technical manual
76-814003C
rev B

practice section 814003C

4003C Line Amplifier with Loopback

contents

1. general description

1.01 The Tellabs 4003C Line Amplifier with Loopback module (figure 1) provides switch-selectable level control, equalization, and impedance matching in both the transmit and receive channels of a 4wire voice-frequency transmission facility. Additionally, the 4003C provides tone-activated or dc-activated equal-level loopback of the facility.

1.02 This practice section is revised to update the text portion of section 7.

1.03 Transmit and receive amplifiers in the 4003C may be individually switch-optioned to provide up to 24dB of either flat gain or flat loss in 0.1dB increments. Maximum output level of each channel is +15dBm, with less than 1% distortion.

1.04 Equalization in both the transmit and receive channels may be prescription-set to introduce up to 7.75dB of slope equalization from 1000 to 3000Hz in 0.25dB increments. The module's equalized gain adjustments are designed to provide frequency response within ±1dB over the 300 to 3000Hz range when used on nonloaded cable facilities.

1.05 The 4003C may be switch-optioned to match 1200, 600, or 150-ohm input and output impedances in both the transmit and the receive channel. Transformers associated with each of the four ports are center-tapped to derive balanced simplex leads that provide for DX, loopback, and other signaling schemes that require a dc path.

1.06 The 4003C provides loopback toward the facility for remote testing of the circuit. Loopback may be tone or dc activated. In the tone-activated mode, 1 of 11 loopback-activation frequencies may be switch-selected; loopback is released in response to the reapplication of loopback tone (two-tone-burst operation). Loopback levels of +16dB, +9dB, −16dB, or −23dB may be prescription-set. In the dc-activated mode, the 4003C activates loopback for the duration of a locally applied ground signal.

1.07 Auxiliary loopback relay contacts are available at the 4003C's 56-pin connector to light an external loopback lamp or disable an associated data set in data applications.

1.08 The front panel of the 4003C is designed so that level adjustments can be made while the module is mounted in place. The 4003C features a full complement of front-panel test jacks to facilitate alignment and maintenance activities. Both bridging and opening bantam-type jacks are provided at each port. A red light-emitting diode (LED) on the front panel lights when the 4003C is in the loopback mode.

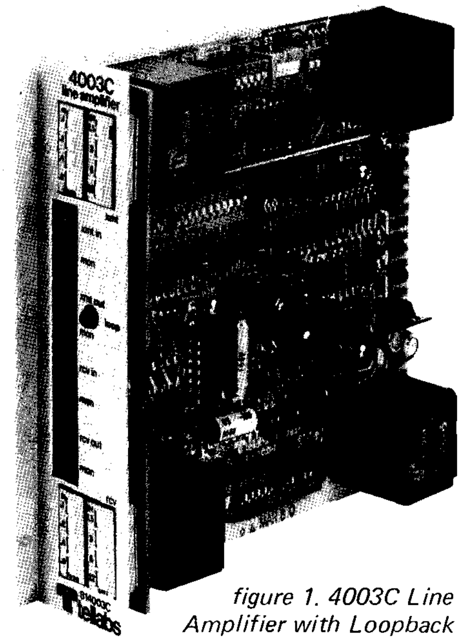


figure 1. 4003C Line Amplifier with Loopback

1.09 The 4003C incorporates an internally regulated power supply that permits operation on −22 to −56Vdc filtered input. Current requirements range from 20mA in the quiescent state to 65mA with both the transmit and receive channels at maximum output.

1.10 Surge protection is provided for the input and the output of both the transmit and the receive channel. Reverse-battery protection and transient-limiting circuitry are provided in each channel's internal power supply circuit.

1.11 As a Type 10 module, the 4003C mounts in one position of a Tellabs Type 10 Mounting Shelf, versions of which are available for relay rack or apparatus case installation. In relay rack applications, up to 12 modules may be mounted across a 19-inch rack, while up to 14 modules may be mounted across a 23-inch rack. In either case, 6 inches of vertical rack space is used.

2. application

2.01 The 4003C Line Amplifier with Loopback is designed for use on 4wire voice-frequency transmission facilities, where it provides bidirectional level control, amplitude equalization, and impedance matching. In addition, the module's tone or

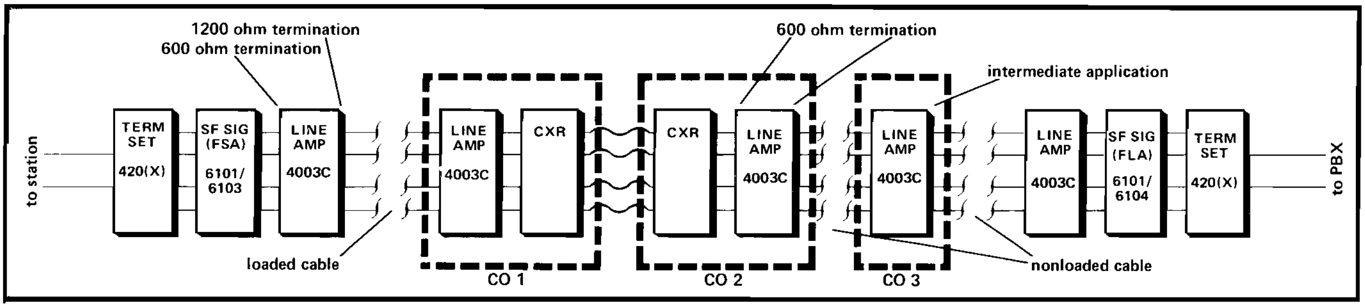


figure 2. Hypothetical circuit employing 4003C Line Amplifiers

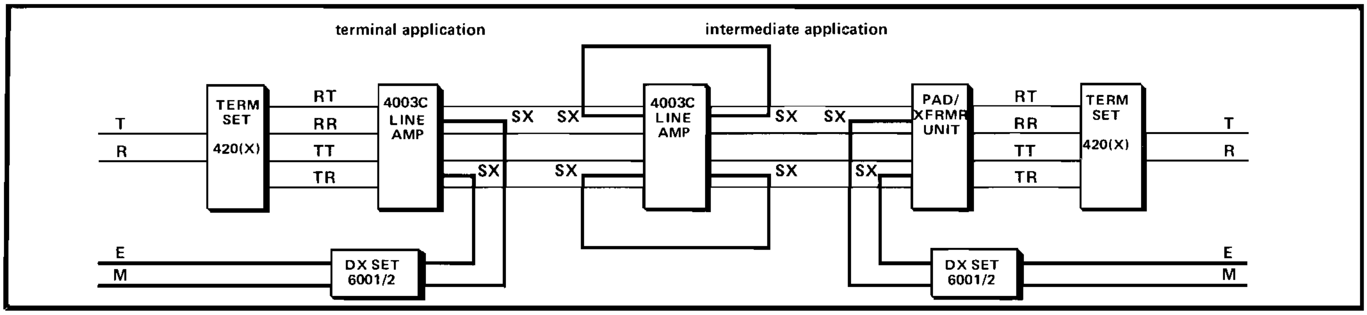


figure 3. 4wire circuit employing DX signaling.

dc-activated loopback circuitry allows remote testing of the facility. Thus, the 4003C is equivalent to a 4wire-to-4wire voice-frequency repeater with loopback. When used with a Tellabs 420X Terminating Set or equivalent, a 2wire-to-4wire voice-frequency repeater with loopback results. The 4003C may be used as either a terminal or an intermediate repeater. Figure 2 shows a hypothetical off-premise-extension (OPX) circuit in which 4003C Line Amplifiers are used in a variety of typical applications.

levels

2.02 Levels in both the transmit and the receive channel are individually set to provide up to 24dB of either flat gain or flat loss in 0.1dB increments. Option switches on the module's printed circuit board allow either gain or loss to be introduced into either channel independently; precise level adjustment for each channel is accomplished via front-panel switches. Maximum output of either channel is +15dBm, with less than 1% distortion.

equalization

2.03 Active slope equalization is provided in both the transmit and the receive channel of the 4003C. Use of the module's equalizers in one or both channels is dependent upon the module's position in the circuit. Equalizing at the receive end of the circuit (post-equalization) is generally preferable to equalizing at the transmit end (pre-equalization). *Pre-equalization tends to amplify high-frequency signals to a level that is conducive to crosstalk. Post-equalization not only eliminates this problem but also expedites the equalization process because the circuit is easier to equalize at the receive end.* In some applications, pre-equalization may be necessary. Use of the 4003C as a bidirectional amplifier at an intermediate point in a 4wire circuit, for example, often requires the use of the transmit-channel equalizer as well as the receive-channel equalizer.

