

**2-WIRE AND 4-WIRE DUPLEX
CHANNEL UNIT DESCRIPTION
D4 CHANNEL BANK
DIGITAL TRANSMISSION SYSTEMS**

CONTENTS	PAGE
1. GENERAL	1
2. CHANNEL UNIT DESCRIPTION	1
A. Application	1
B. Transmission Paths	2
C. Signaling and Supervision	3
3. CIRCUIT OPTIONS	3
4. REFERENCES	3

1. GENERAL

1.01 This section provides a detailed description of the 2-wire and 4-wire duplex signaling units used in the D4 channel banks. The 2-wire duplex signaling (2DX/GT) channel unit is shown in Fig. 1. The J, SD, and ED drawing numbers are shown in Table A.

1.02 Whenever this section is reissued, the reason for reissue will be listed in this paragraph.

1.03 This section provides a functional description of the channel unit(s) at a block diagram level. The transmission paths and signaling circuits that characterize the unit(s) are described herein. Circuit elements that are common to all units (active filters, pulse amplitude modulators and demodulators, gates, and channel unit logic functions) are mentioned in this section and described in detail in the general channel unit descriptive Section 365-170-101. Voice frequency levels, circuit and signaling options, and attenuator settings are given on the circuit layout

record card. The procedures for making the settings and adjustments are covered in Section 365-170-000 (TOP).

2. CHANNEL UNIT DESCRIPTIONS

A. Application

2.01 2-Wire Duplex With Gain Transfer (2DX/GT):

The 2DX/GT units provide 2-way calling with gain transfer capability between PBX locations over T Carrier. This unit has an internal-mounted variable resistor (RLP) and plug options A and B which are used to balance the signaling circuitry to the metallic loop. The 2-wire unit has a 900-ohm hybrid for connection to the customer loop, adjustable attenuators in the transmit and receive paths, and test jack access to the T&R leads on the front panel. An internal reversing switch in the A and B signaling leads (giving signal polarity reversal) permits application flexibility provided the opposite end of the VF extension is compatibly terminated. Figure 2 shows an application of the 2DX/GT channel unit.

2.02 4-Wire Duplex (4DX):

The 4DX unit provides a direct interface between the D4 bank and 4-wire metallic extensions using duplex (DX) signaling. The primary application for the unit is on PBX tie trunk circuits, but it can be used for other applications provided the opposite end of the VF extension is terminated with a compatible DX converter. The DX unit includes gain, equalization, and signaling circuits required to operate with relatively long 4-wire extensions of loaded or nonloaded cable with 1-kHz losses up to 15 dB. Figure 3 shows a typical 4-wire DX tie-line application.

**Reprinted to comply with modified final judgment.

B. Transmission Paths

2.03 2-Wire Duplex with Gain Transfer:

Voice frequency signals enter the channel unit from the 2-wire 900-ohm balanced metallic facility (Fig. 4). Line buildout capacitors (LBOC) are connected across the 2-wire line side of the hybrid transformers. The capacitors are added via slide switches to build out the cable end section to 6K feet.

2.04 The 2-wire 900-ohm balanced line is converted to an unbalanced 4-wire 600-ohm circuit by the hybrid transformers. Selection of either a compromise or precision balance network is made by placement of jumper plugs. The precision balance network is adjusted by slide switches and will match the line impedance to provide up to 35 dB transhybrid loss across the voice frequency band.

2.05 The slope equalizer circuit provides up to 7.5 dB of slope equalization to compensate for the roll-off due to the nonloaded cable capacitance. Slide switches select the values of slope, and the transmit and receive switches are ganged so the same amount of slope is added to both the transmit and receive transmission paths. The output of the equalizer passes through a high pass filter (HPF) to provide a compromise low frequency roll-off for all gauges of cable.

2.06 The transmit amplifier provides 4.4 dB gain to the equalized VF signal. Attenuator ATTEN1 adjusts the output of the receive amplifier to a -8.5 dB TLP at the test jack. ATTEN1 is capable of 16.5 dB attenuation in steps of 0.1 dB.

2.07 The TRMT low pass filter (LPF) has a 4-kHz high frequency cut-off to prevent fold over noise. The voice frequency output of the LPF is pulse amplitude modulated by the junction field effect transistor (JFET) gate which is controlled by pulses from the channel logic circuit and the D4 common circuitry. The PAM VF signal is connected to the D4 common circuits for transmission.

