Addendum: 4024E 4Wire-to-2Wire Terminal Repeater

1. General

1.1 This addendum to Practice Section 814024E, revision C (dated 02/88) is being issued to revise Section 6, Specifications, *transhybrid loss* to read:

transhybrid loss

30dB ERL minimum, with precision port termination of 900 ohms in series with 2.15μF

33dB ERL minimum, with precision port termination of 600 ohms in series with 2.15μF

30dB ERL minimum, with internal CBN and precision termination on 2wire port

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4024E 4Wire-to-2Wire Terminal Repeater

contents

1. general description

1.01 The Tellabs 4024E 4Wire-to-2Wire Terminal Repeater (figure 1) provides active level control and impedance matching between a 4wire voice-frequency (VF) transmission facility and a 2wire VF loop. Active amplitude equalization is available in the 4wire receive path. In effect, the single 4024E module functions both as a line amplifier and as a terminating set, and is commonly referred to as a 24V4-type repeater.

1.02 This practice section is revised to correct switch-optioning information in paragraph 3.10, to correct the *insertion loss* specification in section 6, and to update the text portion of section 7.

1.03 The 4024E module offers the following features and functions:

- From 0 to 24dB of prescription gain or from 0 to 24dB of prescription loss in both the transmit and receive channels, adjustable in 0.1dB increments via front-panel switches, with gain or loss for each channel selected via switch option.
- Maximum 4wire output level of +10dBm.
- Maximum 2wire output level of +8dBm.
- Maximum noise level of 17dBrnC at maximum gain.
- Active prescription slope-type amplitude equalization in the receive channel, which introduces from 0 to 7.5dB of gain at 2804Hz (re 1004Hz) in switch-selectable 0.5dB increments.
- Isolation transformers at both 4wire ports (receive input and transmit output), independently switch-optionable for balanced 1200, 600, or 150-ohm terminating impedance.
- Balanced simplex (SX) and A&B leads at both 4wire ports for duplex (DX) signaling, loopback, or other signaling schemes requiring a dc path.
- Magnetic 4wire-to-2wire hybrid at the 2wire port, providing transformer coupling with balanced, switch-selectable 900 or 600-ohm terminating impedance in series with 2.15μF of capacitance.
- Integral compromise balance network (CBN), providing 900 or 600 ohms in series with 2.15μF at the hybrid's balance port.

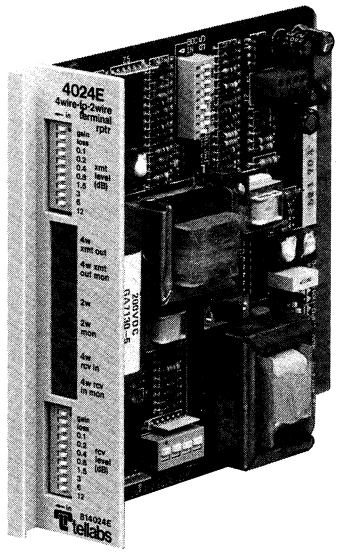


figure 1. 4024E 4Wire-to-2Wire Terminal Repeater

- Printed-circuit-board connector for optional use of a Tellabs 993X PBN plug-on subassembly instead of the module's integral CBN.
- From 0 to 0.062μF of network build-out (NBO) capacitance, switch-selectable in 0.002μF increments, for use either with the module's integral CBN or with an optional 993X PBN subassembly.
- A switch option that allows the A&B leads (inductor-isolated) to be connected to the SX leads to permit dc signaling that either bypasses the module, does not bypass the module, or bypasses the module with reversed polarity. The inductive isolation allows direct A&B-lead connection to low-impedance terminations or battery supplies.
- Standard network channel terminating equipment (NCTE) pinout scheme that allows the 4024E module to be mounted in any of Tellabs' prewired 262 or 262U NCTE Mounting Assemblies.
- Lightning surge protection at all three transmission ports.
- Reverse-battery protection and transient-limiting circuitry.
- RC filtering and decoupling networks that minimize crosstalk coupling and effects of noise on the input power leads.
- Six front-panel bantam-type test jacks (one bridging jack and one opening jack at each port) for alignment and maintenance.
- Operation on filtered, ground-referenced −42 to −56Vdc input power, with current requirements of 30mA at idle and 65mA maximum.

- Type 10 module for mounting in a variety of Tellabs Type 10 Mounting Shelves, which are available in versions for relay-rack and apparatus-case installation. Also mounts in a Tellabs 262 or 262U Mounting Assembly or 19XX Apparatus Case.

2. application

2.01 The Tellabs 4024E 4Wire-to-2Wire Terminal Repeater combines a precision 4wire line amplifier with a 4wire-to-2wire (facility-to-terminal) hybrid terminating set, thereby providing a 24V4-type repeater on a single Type 10 module. Specifically, the 4024E provides bidirectional level control, receive-channel amplitude equalization, and conversion from 4wire operation on the facility side to 2wire operation on the terminal side for VF transmission facilities. The 4024E is commonly used in applications involving PBX trunk circuits, off-premises extensions, 4wire tie lines, and other applications requiring a 24V4 repeater.

2.02 Levels in the 4wire transmit and receive paths of the 4024E are individually prescription-set for precise transmission alignment. Up to 24dB of flat gain or flat loss, in discrete 0.1dB increments, can be introduced into each channel via the module's front-panel *xmt* and *rcv gain/loss* and *level* DIP switches. Adjacent to each DIP-switch position on the module's front panel is the dB value of that switch position. These values are cumulative; the total amount of flat gain or loss introduced into a channel is the sum of that channel's DIP-switch positions set to in.

2.03 From 0 to 7.5dB of prescription-set active slope equalization at 2804Hz (re 1004Hz) can be introduced into the 4024E's 4wire receive path to compensate for the frequency-response characteristics of nonloaded cable. This equalization is introduced in discrete 0.5dB increments via a DIP switch on the module's printed circuit board. The 4024E's equalized gain response is not affected by flat gain or flat loss adjustments, which are used to provide precise transmission alignment. Frequency response of the equalizer is shown graphically in figure 2 and in tabular form in table 1.

Note: *Because the 4024E's transmit channel is generally used to coordinate levels rather than to reduce facility loss, no transmit equalization is available. Transmit (i.e., pre-) equalization tends to amplify high-frequency signals to a level conducive to crosstalk. Receive (i.e., post-) equalization not only eliminates this problem, it also expedites the equalization procedure because the circuit is easier to equalize at the receive end.*

