Testing VF Circuits at T1 Access Points with the T-BERD® 224

Overview

Communication networks are evolving from aging analog systems to improved digital systems. Digital technology and equipment provides a simpler, more cost-effective method of increasing transmission quality. But the transition is not occurring overnight, and there is a large overlap and mix of analog and digital equipment. Upgrading from analog to digital equipment typically begins in the center of the network and grows toward the endpoints. Consequently, many voice and data signals which are transmitted via analog circuits are converted into digital signals at some point along the transmission path so that they can be transmitted within the digital network.

Confusion and problems arise when technicians and engineers have to maintain and troubleshoot combined analog/digital networks. How do you test analog circuits from digital access points? How are analog impairments translated into a string of logical ones and zeros? What tests are valid and useful? What do the results reveal about the problem and its location? This ***Application Note*** will address these questions and provide solutions and troubleshooting techniques using the TTC® (Telecommunication Techniques Corporation) T-BERD 224 PCM Analyzer, a T1 channel access test set which isolates and tests one of the 24 converted analog signals within the digital T1 circuit.

Background

Analog transmission circuits, the age-old workhorses of communication networks, are often referred to as voice frequency (VF) circuits because they traditionally have carried voice traffic within the voice frequency bandwidth (40 Hz to 3900 Hz). However, with the advent of modems, VF circuits have been able to transmit data (i.e., logical ones and zeros) in an analog waveform. Regardless of circuit content, whether voice or data, VF circuits take one of two forms: dail-up or dedicated. Dial-up VF circuits transmit voice or data (via modems) within the Public Switched Telephone Network (PSTN). Dedicated VF circuits typically transmit data via modems over a private line, point-to-point, unshared transmission path.

Through the technology of pulse amplitude modulation, pulse code modulation, and multiplexing, analog waveforms are now converted to digital signals so that they can be transmitted within a digital network. As more and more analog circuits are converted to digital, a digital network begins to evolve. Many individual circuit conversions from analog to digital begin with the use of digital T-Carrier equipment, such as channels banks, multiplexers, and private branch exchanges (PBXs). The T1 equipment converts a VF signal to a digital stream of logical ones and zeros, multiplexes it with 23 other signals, and transmits it within one of the T1 circuit's 24 channels. Network conversions begin when enough T1 equipment, connected via T1 circuits, is operating at key central locations. The connections form a backbone which can be used to connect far-end sites via analog or digital circuits as shown in ***Figure 1.***

T1 circuits that carry VF signals include interoffice trunks, PBX trunks, digital loop carrier (DLC) circuits, digital cross-connects (DCS), and private hi-cap circuits. As an example, DLC systems connect up to 96 analog subscribers to a switch within a central office (CO) via T1 circuits. While the circuits between the CO

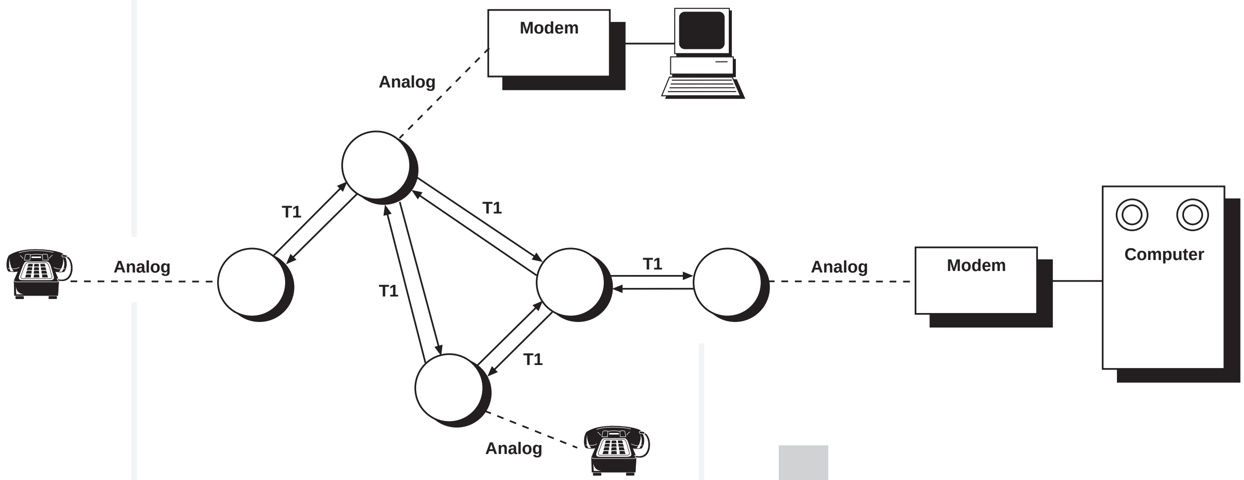

Figure 1
T1 backbone network.

switch and the far-end DLC are digital, the signals transmitted over the local loops between the subscribers and the remote DLC terminal are analog. ***Figures 2 and 3*** show some T1 applications which specifically include VF signals.

The layout of digital networks can cause problems for those who have to troubleshoot analog circuits because the technicians and engineers are typically located at purely digital central locations; an analog form of the signal does not exist at these locations. How does one get at VF problems from the center of the network? Technicians need easy access to the VF circuit to verify the trouble. T1 channel access sets, such as TTC's T-BERD 224, enable technicians to tap a digital T1 circuit and access one of the faulty "analog" signals without disrupting the remaining 23 channels. Once the signal is accessed, the technician performs a variety of tests to determine the source of the fault.

Analog impairments can be detected from a digital access point because analog errors are encoded along with the VF signal. Digital encoders/decoders (codecs), the equipment which converts the analog signal to a digital form and vice versa, cannot differentiate analog errors from the original VF signal and so encodes/decodes the errors too. Furthermore, impairments which may be apparent only in the decoded analog form may be caused by codecs. Consequently, the digitized form of the analog signal will include any impairments originally in the analog signal as well as possible modifications from the codec.

Analog impairments can be divided into nine separate classifications as described below. ***Figures 4 through 12*** provide graphic displays of each impairment.

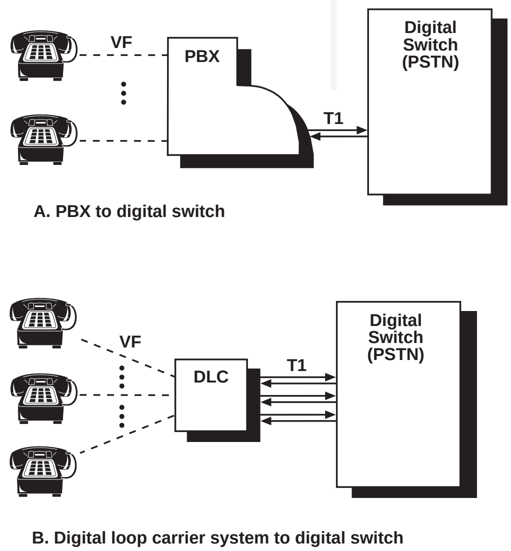

Figure 2
Dial-up applications.

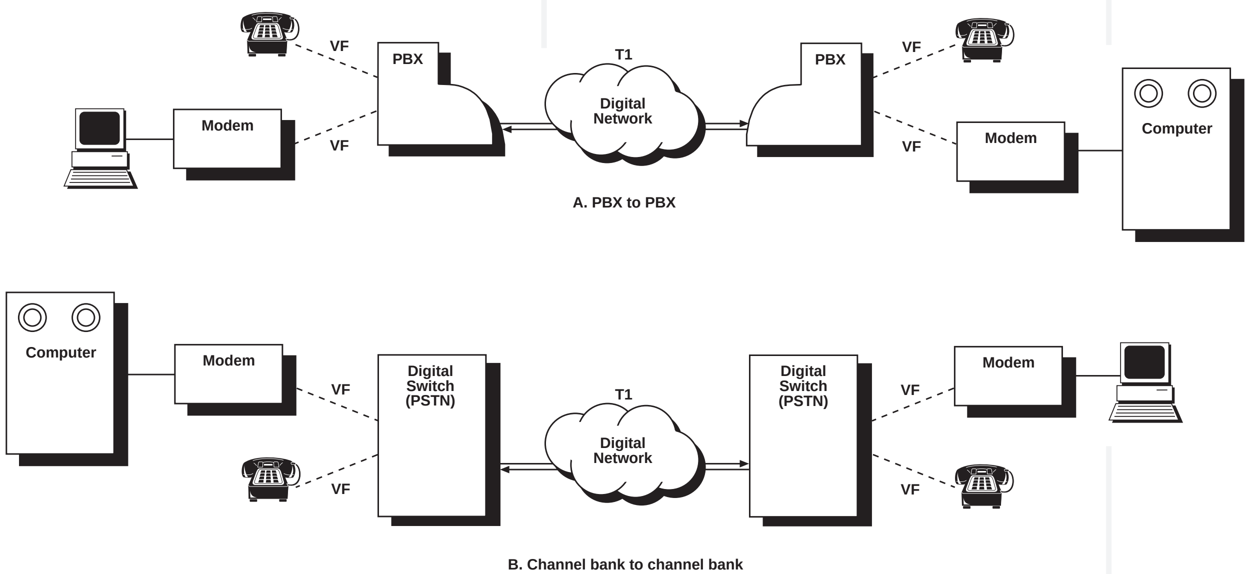

Figure 3
Dedicated applications.

Analog Impairments

Attenuation

Attenuation is the loss of VF signal level typically seen as a loss of amplitude (see ***Figure 4***). Attenuation is manifested in low volume voice conversations. When using data modems, attenuation can prevent detection of carrier tones, or cause inadvertent data errors due to misinterpretation of the signal.

Attenuation is caused by many sources, including resistive losses in metallic transmission media. Attenuation losses are recovered by using amplifiers which duplicate a recovered VF signal at a greater amplitude.

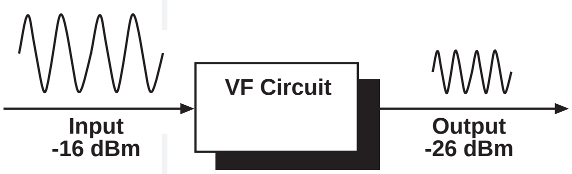

Figure 4
Attenuation.

The analog signal's attenuation, which occurred before the signal reached the digital encoder, *should not* be confused with attenuation of the digital signal. The analog signal's level, attenuated or not, is encoded as a specific string of logical ones and zeros. The digital signal's level is a direct measure of the digital signal's amplitude. Modifying the digital signal's level will not impact the VF signal's amplitude because the encoding of ones and zeros remains the same. So, the analog signal level is independent of the T1 signal level.

Attenuation Distortion

Attenuation distortion is the loss of VF signal level at various frequencies, most often at the higher and/or lower limits of the frequency range (see ***Figure 5***). This distortion causes various, intermittent symptoms such as muffled (high-frequency attenuation) or hissing (low frequency distortion) speech.

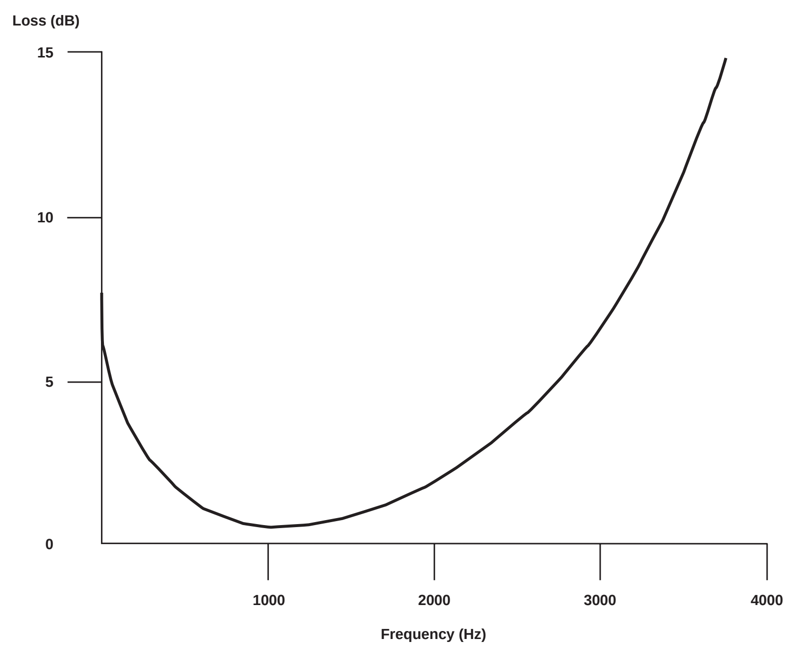

Figure 5
Attenuation distortion.

Attenuation distortion may not always be apparent since men who have low voices do not stress the higher frequency range, while women and children who have high voices do not stress the lower range. While attenuation distortion may not always be apparent during a conversation, distortion, particularly at the higher frequencies, is readily apparent during data transmission due to data's full use of the available bandwidth.

