practice section 824024

4024 2Wire to 4Wire Repeater (24V4)

contents

1.01 The Tellabs 4024 2Wire to 4Wire Repeater (figure 1) provides level control, equalization and impedance matching between 4wire and 2wire voice-frequency transmission facilities. In effect, the single 4024 module functions both as a line amplifier and as a terminating set, and is commonly referred to as a 24V4-type repeater.

1.02 The transmit and receive amplifiers of the 4024 may be prescription-adjusted to provide from −16.5 to +16.5dB of gain in 0.1dB increments. Prescription slope equalization is provided in the receive channel of the 4024 module to compensate for the frequency response of nonloaded cable and, with slightly less effectiveness, loaded cable. Up to 7.5dB of slope equalization may be introduced in 0.5dB increments between 1000Hz and 3000Hz. All gain, attenuator, and equalizer adjustments are prescription-set via DIP switches to simplify both installation and alignment.

1.03 Impedance matching transformers facing the 4wire facility (transmit and receive) may be switch-optioned for a balanced impedance match of 1200, 600 or 150 ohms. These transformers are center-tapped to derive balanced simplex leads that provide for DX, loopback and other signaling schemes requiring a dc path.

1.04 An internal compromise balance network provides switch-selectable 600 or 900 ohm (in series with 2.15μF) 2wire impedance. Network build-out (NBO) capacitors associated with the balance network provide from 0 to 0.062μF (in 0.002μF increments) of NBO capacitance. Provision is made for removal of the internal compromise balance network when use with an external precision balance network is preferred.

1.05 An electronic hybrid and an electronic impedance transformer replace the usual magnetic transformer on the 2wire side, permitting the 4024 to operate with zero insertion loss. Thus, all gain provided by the 4024 is available at its output ports.

1.06 Standard A and B leads (inductor-isolated) are provided on the 2wire portion of the hybrid to accommodate various forms of dc signaling. The inductive isolation also permits direct A and B-lead connection to low-impedance terminations or

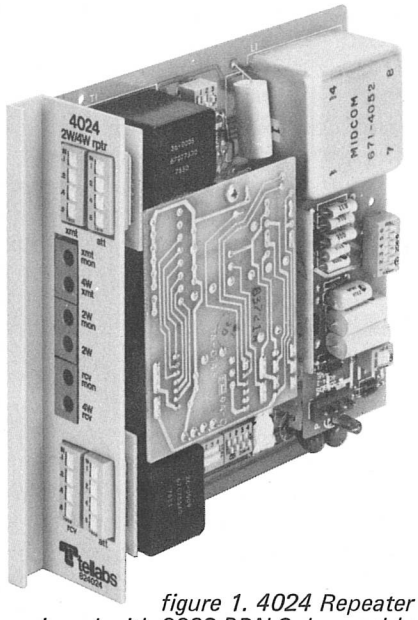


figure 1. 4024 Repeater equipped with 9932 PBN Subassembly

battery supplies. In addition, the A and B leads are shunted internally by a 1.0μF capacitor.

1.07 Surge protection is provided for the input and output of both transmit and receive amplifiers. Reverse-battery protection and transient-limiting circuitry are provided in the amplifiers' internal power supply circuitry. RC filtering and decoupling networks minimize crosstalk coupling and the effects of noise on the input power leads.

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

2. application

2.01 The Tellabs 4024 2Wire to 4Wire Repeater module combines a precision 4wire line amplifier with an electronic hybrid terminating set, thereby providing a 24V4 Type Repeater on a single Type 10 card. Specifically, the 4024 provides bidirectional level control, receive channel equalization and 2wire to 4wire conversion for voice-frequency transmission facilities. The 4024 is commonly used in applications serving PBX trunk circuits, off-premise extensions, 4wire tie lines, and other applications requiring a 24V4 repeater.

2.02 Gain or loss in both the transmit and receive channels is prescription-set via DIP switches

located on the module's front panel and printed circuit board. From −16.5 to +16.5dB of gain, in 0.1dB increments, is achievable in either direction of transmission.

2.03 Up to 7.5dB of slope equalization between 1000 and 3000Hz, in 0.5dB increments, is provided in the 4024's receive channel to compensate for the frequency response characteristics of loaded and nonloaded cable. Because the transmit channel is generally used to coordinate levels rather than to reduce facility loss, no transmit equalization capability is provided. (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 but also expedites the equalization procedure because the circuit is easier to equalize at the receive end.)

2.04 Impedance-matching options of 1200, 600, and 150 ohms in both the 4wire transmit and receive channels allow the 4024 to interface loaded (1200 ohm) or nonloaded (600 or 150 ohm) cable. On the 2wire side, switch-selectable 600 or 900 ohm impedance (in series with 2.15μF capacitance) permits interface with various terminal-side facilities and equipment. The 600-ohm option is selected when the 4024 interfaces nonloaded cable or terminal equipment, while the 900-ohm option is used when the 4024 interfaces loaded cable or switched networks accessing loaded or nonloaded cable.
Note: *The 150-ohm option on the 4wire side provides a nominal degree of slope equalization for nonloaded cable.*

2.05 To compensate for capacitance of office cables or other devices, NBO capacitance of 0 to 0.062μF (in 0.002μF increments) may be introduced. When the 2wire side of the 4024 interfaces loaded cable or short lengths of nonloaded cable terminated in 600 ohms +2.15μF or 900 ohms +2.15μF, the internal NBO capacitors will provide sufficient hybrid balance. However, if the 2wire side is terminated directly into a tel set or nonloaded cable and a tel set, an external precision balance network is recommended to optimize transhybrid loss. External PBN's are also recommended when the 4024 is used in toll applications where the 2wire impedances depart from 900 ohm +2.15μF or 600 ohm +2.15μF impedance terminations.

2.06 The external precision balance network may be provided as either a Tellabs 423X PBN module or, more conveniently, as a Tellabs 993X PBN subassembly. The 423X PBN is a Type 10 module. The 993X subassembly plugs physically and electrically into a 4-pin receptacle (P1) located on the 4024's printed circuit board. The 993X and 423X PBN's are available in several versions to approximate the impedances of specific transmission facilities and for equipment. For additional information on these PBN's, refer to the Tellabs 993X and 423X Practices.

2.07 Both the transmit and receive transformers on the 4wire side are center-tapped to derive simplex leads, which are required for DX signaling, loopback, and other signaling schemes requiring a dc path. A and B leads on the 2wire side will accommodate up to 100mA of direct current without degradation of performance. Inductive isolation of the A and B leads permits direct A- and B-lead connection of low-impedance terminations or battery supplies.

2.08 Front-panel bantam-type test jacks on the 4024 facilitate alignment and maintenance activities while the module is mounted in place. Both bridging and opening jacks are provided on the 2wire side and on each port (transmit and receive) of the 4wire side.

