4119 and 4119S Echo Canceller Modules

Contents

1. General

1.1 The 4119 and 4119S Echo Canceller Modules (hereafter referred to throughout this practice as 4119/S, except where differentiation is necessary) are adaptive, split-type echo cancellers intended for use near the end points of 4-wire transmission facilities that are characterized by appreciable propagation delay. Echo caused by signal reflections from impedance discontinuities and interface points (e.g., 4-wire to 2-wire interfaces) are effectively cancelled by these modules during Voice Frequency (VF) transmission. Therefore, the 4119/S is especially well suited for use in single-hop and double-hop satellite circuits (whose round-trip delays are about 600ms and 1200ms, respectively), and in long terrestrial circuits (those with round-trip delays exceeding 50ms).

1.2 The 4119 and 4119S Modules are identical, except for the presence of circuitry on the 4119S Module that disables echo cancellation during the presence of 2600Hz Single Frequency (SF) signaling tone.

1.3 In conventional applications, echo cancellers are located on the terminal equipment side of SF signaling units and therefore do not have to contend with SF signaling tone. (This is the intended application of the standard 4119 Module.) Certain applications, however, require that an echo canceller be located within the SF signaling link, where SF tone may be present in one or both directions. In such end link applications, the echo canceller must be transparent to SF tone transmission so that no interference occurs between SF signaling and echo cancellation. This means that the canceller must contain circuitry that allows SF tone to bypass its echo control sections. Such circuitry is provided on the 4119S Module. Upon detection of continuous SF tone transmission in either or both channels, the 4119S Module completely disables its echo cancellation and Non-Linear Processor (NLP) (residual echo removal) sections. The SF tone is therefore passed unchanged and intact to the output ports. Approximately 400ms after SF tone ceases, the module resumes its echo cancellation and non-linear processing functions. The tone detection portion of the 4119S Module's disabler circuitry is designed to allow for SF dial pulsing and also for loop start and ground start operation on foreign exchange station end (FXS) and office end (FXO) circuits, where SF tone is on during idle in one or both directions.

1.4 As previously stated, the 4119/S is a split-type echo canceller, meaning that the 4119/S, used at one end of a 4-wire circuit, protects the opposite end of the circuit from echo. Therefore, when the 4119/S (or equivalent) is used at each end of a 4-wire circuit, the parties at both ends are protected from echo.

1.5 Unlike an echo suppressor, which inserts a high impedance into the return path to attenuate echo, the 4119/S digitally computes a highly accurate echo estimate based on the incoming speech signal from the far end. This estimate is then subtracted from the transmit channel (return path) signal. When the transmit signal consists of only echo, the echo is removed, leaving no signal to be returned to the speaker. When the transmit signal consists of both echo (from the far end speaker) and near end speech, only the echo is removed, leaving the near end speech signal intact for transmission to the distant end. The 4119/S allows parties at both ends to talk simultaneously. This is known as full duplex speech or "doubletalk".

1.6 Due to its completely adaptive nature, the 4119/S cancels echo in any circuit whose end path (the path between the 4119/S and the near end terminating set) exhibits at least 6dB of Echo Return Loss (ERL) and no more than 64ms of delay.

Note: End path delay consists of the round-trip propagation delay of all facilities in the end path, fixed delays through transmission and switching equipment, and line dispersion, which is typically 4 to 7ms with a 3400Hz bandwidth.

Reason for Change

1.7 This practice has been reissued to change the module specifications, and to incorporate information from Addendum Section A814119S-A, dated 3/90.

4119/S Features and Options

1.8 Standard 4119/S features are as follows:

- Compliance with International Telegraph and Telephone Consultive Committee (CCITT) recommendations G.164 (for tone disabler) and G.165
- Integral NLP for removing residual echo. A switch option conditions the NLP for operation during both singletalk (only the far end party talking) and doubletalk or, per the above CCITT recommendation, during singletalk only
- 3-position front panel switch that selects any of three operating modes:
  - Normal (norm), in which all echo control circuits are active and the module is fully operational
  - Canceller Only (canclr only), in which the integral NLP is disabled, leaving only the cancellation section operational
  - Disable (disable), in which both the cancellation section and the NLP are disabled, leaving only straight-through transmit and receive transmission paths for testing
- A switch option that conditions the modules for operation on end paths with a maximum propagation delay of either 32 or 64ms
- Switch selectable, soft clipping operation, which adds a small amount of noise at the transmit output to make operation of the canceller less noticeable on noisy end paths
- Integral tone disabler that, upon detection of 2100Hz tone (indicating forthcoming data transmission), disables all echo control circuitry. This renders the module completely transparent in both directions for the duration of the data transmission
- Transformer coupling at all four transmission ports
- Balanced, switch selectable 1200-, 600-, or 150-ohm terminating impedance at the terminal side (terrestrial side) ports (transmit input and receive output)
- Fixed, balanced, 600-ohm terminating impedance at the facility side (satellite side) ports (receive input and transmit output)
- Switch selectable interface Transmission Level Points (TLPs), with a choice of –16 transmit and +7 receive, –4 transmit and +4 receive, or 0 transmit and 0 receive at both the facility and terminal side ports

- Transmit and receive channel attenuators that each provide from 0 to 24dB of prescription set loss in 0.1dB increments, as selected via front panel DIP switches
- An input lead accessible at the module's card edge connector that, upon external application of ground, disables all echo control circuitry for the duration of the ground
- Two front panel bantam-type monitoring jacks that bridge the transmit and receive pairs on the module's facility side
- Two front panel indicator LEDs labeled diverge and disable; diverge lights during far end speech to indicate a "diverged" condition, meaning that the module is unable to compute a correct echo estimate, and disable lights when the echo control circuitry is disabled
- Operation on nominal –24 or –48VDC input battery, with maximum power consumption of 1.8 watts
- Type-10 module packaging for mounting in a Tellabs Type-10 Mounting Shelf, versions of which are available for relay rack (occupying 6 inches of vertical rack space) and apparatus case installation. Can also be mounted in a pre-wired Tellabs 262-Series Network Channel Terminating Unit/Data Station Termination (NCTE/DST) Mounting Assembly

2. Applications

2.1 The primary application of the 4119/S is in 4-wire single-hop and double-hop satellite circuits whose round-trip delays are approximately 600 and 1200ms, respectively, and in 4-wire terrestrial circuits with round-trip delays exceeding 50ms. In such long delay circuits, the operating characteristics of conventional echo suppressors can be objectionable, thereby necessitating the use of echo cancellers.

2.2 The 4119/S functions well in any of the aforementioned circuits because its operation is totally independent of canceller-to-canceller propagation delay. Naturally, the 4119/S can also be used in circuits traditionally protected from echo by suppressors or through the use of Via Net Loss (VNL) techniques.

2.3 In conventional applications, echo cancellers are located on the terminal equipment side of SF signaling units and therefore do not have to contend with SF signaling tone. This is an application of the 4119 Module only, and is depicted in Figure 2-1.

