tellabs
technical manual
76-816113
rev B

practice section 816113

6113 E&M-to-Loop DLL (FXS) Module

contents

1. general description

1.01 The Tellabs 6113 E&M-to-Loop Dial Long Line (Foreign Exchange, Station End) Module (figure 1) provides conversion between E&M signaling and the loop signaling used at the station end of a foreign-exchange (FX) or off-premises-station (OPS) circuit. Specifically, the 6113 converts E-lead signals to loop supervisory and ringing signals toward the station and converts outgoing loop signaling from the station to M-lead outputs. The 6113 is typically used in a 2wire circuit with an associated term set or repeat coil. The resulting two-module arrangement provides facility signaling, loop signaling, and conversion between the two signaling modes at the station end of an FX or OPS circuit.

1.02 This practice section is revised to provide current Tellabs Regional Office telephone numbers in section 7.

1.03 The main application of the 6113 module (and associated term set/repeat coil) is as a loop-to-E&M converter that directly interfaces a facility providing 4wire E&M signaling to a station loop. The 6113 (and associated term set/repeat coil) can be used with either an inband SF or out-of-band signaling module, or with a DX signaling module.

1.04 Switch options condition the 6113 module for loop-start or ground-start operation, normal or reverse-battery loop applications, normal or inverted E-lead operation, and external or negative ring-generator bias.

1.05 Other 6113 features include dial-pulse transient suppression, minimum-break (50ms) transmit pulse correction, M-lead current limiting, a traffic-monitoring lead, idle line termination during idle and dialing, and a re-ring protection circuit.

1.06 The 6113 accommodates applications involving reverse-battery (premonitory-busy) supervision. The 6113 must be optioned for loop-start operation and requires an interrupted ring generator source in this operational mode.

1.07 The 6113 requires a nominal −48Vdc filtered, ground-referenced input (−24Vdc cannot be used). An integral voltage regulator provides regulated voltages to all internal circuitry. Maximum current requirements range from 45mA at idle to 80mA during ringing and to 60mA plus M-lead and loop current when busy, depending upon the module's operating mode.

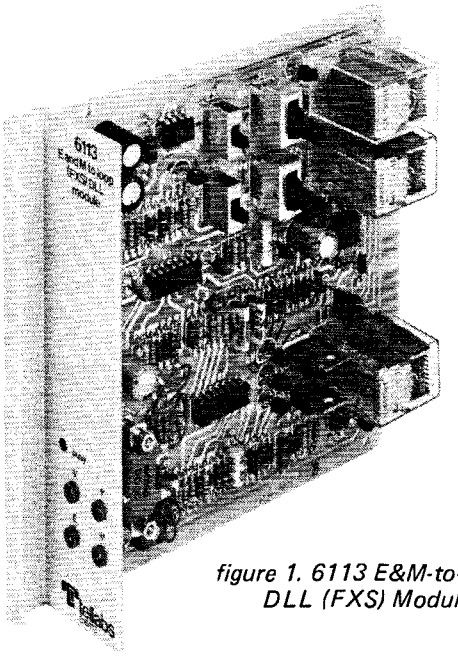


figure 1. 6113 E&M-to-Loop DLL (FXS) Module

1.08 Front-panel test points provide access to battery, ground, E lead, and M lead. A front-panel LED lights to indicate a busy condition.

1.09 The 6113 module 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 of vertical rack space is used.

2. application

2.01 The 6113 E&M-to-Loop DLL (FXS) Module is used at the station end of either an FX or an OPS circuit to provide a loop-to-E&M signaling interface. The 6113 is typically used with an associated term set or repeat coil in a 2wire circuit. The main application of the 6113 is as a stand-alone loop-to-E&M converter that interfaces T-carrier, out-of-band signaling, or a 4wire E&M signaling facility directly. Figure 2 shows one possible application of this type. Other applications are possible for the 6113 and term set/repeat coil as well. Figure 3 shows one such application: when used with a Tellabs 6001/6002 DX Signaling module, the 6113 provides an FXS arrangement with DX facility signaling.

