

**OPERATION AND MAINTENANCE  
MAINTENANCE SUPPORT  
1 X N FREQUENCY DIVERSITY  
DR 6/11-135A AND 135EC  
SYSTEM PERFORMANCE DIAGNOSTICS**

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Alarms, when activated, usually indicate where problems are located, but some system performance problems may not generate an alarm. The source of such problems, when they do occur, can range over a broad spectrum of troubles that are subtle and often difficult to isolate. Generally, these problems will fall into one or more of the following categories:

- A. Higher than normal or intermittently high background error rate
- B. Poor performance due to propagation related problems
- C. Failure to meet requirements of error performance margin tests.

This section of the Maintenance Support manual provides some guidelines and suggested procedures for isolating and resolving such problems.

***This practice is reissued to update the system performance diagnostics and to include the error correction option. The practice is used in binders 421-101-001 and 421-101-060.***

**GENERAL TROUBLE ISOLATION APPROACH**

When performance problems falling in categories A or B above are known to exist in the system and no alarm indications to help localize the problem are present, isolate the hop and station where the problem is located. Otherwise, no meaningful maintenance activity can take place. For problems in category C above, isolation of the hop and station does not have to be the first step because the equipment subset failing the test is known. Troubleshooting to further isolate the problem, in this case, can generally proceed in an orderly fashion. For problems in categories A or B, however, this is not normally the situation. For these types of problems, the best way to begin troubleshooting is to activate the Continuous Monitoring

feature of the built-in performance monitoring system (see "Continuous Performance Monitoring" in the "Tests" tab of this manual). When this monitoring mode is activated, the performance monitors at each station within a terminal-to-terminal switch section are placed in a continuous "report immediately" mode. While in this mode, alarm center personnel can usually localize the problem, if detectable, to a particular radio hop by the remote alarm indications as soon as the problem recurs. By repeated and periodic use of this feature, even the more intermittent type problems may be isolated.

For terminal section performance problems that escape detection using the continuous monitoring feature, locating the problem hop can be much more difficult. An orderly station-by-station, trial-and-error, testing/replacement/remonitor approach is usually necessary to localize the problem. Whenever this trial-and-error approach is necessary, the "cut-in-half" technique (sectionalization) of locating the problem is recommended. With this approach, each new diagnostic step should be made on the basis of trying to determine which half of the remaining system subset has the problem. This is an effective and orderly way to quickly isolate the equipment subset with the problem.

After the suspected hop is isolated or selected on the trial-and-error basis, local monitoring and/or testing at the receive station for that hop is normally done next to help isolate the problem further. The first phase of this testing is aimed at determining whether the problem is located at the transmit or receive end of the radio hop.

If it is not clear which end of the hop has the problem, assume the trouble is at the receive end, since the receiver is more complex. If the location of the trouble is unclear or if the transmit end is suspected, maintenance personnel, equipped with appropriate test equipment and spares, should be at both ends of the hop. The next step is to determine whether the problem is associated with the radio or the digital terminal/regenerator equipment. This may often be determined by using an IF loopback approach to first evaluate the terminal/regenerator equipment independently from the radio. For this test, the IF signal, which would normally connect between the radio and the suspected terminal/regenerator transmitter (or receiver) unit, is connected (*looped-back*) to a receiver (or transmitter) in a terminal/regenerator unit that is known to be working properly. In this mode of operation, the terminal/regenerator transmitter-receiver pair, connected back-to-back, operates on an internally generated digital signal. This internal signal is adequate to catch most terminal or regenerator problems. If the problem occurs again in the looped configuration, assume that it is in the associated digital equipment. If the problem does not recur, it is probably in the radio equipment. For the case where there is no clear choice as to which end of the hop has the problem, the terminal/regenerator equipment at both ends of the hop should be looped and monitored separately before assuming that the problem is in the radio equipment.

If the problem is such that the results of looping and preliminary testing are inconclusive as to the equipment giving the problem, the procedure to be followed depends on which category the problem is in. The guidelines that follow for each type will normally lead to a resolution. If there is no clear indication at the start as to whether the problem is due to equipment causes or external causes, assume that the problem is equipment related. In many cases it will even be necessary to begin troubleshooting by choosing a starting point arbitrarily. When this is the case, the only way to proceed is to begin an orderly replacement process followed by remonitoring to determine if the most recent replacement eliminated the problem.\* Again, the cut-in-half approach is recommended in order to methodically bracket and locate the defective circuit pack or module.

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\* Instead of a "replacement/remonitor" process, a "rotation/remonitor" process may be used to isolate defective units. Units that are common in the equipment associated with all channels may be swapped with similar units in the protection channel equipment. If the problem moves with the units, the isolation process is complete.