3. installation

inspection

3.01 The 4024 4Wire to 2Wire Repeater 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 4024 module mounts in one position of the Tellabs Type 10 Mounting Shelf, which is available in configurations for both relay rack and apparatus case installation. The module plugs physically and electrically into a 56-pin connector at the rear of the Type 10 Shelf.

installer connections

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

3.04 Table 1 lists external connections to the 4024 Repeater. All connections are made via wire wrap at the 56-pin connector at the rear of each module's mounting shelf position. Pin numbers are found on the body of the connector.

connect:	to pin:
4W transmit tip (TT)	55
4W transmit ring (TR)	49
4W transmit simplex (SXT)	51, 53
4W receive tip (RT)	5
4W receive ring (RR)	15
4W receive simplex (SXR)	1, 3
2W tip (T)	41
2W ring (R)	47
A lead	43
B lead	45
External Balance Network	7, 13
BATT (−22 to −56Vdc)	35
GND (ground)	17

table 1. External connections to the 4024 Repeater

option selection

3.05 Ten option switches (all of which are DIP switches) must be set before the 4024 is placed into service. These switches and their functions are described in paragraphs 3.06 through 3.09. Locations of these switches on the module's front panel and printed circuit board are shown in figure 2.

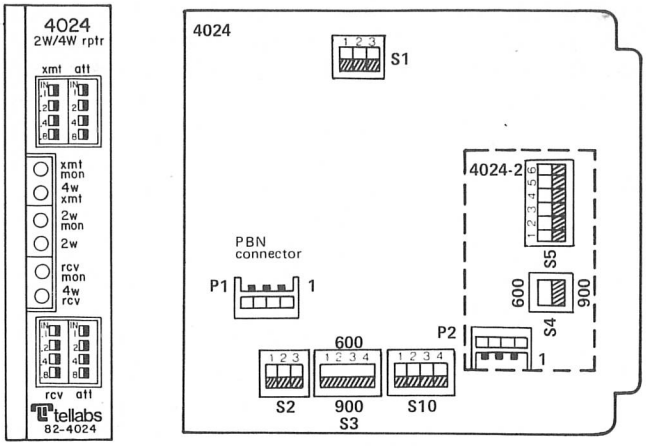


figure 2. Option switch locations

Note: *Verify that all option switches are set as shown in figure 2 before proceeding to the option selection paragraphs.*

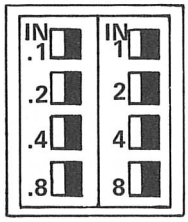


figure 3. 4Wire transmit attenuator switches

4wire transmit optioning

3.06 The 4wire transmit channel's impedance, gain, and attenuation are selected by means of DIP switch *S1* on the module's main board and the *xmt att* (transmit attenuation) DIP switches on the module's front panel. Switch *S1* is a three-position switch that controls the output impedance and gain of the transmit channel. The various settings of *S1* are summarized in table 2. The *xmt att* front-panel switches provide from 0 to 16.5dB of attenuation in 0.1dB increments. The amount of attenuation provided by each switch position appears on the front panel of the module adjacent to each switch position (see figure 3). These values are additive; thus, the amount of attenuation introduced is the sum of those switch positions set to *in*.

switch S1-1	S1-2	result	switch S1-3	result
OFF	OFF	1200 ohms	ON	16.5dB
ON	OFF	600 ohms		
ON	ON	150 ohms	OFF	0dB

table 2. Transmit impedance and flat gain optioning

4wire receive optioning

3.07 The 4wire receive channel's impedance, gain, attenuation, and equalization are selected by means of DIP switch *S2* on the module's main board, the *rcv att* (receive attenuation) DIP switches on the module's front panel, and DIP switch *S10* on the module's main board. Switch *S2* is a three-position switch that controls the input impedance and gain of the receive channel. The various settings of *S2* are summarized in table 3. The *rcv att* front-panel switches provide from 0 to 16.5dB of attenuation in 0.1dB increments. The amount of attenuation provided by each switch position appears on the front panel of the module adjacent to each switch position (see figure 4). Switch *S10* is a four-position switch that controls the active equalization provided in the receive channel. The various settings of switch *S10* are summarized in table 4.

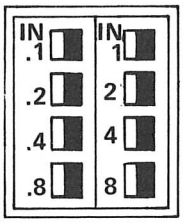


figure 4. 4Wire receive attenuator switches

switch S2-1	S2-2	result	switch S2-3	result
OFF	OFF	1200 ohms	ON	16.5dB
ON	OFF	600 ohms		
ON	ON	150 ohms	OFF	0dB

table 3. Receive impedance and flat gain optioning

switch S10-1	S10-2	S10-3	S10-4	1000Hz* gain (dB)
OFF	OFF	OFF	OFF	–
ON	OFF	OFF	OFF	0.5
OFF	ON	OFF	OFF	1.0
ON	ON	OFF	OFF	1.5
OFF	OFF	ON	OFF	2.0
ON	OFF	ON	OFF	2.5
OFF	ON	ON	OFF	3.0
ON	ON	ON	OFF	3.5
OFF	OFF	OFF	ON	4.0
ON	OFF	OFF	ON	4.5
OFF	ON	OFF	ON	5.0
ON	ON	OFF	ON	5.5
OFF	OFF	ON	ON	6.0
ON	OFF	ON	ON	6.5
OFF	ON	ON	ON	7.0
ON	ON	ON	ON	7.5

*3000Hz equalized gain is twice 1000Hz value shown

table 4. Receive channel active equalization optioning

2wire optioning

3.08 Selection of the impedance matching options, internal compromise balance network, and NBO capacitors are accomplished via DIP switch *S3* located on the module's main board, DIP switch *S4* located on the module's subassembly, and DIP switch *S5*, also located on the subassembly. Switches *S3* and *S4* select either the 600 ohm or 900 ohm 2wire impedance. Both switches **must** be set to either *600* or *900* ohm position to derive the proper impedance at all ports. Switch *S4* also automatically selects the proper internal compromise balance network impedance when set to the *600* or *900* ohm position. The first position of switch *S5* removes the internal compromise balance network. The remaining five positions of switch *S5* control the amount of NBO capacitance introduced into the circuit. The values of these switch positions are listed in table 6. These values are additive; thus, the amount of capacitance introduced is the sum of those switch positions set to *on*.

switch	option choice: on	option choice: off
*S3	600 ohms +2.15μF	900 ohms +2.15μF
*S4	600 ohms +2.15μF	900 ohms +2.15μF

*Switches *S3* and *S4* must be set to the same position.

table 5. Two-wire impedance optioning

switch position	option choice	
	on	off
S5-1	internal comp. net. inserted	internal comp. net. removed
S5-2	0.002μF	0
S5-3	0.004μF	0
S5-4	0.008μF	0
S5-5	0.016μF	0
S5-6	0.032μF	0

table 6. NBO capacitance optioning

external PBN optioning

3.09 When the 2wire portion of the 4024 is terminated directly into a tel set or into nonloaded cable and a tel set, an external PBN is recommended. This PBN may be a Tellabs 993X subassembly, which plugs into a 4-pin receptacle located on the 4024 module, or a Tellabs 423X PBN, which is a Type 10 module. The various Tellabs PBN's and the types of facilities or station equipment with which they are used are listed in table 7.