Attenuation distortion is often caused by capacitive and inductive reactances, carrier filters, loaded cables, transformers, and bridge taps. Each of these, especially loading coils, acts as a filter with limited frequency bandpass and creates distortion at the ends of the frequency range.

DC Offset

DC offset is a DC amplitude modification of the original analog signal due, for example, to a "stuck bit" in a digital/analog codec in the transmission path (see ***Figure 6***). As an example, recall that the original analog signal is sampled 8,000 times per second and that each sample is assigned an 8-bit code. If the codec malfunctions and assigns the first bit position to a logical one for every sample (a "stuck bit"), the decoded signal will be modified such that a positive or negative component will exist in the analog output which will impair the signal.

NOTE: For T-Carrier systems, DC offset is a per channel measurement, not an analysis of the T1 signal's voltage.

Noise

Noise is the basic corruption of the original VF signal; it is any unwanted signal present in the original signal (see ***Figure 7*** on the next page). Noise is found in many forms because of its multiple origins:

- ***Gaussian noise (a.k.a. white or random noise)*** is commonly heard as a background hiss. Gaussian noise is caused not only by electrical interference from a variety of sources including fluorescent lights, but also by thermal noise sources such as faulty electrical components on circuit boards.

- ***Impulse noise,*** often intermittent, sounds like occasional snaps and pops and can disrupt signal quality and cause data errors. Impulse noise is primarily caused by switching and signaling equipment, and is electrical storms. In addition, bit error bursts in the digitized analog signal will be manifested as impulse noise in the VF domain.

- ***Crosstalk noise*** is a coupling of two signals such that another conversation may be heard and possibly deciphered, depending on the severity of the impairment. Crosstalk is caused by poor cable routing, splicing, or insulation such that the signals can be coupled via water or electrical fields.

- ***Quantizing noise*** is a distortion brought about by digital codecs that do not reproduce the analog signal exactly due to a finite number of "decision" levels in the analog/digital conversion process. Quantizing noise is a function of the analog/digital conversion and cannot be totally eliminated.

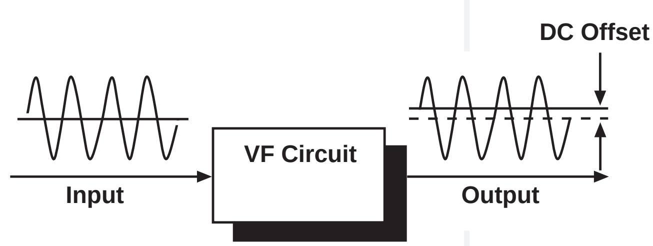

Figure 6
DC offset.

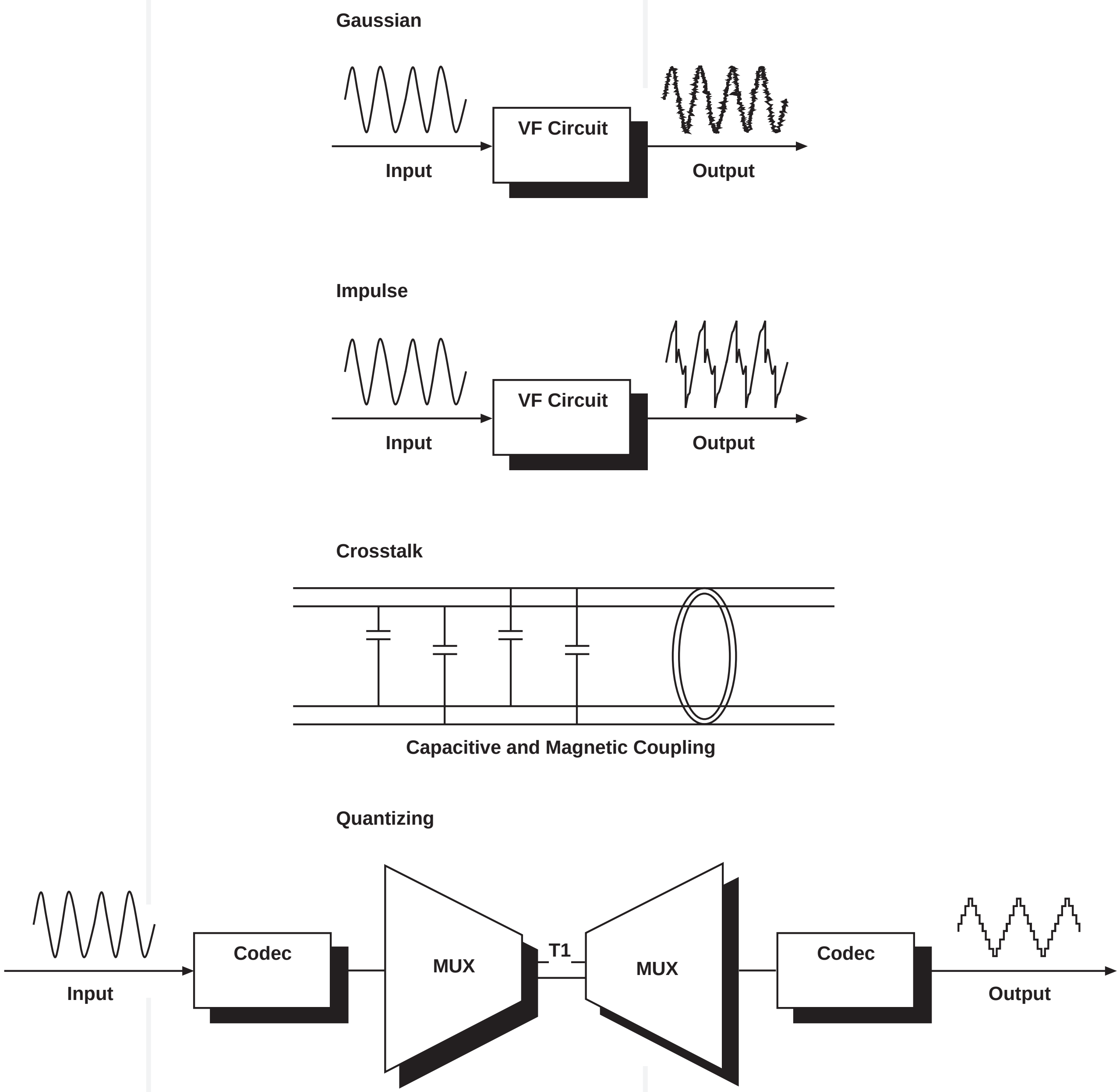

Figure 7
Noise.

Echo

Echo is recognized as a reflection of the transmitted or received VF signal which occurs momentarily after the original transmission or reception (see ***Figure 8***). Echoes are most commonly found in mixed 2-wire/4-wire circuits, and are due to an impedance mismatch at the 2- to 4-wire junctions.

Talker echo occurs when the original speech is reflected at the far 4- to 2-wire junction and returns to the talker. Sometimes the originator will think that he is talking into a tunnel because of the echo he hears.

Listener echo occurs when the talker's speech is reflected from near 4- to 2-wire junction, back to the far 2- to 4-wire junction, and back again to the listener. Due to impedance mismatches at both locations, the receiver will hear the conversation twice.

Envelope Delay Distortion (EDD)

EDD is a phase nonlinearity where the transmission *delay* for certain frequencies, typically those at the edges of the frequency range, is greater than others (see ***Figure 9*** on the next page). (This phenomenon is different from attenuation distortion which affects the signal *level* at various frequencies.) The high and low frequencies take longer to pass through the circuit due to excessive capacitive and inductive reactances brought about by circuit conditions such as load coils and bridge taps.

EDD primarily affects data traffic, especially as bandwidth increases (>9.6 kb/s), because the entire voice frequency range is fully exercised. EDD analysis is typically performed only on special order "conditioned" circuits to verify that all bridge taps, load coils, etc. are removed before service turn-up.

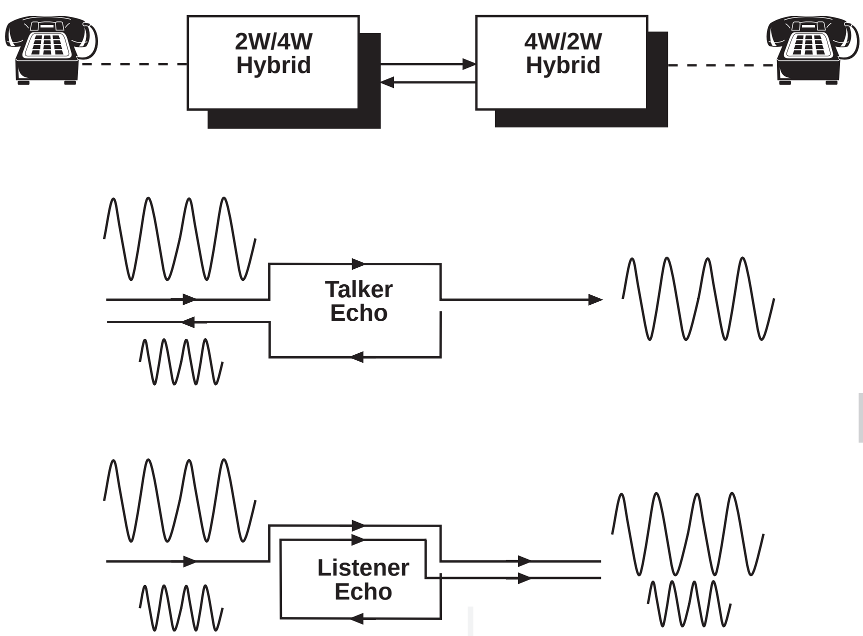

Figure 8
Echo.

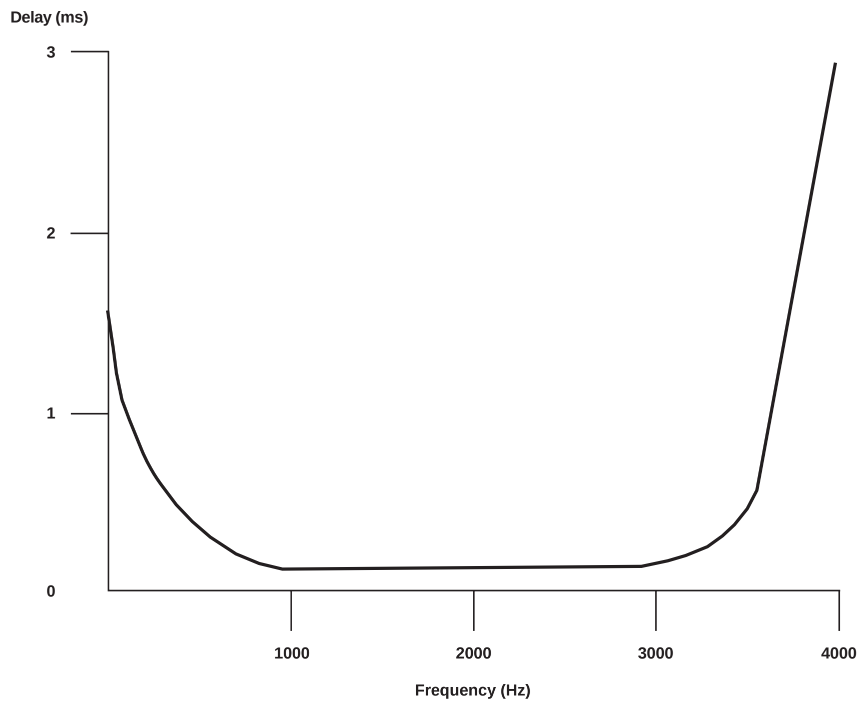

Figure 9
Envelope delay distortion.

Phase and Amplitude Jitter

Phase and amplitude jitter are two impairments which do not affect voice signals so much, but primarily affect data transmission, especially at higher bandwidths (>9.6 kb/s) (see ***Figure 10***). Phase jitter is a modulation of a signal's frequency. Amplitude jitter is a modulation of a signal's amplitude. Both are typically caused by coupling from power line equipment and ring generators.

Intermodulation Distortion (IMD)

IMD (a.k.a. nonlinear distortion) of a VF tone or signal is characterized by additional frequencies which are multiples of the fundamental frequency (see ***Figure 11***). IMD is caused by nonlinearities such as clipping or limiting, which modify the analog signal as it passes through the telephone system. These nonlinearities are caused most often by line repeaters which amplify the signal, as well as by transformers and inductive components.

Transients

Transients are intermittent faults, much like impulse noise, which are the result of intermittent phenomena such as electrical storms, switching equipment, and signaling equipment (see ***Figure 12*** on page 10). There are three types of transients:

- Dropouts are sudden and momentary decreases in the VF signal level.

