating that channel 8 is in manual bypass, the *canceller only* parameter is set, and the channel fails self-testing (see figure 11).

Example 3: To obtain the bypass status for all channels of Sytem unit 4, send the following characters in the order given: *d, Ø, Ø, E*. The 251 System returns the following characters: *d, Ø, Ø, F, Ø, A, 5, 1, 8*. The corresponding bypass bit map is *1111ØØØØ1Ø1ØØ1Ø1ØØØ11 ØØØ*, indicating that the following channels are bypassed: 1, 2, 3, 4, 1Ø, 12, 13, 15, 17, and 24 (refer to figure 12).

6. system circuit description

6.01 This circuit description is intended to familiarize you with the 251 24-Channel Echo Canceller System for application and engineering purposes only. Attempts to troubleshoot the 251-System modules or the 251 Mounting Assembly internally are not recommended and may void your Tellabs warranty. Please refer to the associated 251-System block diagrams, section 7 of this Practice, as an aid in understanding the circuit description.

6.02 The 251 System is a split-type echo canceller system that is located at or near the end points of primary digital multiplexing equipment commonly known as *T1* lines. The transmit-path pulse-code-modulation (PCM) signals from the near-end circuits are processed by the 251 System to remove any echo caused by associated near-end analog channel circuits.

6.03 The receive PCM line is received and regenerated by the 251 System and is used to calculate the echo-estimate signals required for cancelling echoes in the transmit path. The 251-System connection to this line is used only to recover a local copy of the digital speech signals in this path. Thus, no delays are added to and no processing is performed on the receive-path signals.

transmit path

6.04 The transmit-input signal is a 1.544-megabit-per-second serial stream in a bipolar alternate-mark-inversion (AMI) format. Twenty-four channels of digitized voice are multiplexed together in this serial stream. The digitized signals in each transmit channel consist of any near-end speech that is present plus echo signals from the associated receive channel.

6.05 The transmit-input bit stream first goes through the *clock recovery Y* circuitry on the 6952 or 6952A Network Interface Module to recover clock and timing information. The bit stream is then converted into a unipolar transistor-transistor logic (TTL) format. Framing information is also recovered from this bit stream to uniquely identify the digital speech signals for each channel. In addition, the transmit-input bit stream supplies the 251 System with master timing and synchronization (*master timing and framing circuit*).

6.06 To determine the on-hook/off-hook state of a particular channel, *signaling-bit receivers* are connected to the transmit and receive bit streams. These *signaling-bit receivers* are read by the 251 System's microprocessor and used to determine the on-hook/off-hook status of each channel. This status information is then used to determine when a channel is available for automatic self-test and when a channel should be enabled at the beginning of a call. A channel is determined to be on-hook (idle) when all signaling bits in the transmit and receive bit streams indicate an on-hook condition (A=B=Ø) for more than 100 milliseconds. A channel is determined to be off-hook (busy) if **any** signaling bit in the transmit or receive bit stream equals 1.

6.07 Only channel voice signals are processed by the 251 System's echo-cancellation circuitry. Therefore, the *canceller bypass* path and the *output control* circuits are used to reinsert framing bits and signaling bits into their correct positions in the transmit-output bit stream. These circuits can also be used to bypass the echo-cancellation circuitry of selected channels.

6.08 The *test-code-insertion multiplexer* is controlled on a channel-time-slot basis and is used to insert self-test patterns into the cancellation circuits for circuits that are undergoing self-testing. The *Y PCM bus*, whose signals at this time consist of either the digitized channel voice signals or the self-test codes for each channel's time slots, carries these signals from the 6952 or 6952A Network Interface Module to the 6954 Control Interface Module for processing by the cancellation circuits. The *Y PCM bus* also carries these signals to the 6955 Tone Disabler Module (if used) to detect nominal 2100Hz data-disable tone (when present).

6.09 The 6954 module receives the transmit-path signals from the 6952 or 6952A module via the *Y PCM bus*, which contains information for all 24 channels in a time-division-multiplexed format. The speech signals, Y, are transcoded from the 8-bit μ-law PCM representation into a 14-bit two's-complement linear code. The *canceller* subtracts the echo-estimate signal, R, from the near-end transmit signal (Y) to remove the echo. The result is then encoded from two's-complement linear form into an 8-bit μ-law PCM signal, ε, which consists of near-end speech less any echo that was present (ε=Y−R).

6.10 The residual suppressor processes the *canceller* output signal, ε, to generate the signals, E, carried on the *E PCM* bus. This bus carries the *residual suppressor's* E output signals from the 6954 module to the 6952 or 6952A module. The *residual suppressor* operates on a sample-by-sample basis, and it uses no attack or hangover timing (thus, these times are zero). All *canceller* output (ε) samples at a level more than 24dB below the peak X (receive-channel) sample received in the preceding 32 milliseconds (*X MAX*) are suppressed by replacing the ε sample with the μ-law code for zero volts. The *residual suppressor* is disabled for receive (*X MAX*) levels below −41dBm0.

6.11 Signals on the *E PCM* bus are received by the 6952 or 6952A module and distributed to the *output control circuit* and the *self-test circuit*. The *self-test circuit* compares the E samples to a stored copy of the expected test results and places the channel pass/fail states into a register whose contents are read by the 6954 module's microprocessor.

6.12 The *output control circuit* selects the sample to be outputted for each channel either from the *E PCM bus* or from the *canceller bypass* path. This selection is controlled by a set of registers whose contents are written (i.e., generated) by the 6954's microprocessor. The *output control circuit* then reinserts into the transmit-output bit stream the framing and signaling bits that were taken from the transmit-input bit stream and routed around the cancellation circuitry. In this manner, the *output control circuit* generates the serial bipolar (AMI) transmit-output (*TX OUT*) bit stream.

