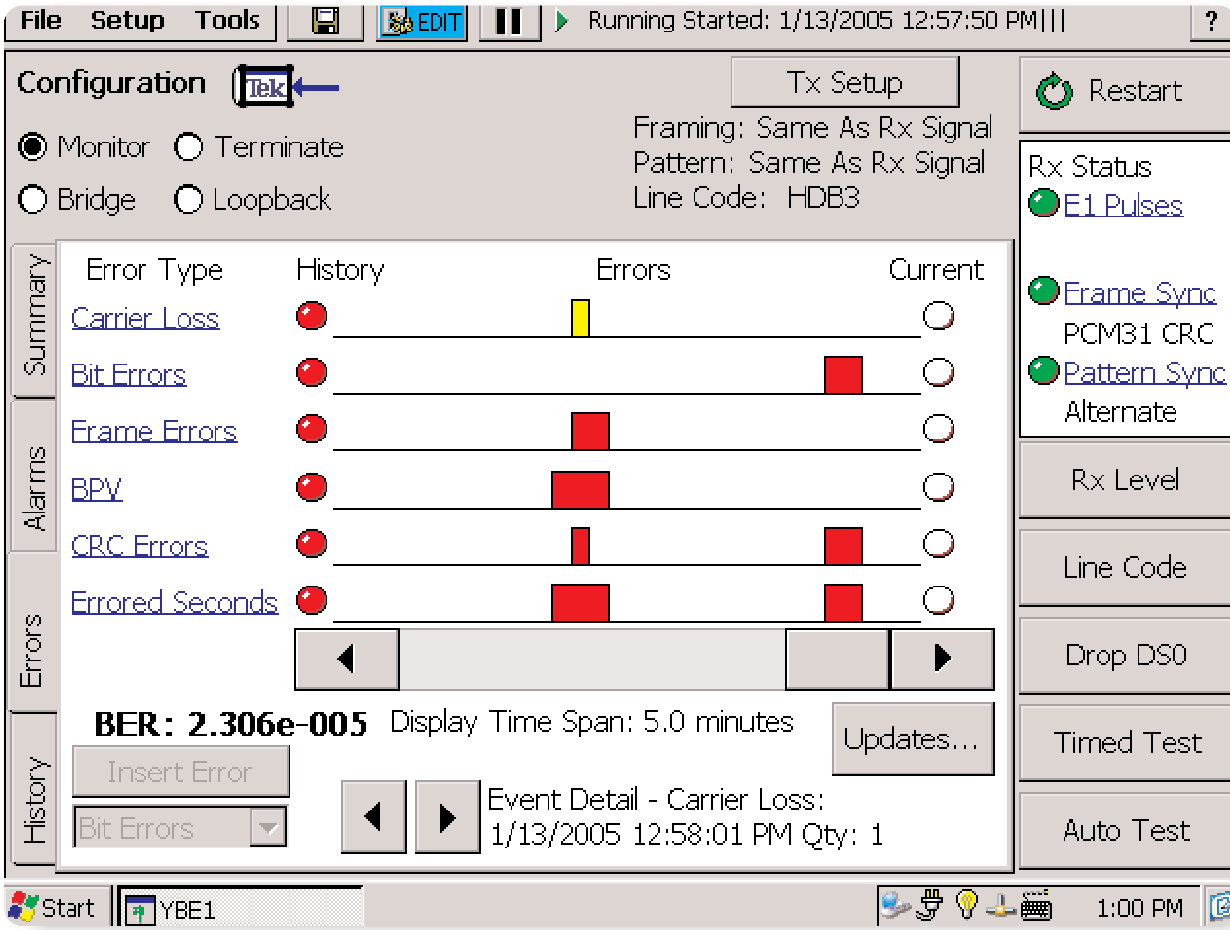
Troubleshooting E1 Lines with the NetTek® YBT1E1 Circuit Tester



This application note addresses the most common measurement challenges faced by technicians who maintain base transceiver stations' wireline connections to the mobile switching center (MSC). It provides practical insights and solutions to troubleshooting some common problems seen on the backhaul lines in wireless networks.

Modes of Operation

The NetTek YBT1E1 circuit tester offers four modes of operation: Monitor, Terminate, Bridge, and Loopback. Use of each mode depends on what you are testing and where you are located in the network.

