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Practice Section 104003C Rev A

LINE AMPLIFIER with LOOPBACK MODULE
MODEL 104003C

Contents:

1. GENERAL

1.01 The Accurate 104003C Line Amplifier with Loopback module 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 104003C provides tone-activated or dc-activated equal-level loopback of the facility.

1.02 The 104003C's transmit and receive amplifiers in the 104003C 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 +7dBm, with less than 1% distortion.

1.03 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 $\pm$ 1dB over the 300 to 3000Hz range when used on nonloaded cable facilities.

1.04 The 104003C may be switched-optioned to match 1200, 600, or 150-ohm impedances at both the facility and terminal ports. Transformers associated with each of the ports are center-tapped to derive balanced simplex leads that provide for DX, loopback, and other signaling schemes that require a dc path.

1.05 The 104003C 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 104003C activates loopback for the duration of a locally applied ground signal.

1.06 Auxiliary loopback relay contacts are available at 104003C's 56-pin connector to light an external loopback lamp or disable an associated data set in data applications.

1.07 The front panel of the 104003C is designed so that level adjustments can be made while the module is mounted in place. The 104003C 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 104003C is in the loopback mode.

1.08 The 104003C incorporates an internally regulated power supply that permits operation on –22 to –56Vdc filtered input. Current requirements range from 30mA in the quiescent state to 65mA with both the transmit and receive channels at maximum output. A green LED on the front panel lights when power is applied to the module.

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

1.10 As a Type-10 module, the 104003C mounts in one position of a Type-10 Mounting 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 104003C Line Amplifier with Loopback is designed for use on 4wire voice-frequency transmission facilities, where it provides bi-directional level control, amplitude equalization, and impedance matching. In addition, the module's tone or dc-activated loopback circuitry allows remote testing of the facility. Thus, the 104003C is equivalent to a 4wire-to-4wire voice-frequency repeater with loopback. The 104003C may be used as either a terminal or an intermediate repeater. Figure 3 shows a hypothetical

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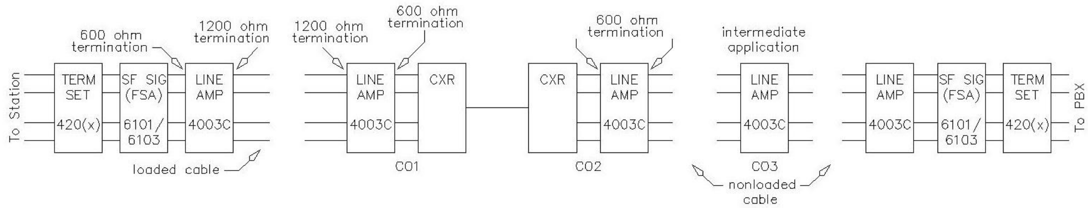
FIGURE 3. Hypothetical Circuit Employing 104003C Line Amplifiers



off-premise-extension (OPX) circuit in which 104003C 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. Front panel switches allow either gain or loss to be introduced into either channel independently. Maximum output of either channel is +7dBm, with less than 1% distortion.

EQUALIZATION

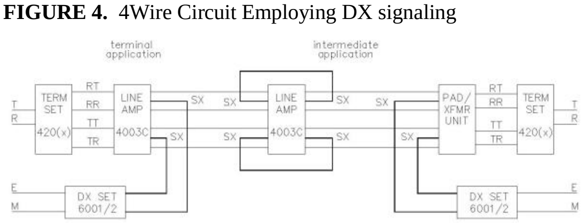
2.03 Active slope equalization is provided in both the transmit and the receive channel of the 104003C. Use of the module's equalizers in one or both channels is dependent upon the module's position in the circuit. Equalizing at the receive end of the circuit (post-equalization) is generally preferable 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 104003C as a bi-directional 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 front panel. 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 the facility and terminal ports may be independently switch-optioned for balanced 1200, 600, or 150-ohm terminating impedance. This allows the 104003C 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.

FIGURE 4. 4Wire Circuit Employing DX signaling



2.06 All four impedance-matching transformers on the 104003C are center-tapped to derive simplex leads, allowing this module to be applied to circuits employing DX, loopback, or other dc signaling schemes (Figure 4).

LOOPBACK

2.07 The loopback feature of the 104003C 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 1040003C 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 104003C modules (when connected in a bridging arrangement) to be individually tested from a central bridging location.

2.09 The module responds to minimum loop-back 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 prescription-set via two-position DIP switch *S4*. 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 104003C's 56-pin connector. The module remains in loopback until the ground potential is removed.