2.08 The received PAM pulses from the D4 common circuitry are demodulated by the receive JFET gate and the output of the receive LPF is reconstructed VF. The standard output level of the LPF is +4.0 dB TLP.

2.09 The idle circuit JFET gate opens the receive circuit when the receive VFs are not present. This removes idle circuit noise from the hybrid transformer and improves the circuit quality.

2.10 Attenuator ATTEN2 adjusts the LPF input level to the equalizer and RCV AMP which sets the correct VF output level for the 2-wire metallic facility. The attenuator has a maximum of 16.5 dB loss in steps of 0.1 dB.

2.11 The slope equalizer is identical to the one used in the transmit path, providing up to 7.5 dB slope equalization. The output of the equalizer passes through an HPF to provide a compromise roll-off for all gauges of cable.

2.12 The output of the equalizer is amplified by the receive amplifier (RCV AMP). The RCV AMP has a gain of about 4.4 dB. The AMP output is coupled to the 2-wire metallic line via the hybrid transformers. The actual 2-wire VF levels are found on the circuit layout record (CLR) card.

2.13 4-Wire Duplex: The 4-wire metallic facility connects to the 4-DX channel unit via the line impedance matching transformers T1 and T2 (Fig. 5). Switches S1 and S5 have four positions: open, 150 ohms, 600 ohms, and 1200 ohms. The open position disconnects the lines from the transformers. The 1200-ohm position is used when the unit is connected to loaded cable. The 600-ohm position is used when the unit is connected to nonloaded cable, and the 150-ohm position is used when the unit is connected to long lengths of nonloaded cable with V4-type equipment at the far end.

2.14 The 4DX transmit transmission path is the same as the 2 DX/GT as discussed in paragraphs 2.05 through 2.07.

2.15 The 4DX receive transmission path is the same as the 2 DX/GT as discussed in paragraphs 2.08 through 2.12 with the exception that the 4DX does not have the idle circuit receive path open feature or slope equalization. ATTEN2 adjusts the output of the REV AMP for the proper VF level on the 4-wire receive pair. The 4-wire transmission levels and control settings will be found on the CLR card.

B. Signaling and Supervision

2.16 DX signaling provides simultaneous signaling and supervision in two directions and requires two signal leads per circuit. The 2DX/GT derives the A and B signal leads by connecting the center taps of the line side of the hybrid transformers across a capacitor. The VF continues to use the balanced pair (Fig. 6).

2.17 The 4DX A and B leads are derived from the center tap of each line transformer, (Fig. 6).

2.18 When an idle condition exists, ground from the PBX circuit on the A and B leads, the bridge in the signaling circuit is balanced. The comparator sends a logic 0 to the D4 common circuits. The PBX then seizes the trunk and the K₁ relay operates, connecting -48 volts to the A lead. The bridge is unbalanced and the comparator transmits a logic 1 to the D4 common circuits. The logic change is transmitted over the T carrier facilities and the far end channel logic circuit operates the M relay and connects -48 volts to the bridge circuit. The -48 volts is connected to the A lead which transmits over the metallic facility to the far end and operates the K₂ relay. Relay K₂ connects -48 volts to the far end PBX circuit. The far end to near end operates the same in reverse direction over the B lead. Thus, duplex signaling and supervision is accomplished by means of the metallic facility and T carrier facilities.

2.19 A switch, NOR/REV, reverses the A and B leads at the input to bridge circuit when required.

3. CIRCUIT OPTIONS

3.01 Signaling and Supervision: The circuit options providing for A & B lead normal or reverse are given in Table B.

3.02 Equalization and Balance: The circuit options for slope equalization and hybrid balance are given in Table C for the 2DX/GT channel unit and Table D for the 4DX channel unit.

3.03 Attenuation and Gain and Loss Parameters: The parameters of insertion gain or loss, attenuator range, and input-output levels are shown in Table E.

3.04 The control settings and VF levels are given on the circuit layout record card and the procedures are covered in Section 365-170-000 (TOP).

3.05 Trunk Processing: Trunk processing is under the control of the D4 channel bank common circuits. A carrier failure results in the removal of -48 volts, thereby releasing the M relay causing the circuit to appear in an idle condition. Using the C option, the M relay is forced on after a delay of 2.5 seconds. Thus, the circuit appears busy and will not be seized during the carrier failure.