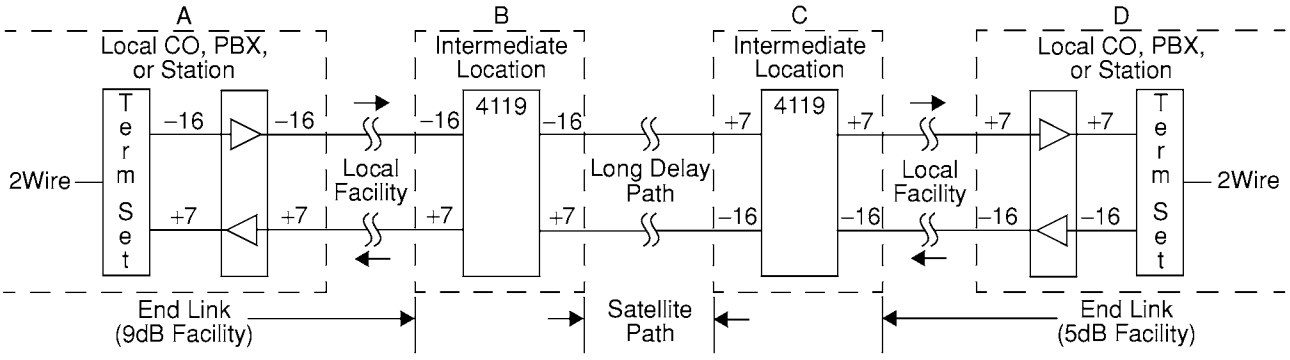

Figure 2-1 Typical 4119 Module Conventional Application

Split-Type Echo Cancellation

2.4 Because it is a split-type echo canceller, one 4119/S (or equivalent) is required at each end of a circuit to protect both parties from echo. In such an arrangement, point A is protected from echo by the 4119/S at distant point B, and point B is protected from echo by the 4119/S at point A. This split-type configuration makes the 4119/S completely insensitive to transmission delays over the long haul link.

2.5 While the 4119/S can be installed at one end of a circuit and a conventional echo suppressor at the other, only the party at the end distant from the 4119/S benefits from its attributes; the other party must contend with the usual echo suppressor operating characteristics.

Operating Modes

2.6 A 3-position slide switch on the front panel selects any of three operating modes:

- Normal (norm), in which both the echo cancellation circuity and NLP (for residual echo removal) are active. This mode is selected for normal module operation.
- Canceller Only (canclr only), in which the echo cancellation circuity is active but the NLP is disabled. This mode is used primarily during testing.
- Disable (disable), in which both the echo cancellation circuity and NLP are disabled, thereby providing straight-through transmit and receive transmission paths. This mode is used during alignment and testing.

Transmission Considerations

End Path ERL Limits

2.7 For proper operation of the 4119/S, the ERL of the end path (the path between the 4119/S and the near end terminating set from which echo is returned) must be 6dB or greater.

End Path Delay Limits

2.8 Maximum round-trip delay of the end path served by a 4119/S must fall within the selected signal processing window of 0 to 32ms or 0 to 64ms for proper operation of the echo canceller. When calculating end path delay, three factors must be considered:

- total round-trip propagation delay of all the facilities that make up the end path,
- fixed delays through transmission and switching equipment in the end path, and
- dispersion (spreading of energy) of those facilities, especially that of loaded cable and the anti-aliasing filters used in channel banks

2.9 Total round-trip dispersion in end paths containing loaded cable and/or channel banks typically ranges from 4 to 7ms. Tables 2-1 and 2-2, and the example following them, may help in calculating end path delays. When making such calculations, note the following:

- The length of any transmission facility must always be doubled to obtain the total round-trip distance.
- The 4119/S effectively cancels multiple echo on an end path as long as that echo does not exceed the selected 32 or 64ms round-trip delay limit.
- For applications with longer end path round-trip delays of 32 to 64ms, the 64ms end path delay option must always be selected.

Note: With the 64ms option selected, the Echo Return Loss Enhancement (ERLE) provided by the 4119/S is approximately 2dB lower than with the 32ms option. Therefore, instead of selecting the 64ms option in applications where end path delay is known only to be 64ms or less, Tellabs recommends that end path delay calculations always be made as directed to ensure the best possible echo cancellation performance.

Transmission Facility	Approximate Wave Speed (Miles/Seconds)	Approximate Propagation Delay (ms/Mile)
Loaded VF Cable	3,000 to 20,000	0.5 to 0.33
Non-Loaded VF Cable	50,000	0.02
T1 Carrier Line	94,000 to 125,000	0.008 to 0.0106
Fiber Optic Cable	100,000	0.01
L-Carrier Coaxial Cable	100,000 to 125,000	0.008 to 0.01
Terrestrial Microwave	140,000	0.007

Table 2-1 Approximate Wave Speeds of Transmission Facilities

Transmission Equipment	Fixed One-Way Delay
PCM Channel Bank	0.125 to 0.5ms (plus dispersion)
Digital Switch	Up to 1.2ms
Transmux	1.8 to 6ms (each conversion)
M13 Mux	0.5ms
Digital Cross-Connect Systems	0.25ms
Note that the above delays are approximations. For delays of specific equipment, consult manufacturer's literature. Also note that some Time Assigned Speech Interpolation (TASI) facilities may exhibit more than 75ms of delay, making them unsuitable for both normal and extended delay cancellers.	

Table 2-2 Approximate Delays Through Transmission/Switching Equipment

End Path Delay Calculation Example

Let's assume that the end path consists of the following:

- a channel bank
- a 500-mile T1 line
- another channel bank
- 5 miles of loaded cable to the subscriber

Round-trip delay for this end path is calculated as follows:

- Round-trip delay of T1 line

= 500 miles x 2 (for round trip) x 1 second/100,000 miles
= 0.0100 second = 10.0ms

- Round-trip delay of loaded cable

= 5 miles x 2 (for round trip) x 1 second/10,000 miles
= 0.001 second = 1ms

- Fixed delay of channel bank

= 0.125ms x 4 = 0.5ms

- Round-trip dispersion of channel banks and loaded cable

= 7ms (estimated)

- Total end path round-trip delay

= 10.0ms + 1ms + 0.5ms + 7ms
= 18.5ms

This delay is well below the 32 or 64ms maximum end path delay for proper signal processing by the 4119/S. Thus, the 4119/S provides effective echo cancellation for this end path.

End Path Signal Linearity

2.10 The 4119/S must be located at a point in an end path where its processed signals are nominally linear. If the 4119/S is located at a point where the signals are non-linear, e.g., after a compressor but before an expander, its performance will be degraded. This is because the 4119/S always creates a linear end path model.

Convergence Time

2.11 In normal operation, upon establishing a voice path the 4119/S begins an initial adaptation process known as convergence. In convergence, the module constructs a mathematical model of the near end path (terminating set and interconnecting facility) to calculate an echo estimate. This convergence process is usually completed in 200ms or less, depending upon the signal level in the receive path. When the person at the distant end begins to talk, some echo is initially heard, but this disappears upon convergence of the 4119/S at that end (typically, within two or three syllables of speech). The same convergence time is required by the 4119/S at the near end of the circuit, after which the transmission path is entirely free of echo. Following convergence, doubletalk is possible without the usual choppiness and lockout that can occur on circuits served by conventional echo suppressors.

Operation During Singletalk and Doubletalk

2.12 During singletalk only, the end path model is continuously updated to provide the best possible echo cancellation. The 4119/S detects doubletalk when signals appearing in the transmit channel are at approximately the same level as signals in the receive channel. When this occurs, the adaptation process is unconditionally halted. Cancellation still takes place and the signal that appears in the transmit channel consists of near end speech plus actual echo, minus the estimated echo signal.

Suitability for Various Circuit Types

2.13 Internal adjustments and factory modifications are not required to condition the 4119/S for use on a particular type of circuit. The module can be used in terrestrial circuits or single- or double-hop satellite circuits just as it arrives from Tellabs. Because the 4119/S functions on a “cross-correlative” basis with respect to speech and echo, rather than on the basis of level detection and hangover time peculiar to echo suppressors, the 4119/S is less susceptible to false operation induced either by echo or noise. To the 4119/S, the only functional difference in the aforementioned types of circuits is the length of time required to exchange words.

Facility Interface Levels

2.14 The 4119/S is designed to interface the transmission facilities on its facility (satellite) and terminal (terrestrial) sides at conventional –16 transmit and +7 receive TLPs, via switch option, at –4 transmit and +4 receive TLPs, or at 0 transmit and 0 receive TLPs. These interface levels can be independently selected at each module port. Overload occurs in each channel at approximately 3dB above the selected TLP.

