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technical manual
76-817213
rev B

practice section 817213

7213 2Wire Hybrid Repeater with DLL

contents

1. general description

1.01 The 7213 2Wire Hybrid Repeater module with Dial Long Line (figure 1) combines the functions of two separate modules that are normally used together: a dial long line (DLL) and a 2wire voice-frequency hybrid repeater. The DLL portion of the 7213 is designed for either loop-start or ground-start operation; it regenerates signaling and supervision to increase the range of a loop-start CO or PBX line circuit, or a ground-start PBX-to-CO trunk. The 2wire-hybrid-repeater portion of the 7213 provides both bidirectional gain and bidirectional active slope-type amplitude equalization. Two integral precision balance networks (PBN's) ensure optimum hybrid balance with a variety of facilities and terminal equipment.

1.02 In the event that this Practice section is reissued, the reason for reissue will be stated in this paragraph.

DLL portion

1.03 On calls toward the station, the DLL portion of the 7213 either bypasses ringing or repeats ringing (starts and applies local ringing generator), as selected via switch option, and trips ringing when the station answers. On calls from the station, the 7213 detects and regenerates off-hook states and repeats dial pulsing. Also, in ground-start operation, the 7213 detects and repeats the tip and ring ground states of a ground-start trunk circuit.

1.04 The 7213 can be switch-optioned to accommodate 48, 72, or 96Vdc talk-battery operation. The module's maximum signaling range is 3000 ohms of loop resistance with 48Vdc talk battery, 4500 ohms of loop resistance with 72Vdc talk battery, and 6000 ohms of loop resistance with 96Vdc talk battery. At 48Vdc talk battery, the 7213 provides 13mA of loop current with 3000 ohms of cable resistance (the maximum allowable), a 200-ohm station instrument, and the 7213's 500-ohm internal resistance.

1.05 Additional features and options of the 7213's DLL portion include switch selection of loop-start or ground-start operation, three switch-selectable ringing modes, provision for distinctive or extended ringing, ring trip during silent or ringing intervals, and loop-current limiting. Dial-pulse distortion of the 7213 is less than 5 percent.

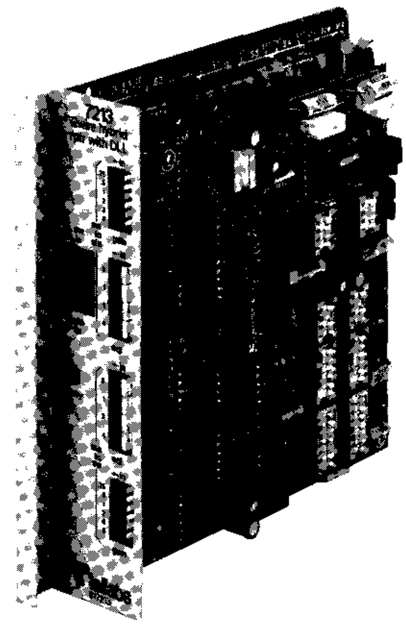


figure 1. 7213 2Wire Hybrid Repeater with DLL

repeater portion

1.06 The 2wire-hybrid-repeater portion of the 7213 provides from 0 to 15.75dB of flat gain in 0.25dB increments selected via front-panel switches. In addition, an active slope equalizer introduces from 0 to 7.5dB of equalized gain at 2804Hz (re 1004Hz) in 0.5dB increments selected via front-panel switches. Gain and equalization can be introduced independently in both directions of transmission (switch-to-station and station-to-switch). The maximum input level to the module is +8dBm; the maximum output level is also +8dBm, with less than 1 percent distortion.

1.07 The switch-side and station-side ports of the 7213 can be independently switch-optioned for 600 or 900-ohm terminating impedance (in series with 2.15μF). Associated with the hybrid at each port is an integral precision balance network (PBN) to optimize hybrid balance, i.e., to maximize trans-hybrid loss. These PBN's can be switch-optioned to provide precision balancing for either loaded or nonloaded cable facilities; they can also be optioned to serve as compromise balance networks (CBN's), in which case they provide a choice of 600 ohms in series with 2.15μF or 900 ohms in series with 2.15μF. Build-out capacitors associated with the 7213's PBN's provide from 0 to 0.127μF of build-out capacitance (BOC) in switch-selectable 0.001μF increments.

general

1.08 The 7213 is side-selectable; an option switch allows the module's station side to be switched to either the A-side or B-side connector pins. (See the 7213 block diagram, section 5 of this Practice, for A-side, B-side, station-side, and facility-side designations and connector pin numbers.) Another option switch selects either of two wiring schemes for the 7213's connector pins. One is a wiring scheme common to a variety of standard Tellabs Type 10 modules; the other is the universal network-terminating-equipment (NTE) wiring scheme of Tellabs' 262U Universal Network Terminating System.

1.09 In addition to the switch-to-station and station-to-switch gain and equalization controls, the front panel of the 7213 contains two bantam-type test jacks, one at the switch-side port and the other at the station-side port. Both are opening jacks that face the module. A front-panel *busy* LED lights when loop current flows.

Note: *In applications where the C.O. reverses battery, any loss of loop current for over 50msec will cause circuit disconnect.*

1.10 The 7213 is a Type 10 module that mounts in one position of a Tellabs Type 10 Mounting Shelf, versions of which are available for relay-rack or apparatus-case installation. In relay-rack applications, up to 12 modules can be mounted across a 19-inch rack, while up to 14 modules can be mounted across a 23-inch rack. In either case, 6 inches or vertical rack space is used.

1.11 As a member of Tellabs' 262U Universal Network Terminating System, the 7213 can also be mounted in any of Tellabs' prewired 262U Mounting Assemblies, versions of which are available for relay-rack and apparatus-case installation. For details, please refer to Tellabs' 262U System brochure. In addition, the 7213 can be used in the prewired Mounting Assemblies of Tellabs' 262 Network Terminating System. For details, please refer to the Tellabs brochure and practice on the 262 System.

2. application

2.01 The 7213 2Wire Hybrid Repeater module with DLL is most commonly used on a loop-start 2wire metallic foreign exchange (FX) or off-premises-station (OPS) circuit (figure 2) that requires voice-frequency gain, amplitude equalization, and signaling-range extension. The 7213 can also be used on a ground-start 2wire metallic PBX-to-CO trunk or on a ground-start PBX line. In any of these applications, the module provides balanced longitudinal isolation between the switch and station sides, thus improving circuit balance and reducing noise.

2.02 The 7213 module can be used in terminal or intermediate applications. A terminal application is one in which one side of the 7213 interfaces a CO, PBX, tel set, or other terminal equipment, or a short length (less than 3 kilofeet) of nonloaded cable. An intermediate application is one in which both sides of the 7213 interface transmission facilities.

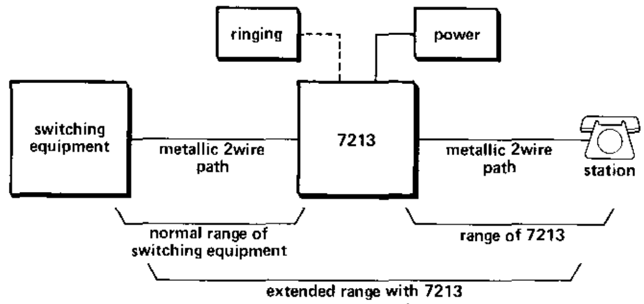


figure 2. 7213 used on 2wire metallic loop-start OPS circuit

DLL portion

2.03 The 7213 module can be used singly or in tandem with other DLL's. In general, the practical limitation on tandem operation is four DLL's, with pulse correction at the DLL's recommended when more than two are operated in tandem. However, because the 7213 does not provide pulse correction, no more than two 7213's should be operated in tandem. If a 7213 is used in tandem with two or three DLL's other than 7213's, these other DLL's must provide pulse correction.