4. REFERENCES

4.01 The following is a list of sections associated with 2DX/GT and 4DX channel units.

SECTION	TITLE
179-100-311	D4 Channel Bank - Signaling Compatibility
365-170-000	D4 Channel Bank - TOP
365-170-100	D4 Channel Bank - Description
365-170-101	D4 Channel Bank - Channel Unit Description
365-170-500	D4 Channel Bank - Maintenance Consideration
660-47Y-ZZZ	Switching Offices - Through and Terminal Balance
855-351-103	D1, D2, D3, and D4 Channel Banks - Application Engineering
855-351-103	D4 Channel Bank Channel Units - Application Engineering

TABLE A

D4 CHANNEL UNITS

J98726()	SD/CD	CHANNEL UNIT TYPE	FACEPLATE MARKING
SD	7C026-0_	2-Wire Duplex With Gain Transfer	2DX/GT
SE	7C027-0_	4-Wire Duplex	4DX

TABLE B

CHANNEL UNIT OPTIONS

CHANNEL UNIT MARKING	OPTION	FUNCTION
2DX/GT (Gray) J98726SD SD7C026-0_	J4 (SD)	When selected, trunk processing (during a carrier failure alarm) will provide an on-hook, releasing the attached customer, followed 2.5 seconds later by an off-hook, making the channel appear busy.
	J3 (PBN)	When selected, terminates hybrid circuit with PBN.
	J3 (CN)	When selected, terminates hybrid circuit with 900 ohms plus 2.15 μ F compromise network (CN).
	A and B	Each option adds 1 μ F capacitance for loop balance. Optimum balance is obtained for all cable gauges of all lengths, either loaded or nonloaded, when 2 μ F capacitance is added. Therefore, it is recommended that both options be exercised.
	N or R	Switch provides for reversal of A and B lead connections.
4DX (Gray) J98726SE SD7C027-0_	A and B	Options each add 1 μ F capacitance for loop balance. Optimum balance is obtained for all cable gauges of all lengths, either loaded or nonloaded, when 2 μ F capacitance is added. Therefore, it is recommended that both options be exercised in all cases.
	C	Option provides a busy condition after 2.5 seconds during carrier failure. When option is not exercised, a continuous idle condition is provided.
	NOR/REV	Switch provides for reversal of simplex connections at 4-wire pairs.

TABLE C

EQUALIZATION AND BALANCE CONTROLS FOR 2DX/GT CHANNEL UNIT

CONTROL		POSITIONS	USED ON CU	FUNCTION
NAME	CIRCUIT BOARD STAMPING			
Slope	S2	0 to 15	All	Switch in position 0 (no numbers showing) provides no equalization, and frequency response is essentially flat. Provides from 0 through 7.5 dB of slope equalization in 16 steps by exposing switch numbers 8, 4, 2, 1 as required.
PBN-LF (for loaded and non-loaded cable; HF for MAT loaded) cable	R/R1	0 to 7 and L	All	Switch used to control the low-frequency impedance characteristics of the PBN. Expose numbers 4, 2, 1 as required. Exposing the L affects the degree of roll-off at the higher frequencies, extending the impedance characteristics of the PBN for synthesizing MAT boarded cable impedances. The R/R1 adjustment will affect the frequency at which the impedance curve levels out and should therefore be adjusted before setting R2.
PBN-HF (for nonloaded cable)	R2	0 to 15	All	Switch used to control the high-frequency impedance characteristics of the PBN for nonloaded cable. Expose numbers 8, 4, 2, 1 as required. Cover all numbers (zero setting) for loaded cable.
PBN-Z (for loaded and non-loaded cable)	Z	0 to 31	All	Switch used to make impedance adjustment, independent of frequency, to the impedance characteristics of the PBN.
PBN-Loaded Nonloaded (Facility)	S4 or S5 or LOADED - NONLOADED	LOADED or NON-LOADED	All	Switch used to select type of cable characteristics to be matched by the PBN. Expose LOADED or NONLOADED as required.
Loop Resistance Balance	RLP	0 to 5 K Ω	2DX/GT	Balances loop resistance in conjunction with unit capacitance balance options A and B (far-end terminating bridge impedance not included).