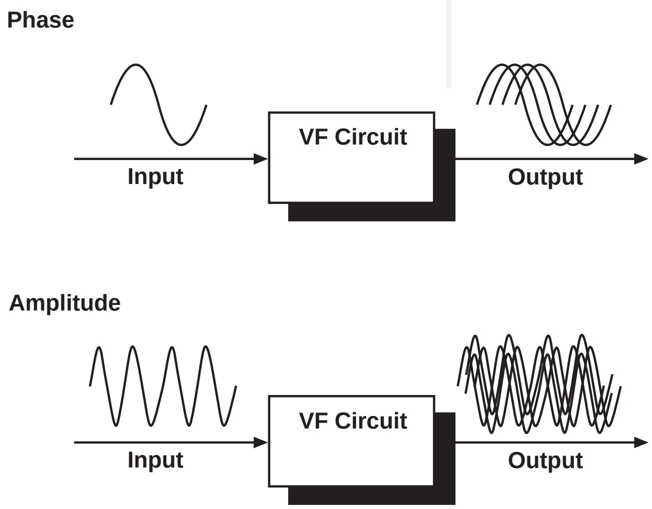

Figure 10
Jitter.

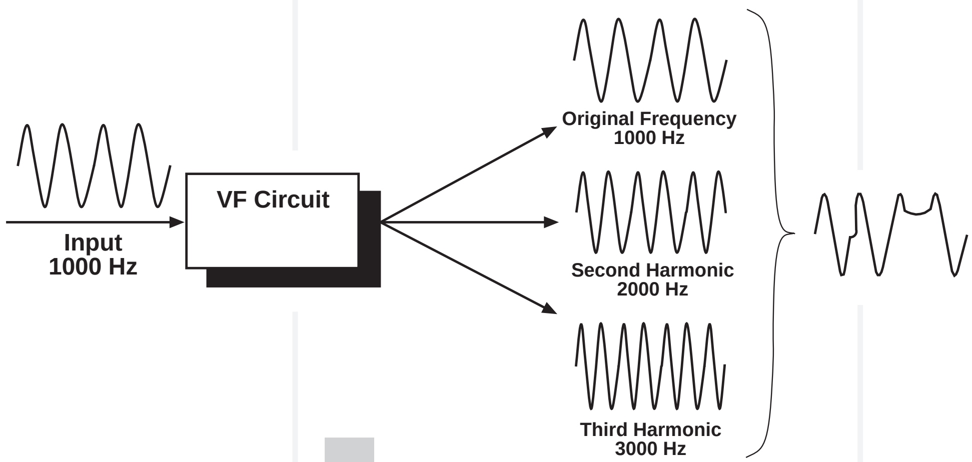

Figure 11
Intermodulation distortion.

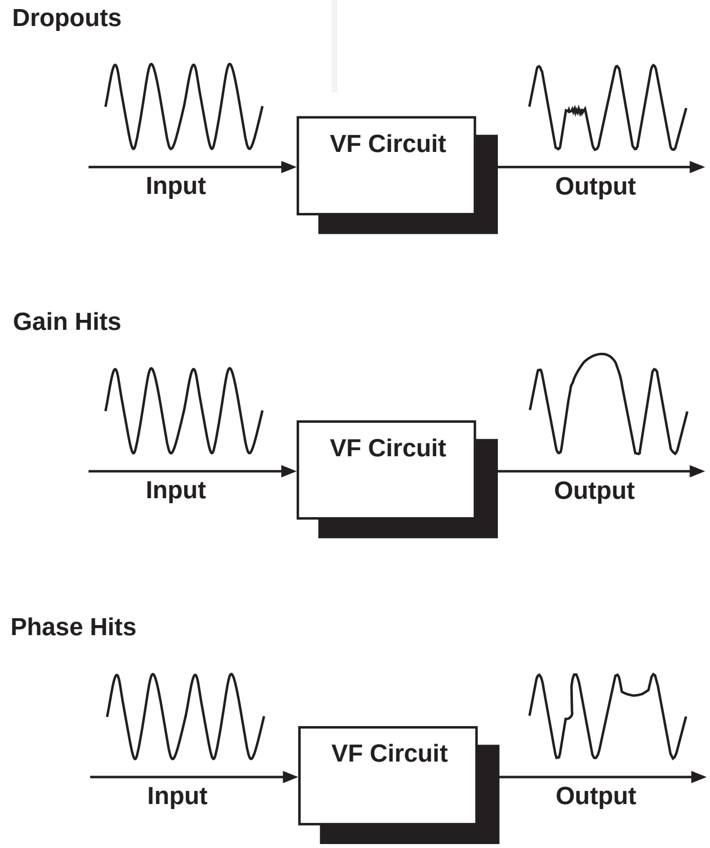

Figure 12 Transients.

- Gain hits are sudden and momentary increases in the VF signal level.

- Phase hits are sudden and momentary changes in phase.

Specifications regarding the duration and amplitude of intermittent faults have been developed that differentiate transients from impulse noise. Typically, transients must last for at least 4 ms.

Corrective Action

VF transmission circuits can be engineered, or “conditioned”, to minimize the sources of error which disrupt service quality, especially for data transmissions >9.6 kb/s. Conditioning typically includes the removal of echo cancelers, load coils, and bridge taps. Without line conditioning, data transmission bandwidths are generally restricted to <9.6 kb/s and distances are limited to 50 miles or less.

Distinguishing VF Channel Problems from T1 Circuit Problems

VF circuit analysis can be performed from either analog or digital (T1) access points. Testing a VF circuit from a T1 access point requires a T1 channel access set, such as the T-BERD 224, so that the specific VF channel can be isolated from the T1 circuit's remaining 23 channels. Then, technicians can analyze both the T1 circuit and the VF channel simultaneously, comparing results to determine where the problem is.

NOTE: When testing VF circuits from T1 access points, it is important to analyze not only the VF channel results, but also the in-service T1 circuit results. Otherwise, T1 circuit problems may be incorrectly interpreted as a VF problem.

For instance, common subscriber voice circuits are often transmitted via a T1 circuit through the interoffice network. Noise such as pops and crackles are heard on the VF circuit when listening to a conversation or to a test tone. Is the problem source within the T1 circuit or within the analog segments of the VF circuit? By listening to other voice channels, or by analyzing the in-service T1 results, such as BPVs, frame errors, or cyclic redudancy checksum (CRC) errors, technicians can isolate the problem to the T1 circuit or to the analog segments and begin to locate the problem source.

NOTE: For complete descriptions of T-Carrier technology, impairments, and testing, see TTC's Technical Note, "T1 Basics", and T-BERD 224 Application Guide.

Testing Voice-Grade vs. Data-Grade VF Circuits

VF circuit analysis is affected not only by the testing location, but also by the type of traffic the analog circuit is carrying – voice or data. Different tests are performed depending upon the channel content. Voice-carrying VF circuits are tested to ensure noise- and echo-free service. Data-carrying VF circuits are tested beyond the minimum requirements of voice-grade service to ensure that a data signal's frequencies, particularly at the high and low ends of the bandwidth, are transmitted relatively free of distortion. The following tests are grouped according to the type of VF circuit being tested.

Basic Tests for all VF Circuits

Three tests are required to analyze any VF circuit (whether it is a voice- or data-grade circuit) from a T1 access point, regardless of content: audio output, level, and frequency. These three tests are used during VF circuit installation, problem verification, and troubleshooting.

NOTE: The test configuration for each of these tests involves a single test set which non-intrusively monitors one or both T1 transmission paths via a resistor-isolated monitor jack or a high-impedance bridge.

One of the 24 channels is isolated so that a) the received content can be sent to the loudspeaker, b) the level of an incoming tone can be measured relative to a one milliwatt reference signal, and c) the frequency of the tone can be determined. The loudspeaker is used regardless of channel content, whereas level and frequency are used primarily when a test tone(s) is applied at some originating point.

Audio Output

Audio output, provided by the T-BERD 224's loudspeaker, is used primarily to verify VF path continuity. A test tone is placed near the circuit's endpoints so that technicians can verify circuit continuity throughout the network.

The loudspeaker also helps to quickly verify audible faults such as low levels, noise, and echo. The loudspeaker helps determine the transmission direction of the faults because the T-BERD 224 can isolate the loudspeaker source to one transmission direction or the other.

Level

Level, expressed in decibels (dBm), is a measure of signal power gain or loss relative to a one milliwalt reference signal. This reference signal is transmitted, often at 1004 Hz, with one milliwatt of power into a 600 ohm termination. The formula for level expressed in dBm is:

$$dBm = 10 \log (Power_{out} W/1E - 03W) =$$
$$10 \log (1E + 03*Power_{out})$$

If the signal level output at a specific circuit location is out of range, the received tone will be either barely audible (level too low), or too loud and somewhat distorted (level too high). Expected receive levels fall between -50 dBm and +3 dBm; signals near -50 dBm are very quiet and difficult to hear while signals near +3 dBm are loud and distorted.

NOTE: While analog signals may be transmitted at levels up to +10 dBm, the maximum level for a channel within a T1 circuit is +3 dBm due to limits within the encoding technique. For a more complete discussion of level parameters and transmission level points (TLP), refer to the "Signal Level Analysis," on the next page and "Transmission Level Points," on page 14, sidebars.

Frequency

Frequency is a measure of a signal's oscillation rate, typically between 60 Hz and 3900 Hz. The higher the rate, the higher the tone's pitch. Frequency is a useful measure of oscillator accuracy and is made in conjunction with other tests.

Basic Tests for Voice-Grade Circuits

In addition to audio, level, and frequency analysis, the following tests are often performed to analyze and qualify VF voice-grade circuits: C-Meassage Noise, C-Notched Noise, S/N Ratio, 3-Tone Slope, Return Loss, and DC Offset.

NOTE: The test configuration requirements are different for each test scenario.

Noise

Noise is measured as noise energy, a signal level expressed in dBrn which is reference to -90 dBm (i.e., 0 dBrn = -90 dBm). Noise can be measured with or without a holding tone, typically at 1004 Hz. Noise measure without a holding tone (idle channel noise) measures the background noise on a VF channel. Noise measured with a holding tone measures the amount of noise induced by a signal being transmitted across the channel. Noise is also measured with filters which are designed for specific applications.

C-Message Noise

C-Message Noise is a measurement of noise through a filter that has a frequency response similar to that of the human ear. It is measured with a quiet termination primarily to determine background noise. The filter weighs the noise according to perceived annoyance to the typical listener. Noise measured using "C" filters is given in dBrnC. Results range typically from 10 to 60 dBrnC.

Test Configuration. No test tones or signals are applied, and the circuit is terminated at some origination point. A single test set monitors one or both T1 transmission paths via a resistor-isolated monitor jack or a high-impedance bridge. The quiet channel is isolated so that background noise can be measured.

C-Notched Noise

C-Notched Noise is also referred to as noise-with-tone since it is a measurement of noise with a 1004 Hz holding tone. C-Notched Noise provides a measure of the noise encountered by a continuous VF data-grade signal, or the noise a listener would hear during a burst of speech. For voice-grade circuits, the holding tone is typically applied at -16 dBm assuming a 0 dB TLP. The holding tone activates the channel equipment, which may induce accompanying harmonic distortion, quantizing noise, phase jitter, and amplitude jitter which become part of the noise. At the test location, a notched filter eliminates the 1004 Hz test tone before the signal noise is analyzed through a C-Message filter. Just like C-Message Noise, C-Notched Noise is expressed in dBrnC; results range typically from 20 dBrnC to 70 dBrnC.

Test Configuration. This test is performed using either a loopback or point-to-point configuration. To test a single transmission direction, a 1004 Hz test tone is applied at some origination point. A single test set monitors the T1 transmission path downstream from the test tone via a resistor-isolated monitor jack or a high impedance bridge. The channel carrying the tone is isolated so that the test tone can be notched out and the accompanying noise can be measured.

Crosstalk Noise

Crosstalk Noise is a measure of noise, expressed in dBrn, caused by crosstalk coupling between two or more circuits along the same transmission path. Crosstalk Noise is measured by driving one circuit with a holding tone at some originating point, and measuring the parallel circuits' noise levels at some receiving point. Crosstalk Noise is measured using a 3 kHz Flat Filter.

Test Configuration. Similar to the C-Message Noise test.

Signal Level Analysis

Signal level, in the most general sense of the term, is a measure of a signal's power received at some point in the circuit. Signal level is most often expressed in dBm, and is a measure of signal power gain or loss relative to a one milliwatt reference signal. Level expressed in dBm is computed using the following formula:

$$\text{dBm} = 10 \log (\text{Power}_{out}/1\text{E-03W})$$
$$= 10 \log (1\text{E} + 03^{*}\text{Power}_{out})$$

Since level expressed in dBm is measured relative to an absolute value, it is considered an *absolute* measurement.

Signal loss or gain, expressed in decibels (dB), is a measure of signal power attenuation or amplification relative to the power of the same signal at another arbitrary point. Signal loss or gain is most commonly measured by subtracting the level of the test signal (in dBm) received at some test location, from the level of the transmitted test signal:

$$\text{Gain or Loss (dB)} = \text{Power}_{out}(\text{dBm}) - \text{Power}_{in}(\text{dBm})$$

Transmission Level Point (TLP)

TLPs are used as a convenient means of expressing signal loss or gain within a circuit. The TLP is a point in the circuit expressed as the ratio (in dB) of the power of the signal at that point to the power of the signal at a reference point, called the 0 TLP. TLP, then, is the measurement of the signal gain or loss rela tive to the 0 TLP. The diagram below shows how the TLPs relate to signal gain and loss in a circuit.