2.04 Up to 7.75dB of slope equalization (1000 to 3000Hz) in 0.25dB increments is provided in both the transmit and the receive channel to compensate for the frequency-response characteristics of loaded and nonloaded telephone cable. Equalized gain is independently switch-optioned into both channels via DIP switches on the module's printed circuit board. The module's equalized gain response is designed to provide frequency response within ±1dB over the frequency range of 300 to 3000Hz when used with any combination of nonloaded cable. **The equalized gain response is not affected by the flat gain (or loss) adjustments, which are used to provide precise transmission levels.**

impedance matching

2.05 Impedance-matching transformers at all four ports (transmit and receive input and output) may be independently switch-optioned for balanced 1200, 600, or 150-ohm terminating impedance. This allows the 4003C to interface loaded cable (1200 ohms), nonloaded cable (600 or 150 ohms), carrier, SX signaling units, terminating sets, or station apparatus (600 ohms). The 150-ohm option is primarily used to provide a small amount of equalization for short segments of nonloaded cable.

2.06 All four impedance-matching transformers on the 4003C are center-tapped to derive simplex leads, allowing this module to be applied to circuits employing DX, loopback, or other dc signaling schemes (figure 3).

loopback

2.07 The loopback feature of the 4003C allows remote testing of the levels and frequency response of the facility. Data set disable leads (TEK5 and TEK6) are provided to electrically disable an associated data set during loopback. Loopback may be tone or dc activated.

2.08 In the tone-activated mode, any 1 of 11 loopback-activation frequencies may be selected via switch option. Loopback is activated by placing the selected loopback tone on the module's receive pair for longer than 1.4 seconds and then removing that tone. The 4003C initiates loopback only upon *removal* of the tone and remains looped until the selected loopback tone is reapplied to the module's receive pair for longer than 0.7 second. The switch-selectable loopback-tone frequency option permits up to eleven 4003C modules (when connected in a bridging arrangement) to be individually tested from a central bridging location.

2.09 The module responds to minimum loopback levels of −18dBm (with receive-channel gain at zero). Gain or loss adjustments in the receive channel will directly increase or decrease the minimum loopback sensitivity on a dB-for-dB basis. The center-frequency stability of each loopback tone is ±0.2%; maximum bandwidth is 75Hz. A 3dB signal-to-guard ratio and the frequency-selection option combine to prevent inadvertent loopback.

2.10 Loopback levels of +16, +9, −16, or −23dB may be pescription-set via two-position DIP switch *S14*. This option permits loopback levels to be coordinated with various TLP's. Standard data TLP's (−3 receive, +13 transmit) require 16dB of gain to provide the 0dB loopback level, Federal Aviation Agency (F.A.A.) data TLP's (−9 receive, 0 transmit) require 9dB of gain, inverted data TLP's (+13 receive, −3 transmit) require 16dB of loss, and conventional voice TLP's (+7 receive, −16 transmit) require 23dB of loss. Once loopback levels are properly set, *equal-level loopback* (i.e., test tone received equals test tone sent [±1dB], referenced to appropriate TLP's) will result.

2.11 In the dc-activated mode, loopback is accomplished through use of a manually operated local key or switch or by manually applying a ground potential to pin 1 of the 4003C's 56-pin connector. The module remains in loopback until the ground potential is removed.

2.12 Common pin assignments allow the 4003C to be interchanged with other Tellabs 400X-series Line Amps or with 4412-series Data Station Termination modules. While a 4412-series module is normally used in data termination applications, a 4003C may, in rare cases, also be used. In data applications, auxiliary relay contacts on the 4003C may be used to disable an associated data set during loopback operation or to light an external loopback lamp.

3. installation

inspection

3.01 The 4003C Line Amplifier with Loopback should be visually inspected upon arrival in order to find possible damage incurred during shipment. If damage is noted, a claim should immediately be filed with the carrier. If stored, the module should be visually inspected again prior to installation.

mounting

3.02 The 4003C module mounts in one position of the Tellabs Type 10 Mounting Shelf, which is available in configurations for both relay rack and apparatus case installation. The module plugs physically and electrically into a 56-pin connector at the rear of the Type 10 Shelf.

installer connections

3.03 Before making any connections to the mounting shelf, make sure that power is **off** and modules are **removed**. Modules should be put into place only **after** they are properly optioned and **after** wiring is completed.

3.04 Table 1 lists external connections to the 4003C. All connections are made via wire wrap at the 56-pin connector at the rear of the module's mounting shelf position. Pin numbers are found on the body of the connector.

connect:	to pin:
XMT TIP OUT	41
XMT RING OUT	47
XMT SIMPLEX OUT	43 and 45
RCV TIP IN	7
RCV RING IN	13
RCV SIMPLEX IN	9 and 11
XMT TIP IN	55
XMT RING IN	49
XMT SIMPLEX IN	51 and 53
RCV TIP OUT	5
RCV RING OUT	15
RCV SIMPLEX OUT	3
LOCAL LOOP (key-controlled loopback)	1
TEK5 (data set disable lead)	19
TEK6 (data set disable lead)	21
BATT (−22 to −56Vdc battery in)	35
GND (ground)	17
DSA POWER (used in 263 Data Station Assembly packages)	37

Note: *In intermediate applications where simplex (SX) signaling is used (see center 4003C in figure 3), strap the simplex leads as follows: RCV SIMPLEX IN (pin 9) to RCV SIMPLEX OUT (pin 3) and XMT SIMPLEX IN (pin 51) to XMT SIMPLEX OUT (pin 43).*

table 1. Installer connections to 4003C

option selection

3.05 Fourteen option switches (all of which are DIP switches) must be set before the 4003C is placed into service. These switches and their functions are described in paragraphs 3.06 through 3.13. Locations of these switches on the module's front panel and printed circuit board are shown in figure 6.

receive-channel optioning

3.06 **Levels.** Switch *S9* conditions the receive-channel amplifier to provide either gain or loss. If gain is required, set *S9* to the *GAIN* position. If loss is required, set *S9* to the *LOSS* position. The precise amount of gain or loss is selected via the front-panel *rcv* level DIP switches. The amount of

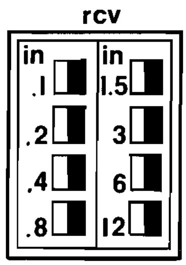


figure 4. Receive-channel level switches

gain or loss provided by each switch position appears on the front panel of the module adjacent to each switch position (see figure 4). These values are additive; thus, the amount of gain or loss selected is the sum of those switch positions set to *IN*.