993X subassemblies	423X Type 10 modules	facilities/eqpt.
9930	4230	19-24ga. H88
9930A	4230A	26ga. H88
9932	4232	nonloaded cable with termination of 900Ω+2.15μF, 600Ω+2.15μF, or tel set
9933	4232	Type 500 tel set

table 7. External PBN information

Note: *With the 4024 optioned for 0dB gain, there is no insertion loss between the 2wire and 4wire ports.*

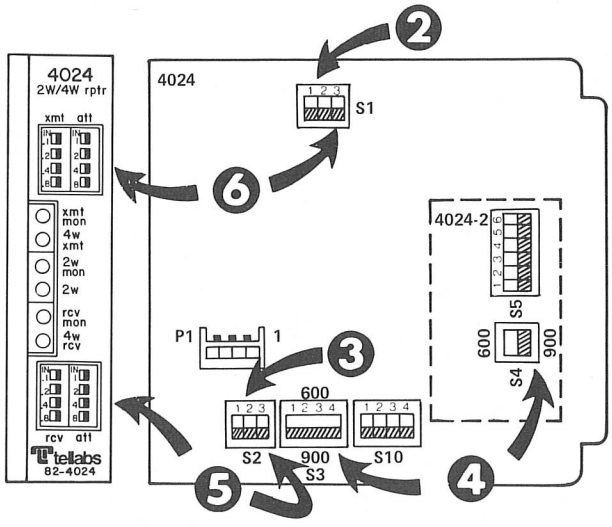
alignment

3.10 This alignment subsection is divided into two parts: preliminary alignment and final alignment verification. In the preliminary alignment procedure, impedance options are selected, equalization is introduced into the receive channel (if required) and gain or attenuation is introduced in both the transmit and receive channels to match the transmission levels specified on the circuit level record (CLR) card. In the final alignment verification procedure, the 4024 is placed into service and end-to-end transmission measurements are made. If the measured levels differ from those specified on the CLR card, the transmit and receive attenuator switches (front-panel mounted) are adjusted to provide the specified levels.

Note: *Two condensed preliminary alignment procedures (figures 5 and 7), two condensed final alignment verification procedures (figures 6 and 8), and a condensed NBO optioning procedure (figure 9) may be used to facilitate the alignment of the 4024 module.*

preliminary alignment

3.11 Refer to the CLR card for the required 4wire transmit output and 4wire receive input impedances. In general, the 1200-ohm option is used when the 4024 interfaces loaded cable; the 600-ohm option is used when the 4024 interfaces nonloaded cable; and the 150-ohm option is used when the 4024 interfaces nonloaded cable and a nominal degree of slope equalization is required. Refer to tables 2 and 3 and set switches *S1-1* and *S1-2* (transmit) and *S2-1* and *S2-2* (receive) as required.



1 Refer to the CLR card and determine the following: 4wire transmit impedance, 4wire receive impedance, 2wire impedance, required 4wire transmit signal level, required 4wire receive signal level, and the required 2wire drop signal level. Once the facility levels are known, determine the following: whether transmit gain or transmit attenuation is required, and whether receive gain or receive attenuation is required. Proceed to step 2 and perform the preliminary alignment procedures in numeric order. The paragraph referenced after each step provides a more detailed explanation of that specific procedure. After completing step 7, proceed to the final alignment verification procedures (figure 6) for instructions on making end-to-end facility measurements.

2 Set S1-1 and S1-2, in accordance with table 2 for 4w transmit impedance. (paragraph 3.06)

3 Set S2-1 and S2-2 in accordance with table 3 for 4w receive impedance. (paragraph 3.07)

4 Set S3 and S4 in accordance with table 5 for 2w impedance. Note: Both switches must be set to the same position. (paragraph 3.08)

5 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 3.16)

receive gain

a. Set S2-3 to on (inserts 16.5dB gain) and set all front-panel rcv att switches to in (inserts 16.5dB attenuation). Remove the amount of attenuation that adds up to the gain desired.

receive attenuation

b. Set S2-3 to off (no gain). Set to in the proper combination of rcv att switches that adds up to the amount of attenuation desired.

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 3.17)

transmit gain

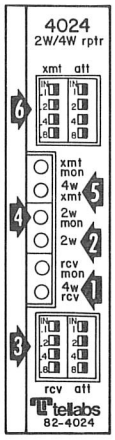
a. Set S1-3 to on (inserts 16.5dB gain) and set all front-panel xmt att switches to in (inserts 16.5dB attenuation). Remove the amount of attenuation that adds up to the gain desired.

transmit attenuation

b. Set S1-3 to off (no gain). Set to in the proper combination of xmt att switches that adds up to the amount of attenuation desired.

7 Insert the 4024 module into its mounting shelf, apply power and proceed to the final alignment verification (without equalization) procedure (figure 6).

figure 5. Preliminary alignment procedure — no equalization



1. Connect properly terminated TMS (receive) to 4w rcv jack. Request distant location to send 1000Hz tone at specified level. Verify tone is present and at level specified on CLR card. (paragraph 3.19)

2. Remove TMS from 4w rcv jack and connect the TMS (properly terminated) to the 2w jack. Request distant location to again send 1000Hz tone at specified level.

3. Determine the difference (if any) between the measured 1000Hz level and the 2wire level specified on the CLR card. If any difference in levels exists, insert or remove attenuation via the rcv att switches to obtain the specified level.

4. Remove TMS from 2w jack and 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 1000Hz tone at specified level.

6. Determine the difference (if any) between the measured 1000Hz level and the 4wire transmit level specified on the CLR card. If any difference in levels exists, insert or remove attenuation via the xmt att switches to obtain the specified level.

7. Remove all test cords from the 4024 and proceed to the NBO capacitor selection procedure (if required), figure 9.

figure 6. Final alignment verification — no equalization

1. Refer to the CLR card and determine the following: 4wire transmit impedance, 4wire receive impedance, 2wire impedance, required 4wire transmit signal levels, required 1000Hz and 3000Hz* 4wire receive signal level, and the required 2wire drop signal level. Once the facility levels are known, determine the following: whether transmit gain or transmit attenuation is required, whether receive gain or receive attenuation is required, and whether receive equalization is required. Proceed to step 2 and perform the preliminary alignment procedures in numeric order. The paragraph referenced after each step provides a more detailed explanation of that specific procedure.
*If the 3000Hz signal level is not specified on the CLR card, receive channel equalization, step 5, cannot be determined at this time. Omit steps 5 and 6 and proceed to step 7. After completing step 8, proceed to the final alignment verification procedures (figure 8) for instructions on making end-to-end facility measurements.