The first goal should always be to determine if the problem is in the radio or the digital equipment. If interruptions in service are permissible, this goal can sometimes be achieved more quickly by "frogging" or reconnecting the IF interconnect signal paths to and from different radio and digital equipment units. With careful monitoring following each reconfiguration, the problem-causing equipment subset can usually be isolated rather rapidly by noting if the problem moves with the reconnection. The block diagrams showing how the system equipment subsets are interconnected are given in this manual. These should be useful for guidance in a troubleshooting process. They are also useful for determining the most expeditious replacement process to follow when trying to isolate a defective unit.

Guidelines for troubleshooting the three categories of problems listed above are given in the remainder of this section. Note that, unless otherwise specified, the tests called for in the guidelines are found under the "Tests" tab of this manual. When tests from the other station O&M manuals are required, their locations are specified.

## NORMAL ERROR PERFORMANCE PARAMETERS

The quality (error performance) of the end-to-end (DS3-to-DS3) system transmission is the primary concern. In order to meet DDS (Digital Data Service) objectives, a DR 6/11-135 system must meet a background BER (bit-error-rate) objective not exceeding  $3 \times 10^{-10}$  times the number of hops between DS3 terminal points. For MTS (Message Telephone Service), this objective is relaxed to a  $10^{-7}$  level. In order to meet end-to-end objectives, the BER of each regenerated hop must operate within allocated BER objectives referred to as maintenance limits. When properly installed and maintained, each hop of a DR 6/11-135 digital radio system should easily meet these internal per-hop, radio-line background BER objectives.

The maintenance limits for per-hop BER performance are actually given in terms of meeting a specific error performance objective with a specific level of tone interference injected into the IF signal path of each hop (over-the-air S/I test). However, an upper limit may be established for the background error rate that may be expected on hops that meet this S/I vs BER objective. The background BER is based on the statistical characteristics of the signal and the normal noise and interference in a channel. These characteristics and the S/N (signal-to-noise) ratio under normal conditions ultimately determine the S/I vs BER and the long-term background BER of a regenerated radio hop. With a fixed signal level, the S/N ratio depends on the noise bandwidth. Since the noise bandwidth depends, in turn, on whether the system is equipped with the error-correction feature, both the S/I vs BER and the long-term BER also depend on whether error-correction is equipped. When these statistical characteristics are normal, the relationship between the S/I vs BER performance and the long-term BER is very predictable. For systems without the error correction feature, each regenerated hop that meets the indicated S/I objective should perform with a background BER of  $4 \times 10^{-11}$  or less. The corresponding upper limit for hops in systems equipped for error correction is  $10^{-9}$ . If a hop meets the S/I vs BER requirement and is then observed to have a background BER exceeding the above expected maintenance limit, suspect an abnormal noise or interference situation.

Typically, each hop will operate with a BER that is somewhat less than the maintenance limit when initially installed and, barring equipment failures, will operate and maintain an error performance level well within the maintenance-limit objective. For example, operation with background BERs of  $4 \times 10^{-12}$  and  $2 \times 10^{-10}$  for systems without and with error correction are typical at installation time.

Since it will help to clarify the role of the error correction feature, the higher per-hop BER maintenance limit specified for regenerated hops in systems equipped with this feature is worth some explanation. When the error correction feature is used, additional overhead bits must be inserted into the radio line digital signal. These additional data bits, which are required to provide coding necessary to provide the error correction feature, result in a wider signal spectrum and, thus, require tighter signal control filtering at each digital transmitter (at terminals and regenerators) to keep the radiated spectrum within the requirements allocated by the FCC. The impact of this tighter spectrum control is a slight decrease in the signal-to-noise vs BER performance of the digital processing equipment associated with each hop. This results in a degraded internal or per-hop background BER as can be seen by the higher allowed hop BER maintenance limit. Note that this per-hop degradation is more than compensated for in the DS3-to-DS3 performance that is achievable with systems using the error correction feature. This is illustrated by the fact that the DS3-to-DS3 background error rate is guaranteed to be  $10^{-13}$  or less on a 10-hop system deployed with error correction, even with each hop operating at the  $10^{-9}$  BER maintenance limit. On the other hand, the guaranteed DS3-to-DS3 performance for the same 10-hop system deployed without error correction becomes  $4 \times 10^{-10}$  with all hops operating at the  $4 \times 10^{-11}$  BER maintenance limit.