2.04 In either single or tandem applications, the 7213 can be located at any point on a loop where it can be mounted, powered, and optionally supplied with ringing. There are two restrictions on the use of the 7213: (1) on the station side, the distance to the station (or to the next DLL) must be within the range limit of the 7213, and (2) on the switch side, the distance to the switching equipment must be within the range limit of the switching equipment (or of a preceding DLL).

2.05 The 7213 can be switch-optioned for internal or external application of talk battery to the station-side loop. With the internal option selected, 48Vdc talk-battery potential derived from the module's −48Vdc input power source is applied (through 500 ohms of resistance) to the loop. With the external option selected, either 48, 72, or 96Vdc talk-battery potential from a local source separate from the module's input power source is applied (through 500 ohms of resistance) to the loop. The advantage of the internal option is that fewer connections need be made to the module. The advantage of the external option is that talk-battery potential is not limited to 48Vdc.

2.06 With the external talk-battery option in effect, either a −48, −72, or −96Vdc potential can be placed on the 7213's ring power lead (B PWR), and either a +48Vdc, +24Vdc, or ground (0Vdc) potential can be placed on the module's tip power lead (A PWR). The difference between these potentials determines the total talk-battery voltage extended toward the station. For example, with −48Vdc on the B PWR lead and +24Vdc on the A PWR lead, the difference between −48 and +24 is 72; thus, 72Vdc talk battery is extended toward the station. Please note that the difference between the voltages applied to the B PWR and A PWR leads must not exceed 96Vdc. Also, because talk battery is applied to the loop through 500 ohms of resistance, this internal resistance must be considered when calculating station loop current (see table 3 in section 3 of this Practice).

2.07 Current-limiting circuitry is provided by the 7213 for the station-side loop. This prevents damage both to the module and to external equipment and enhances the module's ability to operate in short-loop situations. Current flow is normally limited to approximately 100mA by the 7213's nominal 500-ohm battery-feed resistance. Under fault conditions, however, or whenever the current draw exceeds approximately 100mA, two thermistors perform the current-limiting function automatically.

2.08 Ringing toward the station can be repeated or bypassed by the 7213. In the bypassed-ringing (*BYP*) mode, ringing generated at the switching equipment is passed through the 7213 unaltered and retains its original range limitations. In the repeated-ringing (*RPT* and *RGB*) modes, the local ringing generator can be biased in any of several ways, with the bias voltage supplied by a dc source connected in series with the ac ringing source. Specifically, in the *RPT* mode, bias is determined by the difference in potential between the RING GEN lead and the RING GEN RET (return) lead. In the *RGB* mode, bias is determined by the difference in potential between the RING GEN and GND (ground) leads if the internal talk-battery option is selected, or by the difference in potential between the RING GEN and A PWR leads if the external talk-battery option is selected. Thus, ring-generator bias can be 48, 72, or 96Vdc, and it is this bias that determines the maximum ring-trip range (which is the limiting factor in ringing) toward the station. With 48Vdc bias, maximum ring-trip range is 3000 ohms; with 72Vdc bias, 4500 ohms; and with 96Vdc bias, 6000 ohms.

2.09 In both repeated-ringing modes (*RPT* and *RGB*), the 7213 derives a MACH. ST. (machine start) lead to start a local ringing generator when ringing is applied toward the 7213 by the switching equipment.

2.10 A switch option conditions the 7213 for loop-start or ground-start operation. In ground-start applications, the RING GEN RET lead should not be negatively biased because this places a negative bias on the station-side tip lead during ringing. The associated PBX trunk circuit often requires that the tip lead be at ground or positive potential for proper operation of the incoming-call circuitry. If the PBX trunk circuitry requires this ground or positive potential, a negatively biased ringing generator or a positive voltage connected to the RING GEN RTN lead is required to operate the DLL and the trunk circuitry.

2.11 When the 7213 is used in the ground-start mode on a PBX-to-CO trunk, the sensitivity of the PBX's tip-ground sensing circuitry must be considered. In cases where the 7213 must be located at a distance exceeding the range of this sensing circuitry, external positive voltage can be applied to the 7213's A PWR lead. This positive voltage replaces the normal ground potential and thus extends the range of the PBX sensing circuitry.

2.12 The 7213 reliably detects and repeats ringing bursts and silent intervals as short as 100 milliseconds. This allows the 7213 to accommodate short ringing intervals typical of PBX's that use nonstandard ringing sequences for precedence or priority alerting. Ring-up and release delays are essentially symmetrical; thus, the ringing intervals are not shortened as they are repeated through the module. In addition, a switch option on the 7213 permits extension of each ringing interval by approximately 1 second. This option is intended primarily for use in OPS applications where a short ringing interval from a PBX may not be recognized by ringing detectors or alerting devices at a distant central office or station location.

2.13 The 7213 can be used on circuits where ringing is any type **except** multiparty biased selective ringing. When other forms of multiparty selective ringing (such as harmonic or decimonic ringing) are used, the 7213 must be configured for bypassed rather than repeated ringing, and the ringing supplied from the switching equipment must be biased in either of two ways: (1) negatively biased or (2) grounded, with the return side biased to a dc potential. In multiparty situations where 10, 20, or more ringers are used on a circuit, any combination of 5 ringers can be rung simultaneously.

repeater portion

2.14 The hybrid-repeater portion of the 7213 module provides prescription-set bidirectional gain and amplitude equalization for a 2wire voice-frequency transmission facility. In both directions of transmission (switch-to-station and station-to-switch), from 0 to 15.75dB of flat gain can be introduced in 0.25dB increments via front-panel DIP switches.

2.15 The switch-side port and the station-side port of the 7213 can be independently switch-optioned for balanced 600 or 900-ohm terminating impedance (in series with 2.15μF). The 600-ohm option is typically selected for interface with a PBX or nonloaded cable, while the 900-ohm option is selected for interface with switched networks or loaded cable.

2.16 From 0 to 7.5dB of prescription-set active slope equalization at 2804Hz (re 1004Hz) can be introduced in both directions of transmission to compensate for the frequency-response characteristics of nonloaded cable. This equalization is introduced in discrete 0.5dB increments via front-panel DIP switches. The module's equalized gain response is not affected by flat gain adjustments, which are used to provide precise transmission alignment.

2.17 Associated with each of the 7213's two hybrids is a precision balance network (PBN) designed to achieve optimum hybrid balance, i.e., maximum transhybrid loss, with a variety of facilities and terminal equipment. These PBN's can be switch-optioned to provide precision balancing for loaded or nonloaded cable facilities. As an alternative, both PBN's can be switch-optioned to serve as compromise balance networks (CBN's), in which case they provide a choice of 600 ohms in series with 2.15μF or 900 ohms in series with 2.15μF.

general

2.18 The 7213 is side-selectable; its station side can be connected to either the A-side or B-side connector pins by means of a switch option. (See the block diagram, section 5 of this Practice, for station-side, facility-side, A-side, and B-side designations and connector pins.) In addition, either of two wiring schemes for the 7213's connector pins can be selected via switch option. One is a wiring scheme common to a variety of standard Tellabs Type 10 modules; the other is the universal network-terminating-equipment (NTE) wiring scheme of Tellabs' 262U Universal Network Terminating System.