2. Set S1-1 and S1-2 in accordance with table 2 for 4w transmit impedance. (paragraph 3.06)

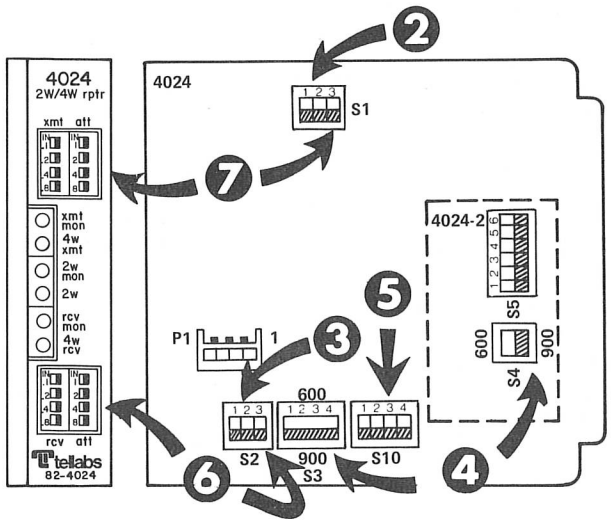
3. Set S2-1 and S2-2 in accordance with table 3 for 4w receive impedance. (paragraph 3.07)

4. Set S3 and S4 in accordance with table 5 for 2w impedance. Note: Both switches must be set to the same position. (paragraph 3.08)

5. Determine if equalization is required in the receive channel, and the type of cable the 4024 interfaces. Perform the appropriate equalization procedure as described below.

equalization — loaded cable
Determine the difference (in dB) between the 1000Hz and 3000Hz signal levels. Divide this difference by 2 and, referring to table 4, set switch S10 for the required (nearest but lower value) amount of equalization. (paragraph 3.14)

equalization — nonloaded cable
Determine the difference (in dB) between the 1000Hz and 3000Hz signal levels. Subtract 2dB from this difference and, referring to table 4, set switch S10 for the required (nearest but lower value) amount of equalization. (paragraph 3.13)



equalization — mixed cable
See final alignment verification procedure. (figure 8)

6. Note: The amount of equalization added in step 5 must be added to the specified 4wire receive level to obtain an equalized 4wire receive level.

If the specified 2w level is higher than the equalized 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 3.16)

receive gain
a. Set S2-3 to on (inserts 16.5dB of gain) and set all front-panel rcv att switches to in (inserts 16.5dB attenuation). Remove the amount of attenuation that adds up to the gain desired.

receive attenuation
b. Set S2-3 to out (no gain). Set to in the proper combination of rcv att switches that adds up to the amount of attenuation desired.

7. 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 3.17)

transmit gain
a. Set S1-3 to on (inserts 16.5dB gain) and set all front-panel xmt att switches to in (inserts 16.5dB attenuation). Remove the amount of attenuation that adds up to the gain desired.

transmit attenuation
b. Set S1-3 to out (no gain). Set to in the proper combination of xmt att switches that adds up to the amount of attenuation desired.

8. Insert the 4024 module into its mounting shelf, apply power and proceed to the final alignment verification (with equalization) procedure. (figure 8)

figure 7. Preliminary alignment procedure — with equalization

1. Connect properly terminated TMS (receive) to 4w rcv jack. Request distant location to send 1000Hz and 3000Hz tone at specified level. Measure and record these levels. (paragraph 3.19)

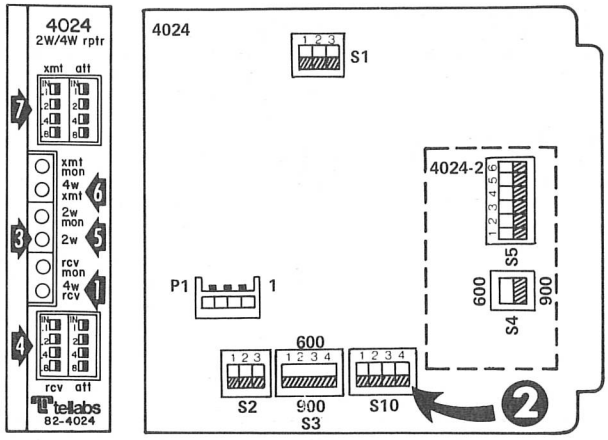
2. If receive equalization was determined in the preliminary alignment procedure (figure 7), omit this step and proceed to step 3. If not, determine the type of cable the 4024 interfaces and perform the appropriate equalization procedure below.

equalization — loaded cable
Determine the difference (in dB) between the 1000Hz and 3000Hz signal levels measured in step 1. Divide this difference by 2 and, referring to table 4, set 4-position switch S10 for the required (nearest but lower value) amount of equalization. (paragraph 3.14)

equalization — nonloaded cable
Determine the difference (in dB) between the 1000Hz and 3000Hz signal levels measured in step 1. Subtract 2dB from this difference and, referring to table 4, set 4-position switch S10 for the required (nearest but lower value) amount of equalization. (paragraph 3.13)

equalization — mixed loaded and nonloaded cable
Use the nonloaded cable equalization procedure above.

3. Remove TMS from 4w rcv jack and connect the TMS (properly terminated) to the 2w jack. Request distant location to again send 1000Hz tone at specified level. Measure and record this level.



4. Determine the difference (if any) between the measured 1000Hz level and the 2wire level specified on the CLR card. If any difference in levels exists, insert or remove attenuation via the rcv att switches to obtain the specified level.

5. Remove TMS from 2w jack and connect the properly terminated TMS (receive) to 2w mon jack. Insert opening plug into 2w jack and request 2wire location to send 1000Hz tone at specified level. Verify tone is present and at level specified. (paragraph 3.20)

6. Remove TMS from 2w mon jack and connect the TMS (properly terminated) to the 4w xmt jack. Remove opening plug from 2w jack. Request 2wire location to again send 1000Hz tone at specified level.

7. Determine the difference (if any) between the measured 1000Hz level and the 4wire transmit level specified on the CLR card. If any difference in levels exists, insert or remove attenuation via the xmt att switches to obtain the specified level.

