tellabs
technical manual
76-824024B
rev A

practice section 824024B

4024B 2Wire-to-4Wire Repeater (24V4) Network Terminating Module

contents

1. general description

1.01 The Tellabs 4024B 2Wire-to-4Wire Repeater Network Terminating Module (figure 1) provides active level control and impedance matching between a 4wire and a 2wire voice-frequency transmission facility and also provides amplitude equalization in the 4wire receive path. In effect, the single 4024B 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 reissued to cover the Issue 2 version of the 4024B module (Tellabs part number **824024B**). The Issue 2 module is identical to its Issue 1 predecessor except for the addition of a front-panel power-on indicator LED.

1.03 The 4024B's transmit and receive amplifiers can be independently prescription-set (via front-panel switches) to provide from −24 to +24dB of gain in discrete 0.1dB increments. Because the module's insertion loss is less than 1dB, nearly all gain provided by the module is available at its output ports. Maximum output level of each channel is +8dBm.

1.04 In addition to active level-control circuitry, the 4024B features active slope-type amplitude-equalization circuitry in its 4wire receive path. This equalizer can be prescription-set to provide from 0 to 7.5dB of gain, in switch-selectable 0.5dB increments, at 2804Hz (re 1004Hz).

1.05 Transformers on the 4024B's 4wire side can be independently switch-optioned for balanced 1200, 6001or 150-ohm terminating impedance at both the transmit and receive ports. The 150-ohm options provide approximately 2dB of slope equalization (in the receive channel, this is in addition to any provided by the active slope equalizer) for long sections of nonloaded cable through the deliberate impedance mismatch. Both of the 4024B's facility-side transformers are center-tapped to derive balanced simplex (SX) leads, which provide for DX, loopback, or other signaling schemes requiring a dc path. On the 2wire side, the module can be switch-optioned for balanced 900 or 600-ohm terminating impedance (in series with 2.15μF).

1.06 An internal compromise balance network (CBN) automatically provides the same impedance

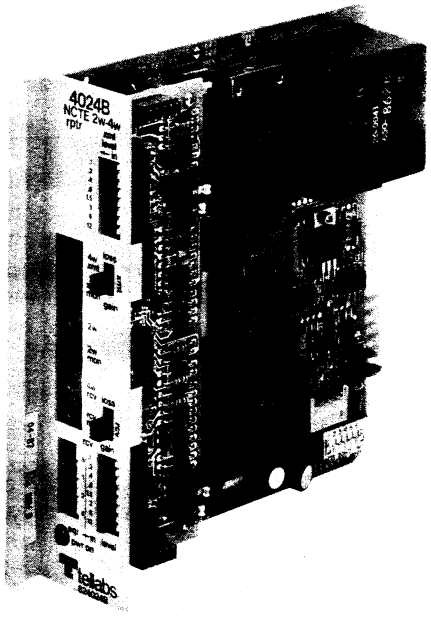


figure 1. 4024B 2Wire-to-4Wire Repeater (24V4) Network Terminating module

at the hybrid's balance port (900 or 600 ohms in series with 2.15μF) as that selected for the 2wire port. Network buildout (NBO) capacitors associated with the balance network provide from 0 to 0.062μF (in 0.002μF increments) of NBO capacitance. The internal CBN can be switch-optioned out of the circuit when use of an external precision balance network (PBN) is preferred. This PBN can be provided either as a Tellabs 993X PBN plug-on subassembly or as an external PBN module (e.g., a Tellabs 423X).

1.07 Standard A&B leads (inductor-isolated) on the 2wire side of the hybrid accommodate various forms of dc signaling. A switch option allows the A&B leads to be connected to the SX leads in either a normal or reversed mode so that dc signaling bypasses the module. The inductive isolation permits direct A&B-lead connection to low-impedance terminations or battery supplies. In addition, a switch option allows the A&B leads to be shunted internally by a 0.56μF filter capacitor.

1.08 An internally regulated power supply in the 4024B permits operation on filtered, ground-referenced −22 to −56Vdc input. Current requirements are 30mA at idle and 60mA maximum.

1.09 Surge protection is provided for the input and output of both the transmit and receive amplifiers. Reverse-battery protection and transient-limiting circuitry are provided in the reepeater's internal power supply circuitry. Resistance-capacitance filtering and decoupling networks minimize cross-talk coupling and the effects of noise on the input power leads.

1.10 In addition to transmit and receive gain/loss selection switches, transmit and receive level-control DIP switches, and a receive equalizer DIP switch, the front panel of the 4024B contains six bantam-type test jacks to facilitate alignment and maintenance. Specifically, both a bridging jack and an opening jack facing the module are provided at each of the 4024B's ports (4wire transmit, 4wire receive, and 2wire). Also located on the front panel is a *pwr on* LED that lights when power is applied to the module.

1.11 A Type 10 module, the 4024B mounts in one position of a Tellabs Type 10 Mounting Shelf, versions of which are available for relay-rack and apparatus-case installation. In relay-rack applications, up to 12 modules can be mounted across a 19-inch rack, while up to 14 modules can be mounted across a 23-inch rack. In either case, 6 inches of vertical rack space is used.

1.12 The 4024B is a member of Tellabs' 262U Universal Network Terminating System of modules and enclosures. Thus, it can also be mounted in any of Tellabs' prewired 262U Mounting Assemblies, versions of which are available for relay-rack and apparatus-case installation. For detailed information, refer to the Tellabs brochure describing the 262U Universal Network Terminating System.

2. application

2.01 The Tellabs 4024B 2Wire-to-4Wire Repeater Network Terminating Module combines a precision 4wire line amplifier with a 2wire-to-4wire hybrid terminating set, thereby providing a 24V4-type repeater on a single Type 10 card. Specifically, the 4024B provides bidirectional level control, receive-channel equalization, and 2wire-to-4wire conversion for voice-frequency transmission facilities. The 4024B is commonly used in applications serving 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 4024B 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* selection switches and *xmt* and *rcv 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 The impedance-matching transformers on the 4wire (facility) side of the 4024B 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 approximately 2dB of slope-type amplitude equalization for long sections of nonloaded cable through the deliberate impedance mismatch. The 4024B's facility-side transformers also derive simplex (SX) leads that can be used for duplex (DX), loopback, or other signaling schemes requiring a dc path.