3. installation

inspection

3.01 The 7213 2Wire Hybrid Repeater module with DLL should be visually inspected upon arrival to find possible damage incurred during shipment. If damage is noted, a claim should immediately be filed with the carrier. If stored, the module should be visually inspected again prior to installation.

mounting

3.02 The 7213 mounts in one position of a Tellabs Type 10 Mounting Shelf or in one position of a Tellabs 262U or 262 Mounting Assembly. The module plugs physically and electrically into a 56-pin connector at the rear of its Shelf or Assembly position.

3.03 In applications where a 7213 module is to be installed in a 262U or 262 Assembly, no external connections to the module need be made because all internal connections in these Assemblies are factory-prewired. External connections are made to the Assemblies via female 25-pair microribbon connector-ended cables arranged in accordance with Universal Service Order Code (USOC) RJ2HX. If the customer's terminal equipment has been cabled in accordance with USOC RJ2HX, direct cable connection to the 262U or 262 Assembly and the customer's equipment is possible. If not, cross-connections between the Assembly and the local terminal equipment must be made at an intermediate connectorized terminal block.

installer connections

3.04 When a 7213 module is to be installed in a conventional Type 10 Shelf, external connections to the module must be made. 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.

3.05 Table 1 lists external connections to the 7213 module. All connections are made via wire wrapping to the 56-pin connector at the rear of the module's mounting shelf position. Pin numbers are found on the body of the connector.

connect:	**to pin:** STANDARD*	NTE**
A-SIDE TIP	51	55
A-SIDE RING	33	49
B-SIDE TIP	41	41
B-SIDE RING	49	47
A PWR (A-lead power)	13	13
B PWR (B-lead power)	53	53
RING GEN (ring generator)	45,46	45,46
RING GEN RET (ring generator return)	11,12	11,12
MACH ST (ring generator start)	37	37
–BATT (–48Vdc battery in)	35	35
GND (ground)	17	17

*Switch *S20* set to *STD* position.
**Switch *S20* set to *NTE* position.

Note: *An internal jumper is provided between pins 2 and 4.*

table 1. External connections to 7213

option selection

3.06 The 7213's printed circuit board contains 16 option switches, the locations of which are shown in figure 3. Eight of these switches (one of which is a two-position DIP switch that controls two separate options) must be set before the module is aligned and placed into service. The other eight, along with the front-panel *gain* and *eql* switches, are used in alignment and are covered later in this Practice. Table 2 summarizes the 7213's printed-circuit-board non-alignment-related switch options; detailed instructions on selecting these options are provided below.

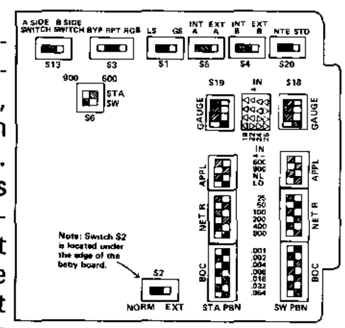


figure 3. 7213 option switch locations

Note: *Included in table 2 is a checklist for prescription optioning of the 7213. Prior to installation, check marks can be placed in the appropriate boxes to indicate the required options. During installation, the module can then be quickly and easily optioned as indicated in the table without referring to the detailed optioning instructions in the text.*

3.07 Switch *S1* selects either the loop-start or ground-start supervisory mode. Set *S1* to the *LS* position for loop start or to the *GS* position for ground start as required for the module's particular application.

3.08 Switches *S4* and *S5* determine whether the talk battery extended to the station by the 7213 is internally or externally derived. For internal talk battery (from the same nominal –48Vdc source that powers the module via pins 35 and 17), set *S4* to *INTB* and *S5* to *INTA*. With internal talk battery selected, no connections need be made to the A

option	switch	selections	settings	check-list
signaling mode	S1	loop start	LS	
		ground start	GS	
ring-lead talk-battery feed	S4	internal battery (potential at −BATT)	INTB	
		external battery (potential at B PWR)	EXTB	
tip-lead talk-battery feed	S5	internal battery (potential at GND)	INTA	
		external battery (potential at A PWR)	EXTA	
switch-side port impedance	S6-SW	600 ohms + 2.15μF	600	
		900 ohms + 2.15μF	900	
station-side port impedance	S6-STA	600 ohms + 2.15μF	600	
		900 ohms + 2.15μF	900	
switch-side/ station-side port assignment	S13	A side is switch side; B side is station side	A SIDE SWITCH	
		B side is switch side; A side is station side	B SIDE SWITCH	
pinout configuration (see table 1)	S20	standard Tellabs Type 10 pinouts	STD	
		NTE pinouts (Tellabs 262U System)	NTE	
ringing mode	S3	bypassed ringing	BYP	
		repeated ringing; ring-generator bias determined by potential between RING GEN and RING GEN RET leads	RPT	
		repeated ringing; ring-generator bias determined by potential between RING GEN lead and either GND lead (*S5* set to *INTA*) or A PWR lead (*S5* set to *EXTA*)	RGB	
normal/ extended ringing	S2	normal (non-extended) ringing interval; required with distinctive or shortened ringing patterns and with bypassed ringing (*S3* set to *BYP*)	NORM	
		extended (by 1 second) ringing interval; required in repeated-ringing applications (*S3* set to *RPT* or *RGB*) where ringing interval from a PBX is too short to initiate ringing by 7213	EXT	

table 2. Summary and checklist, non-alignment-related switch options of 7213

PWR and B PWR leads (pins 13 and 53, respectively) but the module is limited to 48Vdc talk-battery operation. For external talk battery, set *S4* to *EXTB* and *S5* to *EXTA*. With external talk battery selected, the talk-battery potential is the difference between the potentials connected to the A PWR and B PWR leads. For example, if the A PWR potential is +24Vdc and the B PWR potential is −48Vdc, the talk-battery potential is 72Vdc. The A PWR potential must always be positive or ground, the B PWR potential must always be negative, and the difference between these two potentials must never exceed 96Vdc. The resultant signaling and supervisory range limits are listed in table 3.

Note: *In applications where the A PWR and B PWR leads are prewired to external potentials and the difference between these potentials exceeds 96Vdc, switches* S4 *and* S5 *can be used in combination to derive an acceptable talk-battery potential. For example, in an application where the A PWR potential is +24Vdc and the B PWR potential is −96Vdc, setting both* S4 *and* S5 *for external talk battery would result in a talk-battery potential of 120Vdc, which the module cannot accommodate. However, an acceptable talk-battery potential can be derived either by selecting internal −48Vdc talk battery (*S4 *set to* INTB, S5 *set to* INTA*) or by setting* S4 *and* S5 *as indicated below (the module and external power supplies must be referenced to the same ground). Again, please be aware that the A PWR potential must be positive or ground and the B PWR potential must be negative.*

S4	S5	talk battery
INTB	EXTA	72Vdc (+24V on A PWR, −48V on B PWR)
EXTB	INTA	96Vdc (gnd on A PWR, −96V on B PWR)

3.09 Two-position DIP switch *S6* selects 600 or 900-ohm terminating impedance independently for each side of the module. For 600-ohm impedance on the station side, set the *STA* position of *S6* to *600*; for 900-ohm station-side impedance, set *S6-STA* to *900*. Similarly, for 600-ohm impedance on the switching side of the module, set the *SW* position of *S6* to *600*; for 900-ohm switching-side impedance, set *S6-SW* to *900*.

