

**FOREIGN EXCHANGE
CHANNEL UNIT DESCRIPTION
D4 CHANNEL BANK
DIGITAL TRANSMISSION SYSTEMS**

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1. GENERAL

1.01 This section provides a detailed description of the foreign exchange (FX) channel units used in the D4 Channel Bank. The types of FX channel units are shown in Table A with their respective codes, SD and J drawing numbers. A typical FX channel unit is shown in Fig. 1.

1.02 This section is reissued to include information on 2-wire 600-ohm FX channel units, 2FXS6 and 2FXO6. Revision arrows are used to emphasize the more significant changes.

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

2. CHANNEL UNIT DESCRIPTION

A. Application

2.01 The foreign exchange (FX) channel units provide an interface between the D4 Channel Bank and the central office or station ends of FX trunks, off premise stations (OPS), wide area telephone service (WATS), or FX lines from a private branch exchange (PBX). See Fig. 2.

2.02 The channel units provide signaling and supervision in the ground start mode for FX trunks and loop start mode for OPS, WATS, and FX lines from PBXs. ♦The channel units are 900 ohms impedance with the exception of the 2FXO6 and 2FXS6 which were designed to interface in close proximity with a 600-ohm PBX.♦

2.03 ♦As shown in Table B, the 2-wire FX office end (2FXO), station end (2FXS), and station end 600-ohm (2FXS6) channel units will function in both the ground and loop start signaling modes. The 2-wire FX loop-start only office end (2FXOLS), station end (2FXSLS), and office end 600-ohm (2FXO6) channel units provide a simpler FX unit when only loop-start will be required. When additional circuit gain is required, the 2-wire FX office end with gain transfer (2FXO/GT) and station end with gain transfer (2FXS/GT) channel units provide up to 6 dB gain transfer in either the loop or ground start signaling modes.♦

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2.04 The 4-wire FX office end (4FXO) and station end (4FXS) channel units provide signaling and supervision as mentioned in paragraph 2.02. These units contain gain, active equalization circuits, and switchable input-output impedance required on 4-wire extensions.

B. Transmission Paths 2FXO, 2FXS, 2FXOLS, 2FXSLS, 2FXO6, and 2FXS6

2.05 The 2-wire line is converted to an unbalanced 4-wire by means of a 2-transformer hybrid (Fig. 3). The compromise network (COMP NET) is electrically equivalent to the line impedance and balances the hybrid to attain required echo return loss.

2.06 The network buildout capacitor (NBOC) is used for trunk balancing in the 2FXO, 2FXS, and 2FXS6 units. It is connected in parallel with the compromise network and is selected by means of jumper plugs.

2.07 The TRMT attenuator adjusts the required -8.5 dB TLP at the transmitting TEST JACK in 0.1 dB steps. The TRMT FILTER passes voice frequencies (VF) from 400 to 2800 Hz and connects to the gating circuit.

2.08 The gating circuit samples the VF under the control of timing pulses from the channel logic circuit. The pulse amplitude modulated (PAM) output is connected to the D4 common circuits.

2.09 The proper channel received PAM pulses are selected by a gate which is under control of the channel logic circuit. The RCV FILTER reconstructs the VF signal and the output is the standard transmission level +4.0 dB TLP at the test jack.

2.10 The RCV attenuator adjusts the channel unit VF output to the desired TLP.

2FXO/GT and 2FXS/GT Channel Units

2.11 The transmission paths of the 2FXO/GT and 2FXS/GT (Fig. 4) are the same as the 2-wire channel unit without gain transfer except for the following.

- (1) Line buildout capacitors (LBOC) instead of NBOC.

- (2) Activate slope equalization with gain.

- (3) Interruption of transmission path during on hook.

- (4) Precision balancing network.

2.12 Selection of the compromise balance network (CN) or the precision balance network (PBN) is accomplished via jumper plugs. The PBN is capable of matching the impedance of nonloaded cable and H-88 loaded cable. The PBN adjustments allow a sufficient transhybrid loss to be maintained over the voice band to maintain singing margin in the presence of insertion gain.

2.13 Line buildout capacitors are connected in parallel with the 2-wire side of the hybrid. The capacitors are selected via slide switches to build out loaded cable end section to 6K feet.

2.14 The slope transmit and receive equalizers provide up to 7.5 dB of slope equalization to compensate for the high frequency roll-off due to unloaded trunk or station cable. The amount of slope is selectable via switches which are ganged with the transmit equalizer to provide the same amount of slope equalization in both the transmit and receive circuits. A gate opens the receive circuit during the idle or signaling states to prevent oscillation.

2.15 The transmission path is opened during the idle or signaling states to prevent oscillation. This would occur because the idle 2-wire end degrades the singing margin.

4FXO and 4FXS Channel Units

2.16 Voice frequency signals from the line enter the 4FXO or 4FXS channel unit through transformer T1 (Fig. 5). A switch provides for several different terminating impedances:

- (1) Open
- (2) 600 ohms for nonloaded cable
- (3) 1200 ohms for loaded cable
- (4) 150 ohms for long, nonloaded cable with V4 type equipment at the opposite end of the cable.

2.17 The active equalizer is capable of providing post equalization for all groups of nonloaded and H-88 loaded cables with up to 15 dB of 1-kHz insertion loss. Three sets of switches provide 16 settings each for slope (SL) roll-off, the 3250-Hz bump height (HT), and the bump bandwidth (BW). A single switch sets a low frequency pole at 401 Hz for loaded cable (L) or 1800 Hz for nonloaded cable (N).

2.18 The TRMT Attenuator adjusts the required -8.5 dB TLP at the transmitting TEST JACK in 0.1 dB steps. The TRMT FILTER passes voice frequencies (VF) from 400 to 2800 Hz and connects to the gating circuit.