TABLE D

EQUALIZATION AND BALANCE CONTROLS FOR 4DX CHANNEL UNIT

CONTROL		POSITIONS	USED ON CU	FUNCTION
NAME	CIRCUIT BOARD STAMPING			
Slope	SL	0 to 15	All	Switch in position 0 (no numbers showing) provides no equalization and unit frequency response is essentially flat; ie, for 0 dB at 1 kHz, 500 Hz = -0.4 dB and 3000 Hz = + 0.1 dB. As switch position number increases, gain at 1 kHz increases to + 6.6 dB (N) or + 11.4 dB (L) for position 15 (numbers 1, 2, 4, and 8 showing). With N selected, gain at 500 Hz decreases to -4 dB relative to 1 kHz and gain at 3000 Hz increases to + 4.4 dB relative to 1 kHz. SL is the primary primary unit low-frequency equalization control.
Height	HT	0 to 15	All	Switch in position 0 (no numbers showing) provides no equalization. As switch position number increases, gain at 3250 Hz increases to + 11 dB for position 15 (numbers 1, 2, 4, and 8 showing) relative to 1 kHz. Used in conjunction with bandwidth (BW) as primary unit high-frequency equalization controls.
Bandwidth	BW	0 to 15	All	Switch in position 0 (no numbers showing) or HT control in position 0 provides no equalization. As switch position number increases, width of gain "bump" at 3250 Hz increases: height of "bump" is still determined by HT control.
Facility	N/L	N or L	All	Switch set to N (N showing) for nonloaded cable applications and generally set to L (L showing) for loaded cable applications. With switch set to N, SL control provides greater equalization at higher frequencies than it does with the switch set to L.
Transmit Path Input Impedance	S1 or OPEN/150	Open, 1200, 600, or 150	All	Selects input impedance see by line; 1200 ohms for loaded cable; 600 ohms or 150 ohms for nonloaded cable.
Receive Path Output Impedance	S2 or S5 or OPEN/150	Open, 1200, 600, or 150	All	Selects output impedance seen by line; positions same as S1.
Loop Resistance Balance	RLP	0 to 5 k Ω	4DX only	Balances loop resistance in conjunction with unit capacitance balance options A and B (far-end terminating bridge impedance not included).

TABLE E

CHANNEL UNIT ATTENUATION, GAIN, AND LOSS PARAMETERS

CHANNEL UNIT	TRANSMIT PATH (T, R TO TST JACK -8.5 dB TLP POINT)				RECEIVE PATH (TST JACK + 4.0 dB TLP POINT TO T1, R1, OR T, R (2W))			
	G_T INSERTION GAIN (+) OR LOSS (-) dB	ATTENUATOR RANGE (dB)	INPUT LEVEL AT, T, R, (dB) (SEE NOTE)		G_R INSERTION GAIN (+) OR LOSS (-) dB	ATTENUATOR RANGE (dB)	OUTPUT LEVEL AT, T1, R1 (dB) (SEE NOTE)	
			MIN	MAX			MIN	MAX
2DX/GT	+ 0.5	0 - 16.5	- 9.0	0	+ 2.0	0 - 16.5	- 9.0	+ 6.0
*4DX	+ 6.5	0 - 16.5	*	*	+ 2.0	0 - 16.5	- 9.0	+ 6.0

Note: Special service channel unit input and output levels are recommended values. In some cases, attenuator ranges cover a wider distribution of levels. It is recommended that circuit levels be constrained within the input and output levels specified in the table.

* Units with active post equalization.