Note: *The 7213 provides 0.0dB power transfer for any combination of impedance settings.*

3.10 Switch *S13* controls the module's switch-side/station-side port assignment. To connect the A side of the 7213 to the switch side and the B side to the station side, set *S13* to the *A SIDE SWITCH* position. To connect the B side of the 7213 to the switch side and the A side to the station side, set *S13* to the *B SIDE SWITCH* position.

3.11 Switch *S20* selects either standard or network-terminating-equipment (NTE) pinouts (see table 1) for the module's card-edge connector pins. For standard pinouts, set *S20* to *STD*. For NTE pinouts (as are required when the 7213 is used in a Tellabs 262U Universal Network Terminating System Mounting Assembly), set *S20* to *NTE*.

3.12 Bypassed or repeated ringing is selected via switch *S3*. For bypassed ringing, set *S3* to *BYP*. (With bypassed ringing, no connections need be made to the RING GEN lead [pin 45 or 46] or to the RING GEN RET lead [pin 11 or 12].) For repeated ringing with ring-generator bias determined by the difference in dc potential between the RING GEN and RING GEN RET leads, set *S3* to *RPT*. (In this case, the RING GEN lead must be negative with respect to the RING GEN RET lead.) For repeated ringing with ring-generator bias determined by the difference in dc potential between the RING GEN lead and either the GND lead (*S5* set to *INTA*) or the A PWR lead (*S5* set to *EXTA*), set *S3* to *RGB*. (In this case, the RING GEN lead must be negative with respect to the GND or A PWR lead.) As stated previously, ring-generator bias can be 48, 72, or 96Vdc. The resultant ring-trip range limits are listed in table 3.

ring-trip range (note 1)	possible talk battery sources		possible ring generator bias sources		
	internal (S4 and S5 set to INT)	external (S4 and S5 set to EXT)	bypassed ringing (S3 set to BYP)	repeated ringing (S3 set to RGB)	repeated ringing (S3 set to RPT)
0 to 3000 ohms (provides 23mA over 1390-ohm cable; see note 3)	−48Vdc on BATT; ground on GND	−48Vdc on BPWR; ground on APWR	note 2	48Vdc total bias potential between RING GEN and either ground (INTA) or APWR (EXTA) (external source)	48Vdc total bias potential between RING GEN and RING GEN RET (external source)
200 to 4500 ohms (provides 23mA over 2430-ohm cable; see note 3)	not applicable	−48Vdc on BPWR; +24 Vdc on APWR or −72Vdc on BPWR; ground on APWR	note 2	72Vdc total bias potential between RING GEN and either ground (INTA) or APWR (EXTA) (external source)	72Vdc total bias potential between RING GEN and RING GEN RET (external source)
500 to 6000 ohms (provides 23mA over 3470-ohm cable; see note 3)	not applicable	−48Vdc on BPWR; +48Vdc on APWR or −72Vdc on BPWR; +24Vdc on APWR or −96Vdc on BPWR; ground on APWR	note 2	96Vdc total bias potential between RING GEN and either ground (INTA) or APWR (EXTA) (external source)	96Vdc total bias potential between RING GEN and RING GEN RET (external source)

Note 1: *Either talk-battery potential or ring-generator bias potential (whichever is lower) limits the range. For example, with 96Vdc talk-battery potential and 48Vdc ring generator bias, the circuit is limited to 3000 ohms of loop resistance.*
Note 2: *The maximum range depends on the ringing-generator bias from the switching equipment and the total resistances of the switch-side and station-side loops.*
Note 3: *Cable resistance is derived by taking into account the module's internal 500-ohm resistance and by assuming a 200-ohm tel-set resistance.*

table 3. Ring-trip ranges with various talk-battery and ring-generator-bias options

3.13 Switch *S2* selects either normal or extended ringing for repeated-ringing applications. If either of the 7213's repeated-ringing options (*RPT* or *RGB*) is selected and the short ringing interval from a PBX is not sufficient to initiate ringing by the 7213 (as may be the case in OPS applications), set *S2* to the *EXT* position to extend the ringing interval by approximately 1 second. If extended ringing is not required in a repeated-ringing application or if a distinctive or shortened ringing pattern is to be used, set *S2* to *NORM*. Also set *S2* to *NORM* in all bypassed-ringing applications.

alignment

3.14 Alignment of the 7213 module consists of aligning the switch-side and station-side PBN's for optimum transhybrid loss and setting the switch-to-station and station-to-switch gain and equalization. As a prescription module, the 7213's alignment-related printed-circuit-board and front-panel switches are set in accordance with predetermined settings (see note 1 below). The PBN settings are obtained from tables in Tellabs Supplement section 8X7213. Use of these tables requires knowledge of the cable gauges and lengths of the facilities. Refer to Supplement section 8X7213 for detailed information on deriving PBN settings from cable parameters. The gain and equalization settings are determined from information in the Circuit Layout Record (CRL). Table 4 summarizes the 7213's alignment-related switches and switch options.

Note 1: *Included in table 4 is a checklist for prescription alignment of the 7213. Prior to installation, check marks can be placed in the appropriate boxes to indicate the required settings. During installation, the module can then be quickly and easily aligned as indicated in the table without referring to the detailed alignment instructions in the text.*

Note 2: *This Practice contains no information on manual alignment of the 7213 module. Manual alignment is a long and involved procedure that is unnecessary for most applications. If an application requires manual alignment, contact the Tellabs Applications Engineering Group at (312) 969-8800 for details on manual alignment procedures.*

cable length (kilofeet)	required BOC (μF)	
	high-capacitance cable (0.083μF/mile)	low-capacitance cable (0.066μF/mile)
0.00	0.000	0.000
0.25	0.004	0.003
0.50	0.008	0.006
0.75	0.012	0.009
1.00	0.016	0.012
1.25	0.020	0.016
1.50	0.024	0.019
1.75	0.027	0.022
2.00	0.031	0.025
2.25	0.035	0.028
2.50	0.039	0.031
2.75	0.043	0.034
3.00	0.047	0.037