Monitor

The monitor mode is designed for in-service monitoring of E1 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. In monitor mode, the YBT1E1 receiver is set for 120 Ohms nominal input impedance for twisted pair connections (75 Ohms when the BNC adapter is used). The YBT1E1's sensitivity is boosted with an internal pre-amplifier to account for the 20 dB resistive loss at the DSX port. In this mode, the YBT1E1 transmitter is disabled, just to prevent accidental disturbance of the E1 signal in case the wrong DSX connector is used.

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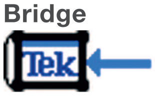
Terminate

The terminate mode is designed for use in out-of-service testing of E1 lines at a DSX patch panel. The YBT1E1 transmitter sends data according to the transmitter settings in the Setup menu, including framing, line-code, and BER pattern. The YBT1E1 receiver is also set according to the Setup menu settings. In Terminate mode, the YBT1E1 receiver compensates for up to 10 dB of cable loss for E1 lines. Terminate mode provides a nominal 120 Ohm input impedance for twisted pair connections (75 Ohms when the BNC adapter is used).

Loopback

Loopback mode is intended for out-of-service testing of E1 lines. In this mode, the YBT1E1 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 YBT1E1 also makes measurements on the received data. Loopback mode provides a nominal 120 Ohm input impedance for twisted pair connections (75 Ohms when the BNC adapter is used), and compensates for up to 10 dB of cable loss for E1 lines.

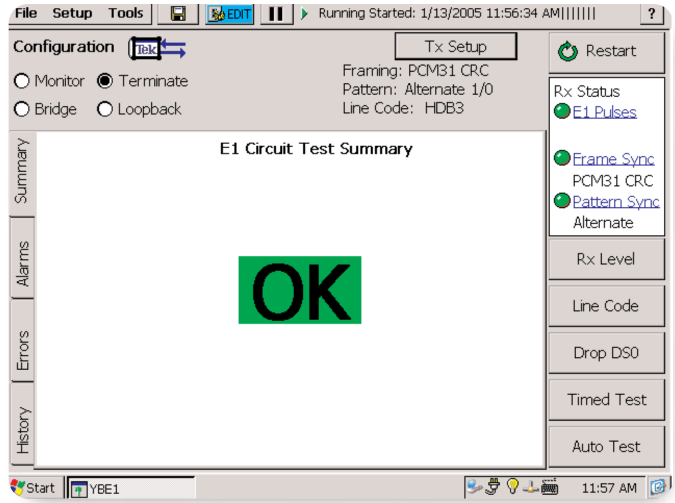
Bridge



Bridge mode provides greater than 1 kOhms input impedance for in-service monitoring, bridging the YBT1E1 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 YBT1E1 Summary Screen

Figure 1 shows an example of the YBT1E1 summary screen while monitoring a live-traffic E1 line. This screen is designed to give the user a quick overview



▶ **Figure 1.** *YBT1E1 Summary Screen.*

of the E1 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.

From this screen, you can observe that the E1 circuit is currently OK, experiencing no problems. The Rx Status indicators along the right of the display are showing that: E1 pulses are present at an acceptable signal level; the line is configured for PCM31 CRC framing; and an alternate 1/0 test pattern is being used.

A useful feature of the YBT1E1 is that the status indicators (right column) 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 three green indicators indicate the following:

1. Valid E1 pulses
2. The detected framing matches the selected PCM31 CRC framing
3. The detected pattern matches the selected (alternate) pattern

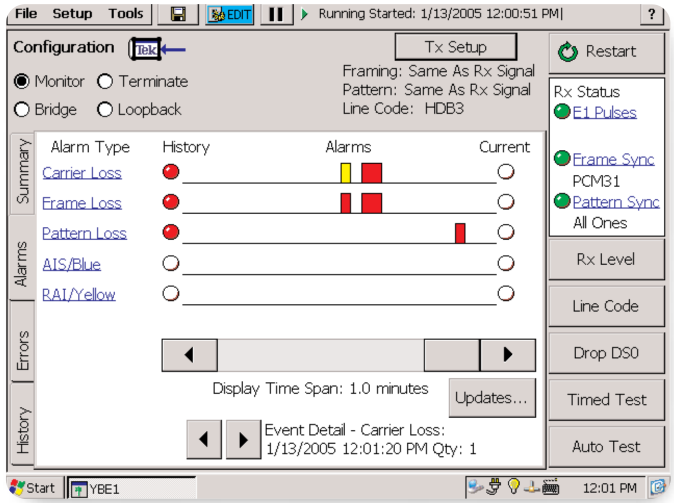
Understanding and Troubleshooting Alarms