8. Remove all test cords from the 4024 and proceed to the NBO capacitor selection procedure (if required), figure 9.

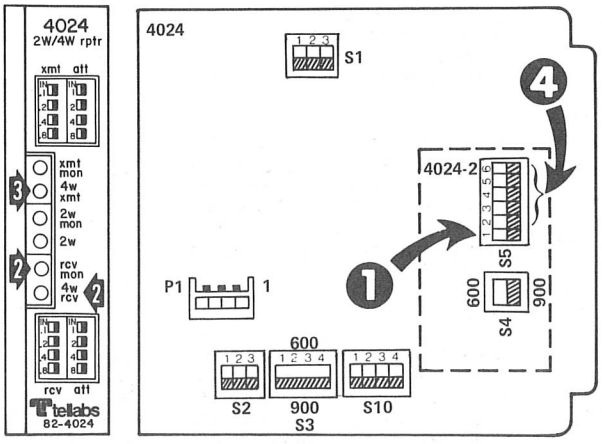
figure 8. Final alignment verification — with equalization

1. Determine if an external PBN is required, or if the internal compromise network provides sufficient transhybrid loss. If the internal compromise network is used, set S5-1 to on and proceed to step 2. If an external PBN is required, set S5-1 to off and refer to the PBN's practice for the proper alignment procedure.

2. Terminate the 2wire loop and insert an opening plug into the 4w rcv jack. Connect properly terminated TMS (transmit) to rcv mon jack and send 2000Hz tone at the specified 1000Hz signal level.

3. Connect properly terminated TMS (receive) to 4w xmt jack.

4. Refer to table 6 and set the proper combination of switches S5-2 through S5-6 to the in position that results in the lowest reading (maximum transhybrid loss) on the TMS.



5. Remove all test cords. Alignment procedure is completed.

figure 9. NBO options

3.12 Selection of impedance matching (compromise balance network) at the 2wire port is accomplished via switches *S3* and *S4*. Generally, the 600-ohm-plus-2.15μF option is used when the 2wire port interfaces nonloaded cable, while the 900-ohm-plus-2.15μF option is used when the 2wire port interfaces loaded cable. Set switches *S3* and *S4* as required in accordance with table 5.

Note: *If the 3000Hz signal level is not specified on the CLR card, receive channel gain and equalization cannot be determined at this time. Omit paragraphs 3.13 through 3.16 and proceed to the 4wire transmit gain procedure, paragraph 3.17. Receive gain and equalization will be determined in the final alignment verification procedures, beginning with paragraph 3.18.*

receive equalization — nonloaded cable

3.13 Refer to the CLR card for specified 1000Hz and 3000Hz receive signal levels. Determine the difference (in dB) between the 1000Hz and 3000Hz levels. Subtract 2dB from this difference and, referring to table 4, set 4-position switch *S10* for the required (nearest but lower value) amount of equalization. *(This setting flattens the response and adds 1000Hz gain equal to the amount of equalization selected. Therefore, when calculating receive gain (paragraph 3.16), the amount of equalized gain selected above must be added to the specified 4wire receive level to obtain an equalized 4wire level.)*

receive equalization — loaded cable

3.14 A loaded cable facility can be partially equalized with the equalized gain provided by the 4024 module. Refer to the CLR card for specified 1000Hz and 3000Hz receive signal levels. Determine the difference (in dB) between the 1000Hz and 3000Hz levels. Divide this difference by 2 and, referring to table 4, set 4-position switch *S10* for the required (nearest but lower value) amount of equalization. *(This setting flattens the response and adds 1000Hz gain equal to the amount of equalization selected. Therefore, when calculating receive gain (paragraph 3.16), the amount of equalized gain selected above must be added to the specified 4wire receive level to obtain an equalized 4wire level.)*

receive equalization — mixed cable

3.15 In order to determine the amount of equalization required when the 4024 module is used on mixed loaded and nonloaded facilities, end-to-end facility measurements must be taken. This procedure will be performed in the final alignment verification subsection, paragraph 3.19. Proceed to paragraph 3.16 and complete the remainder of the preliminary alignment procedures.

receive gain/attenuation

3.16 Refer to the CLR card for the specified 1000Hz 4wire receive and 2wire drop signal levels. If equalization was introduced, add the equalized gain figure (determined above) to the specified 1000Hz 4wire receive level to obtain an equalized 4wire receive level. Calculate the difference between the equalized 4wire receive level (or the specified 1000Hz 4wire receive level if no equalization was inserted) and the 2wire level. If the specified 2wire level is higher, gain must be added. Set switch *S2-3* to the *on* position (inserts 16.5dB gain) and set all front-panel *rcv att* switches to the *in* position (inserts 16.5dB attenuation). The amount of gain and attenuation now offset (cancel) each other. Remove (by setting the appropriate combination of *rcv att* switches to the out position) the amount of attenuation that adds up to the amount of gain desired. If the specified 2wire level is less than the 4wire level (with or without equalization), attenuation must be added. Set switch *S2-3* to the *OFF* position (no gain) and set to *in* the proper combination of *rcv att* switch positions that adds up to the amount of attenuation desired.

transmit gain/attenuation

3.17 Refer to the CLR card for the specified 1000Hz 2wire drop and 4wire transmit signal levels. If the specified 4wire transmit level is higher than the 2wire level, gain must be added. Calculate the difference between these two levels, set switch *S1-3* to the *ON* position (insert 16.5dB gain), and set all front-panel *xmt att* switches to the *in* position (insert 16.5dB attenuation). The amount of gain and attenuation now cancel each other. Remove (by setting the appropriate combination of *xmt att* switches to the out position) the amount of attenuation that adds up to the amount of gain desired. If the specified 4wire transmit level is lower than the 2wire level, attenuation must be added. Set switch *S2-3* to the *OFF* position (no gain) and set to *in* the proper combination of *xmt att* switch positions that adds up to the amount of attenuation desired.

final alignment verification

Note: *With the 4024 optioned for 0dB gain (or loss), there is no insertion loss between the 2wire and 4wire ports.*

3.18 In this final alignment verification procedure, the 4024 module is placed into service, signal level measurements are taken, and the front-panel *xmt att* and *rcv att* switches are adjusted (trimmed) to meet the levels specified on the CLR. Attenuation or gain introduced by trimming does not affect the equalization characteristics that may have been previously introduced by the equalization gain switches. **It is strongly recommended that no trimming be attempted with the equalized gain switches.**

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

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

A. Connect a properly terminated transmission measuring set (TMS) (receive) to the *4w rcv* jack. Request distant location to send 1000Hz and 3000Hz tone at the levels specified on the CLR card. Verify that tone is present, and record the levels.

B. If receive-channel equalization was determined in the preliminary alignment procedure

(paragraph 3.13 or 3.14), omit this step and proceed to step C. If not, determine the type of cable the 4024 interfaces and, using the 1000Hz and 3000Hz levels measured in step A, perform the equalization procedure in paragraph 3.13 or 3.14.

C. Remove the TMS from the *4w rcv* jack and connect the TMS (properly terminated) to the *2w* jack. Request the distant location to again send 1000Hz tone at the level specified on the CLR card.