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

2.05 From 0 to 7.5dB of prescription-set active slope equalization at 2804Hz (re1004Hz) can be introduced into the 4024B's 4wire receive path to compensate for the frequency-response characteristics of nonloaded cable. This equalization is introduced in discrete 0.5dB increments via front-panel DIP switches. The module'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 4024B's transmit channel is generally used to coordinate levels rather than to reduce facility loss, no transmit equalization is available. Transmit, or pre-, equalization tends to amplify high-frequency signals to a level conducive to crosstalk. Receive, or post-, equalization not only eliminates this problem, it also expedites the equalization procedure because the circuit is easier to equalize at the receive end.*

2.06 The 4024B's hybrid can be switch-optioned to function either with the module's internal compromise balance network (CBN), which provides an impedance of 900 or 600 ohms in series with 2.15μF, or with a separate precision balance network (PBN). In applications where the 4024B's 2wire port interfaces loaded cable or a short length

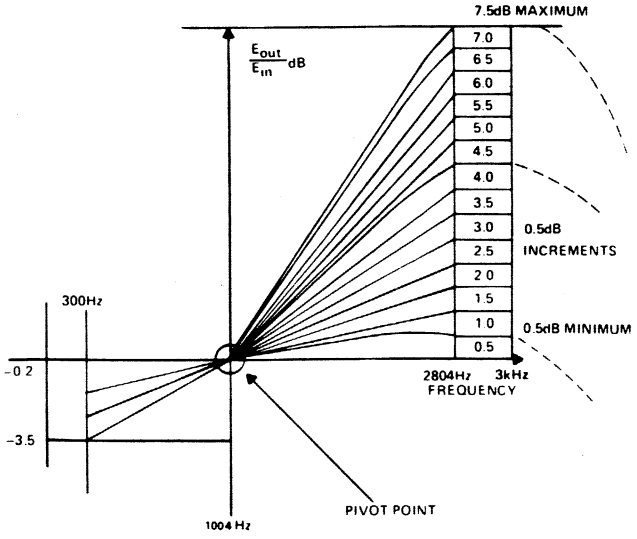


figure 2. Typical response curves for receive-channel active slope equalization

receive equalizer switch setting (dB)	equalized gain (in dB) introduced at various frequencies								
	300Hz	400Hz	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
0.5	−0.23	−0.19	−0.15	−0.06	0.0	+0.15	+0.24	+0.43	+0.50
1.0	−0.52	−0.42	−0.33	−0.13	0.0	+0.32	+0.52	+0.93	+1.07
1.5	−0.75	−0.60	−0.49	−0.18	0.0	+0.46	+0.74	+1.33	+1.54
2.0	−1.00	−0.80	−0.64	−0.24	0.0	+0.61	+0.98	+1.76	+2.04
2.5	−1.22	−0.98	−0.78	−0.29	0.0	+0.75	+1.20	+2.15	+2.49
3.0	−1.50	−1.20	−0.95	−0.36	0.0	+0.90	+1.45	+2.60	+3.01
3.5	−1.71	−1.37	−1.09	−0.41	0.0	+1.03	+1.65	+2.97	+3.45
4.0	−2.02	−1.63	−1.29	−0.49	0.0	+1.22	+1.95	+3.54	+4.12
4.5	−2.25	−1.79	−1.42	−0.53	0.0	+1.33	+2.14	+3.90	+4.56
5.0	−2.49	−1.98	−1.57	−0.59	0.0	+1.47	+2.36	+4.32	+5.08
5.5	−2.68	−2.14	−1.69	−0.63	0.0	+1.58	+2.53	+4.67	+5.51
6.0	−2.89	−2.30	−1.81	−0.68	0.0	+1.69	+2.72	+5.05	+5.99
6.5	−3.07	−2.44	−1.93	−0.72	0.0	+1.79	+2.87	+5.38	+6.41
7.0	−3.29	−2.61	−2.05	−0.76	0.0	+1.89	+3.05	+5.76	+6.90
7.5	−3.45	−2.74	−2.15	−0.78	0.0	+1.98	+3.19	+6.06	+7.30

table 1. Typical receive-channel slope equalization

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 will be required. Generally, a separate PBN is also necessary in applications where the 4024B's 2wire port interfaces a tel set directly or interfaces a long length of nonloaded cable. Separate PBN's are also recommended when the 4024B is used in toll, tandem, and many special-services applications.

2.07 The PBN used with the 4024B can be provided either as a Tellabs 423X PBN module or, more conveniently, as a Tellabs 993X PBN subassembly that plugs physically and electrically into a four-pin receptacle on the 4024B's printed circuit board. The 993X and 423X PBN's are available in several versions to approximate the impedances of specific transmission facilities and station equipment. For complete information on these PBN's, refer to the Tellabs 993X and 423X practices.

2.08 To further improve hybrid balance (i.e., increase transhybrid loss) in applications where a PBN for loaded cable is used with the 4024B module, from 0 to 0.062μF of network build-out (NBO) capacitance can be introduced across the 4024B's balance port. Less commonly, NBO capacitance is used in conjunction with a CBN to compensate for the capacitance of office cables or for the presence of drop build-out (DBO) capacitors on the 2wire loop. Please note that while NBO capacitance can be used with a CBN or with a PBN for 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 transhybrid loss obtained in such applications depends upon individual circuit characteristics.

2.09 Both the transmit and receive transformers on the 4024B'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. A&B leads on the 2wire side accommodate up to 100mA of direct current without degradation of performance. Inductive isolation of these leads permits direct A&B-lead connection of low-impedance terminations or battery supplies. An option switch either selects normal SX-lead derivation on the 4wire side, or allows dc signals to be bypassed through the module by connecting the A&B-lead inductors directly to the SX leads in either a normal or reverse arrangement. The reverse-bypass option is used in tandem applications and also to compensate for wiring reversals at other points in the circuit.

2.10 The A&B-lead filter capacitor in the 4024B may cause excessive ring-generator loading when ringing through the A&B leads at high ringing frequencies. This excessive ringing current can result in low ringing voltage and possible pretrip. Use of the filter capacitor may also contribute to dial-pulse distortion. If either of these problems occurs, the filter capacitor should be switch-optioned out of the circuit.