2.12 Common pin assignments allow the 104003C to be interchanged with other 10400X-series Line Amps or with 4412-series Data Station Termination modules. While a 4412-series module is normally used in data termination applications, a 104003C may, in rare cases, also be used. In data applications, auxiliary relay contacts on the 104003C may be used to disable an associated data set during loopback operation or to light an external loopback lamp.

3. INSTALLATION

3.01 The 104003C 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.

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MOUNTING

3.02 The 104003C module mounts in one position of a 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 104003C module. All connections are made via wire wrapping to the 56-pin connector at the rear of the module's mounting shelf position. Pin numbers are found on the body of the connector.

Table 1. Installer Connections to 104003C

CONNECT	TO PIN
XMT TIP OUT	41
XMT OUT RING	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 104003C in Figure 4), 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).*

OPTION SELECTION

3.05 Option switches must be set before the 104003C is placed into service. These switches and their functions are described in paragraphs 3.6 through 3.10. Locations of these switches on the module's front panel and printed circuit boards are shown in Figure 5.

CHANNEL OPTIONING

3.06 Levels. The front panel Gain/Loss slide switches for the transmit and receive channels conditions the corresponding channel amplifier to provide either gain or loss. If gain is required, set the switch to the *GAIN* position. If loss is required, set the switch to the *LOSS* position. The precise amount of gain or loss is selected via the front-panel transmit level and receive 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*.

EQUALIZATION

3.07 Two five-position DIP switches located on the front panel introduce from 0 to 7.75dB of slope equalization in 0.25dB increments in both transmit and receive channels. The various settings of both equalizers are shown in Table 2.

Table 2. Transmit and Receive channel equalized gain optioning.

Switch positions 0.25	0.5	1.0	2.0	4.0	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.					

IMPEDANCE MATCHING

3.08 Two slide switches located on the main pcb select the input/output impedances of the facility port (receive in/transmit out – S2) and the terminal port (transmit in/receive out – S4). Each port may be set to impedances of 150 ohms, 600 ohms or 1200 ohms. See Figure 5 for location of these switches.

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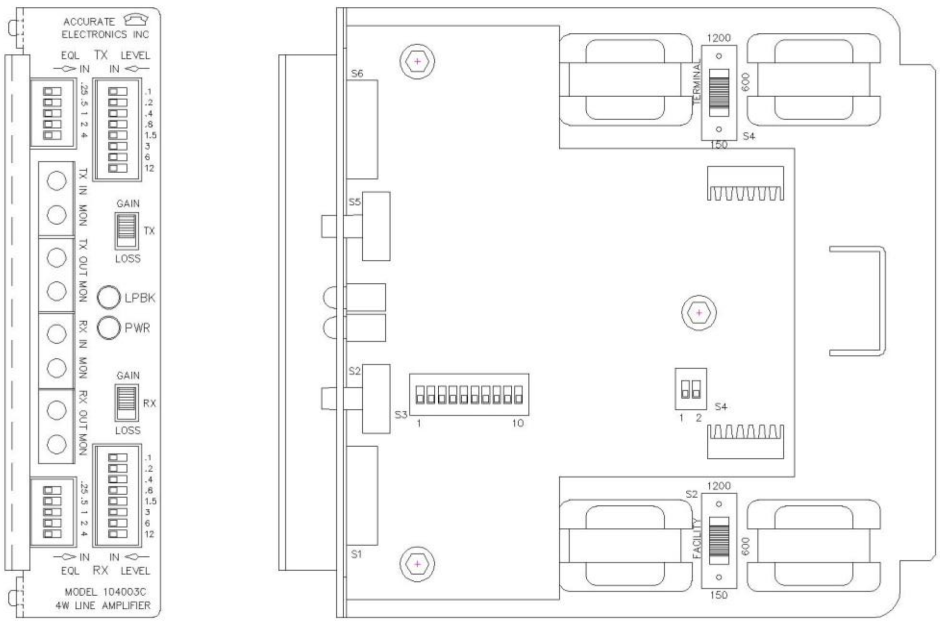
FIGURE 5. Module Switch Locations.



TONE-LOOPBACK FREQUENCY

3.09 Tone-loopback frequency is selected by means of 10-position DIP switch (S3) located on the 104003C's daughter pcb. Only 1 switch position is required to select any 1 of 11 available frequencies. The available loopback frequencies and settings of switch *S3* are summarized in Table 3.

Table 3. Loopback Frequency Selection.