table 5. Build-out capacitance (BOC) for terminal applications

option	switch	selections	settings	check-list
Note: *For all front-panel and printed-circuit-board DIP switches, the* IN *position is to the* left *and the* OUT *position is to the* right, *as indicated on the front panel and printed circuit board adjacent to the switches. Depending on the orientation of the DIP switch block, the* IN *position may or may not be the* ON *position indicated on the switch block.*				
switch-to-station gain	front-panel sw to sta gain DIP switch*	0.25dB	.25 to IN	
		0.5dB	.5 to IN	
		1dB	1 to IN	
		2dB	2 to IN	
		4dB	4 to IN	
		8dB	8 to IN	
switch-to-station equalization	front-panel sw to sta eql DIP switch**	0.5dB	.5 to IN	
		1dB	1 to IN	
		2dB	2 to IN	
		4dB	4 to IN	
station-to-switch gain	front-panel sta to sw gain DIP switch*	0.25dB	.25 to IN	
		0.5dB	.5 to IN	
		1dB	1 to IN	
		4dB	4 to IN	
		8dB	8 to IN	
station-to-switch equalization	front-panel sta to sw eql DIP switch**	0.5dB	.5 to IN	
		1dB	1 to IN	
		2dB	2 to IN	
		4dB	4 to IN	
station-side PBN application	STA PBN APPL 1 through 4	station-side PBN excluded	STA PBN APPL 1 through 4 OUT	
		PBN for loaded cable	STA PBN APPL 1 (LD) IN; STA PBN APPL 2 through 4 OUT	
		PBN for non-loaded cable	STA PBN APPL 2 (NL) IN; STA PBN APPL 1, 3, and 4 OUT	
		CBN impedance of 600 ohms plus 2.15μF	STA PBN APPL 4 (600) IN; STA PBN APPL 1 through 3 OUT	
		CBN impedance of 900 ohms plus 2.15μF	STA PBN APPL 3 (900) IN; STA PBN APPL 1, 2, and 4 OUT	
conditioning of station-side PBN for cable gauge interfaced on station side (loaded cable only)	S19-1 through S19-4 (STA PBN GAUGE)	19 gauge	S19-1 through S19-4 IN	
		22 gauge	S19-1 OUT; S19-2 through S19-4 IN	
		24 gauge	S19-1 and S19-2 OUT; S19-3 and S19-4 IN	
		26 gauge	S19-1 through S19-3 OUT; S19-4 IN	
build-out capacitance (BOC) for station-side PBN	STA PBN BOC 1 through 7†	0.001μF	STA PBN BOC 7 (.001) IN	
		0.002μF	STA PBN BOC 6 (.002) IN	
		0.004μF	STA PBN BOC 5 (.004) IN	
		0.008μF	STA PBN BOC 4 (.008) IN	
		0.016μF	STA PBN BOC 3 (.016) IN	
		0.032μF	STA PBN BOC 2 (.032) IN	
		0.064μF	STA PBN BOC 1 (.064) IN	
network resistance for station-side PBN	STA PBN NET R 1 through 6††	25 ohms	STA PBN NET R 1 (25) IN	
		50 ohms	STA PBN NET R 2 (50) IN	
		100 ohms	STA PBN NET R 3 (100) IN	
		200 ohms	STA PBN NET R 4 (200) IN	
		400 ohms	STA PBN NET R 5 (400) IN	
		800 ohms	STA PBN NET R 6 (800) IN	
switch-side PBN application	SW PBN APPL 1 through 4	switch-side PBN excluded	SW PBN APPL 1 through 4 OUT	
		PBN for loaded cable	SW PBN APPL 1 (LD) IN; SW PBN APPL 2 through 4 OUT	
		PBN for non-loaded cable	SW PBN APPL 2 (NL) IN; SW PBN APPL 1, 3, and 4 OUT	
		CBN impedance of 600 ohms plus 2.15μF	SW PBN APPL 4 (600) IN; SW PBN APPL 1 through 3 OUT	
		CBN impedance of 900 ohms plus 2.15μF	SW PBN APPL 3 (900) IN; SW PBN APPL 1, 2, and 4 OUT	

continued on next page

table 4. Summary and checklist, alignment-related switches and switch options of 7213

BOC for terminal applications

3.15 In terminal applications, it is sometimes necessary to compensate the capacitance of office wiring. To adjust the build-out capacitance (BOC) to compensate for the capacitance of the cable running to a terminal, first determine whether the cable is high-capacitance (0.083μF per mile) or low-capacitance (0.066μF per mile), and determine the length of the cable to the nearest quarter-kilofoot. Then use table 5 to determine the required amount of BOC. Finally, set to *in* the combination of *STA* or *SW PBN BOC* switches whose sum is equal to the required BOC. For example, suppose 1.5 kilofeet of high-capacitance cable on the station side is to be compensated. From table 5, the required BOC is 0.024μF. Therefore, switches *STA PBN BOC 3 (.016)* and *4(.008)* are set to *in* and the remaining *STA PBN BOC* switches are left *out*. If the cable capacitance cannot be determined, use 0.015μF of BOC per kilofoot of cable. For example, suppose 2 kilofeet of unknown-capacitance cable on the station side is to be compensated. The required BOC is 2 x 0.015 = 0.030μF. Therefore, switches *STA PBN BOC 3 (.016), 4 (.008), 5 (.004),* and *6 (.002)* are set to *in* and the remaining *STA PBN BOC* switches are left *out*.

PBN trimming

3.16 In some cases, the PBN settings obtained from Supplement section 8X7213 do not yield satisfactory transhybrid loss (see note below). In these cases, PBN trimming is required. The following procedure describes how to trim the station-side PBN. To trim the switch-side PBN, use the same procedure, but substitute SW and *sw* for STA and *sta* and vice versa.

To trim the station-side PBN, proceed as follows:

A. Record the settings of the *SW PBN APPL* switches.

Arrange an RLTS for either 600-ohm or 900-ohm terminating impedance. If 600-ohm terminating impedance is selected, temporarily set switch *SW PBN APPL 4 (600)* to *in* and set all remaining *SW PBN APPL* switches to *out*. If 900-ohm terminating impedance is selected, temporarily set switch *SW PBN APPL 3 (900)* to *in* and set all remaining *SW PBN APPL* switches to *out*. (The *SW PBN APPL* switches will be restored to their original settings in step B.) Connect the RLTS to the front-panel *sw in* jack.

B. Apply power to the module and follow the flowchart in figure 4 to trim the *STA PBN BOC* and *NET R* switches. Then disconnect the RLTS from the *sw in* jack. Restore the *SW PBN APPL* switch settings recorded in step A. This completes trimming of the station-side PBN.

Note: *PBN trimming is generally not required and should be performed only if unsatisfactory transhybrid loss is obtained from the prescription settings.*

option	switch	selections	settings	check-list
conditioning of switch-side PBN for cable gauge interfaced on switch side (loaded cable only)	S18-1 through S18-4 (SW PBN GAUGE)	19 gauge	S18-1 through S18-4 IN	
		22 gauge	S18-1 OUT; S18-2 through S18-4 IN	
		24 gauge	S18-1 and S18-2 OUT; S18-3 and S18-4 IN	
		26 gauge	S18-1 through S18-3 OUT; S18-4 IN	
build-out capacitance (BOC) for switch-side PBN	SW PBN BOC 1 through 7†	0.001µF	SW PBN BOC 7 (.001) IN	
		0.002µF	SW PBN BOC 6 (.002) IN	
		0.004µF	SW PBN BOC 5 (.004) IN	
		0.008µF	SW PBN BOC 4 (.008) IN	
		0.016µF	SW PBN BOC 3 (.016) IN	
		0.032µF	SW PBN BOC 2 (.032) IN	
		0.064µF	SW PBN BOC 1 (.064) IN	
network resistance for switch-side PBN	SW PBN NET R 1 through 6††	25 ohms	SW PBN NET R 1 (25) IN	
		50 ohms	SW PBN NET R 2 (50) IN	
		100 ohms	SW PBN NET R 3 (100) IN	
		200 ohms	SW PBN NET R 4 (200) IN	
		400 ohms	SW PBN NET R 5 (400) IN	
		800 ohms	SW PBN NET R 6 (800) IN	

*The front-panel *sw to sta gain* and *sta to sw gain* DIP-switch positions are additive. Total flat gain introduced in either direction is the sum of that direction's *gain* switch positions set to *IN*. For no gain in a particular direction, set all positions of that direction's *gain* switch to *OUT*.

**The front-panel *sw to sta eql* and *sta to sw eql* DIP-switch positions are additive. Total equalized gain introduced at 2804Hz (re 1004Hz) in either direction is the sum of that direction's *eql* switch positions set to *IN*. For no equalization in a particular direction, set all positions of that direction's *eql* switch to *OUT*.

†The *STA PBN BOC* and *SW PBN BOC* DIP-switch positions are additive. Total build-out capacitance introduced for either PBN is the sum of that PBN's *BOC* switch positions set to *IN*. For no build-out capacitance for a particular PBN, set all positions of that PBN's *BOC* switch to *OUT*.