Note: Continuous signal levels exceeding the stated overload points can result in temporary divergence of the 4119/S.

Level Control

2.15 On the terminal side, adjustable precision attenuators in both the transmit and receive channels provide for coordination between actual terminal side facility levels and the TLPs selected for terminal side interface on the module. From 0 to 24dB of attenuation, in 0.1dB increments, can be introduced into each channel independently via front panel DIP switches.

Terminating Impedances

2.16 Balanced 1200-, 600-, or 150-ohm terminating impedance can be selected via switch option for both ports (transmit input and receive output) on the terminal (terrestrial) side of the 4119/S. The 1200-ohm option interfaces loaded cable, the 600-ohm option interfaces non-loaded cable or a carrier channel, and the 150-ohm option provides a small amount of slope-type amplitude equalization for non-loaded cable through the deliberate impedance mismatch. Fixed, balanced, 600-ohm terminating impedance is provided at both ports (transmit output and receive input) on the facility (satellite) side to interface the associated equipment – normally, a co-located carrier channel – on that side.

Residual Echo Processing Modes

2.17 A switch option on the 4119/S selects either of two modes of residual echo processing.

- In the first, the integral NLP operates to remove any residual echo during both singletalk and doubletalk.
- In the second, the NLP is disabled during doubletalk per CCITT recommendation G.165.

Note: With the front panel operating mode switch set to canclr only (canceller only), the NLP is disabled entirely, i.e., during both single and doubletalk.

Normal or Soft Clipping Operation

2.18 Normal operation of the NLP temporarily quiets the residual echo resulting from the echo at the transmit input along with any background noise from the end path. This results in momentary quieting of the transmit output to the far end talker. If the noise level of the end path is relatively high, e.g., from old circuits, this momentary quieting can be noticeable. To make this effect less noticeable, a soft clipping switch option on the 4119/S can be set to introduce a small amount of noise at its transmit output. Be aware that, although this option makes operation of the 4119/S virtually undetectable to the far end talker, it can increase its residual echo level to –60dBm0.

Integral 2100Hz Data Tone Disabler

2.19 Because it is generally preferred that echo cancellation not take place during the transmission of data, even though, in many applications, the presence of an echo canceller can actually enhance data transmission, the 4119/S contains an integral data tone disabler. In response to nominal 2100Hz tone from a data modem or a disabling tone source, the tone disabler disables all echo control circuitry of the 4119/S, rendering it transparent to data transmission in both directions. Because data transmission is more tolerant of echo than voice transmission, the circuit functions normally without echo cancellation in the data mode. The 4119/S automatically returns to normal operation (the echo cancellation mode) when data transmission on the circuit ceases in both directions. After resuming normal operation, the 4119/S again requires a convergence interval prior to echo cancellation.

Self-Diagnostic Circuitry

2.20 The 4119/S contains integral self-diagnostic circuitry that provides continuous on-line monitoring of its echo cancellation performance. If the 4119/S cannot achieve convergence and remains in a diverged condition, its front panel diverge LED lights during far end singletalk.

Tandem Path Applications

2.21 In certain applications, a switching system sets up a tandem path involving two links that are both equipped with echo control devices (see Figure 2-2). If the two intermediate devices – those closest to the switch – are echo suppressors, these suppressors must be disabled by the switch regardless of whether the distant end devices are echo cancellers or echo suppressors. If the two intermediate devices are echo cancellers, these cancellers need not be disabled by the switch regardless of whether the distant end devices are echo suppressors

or echo cancellers. When possible, it is recommended that intermediate 4119/Ss be disabled by application of ground (from the switch) to their external ground disable input leads (pin 18 or 43), in which case echo cancellation remains disabled for as long as the ground is applied.

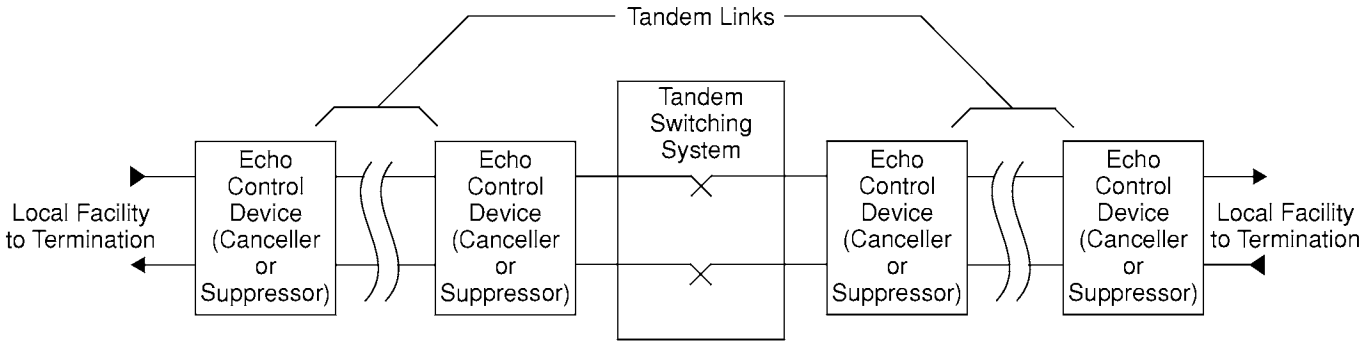

Figure 2-2 Tandem Path Involving Two Links, Both With Echo Control Devices

3. Installation

Inspection

3.1 Visually inspect the 4119/S upon its arrival to detect any possible damage incurred during shipment. If damage is noted, immediately file a claim with the carrier. If the module is stored, re-inspect it prior to installation.

Mounting

3.2 The 4119/S mounts in one position of a Tellabs Type-10 Mounting Shelf or in a pre-wired Tellabs 262-Series NCTE/DST Mounting Assembly. The module plugs physically and electrically into a 56-pin connector at the rear of its shelf or assembly position.

Connections

3.3 Before making any connections to the mounting shelf or assembly, make sure that the power is off and modules are removed. Modules should be placed only after they are properly optioned and after wiring is completed.

3.4 Table 3-1 lists external connections to the 4119/S. All connections are made via wire wrapping to the 56-pin connector at the rear of the mounting shelf position. Pin numbers are found on the body of the connector.

Connect to:	Pin #
Receive Input Tip (From Distant End, Facility [Satellite] Side)	7
Receive Input Ring (From Distant End, Facility [Satellite] Side)	13
Transmit Output Tip (To Distant End, Facility [Satellite] Side)	41
Transmit Output Ring (To Distant End, Facility [Satellite] Side)	47
Receive Output Tip (To Near End Term Set, Terminal [Terrestrial] Side)	5
Receive Output Ring (To Near End Term Set, Terminal [Terrestrial] Side)	15
Transmit Input Tip (From Near End Term Set, Terminal [Terrestrial] Side)	55
Transmit Input Ring (From Near End Term Set, Terminal [Terrestrial] Side)	49
External Ground Disable Input Lead	18 and 43
–BATT (–22 to –56VDC Filtered, Ground Referenced)	35
GND (Ground)	17

Table 3-1 External Connections to 4119/S

Option Selection

3.5 Five option switches must be set before the 4119/S is placed into service. Two are 3-position slide switches; the others are 4-position DIP switches. One slide switch is on the front panel. The other, along with two of the DIP switches, is on the main printed circuit board. The third DIP switch is on the large “baby” board. Locations of these switches are shown in Figure 3-1. The first 10 entries in Table 3-2 summarize all switch options and provide a convenient checklist that can be filled out either prior to installation for prescription optioning or during installation to serve as a record for future reference. Refer to Figure 3-1 and Table 3-2, and set each option switch on the 4119/S as required.

