Technical Manual
76.81258X-D
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Practice Section 812581/812582


# 2581 and 2582 E1 Echo Canceller Modules

## Contents



## Revision Notice

This practice has been revised to . . .

- remove the front panel and system configuration information (see paragraph 3.8)
- update the Block Diagram to include the Integrated Services Digital Network (ISDN) (Q.931) and CLEARCALL Acoustic Coupling Elimination (ACE) features

## Reference Documentation

For additional information see the Tellabs manuals that are a part of the *258 Documentation Set*, #80.4232, which is shipped with each mounting assembly, or can be obtained through your Tellabs representative.

## 1. Description

1.1 The 258 E1 echo canceller system is ideally suited for use in the public switched telephone network, as well as in digital wireless networks. In these networks, the 258 echo cancellers effectively remove *hybrid* echo caused by electrical coupling at 2-wire-to-4-wire conversion points, and acoustic echo generated from certain types of telephones. The 258 system uses state-of-the-art echo cancellation and nonlinear processing techniques to ensure that the subscriber's call is echo-free, regardless of the source of echo.

1.2 The 81.2581 and 81.2582 E1 echo canceller modules provide adaptive, split-type echo control and connect directly to 2.048Mbps E1 Pulse Code Modulation (PCM) systems. The module can operate as a stand-alone unit monitoring the channel busy/idle status, or can be controlled from a V.24-compatible Serial Communications Port (SCP). The module provides selectable A-Law/µ-Law operation.

**Note: The 81.2581 and 81.2582 modules are referred to throughout this practice as the 258X module, except where differentiation is necessary.**

## Features

1.3 The 258X module offers these features . . .

- fully compliant with International Telecommunications Union — Telecommunication Standardization Sector (ITU-T) recommendations G.165 and G.168
- FLEXWARE™ performance options enhance Non-Linear Processor (NLP) control
- optional quality enhancements (see *258 E1 Echo Canceller System Release Notes*, [part of the *258 Documentation Set*, #80.4232] for further information)
- protects against echo caused by 2-wire-to-4-wire converters (hybrids)
- protects against echo caused by most analog mobile phones, including acoustical echo from analog hands-free systems
- greater than 35dB Echo Return Loss Enhancement (ERLE) typical (with 6dB Echo Return Loss [ERL] and receive input level = –10dBm0) for hybrid connections
- greater than 34dB combined ERL and ERLE within 50 milliseconds (ms)
- selectable 0, 3, and 6dB minimum ERL endpath capability
- 32ms (2581 module) and 64ms (2582 module) (96 and 128ms optional) endpath delay settings are available
- two V.24 SCPs support remote control and maintenance activities
- Dynamic Signal Transfer™ (DST) allows natural far-end background sounds to be heard for superior subjective performance
- Timeslot 16 control (for CEPT Multiframe [MF] applications)
- idlecode monitoring for busy/idle detection
- front access provisioning with optional 81.2581MC and 81.2582MC E1 master canceller modules
- optional High-Level Compensation (HLC) subassembly attenuates high transmission levels
- user-friendly front panel includes alarm and status LEDs
- automatic surveillance of idle channels and on-line performance monitoring
- enhanced alarm indications for easy network fault isolation
- loopback of PCM streams to enhance maintenance and fault isolation
- ITU-T recommendation G.704 Cyclic Redundancy Check-4 (CRC-4) compatible
- attenuates PCM phase jitter; see Section 9.
- ITU-T recommendation G.165 Data Tone Disabler (DTD) (requires 2 phase reversals) or ITU-T recommendation G.164 DTD
- built-in Signaling Tone Disabler (STD) supports ITU-T #5 signaling, ITU-T #6 and #7 Voice Path Assurance (VPA) check tones, Single Frequency (SF) (2600Hz), or 2280Hz
- low power requirements
  - — 5.9W, typical at 48V (2581 module)
  - — 8.8W, typical at 48V (2582 module)
- selectable A-Law or µ-Law PCM encoding
- user-friendly menus via RS-232 port for remote control
- utilizes flash memory for field upgrades or enhancements

## System Components

1.4 The 258 system consists of echo canceller modules (including optional master canceller modules), optional subassemblies, blank modules, mounting assemblies, power converter modules, and ancillary equipment to support varied customer specific applications. For a complete list of these components, see the *258 E1 Echo Canceller System Overview and Regulatory Information* practice (part of the *258 Documentation Set*).

# 2. Applications

2.1 The 258 system is intended for use near the end points of digital carrier facilities characterized by significant end-to-end propagation delays. Echo from the associated Voice Frequency (VF) channel circuit components is effectively cancelled by the 258 system. This echo is caused by signal reflections at impedance discontinuity and interface points such as 4-wire-to-2-wire conversions.

## Split-Type System

2.2 The 258X module is a split-type design. Each canceller protects the opposite end of the circuit from echo in return path channels; that is, the near end canceller protects the far end from echo. The split-type configuration makes the 258 system completely insensitive to long-haul transmission delays on intermediate carrier links and therefore allows the system to operate effectively regardless of the duration of these delays. Thus, the 258 system is well suited for a broad range of digital network applications, including mobile cellular networks, single-hop or double-hop satellite circuits — whose round-trip delays are approximately 200ms, 600ms, and 1200ms, respectively — and terrestrial circuits, where the operational characteristics of echo suppressors or Via Net Loss (VNL) designs may be undesirable, or any time propagation delays exceed 30ms.

## Convergence

2.3 A signal at the receive-in port, followed by the signal's echo at the send-in port, causes the system to begin an adaptation process known as convergence. During convergence, a digital signal processing circuit, called a convolution processor, 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. The adaptation process is continuous and responds to changes while the call is in progress, except when doubletalk is detected.

## Echo Cancellation

2.4 When the sendpath signal consists of both near end speech and echo from the far end speaker, the 258 system removes only the echo signal, leaving the near end speech signal intact for transmission toward the distant end. Thus, parties at both ends can talk simultaneously — 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 — singletalk — the send-in signal consists entirely of echo, which the 258 system removes by subtracting the echo estimate from the echo signal. Any residual echo, which is typically less than –40dBm0, is removed by an integral NLP.

### Non-Linear Processor

2.5 The NLP removes the small amount of residual echo left after cancellation. This circuit incorporates a number of technological advances and options to achieve optimum subjective performance in the network.

#### Options

2.6 Three basic user-selectable options are available . . .

- off — canceller only — normally used only for laboratory test purposes
- on — normal — NLP is always on (default)
- ITUT — ITU-T mode — NLP off during doubletalk

## FLEXWARE Performance Options

2.7 The 258 system provides customers worldwide with the flexibility to *fine-tune* the cancellers' performance to their unique network applications. Three settings are available . . .

- Universal (default setting) — provides the best overall performance. It excels in doubletalk and echo control performance under normal to extremely harsh network conditions. This mode also features good tandem performance.
- Mobile — provides the best tandem performance. Overall doubletalk performance and echo control is outstanding under normal network conditions. Also, this mode provides the best performance for calls where high levels of background noise can be encountered, such as in wireless networks.
- Gateway — provides good overall performance, and excellent performance in networks where conditions of high or mismatched levels with possible low ERLs may exist. Tandem performance is good, but not outstanding. This mode provides very stable performance under many conditions.

2.8 Tellabs recommends the universal setting for most applications. However, FLEXWARE can be optioned for the type of problems or conditions that may be present in your network.

## PCM Idlecode Detection

2.9 When configured for this mode, the module monitors the actual eight bits of PCM data embedded in each timeslot. A comparison is done of those eight bits against the PCM idlecode pattern (configured by the user). The comparison output is integrated over a 120ms period. If a match exists (allowing the $10^{-4}$ bit error rate), the channel is bypassed (declared idle). If a match does not exist, the channel is made active (declared busy). This methodology requires no external connections; all information is embedded in the PCM stream.

## Timeslot 16 (TS16) Control

2.10 When configured for this mode, the canceller monitors the TS16 control bits to determine busy/idle status for each channel. The TS16 control data is broken down into four signaling bits for each channel (labeled a, b, c, d). Since there are eight bits available in each timeslot, control for two channels is provided in each TS16 location.

2.11 If a switch is utilizing TS16 control, there are 30 voice channels, one control timeslot (TS16), and one standard framing/alarm timeslot (TS0) in each 2.048Mbit frame. The four TS16 control bits (a, b, c, d) must be provided for each of the 30 voice channels. Since two sets of control bits are combined into each TS16, there are fifteen TS16s required to include all the busy/idle information for the 30 voice channels. In addition to these fifteen TS16s for busy/idle information, a TS16 Multiframe Alignment/alarm Word (MFAW) is required to show the downstream equipment where the start of this TS16 data occurs. Thus, there are sixteen TS16s in a given TS16 MF (one for MF framing as well as MF alarms, and 15 for passing the control bits). Since there is only one TS16 per 2.048Mbit frame, a TS16 MF requires sixteen 2.048Mbit frames to include all of its data.