FREQUENCY (Hz)	S3 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.	

LOOPBACK LEVELS

3.10 Loopback levels of +16, +9, -16, or –23dB are selected via DIP switch *S4*, located on the 104003C's daughter pcb. Loopback level options are described in paragraph 2.10; the various settings of switch *S4* are summarized in Table 4.

Table 4. Loopback Level Selection.

Loopback Levels	Switch Positions	
	S4-1	S4-2
+16dB	Off	Off
+9dB	Off	On
-16dB	On	Off
-23dB	On	On

ALIGNMENT

3.11 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 104003C 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 TX and RX 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 104003C module.*

PRELIMINARY ALIGNMENT

3.12 Refer to the CLR card for the required facility port and terminal port 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. Use S2 (Main Board) to set the facility port impedance and S4 (Main Board) to set the terminal port impedance.

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Note: *If the 3000Hz signal level is not specified on the CLR card, gain and equalization cannot be determined at this time. Omit paragraphs 3.13 through 3.18 and proceed to paragraph 3.19. Gain and equalization will be determined in the final alignment verification procedures, beginning with paragraph 3.20.*

RECEIVE-CHANNEL EQUALIZATION

3.13 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 (predominately 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 front panel RX EQL switch 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 3.14), 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 1.5dB from this difference and, referring to table 2, set front panel RX EQL switch 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 3.14), the amount of 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 front panel RX EQL switch 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 3.14), the amount of equalized gain selected above must be added to the specified receive input level to obtain and equalized receive input level.*

RECEIVE-CHANNEL LEVELS

3.14 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 3.13), 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.

3.15 Set front panel RX GAIN/LOSS switch to introduce either gain or loss into the receive channel, as required. Set to the IN position the proper combination of front-panel RX LEVEL switches that adds up to the required amount of gain or loss.

TRANSMIT-CHANNEL EQUALIZATION

3.16 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 (predominately 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 front panel TX EQL switch 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-channels levels (paragraph 3.17) 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 1.5dB from this difference and, referring to table 2, set front panel TX EQL switch 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 3.17), 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 (predominately 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 front panel TX EQL switch 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 3.17), 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

3.17 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 3.16), 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.

3.18 Set front panel TX GAIN/LOSS switch to introduce either gain or loss into the transmit channel, as required. Set to IN the proper combination of front panel TX LEVEL switches that add up to the required amount of gain or loss.

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FINAL ALIGNMENT VERIFICATION

3.19 In this final alignment verification procedure, the 104003C is placed into service, signal level measurements are taken, and the front-panel TX LEVEL and RX 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

3.20 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 RX IN MON jack and insert an opening plug into the RX IN jack. Request that the distant location send 1000Hz and 3000Hz tone at the level specified on the CLR card. Verify that the tone is present and record these levels.
- **B.** If receive-channel equalization and gain were determined in the preliminary alignment procedure (paragraphs 3.13 through 3.15), 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 3.13 through 3.15.
- **C.** Disconnect the TMS and remove the opening plug. Connect the TMS (receive) to the RX 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 exist, insert or remove gain via the front-panel RX 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 300to 3000Hz. If the measured levels meet the desired frequency response characteristic, the equalizer is properly set.

TRANSMIT CHANNEL

3.21 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* TX IN *jack at the specified level and omit steps B and C.*

- **A.** Connect a properly terminated TMS (transmit) to the TX 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 3.16 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.** 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 (or step A if equalization is not required). If any difference in levels exists, insert or remove gain via the front-panel TX 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.

4. CIRCUIT DESCRIPTION

4.01 This circuit description is designated to familiarize you with the 104003C Line Amplifier with Loopback module for engineering and application purposes only. Attempts to test or troubleshoot the 104003C 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 Figure 1 (see page 10) of this Practice, as an aid in following the circuit description.

4.02 The power supply in the 104003C 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 transorb between input battery and ground limits high-level supply transient to a safe level.

4.03 The transmit and receive sections of the 104003C 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.

4.04 Clamping diodes limit the amplifiers' input and output voltages 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 TX and RX 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 front panel.

TONE-ACTIVATED LOOPBACK

4.05 The input for tone-activated loopback is obtained from the output of the receive equalizer. 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 modules' 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.