2.19 The gating circuit samples the VF under the control of timing pulses from the channel logic circuit. The pulse amplitude modulated (PAM) output is connected to the D4 common circuits.

2.20 The proper channel received PAM pulses are selected by a gate which is under control of the channel logic circuit. The RCV FILTER reconstructs the VF signal and the output is the standard transmission level +4.0 dB TLP at the test jack.

2.21 The RCV attenuator adjusts the channel unit VF output to the desired TLP.

C. Signaling and Supervision

2.22 The 2FXO, 2FXS, 2FSX6, 2FXO/GT, 2FXS/GT, 4FXO, and 4FXS channel units operate on either loop start or ground start mode of signaling and supervision. The 2FXOLS, 2FXO6 and 2FXSLS operate in the loop start mode only.

2.23 The ground start signaling mode is used primarily in FX trunk applications, and the loop start mode is used with OPS, WATS, or FX lines. The signaling features of the FX channel units are shown in Table B.

Loop Start Mode

2.24 In the loop start mode (Fig. 6) 20-Hz ringing signals from the central office (CO) are detected by the FXO ringing detector circuit which changes the logic state in the B signaling channel. The FXS logic circuit receives the logic change and operates the RNG relay. The RNG relay connects 20-Hz ringing signals to the station loop.

When the station goes off hook, the ring trip detector during the 2-second ringing or the loop closure detector during the 4-second silent interval changes the logic state in the D4 signaling channel A. The FXO logic circuit detects the logic change and operates the LC relay, closing the loop to the CO. The CO removes the 20-Hz ringing, and the talking circuit is completed.

2.25 When the station places a call, the off hook is detected by the FXS loop closure detector, and the logic state of the D4 signaling channel A is changed. This change is detected by the FXO logic circuit and the LC relay is operated, closing the loop to the CO. When the CO loop closes, dial tone is furnished to the station. Dial pulsing at the FXS end opens and closes the station loop. The dial pulsing, via the logic circuits and D4 signaling channel A, operates and releases the LC relay which effectively loops pulses to the CO. Upon completion of the dial pulsing, the talking circuit is complete.

2.26 Supervision of the call is accomplished by means of the CO and station end loops. When the station goes on hook, the LC relay opens the loop to the CO, indicating an on-hook condition. When the CO station goes on hook, the CO loop is opened.

Ground Start Mode

2.27 The ground start mode uses ring ground, tip ground, and open and closed loop as signaling information (Fig. 7). When the FXS end goes off hook, a ground is placed on the ring of the station loop. The FXS channel unit ring ground detector senses the ground and transmits via the D4 signal channel B to the FXO end the ring ground information. The FXO channel unit operates the ring ground (RG) relay, placing a ground on the ring of the metallic loop to the CO.

2.28 When the CO receives ground on the ring, it answers back with a ground on the tip. The FXO channel unit detects the tip ground and transmits the information via the D4 signal channel A to the FXS channel unit. The FXS unit operates the tip ground (TG) relay, feeding filtered battery to the station by closing the loop. ♦The TG relay operation also converts the detector from ring ground to a loop closure configuration and transfers its output from signaling channel A to B.♦ The FXO unit in turn operates the LC relay, closing

the metallic loop to the CO switch, and releases the RG relay.

2.29 Dial tone is furnished to the station from the CO switch, and dial pulsing is accomplished by the open and closed station loop and pulsing of the LC relay at the office end. Circuit supervision is by means of opening the loop from either end.

2.30 When a call request for the FX station comes into the CO, the switch connects to the FX trunk, grounds the tip and connects 20-Hz ringing signal to the ring lead of the loop. The FXO channel unit ground detector sends a tip ground on the signal channel A, and the ringing detector circuit transmits the ringing signal via the signal channel B to the FXS. The FXS signaling logic circuit operates the TG relay providing filtered talking battery to the now closed station loop and operates the RNG relay, connecting 20-Hz ringing signal to the station loop.

2.31 When the station goes off hook, the ring trip detector during the 2-second ringing or the loop closure detector during the 4-second silent interval changes the logic state in the D4 signaling channel A. The FXO then operates the LC relay, closing the loop to the CO completing the talking circuit. Supervision is via the closed loops, and the call may be terminated by either the CO disconnecting or the station going on hook.

2.32 During a carrier failure the TG, RNG, or LC and RG relays release; thereby releasing the trunks or lines. Depending on the options selected, the TG, RG, or LC relay is operated after 2.5 seconds making the trunk appear busy; thereby preventing it from being seized during the failure.

3. CIRCUIT OPTIONS AND CONTROLS

Options

3.01 The signaling, supervision, and transmission options on FX channel units are described in Table C. The options are selected by means of socket and plug combinations.

Attenuation, Gain, and Loss Parameters

3.02 Table D provides a listing by channel unit of the insertion gain or loss of the units, the range of the unit attenuators, and the input and output TLP ranges.

Equalization and Balance Controls

3.03 Equalization: The equalization is accomplished by adding networks that compensate for the high and low frequency roll-off due to the characteristics of nonloaded and loaded cable facilities. Table E gives the equalization controls of the 2FSX/GT and 2FXO/GT channel units, and Table F gives the controls for the 4FXS and 4FXO channel units.

3.04 Hybrid Balance: When a hybrid is used in a 2-wire to 4-wire circuit arrangement, the loss between the 4-wire circuits is termed transhybrid loss. To obtain a high value of transhybrid loss, the impedance or electrical characteristics of the network must balance that of the 2-wire line. This is particularly important when gain transfer is employed. When the hybrid is used in a circuit not requiring high transhybrid loss, a compromise network consisting of a resistor and capacitor may be used. In a circuit where high transhybrid loss is required, a PBN is used. The fine adjustments afforded by the PBN result in high transhybrid loss.