2.12 When configured for TS16 control mode, the module monitors the TS16 MFAW, determines the start of the TS16 MF, checks for TS16 alarms, and extracts the TS16 control bits properly. The TS16 control bits provide the busy/idle status for each channel. Each switch can encode busy/idle status using any one of the four control bits associated with each channel. In addition, the switch can encode a busy as a high on the selected bit or as a low on the selected bit. Thus, the 258 system allows for selection of the following . . .

- send or receive side signaling bit extraction
- a, b, c, or d bit monitoring
- busy state (i.e., high = busy, or low = busy)

2.13 The 258 system is designed to respond to TS16 signaling bits within 50ms. This methodology requires no external connections. All busy/idle information is embedded into a dedicated timeslot of the PCM stream.

## Dynamic Signal Transfer

2.14 One of the problems with previous designs of NLP is noise modulation or noise pumping. When the far end speaker talks, the NLP is dynamically adjusted to remove the speaker's residual echo. As a side effect, however, any background noise that is present in the send side of the near end canceller circuit is attenuated by the NLP, also. This noise may consist of electronic noise from older circuits, background environmental sounds, such as people talking, a radio playing, or a computer printer. When the far end speaker stops talking, the noise that had been quieted, returns. One of the techniques that has been used in the past (not by Tellabs) is to inject random noise into the send output when the NLP activates. This technique can work if the source of the background noise is electronic and the spectrum of the injected noise is close to that of the background noise. Unfortunately, with more modern digital networks, the idle channel noise from electronic power has been significantly reduced and the background noise tends to be more environmental sounds picked up by the telephone handset. When random noise is injected in these situations, it is a distracting change in background level. The Tellabs solution to this problem is Dynamic Signal Transfer (DST). The background level is measured and the NLP is dynamically adjusted to allow background sounds to pass through without altering the spectrum. To select this feature, set the DST on.

## Master Canceller (Optional)

2.15 Front access provisioning is available with the optional 2581MC and 2582MC master canceller modules. See the *2581MC and 2582MC E1 Master Canceller Modules* practice for further details.

## A-Law/µ-Law

2.16 The 258X module can be optioned for either A-Law or µ-Law encoding operation on a 2.048Mbps bit stream.

**Note: µ-law is not currently supported on 2543 or 2544 modules, or on 25VX subassemblies.**

## Backward Compatibility

2.17 The 258X module is plug compatible with 254- and 452-series mounting assemblies. When using the 258X module in a 254- or 452-series mounting assembly, note that . . .

- the 5330 power converter must be used. The 5140A power converter is intended for use in the 258 mounting assemblies only.
- the 2543 and 2544 modules can be used with the 258X module. However, if the 258X module is equipped with a 2563B or 2563C subassembly, the HLC circuitry on the 2543/2544 is automatically disabled by the 258X module upon power-up. When the module is mounted in a 254 mounting assembly, the maintenance port is not available.
- the µ-Law PCM encoding scheme cannot be used when the 258X module is used with 2543 or 2544 modules or 25VX subassemblies.

## Disabler and Subassembly Options

2.18 The 258X module has built-in DTDs and in-band STDs.

### Data Tone Disabler

2.19 There are three DTD options available . . .

- G164 (responds to 2100Hz tone with or without phase reversals)
- G165 (responds to 2100Hz with two periodic 180-degree phase reversals)
- off

The DTD is controlled via the V.24 link or master canceller.

### Signaling Tone Disabler

2.20 The built-in STD can be optioned for any of the following: 2280Hz, 2600Hz (SF), ITU-T #5, and ITU-T #6/#7 signaling disabler. The 2563A subassembly is not required for in-band signaling detection.

### 25VX Subassemblies

2.21 Various feature capabilities are available with the addition of 25VX subassemblies. See the *258 E1 Echo Canceller Release Notes* for further information.

### 2563B Subassembly

2.22 The HLC capability is available with the 2563B subassembly. The HLC circuit enhances the subjective quality of transmission when high levels are present. When far end talk power is excessive or transmission levels being received from the far end are not properly adjusted, distortion can result. HLC reduces these high signal levels to provide subjectively improved voice quality levels. The HLC circuit is applied to the receive-in port of an echo canceller.

**Note: The 25VX and 2563B subassemblies cannot be used at the same time.**

## Endpath Updates

2.23 After convergence, the 258 system continues to monitor the echo delay and ERL characteristics of the endpath. During periods of singletalk, the convolution processor repeatedly updates its mathematical model to match these observed characteristics. Thus, any change in the endpath, such as a line being switched or cellular handshake, results in a new endpath model being created by the convolution processor to accommodate the changed echo characteristics. After achieving a convergence, the 258 system performs echo cancellation as long as the channel is busy, keeping the sendpath free of echo for the duration of the call.

2.24 A typical 258 system application is shown in Figure 2-1. The primary cause of echo received at City B is the 4-wire-to-2-wire VF terminating set at City A. Transmission signal reflections at this interface are heard as echo in the corresponding far end receive channel. The City A 258 system actually protects the far end receive channels from echo. The City B 258 system protects City A receive channels from echo. This split-type configuration provides effective echo control regardless of the total delay in the intermediate transmission links.

**Note: Later paragraphs in this section will help users determine the actual endpath delay for selecting the proper echo canceller. However, this is not intended to be a training document nor does it contain the details needed to determine the actual numbers for endpath delay. Properly trained transmission engineering personnel should be consulted for determining the delay, the ERL expected, and for proper optioning of the canceller.**

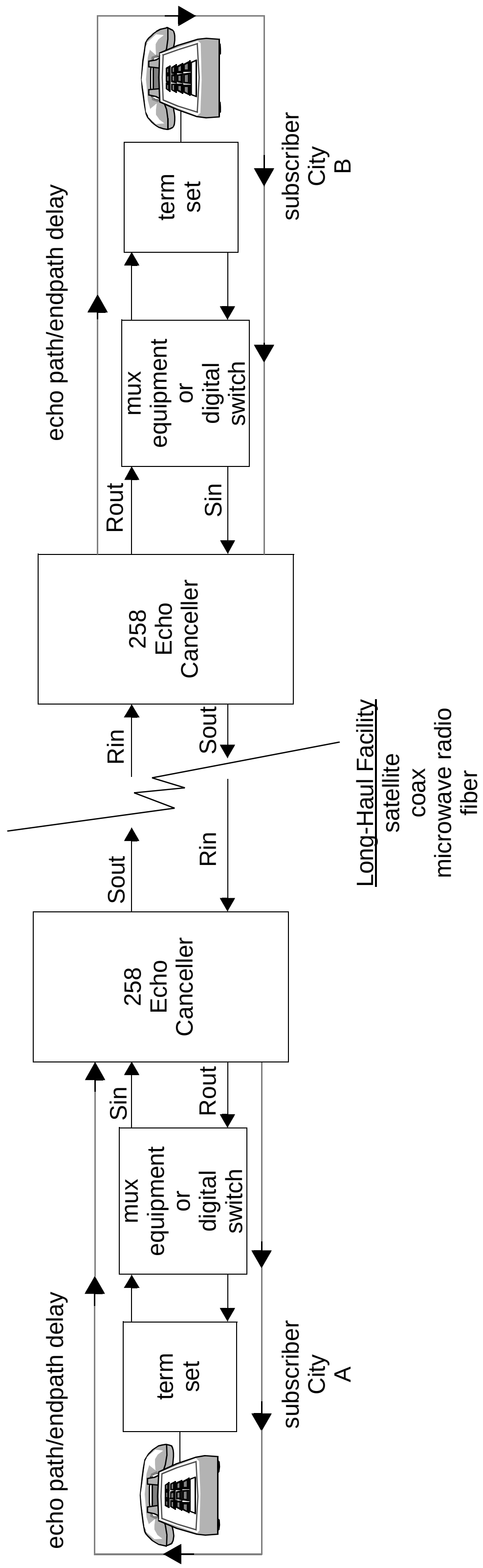


***Figure 2-1 Typical 258 system long-haul facility network application***

## Endpath Requirements

2.25 The portion of the telephone network connected between the receive-out port and the send-in port is called the endpath. The endpath must meet three primary requirements for proper operation of an echo canceller . . .

- It must be within the maximum delay range of the echo canceller.
- For best results, the ERL should be optimized as high as possible.
- It must exhibit linear delay characteristics.

### Delay

2.26 The maximum delay of an endpath when a 2582 module is used is 64ms; 128ms with the optional 2584G/H extended endpath delay subassembly.

2.27 Tellabs recommends the use of only the minimum required amount of canceller delay to match the endpath requirement. This avoids wasting power and assures maximum transmission performance characteristics.

