Troubleshooting T1 Lines with the NetTek™ YBT1 Circuit Tester

Measurement Challenges for Field Service Technicians

Introduction

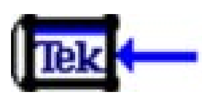
This application note, along with its companion primer, "T1 Network Technology: Essentials for Successful Field Service Technicians," addresses the most common measurement challenges faced by technicians who maintain base transceiver stations' wireline connections to the MSC. The application note provides practical insights and solutions to troubleshooting some common problems seen on the backhaul lines in wireless networks. The primer provides an overview of T1 technology, describes common T1 network topologies, and introduces key T1 measurement principles.

Troubleshooting T1 Circuits with the NetTek YBT1 Circuit Tester

Test Set Modes of Operation

The NetTek YBT1 circuit tester offers four modes of operation: Monitor, Terminate, Bridge, and Loopback. These modes are each useful depending upon what type of testing you're needing, and where you're located in the network.

Monitor



The monitor mode is designed for in-service monitoring of T1 lines at a DSX monitor port. At the DSX monitor port, the signal is resistor-isolated from the pass-through signal, and is 20 dB lower than the signal at the OUT jack. (The reader may wish to refer to figure 11 of the T1 Network Technology Primer.) In monitor mode, the YBT1 receiver is set for 100 ohms nominal input impedance, and the sensitivity is boosted with an internal pre-amplifier to account for the 20 dB resistive loss at the port. In this mode, the transmitter is disabled, just to prevent accidental disturbance of the signal in case the wrong connector is used.

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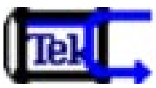
Terminate

The terminate mode is designed for use in out-of-service testing of T1 lines at a DSX patch panel. The transmitter sends data according to the transmitter settings in the Setup menu, including framing, line-code, and BER pattern. The receiver is also set according to the Setup menu settings. In Terminate mode, the YBT1 receiver compensates for up to 10 dB of cable loss for T1 lines. Terminate mode provides a nominal 100 ohm input impedance.

Loopback



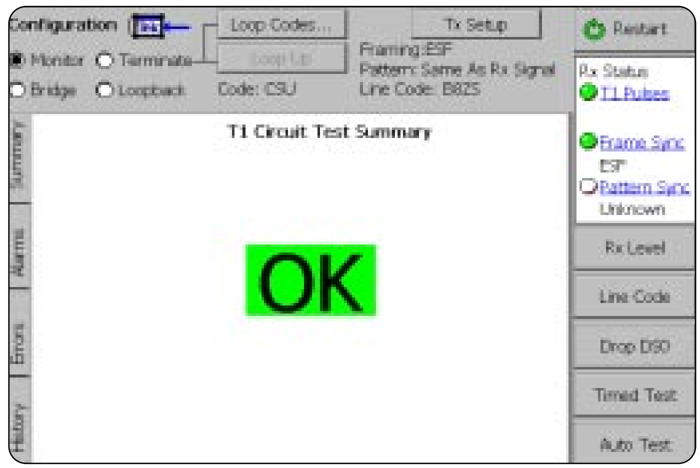
Loopback mode is intended for out-of-service testing of T1 lines. In this mode, the YBT1 performs a "line loopback" of the data from the receiver to the transmitter – it transmits exactly what comes in on the receiver, emulating a network element. In this mode, the YBT1 also makes measurements on the received data. Loopback mode is useful when testing from the far end of a T1 line, replacing a "hard" loopback with an intelligent loopback that can also examine the incoming data. In point-to point testing, this would allow technicians to isolate problems to either the transmit or receive paths of the Tx/Rx path. Loopback mode provides a nominal 100 ohm input impedance and compensates for up to 10 dB of cable loss for T1 lines. Note that this mode *will not work* with a loopback plug at the other end, because there would then be no element sourcing data to the YBT1 receiver.

Bridge

Bridge mode provides greater than 1 kohms input impedance for in-service monitoring, bridging the receiver input across lines that are terminated elsewhere in the network. Testing in this fashion allows you to connect to the physical copper pairs (typically done at binding posts or wiring blocks), without interrupting the signal. You may, however, induce bit errors during the connection process. Also, you *must* be careful in connecting in bridge mode; if you accidentally short to another pair, you could easily take down more than one span – the one you're testing and the one you short to. The Bridge mode compensates for cable loss up to 10 dB.

The YBT1 Summary Screen

Figure 1 below shows an example of the YBT1 summary screen while monitoring a live-traffic T1 line. This screen is designed to give the user a quick overview of the T1 circuit status without having to examine the particular details of the circuit performance. You can use this screen for most of your monitoring and verification tasks. Troubleshooting, described in a separate section, uses some of the other measurement screens available through the buttons on the right.



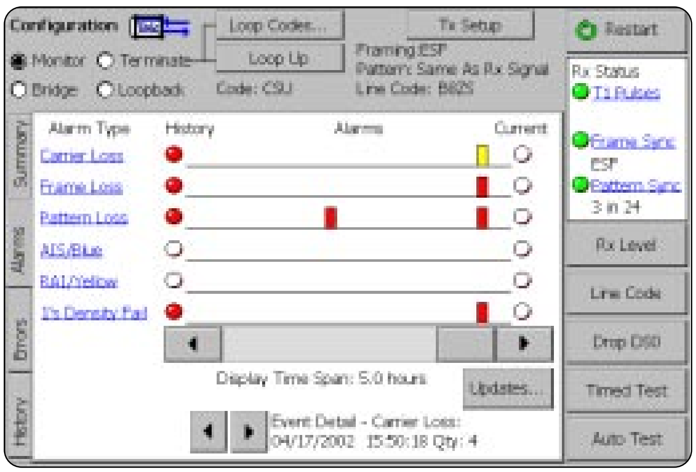
▶ ***Figure 1:*** *YBT1 Summary Screen*

From this screen, you can observe that the T1 circuit is currently OK, experiencing no problems. The Rx Status indicators along the right of the display are showing that: T1 pulses are present at an acceptable signal level; the line is configured for ESF framing; the pattern is unknown and there is no pattern sync because the instrument is monitoring live traffic.

A useful feature of the YBT1 is that the status indicators will always attempt to auto-detect the signals on the line and tell you what it found, independent of the transmit/receive settings. A green indicator informs you that the detected signals match the currently selected settings, a red indicator informs you of a mismatch. A white indicator informs you that auto-detect is in progress (receiving), or has inconclusive results. In the example shown above, the white indicator and Unknown label for the received pattern indicate that the incoming signal does not match any of the known BER test patterns built into the YBT1.

Understanding and Troubleshooting Alarms

Several different types of alarms are defined for T1 systems. Alarms are used to indicate the presence of a problem somewhere in the T1 system; whereas errors represent a quantifiable measurement of conditions which may be contributing to the problem. Alarms can be observed using in-service testing methods – patching in the YBT1 test equipment to the monitor port of a DSX-1 panel, with the YBT1 put in MONITOR mode. The alarms that are monitored by the YBT1 are Carrier Loss, Frame Loss, Pattern Sync Loss, AIS/Blue Alarm, RAI/Yellow Alarm, and Ones Density Alarm.