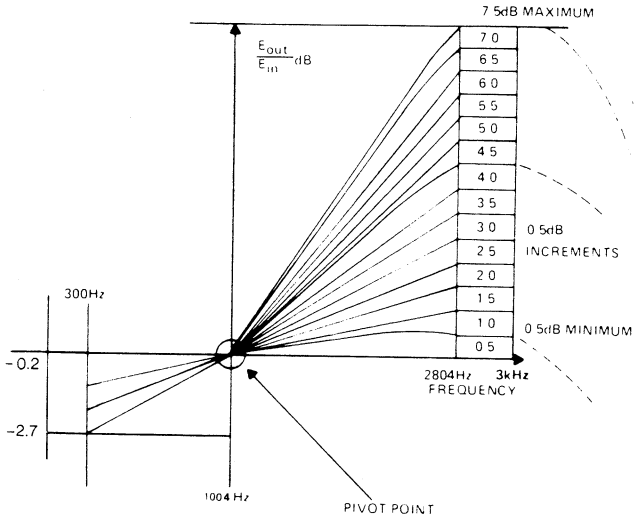


figure 2. Typical response curves for receive-channel active slope equalization

2.04 The impedance-matching transformers on the 4wire (facility) side of the 4024E can be switch-optioned for 1200 ohms to interface loaded cable, for 600 ohms to interface nonloaded cable or carrier, or for 150 ohms to provide a small amount of

receive equalizer switch setting (dB)	equalized gain (in dB) introduced at various frequencies								
	300Hz	404Hz	500Hz	800Hz	1004Hz	1500Hz	1800Hz	2500Hz	2804Hz
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.5	−0.2	−0.2	−0.1	−0.1	0.0	+0.2	+0.3	+0.4	+0.5
1.0	−0.3	−0.3	−0.3	−0.1	0.0	+0.4	+0.5	+0.9	+1.0
1.5	−0.5	−0.5	−0.4	−0.2	0.0	+0.5	+0.8	+1.3	+1.5
2.0	−0.7	−0.6	−0.5	−0.2	0.0	+0.7	+1.1	+1.8	+2.0
2.5	−0.9	−0.8	−0.7	−0.3	0.0	+0.9	+1.4	+2.2	+2.5
3.0	−1.1	−0.9	−0.8	−0.3	0.0	+1.1	+1.6	+2.7	+3.0
3.5	−1.2	−1.1	−0.9	−0.4	0.0	+1.3	+1.9	+3.1	+3.5
4.0	−1.5	−1.3	−1.2	−0.5	0.0	+1.3	+2.0	+3.4	+3.9
4.5	−1.6	−1.5	−1.3	−0.5	0.0	+1.5	+2.3	+3.9	+4.4
5.0	−1.8	−1.6	−1.4	−0.6	0.0	+1.6	+2.5	+4.3	+4.9
5.5	−2.0	−1.8	−1.5	−0.6	0.0	+1.8	+2.8	+4.8	+5.5
6.0	−2.2	−2.0	−1.7	−0.7	0.0	+1.9	+3.0	+5.2	+6.0
6.5	−2.4	−2.1	−1.8	−0.8	0.0	+2.1	+3.2	+5.6	+6.5
7.0	−2.6	−2.3	−2.0	−0.8	0.0	+2.2	+3.4	+6.0	+7.0
7.5	−2.7	−2.5	−2.1	−0.9	0.0	+2.3	+3.6	+6.4	+7.5

table 1. Typical receive-channel active slope equalization

slope-type amplitude equalization for long sections of nonloaded cable through the deliberate impedance mismatch. (In the receive channel, this is in addition to any equalization provided by the integral active slope equalizer.) The 4024E's 4wire facility-side transformers also derive SX leads that can be used for DX, loopback, or other signaling schemes requiring a dc path (see paragraph 2.09).

2.05 On the 4024E's 2wire (terminal) side, switch-selectable 900 or 600-ohm terminating impedance in series with 2.15μF permits interface with various terminal-side facilities and equipment. The 900-ohm option is used when the 4024E interfaces loaded cable or switched networks accessing loaded or nonloaded cable, while the 600-ohm option is selected when the 4024E interfaces nonloaded cable or terminal equipment.

2.06 The 4024E's hybrid can be switch-optioned to function either with the module's internal compromise balance network (CBN), which provides a switch-selectable 900 or 600 ohm impedance in series with 2.15μF, or with a separate precision balance network (PBN). In applications where the 4024E's 2wire port interfaces loaded cable or a short section of nonloaded cable, the module's CBN will often provide adequate hybrid balance (transhybrid loss). However, if the CBN does not provide sufficient hybrid balance in these applications, a separate PBN is required. Generally, a separate PBN is also necessary in applications where the 4024E's 2wire port interfaces a telephone set directly or interfaces a long section of nonloaded cable. Separate PBN's are also recommended when the 4024E is used in toll, tandem, and many special-services applications.

2.07 The PBN designed for use with the 4024E is the Tellabs 993X PBN subassembly, which plugs physically and electrically into a four-pin receptacle on the 4024E's printed circuit board. The 993X PBN is available in several versions to approximate the impedances of specific transmission facilities and station equipment. For additional information on the 993X PBN, refer to the Tellabs 993X practice.

2.08 To further improve hybrid balance (i.e., increase transhybrid loss) in applications where a PBN for loaded cable is used with the 4024E module, from 0 to 0.062μF of network build-out (NBO) capacitance can be introduced across the 4024E's balance port. Less commonly, NBO capacitance is used in conjunction with a CBN to compensate for the capacitance of terminal cables or for the presence of drop build-out (DBO) capacitors on the 2wire loop. Please note that while NBO capacitance can be used in CBN applications other than those just mentioned or with a PBN for either nonloaded cable or a tel set, the NBO capacitance introduced in these cases may or may not result in significantly improved hybrid balance. The amount of additional transhybrid loss obtained in such applications depends upon individual circuit characteristics.

2.09 As mentioned above, both the transmit and receive transformers on the 4024E's 4wire side are center-tapped to derive SX leads, which are required for DX signaling, loopback, and other signaling schemes requiring a dc path. The A&B leads on the module's 2wire side accommodate up to 90mA of direct current without significant degradation of performance. Inductive isolation of these leads permits direct A&B-lead connection of low-impedance terminations or battery supplies. An option switch permits external signaling (i.e., connects the SX leads and A&B leads to separate module pinouts), bypassed signaling (i.e., internally connects the SXT lead to the A lead and the SXR lead to the B lead), or bypassed signaling with reversed polarity (i.e., internally connects the SXR lead to the A lead and the SXT lead to the B lead.) Bypassed signaling with reversed polarity is used in tandem applications and also to compensate for wiring reversals at other points in the circuit.

3. installation

inspection

3.01 The 4024E 4Wire-to-2Wire Terminal Repeater 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 4024E module mounts in one position of a Tellabs Type 10 Mounting Shelf. The module plugs physically and electrically into a 56-pin connector at the rear of the shelf. The 4024E can also be mounted in one position of a prewired Tellabs 262 or 262U Universal Network Terminating System Assembly (with NCTE pinouts) or in one position of a Tellabs 19XX Apparatus Case.

installer connections

3.03 Before making any connections to a nonprewired shelf or case, ensure 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 2 lists external connections to the 4024E Repeater. In non-prewired applications, 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.

3.05 When the 4024E is installed in a 262U NCTE Assembly, all external connections to the module are made to a 25-pair connectorized (female) micro-ribbon cable. This cable is arranged in accordance with Universal Service Order Code (USOC) RJ2HX. If the customer's terminal equipment is cabled in accordance with USOC RJ2HX, direct cable connection between the 262U System Assembly and the customer's equipment is possible. If not, cross-connections between the 262U

connect:	to pin:
4WIRE XMT TIP	41
4WIRE XMT RING	47
4WIRE XMT SX (simplex)	43
4WIRE RCV TIP	7
4WIRE RCV RING	13
4WIRE RCV SX (simplex)	9 or 11
2WIRE TIP	55
2WIRE RING	49
A lead	5 or 51
B lead	3 or 15
−BATT (−42 to −56Vdc filtered input)	35
GND (ground)	17

table 2. External connections to 4024E

System Assembly and the local terminal equipment must be made at an intermediate connectorized terminal block. The cables required for connection to the 4024E depend upon the 262U Assembly position in which the module is installed.