In the above circuit, the signal level at point B should be 7 dB greater than the signal level at point A, the 0 TLP. The signal level at point C should be 15 dB lower than the signal level at point A.

How do readings taken in dBm0 relate to readings taken in dBm? Signal levels expressed in dBm0 define the signal level relative to the 0 TLP. For example, if the actual level of the signal at point B in the above circuit measured +10 dBm, its value expressed in dBm0 would be +3 dBm0. In other words:

dBm0 = Signal Power (dBm) - TLP (dB)

Therefore, the signal level in dBm0 should be the same points A, B, and C in the above drawing. Drastic differences in dBm0 readings may indicate a problem between particular sections of the circuit.

NOTE: The same formula applies for referencing noise to the 0 TLP (dBrnC0, dBrn0). Also the T-Carrier based VF circuits are always a 0 dB TLP by definition.

S/N Ratio

S/N Ratio is a ratio, expressed in decibels (dB), of the holding tone's level to the measured noise-with-tone:

S/N (dB) = Level (dBm)/C-Notched noise (dBrnC)

S/N Ratio provides a quick analysis of circuit quality. Typically, higher ratios indicate lower noise and therefore better quality. Lower ratios can indicate poor quality due to excessive noise or poor level. Results range generally from 10 dB to 45 dB.

Test Configuration. Similar to the C-Notched Noise test.

3-Tone Slope

3-Tone Slope analysis is used to estimate attenuation distortion on a VF circuit. It is a comparison of received loss measured at both 404 Hz and 2804 Hz, to the received loss at 1004 Hz:

A. Level (@1004 Hz) dBm - Level (@404 Hz) dBm = dB

B. Level (@1004 Hz) dBm - Level (@2804 Hz) dBm = dB

Tones are typically transmitted at -16 dBm assuming a 0 dB TLP. For dedicated VF circuits, the differences between the level at 1004 Hz and the other two tones are between -2 dB (gain) and +10 dB (loss). For PSTN circuits, the differences should be ≤+14 dB.

Test Configuration. Similar to the Level test.

Return Loss

Return loss is a ratio, expressed in dB, of a signal's transmitted power to the power reflected back to the originating end (i.e., echo) due to an impedance mismatch in a mixed 2-wire/4-wire circuit. Return loss is defined as:

R.L. (dB) = Power transmitted (dBm) - Reflected Power Received (dBm)

As the return loss increases, the power of the returned signal decreases (assuming that the transmitted power remains relatively constant), thereby causing less of an echo. If return loss is small, the reflected power is sizable, and the talker or listener, or both, will think they are talking through a tunnel due to the echoes. If return loss is low for data signals, the occurring echoes may distort the signal and therefore induce data errors.

Three return loss measurements, which differ in frequency spectral content and measurement filters, can be made to determine which section of the frequency spectrum is the cause of the echo. Return loss mea-surements require a quiet termination at the distant end so that the reflection of transmitted signal may be measured.

Echo Return Loss

Echo Return Loss is a measurement of return loss in the mid-range frequencies. Results range between 0 dB and 50 dB.

Singing Return Loss Low and High (SRL-LO, SRL-HI)

SRL-LO and SRL-HI are measurements of return loss in the low (200 Hz to 500 Hz) or high (2500 Hz to 3200 Hz) frequency ranges. Results range between 0 dB and 50 dB.

Test Configuration. For all return loss measurements, a single test set is used to transmit and receive test tones. A quiet termination is provided at some “far” location, typically on the other side of 2-wire/ 4-wire hybrid, so that the reflected transmitted power may be measured.

DC Offset

DC Offset is a measure, expressed in mV, of positive or negative DC components within the analog signal. It is useful for detecting faulty codec operation. Good codecs should provide a result of 0 mV. The T-BERD 224’s DC Offset result ranges from +127 mV to -127 mV.

Test Configuration. Similar to the Level test.

Basic Tests for Data-Grade Circuits

In addition to level, frequency, and the other voice-grade tests just described, the following tests are performed to analyze and qualify VF data-grade circuits: 3 kHz Flat Noise, P/AR, and Frequency Sweep vs. Level. The 3kHz Notched Noise test, while not a standard test, is gaining popularity for testing data circuits and is included for that purpose. Other specialized tests such as EDD, IMD, and Transients are beyond the scope of this ***Application Note.***

Noise

Noise can be very disruptive to data transmissions which are much more sensitive to line impairments. Since the C-Message Noise filters are designed to analyze the noise most apparent to the human ear, C-Message and C-Notched Noise are not the best measurements to make for VF data-grade circuits. Instead, filters which are more relevant to data transmissions should be used:

3 kHz Flat Noise

3 kHz Flat Noise, expressed in dBrn, is measured through a 3 kHz Flat Filter and investigates the presence of idle channel noise such as crosstalk, white noise, and impulse noise. A quiet termination at the circuit’s originating end is required. Results range from 20 dBrn to 70 dBrn.

Test Configuration. Similar to the C-Message Noise test.

3 kHz Notched Noise

3 kHz Notched Noise, expressed in dBrn, is a measurement of noise with a 1004 Hz holding tone (typically at -16 dBm assuming a 0 dB TLP) applied at the circuit’s originating point. The 3 kHz Notched Noise test provides a measure of the noise encountered by a

continuous data signal because the holding tone activates the channel equipment which can create noise. Results range from 20 dBrn to 70 dBrn.

Test Configuration. Similar to the C-Notched Noise test.

Peak-to-Average Ratio (P/AR)

P/AR, expressed in units, is measured by comparing a received P/AR signal to a known P/AR waveform. The P/AR signal is a complex waveform whose spectral content consists of 16 non-harmonically related tones, with known envelope shape, which approximates a data signal. P/AR analysis measures signal dispersion or spreading due to transmission imperfections such as EDD, noise, and bandwidth reduction, and nonlinearities such as clipping and compression. While P/AR cannot isolate the impairment type or cause, it is a non-tariffed figure of merit used to quickly appraise a circuit's data transmission quality. Typically, higher level tests such as EDD and IMD are not performed unless the P/AR result is out of a provider-acceptable range within the entire P/AR range of 0 to 120. A perfect channel would provide a reading of 100 units.

Test Configuration. This test is typically performed using two test sets in a point-to-point configuration. Both transmission directions may be tested simultaneously by having each test set transmit the P/AR spectrum toward the opposite test set. Each test set then isolates the channel carrying the test tones so that the P/AR can be measured.

Frequency Sweep vs. Level

Frequency Sweep vs. Level is a detailed analysis of attenuation distortion; amplitude changes are analyzed over a frequency range at specific intervals. Frequency sweep analysis provides more detail of attenuation distortion than 3-Tone Slope analysis because the entire frequency bandwidth can be analyzed at multiple intervals instead of only at three distinct frequencies. This detailed analysis is important for VF circuits transmitting data since data requires consistent quality over the entire frequency range. Even so, the frequncy range of 2504 to 2750 Hz should not be tested to avoid inadvertent loopbacks or billings caused by 2713 Hz and 2600 Hz tones respectively.

Test Configuration. Similar to the Level test.

Application 1: Testing Voice-Grade VF Circuits from a T1 Access Point

The following application demonstrates how the T-BERD 224 can be used to evaluate the *overall* performance of a voice-grade VF circuit from a T1 access point. This application is most often used on T1 channels carrying voice traffic within interoffice trunks, PBX trunks, and DLC circuits (e.g., SLC®-96 and SLC Series 5). It is useful:

- When installing voice-grade VF services through T1 circuits and verifying point-to-point continuity.
- When locating VF faults such as noise, echo, or excessive loss from a CO that provides T1 circuit access only.
- When testing VF circuits at a T1 access point via level, frequency, noise, and return loss tests.

By placing the T-BERD 224 in-line so that the T1 circuit passes through the unit, users can overwrite any channel's contents with test tones to perform straightaway or loopback tests, without disrupting the remaining 23 channels.

NOTE: When the T-BERD 224 is inserting test tones in one direction, it transmits an idle code into the selected channel in the opposite direction to prevent loop and test tones from being transmitted throughout the rest of the circuit.

While performing an out-of-service test on a specific channel, the T-BERD 224 is analyzing both T1 inputs for BPVs, frame errors, and signal impairments. Consequently, this is *both* an in-service T1 test as well as an out-of-service VF test. **By comparing the T1 results with the channel results, technicians can determine if the problem source is in the analog or T1 portion of the transmission circuit.**

There are two methods of performing VF circuit analysis: end-to-end testing and loopback testing. The T-BERD 224 configuration is similar for both types of testing. The two major differences which are addressed in the following sections are:

- The equipment needed.
- The establishment of a loopback.

End-to-End Testing

End-to-end testing is performed with two test sets such that analysis is performed in both directions simultaneously, as shown in ***Figure 13.*** Since testing is performed from a T1 access point, at least *one* of the two test sets will be a T-BERD 224. The other test set will very often be an analog VF test set capable of transmitting and receiving various tones and waveforms from an analog access point.

End-to-end testing is often performed on voice-grade circuits because VF loopbacks many times cannot be remotely established via loop codes or tones. Further, since end-to-end analysis enables technicians to find the error source direction, *as well as* location, it is better than loopback testing.

Loopback Testing

Loopback testing is performed with one T-BERD 224 as shown in ***Figure 14*** on the next page. A far-end, hard loop is provided so that the transmitted test tones can return to the T-BERD 224 for analysis.

NOTE: Both transmission directions are tested, but results will indicate general error source location, *not* direction.

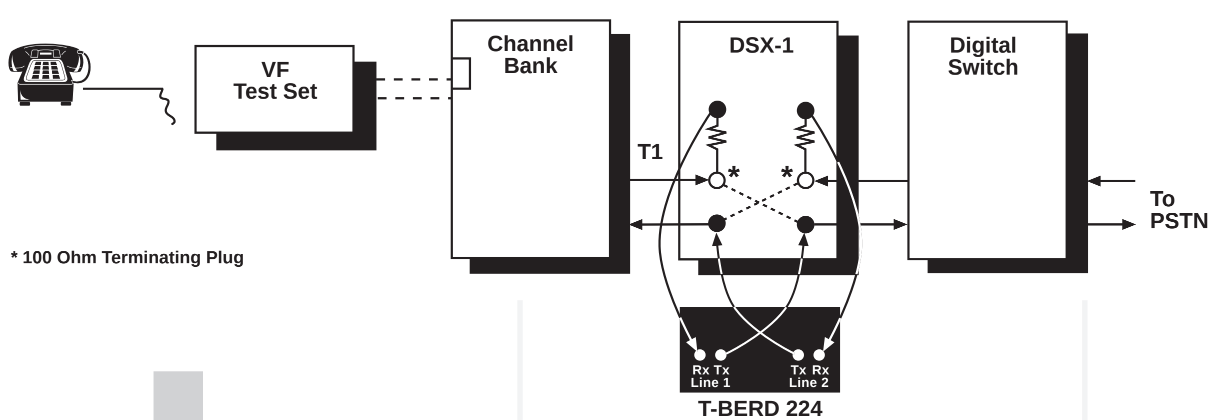

Figure 13
End-to-end testing.

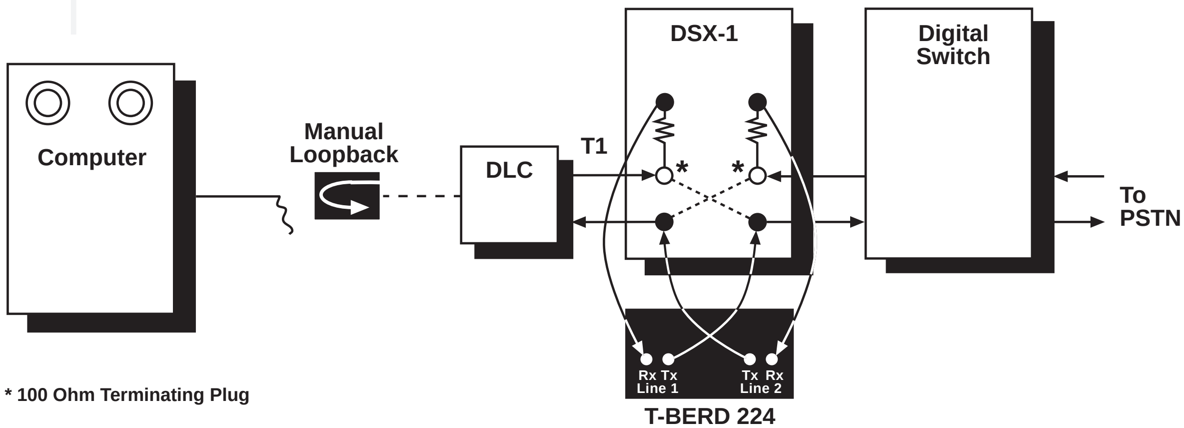

Figure 14
Loopback testing.