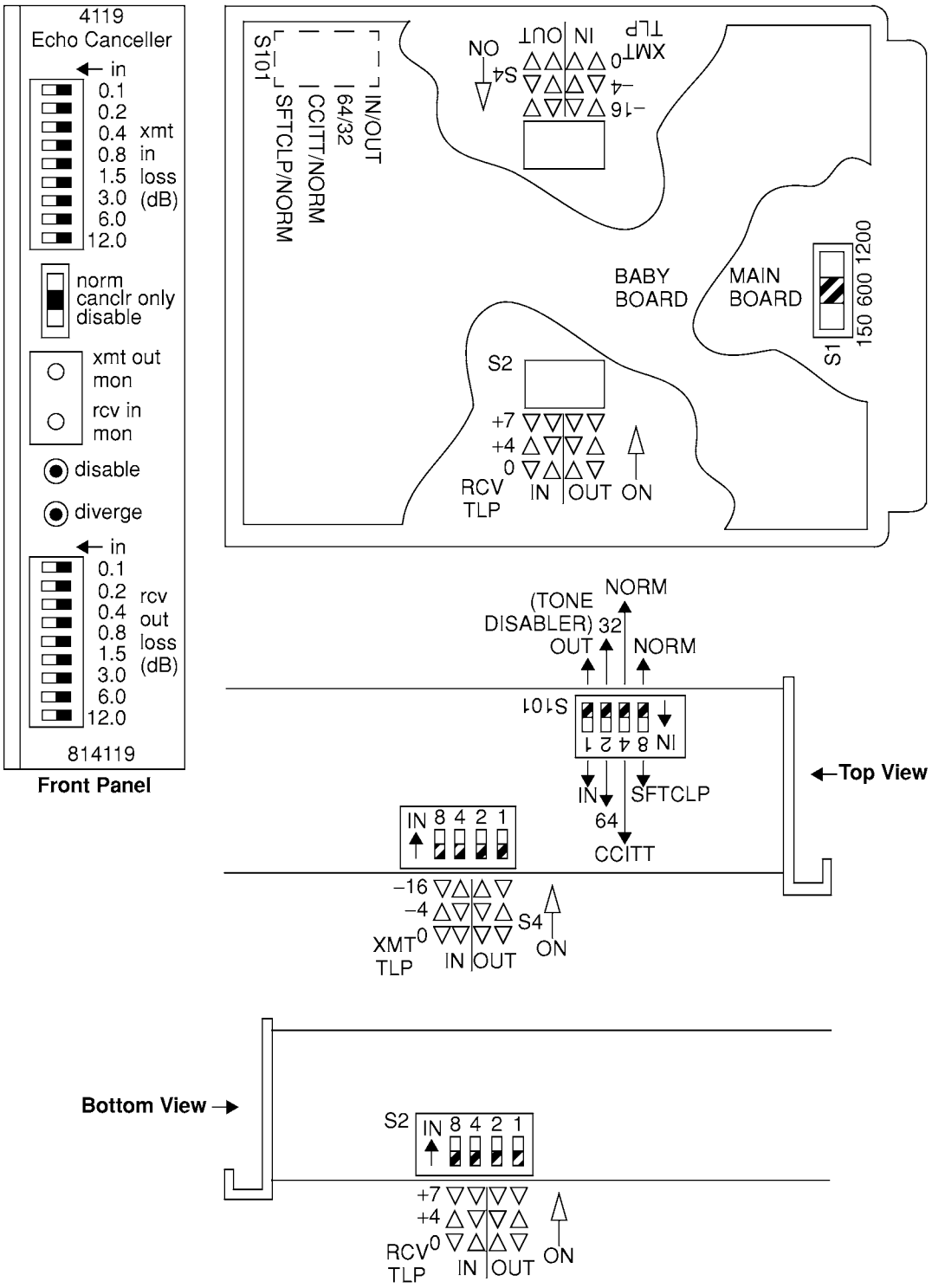

Figure 3-1 Option and Alignment Switch Locations

Switch Option or Alignment Function	Switch	Selection	Setting	Check-list
Operating Mode of Echo Control Circuitry	Front Panel norm/ canclr only/ disable Switch	Normal operation (canceller circuitry and NLP active)	norm	
		Canceller only (canceller circuitry active, NLP disabled; used during testing)	canclr only	
		Disable (canceller circuitry and NLP disabled; used during alignment and testing)	disable	
Terminating Impedances at Terminal Side (Terrestrial Side) Ports (xmt in, rcv out)	S1	1200 ohms (for loaded cable)	1200	
		600 ohms (for non-loaded cable)	600	
		150 ohms (extra slope equalization for non-loaded cable)	150	
2100Hz Tone Disabler Operation	S101-1	Tone disabler enabled (in circuit)	IN	
		Tone disabler disabled (out of circuit)	OUT	
End Path Delay Processing Window	S101-2	32ms, maximum	32	
		64ms, maximum	64	
Residual Echo Processing Mode (NLP)*	S101-4	NLP enabled during singletalk and doubletalk	norm	
		NLP disabled during doubletalk per CCITT rec. G.165	CCITT	
Soft Clipping Operation (Insertion of Small Amount of Noise at xmt Output)	S101-8	Enabled (to make canceller operation less noticeable on noisy end paths)	SFTCLP	
		Disabled	norm	
Receive Input TLP	S2-8 and S2-4	+7TLP	S2-8 OFF S2-4 OFF	
		+4TLP	S2-8 ON S2-4 ON	
		0TLP	S2-8 OFF S2-4 ON	
Receive Output TLP (if not known and alignment is to be non-prescription, initially select +7)	S2-2 and S2-1	+7TLP	S2-2 OFF S2-1 OFF	
		+4TLP	S2-2 OFF S2-1 ON	
		0TLP	S2-2 ON S2-1 OFF	
Transmit Input TLP (if not known and alignment is to be non-prescription, initially select –16)	S4-8 and S4-4	–16TLP	S4-8 OFF S4-4 ON	
		–4TLP	S4-8 ON S4-4 OFF	
		0TLP	S4-8 OFF S4-4 OFF	

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Table 3-2 Summary and Checklist of 4119 /S Switch Options and Alignment Switch Settings

Switch Option or Alignment Function	Switch	Selection	Setting	Check-list
(Continued from previous page) Transmit Output TLP	S4-2 and S4-1	–16TLP	S4-2 ON S4-1 OFF	
		–4TLP	S4-2 OFF S4-1 ON	
		0TLP	S4-2 OFF S4-1 OFF	
Transmit Input Attenuation (loss)**	Front panel xmt in loss DIP switch **	0.1dB	0.1 to IN	
		0.2dB	0.2 to IN	
		0.4dB	0.4 to IN	
		0.8dB	0.8 to IN	
		1.5dB	1.5 to IN	
		3.0dB	3.0 to IN	
		6.0dB	6.0 to IN	
		12.0dB	12.0 to IN	
Receive Output Attenuation (loss) **	Front panel rcv out loss DIP switch**	0.1dB	0.1 to IN	
		0.2dB	0.2 to IN	
		0.4dB	0.4 to IN	
		0.8dB	0.8 to IN	
		1.5dB	1.5 to IN	
		3.0dB	3.0 to IN	
		6.0dB	6.0 to IN	
		12.0dB	12.0 to IN	

* Remember that residual echo processing takes place, i.e., the NLP is active, only when the front panel operating mode switch is set to norm.

** The eight positions of the front panel xmt in loss and rcv out loss DIP switches are cumulative. Total loss (in dB) introduced into a channel is the sum of that channel's loss DIP switch positions set to in.

Table 3-2 Summary and Checklist of 4119 /S Switch Options and Alignment Switch Settings

Alignment Overview

3.6 To align the 4119/S, complete the following procedure:

1. Set the receive channel loss to coordinate terminal (terrestrial) side output levels with the facility (satellite) side interface level.
2. Set the transmit channel loss to coordinate input levels from the terminal (terrestrial) side with the facility (satellite) side interface level.