3.06 When installed in a 262U Assembly, the 4024E requires no option strapping to provide dc signaling continuity or pinout compatibility. However, connections between the 4024E's SXT and SXR leads and external equipment (SX current source or signaling set) must be made at the 262U's option-strapping terminal blocks. In these applications, the SXT lead is equivalent to the 262U A-option lead, and the SXR lead is equivalent to the 262U C-option lead. Refer to the Tellabs 262U System drawings for details.

option selection

3.07 Optioning the 4024E module consists of selecting the terminating impedance at both 4wire ports and at the 2wire port, conditioning the module either for use with its internal CBN or with a 993X plug-on PBN, selecting the appropriate CBN impedance (if used), and selecting external, bypassed, or reverse-polarity bypassed operation of the A&B leads. Locations of the option switches on the 4024E's printed circuit board are shown in figure 3. Table 3 gives a brief explanation of the function and settings of each option switch, along with a convenient optioning and alignment checklist. The checklist can be filled out (by checking the appropriate box for each switch) either prior to installation to allow for prescription optioning and alignment of the module, or as the module is being optioned and aligned to provide a record for future reference. Detailed instructions for optioning the 4024E are provided in paragraphs 3.08 through 3.13.

Note: *Introduction of NBO capacitance is covered under alignment in paragraphs 3.22 through 3.25 of this practice.*

3.08 **2Wire Port Impedance.** Terminating impedance at the 4024E's 2wire port is selected via positions *1* and *2* of nine-position DIP switch *S5* as follows:

- For 900 ohms in series with 2.15μF (as is normally required for interface with loaded cable or 900-ohm equipment), set *S5-1* to *OFF* and *S5-2* to *ON.*
- For 600 ohms in series with 2.15μF (as is normally required for interface with nonloaded cable or 600-ohm equipment), set *S5-1* to *ON* and *S5-2* to *OFF.*

3.09 **4Wire Receive Port Impedance.** Terminating impedance at the 4024E's 4wire receive port is selected via positions *1* and *2* of four-position DIP switch *S1* as follows:

- For 1200 ohms (as is normally required for interface with loaded cable), set *S1-1* to *OFF* and *S1-2* to *OFF.*
- For 600 ohms (as is normally required for interface with nonloaded cable), set *S1-1* to *OFF* and *S1-2* to *ON.*
- For 150 ohms (which provides a small amount of slope equalization for long sections of nonloaded cable through the deliberate impedance mismatch), set *S1-1* to *ON* and *S1-2* to *OFF.*

3.10 **4Wire Transmit Port Impedance.** Terminating impedance at the 4024E's 4wire transmit port is selected via positions 3 and 4 of four-position DIP switch S1 as follows:

- For 1200 ohms (as is normally required for interface with loaded cable), set *S1-3* to *OFF* and *S1-4* to *OFF.*
- For 600 ohms (as is normally required for interface with nonloaded cable), set *S1-3* to *OFF* and *S1-4* to *ON.*
- For 150 ohms (which provides approximately 2dB of slope equalization for long sections of nonloaded cable through the deliberate impedance mismatch), set *S1-3* to *ON* and *S1-4* to *OFF.*

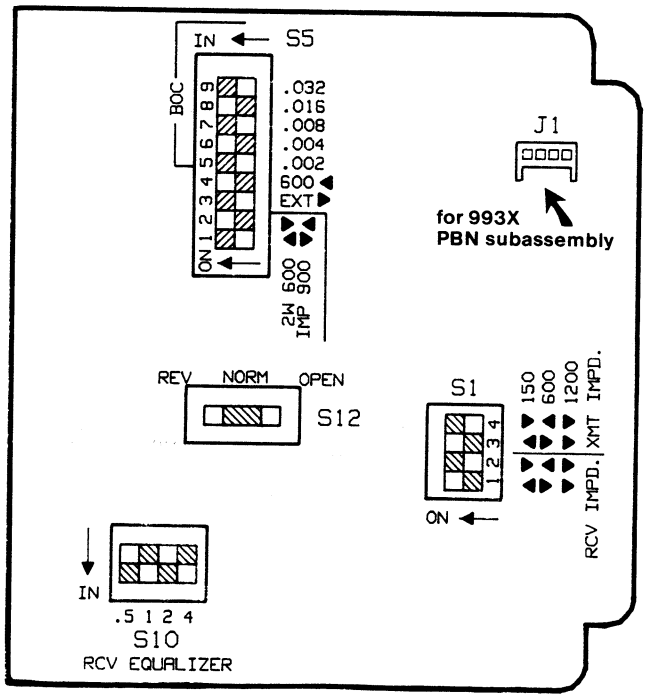


figure 3. 4024E option switch locations

switch option	switch	selection	settings	checklist
terminating impedance, 2wire port	S5-1 and S5-2	900 ohms plus 2.15μF (for loaded cable or 900-ohm equipment)	S5-1 to OFF S5-2 to ON	
		600 ohms plus 2.15μF (for nonloaded cable or 600-ohm equipment)	S5-1 to ON S5-2 to OFF	
terminating impedance, 4wire receive port	S1-1 and S1-2	1200 ohms (for loaded cable)	S1-1 to OFF S1-2 to OFF	
		600 ohms (for nonloaded cable)	S1-1 to OFF S1-2 to ON	
		150 ohms (extra slope equalization for nonloaded cable)	S1-1 to ON S1-2 to OFF	
terminating impedance, 4wire transmit port	S1-3 and S1-4	1200 ohms (for loaded cable)	S1-3 to OFF S1-4 to OFF	
		600 ohms (for nonloaded cable)	S1-3 to OFF S1-4 to ON	
		150 ohms (extra slope equalization for nonloaded cable)	S1-3 to ON S1-4 to OFF	
inclusion or exclusion of internal compromise balance network (CBN)	S5-3	CBN included in circuit	ON	
		CBN excluded from circuit (for use of plug-on or external PBN)	OFF	
internal CBN impedance options (with S5-3 set to ON)	S5-4	900 ohms plus 2.15μF	OFF	
		600 ohms plus 2.15μF	ON	
A&B-lead and SX-lead dc signaling options	S12	external (A&B leads and SX leads available separately at module pinouts)	OPEN	
		bypassed signaling	NORM	
		bypassed signaling with reversed polarity	REV	
receive-channel gain or loss	front-panel *rcv level* DIP switch, *gain* and *loss* positions	gain	gain in loss out	
		loss	gain out loss in	
receive-channel level (either gain or loss, as selected above)*	front-panel *rcv level* DIP switch, dB-value positions	0.1dB	0.1 in	
		0.2dB	0.2 in	
		0.4dB	0.4 in	
		0.8dB	0.8 in	
		1.5dB	1.5 in	
		3dB	3 in	
		6dB	6 in	
		12dB	12 in	
receive-channel slope equalization**	RCV EQUALIZER DIP switch (S10-1 through S10-4)	0.5dB	S10-1 in	
		1.0dB	S10-2 in	
		2.0dB	S10-3 in	
		4.0dB	S10-4	

table 3 continued on next page

switch option	switch	selection	settings	checklist
transmit-channel gain or loss	front-panel *xmt level* DIP switch, *gain* and *loss* positions	gain	gain to in loss to out	
		loss	gain to out loss to in	
transmit-channel level (either gain or loss as selected above)*	front-panel *xmt level* DIP switch, dB-value positions	0.1dB	0.1 in	
		0.2dB	0.2 in	
		0.4dB	0.4 in	
		0.8dB	0.8 in	
		1.5dB	1.5 in	
		3dB	3 in	
		6dB	6 in	
		12dB	12 in	
network build-out (NBO) capacitance***	S5-5 through S5-9	0.002μF	S5-5 ON	
		0.004μF	S5-6 ON	
		0.008μF	S5-7 ON	
		0.016μF	S5-8 ON	
		0.032μF	S5-9 ON	

* The dB-value positions of the 4024E's front-panel *rcv level* and *xmt level* DIP switches are cumulative. Total gain or loss introduced into a channel is the sum of that channel's dB-value DIP-switch positions set to *in*. For zero gain or loss in a channel, set all dB-value positions of that channel's front-panel *level* DIP switch to *out*.