6.13 The transmit-output (*TX OUT*) CO equalizer subassembly on the 251 Assembly's backplane receives the 6-volt peak transmit-output signal from the 6952 or 6952A module and provides the proper attenuation and compensation for cabling such that the DX-1 cross-connect frame receives a 3-volt peak transmit-output signal with the correct pulse shape.

receive path

6.14 Like the transmit-input signal, the receive-input signal consists of a 1.544-megabit-per-second bipolar bit stream. This bit stream is received by a clock recovery and synchronization circuit (*clock recovery X*) and regenerated to create the receive-output bit stream. Like the transmit-output bit stream, the receive-output (*RX OUT*) bit stream from the 6952 or 6952A module is received by its own CO equalizer subassembly on the 251 Assembly's backplane. This equalizer attenuates the 6-volt peak receive-output signal and provides proper compensation for cabling such that the DX-1 cross-connect frame receives a 3-volt peak receive-output signal with the proper pulse shape.

6.15 The 6952 or 6952A module's *clock recovery X* circuit is followed by *framing* circuitry that identifies individual channel time slots. The receive signals then pass through a *frame synchronization buffer* to establish frame synchronization between the receive and transmit channels. The *frame synchronization buffer* also compensates for small variations in frequency between the receive and transmit paths. If the frequency of the receive-path bit stream is slightly higher than that of the transmit-path bit stream, a frame will periodically be skipped by the *frame synchronization buffer*. Likewise, if the receive serial bit stream is slightly lower in frequency than the transmit bit stream, a frame will periodically be repeated. The infrequent skipping or repeating of one frame of data on the receive path appears to the cancellation circuits as a small change in the end path (a 125-microsecond phase shift), which results in a decrease in echo cancellation until the System adapts to the "new" end path. This adaptation normally occurs within one or two syllables of speech.

6.16 The output of the *frame synchronization buffer* provides input to the *test-code-insertion multiplexer*, just as is done on the transmit path. The *test-code-insertion multiplexer* is controlled on a time-slot basis for insertion of the receive test code signals into specific channel time slots while the channel is in a self-test routine. The signals on the *X PCM bus* are then sent from the 6952 or 6952A module to the 6951 or 6951A Channel Unit Modules, where they are used to calculate the echo estimate, R, and also to the 6955 Tone Disabler Module (if present), where they are monitored for the presence of nominal 2100Hz digital data-disable tone.

echo canceller

6.17 Signals on the *X PCM bus* are received by each 6951 or 6951A module and go to their *convolution processors*. Each channel has its own *convolution processor* (or, if the 6951A is used, its own pair of *convolution processors*), which constructs a mathematical model (the impulse response, H) of the near-end circuit for that channel. For each frame (125 microseconds), the *convolution processor(s)* selects its receive input signal (X) from the proper time slot and uses it to calculate the echo-estimate signal (R=X*H). The echo estimate (R) is then outputted in the correct time slot to the *R bus*, which carries the echo estimate to the 6954 module for use by the *canceller*. Each channel's *convolution processor(s)* also generates a peak-X (*X MAX*) signal on the *R bus*. The *X MAX* signal for any channel is the signal with the highest level received via the *X PCM bus* during the preceding 32 milliseconds.

6.18 The 6954 module removes the echo estimate (R) and the *X MAX* information from the *R bus*, and the *canceller* subtracts R from the near-end transmit signal, Y, to generate ε, the *canceller* output. The *X MAX* information is used to perform several threshold comparisons.

6.19 The *near-end speech detector* indicates a doubletalk condition when the Y signal is greater than a level 6dB below the peak-X signal, *X MAX*. The *doubletalk hangover timers* "stretch" the doubletalk indications such that a doubletalk sample every 75 milliseconds or less is recognized as a continuous doubletalk condition. During periods of doubletalk, echo cancellation continues but no updates are made to the mathematical model of the near-end echo path in that channels *convolution processor(s)*. During periods of singletalk, the *canceller* output signal (ε) consists only of error in the echo estimate. Therefore, ε is used by the *update control* circuits to determine how to modify the mathematical model of near-end echo paths for that channel to get a better echo-estimate signal (R) during the next frame. The *update control* signals are sent from the 6954 module to each 6951 or 6951A module.

6.20 The *residual suppressor* is controlled by the comparison of the canceller output (ε) to a threshold level 24dB below *X MAX*. If ε is below this threshold, the residual suppressor replaces the canceller output signal (ε) with a digital null signal. This removes any residual echo resulting from small errors in the echo-estimate signal calculated by the *convolution processor(s)*. The *residual suppressor* is enabled only while the receive signal level (*X MAX*) is greater than −41dBm0.

