tellabs
technical manual
76-824001A
rev A

practice section 824001A

4001A Line Amplifier

contents

1. general description

1.01 The 4001A Line Amplifier module (figure 1) consists of two independent and identical circuits that each provide level control, impedance matching, and amplitude equalization for a voice-frequency transmission facility. These two circuits, designated *amp 1* and *amp 2*, can serve the transmit and receive channels of a 4wire facility, or they can be used as unidirectional amplifiers on two separate circuits.

1.02 This Practice section is reissued to cover the Issue 2 version of the 4001A module (Tellabs part number **824001A**). The Issue 2 module differs from its Issue 1 counterpart through the addition of a 150-ohm terminating-impedance switch option at the input and output ports of both the amp 1 and amp 2 circuits.

1.03 Each amplifier on the 4001A can be independently switch-optioned for either of two gain ranges: −2 to +35dB or −15 to +6dB. Within the selected gain ranges, levels are continuously adjustable (with accuracy to ±0.1dB) via front-panel controls. The maximum output of each amplifier is +17dBm, with less than 1 percent distortion.

1.04 Transformers at the input and output ports of both circuits on the 4001A can be switch-optioned for balanced 1200, 600, or 150-ohm terminating impedance. All four transformers are center-tapped to derive balanced simplex leads that provide for DX, loopback, and other signaling schemes that require a dc path.

1.05 Identical amplitude-equalization circuitry in each of the 4001A's two circuits can be independently switch-optioned for any of three equalization modes. These modes are *BYP* (equalizer bypassed, flat response), *EQL* (high-low equalization for loaded cable or carrier), and *NL* (slope equalization for nonloaded cable).

1.06 In addition to level, high-frequency equalization, and low-frequency equalization controls for each circuit, the 4001A's front panel contains a full complement of eight 310-type test jacks to facilitate alignment and maintenance. One opening jack facing the module and one monitoring jack facing the facility are provided at the input and output ports of each of the 4001A's two circuits.

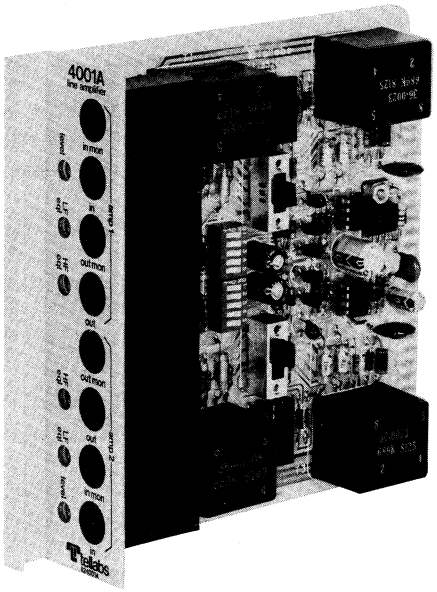


figure 1. 4001A Line Amplifier

1.07 An internally regulated power supply permits the 4001A to operate on filtered, ground-referenced −22 to −56Vdc input. Current requirements range from 20mA at idle to 60mA with both amplifiers at maximum output.

1.08 Surge protection is provided for the input and output of both amplifiers. Reverse-battery protection and transient-limiting circuitry are provided in the amplifiers' internal power supply circuitry.

1.09 The 4001A is a Type 10 module that mounts in one position of a Tellabs Type 10 Mounting Shelf, versions of which are available for relay-rack and apparatus-case installation. In relay-rack applications, up to 12 modules can be mounted across a 19-inch rack, while up to 14 modules can be mounted across a 23-inch rack. In either case, 6 inches of vertical rack space is used.

2. application

2.01 The 4001A Line Amplifier module is designed either to provide bidirectional (transmit and receive) level control and amplitude equalization for a 4wire voice-frequency (VF) transmission facility or to provide unidirectional level control and amplitude equalization for two separate unidirectional VF channels (see figure 2). The module also provides input and output impedance matching, longitudinal isolation, and surge protection for the facilities served by its two amplifier/equalizer circuits.

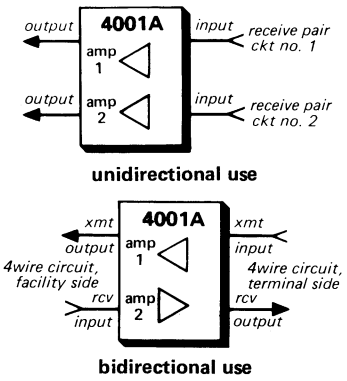


figure 2. Unidirectional and bidirectional applications

2.02 In itself, the 4001A is equivalent to a 4wire-to-4wire (44V4) VF repeater. When paired with a Tellabs 4wire-to-2wire Terminating Set module (420X, 4942, or equivalent), a 2wire-to-4wire (24V4) repeater results. The 4001A can be used as either a terminal or an intermediate repeater (see figure 3).

levels

2.03 The level-control circuitry in each circuit of the 4001A can be independently switch-optioned for either of two gain ranges: −2 to +35dB or −15 to +6dB. The lower range is provided to accommodate those applications (some data sets, for example) where output levels are too high and must be attenuated. Within the selected gain range, levels can be set to within ±0.1dB via a front-panel *level* control. The maximum output level of each circuit is +17dBm, with less than 1 percent distortion.

impedance matching

2.04 Impedance-matching transformers at each port (input and output) of both circuits on the 4001A can be independently switch-optioned for balanced 1200, 600, or 150-ohm terminating impedance. Thus, on both sides of each circuit, the module can interface a variety of facilities and equipment, as listed below.

impedance	facility or equipment interfaced
1200 ohms	loaded cable
600 ohms	nonloaded cable, carrier, SF and DX signaling units, term sets, station apparatus
150 ohms	short lengths of nonloaded cable (see note)
Note: *The 150-ohm terminating-impedance option is used primarily to provide a small degree of slope amplitude equalization on short nonloaded cable facilities through the resultant impedance mismatch.*	

2.05 All four impedance-matching transformers on the 4001A module are center-tapped to derive balanced simplex leads, thus allowing the module to be used on circuits employing DX, loopback, or other dc signaling schemes.

equalization

2.06 Amplitude equalization is provided in both channels of the 4001A. Whether one or both channels' equalizers are used depends 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 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 4001A module as a bidirectional amplifier at an intermediate point in a 4wire circuit, for example, often requires the use of the transmit equalizer as well as the receive equalizer.