2.28 The total endpath delay is made up of four types of delay . . .

- propagation delay over transmission lines
- fixed delays through transmission and switching equipment
- dispersion through channel banks
- loaded VF cable

2.29 When calculating endpath delay, the total round-trip delay between R-out and S-in (see Figure 2-1) must be considered.

### Echo Return Loss

2.30 The endpath ERL should be optimized to achieve the finest transmission performance. This applies even when not using an echo canceller. ERL is mostly a function of the capability of the hybrid circuit to match impedances of the 2-wire line, which generally connects to the phone or subscriber, and the 4-wire line, where the separate transmit and receive paths exist. A precision balance network is often built into the hybrid — or term set, as it is often referred to — and it has adjustments to maximize the ERL. Tellabs encourages users to maximize the performance of these circuit elements whenever possible.

2.31 The 258X module can function satisfactorily with ERLs as low as zero. However, doubletalk — simultaneous near end speech — is not detected as quickly when the 0 or 3dB ERL option is selected. The performance may be slightly less than optimal. Many applications exist where the owner of the canceller does not have control over the hybrid and must interface to less than optimal conditions. The 258X module does perform under harsh conditions, but there are minor performance penalties. Tellabs recommends that whenever possible, ERL adjustments should be maximized to get the best performance from the cancellers.

### Linearity

2.32 The 258X module is designed to model endpaths that are linear. Nonlinear signals, such as those caused by a compressor, overloaded transmission equipment, or excessive quantizing distortion, result in degraded cancellation.

### Dispersion

2.33 Loaded VF cable and the anti-aliasing filters used in channel banks are steep low-pass filters that exhibit dispersion, or spreading of energy over time. The round-trip dispersion through one channel bank is typically 4ms. However, this type of delay does not add algebraically like other fixed delays. If there are multiple connections through back-to-back channel banks in the endpath, the dispersion does not increase by an amount equal to 4ms multiplied by the number of PCM MUX (channel banks), but only to approximately 7ms. The bulk of the dispersion occurs in the first channel bank filter. Therefore, once propagation and fixed delays have been calculated, simply add 4ms to 7ms to account for the total dispersion in the system.

## Example of Endpath Delay Calculation

2.34 Assume the endpath consists of the following: an 804 kilometer (km) PCM-30 line, a channel bank, 8km of loaded cable, and a terminating set at the subscriber location. Round-trip delay for this endpath is calculated as follows . . .

round-trip delay of E1 line:

= 804km x 2 (for round trip) x 1 sec/151,000km

= .010649006 sec = 10.6ms

round-trip fixed delay through PCM MUX, (channel bank):

= 0.125ms x 2

= 0.25ms

round-trip delay of loaded cable:

= 8km x 2 (for round trip) x 1 sec/16,000km

= 0.001 sec = 1ms

round-trip dispersion of PCM MUX (channel banks) and loaded cable:

= 7ms (estimated)

total endpath round-trip delay:

= 10.6ms + 0.25ms + 1ms + 7ms

= 18.85ms

## Propagation Delay

2.35 The velocity of propagation varies greatly depending upon the medium. The velocity varies from about 225,000km/sec for microwave radio to 16,000km/sec for loaded VF cable. On metallic cable, the wave speed (about 16,000km/sec) is a function of many variables including wire gauge, type of insulation, and loading used. Other media also vary with certain parameters, so the values given in Table 2-1 should be used as guidelines only. These delays are for one-way propagation only. For the total delay, the values calculated must be multiplied by 2.

| medium | wave speed | propagation delay |
|---|---|---|
| microwave radio | 220,000km/sec | 0.004ms/km |
| coax cable carrier | 160,000 to 200,000km/sec | 0.005 to 0.006ms/km |
| fiber optic cable | 160,000km/sec | 0.006ms/km |
| PCM carrier | 150,000 to 200,000km/sec | 0.005 to 0.007ms/km |
| nonloaded VF cable | 80,000km/sec | 0.012ms/km |
| loaded VF cable | 4,800 to 32,000km/sec | 0.031 to 0.205ms/km |

***Table 2-1 Transmission medium delay***

## Fixed Delay

2.36 All transmission and switching equipment exhibits some delay. For accurate information, the manufacturer's data should be consulted, but Table 2-2 can serve as a starting point. When referencing manufacturer's data, determine if delays listed are one-way or two-way. Again, one-way delay values must be doubled for the total value.

| transmission equipment | fixed delay one-way |
|---|---|
| PCM MUX equipment (channel banks) | 0.125 to 0.5ms, plus dispersion |
| digital switch | up to 1.2ms |
| digital cross-connect | 0.25ms |

***Table 2-2 Transmission equipment delay***

**Note: Some equipment is unsuitable for use in the endpath due to excessive or time-varying delay. For example, Time Assignment Speech Interpolation (TASI) facilities can exhibit over 75ms of variable delay and echo through them cannot be fully processed by the normal or extended delay cancellers. Some PBX units rapidly vary the amount of delay from two to three frames while a call is in progress. This varying delay seriously degrades cancellation performance. However, a PBX that maintains a fixed delay does not cause a problem. Equipment that exceeds the maximum endpath delay requirements or that exhibits varying delay may be used in the long-haul side of the 258X module and does not affect echo cancellation performance.**

## Network Interface

2.37 The 258 system interfaces the digital network directly on the 2.048Mbps digital path and thus eliminates the need for per-channel echo control devices on the associated VF circuits. At this interface level, both the send and receive ports of the 258 system accommodate multiplexed input signals in serial stream with segmented A-law or µ-Law (selectable) companded PCM coding and even bit inversion. Signals are transmitted using the HDB3 line code.

## Equipment Selection

2.38 Depending on the results of the calculations for determining the endpath delay, selection of the appropriate canceller can proceed; either the . . .

- 2581 — 32ms echo canceller, or the
- 2582 — 64ms echo canceller

## Echo Cancellation Control

2.39 Echo cancellation control is determined from two sources: the PCM line and the user configured canceller state. The system performs echo cancellation on channels in the active state. Echo cancellation is not performed on channels in the bypass state. A channel's active/bypass state is determined by the decision hierarchy shown in Figure 2-2. Table 2-3 provides examples of how higher level control overrides the lower level active/bypass control.

**LEVEL 1: Alarms**

Any PCM alarm, module failure, or channel self-test failure forces the channel into the bypass state.

**LEVEL 2: Tone Disabler**

When either the DTD or STD detects the disable signal, the module puts that channel into the bypass state to allow a call to pass data or a test tone through without being altered.

**LEVEL 3: Forced Active*/Forced Bypass (*see Important statement below Figure 2-2)**

The user may force a channel into the bypass or active state from the front panel or either of the V.24 serial ports. This is the only hierarchy configuration parameter stored in nonvolatile memory.

**LEVEL 4: CCS Busy/CCS Idle**

The Common Channel Signaling (CCS) busy and idle commands may be issued via the V.24 ports only. These commands are provided for applications where the active/bypass state of the canceller needs to be controlled by external equipment such as a digital switch.

**LEVEL 5: PCM Busy/Idle (In-Band Signaling)**

This lowest level of the decision hierarchy is controlled by the signaling state determined from the PCM stream directly. When optioned for idlecode monitoring, the channel is put into the bypass state when the selected idlecode pattern is detected on a channel. A unit optioned for the TS16 (Channel Associated Signaling [CAS]) mode uses the state of the selected CAS bit in TS16 from each frame in the MF to determine the active/bypass state for all channels.

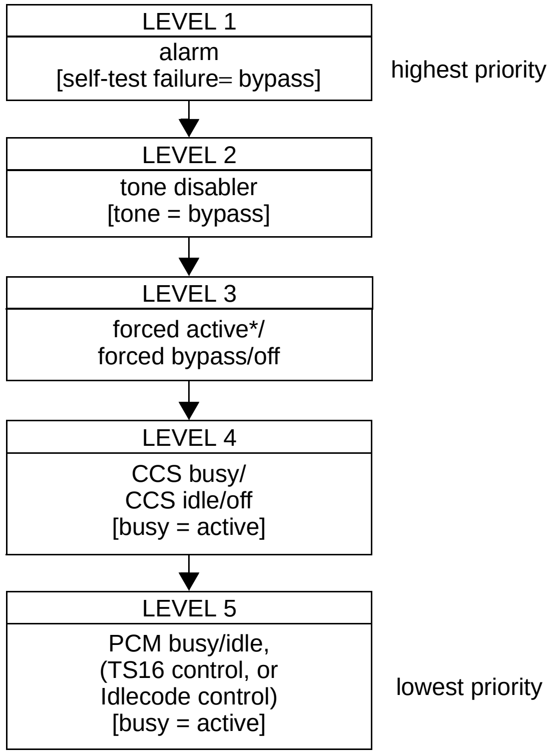


***Figure 2-2 Active/bypass decision hierarchy***

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**Important: *The forced active mode is to be used for diagnostic purposes only. Using the forced active mode during normal operation allows echo at the beginning of the call.**

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| alarm detected | tone detected | forced active*/ forced bypass/ off | CCS busy/ CCS idle/Off | PCM busy/ PCM idle | active/ bypass |
|---|---|---|---|---|---|
| no alarm | no tone | off | off | **idle** | bypass |
| no alarm | no tone | off | off | **busy** | active |
| no alarm | no tone | off | **CCS busy** | (don't care) | active |
| no alarm | no tone | off | **CCS idle** | (don't care) | bypass |
| no alarm | no tone | **forced active*** | (don't care) | (don't care) | active |
| no alarm | no tone | **forced bypass** | (don't care) | (don't care) | bypass |
| no alarm | **tone** | (don't care) | (don't care) | (don't care) | bypass |
| **alarm** | (don't care) | (don't care) | (don't care) | (don't care) | bypass |

Note: *See forced active mode **Important** statement below Figure 2-2.