3.07 **Equalization.** Switch *S10* is a five-position DIP switch that introduces from 0 to 7.75dB of slope equalization in 0.25dB increments. The various settings of *S10* are summarized in table 2.

switch positions S10-1	S10-2	S10-3	S10-4	S10-5	1000Hz* gain (dB)
off	off	off	off	off	–
on	off	off	off	off	0.25dB
off	on	off	off	off	0.5dB
on	on	off	off	off	0.75dB
off	off	on	off	off	1.0dB
on	off	on	off	off	1.25dB
off	on	on	off	off	1.5dB
on	on	on	off	off	1.75dB
off	off	off	on	off	2.0dB
on	off	off	on	off	2.25dB
off	on	off	on	off	2.5dB
on	on	off	on	off	2.75dB
off	off	on	on	off	3.00dB
on	off	on	on	off	3.25dB
off	on	on	on	off	3.5dB
on	on	on	on	off	3.75dB
off	off	off	off	on	4.00dB
on	off	off	off	on	4.25dB
off	on	off	off	on	4.50dB
on	on	off	off	on	4.75dB
off	off	on	off	on	5.00dB
on	off	on	off	on	5.25dB
off	on	on	off	on	5.5dB
on	on	on	off	on	5.75dB
off	off	off	on	on	6.0dB
on	off	off	on	on	6.25dB
off	on	off	on	on	6.50dB
on	on	off	on	on	6.75dB
off	off	on	on	on	7.0dB
on	off	on	on	on	7.25dB
off	on	on	on	on	7.50dB
on	on	on	on	on	7.75dB

*3000Hz equalized gain is twice 1000Hz level shown.

table 2. Receive-channel equalized gain optioning

3.08 **Impedance Matching.** Switch *S7* is a two-position DIP switch that selects the input impedance of the receive channel. Switch *S8*, also a two-position switch, selects the output impedance. The various settings of *S7* and *S8* are summarized in tables 3 and 4, respectively.

switch positions S7-1	S7-2	result (ohms)
off	off	1200
on	off	600
on	on	150

table 3. Receive-channel input impedance optioning

switch positions S8-1	S8-2	result (ohms)
off	off	1200
on	off	600
on	on	150

table 4. Receive-channel output impedance optioning

transmit-channel optioning

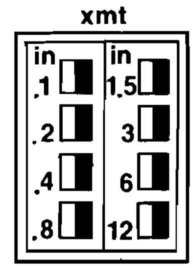


figure 5. Transmit-channel level switches

3.09 **Levels.** Switch *S3* conditions the transmit channel amplifier to provide either flat gain or loss. If gain is required, set *S3* to the *GAIN* position. If loss is required, set *S3* to the *LOSS* position. The precise amount of gain or loss is selected via the front-panel *xmt* level DIP switches. The amount of gain or loss provided by each switch position appears on the front panel of the module adjacent to each switch position (see figure 5). These values are additive; thus, the amount of gain or loss selected is the sum of those switch positions set to *IN*.

3.10 **Equalization.** Switch *S4* is a five-position DIP switch that introduces up to 7.75dB of slope equalization in 0.25dB increments. The various settings of S4 are summarized in table 5.

switch positions S4-1	S4-2	S4-3	S4-4	S4-5	1000Hz* gain (dB)
off	off	off	off	off	–
on	off	off	off	off	0.25dB
off	on	off	off	off	0.5dB
on	on	off	off	off	0.75dB
off	off	on	off	off	1.0dB
on	off	on	off	off	1.25dB
off	on	on	off	off	1.5dB
on	on	on	off	off	1.75dB
off	off	off	on	off	2.0dB
on	off	off	on	off	2.25dB
off	on	off	on	off	2.5dB
on	on	off	on	off	2.75dB
off	off	on	on	off	3.00dB
on	off	on	on	off	3.25dB
off	on	on	on	off	3.5dB
on	on	on	on	off	3.75dB
off	off	off	off	on	4.00dB
on	off	off	off	on	4.25dB
off	on	off	off	on	4.50dB
on	on	off	off	on	4.75dB
off	off	on	off	on	5.00dB
on	off	on	off	on	5.25dB
off	on	on	off	on	5.5dB
on	on	on	off	on	5.75dB
off	off	off	on	on	6.0dB
on	off	off	on	on	6.25dB
off	on	off	on	on	6.50dB
on	on	off	on	on	6.75dB
off	off	on	on	on	7.0dB
on	off	on	on	on	7.25dB
off	on	on	on	on	7.50dB
on	on	on	on	on	7.75dB

*3000Hz equalized gain is twice 1000Hz level shown.

table 5. Transmit-channel equalized gain optioning

3.11 **Impedance Matching.** Switch *S1* is a two-position DIP switch that selects the input impedance of the transmit channel. Switch *S2,* also a two-position switch, selects the output impedance. The various settings of *S1* and *S2* are summarized in tables 6 and 7, respectively.

tone-loopback frequency

3.12 Tone-loopback frequency is selected by means of 10-position DIP switch *S13* located on

switch positions S1-1	S1-2	result (ohms)
off	off	1200
on	off	600
on	on	150

table 6. Transmit-channel input impedance optioning

switch positions S2-1	S2-2	result (ohms)
off	off	1200
on	off	600
on	on	150

table 7. Transmit-channel output impedance optioning

the 4003C's subassembly. Only 1 switch position is required to select any 1 of 11 available frequencies. The available loopback frequencies and settings of switch *S13* are summarized in table 8.

frequency (Hz)	S13 switch position set to *ON**
2813	all switch positions OFF
2713	1
2513	2
2413	3
1913	4
1813	5
1713	6
1613	7
1513	8
1413	9
1313	10

*All other S13 switch positions **must** be set to the *OFF* position.

table 8. Loopback frequency selection

loopback levels

3.13 Loopback levels of +16, +9, −16, or −23dB are selected via DIP switch *S14*, located on the 4003C's subassembly. Loopback level options are described in paragraph 2.10; the various settings of switch *S14* are summarized in table 9.

loopback levels	switch positions S14-1	S14-2
+16dB	off	off
+9dB	off	on
−16dB	on	off
−23dB	on	on

table 9. Loopback level selection

alignment

3.14 This alignment subsection is divided into two parts: preliminary alignment and final alignment verification. In the preliminary alignment procedure, impedance options are selected, equalization is introduced into the receive and the transmit channel (if required), and gain or attenuation is introduced in both the transmit and the receive channel to match the transmission levels specified on the circuit level record (CLR) card. In the final alignment verification procedure, the 4003C is placed into service and end-to-end transmission measurements are made. If the measured levels differ from those specified on the CLR card, the front-panel *xmt* and *rcv* level switches are adjusted to provide the specified levels.

Note: *Two condensed preliminary alignment procedures (figures 6 and 8) and two condensed final alignment verification procedures (figures 7 and 9) may be used to facilitate alignment of the 4003C module.*

preliminary alignment

3.15 Refer to the CLR card for the required transmit and receive input and output impedances. In general, the 1200-ohm option is used to interface loaded cable, the 600-ohm option is used to interface nonloaded cable, carrier, station apparatus, or SF signaling units, and the 150-ohm option is used to interface short segments of nonloaded cable in applications where a small degree of slope equalization is required. Refer to tables 3 and 4 and set switches *S7* and *S8* (receive input and output) as required. Refer to tables 6 and 7 and set switches *S1* and *S2* (transmit input and output) as required.