2.02 The 6113 can be used in loop-start or ground-start applications. Loop-start signaling is common in FX and OPS applications involving a single station instrument. Ground-start signaling is

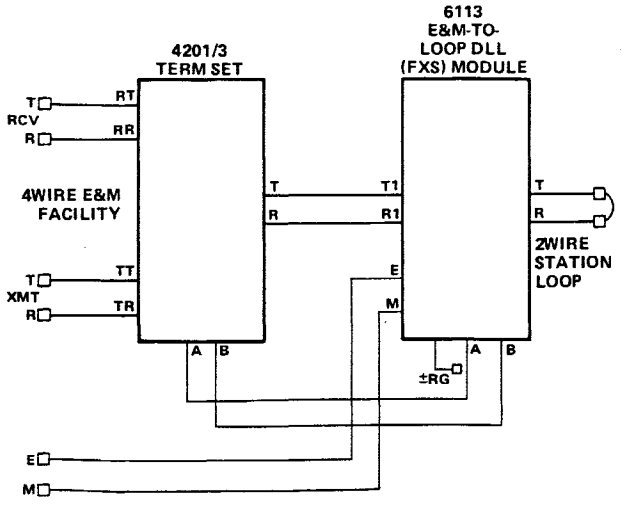


figure 2. 6113 in 4wire E&M-to-loop application

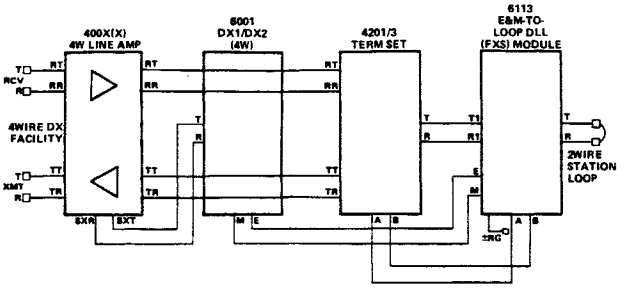


figure 3. 6113 in 4wire DX-to-loop application

used in applications where "head-on" or "glare" can be a problem, such as when trunking into a PBX.

2.03 The 6113 can be physically located in the circuit at a distance of up to 2000 ohms from the associated station or PBX trunk. Signaling limits on the facility side are related to external resistances of the E&M leads; typically, these resistances are 500 ohms or less.

2.04 The 6113 automatically provides the following circuit functions: dial-pulse transient suppression, minimum-break (50ms) pulse correction in the transmit path, M-lead current limiting, idle-line termination via the CC relay during idle and dialing, and a re-ring protection circuit.

station interface

2.05 Applications of the 6113 involving a 4wire transmission facility and a 2wire station or PBX trunk interface require a 2wire-to-4wire terminating set (e.g., a Tellabs 420X), through which the 6113 provides the required signaling and supervisory conditioning. Signaling between the 6113 and the term set is accomplished via a combination of the A and B and station transmission (tip and ring) leads. The loop current source is connected through the A and B leads, and loop closure is achieved when the associated station or PBX trunk goes off-hook. Use of the Tellabs 4203 Term Set is recommended, because the 4203 contains an A-and-B-lead inductor (not present in the 4201 Term Set) that isolates the battery supply to improve hybrid balance and to reduce the effects of battery noise.

2.06 In applications involving a 2wire transmission facility and a 2wire station or PBX trunk, a repeat coil (e.g., a Tellabs 442X) must be used to derive the 6113 interface to the station or PBX equipment.

loop-to-E&M applications

2.07 The primary application of the 6113 (with associated term set or repeat coil) is as a stand-alone pair used to convert loop signals from the station end to E&M signals for direct interface with a transmission facility using E&M signaling. This application is most commonly encountered in applications involving T-carrier channels, out-of-band signaling, or 4wire DX circuits interfacing a station loop. Figure 2 shows a typical application of this type.