▶ ***Figure 2:** YBT1 Alarm WIndow*

A sample screen is shown in Figure 2. From this view, you can observe that Carrier Loss, Frame Loss, Pattern Sync Loss, and Ones Density Failures occurred nearly simultaneously. The yellow highlighted event, Carrier Loss, shows a time and date stamp at the bottom of the screen. Using this screen, you can view Current alarm status with the indicators on the right side of the display, and History alarm status along the left row of indicators. The scrolling display between gives you a live look at possible time correlation between the alarm events. T1 alarms and their possible causes are described below.

Carrier Loss Alarm

The Carrier Loss (also known as Loss of Signal or LOS) alarm is defined as the absence of "marks" in the incoming data – poor or no received signal level. For the YBT1, this alarm illuminates after 1 ms (approximately 1500 bit-periods) of "no pulses" condition after initial signal detection. When the signal is detected again, it must be present for at least 1 ms before the carrier loss alarm is cleared. When the Carrier Loss alarm is active, Frame Loss and Pattern Sync Loss alarms may also be active. You may measure the signal level using the YBT1 Rx Level measurement function. Carrier loss is usually caused by a failed network element such as a repeater, a misconfigured mux or DACS, or a completely failed connection. Note that when this condition is observed, the YBT1 does *not* generate an AIS signal on its transmitter.

Frame Loss Alarm

The Frame Loss alarm (also known as Loss of Frame, or LOF) is declared when more than 2 out of 5 F_T bits are found in error for D4 (SF) Framing, or 2 out of 5 FPS bits in ESF framing format are found to be in error. For D4 framing, the Frame Loss alarm is cleared after detection of two consecutive complete framing sequences. Likewise for ESF framing, the Frame Loss alarm is cleared after detection of two consecutive FPS bit sequences. Frame loss can be caused by a number of problems including bad connections, poor signal level, noise/interference on the line, or line frequency offsets (T1 line frequency that deviates from the nominal 1,544,000 Hz bit frequency).

Pattern Sync Loss

The Loss of Pattern Sync alarm is specific to BER test equipment, and it may only be observed on test equipment when performing out-of-service testing. This alarm is declared if more than 200 bit errors in 1000 bits are detected. The Pattern Sync alarm is cleared when the incoming pattern is again detected, and observed less than 200 bit errors in 1000 bits. Pattern sync losses occur under conditions of significant bit errors, and may be caused by poor received signal level due to faulty network elements, or by one side bad of the connection pair, or line frequency offsets that may be caused by poor clock recovery.

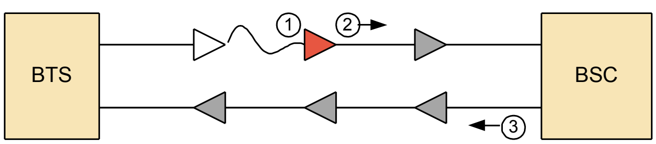
AIS / Blue Alarm

The Alarm Indication Signal (AIS) alarm is declared if no more than 2 zeros are detected in the time interval of 12 complete frames. The AIS is an unframed, all-ones signal transmitted on the T1 line.[IV]

Network equipment transmits the AIS alarm instead of the "normal" signal when there is a Loss Of Signal (LOS) and Loss Of Framing (LOF) condition at the receive side of the equipment. The AIS is sent to maintain synchronous transmission and to indicate to downstream equipment that there is a transmission interruption either at the equipment originating the AIS, or in the upstream equipment. You can get AIS if the line isn't configured or connected yet, or if there is some transmission problem somewhere in the span. Figure 3 shows an example of how AIS and RAI alarms (discussed below) are related, and how you can interpret them. Note that the YBT1 will not actually transmit the AIS signal, but rather reports that it is receiving the AIS alarm from the line.

RAI / Yellow Alarm

The Remote Alarm Indication (RAI) alarm is sent in the "upstream" direction if the equipment is either receiving an AIS alarm, is receiving no signal (an LOS condition), or has lost receiver framing (an LOF condition) in the "downstream" direction. In D4 / SF framing mode, an RAI alarm is indicated by transmitting a zero in the bit 2 position of every DS0 time slot. In ESF framing, an RAI alarm is indicated by a specific bit-oriented message in the FDL bit stream. Figure 3 shows an example of how RAI may be observed in the network.



1. A repeater (shown in red) loses the signal coming from the BTS due to a faulty copper pair
2. With no received signal, the repeater transmits an AIS alarm signal "downstream" towards the BSC
3. The BSC terminating equipment recognizes the incoming AIS, and transmits an RAI alarm signal back "upstream" towards the BTS to inform the far end of the problem

▶ ***Figure 3:*** *An Example of AIS and RAI alarms*

In this example, the AIS will only be observed at the BSC end of the fault, indicating an "upstream" problem on the receive side. The RAI may be observed anywhere along the return path to the BTS, and at the BTS, but the AIS will *not* be observed in this direction, since there is no transmission problem in this direction. Again, note that the YBT1 itself does not transmit the RAI alarm, it simply reports that it is receiving the alarm code from the line.

Ones Density Alarm

The Ones Density Alarm is *not* an alarm received through the network. It is specific to test equipment and network equipment such as CSUs. The alarm is flagged if the pulse density falls below that defined in ANSI T1.403 [1]. It may indicate a problem in the network configuration, especially if it is configured for B8ZS clear channel capability.

For the "Loss" alarms, the YBT1 does not declare a "loss" condition until it has actually first successfully detected the "sync" condition. For example, it will not declare a Frame Loss condition until after it has first successfully achieved framing synchronization with the selected framing mode. Also, once the alarm condition is cleared on the line, regardless of the alarm, the alarm indication will remain in the History, and in the Alarms Count history until the measurement is restarted.

Troubleshooting Backhaul Timeslot Configuration Problems

The YBT1 offers a unique tool to help identify and troubleshoot problems that may be caused by incorrect configuration of the DS0 time-slots. Incorrect timeslot configuration can be caused by DS0 muxing problems, improper DACS configuration, mis-wiring at the MDF, etc. The Drop DS0 window, as shown in Figure 4, provides both the capability of visualizing the timeslot configuration, and performing an "audio DS0 drop" so that you can listen to the individual DS0 channel contents.

This view displays the data activity for each of the T1 time slots, referred to as the channelgram display. Activity is indicated as percentage ones density in the time slot, represented as a unique color for ones-density categories ranging from all "zeros" through all "ones" in 10 percent increments. It will also show "Line not Available" status, indicating either LOS or LOF conditions. Each of the thirty data record rows in the display represents a user-defined period of time. Over multiple time periods, the display builds up row by row, with the oldest row being dropped off the top as the new row is added to the bottom.

BTS technicians typically know the expected DS0 channel configuration for the T1 lines serving their base stations. Usually, these configurations are common throughout the service region, but there are always exceptions. Using the channelgram display and the audio drop, the technician can confirm the expected configuration is present on the T1 under test.

1 ANSI T1.403-1995 section 6.2.9 defines the pulse density (ones density) requirement as at least N ones in every window of 8(N + 1) bits where N is between 1 and 23, and no more than 15 consecutive zeros.