3.05 The equalization and impedance controls are given in Tables E and F.

3.06 The selection and settings of the controls are given in Section 855-351-105.

Line Build-out Capacitors (LBOC)

3.07 The LBOC options are provided on the 2-wire gain transfer channel units for interfacing loaded cable. The capacitance is inserted as required to build out the cable end sections to an electrical equivalent of 6000 feet. Consult office records for the proper values prescribed.

4. REFERENCES

4.01 The following is a list of sections associated with D4 FX 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

SECTION	TITLE	SECTION	TITLE
365-170-101	D4 Channel Bank—Channel Unit Description	660-47V-ZZZ	Switching Offices—Through and Terminal Balance
365-170-500	D4 Channel Bank—Maintenance Considerations	855-351-105	D4 Channel Units—Application Engineering

TABLE A

FX CHANNEL UNITS

J98726()	SD/CD	CHANNEL UNIT TYPE	FACEPLATE MARKING
BD	3C325-0__	2-Wire Foreign Exchange Station End	2FXS
BE	3C326-0__	2-Wire Foreign Exchange Office End	2FXO
BK	3C338-0__	2-Wire Foreign Exchange Station End Loop-Start	2FXSLS
BL	3C339-0__	2-Wire Foreign Exchange Office End Loop-Start	2FXOLS
SB	7C024-0__	4-Wire Foreign Exchange Station End	4FXS
SC	7C025-0__	4-Wire Foreign Exchange Office End	4FXO
SG	7C029-0__	2-Wire Foreign Exchange Station End With Gain Transfer	2FXS/GT
SK	7C032-0__	2-Wire Foreign Exchange Office End With Gain Transfer	2FXO/GT
SR	3C459-0__	2-Wire Foreign Exchange Station End 600-Ohm	2FXS6
SS	3C460-0__	2-Wire Foreign Exchange Office End 600-Ohm	2FXO6

TABLE B

FX CHANNEL UNIT
FEATURES

UNIT	OFFICE END	STATION END	LOOP START	GRND START	2 WIRE	4 WIRE	INSERTION GAIN	900Ω	600Ω
2FXO	•		•	•	•			•	
2FXOLS	•		•		•			•	
2FXO6	•		•		•				•
2FXO/GT	•		•	•	•		•	•	
4FXO	•		•	•		•	•	SWITCHABLE	
2FXS		•	•	•	•			•	
2FXSLS		•	•		•			•	
2FXS6		•	•	•	•				•
2FXS/GT		•	•	•	•		•	•	
4FXS		•	•	•		•	•	SWITCHABLE	

◆TABLE C◆

CHANNEL UNIT OPTIONS

CHANNEL UNIT MARKING	OPTION	FUNCTION WITH WHITE OF JACK EXPOSED
2FXS (TAN DOT) J98726BD SD3C325-0_	SD (CN6) (CN9) (SL1 and SL2)	Trunk busied during a carrier failure by option applying ground to the tip lead. Selects 600-ohm compromise balance network. Selects 900-ohm compromise balance network. Always used.
2FXSLS (GRAY) J98726BK SD3C338-0_	STA 4ESS (CN6) (CN9) (SL1 and SL2)	Provides resistive balance network for nonswitched loops connected to station sets. Ties A and B signaling channels together. Selects 600-ohm compromise balance network. Selects 900-ohm compromise balance network. Always used.
2FXS6 (GRAY) J98726SR SD3C459-0_	SD	Trunk busied after a carrier failure by option applying ground to the tip lead.
2FXS/GT (GRAY) J98726SG SD7C029-0_	SD or J4 PBN or J3 J6 (SL1 and SL2) (J5)	Trunk busied during a carrier failure by option applying ground to the tip lead. Provides internal Precision Balance Network. Provides -72V battery feed for loops longer than () ohms when 72V is available in bay. Always used. Always used.

◆TABLE C (Contd)◆

CHANNEL UNIT OPTIONS

CHANNEL UNIT MARKING	OPTION	FUNCTION WITH WHITE OF JACK EXPOSED
4FXS (GRAY) J98726SB SD7C024-0_	SD N/R or J6 and J7 J2 J3 and J4	Trunk busied during a carrier failure by option applying ground to the tip lead. Reverses the multiplexed signaling leads. Provides -72V battery feed for loops longer than () ohms when 72V is available in bay. Always used.
2FXO (GREEN) J98726BE SD3C326-0_	LX1 and 2 GS or GS1 and 2 LS RG (CN9)	Increases loop current for loops longer than 600 ohms. Ground start signaling. Loop busied by applying loop closure during a carrier failure. Trunk busied by applying a ring ground during a carrier failure. Provides 900-ohm compromise balance network.
2FXOLS (GRAY) J98726BL SD3C339-0_	LX1 and LX2 LS 4ESS (CN9)	Increases loop current for loops longer than 600 ohms. Loop busied by applying loop closure during a carrier failure. Ties A and B signaling channels together. Selects 900-ohm compromise balance network.
2FXO6 (GRAY) J98726SS 3C460-0_	LX1 and 2 LS 4ESS	Increases loop current for loops longer than 600 ohms. Loop busied by applying loop closure during a carrier failure. Ties A and B signaling channels together.