DX applications

2.08 The 6113 can be used to interface a 4wire DX facility with the loop-signaling mode used at the station end of an FX or OPS circuit. On 4wire transmission facilities, the 6113 can be used with the Tellabs 6001 DX1/DX2 Signaling Module or with the Tellabs 6042 or 6044 Network Terminating Modules; on 2wire transmission facilities, the 6113 can be used with the Tellabs 6002 DX1/DX2 Signaling Module or the Tellabs 6041 Network Terminating Module.

2.09 In 2wire applications, no external facility-interface module is needed because the 6002 and 6041 modules contain the necessary repeat coil. In 4wire applications, such as that shown in figure 3, additional modules may be required. On the 6113's facility side, a line amplifier (e.g., a Tellabs 4001) or a pad/transformer module (e.g., a Tellabs 4411) must be used to derive transmit and receive simplex leads for inputs from the facility to the 6001. (As an alternative, the 6044 Network Terminating Module can be used in lieu of a 6001 and 4001/4411 combination.) On the station side, a term set (e.g., a Tellabs 4201 or 4203) provides the 4wire-to-2wire termination and level control. Alternatively, the 6042 Network Terminating Module can be used to provide the 4wire-to-2wire termination, level control, and DX signaling required in a 4wire DX-to-loop application.

other applications

2.10 Other applications for the 6113, such as interfacing an E&M SF transmission facility, are possible with the addition of one or more modules. Figure 4 shows one possible 4wire E&M SF facility-to-loop application. Please call Tellabs Customer Service at one of the telephone numbers listed in paragraph 7.02 if additional application information is required.

power

2.11 The 6113 must operate from filtered, ground-referenced −48Vdc input. An integral voltage regulator provides the −24Vdc and −12Vdc

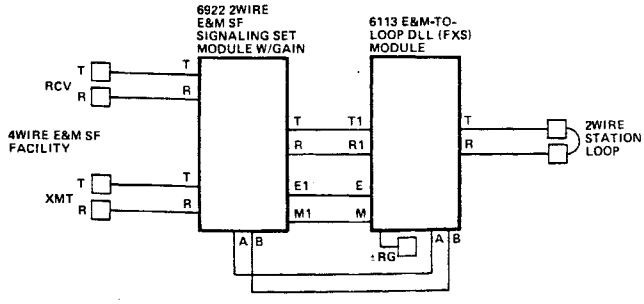


figure 4. 6113 in 4wire E&M SF-to-loop application

supplies required by certain internal circuitry of the 6113.

traffic monitoring

2.12 The 6113 derives a traffic-monitoring (TRAF. MON.) lead that can be used for peg-count metering and time-used measurements. This lead provides a ground output to external equipment whenever the associated station is off-hook, and is open while the station is on-hook. The traffic-monitoring lead does not follow E-lead dial pulses; it remains at ground potential during dialing and is open during ringing.

reverse-battery applications

2.13 The 6113 accommodates reverse-battery supervision (for premonitory-busy applications). When used in the reverse-battery mode, the 6113 must always be optioned for loop-start operation and in most cases, for inverted E-lead operation. Further, it requires an interrupted ring generator input if conventional interrupted ringing is desired. The 6113 provides forward-disconnect capability in the loop-start, reverse-battery mode. This is not possible in the loop-start, normal-loop-battery mode.

3. installation

inspection

3.01 The 6113 E&M-to-Loop DLL (FXS) Module should be visually inspected upon arrival in order to find possible damage incurred during shipment. If damage is noted, a claim should immediately be filed with the carrier. If stored, the module should be visually inspected again prior to installation.

mounting

3.02 The 6113 mounts in one position of a Tellabs Type 10 Mounting Shelf, which is available in configurations for both relay-rack and apparatus-case installation. The module plugs physically and electrically into a 56-pin connector at the rear of the shelf.