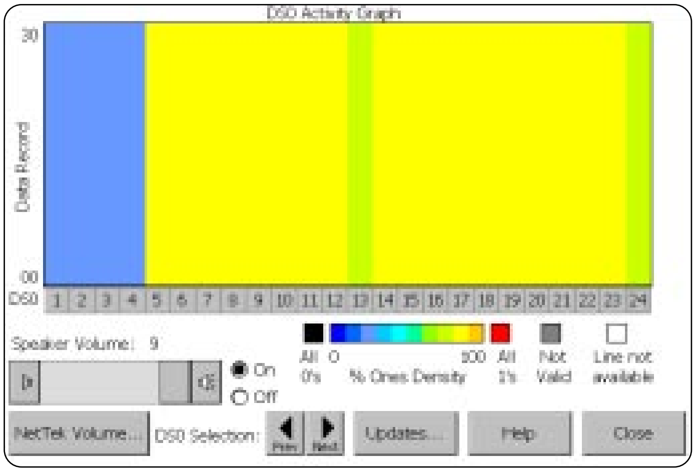


Figure 4: *Drop DS0 Measurement Window*

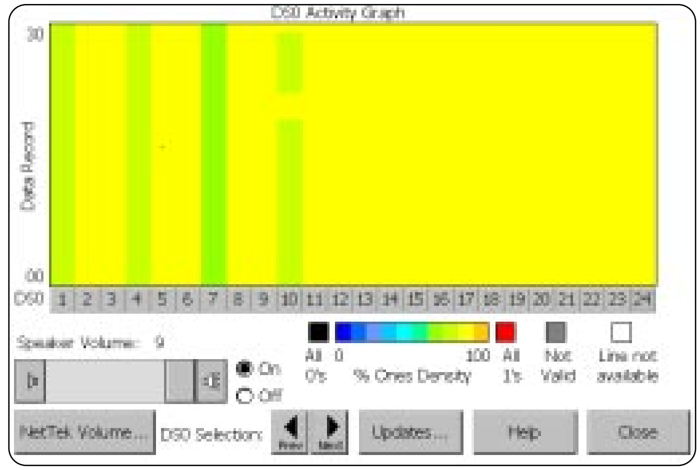


Figure 5: *T1 configured with PRI*

The display in Figure 4 shows a "live" T1 serving a CDMA base station. From this picture, you could confirm that DS0 slot 24, used as the control channel in this configuration, is active, containing about 50 percent ones density. Although not shown in this particular result, traffic activity will cause ones density fluctuations in the control channel associated with control signaling, which may help you spot the control channel more easily. You may also confirm DS0 channel 13, the backup control channel for this BTS, appears to be active. DS0 channels 1 through 4 are concatenated in a packet-pipe configuration common among some CDMA base stations. The remaining channels in this display are unused, and you can discern that the "idle" pattern used to fill these channels carries between 80-90 percent ones density, so probably consists of some combination of 7 "ones" and one "zero."

Some BTS technicians have "trained" their ears to listen to the control channel to verify it is operating correctly. The YBT1 will support this feature as well, allowing technicians to select any one of the DS0s to drop the data channel to the speaker. Using this screen, and the Audio Drop capability, you should be able to verify the protocol between the BTS and the MSC is up and functioning correctly on channel 24.

Figure 5 shows a T1 configured with ISDN PRI, a method which is sometimes employed in wireless backhaul configurations. From the picture, you can confirm the expected configuration:

– DS0 channel 1 is the PRI D-channel control

– DS0 slots 4, 7, and 10 are in-use

– DS0 slot 10 had at least two "call sessions" during the displayed time, displaying the channel "idle" pattern between sessions.

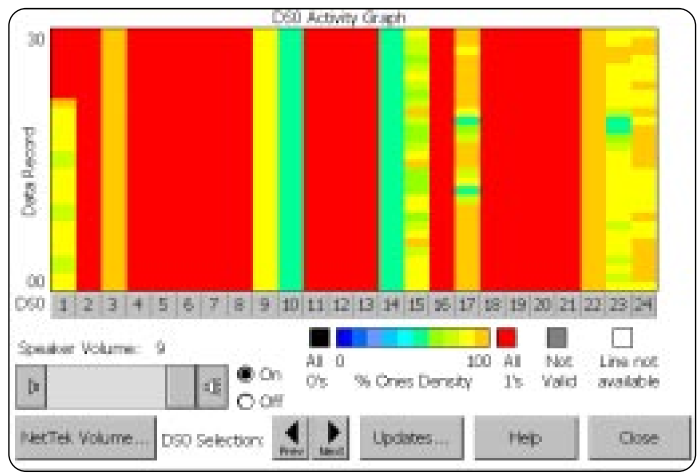


Figure 6: *T1 with voice traffic*

Voice traffic appears slightly differently on a T1 that is configured as a PRI and is connected to a PBX, as shown in Figure 6. Although this configuration is not encountered in most wireless backhaul test applications, it is worth observing the differences between the displays shown in Figure 4 and Figure 5 and that shown in Figure 6. The idle pattern in this T1 is all ones. The PRI control channel is not apparently resident in this T1. Remember that one PRI D-channel can provide control for up to 4 PRI T1s. Channels 1, 15, 17, 23, and 24 appear to be carrying active conversations, with the fluctuations in amplitude (ones density) obvious in the display. The remaining "active" channels aren't showing significant changes in ones density, but are not carrying the idle pattern, so they are apparently in use.

The Drop DSO display provides two tools for confirming the correct time slot configuration for T1 circuits. The familiar audio drop feature allows you to listen to the data on the channel, and using your trained ear, hear the expected "motorboat" noise usually found on BTS control channels. The second, and unique, channelgram feature allows you to visualize the same information in the form of ones density variations. The combination of the video and audio information within one display provides a powerful set of troubleshooting tools for confirming the expected DS0 slot configuration of your T1 lines.

Troubleshooting Intermittent T1 Problems

Intermittent problems are probably the most difficult and frustrating problems to solve, as any number of things could contribute to intermittent faults, including poor wiring connections, faulty repeaters, marginal line powering configurations, or even line-code mismatch problems. Some intermittent problems may be periodic, occurring at seemingly regular intervals, such as might be caused by Telco periodic maintenance routines or even a shift change at a nearby factory causing heavier loading on the backhaul. Others can be seemingly random, but without appropriate tools, it is difficult or nearly impossible to determine whether there is any relation to other events. In general, though, intermittent problems are best detected using some form of long-term in-service monitoring.

The YBT1 has a couple of unique features that can aid in troubleshooting these intermittent failures – the scrolling Alarms and Errors event displays and the Alarm/Error Count display with timestamps. A sample of the scrolling display is shown in Figure 7. As you can see from the display, the time represented between the History error Indicators on the left side and the Current error indicators on the right side is selected for 5 hours. This time span is user-selectable from one minute up to a total of 25 hours. When events are captured (by the Current indicators), they proceed across the display as time passes towards the History indicators. Events that scroll off the screen are still visible either by moving the scroll bar at the bottom of the display, or by examining the Alarms/Error Count Test History screen, shown in Figure 9.

From the display in figure 7, you can tell at a glance that Carrier Loss (LOS) and Bit Errors, CRC Errors, and Errored Seconds have been observed during the test, as shown by the History indicators. The Carrier Loss event, selected and highlighted in yellow, carries a timestamp which is displayed at the bottom of the screen. In this example, the carrier loss occurred at 7:51:57 on 04/18/2002. The Bit Errors and corresponding Errored Seconds events also carry timestamps that may be seen simply by selecting (highlighting) the event.