Note: *If the 3000Hz signal level is not specified on the CLR card, gain and equalization cannot be determined at this time. Omit paragraphs 3.16 through 3.21 and proceed to paragraph 3.22. Gain and equalization will be determined in the final alignment verification procedures, beginning with paragraph 3.23.*

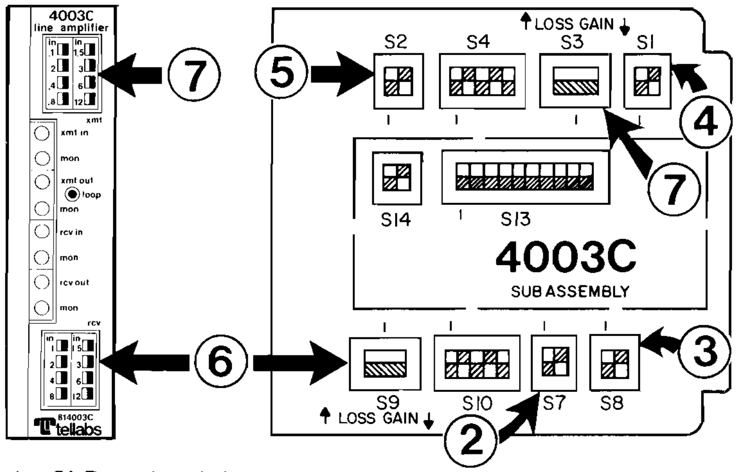
receive-channel equalization

3.16 Refer to the CLR card for the specified 1000Hz and 3000Hz receive input signal levels. If it is desirable to flatten the frequency response of the facility, determine the type of cable the module interfaces and proceed as follows:

A. **Loaded cable or mixed (predominantly loaded) cable:** If the module interfaces loaded cable or mixed loaded and nonloaded cable and the **loaded** cable section is predominant (i.e., up to 9 kilofeet of nonloaded cable), the facility can be partially equalized with the equalized gain provided by the module. Determine the difference (in dB) between the 1000Hz and 3000Hz signal levels. Divide this difference by **2** and, referring to table 2, set switch *S10* for the required amount of equalized gain. If the **exact** amount cannot be selected, use the nearest *lower* value to avoid over-equalization. *This setting flattens the response between 1000Hz and 3000Hz by adding 1000Hz gain equal to the amount of equalized gain selected and 3000Hz gain equal to two times the amount of equalized gain selected. When calculating receive-channel levels (paragraph 3.17), the amount of equalized gain selected above must be added to the specified receive input level to obtain an equalized receive input level.*

B. **Nonloaded cable:** If the module interfaces nonloaded cable, determine the difference (in dB) between the 1000Hz and 3000Hz signal levels. Subtract **1.5**dB from this difference and, referring to table 2, set switch *S10* for the required amount of equalized gain. If the **exact** amount cannot be selected, use the nearest *lower* value to avoid over-equalization. *This setting flattens the response between 1000Hz and 3000Hz by adding 1000Hz gain equal to the amount of equalized gain selected and 3000Hz gain equal to two times the amount of equalized gain selected. When calculating receive-channel levels (paragraph 3.17), the amount of*

alignment continued on page 9



1 Refer to the CLR card and determine the following: receive input and output impedances, transmit input and output impedances, receive 1000Hz input and output signal levels, and transmit 1000Hz input and output signal levels. Once the facility levels are known, proceed to step 2 and perform the remaining preliminary alignment steps in numeric order. The paragraph referenced after each step contains a more detailed explanation of that specific procedure. After completing step 8, proceed to the final alignment verification (without equalization) procedure (figure 7) for instructions on making end-to-end measurements.

2 Set *S7-1* and *S7-2* in accordance with table 3 for receive input impedance. (paragraph 3.08)

3 Set *S8-1* and *S8-2* in accordance with table 4 for receive-output impedance. (paragraph 3.08)

4 Set *S1-1* and *S1-2* in accordance with table 6 for transmit-input impedance. (paragraph 3.11)

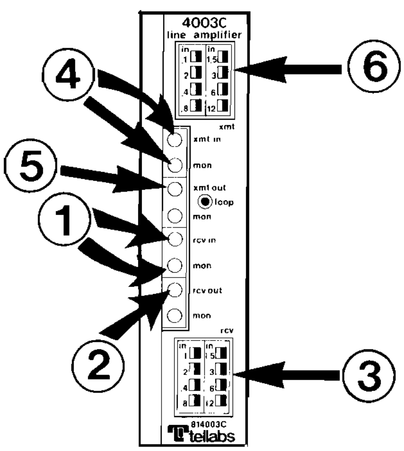
5 Set *S2-1* and *S2-2* in accordance with table 7 for transmit-output impedance. (paragraph 3.11)

6 If the specified receive input level is lower than the specified receive output level, gain must be added. If it is higher, loss must be added. Set *S9* to either *GAIN* or *LOSS*, as required. To determine the required amount of gain or loss, calculate the difference (in dB) between the specified receive input level and the specified receive output level. Set to *IN* the proper combination of front-panel *rcv* level switches that adds up to the required amount of gain or loss. (paragraphs 3.17 and 3.18)

7 If the specified transmit input level is lower than the specified transmit output level, gain must be added. If it is higher, loss must be added. Set *S3* to either *GAIN* or *LOSS*, as required. To determine the required amount of gain or loss, calculate the difference (in dB) between the specified transmit input level and the specified transmit output level. Set to *IN* the proper combination of front-panel *xmt* level switches that adds up to the required amount of gain or loss. (paragraphs 3.20 and 3.21)

8 Insert the module into its mounting position, apply power, and proceed to the final alignment verification (without equalization) procedure (figure 7).

figure 6. Preliminary alignment procedure — no equalization



1 Connect a properly terminated TMS (receive) to the *rcv in mon* jack and insert an opening plug into the *rcv in* jack. Request that personnel at the distant facility-side location send 1000Hz tone at their specified level. Verify that tone is present and at the level specified on the CLR card. (paragraph 3.23)

2 Disconnect the TMS and remove the opening plug. Connect the properly terminated TMS (receive) to the *rcv out* jack. Request that personnel at the distant terminal-side location again send 1000Hz tone at their specified level. Verify that tone is present and record the level. (paragraph 3.23)

3 Determine the difference (in dB) between the measured receive output level (step 2) and the receive output level specified on the CLR. If any difference in levels exists, insert or remove gain via the front-panel *rcv* level switches to obtain the specified receive output level. (paragraph 3.23)

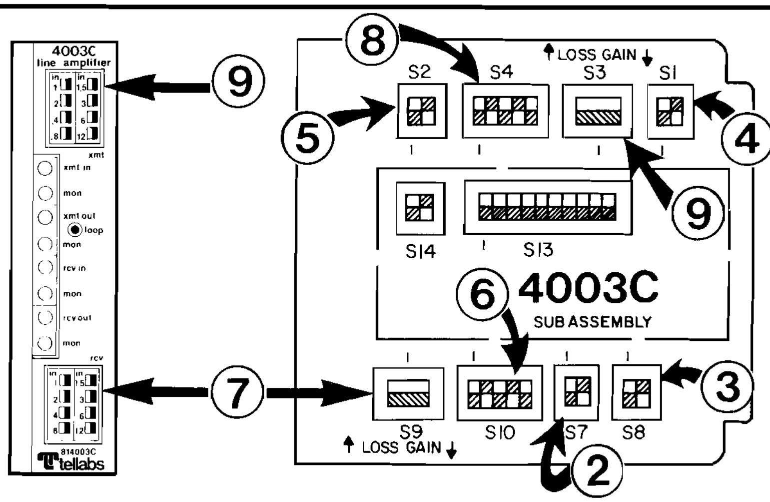
4 Disconnect the TMS. Connect the properly terminated TMS (receive) to the *xmt in mon* jack and insert an opening plug into the *xmt in* jack. Request that personnel at the distant terminal-side location send 1000Hz tone at their specified level. Verify that tone is present and at the level specified on the CLR card. (paragraph 3.24)

5 Disconnect the TMS and remove the opening plug. Connect the properly terminated TMS (receive) to the *xmt out* jack. Request that personnel at the distant terminal-side location again send 1000Hz tone at their specified level. Verify that tone is present and record the level. (paragraph 3.24)

6 Determine the difference (in dB) between the measured transmit output level (step 5) and the transmit output level specified in the CLR. If any difference in levels exists, insert or remove gain via the front-panel *xmt* level switches to obtain the specified transmit output level. (paragraph 3.24)

7 Remove all test connections. Alignment is completed.

figure 7. Final alignment verification — no equalization



1 Refer to the CLR card and determine the following: receive input and output impedances, transmit input and output impedances, receive 1000 and 3000Hz* input and output signal levels, transmit 1000Hz and 3000Hz* input and output signal levels, and the distant (receive channel) location's receive 1000Hz and 3000Hz* input signal levels. Once the facility levels are known, proceed to step 2 and perform the remaining preliminary alignment steps in numeric order. The paragraph referenced after each step contains a more detailed explanation of that specific procedure. After completing step 10, proceed to the final alignment verification with equalization procedure (figure 9) for instructions on making end-to-end measurements.