3. installation

inspection

3.01 The 4024B 2Wire-to-4Wire Repeater Network Terminating Module should be visually inspected upon arrival in order to find possible damage incurred during shipment. If damage is noted, a claim should immediately be filed with the carrier. If stored, the module should be visually inspected again prior to installation.

mounting

3.02 The 4024B 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 4024B can also

be mounted in one position of a prewired Tellabs 262U Universal Network Terminating System Assembly.

installer connections

3.03 Before making any connections to a non-prewired 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 2 lists external connections to the 4024B Repeater. 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.

connect:	to pin:
4WIRE XMT TIP	41
4WIRE XMT RING	47
4WIRE XMT SX (simplex)	43 or 45
4WIRE RCV TIP	7
4WIRE RCV RING	13
4WIRE RCV SX (simplex)	9 or 11
2WIRE TIP	55
2WIRE RING	49
A lead	51
B lead	53
EXT. BAL. NET. (external PBN)	5 and 15
−BATT (−22 to −56Vdc filtered input)	35
GND (ground)	17

table 2. External connections to 4024B

3.05 When the 4024B is installed in a 262U NTS Assembly, all external connections to the module are made to a 25-pair connectorized (female) micro-ribbon cable. The cable is connected in accordance with Universal Service Order Code (USOC) RJ2HX. If the customer's terminal equipment has been 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 Assembly and the local terminal equipment must be made at an intermediate connectorized terminal block. Cabling information for the 4024B installed in a 262U Assembly is given in table 3. The cables required for connection to the 4024B depend upon the shelf position in which the module is installed.

3.06 When installed in a 262U Assembly, the 4024B requires no option strapping to provide dc signaling continuity or pinout compatibility. However, connections between the 4024B's SXT and SXR leads and external equipment (simplex current source or signaling sets) 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 262U system practice for details.

option selection

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

3.08 Switches *S1* and *S2* select 1200, 600, or 150-ohm terminating impedance at the 4024B's 4wire transmit and receive ports, respectively. Set *S1* and *S2* to the *1200, 600,* or *150* position as required. Generally, the 1200-ohm option is used for loaded cable, the 600-ohm option is used for nonloaded cable or carrier, and the 150-ohm

4024B lead designation	card connector pin no.	NTM lead designation	shelf position (circuit number)*											
			1	2	3	4	5	6	7	8	9	10	11	12
4w RT	7	RT	1-26	1-28	1-30	1-32	1-34	1-36	1-38	1-40	1-42	1-44	1-46	1-48
4w RR	13	RR	1-1	1-3	1-5	1-7	1-9	1-11	1-13	1-15	1-17	1-19	1-21	1-23
4w TT	41	TT	1-27	1-29	1-31	1-33	1-35	1-37	1-39	1-41	1-43	1-45	1-47	1-49
4w TR	47	TR	1-2	1-4	1-6	1-8	1-10	1-12	1-14	1-16	1-18	1-20	1-22	1-24
2w T	55	T	2-26	2-30	2-34	2-38	2-42	2-46	3-26	3-30	3-34	3-38	3-42	3-46
2w R	49	R	2-1	2-5	2-9	2-13	2-17	2-21	3-1	3-5	3-9	3-13	3-17	3-21

*The numbers listed below each shelf position indicate the cable number and the connector pin number, e.g., 1-26 indicates cable 1 pin 26.

Note: This table is accurate for all 262U Assemblies with 12 circuits or less, and for the topmost shelf (shelf 1) of assemblies with up to 84 circuits. Cables and circuits for each successive shelf increase in increments of 3 and 12, respectively (e.g., for shelf 2, cable 4 corresponds to cable 1, cable 5 to cable 2, and cable 6 to cable 3; circuits 13 through 24 correspond to circuits 1 through 12).

table 3. 262U connector wiring

option is used to provide approximately 2dB of slope equalization for long sections of nonloaded cable through the deliberate impedance mismatch.

3.09 Switches *S3* and *S4* select either 900 or 600-ohm terminating impedance at the 2wire port. **Both switches must be set to the same position (*900* or *600*) for proper operation.** Switch *S4* also automatically selects the proper internal compromise balance network (CBN) impedance (900 or 600 ohms) in series with a 2.15μF capacitive component.

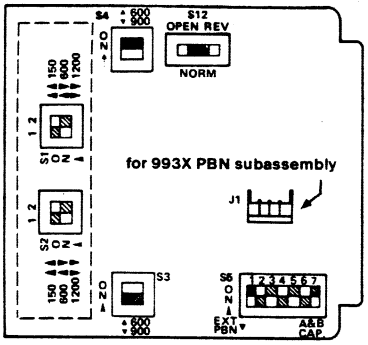


figure 3. 4024B option switch locations

function	switch	selections	settings	check-list
4wire transmit port impedance (paragraph 3.08)	S1	150 ohms	S1-1 and S1-2 ON	
		600 ohms	S1-1 ON, S1-2 OFF	
		1200 ohms	S1-1 and S1-2 OFF	
4wire receive port impedance (paragraph 3.08)	S2	150 ohms	S2-1 and S2-2 ON	
		600 ohms	S2-1 ON, S2-2 OFF	
		1200 ohms	S2-1 and S2-2 OFF	
2wire port impedance (paragraph 3.09)	S3 and S4	600 ohms	S3 and S4 ON	
		900 ohms	S3 and S4 OFF	
internal compromise balance network (paragraph 3.10)	S5-1	included	S5-1 ON	
		excluded (for PBN use)	S5-1 OFF	
network build-out (NBO) capacitance (paragraph 3.11)	S5-2 through S5-6	0.002μF	S5-2 ON	
		0.004μF	S5-3 ON	
		0.008μF	S5-4 ON	
		0.016μF	S5-5 ON	
		0.032μF	S5-6 ON	
A&B-lead filter capacitor (paragraph 3.12)	S5-7	included	S5-7 ON	
		excluded	S5-7 OFF	
A&B-lead bypass (paragraph 3.13)	S12	normal A&B lead operation	S12 OPEN	
		signaling bypassed through 4024B	S12 NORM	
		signaling bypassed, A&B lead reversed	S12 REV	

table 4. Switch option summary and checklist

3.10 The 4024B's internal CBN is included in or excluded from the circuit via position *1* of DIP switch *S5*. Set *S5-1* to the *ON* (closed) position if the module's internal CBN is to be used. Set *S5-1* to the *OFF* (open) position if a separate PBN (either a Tellabs 993X PBN subassembly, a Tellabs 423X PBN module, or equivalent) is to be used instead of the CBN. The various Tellabs PBN's and the type of facilities and station equipment with which they are used are listed in table 5.