2.07 The amplitude-equalization circuitry in each of the 4001A's two circuits is identical, providing a choice of three switch-selectable equalization modes. These modes are *BYP* (equalizer bypassed, flat response), *EQL* (high-low equalization for loaded cable or carrier), and *NL* (slope equalization for nonloaded cable).

2.08 The *BYP* mode is selected if only flat gain is desired in an application. In this mode, all equalization is removed and the frequency response of the module is flat (within ±1dB of the 1000Hz level) from 200Hz to 4000Hz.

2.09 The *EQL* mode (high-low equalization for loaded cable or carrier) provides a variety of low-frequency and high-frequency gain shapes to compensate for loss in loaded cable or other transmission facilities. Additionally, both low-end and high-end roll-off are provided to attenuate out-of-band noise at both ends of the voice-frequency spectrum and to improve stability when the 4001A is used with a 4wire-to-2wire term set in 24V4-repeater applications. Amplitude "bumps" can be independently adjusted at the high and low ends of the amplifier response, equalizing the frequency response of a transmission facility between approximately 300 and 3200Hz. In the *EQL* mode, amplitude equalization is controlled by the front-panel controls labeled *LF eql* (low frequency) and *HF*

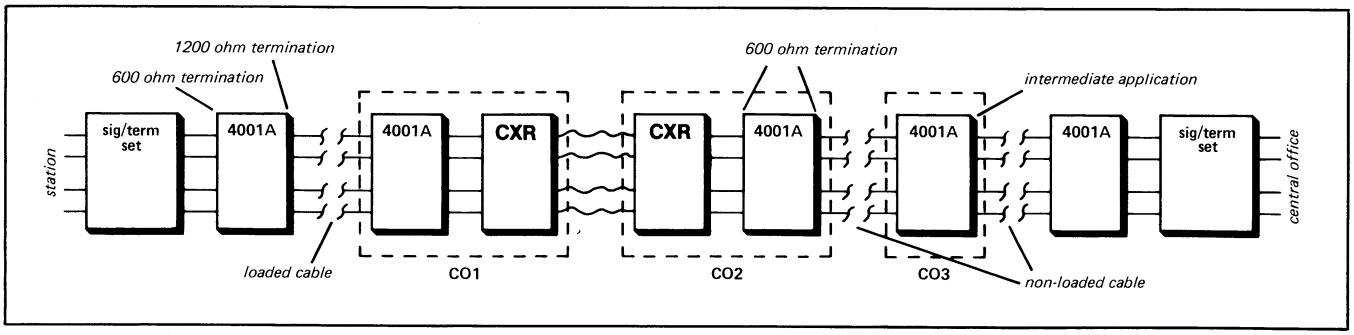


figure 3. Hypothetical circuit using 4001A Line Amplifier, showing terminal and intermediate applications and interfaces

eql (high frequency). With the *LF eql* and *HF eql* controls adjusted to minimum settings, low-end roll-off begins at approximately 600 Hz and high-end response is depressed about 1dB at 3000 Hz, with 12dB per-octave roll-off above that frequency. At moderate settings of the *LF eql* and *HF eql* controls, bumps begin to occur at approximately 300 and 3200 Hz. High-frequency and low-frequency adjustments generally do not interact. Figures 4, 5, and 6 show typical response curves for low-frequency, high-frequency, and combined high and low-frequency equalizer settings in the *EQL* mode.