Several different types of alarms are defined for E1 systems. Alarms are used to indicate the presence of a problem somewhere in the E1 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 the YBT1E1 test equipment into the monitor port of a DSX-1 panel, with the YBT1E1 in MONITOR mode. The alarms that are monitored by the YBT1E1 are: Carrier Loss, Frame Loss, Pattern Sync Loss, AIS/Blue Alarm, and RAI/Yellow Alarm.

A sample screen is shown in Figure 2. From this view, you can observe that Carrier Loss and Frame Loss 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. E1 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 YBT1E1, this alarm illuminates after 1 ms (approximately 2048 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 YBT1E1 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 YBT1E1 does not generate an AIS signal on its transmitter.



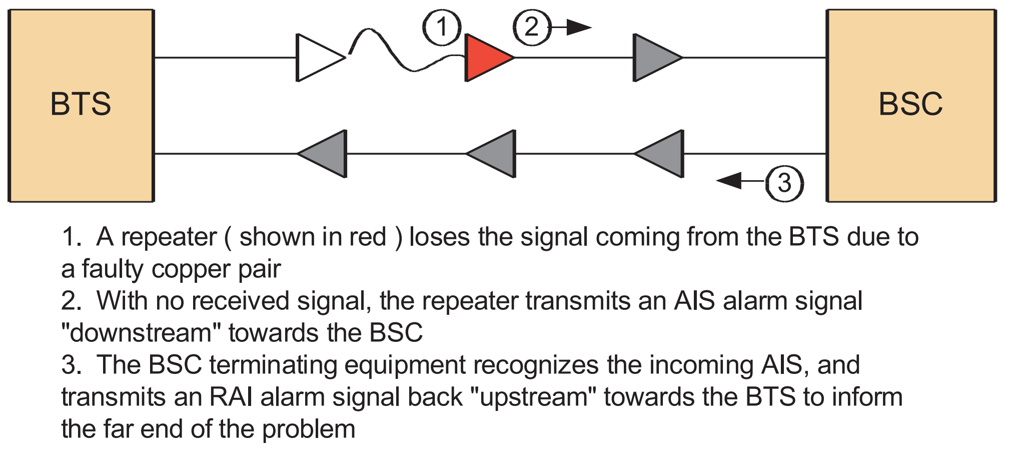
▶ **Figure 2.** *YBT1E1 Alarm Window.*

Frame Loss Alarm

The Frame Loss alarm (also known as Loss of Frame, or LOF) is declared when 3 consecutive frame alignment signals (FAS) have been received with an error. The Frame Loss alarm is cleared when frame n has a correct FAS word, frame n+1 has a correct service word, and frame n+2 has a correct FAS word. 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 (E1 line frequency that deviates from the nominal 2.048 MHz 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 4096 bit errors in 2,048,000 bits are detected. The Pattern Sync alarm is cleared when the incoming pattern is again detected, and observed less than 4096 bit errors in 2,048,000 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.



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

AIS / Blue Alarm

The Alarm Indication Signal (AIS) alarm is declared if no zeros are detected in 250 microseconds. The AIS is an unframed, all-ones signal transmitted on the E1 line.[1]

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 YBT1E1 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 receiving an AIS alarm, receiving no signal (an LOS condition), or has lost receiver framing (an LOF condition) in the “downstream” direction. An RAI alarm is indicated by transmitting a zero in the bit 3 position of channel 1. Channel 1 is the control channel for most E1 control information. Figure 3 shows an example of how RAI may be observed in the network.

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 YBT1E1 itself does not transmit the RAI alarm, it simply reports that it is receiving the alarm code from the line.

Troubleshooting Backhaul Timeslot Configuration Problems

The YBT1E1 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.