♦TABLE C (Contd)♦

CHANNEL UNIT OPTIONS

CHANNEL UNIT MARKING	OPTION	FUNCTION WITH WHITE OF JACK EXPOSED
2FXO/GT (GRAY) J98726SK 7C032-0_	J2 or LX1 and 2 GS or GS1 and 2 or J4 LS RG PBN or J6 J5	Increases loop current for loops longer than 600 ohms. Ground start signaling. Loop busied by applying loop closure during a carrier failure. Trunk busied by applying a ring ground during a carrier failure. Provides internal Precision Balance Network. Always used.
4FXO (GRAY) J98726SC 7C025-0_	LX1 GS or GS1 and 2 LS RG NR or J4 and J5	Increases loop current for loops longer than 600 ohms. Ground start signaling. Loop busied by applying loop closure during a carrier failure. Trunk busied by applying a ring ground during a carrier failure. Reverses the multiplexed signaling leads.

TABLE D
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
SPECIAL SERVICE								
2FXO	-4.0	0 — 6.3	-4.5	+1.8	-4.0	0 — 6.3	-6.3	0
2FXS	-4.0	0 — 6.3	-4.5	+1.8	-4.0	0 — 6.3	-6.3	0
2FXOLS	-4.0	0 — 6.3	-4.5	+1.8	-4.0	0 — 6.3	-6.3	0
2FXS6		0 — 16.5	-6.2	0	-4.0	0 — 16.5	-8.2	0
2FXO6		0 — 16.5	-6.9	0	-4.0	0 — 16.5	-6.9	0
2FXS/GT	+0.5	0 — 16.5	-9.0	0	+2.0	0 — 16.5	-8.0	+6.0
2FXO/GT	+0.5	0 — 16.5	-9.0	0	+2.0	0 — 16.5	-8.0	+6.0
4FXO	+6.5	0 — 16.5	*	*	+2.0	0 — 16.5	-8.0	+6.0
4FXS	+6.5	0 — 16.5	*	*	+2.0	0 — 16.5	-4.0	+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 with the input and output levels specified in the table.

* Units with active post equalization.

TABLE E

EQUALIZATION AND IMPEDANCE CONTROLS FOR 2-WIRE CHANNEL UNITS

CONTROL		POSITIONS	USED ON CU	FUNCTION
NAME	CIRCUIT BOARD STAMPING			
Slope	(S2) SL	0 to 15	GT	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 nonloaded cable; HF for MAT loaded cable)	R/R1	0 to 7 and L	GT	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	GT	Switched 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 nonloaded cable)	Z	0 to 31	GT	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 NONLOADED	GT	Switch used to select type of cable characteristics to be matched by the PBN. Expose LOADED or NONLOADED as required.
NBOC	2, 4, 8, 16, 32, 64	2, 4, 8, 16, 32, 64	2FXS 2FXS6 2FXO 2FXLS 2FXOLS	Network build-out capacitors are used to balance the drop side wiring capacitance, and are set to the value prescribed for the office.
LBOC	S1 or LBOC	A, B, C, D, E, F	GT	Line build-out capacitors are used to build out loaded cable end sections to 6000 feet.

Note: For the setting of these controls see BSP 855-351-105.

TABLE F

EQUALIZATION AND IMPEDANCE CONTROLS FOR 4-WIRE CHANNEL UNITS

CONTROL		POSITIONS	FUNCTION
NAME	CIRCUIT BOARD STAMPING		
Slope	SL	0 to 15	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 unit low-frequency equalization control.
Height	HT	0 to 15	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	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	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	TRMT or S1	Open 1200, 600, or 150	Selects input impedance seen by line; 1200 ohms for loaded cable; 600 ohms or 150 ohms for nonloaded cable.
Receive Path Output Impedance	RCV or S2	Open, 1200, 600, or 150	Selects output impedance seen by line; positions same as S1.

