Society of Cable Telecommunications Engineers

ENGINEERING COMMITTEE
Interface Practices Subcommittee

AMERICAN NATIONAL STANDARD

ANSI/SCTE 48-2 2008

Test Procedure for Measuring Relative Shielding Properties of Active and Passive Coaxial Cable Devices Using Agilent Magnetic Close Field Probe

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140 Philips Road
Exton, PA 19341

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1.0 SCOPE/DISCLAIMER

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This document is intended to outline the use of the Agilent 10940A/10941A Close Field probes (or similar devices) in determining the Relative Shielding Effectiveness of various cable telecommunication system devices. Throughout this document are details, paraphrasing, formulae and procedures derived from various Hewlett-Packard printed documents, used with their permission, but with no acknowledgement or responsibility as to their accuracy or suitability with regards their applicability to the intended measurement result. All procedures and conclusions are those of the authors of this document.

This document outlines the procedures for determining the relative Shielding Effectiveness of cable telecommunication system devices employing a combination of Close Field probes and various Scalar Test equipment packages, through the use of defined, repeatable test practices.

For clarity, the various models of close field probes are hereinafter referred to as the "probe". Figure 1

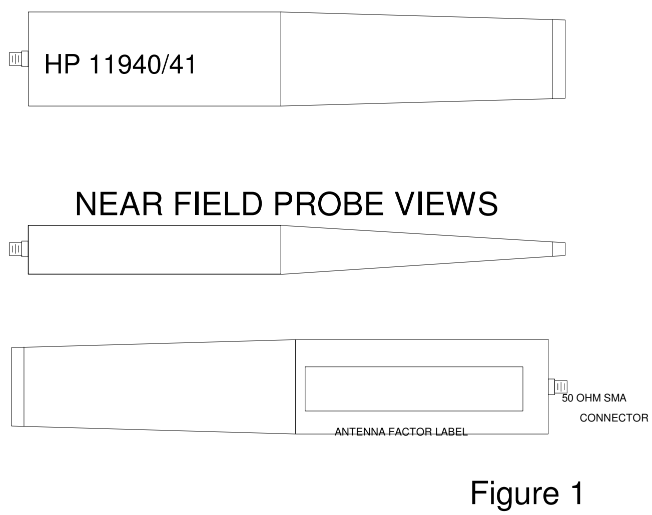


FIGURE 1: Near Field Probe Views

2.0 CAUTION AND WARNINGS

2.1 The tests proposed in this document involve the use of RF Signal levels which could be damaging or destructive to some cable telecommunication system equipment. Read all procedures completely before beginning any testing. After testing, restore test equipment settings to safe levels to avoid inadvertent problems with future tests. If in doubt, consult the equipment manufacturer for approval prior to testing.

2.2 This procedure may suggest the direct interconnection of 50 Ω and 75 Ω devices. RF implications aside, such interconnections must only be performed with a universally mechanically compatible connector type, such as "BNC". Under no circumstances may 50 Ω and 75 Ω type "N" connectors be interconnected.

Connecting a 75 Ω type "N" Male connector to a 50 Ω type "N" Female connector results in no contact.

Connecting a 50 Ω type "N" Male connector to a 75 Ω type "N" Female connector results in the destruction of the female type "N" connector.

3.0 THE "PROBE"

The Probe is a Balanced Magnetic Field sensor, which delivers an output voltage dependent on the Magnetic or "H" field present. The Probe senses magnetic fields through two printed circuit loops at the probe tip. Maximum sensitivity is orthogonal to the long edge of the Probe tip as shown in Figure 2.

Available probe types are employed depending on the frequency range to be tested. Usually Probes are classified as High or Low Frequency 30 MHz to 1 GHz and 5-30 MHz.

Most available probes are 50 Ω devices, which can present some operational difficulties when employed with conventional cable telecommunication system 75 Ω test equipment. Adaptation of these devices to 75 Ω systems is detailed in the "Set-up and Calibration" section 7.1.