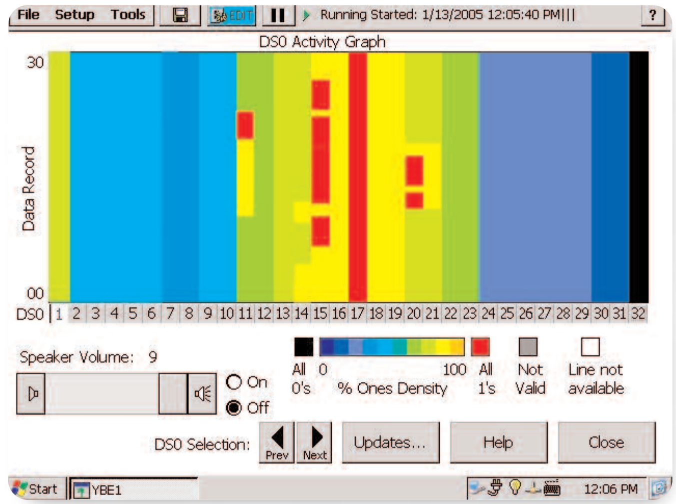
[1] ITU-T G.704 Telecommunications Standardization Sector of ITU (10/98) and ITU-T G.775 Loss of Signal (LOS) and Alarm Indication Signal (AIS) defect detection and clearance criteria.

This view displays the data activity for each of the E1 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 E1 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 E1 under test.

Some BTS technicians have "trained" their ears to listen to the control channel to verify it is operating correctly. The YBT1E1 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 any DS0.

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 E1 lines.



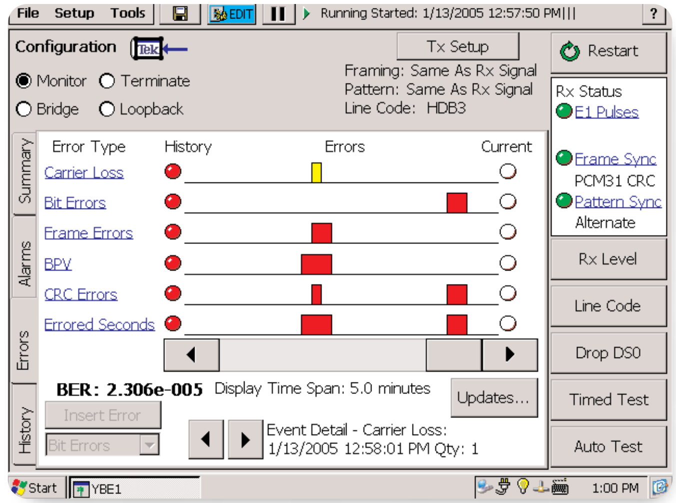
▶ **Figure 4.** *Drop DS0 Measurement Window.*

Troubleshooting Intermittent E1 Problems

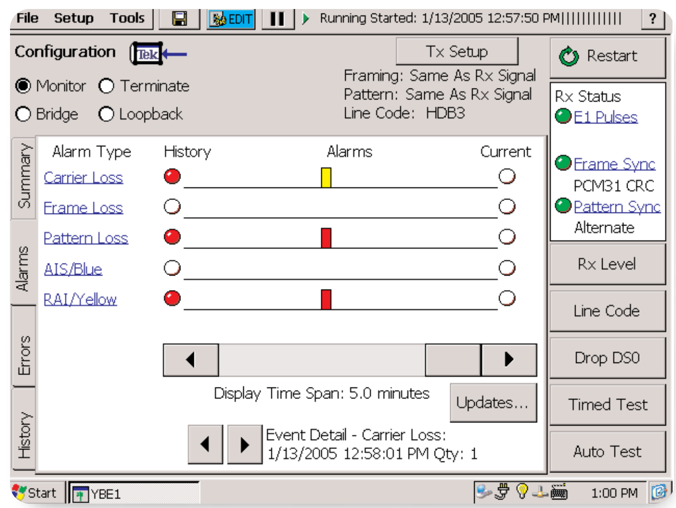
Intermittent problems are probably the most difficult and frustrating problems to solve, as any number of things could contribute to intermittent faults, including poor wiring connections, faulty repeaters, marginal line powering configurations, or even line-code mismatch problems. Some intermittent 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 YBT1E1 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 5. 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 minutes. 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 7.