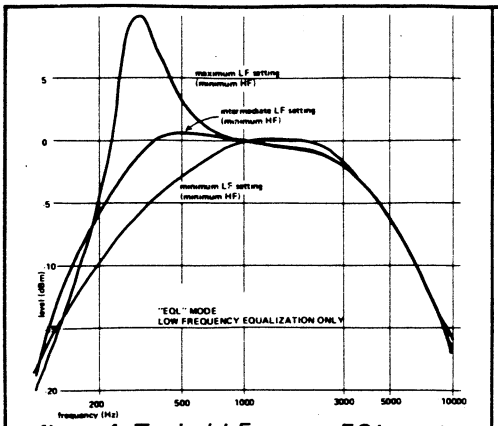


figure 4. Typical LF curves, EQL mode

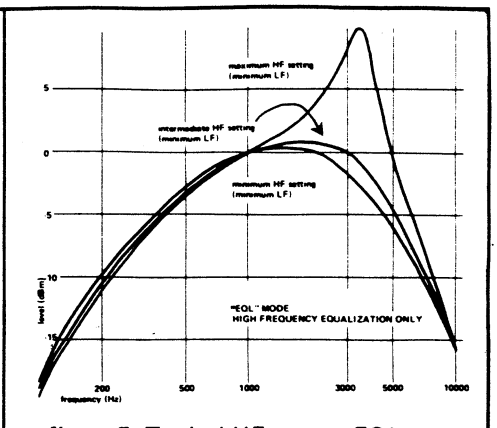


figure 5. Typical HF curves, EQL mode

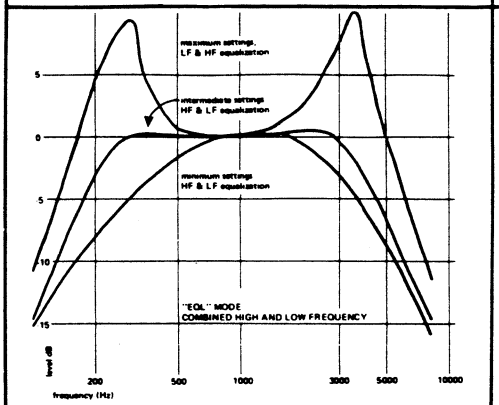


fig 6. Typical combined curves, EQL mode

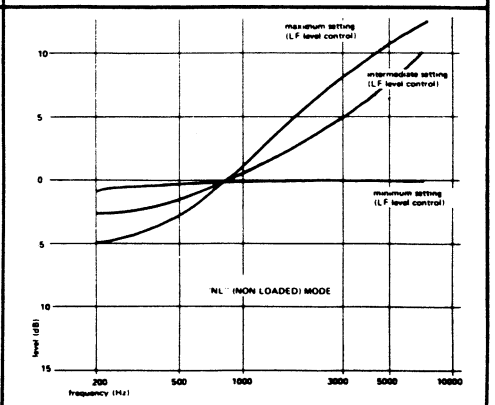


figure 7. Typical curves, NL mode

2.10 The *NL* (nonloaded cable) equalization mode provides slope equalization for adjusting the module's frequency response to complement that of various lengths and gauges of nonloaded cable. Equalization in the *NL* mode can be adjusted from flat to a nominal 4dB-per-octave slope via the module's front-panel *LF eql* control. Figure 7 shows typical response curves for the *NL* equalization mode.

3. installation

inspection

3.01 The 4001A Line Amplifier module should be visually inspected upon arrival to find possible damage incurred during shipment. If damage is noted, a claim should immediately be filed with the carrier. If stored, the module should be visually inspected again prior to installation.

mounting

3.02 The 4001A Line Amplifier 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 shelf.

installer connections

3.03 Before making any connections to the mounting shelf, ensure that power is **off** and modules are **removed**. The 4001A module should be put into place only **after** it is properly optioned and **after** wiring is completed.

3.04 Table 1 lists external connections to the 4001A module. All connections are made via wire wrapping 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.

options

3.05 Four switch options, two of which are five-position DIP switches, must be set before the 4001A can be placed into service. Locations of these switches on the module's printed circuit board are shown in figure 8.

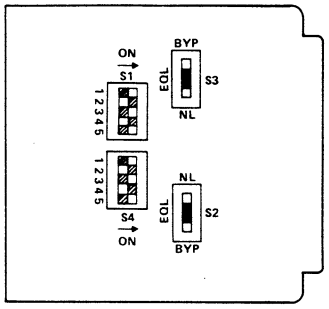


figure 8. 4001A option locations

3.06 The five positions of DIP switch *S1* are used to select the input and output port impedances and the gain range for the amp 1 circuit. The

connect:	to pin:
AMP 1 IN TIP	55
AMP 1 IN RING	49
AMP 1 IN SIMPLEX	53 and 51
AMP 1 OUT TIP	41
AMP 1 OUT RING	47
AMP 1 OUT SIMPLEX	43 and 45
AMP 2 IN TIP	7
AMP 2 IN RING	13
AMP 2 IN SIMPLEX	9 and 11
AMP 2 OUT TIP	5
AMP 2 OUT RING	15
AMP 2 OUT SIMPLEX	1 and 3
−BATT (−22 to −56Vdc filtered input)	35
GND (ground)	17

table 1. External connections to 4001A

impedance	amp 1 in		amp 1 out		amp 2 in		amp 2 out	
	S1-2	S1-3	S1-4	S1-5	S4-3	S4-4	S4-1	S4-2
150 ohms	ON	ON	ON	ON	ON	ON	ON	ON
600 ohms	OFF	ON	OFF	ON	ON	OFF	ON	OFF
1200 ohms	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF

table 2. Impedance optioning

gain range	amp 1	amp 2
	S1-1	S4-5
high (−2 to +35dB)	OFF	OFF
low (−15 to +6dB)	ON	ON

table 3. Gain range optioning

five positions of DIP switch *S4* are used to select these same options for the amp 2 circuit. Set these switches for the desired port impedances as directed in table 2 and for the desired gain ranges as directed in table 3.

3.07 Switches *S2* and *S3* are used to select the equalization mode for the amp 2 and amp 1 circuits, respectively. Set each switch to the *BYP* position if no equalization is desired for the corresponding circuit, to the *EQL* position to provide high-low equalization for loaded cable or carrier, or to the *NL* position to provide slope equalization for nonloaded cable.

alignment

3.08 The two circuits (amp 1 and amp 2) of the 4001A are identical. Thus, in applications where the module serves as two unidirectional amplifiers, alignment of the two circuits is identical. However, in applications where the 4001A serves as a bidirectional amplifier in a 4wire path, one circuit must be aligned as a receive channel and the other as a transmit channel. Thus, as an arbitrary choice, it is assumed in the following procedures that the application is bidirectional and that amp 1 is the receive channel and amp 2 is the transmit channel. In unidirectional applications, either the receive or the transmit alignment procedure can be used for both amp 1 and amp 2, depending upon whether the module is being used for post-amplification and post-equalization at the receive end of a circuit or for pre-amplification and pre-equalization at the transmit end of a circuit. (The latter application is less common.)

3.09 **Prealignment.** Before beginning alignment of the 4001A, proceed as follows:

A. Ensure that all front-panel level and equalization controls are adjusted fully counterclockwise (CCW).

B. For each of the module's two circuits, ensure that input and output impedance optioning is correct, that the **lower** gain range is selected, and that the equalization option switch is set to *BYP* for no equalization.

C. Insert the module into its mounting position and apply power.

3.10 **Receive-Channel Level Adjustment.** To adjust the 4001A's receive-channel level, proceed as directed below. Please remember that, as mentioned above, amp 1 of the 4001A is designated the receive channel in the procedures in this Practice, but this is an arbitrary choice. Also, please note that in the procedures that follow, end-to-end measurements must be made.

A. Insert an opening plug into the *amp 1 in* jack.

B. Arrange the receive portion of a transmission measuring set (TMS) for terminated measurement at the receive (amp 1) input impedance selected on the module and connect it to the *amp 1 in mon* jack.

C. Request personnel at the distant end of the circuit to send 1000Hz tone at the output level specified in the circuit layout record (CLR).

D. Verify the received level against the local receive input level specified in the CLR.

E. Remove the opening plug. Arrange the receive portion of the TMS for terminated measurement at the receive (amp 1) output impedance selected on the module and connect it to the *amp 1 out* jack.