D. Determine the difference (if any) between the measured 1000Hz level and the 2wire level specified on the CLR card. If any difference exists, insert or remove attenuation via the front-panel *rcv att* switches to obtain the specified level.

3.20 Transmit Channel. To perform the transmit-channel final alignment verification, proceed as follows:

A. Remove the TMS from the *2w* jack and connect the properly terminated TMS (receive) to the *2w mon* jack. Insert an opening plug into the *2w* jack and request the 2wire location to send 1000Hz tone at the level specified on the CLR card. Verify that tone is present and at the specified level.

B. Remove the TMS from the *2w mon* jack and connect the TMS (properly terminated) to the *4w xmt* jack. Remove the opening plug from the *2w* jack, and request the 2wire location to again send 1000Hz tone at the level specified on the CLR card.

C. Determine the difference (if any) between the measured 1000Hz level and the 4wire transmit level specified on the CLR card. If any difference exists, insert or remove attenuation via the front-panel *xmt att* switches to obtain the specified level.

balance network

3.21 If the 2wire port is terminated in either 900 or 600 ohms (in series with 2.15μF), the internal compromise network is inserted by setting switch *S5-1* to the *on* position and by setting switches *S3* and *S4* to match the 2wire terminating impedance. In addition, if a relatively short length of cable exists between the above termination and the 4024, its effect may be compensated for by inserting NBO capacitance (switches *S5-2* through *S5-6*) corresponding to the mutual capacitance of the facility (0.0157μF/kf nominal). If the 2wire port is terminated in a telephone set, extensive nonloaded facilities, etc., a PBN may be used to improve balance (i.e., increase transhybrid loss). When a PBN is used, the internal compromise network should be removed by setting switch *S5-1* to the *off* position. The PBN should then be adjusted, together with NBO capacitance, according to the PBN practice. If a PBN is not required, adjust the NBO capacitors as follows:

A. Set switch *S5-1* to the *on* position (this inserts the NBO capacitor network) and request that the distant 2wire loop be terminated. Insert an opening plug into the *4w rcv* jack. Connect a properly terminated TMS (transmit) to the *rcv mon* jack and send 2000Hz tone at the specified 1000Hz signal level.

B. Connect a properly terminated TMS (receive) to the *4w xmt* jack.

C. Refer to table 6 and set to *on* the proper combination of switches *S5-2* through *S5-6* that results in the lowest reading (maximum transhybrid loss) on the TMS. Remove all test cords. The alignment procedure is now completed.

programmed installation

3.22 The 4024 module is designed so that all options, including gain, equalization and attenuation, can be specified prior to installation. This "engineered" installation is made possible by the 4024 module's switch-selectable options and prescription alignment capability. Where computer-controlled test equipment is used, a subsequent printout will verify the engineering results. Any deviation from the required levels can then be adjusted, in 0.1dB increments, via the front-panel attenuator switches. A receive equalization gain chart (table 8), a chart of typical cable losses (table 9), and an example of a typical programmed installation are provided to aid the engineer in designing a programmed installation.

S10 setting 1000Hz gain	300 Hz*	500 Hz	1000 Hz	1500 Hz	2000 Hz	2500 Hz	3000 Hz
0.5dB	0.5	0.3	0.5	0.7	0.9	1.0	1.0
1.0	0.5	0.4	1.0	1.4	1.7	1.9	2.0
1.5	0.6	0.6	1.5	2.2	2.6	2.9	3.1
2.0	0.7	0.8	2.0	3.0	3.7	4.0	4.1
2.5	0.8	1.0	2.5	3.6	4.3	4.7	4.8
3.0	0.8	1.1	2.9	4.5	5.4	5.9	6.2
3.5	0.9	1.4	3.5	5.1	6.1	6.6	6.9
4.0	1.0	1.6	4.0	6.0	7.2	7.8	8.0
4.5	1.1	1.8	4.6	6.8	8.1	8.8	9.1
5.0	1.2	2.0	5.0	7.4	8.9	9.7	10.0
5.5	1.3	2.2	5.6	8.2	9.9	10.6	11.0
6.0	1.3	2.3	6.1	9.1	10.8	11.7	12.0
6.5	1.4	2.6	6.6	9.6	11.4	12.4	12.7
7.0	1.5	2.7	7.1	10.4	12.5	13.6	14.1
7.5	1.6	3.0	7.6	11.0	13.2	14.3	14.8

*With 600 ohm settings, the 300Hz level with no gain is +0.5 re to 1000Hz. See specifications.

table 8. Receive equalization gain measurements (typical results)

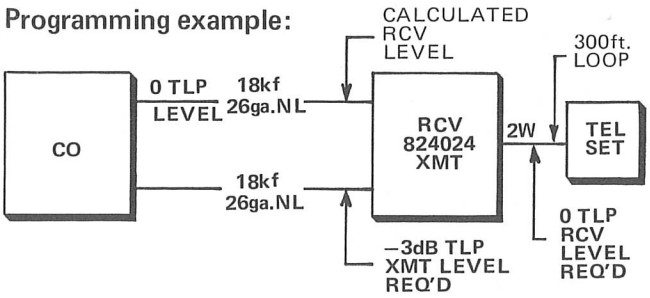
	300Hz	500Hz	1000Hz	2000Hz	3000Hz
26NL, 0.079μF/mi.	0.298	0.390	0.542	0.762	0.925
24NL, 0.084μF/mi.	0.238	0.312	0.444	0.615	0.750
22NL, 0.082μF/mi.	0.190	0.242	0.341	0.478	0.580
19NL, 0.084μF/mi.	0.134	0.172	0.241	0.330	0.394

table 9. Nominal nonloaded cable losses (dB/kf)

Note 1: *The above data assumes infinite cable length with the cable terminated in its characteristic impedance. However, typical termination is 600 ohms and the cable length is not infinite; therefore, actual response may be slightly flatter when actual cable facilities are used.*

Note 2: *Calculations performed and option switches set in the following example are explained in paragraphs 3.10 through 3.21 of this section.*

Programming example:



1. **4wire receive**

A. Active equalization:

freq. (Hz)	300	500	1000	2000	3000
loss (dB)	5.36	7.02	9.76	13.72	16.65

table A. Calculated losses for 18kf of 26ga nonloaded cable

From table A, 16.65dB −9.76dB = 6.89dB
6.89dB −2dB required droop = 4.89dB
Therefore, set *S10* to 4.5dB.