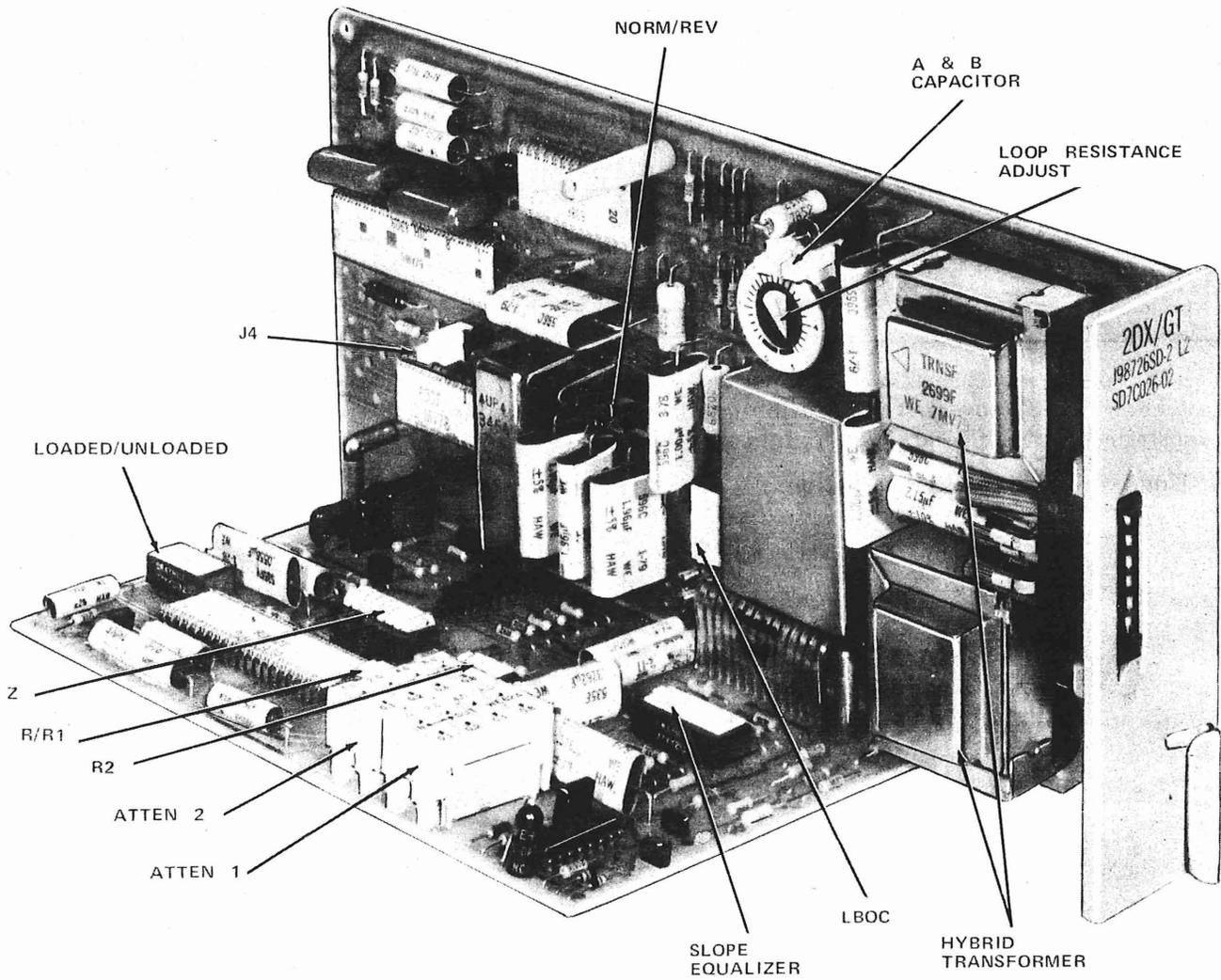


Fig. 1—2-Wire Duplex With Gain Transfer

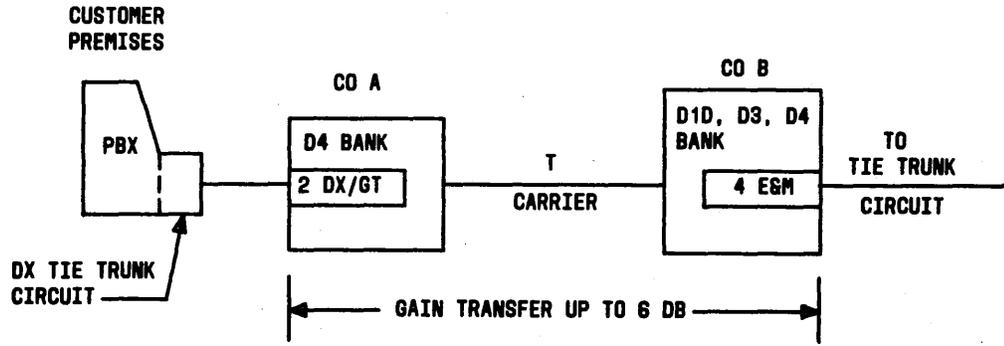