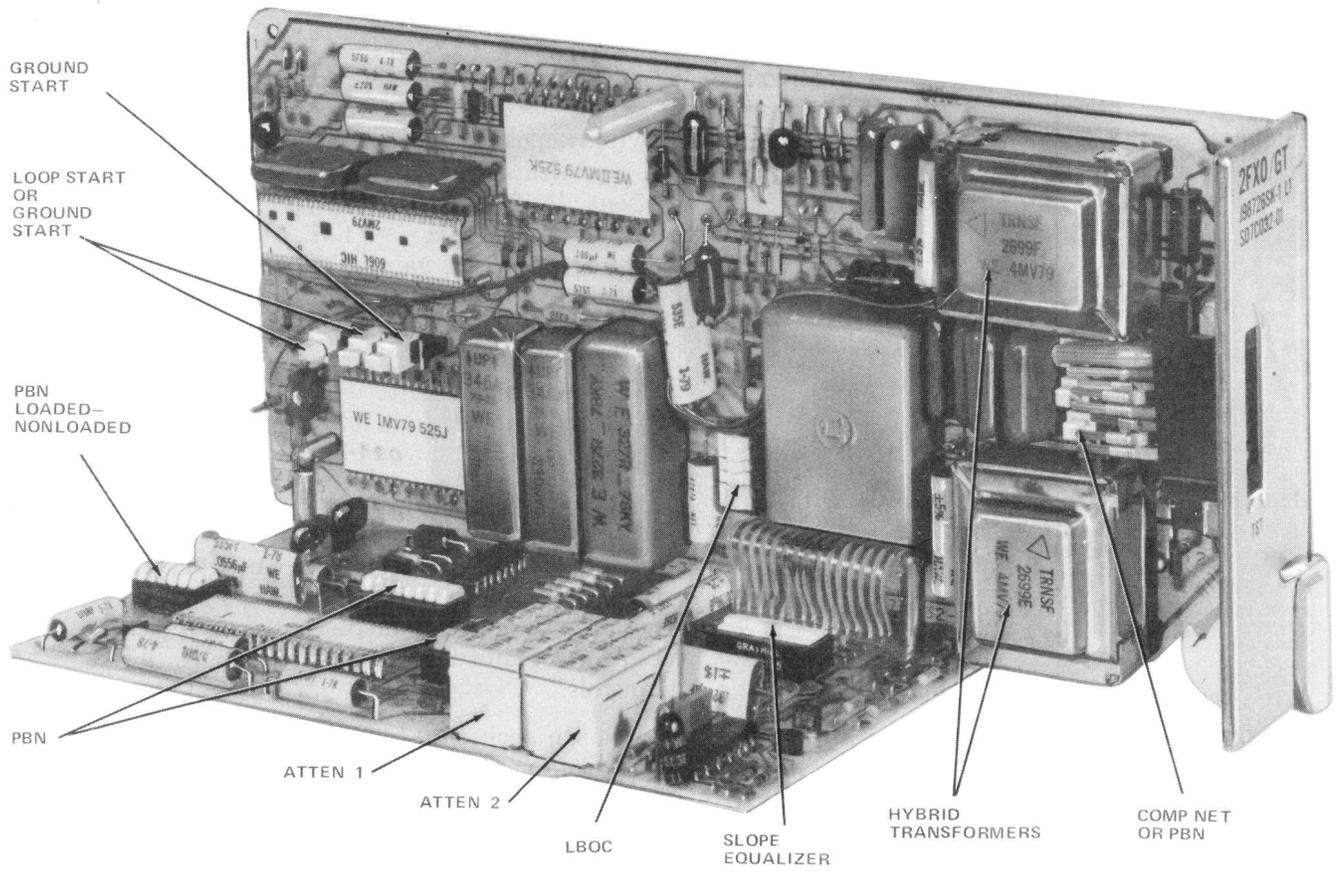


Fig. 1—Typical Foreign Exchange Channel Unit

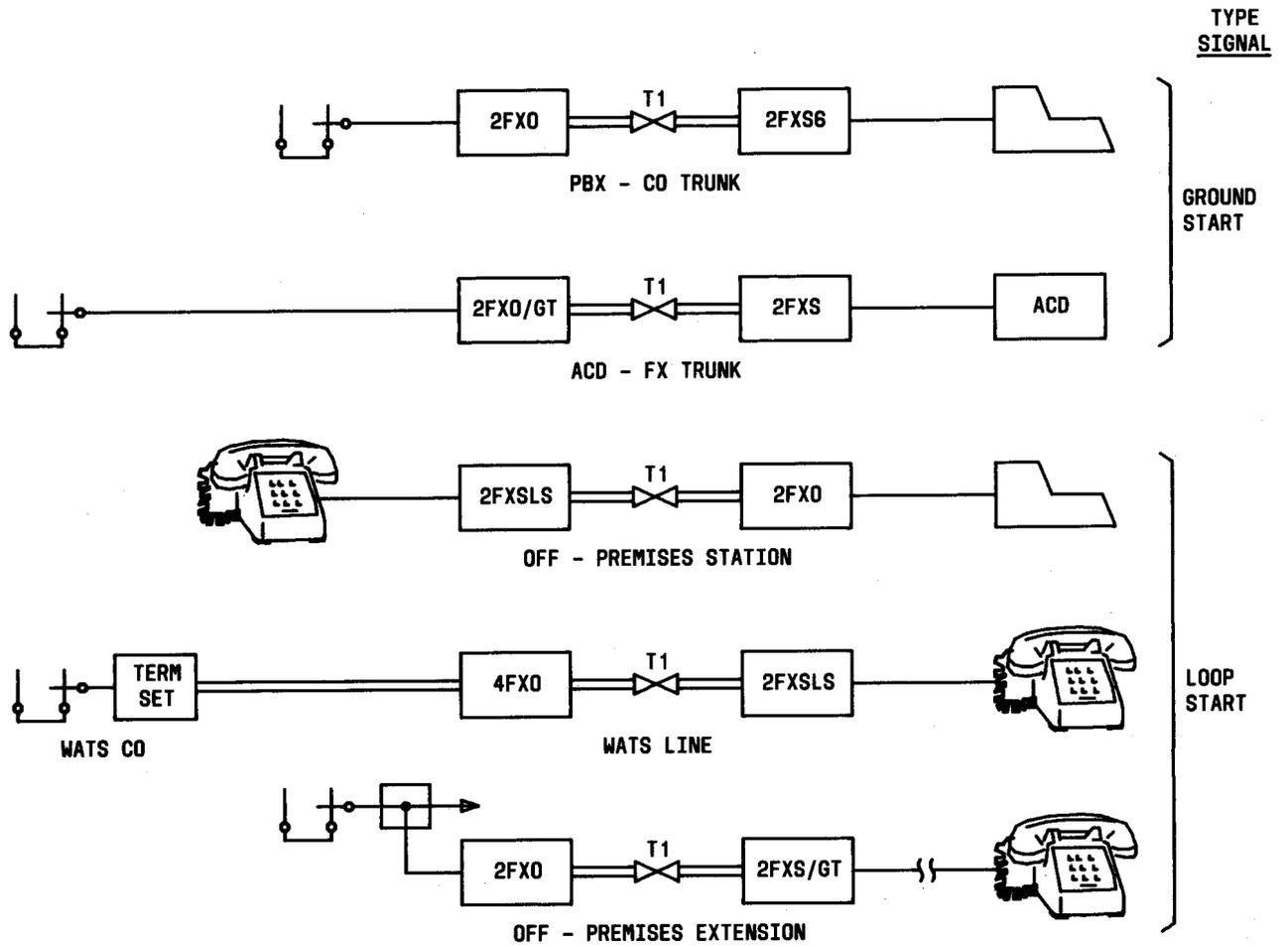


Fig. 2—Typical Application of FX Channel Unit