facilities/eqpt.	993X PBN subassemblies*	423X PBN modules (Type 10)
19-24ga. H88	9930	4230
26ga. H88	9930	4230A
nonloaded cable with termination of 900Ω + 2.15μF, 600Ω + 2.15μF, or tel set	9932	4232
*The 993X subassemblies are recommended for use when the 4024B is installed in a 262U Assembly.		

table 5. External PBN information

3.11 Network build-out capacitance is introduced via positions *2* through *6* of DIP switch *S5*. Values of these switch positions are listed in table 4. These values are cumulative; thus, the amount of NBO capacitance introduced is the sum of those switches set to the *ON* (closed) position. To introduce the required amount of NBO capacitance, proceed as directed in paragraph 3.21 and set switches *S5-2* through *S5-6* accordingly.

3.12 The A&B-lead filter capacitor (see paragraph 2.10) is included or excluded via position *7* of DIP switch *S5*. Set *S5-7* to the *ON* (closed) position to include the A&B-lead capacitor in the circuit. Set *S507* to the *OFF* (open) posiiton to exclude the capacitor.

3.13 Option switch *S12* conditions the A&B leads and the SX leads for normal, bypass, or reverse-bypass dc signaling operation. With switch *S12* set to the *NORM* position, the SXR lead is connected to the 2wire ring lead through the B-lead inductor and the SXT lead is connected to the 2wire tip lead through the A-lead inductor, thus providing dc signaling continuity through the 4024B. The connections between the simplex leads and the tip and ring leads can be reversed by setting switch *S12* to the *REV* position. When the 4024B is installed in a 262U Assembly, switch *S12* must be set to either the *NORM* or *REV* position.

alignment

3.14 Alignment of the 4024B module consists of setting the transmit and receive transmission levels and the receive amplitude equalization. After all options on the 4024B are selected, two methods of alignment are available: prescription or direct measurement (non-prescription). With the prescription method, the 4024B's front-panel *xmt gain/loss, xmt level, rcv gain/loss, rcv level,* and *rcv eql* switches are set in accordance with the specifications on the circuit layout record (CLR). Procedures for prescription alignment of the 4024B are given in paragraphs 3.15 through 3.17. In cases 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 4024B's ports to determine the required settings of the front-panel switches. The non-prescription alignment procedures are given in paragraphs 3.18 through 3.25 and figures 4 through 6.

prescription level adjustment, transmit and receive

3.15 To adjust the transmit and receive levels on the 4024B, proceed as follows: From the CLR, determine whether gain or loss is required in each channel and set the front-panel *xmt* and *rcv* slide switches to the appropriate position *(loss* or *gain).* Next, determine (from the CLR) and select the amount of gain or loss required in each channel via the front-panel *xmt level* and *rcv level* DIP switches. 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 DIP-switch positions set to *in.*

prescription receive equalization

3.16 To adjust the receive equalization on the 4024B, proceed as follows: From the CLR, determine the amount of equalized gain required at 2804Hz (re 1004Hz). Equalization is introduced into the receive channel via the front-panel *rcv eql* DIP switch. The specific amount of equalized gain at 2804Hz (re 1004Hz) introduced via each DIP-switch position is indicated in the front panel 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 the DIP-switch positions set to *in.* Because the amounts of required equalization given in the CLR may be specified to the nearest 0.1dB (while the 4024B's *rcv eql* 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 switches to 0.5dB. If 0.8 to 1.2dB of equalized gain is required, set the switches to 1dB of equalized gain is required, set the switches to 1dB. Similarly, if 1.3 to 1.7dB of equalized gain is required, set the switches to introduce 1.5dB, and so on upward through the switch's range. If no equalization is required, ensure that no positions of the *rcv eql* DIP switch are set to *in.*

post-alignment testing

3.17 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 subsequent printout will verify the alignment results. Any deviation from the required levels can then be adjusted via the front-panel switches. If computer-controlled test equipment is not available, the alignment results can be confirmed by performing the measurements in the condensed test procedures in figures 4 through 7 of this practice.

non-prescription receive-level adjustment

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

Note: *A condensed non-prescription receive level adjustment procedure, which can also be used to verify prescription level adjustments, is given in figure 4.*

A. Ensure that no front-panel *rcv level* DIP-switch positions are set to *in.* Also ensure that the 4wire receive port impedance switch (*S2*) and the 2wire port impedance switches (*S3* and *S4*) are set correctly.

B. Arrange the receive portion of a transmission measuring set (TMS) for bridged measurement at the 4wire receive port impedance selected on the 4024B. Connect the receive portion of the TMS to the 4024B's *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.

C. Disconnect the TMS from the *rcv mon* jack. Arrange the TMS for terminated measurement at the 2wire port impedance selected on the 4024B and connect it 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 the transmit level adjustment (paragraph 3.19). 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 *rcv* slide switch to the *gain* position; if the specified level is lower than the measured level, set the *rcv* slide switch to the *loss* position. Then set to *in* that combination of *rcv level* DIP switch positions which equals the required amount of gain or loss (i.e., the difference between the specified level and the measured level).