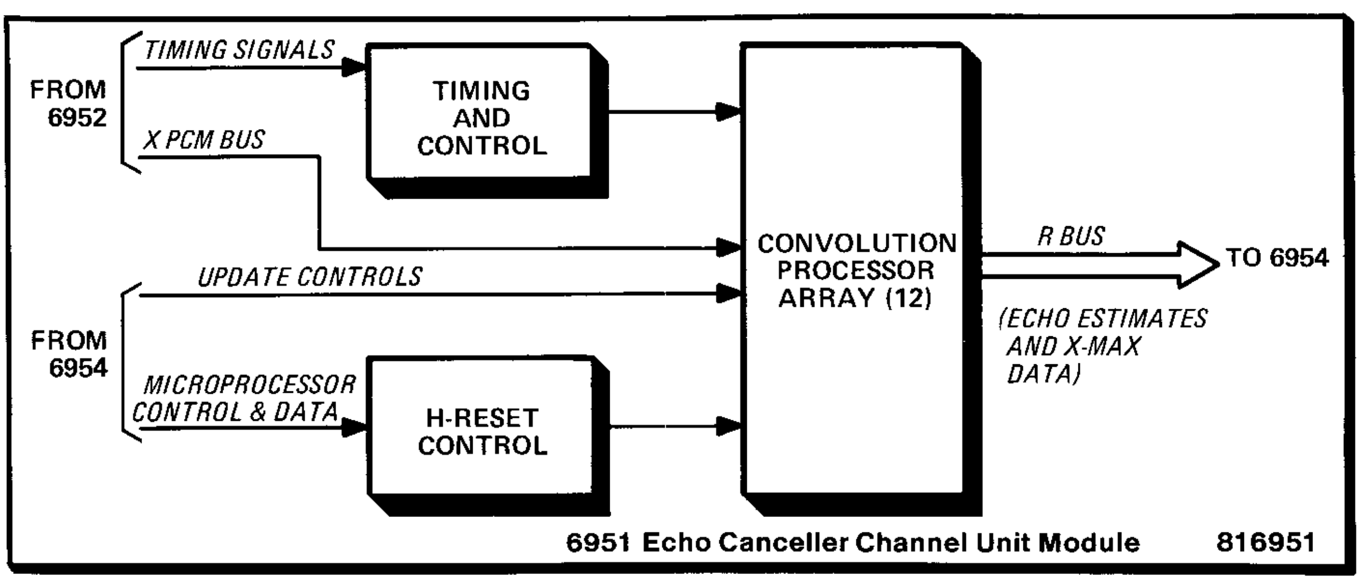
other circuits and features

6.21 The self-test pattern-generation and control circuits perform automatic self-test sequences on selected channels under command of the *control interface*. During these tests, the transmit path is routed around the *canceller* (thus bypassing it completely) to avoid inserting any test patterns onto the digital network. Test patterns are generated for both the X and Y inputs to the *canceller* circuits and are inserted into the correct time slots for the channel under test. The residual-suppressor output signal (E) for a channel is then monitored during the correct time slot to determine whether the test is passed or failed. At the end of the test sequence, the test results are communicated to the *control interface*.

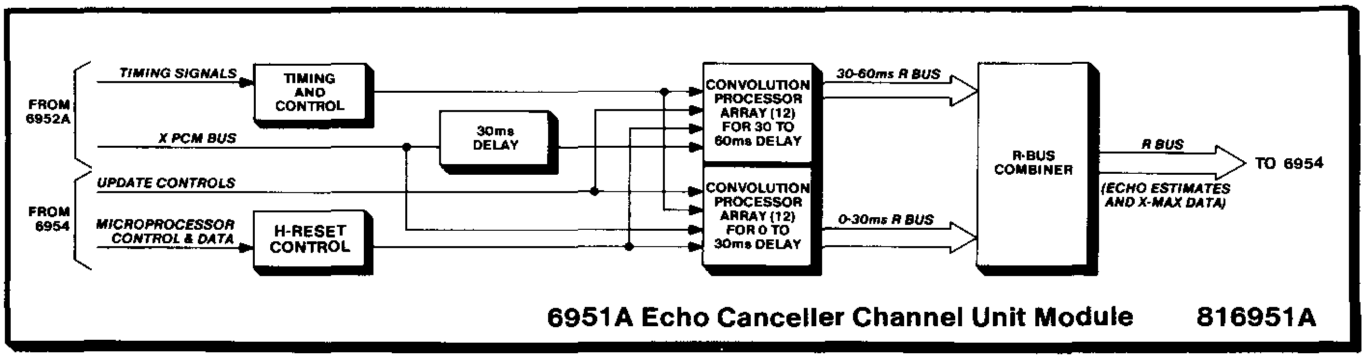
6.22 The *control interface* assigns channels for self-test based on the on-hook/off-hook status of the channels. Idle channels in the on-hook state are marked as being available for the next self-test sequence. If the *control interface* detects an on-hook-to-off-hook transition on a channel while it is undergoing a self-test routine, the self-test is immediately aborted.

6.23 Provision is made for use of an optional *6955 Tone Disabler Module* in the 251 System. The 6955 monitors the X and Y inputs to the *canceller* circuits for the presence of nominal 2100Hz digital data-disable tone. If this tone is detected for the required time period on either the transmit or receive path of a channel, the channel is bypassed until the absence of a holding signal on that channel is confirmed or until the channel goes back on-hook. This disable-duration selection (i.e., disabling only during the presence of tone or disabling from the receipt of tone until the end of the call [even if tone is removed prior to the end of the call]) is made independently for each channel via DIP switches on the 6955 module's front panel.