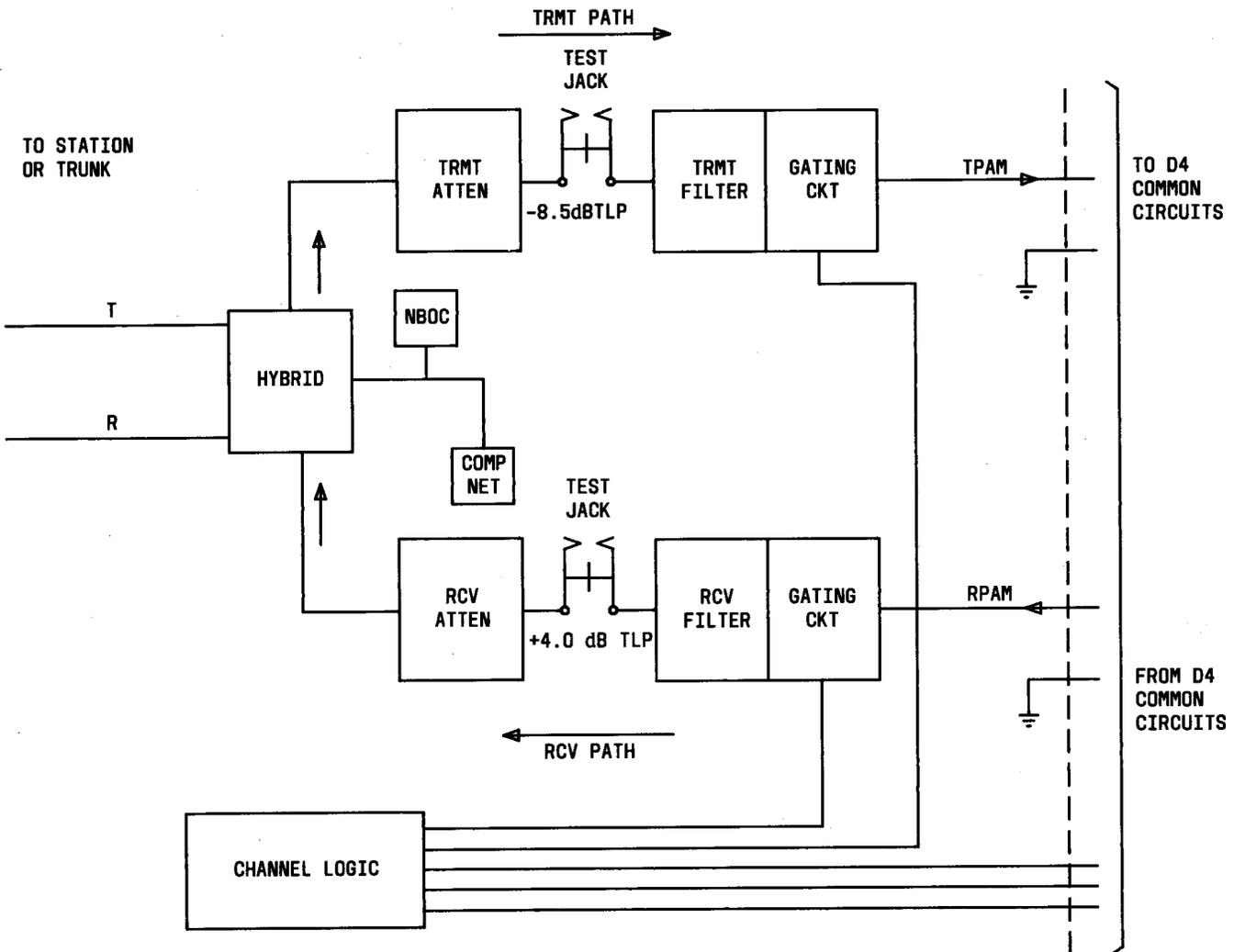


Fig. 3—Transmission Paths of 2-Wire FX Channel Units Without Gain Transfer

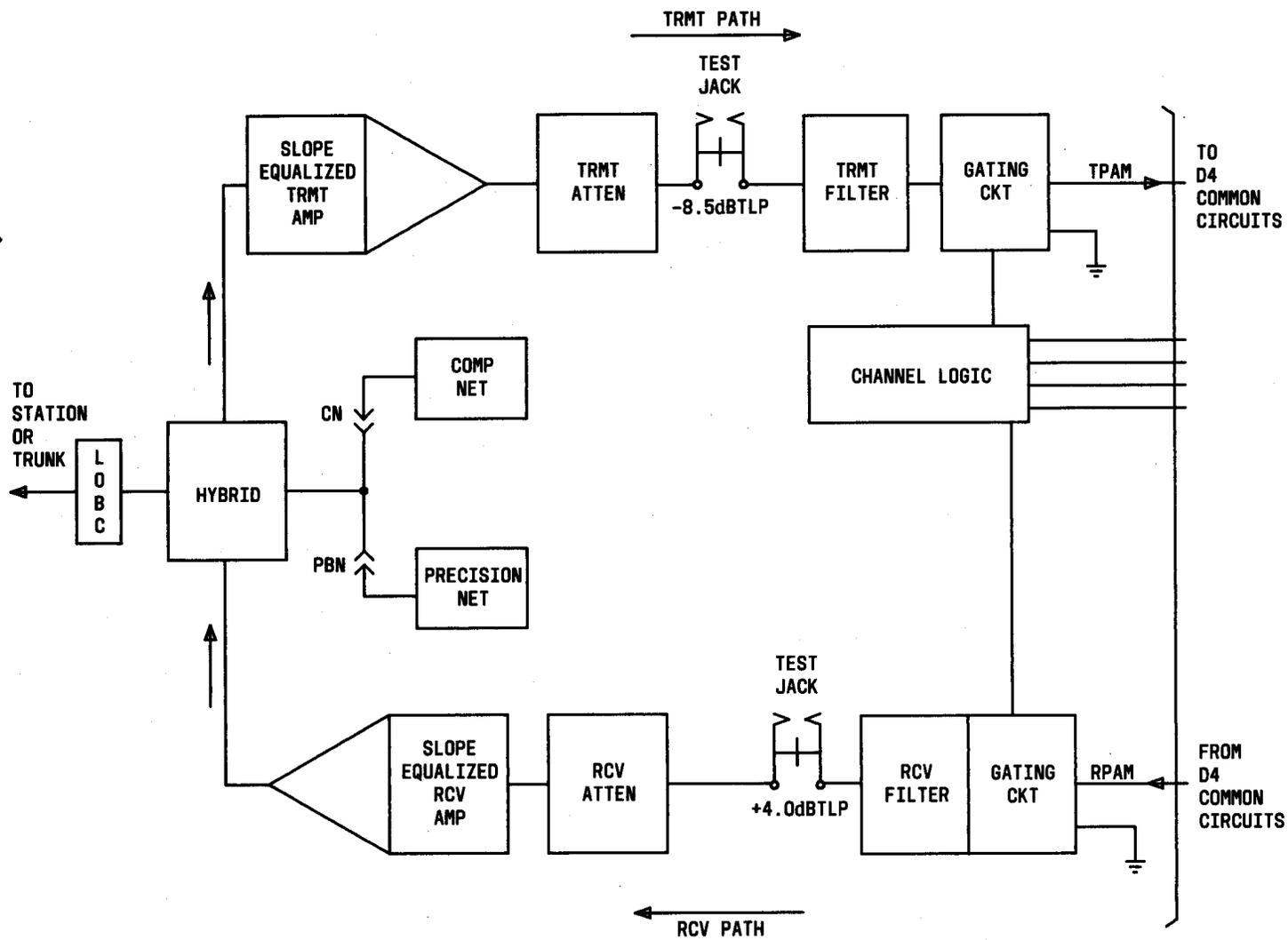