F. Request that personnel at the distant end of the circuit again send 1000Hz tone at the specified level. Adjust the 4001A's *amp 1 level* control clockwise (CW) until the TMS indicates the desired receive output level. If the desired level cannot be achieved with the lower gain range, adjust the *amp 1 level* control fully CCW, reoption amp 1 for the higher gain range (see table 3), and again adjust the *amp 1 level* control CW until the TMS indicates the desired level.

3.11 **Receive-Channel Equalization.** To determine whether or not receive-channel equalization is required, and to adjust the module's receive (amp 1) equalizer controls if it is, proceed as follows:

A. Ensure that option switch *S3* is set to the *BYP* position and that the *amp 1 LF eql* and *HF eql* controls are adjusted fully CCW. (Although these operations are not mandatory for completing the frequency run in steps B and C, they are a convenient starting point for the overall receive equalization procedure.)

B. Insert an opening plug into the module's *amp 1 in* jack. Arrange the receive portion of the TMS for terminated measurement at the receive (amp 1) input impedance selected on the module. Connect the receive portion of the TMS to the *amp 1 in mon* jack. Have the distant end send 1000Hz tone at the level specified on the CLR. Verify that the TMS reading equals the CLR-specified receive input level.

C. Have the distant end send tone at various frequencies across the voice band (300 to 3400Hz), and measure and record the level for each frequency. If the measured frequency response is acceptably flat, no receive-channel equalization is required. Therefore, leave *S3* in the *BYP* position and the *amp 1 HF eql* and *LF eql* controls fully CCW to exclude the amp 1 equalizer. If the measured frequency response is not acceptably flat, set *S3* to the *NL* position if the facility is nonloaded cable or to the *EQL* position if the facility is loaded cable or carrier. Remove the opening plug.

D. The remainder of this procedure contains instructions for receive-channel equalization adjustment. Unless flat response with high-end and low-end roll-off is desired (in which case a local tone source may be used), again arrange for the distant end to send tone at various frequencies. Proceed to step E for loaded-cable equalization instructions, to step F for nonloaded-cable equalization instructions, or to step G for instructions on providing flat response with high-end and low-end roll-off for carrier.

E. For **loaded cable** equalization, arrange the receive portion of the TMS for terminated measurement at the receive (amp 1) output impedance selected on the module. Connect the receive portion of the TMS to the module's *amp 1 out* jack. Also ensure that switch *S3* is set to the *EQL* (high-low equalization mode) position and that the transmit portion of the TMS is still disconnected from the circuit. Request the distant end to send 1000 and 300Hz tones at the CLR-specified level. Measure and record the levels at which these tones are received (the 300Hz level will be lower). Adjust the *amp 1 LF eql* control CW until the 300Hz level equals the 1000Hz level. This adjustment will change the 1000Hz level because as the *amp 1 LF eql* control is adjusted CW, levels are boosted across much of the voice band, with low frequencies boosted more than midband frequencies. Therefore, have 1000Hz and 300Hz tone sent again, and readjust the 300Hz level (via the *amp 1 LF eql* control) to match the 1000Hz level. Proper low-frequency equalization is achieved when no further adjustment of the 300Hz level is required to match (within acceptable tolerances) the 1000Hz level. Several rounds of measurement and adjustment may be required for low-frequency equalization. Now have the distant end send 1000 and 3000Hz tone at the CLR-specified level. Measure and record the levels at which these tones are received (the 3000Hz level will be lower). Adjust the *amp 1 HF eql* control CW until the 3000Hz level equals the 1000Hz level. This adjustment will change the 1000Hz level because, as the *amp 1 HF eql* control is adjusted clockwise, levels are boosted across much of the voice band, with high frequencies boosted more than midband frequencies. Therefore, have 1000Hz and 3000Hz tone sent again, and readjust the 3000Hz level (via the *amp 1 HF eql* control) to match the 1000Hz level. This single repetition is usually sufficient for high-frequency equalization. Proceed to steps H and I.

F. For **nonloaded cable** equalization, ensure that switch *S3* is set to the *NL* (nonloaded-cable slope equalization) position and that the TMS is connected as described in step E. *The* amp 1 HF eql *control is not used in this mode and should therefore be adjusted fully CCW before adjusting the* amp 1 LF eql *control.* Have the distant end send 3000 and 300Hz tones at the CLR-specified level. Measure and record the levels at which these tones are received (the 3000Hz level will be lower). Adjust the *amp 1 LF eql* control CW until the level at 300Hz equals that recorded for 3000Hz. This adjustment will change the 3000Hz level because, as the *amp 1 LF eql* control is adjusted CW, levels are attenuated across the entire voice band, with low frequencies attenuated more than high frequencies. Therefore, have 3000Hz and 300Hz tone sent again, and readjust the 300Hz level (via the *amp 1 LF eql* control) to match the 3000Hz level. Proper equalization is achieved when no further adjustment of the 300Hz level is required to match (within acceptable tolerances) the 3000Hz level. Several rounds of measurement and adjustment may be required in this procedure. Proceed to step I.

G. For **carrier** interface, flat response with high-end and low-end roll-off is typically required. To achieve this, ensure that switch *S3* is set to the *EQL* position and that the receive portion of the TMS (properly terminated) is connected to the *amp 1 out* jack. For this adjustment, a local tone source can be used; therefore, connect the transmit portion of the TMS to the *amp 1 in* jack and arrange it for 300Hz and 1000Hz tone output at the CLR-specified input level and at the receive (amp 1) input impedance selected on the module. Adjust the *amp 1 LF eql* control CW until the 300Hz level equals the 1000Hz level. This adjustment will change the 1000Hz level (see step E), so have 1000Hz and 300Hz tone sent again and readjust the 300Hz level (via the *amp 1 LF eql* control) to match the 1000Hz level. Proper low-frequency equalization is achieved when no further adjustment of the 300Hz level is required to match (within acceptable tolerances) the 1000Hz level. Several rounds of measurement and adjustment may be required for low-frequency equalization. Now arrange the TMS for 3400Hz and 1000Hz tone output at the CLR-specified input level. Adjust the *amp 1 HF eql* control CW until the 3400Hz level equals the 1000Hz level. This adjustment will change the 1000Hz level (see step E), so have 1000Hz and 3400Hz tone sent again and readjust the 3400Hz level (via the *amp 1 HF eql*

control) to match the 1000Hz level. This single repetition is usually sufficient for high-frequency equalization. When the *amp 1 LF eql* and *amp 1 HF eql* controls are adjusted in this manner, roll-off is automatically provided below 300Hz and above 3400Hz. Proceed to steps H and I.

