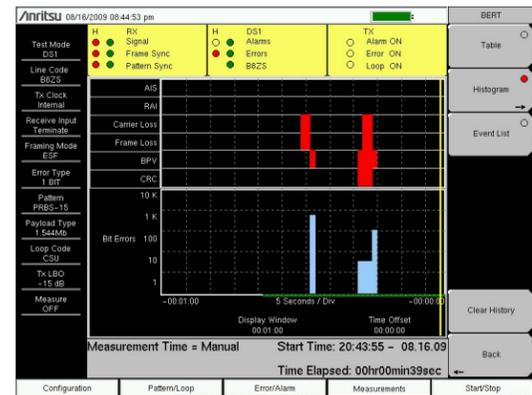


## Backhaul Testing Overview



### Why do Wireless Operators test T1 Circuits?

Well managed T1 circuits help ensure cellular up-time. Good network management practices include testing prior to acceptance, as well as testing for troubleshooting purposes. In either case, good T1 troubleshooting tools are needed.

Troubleshooting can often be done by monitoring an in-service signal, either through a smart jack or dedicated test equipment, while looking for errors. Once spotted, test equipment is normally needed to locate the cause of the error.

However, in some cases, in-service testing is not enough, and an out-of-service Bit Error Test (BERT), is required. A BERT involves generating a bit pattern, sending it down the T1 line, looping it back at the far end of the line, and seeing how accurately the bits are returned to the test set. This technique can be used to find and repair many T1 problems.

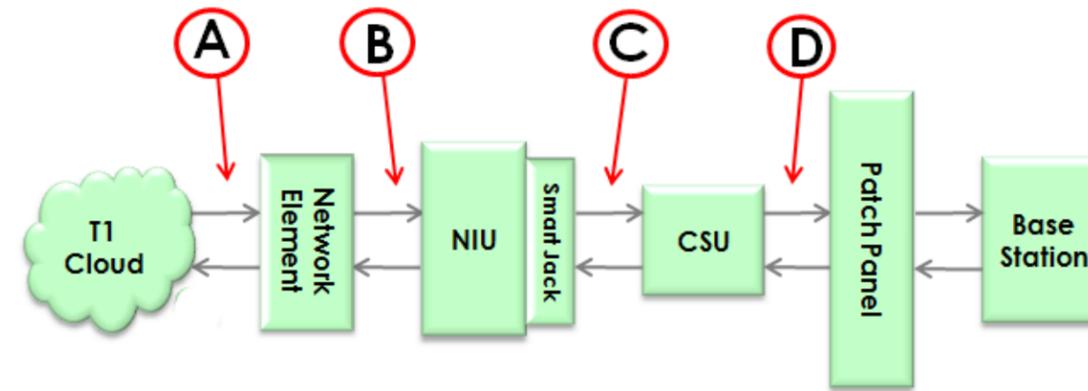
### Bridge and Monitor Mode

The BTS Master or Cell Master T1 test set can run in Monitor, Bridge, Loopback, and Terminate mode. Two of these modes, Bridge and Monitor modes, may be used for in-service monitoring of T1 signals.

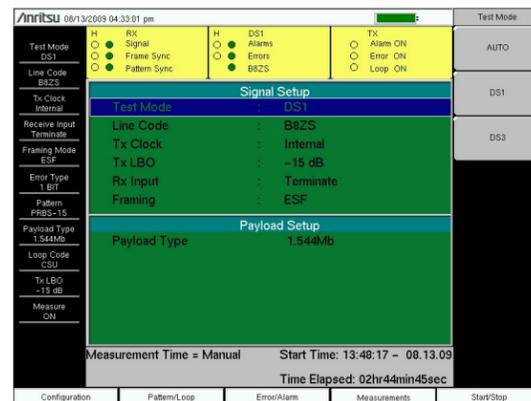
Bridge mode is a receive-only test mode used by the T1 tester. In Bridge Mode, the test set has a high impedance 1,000 Ohm input, and uses a test cable with clips. These clips, due to the instrument's high impedance, can be attached anywhere in the T1 circuit without creating excessive load. Bridge mode is very useful when monitoring live T1 signals for Alarms and Errors.