The alarm-reporting thresholds for hop related error performance depend on the service being carried and on whether or not the system is equipped for error correction. When set

for DDS, the built-in performance monitoring feature of the DR 6 and 11 systems will normally detect and report performance problems that cause hop error rates in excess of  $3 \times 10^{-10}$  and  $10^{-8}$  for systems deployed without and with the error correction feature respectively. These thresholds are usually adequate to initiate correction maintenance activity before serious DS3-to-DS3 degradation occurs. If the performance monitor thresholds are set for MTS quality, only error bursts in excess of  $10^{-5}$  or misframe activity are monitored and reported, since objectives are not as stringent for this type of service. (For more detailed definitions of the various performance alarm thresholds, refer to the Continuous Performance Monitoring section under the "Tests" tab.)

Normally, the procedures given in the station operation and maintenance manuals are sufficient to track down and eliminate the problems that activate alarms at the alarm center. In some cases, the procedures given in the station operation and maintenance manuals are inadequate; therefore, diagnostic and test procedures given in the "Tests" tab of this manual are useful in troubleshooting such alarmed problems. When this is the case, the station operation and maintenance manuals reference these procedures for additional help.

## **HIGHER THAN NORMAL BACKGROUND ERROR RATE PROBLEMS**

As long as the system background BER performance is within the maintenance-limit objectives, corrective maintenance activity is unnecessary. However, a significant change in the original background error rate that is noted by external observation or by an end-to-end system measurement could indicate degrading equipment or the onset of increased interference from an external source. Therefore, even though performance may still be acceptable, some preliminary investigative work may be warranted to ward off further degradation to an out-of-limit condition.

Unless the degraded hop can be isolated, no meaningful activity can take place. For this purpose, repeated and periodic use of the the Continuous Monitoring feature of the performance monitoring system is suggested. This may help to isolate the degraded hop by catching and reporting high error-rate events. Normally, using the Continuous Monitoring feature coupled with the other procedures given in the General Trouble Isolation Approach section should isolate the problem hop and make it possible to determine whether the problem is at the transmit or receive end station.

Once the suspected hop and transmitter/receiver pair are isolated or even arbitrarily selected for further troubleshooting, it is recommended that the " Over-the-Air S/I Stress Check" be done on that hop. This will show if the abnormal background error rate problem is possibly due to a loss of signal-to-noise margin. If the hop fails the over-the-air test, the IF Loopback S/I Stress Checks should be done on the associated terminal/regenerator to determine if the loss of performance margin is due to the radio or digital equipment.

If the loopback tests show that either the transmit or receive digital terminal/regenerator equipment fails the S/I performance test requirements, correct the problem before proceeding. An orderly replacement process, while monitoring the S/I performance, will normally restore a degraded terminal or regenerator subset to an acceptable performance level. Once the digital equipment meets requirements, the over-the-air test should be repeated, and if the system is now within limits, it should be monitored to see if the original problem has been eliminated.

If the loopback S/I tests show that the transmitter and receiver terminal/regenerator equipment meets requirements or if the system still fails the over-the-air requirements following correction of out-of-limit terminal or regenerator equipment, a problem probably exists in the radio equipment. The radio parameters listed on the radio DATA CARD should be checked to see if any significant changes have occurred that could possibly account for the problem. If necessary, replace and/or adjust any units found to be out of limits or that cannot be brought into limits by allowed adjustments. At a radio transmitter, the Alignment Check is especially critical since transmitter alignment can have a large impact on hop S/I performance. Follow the appropriate charts in the " Radio Receiver Procedures," " Radio Transmitter Procedures," and/or the " Replacement" tabs of the applicable station O&M manual for these checks and replacements.

If the above procedures and replacements do not resolve the problem or if all transmitter and/or receiver units appear to be working properly, the problem may be caused by excessive transmission distortions or possibly by external interferences in the radio hop. Perform the Radio Transmission Tests and Fade Margin and Interference Tests in the " Tests" tab. These tests and the guidelines contained within them should help to resolve any problems associated with the radio due to any of these causes.

## INTERMITTENTLY HIGH ERROR RATE PROBLEMS

If the problem is such that the system error performance is intermittently degraded enough to be unacceptable but is undetected by the monitors in their normal operating state, maintenance action normally cannot be deferred. Notification of such problems will usually come from an external source, such as a complaining customer or maintenance personnel in an interconnecting system. These problems may be due to intermittent events where the time between high BER events is such that the alarm threshold associated with the normal event-counting-and-sampling interval of the on-line monitor is not exceeded. In unusual cases, such unreported problems might also be caused by defective performance monitoring at a station that should be detecting the problem.

With intermittent problems, the procedures given in the General Trouble Isolation Approach section are useful for isolating the problem hop and station. With intermittent problems, however, the wait-and-see period required after each change in system configuration to determine whether the problem has moved or disappeared is usually much longer than that required with a steady, repetitive high background error problem. For troubleshooting and locating intermittent problems, using the Continuous Monitoring mode of the performance monitors is the first recommended step. With careful analysis of remote indications, the alarm center personnel may be able to identify the hop with the intermittent problem at the next recurrence of a high-error event. For intermittent problems, observation over longer periods will normally be required to catch such an event. Defective performance monitoring equipment, if it exists, should also become apparent when an attempt is made to activate this mode.