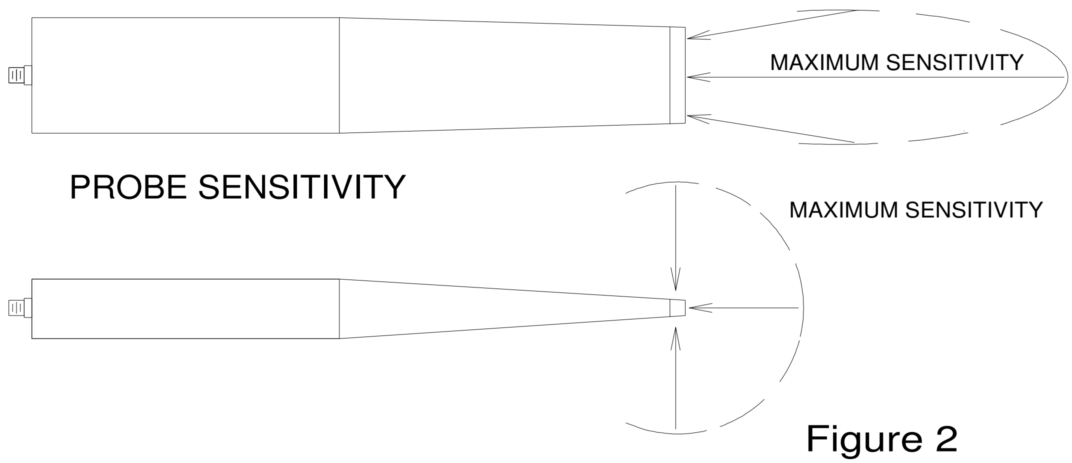


FIGURE 2: Probe Sensitivity

4.0 THEORY OF OPERATION

Theoretically, every source of Electromagnetic Radiation must be comprised of both a Magnetic (or "H") field, and an Electric (or "E") Field.

While the absolute correlation between the magnitude of the Magnetic field detected, and the absolute magnitude of the radiated Electromagnetic field is dependent on many factors, there is a direct Relative relationship between the two. Any improvement in suppression of the "H" field results in a corresponding reduction in the Open Air Electromagnetic radiated field strength.

For purposes of this document, most cable telecommunication system operators have accepted that Near Field measurement capabilities of at least than 100 dB lower than the highest internal signal level are required, and this procedure is intended to allow measurements in excess of 120 dB.

5.0 EQUIPMENT REQUIRED

5.1 Scalar Signal Level Measurement test setup having the following capabilities:

A signal transmitter, operating over the desired frequency range, with an output capability of

2 mW (+51.75 dBmV).

A signal detector, capable of receiving signals lower in level than 2 pW (-40 dBmV).

For convenience, a swept test system is recommended, although a tunable single frequency setup can be employed.

Some typical swept equipment configurations are:

1: Scalar Network Analyzer (Agilent 871*) Series or equivalent. (Figure 3)

2: Spectrum Analyzer with Tracking Generator Agilent 8591 OPT 11, Agilent 85640A (Figure 4)

3: Analog Cable Sweep system

If only a Tunable Single Frequency setup is considered, then the equipment should consist of: (Figure 5)

1: Agile Modulator or variable signal generator

2: Signal Level Meter or Spectrum Analyzer.