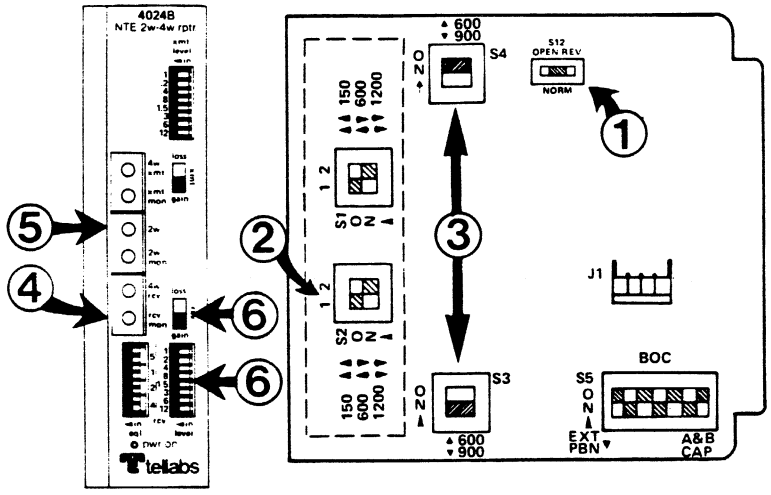
Note: *The amount of loss or gain introduced by each position of the* rcv level *switch is indicated on the front panel. These switch positions are cumulative; the total amount of gain or loss introduced is the sum of those switch positions set to* in.

non-prescription transmit level adjustment

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

Note: *A condensed non-prescription transmit level adjustment procedure, which can also be used to verify prescription level adjustments, is given in figure 5.*

A. Ensure that no front-panel *xmt level* DIP-switch positions are set to *in.* Also ensure that the



1 Refer to the CLR card and determine the following: 4wire receive impedance, 2wire impedance, required 4wire receive signal level, and the required 2wire drop signal level. Ensure that S12 is set properly (3.13). Once the facility levels are known, determine whether receive gain or receive attenuation is required. Proceed to step 2 and perform the alignment procedures in numeric order. The paragraph referenced after each step provides a more detailed explanation of that specific procedure. After completing step 6, proceed to the transmit level alignment procedure (figure 5).

2 Set S2-1 and S2-2 in accordance with table 4 for 4w receive impedance. (paragraph 3.08).

3 Set S3 and S4 to the appropriate positions for 2w impedance. Note: Both switches must be set to the same position. (paragraph 3.09).

4 Connect properly terminated TMS (receive) to rcv mon jack. Request distant location to send 1004Hz tone at specified level. Verify tone is present and at level specified on CLR card. (paragragh 3.18).

5 Remove TMS from rcv mon jack and connect the TMS (properly terminated) to the 2w jack. Request distant location to again send 1004Hz tone at specified level.

6 If the specified 2w level is higher than the 4w receive level, gain must be added in accordance with step a. If it is lower, attenuation must be added in accordance with step b. (paragraph 3.18).

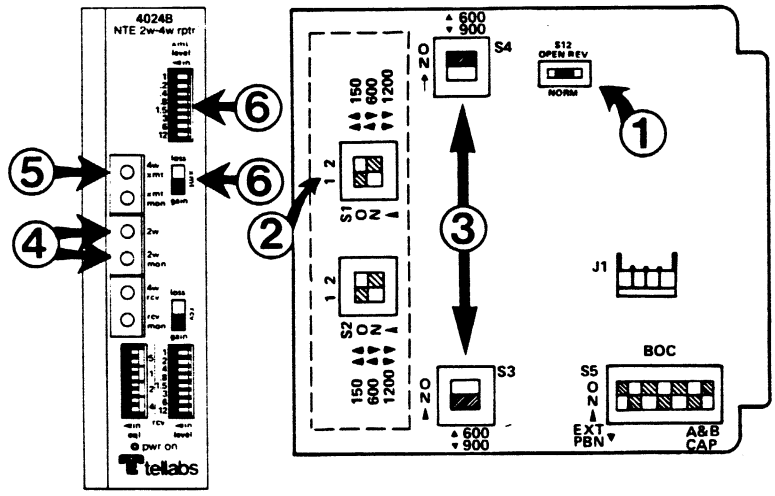
Receive Gain:

a. Set the front-panel rcv gain/loss switch to the gain position. Set the rcv level switches in the combination that equals the required gain.

Receive Attenuation:

b. Set the front-panel rcv gain/loss switch to the loss position. Set the rcv level switches in the combination that equals the required attenuation.

figure 4. Condensed non-prescription receive level alignment



1 Refer to the CLR card and determine the following: 4wire transmit impedance, 2wire impedance, required 4wire transmit signal level, and the required 2wire drop signal level. Ensure that S12 is set properly (3.13). Once the facility levels are known, determine whether transmit gain or transmit attenuation is required. Proceed to step 2 and perform the alignment procedures in numeric order. The paragraph referenced after each step provides a more detailed explanation of that specific procedure. After completing step 6, proceed to the receive equalization procedure (figure 6).

2 Set S1-1 and S1-2, in accordance with table 4 for 4wire transmit impedance. (paragraph 3.08).

3 Set S3 and S4 to the appropriate positions for 2wire impedance. Note: Both switches must be set to the same position. (paragraph 3.09).

4 Connect TMS receive (properly terminated) to 2w mon jack. Insert opening plug into 2w jack and request 2wire location to send tone at specified level. Verify tone is present and at level specified on CLR card.

5 Remove TMS from 2w mon jack and connect the TMS (properly terminated) to the 4w xmt jack. Request 2wire location to again send 1004Hz tone at specified level.

6 If the specified 4w transmit level is higher than the 2w level, gain must be added in accordance with step a. If it is lower, attenuation must be added in accordance with step b. (paragraph 3.19).

Transmit Gain:

a. Set the front-panel xmt gain/loss switch to the gain position. Set the xmt level switches in the combination that equals the required gain.

Transmit Attenuation:

b. Set the front-panel xmt gain/loss switch to the loss position. Set the xmt level switches in the combination that equals the required attenuation.

figure 5. Condensed non-prescription transmit level alignment

4wire transmit port impedance switch (*S1*) and the 2wire port impedance switches (*S3* and *S4*) are set correctly.