Once the suspected hop and transmitter/receiver pair are isolated or selected for further troubleshooting, determine whether the intermittent problem is in the radio or digital equipment. If the preliminary isolation procedures indicate the problem is at the transmitting or receiving end of the hop, the next recommended step is to loop the digital equipment at the associated end of the hop. Then, look for the intermittent problem using either remote or local performance monitoring. (See the pseudo or CRC error monitoring procedure in the "Tests" tab of this manual.) If it is not clear which end of the hop has the intermittent problem, the digital equipment at each end should be looped and monitored in order to isolate the problem to either the radio or digital equipment.

Before beginning the final stages of troubleshooting an intermittent problem, observe the character of the problem very closely to see if there is any pattern or periodicity to it. If it has an identifiable period, the problem could be caused by some external interference. If so, the problem is most likely due to radiation from nearby equipment with excessive leakage or pickup from some other radio signal, such as a radar signal, which is leaking into the payload receiver. In the latter case, the problem may only occur during certain atmospheric conditions which amplify the effect of an interferer (during fading periods of the desired signal, for example). A study of the nearby equipment and other potential interfering radio signals in the surrounding area may prove helpful at identifying the problem. The Fade Margin and Interference Tests may also uncover such problems. These tests must be done recognizing the intermittent nature of the potential interference. Otherwise, the potential interferer may be missed.

If it is determined that the source of the intermittent problem is equipment related and the suspected equipment subunit is identified, the only effective way to isolate it further is to methodically replace or rotate units in that equipment and then remonitor to determine if the problem has been eliminated or moved with unit rotation. If service interruptions can be tolerated, speed up this process can by moving multiple units between working shelves and monitoring all the shelves into which units from the suspected shelf have been moved. This process, though tedious, should ultimately isolate the defective unit or units.

After the problem has been located and repaired, continuous monitoring is recommended for an adequate time to ensure that the repair was successful.

## **TROUBLESHOOTING PROPAGATION RELATED PROBLEMS**

When abnormal error conditions are suspected to be occurring during times of propagation disturbances and the poor performing radio hop is not known, activate the Continuous Monitoring mode of the performance monitoring system first to help isolate the radio hop causing the problem. To improve the probability of isolating the suspected radio hop, the results of continuous monitoring should be watched closely during the period when propagation disturbances are expected. Once the alarm center personnel have identified the suspected radio hop by the remote alarm information, perform the Radio Transmission Tests in this manual and the Over-the-Air Propagation Distortion Performance Check procedure in the applicable station O&M manual for the T/R pair indicating the problem. These tests will usually isolate any defective circuits in the radio or digital equipment that are failing to correct properly for the propagation distortions for which they were designed.

If the associated radio receiver is equipped with space diversity, perform the Combiner Performance Check in the station O&M manual. If the combiner and/or a replacement fails the performance check, perform the Radio Transmission Test and DADE Tests in the "Tests" tab. If any corrections are made to meet the requirements of these tests, repeat the combiner check.

If the transmission and propagation distortion tests fail to isolate the source of a propagation related problem, perform the Fade Margin and Interference test on the suspected hop and T/R pair. This test procedure will normally help to identify the possible causes of inadequate fade margin and excessive interference. Once such problems have been identified, the necessary corrective action is usually obvious. The Phase-Plane Display procedure may also help in the diagnosis.

## **TROUBLESHOOTING EQUIPMENT THAT FAILS TO MEET THE REQUIREMENTS OF ERROR PERFORMANCE MARGIN TESTS**

Tests to determine hop or system error performance are often made while troubleshooting alarms using the station O&M manuals. Similar performance tests are made in conjunction with the annual FCC (Federal Communications Commission) performance checks. Generally, these tests involve Over-the-Air S/I Stress Checks that evaluate error performance margin during normal and simulated abnormal propagation conditions. When the requirements of these performance tests are not met, procedures in the applicable station O&M manuals should normally isolate and resolve the problem. In some cases, the station manual procedures may be inadequate to resolve a problem. This is especially true when the problem is the result of external causes or excessive distortion in the radio transmission characteristics that cannot be isolated to or corrected by changing transmitter or receiver units. The Radio Transmission Tests and Fade Margin and Interference Tests in the "Tests" tab should be performed. The Phase-Plane Display Test is also recommended as an aid in making qualitative judgments regarding performance degradations. The observations and results of these tests will usually lead to a solution of most error performance margin problems.

### **ISSUING ORGANIZATION**

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