††The *STA PBN NET R* and *SW PBN NET R* DIP-switch positions are additive. Total network resistance introduced for either PBN is the sum of that PBN's *NET R* switch positions set to *IN*. For no network resistance for a particular PBN, set all positions of that PBN's *NET R* switch to *OUT*.

table 4. Summary and checklist, alignment-related switches and switch options of 7213

post-alignment testing

3.17 After alignment is completed, performance of the 7213 module should be verified via end-to-end tests. Originate a call from the station side and verify that the call is established and that a talk path exists. Repeat the test from the switch side. If these tests do not succeed or performance is inadequate, refer to section 7.

4. circuit description

4.01 This circuit description is intended to familiarize you with the 7213 2Wire Hybrid Repeater with DLL module for engineering and application purposes only. Attempts to troubleshoot the 7213 internally are not recommended. Procedures for recommended troubleshooting in the field are limited to those prescribed in section 7 of this Practice. Refer to the 7213 block diagram, section 5 of this Practice, as an aid in following the circuit description.

2wire hybrid repeater portion

4.02 The 7213 module separates the bidirectional 2wire path into two unidirectional 4wire paths by means of a single-coil *hybrid* and a universal *PBN* at each of the module's two ports. Because the switch-to-station and station-to-switch paths are identical, only the first is described.

4.03 Voice signals entering the switch-side port are passed by the *hybrid* to the *repeater enable* circuit. This circuit passes the signals only when the station-side loop is closed. The signals then pass through a *high-pass filter* and a *low-pass filter* (which increase the stability of the repeater) to the *sw to sta equalizer* circuit.

4.04 The *sw to sta equalizer* circuit provides up to 7.5dB of active slope equalization at 2804Hz with respect to 1004Hz in 0.5dB steps. The amount of equalization required is selected by means of front-panel switches. The signals then pass to the *sw to sta gain* circuit. This circuit provides 15.75dB of gain in 0.25dB steps. The amount of gain required is selected by means of front-panel switches.

4.05 The output signals from the *sw to sta gain* circuit are buffered by a *driver* circuit and applied to the station-side *hybrid*. The signals exit the 7213 via the station-side port.

DLL portion: loop-start station-side seizure

4.06 Loop current is provided either by the internal –48Vdc *power supply* or by externally supplied power connected to the A PWR and B PWR leads. In either case, loop current is limited by feed-through resistors and thermistors contained in the *battery feed* network.

4.07 Seizure is initiated by a station-side loop closure, which operates the *loop closure detector* circuit. The *loop closure detector* circuit operates

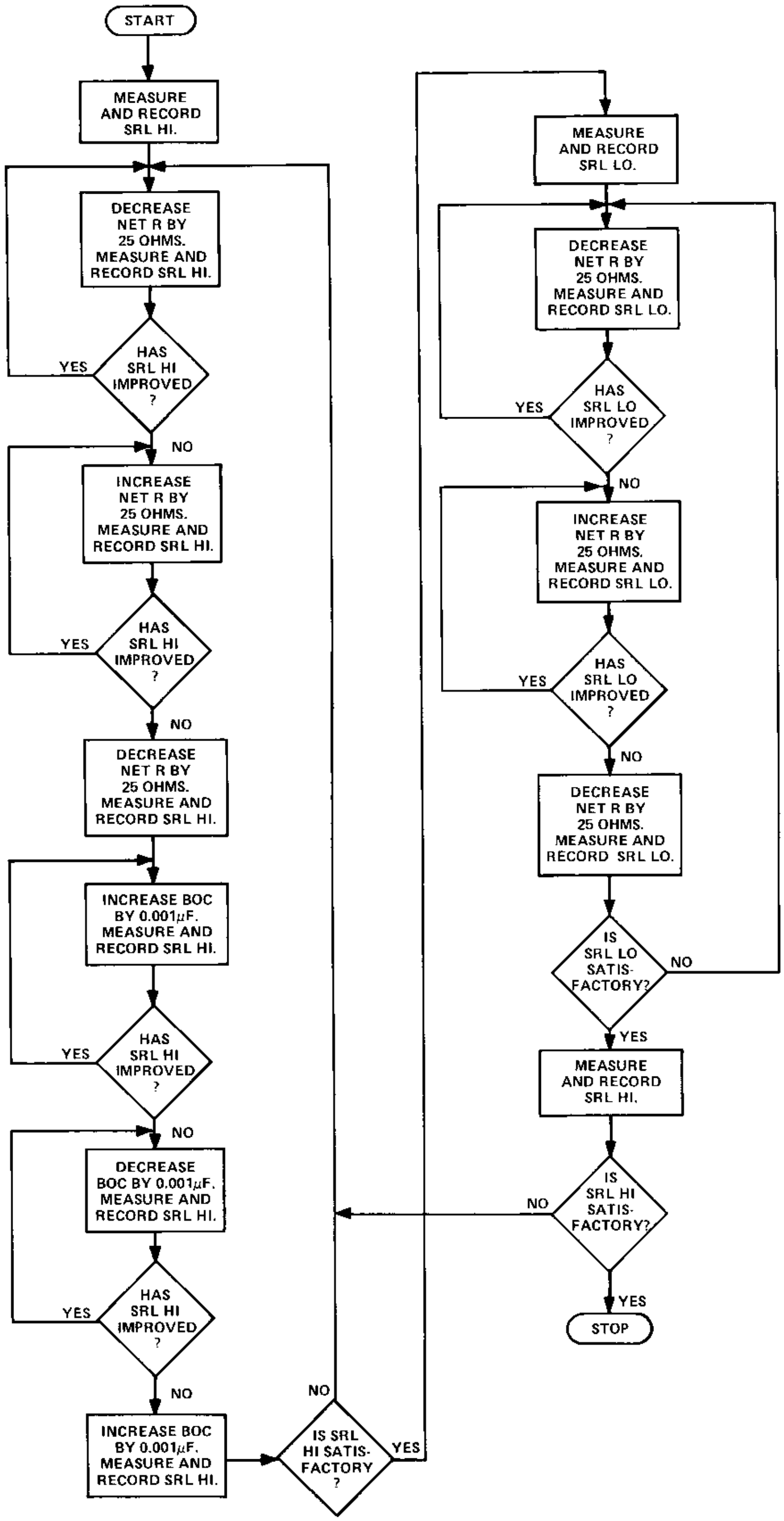


figure 5. PBN trimming flowchart

the *A relay*, lights the front-panel *busy* LED, and enables the 2wire repeater portion of the 7213 by operating the *repeater enable* circuits. The closed *A relay* contacts close the switching-side loop. The switching equipment detects the loop closure and applies dial tone to the switch-side port. The dial tone is conveyed to the station side via the 2wire repeater portion of the 7213.

4.08 Station-side dialing is sensed by the *loop closure detector* circuit, which causes the *A relay* to pulse the switch-side loop.

4.09 Disconnect is produced by a sustained on-hook (no loop current) from the station side. This causes the *A relay* to release, which opens the switch-side loop.

DLL portion: loop-start switch-side seizure

4.10 Seizure is initiated by application of ringing voltage by the switching equipment to the switch-side tip and ring leads. The ringing voltage is detected by the *ring detector* circuit, which operates the *RU relay*. The closed *RU relay* contacts apply ringing voltage to the station side through the ringing-mode selection switch (*S3*) and the *ring trip detector* circuit. If *S3* is in the bypass (*BYP*) position, the ring voltage applied to the switch side is connected to the station side by the operated *RU relay*. If *S3* is in the *REPT* or *RGB* position, the operated *RU relay* applies locally supplied ring voltage to the station side. The *ring detector* circuit repeats the ringing toward the station until a ring trip signal is detected or the call is abandoned.