3.7 At alignment time, all option switches should already be properly set as described above.

Prescription Alignment

3.8 Because 4119/S alignment settings are controlled by front panel DIP switches, prescription alignment of the module is possible. In prescription alignment, the rcv out loss and xmt in loss switches are set in accordance with specifications on the Circuit Layout Record (CLR). The last two entries in Table 3-2 summarize the alignment switch settings and provide a checklist for prescription alignment. To use this part of Table 3-2, indicate required alignment switch settings in the checklist column prior to installation. Then, at alignment time, align the 4119/S by setting each switch as indicated in the table (or on the CLR, if preferred).

Pre-Alignment Tasks for Non-Prescription Alignment

3.9 In non-prescription alignment, access to the appropriate ports is typically provided via an external jackfield. Before beginning actual alignment, be sure to do the following:

1. Disable all of the echo control circuitry by setting the front panel operating mode switch to the disable position or by grounding connector pin 18 or 43.
2. Verify that TLP optioning is correct at all four of the ports. The proper terminal (terrestrial) side TLPs may not be available from circuit records. Therefore, the following alignment procedures take this into account and provide appropriate instructions for determining correct TLP settings. In such cases, initially set the terminal (terrestrial) side TLPs for the standard –16 transmit and +7 receive. In contrast, the facility (satellite) side TLPs for interface with what is normally co-located carrier equipment should be known and must be properly set before alignment.
3. Set all positions of the front panel xmt in loss and rcv out loss DIP switches to out for zero loss in each channel.

Note: Because the terminal (terrestrial) side port impedance settings are 1200, 600, and 150 ohms, while most Transmission Measuring Sets (TMSs) provide 900-, 600-, and 135-ohm settings, observe the following guidelines to obtain correct level measurements and settings when aligning the 4119/S:

- **If the module is optioned for 150 ohms and you use the 135-ohm setting on the TMS, the slight impedance mismatch can affect level measurements by as much as 0.5dB. Therefore, we recommend that you re-option the terminal (terrestrial) side ports for 600 ohms (set switch S1 to 600) and use the 600-ohm setting on the TMS. When alignment is completed, reset S1 for 150 ohms as required.**
- **If the module is optioned for 1200 ohms, do not use the 900-ohm setting on the TMS. Instead, re-option the module for 600 ohms and use the 600-ohm setting on the TMS. When alignment is completed, reset S1 for 1200 ohms as required.**
- **If the TMS does not have independent transmit and receive impedance settings, option both the TMS and the module for 600 ohms during alignment; reset S1 as required when alignment is completed.**

Receive Channel Alignment

3.10 Align the receive channel as follows:

1. Arrange the transmit portion of a TMS for 1004Hz tone output at +7dBm if the receive input port is optioned for a +7TLP, at +4dBm if the port is optioned for a +4TLP, or at 0dBm if the port is optioned for a 0TLP. If the TMS has a separate transmit impedance setting, select 600 ohms. Connect this signal to the 4119/S rcv in port.
2. Arrange the receive portion of the TMS for terminated measurement at the terminal (terrestrial) side impedance selected on the module. If this impedance is not available on the TMS, see the note under paragraph 3.9 for instructions. Connect the receive portion of the TMS to the 4119/S rcv out port.
3. Adjust the front panel rcv out loss attenuator switches until the desired receive channel output level is achieved, as indicated by the TMS. If the desired receive output level cannot be achieved with the existing receive output TLP setting, select another TLP setting that allows the desired level to be achieved.

Transmit Channel Alignment

3.11 Align the transmit channel as follows:

1. From the CLR or from actual measurement, determine the level (in dBm) at the 4119/S's transmit input port when 1004Hz alignment tone is being sent at the proper level from the distant end of the terminal (terrestrial) side facility.
2. Arrange the transmit portion of the TMS for 1004Hz tone output at the level determined in step 1, and connect it to the 4119/S xmt in port. If the TMS has a separate transmit impedance setting, select the impedance for which the terminal (terrestrial) side ports are optioned. If this impedance is not available on the TMS, see the note under paragraph 3.9 for instructions. As an alternative to using the TMS as a tone source, request personnel at the distant end of the terminal (terrestrial) side facility to send 1004Hz alignment tone as described above.
3. Arrange the receive portion of the TMS for 600-ohm terminated measurement, and connect it to the 4119/S xmt out port.
4. Set the front panel xmt in loss attenuator switches to achieve exactly the transmit input TLP (–16, –4, or 0) selected on the module. For example, if the transmit input level is +2.5dBm and the module is optioned for a –4 transmit input TLP, you would adjust the xmt in loss attenuator switches for 6.5dB of loss, which is the difference between +2.5 and –4. If the existing transmit input TLP setting cannot be achieved via the xmt in loss switches, re-option the module for a transmit input TLP that can be achieved, then reset the xmt in loss switches to achieve that level. Note that this xmt in loss setting must be precisely made if the module is to accurately provide the selected transmit output TLP.
5. At this time, the TMS should indicate either –16, –4, or 0dBm, corresponding to the selected transmit output TLP. If this is not the case, verify that you have performed steps 1 through 3 correctly, then carefully repeat step 4.
6. Alignment of the 4119/S is now complete. Remove all test cords. If necessary, reset switch S1 for the proper terminal (terrestrial) side terminating impedances. Finally, remove the module from the disabled state by setting the front panel operating mode switch to norm or by removing the ground from connector pin 18 or 43.

4. Circuit Description

4.1 This circuit description will familiarize you with the 4119/S for engineering and application purposes only. Attempts to troubleshoot the 4119/S internally are not recommended and may void its warranty. Testing procedures should be limited to those described in Section 7. To aid your understanding of this circuit description, refer to the Block Diagram in Section 5.

Receive Path

4.2 A speech signal (from the far end) at the receive input port is connected to TLP buffer amp 1 by way of a balancing transformer (600-ohm impedance). TLP buffer amp 1 conditions this signal (X) for processing by the bandpass filter and analog to digital converter. The signal is then passed directly to the digital to analog converter, low pass filter, and TLP buffer amp 2. The signal passes through the 0 to 24dB attenuator before it reaches the receive output port by way of an impedance matching (1200, 600, or 150 ohms) transformer.

Transmit Path

4.3 A signal (near end speech and echo) at the transmit input port is connected to TLP buffer amp 3 via an impedance matching (1200, 600 or 150 ohms) transformer and the 0 to 24dB attenuator. From TLP buffer amp 3, this signal (Y) contains echo from the receive output port and, when near end speech is present, is processed by the bandpass filter and analog to digital converter. The Y signal is then passed to the summing junction (Σ), where the echo cancellation circuitry subtracts the digital echo estimate (R) from the Y signal to obtain an error signal (ε). The echo estimate (R) is derived through processing of the X signal by the

one or two convolution processors (see paragraph 4.4). If the error signal contains any low-level residual echo, the NLP operates to further attenuate that echo. The error signal is then processed by the digital to analog converter and low pass filter and sent to TLP buffer amp 4. The transmit output is isolated from TLP buffer amp 4 via a transformer (600 ohms).

Echo Cancellation

4.4 Actual echo cancellation is performed by one (with the 32ms end path delay option selected) or two (with the 64ms option selected) Very Large Scale Integration (VLSI) circuit chips called convolution processors. These devices receive their signal from the X path via that path's bandpass filter and analog to digital converter. This digital X signal, which is stored in companded A-law form, is convolved with the estimated end path impulse response (H) to output a digital echo estimate that is a 12-bit number in twos complement form. This digital echo estimate (R) is subtracted (in the digital domain) from the Y signal at the summing junction in the controller Integrated Circuit (IC) to obtain the error signal.

4.5 The control signals for updating the H estimate derived within the convolution processor(s) are generated in the controller IC by the update control circuitry. The update control circuitry compares the signal with various internal thresholds and X peaks (see paragraph 4.6) to determine the update co-efficients.