*If the 3000Hz signal levels are not specified on the CLR, equalization and gain (steps 6 through 9) cannot be determined at this time. After completing step 5, omit steps 6 through 9 and proceed to step 10. After completing step 10, proceed to figure 9.

2 Set *S7-1* and *S7-2* in accordance with table 3 for receive-input impedance. (paragraph 3.08)

3 Set *S8-1* and *S8-2* in accordance with table 4 for receive-output impedance. (paragraph 3.08)

4 Set *S1-1* and *S1-2* in accordance with table 6 for transmit-input impedance. (paragraph 3.11)

5 Set *S2-1* and *S2-2* in accordance with table 7 for transmit-output impedance. (paragraph 3.11)

6 If equalization is desired in the receive channel, refer to the CLR card for the specified 1000Hz and 3000Hz receive input signal levels. Determine the type of cable that the module interfaces, and perform the appropriate equalization procedure, as described below. (paragraph 3.16)

loaded cable and predominantly loaded mixed cable

Determine the difference (in dB) between the 1000Hz and 3000Hz signal levels. Divide this difference by 2 and, referring to table 2, set switch *S10* for the required (nearest but lower) amount of equalized gain.

nonloaded cable

Determine the difference (in dB) between the 1000Hz and 3000Hz signal levels. Subtract 1.5dB from this difference and, referring to table 2, set switch *S10* for the required (nearest but lower) amount of equalized gain.

predominantly nonloaded mixed cable

Determine the difference (in dB) between the 1000Hz and 3000Hz signal levels. Subtract 2dB from this difference and, referring to table 2, set switch *S10* for the required (nearest but lower) amount of equalized gain.

7 **Note:** *The amount of equalized gain added in step 6 must be added to the specified 1000Hz receive input signal level to obtain an equalized receive input level.*

If the equalized receive input level is lower than the specified receive output level, gain must be added. If it is higher, loss must be added. Set *S9* to either *GAIN* or *LOSS,* as required. To determine the required amount of gain or loss, calculate the difference (in dB) between the equalized receive input level and the specified receive output level. Set to *IN* the proper combination of front-panel *rcv* level switches that adds up to the required amount of gain or loss. (paragraphs 3.17 and 3.18)

8 If equalization is desired in the transmit channel, refer to the CLR card for the specified 1000Hz and 3000Hz receive input signal levels at the distant (receive channel) location. Determine the type of cable that the module interfaces, and perform the appropriate equalization procedure, as described below. (paragraph 3.19)

loaded cable and predominantly loaded mixed cable

Determine the difference (in dB) between the 1000Hz and 3000Hz signal levels. Divide this difference by 2 and, referring to table 5, set switch *S4* for the required (nearest but lower) amount of equalized gain.

nonloaded cable

Determine the difference (in dB) between the 1000Hz and 3000Hz signal levels. Subtract 1.5dB from this difference and, referring to table 5, set switch *S4* for the required (nearest but lower) amount of equalized gain.

predominantly nonloaded mixed cable

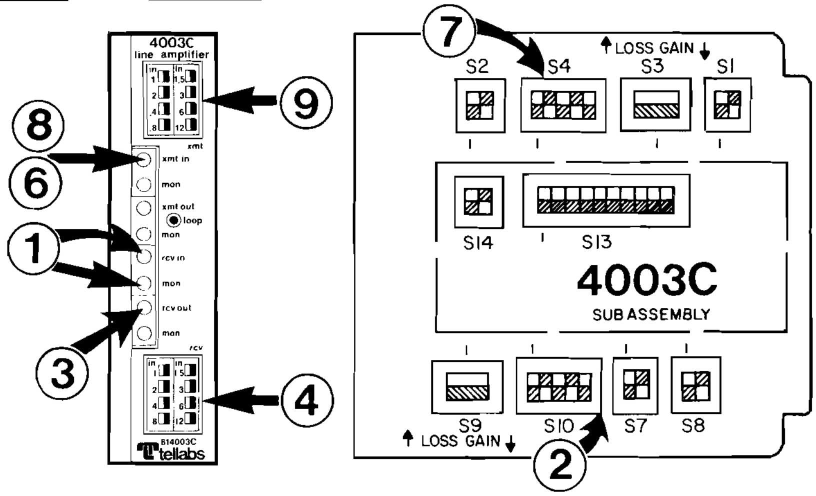
Determine the difference (in dB) between the 1000Hz and 3000Hz signal levels. Subtract 2dB from this difference and, referring to table 5, set switch *S4* for the required (nearest but lower) amount of equalized gain.

9 **Note:** *The amount of equalized gain added in step 8 must be added to the specified 1000Hz transmit input level to obtain an equalized transmit input level.*

If the equalized transmit input level is lower than the specified transmit output level, gain must be added. If it is higher, loss must be added. Set *S3* to either *GAIN* or *LOSS,* as required. To determine the required amount of gain or loss, calculate the difference (in dB) between the equalized transmit input level and the specified transmit output level. Set to *IN* the proper combination of front-panel *xmt* level switches that adds up to the required amount of gain or loss. (paragraphs 3.20 and 3.21)

10 Insert the module into its mounting, apply power, and proceed to the final alignment (with equalization) procedure (figure 9).

figure 8. Preliminary alignment procedure — with equalization



1 Connect a properly terminated TMS (receive) to the *rcv in mon* jack and insert an opening plug into the *rcv in* jack. Request that personnel at the distant facility-side location send 1000Hz and 3000Hz tones at their specified level. Verify that tone is present and record these levels. (paragraph 3.23)

2 If receive equalization was determined in the preliminary alignment procedure, omit this step and proceed to step 3. If not, determine the type of cable that the module interfaces and, with the measured levels from step 1, perform the appropriate equalization procedure as described below. (paragraph 3.16)

loaded cable and predominantly loaded mixed cable

Determine the difference (in dB) between the 1000Hz and 3000Hz signal levels. Divide this difference by 2 and, referring to table 2, set switch *S10* for the required (nearest but lower) amount of equalized gain.

nonloaded cable

Determine the difference (in dB) between the 1000Hz and 3000Hz signal levels. Subtract 1.5dB from this difference and, referring to table 2, set switch *S10* for the required (nearest but lower) amount of equalized gain.

predominantly nonloaded mixed cable

Determine the difference (in dB) between the 1000Hz and 3000Hz signal levels. Subtract 2dB from this difference and, referring to table 2, set switch *S10* for the required (nearest but lower) amount of equalized gain.

3 Disconnect the TMS and remove the opening plug. Connect the properly terminated TMS (receive) to the *rcv out* jack. Request that the distant location again send 1000Hz tone at their specified level. Verify that tone is present and record the level. (paragraph 3.23)

4 Determine the difference (in dB) between the measured 1000Hz receive output level (step 3) and the 1000Hz output level specified on the CLR. If any difference in levels exists, insert or remove gain via the front-panel *rcv* level switches to obtain the specified receive output level. (paragraph 3.23)

5 To complete receive-channel verification, perform a frequency run, measuring and recording levels at appropriate intervals from 300 to 3000Hz. If the measured levels meet the desired frequency-response characteristics, the equalizer is properly set.

6 Disconnect the TMS. Connect the properly terminated TMS (transmit) to the *xmt in* jack and send 1000Hz and 3000Hz tones at the specified level. Request that personnel at the distant facility-side (receive) location measure and record the level of each tone. (paragraph 3.24)

7 If transmit equalization was determined in the preliminary alignment procedure, omit this step and proceed to step 8. If not, determine the type of cable that the module interfaces and, with the measured levels from step 6, perform the appropriate equalization procedure as described below. (paragraph 3.19)

loaded cable and predominantly loaded mixed cable

Determine the difference (in dB) between the 1000Hz and 3000Hz signal levels. Divide this difference by 2 and, referring to table 5, set switch *S4* for the required (nearest but lower) amount of equalized gain.

nonloaded cable

Determine the difference (in dB) between the 1000Hz and 3000Hz signal levels. Subtract 1.5dB from this difference and, referring to table 5, set switch *S4* for the required (nearest but lower) amount of equalized gain.

predominantly nonloaded mixed cable

Determine the difference (in dB) between the 1000Hz and 3000Hz signal levels. Subtract 2dB from this difference and, referring to table 5, set switch *S4* or the required (nearest but lower) amount of equalized gain.