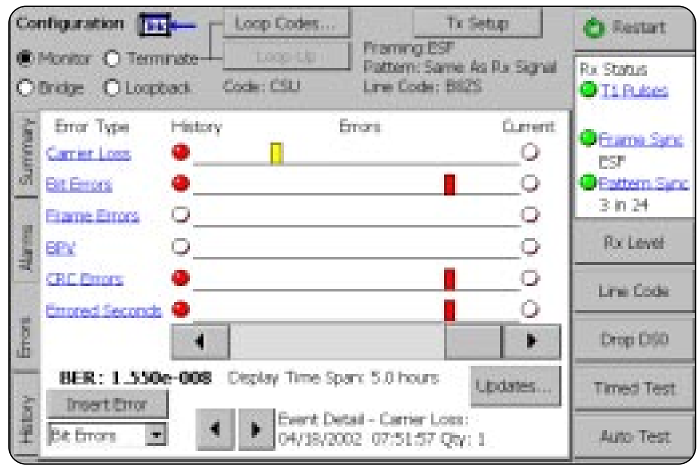


Figure 7: *YBT1 Errors display*

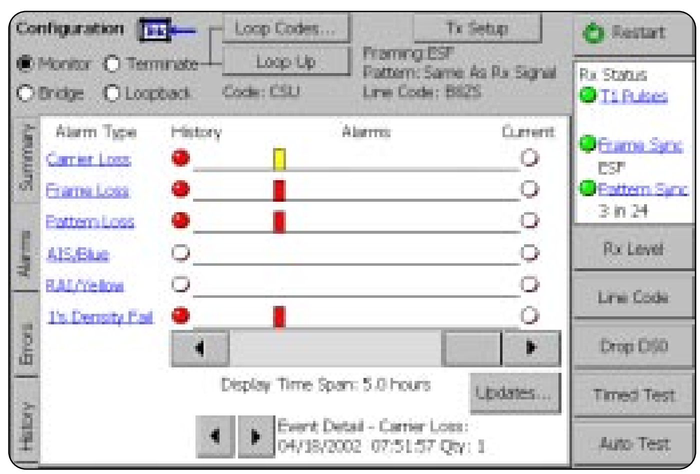
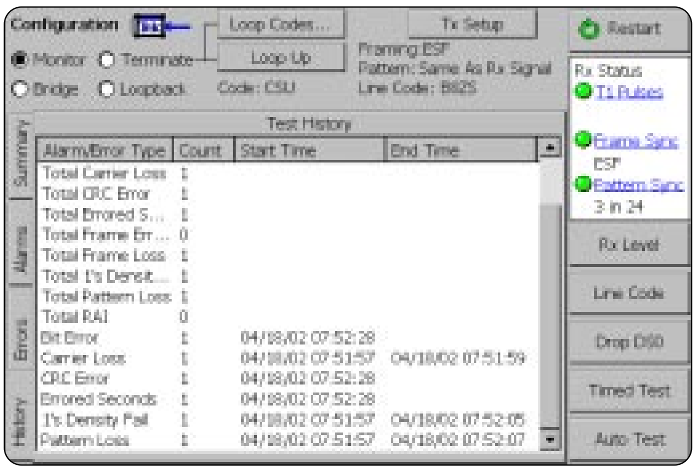


Figure 8: *YBT1 Alarms display*

Using these scrolling displays, you can look for a time correlation between events on the T1 span. If you compare the events shown in Figure 7: YBT1 Errors display and those shown in Figure 8: YBT1 Alarms display, you can see that the represented time span is identical. The Carrier Loss event actually appears on both displays. But in the Alarms display, you can see that in addition to the Carrier Loss, the line experienced Frame Loss (LOF), Pattern Sync Loss, and a Ones Density Alarm during the same time period. These additional alarms could be expected to be associated with the Carrier Loss alarm.



▶ ***Figure 9:*** *YBT1 Test History Count display*

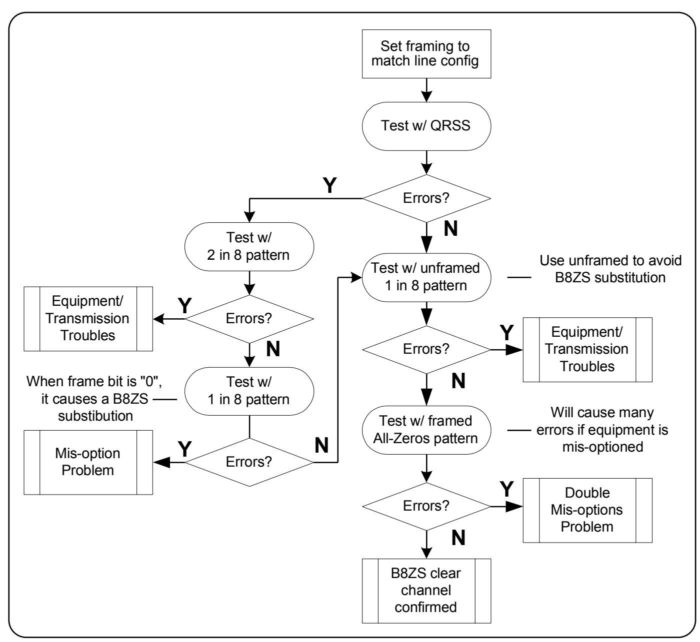
The display shown in Figure 9 allows you to view the total event count received during the test duration, and also the time stamps for the individual events. For Alarm events, there is not only a Start Time stamp, but also an End Time stamp, since a single alarm event can be present for a period of time, unlike an event such as a bit error which is virtually instantaneous.

Using these tools, you can easily observe the events that might be affecting your T1 service and see if there is any time correlation between errors and alarms. Then identifying a time correlation with known or suspected external events may allow you to narrow the scope of your testing, or even to pass the problem along to the Telco technicians responsible for servicing your T1 lines. As you know, the more information you are armed with, the more likely it is you can solve the problem.

Identifying Line Code Mismatch Problems

One of the more common problems impacting wireless network T1 backhauls today is accidental mis-configuration of the T1 line coding. Telcos are continuously grooming their interoffice trunks to ensure efficient use of the bandwidth. These interoffice links may be DS3's, or DS3's muxed into SONET rings. In any case, re-configuring muxes and demuxes with different contents leaves open the opportunity for mis-configuration. While your network may require clear-channel lines to the BTS, your service may get moved to a circuit that was previously occupied by a voice-grade T1 configured for AMI with robbed-bit signaling. Just one missed configuration on a piece of equipment through the link can cause you many headaches. When a network element in the middle of the span is mis-configured, errors will occur, but the errors may be data-content dependent, and may be difficult to track down. However, the good news is that there is a reasonably definitive test for finding an AMI-provisioned element in a B8ZS circuit.