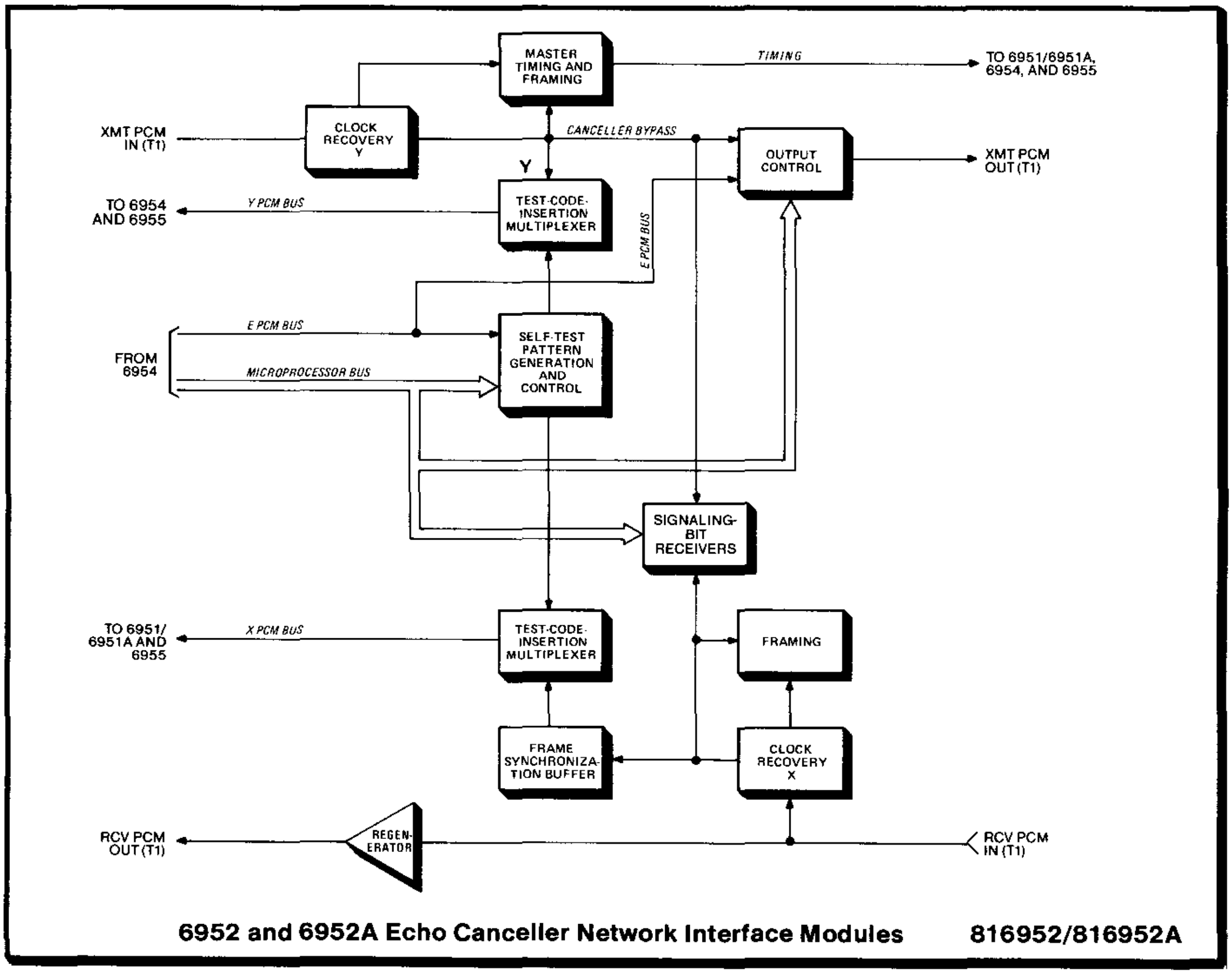
6.24 The *control interface* provides all high-level timing and control functions for the System. These include monitoring and decoding of signaling to determine on-hook/off-hook status, monitoring and control of self-test circuits, monitoring of control inputs (i.e., inputs from the 6954 module's front panel), driving of the 6954's *channel* and *status* LED's, monitoring of the *remote control/status interface*, and providing several timing functions for *update and control circuits*. In addition, all alarms detected within the 251 System are communicated to the *control interface* so that they can be displayed on the 6954's *channel* and *status* LED's.