8 Again send 1000Hz tone at the specified level. Request that personnel at the distant facility-side (receive) location measure and record the 1000Hz level. (paragraph 3.24)

9 Determine the difference (in dB) between the distant facility-side (receive) location's specified 1000Hz input level and the level measured in step 8. If any differences in levels exists, insert or remove gain via the front-panel *xmt* levels to obtain the required level. (paragraph 3.24)

10 To complete transmit-channel verification, perform a frequency run, measuring and recording levels at appropriate intervals from 300 to 3000Hz. If the measured levels meet the desired frequency-response characteristics, the equalizer is properly set.

11 Remove all test connections. Alignment is completed.

figure 9. Final alignment verification — with equalization

equalized gain selected above must be added to the specified receive input level to obtain an equalized receive input level.

C. Mixed (predominantly nonloaded) cable: If the module interfaces mixed nonloaded and loaded cable and the **nonloaded** cable section is predominant (i.e., 9 kilofeet or more of nonloaded cable), determine the difference (in dB) between the 1000Hz and 3000Hz signal levels. Subtract 2dB from this difference and, referring to table 2, set switch *S10* for the required amount of equalized gain. If the **exact** amount cannot be selected, use the nearest *lower* value to avoid over-equalization. *This setting flattens the response between 1000Hz and 3000Hz by adding 1000Hz gain equal to the amount of equalized gain selected and 3000Hz gain equal to two times the amount of equalized gain selected. When calculating receive-channel levels (paragraph 3.17), the amount of equalized gain selected above must be added to the specified receive input level to obtain an equalized receive input level.*

receive-channel levels

3.17 Refer to the CLR card for the specified 1000Hz receive input and receive output signal levels. If equalized gain was inserted in the receive channel (paragraph 3.16), add the amount of equalized gain used to the specified receive input level to obtain an equalized receive input level. Calculate the difference (in dB) between the equalized receive input level (or the specified receive input level if equalization was not used) and the specified receive output level to determine how much gain or loss must be added to achieve the specified receive output level.

3.18 Set *S9* to introduce either gain or loss into the receive channel, as required. Set to the *IN* position the proper combination of front-panel *rcv* level switches that adds up to the required amount of gain or loss.

transmit-channel equalization

3.19 Refer to the CLR card for the specified 1000Hz and 3000Hz signal levels at the distant (receive-channel) location. If it is desirable to flatten the frequency response of the facility, determine the type of cable the module interfaces and proceed as follows:

A. Loaded cable or mixed (predominantly loaded) cable: If the module interfaces loaded cable or mixed loaded and nonloaded cable and the **loaded** cable section is predominant (i.e., up to 9 kilofeet of nonloaded cable), the facility can be partially equalized with the equalized gain provided by the module. Determine the difference (in dB) between the 1000Hz and 3000Hz signal levels. Divide this difference by 2 and, referring to table 5, set switch *S4* for the required amount of equalized gain. If the **exact** amount cannot be selected, use the nearest *lower* value to avoid over-equalization. *This setting flattens the response between 1000Hz and 3000Hz by adding 1000Hz gain equal to the amount of equalized gain selected and 3000Hz gain equal to two times the amount of equalized gain selected. When calculating transmit-channel levels (paragraph 3.20), the amount of equalized gain selected above must be added to the specified transmit input level to obtain an equalized transmit input level.*

B. Nonloaded cable: If the module interfaces nonloaded cable, determine the difference (in dB) between the 1000Hz and 3000Hz signal levels. Subtract **1.5**dB from this difference and, referring to table 5, set switch *S4* for the required amount of equalized gain. If the **exact** amount cannot be selected, use the nearest *lower* value to avoid over-equalization. *This setting flattens the response between 1000Hz and 3000Hz by adding 1000Hz gain equal to the amount of equalized gain selected and 3000Hz gain equal to two times the amount of equalized gain selected. When calculating transmit-channel levels (paragraph 3.20), the amount of equalized gain selected above must be added to the specified transmit input level to obtain an equalized transmit input level.*

C. Mixed (predominantly nonloaded) cable: If the module interfaces mixed nonloaded and loaded cable and the **nonloaded** cable section is predominant (i.e., 9 kilofeet or more of nonloaded cable), determine the difference (in dB) between the 1000Hz and 3000Hz signal levels. Subtract 2dB from this difference and, referring to table 5, set switch *S4* for the required amount of equalized gain. If the **exact** amount cannot be selected, use the nearest *lower* value to avoid over-equalization. *This setting flattens the response between 1000Hz and 3000Hz by adding 1000Hz gain equal to the amount of equalized gain selected and 3000Hz gain equal to two times the amount of equalized gain selected. When calculating transmit-channel levels (paragraph 3.20), the amount of equalized gain selected above must be added to the specified transmit input level to obtain an equalized transmit input level.*

transmit-channel levels

3.20 Refer to the CLR card for the specified 1000Hz transmit input and transmit output signal levels. If equalized gain was inserted in the transmit channel (paragraph 3.19), add the amount of equalized gain used to the specified transmit input level to obtain an equalized transmit input level. Calculate the difference (in dB) between the equalized transmit input level (or the specified transmit input level if equalization was not used) and the specified transmit output level to determine how much gain or loss must be added to achieve the specified transmit output level.

3.21 Set switch *S3* to introduce either gain or loss into the transmit channel, as required. Set to *IN* the proper combination of *xmt* level switches that adds up to the required amount of gain or loss.

final alignment verification

3.22 In this final alignment verification procedure, the 4003C is placed into service, signal level measurements are taken, and the front-panel *xmt* and *rcv* level switches are reset, as required, to meet the levels specified on the CLR card. Attenuation or gain introduced at this time does not affect the equalization characteristics that may have been previously introduced via the equalized gain switches. **It is strongly recommended that no 1000Hz level adjustments be attempted with the equalized gain switches.**

receive-channel

3.23 To perform the receive-channel's final alignment verification, proceed as follows:

Note: *If receive-channel equalization is not required, request that the distant location only send 1000Hz tone at the specified level and omit step B.*

A. Connect a properly terminated TMS (receive) to the *rcv in mon* jack and insert an opening plug into the *rcv in* jack. Request that the distant location send 1000Hz and 3000Hz tone at the level specified on the CLR card. Verify that tone is present and record these levels.

B. If receive-channel equalization and gain were determined in the preliminary alignment procedure (paragraphs 3.16 through 3.18), omit this step and proceed to step C. If not, determine the type of cable the module interfaces and, with the 1000Hz and 3000Hz levels measured in step A, perform the equalization (if required) and gain procedures in accordance with paragraphs 3.16 through 3.18.

C. Disconnect the TMS and remove the opening plug. Connect the TMS (receive) to the *rcv out* jack. Request that the distant location again send 1000Hz tone at the level specified on the CLR card.

D. Determine the difference (in dB) between the measured 1000Hz receive output level (step C) and the receive output level specified on the CLR. If any difference in levels exists, insert or remove gain via the front-panel *rcv* level switches to obtain the specified receive output level.

E. To complete receive-channel verification, perform a frequency run, measuring levels at appropriate intervals from 300 to 3000Hz. If the measured levels meet the desired frequency-response characteristic, the equalizer is properly set.

transmit channel

3.24 To perform the transmit-channel's final alignment verification, proceed as follows:

Note: *If transmit-channel equalization is not required, insert 1000Hz tone into the* xmt in *jack at the specified level and omit steps B and C.*

A. Connect a properly terminated TMS (transmit) to the *xmt in* jack. Send 1000Hz and 3000Hz tones at the specified level. Request that personnel at the distant facility-side (receive) location measure and record the level of each tone.