B. Arrange the receive portion of the TMS for terminated measurement at the 2wire port impedance selected on the 4024B. Connect the receive portion of the TMS to the *2w mon* jack on the 4024B, and insert an opening plug into the *2w* 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. Connect the receive portion of the TMS to the *4w xmt* jack (ensure that the TMS impedance is correct), and request the 2wire location to again send 1004Hz test tone at the specified level. If the level measured at the *4w xmt* jack is the same as that specified by the CLR, proceed to the receive equalization procedure (paragraph 3.20). 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 *xmt* slide switch to the *gain* position; if the specified level is lower than the measured level, set the *xmt* slide switch to the *loss* position. Then set to *in* that combination of *xmt level* 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 position of the* xmt level *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 switch positions set to* in.

non-prescription receive equalization adjustment

3.20 To determine the need for receive-channel equalization (i.e., post-equalization at the local end of the 4wire facility), and to adjust the 4024B'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:

Note: *A condensed non-prescription receive equalization adjustment procedure, which can also be used to verify prescription equalization adjustment, is given in figure 6.*

A. Ensure that no front-panel *rcv eql* DIP-switch positions are set to *in*. Also ensure that the 4wire receive port impedance switch (*S2*) is set correctly.

B. Arrange the receive portion of a TMS for bridged measurement at the 4wire receive port impedance selected on the 4024B. Connect the receive portion of the TMS to the 4024B's *rcv mon* jack. Request the distant 4wire end to send 1004Hz test tone at the level specified on the CLR. Verify the presence of test tone and record the level.

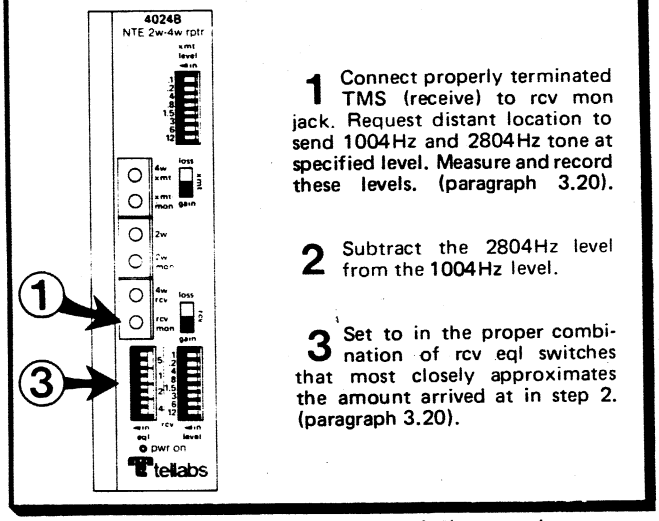


figure 6. Condensed non-prescription receive equalization alignment

C. Then have the distant end send 2804Hz test tone at the level specified on the CLR. Measure and record the received 2804Hz test tone. Subtract the 2804Hz level from the 1004Hz level recorded in step B.

D. Then set to *in* the proper combination of *rcv eql* DIP switches that approximates as closely as possible the measured difference, i.e., the amount of equalized gain required, as directed in table 6.

1004Hz-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 6. Equalized gain settings from cable loss data

balance network and NBO capacitance

3.21 **Determining Transhybrid Loss.** If the 4024B's 2wire port interfaces loaded cable or a short length of nonloaded cable, insert the module's internal CBN by setting switch *S5-1* to the *ON* position and by setting switches *S3* and *S4* for the

appropriate 2wire terminating impedance (900 or 600 ohms). Measure the resulting transhybrid loss as directed in steps A through C of paragraph 3.24 to ensure that this loss meets the requirements of the circuit. If it does not, 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 3.22 through 3.25.

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

3.22 **Using a PBN.** If the 4024B's 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 nonloaded cable, a separate PBN can be used to improve hybrid balance. When an external or plug-on PBN is used, exclude the 4024B's internal CBN from the circuit by setting switch *S5-1* to the *OFF* position. Then adjust the PBN as directed in the PBN practice.

3.23 To further improve hybrid balance when a PBN for loaded cable is used with the 4024B, proceed as follows:

A. Ensure that switch *S5-1* is set to *OFF* to exclude the 4024B's internal CBN.
B. Refer to table 4 and set to *ON* that combination of switches *S5-2* through *S5-6* which introduced 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 3.24. Otherwise, remove all test cords; alignment is completed.

3.24 **Introducting NBO Capacitance by TMS Measurement When Required Amount Is Unknown (CBN and PBN Applications).**To introduce NBO capacitance to compensate for office cable capacitance or for DBO capacitors on the 2wire loop, or to achieve optimum results with a PBN for loaded cable if the required amount of NBO capacitance is not known, proceed as follows:

A. Ensure that switch *S5-1* is set to *OFF* and request that the distant end of the 2wire loop be terminated.
B. Arrange the transmit portion of a TMS for 2000Hz tone output at the CLR-specified 4wire receive level. Connect this signal to the 4024B's *4w rcv* jack.
C. Connect the receive portion of the TMS, arranged for properly terminated level measurement, to the 4024B's *4w xmt* jack.
D. Refer to table 4 and set to *ON* that combination of switches *S5-2* through *S5-6* which results in the lowest reading (maximum transhybrid loss) on the TMS. Remove all test cords; alignment is completed.

3.25 **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 3.24 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 3.24 must be performed.*

A. From table 7, calculate the required amount of NBO capacitance for the type and length of cable interfacing the module's 2wire port. (For example, if 3.6 kilofeet of high-capacitance cable interfaces the module's 2wire port, multiply 3.6 kilofeet by 0.016μF per kilofoot to obtain 0.0576μF.)
B. Set to *ON* that combination of switches *S5-2* through *S5-6* which most closely approximates the calculated amount of NBO capacitance. (For the example in step A, you would set *S5-6, S5-5, S5-4,* and *S5-2* to *ON* to obtain 0.058μF, the closest possible amount to 0.0576μF.) Then remove all test cords; alignment is completed.

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

table 7. Guidelines for introducing NBO capacitance (in conjunction with CBN) by formula to compensate for office cable capacitance

4. circuit description

4.01 This circuit description is designed to familiarize you with the 4024B 2Wire-to-4Wire Repeater Network Terminating Module for engineering and application purposes only. Attempts to test or troubleshoot the 4024B internally are not recommended and may void your Tellabs 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 4024B block diagram, section 5 of this practice, as an aid in following the circuit description.

power supply

4.02 The *power supply* in the 4024B 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 A magnetic *2wire-to-4wire hybrid* with switch-selectable 900 or 600-ohm input impedance (in series with 2.15μF capacitance) interfaces

the 2wire side on an ac basis. 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 4024B is 180 ohms. An option switch allows a 0.56μF capacitor to be connected across the A&B leads.