H. After step E or G is completed, both equalizer controls should be trimmed to compensate for any interaction between the low-frequency and high-frequency sections. (Normally, this is necessary only when the two sections are adjusted for nearly maximum correction, but it is always a good idea to verify equalization across the full bandwidth.) Because the *amp 1 HF eql* control was the last to be adjusted, the *amp 1 LF eql* control must be trimmed first. For loaded cable, have 1000Hz and 300Hz tone sent again as described in step E. For carrier, arrange the TMS for 1000Hz and 300Hz tone output as described in step G. Trim the *amp 1 LF eql* control until the 300Hz level matches the 1000Hz level. Next, for loaded cable, have 1000Hz and 3000Hz tone sent again as described in step E. For carrier, arrange the TMS for 1000Hz and 3400Hz tone output as described in step G. Trim the *amp 1 HF eql* control until the 3000 or 3400Hz level matches the 1000Hz level. Now go back and retrim in exactly the same manner, trimming the *amp 1 LF eql* control first, then the *amp 1 HF eql* control. Repeat until no further trimming is necessary to match levels at both the high and low ends.

I. After proper equalization has been achieved, readjust the front-panel *amp 1 level* control to provide the desired 1000Hz gain. (Gain adjustment will not affect equalizer response.)

3.12 **Transmit-Channel Level Adjustment.** To adjust the 4001A's transmit-channel level, proceed as directed below. Please remember that, as mentioned above, amp 2 of the 4001A is designated the transmit channel in the procedures in this Practice, but this is an arbitrary choice. Also, please note that in the procedures that follow, end-to-end measurements must be made.

A. Arrange the transmit portion of a transmission measuring set (TMS) for 1000Hz tone output at the transmit input level specified on the circuit layout record (CLR) and at the transmit (amp 2) input impedance selected on the module. Connect this signal to the *amp 2 in* jack.

B. Arrange the receive portion of the TMS for terminated measurement at the facility-side transmit (amp 2) output impedance selected on the module. Connect the receive portion of the TMS to the *amp 2 out* jack.

C. Adjust the *amp 2 level* control clockwise (CW) until the TMS indicates the desired transmit output level. If the desired level cannot be achieved with the lower gain range, adjust the *amp 2 level* control fully CCW, reoption amp 2 for the higher gain range (see table 3), and again adjust the *amp 2 level* control CW until the TMS indicates the desired level.

3.13 **Transmit-Channel Equalization.** Transmit-channel (amp 2) equalization is normally left flat (switch *S2* set to *BYP*) in favor of receive-channel post-equalization at the distant end of the facility. Whether or not transmit (i.e., pre-) equalization must be used can be determined by sending test tone at frequencies between 300 and 3400Hz (inclusive) and at the CLR-specified transmit output level from the local end to the distant end, where level measurements are made. If frequency response at the distant end is unacceptable and if equalization at that end is either inadequate or unavailable, the module's transmit equalizer can be used. To send tone to the distant end and, if necessary, to adjust the transmit (amp 2) equalizer, proceed as follows:

A. Ensure that switch *S2* is set to *BYP* and that the *amp 2 HF eql* and *LF eql* controls are adjusted fully CCW for no equalization. (Although this is not mandatory for completing the frequency run in steps B and C, it is a convenient starting point for the overall transmit equalization procedure.)

B. Insert an opening plug into the module's *amp 2 out* jack. Connect the transmit portion of a TMS, arranged for the transmit (amp 2) output impedance selected on the module, to the module's *amp 2 out mon* jack.

C. Send test tone at frequencies between 300 and 3400Hz (inclusive) and at the CLR-specified transmit output level toward the distant end. Have personnel at that end measure the received levels and determine whether transmit-channel pre-equalization via the 4001A is required. If transmit equalization **is not required**, no further adjustments need be made. If transmit equalization **is required**, proceed to step D for loaded-cable equalization instructions, to step E for non-loaded-cable equalization instructions, or to step F for instructions on providing flat response with high-end and low-end roll-off for carrier.

D. For **loaded cable** equalization, set *S2* to the *EQL* position and send 1000 and 300Hz tones, both at the CLR-specified transmit output level, to the distant end. Have distant-end personnel measure and report the received levels (the 300Hz level will be lower). Adjust the *amp 2 LF eql* control CW until the distant end reports that the 300Hz level equals the 1000Hz level. This adjustment will change the 1000Hz level because, as the *amp 2 LF eql* control is adjusted CW, levels are boosted across much of the voice band, with low frequencies boosted more than midband frequencies. Therefore, send 1000Hz and 300Hz tones again, and readjust the 300Hz level (via the *amp 2 LF eql* control) to match the 1000Hz level. Proper low-frequency equalization is achieved when no further adjustment

of the 300Hz level is required to match (within acceptable tolerances) the 1000Hz level. Several rounds of measurement and adjustment may be required for low-frequency equalization. Now send 1000 and 3000Hz tone at the CLR-specified transmit output level. Have distant-end personnel measure and report the received levels (the 3000Hz level will be lower). Adjust the *amp 2 HF eql* control CW until the distant end reports that the 3000Hz level equals the 1000Hz level. This adjustment will change the 1000Hz level because, as the *amp 2 HF eql* control is adjusted CW, levels are boosted across much of the voice band, with high frequencies boosted more than midband frequencies. Therefore, send 1000Hz and 3000Hz tone again, and readjust the 3000Hz level (via the *amp 2 HF eql* control) to match the 1000Hz level. This single repetition is usually sufficient for high-frequency equalization. Proceed to steps G and H.