Doubletalk Detector and Hangover Timer

4.6 The doubletalk detector and hangover timer circuitry is activated when the Y signal is large compared to the output of the X-path peak detector. The doubletalk detector and hangover timer's output is used to inhibit the update control circuitry, thereby preventing updating of the convolution processor's H estimate during doubletalk.

Residual Echo Control

4.7 The NLP operates to prevent residual echo from reaching the transmit output port when either of the following conditions exists:

- The NLP is not disabled via the front panel operating mode switch.
- No external disabling signal is detected. This signal can be a ground on pin 18 or 43, or it can be nominal 2100Hz disabling tone if the integral 2100Hz tone disabler is enabled.

Disabling Cancellation

4.8 A red disable LED on the front panel lights when the module is disabled under any of the following conditions:

- The front panel operating mode switch is set to the disable position.
- Nominal 2100Hz disabling tone is detected (when the integral 2100Hz tone disabler is enabled).
- Ground on pin 18 or 43 is detected.
- 2600Hz signaling tone is detected (4119S Module only)

4.9 When the front panel operating mode switch is set to the disable position, the co-efficients in the H register of the convolution processor(s) are all set to zero. When the contents of the H register are zero, the echo estimate (R) is zero and, as a result, no echo estimate is subtracted from the Y signal. In addition, the H register is reset to zero when any of the following conditions exists:

- Nominal 2100Hz disabling tone is detected (when the integral 2100Hz tone disabler is enabled).
- Ground on pin 18 or 43 is detected.
- The H divergence detector internal to the convolution processor(s) determines that the H register is in a diverged state.

Integral Tone Disabler (per CCITT Recommendation G.164)

4.10 The integral 2100Hz tone disabler monitors the X and Y signal paths for nominal 2100Hz data tone. When the 2100Hz tone disabler detects this tone, it completely disables both the echo cancellation section and the NLP for the duration of the data transmission, lighting the front panel disable LED and resetting and holding at zero the H registers of the convolution processor(s).

Divergence Monitor Circuit

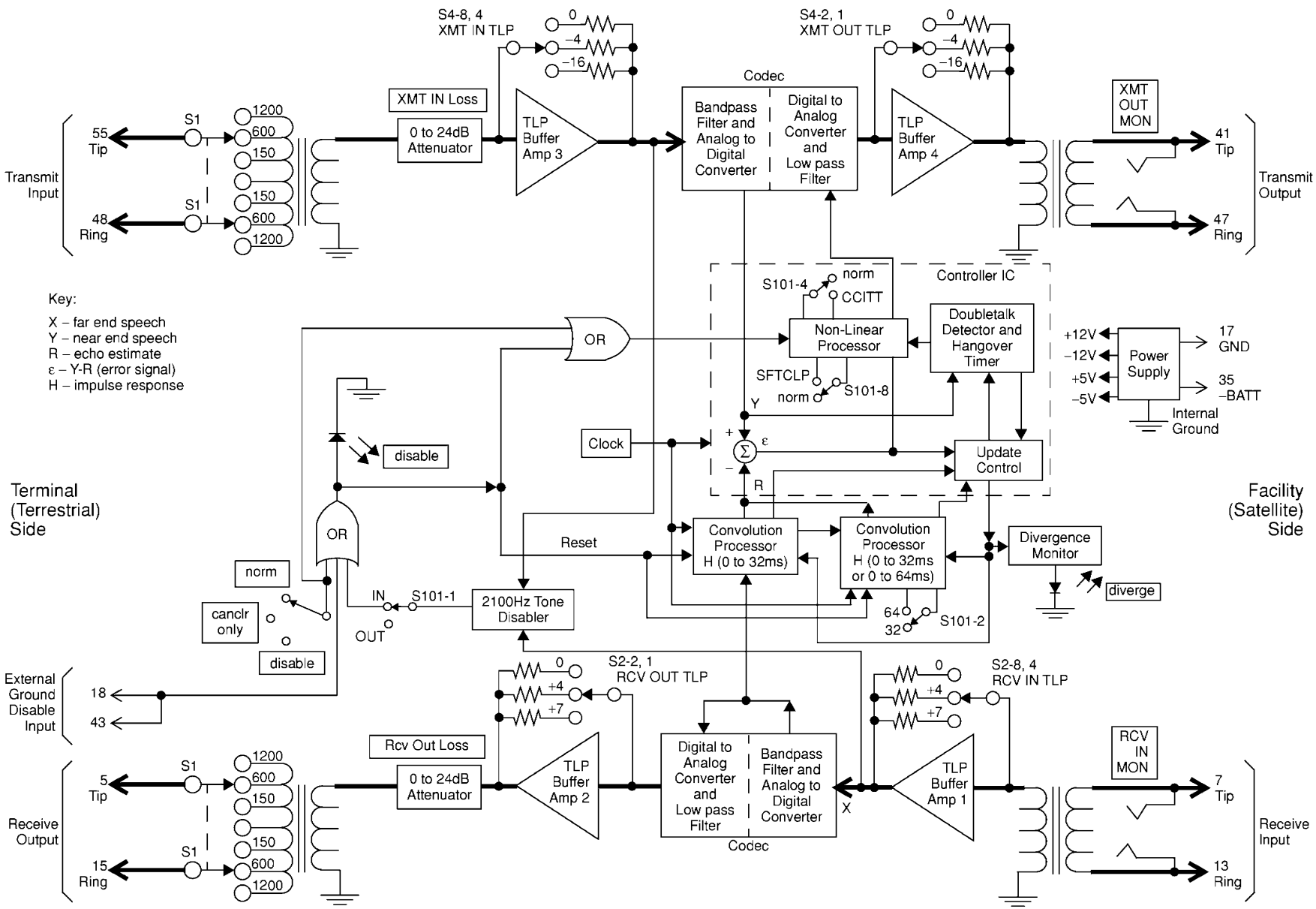
4.11 The divergence monitor circuit monitors the amount of updating provided to the convolution processor(s). An excessive amount of updating over a 200ms interval (except during the convergence process when much updating is normal) is recognized by the divergence monitor as a diverged condition, which causes the front panel diverge LED to light and flash in accordance with the activity occurring in the receive path.

Power Supply

4.12 A switching-type power supply converts –22 to –56VDC filtered input to the +5, –5, +12, and –12VDC voltages used by the internal circuitry. This power supply is not an isolated supply (see the Caution notice following paragraph 3.4 for details).

No cauton notice found (2/20/2020 S. Kerman)

5. Block Diagram



6. Specifications

Common

Dynamic Range (Transmit and Receive)	• +3 to –60dBm0
Frequency Response (Disable Mode)	• < ± 0.5dB, 300 to 3000Hz (re 1004Hz)
Return Loss	• > 20dB, all ports
Signal to Distortion Ratio	• 33dB typical for input signal levels between –30 and 0dBm at 1000Hz
Signal Processing Window	• 0 to 32ms or 0 to 64ms, switch selectable
Minimum End Path Return Loss for Convergence in Less Than 250ms	• 6dB
Total Harmonic Distortion	• < 1.5% (1.2%, typical) for 1000Hz signal at 0dBm input level in transmit or receive path
Insertion Loss	• 0 ± 0.3dB at 1004Hz
Terminating Impedances	• Transmit input and receive output (terminal [terrestrial] side ports): 150, 600, or 1200 ohms ± 10%, balanced, switch selectable • Transmit output and receive input (facility [satellite] side ports): 600ohms ± 10% fixed, balanced
Facility (Satellite) and Terminal (Terrestrial) Side Transmission Interface Levels	• Transmit channel: –16, –4, or 0TLP, independently switch selectable at both ports • Receive channel: +7, +4, or 0TLP, independently switch selectable at both ports
Terminal (Terrestrial) Side Attenuation Range	• 0 to 24dB in 0.1dB increments, independently switch selectable in transmit and receive channels
Input Voltage Requirements	• –22 to –56VDC, filtered, ground referenced
Input Current Requirements	• At –48VDC: 37mA, maximum (1.8W), 30mA, typical (1.44W) • At –24VDC: 75mA, maximum (1.8W), 60mA, typical (1.44W) • Inrush current: 350mA, maximum