Monitor mode is similar to Bridge mode, except that the impedance is set to 100 Ohms, suitable for using a DSX Monitor test port. Monitor mode wires have Bantam Jacks on both ends.

## T1 Block Diagram of Customer Premises Equipment (CPE)



### In-Service Setup



The BTS Master or Cell Master T1 tester is normally setup like this:

- Test mode to DS1
  - For any T1 line
- Line Code to B8ZS
  - The default for data circuits
- Tx Clock to Internal
  - Allows accurate T1 frequency checks from internal clock
- Tx LBO
  - -15 dB when close to the transmitting equipment
  - If further away, use attenuation table in right column as a guide.
- Rx Input to Bridge or Monitor
  - Bridge if clipping to T1 wires
  - Monitor if using a DSX monitor Port
- Framing to ESF
  - ESF is the most common framing type
  - Use Auto if unsure
- Payload Type
  - 1.544 Mb (full data rate)

### In-Service Fault Localization Using CRCs and BPVs

When hooked up at point "C," in the diagram above, the BTS Master or Cell Master should be seeing signal (carrier) and frame sync, no CRC errors, and a normal signal level. Faults at this point are often Telco upstream issues.

To monitor the signal at point "C," a DSX or smart jack may be used, if installed. If not, the instrument can be set to Bridge Mode and clipped to the signal line.

Errors can be used for fault isolation within CPE. If the CPE setup uses Extended Super Frame (ESF) format, and B8ZS, which is common for digital data, Cyclic Redundancy Check (CRC) errors and Bi-Polar Violations (BPVs) can be used to spot a faulty span. In this case there are two simple rules to remember:

- CRC errors propagate downstream from the source
  - Bi-Polar Violations (BPV's) are local to the faulty span.
- For example, if there is a fault at the Network Element on the way to the BTS, the circuit illustrated above would likely test out like this:
- Point "A"
    - No CRC errors
    - No BPV errors
  - Point "B"
    - CRC Errors
    - BPV Errors
  - Point "C" and "D"
    - No BPV Errors

In the case of a circuit provisioned with Super Frame (SF) framing, there are no CRCs, and so no CRC errors. However, a faulty span will still have BPV errors.

This CRC/BPV span troubleshooting technique is also useful when in loopback mode.

## CRCs and BPVs



**CRC**, or the Cyclic Redundancy Check numbers, are included in the Extended Super-Frame (ESF) format. If the received CRC and the CRC calculated from the received data do not agree, the received data must be in error.

**Guideline:** No CRC errors are allowed in a 15 minute ESF monitoring session.

**Consequences:** CRC errors result in a lower overall throughput for the T1 link. These errors can indicate problems bad enough to shut down the link.

**Common Faults:** Provisioning errors, including timing, framing, and AMI/B8ZS settings. Other common faults include frayed insulation, ground loops, unwanted resistance from loose connections and corrosion.

**BPVs** (Bi-Polar Violations) are when the signal does not switch polarity every time a "1" is transmitted. BPVs are local to the span with the fault.

**Guideline:** No BPVs received in a 15 minute monitoring session.

**Consequences:** BPVs are a symptom of low signal quality and result in lower, or no, throughput.

**Common Faults:** BPV's can be generated by faulty provisioning, including lines with mixed AMI/BPV settings, noise on the line, or a weak signal.

**Carrier Loss**, shown in the illustration to the left, keeps track of times that the AMI/B8ZS carrier is interrupted.

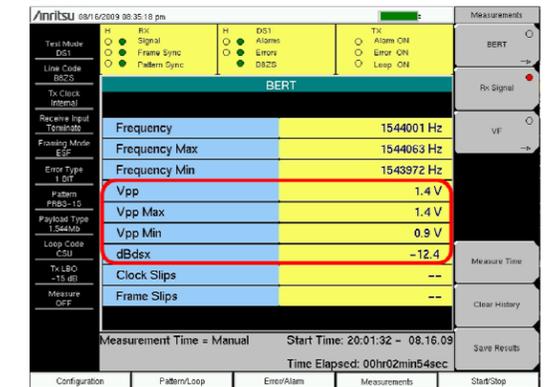
**Guideline:** Carrier loss is not acceptable in a T1 circuit.