4.04 Connected to the *2wire-to-4wire hybrid* are conventional transmit, receive, and balance network leads. The module's internal compromise balance network (CBN) is composed of the 900 or 600 ohm (in series with 2.15μF capacitance) impedance termination, network build-out capacitors, and provision for connecting a separate precision balance network (PBN). The internal CBN is removed and the module conditioned for use with a PBN by switch *S5-1*.

4wire transmit section

4.05 The output of the *2wire-to-4wire hybrid* is connected to the *xmt amplifier*, which is controlled by the front-panel *xmt gain/loss* slide switch and *xmt level* DIP switch. The *xmt gain/loss* slide switch determines whether gain or loss is provided in the transmit path; the *xmt level* switch inserts the specific amount of gain or loss. The transmit signal is then applied to the *output amplifier*. The output voltage of the *output amplifier* is limited to internal power potentials by diodes that also provide lightning protection for the 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. Output impedance of 1200, 600, or 150 ohms is provided by switch selection of one, two, or all three resistors in the output impedance circuit.

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 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 on the facility side.

4.08 Lightning protection is provided for the *input amplifier* by diodes that prevent incoming voltage surges from exceeding internal power voltages. The output of the *input amplifier* is connected to the *rcv amplifier*, which is controlled by the front-panel *rcv gain/loss* slide switch and *rcv level* DIP switch. The *rcv gain/loss* slide switch determines whether gain or loss is provided in the receive path; the *rcv level* switch inserts the specific amount of gain or loss. The output of the *rcv amplifier* feeds a series-connected *receive equalizer amplifier,* which provides active slope equalization for the receive path. The amount of slope equalization provided is determined by the front-panel four-position *rcv eql* DIP switch. The output of the *receive equalizer amplifier* is connected to the *2wire-to-4wire hybrid* and then to the 2wire port.

signaling

4.09 DC signaling through the 4024B is accomplished by the simplex leads (SXT and SXR) on the facility side and by the A&B leads on the station side. Option switch *S12* allows for normal signaling operation, bypass operation, or reverse bypass operation. In the normal mode (*S12* set to *OPEN),* dc signals are derived from the facility by SXR lead. These signals are processed by a signaling unit and passed on to the station on separate leads, or on the station side ring (R) lead via the 4024B's B lead. Signals from the station are derived from the tip (T) lead by the A-lead inductor and are applied to the facility by the SXT lead either directly from the A lead or via a signaling module. The A&B leads can also be used to supply talk battery to the station via the T&R leads. In the bypass mode (*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 simplex leads and the A&B leads. In the reverse-bypass mode (*S12* set to *REV*), the connections between the SX leads and the A&B-lead inductor are reversed. This configuration is used in tandem applications and also to compensate for wiring reversals at other points in the circuit.

6. specifications

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

maximum output level (4wire xmt and 2wire)
no visible clipping at output level of +8dBm

frequency response, both channels (with no equalization in receive channel)
+0.7, −0.9dB, 300 to 3000Hz, at maximum gain

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

4wire-port terminating impedances (rcv and xmt)
1200, 600, or 150 ohms, balanced, individually switch-selectable at each port

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

simplex current
125mA maximum, with 5mA maximum unbalance

A&B-lead resistance
180 ohms nominal

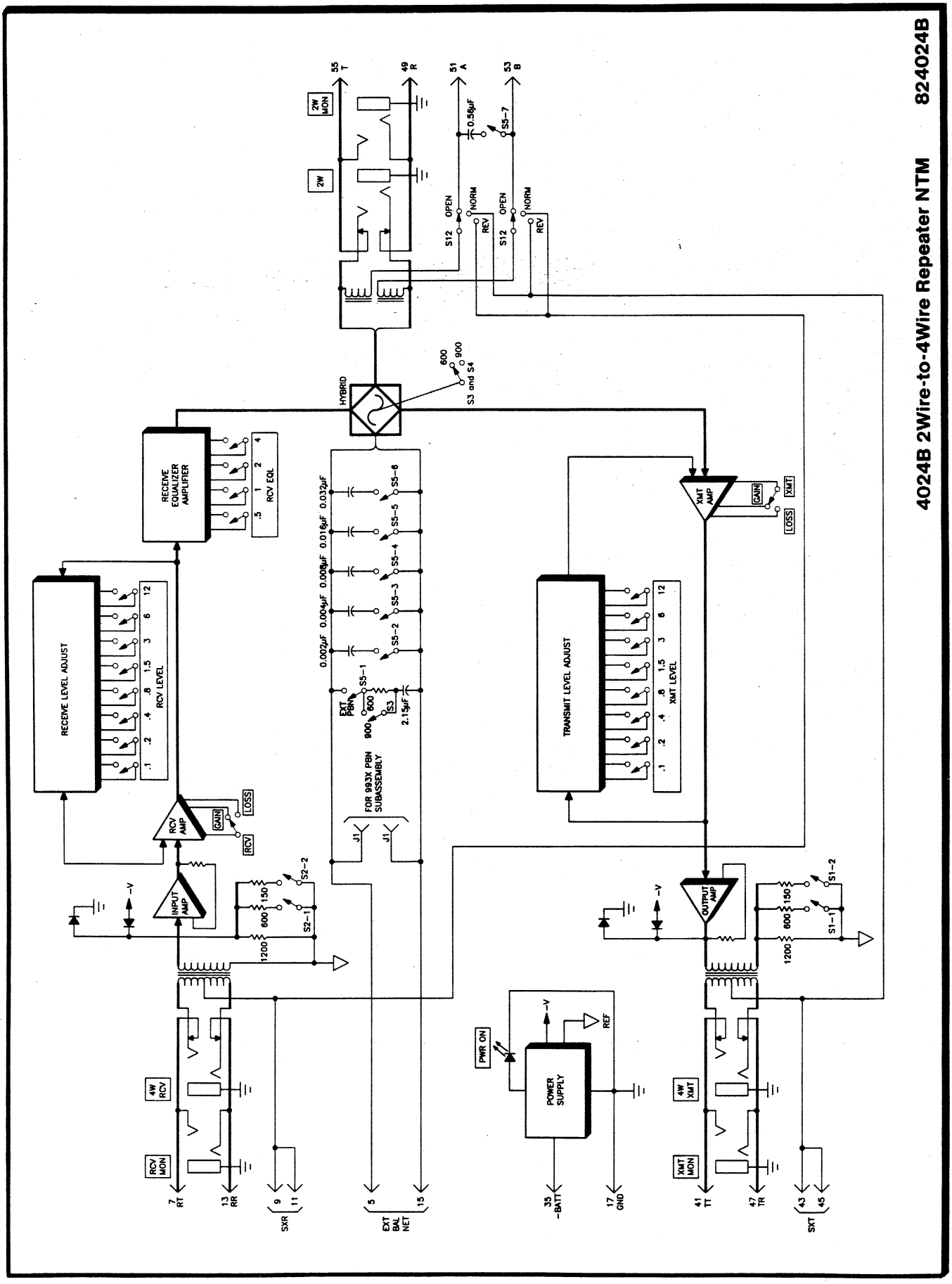
dc current capability
no performance degradation for A&B-lead current up to 100mA