installer connections

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

3.04 Table 1 lists external connections to the 6113 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:
T (to station tip lead) (see note 1)	47
R (to station ring lead) (see note 1)	53
T1 (to associated hybrid or repeat coil)	49
R1 (to associated hybrid or repeat coil)	51
A (to associated hybrid or repeat coil)	23
B (to associated hybrid or repeat coil)	19 or 25
E lead	43
M lead	15
TRAF. MON.	29
RING GEN. (see note 2)	55 or 56
EXT. RING GEN. BIAS	39 or 40
RING GEN. START	13
N.O. CC RELAY CONTACT (to associated repeater)	5
COM. CC RELAY CONTACT (to associated repeater)	3
N.C. CC RELAY CONTACT (to associated repeater)	2
N.O. CC RELAY CONTACT (to associated repeater)	9
COM. CC RELAY CONTACT (to associated repeater)	7
N.C. CC RELAY CONTACT (to associated repeater)	8
−BATT (−44 to −56Vdc, filtered, ground-referenced)	35
GND (ground)	17

Note 1: *For reverse-battery (premonitory-busy) applications, connect PBXtrunk or station tip to pin 53, and ring to pin 47.*

Note 2: *If circuit operation requires ring generator in the loop-start, reverse-battery mode or the ground-start mode, negatively-superimposed ring generator must be connected to pin 55 (or 56) for proper circuit operation. If circuit operation does not require ring generator, then −48Vdc must be connected to pin 55 (or 56) for proper circuit operation.*

table 1. External connections to 6113 module

options and alignment

3.05 No alignment of the 6113 module is required. However, four option switches must be set before the 6113 is placed into service. These switches and their functions are described in paragraphs 3.06 through 3.09. Figure 5 shows the locations of these switches on the module's printed circuit board.

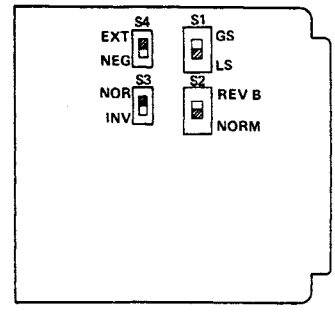


figure 5. 6113 option switch locations

3.06 Switch *S1* selects either the loop-start or ground-start supervisory mode. Set *S1* to the *LS* position for loop-start operation or to the *GS* position for ground-start operation.

3.07 Switch *S2* selects either normal or reverse-battery operation. Set *S2* to *NORM* for normal-loop-battery operation or to the *REV B* position for reverse-battery operation.

3.08 Switch *S3* selects either normal or inverted E-lead operation. Set *S3* to *NOR* for the normal E-lead configuration or to the *INV* position for the inverted E-lead configuration.

Note: Use of either the normal or inverted E-lead configuration (loop-start mode only) is dependent upon the idle/busy E-lead states present on the transmission facility. Set *S3* to *NOR* when the E-lead is grounded during idle and open when busy; set *S3* to *INV* when the E-lead is open at idle and grounded when busy. Reverse-battery (premonitory-busy) applications **usually** require the **inverted** E-lead configuration.

3.09 Switch *S4* selects either negative or external ring-generator bias. Set *S4* to *NEG* for negative ring-generator bias or to the *EXT* position for external ring-generator bias (for ground-connected ring generator applications).

4. circuit description

4.01 This circuit description is intended to familiarize you with the 6113 E&M-to-Loop DLL (FXS) Module for application and engineering purposes only. Attempts to troubleshoot the 6113 internally are not recommended and may void your warranty. Procedures for recommended testing and troubleshooting in the field are limited to those prescribed in section 7 of this Practice. Refer to the 6113 block diagram, section 5 of this Practice, as an aid in following this circuit description.

4.02 The 6113 provides ringing and, if so optioned, loop reversal toward a station or PBX trunk in response to an E-lead signal, and derives an M-lead output from detection of loop status on the station or trunk loop. The two functions are independent except for control of ringing during off-hook intervals (ring trip and ring inhibit).

4.03 Ringing toward the associated station or PBX loop is controlled from the input E-lead via the *E-lead sense* circuit and a delay timer that aids in preventing false momentary ringing. Included in this circuitry is a ringing latch that prevents re-ring if the local station goes on-hook before the E-lead is released.