** The four positions of the *RCV EQUALIZER* DIP switch (*S10-1* through *S10-4*) are cumulative. Total gain introduced at 2804Hz (re 1004Hz) is the sum of those *S10* switch positions set to *IN*. **For no receive equalization,** set all four positions of *S10* to *OUT*.

*** Network build-out (NBO) capacitance switches *S5-5* through *S5-9* are cumulative. Total NBO capacitance introduced is the sum of these DIP-switch *S5* positions set to *IN*. For zero NBO capacitance, set *S5-5* through *S5-9* to *OUT*.

table 3. 4024E switch-option and alignment-switch summary and checklist

3.11 **Inclusion or Exclusion of CBN.** The 4024E's integral compromise balance network (CBN) is inserted into or excluded from the circuit via position *3* of nine-position DIP switch *S5* as follows:

- To include the CBN in the circuit, as is normally required when a plug-on or external PBN is not used, set *S5-3* to *ON*.
- To exclude the CBN from the circuit for use of a plug-on or external PBN instead, set *S5-3* to *OFF (EXT)*.

3.12 **CBN Impedance.** When the 4024E's integral CBN is optioned into the circuit (*S5-3* set to *ON*), the CBN's balancing impedance is selected via position *4* of nine-position DIP switch *S5* as follows:

- In applications where the 2wire port impedance is 600 ohms (*S9* set to *600*), set *S5-4* to *ON* to provide 600 ohms of balancing impedance in series with 2.15μF.
- In applications where the 2wire port impedance is 900 ohms (*S9* set to *900*), set *S5-4* to *OFF* to provide 900 ohms of balancing impedance in series with 2.15μF.

Note: *In applications where the 4024E's integral CBN is excluded from the circuit (*S5-3 *set to* OFF*), switch* S5-4 *is nonfunctional. It can therefore be left in either the* ON *or* OFF *position with no effect upon operation of the module.*

3.13 **A&B-Lead and SX-Lead DC Signaling Options.** Three-position slide switch *S12* conditions the 4024E's A&B leads and SX leads for three different dc signaling arrangements as follows:

- For external signaling, in which the 4024E's A&B leads and SX leads are connected to (and therefore available separately at) the module's pinouts, set *S12* to *OPEN*.
- For bypassed signaling, in which case the 4024E's SXT lead is internally connected to the A lead and the SXR lead is internally connected to the B lead, set *S12* to *NORM*.
- For bypassed signaling with reversed polarity, in which case the 4024E's SXT lead is internally connected to the B lead and the SXR is internally connected to the A lead, set *S12* to *REV*.

Note: *When the 4024E is installed in a Tellabs 262U Mounting Assembly,* S12 *must be set to either the* NORM *or* REV *position for dc cut-through signaling.*

3.14 **Installing Optional PBN Subassembly.** In applications where an optional Tellabs 993X Precision Balance Network subassembly is to be used on the 4024E, refer to figure 3 for the appropriate connector location and install the subassembly as follows:

- Ensure that position *3* of DIP switch *S5* is set to *OFF* to exclude the module's internal CBN from the circuit.
- Plug the 993X PBN subassembly into four-pin female connector *J1* on the module's printed circuit board. Then install and tighten the screw that secures the subassembly's standoff post to the main board.

alignment

3.15 Alignment of the 4024E module consists of setting the transmit and receive transmission levels

and the receive amplitude equalization, and, where required, introducing NBO capacitance to achieve optimum hybrid balance. After all options on the 4024E are selected, two methods of alignment are available: *prescription* and *direct measurement* (non-prescription). With the prescription method, the 4024E's front-panel *xmt gain/loss, xmt level, rcv gain/loss* and *rcv level* switches and the printed-circuit-board *rcv equalizer* switches are set in accordance with the specifications on the circuit layout record (CLR). Procedures for prescription alignment of the 4024E are given in paragraphs 3.16 through 3.18. In applications where the information provided by the CLR is inadequate, it is necessary to perform the direct-measurement (non-prescription) alignment procedure. The non-prescription procedure consists of making measurements at the 4024E's ports to determine the required settings of the alignment switches. The non-prescription alignment procedures are given in paragraphs 3.19 through 3.27.

prescription level adjustment, transmit and receive

3.16 To adjust the transmit and receive levels on the 4024E, proceed as follows: From table 3 or the CLR, determine whether gain or loss is required in each channel. If gain is required in a channel, set the *gain* position of that channel's front-panel *level* DIP switch to *in* and the adjacent *loss* position of the same DIP switch to *out*. If loss is required in a channel, set the *loss* position of that channel's level DIP-switch to *in* and the adjacent *gain* position of the same switch to *out*. Next, determine (from the CLR) the amount of gain or loss required in each channel. Then, to achieve the required levels, set the appropriate combinations of *xmt level* and *rcv level* DIP switches to the *in* position. The specific amount of loss or gain (in dB) introduced by each DIP-switch position is indicated on the front panel adjacent to the switch position. These switch positions are cumulative; the total amount of flat gain or flat loss introduced into a channel is the sum of that channel's *level* DIP-switch positions set to *in*.

prescription receive equalization

3.17 To adjust the receive-channel slope-type amplitude equalization on the 4024E, proceed as follows: From table 3 or the CLR, determine the amount of equalized gain required at 2804Hz (re 1004Hz). Equalization is introduced into the receive channel via the four-position *RCV EQUALIZER* DIP switch *(S10)*. The specific amount of equalized gain at 2804Hz (re 1004Hz) introduced via each DIP-switch position is indicated on the printed circuit board adjacent to the switch position. These switch positions are cumulative; the total amount of equalized gain (0 to 7.5dB) introduced is the sum of those *RCV EQUALIZER* DIP-switch positions set to *IN*. Because the amount of required equalization given in the CLR may be specified to the nearest 0.1dB (while the 4024E's *RCV EQUALIZER* switch is arranged in 0.5dB increments), use the following guidelines for rounding up or down when setting the switches: If, for example, 0.3 to 0.7dB of equalized gain is required, set the switch for 0.5dB. If 0.8 to 1.2dB of equalized gain is required, set the switch for 1dB. Similarly, if 1.3 to 1.7dB of equalized gain is required, set the switch for 1.5dB, and so on upward through the switch's range. If no equalization is required, ensure that no positions of the *RCV EQUALIZER* DIP switch are set to *IN*.

post-alignment testing

3.18 After the transmission levels and receive equalization are set, it may be desirable to confirm the results via end-to-end tests. Where computer-controlled test equipment is used, a printout will verify the alignment results. Any deviation from the required levels can then be adjusted via the front-panel *level* switches and printed-circuit-board *RCV EQUALIZER* switch. If computer-controlled test equipment is not available, the alignment results can be confirmed by performing the measurements in the non-prescription alignment procedure below.

prealignment switch settings for non-prescription alignment

3.19 Before beginning actual non-prescription alignment of the 4024E, do the following:

A. Ensure that all option switches (see table 3 for a listing), especially those that select the module's 4wire receive, 4wire transmit, and 2wire port impedances, are properly set.
B. Ensure that the module's receive equalizer is excluded from the circuit (all four positions of DIP switch *S10* set to *OUT*).
C. Ensure that no NBO capacitance is introduced (positions *5* through *9* of DIP switch *S5* set to *OFF*).
D. Set all positions of the front-panel *rcv level* and *xmt level* DIP switches to the *out* position for zero gain or loss in each channel.