insertion loss (with gain at 0dB)
±0.8dB nominal

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

harmonic distortion
less than 1%THD at 0dBm

crosstalk loss between units in adjacent shelf slots
90dB minimum at 1004Hz


4024B 2Wire-to-4Wire Repeater NTM 824024B
5. block diagram
2W MON
2W
4W RCV
RCV MON
4W XMT
XMT MON
HYBRID
RECEIVE EQUALIZER AMPLIFIER
RCV EQL
RECEIVE LEVEL ADJUST
RCV LEVEL
RCV AMP
GAIN
LOSS
RCV
INPUT AMP
TRANSMIT LEVEL ADJUST
XMT LEVEL
XMT AMP
XMT
OUTPUT AMP
FOR 993X PBN SUBASSEMBLY
EXT PBN
POWER SUPPLY
PWR ON
REF
S12 OPEN
NORM
REV
S5-7
S3 and S4
S1-1
S1-2
S2-1
S2-2
S5-1
S5-2
S5-3
S5-4
S5-5
S5-6
0.56µF
0.032µF
0.016µF
0.008µF
0.004µF
0.002µF
2.15µF
600
900
150
1200
J1
55 T
49 R
51 A
53 B
7 RT
13 RR
9
11
SXR
5
EXT BAL NET
15
35 -BATT
17 GND
41 TT
47 TR
43
45
SXT

4wire-port echo return loss
20dB minimum vs. 1200, 600 or 150 ohms, resistive

2wire echo return loss
30dB minimum vs. 900 or 600 ohms in series with 2.15μF

noise
2wire: 20dBrnC maximum at maximum gain
4wire xmt: 20dBrnC maximum at maximum gain

delay distortion (with no receive equalization)
4wire rcv to 2wire: 300μs, 500 to 4000Hz, re 1800Hz
2wire to 4wire xmt: 300μs, 500 to 4000Hz, re 1800Hz

transhybrid loss
45dB ERL minimum, with precision port termination of 900 or 600 ohms in series with 2.15μF

longitudinal balance
60dB minimum, 300 to 3000Hz, with A and B leads connected to battery and ground or left open

input power requirements
voltage: −22 to −56Vdc, filtered, ground referenced
current: 60mA maximum, 30mA idle

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

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

weight
14 ounces (397 grams)

mounting
one position of a Tellabs Type 10 Mounting Shelf, 262U NTS Assembly, 224A 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 4024B 2Wire-to-4Wire Repeater Network Terminating Module. The checklist is intended as an aid in the localization of trouble to a specific module. If a module is suspected of being defective, a new one should be substituted and the test conducted again. If the substitute module operates correctly, the original module should be considered defective and returned to Tellabs for repair or replacement 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.

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

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

USA customers: Contact Tellabs Customer Service at your Tellabs Regional Office.

Canadian customers: Contact Tellabs Customer Service at our Canadian headquarters in Mississauga, Ontario.

International customers: Contact your Tellabs distributor.

US Atlantic Region: (203) 798-0506
US Capital Region: (703) 478-0468
US Central Region: (312) 357-7400
US Southeast Region: (305) 834-8311
US Southwest Region: (214) 869-4114
US Western Region: (714) 850-1300
Canada: (416) 624-0052

7.03 If a module is diagnosed as defective, follow the *replacement* procedure in paragraph 7.04 when a critical service outage exists (e.g., when a system or a critical circuit is down and no spares are available). If the situation is not critical, follow the *repair and return* procedure in paragraph 7.05.

replacement

7.04 To obtain a replacement module, notify Tellabs via letter or telephone (see addresses and numbers below) or via TWX (910-695-3530 in the USA, 610-492-4387 in Canada). Be sure to provide all relevant information, including the 8X4024B part number that indicates the issue of the module in question. Upon notification, we shall ship a replacement module to you. If the module in question is in warranty, the replacement will be shipped at no charge. Pack the defective module in the replacement module's carton, sign the packing slip included with the replacement, and enclose it with the defective module (this is your return authorization). Affix the preaddressed label provided with the replacement module to the carton being returned, and ship the module prepaid to Tellabs.

repair and return

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

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

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

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

testing guide checklist

Note 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 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 −10dBm into *rcv mon* jack. Vary gain/loss controls over their entire ranges.	Signal level corresponds to gain or loss settings, with maximum gain of approximately 23dB and maximum loss of aproximately 25dB ☐.	Power ☐. Wiring ☐. Proper impedance terminations ☐. Impedance switches properly set ☐. Level settings ☐. Replace 4024B 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 impedance correct ☐.
2wire-to-4wire transmit gain/ loss	Insert opening plug into *4w rcv* jack. Connect properly terminated TMS (receive) to *4w xmt* jack. Use TMS (xmt) to insert 1004Hz test tone at −10dBm into *2w jack.* Vary gain/loss controls over their entire ranges.	Signal level corresponds to gain or loss settings, with maximum gain of approximately 23dB and maximum loss of approximately 25dB ☐.	Same as above ☐.

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