4.04 In ground-start applications, the 6113 opens the local tip lead via a *TG* relay contact and provides tip ground under control of the E lead. In loop-start reverse-battery applications, the same relay is used to reverse the loop tip and ring leads toward the station or trunk, again in response to an E-lead input signal.

4.05 Ringing current is supplied toward the station or trunk through an optically isolated *ring-trip* sensing circuit when the *RU* (ring-up) relay is energized. Ringing is applied directly to the loop tip and ring leads, and the tip and ring leads of the associated repeat coil (or 4wire terminating set) are opened during ringing to prevent loading of the ringing source. Ringing (and, in the ground-start mode, tip-ground continuity) may be activated by either ground or open input to the module's E lead, depending upon optioning of switch *S3*. Similarly, loop reversal can be effected, using either E-lead state, if the reverse battery option is selected via switch *S2*.

4.06 Local ring trip during the ringing interval is accomplished through use of a bidirectional opto-isolator that detects and responds to the dc component of the composite ac/dc ringing signal. The external ringing source may be either biased or unbiased, but unbiased ring generator requires that an external dc bias be applied to the module's *external ring generator bias* lead. Switch *S4* accommodates this option.

4.07 A balanced *loop current sense* and battery feed circuit provides local loop current via the A and B leads of the associated repeat coil or term set and determines the supervisory status of the loop. Supervisory and dialing transitions are detected, delayed approximately 25ms, and converted to appropriate M-lead output states. A *minimum break pulse corrector* following the *delay* circuit ensures that dial pulses are transmitted with a break interval of at least 50ms. Pulses with break intervals longer than 50ms are transmitted as M-lead outputs with unaltered timing.

4.08 The M-lead output consists of a diode-protected transistor switch driven by a Schmitt-trigger level translator circuit. Current limiting in the battery lead is provided by a positive-temperature-coefficient thermistor that limits output current to less than 100mA.

4.09 The 6113 derives a traffic-monitoring lead that provides a transistor ground output when the local station or trunk is off-hook and that is open when the loop is idle. Additionally, a second loop-status monitoring circuit is used to control a *CC* relay that provides idle line termination and dial transient suppression. Contacts of this relay are available externally to control an associated repeater, if desired.