NOTE: With the proliferation of 1/0 DCSs in the network, access to VF circuits is best obtained via the DCS Test Access Digroup (TAD). The 1/0 DCS outputs the VF circuit to its test T1 port; in effect, the DCS performs a drop and insert operation (see ***Figure 15***). The T-BERD 224 operation is the same in both the TAD testing application and the DSX-1 application.

Equipment

Since end-to-end analysis is more prevalent, this application will describe end-to-end testing requirements.

At the T1 access point, the following equipment is required:

1 – T-BERD 224 PCM Analyzer, including the VF Analysis Option (TTC Model No. 41502).

4 – Cables. To connect the T-BERD 224 to the T1 circuit, use *four* cables from one of the following types:
Bantam plug to bantam plug
(TTC Model No. CB-10615)
Bantam plug to WECO 310 plug
(TTC Model No. CB-10559)

NOTE: To ensure proper results, use the proper cable. Using a bantam plug to a WECO 310 adapter plug, as opposed to an adapter cable, may cause BPVs, leading to erroneous results.

At the analog VF access point, the following equipment is required:

1 – Analog VF test set complete with necessary cables.

Figure 16 depicts the T-BERD 224 PCM Analyzer. The numbers for each item in the figure corresponnds to the front panel component that controls each configuration activity.

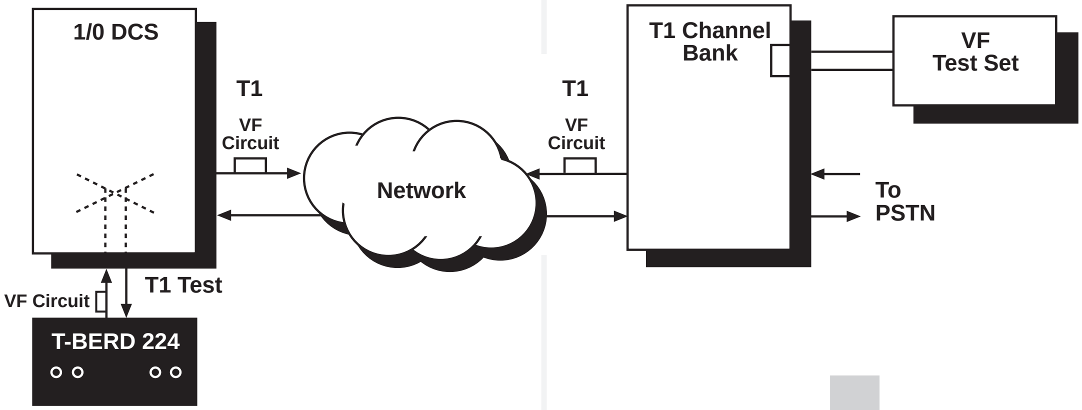

Figure 15
VF testing via T1 test points.

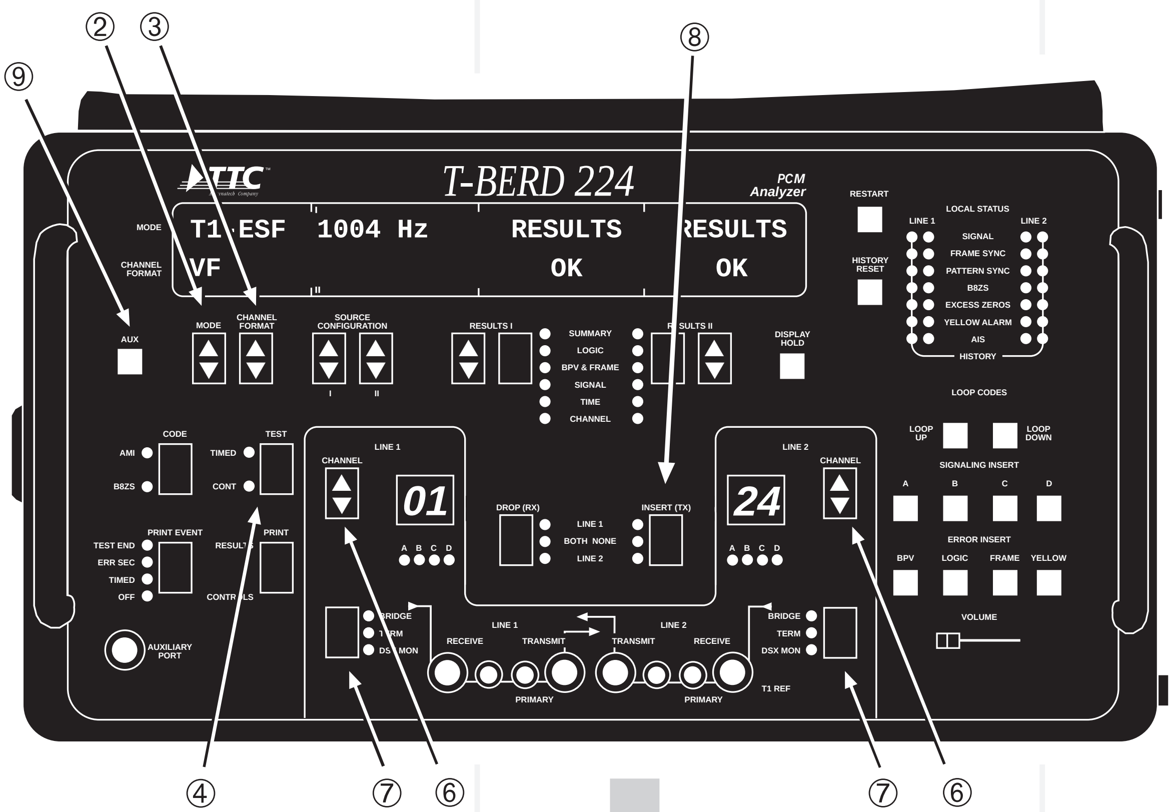

Figure 16
T-BERD 224 PCM Analyzer front panel.

Configuring and Cabling the T-BERD 224

The following steps configure the T-BERD 224 for basic operation.

1. Press the T-BERD 224's side panel power switch to the ON position.

2. Press the MODE switch to select the desired T1 framing format (e.g., T1-D4). If the mode is unknown, select AUTO and let the T-BERD 224 determine the mode automatically once it is connected to the T1 circuit.

3. Press the CHANNEL FORMAT switch to display VF for Voice Frequency.

4. Set the TEST switch to CONT.

5. Adjust the VOLUME slide switch to mid-range.

6. Press the CHANNEL switches for LINE 1 and LINE 2 to select the proper channel numbers carrying the voice traffic in question.

7. Press the RECEIVE INPUT switches for both LINE 1 and LINE 2 to illuminate the LED next to the DSX MON label.

   NOTE: The DSX MON input termination is for resistor-isolated jacks only. If the T-BERD 224 is bridged to the circuit using alligator clips or connected via non-isolated monitor jacks, select BRIDGE.

8. Set the INSERT (TX) switch to NONE, and DROP (RX) switch to both.

9. Press the AUX switch to enable the auxiliary functions and use the MODE switch to display AUX 05. Verify that the LBO is set to 0 dB for both LINE 1 and LINE 2. If not, use the SOURCE CONFIGURATION II and RESULTS I category switches to set each LBO to 0 dB.

10. Connect the T-BERD 224 LINE 1 RECEIVE input connector to the appropriate MON jack on the patch bay as shown in ***Figure 17,*** Nos. 1 and 2.

    NOTE: ***Figure 17*** provides a step-by-step numbering scheme for connecting the T-BERD 224 to a T1 circuit for performing drop and insert testing.

    WARNING: Do not connect the TRANSMIT output jack to the line until Steps 1 through 12 are performed to avoid taking the line down.

11. Verify that the green SIGNAL and FRAME SYNC LEDs are illuminated for the T1 input, and that the B8ZS LED indicator is illuminated if the circuit is using clear channel (B8ZS) line coding. If the SIGNAL LED is illuminated yet the FRAME SYNC LED is not, check the MODE display to verify proper selection of line format (e.g., T1-D4, T1-ESF, T1-SLC).

12. Press the CODE switch to select the line coding. To select the proper code, observe the STATUS and ALARM LEDs for LINE 1. If the B8ZS LED is illuminated, select B8ZS; otherwise, select AMI.

13. Assuming that the T-BERD 224 has frame sync as indicated by the FRAME SYNC LED, connect a T1 cable *first* to the T-BERD 224's LINE 1 TRANSMIT output jack, and *then* to the patch bay jack as shown in ***Figure 17,*** Nos. 3 and 4.

    WARNING: Connecting the cable into the patch bay jack before connecting the other end into the T-BERD 224 will take down the T1 circuit.

14. Repeat Steps 10 through 13 for LINE 2.

15. Insert 100 ohm terminating plugs into the patch bay jacks as shown in ***Figure 17,*** Nos. 9 and 10, to avoid line imbalances.

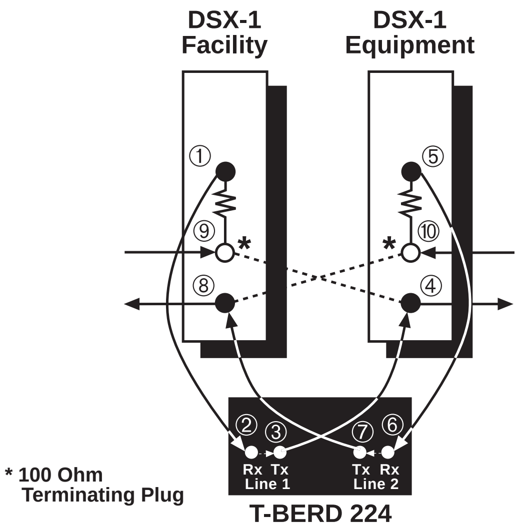

Figure 17
Connecting the T-BERD 224 to a patch bay jack.

Results

A. Retrieving In-Service Results of the T1 Circuit

While out-of-service analysis is performed on one of the 24 T1 channels, in-service analysis of the entire T1 circuit is performed simultaneously.

NOTE: All results, including the T1 results, are reset to 0 each time the TEST RESTART switch or a major switch such as SOURCE CONFIGURATION I or II, is pressed.

1a. Press the RESULTS I category switch to illuminate the LED next to SUMMARY.

2a. If "RESULTS OK" is not shown in the RESULTS I display, press the RESULTS I arrow switch to scroll through the key, non-zero results regarding the T1 circuit's in-service performance.

B. Measuring Level, Frequency, C-Notch Noise and S/N Ratio

The following procedure assumes that Steps 1 through 15 have been performed and that a 1004 Hz, -16 dBm test tone is being transmitted toward the T-BERD 224 from the far-end VF test set as shown in ***Figure 13*** on page 17.

NOTE: The following sequence of transmitting and measuring specific tones and results *must* be performed at the far-end test set simultaneously for proper circuit analysis.

1b. Press the SOURCE CONFIGURATION I switch to display LEVEL. The SOURCE CONFIGURATION I display will then change to "LEV@xxxxHz" which indicates the frequency output where xxxx is the current frequency setting.

2b. Press the SOURCE CONFIGURATION II switch to select the transmit level (typically -16 dBm).

3b. Press the SOURCE CONFIGURATION I switch to display 3-TONE SLP.

4b. Press the SOURCE CONFIGURATION II switch to display 1004 Hz. The T-BERD 224 is now configured to transmit a 1004 Hz tone at -16 dBm in the selected channel.

5b. To insert the 1004 Hz test tone into the channel (selected in Step 6) toward the far-end test set, press the INSERT (TX) switch to either LINE 1 or LINE 2, depending on the far-end test set's location. For the example shown in ***Figure 13*** on page 17**,** the INSERT selection should be set to LINE 2 to transmit the VF test tone from the T-BERD 224 to the far-end test set.

NOTE: An idle code of All Ones will be transmitted into the channel selected for LINE 1 to *prevent* loop and test tones from being transmitted throughout the rest of the circuit.

6b. Press the DROP (RX) switch to select the line opposite of the INSERT selection. For the example shown in ***Figure 13*** on page 17, the DROP selection should be set to LINE 1.

7b. Verify continuity by listening to the 1004 Hz test tone using the internal loudspeaker's VOLUME slide switch.

8b. Press the RESULTS I category switch to illuminate the LED next to CHANNEL.

9b. Press the RESULTS I arrow switch to display the VF frequency (N81 VF FREQ), where N equals the line number selected by the DROP (RX) switch (LINE 1). Verify the reception of a 1004 Hz tone from the far-end test set.

10b. Press the RESULTS II category switch to illuminate the LED next to CHANNEL.

11b. Press the RESULTS II arrow switch to display the VF level (N82 VF LVL) of the tone received by the T-BERD 224. Record the result.