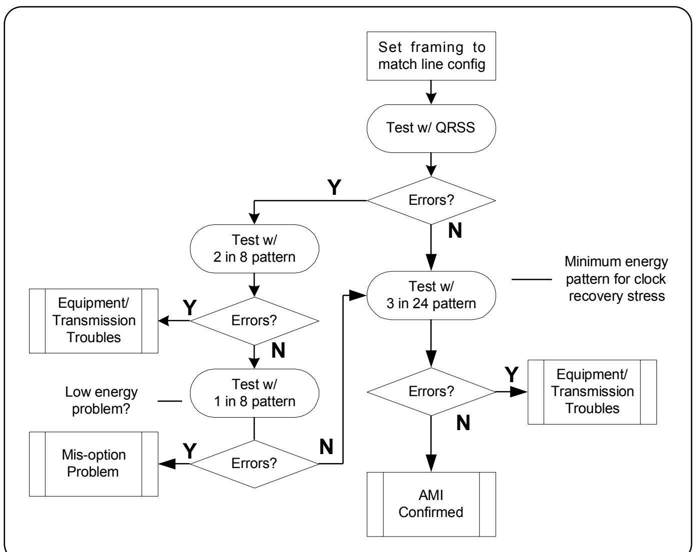
The following work flow diagram leads you through a process that will check the circuit for the presence of clear channel equipment mis-optioned for AMI, and also provides a check as to the performance of the circuit under test. The diagram is taken from an ANSI T1 technical report on DS1 testing[1] and slightly modified. The flowchart assumes that you have already taken the line out-of-service and already have a loop back configured at the far end of the line. Your test set is plugged-in to the circuit, configured for B8ZS line code, and you are ready to begin testing.



▶ ***Figure 10:*** *B8ZS clear channel verification test flow diagram*

Note that the use of the All Ones pattern through some types of DS3 equipment may cause DS1 failures if the DS3 multiplex equipment is not properly optioned, likely appearing as AIS on the received signal. Also note that the YBT1 does not allow for unframed pattern transmission. However, you may skip that step and still have a valid test for mis-optioned B8ZS configuration.

There is an equivalent work flow for testing lines that should be configured for AMI, but may be mis-optioned for clear channel B8ZS operation, or may have other circuit-related problems. You may note that in the case of an AMI circuit that is mis-optioned for B8ZS, there are back-to-back combinations of equipment which, if both are mis-optioned for B8ZS, will be self-correcting and will not be discovered using the testing flow diagram shown in Figure 11 below. Again, the flowchart assumes that you have already taken the line out of service, and already have a loop-back configured at the far end of the line. Your test set is plugged-in to the circuit, configured for AMI line code, and you are ready to begin testing.



▶ ***Figure 11:*** *AMI option verification test flow diagram*

Loopback Testing

Loopback testing is one of the two methods of performing out-of-service testing. Remember that out-of-service testing can be either point-to-point, with test instrumentation at both ends of the T1 span, or by creating a loopback at the far end of the span and using a single instrument to measure the round-trip performance of the T1 line. Because loopback testing only requires a single test instrument and operator, it is more convenient and more efficient than point-to-point testing. However, the downside to loopback testing is that it can only analyze the combined performance of both the transmit and receive path at the same time; *you cannot easily distinguish on which side the problem exists*. However, loopback testing typically can offer enough information to the wireless test technicians so that they may clearly assign responsibility for clearing the fault – to either themselves or the Telco.

There are several ways to achieve a loopback on a T1 circuit; most of these involve some method of manual intervention from a technician or operator at the far end of the circuit. These manual forms may include inserting loop plugs at a patch panel, forcing a CSU or NIU into loop-back from their front panel, or logging into the network via computer control and telling the element to loop back the signal. Another option open for the test technician is to use the loopback codes that are defined as part of the T1 standards and a test set capable of sending them. In most cases of loopback testing, though, the line must be taken out of service, so the MSC technician should be informed.

T1 network elements within the customer premise (either the BTS or the MSC) are typically programmed only to respond to loopback commands received from their network side. For example, in the diagram shown in Figure 12, the BTS NIU would *not* respond to a loopback command coming from the T1 tester shown in the diagram. However, it would respond to a similar loopback command if it were sent from the DSX-1 in the MSC, because it would be received on its “network” side. The Network Channel Terminating Equipment (NCTE) in the MSC, which may be an M13, a DACS, etc., will respond to loopback signals coming from the network side, but typically not from the switch side.

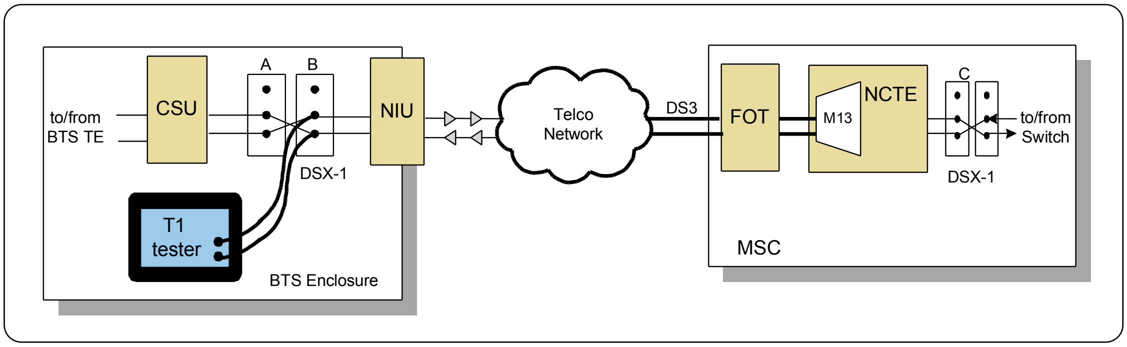


Figure 12: Typical BTS/MSC loopback test configuration

ANSI T1 standards define two formats of loop code control: In-band loop codes, and out-of-band loop codes. In-band codes are actually transmitted in place of payload data (but not framing bits) and are repeated continuously for a period of 5 seconds. They are defined for use with either D4 (Superframe) or ESF framing formats. Out-of-band loop codes are only defined for ESF framing, since an out-of-band communication link does not exist for D4 framing. (Refer to the section titled "Extended Superframe Format (ESF) Framing" in the T1 Network Technology Primer.)

There are also two types of loop codes: line loopback and payload loopback. Line loopbacks result in the full 1.544 Mbps stream looping back from receiver to transmitter; in other words, framing bits are included in the loopback. In payload loopback, only the 1.536 Mbps user channel data is looped back, the framing is generated by the equipment performing the loopback. Note that for D4 framing, only line loopbacks are defined, but ESF framing format supports both types.

The YBT1 only employs line loopback codes; however it offers them in each of the two formats (in-band and out-of-band), and allows you to select which of these loop codes you wish to use, as shown in Table 1.

Table 1: Defined Loopback Codes [II,IV]

TYPE	In-band loop codes	
	Up	Down
CSU	10000*	100
NIU [2] FAC1	1100	1110
NIU [3] FAC2	11000	11100
User Defined	3 to 8-bit pattern	3 to 8-bit pattern
Out-of-band Loop codes		
ESF Line Loopback	0000 1110 1111 11110011 1000 1111 1111	
ESF Network Loopback	0001 0010 1111 11110010 0100 1111 1111	

* bits are transmitted rightmost bit first

The in-band loop codes that are available are defined for the NIU, or DS1 Interface Connector, and the CSU, or customer installation equipment. The example above shows several ways to employ the loopback codes for isolating problems in the T1 link. As shown in Figure 12, the tester is plugged-in to DSX-1 panel B at the BTS and is testing toward the network and the MSC. Using the CSU loop code would activate a loopback in the terminating equipment (NCTE) at the MSC – the first element in the system beyond the network demarcation. This would allow you to isolate a problem between the DSX-1 and the NCTE, which primarily consists of the Telco network, along with the cable connections to the NCTE and the DSX-1 on either end.