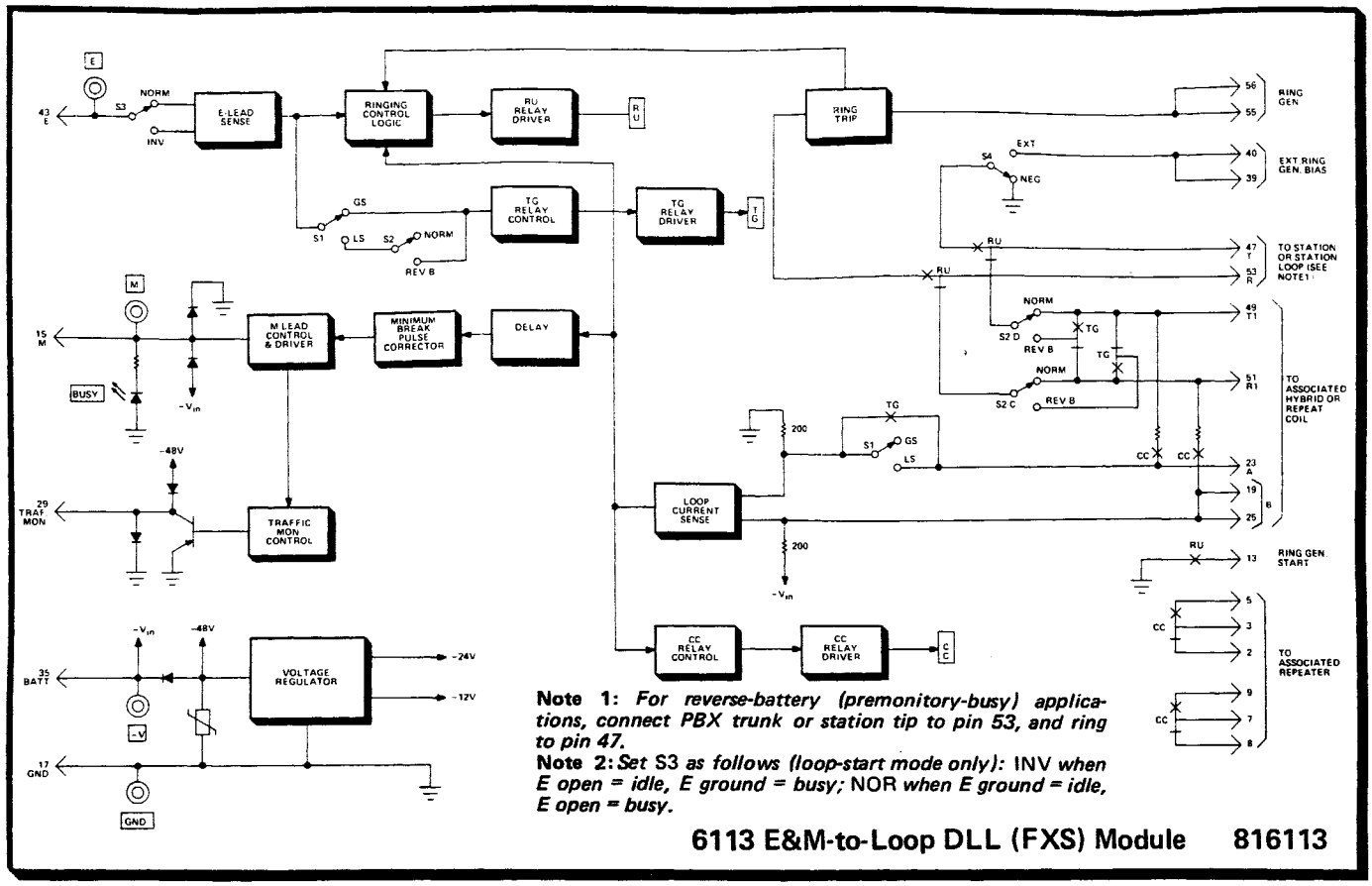
4.10 Internal power for the 6113 is supplied through a series *voltage regulator* and reference circuit that derives appropriate internal voltages. A series diode protects the circuit from reversed power connections, and a transient suppressor across the power input leads limits power transients to tolerable levels.

6. specifications

external E-lead resistance to ground
500 ohms maximum

ringing frequency range
16 to 67Hz

ring-up delay	*ring-release delay*
100 to 200ms	**75 to 175ms**



5. block diagram

tip ground delay (ground-start mode)
80 to 120ms

reverse-battery mode
seizure delay: 50 to 75ms
release delay: 50 to 150ms

traffic monitoring lead delays
seize: 10 to 30ms
release: 300 to 400ms

tip-ground release delay (ground-start mode)
50 to 100ms

ring trip range
0 to 3000-ohm loop

pre-trip margin
will not pretrip with up to 4μF capacitance and 30 kilohms loop leakage

loop sensing range
–48Vdc: 3000 ohms external resistance

M-lead pulsing-rate range
7.5 to 14pps

M-lead delay
25 ±3ms

dial-pulse correction
minimum-break, with minimum break duration of 50 ±2ms

dial-pulse distortion
maximum 3.0% distortion for input breaks longer than 50ms

maximum M-lead current
0.5 ampere

longitudinal balance
60dB minimum

longitudinal (signaling) environment
equivalent to 30Vac rms line induction (measured with unit removed, and tip and ring connected together to ground through a 500-ohm resistor)

CC-relay operate delay (for idle-line termination and transient suppression)
10 ±5ms

CC-relay release delay
150 ±25ms

input voltage
–44 to –56Vdc, filtered, earth-ground-referenced

current during ringing
LS: 55 to 75mA
GS: 70 to 90mA

idle current
35 to 55mA

busy current (loop start)
45 ± 10mA plus A&B and M lead

busy current (ground start)
60 ± 10mA plus M lead and loop

operating environment
32° to 130°F (0° 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
10 ounces (284 grams)

mounting
relay rack or apparatus case via one position of 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 6113 E&M-to-Loop DLL (FXS) 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 6113 module. Unauthorized testing or repairs may void the module's warranty. Also, if the module is part of a registered system, unauthorized repairs will result in noncompliance with part 68 of the FCC rules and regulations.