12b. Using either the RESULTS I or the RESULTS II arrow switch, display and record C-Notched Noise (N87 C-NOTCH), and Signal-to-Noise Ratio (N88 S/N) where N equals the line number selected by the DROP (RX) switch.

C. Measuring 3-Tone Slope

The following procedure assumes that Steps 1 through 15 and 1b through 8b have been performed, and that a far-end test set capable of sending 404 Hz, 1004 Hz, and 2804 Hz tones is positioned as shown in ***Figure 13*** on page 17. The LEVEL result from Steps 1b through 8b will be used in conjunction with the following procedure to estimate the circuit's frequency response or attenuation distortion.

NOTE: The following sequence of transmitting and measuring specific tones and results *must* be performed at the far-end test set simultaneously for proper circuit analysis. Or, perform a far-end loopback of the far-end circuit (see ***Section F***).

1c. Press the SOURCE CONFIGURATION I switch to display LEVEL (LEV@404 Hz).

2c. Press the SOURCE CONFIGURATION II switch to select the transmit level (typically -16 dBm).

3c. Press the SOURCE CONFIGURATION I switch to display 3-TONE SLP.

4c. Press the SOURCE CONFIGURATION II switch to display 404 Hz.

5c. Press the RESULTS I category switch to illuminate the LED next to CHANNEL.

6c. Press the RESULTS I arrow switch to display the VF frequency (N81 VF FREQ), where N equals the line number selected by the DROP (RX) switch. Verify the reception of a 404 Hz tone from the far-end test set.

7c. Press the RESULTS II category switch to illuminate the LED next to CHANNEL.

8c. Press the RESULTS II result switch to display the VF level (N82 VF LVL), where N equals the line number selected by the DROP (RX) switch. Record the result and compare it with the measured level of the 1004 Hz tone.

9c. Press the SOURCE CONFIGURATION II switch to display 2804 Hz.

10c. Verify the reception of a 2804 Hz tone from the far-end test set by observing the RESULTS I display (N81 VF FREQ).

11c. Record the result (N82 VF LVL) now displayed in the RESULTS II window and compare it with the measured level of the 1004 Hz tone.

D. Measuring C-Message Noise

The following procedure assumes that Steps 1 through 15 have been performed and that a quiet termination (i.e., a 400, 600, or 1200 ohm terminating resistance) is being provided by the far-end test set as shown in ***Figure 13*** on page 17.

NOTE: The following sequence of transmitting and measuring specific tones and results *must* be performed at the far-end test set simultaneously for proper circuit analysis.

1d. Press the SOURCE CONFIGURATION I switch to display QUIET.

2d. To insert the quiet termination into the channel (selected in Step 6) toward the far-end test set, press the INSERT (TX) switch to either LINE 1 or LINE 2, depending on the far-end test set's location. For the example shown in ***Figure 13*** on page 17, the INSERT selection should be set to LINE 2 to transmit the VF test tone from the T-BERD 224 to the far-end test set.

NOTE: An idle code of All Ones will be transmitted into the channel selected for LINE 1 to *prevent* loop and test tones from being transmitted throughout the rest of the circuit.

3d. Press the DROP (RX) switch to select the line opposite of the INSERT selection. For the example shown in ***Figure 13*** on page 17, the DROP selection should be set to LINE 1.

4d. Press the RESULTS I category switch to illuminate the LED next to CHANNEL.

5d. Press the RESULTS I arrow switch to display the VF frequency (N81 VF FREQ), where N equals the line number selected by the DROP (RX) switch. Verify the reception of a 0 Hz tone (Quiet) from the far-end test set.

6d. Press the RESULTS II category switch to illuminate the LED next to CHANNEL.

7d. Press the RESULTS II arrow switch to display the C-Message Noise (N86 C-MSG), where N equals the line number selected by the DROP (RX) switch. Record the result.

E. Measuring Return Loss

The following procedure assumes that Steps 1 through 15 have been performed and that a quiet termination is being provided by the far-end test set as shown in ***Figure 13*** on page 17.

NOTE: The following sequence of transmitting and measuring specific tones and results *must* be performed at the far-end test set simultaneously for proper circuit analysis. Performing this test with anything other than a quiet termination at the far-end (such as a loopback) will provide errone-ous results.

1e. Press the SOURCE CONFIGURATION I switch to display ERL.

NOTE: When this or any return loss function (e.g., ERL, SRL-HI, SRL-LO) is selected, the following message is displayed: "SET BURST FREQ IN AUX 22". Pressing the AUX switch changes the display immediately to the AUX 22 VF BURST display; the BURST frequency and level for echo canceller suppression can be easily selected. If the BURST is set to ON, the selected burst frequency is transmitted automatically before any return loss measurements are made so that echo cancellers are disabled during the test. Pressing the AUX switch one more time returns the display to normal operation.

2e. To insert the return loss test tones into the channel (selected in Step 6) toward the far-end test set, press the INSERT (TX) switch to either LINE 1 or LINE 2, depending on the far-end test set's location. For the example shown in ***Figure 13*** on page 17, the INSERT selection should be set to LINE 2 to transmit the VF test tone from the T-BERD 224 to the far-end test set.

NOTE: An idle code of All Ones will be transmitted into the channel selected for LINE 1 to *prevent* loop and test tones from being transmitted throughout the rest of the circuit.

3e. Press the DROP (RX) switch to select the line opposite of the INSERT selection. For the example shown in ***Figure 13*** on page 17, the DROP selection should be set to LINE 1.

4e. Press the RESULTS I category switch to illuminate the LED next to CHANNEL.

5e. The channel's Echo Return Loss (N92 ERL), where N equals the line number selected by the DROP (RX) switch, is displayed. Record the result.

6e. Press the SOURCE CONFIGURATION I switch to display SRL-HI.

7e. The channels's SRL-HI (N93 SRL-HI), where N equals the line number selected by the DROP (RX) switch, is displayed. Record the result.

8e. Press the SOURCE CONFIGURATION I switch to display SRL-LO.

9e. The channel's SRL-LO (N94 SRL-LO), where N equals the line number selected by the DROP (RX) switch, is displayed. Record the result.

Fault Isolation

When interpreting the results, it is important to first analyze the in-service T1 circuit results. Problems apparent within the T1 channels may be caused by BPVs, CRC errors, or timing slips on the T1 circuit. Before troubleshooting any VF circuit problem, find and repair any T1 circuit problems first.

To localize problems, break the T1 circuit into manageable sections one step at a time as shown in ***Figure 18.*** In Stage 1, verify that errors are occurring somewhere in the circuit. In Stage 2, test a section of the circuit and "circle-in" on the source (or sources) of errors. If errors still occur at Stage 2, at least *one* of the error sources is between your location and the far-end. To make sure no sources of errors have been missed, test the circuit section between Stage 1 and Stage 2. In this manner, you can quickly and methodically isolate faults within the circuit. Before determining that the circuit is good, test it one more time end-to-end for verification.

Results Interpretation

Once results are known, it is possible to isolate the cause of disrupted and degraded service. Since every T1/VF circuit is different, it is nearly impossible to list all the causes. ***Table 1*** shows various result combinations and *possible* problem causes.

Application 2: Testing Data-Grade VF Circuits from a T1 Access Point

The following application demonstrates how the T-BERD 224 can be used to evaluate the *overall* performance of a data-grade VF circuit from a T1 access point. This application is *most often used* on T1 channels carrying data traffic within interoffice trunks, DLC circuits (e.g., SLC-96 and SLC Series 5), and dedicated trunks between channel banks. It is useful:

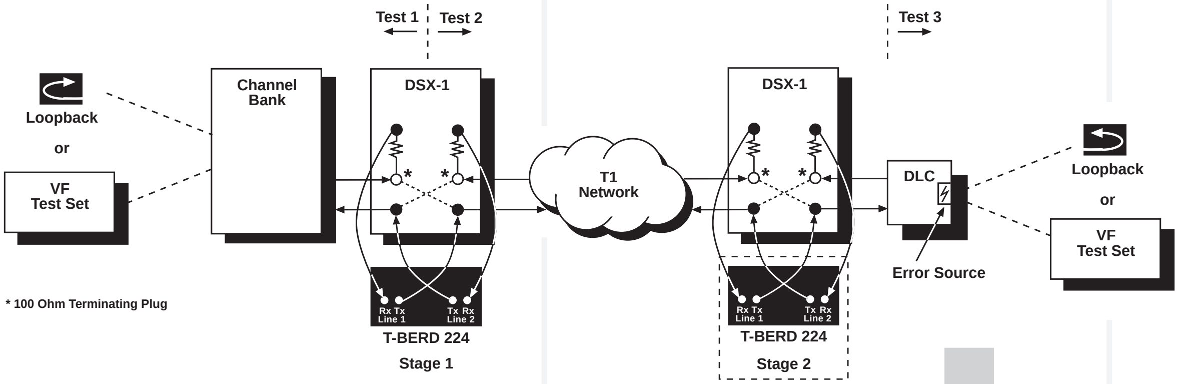

Figure 18
Sectionalizing problem sources.

Table 1
Correlation of results and problem causes.

Result	Result Displayed by the T-BERD 224	Problem
Bipolar Violations Audible Noise	BPVs FRM ERR CRC ERR	Local T1 problem. Possibly faulty T1 repeater, span line noise, crosstalk, poor line cabling, bad cabling between test and circuit, corroded "dirty" cable plugs.
Frame Errors CRC Errors	FRM ERR CRC ERR	Typically a far-end T1 span problem. Sectionalize further. Check cross-connect switches, multiplexers, and repeaters, as well as the cabling between these devices.
Timing Slips Voice Dropouts	TIM SLP	T1 timing problem. Check channel bank and multiplexer timing settings. Verify one master, remainder slaves.
T1 Results OK VF Level Low	SUMMARY RESULTS OK VF LVL out-of-spec	VF circuit problem. Check level and LBO settings on modems, line repeaters, channel bank plug-ins, and multiplexer cards. Check VF local loop for shorts, opens, grounds, etc.
T1 Results OK Audible Echoes Return Loss Low	SUMMARY RESULTS OK ERL, SRL-HI, or SRL-LO out-of-spec	2-wire/4-wire hybrid converter impedance mismatch. Check impedance settings.
T1 Results OK Audible Distortion Sloped Tone Distortion	SUMMARY RESULTS OK Slope out-of-spec	VF circuits problem – attenuation distortion. Check VF line repeaters, and line cards containing digital/analog converters. May require reconditioning analog local loop (remove load coils, etc.).
T1 Results OK Idle Channel Noise	SUMMARY RESULTS OK C-Message Noise out-of-spec	VF circuit problem. Crosstalk from adjacent cable pairs, 60 Hz induction from power lines, possible VF local loop problems (one side open, unbalanced line).
T1 Results OK Noise with Tone out-of-spec	SUMMARY RESULTS OK C-Notch and S/N out-of-spec	VF circuit problem. Bad line card in the channel bank, multiplexer, or SLC terminal, bad VF repeater, 1004 Hz tone out-of-range.

- When installing data-grade VF services through T1 circuits.

- When locating the source of data-grade impairments from a CO that provides T1 circuit access only.

- When testing data-grade VF circuits at a T1 access point via 3 kHz Flat Noise, 3 kHz Notched Noise, P/AR, and Frequency Sweep vs. Level tests.

NOTE: It is highly recommended that the tests described for voice-grade circuits, such as level, frequency, and return loss, be performed as well to fully analyze the VF circuit.

By placing the T-BERD 224 in-line with the T1 circuit so that the T1 circuit passes through the unit, users can overwrite any channel's contents with test tones to perform straightaway or loopback tests without disrupting the remaining 23 channels.

NOTE: When the T-BERD 224 is inserting test tones in one direction, it transmits an idle code into the selected channel in the opposite direction to prevent loop and test tones from being transmitted throughout the rest of the circuit.

While performing an out-of-service test on a specific channel, the T-BERD 224 is analyzing both T1 inputs for BPVs, frame errors, and signal impairments. Consequently, this application covers *both* in-service T1 testing as well as out-of-service VF testing. By comparing the T1 results with the channel results, technicians can determine if the problem source is in the analog or T1 portion of the transmission circuit.

There are two methods of performing VF circuit analysis: end-to-end testing and loopback testing. The T-BERD 224 configuration is similar for both types of testing. The two major differences addressed in the following sections are:

- The equipment needed.

- The establishment of a loopback.

End-to-End Testing

End-to-end testing is performed with two test sets such that analysis is performed in both directions simultaneously, as shown in ***Figure 19.*** Since testing with the T-BERD 224 is performed from a T1 access point, the other test set will be either another channel access set or a standard analog VF test set capable to transmitting and receiving various tones and waveforms.

Even though end-to-end analysis requires coordinating two test sets, it provides more thorough testing because the error sources direction, *as well as* location, can be found more quickly.

