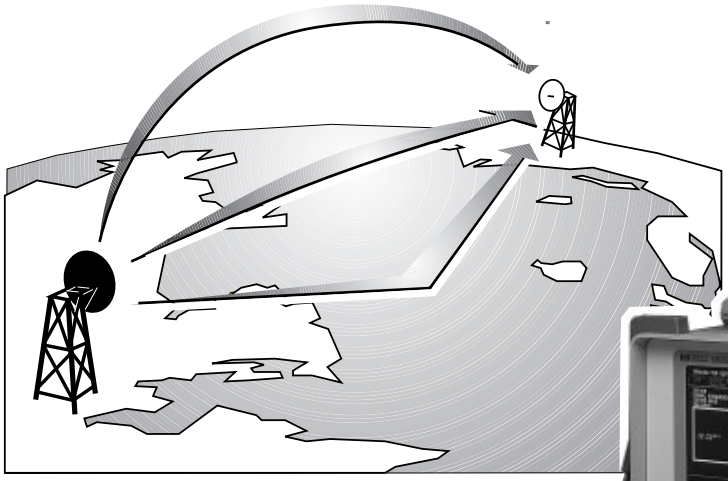
Testing PDH digital radios under multipath fade conditions

Product note

HP 37717B/C communications performance analyzer



HP 37717C communication performance analyzer

Multipath fade conditions typically cause notches in the pass band across a PDH digital radio's channel. The notches occur at random intervals and it's during these periods that the communication link is vulnerable to excessive bit error ratio (BER). Should the BER then hit an outage threshold, the channel would normally be taken out of service.

Equalizers are used in the radio receiver to counteract fading events and make the receiver channel more resilient against high BER periods. However, as they are essentially inactive until fading occurs, it is impossible to know how they will respond until they're required to. Since fading is one of the predominant causes of unacceptable bit errors and link outages, it is especially important that an equalizer is tested at regular intervals.

This product note describes an out-of-service test that can be used to monitor an equalizer's susceptibility to multipath conditions and its ability to compensate for multipath fading. The test can be applied at the manufacturing stage, during installation and routine maintenance, and often troubleshooting.

Measuring a radio's protection circuits

Introduction

One of the biggest problems facing radio network operators is identifying faulty or out-of-adjustment equalizers.

Equalizers are designed with frequency selective automatic gain control (AGC). This allows them to react instantaneously to fade conditions by peaking the transmission signal as necessary to maintain the link. However, if an equalizer is defective or is out-of-adjustment, it may cause spurious errors or error hits. A faulty equalizer may also function correctly during normal operation but fail to correct even the slightest multipath fades. Either case will lead to poor link performance where the cause is difficult to diagnose.

The M-curve (sometimes called the W-Curve or signature) is the most common test of equalizer performance. It characterizes an equalizer using points on a curve to separate acceptable performance from unacceptable performance. The test is performed by moving a notch frequency to each of a number of frequency positions. At each position, the notch is made progressively deeper until the radio reaches the chosen threshold BER (often 10^{-3} or 10^{-6}) at which point the radio loses synchronization and emits errors.

On loss of synchronization, the errors emitted by the radio are detected by the BER tester. The tester produces an error output to the multipath fade simulator which in turn produces a point on an internally generated M-curve. This process is repeated at the different notch frequencies and depths until all are recorded.