E. For **nonloaded cable** equalization, set *S2* to the *NL* position. *The* amp 2 HF eql *control is not used in this mode and should therefore be adjusted fully CCW before adjusting the* amp 2 LF eql *control.* Send 3000 and 300Hz tones, both at the CLR-specified transmit output level, to the distant end. Have distant-end personnel measure and report the received levels (the 3000Hz level will be lower). Adjust the *amp 2 LF eql* control CW until the distant end reports that the 300Hz level equals the 3000Hz level. This adjustment will change the 3000Hz level because, as the *amp 2 LF eql* control is adjusted CW, levels are attenuated across the entire voice band, with low frequencies attenuated more than high frequencies. Therefore, send 3000Hz tone again, and readjust the 300Hz level (via the *amp 2 LF eql* control) for a match at the distant end. Proper equalization is achieved when no further adjustment of the 300Hz level is required to match (within acceptable tolerances) the 3000Hz level. Several rounds of measurement and adjustment may be required in this procedure. Proceed to step H.

F. For **carrier** interface, flat response with high-end and low-end roll-off is typically required. To achieve this, set switch *S2* to the *EQL* position and send 1000 and 300Hz tones, both at the CLR-specified transmit output level, to the distant end. Have distant-end personnel measure and report the received levels (the 300Hz level will be lower). Adjust the *amp 2 LF eql* control CW until the distant end reports that the 300Hz level equals the 1000Hz level. This adjustment will change the 1000Hz level (see step D), so send 1000Hz and 300Hz tones again, and readjust the 300Hz level (via the *amp 2 LF eql* control) to match the 1000Hz level. Proper low-frequency equalization is achieved when no further adjustment of the 300Hz level is required to match (within acceptable tolerances) the 1000Hz level. Several rounds of measurement and adjustment may be required for low-frequency equalization. Now send 3400Hz and 1000Hz tones at the CLR-specified transmit output level. Have distant-end personnel measure and report the received levels (the 3400Hz level will be lower). Adjust the *amp 2 HF eql* control CW until the distant end reports that the 3400Hz level equals the 1000Hz level. This adjustment will change the 1000Hz level (see step D), so have 1000Hz and 3400Hz tone sent again and readjust the 3400Hz level (via the *amp 2 HF eql* control) to match the 1000Hz level. This single repetition is usually sufficient for high-frequency equalization. When the *amp 2 LF eql* and *amp 2 HF eql* controls are adjusted in this manner, roll-off is automatically provided below 300Hz and above 3400Hz. Proceed to steps G and H.

G. After step D or F is completed, both equalizer controls should be trimmed to compensate for any interaction between the low-frequency and high-frequency sections. (Normally, this is necessary only when the two sections are adjusted for nearly maximum correction, but it is always a good idea to verify equalization across the full bandwidth.) Because the *amp 2 HF eql* control was the last to be adjusted, the *amp 2 LF eql* control must be trimmed first. For loaded cable or carrier, send 1000Hz and 300Hz tones again as described in step D or F. Trim the *amp 2 LF eql* control until the 300Hz level matches the 1000Hz level. Next, for loaded cable, send 1000Hz and 3000Hz tones again as described in step D. For carrier, send 1000Hz and 3400Hz tones as described in step F. Trim the *amp 2 HF eql* control until the 3000 or 3400Hz level matches the 1000Hz level. Now go back and retrim in exactly the same manner, trimming the *amp 2 LF eql* control first, then the *amp 2 HF eql* control. Repeat until no further trimming is necessary to match levels at both the high and low ends.

H. After proper equalization has been achieved, readjust the front-panel *amp 2 level* control to provide the desired 1000Hz gain. (Gain adjustment will not affect equalizer response.)

4. circuit description

4.01 This circuit description is designed to familiarize you with the 4001A Line Amplifier module for engineering and application purposes only. Attempts to troubleshoot the 4001A internally are not recommended. Troubleshooting procedures should be limited to those prescribed in section 7 of this Practice. Please refer to the block diagram, section 5 of this Practice, as an aid in following the circuit description.

power supply

4.02 The 4001A's *power supply* is a series-pass 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.

amp 1 and amp 2 circuits

4.03 Each identical circuit (amp 1 and amp 2) of the 4001A uses input and output transformers to interface external facilities and to derive simplex leads at both ports. Lightning protection is provided on the secondaries of both transformers through use of a multi-junction varistor on the input transformer and an avalanche diode on the output transformer. Precision resistors are used to establish the switch-selectable input and output impedances.

4.04 In each channel, a quad operational amplifier integrated circuit is used to provide gain for the active filters, isolation between the equalizer and amplifier sections, and channel voltage gain. The *voltage amplifier* stage uses both negative and positive feedback, with gain controlled by varying the negative feedback. This approach to gain control provides, in addition to optimum gain stability and setability, optimum output signal-to-noise performance.

4.05 Low-frequency equalization in each channel is provided by an active two-pole *high-pass filter*. The natural frequency of the filter is set at 260Hz, and the damping factor of the filter is varied to derive low-frequency equalization. With the *LF eql* potentiometer fully counterclockwise, filter loop gain is unity and the filter shape is overdamped. As the *LF eql* potentiometer is adjusted approximately ¼ turn clockwise, the response becomes critically damped (damping factor of 0.707). Full clockwise rotation produces a damping factor of about 0.2, which yields an underdamped response with a gain peak of approximately 12dB at 300Hz.

4.06 With switches *S3* (amp 1 circuit) and *S2* (amp 2 circuit) in the *NL* position, the loop gain of each channel's active *high-pass filter* is fixed at unity, producing the overdamped response, and an additional RC high-pass section is introduced, producing a monotonically increasing output frequency characteristic complementary to that of nonloaded telephone cable.