Environmental

Operating Environment	• +32° to +122° F (0° to +50° C), humidity 5 to 95% (no condensation)
Dimensions	• 5.58 inches (14.17cm) high • 1.42 inches (3.61cm) wide • 5.96 inches (15.14cm) deep
Weight	• 14.7 ounces (417 grams)
Mounting	• Relay rack or apparatus case via one position of a Tellabs Type-10 mounting shelf; can also be mounted in a Tellabs 262-Series NCTE/DST Mounting Assembly

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Echo Cancellation and Non-Linear Processing

Specifications Continued

Residual Echo Level (REL) per CCITT Recommendation G.165 for Receive Input Level of –30 to –10dBm0	• REL ≤ –40dBm0 in canceller only mode • REL ≤ –65dBm0 in normal mode
Echo Return Loss Enhancement (ERLE) During Doubletalk	• ERLE ≥ 20dB for signal at –10dBm input level and with 6dB ERL • For additional ERLE performance information, see Figure 6-1 (shows ERLE with 32ms end path delay; ERLE is approximately 2dB lower with 64ms end path delay)
Convergence Rate	• 90% of ERLE attained in 200ms or less, with receive input signals at –10dBm0 and ERL of 6dB

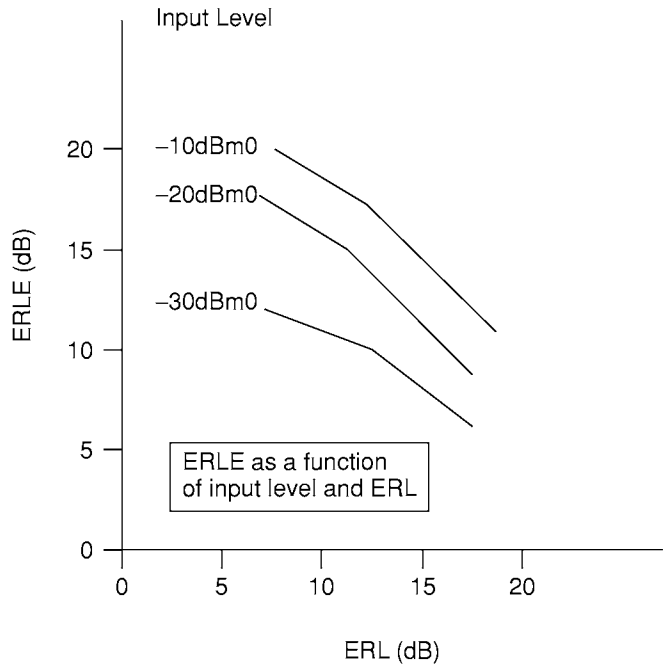

Figure 6-1 ERL and ERLE During Doubletalk

Integral Tone Disabler

Detection Band	• 2010 to 2240Hz
Detection Threshold	• –31dBm0
Disable Operate Time	• 300 ± 100ms
Disable Release Delay	• 250 ± 150ms
Signal to Noise Ratio to Allow Disabling	• 0 to 5dB
Disabler Recycle Time	• 30 ± 10ms
Hold Signal Bandwidth After Disabling	• 300 to 3800Hz, typical
Guard Band	• 500 to 1700Hz

Continued on Next Page

Disabler Circuit (4119S Module Only)

Specifications Continued

SF Tone Detection Level Range	• –20dBm0 and above
SF Tone Detection Frequency Band	• 2600 ± 15Hz
Signal to Guard Ratio	• 6dB, typical
Detection Time	• 40ms, typical
Hangover Time	• 400 ± 50ms
Guard Band	• 800 to 2450Hz

7. Testing, Technical Assistance, Repair and Return

7.1 The following testing guide (Table 7-1) will assist in the installation, testing, and troubleshooting of the 4119/S, and will aid in the localization of trouble to this specific equipment. If technical assistance is required, refer to paragraph 7.2 for phone numbers. If the equipment seems to be defective, substitute new equipment (if possible), and conduct the test again. If the substitute operates correctly, the original should be considered defective and returned to Tellabs for repair or replacement, as directed in paragraph 7.3. We strongly recommend that no internal (component-level) testing or repairs be attempted on the equipment; unauthorized testing or repairs may void its warranty.

Notes:

1. **The testing procedures for this equipment are better performed when an external jackfield is used for access to the appropriate ports of the module. The following procedures are based upon the assumption that a jackfield will be used.**
2. **White noise is the recommended test signal input. A sine wave input is not recommended because such tones do not represent actual conditions encountered in end to end circuits. Furthermore, sine waves yield improper convergence readings. For these same reasons, pseudo random noise generators with digital shift registers are also not recommended.**
3. **Suggested test equipment is a General Radio 1381 Noise Generator Set arranged for a 5kHz bandwidth and a 2 conductivity level, or the noise generator portion of a Wiltron 9041 Return Loss Measuring Test Set with appropriate level attenuation.**
4. **Recommended test signal input level to the 4119/S is 60 to 80dBrnC0 (–30 to –10dBm0).**
5. **End path circuitry should be free of non-linear signals, such as those caused by compressors, TASI systems, excessive quantizing distortion, and time variable signal delays.**
6. **For specialized echo canceller testing procedures, consult CCITT recommendation G.165.**

Test	Test Procedure	Normal Result	If Normal Conditions Are Not Met, Verify:
Idle Operation, Receive Channel	Disable 4119/S by setting front panel operating mode switch to disable position or by grounding connector pin 18 or 43. Arrange transmit portion of TMS for 1004Hz tone output at 0dBm0 (0dBm with 0TLP selected for receive input port, +4dBm with +4TLP selected, +7dBm with +7TLP selected). If TMS has separate transmit impedance setting, select 600 ohms. Connect this signal to rcv in port. Arrange receive portion of TMS for properly terminated measurement (see note below) and measure signal output at rcv out port. **Note:** If impedance selected on module via switch S1 is not available on TMS, select 600 ohms on module and receive portion of TMS; then reset S1 appropriately at completion of this test.	• Receive output level indicated on TMS is attenuated by amount selected via front panel rcv out loss attenuator switches.	• Front panel mode switch properly set or pin 18 or 43 grounded. • Switch S1 properly set. • Rcv TLPs (switch S2) properly set. • Rcv out loss attenuator switches properly set. • No double terminations at receive input and receive output ports. • Replace module and retest.
Idle Operation, Transmit Channel	Leave front panel operating mode switch in disable position. Disconnect transmit portion of TMS from rcv in port. Arrange transmit portion of TMS for 1004Hz tone output at transmit input level specified on CLR. If TMS has separate transmit impedance setting, select same impedance as switch S1 setting (see note at end of Idle Operation, Receive Channel test). Connect this signal to xmt in port. Disconnect receive portion of TMS from rcv out port, arrange receive portion for 600-ohm terminated measurement, and measure signal output at xmt out port.	• Transmit output level indicated on TMS is 0 ± 0.3dBm, with 0TLP selected for transmit output port, –4 ± 0.3dBm, with –4TLP selected, or –16 ± 0.3dBm, with –16TLP selected.	• Front panel mode switch properly set, or pin 18 or 43 grounded. • Switch S1 properly set. • Xmt TLPs (switch S4) properly set. • Xmt in loss attenuator switches properly set. • No double terminations at transmit input and transmit output ports. • Replace module and retest.
Continued on Next Page			