Further isolation could be performed from the MSC side, where the cabling and DSX-1 connections could be tested by patching in at the C side of the MSC DSX-1 for testing toward the network. In testing toward the network at panel C, the NIU loopcode would be sent to the network to loop back the NIU at the BTS site.

Two other points to add about loopback testing:

– User defined loop codes: Many types of equipment allow the installer to set installation-specific loop codes, or contain manufacturer-specific loop codes, so the YBT1 allows you to program one of these non-standard loop codes. This may allow you to further isolate problems within the network by having looping control over additional elements.

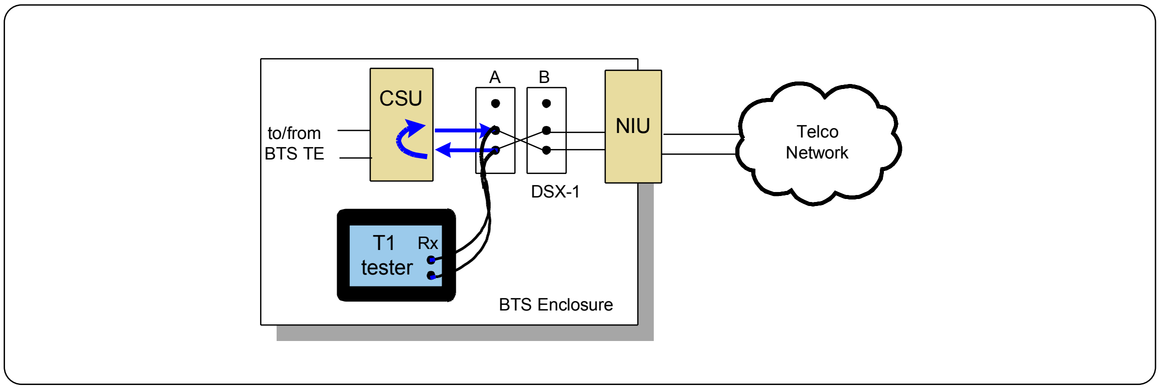
– Equipment that responds to loop codes typically can be set to automatically loop down after some programmable time period, usually 20 minutes. This prevents a span element from being looped-up accidentally and then left looped-up, taking the span down permanently. You need to be aware of such timeout periods, if performing long-term testing on a span that has been remotely looped up.

2 The FAC1 NIU loop code is not defined in the TR-TSY-000312 DS1 Interface Connector standard, but is still used in older deployments.

3 The default NIU (DS1 Interface Connector) activation and deactivation codes are FAC2 as defined the TR-TSY-000312 DS1 Interface Connector standard.

So for example, from the diagram shown in Figure 13, you could test from:

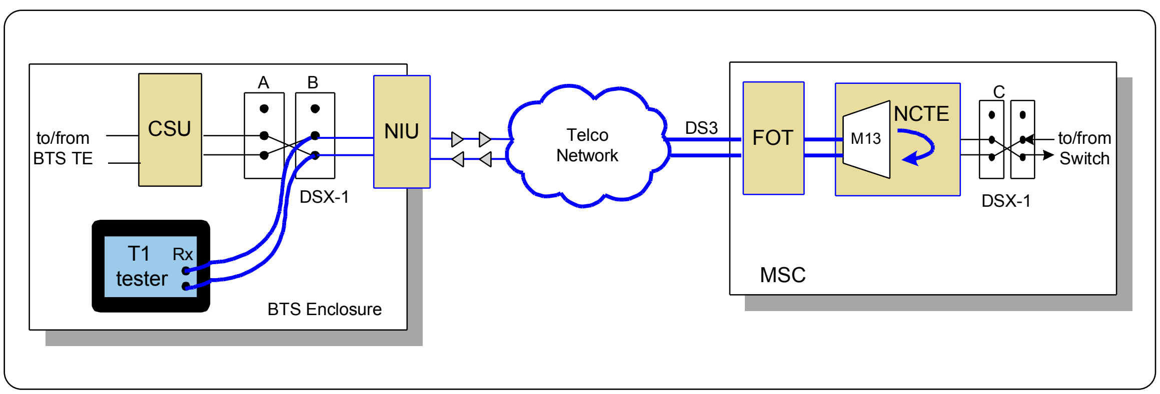
Patch Panel	Using Loop code	Loops Back	Tests Section	Results	Ref. Figure
A	CSU In-band	BTS CSU Rx to Tx	Wiring inside BTS from DSX-1 through CSU and back, tests CSU	Proves inside wiring and CSU are functioning correctly	Figure 13



▶ ***Figure 13:*** *CSU Loopback inside BTS*

or you could test from:

Patch Panel	Using Loop code	Loops Back	Tests Section	Results	Ref. Figure
B	CSU In-band	MSC NCTE	BTS wiring from DSX-1 to NIU, Telco network, MSC wiring to NCTE	Proves inside wiring and network circuit through NCTE are functioning correctly	Figure 14
B	ESF Line Loopback	MSC NCTE	BTS wiring from DSX-1 to NIU, Telco network, MSC wiring to NCTE	Proves inside wiring and network circuit through NCTE are functioning correctly	Figure 14



▶ ***Figure 14:*** *NCTE loopback towards the network from BTS* *or* you could test from:

Patch Panel	Using Loop code	Loops Back	Tests Section	Results	Ref. Figure
C	NIU FAC2	BTS NIU	MCS wiring from DSX-1 to NCTE, through Telco network to the NIU	Proves MSC inside wiring and network circuit through to NIU are functioning correctly	Figure 15
C	ESF Network Loopback	BTS NIU	MCS wiring from DSX-1 to NCTE, through Telco network to the NIU	Proves MSC inside wiring and network circuit through to NIU are functioning correctly	Figure 15

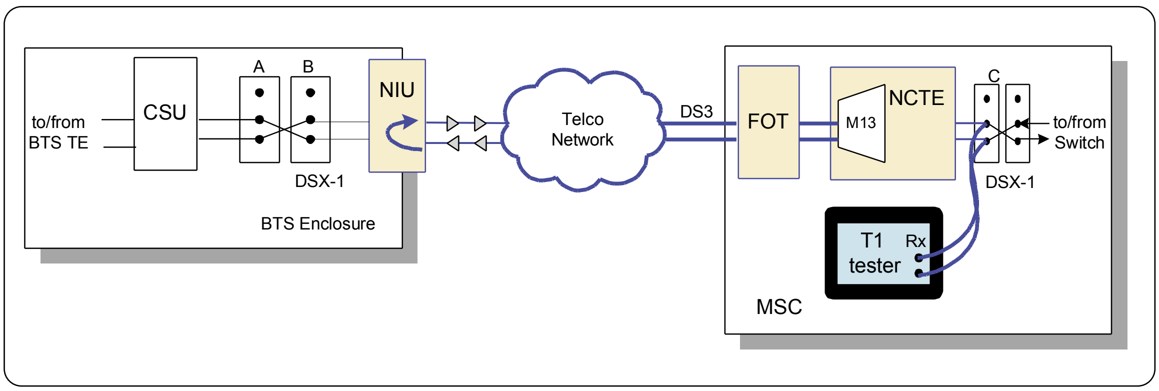


Figure 15: *NIU Loopback through the network from MSC*

or you could test from:

Patch Panel	Using Loop code	Loops Back	Tests Section	Results	Ref. Figure
C	CSU	BTS CSU	MCS wiring from DSX-1 to NCTE, through Telco network, through BTS wiring to the CSU	Proves MSC inside wiring and network circuit through the BTS NIU and CSU, along with the BTS inside wiring are functioning correctly	Figure 16
C	ESF Line Loopback	BTS CSU	MCS wiring from DSX-1 to NCTE, through Telco network, through BTS wiring to the CSU (same as previous test)	Proves MSC inside wiring and network circuit through the BTS NIU and CSU, along with the BTS inside wiring are functioning correctly	Figure 16

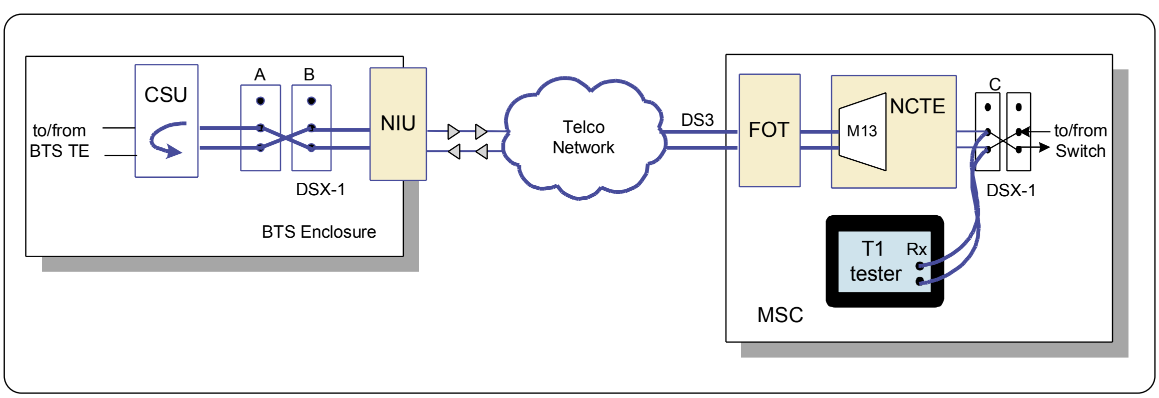


Figure 16: *CSU Loopback through the network from MSC*

Loopback testing is one of the two methods of performing out-of-service testing. There are two ways to perform loopback testing – either manually with someone at the far end, or by sending standards-defined loopback codes through the network. Loopback testing typically can offer enough information to the wireless test technicians so that they may clearly assign responsibility for clearing the fault – to either themselves or the Telco.

Appendix A: Glossary and Acronyms [IV, V]

AIS Alarm Indication Signal
A signal transmitted in place of the normal signal to maintain transmission continuity and to indicate to the receiving equipment that there is a transmission problem located either at the equipment originating the AIS signal or upstream of that equipment

AMI Alternate Mark Inversion
A line code that uses a ternary (three level) signal to convey binary digits in which successive binary ones ("marks" or pulses) are of alternating polarity, either positive or negative, equal in amplitude. A binary zero ("space") is transmitted as no pulse, or zero amplitude. North American implementations use signal elements representing binary ones that are non-zero for only half the bit interval period

ANSI
American National Standards Institute

Backhaul
Term used to commonly refer to digital transmissions carrying signals from the Base Transceiver Station (BTS) sites "back" to the Mobile Switching Center (MSC) in the networks of wireless operators

BER
Bit Error Rate: A measure of transmission quality expressed as a ratio. It is the number of wrong bits received divided by the total number of bits received, and is often expressed as a negative exponent. For example, "10 to the –8" indicates one in 100 million bits (1 of 100,000,000) are in error.

BERT
Bit Error Rate Test. A test in which a known pattern is transmitted across a medium to a receiver programmed with the same pattern. The receiver looks at the incoming pattern and counts a bit error for every received bit that is different from the programmed bit pattern. Data is presented as a BER.

Blue Alarm
Refer to AIS

BPV Bipolar Violation
In a bipolar signal, a one (mark or pulse) that has the same polarity as the previous one (mark or pulse)

B8ZS
Bipolar with 8-zero Substitution. A coding scheme in which the transmitter "substitutes" a fixed pattern of ones, zeros, and BPVs in place of 8 consecutive zeros. This is a very specific pattern, each block of eight consecutive zeros is replaced with 000VB0VB, where B represents and inserted "1" bit, and V represents an inserted "1" that is a bipolar violation

BTS
Base Transceiver Station

Carrier
An organization that provides telecommunications service to the public.

Channel
A channel is defined as one or more digital time slots established to provide a communications path between a message source and its destination.

Channelized
Payload digit time slots are assigned in a fixed pattern to signal elements from more than one source, each operating at a slower digital rate. See TDM.

CDPD
Cellular Digital Packet Data. A set of protocols for transmission of packetized data over cellular networks, transmitting data at 19.2 kbps. Packetized data is transmitted over idle 30kHz carrier channels without disrupting voice traffic or requiring additional bandwidth.

Churn
Customer turnover – changing carriers, usually implies rapid changes and low consumer loyalty

Clear Channel

A characteristic of a DS1 transmission path in which the 192 “information” bits in a frame can represent any combination of zeros and ones without restrictions. This allows for direct transmission of data to Europe, and for creation of large concatenated “pipes” of data. In North America, two long-standing problems have impeded clear-channel capabilities, but may be resolved through:

– Complete end-to-end out-of-band signaling, achieved through the SS7 network and ESF framing.

– B8ZS line coding, allowing users to send any type of information within the DS0, including long strings of zeros.

CO

Central Office. Local Telco office within the PSTN that terminates subscriber lines, and through which the T1 networks may be routed.

CRC

Cyclic Redundancy Check. A field used to detect errors in blocks of data transmitted across communication links. The detection is determined by a formula applied at both the transmit and receive ends.

CSU

Channel Service Unit. A customer-owned, physical layer device that provides framing, coding, and facility equalization functions, as well as performance monitoring and history reports on the T1 links in both transmit and receive directions. The CSU connects customer equipment (the BTS line card) to the Telco’s digital transmission equipment(the NIU), and is responsible for maintaining a high-quality, synchronized signal at either interface

D4

refer to Superframe

DACS

Digital Access Cross connect System. Transmission equipment which is used to re-arrange the channels which are assigned to particular time slots between the incoming and outgoing digital transmission signals. This device essentially performs a switching function with the input / output relationships assigned through an administration function (SW control).

DS0

Digital Signal, level 0. A digital signal transmitted at the nominal rate of 64 kbps

DS1

Digital Signal, level 1. A digital signal transmitted at the nominal rate of 1.544Mbps. Usually provisioned to carry 24 DS0-level signals.