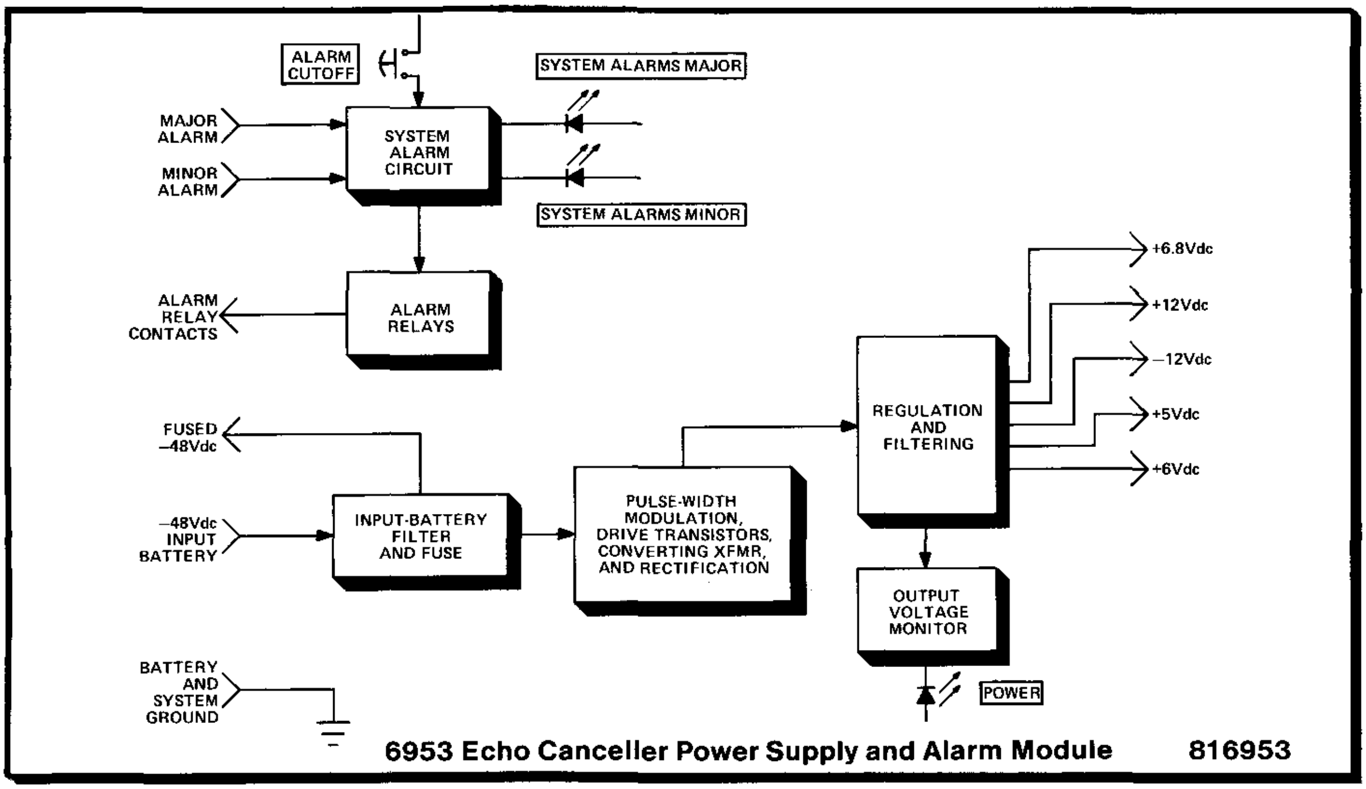
7.1. block diagram, 6951 module



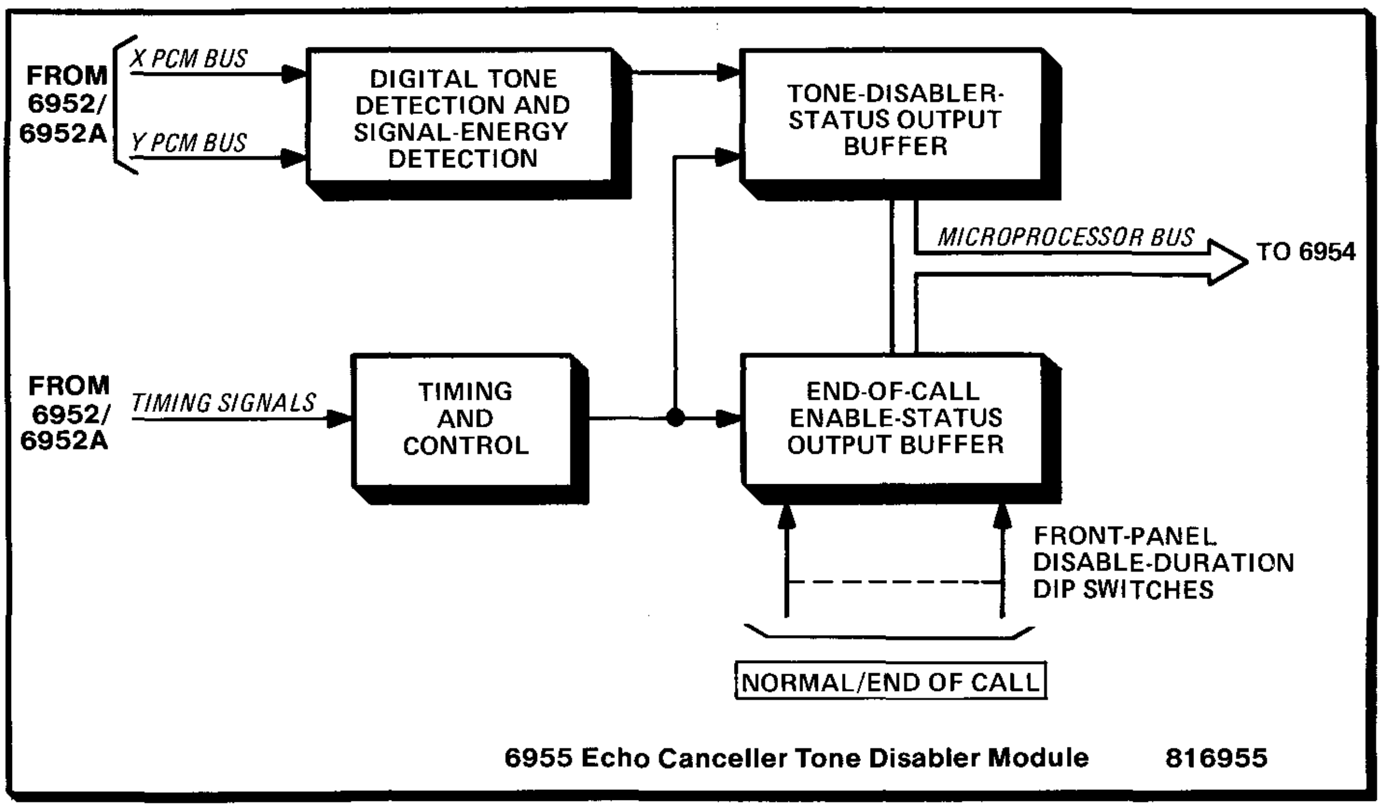
7.2 block diagram, 6951A module



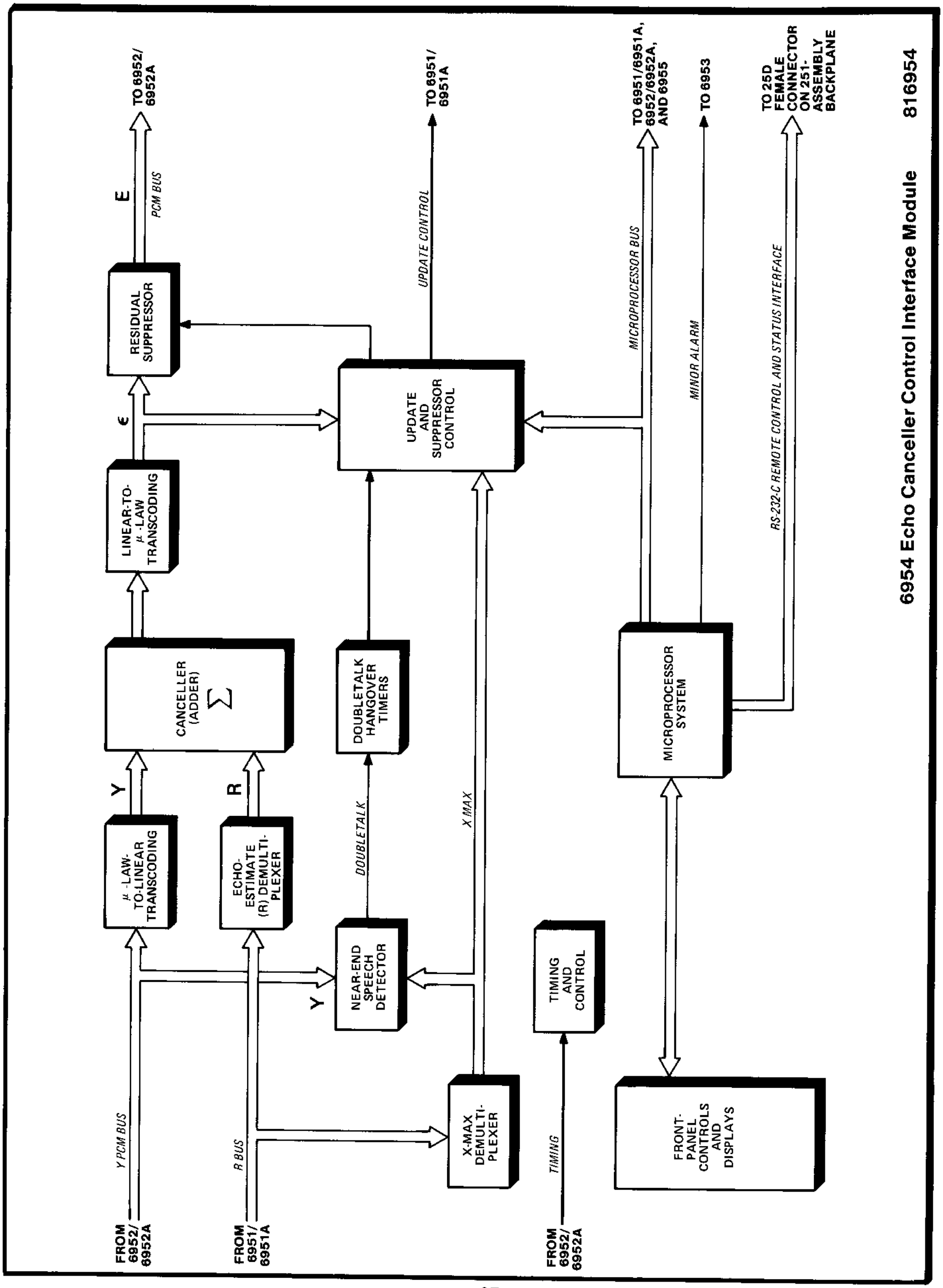
7.3. block diagram, 6952 and 6952A modules



7.4. block diagram, 6953 module

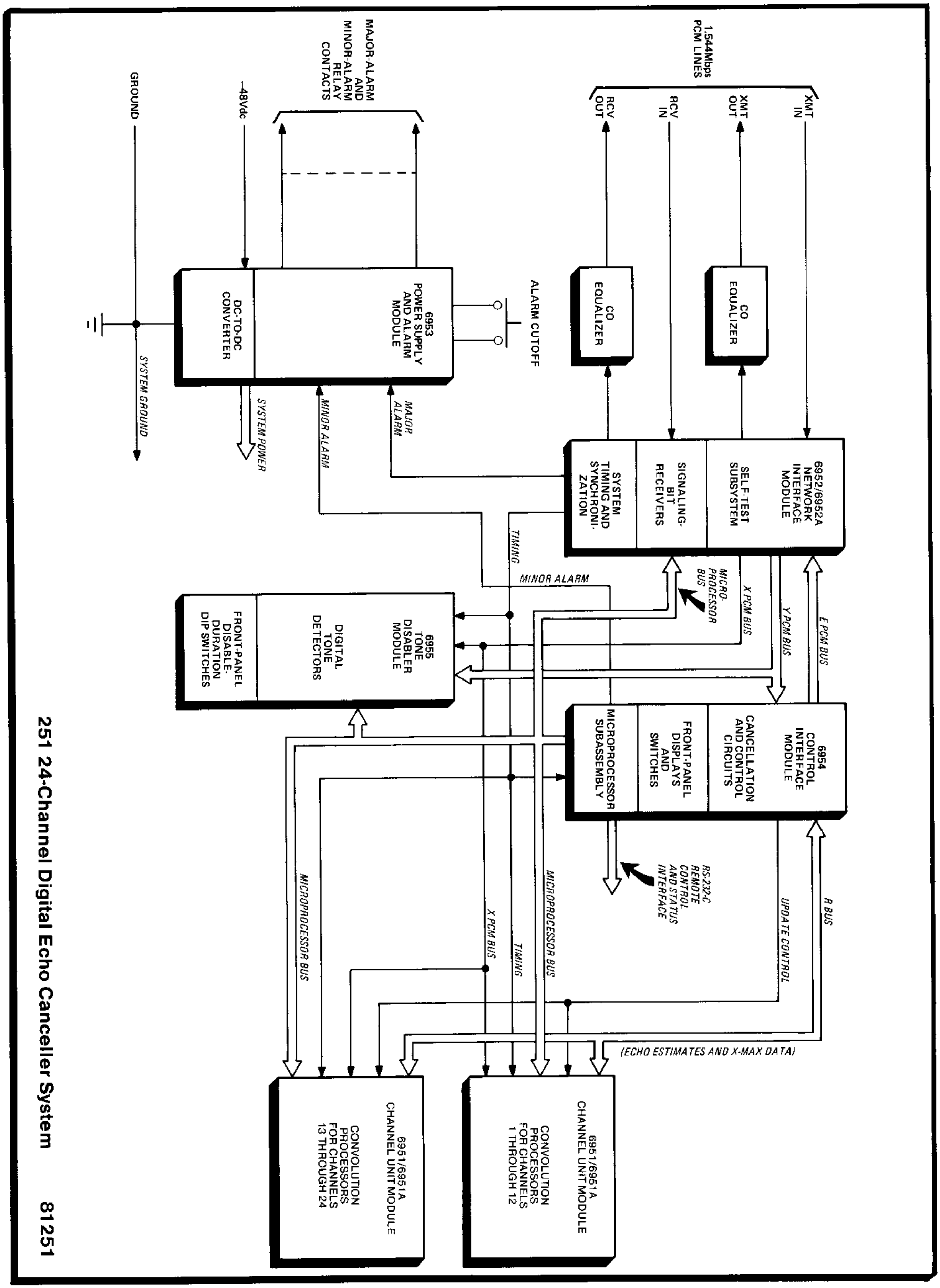


7.5 block diagram, 6955 module



7.6 block diagram, 6954 module

7.7 block diagram, 251 System



251 24-Channel Digital Echo Canceller System 81251

8. specifications

network interface

message signal format
DS-1 (bipolar AMI), at 1.544 megabits per second with segmented μ-255 companded PCM coding. The all-zero code is suppressed.