B. If transmit-channel equalization and gain were determined in the preliminary alignment procedure (paragraphs 3.19 through 3.21), omit this step and proceed to step C. If not, determine the type of cable the module interfaces and, with the 1000Hz and 3000Hz levels measured in step A, perform the equalization (if required) and gain procedures in accordance with paragraphs 3.19 through 3.21.

C. Again send 1000Hz tone at the specified level. Request that personnel at the distant (facility-side) receive location measure and record the 1000Hz level.

D. Determine the difference (in dB) between the distant facility-side (receive) location's specified 1000Hz input level and the level measured in step C. If any difference in levels exists, insert or remove gain via the front-panel *xmt* level switches to obtain the required level.

E. To complete transmit-channel verification, perform a frequency run, measuring levels at appropriate intervals from 300 to 3000Hz. If the measured levels meet the desired frequency-response characteristic, the equalizer is properly set.

6. specifications

Note: *Transmit-channel and receive-channel specifications are identical.*

terminating impedance (any port, input or output)
switchable 1200, 600, or 150 ohms, balanced

flat gain/loss
–24 to +24dB in 0.1dB increments, prescription-set via front-panel switches (gain or loss determined by switch option)

deviation from gain setting indicated by front-panel switches
±0.25dB maximum, re 1000Hz

maximum recommended output level
+15dBm

total harmonic distortion
less than 1% at +15dBm output level

equalized gain
0 to 7.75dB differential between 1000 and 3000Hz levels, switch-selectable in 0.25dB increments

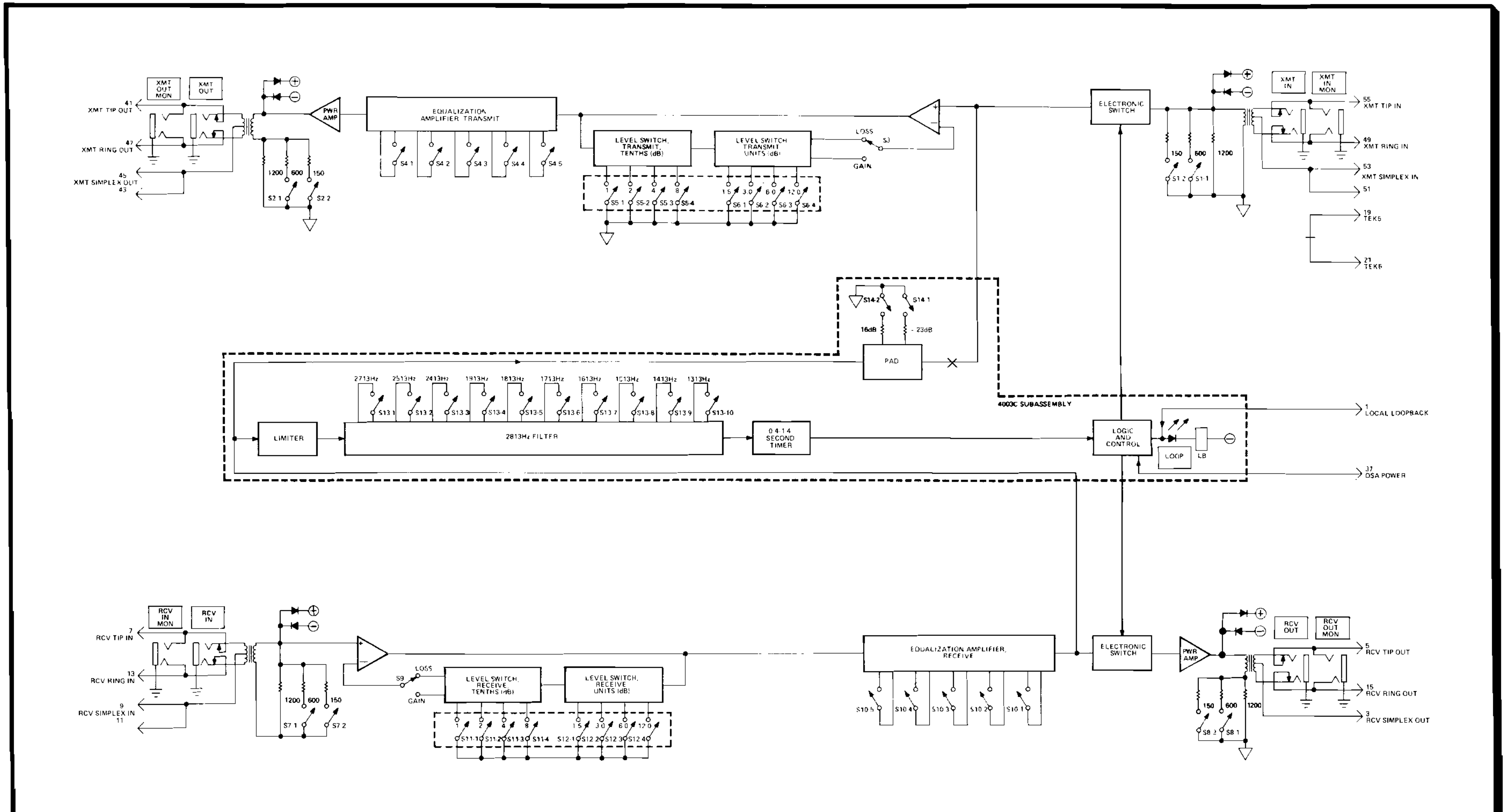
frequency response deviation
±1.0dB, re 1000Hz, 300 to 3000Hz

delay distortion
less than 125μs, 300 to 3000Hz, re 1000Hz (measured worst case with equalization)

crosstalk loss (between channels)
85dB minimum, re 1000Hz
75dB minimum, re 3000Hz

noise
15dBrnC maximum at maximum gain

specifications continued on page 12



4003C Line Amplifier with Loopback 814003C

5. block diagram

crosstalk loss (between units in adjacent, above, or below shelf slots)
90dB minimum, re 1000Hz
85dB minimum, re 3000Hz

simplex (SX) current
120mA maximum, with 5mA maximum unbalance

tone loopback threshold
−18dBm with no gain (Receive channel gain or loss adjustments will directly increase or decrease the minimum loopback sensitivity on a dB-for-dB basis.)

tone loopback signal-to-guard ratio
3dB minimum

tone loopback frequency
1 of 11 prescription set, center stabilities ±0.2%, 75Hz bandwidth (see table 8)

operating times, tone loopback
initiate: 1.4 seconds maximum, loopback after removal of tone
release: 0.7 second maximum, release during tone (two-tone-burst operation)

local dc loopback
ground to operate; 25mA current

loopback levels
+16dB, +9dB, −16dB or −23dB (±1dB), switchable

input power
−22 to −56Vdc, 65mA maximum, 25mA quiescent

operating environment
20° to 130°F (−7° to 54°C), humidity to 95% (no condensation)

weight
16 ounces (454 grams)

dimensions
5.58 inches (14.17cm) high
1.42 inches (3.61cm) wide
5.96 inches (15.14cm) deep

mounting
relay rack or apparatus case via one position of Tellabs Type 10 Mounting Shelf

4. circuit description

4.01 This circuit description is designed to familiarize you with the 4003C Line Amplifier with Loopback module for engineering and application purposes only. Attempts to test or troubleshoot the 4003C internally are not recommended. Procedures for recommended testing and troubleshooting in the field are limited to those prescribed in section 7 of this Practice. Please refer to the 4003C block diagram, section 5 of this Practice, as an aid in following the circuit description.