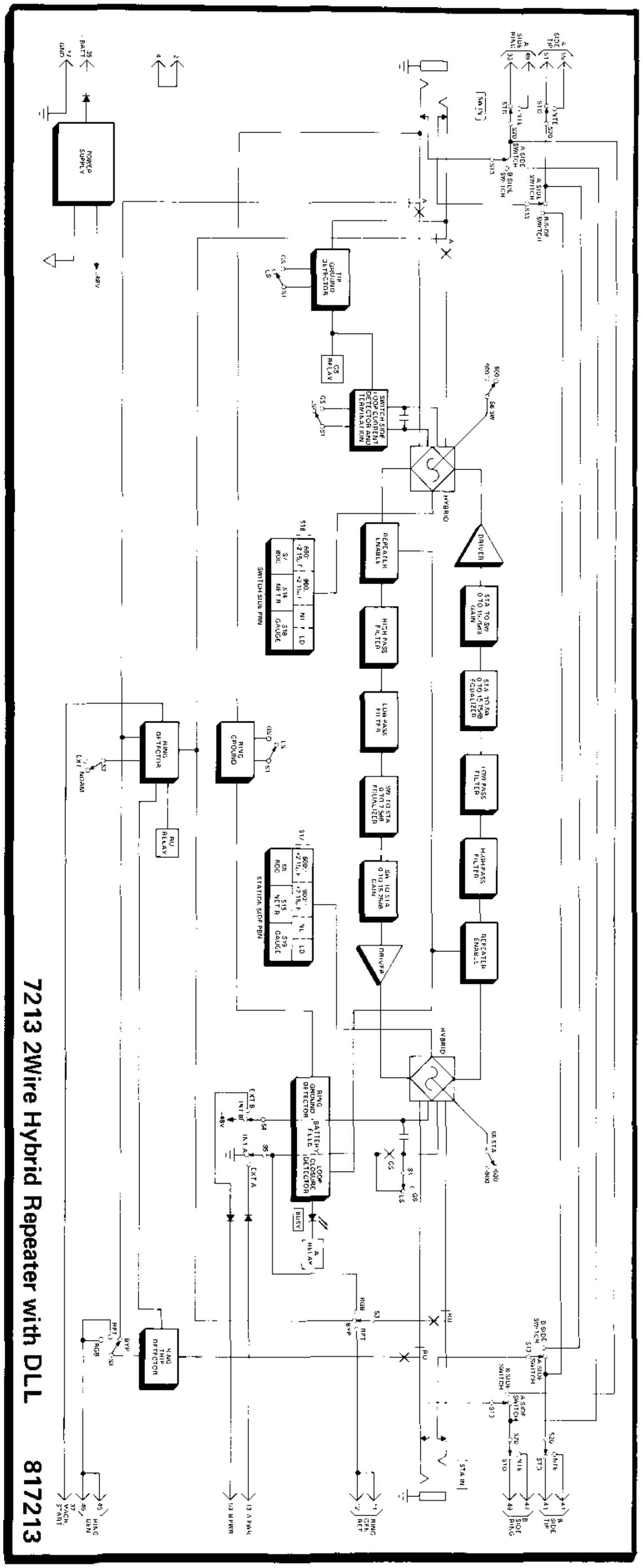
4.11 When the station answers the call, current flows through the *ring trip detector* circuit, which causes the *ring detector* circuit to release the *RU relay*. This removes the ringing voltage from the station side and causes loop current to flow through the *loop closure detector* circuit, which operates the *A relay*, thereby closing the switch-side loop. The switching equipment detects the loop closure and removes the ringing voltage from the switch side.

4.12 Disconnect occurs as described for loop-start station-side seizure (paragraph 4.09).

DLL portion: ground-start station-side seizure

4.13 Seizure is initiated by application of a ground by the station to the station-side ring lead. The ring ground is detected by the *ring ground* circuit, which applies a ground to the switch-side ring lead. The switching equipment detects the ring ground and applies a tip ground and dial tone. The switch-side tip ground is detected by the *tip ground detector* circuit, which operates the *GS relay*. A closed *GS relay* contact grounds the stationside tip lead. The station detects the tip ground and, in response, removes

5. block diagram



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the ring ground and closes the loop. This operates the *A relay*, thereby closing the switch-side loop. Dial tone is conveyed to the station side via the 2wire repeater portion of the 7213. Operation during dial pulsing is as described for loop-start station-side seizure (paragraph 4.08).

4.14 Disconnect is produced either by a sustained on-hook (no loop current) from the station, which causes the *A relay* to release and opens the switch-side loop, or by the switching equipment removing its tip ground (forward disconnect), which releases the *GS relay* and removes the tip ground from the station side.

DLL portion: ground-start switch-side seizure

4.15 Seizure is initiated by application of a ground by the switching equipment to the switch-side tip lead. The tip ground is detected by the *tip ground detector* circuit, which operates the *GS relay*. A closed *GS relay* contact grounds the station-side tip lead. The tip ground is detected by the station equipment (usually a PBX trunk circuit), which provides a termination.

4.16 Ringing is sensed as described for loop-start switch-side seizure (paragraph 4.10) and, through operation of the *RU relay*, is extended toward the station equipment. Ring trip and disconnect also occur as described for loop-start switch-side seizure (paragraphs 4.11 and 4.12).

power supply

4.17 The *power supply* in the 7213 module 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 power connections.

6. specifications

repeater portion

gain range
0.0 to +15.75dB in 0.25dB increments (re 1000Hz)

gain deviation from that indicated by gain switches
±0.3dB

active slope equalization
0.0 to +7.5dB in 0.5dB increments at 2804Hz (re 1004Hz)

2wire impedance (both ports)
600 ohms + 2.15μF or 900 ohms + 2.15μF

2wire return loss
24dB ERL with either 600 ohms + 2.15μF or 900 ohms + 2.15μF termination and no gain or equalization

noise (C message)
less than 15dBrnC with maximum gain

harmonic distortion
less than 1% THD at +8dBm output level

delay distortion
less than 100μs between 1000 and 2400Hz

maximum input level	*maximum output level*
+8dBm	**+8dBm**

crosstalk loss between units in adjacent shelf positions
greater than 80dB between 200 and 4000Hz

longitudinal balance
55dB minimum, 200 to 3400Hz
frequency response
+1, –2dB between 400 and 4000Hz (re 1000Hz)

DLL portion

station-side range limits
48Vdc operation: 0 to 3000 ohms loop resistance plus tel set (200 ohms nominal)
72Vdc operation: 200 to 4500 ohms loop resistance plus tel set (200 ohms nominal)
96Vdc operation: 500 to 6000 ohms loop resistance plus tel set (200 ohms nominal)

station-side loop current
90mA maximum for reliable operation; 100mA current limiting

switch-side loop current
0-ohm loop, 400-ohm battery feed, 48Vdc battery: 75mA maximum for reliable operation: 90mA

dialing distortion
less than 5%

dialing speed
6 to 12pps

repeated ringing voltage
85 to 130Vac, 16 to 67Hz
(battery- or ground-connected ring generator)

ring sensitivity (switch side)
45Vac rms, 16 to 67Hz

ring-trip range
48Vdc bias: 3000 ohms loop resistance
72Vdc bias: 4500 ohms loop resistance
96Vdc bias: 6000 ohms loop resistance
(either superimposed or grounded ring generator)

ringing capability
all modes except multiparty biased selective
(up to 5 ringers can be rung simultaneously)

false-ring-trip guard
will not false ring trip up to 4μF + 0 ohms or 5μF + 1000 ohms

minimum facility leakage resistance (station side)
tip to ring, tip to ground, or ring to ground: 20 kilohms

minimum facility leakage resistance (switch side)
tip to ring, tip to ground, or ring to ground: 25 kilohms

common specifications

power requirements
voltage: –44 to –56Vdc
current (–48Vdc): 45mA idle, 75mA maximum (plus station loop current)