Note: *In the alignment procedures that follow, you will be instructed to arrange the transmit and receive portions of a transmission measuring set (TMS) to match certain terminating impedances selected on the 4024E module. Most TMS's provide 900, 600, and 135-ohm settings but not the 150 and 1200-ohm settings that are available at the module's 4wire facility-side ports. Therefore, please observe the following guidelines to obtain correct level measurements and settings when aligning the 4024E by means of a typical TMS:*

- *If the module is optioned for 150 ohms, use the 135-ohm setting on the TMS. The slight impedance mismatch will not affect level measurements appreciably.*
- *If the module is optioned for 1200 ohms, do not use the 900-ohm setting on the TMS. Instead, reoption the module for 600 ohms and use the 600-ohm setting on the TMS. Then, when alignment is completed, reoption the module for 1200 ohms as required.*

- *If the TMS does not have independent transmit and receive impedance settings, option both the TMS and all three ports of the module for 600 ohms during alignment; then reoption the module as required when alignment is completed.*

non-prescription receive-level adjustment

3.18 To adjust the receive level of the 4024E when prescription level settings are not given in the CLR or when the given settings do not provide adequate results, proceed as follows:

A. Arrange the receive portion of a transmission measuring set (TMS) for bridged measurement at the impedance selected for the 4wire receive port (see note preceding paragraph 3.20). Connect the receive portion of the TMS to the 4024E's *4w rcv mon* jack. Have the distant location send 1004Hz test tone at the specified level. Verify that test tone is present and record the level.

B. Also have the distant location send 2804Hz test tone at the same level. Verify that test tone is present and record the level. This will be used later in the alignment procedure for determining whether or not receive-channel equalization is required.

C. Disconnect the TMS from the *4w rcv mon* jack. Arrange the receive portion of the TMS for terminated measurement at the impedance selected for the 2wire port (either 900 or 600 ohms). Connect the receive portion of the TMS to the *2w* jack. Request the distant 4wire location to again send 1004Hz test tone at the specified level. If the level measured at the *2w* jack is the same as that specified by the CLR, proceed to receive equalization adjustment (paragraph 3.20). If the measured level is different from the required level, proceed to step D.

D. If the specified 2wire level is **higher** than the measured level, set the *gain* position of the front-panel *rcv level* DIP switch to *in* and the adjacent *loss* DIP-switch position to *out*. If the specified 2wire level is **lower** than the measured level, set the *loss* position of the front-panel *rcv level* DIP switch to *in* and the adjacent *gain* DIP-switch position to *out*.

E. Finally, set to *in* that combination of *rcv level* dB-value DIP-switch positions which equals the required amount of gain or loss (i.e., the difference between the specified level and the measured level).

Note: *The amount of loss or gain introduced by each dB-value position of the* rcv level *DIP switch is indicated on the front panel. These switch positions are cumulative; the total amount of gain or loss introduced is the sum of those dB-value switch positions set to* in.

non-prescription receive equalization adjustment

3.21 To determine the need for receive-channel equalization (i.e., post-equalization at the local end of the 4wire facility), and to adjust the 4024E's receive equalizer when prescription settings are not given in the CLR or when the given settings do not provide adequate results, proceed as follows:

A. Subtract the 2804Hz level measured in paragraph 3.20, step B, from the 1004Hz level measured in paragraph 3.20, step A. If the difference is 0.2dB or less, no equalization is required, so proceed to transmit level adjustment, paragraph 3.22. If the difference is 0.3dB or greater, proceed to step B.

B. Set to *IN* the proper combination of *RCV EQUALIZER (S10)* DIP-switch positions that approximates as closely as possible the measured difference, i.e., the amount of equalized gain required, as directed in table 4.

1000Hz-2804Hz difference	amount of equalized gain required
0.0 to 0.2dB	0.0dB
0.3 to 0.7dB	0.5dB
0.8 to 1.2dB	1.0dB
1.3 to 1.7dB	1.5dB
1.8 to 2.2dB	2.0dB
2.3 to 2.7dB	2.5dB
2.8 to 3.2dB	3.0dB
3.3 to 3.7dB	3.5dB
3.8 to 4.2dB	4.0dB
4.3 to 4.7dB	4.5dB
4.8 to 5.2dB	5.0dB
5.3 to 5.7dB	5.5dB
5.8 to 6.2dB	6.0dB
6.3 to 6.7dB	6.5dB
6.8 to 7.2dB	7.0dB
7.3 to 7.7dB	7.5dB

table 4. Equalized gain setting from cable loss data

non-prescription transmit level adjustment

3.22 To adjust the transmit level of the 4024E when prescription level settings are not given in the CLR or when the given settings do not provide adequate results, proceed as follows:

A. Ensure that no front-panel *xmt level* DIP-switch positions are set to *in*. Also ensure that the 4wire transmit port impedance (switches *S1-3* and *S1-4*) and the 2wire port impedance (switches *S5-1* and *S5-2*) are set correctly.

B. Insert an opening plug into the *2w* jack. Arrange the receive portion of the TMS for bridged measurement at the impedance selected for the 2wire port (either 900 or 600 ohms). Connect the receive portion of the TMS to the *2w mon* jack. Request the distant 2wire location to send 1004Hz test tone at the specified level. Verify that test tone is present and record the level.

C. Remove the TMS connection from the *2w mon* jack and the opening plug from the *2w* jack. Arrange the receive portion of the TMS for terminated measurement at the impedance selec-

ted for the 4wire transmit port (see note preceding paragraph 3.20). Connect the receive portion of the TMS to the *4w xmt in* jack, and request the 2wire location to again send 1004Hz test tone at the specified level. If the level measured at the *4wire xmt out* jack is the same as that specified on the CLR, proceed to balance network and NBO capacitance adjustment (paragraph 3.22). If the measured level is different from the required level, proceed to step D.

D. If the specified 4wire transmit level is **higher** than the measured level, set the *gain* position of the front-panel *xmt level* DIP switch to *in* and the adjacent *loss* DIP-switch position to *out*. If the specified level is **lower** than the measured level, set the *loss* position of the front-panel *xmt level* DIP switch to *in* and the adjacent *gain* DIP-switch position to *out*.
E. Finally, set to *in* that combination of *xmt level* dB-value DIP-switch positions which equals the required amount of gain or loss (i.e., the difference between the specified level and the measured level).