***Table 2-3 Examples of active/bypass decision hierarchy***

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**Note: This table reads from left to right. Each column corresponds to a level in the decision hierarchy chart shown in Figure 2-2. The last column on the right is the cancellation state of the channel.**

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### Automatic Self-Test

2.40 The 258X module's self-test automatically verifies proper operation. The self-test sequence scans each channel at regular intervals for active/bypass status. Bypass channels are marked available for test. The testing sequence is halted for any channel that goes active during testing. For additional information, see *Module Diagnostics*, Section 5.

## 3. Installation

**Caution:** **STATIC-SENSITIVE EQUIPMENT! When unpacking and handling the equipment, be sure to wear a grounded wrist strap to protect it from possible static-discharge damage.**

### Inspection

3.1 Inspect the equipment upon its arrival to determine any possible shipping damage. If damage is found, immediately file a claim with the carrier. If the equipment has been in storage, reinspect it prior to installation.

### Module Placement in the Mounting Assembly

3.2 The 258X modules must be placed in slots 2 through 17 of the 258 mounting assembly. **Exception:** in the front access 258FA mounting assembly, the 258X modules must occupy slots 3 through 17, with slot 2 being reserved for the 2585 alarm and access module. In all 258 mounting assemblies, slots 1 and 18 are reserved for the 5140A power converter module.

**Note:** **For information about the 258FA mounting assembly, 2585 alarm and access module, and 5140A power converter module, see their associated practices (#76.810258FA, #76.I812585, and #76.825140A, respectively).**

3.3 The optional 258XMC module operates as a normal echo canceller in any slot, but to enable the master canceller features it must be installed in slots 16 and 17.

3.4 See Figure 3-1 for a module placement diagram.

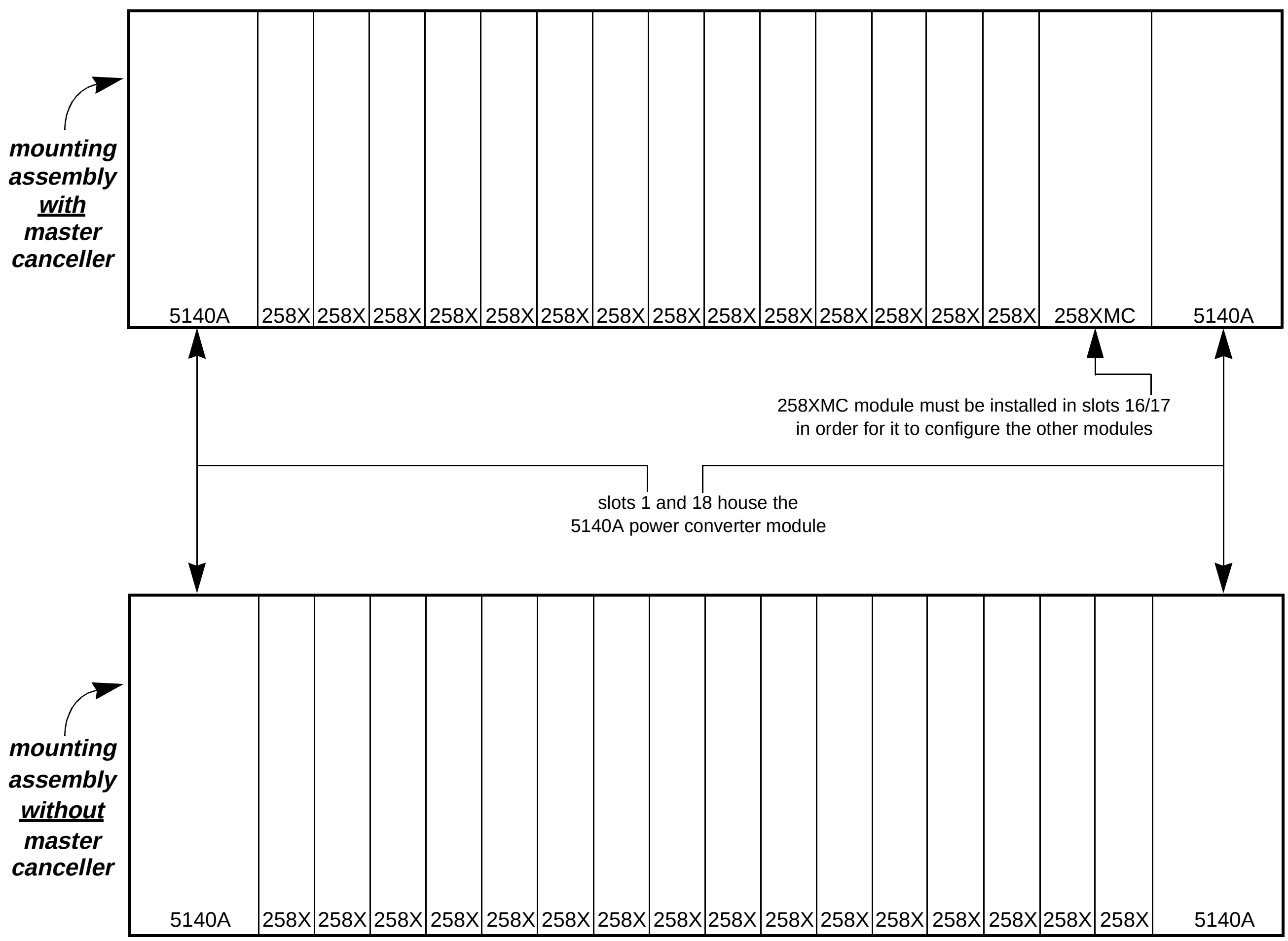



***Figure 3-1 258X module placement in rear-access mounting assembly***

## Initial Power-Up Sequence

3.5 During power-up, the 258X module performs extensive internal testing. The menu entry command and all four-character commands do not respond. When the power-up sequence is complete, the system responds normally to all V.24 commands. When the module passes power-up self-test and valid PCM signals are applied to the ports, only the green **selftest ok** and **pwr** LEDs light. (For factory default configurations, see the *258 E1 Echo Canceller User Interface Document*.)

### If Problems Are Encountered

3.6 If the module detects an internal failure during the power-up sequence, the **fault** LED lights. The unit is not field serviceable and must be replaced. Return the module to Tellabs, as described in paragraph 10.9.

## Installation Within the Network

3.7 To ensure that the 258X module has been properly installed in the network . . .

1. Verify that the endpath side has been connected to the send-in and receive-out ports.
2. Check continuity of wiring to the echo canceller mounting assembly. Program the echo canceller to forced bypass mode. At the cross-connect panel or other E1 access point, insert a framed PCM signal with a 1004Hz tone present on channel 1 into the send-in port of the echo canceller. Place the module into loopback (system mode configuration) and monitor for the tone at the receive-out port.
3. Program the module for the desired application. Information about front panel controls can be found in the *258 E1 Echo Canceller User Interface Document*. Information about SCPs can be found in this document in Section 4.

See Figure 6-1 for an orientation illustration.

## Front Panel Controls and System Configuration

3.8 Front panel LEDs provide the means for programming or monitoring both system and individual channel operating parameters. For more information about front panel operations and system configuration, see the *258 E1 Echo Canceller User Interface Document*, which includes an illustration of the module's front panel and a system configuration table with factory defaults specified.

# 4. Serial Communications Ports

## System Configuration and Status

4.1 The 258X module can be configured via several different user-friendly interfaces . . .

- control port American Standard Code for Information Interchange (ASCII) four-character commands or menus
- maintenance port four-character commands or menus
- master canceller front panel displays

**Note: The four-character command and menu sets are identical on both serial ports. The maintenance port is only available when the master canceller is not active. See the *258 E1 Echo Canceller User Interface Document* for additional information.**

## General

4.2 The 258X module's two SCPs are designated control port and maintenance port. Communication can occur over either SCP through the use of either V.24 ASCII commands or a menu. However, the control port is a high-priority link designed for dedicated busy/idle switch control of individual channels via the ASCII character CCS commands. The maintenance port is designed to handle the lower-priority tasks of optioning the module and providing maintenance information about the module or PCM line.