Fig. 2—An Application of 2DX/GT

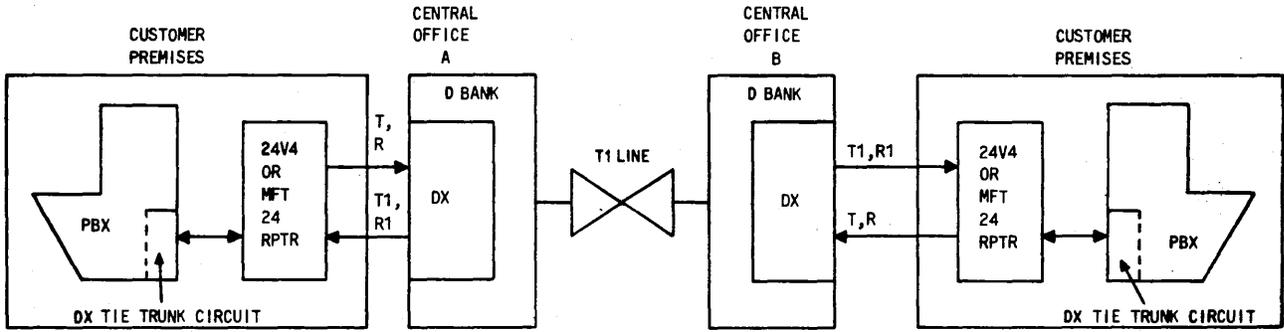


Fig. 3—Typical 4DX Tie Line Application