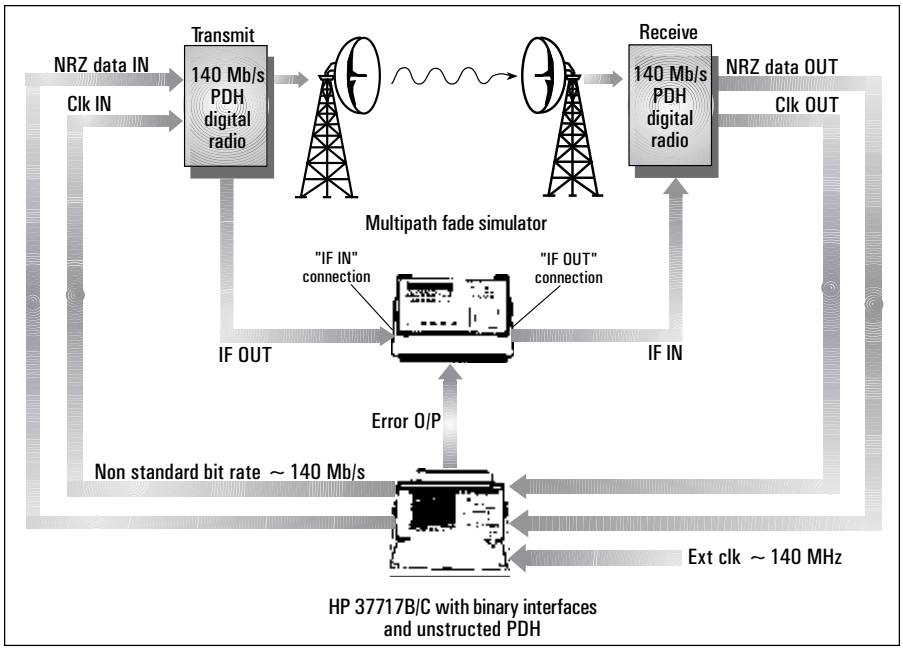


Figure 1. Test configuration diagram

By providing a measure of the digital radio receiver's multipath susceptibility, the M-curve identifies the fading conditions under which the radio will operate properly. This indicates the true measure of the radio link's performance, and more importantly, whether the equalizer meets an acceptable performance criterion.

Identifying a defective equalizer

Hewlett-Packard's solution to providing comprehensive equalizer testing is to use an HP 37717B/C communications performance analyzer in conjunction with an HP 11757B multipath fading simulator. This combination offers a quick and simple way, for both manufacturing and field applications, to determine a radio's ability to track and compensate for multipath fading through the detection of errors.

To precisely characterize the radio's equalizer, the fade simulator automatically provides notches at various frequencies and depths to stress the equalizer with controlled amounts of multipath fading.

Non-standard bit rate PDH binary interfaces from 700 Kb/s to 170 Mb/s (derived from the network or externally applied clock) are provided by the BER analyzer. This ensures the radio's transmission bandwidth is tested fully. The analyzer's error output is used to help generate the multipath measure, the M-curve, on the simulator.

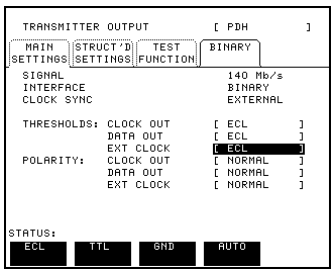
A hardcopy of the M-curve can be compared to one measured during the radio's commissioning or the radio's documented specifications to check for deterioration in performance.

Configuring the equipment

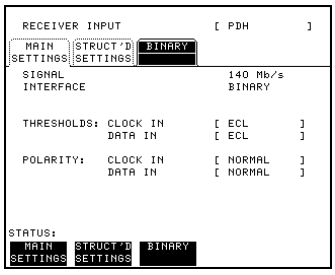
Connect the HP 37717B/C communications performance analyzer and the HP 11757B multipath fading simulator to the digital radio network equipment as shown in figure 1 (a possible manufacturing configuration).

Note that if there is no network clock available, the HP 37717B/C option 200 provides a binary interface (option UH3), unstructured PDH (option UKK) and a low-cost synthesizer (HP 8647A signal generator) to supply non-standard bit rate operation via its external clock input.

1. Set the HP 37717B/C transmit MAIN SETTINGS display as shown:



2. Set the HP 37717B/C receiver SETTINGS as shown:



3. Press the PRESET key on the HP 11757B simulator interface.
4. Press MEAS TYPE, use the up arrow key to select STATIC M-CURVE, then press ENTER.
5. Set the START and STOP frequencies to the transmission bandwidth of interest.
6. Press MEAS then ENTER.

Performing the measurement

An equalizer's sensitivity during multipath fading conditions can now be characterized. To simulate real traffic, the BER tester is set to generate and receive a PRBS at the required PDH non-standard bit rate binary clock and data.

A calibrated amount of fading is then introduced to the equalizer. This is done at intermediate frequencies (IF) and is applied to the signal arriving at the radio receiver.