B. Flat gain:

frequency	300	500	1000	2000	3000
cable losses (Hz)	5.36	7.02	9.76	13.72	16.65
equalization +4.5dB gain (dB)	1.1	1.8	4.6	8.1	9.1
net loss (dB)	4.3	5.2	5.2	5.6	7.5

table B. Calculated flat gain results

From table B, calculated flat gain is 5.2dB. Set receive attenuators to *off*, resulting in 5.2dB of gain.
Resultant calculated facility response is shown in table C, and actual measured facility response is shown in table D.

freq. (Hz)	300	500	1000	2000	3000
net loss after final adjust. (dB)	+0.9	0.0	0.0	−0.4	−2.3

table C. Calculated facility response

freq. (Hz)	300	500	1000	2000	3000
cable loss (dB)	−6.7	−7.3	−8.8	−10.6	−15.5
net loss* (dB)	−1.6	−1.2	0.0	0.0	−2.2
*With 4.5dB equalized gain and 4.3dB flat gain.					

table D. Actual measured facility response

C. Impedance: 600 ohms plus gain. Set *S2-1* and *S2-3* to *on* and *S2-2* to *off*.

2. **4wire transmit**

A. Impedance: 600 ohms (set *S1-1* to *on* and *S1-2* to *off*).

B. Gain: none (set *S1-3* to *off*).

C. Attenuation: 3dB (set transmit attenuators for 3dB loss)

3. **Balance network**

A. NBO capacitors: (0.3kf) (0.0157μF/kf = 0.0047μF. Set *S5-3* to *in*.

B. PBN: Tellabs 9933 (set *S5-1* to *out*)

C. 2wire impedance: 600 ohms + 2.15μF (set *S3* and *S4* to *on*)

4. **circuit description**

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

4.02 The power supply in the 4024 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 An *electronic hybrid* with switch-selectable input impedance (600 or 900 ohms 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 tip and ring leads, and the other furnishing A and B leads. Current-dropping resistors (28 ohm) feed an inductor-cancelling circuit that eliminates the unwanted ac bridging impedance of the inductor. With the A and B leads shorted, the total dc resistance of the 4024 is 236 ohms.

4.04 Connected to the *electronic hybrid* are conventional transmit, receive, and balance network leads. The balance network is composed of the 600 or 900 ohm (in series with 2.15μF capacitance) impedance termination, network build-out capacitors, and provision for an external precision balance network. The internal balance network is removed and the external PBN inserted by switch *S5-1*.

4wire transmit

4.05 The output of the 4wire transmit channel uses a transformer to interface the transmission facility and to derive the tip, ring, and simplex leads. The secondary of the transformer is connected to the transmit amplifier and the output impedance circuit, which consists of three resistors. Switch selection of one, two, or all three resistors provides the 1200, 600, or 150-ohm output impedance.

4.06 Diodes that limit the amplifier's output voltage to internal power potentials also provide lightning protection for the transmit amplifier. The gain of the amplifier is controlled by switch *S1-3*, which provides 16.5dB of lumped gain when

set to *on* and no gain when set to *off*. The remaining transmit circuitry connects the output amplifier's input to the output of the *electronic hybrid* through a series of attenuator switches. These switches, in combination with the gain switch, provide the means to align the transmit amplifier.

4wire receive channel

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 simplex leads. The secondary of the transformer is coupled to a resistive bridging network and to the receive amplifier. The bridging network (switch-selected) provides either 1200, 600, or 150-ohm impedance matching to the facility.

4.08 Lightning protection is provided to the receive amplifier by diodes that prevent incoming voltage surges from exceeding internal power voltages. Amplifier gain is controlled by switch *S2-3* which provides 16.5dB of gain when set to *on* and zero gain when set to *off*. The output of the receive amplifier feeds an attenuator circuit and a series-connected, *equalized-gain amplifier*. The flat gain amplifier, attenuator circuit, and equalizer amplifier are prescription-adjusted and provide the means to align the receive channel. The output of the equalizer amplifier is connected to the *electronic hybrid* and then to the 2wire port.

6. specifications

gain range (xmt and rcv)
−16.5 to +16.5dB, switched

maximum output
no visible clipping at output level of +8dBm

transmit frequency response
±0.3dB, 500 to 3000Hz, re 1000Hz, at maximum gain
±0.5dB, 300 to 500Hz, re 1000Hz, at maximum gain

receive equalized gain
up to 7.5dB in 0.5dB increments between 1000 and 3000Hz

receive frequency response with maximum equalization (re 1000Hz)

frequency	equalization
300Hz	−5.9dB
500Hz	−4.5dB
1000Hz	0dB
2000Hz	+5.7dB
3000Hz	+7.5dB

4wire impedance (rcv and xmt)
switchable 1200, 600, or 150 ohms balanced

2wire impedance
switchable 900 or 600 ohms in series with 2.15μF balanced

simplex current
125mA maximum, with 5mA maximum unbalance

A and B lead resistance
236 ohms nominal

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

insertion loss (with gain at 0dB)
zero, nominal

NBO capacitance
0 to 0.062μF in 0.002μF increments

harmonic distortion
second harmonic −65dBm, third harmonic −79dBm for (output at 0dBm)

crosstalk loss between units in adjacent shelf slots
90dB minimum at 1000Hz

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

2wire echo return loss
40dB minimum vs. 900 or 600 ohms in series with 2.15μF

noise
2wire: 9dBrnC at maximum gain
xmt 4wire: 10dBrnC at maximum gain

delay distortion (with no equalization)
rcv to 2wire at maximum gain: 210μsec, 500 to 4000Hz, re 1800Hz
2wire to xmt at maximum gain: 20μsec, 500 to 4000Hz, re 1800Hz

transhybrid loss
50dB ERL and ERL HI, 40dB ERL LO minimum with precision port terminations 900 or 600 ohm in series with 2.15μF
20dB minimum with 993X or 423X PBN, 35dB typical

longitudinal balance
60dB minimum, 300 to 3000Hz, with A and B leads connected to battery and ground
50dB minimum, 300 to 3000Hz, with A and B leads open

input power
−22 to −56Vdc, 60mA maximum, 20mA quiescent

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 (3.16cm) wide
5.96 inches (15.14cm) deep

weight
14 ounces (397 grams)

mounting
one position of Tellabs Type 10 Mounting Shelf or 224 Repeater Assembly, or 19XX Apparatus Case