4.02 The power supply in the 4003C is a simple *series voltage regulator* that uses a zener diode as a reference source. A series diode in the negative input lead protects the circuit against reversed input power connections, and a high-voltage zener diode between input battery and ground limits high-level supply transients to a safe level.

4.03 The transmit and receive sections of the 4003C are identical. Input and output transformers are used to interface external circuits. These transformers also derive simplex leads at all four ports (transmit and receive, input and output). A secondary winding of each transformer is connected to the channel amplifier and to the output impedance circuit, which consists of three resistors. Switch selection of one, two, or all three resistors provides the 1200, 600, or 150-ohm output impedance.

4.04 Clamping diodes limit the amplifiers' output voltage to internal power potentials and provide surge protection at each of the four ports. Each channel's amplifier section is controlled by an option switch that introduces either negative feedback to provide loss or positive feedback to provide gain. The precise amount of gain or loss selected is via the front-panel *xmt* and *rcv* level switches. The output of each channel amplifier also feeds a series-connected equalized-gain amplifier that provides up to 7.75dB of slope equalization via DIP switches on the module's printed circuit board.

tone-activated loopback

4.05 The input for tone-activated loopback is obtained from the output of the receive *power amp.* The tone is detected by a *2813Hz filter* circuit, preceded by a *limiter* for signal-to-guard control. The output of the *2813Hz filter,* at resonance, starts the 1.4-second timing cycle. The *logic* circuitry determines the status of the LB relay and sets the *timer* for 1.4 seconds if the LB relay is released. The LB relay remains activated until a second loopback tone is placed on the module's receive pair for longer than 0.7 second.

local dc loopback

4.06 Local application of a ground potential to pin 1 operates relay LB directly, resulting in the activation of loopback. The LB relay will remain operated (looped) until the ground potential is manually removed from pin 1.

loopback level

4.07 A prescription-set amplifier/attenuator circuit is located in the loopback path between the receive and transmit channels. This circuit provides for the adjustable +16dB, +9dB, −16dB or −23dB loopback level.

7. testing and troubleshooting

7.01 The **testing guide checklist** in this section may be used to assist in the installation, testing, or troubleshooting of the 4003C Line Amplifier module with Loopback. The checklist is intended as an aid in the localization of trouble to this specific equipment. If the equipment is suspected of being 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 below. We strongly recommend that no internal (component-level) testing or repairs be attempted on the equipment. Unauthorized testing or repairs may void its warranty. Also, if the equipment is part of a registered system, unauthorized repairs will result in noncompliance with Parts 15 and/or 68 of the FCC Rules and Regulations.

Note: *Although repair service always includes an attempt to remove any permanent markings made by customers on Tellabs equipment, the success of such attempts cannot be guaranteed. Therefore, if equipment must be marked* ***defective*** *or* ***bad,*** *we recommend that it be done on a piece of tape or on a removable stick-on label.*

technical assistance via telephone
7.02 If a situation arises that is not covered in the **testing guide checklist,** contact Tellabs Customer Service as follows:

USA customers: Contact your Tellabs Regional Office listed below.

region	telephone	office location
US Atlantic	(203)798-0506	Danbury, CT
US Capital	(703)478-0468	Washington, DC
US Central	(312)357-7400	Chicago, IL
US Southeast	(305)834-8311	Orlando, FL
US Southwest	(214)869-4114	Dallas, TX
US Western	(714)850-1300	Orange County, CA

Canadian customers: Contact our Canadian headquarters in Mississauga, Ontario. Telephone (416)624-0052.

International customers: Contact your Tellabs distributor.

selecting correct product service procedure
7.03 If equipment is diagnosed as defective or if in-service equipment needs repair, follow the **product return procedure** in paragraph 7.04 in all cases except those where a critical service outage exists (e.g., where a system or a critical circuit is down and no spares are available). In critical situations, or if you wish to return equipment for reasons other than repair, follow the **product replacement procedure** in paragraph 7.05.

product return procedure (for repair)
7.04 To return equipment for repair, first contact Tellabs Product Services (see addresses and numbers below) to obtain a Material Return Authorization (MRA). A service representative will request key data (your company's name and address, the equipment's model and issue numbers and warranty date code, and the purchase order number for the repair transaction). The service representative will then give you an MRA number that identifies your particular transaction. After you obtain the MRA number, send the equipment prepaid to Tellabs (attn: Product Services).

in the USA:
Tellabs, Inc.
4951 Indiana Avenue
Lisle, Illinois 60532
telephone (312) 969-8800

in Canada:
Tellabs Communications Canada, Ltd.
1200 Aerowood Drive, Unit 39
Mississauga, Ontario, Canada L4W 2S7
telephone (416) 624-0052

Enclose an explanation of the malfunction, your company's name and address, the name of a person to contact for further information, and the purchase order number for the transaction. Be sure to write the MRA number clearly on the outside of the carton being returned. Tellabs will inspect, repair, and retest the equipment so that it meets its original performance specifications and then ship the equipment back to you. If the equipment is in warranty, no invoice will be issued. Should you need to contact Tellabs regarding the status of a repair, call or write the Product Services department at our Lisle or Mississauga headquarters as directed above.

product replacement procedure
7.05 For critical service outages, Tellabs offers a choice of two replacement services (if the product is in replacement stock) in lieu of the 15-day repair and return service described above. These are **overnight express service** (at extra cost) anywhere in the USA and **five-day expedited delivery** (at no extra cost) anywhere in the USA and Canada. To obtain replacement equipment via either of these services, contact your Tellabs Regional Office in the USA or our Canadian headquarters in Mississauga, Ontario, for details, costs (if applicable), and instructions. Telephone numbers are given in paragraph 7.02. A service representative will request key data (your company's name and address, the equipment's model and issue numbers and warranty date code, and the purchase order number for the replacement transaction). Tellabs will then ship the replacement to you in accordance with the replacement service you request. An invoice in the amount of the replacement's current price plus any applicable service charges will be issued after the replacement is shipped. When you receive the replacement, pack the equipment to be returned in the replacement's carton, sign and enclose the packing list, affix to the carton the preaddressed label provided, and ship the carton prepaid to Tellabs at our USA or Canadian headquarters. When we receive the defective equipment (within 30 days of our issuing the replacement), the invoice will be adjusted to reflect only service charges (if applicable). Please note that OEM, modified, and manufacture-discontinued equipment is not available via overnight express service.

testing guide checklist on next page

testing guide checklist

test	test procedure	normal result	if normal conditions are not met, verify:
receive level	Connect properly terminated TMS (receive) to *rcv out* jack. Insert 1000Hz test tone at specified level into *rcv in* jack.	Signal level corresponds to gain or loss settings ☐.	Power ☐. Wiring ☐. Proper impedance termination (check for double terminations) ☐. Impedance switches (*S7* and *S8*) properly set ☐. Level switches (*S9* and front-panel *rcv* level) properly set ☐. Replace module and retest ☐.
transmit level	Connect properly terminated TMS (receive) to *xmt out* jack. Insert 1000Hz test tone at specified level into *xmt in* jack.	Signal level corresponds to gain or loss settings ☐.	Power ☐. Wiring ☐. Proper impedance terminations (check for double terminations) ☐. Impedance switches (*S1* and *S2*) properly set ☐. Level switches (*S3* and front-panel *xmt* level) properly set ☐. Replace module and retest ☐.
tone loopback	Connect selected loopback tone at level indicated in CLR to *rcv in* jack; after 2 seconds change frequency to 1kHz; measure output at *xmt out* jack.	*Loop* LED lights ☐. Measured transmit level within ±1dB of transmit level indicated on CLR ☐.	Transmit and receive levels properly aligned ☐. Correct loopback tone selected *S13* ☐. Lower loopback tone level 10dB and retest ☐. Replace and retest ☐.
tone loopback release	Change test signal to selected loopback tone.	*Loop* LED off after approximately 1 second ☐.	Momentarily operate manual loopback (ground pin 1) ☐. Check transmit pair for shorted pairs ☐. Replace and retest ☐.