When the notch reaches the radio's threshold BER (normally 10^{-3} or 10^{-6}), bit errors are generated and subsequently detected by the analyzer. The notch depth and frequency at the point where the equalizer is unable to compensate for fading are automatically recorded by the simulator. The notch is then moved to another frequency to test against the BER threshold again.

Resulting errors from each point allow the mutipath fade simulator to complete a characterization of the radio in the form of the M-Curve. An example is shown in figure 3.

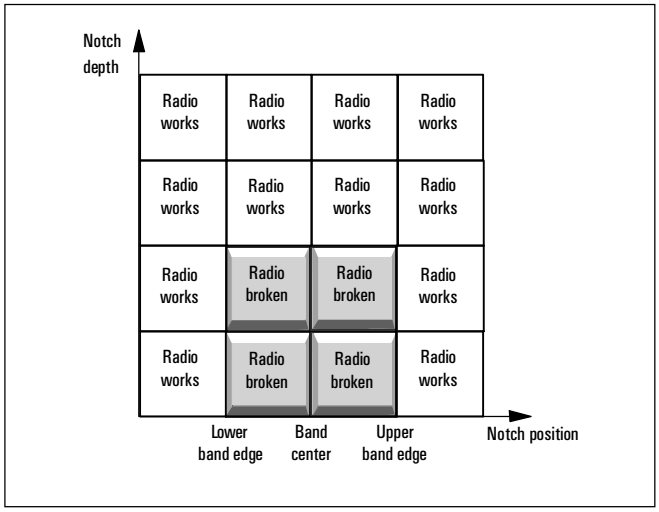


Figure 2. Model of M-curve measurement diagram showing separation of unacceptable and acceptable radio performance.

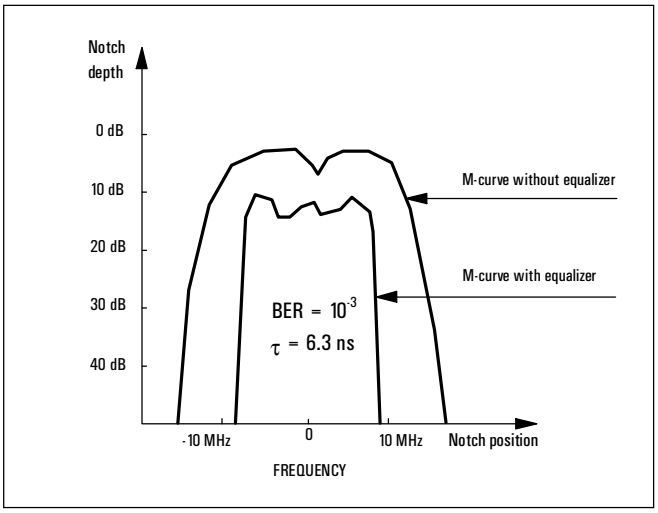


Figure 3. Plot of typical M-curve measurement diagram. The M-curve must always include the threshold BER value and the delay.

HP 37717B/C communications performance analyzer


HP 37717B communications performance analyzer

Offers a modular, upgradeable one-box solution for installation, commissioning, and field maintenance. This rugged, portable tester allows comprehensive functional testing of SDH, PDH and ATM equipment including jitter generation and test. The HP 37717C has a color display and graphics printer, with the HP 37717B monochrome version providing a budget solution, and a 20-column printer. Both instruments include a 3.5-inch disk drive to ease results retrieval, test firmware upgrades, and analysis.

HP 11757B multipath fading simulator

Realistically simulates natural multipath fading impairments for stress testing equalizers and other protection circuits. It makes a range of multipath measurements including static signature (M-curve), dynamic S- and M-curve, hysteresis M-curve, recovery time and dispersive fade margin. Its built-in printer provides hardcopy results of both the signature plot and tabular data for comparison with different radios and manufacturer's specifications.

Related literature

- HP 37717B/C generic brochure, 5964-0106E
- HP 37717B/C technical specifications, 5964-2255E
- HP 37717B configuration guide, 5965-5764E
- HP 37717C configuration guide, 5965-5621E
- HP 11757B brochure, 5091-1052E

Application notes:

- Digital theory and measurements, 5091-4777E
- Measuring digital microwave radio M-curves, 5959-7859E
- Tools for digital microwave radio installation and maintenance, 5091-4653E

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