4.07 High-frequency equalization in each channel is provided by an active two-pole *low-pass filter* whose natural frequency is 3500Hz. Amplitude equalization is again provided by varying the damping factor of the filter. The damping factor, and thus high-frequency equalization is controlled by the *HF eql* potentiometer. With the *HF eql* potentiometer fully counterclockwise, the damping factor of the *low-pass filter* is about 1.5, which is near critical damping and maximum flat response. As the *HF eql* potentiometer is adjusted clockwise, high-frequency gain is enhanced relative to that at 1000Hz, and at full clockwise rotation, gain at 3500Hz is approximately 12dB greater than gain at 1000Hz. The filter provides 12dB-per-octave roll-off above the natural frequency.

4.08 Following each channel's high-frequency equalizer is a unity-gain *buffer amplifier* that isolates the impedance variations of the filters from the voltage *amplifier*. An emitter-coupled output *power amplifier* provides power gain and establishes the output impedance for each channel. In the bypass mde, the two equalizer stages are bypassed and the input to the *buffer amplifier* is provided directly from the input transformer.

6. specifications

amp 1 and amp 2 circuits

gain range
−2 to +35dB or −15 to +6dB, switch selectable

distortion
less than 1% at +10dBm output level

maximum output level
no visible clipping at output level of +17dBm

frequency response, BYP (no equalization) mode
±1dB reference 1000Hz level, 200 to 4000Hz

slope equalization, NL (nonloaded) mode
nominal 4dB-per-octave slope (see figure 7 for typical curves)

high-low equalization, EQL (loaded cable or carrier) mode
- **maximum HF equalization provides a minimum of 10dB at 3500Hz ±100Hz, reference 1000Hz level**
- **minimum HF equalization provides −1dB at 3500Hz ±100Hz, reference 1000Hz level**
- **maximum LF equalization provides a minimum of 10dB at 280Hz ±40Hz, reference 1000Hz level**
- **minimum LF equalization provides −6dB at 280Hz ±40Hz, reference 1000Hz level**

(see figures 4, 5, and 6 for typical curves)

noise
20dBrnC maximum at 35dB gain

longitudinal balance
60dB minimum

delay distortion
less than 100μs from 400 to 4000Hz; less than 50μs from 600 to 4000Hz

input impedance
600 or 1200 ohms ±5%
or 150 ohms ±15%, balanced, switch selectable

output impedance
600 or 1200 ohms ±5%
or 150 ohms ±15%, balanced, switch selectable

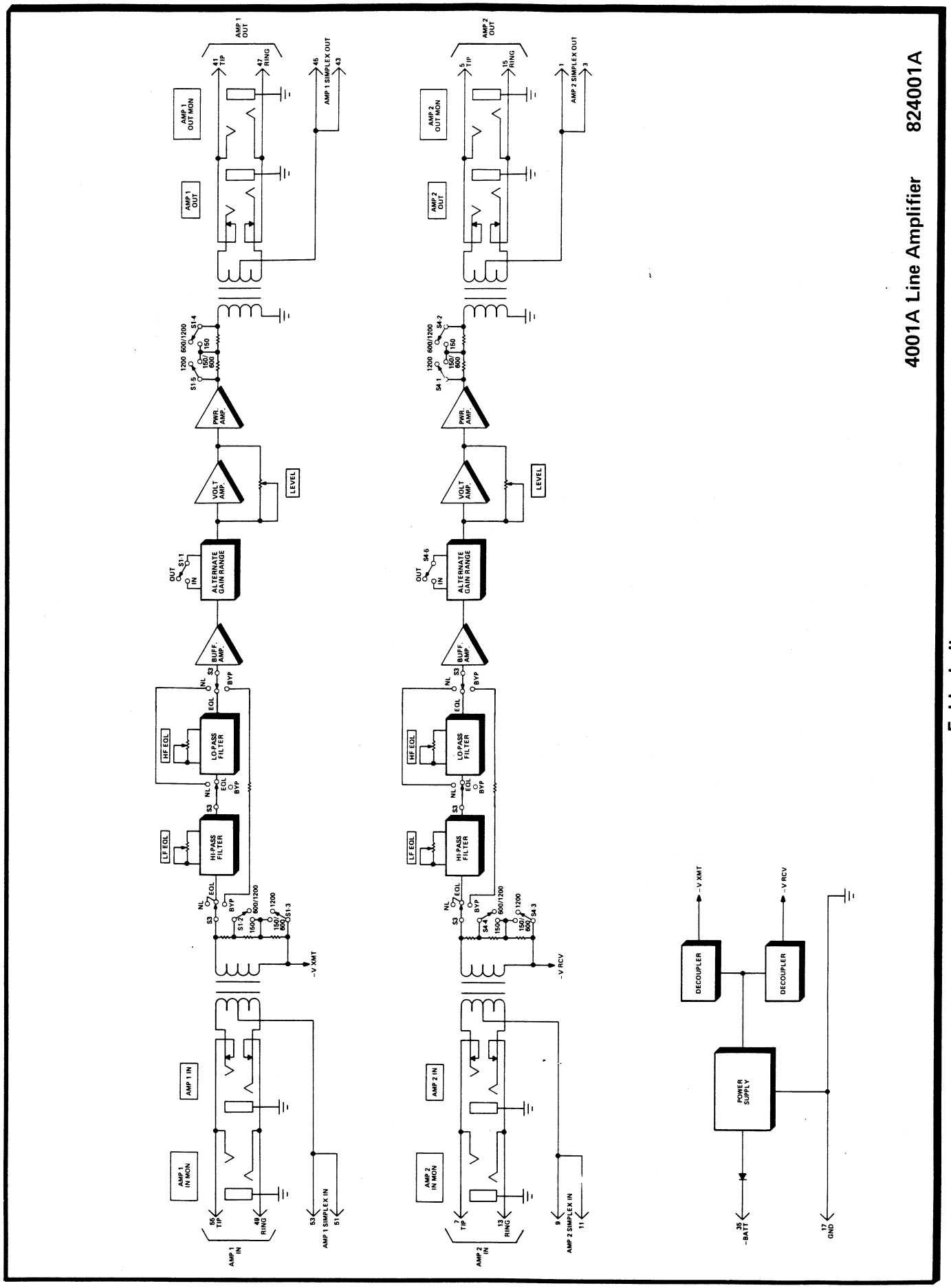
simplex current
120mA maximum, with 5mA maximum unbalance

general specifications

crosstalk coupling
greater than 85dB equal-level coupling loss, either amplifier, 300 to 4000Hz

input power requirements
voltage: −22 to −56Vdc, filtered, ground referenced
current: 20mA at idle, 60mA maximum with both amp 1 and amp 2 at maximum (+17dBm) output level

specifications continued on page 10



5. block diagram

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

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

weight
15 ounces (425 grams)

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

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 4001A Line Amplifier module. The Checklist is intended as an aid in the localization of trouble to a specific module. If a module is suspected of being defective, a new one should be substituted and the test conducted again. If the substitute module operates correctly, the original module should be considered defective and returned to Tellabs for repair or replacement. We strongly recommend that no internal (component-level) testing or repairs be attempted on the 4001A module. Unauthorized testing or repairs may void the module's warranty.