Table 7-1 Testing Guide

Test	Test Procedure	Normal Result	If Normal Conditions Are Not Met, Verify:
Disable Sequence (With Integral 2100Hz Tone Disabler Enabled)	Set front panel mode switch to norm or remove ground from pin 18 or 43. Arrange transmit portion of TMS for 2100Hz tone output at –10dBm0 (–10dBm with 0TLP selected for receive input port, –6dBm with +4TLP selected, –3dBm with +7TLP selected). Do not connect this signal to module at this time. Instead, arrange receive portion of same TMS for properly terminated measurement (see note at end of Idle Operation, Receive Channel test) and connect it to rcv out port. Then arrange transmit portion of **second** TMS for 1004Hz tone output at –20dBm0 (–20dBm with 0TLP selected for transmit output port, –24dBm with –4TLP selected, –36dBm with –16TLP selected). Again, do not connect this signal to module at this time. Instead, arrange receive portion of **second** TMS for 600-ohm terminated measurement and connect it to xmt out port. Then connect 2100Hz signal from **first** TMS to rcv in port, wait about 1 second, and connect 1004Hz signal from **second** TMS to xmt in port. Observe output level on each TMS and disable LED on front panel.	• Receive output level (indicated on 2100Hz TMS) is attenuated by amount selected via front panel rcv out loss attenuator switches. • Transmit output level (indicated on 1004Hz TMS) is –20 ± 0.3dBm0 (–20 ± 0.3dBm with 0TLP selected for transmit output port, –24 ± 0.3dBm with –4TLP selected, or –36 ± 0.3dBm with –16TLP selected). • disable LED lights.	• Switch S101-1 set to ON. • Front panel mode switch set to norm. • Ground not applied to pin 18 or 43. • Front panel attenuator switches properly set. • Replace module and retest.
Disable Sequence (With Integral 2100Hz Tone Disabler Enabled)	Change frequency of receive channel signal (**first** TMS) from 2100Hz to 1004Hz and observe output level on TMS.	• Receive output level (indicated on 2100Hz TMS) is attenuated by amount selected via front panel rcv out loss attenuator switches.	• Switch S101-1 set to ON. • Front panel mode switch set to norm. • Ground not applied to pin 18 or 43. • Front panel attenuator switches properly set. • Replace module and retest.
Re-enabling of Canceller (With Integral 2100Hz Tone Disabler Enabled)	Remove both rcv and xmt channel signals.	• disable LED goes off.	• Switch S101-1 set to ON. • Front panel mode switch set to norm. • Ground not applied to pin 18 or 43. • Front panel attenuator switches properly set. • Replace module and retest.
Continued on Next Page			

Table 7-1 Testing Guide

Test	Test Procedure	Normal Result	If Normal Conditions Are Not Met, Verify:
Doubletalk Detector Check	Change level of **second** TMS to –10dBm0 at 1004Hz (–10dBm for 0TLP, –14dBm for –4TLP, –26dBm for –16TLP). Set **first** TMS for –10dBm0 level at 1004Hz (–10dBm for 0TLP, –6dBm for +4TLP, –3dBm for +7TLP). With no signal applied to xmt and rcv inputs, i.e., to rcv in and xmt in ports, momentarily set front panel mode switch to disable position, then back to norm. Connect signal from **second** TMS to xmt in port. Then connect signal from **first** TMS to rcv in port.	• Receive output level is attenuated by amount selected via front panel rcv out loss attenuator switches. • Transmit output level is –10 ± 0.3dBm0 (0 ± 0.3dBm with 0TLP selected for transmit output port, –14 ± 0.3dBm with –4TLP selected, or –26 ± 0.3dBm with –16TLP selected). • disable LED goes off.	• Switch S101-1 set to ON. • Front panel mode switch set to norm. • Ground not applied to pin 18 or 43. • Front panel attenuator switches properly set. • Replace module and retest. • Rcv input signal not applied before xmt input signal (remove both signals and retest). • Replace module and retest.
Divergence Monitor	Set front panel mode switch to norm position. Place module into service and initiate VF signal transmission in both directions.	• Front panel diverge LED goes off after initial convergence period (200ms, maximum, equivalent to two or three syllables of speech).	• Ground not applied to pin 18 or 43. • Front panel mode switch properly set. • Xmt and rcv interface TLPs (switches S2 and S4) properly set. • Replace module and retest.
Bench Testing Canceller for ERL and ERLE Levels	Set front panel mode switch to canclr only position. Arrange output or recommended (or equivalent) noise generator for –10 to –30dBm0 level. Connect noise generator output to rcv in port. Connect attenuator or desired end path circuitry between rcv out and xmt in ports. Arrange receive portion of TMS for bridged measurement and for C-message weighting. Connect receive input port of TMS to rcv out port, and measure and record this level. Disconnect TMS and connect its receive input port to xmt in port. Measure and record this level. Disconnect TMS and connect its receive input port to xmt out port. Measure and record this level.	• ERL level agrees with attenuator setting or end path value (ERL = rcv out level – xmt in level). • ERLE level agrees with Figure 6-1 in specifications based on input level and ERL (ERLE = xmt in level – xmt out level).	• Replace module and retest.

Table 7-1 Testing Guide

Technical Assistance

7.2 Contact Tellabs Technical Assistance as follows:

Location	Telephone	FAX
Tellabs International, Inc., Sucursal Buenos Aires, **Argentina**	+541.393.0764, .0892, or .0835	+541.393.0732
Tellabs Pty Ltd., Milsons Point NSW, Sydney, **Australia**	+61.2.9966.1043	+61.2.9966.1038
Tellabs Canada Ltd., Mississauga, Ontario, **Canada**	905/858-2058	905/858-0418
Tellabs International, Inc., Beijing, **China**	+86.10.501.1873	+86.10.501.1871
Tellabs International, Inc., **Dubai, U.A.E.**	+971.4.373250	+971.4.376526
Tellabs U.K. Ltd., Bucks, **England**	+44.1494.555800	+44.1494.555801
Martis Oy, Espoo, **Finland**	+358.0.502.771	+358.0.502.7815
Tellabs GmbH, Munich, **Germany**	+49.89.212133.0	+49.89.212133.20
Tellabs H.K. Ltd., **Hong Kong**	+852.2866.2983	+852.2866.2965
Tellabs GmbH Rep. Office, **Hungary**	+36.1.268.1220	+36.1.268.1222
Tellabs International, Inc., Bangalore, **India**	+91.80.6610826	+91.80.6615908
Tellabs, Ltd., County Clare, **Ireland**	+353.61.471433	+353.61.471000/472004
Tellabs de **Mexico**	525.282.1107, .1432, .1050, or .0981	525.282.0218
Tellabs Singapore Private, Ltd., **Singapore**	+65.736.2855	+65.736.1231
Tellabs International, Inc., Seoul, **South Korea**	+82.2.589.0667 or .0668	+82.2.589.0669
Tellabs Southern Europe s.a., Barcelona, **Spain**	+34.3.414.70.16	+34.3.414.69.25
Tellabs International, Inc., Stockholm, **Sweden**	+46.8.678.4040	+46.8.678.4041
Tellabs International, Inc., Bangkok, **Thailand**	+662.262.9065	+662.661.1141
USA and **Puerto Rico**	(800) 443-5555*	708/512-7097
*All other **Caribbean** and **South American** locations, or if the toll-free number is busy, telephone 708/969-8800		

Repair and Return

7.3 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
Martis Oy, Espoo, **Finland**	+358.0.502.771	+358.0.502.7815
Tellabs Canada Ltd., Mississauga, Ontario, **Canada**	905/858-2058	905/858-0418
Tellabs, Ltd., County Clare, **Ireland**	+353.61.471433	+353.61.471000/472004
Tellabs Operations, Inc., **Lisle, IL USA**	(800) 443-5555 (USA and Puerto Rico only) 708/969-8800 (other International)	708/512-7097 (both)

7.4 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 non-permanent materials and in a manner consistent with the correct handling of electrostatically sensitive devices.