**Consequences:** The line is dropped.

**Common Faults:** This is a severe fault and will normally be caused by broken equipment or a broken line.

If seen during initial test equipment setup, be sure to check the instrument cables and their hook up points as shown on the next page, under the "Status Bar" heading.

## Vpp, Carrier Loss, and Frame Loss



**Vpp:** Voltage Peak-to-Peak, is a measure of the T1 signal amplitude. This is also measured as dBdsx where 6 Vpp equals 0 dBdsx.

**Guideline:** Many installations require 6 Vpp or 0 dBdsx at the NIU and assume these attenuations:

Wire Gauge	Attenuation in dB/100 feet
22	0.45 dB
24	0.58 dB
26	0.75 dB

**Consequences:** Unusually low Vpp leads to a high bit error rate, alarms, loss of sync and loss of carrier. Unusually high Vpp leads to signal clipping and bit errors.

**Common Faults:** Wrong Vpp settings, wrong attenuation settings, shorts, opens, corrosion, damaged insulation, and damaged network components.

**Frame Loss**, shown in the illustration to the left, counts errors in the framing bits. Since framing bits occur once every 193 bits, framing errors do not accumulate as fast as other errors. When monitored for extended periods of time, framing errors can become a valuable indication of signal quality.

**Guideline:** No framing errors during a 24 hour monitoring session.

**Consequences:** Similar to CRC faults.

**Common Faults:** Similar to CRC faults.

### Frequent Causes of T1 Problems

1. Signal level too high - Set too high at Smart Jack or CIU
2. Signal level too low - Loose connection or partial short caused by loss of insulation
3. Noise on the line - Loss of insulation allowing stray voltage to enter.

### T1 Concepts & Terms

T1 or DS1, as a standard, has been around since the 1960’s and has evolved from a way to carry multiple voice conversations on one line to a way to carry digital data on a wide variety of physical interfaces. There are many physical configurations available to fit different roles.

T1 voice signals are digitized at an 8,000 kHz rate with 8 bits of resolution. Digital signals use this rate, or multiples of this rate. For transmissions, T1 data is encoded as an Alternate Mark Inversion (AMI) signal,

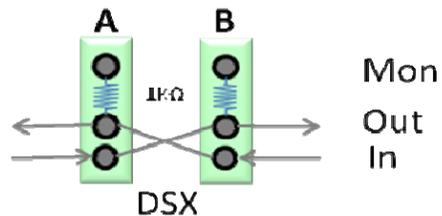
The AMI signal encodes a “1” as a + or - 3 volt signal and a “0” as zero volts. Every “1” alternates its polarity to avoid excessive DC offset.

Having two “1”s of the same polarity is called a Bi-Polar Violation, (BPV) and is a sure sign of bad data.



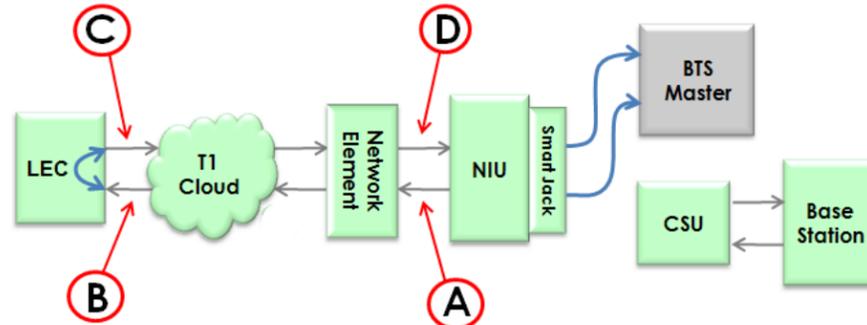
Since the “1”s data is also used for clock recovery, there can be no more than 8 zeros in a row. This restriction is OK for voice data, but does not work well for digital data. In this case, a specific pattern with intentional Bi-Polar violations, Bi-Polar with 8 Zero Substitution (B8ZS), is substituted for the 8 zeros. A receiver set to AMI will show errors if it receives a B8ZS signal.