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

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

weight
approximately 16 ounces (454g)

mounting
relay rack or apparatus case via one position of a Tellabs Type 10 Mounting Shelf

7. testing and troubleshooting

7.01 The Testing Guide Checklist in this section may be used to assist in the installation, testing, or troubleshooting of the 7213 2Wire Hybrid Repeater with DLL module. The Checklist is intended as an aid in the localization of trouble to a specific module. If a module is suspected of being defective, a new one should be substituted and the test conducted again. If the substitute module operates correctly, the original module should be considered defective and returned to Tellabs for repair or replacement. We strongly recommend that no internal (component-level) testing or repairs be attempted on the 7213 module. Unauthorized testing or repairs may void the module's warranty.

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

7.02 If a situation arises that is not covered in the Checklist, contact Tellabs Customer Service at your Tellabs Regional Office or at our Lisle, Illinois, or Mississauga, Ontario, Headquarters. Telephone numbers are as follows:

US central region: (312) 969-8800
US northeast region: (412) 787-7860
US southeast region: (305) 645-5888
US western region: (702) 827-3400
Lisle Headquarters: (312) 969-8800
Mississauga Headquarters: (416) 624-0052

7.03 If a 7213 is diagnosed as defective, the situation may be remedied by either *replacement* or *repair and return*. Because it is more expedient, the *replacement* procedure should be followed whenever time is a critical factor (e.g., service outages, etc.).

replacement

7.04 To obtain a replacement 7213 module, notify Tellabs via letter (see addresses below), telephone (see numbers above), or twx (910-695-3530 in the USA, 610-492-4387 in Canada). Be sure to provide all relevant information, including the 8X7213 part number that indicates the issue of the module in question. Upon notification, we shall ship a replacement module to you. If the module in question is in warranty, the replacement will be shipped at no charge. Pack the defective 7213 in the replacement module's carton, sign the packing slip included with the replacement, and enclose it with the defective module (this is your return authorization). Affix the preaddressed label provided with the replacement module to the carton being returned, and ship the module prepaid to Tellabs.

repair and return

7.05 Return the defective 7213 module, shipment prepaid, to Tellabs (attn: repair and return).

in the USA: Tellabs Incorporated
4951 Indiana Avenue
Lisle, Illinois 60532

in Canada: Tellabs Communications Canada, Ltd.
1200 Aerowood Drive, Unit 39
Mississauga, Ontario, Canada L4W 2S7

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

testing guide checklist

test	test procedure	normal conditions	if normal conditions are not met, verify:
circuit idle (loop start)	Connect VOM (set to 50 or 250Vdc scale) to switching-side tip and ring, then to station-side tip and ring.*	*Busy* LED unlit ☐. Minimum −48Vdc battery across switching-side tip and ring ☐. Minimum −48Vdc local talk battery across station-side tip and ring with tip positive ☐.	Power ☐. Wiring ☐. No excessive cable leakage ☐. No ground on ring ☐. No open switching cable pairs ☐. Switching equipment not defective ☐. Switch *S1* set to *LS* ☐.
circuit idle (ground start)	Connect VOM (set to 50 or 250Vdc scale) to switching-side tip and ground, then to switching-side ring and ground.*	Nominal −48Vdc on tip ☐. Nominal −48Vdc on ring ☐.	Power ☐. Wiring ☐. No ground on tip ☐. No open or ground on ring ☐. Switch *S1* set to *GS* ☐. Switching equipment not defective ☐.
ringing	With VOM set to 250Vac scale, measure ringing voltage across switching-side tip and ring, then across station-side tip and ring.*	*Busy* LED unlit ☐. Minimum 45Vac switching-side ringing voltage ☐. In repeated ringing, station-side ringing follows switching-side ringing, 65Vac minimum ☐. In bypassed ringing, station-side ringing voltage same as switching-side ☐.	Switch *S3* correctly set (see paragraph 3.12) ☐. In repeated ringing mode, check local ringing source ☐.**
ring trip	With tel set on station side, use VOM (at 250Vac, then 50Vdc scales) to observe ring trip on both station and switching sides of module. (Access at station-side tip and ring and switching-side tip and ring.*)	Place telephone set off-hook during ring cycle; *busy* LED lights ☐, and ring voltage is removed from both station and switching sides ☐. After ring trip occurs, dc loop voltage drops on both switching and station sides ☐.	Station is within specified range of DLL ☐. DC-biased ring generator is present ☐.
supervision (loop start)	With VOM set to 100mA scale, measure current across station-side tip and ring.*	*Busy* LED is lit ☐. Current is between 80 and 100mA ☐.	Local power ☐. Option switches correctly set ☐.
supervision (ground start)	Set VOM to 50 or 250Vdc scale and connect it across switching-side ring and ground. Then connect station-side ring to ground.*	VOM indicates less than −15Vdc ☐. *Busy* LED lit ☐.	Local power ☐. Switch *S1* set to *GS* ☐.
	Set VOM as above and connect it across station-side tip and −48Vdc. Then connect switching-side tip to ground.*	VOM indicates nominal −48Vdc ☐.	Same as above ☐.
dialing	With tel set connected to station side, connect VOM (50Vdc scale) across switching-side tip and ring.* Go off-hook with tel set and commence dialing.	*Busy* LED follows dial pulses ☐. VOM also follows dial pulses, indicating −20 to −30Vdc during pulsing ☐.	Switches *S4* and *S5* correctly set ☐. Longitudinal voltages with tel set off-hook are less than 10Vac (see below) ☐.
	Set VOM to 50Vac scale and connect it to station-side tip and ground. Go off-hook with tel set and observe longitudinal-voltage reading on VOM. Repeat with VOM connected to station-side ring and ground.	With tel set off-hook, VOM indicates less than 10Vac in both cases ☐.	(If VOM indicates 10Vac or greater, locate and eliminate source(s) of excessive longitudinal voltages.)
call release	Go back on-hook with station-side tel set.	*Busy* LED goes off when tel set is placed on-hook ☐.	Longitudinal voltages are less than 10Vac (see above) ☐. No excessive cable leakage ☐.
transmission quality	Establish talk path through 7213 module, i.e., place a call over the circuit.	No singing (oscillation) or hollow sound ☐.	Gain setting correct ☐. Equalizer setting correct ☐. Return loss with gain and equalization acceptable: ERL ☐, SRL LO ☐, SRL HI ☐. Return loss without gain or equalization acceptable: ERL ☐, SRL LO ☐, SRL HI ☐. PBN settings correct ☐. If trouble persists, reduce gain and/or equalization ☐, and realign PBN ☐.

*The appropriate backplane pins to use are determined by option switches *S13* and *S20*; see table 1.

**If the loop between the DLL and the station has excessive leakage resistance, or if the impedance between tip and ring or between ring and ground exceeds 4μF + 0 ohms, or 5μF + 1 kilohm, pre-trip may occur. This will be evidenced by a short burst of ringing during each ringing cycle. If this symptom occurs, correct the abnormal loop condition.