5. MECHANICAL OUTLINE

5.01 See FIGURE 2.

6. SPECIFICATIONS

6.01 Electrical

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

Facility/Terminal Port Impedances:

	Switchable 1200, 600, or 150 ohms, balanced
Flat Gain or 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:
+7dBm

Total Harmonic Distortion:
less than 1% at +7dBm 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

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 3)

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

6.02 Environmental

Operating Environment: 20° to 130°F (-7 to 54°C)

Humidity: to 95% (no condensation)

6.03 Physical

Dimensions: 5.58" H x 1.42" W x 5.96" D (14.17cmH x 3.61cmW x 15.14cmD)

Weight: 16 ounces (454 grams)

Mounting: relay rack or apparatus case via one position of an Accurate Type-10 Mounting Shelf

7. TESTING AND TROUBLESHOOTING

7.01 The Testing Guide Checklist (Table 5.) may be used to assist in the installation, testing or troubleshooting of the 104003C Prescription Line Amplifier. 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 Accurate for repair or replacement as directed below. We strongly recommend that no internal (component-level) testing or repairs be attempted on the module. Unauthorized testing or repairs may void the module's warranty. Also, if the module is part of a registered system, unauthorized repairs will result in noncompliance with Part 68 of the FCC Rules and Regulations.

TECHNICAL ASSISTANCE

7.02 Contact Accurate Electronics, Inc. 503.641.0118, FAX: 503.646.3903; Mail: PO Box 1654, Beaverton OR 97075-1654.

RETURN PROCEDURE (FOR REPAIR)

7.03 To return equipment for repair, first contact Accurate Electronics, Inc. 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. Accurate Electronics 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.

8. MAINTENANCE

8.01 No preventive maintenance is required. General care is recommended.

9. WARRANTY

9.01 All Accurate Electronics Inc. products carry a full FIVE (5) YEAR warranty on materials and workmanship. See WARRANTY in front of catalog.

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

9.02 If a situation arises that is not covered in the checklist, contact Accurate Customer Service as follows (telephone number are given below):

Contact Accurate Electronic Customer Service

9.03 If a module is diagnosed a defective, follow the replacement procedure in paragraph 9.04 when a critical service outage exists (e.g., when a system of a critical circuit is down and no spares are available). If the situation is not critical, follow the repair and return procedure in paragraph 9.05.

Replacement

9.04 To obtain a replacement module, notify Accurate Electronics. Be sure to provide all relevant information, including the 104003C 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 Accurate Electronics.

Repair and Return

9.05 Return the defective module, shipment prepaid, to Accurate Electronics Inc. :

ACCURATE ELECTRONICS INC.
ATTN: REPAIR AND RETURN
8687 SW HALL BLVD. #100
BEAVERTON, OREGON 97008 USA

WWW.ACCURATE.ORG PO BOX 1654 97075-1654 8687 SW HALL BLVD 97008 BEAVERTON OR USA 503.641.0118 FAX 503.646.3903

10. CONDENSED ALIGNMENT PROCEDURES

Figure 6. Preliminary alignment procedure- no equalization

1.) Refer to the CLR card and determine the following: facility port impedance, terminal port impedance, 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 6, proceed to the final alignment verification (without equalization) procedure (Figure 7) for instructions on making end –to-end measurements.

2.) Set *S2* (Main Board) for facility port impedance. (paragraph 3.8)

3.) Set S4 (Main Board) for terminal port impedance. (paragraph 3.8)

4.) 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 front panel RX GAIN/LOSS switch 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 RX LEVEL switches that adds up to the required amount of gain or loss. (paragraph 3.6)

5.) 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 front panel TX GAIN/LOSS switch 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 TX LEVEL switches that adds up to the required amount of gain or loss. (paragraph 3.6)

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

Figure 7. Final alignment verification-no equalization

1.) Connect a properly terminated TMS (receive) to the RX IN MON jack and insert an opening plug into the RX IN 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 3.20)

2.) Disconnect the TMS and remove the opening plug. Connect the properly terminated TMS (receive) to the RX OUT jack. Request that personnel at the distant facility-side location again send 1000Hz tone at their specified level. Verify that tone is present and record the level. (paragraph 3.20)

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 their front-panel RX LEVEL switches to obtain the specified receive output level. (paragraph 3.20)

4.) Disconnect the TMS. Connect the properly terminated TMS (receive) to the TX IN MON jack and insert an opening plug into the TX 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 3.21)

5.) Disconnect the TMS and remove the opening plug. Connect the properly terminated TMS (receive) to the TX 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 3.21)

6.) Determine the difference (in dB) between the measured transmit out-put level (step 5) and transmit output level specified in the CLR. If any difference in levels exist, insert or remove gain via the front-panel TX LEVEL switches to obtain the specified transmit output level. (paragraph 3.21)

7.) Remove all test connection. Alignment is completed.