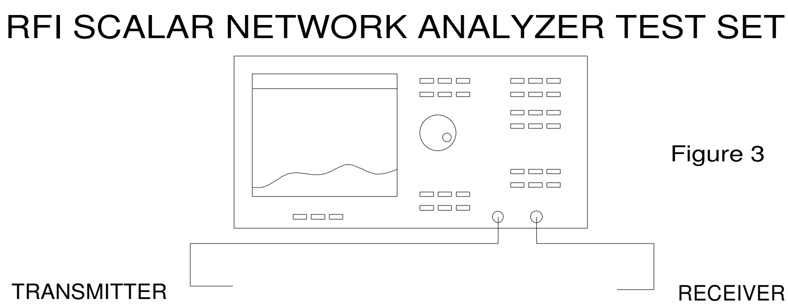


FIGURE 3: RFI Scalar Network Analyzer Test Set

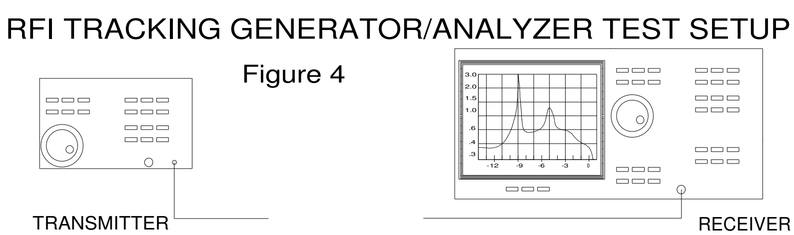


FIGURE 4: RFI Tracking Generator/Analyzer Test Setup

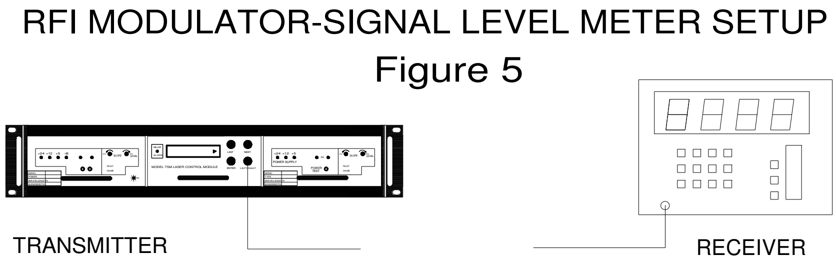


FIGURE 5: RFI Modulator-Signal Level Meter Setup

5.2 Post Amplifier having the following capabilities:

Gain 42 to 47 dB (+/- 1 dB) across the desired frequency band. As this amplifier will be operating at very low RF levels, it can be safely built up of two amplifiers cascaded. As an example, two close coupled 30 dB gain Line amplifiers, with ~10 dB interstage attenuation pads will suffice.

5.3 Highly shielded interconnect cables and "F" Terminators.

Due to the very sensitive nature of this test, it is imperative that the cable or interconnect employed between the transmission device and the device to be tested have a leakage suppression at least 20 dB better than the target measurement.

Where physically feasible, depending on the form factor and mass of the device to be tested, the ideal test condition is a direct Connector interconnect between the device under test and the transmission device. This can involve connecting small light devices such as splitters directly to the transmission port with a connector adapter.

If this type of connection is not possible, then a multiple shield or semi-rigid cable interconnect is required. All connectors and terminators should be threaded type (avoid push-on connectors) and torqued to 30 in/lb.

6.0 POST AMPLIFIER AND "K" FACTOR

The total gain or loss between the Probe and the Receiving device is referred to as the "K" factor. For ease of measurement, the "K" factor should be an even number, with 40 dB being ideal.

The Probe is a 50 Ω device, and if directly connected to a 75 Ω load, will exhibit a Return Loss of 14dB, and a signal transformation apparent Voltage Gain of +1.75 dB. While this value expressed as a decimal is somewhat irrelevant in the context of a 120 dB dynamic range test, it is included for sake of accuracy. The Return Loss is irrelevant in this measurement. Alternatively, a Minimum Loss Pad having a loss of 5.7 dB may be employed between the Probe and the Post Amplifier if absolute accuracy is demanded.

If a direct connection is to be employed (NOTE THE WARNING CONCERNING "N" CONNECTOR MATING), then the Post amplifier should be set up to 38.25 dB flat gain across the band of interest. The net result will be a "K" factor of 40 dB.

If a Minimum Loss Pad is employed, the amplifier should be set to 45.7 dB gain, again resulting in a 40 dB "K" factor. Figure 6

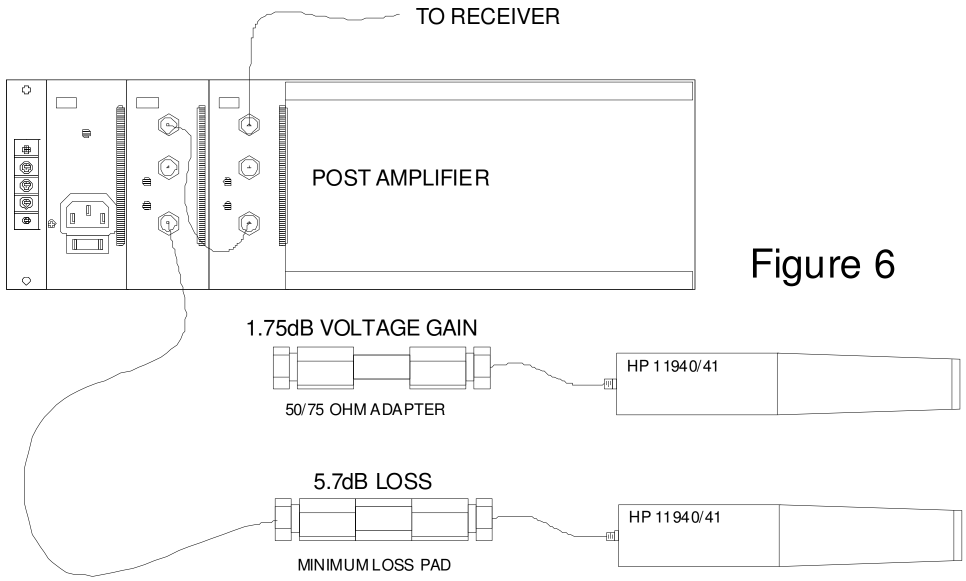


FIGURE 6: 50 Ω to 75 Ω type "N" Transition

7.0 TEST PROCEDURE

NOTE: Due to the extremely low recovered signal levels and high dynamic range employed in this test, it is practically impossible to achieve measurement accuracy closer than +/- 3 dB. As will be seen however, in a test for relative level ratios in excess of 100 dB, this error is insignificant.