**The easiest place to hook up**, if present, is to a DSX-1 Patch panel, diagrammed below. The monitor jack is useful for in-service signal monitoring as discussed on the other side of this document. The T1 test set should be set to “Monitor” mode to use these jacks. The Out and In ports are for out-of-service loopback testing. Use of these ports takes the data connection down.



The BTS Master should be set to **Terminate Mode** when plugged into the DSX-1 Out and In ports. Terminate mode is also used with the RJ-48 jacks commonly used between T1 circuit elements. In either case, a loopback is required somewhere else on the T1 circuit to return the transmitted signal to the BTS Master’s receiver.

### T1 BER Line Testing with Loopbacks



### Loopbacks, Errors, and Alarms

Alarms and Errors are generated on Local Exchange Carrier (LEC) lines, and sometimes, on a network operator’s Customer Premises Equipment (CPE). Often, the quickest route to the resolution of a problem may be to assist the LEC with a loopback test. In any case, it is helpful to understand how alarms and errors work.

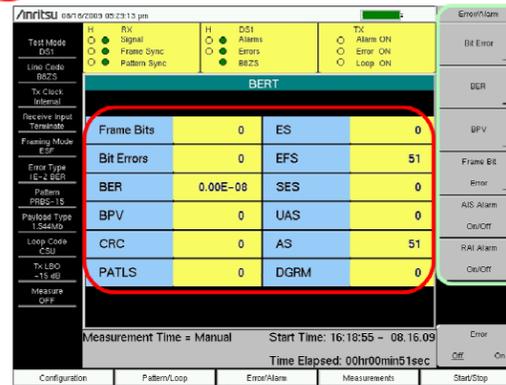
Loopbacks, together with a BERT test, are used to locate the source of both alarms and errors. Loopbacks can be created:

- Manually, with a special RJ-48 jack or by pressing a loopback button on network equipment.
- With software, by sending a code from the BTS Master to the network element to be looped up. This can quickly identify affected spans over a large area.
- Head-to-Head with a second BTS Master, which offers the most information about the fault. This is the quickest method to isolate faulty spans over a small physical area and is commonly used to test CPE.

### Inserting Errors

Once a loopback is in place, the Start/Stop button pressed, and the BTS Master sending and receiving a signal, it’s a good idea to cause the BTS Master to transmit a burst of BER errors to verify the hookup.

Referring to the screen shot to the right, errors can be inserted with the buttons in the green box and viewed using the readouts indicated in the red box.



### Errors

If the Error light is on, at least one bit has been dropped in a loopback test. Signal, Frame Sync, and Pattern Sync, must be green before the error indication is accurate.

### Alarms

Carrier Loss, or Loss Of Frame, shown in the next column to the right in a green box, happens on the span with a fault. Check upstream, on that span, from the test point to locate the fault. If a fault is at point “A,” there will be a Loss of Frame (LOF) on that span.

Alarm Indication Signal, (AIS) or the Blue Alarm, indicates a fault on a T1 span upstream from the test point, but not on the current span. If there is a LOF at “A,” there will be an AIS at point “B.”

A Remote Alarm Indication (RAI), or Yellow Alarm, indicates a fault on the other side of the T1 line from the side being monitored. If there is a LOF at point “B” or “A,” there will be a RAI at point “C” and “D.”