Figure 8. Preliminary alignment procedure –with equalization

1.) Refer to the CLR card and determine the following: facility port impedance, terminal port impedance, 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 8, 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 4 through 7) cannot be determined at this time. After completing step 3, omit steps 4 through 7 and proceed to step 8. After completing step 8, proceed to Figure 9.

2.) Set S2 (Main Board) for facility port impedance. (paragraph 3.8)

3.) Set S4 Main Board) for terminal port impedance. (paragraph 3.8)

4.) 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 3.13)

- <u>Loaded cable and predominately loaded mixed cable</u>

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

- <u>Nonloaded cable</u>

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

- <u>Predominately nonloaded mixed cable</u>

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

5.) Note: The amount of equalized gain added in step 4 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 front panel RX GAIN/LOSS switch to either GAIN or LOSS, as required. To determine the required amount of gain or loss, calculate the difference (in dB) between the equalized

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receive input level and the specified receive output level. Set to IN the proper combination of front-panel RX LEVEL switches that add up to the required amount of gain or loss. (paragraphs 3.14 and 3.15)

6.) 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 3.16)

- <u>Loaded cable and predominately loaded mixed cable</u>

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

- <u>Nonloaded cable</u>

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

- <u>Predominately nonloaded mixed cable</u>

  Determine the difference (in dB) between the 1000Hz and 3000Hz signal levels. Subtract 2dB from this difference and, referring to table 2, set front panel TX EQL switch 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 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 front panel TX GAIN/LOSS switch 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 TX LEVEL switches that add up to the required amount of gain or loss. (paragraphs 3.17 and 3.18)

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

<u>Figure 9. Final alignment procedure –with equalization</u>

1.) Connect a properly terminated TMS (receive) to the RX IN MON jack and insert an opening plug into the RX 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 3.20)

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 3.13)

- <u>Loaded cable and predominantly loaded mixed cable</u>

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

- <u>Nonloaded cable</u>

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

- <u>Predominately nonloaded mixed cable</u>

  Determine the difference (in dB) between the 1000Hz and 3000Hz signal levels. Subtract 2dB from this difference and, referring to table 2, set front panel RX EQL switch 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 RX 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 3.20)

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 exist, insert or remove gain via the front-panel RX LEVEL switches to obtain the specified receive output level. (paragraph 3.20)

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 TX 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 3.21)

7.) If the 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 3.16)

- Loaded cable and predominately 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 front panel TX EQL switch 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, refereeing to table 2, set front panel TX EQL switch for the required (nearest but lower) amount of equalized gain.

- Predominately 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 front panel TX EQL switch for 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 measured and recorded the 1000Hz level. (paragraph 3.21)

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 exist, insert or remove gain via the front-panel TX LEVEL switches to obtain the required level. (paragraph 3.21)

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.

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TABLE 5. Test Procedure.

Test	Test Procedure	Normal results	If Normal Conditions Are Not Met, Verify:
Receive Level	Connect properly terminated TMS (receive) to *RX OUT* jack. Insert 1000Hz test tone at specified level into *RX IN* jack.	Signal level corresponds to gain or loss setting.	-Power -Wiring -Proper impedance termination (check for double termination) -Impedance switches (S2 and S4) properly set -Level/Equalizer switches (front-panel *RX LEVEL* and *RX EQL)* properly set -Replace module and re-test
Transmit Level	Connect properly terminated TMS (receive) to *TX OUT* jack. Insert 1000Hz test tone at specified level into *TX IN* jack.	Signal level corresponds to gain or loss setting.	-Power -Wiring -Proper impedance terminations (check for double terminations) -Impedance switches (S2 and S4) properly set. -Level/Equalizer switches (front-panel *TX Level and TX EQL*) properly set -Replace module and re-test
Tone loopback	Connect selected loopback tone at level indicated in CLR to *RX IN* jack; after 2 seconds change frequency to 1kHz; measure output at *TX OUT* jack.	*LPBK* LED lights. Measured transmit level within $\pm$1dB of transmit level indicated on CLR.	-Transmit and receive levels properly aligned. -Correct looopback tone selected at S3. -Lower loopback tone level 10dB and retest. -Replace module and retest
Tone loopback release	Change test signal to selected loopback tone.	*LPBK* LED off after approximately 1Second.	-Momentarily operate manual loopback (ground pin 1). -Check transmit pair for shorted pairs. -Replace module and retest.

FIGURE 1. CIRCUIT DESCRIPTION.