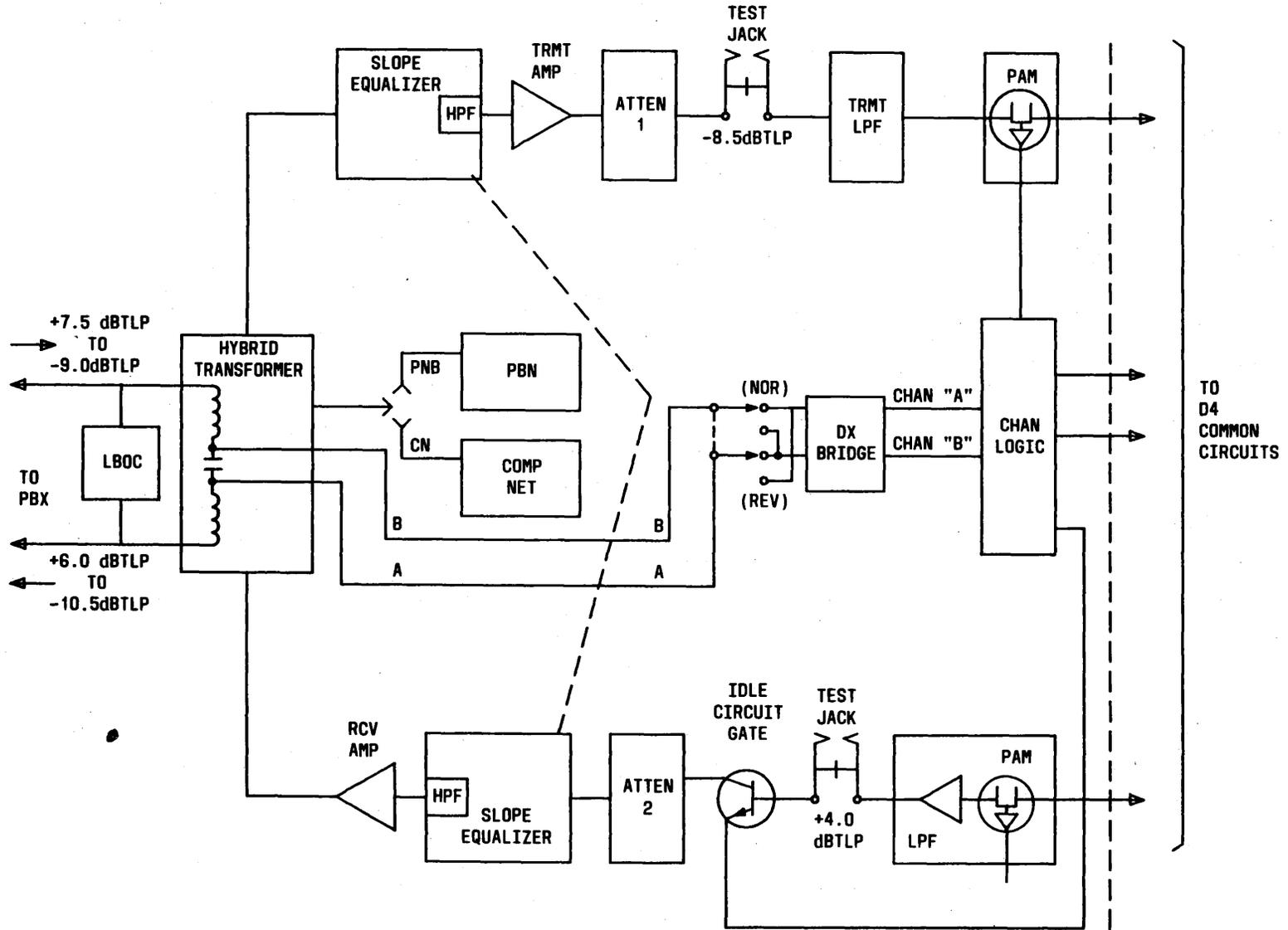


Fig. 4—2DX/GT Transmission Paths

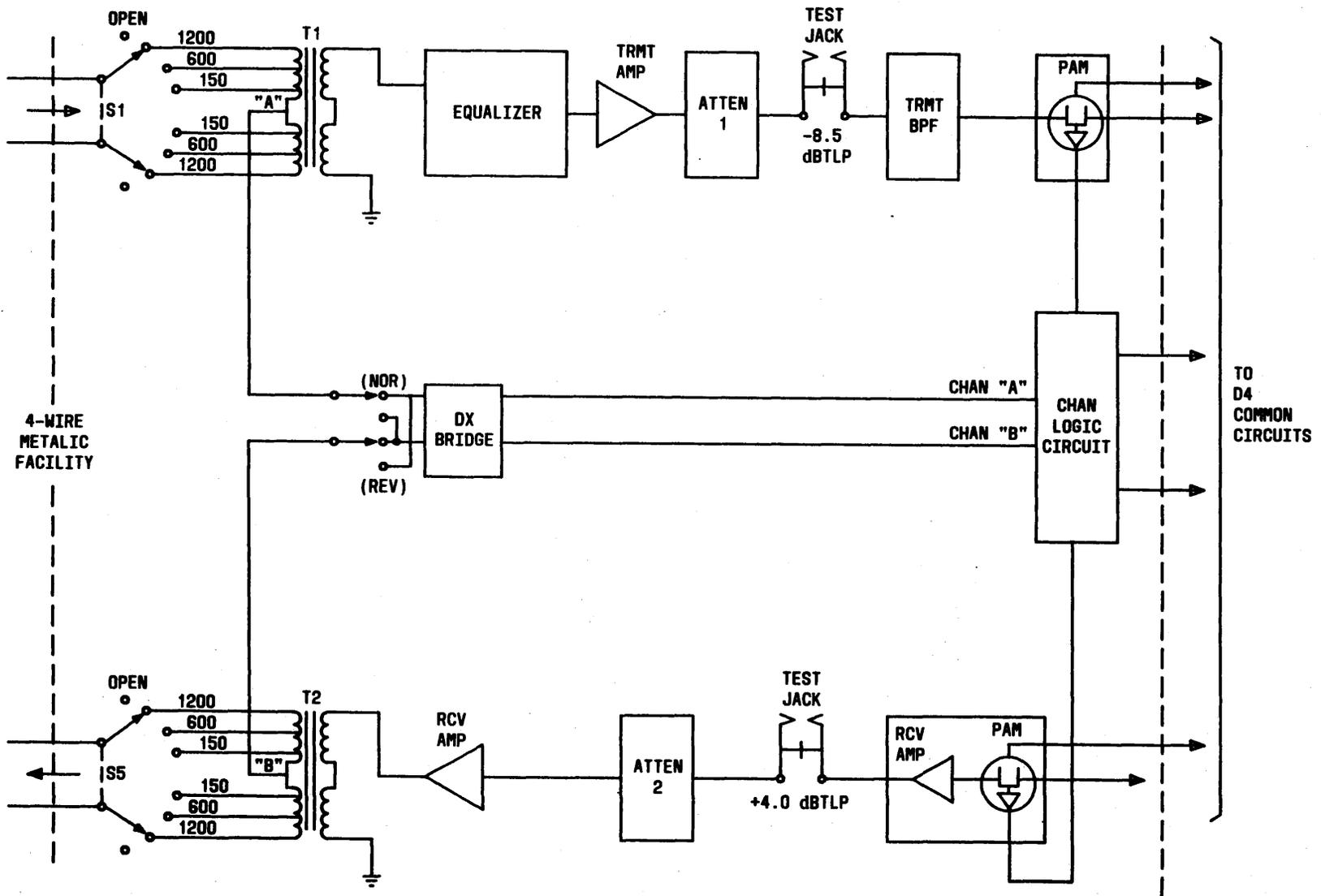