Note: *The amount of loss or gain introduced by each dB-value position of the* xmt level *DIP switch is indicated on the front panel. These switch positions are cumulative; the total amount of gain or loss introduced is the sum of those dB-value switch positions set to* IN.

balance network and NBO capacitance

3.23 **Determining Transhybrid Loss.** If it is not known whether the module's internal CBN will provide adequate hybrid balance (transhybrid loss) in a particular application, make this determination as follows:

A. Ensure that the CBN is inserted and properly optioned (DIP switches *S5-3* and *S5-4*) as directed in table 3 or paragraphs 3.11 and 3.12.
B. Arrange the transmit portion of the TMS for 1004Hz tone output at the CLR-specified 4wire receive level. If the transmit portion of the TMS has a separate impedance setting, select the impedance for which the module's 4wire receive port is optioned (see note preceding paragraph 3.20). Connect this signal to the module's *4w rcv in* jack.
C. Arrange the receive portion of the TMS for terminated measurement at the impedance selected for the 4wire transmit port (see note preceding paragraph 3.20). Connect the receive portion of the TMS to the module's *4w xmt out* jack.
D. If the measured output level is too high (i.e., if transhybrid loss is insufficient) to meet the circuit requirements of the application, a PBN may be required or, occasionally, introduction of NBO capacitance in conjunction with the CBN may be necessary to compensate for terminal cable capacitance or for drop build-out (DBO) capacitors on the 2wire loop. These situations are covered in paragraphs 3.24 through 3.27.

Note: *When the 4024E's CBN is used, NBO capacitance is generally not required, although it is used in infrequent cases to compensate for capacitance of terminal cables or for drop build-out (DBO) capacitors on the 2wire loop.*

3.24 **Using a PBN.** If the 4024E's internal CBN does not provide sufficient hybrid balance (transhybrid loss), or if the module's 2wire port interfaces a tel set directly or interfaces a long length of non-loaded cable, an optional Tellabs 993X PBN plug-on subassembly can be used to improve hybrid balance. When a PBN is used, exclude the module's internal CBN from the circuit by setting switch *S5-3* to *OFF*. Then adjust the PBN as directed in the PBN practice.

3.25 To further improve hybrid balance, especially when a PBN for loaded cable is used, proceed as follows:

A. Ensure that switch *S5-3* is set to *OFF* to exclude the 4024E's internal CBN.
B. Refer to table 3 and set to *IN* (*ON*) that combination of DIP-switch *S5* positions *5* through *9* which introduces the appropriate amount of NBO capacitance, as directed in the PBN practice or on the CLR. If this amount is not known, proceed to paragraph 3.26. Otherwise, remove all test cords; alignment of the 4024E is complete.

3.26 **Introducing NBO Capacitance by TMS Measurement When Required Amount Is Unknown (CBN and PBN Applications).** To introduce NBO capacitance to compensate for terminal cable capacitance or for DBO capacitors on the 2wire loop when the module's internal CBN is used, or to achieve optimum hybrid balance with a PBN (especially with one for loaded cable) when the required amount of NBO capacitance is not known, proceed as follows:

A. Request that the distant end of the 2wire loop be terminated.
B. Arrange the transmit portion of the TMS for 2000Hz tone output at the CLR-specified 1004Hz 4wire receive level. If the TMS has a separate transmit impedance setting, select the impedance for which the module's 4wire receive port is optioned (see note preceding paragraph 3.20). Connect this signal to the module's *4w rcv in* jack.
C. Arrange the receive portion of the TMS for terminated measurement at the impedance selected for the 4wire transmit port (see note preceding paragraph 3.20). Connect the receive portion of the TMS to the 4024E's *4w xmt out* jack.
D. Using positions *5* through *9* of DIP switch *S5*, add NBO capacitance until the TMS level reading is at its **lowest** point (i.e., add NBO capacitance until the TMS reading reaches a minimum and then starts to rise; then return to the setting that produced the minimum reading).

At this point, alignment of the 4024E is complete. Disconnect the TMS from the module.

3.27 **Introducing NBO Capacitance by Formula When Required Amount Is Unknown (Some CBN Applications).** If the module's internal CBN is being used and an easier method of introducing NBO capacitance (generally, to compensate for office cable capacitance) is desired than the procedure in paragraph 3.26, proceed as follows:

Note: *The amount of NBO capacitance introduced by this method should provide adequate results in most applications. If it does not, the procedure in paragraph 3.26 must be performed.*

A. From table 5, calculate the required amount of NBO capacitance for the type and length of cable interfacing the module's 2wire port. (For example, if 1.2 kilofeet of high-capacitance cable interfaces the module's 2wire port, multiply 1.2 kilofeet by 0.016μF per kilofoot to obtain 0.0192μF.)

B. Set to *IN* (*ON*) that combination of DIP-switch *S5* positions *5* through *9* which most closely approximates the calculated amount of NBO capacitance. (For the example in step A, you would set *S5-6* and *S5-8* to *IN* (*ON*) to introduce 0.020μF, the closest possible amount to 0.0192μF.) At this point, alignment of the 4024E is complete. Disconnect the TMS from the module.

type of cable interfacing 2wire port:	amount of NBO capacitance to be introduced for each kilofoot of cable between module and local terminal equipment:
high capacitance (0.083μF per mile)	0.016μF per kilofoot
low capacitance (0.066μF per mile)	0.012μF per kilofoot

table 5. Guidelines for introducing NBO capacitance (in conjunction with CBN) by formula to compensate for terminal cable capacitance

4. circuit description

4.01 This circuit description is designed to familiarize you with the 4024E 4Wire-to-2Wire Terminal Repeater module for engineering and application purposes only. Attempts to test or troubleshoot the 4024E internally are not recommended and may void its warranty. Procedures for recommended testing and troubleshooting in the field are limited to those prescribed in section 7 of this practice. Please refer to the 4024E block diagram, section 5 of this practice, as an aid in following the circuit description.

power supply

4.02 The *power supply* in the 4024E is a series-regulated bipolar supply 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.

2wire section

4.03 Lightning protection is provided at all ports to prevent incoming voltage surges from exceeding internal power voltages. A magnetic 4wire-to-2wire (facility-to-terminal) hybrid with switch-selectable 900 or 600-ohm input impedance (in series with 2.15μF of capacitance) provides the 2wire side interface. The dc interface is provided by a balanced two-winding inductor, with one end of each winding providing T&R leads and the other furnishing A&B leads. With the A&B leads shorted, the total dc resistance of the 4024E is 240 ohms (nominal).

4.04 Conversion from 4wire to 2wire operation is achieved through a conventional 4wire-to-2wire hybrid. The 2wire compromise balance network (CBN) is composed of a 900 or 600-ohm impedance termination (in series with 2.15μF of capacitance) and switch-selectable network build-out (NBO) capacitors (0 to 0.062μF). In addition, provision is made for use of a plug-on precision balance network (PBN) subassembly (Tellabs 993X). The internal (CBN) is removed and the module conditioned for use with the plug-on PBN via switch option.

4wire transmit section

4.05 The output of the 4wire-to-2wire hybrid is connected to the *transmit amplifier/attenuator,* which is controlled by the front-panel *xmt level* DIP switch. The *gain* and *loss* positions of the *xmt level* switch determine whether gain or loss is provided in the transmit path, while the other eight positions of the xmt level switch insert the specific amount of gain or loss desired. The transmit signal is then applied to an output amplifier.