Fig. 4—Transmission Paths of 2FXO/GT and 2FXS/GT Channel Units

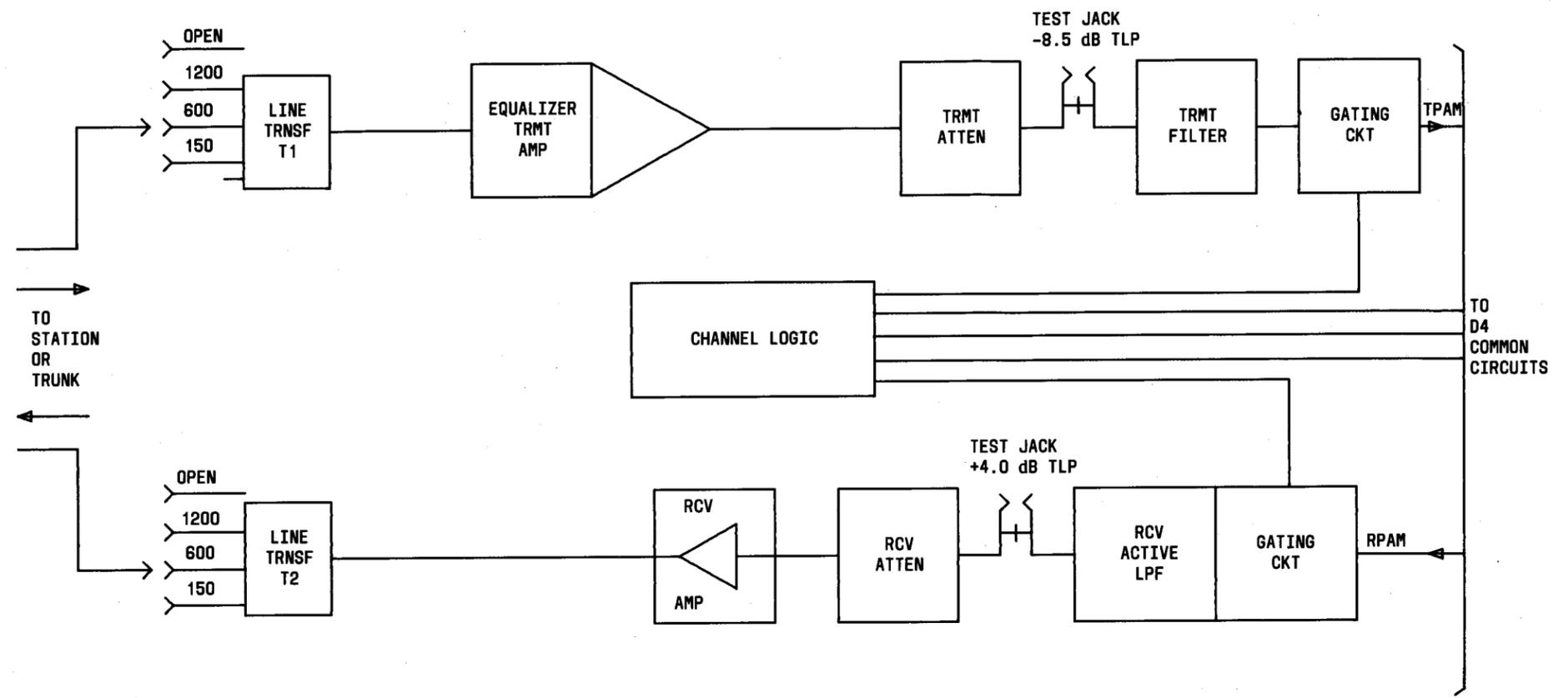


Fig. 5—Transmission Paths of 4FXO and 4FXS Channel Units