4.3 The 258 system SCPs are V.24 Electronics Industries Association (EIA) RS-232-C compatible. The SCPs are accessed via separate 25-pin D-subminiature connectors located on the rear of the 258 mounting assemblies. The ports can be independently daisy chained through multiple assemblies (up to 128 modules per link) and are intended for high-speed per-channel control of the echo canceller, so the fewer modules per daisy chain link the better. The system unit number (V.24 address) for each module is determined via the mounting position and options. Regardless of the SCP link configurations, the address is the same for both SCPs of a given module.

4.4 Prior to communication via the V.24 ports, switch options on the rear of the mounting assembly — i.e., shelf ID select and end of daisy chain — must be selected for proper mounting assembly and module addressing. See the *258X Mounting Assemblies* practice.

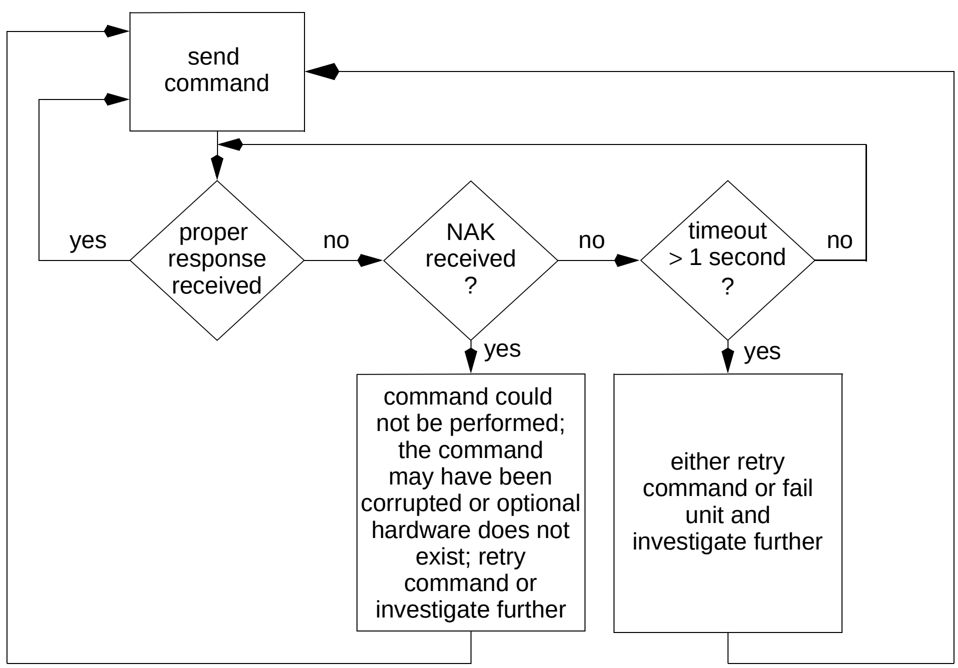
## V.24 Parameters

4.5 Each SCP is a full-duplex asynchronous link with seven data bits, one start bit, one stop bit, and even parity. Since the ports echo all received characters when end of daisy chain is set, the controlling terminal should be configured for remote echoplex operation. The 258 system functions with any of the following baud rates: 300, 600, 1200, 2400, 4800, 9600, 19200, or 38400. The display area of the terminal should be 80 columns by 24 lines. Data Terminal Ready (DTR) handshake should be enabled for units connected to the control port. This handshake is not available on the maintenance port. The SCPs may be configured to run at different baud rates to suit the user's application. If the auto baud feature is enabled, entering <break> <CR> a few times forces the baud rate of all modules on that SCP to the transmitted <CR> baud rate. The autobaud feature is very useful for getting all cancellers on a serial link back to a nondefault value after a set default command has been issued.

4.6 The 258 system supports the ASCII command/response protocol originally specified by the 256 echo cancellers, with some clarifications. This information is useful for anyone implementing automated control of the 258 system via ASCII commands.

- Real-time high throughput communications must use the control port.
- All communications must adhere to the specified command/response protocol.
- The response time for a command is measured from the last character received by the canceller to the first character of the response received by the controlling equipment.
- The canceller's response for all 256-compatible commands is less than 65ms.
- The canceller's response for non-256-compatible commands may be longer than 65ms.
- Canceller response times for valid commands vary based on system loading, but are guaranteed to be less than one second (typically 20ms).

The protocol can be summarized by the following flowchart . . .




## V.24 ASCII Character Command Interface

4.7 A sequence of ASCII characters — i.e., a command — can be used to control the 258 system. Users preferring this method should refer to the *258 E1 Echo Canceller User Interface Document*, which details the exact ASCII codes used to communicate with a 258 system.

### Menu Interface

4.8 A menu format is provided with the 258X module and resides within the on-board firmware. The menus display English text and accept simple user responses. The program has been designed to be self-prompting and self-explanatory.

### Mounting Assembly Compatibility

4.9 The 258X module is compatible with both the 254 PCM-30 echo canceller and 452 PCM-30 transcoder mounting assemblies. Serial port menus are available on both of these mounting assemblies if the SCP is not used for switch control purposes. The maintenance port is not available on either of these assemblies.

# 5. Module Diagnostics

5.1 The echo canceller performs three different types of integrity tests to verify proper functionality of the module: power-up diagnostics, per-channel self-test, and on-line audit.

## Power-up Diagnostics

5.2 Power-up diagnostics are run upon powering up a unit. Upon successful completion of the power-up diagnostics, the **selftest ok** LED lights. If any test fails, the unit stores the failed test code in nonvolatile memory and re-powers the module. If the same failure occurs twice in consecutive power-up attempts, the unit places all channels in bypass with the **fault** LED lit. The only feature functional on the module in this case is a limited version of the serial port. By selecting the failed canceller via the V.24 interface, a FAIL xxxx code can be retrieved.

## Per-Channel Self-Test

5.3 Per-channel self-test is an automatic test of the convolution processor. It is run on channels that are not currently performing cancellation. The purpose of this is to verify the cancellation circuitry for each channel.

5.4 One channel at a time is tested. Channels are subjected to self-test at regular intervals. If a channel currently running per-channel self-test is signaled to begin cancellation, the self-test is halted immediately. The channel is then reset and cancellation is enabled. Any channel that fails per-channel self-test is forced to bypass until it passes self-test. One or more channels failing self-test is a deferred alarm. Failure of all channels is an urgent alarm.

5.5 Even if a channel fails and later passes self-test, the channel number is stored in the self-test history register. This allows for easier detection of intermittent self-test failures.

5.6 The self-test history register can be accessed via the control or maintenance port. When the history register is read from the SCP, the history can be saved. A separate clear command is available when using the SCP.

## On-Line Audit

5.7 On-line audit is a series of tests that verify basic functional blocks in the canceller. These tests are divided into two categories: nonfatal errors and fatal errors.

5.8 With nonfatal errors the canceller continues functioning. Failures from the following modules constitute a nonfatal error . . .

- power supply #1 (if present)
- power supply #2 (if present)
- +12V on canceller module
- off-board HLC (if present when used in 254 or 452 mounting assemblies)
- on-board HLC (if present)

5.9 The following is a list of some of the functions that are verified during normal operation audit checks. Failure of any of these functions causes a fatal error code.

- flash memory checksum
- nonvolatile memory parity check
- programmable hardware configuration readback
- tone disabler program memory verification/checksum
- optional subassembly integrity

5.10 When a fatal error is detected it is stored in nonvolatile memory and the module is powered up again. If the error is not intermittent, power-up diagnostics catch the problem and lock the module, as described in paragraph 5.2. In the case where the error is intermittent, power-up diagnostics may not catch the problem. Therefore, if two errors are seen by these audit tests within one hour, all channels are bypassed and the **fault** LED is lit. If a terminal is available, obtain the fail code (see the *258 E1 Echo Canceller User Interface Document*) and record the code. Return this information, along with the module, to Tellabs, as described in paragraph 10.9.

### Loopback

5.11 The 258X module provides regenerative loopback of both the line and drop sides of the canceller. When the module is placed into loopback, the send-in bit stream is regenerated at the receive-out port (drop) and the receive-in bit stream is regenerated at the send-out port (line). In both cases, the regenerated bit stream is an exact reproduction of the bit stream received at the associated input port.

## 6. PCM Alarms

6.1 PCM alarms are indicated by front panel LEDs. They are grouped into two categories, send-in (drop) and receive-in (line). See Figure 6-1 and Tables 6-1 and 6-2 for alarm reference information.