Loopback Testing

Loopback testing is performed with one T-BERD 224 as shown in ***Figure 20.*** For data-grade VF circuits equipped with an 829 termination, a far-end loopback is established by sending a 2713 Hz tone toward the 829 termination for a specified time limit, which activates the loopback. The T-BERD 224's transmitted test tones can then be received from the return path for analysis.

NOTE: Both transmission directions are tested, but results will indicate general error source location, but not direction. Since loopback testing is performed by one technician with only one test set, it is useful when quick fault isolation is desired. A description of how to establish an 829 termination loopback using the T-BERD 224 is described in ***Section F*** of the following application.

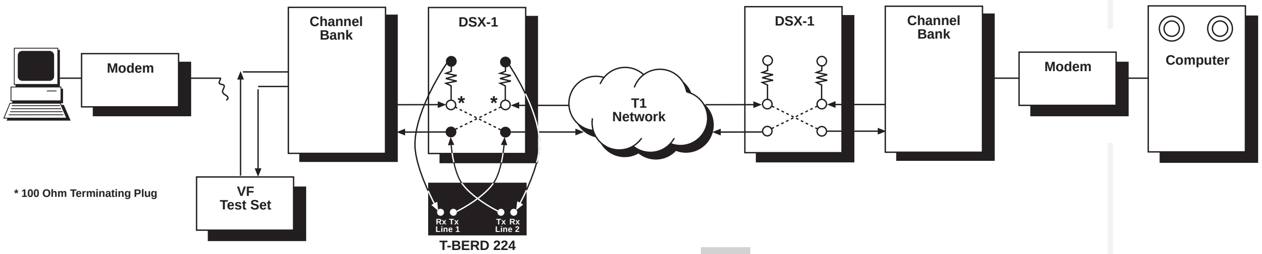

Figure 19
End-to-end testing.

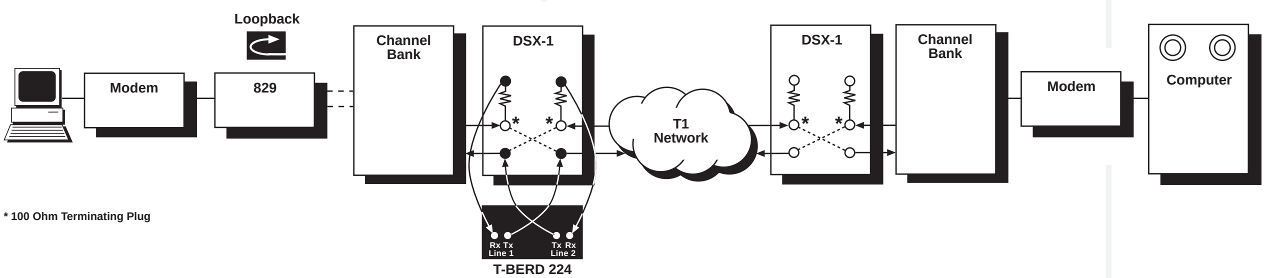

Figure 20
Loopback testing.

Equipment

Since some data-grade circuit tests should *not* be performed using loopbacks, this application will describe end-to-end testing requirements.

At the T1 access point, the following equipment is required:

1 – T-BERD 224 PCM Analyzer, including the VF Analysis Option (TTC Model No. 41502).

4 – Cables. To connect the T-BERD 224 to the T1 circuit, use *four* cables from one of the following types:
Bantam plug to bantam plug
(TTC Model No. CB-10615)
Bantam plug to WECO 310 plug
(TTC Model No. CB-10559)

NOTE: To ensure proper results, use the proper cable. Using a bantam plug to a WECO 310 adapter plug, as opposed to an adapter cable, may cause BPVs, leading to erroneous results.

At the remote, analog test location, the following equipment is required:

1 – Analog test set capable of transmitting and receiving the spectrum of frequency and P/AR tones.
1 – Set of necessary cables.

Configuring and Cabling the T-BERD 224

The following steps configure the T-BERD 224 for basic operation.

1. Press the T-BERD 224's side panel power switch to the ON position.

2. Press the MODE switch to select the desired T1 framing format (e.g., T1-D4). If the mode is unknown, select AUTO and let the T-BERD 224 determine the mode automatically once it is connected to the T1 circuit.

3. Press the CHANNEL FORMAT switch to display VF for Voice Frequency.

4. Set the TEST switch to CONT.

5. Adjust the VOLUME slide switch to mid-range.

6. Press the CHANNEL switches for LINE 1 and LINE 2 to select the proper channel numbers carrying the voice traffic in question.

7. Press the RECEIVE INPUT switches for both LINE 1 and LINE 2 to illuminate the LED next to the DSX MON label.

   NOTE: The DSX MON input termination is for resistor-isolated jacks only. If the T-BERD 224 is bridged to the circuit using alligator clips or connected via non-isolated monitor jacks, select BRIDGE.

8. Set the INSERT (TX) switch to NONE and drop to both.

9. Press the AUX switch to enable the auxiliary functions and use the MODE switch to display AUX 05. Verify that the LBO is set to 0 dB for both LINE 1 and LINE 2. If not, use the SOURCE CONFIGURATION II and RESULTS I category switches to set each LBO to 0 dB.

10. Connect the T-BERD 224 LINE 1 RECEIVE input connector to the appropriate MON jack on the patch bay as shown in ***Figure 21,*** Nos. 1 and 2.

    NOTE: ***Figure 21*** provides a step-by-step numbering scheme for connecting the T-BERD 224 to a T1 circuit for performing drop and insert testing.

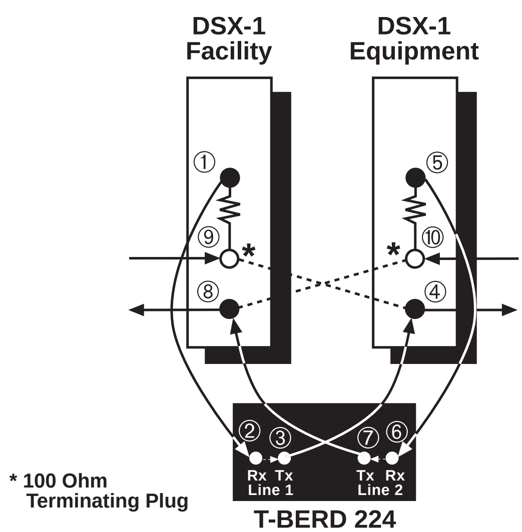

Figure 21
Connecting the T-BERD 224 to a patch bay jack.

WARNING: Do not connect the TRANSMIT output jack to the line until Steps 1 through 12 are performed to avoid taking the line down.

11. Verify that the green SIGNAL and FRAME SYNC LEDs are illuminated for the T1 input, and that the B8ZS LED indicator is illuminated if the circuit is using clear channel (B8ZS) line coding. If the SIGNAL LED is illuminated yet the FRAME SYNC LED is not, check the MODE display to verify proper selection of line format (e.g., T1-D4, T1-ESF, T1-SLC).

12. Press the CODE switch to select the line coding. To select the proper code, observe the STATUS and ALARM LEDs for LINE 1. If the B8ZS LED is illuminated, select B8ZS; otherwise, select AMI.

13. Assuming that the T-BERD 224 has frame sync as indicated by the FRAME SYNC LED, connect a T1 cable *first* to the T-BERD 224's LINE 1 TRANSMIT output jack, and *then* to the patch bay jack as shown in ***Figure 21,*** Nos. 3 and 4.

WARNING: Connecting the cable into the patch bay jack before connecting the other end into the T-BERD 224 will take down the T1 circuit.

14. Repeat Steps 10 through 13 for LINE 2.

15. Insert 100 ohm terminating plugs into the patch bay jacks as shown in ***Figure 21,*** Nos. 9 and 10, to avoid line imbalances.

Results

A. Retrieving In-Service Results of the T1 Circuit

While out-of-service analysis is performed on one of the 24 T1 channels, in-service analysis of the entire T1 circuit is performed simultaneously.

NOTE: All results, including the T1 results, are reset to 0 each time the TEST RESTART switch or a major switch such as SOURCE CONFIGURATION I or II, is pressed.

1a. Press the RESULTS I category switch to illuminate the LED next to SUMMARY.

2a. If "RESULTS OK" is not shown in the RESULTS I display, press the RESULTS I arrow switch to scroll through the key, non-zero results regarding the T1 circuit's in-service performance.

B. Measuring 3 kHz Notched Noise

The following procedure assumes that Steps 1 through 15 have been performed.

NOTE: The following sequence of transmitting and measuring specific tones and results *must* be performed at the far-end test set simultaneously for proper circuit analysis.

1b. Press the SOURCE CONFIGURATION I switch to display LEVEL (LEV@1004Hz).

2b. Press the SOURCE CONFIGURATION II switch to select the transmit level (typically -13 dBm).

3b. Press the SOURCE CONFIGURATION I switch to display 3-TONE SLP.

4b. Press the SOURCE CONFIGURATION II switch to display 1004 Hz.

5b. To insert the test tone into the channel (selected in Step 6) toward the far-end test set, press the INSERT (TX) switch to either LINE 1 or LINE 2, depending on the far-end test set's location. For the example shown in ***Figure 19*** on page 27, the INSERT selection should be set to LINE 2 to transmit the VF test tone from the T-BERD 224 to the far-end test set.

NOTE: An idle code of All Ones will be transmitted into the channel selected for LINE 1 to *prevent* loop and test tones from being transmitted throughout the rest of the circuit.

6b. Press the DROP (RX) switch to select the line opposite of the INSERT selection. For the example shown in ***Figure 19*** on page 27, the DROP selection should be set to LINE 1.

7b. Verify continuity by listening to the 1004 Hz test tone using the internal loudspeaker's VOLUME slide switch.

8b. Press the RESULTS I category switch to illuminate the LED next to CHANNEL.

9b. Press the RESULTS I arrow switch to display the VF frequency (N81 VF FREQ), where N equals the line number selected by the DROP (RX) switch (LINE 1). Verify the reception of a 1004 Hz tone from the far-end test set.

10b. Press the RESULTS II category switch to illuminate the LED next to CHANNEL.

11b. Press the RESULTS II arrow switch to display the 3 kHz Notched Noise (N85 3K NCH), where N equals the line number selected by the DROP (RX) switch. Record the result.

C. Measuring 3 kHz Flat Noise

The following procedure assumes that Steps 1 through 15 have been performed.

NOTE: The following sequence of transmitting and measuring the test tones *must* be performed at the far-end test set simultaneously for proper circuit analysis.

1c. Press the SOURCE CONFIGURATION I switch to display QUIET.

2c. To insert the quiet termination into the channel (selected in Step 6) toward the far-end test set, press the INSERT (TX) switch to either LINE 1 or LINE 2, depending on the far-end test set's location. For the example shown in ***Figure 18*** on page 25, the INSERT selection should be set to LINE 2 to transmit the VF test tone from the T-BERD 224 to the far-end test set.

NOTE: An idle code of All Ones will be transmitted into the channel selected for LINE 1 to *prevent* loop and test tones from being transmitted throughout the rest of the circuit.

3c. Press the DROP (RX) switch to select the line opposite of the INSERT selection. For the example shown in ***Figure 19*** on page 27, the DROP selection should be set to LINE 1.

4c. Press the RESULTS I category switch to illuminate the LED next to CHANNEL.

5c. Press the RESULTS I arrow switch to display the VF frequency (N81 VF FREQ), where N equals the line number selected by the DROP (RX) switch. Verify the reception of a 0 Hz tone (Quiet) from the far-end test set.

6c. Press the RESULTS II category switch to illuminate the LED next to CHANNEL.

7c. Press the RESULTS II arrow switch to display the 3 kHz Flat Noise (N84 3K FLAT), where N equals the line number selected by the DROP (RX) switch. Record the result.

D. Frequency Sweep vs. Level Analysis (Channel Transfer Function)

The following procedure assumes that Steps 1 through 15 have been performed.

NOTE: The following sequence of transmitting and measuring the test tones *must* performed at the far-end test set simultaneously for proper circuit analysis. Or, the far-end may be looped if an 829 loopback device is present at the far-end.

1d. Press the SOURCE CONFIGURATION I switch to display SWEEP. When this function is selected, the following message, "SETUP SWEEP PARAMS IN AUX 21", is temporarily displayed.

2d. Press the AUX switch to set the Sweep (AUX 21 SWEEP) parameters.

3d. Press the SOURCE CONFIGURATION I switch to select *END-POINT.

NOTE: The "*" symbol indicates that more selections can be retrieved by pressing the display window's corresponding switch.

4d. Press the RESULTS I category switch to select the start frequency (e.g., 100 Hz).

5d. Press the RESULTS II arrow switch to select the stop frequency (e.g., 3900 Hz).

6d. Press the SOURCE CONFIGURATION I switch to select *STEP.

7d. Press the RESULTS I category switch to select the incremental frequency STEP SIZE (e.g., 100 Hz).

8d. Press the RESULTS II arrow switch to select the duration (in seconds) of each transmitted frequency or STEP-INTVL (e.g., 1.5).