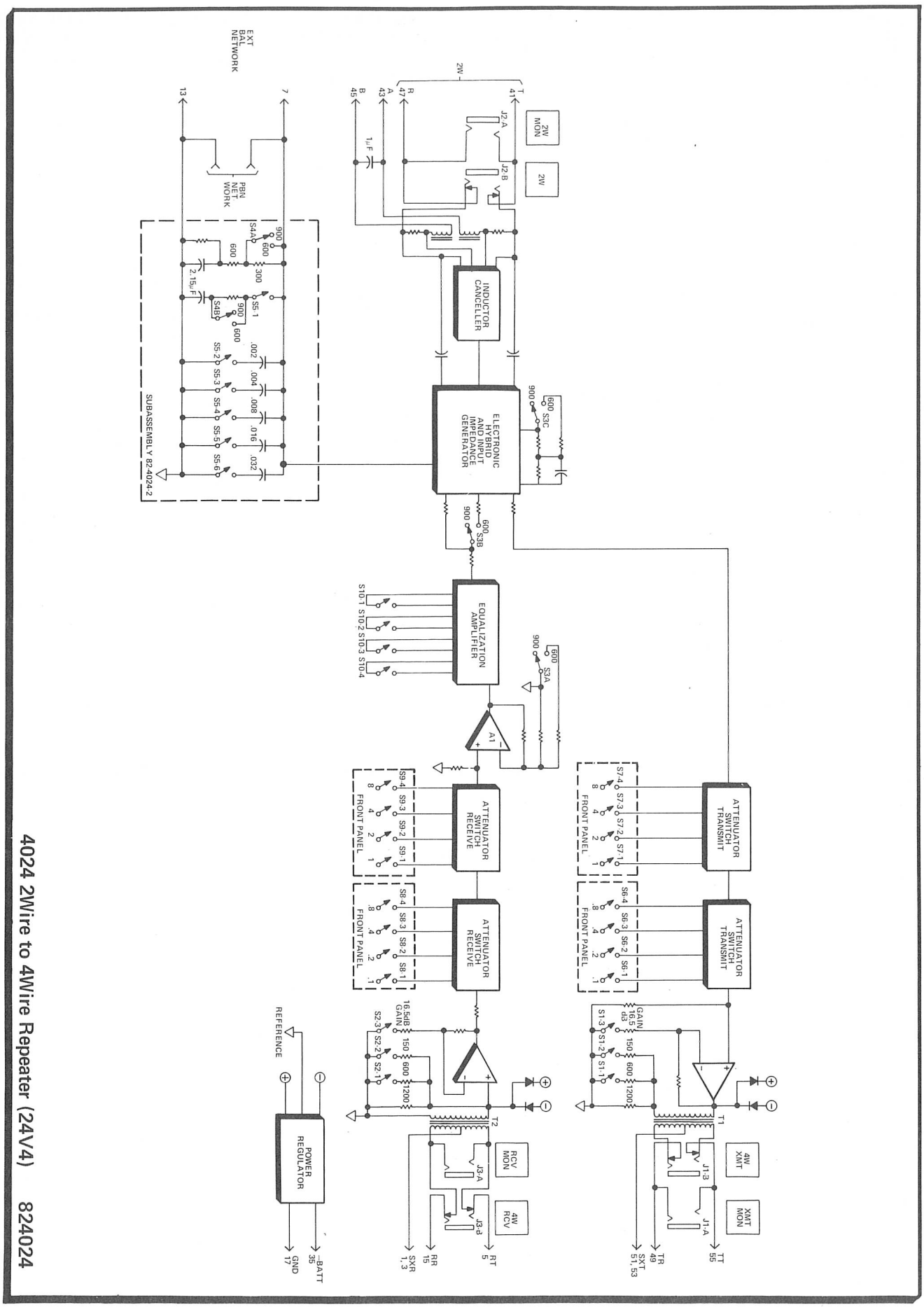
7. testing and troubleshooting

7.01 The Testing Guide Checklist may be used to assist in the installation, testing or troubleshooting of the 4024 2Wire to 4Wire Repeater module. The Testing Guide 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 module 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. It is strongly recommended that no internal (component level) testing or repairs be attempted on the 4024 module. Unauthorized testing or repairs may void the module's warranty.

7.02 If a situation arises that is not covered in the Checklist, contact Tellabs Customer Service at (312) 969-8800 for further assistance.

7.03 If a 4024 is diagnosed as defective, the situation may be remedied by either *replacement* or *repair and return*. Because it is the more expedient

testing and troubleshooting continued on page 12



5. block diagram

4024 2Wire to 4Wire Repeater (24V4) 824024

method, the *replacement* procedure should be followed whenever time is a critical factor (e.g., service outages, etc.).

replacement

7.04 If a defective 4024 is encountered, notify Tellabs via telephone [(312)969-8800], letter [see below], or twx [910-695-3530]. Notification should include all relevant information, including the 8X4024 part number (from which we can determine the issue of the 4024 in question). Upon notification, we shall ship a replacement module to you. If the warranty period of the defective module has not elapsed, the replacement module will be shipped at no charge. Package the defective module in the replacement module's carton; sign the packing list included with the replacement module 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 equipment prepaid to Tellabs.

repair and return

7.05 Return the defective 4024 Repeater, shipment prepaid, to: Tellabs Incorporated
4951 Indiana Avenue
Lisle, Illinois 60532
Attn: repair and return dept.

Enclose an explanation of the module's malfunction. Follow your company's standard procedure with respect 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

test	test procedure*	normal result	if normal conditions are not met, verify:
receive 4wire to 2wire gain	Place opening plug into *4w rcv* jack. Connect properly terminated TMS (receive) to *2w* jack. Insert 1000Hz test tone at specified level into *rcv mon* jack.	Signal level corresponds to gain or attenuator settings ☐.	Power ☐. Wiring ☐. Proper impedance terminations ☐. Impedance switches properly set ☐. Gain settings ☐. Attenuation settings ☐. Replace 4024 and retest ☐.
2wire to 4wire transmit gain	Place opening plug into *4w rcv* jack. Connect properly terminated TMS (receive) to *4w xmt* jack. Insert 1000Hz test tone at specified level into *2w* jack.	Signal level corresponds to gain or attenuator settings ☐.	Same as above ☐.

**Do not use an unbalanced measuring device or signal source for 2wire level measurements since erroneous reading will occur.*

Note: *Where dissimilar facilities are encountered (i.e., where 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 measuring set connected to the appropriate montior jack (e.g.,* rcv 4wire mon *when testing receive levels).*

Tellabs Incorporated
4951 Indiana Avenue, Lisle, Illinois 60532
telephone (312) 969-8800

Addendum 824024
1 April 1981

This addendum to Practice section 824024 dated 1 January 1980 provides revised transmit-channel alignment information for use in applications where the 4024's 2wire port is optioned for 900-ohm terminating impedance.

When the 2wire port impedance is set to 900 ohms and the transmit-channel gain and attenuation switches are set to *OFF* (0dB of gain and attenuation), an actual 1.8dB of gain is inserted between the 2wire port and the 4wire transmit port. Therefore, when prescription-aligning the transmit channel in programmed installation applications or when using cable records for gain calculations, a correction factor of 1.8dB must be used. That is, an additional 1.8dB of attenuation must be added to all gain or loss settings to compensate for this inherent gain. For example, to achieve an actual 0dB of gain between the 2wire port and the 4wire port, 1.8dB of attenuation must be inserted into the transmit channel via the front-panel *xmt att* switches.

This inherent gain is not present in the receive channel, and no correction factors are required in aligning this channel.