4.06 The output of the 4wire transmit channel uses a transformer to interface the transmission facility and to derive the tip, ring, and simplex (SX) leads. The secondary winding of the transformer is coupled to a resistive bridging network and to the output of the transmit amplifier. The bridging network provides switch-selectable 1200, 600, or 150-ohm terminating impedance and level coordination on the facility side, and maintains amplifier gain settings regardless of impedance settings (i.e., impedance settings may be changed without affecting gain settings and output levels). Lightning protection is provided for the output amplifier to prevent incoming voltage surges from exceeding internal power voltages.

4wire receive section

4.07 The input of the 4wire receive channel also uses a transformer to interface the transmission facility and to derive the tip, ring, and (SX) leads. The secondary winding of the transformer is coupled to a resistive bridging network and to the input amplifier. The bridging network provides switch-selectable 1200, 600, or 150-ohm terminating impedance and level coordination on the facility side, and maintains amplifier gain settings regardless of impedance settings (i.e., impedance settings may be changed without affecting gain settings and output levels).

4.08 Lightning protection is provided for the input amplifier to prevent incoming voltage surges from exceeding internal power voltages. The output of the input amplifier is connected to the *receive amplifier/attenuator,* which is controlled by the front-panel *rcv level* DIP switch. The *gain* and *loss* positions of the *rcv level* DIP switch determine whether gain or loss is provided in the receive path, while the other eight positions of the *rcv level* switch introduce the specific amount of gain or loss desired. The output of the *receive amplifier/attenuator* feeds a series-connected *receive equalizer* amplifier, which provides active slope-type amplitude equalization for the receive path. The amount of slope equalization introduced is determined by the four-position *RCV EQUALIZER DIP* switch. The output of the *receive equalizer* amplifier is connected to the 4wire-to-2wire hybrid and thence to the 2wire port.

signaling

4.09 DC signaling through the 4024E is accomplished by the simplex leads (SXT and SXR) on the 4wire (facility) side and by the A&B leads on the 2wire side. Option switch *S12* selects either external signaling (i.e., externally connects the simplex and A&B leads to separate module pinouts), bypassed signaling (i.e., internally connects SXT to the A lead and SXR to the B lead), or bypassed signaling with reversed polarity (i.e., internally connects SXR to the A lead and SXT to the B lead). If external signaling is selected (*S12* set to *OPEN*), dc signals are derived from the facility by the SXR lead. These signals are processed by a signaling unit external to the 4024E and passed on to the 2wire ring lead via the 4024E's B lead. Signals from the 2wire side are derived from the 2wire tip lead by the A-lead inductor, processed by the external signaling unit, and are applied to the facility by the SXT lead. The A&B leads can also be used to supply talk battery to a station via the tip and ring leads. If bypassed signaling is selected (*S12* set to *NORM*), the A-lead inductor is connected directly to the SXT lead and the B-lead inductor is connected directly to the SXR lead, thus eliminating the need for external wiring between the SX leads and the A&B leads. If bypassed signaling with reversed polarity is selected (*S12* set to *REV*), the connections between the SX leads and the A&B-lead inductors are reversed. This configuration is normally used in tandem applications and also to compensate for wiring reversals at other points in the circuit.

6. specifications

gain/loss range (transmit and receive)
0 to 24dB of gain or 0 to 24dB of loss in switch-selectable 0.1dB increments, with gain or loss selected via switch option

maximum 2wire output level
+8dBm

maximum 4wire output level
+10dBm

frequency response (both channels at 600 ohms, no receive equalization)
−2.0, +0.3dB, 200 to 3000Hz, re 1000Hz
−1.3, +0.3dB, 3000 to 3400Hz, re 1000Hz

receive amplitude equalization
active prescription slope-type, providing from 0 to 7.5dB of gain at 2804Hz (re 1004Hz) in switch-selectable 0.5dB increments

typical receive frequency response with maximum equalization (re 1004Hz)

frequency	equalization
300Hz	−2.9dB
500Hz	−2.1dB
1004Hz	0.0dB
1800Hz	+3.6dB
2804Hz	+7.4dB

4wire-port terminating impedances (xmt and rcv)
1200, 600, or 150 ohms, balanced, switchable

2wire-port terminating impedance
900 or 600 ohms in series with 2.15μF, balanced, switchable

simplex current
90mA maximum

2wire dc resistance with A&B-lead inductors
240 ohms nominal

dc current capability
no significant performance degradation for A&B-lead current up to 90mA

insertion loss (with gain at 0dB)
±0.2dB maximum at 600 ohms

NBO capacitance
0 to 0.062μF in switch-selectable 0.002μF increments

total harmonic distortion
less than 1% at maximum output level, 500 to 3400Hz

crosstalk loss between units in adjacent shelf slots
80dB minimum, 200 to 3400Hz

4wire-port echo return loss
20dB minimum vs. 1200 or 600 ohms, resistive

2wire echo return loss
25dB minimum vs. 900 or 600 ohms in series with 2.15μF

noise
17dBrnC maximum at maximum gain

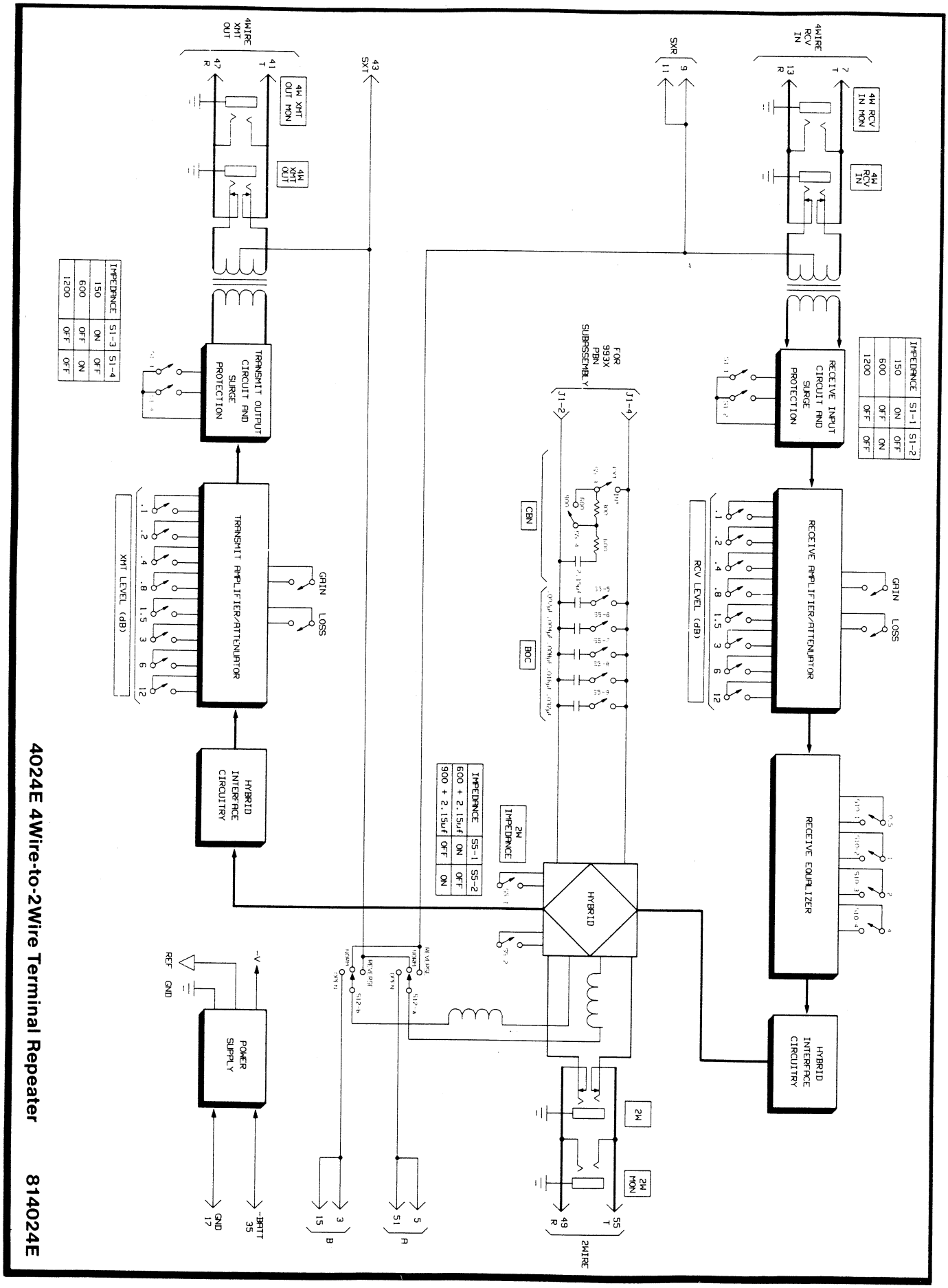
peak-to-average ratio (P/AR)
greater than 98