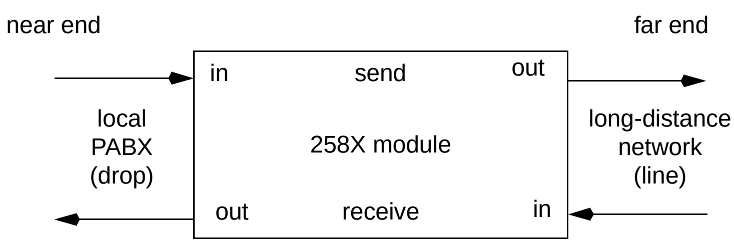



***Figure 6-1 258-to-facility orientation***

| alarm LED | alarm type | |
|---|---|---|
| send-in (drop) | local (always on) | excessive bit error ratio, loss of signal, or loss of framing (loss of frame sync or loss of CRC-4 synchronization) |
| | remote (always on) | loss of synchronization at near end channel bank or switch, detected at the 258 |
| | AIS (always on) | all ones detected, signifying upstream equipment failure |
| receive-in (line) | local (always on) | excessive bit error ratio, loss of signal, or loss of framing (loss of frame sync or loss of CRC-4 synchronization) |
| | remote (always on) | loss of synchronization at near or far end channel bank or switch, detected at the 258 |
| | AIS (always on) | all ones detected, signifying upstream equipment failure |

***Table 6-1 2.048Mbps alarms***

| alarm LED | alarm type | |
|---|---|---|
| send-in (drop) | local (flashing) | loss of MF synchronization at 258 |
| | remote (flashing) | loss of MF synchronization at near end channel bank or switch, detected at 258 |
| | AIS (flashing) | all ones detected in TS16, signifying upstream MF equipment failure |
| receive-in (line) | local (flashing) | loss of MF synchronization at 258 |
| | remote (flashing) | loss of MF synchronization at near end channel bank or switch, detected at 258 |
| | AIS (flashing) | all ones detected in TS16, signifying upstream MF equipment failure |

***Table 6-2 Multiframe alarms***

## System Alarms

6.2 When fault conditions are detected by the 258X module, they are classified as either urgent or deferred. In addition, each of the two alarm classes activate relays on the 258 mounting assemblies. The output of these relays can be connected by the installer to the optional alarm panel.

**Note: Urgent, deferred, and service alarm relay states are not displayed on the optional master canceller front panel.**

### Urgent Alarms

6.3 Urgent alarms are caused by . . .

- loss of signal, framing loss, MF sync loss, or excessive bit error ratio at the send-in port
- loss of signal, framing loss, MF sync loss, or excessive bit error ratio at the receive-in port
- self-test failure of all channels
- internal module fault
- loss of +5V supply

**Note: An urgent alarm indication also occurs upon initial power-up.**

### Deferred Alarms

6.4 Deferred alarms are caused by . . .

- Bit Three Remote (B3R) alarm MF remote at the send-in port
- B3R alarm MF remote at the receive-in port
- Alarm Indication Signal (AIS) or MF AIS received at the send-in port
- AIS or MF AIS received at the receive-in port
- self-test failure of one or more channels
- single power converter failure

### Service Alarms

6.5 Service alarms are activated when an urgent or deferred alarm is declared.

**Note: There is no front panel indication of the service alarm on the 258X module.**

## Alarm Cut Off, Lamp Test, and PCM Alarm History

6.6 Momentarily depressing the power converter’s Alarm Cut Off (**ACO)** pushbutton causes the **ACO** LED to illuminate and restore the corresponding alarm relay to its normal state, thereby clearing the external alarm indications. However, front panel alarm indications remain until the fault is cleared.

6.7 Depressing the **ACO** pushbutton for more than one second places all modules in the mounting in a lamp test mode for approximately three seconds; this should cause all LEDs to be lit. If an LED fails to light during this test, the module is defective and should be replaced.

6.8 Depressing the **ACO** pushbutton for more than three seconds causes the 258X module to display the ALARM HIST of the PCM alarm history register and/or any remembered self-test failures via the front panel alarm LEDs. The PCM alarm history register is cleared after this.

6.9 The 258X module stores in a PCM alarm history register the last PCM alarm that has cleared for each PCM span.

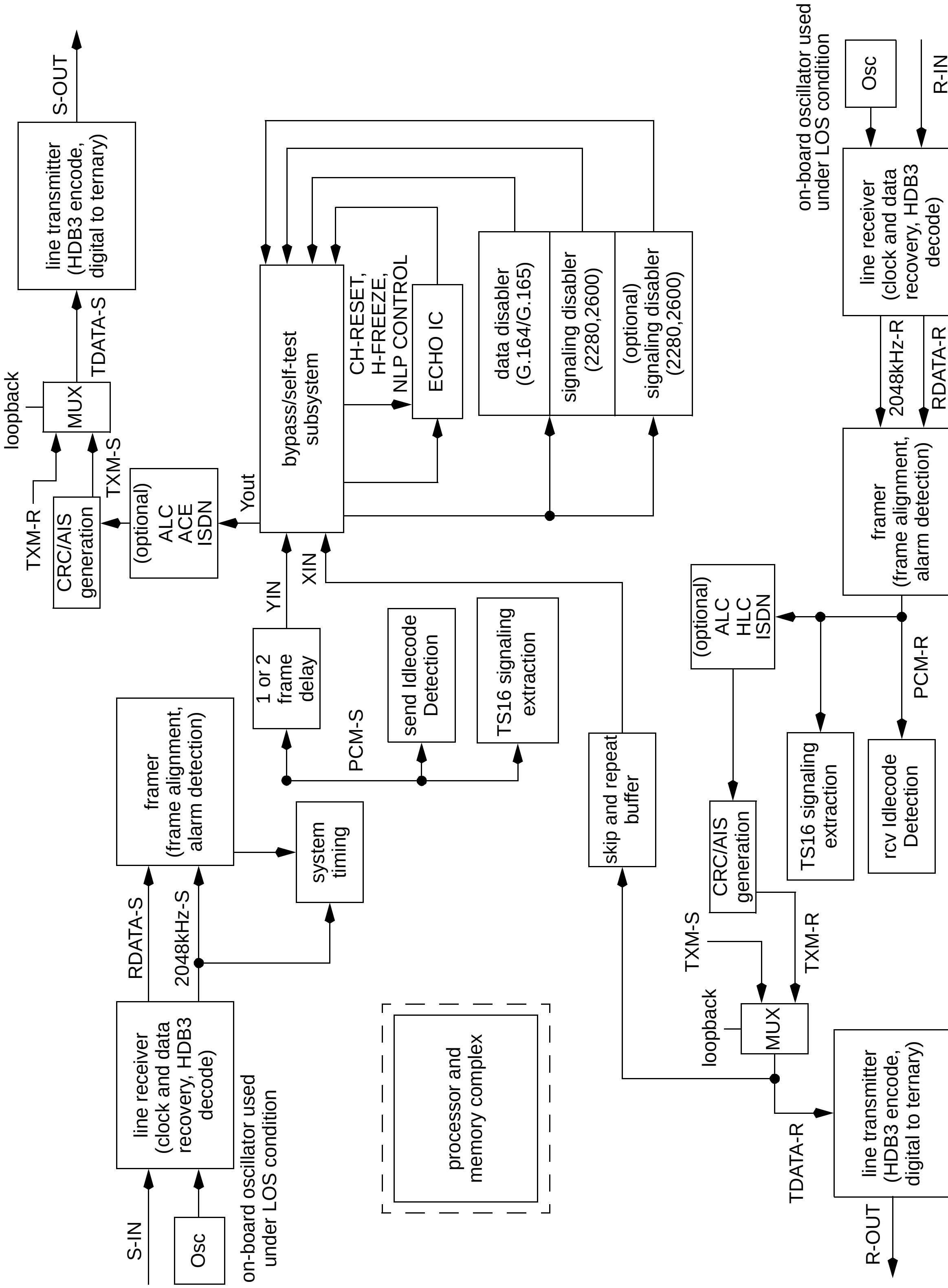
## Alarm Timings and Interaction

6.10 When a 258X module loses synchronization at either PCM input, a local alarm is generated immediately, and an AIS is transmitted at the respective output. From 500ms to 750ms later, an urgent alarm is generated. When synchronization is restored, both the local alarm and AIS transmission immediately cease. From 500ms to 750ms after restoration, the urgent alarm is retired.

6.11 When a module receives AIS at either PCM input, AIS is transmitted at the respective output and a deferred alarm is generated 250ms to 500ms later. When synchronization is restored, AIS transmission ceases immediately and the deferred alarm is retired 250ms to 500ms later.

6.12 When a module receives a B3R alarm at either PCM input, the alarm is transmitted at the corresponding output and a deferred alarm is declared immediately. When synchronization is restored, the deferred alarm is retired immediately.