7.02 If a situation arises that is not covered in the Checklist, contact Tellabs Customer Service at your Tellabs Regional Office (in Canada, at our Mississauga, Ontario, headquarters). Telephone numbers are as follows:

US atlantic region: (203) 798-0506
US capital region: (703) 478-0468
US central region: (312) 357-7400
US southeast region: (305) 834-8311
US southwest region: (214) 869-4114
US western region: (714) 850-1300
Canada: (416) 624-0052

7.03 If a 6113 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 6113 module, notify Tellabs via letter (see addresses below), telephone (see numbers below), or twx (910-695-3530 in the USA, 610-492-4387 in Canada). Be sure to provide all relevant information, including the 8X6113 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 6113 in the replacement module's carton, sign the packing slip included with the replacement module, and enclose it with the defective module (this is your return authorization). Affix the preaddressed label provided with the replacement module to the carton being returned, and ship the module prepaid to Tellabs.

repair and return

7.05 Return the defective 6113 module, shipment prepaid, to Tellabs (attn: repair and return).

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

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

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

testing guide checklist

Note 1: *This testing guide checklist is based on the assumption that the 6113 is optioned as follows (unless otherwise stated): S1 set to LS; S2 set to NORM; S3 set to NOR; S4 set to NEG. This is a local test; no term set or outside calls are required. There are three complete test procedures in this table, one for each operational mode. Only the mode being used need be tested to verify operation. Use of a card extender (Tellabs 9801, 9802C, or equivalent) is recommended.*
Note 2: *The following preconditions must also be met:*
(1) A test telephone set with ringer (tel set) is required.
(2) Temporarily strap the A lead (pin 23) to the T1 lead (pin 49) and the B lead (pin 25) to the R1 lead (pin 51).
(3) Negatively-superimposed ring generator must be connected to pin 55 for loop-start, normal-loop-battery tests; negative battery must be connected to pin 55 for both ground-start tests and loop-start, reverse-battery tests.

test	test procedure	normal result	if normal conditions are not met, verify:
incoming idle, loop start, normal loop battery	Use VOM (set to voltage range that will measure negative input battery voltage) to measure dc voltage between *ground* and $-V$ test points.	Meter shows negative input battery voltage ☐.	Option switches correctly set ☐. Wiring ☐. Power ☐. Replace 6113 and retest ☐.
	Apply ground to E lead. Use VOM to measure T-lead voltage (with reference to $-V$ test point) and R-lead voltage (with reference to *ground* test point.	Meter shows approximately same voltage as input battery in both cases ☐.	