9d. Press the SOURCE CONFIGURATION I switch to delect *SKIP.

10d. Press the RESULTS I category switch to select the high end of the frequency bandwidth that is not to be transmitted (e.g., 2750 Hz).

11d. Press the RESULTS II arrow switch to select the low end of the frequncy bandwidth that is not to be transmitted (e.g., 2550 Hz).

12d. Press the MODE switch to select AUX 23 PRT OPT and configure the T-BERD 224 for a frequency vs. level printout. Verify that a printer is connected to the T-BERD 224 and that it is turned ON and is ON-LINE.

13d. Press the AUX switch to exit the auxiliary function display.

14d. Press the SOURCE CONFIGURATION II switch to select the transmit level (e.g., -16.0 dBm).

15d. To insert the frequencies into the channel (selected in Step 6) toward the far-end, press the INSERT (TX) switch to either LINE 1 or LINE 2, depending on the far-end test set's location. For the example shown in ***Figure 19*** on page 27, the INSERT selection should be set to LINE 2 to transmit the VF test tone from the T-BERD 224 to the far-end test set.

NOTE: An idle code of All Ones will be transmitted into the channel selected for LINE 1 to *prevent* loop and test tones from being transmitted throughout the rest of the circuit.

16d. Press the DROP (RX) switch to select the line opposite of the INSERT selection. For the example shown in ***Figure 19*** on page 27, the DROP selection should be set to LINE 1.

17d. Press the RESULTS I category switch to illuminate the LED next to CHANNEL.

18d. Press the RESULTS I arrow switch to display the VF frequency (N81 VF FREQ), where N equals the line number selected by the DROP (RX) switch.

19d. Press the RESULTS II category switch to illuminate the LED next to CHANNEL.

20d. Press the RESULTS II arrow switch to display the VF level (N82 VF LVL), where N equals the line number selected by the DROP (RX) switch. Assuming that the T-BERD 224 is connected to a printer and is configured to print as described in Step 12d, the measured level for each transmitted frequency will be printed after the entire frequency sweep is performed.

E. Measuring P/AR

The following procedure assumes that Steps 1 through 15 have been performed. Although it is possible to perform a P/AR test with a far-end loopback, it is not recommended because impairments on the return path may "correct" the results which indicate faults on the transmit path. Consequently, an end-to-end test using a T-BERD 224 at a T1 access point, and a second P/AR test set at a far-end location are recommended for this analysis.

NOTE: If performing an end-to-end test, the following sequence of transmitting and measuring the P/AR spectrum *must* be performed at the far-end test set simultaneously for proper circuit analysis.

1e. Press the SOURCE CONFIGURATION I switch to display P/AR.

2e. Press the SOURCE CONFIGURATION II switch to select the level of the transmitted P/AR spectrum (typically -13 dBm).

3e. To insert the P/AR spectrum into the channel (selected in Step 6) toward the far-end test set, press the INSERT (TX) switch to either LINE 1 or LINE 2, depending on the far-end test set's location. For the example shown in ***Figure 19*** on page 27, the INSERT selection should be set to LINE 2 to transmit the VF test tone from the T-BERD 224 to the far-end test set.

NOTE: An idle code of All Ones will be transmitted into the channel selected for LINE 1 to *prevent* loop and test tones from being transmitted throughout the rest of the circuit.

4e. Press the DROP (RX) switch to select the line opposite of the INSERT selection. For the example shown in ***Figure 19*** on page 27, the INSERT selection should be set to LINE 2 to transmit the VF test tone from the T-BERD 224 to the far-end test set.

5e. Press the RESULTS I category switch to illuminate the LED next to CHANNEL.

6e. Press the RESULTS I arrow switch to display the measured P/AR (N90 P/AR), where N equals the line number selected by the DROP (RX) switch. Record the result.

F. Establishing an 829 Termination Loopback

The following procedure assumes that Steps 1 through 15 have been performed.

1f. Press the SOURCE CONFIGURATION I switch to display 2713.

2f. Press the SOURCE CONFIGURATION II switch to display ON.

3f. To insert the 2713 Hz test tone into the channel (selected in Step 6) toward the remote 829 termination, press the INSERT (TX) switch to either LINE 1 or LINE 2, depending on the desired loopback location. For the example shown in ***Figure 20*** on page 27, the INSERT selection should be set to LINE 2 to transmit the VF test tone from the T-BERD 224 to the far-end loopback.

NOTE: An idle code of All Ones will be transmitted into the channel selected for LINE 1 to *prevent* loop and test tones from being transmitted throughout the rest of the circuit.

4f. Press the DROP (RX) switch to select the line opposite of the INSERT selection. For the example shown in ***Figure 20*** on page 27, the DROP selection should be set to LINE 1.

5f. Verify the loopback by listening to the 2713 Hz test tone using the internal loudspeaker's VOLUME slide switch.

6f. After the loopback is confirmed, press the SOURCE CONFIGURATION II switch to OFF to turn off the 2713 Hz loopback tone. The far-end is now looped, enabling single-ended testing of the VF circuit.

7f. To remove the loopback after performing various test, transmit the 2713 Hz tone toward the 829 termination once again.

Fault Isolation

When interpreting the results, it is important to first analyze the in-service T1 circuit results. Problems apparent within the T1 channels may be caused by BPVs, CRC errors, or timing slips on the T1 circuit. Before troubleshooting any VF circuit problem, find and repair any T1 circuit problems first.

To localize problems, break the T1 circuit into manageable sections one step at a time as shown in ***Figure 22.*** In Stage 1, verify that errors are occurring somewhere in the circuit. In Stage 2, test a section of the circuit and "circle-in" on the source (or sources) of errors. If errors still occur at Stage 2, at least *one* of the error sources is between your location and the far-end. To make sure no sources of errors have been missed, test the circuit section between Stage 1 and Stage 2. In this manner, you can quickly and methodically isolate faults within the circuit. Before determining that the circuit is good, test it one more time end-to-end for verification.

Results Interpretation

Once results are known, it is possible to isolate the cause of disrupted and degraded service. Since every T1/VF circuit is different, it is nearly impossible to list all the causes. ***Table 2*** on the next page shows various results combinations and *possible* problem causes.

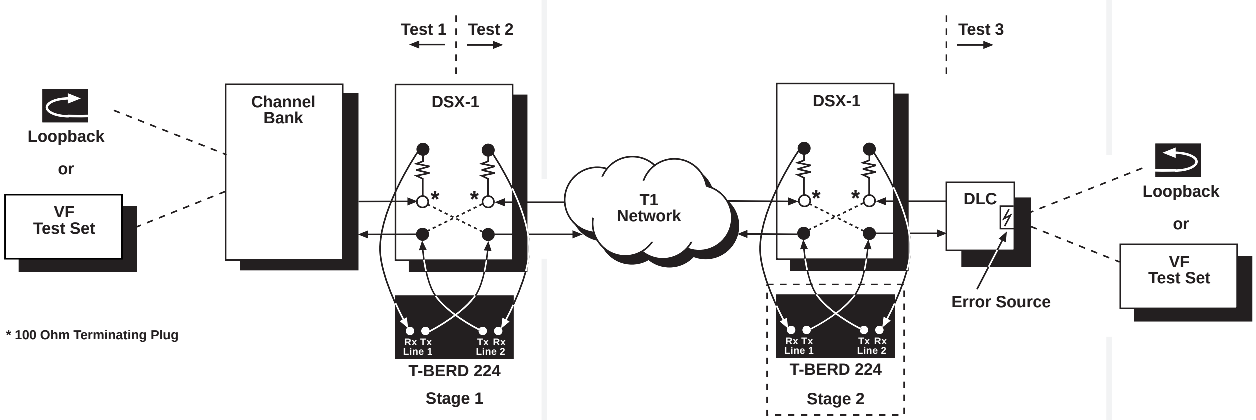

Figure 22
Sectionalizing problem sources.

Result	Result Displayed by the T-BERD 224	Problem
Bipolar Violations Audible Noise	BPVs FRM ERR CRC ERR	Local T1 problem. Possibly faulty T1 repeater, span line noise, crosstalk, poor line cabling, bad cabling between test set and circuit, corroded "dirty" cable plugs.
Frame Errors Errors	FRM ERR CRC ERR	Typically a far-end T1 span problem. Sectionalize further. Check CRC cross-connect switches, multiplexers, and repeaters, as well as the cabling between these devices.
Timing Slips Data Dropouts	TIM SLP	T1 timing problem. Check channel bank and multiplexer timing settings. Verify one master, remainder slaves.
T1 Results OK Data Errors	SUMMARY RESULTS OK Gain vs. Frequency Curve out-of-spec	Possible VF circuit problem. Check local span for sources of attenuation distortion such as bridge taps, companders, and equalizers.
T1 Results OK Idle Channel Noise	SUMMARY RESULTS OK 3K FLT Noise out-of-spec	VF circuit problem. Check for crosstalk from adjacent circuits, 60 Hz induction from power lines, possible VF local loop problem (one side open, unbalanced lines, etc.).
T1 Results OK Noise with Tone out-of-spec	SUMMARY RESULTS OK 3K NCH out-of-spec	VF circuits problem. Bad line card in channel bank, multiplexer, or SLC terminal. Bad VF repeater, 1004 Hz tone out-of-range.
T1 Results OK P/AR out-of-range	SUMMARY RESULTS OK P/AR out-of-spec	Poor return loss, attenuation distortion, or EDD. Separately perform return loss, frequency sweep, and EDD test. **NOTE:** External TIMS set required for EDD test.

Table 2
Correlation of results and problem causes.

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Notes

Notes

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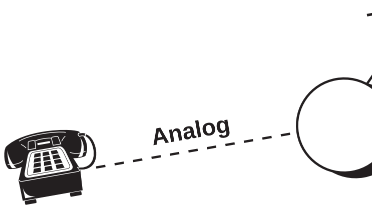

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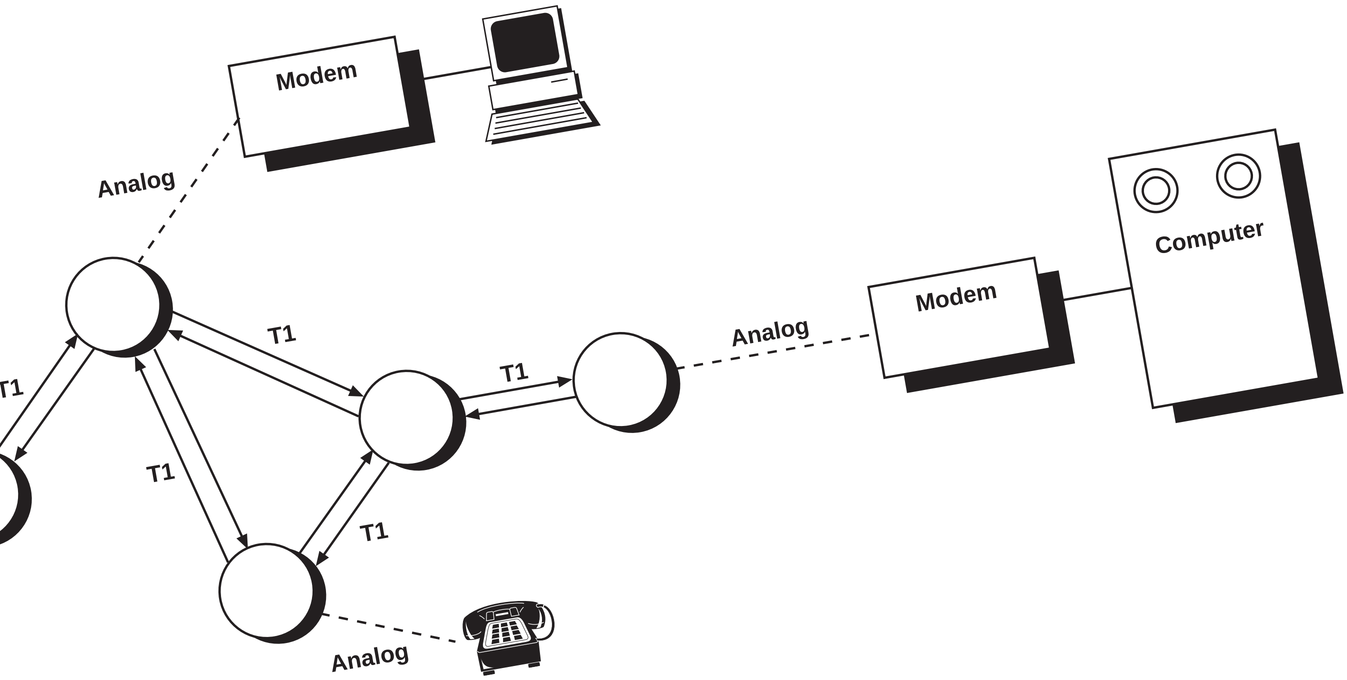
Testing VF Circuits

Application Note



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