# 7. Block Diagram



# 8. Acronyms

| | |
|---|---|
| ACO | Alarm Cut Off |
| AIS | Alarm Indication Signal |
| ALC | Automatic Level Control |
| ASCII | American Standard Code for Information Interchange |
| B3R | Bit Three Remote |
| CAS | Channel Associated Signaling |
| CCS | Common Channel Signaling |
| CRC-4 | Cyclic Redundancy Check-4 (four-bit number) |
| DST | Dynamic Signal Transfer |
| DTD | Data Tone Disabler |
| DTR | Data Terminal Ready |
| EIA | Electronics Industries Association |
| ERL | Echo Return Loss |
| ERLE | Echo Return Loss Enhancement |
| HLC | High-Level Compensation |
| ITU-T | International Telecommunications Union — Telecommunication Standardization Sector |
| MF | Multiframe |
| MFAW | Multiframe Alignment/alarm Word |
| NAK | Not Acknowledge (ASCII hex 15) |
| NLP | Non-Linear Processor |
| PCM | Pulse Code Modulation |
| SCP | Serial Communications Port |
| SF | Single Frequency |
| STD | Signaling Tone Disabler |
| TASI | Time Assignment Speech Interpolation |
| TLP | Transmission Level Point |
| VF | Voice Frequency |
| VNL | Via Net Loss |
| VPA | Voice Path Assurance |

# 9. Specifications

## network interface

| | |
|---|---|
| *interface* | • complies with ITU-T G.703 for E1 transmission |
| *line coding* | • HDB3 per ITU-T G.703 and G.704 |
| *line rate* | • 2.048Mbps ± 50 ppm as per ITU-T G.703 |
| *PCM encoding* | • A-Law or µ-Law (selectable) as per ITU-T G.711 |
| *jitter tolerance* | • complies with ITU-T G.704<br>• meets ITU-T G.823 for jitter tolerance, jitter transfer, residual jitter out<br>• meets BABT/OFTEL TR002/003 for jitter tolerance, jitter transfer, residual jitter out |
| *port impedances* | • 75-ohm unbalanced coaxial and/or 120-ohm balanced wire wrapped shielded |
| *signal processing delay* | • send channel: (1 frame + delay mode) 238 µsec ± 5 percent (maximum of 250 µsec)<br>(2 frame + delay mode) 363 µsec ± 5 percent (maximum of 381 µsec)<br>• receive channel: (HLC off/not present) 56 µsec ± 5 µsec<br>(HLC on) 64 µsec ± 5 µsec |
| *framing format* | • complies with ITU-T G.704 |

## canceller circuits

| | |
|---|---|
| *standards compliance* | • fully compliant with ITU-T recommendations G.165 and G.168 |
| *echo return loss enhancement* | • greater than 35dB with a minimum ERL of 6dB at an equivalent receive-input level of 0.0dBm0 (NLP disabled) |
| *convergence* | • greater than 34dB combined ERL and ERLE within 50ms |
| *maximum endpath round-trip delay* | • 32ms or 64ms (96ms or 128ms optional) |
| *minimum endpath echo return loss* | • 0dB, 3dB, or 6dB, selectable |
| *data tone disabler* | • 2100Hz per ITU-T recommendation G.164 or 2100Hz, with phase reversal per ITU-T recommendation G.165 |
| *signaling tone disabler* | • selections compatible with ITU-T recommendation for #5, #6 and #7, 2600Hz, or 2280Hz in-band signaling tones |

## physical

| | |
|---|---|
| *dimensions* | • height: 222mm (8.7 inches)<br>• width: 20mm (.8 inches)<br>• depth: 202mm (7.9 inches) |
| *weight* | • 422.42 grams (14.9 ounces) |

## environmental

| | |
|---|---|
| *operating temperature* | • 0° to +50°C (+32° to +122°F) |
| *storage temperature* | • –50° to +85°C (–58° to +188°F) |
| *input voltage* | • –48VDC nominal or –60VDC nominal, –40 to –75VDC full range to the 5140A module |

## power consumption

*power draw watts* • see following table . . .

| module | typical power draw | |
|---|---|---|
| | **watts @ 5VDC** | **watts @ 48VDC** |
| 2581 | 4.75 | 5.9 |
| 2582 | 6.8 | 8.8 |

# 10. Testing, Troubleshooting, Technical Assistance, Repair and Return

10.1 This section will serve as an aid in the localization of trouble to the specific equipment covered in this practice. If a situation arises that is not covered, contact Tellabs Technical Assistance — see paragraph 10.8 for phone numbers.

10.2 If the equipment seems to be defective, substitute new equipment (if possible) and test the substitute. If the substitute equipment operates correctly, the original equipment should be considered defective and returned to Tellabs for repair or replacement, as directed in paragraph 10.9.

10.3 We strongly recommend that no internal (component-level) testing or repairs be attempted on this equipment; unauthorized testing or repairs may void its warranty.

## Data Tone Disabler Test

10.4 To test the DTD for proper operation, perform the following steps . . .

1. Option the canceller for G.164 DTD (see the *258 E1 Echo Canceller User Interface Document*).
2. Activate cancellation on channel 1 by selecting forced active* mode using the four-character V.24 commands or the optional master canceller. Verify that the canceller is active.
3. Apply a 2100Hz PCM encoded disabling tone on channel 1 of the send-in port of the canceller. Verify that the canceller is not active.
4. Repeat procedure at the receive-in port.

**Note: *See forced active mode Important statement below Figure 2-2.**

## Echo Cancellation Test

10.5 To ensure that the 258X module has been installed in the network properly, perform the following test. With a module connected as shown in Figure 10-1, 35dB of echo cancellation should be obtained.

1. Option the module for the canceller only (NLP off) mode (see the *258 E1 Echo Canceller User Interface Document*).
2. Select forced bypass operation on channel 1.
3. Set the attenuator for 10dB of loss.
4. Set the noise generator for a 5kHz bandwidth and 2σ clipping level.
5. Verify that all Transmission Level Point (TLP) shifts have been taken into account.
6. Adjust the noise generator for a –10dBm0p or 80dBrnC0 output level. The transmission test set should now read –20dBm0p or 70dBrnC0.
7. Activate cancellation by selecting forced active* mode (*see forced active mode **Important** statement below Figure 2-2). The transmission test set should read less than or equal to –55dBm0p or 35dBrnC0 (waiting several seconds until the test instrument provides a stable reading).

**Notes:**

1. **For proper test results, it is essential that white noise be used for this test (see Note 2 below). Pseudo-random noises or tones give different test results. For more information about echo canceller testing, see ITU-T recommendation G.165.**
2. **The Genrad 1381 noise generator is used for laboratory measurements at Tellabs. The Wiltron 9041 or 9601 built-in noise generators also give good results.**

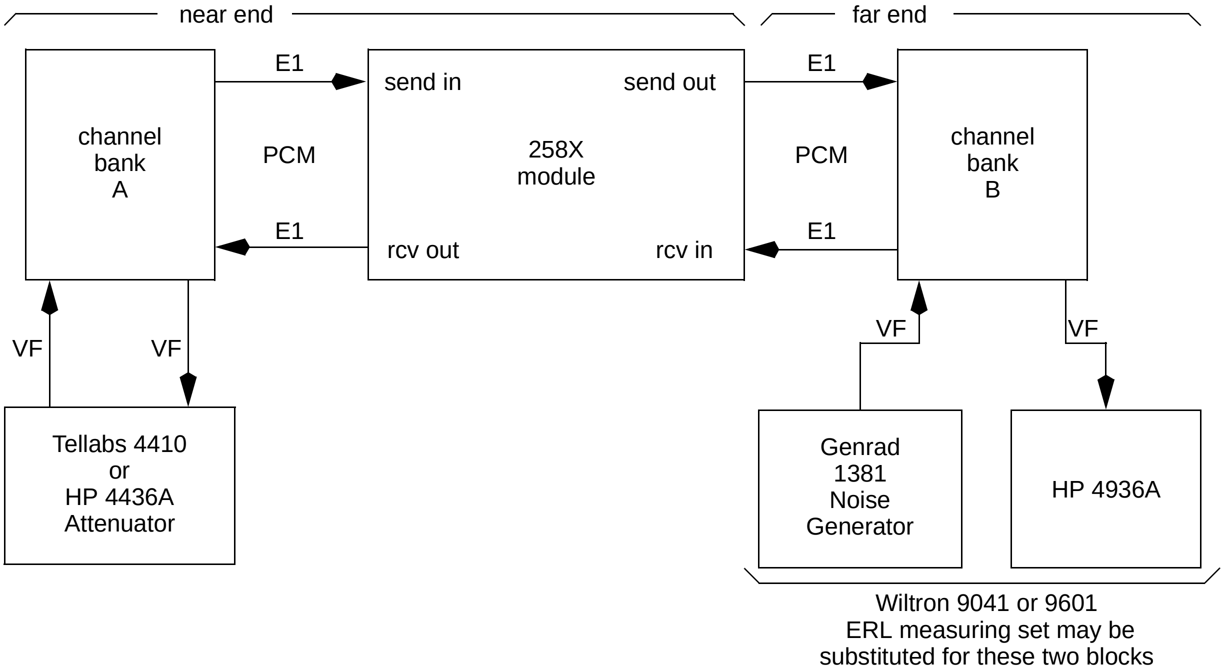



***Figure 10-1 Echo cancellation performance test***

## Error Codes

10.6 For a list of the error codes that are displayed at the V.24 SCPs when the module fails, see the *258 E1 Echo Canceller User Interface Document*.