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

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

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

7.03 If a 4001A is diagnosed as defective, the situation may be remedied by either *replacement* or *repair and return*. Because it is more expedient, the *replacement* procedure should be followed whenever time is a critical factor (e.g., service outages, etc.).

replacement

7.04 To obtain a replacement 4001A module, notify Tellabs via letter (see addresses below), telephone (see numbers above), or twx (910-695-3530 in the USA, 610-492-4387 in Canada). Be sure to provide all relevant information, including the 8X4001A part number that indicates the issue of the module in question. Upon notification, we shall ship a replacement module to you. If the module in question is in warranty, the replacement will be shipped at no charge. Pack the defective module in the replacement module's carton, sign the packing slip included with the replacement, and enclose it with the defective module (this is your return authorization). Affix the preaddressed label provided with the replacement module to the carton being returned, and ship the module prepaid to Tellabs.

repair and return

7.05 Return the defective 4001A module, shipment prepaid, to Tellabs (attn: repair and return).

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

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

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

testing guide checklist

Note: *Because the two circuits (amp 1 and amp 2) of the 4001A are identical, this checklist applies to each circuit.*

test	test procedure	normal result	if normal conditions are not met, verify:
higher gain range	Ensure that circuit being tested (amp 1 or amp 2) is optioned for higher gain range (see table 3) and *BYP* (no equalization) mode. Arrange xmt portion of transmission measuring set (TMS) for 1000Hz tone output at −20dBm and at input impedance selected on module. Connect this signal to *amp X in* jack. Arrange rcv portion of TMS for terminated measurement at output impedance selected on module, and connect it to *amp X out* jack. Adjust *amp X level* control over its entire range.	With *amp X level* control fully counterclockwise (CCW), output level approx. 2dB lower than input level ☐. With *amp X level* control fully clockwise (CW), output level approx. 35dB higher than input level ☐.	Power ☐. Wiring ☐. Proper impedance terminations (check for double terminations) ☐. Impedance option switches properly set ☐. Equalizer option switch set to *BYP* ☐. Gain range option switch properly set ☐. Output level not exceeding +17dBm overload point ☐. Replace module and retest ☐.
lower gain range	Ensure that circuit being tested (amp 1 or amp 2) is optioned for lower gain range (see table 3) and *BYP* (no equalization) mode. Maintain TMS connections as described above, but change TMS output level to −10dBm. Adjust *amp X level* control over its entire range.	With *amp X level* control fully CCW, output level approx. 15dB lower than input level ☐. With *amp X level* fully CW, output level approx. 6dB higher than input level ☐.	Same as above ☐.
equalization, *EQL* (high-low) mode	Set equalizer switch of circuit being tested (*S3* for amp 1, *S2* for amp 2) to *EQL* position. Reoption circuit being tested for higher gain range (see table 3). Maintain TMS connections as described above, but change TMS tone level to −20dBm. Adjust *amp X level* control for a convenient test level, e.g., 0dBm. Adjust *amp X LF eql* and *HF eql* controls over their entire ranges as you vary input frequency from 200 to 4000Hz.	With *amp X LF eql* and *HF eql* controls fully CCW, 1000Hz level approx. 3dB lower in *EQL* mode than in *BYP* mode ☐. As *LF eql* and *HF eql* controls are adjusted CW, 1000Hz level increases a few dB and, with controls fully CW, gain peaks of at least 10dB (re 1000Hz level) occur at approx. 300 and 3600Hz ☐.	Power ☐. Wiring ☐. Proper impedance terminations (check for double terminations) ☐. Slide *S3* or *S2* to alternate position and back to clean contacts ☐. Impedance option switches properly set ☐. Input tone level approx. constant over test frequency range ☐. Levels not exceeding +17dBm overload point ☐. Replace module and retest ☐.
equalization, *NL* (slope) mode	Set equalizer switch of circuit being tested (*S3* for amp 1, *S2* for amp 2) to *NL* position. Maintain TMS connections as described above. Arrange TMS for 1000Hz tone output at −20dBm. Adjust *amp X level* control for a convenient test level, e.g., 0dBm. Adjust *amp X LF eql* control (but **not** *HF eql* control) over its entire range as you vary input frequency from 300 to 4000Hz.	With *amp X LF eql* control fully CCW, 1000Hz level approx. 2dB lower in *NL* mode than in *BYP* mode ☐. As *LF eql* control is adjusted CW, 1000Hz level decreases ☐. With *LF eql* control fully CW, levels compared to those at full CCW rotation are as follows: 400Hz down approx. 23dB ☐; 1000Hz down approx. 14dB ☐; 4000Hz down approx. 3.5dB ☐.	Same as above ☐.
noise	Insert shorting plug into *amp X in* jack. Using noise test set, measure noise at *amp X out* jack (terminated measurement) or between amp X output tip and ring connector pins (monitor measurement; see table 1 for pin numbers).	Measured noise less than 20dBrnC for all level settings and all three equalizer switch positions ☐. Noise level follows level settings ☐.	Input to amp X shorted ☐. Noise test set at proper terminating impedance ☐. High RF environment affecting test set ☐. Replace module and retest ☐.

Tellabs Incorporated
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telephone (312) 969-8800 twx 910-695-3530