From the display in Figure 5, you can tell at a glance that Carrier Loss (LOS) and Bit Errors, Frame Errors, BPV, 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 12:58:01 on 01/13/2005. The Bit Errors and corresponding Errored Seconds events also carry timestamps that may be seen simply by selecting (highlighting) the event.



▶ **Figure 5.** *YBT1E1 Errors display.*

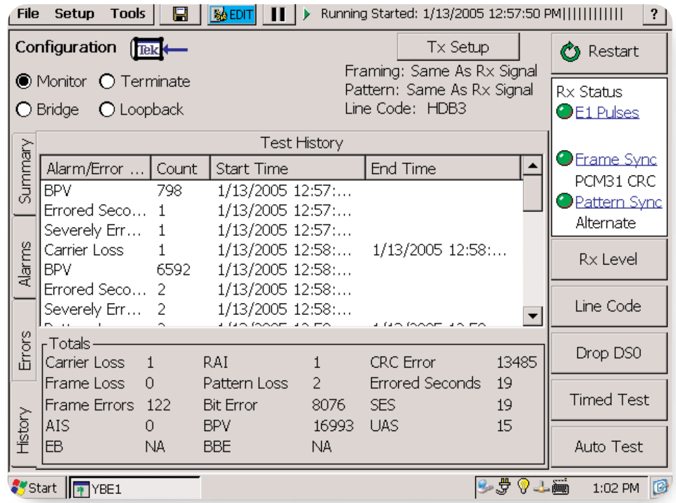


▶ **Figure 6.** *YBT1E1 Alarms display.*

Using these scrolling displays, you can look for a time correlation between events on the E1 span. If you compare the events shown in Figure 5: YBT1E1 Errors display and those shown in Figure 6: YBT1E1 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 Pattern Sync Loss, and a RAI/Yellow Alarm during the same time period. These additional alarms could be expected to be associated with the Carrier Loss alarm.

The display shown in Figure 7 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 E1 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 E1 lines. As you know, the more information you are armed with, the more likely it is you can solve the problem.



▶ **Figure 7.** *YBT1E1 Test History Count display.*

Loopback Testing

Loopback testing for E1 lines is performed by creating a loopback at the far end of the span and using a single instrument to measure the round-trip performance of the E1 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. 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

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.

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).

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.

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 30 kHz carrier channels without disrupting voice traffic or requiring additional bandwidth.

CO

Central Office. Local Telco office within the PSTN that terminates subscriber lines, and through which the E1 networks may be routed.

CRC

Cyclic Redundancy Check. A method 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. E1 uses a 4 bit CRC (CRC-4) for error checking.

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 E1 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.

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 2.048 Mbps. Usually provisioned to carry 32 DS0-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.

Double Frame

A pair of frames where time slot 0 of the first frame contains the Frame Alignment Signal (FAS) and time slot 0 of the second frame contains control information that is not equal to a FAS word.

E1

A four-wire digital line trunk that can carry 2.048 Mbps.

FAS

Frame alignment signal

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 consists of 32 channels or time slots of 8 bits each. The first time slot is used for control.

HDB3

High Density Bipolar Order 3 Encoding. HDB3 is a bipolar signaling technique (using both positive and negative pulses) based on Alternate Mark Inversion (AMI). Extends AMI by inserting violation codes whenever there is a run of 4 or more zeros.

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.

ITU

International Telecommunication Union, Geneva, Switzerland, formerly the CCITT (Consultative Committee for International Telephony and Telegraphy), is an international organization founded in 1865. It is now part of the United Nations System that sets communications standards for global telecom networks. The ITU is comprised of more than 185 member countries.

LAPD

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

Line Repeater

Refer to 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 E1 terms.

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.

Multiframe

16 frames grouped into two sets of 8. Allows space for the CRC bits, which are determined for a group of frames and sent in the control words of the following 8 frames.

Mux

Multiplexer. Equipment that aggregates two or more channels onto a single transmission facility, where each channel takes a constant, determined space.

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 248 information bits for PCM31 and 240 for PCM30.

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.

PCM30

Of the 32 time slots, the first and the 16th are used for control while the remaining 30 are available for data.

PCM31

Of the 32 time slots, only the first is used for control while the remaining 31 are available for data.

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 2 times a second in E1 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.

Smartjack

Refer to NIU

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.

Yellow Alarm

Refer to RAI

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