DS3

Digital Signal, level 3. A digital signal transmitted at the nominal rate of 44.736 Mbps. Usually provisioned to contain 28 DS1-level signals.

DSX

Digital Cross-connect. a manual cross-connect point that primarily serves as a test access point for DS1 signals and for substituting operational equipment when necessary.

ESF

Extended Super Frame. A framing format employed in T1 systems consists of twenty-four consecutive T1 frames (each T1 frame containing 24 DS0s). This format provides FPS bits for framing, CRC bits for error checking, and FDL bits for maintenance signaling information out-of-band from payload data.

FOT

Fiber-optic terminal.

Frame

On digital transmission facilities in the telephone network the digital bit stream is organized into fixed units, called frames, with are transmitted 8000 times per second, or every 125 microseconds. A frame typically consists of a block of data with one time slot from each channel plus synchronization and other overhead bits.

FDL

Facility Data Link. Refer to ESF.

Grooming

A term commonly used to describe the activity of removing idle or unused channels from the transmission paths, combining and forwarding only the channels / slots that are assigned for use. This is only effective when large numbers of lines are muxed together into larger “pipes”, such as combining a large number of T1s into DS3 channels. Bandwidth can be conserved, using fewer or a single DS3, if the unused or unassigned DS0s or DS1s are removed from the transmission.

In-band

Using or involving the information digit time slots of a DS1 frame, exclusive of the framing bit i.e payload data.

ISUP

Integrated Systems Digital Network (ISDN) User Part. SS7 protocol that defines messages, protocol, and procedures for call setup and teardown for circuit-switched calls.

LAPD

Link Access Protocol – D channel. A protocol used in ISDN systems, defined by ITU standard Q.921.

LBO

Line Build Out. An electrical network used to simulate a length of cable.

Line Repeater

see Repeater

LOF

Loss of Framing

Loopback

A state of a transmission facility in which the received signal is returned towards the sender.

LOS

Loss of Signal – indicated by a blue alarm, or AIS in T1 terms.

M13

A multiplexer in the digital hierarchy that multiplexes 28 DS1 signals into a single DS3 signal. A duplex device, this also performs the demux function as well.

MDF

Main Distribution Frame. The main wiring frame within a Telco CO.

MSC

Mobile Switching Center. The switching control interface for the mobile network base stations, and interface with the PSTN

Mux

Multiplexer. Equipment that aggregates two or more channels onto a single transmission facility, where each channel takes a constant, determined space. For example, a T1 mux takes in multiple DS0s and "muxes" them into a T1.

NCTE

Network Channel Terminating Equipment. Equipment that originates or terminates signals at the specified rate. Typically the endpoint in a transmission system.

NIU

Network Interface Unit. Considered the demarcation point between the network and the customer premises. The primary function of the NIU is to provide signal regeneration, DC isolation from the network to the customer premise, loopback capabilities for network testing. It is often referred to as a "smartjack" because it provides loopback capabilities and can collect and return performance data to the Telco Central Office

Ones Density

Refer to Pulse Density

Payload

The 192 information bits of a DS1 frame

PCM

A technique which converts analog voice and data into a digital bit stream. The amplitude of the analog signal is sampled at 8000 times per second, and the sample is converted to an 8-bit value. North American system us a non-linear encoding scheme (μ-law) to preserve fidelity within the 8-bit slot.

PRI

ISDN Primary Rate signal. A 1.544 Mbps channelized DS1 with one channel assigned to carry LAPD protocol messages for call control and maintenance signaling – the D-channel, and 23 channels assigned for bearer (user) data – the B-channels.

PSTN

Public Switched Telephony Network

Pulse Density

A measure of the number of "ones" (marks, pulses) in relation to the total number of bit time slots transmitted.

QRSS

Quasi-Random Signal Source. A pseudo-random binary sequence (PRBS) that is based on a 20-bit shift register, and it generates every possible combination of ones and zeros (of 20 consecutive bits), and repeats every 1,048,575 bits, or about 1.5 times a second in T1 applications. Strings of zeros longer than 14 are suppressed so it doesn't violate ones density requirements.

RAI

Remote Alarm Indication. A signal transmitted from terminal equipment in the outgoing direction when it determines that it has lost the incoming signal, or when it receives an AIS signal in the incoming direction. RAI is also called the Yellow Alarm.

Repeater

A bi-directional device in a full-duplex transmission facility that recovers, reconstructs, and retransmits the received signal. Usually powered from the line. Sometimes referred to as a regenerator.

SF
Refer to Superframe

Superframe
A framing format consisting of twelve consecutive frames employed in T1 networks, also referred to as D4 framing. The D4 Superframe format is a structure in which the F (frame) bits are used for framing alignment only. In this format, the F bits are actually divided into two groups: F_T bits are used exclusively to identify frame boundaries; F^S bits, and may be used to identify frames that carry signaling

TDM
Time Division Multiplexing. The process of assigning channels to a time slot within a data stream

Telco
Telephone Company – a local exchange carrier.

TE
Terminal Equipment. Equipment that originates or terminates signals at the specified rate. Typically the endpoint in a transmission system.

Short Haul
For T1 communications, short-haul is defined a signals transmitted up to 650' through 22 gauge ABAM cable.

Smartjack
Refer to NIU

Yellow Alarm
Refer to RAI

[I] Committee T1 – Telecommunications, Report No. 25. *A Technical Report on Test Patterns for DS1 Circuits*, November, 1993

[II] TR-TSY-000312 DS1 Interface Connector standard, ANSI T1.403-1995 *Network-to-Customer Installation-DS1 Metallic Interface*

[III] ANSI T1.102-1993 *Digital Hierarchy – Electrical Interfaces*

[IV] ANSI T1.403-1995 *Network-to-Customer Installation-DS1 Metallic Interface*

[V] Telecommunications Research Associates (TRA) glossary *Emerging Technologies* 1995.

K1205 / K1297 Protocol Testers

The K1205 and K1297 are portable, multi-protocol, multi-interface protocol testers that offer modular expandability and upgradeability to help you keep pace with emerging standards. K1205 is designed for non-intrusive network monitoring and analysis, while the K1297 offers extended simulation capabilities for testing telecom equipment and networks.

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ASEAN Countries & Pakistan (65) 6356 3900

Australia & New Zealand (65) 6356 3900

Austria +43 2236 8092 262

Belgium +32 (2) 715 89 70

Brazil & South America 55 (11) 3741-8360

Canada 1 (800) 661-5625

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Denmark +45 44 850 700

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France & North Africa +33 (0) 1 69 86 80 34

Germany +49 (221) 94 77 400

Hong Kong (852) 2585-6688

India (91) 80-2275577

Italy +39 (02) 25086 1

Japan (Sony/Tektronix Corporation) 81 (3) 3448-3111

Mexico, Central America & Caribbean 52 (55) 56666-333

The Netherlands +31 (0) 23 569 5555

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Poland +48 (0) 22 521 53 40

Republic of Korea 82 (2) 528-5299

Russia, CIS & The Baltics +358 (9) 4783 400

South Africa +27 11 254 8360

Spain +34 (91) 372 6055

Sweden +46 8 477 6503/4

Taiwan 886 (2) 2722-9622

United Kingdom & Eire +44 (0) 1344 392400

USA 1 (800) 426-2200

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