test	test procedure	normal result	if normal conditions are not met, verify:
outgoing idle, loop start, normal loop battery	Use VOM to measure dc voltage between $-V$ and *M*-lead test points.	Meter shows approximately same voltage as input battery (with no load on M lead) ☐.	Same as above ☐.
outgoing seizure, loop start, normal loop battery	Connect tel set to T and R leads and place off-hook. Use VOM to measure dc voltage between *ground* and *M*-lead test points.	*Busy* LED lights ☐. Meter shows approximately same voltage as input battery ☐.	Same as above ☐.
incoming seizure, loop start, normal loop battery	Place tel set on-hook. Open E lead. Place tel set off-hook. Use VOM to measure dc voltage between *ground* and *M*-lead test points.	Tel set rings ☐. *Busy* LED lights ☐. Ringing trips ☐. Meter shows approximately same voltage as input battery ☐.	Same as above ☐.
re-ring protection, loop start, normal loop battery	Place tel set on-hook. Use VOM to measure dc voltage between *M*-lead and $-V$ test points. Remove all test connections when testing completed.	*Busy* LED unlit ☐. Tel set does **not** ring ☐. Meter shows approximately same voltage as input battery ☐.	Same as above ☐.
incoming idle, ground start	Set switch *S1* to *GS*. With E lead open, use VOM (set to voltage range that will measure negative input battery voltage) to measure T-lead voltage with reference to $-V$ test point. Also measure R-lead voltage with reference to *ground* test point.	Meter shows no voltage on T lead (meter may show capacitance kick) ☐. Meter shows approximately same voltage as input battery on R lead ☐.	Same as above ☐.
outgoing idle, ground start	Use VOM to measure dc voltage between $-V$ and *M*-lead test points.	Meter shows approximately same voltage as input battery ☐.	Same as above ☐.
incoming seizure, ground start	Connect tel set to T and R leads. Place ground on E lead. Use VOM to measure T-lead voltage with reference to $-V$ test point. Place tel set off-hook. Use VOM to measure dc voltage between *ground* and *M*-lead test points.	Meter shows approximately same voltage as input battery ☐. *Busy* LED lights ☐. Meter shows approximately same voltage as input battery ☐.	Same as above ☐.
re-ring protection, ground start	Place tel set on-hook. Use VOM to measure dc voltage between ring gen. start lead (pin 13) and $-V$ test point.	*Busy* LED unlit ☐. Meter shows no voltage present ☐.	Same as above ☐.
outgoing seizure, ground start	Remove E-lead ground. Connect tel set to R lead and ground. Place tel set off-hook. Use VOM to measure voltage between *ground* and *M*-lead test points.	*Busy* LED lights ☐. Meter shows approximately same voltage as input battery ☐.	Same as above ☐.

test	test procedure	normal result	if normal conditions are not met, verify:
CO acknowledgement, ground start	Apply ground to E lead. Use VOM to measure T-lead voltage (with reference to $-V$ test point). Remove all test connections when testing completed.	Meter shows approximately same voltage as input battery (T lead at ground) ☐.	Same as above ☐.
incoming idle, loop start, reverse battery	Set switches *S1, S2,* and *S3* to *LS, REV B,* and *INV,* respectively. Use VOM (set to voltage range that will measure negative input battery voltage) to measure voltages from T lead to *ground* test point and from R lead to $-V$ test point.	Meter shows approximately same voltage as input battery in both cases ☐.	Same as above ☐.
outgoing idle, loop start, reverse battery	Use VOM to measure dc voltage between *M*-lead and $-V$ test points.	Meter shows approximately same voltage as input battery ☐.	Same as above ☐.
outgoing seizure, loop start, reverse battery	Connect tel set to T and R leads. Place tel set off-hook. Use VOM to measure dc voltage between *M*-lead and *ground* test points. Remove VOM leads from test points and connect negative VOM lead to T lead and positive VOM lead to R lead. Disconnect VOM leads when completed.	*Busy* LED lights ☐. Meter shows approximately same voltage as input battery ☐. With VOM leads connected as indicated, VOM shows positive voltage ☐.	Same as above ☐.
CO acknowledgement, loop start, reverse battery	Apply ground to E lead. Connect positive VOM lead to T lead and negative VOM lead to R lead (i.e., reverse of preceding step). Remove E-lead ground and VOM connections when completed.	With E lead grounded and VOM leads connected as indicated, VOM shows positive voltage ☐.	Same as above ☐.
incoming seizure, loop start, reverse-battery	Place tel set on-hook. Apply ground to E lead. Use VOM to measure dc voltages from T lead to $-V$ test point, and from R lead to *ground* test point. Place tel set off-hook. Use VOM to measure dc voltage between *M*-lead and *ground* test points.	Meter shows approximately same voltage as input battery in both cases ☐. Meter shows approximately same voltage as input battery ☐.	Same as above ☐.
re-ring protection, loop start, reverse battery	Place tel set on-hook. Use VOM to measure dc voltage between *M*-lead and $-V$ test points. Also measure dc voltage from ring gen. start lead (pin 13) to $-V$ test point. Remove all test connections when tests are completed.	Meter shows approximately same voltage as input battery ☐. Meter shows no voltage present ☐.	Same as above ☐.