message signal levels
transmit input (TX IN) and receive input (RX IN): 0.75 to 3.7V, base to peak
transmit output (TX OUT) and receive output (RX OUT): 3 to 6V, base to peak, adjustable to 6V maximum peak level by choice of three CO Equalizer subassemblies

clock frequency change between input and output ports
none

signal processing delay
transmit channel: less than 0.200ms, transmit input to transmit output
receive channel: none

clock recovery circuitry
introduced timing jitter: less than 25 degrees peak (loaded Q is 80 to 120 per DS-1 rate system specification)

framing format
in accordance with CCITT recommendation G.733 and D3 channel-bank specifications, framing pulses in both the transmit and receive channels are passed through the 251 System unaltered

frame synchronization
frame synchronization is achieved in less than the maximum average of 50ms specified for D3 channel banks. Receive-channel framing is synchronized by the transmit-input bit stream.

quantizing noise during signal processing
meets D3 channel-bank specifications

port impedances
100 ohms nominal, balanced, at all four ports

remote control/status interface (required with common-channel signaling [CCS])
signal format: serial, compatible with EIA standard RS-232-C
control command transmission: seven-bit ASCII code
data-transfer rate: selectable for 300, 600, 1200, 2400, 4800, or 9600 bits per second

6955 Tone Disabler Module (optional; meets CCITT recommendation G.164)
operate time: 300 ±100ms for continuously applied conditioning tone between −31 and 0dBm0
conditioning band: 2010 to 2240Hz
conditioning-band sensitivity: −31dBm0 nominal sensing of both transmit and receive paths
guard band: 500 to 1775Hz and 2465 to 3000Hz
guard signal ratio: white-noise energy level required to inhibit disabling is no greater than level of conditioning-band signal and not less than a level 5dB below that of conditioning-band signal
hold band: tone disabler releases for any signal between 500 and 3000Hz having a level lower than −36dBm0

alarm outputs
major and minor external alarm outputs are provided by dedicated pairs of form-C relay contacts rated at 1 ampere (two pairs each for major and minor alarms); a closure between NC and C contacts indicates an alarm condition

cancellation section

Note: *The cancellation section of the 251 System meets CCITT recommendation G.165.*

convolution processor
number of coefficients: 254; this accommodates a maximum end-path delay of 30ms
echo-return loss enhancement: convolution processor is capable of achieving ERLE of at least 26dB with 8dB of ERL at an equivalent receive-input level of −10dBm0
convergence time: less than 200ms for minimum ERLE of 24dB

near-end speech detector
speech-detection threshold: presence of near-end speech is acknowledged when transmit-input level exceeds a threshold 6dB below receive level
threshold timing: after detection of near-end speech, update processing enters HOLD mode until absence of speech is detected for an interval of 75ms

residual suppressor
threshold level: transmit-input samples more than 24dB below maximum receive-input level (a 32ms averaging interval is used) are suppressed
timing: no insertion or removal timing is used (delays are therefore zero)

power requirements

input voltage
−44 to −56Vdc, filtered, ground referenced

maximum ac ripple
300mV peak-to-peak at 120Hz

power consumption for single (24-channel) 251 System (at nominal −48Vdc battery and 25°C)
typical:
- **251 System with 6951 Channel Unit Modules: 33.5 watts (0.697A)**
- **251 System with 6951A Channel Unit Modules: 37.1 watts (0.773A)**
- **For 251 Systems with optional 6955 Tone Disabler Module, add 5 watts (0.104A) to the above figures.**

maximum (with optional 6955 Tone Disabler Module):
- **251 System with 6951 Channel Unit Modules: 45 watts (0.938A)**
- **251 System with 6951A Channel Unit Modules: 49 watts (1.02A)**

input power fusing
single 1⅓-ampere Bussman GMT-type fuse located on front panel of 6953 Power Supply and Alarm Module

physical

module dimensions (each module)
height: 6.71 inches (17.04cm)
width: 1.42 inches (3.61cm)
depth: 12.94 inches (32.87cm)

251 Assembly dimensions (one 251 Assembly houses two 251 Systems)
height: 7 inches (17.8cm)
width: 251A, 19 inches (48.3cm)
251B, 23 inches (58.4cm)
depth: 14.4 inches (36.6cm)

weights
6951 module: 14 ounces (397 grams)
6951A module: 32 ounces (907 grams)
6952 module: 21 ounces (595 grams)
6952A module: 21 ounces (595 grams)
6953 module: 17 ounces (482 grams)
6954 module: 22 ounces (624 grams)
6955 module: 12 ounces (340 grams)
251A (19-inch) Assembly:
12 pounds 2 ounces (5.5 kilograms)
251B (23-inch) Assembly:
13 pounds 4 ounces (6.0 kilograms)

251 Assembly heat dissipation
Assembly is suitably vented to allow heat to be dissipated by air convection without use of cooling fans

environment
operating temperature: normal range, +5° to +50°C (41° to 122°F); however, System can tolerate temperatures from −10° to +50°C (14° to 122°F) over short term, i.e., up to 72 consecutive hours, not to exceed 15 days per year
shipping and storage temperature: −58° to +185°F (−50° to +85°C)
operating altitude: up to 11,500 feet (3500 meters)
relative humidity: normal range, 5% to 95% (no condensation); however, System can tolerate relative humidity from 2% to 98% (no condensation) over short term (see above)

reliability
MTBF (mean time before failure for 251 System with 6951 Channel Unit Modules, excluding 6955 Tone Disabler Module:
≥33,500 hours
MTBF for 251 System with 6951 Channel Unit Modules and optional 6955 Tone Disabler Module:
≥30,000 hours
MTBF for 251 System with 6951A Channel Unit Modules, excluding 6955 Tone Disabler Module:
≥24,500 hours
MTBF for 251 System with 6951A Channel Unit Modules and optional 6955 Tone Disabler Module:
≥23,000 hours