Fig. 5—4DX Transmission Paths

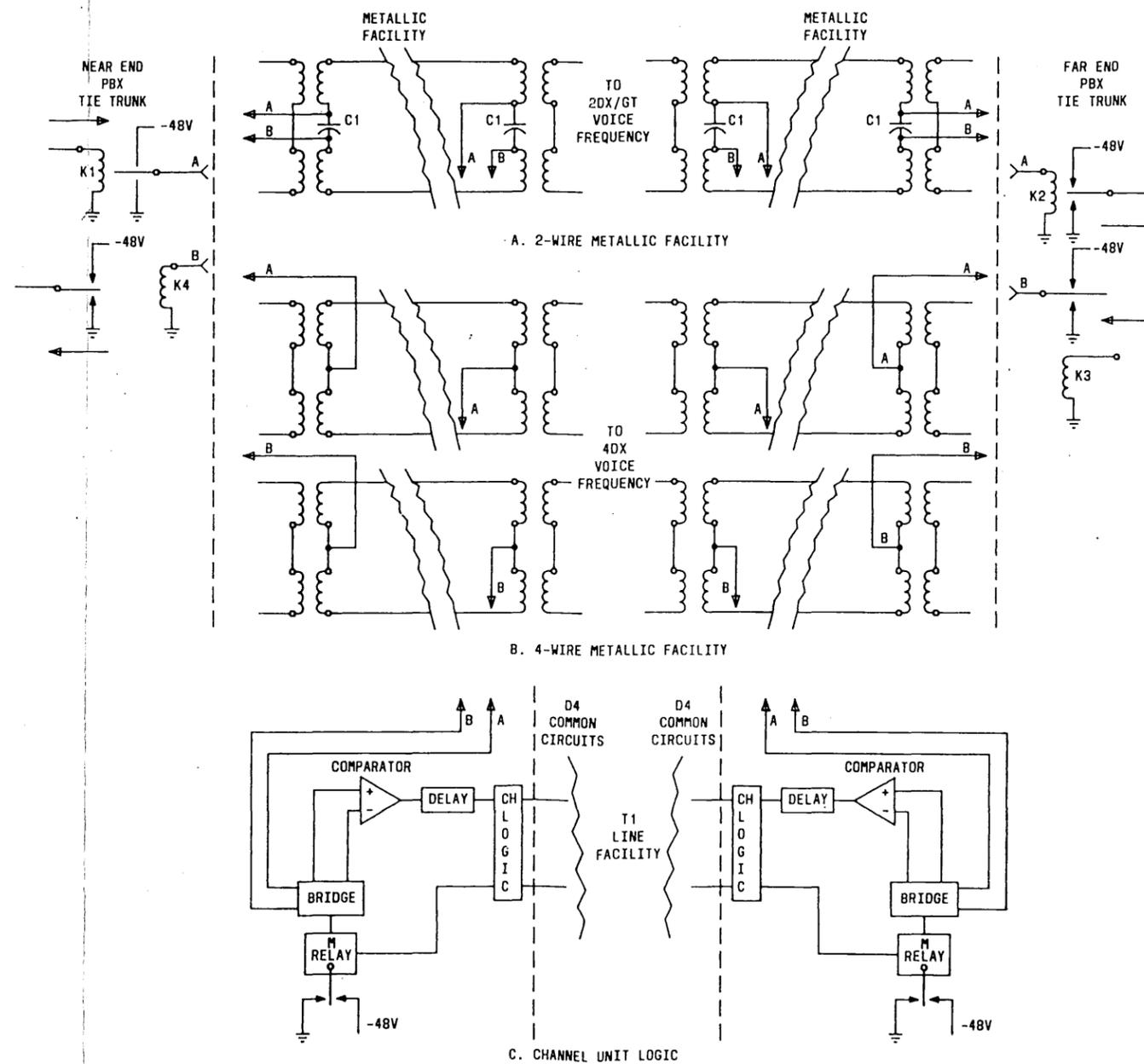


Fig. 6—2DX/GT and 4DX Signaling