transhybrid loss
33dB ERL minimum, with precision port termination of 900 or 600 ohms in series with 2.15μF
30dB ERL minimum, with internal CBN and precision termination on 2wire port

longitudinal balance
4wire: 60dB minimum, 200 to 3000Hz
2wire: 60dB minimum, 200 to 1000Hz; 55dB minimum at 3000Hz

input power requirements
voltage: −42 to −56Vdc, filtered, ground referenced
current: 65mA maximum, 30mA idle (typical)

operating environment
32° to 122°F (0° to 50°C), humidity to 95% (no condensation)



5. block diagram

4024E 4Wire-to-2Wire Terminal Repeater 814024E

dimensions
5.58 inches (14.17cm) high
1.42 inches (3.16cm) wide
5.96 inches (15.14cm) deep

weight
15 ounces (425 grams)

mounting
relay rack or apparatus case via one position of a Tellabs Type 10 Mounting Shelf. Also mounts in one position of a Tellabs 262 or 262U Mounting Assembly or 19XX Apparatus Case.

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 4024E 4Wire-to-2Wire Termination Repeater Module. The checklist is intended as an aid in the localization of trouble to this specific equipment. If the equipment is suspected of being defective, substitute new equipment (if possible) and conduct the test again. If the substitute operates correctly, the original should be considered defective and returned to Tellabs for repair or replacement as directed below. We strongly recommend that no internal (component-level) testing or repairs be attempted on the equipment. Unauthorized testing or repairs may void its warranty. Also, if the equipment is part of a registered system, unauthorized repairs will result in noncompliance with Parts 15 and/or 68 of the FCC Rules and Regulations.

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

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

USA customers: Contact your Tellabs Regional Office listed below.

region	telephone	office location
US Northeast	(203)798-0506	Danbury, CT
US Capital	(703)359-9166	Washington, DC
US Central	(312)357-7400	Chicago, IL
US Southeast	(305)834-8311	Orlando, FL
US Southwest	(214)869-4114	Dallas, TX
US Western	(714)850-1300	Orange County, CA

Canadian customers: Contact our Canadian headquarters in Mississauga, Ontario. Telephone (416)858-2058.

International customers: Contact your Tellabs distributor.

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

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

in the USA:
Tellabs, Inc.
4951 Indiana Avenue
Lisle, Illinois 60532-1698
telephone (312)969-8800

in Canada:
Tellabs Communications Canada, Ltd.
2433 Meadowvale Boulevard
Mississauga, Ontario, Canada L5N 5S2
telephone (416)858-2058

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

product replacement procedure
7.05 For critical service outages, Tellabs offers a choice of two replacement services (if the product is in replacement stock) in lieu of the 15-day repair and return service described above. These are **overnight express service** (at extra cost) anywhere in the USA and **five-day expedited delivery** (at no extra cost) anywhere in the USA and Canada. To obtain replacement equipment via either of these services, contact your Tellabs Regional Office in the USA or our Canadian headquarters in Mississauga, Ontario, for details, costs (if applicable), and instructions. Telephone numbers are given in paragraph 7.02. A service representative will request key data (your company's name and address, the equipment's model and issue numbers and warranty date code, and the purchase order number for the replacement transaction). Tellabs will then ship the

replacement to you in accordance with the replacement service you request. An invoice in the amount of the replacement's current price plus any applicable service charges will be issued after the replacement is shipped. When you receive the replacement, pack the equipment to be returned in the replacement's carton, sign and enclose the packing list, affix to the carton the preaddressed label provided, and ship the carton prepaid to Tellabs at our USA or Canadian headquarters. The defective equipment must be received within 30 days of the replacement's ship date. When we receive the defective equipment, a credit will be issued, leaving a balance due on the replacement's invoice that reflects only the express service and/or out-of-warranty charges, if any. Returns received more than 30 days after the replacement's ship date **will not be accepted for credit** but instead will be returned to you, thereby rendering the replacement's invoice due and payable. Please note that OEM, modified, and manufacture-discontinued equipment is not available via overnight express service.

testing guide checklist

Note 1: *Do not use an unbalanced measuring device or signal source for 2wire level measurements, or erroneous readings will occur.*

Note 2: *Where dissimilar facilities are encountered (i.e., where the 4wire facility is nonloaded cable and the 2wire facility is loaded cable or vice versa), the test tone level must be measured by a separate transmission measuring set connected to the appropriate monitor jack (e.g.,* 4wire rcv in mon *when testing receive levels).*

test	test procedure	normal result	if normal conditions are not met, verify:
4wire-to-2wire receive gain/loss	Connect properly terminated TMS (receive) to *2w* jack. Use TMS (xmt) to insert 1004Hz test tone at −20dBm into *4w rcv in mon* jack. Vary gain/loss controls over their entire ranges.	Signal level corresponds to gain or loss settings, with maximum gain of approximately 24dB and maximum loss of approximately 24dB ☐.	Power ☐. Wiring ☐. Proper impedance terminations ☐. Impedance switches properly set ☐. Level settings ☐. Replace 4024E and retest ☐.
receive equalization	Maintain connections as above. Adjust *rcv eql* DIP switch for no equalization (no positions set to *IN*). Adjust module's receive output level for 0dBm at 1004Hz. Change input frequency to 2804Hz and add equalization (up to maximum) by setting all *rcv eql* DIP-switch positions to *IN* one by one.	Receive output level at 2804Hz increases to +7.5dBm as equalization is added ☐.	Input level at 2804Hz same as at 1004Hz ☐. Terminating impedances correct ☐.
2wire-to-4wire transmit gain/loss	Insert opening plug into *4w rcv in* jack. Connect properly terminated TMS (receive) to *4w xmt out* jack. Use TMS (xmt) to insert 1004Hz test tone at −20dBm into *2w* jack. Vary gain/loss controls over their entire ranges.	Signal level corresponds to gain or loss settings, with maximum gain of approximately 24dB and maximum loss of approximately 24dB ☐.	Same as above ☐.