9. testing and troubleshooting

Note: *When the 251 24-Channel Digital Echo Canceller System is initially installed, the initial power-on sequence in paragraph 3.15 should be observed and the self-test checkout procedure in paragraph 3.16 should be performed. If these things have not yet been done, do them at this time. If, when they are completed, trouble indications remain displayed on one or more System modules, the* system troubleshooting guide *in this section can be used to isolate the problem.*

9.01 The *system troubleshooting guide* in this section can be used to assist in the installation, testing, or troubleshooting of the 251 24-Channel Digital Echo Canceller System. The guide is intended as an aid in the localization of trouble to a specific module. If a module is suspected of being defective, a new one should be substituted and the self-test procedure performed again. If the substitute module operates correctly, the original module should be considered defective and returned to Tellabs for repair or replacement. We strongly recommend that no internal (component-level) testing or repairs be attempted on any 251-System module or mounting assembly. Unauthorized testing or repairs may void the item's warranty.

9.02 Tellabs warrants the 251 System to be free of defective components, workmanship, and design for a period of two years from the date of manufacture, when applied as outlined in our Practices, subject to handling and installation commensurate with industry standards for solid-state electronic equipment. If any 251-System module or mounting assembly does not prove to be free of defective components, workmanship, and design under these criteria, Tellabs will replace or repair it free of charge.

Note: *Warranty service does not include removal of permanent customer markings on the front panels of Tellabs modules, although an attempt will be made to do so. If a module must be marked* defective, *we recommend that it be done on a piece of tape or on a removable stick-on label.*

9.03 If a situation arises that is not covered in the *system troubleshooting guide*, contact Tellabs Customer Service at your Tellabs Regional Office or at our Lisle, Illinois, or Mississauga, Ontario, Headquarters. Telephone numbers are as follows:

US central region: (312) 969-8800
US northeast region: (412) 787-7860
US southeast region: (305) 645-5888
US western region: (702) 827-3400
Lisle Headquarters: (312) 969-8800
Mississauga Headquarters: (416) 624-0052

9.04 If a 251 System module or mounting assembly is diagnosed as defective, the situation may be remedied by either *replacement* or *repair and return*. Because it is more expedient, the *replacement* procedure should be followed whenever time is a critical factor (e.g., service outages, etc.).

replacement

9.05 To obtain a replacement 251-System module or mounting assembly, notify Tellabs via letter (see addresses below), telephone (see numbers above), or twx (910-695-3530 in the USA, 610-492-4387 in Canada). Be sure to provide all relevant information, including the 8XXXXX part number that indicates the issue of the item in question. Upon notification, we shall ship a replacement to you. If the equipment in question is in warranty, the replacement will be shipped at no charge. Pack the defective equipment in the replacement's carton, sign the packing slip included with the replacement equipment, and enclose it with the defective equipment (this is your return authorization). Affix the preaddressed label provided with the replacement to the carton being returned, and ship the equipment prepaid to Tellabs.

repair and return

9.06 Return the defective equipment, shipment prepaid, to Tellabs (attn: repair and return).

in the USA: Tellabs Incorporated
4951 Indiana Avenue
Lisle, Illinois 60532

in Canada: Tellabs Communications Canada, Ltd.
1200 Aerowood Drive, Unit 39
Mississauga, Ontario, Canada L4W 2S7

Enclose an explanation of the malfunction. Follow your company's standard procedure with regard to administrative paperwork. Tellabs will repair the equipment and ship it back to you. If the equipment is in warranty, no invoice will be issued.

system troubleshooting guide

trouble condition			
module	**indication**	**problem description**	**action to be taken**
6954	0.0.	EPROM checksum error in 6954 module.	Replace 6954 module.
6954	X.X. (where XX is a channel number between 1 and 12)*	Faulty convolution processor on first (lefthand) 6951/6951A module in System.	Replace first 6951/6951A module in System.
6954	X.X. (where XX is a channel number between 13 and 24)*	Faulty convolution processor on second (righthand) 6951/6951A module in System.	Replace second 6951/6951A module in System.
6954	X.X. (where all channel numbers are displayed one by one)*	Faulty common channel circuits on 6954 or 6952/6952A module.	(1) Replace 6954 module. (2) Replace 6952/6952A module.
6952/ 6952A	red *transmit local* LED lighted	Loss of transmit T1-line synchronization detected locally.	(1) Check transmit-input T1 line. (2) Replace 6952/6952A module.
6952/ 6952A	yellow *transmit remote* LED lighted	Near-end channel bank has detected loss of synchronization on its receive T1 line.	(1) Check channel bank. (2) Check transmit-input T1 line. (3) Check receive-output T1 line.
6952/ 6952A	red *receive local* LED lighted	Loss of receive T1-line synchronization detected locally.	(1) Check receive-input T1 line. (2) Replace 6952/6952A module.
6952/ 6952A	yellow *receive remote* LED lighted	Far-end channel bank has detected loss of synchronization on its receive T1 line.	(1) Check channel bank. (2) Check receive-input T1 line. (3) Check transmit-output T1 line.
6953	major-alarm relay operation without LED indication	Faulty power supply in 6953 module or blown input-power fuse on 6953's front panel.	(1) Check input-power fuse. (2) Replace 6953 module.

* The 6954's *status test* LED and the 6953's *system alarms minor* LED will also be lighted when a channel number is displayed as indicated.