10.7 Table 10-1 will assist with troubleshooting the module when the optional master canceller is being used.

| symptoms | | |
|---|---|---|
| **top display (available on master canceller only)** | **bottom display (available on master canceller only)** | **possible source of problem** |
| FAIL or DEAD*<br>(solid display) | 0001 — 6FFF<br>(solid display) | Power-up failure occurred. Note failed test number on repair tag and return unit to Tellabs for repair. |
| FAIL<br>(flashing display) | CH00 — CH31<br>(flashing display) | Channel self-test failure occurred. Module is defective. Note failed channel number on repair tag and return unit to Tellabs for repair. |
| FAIL<br>FAIL<br>FAIL<br>(flashing displays) | PS#1<br>PS#2<br>HLCx<br>(flashing displays) | Failure occurred, not on canceller, not fatal . . .<br>power supply #1<br>power supply #2<br>external HLC board |
| FAIL<br>FAIL<br>(flashing displays) | HLC<br>+12V<br>(flashing displays) | Failure occurred on canceller, not fatal . . .<br>On-board HLC<br>+12V supply on canceller (If all modules in the mounting assembly have the same failure, the power supply is bad. If only one module on the mounting assembly has the failure, just that module is bad.) |
| CH00 (not error)<br>(solid display) | Mix<br>(flashing display) | Channels are not all configured the same. Module is not defective. |
| continued . . . | | |

***Table 10-1 Troubleshooting Guide***

| **symptoms** | | **possible source of problem** |
|---|---|---|
| **top display (available on master canceller only)** | **bottom display (available on master canceller only)** | |
| Canceller fails to cancel, although PCM alarms are extinguished and **canclr active** LED is lit for channel. | | (1) Check network conditions. Line and drop connections to canceller may be reversed.<br>(2) H-RESET, H-HOLD, or LOOPBACK may be activated. These are only test modes and should be disabled.<br>• LOOPBACK can be accessed via the front panel or V.24 ports.<br>• H-RESET and H-HOLD can only be accessed via V.24 ports. |
| Canceller fails to respond to idle codes. | | (1) Expected idlecode pattern may not be properly defined. Check on front panel or in V.24 menus.<br>(2) The canceller may be configured for TS16 control rather than idle codes. These are mutually exclusive PCM busy/idle control modes.<br>(3) Canceller may have a higher-priority active/bypass request than PCM — i.e., CCS busy/idle, forced active†/bypass, tone disabled. |
| Canceller fails to respond to TS16 control. | | (1) Control bit and polarity may be optioned improperly. Check via front panel or V.24 to verify canceller configuration.<br>(2) The canceller may be configured for idlecodes rather than TS16 control. These are mutually exclusive PCM busy/idle control modes.<br>(3) Canceller may have a higher-priority active/bypass request than PCM — i.e., CCS busy/idle, forced active†/bypass, tone disabled. |
| Poor cancellation. | | (1) Maximum endpath delay may have been exceeded. Re-calculate actual endpath delay.<br>(2) ERL in the network may not match expected ERL in the canceller. There are three options in the canceller: 0dB, 3dB, 6dB. |
| Canceller is not responding to disabling tones. | | (1) Tone disabler may be optioned improperly — i.e., disabled; wrong disabler selected.<br>(2) Tone may be out of detection bandwidth. |
| Red **local** LED is on. PCM provides 2.048Mbps framing properly. | | (1) CRC-4 may be enabled. CRC-4 sync loss is the declared alarm. Module is not defective; the network and module are not configured consistently. |

*The master canceller does not display other cancellers' FAIL or DEAD information.

†See forced active mode **Important** statement below Figure 2-2.

***Table 10-1 Troubleshooting Guide***

## Technical Assistance

10.8 Contact Tellabs Technical Assistance as follows . . .

| location | telephone | FAX |
|---|---|---|
| **Argentina** — Tellabs International, Inc., Sucursal Buenos Aires | +541.393.0764, .0892, or .0835 | +541.393.0732 |
| **Australia** — Tellabs Pty Ltd., Milson's Point NSW, Sydney | +61.2.9966.1043 | +61.2.9966.1038 |
| **Brazil** — Tellabs International, Inc., Rio de Janeiro | +5521.518.2224 | +5521.516.7063 |
| **Brazil** — Tellabs International, Inc., Sao Paulo | +55.11.5505.3009 | +55.11.5506.7175 |
| **Canada** — Tellabs Comm. Canada Ltd., Mississauga, Ontario | 905.858.2058 | 905.858.0418 |
| **China** — Tellabs International, Inc., Beijing | +86.10.6510.1871 | +86.10.6510.1872 |
| **Colombia** — Tellabs International, Santa Fe de Bogota | +571.623.3162 or .3216 | +571.623.3047 |
| **England** — Tellabs U.K. Ltd., Bucks | +44.1494.555800 | +44.1494.555801 |
| **Finland** — Tellabs Oy, Espoo | +358.9.413.121-main # | +358.9.4131.2815 |
| **France** — Tellabs SAS, Guyancourt | +33.1.345.20838 | +33.1.309.60170 |
| **Germany** — Tellabs GmbH, Munich | +49.89.54.90.05.+ext. or 0 (switchboard) | +49.89.54.90.05.44 |
| **Hong Kong** — Tellabs H.K. Ltd. | +852.2866.2983 | +852.2866.2965 |
| **Hungary** — Tellabs GmbH Rep. Office, Budapest | +36.1.2681220 | +36.1.2681222 |
| **India** — Tellabs International, Inc., Bangalore | +91.80.2261807 or .2266850 | +91.80.2262170 |
| **India** — Tellabs International, Inc., New Delhi | +91.11.6859824 | +91.11.6859824 |
| **Ireland** — Tellabs, Ltd., County Clare | +353.61.703000 | +353.61.703333 |
| **Italy** — Tellabs Italia SRL, Roma | +39.6.52207.205 | +39.6.52207.206 |
| **Japan** — Tellabs International, Inc., Tokyo | +81.3.5322.2977 | +81.3.5322.2929 |
| **Lebanon** — Tellabs Oy, Dbayeh | +961.4.525.929 | +961.4.525.171 |
| **Mexico** — Tellabs de Mexico | +525.255.0057 | +525.255.0061 |
| **Netherlands** — Tellabs Netherlands b.v. | +31.30.6004070 | +31.30.6004090 |
| **Philippines** — Tellabs International, Inc., Sucat, Muntinlupa City | +63.2.838.0970 | ——— |
| **Singapore** — Tellabs Singapore Pte, Ltd. | +65.3367.611 | +65.3367.622 |
| **Republic of South Africa** — Tellabs Pty Ltd., Hennopsmeer | +27.12.672.8025 | +27.12.672.8024 |
| **South Korea** — Tellabs International, Inc., Seoul | +82.2.589.0667 | +82.2.589.0669 |
| **Spain** — Tellabs Southern Europe s.a., Madrid | +34.91.315.48.56 | +34.91.315.77.70 |
| **Sweden** — Tellabs AB, Stockholm | +46.8.440.4340 | +46.8.440.4341 |
| **Thailand** — Tellabs International, Inc., Bangkok | +662.642.7817 | +662.642.7820 |
| **USA** and **Puerto Rico** | 800.443.5555* | 630.512.7097 |
| *All other **Caribbean** and **South American** locations, or if the toll-free number is busy, telephone 630.378.8800 | | |

5.28.98

## Repair and Return

10.9 If equipment needs repair, contact Tellabs' Product Services Department with the equipment's model and issue numbers and warranty date code. You will be issued a Material Return Authorization (MRA) number and instructions on how and where to return the equipment.

| location | telephone | FAX |
|---|---|---|
| **Finland** — Tellabs Oy, Espoo | +358.9.413.121-main # | +358.9.4131.2815 |
| **Canada** — Tellabs Comm. Canada Ltd., Mississauga, Ontario | 905.858.2058 | 905.858.0418 |
| **Ireland** — Tellabs, Ltd., County Clare | +353.61.703000 | +353.61.703333 |
| **Lisle, IL USA** — Tellabs Operations, Inc. | 800.443.5555 (USA and Puerto Rico only)<br>630.378.8800 (other International) | 630.512.7097 (both) |

5.28.98

10.10 Repair service includes an attempt to remove any permanent markings made by customers on Tellabs equipment. If equipment must be marked, it should be done with nonpermanent materials and in a manner consistent with the correct handling of electrostatically sensitive devices.