### Status Bar

The status bar is quite useful when setting up for a test. The “H” column indicate signal history, while the next column to the right shows current issues. This can be used to check instrument setup. If signal and frame sync are green, the cables are hooked up right and the proper

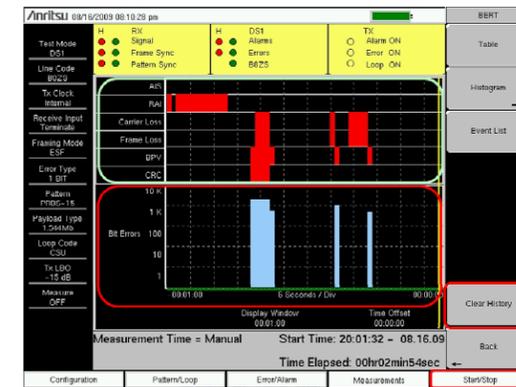
H	RX
○	Signal
○	Frame Sync
○	Pattern Sync

framing (SF or ESF) has been selected. When in monitor or bridge modes, pattern sync cannot be green.

The **DS1** column is a quick way to check for alarms, errors, and B8ZS line coding.

H	DS1
○	Alarms
○	Errors
○	B8ZS

### Errors and BERT Testing



A Bit Error Rate Test (**BERT**) measures how accurately a circuit can send and receive data. BER testing is always an out-of-service activity. BER tests require the BTS Master at the near end of the span and a loopback at the far end of the span. The hookup is illustrated in the figure above and to the left. The measurement is shown surrounded in red, above.

**Guideline:** For troubleshooting tests, circuits should test with no Bit Errors over a 15 minute period. For acceptance tests, circuits should test with few or no errors over a 24 hour period.

**Consequences:** BERT errors will cause re-transmissions and a lower over-all data rate. Large numbers of errors will shut down the circuit.

**Common Faults:** wrong circuit options, poor signal replication, wrong signal levels, framing slips, frequency errors, clock slips, or damaged wiring.

### Common Controls

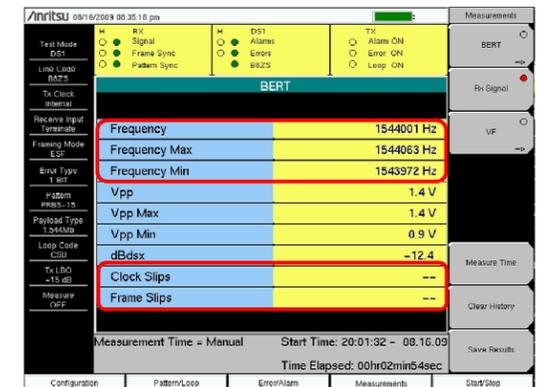
The **Start/Stop** button, indicated with a small red box above, will either start, or stop, measurements. By default, this button is off and should be pressed to start measurements.

The **Clear History** button, also marked with a small red box above, will reset unintentional errors.

The **Tx** column shows what the BTS Master is generating for its output. The BTS Master is capable of generating Alarms, Errors, and serving as a Loopback device with full signal monitoring.

○	TX
○	Alarm ON
○	Error ON
○	Loop ON

### Frequency, Clock, and Framing Slips



**Frequency** refers to the number of bits per second on the 1.544 Mbps T1 line.

**Guideline:** +/- 50 bps from 1,544,000 bps.

**Consequences:** Poor frequency accuracy leads to slipped frames and data loss. This is a particular issue with multi-line links.

**Common Faults:** Low accuracy signal from LEC, lack of synchronization on the upstream side, clocking plan errors.

**Clock Slips** are a count of the difference between a reference T1 clock and the T1 line measured. One clock slip is a difference of one clock time period. The BTS Master can measure clock slips between T1 lines if the master line is used as its external reference.

**Guideline:** Near zero

**Consequences:** Enough clock slips create a frame slip, and eventually, lost data.

**Common faults:** Mis-configuration of T1 clocking sources or a bad GPS timing reference. This is particularly important when multiple T1 lines share the data load.

**Frame Slip** measurements also require a T1 reference clock. Controlled frame slips loose or duplicate a frame and uncontrolled slips loose or gain part of a frame.

**Guideline:** Near zero.

**Consequences:** Excessive frame slips will reduce throughput. Uncontrolled slips loose data while re-syncing.

**Common faults:** See clock slip common faults.

### Line Synchronization

The BTS Master or Cell Master can check for synchronization of multiple line T1 links by:

- Checking the frequency of each line
- Looking for clock slips or frame slips while using one of the lines as its external reference clock