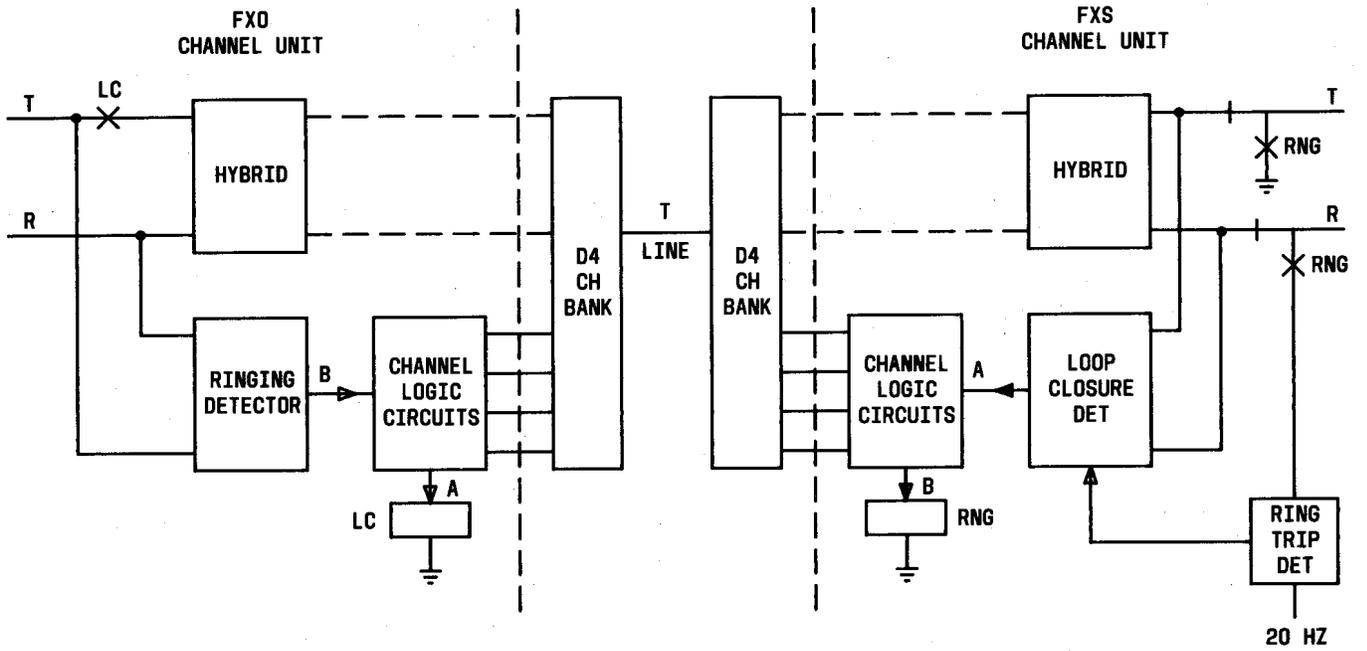


Fig. 6—Loop Start Signaling and Supervision

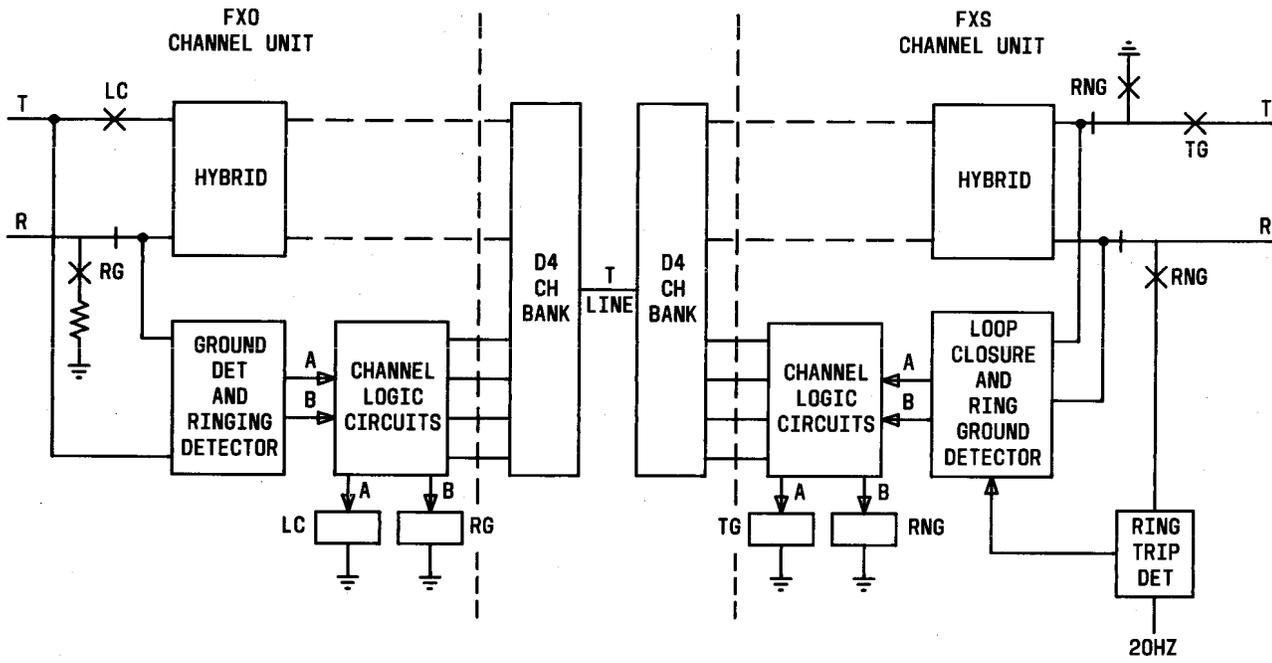


Fig. 7—Ground Start Signaling and Supervision