7.1 SET-UP AND CALIBRATION

With the test equipment set to a safe drive level (+20 dBmV Max), sweep and align the Post Amplifier to a flat gain +/-0.75 dB of either 38.5 or 45.7 dB, depending on the Probe interconnect manner to be employed. (Figure 7, typically shown in the detailed response of Figure 7A.)

FIGURE 7: RFI Post Amplifier Set-up

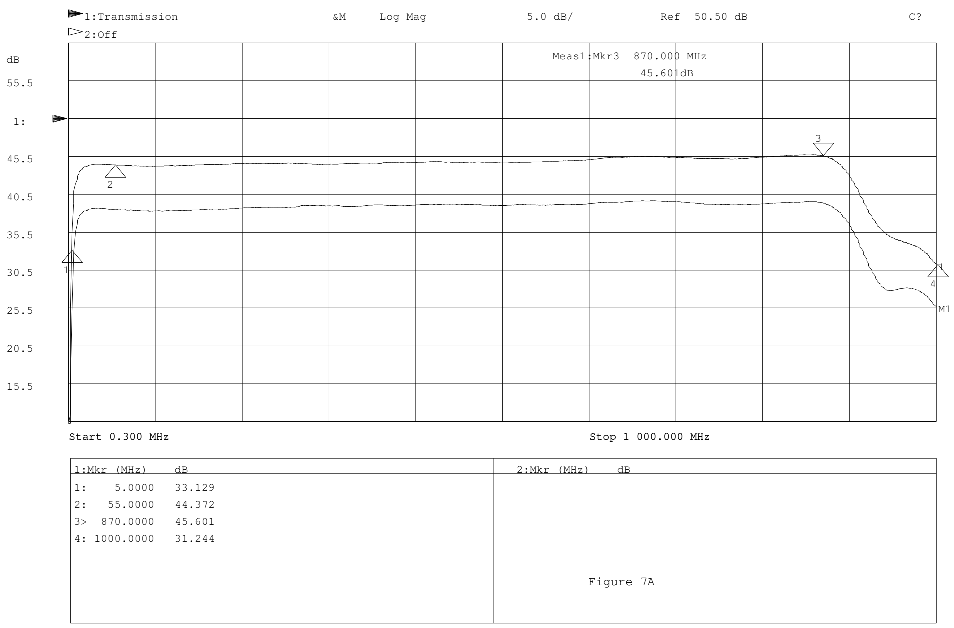
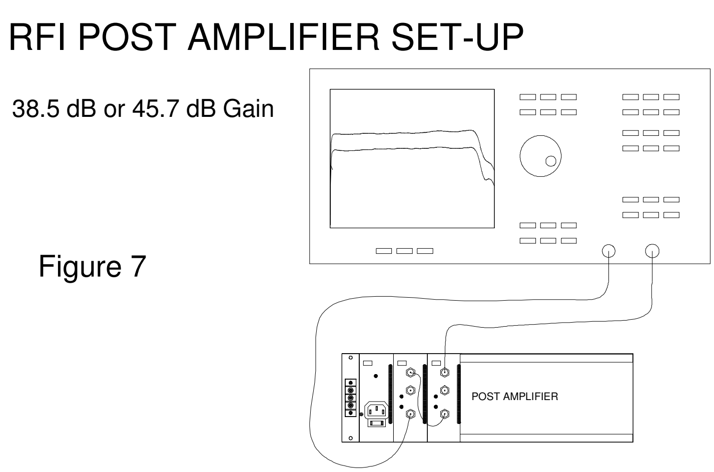


FIGURE 7A: Direct or Minimum Loss Pad Calibration



Disconnect the Post Amplifier from the Measurement equipment and set aside.

Set the test equipment transmission level to +50 dBmV, and establish a receive reference of +50 dBmV. On a Scalar Analyzer, this can be accomplished by setting the received +50 dBmV at the top line of the display and storing the trace. On a Spectrum Analyzer, set the received +50 dBmV at the top line of the display and note the Attenuator setting. In either case, a display setting of 10 dB/DIV is desirable.

It is now necessary to locate the –30 dBmV reference point.

If using a Scalar analyzer having 10 Graticule divisions of 10 dB/DIV on screen range, this point is 8 divisions below the reference. (Figure 8)

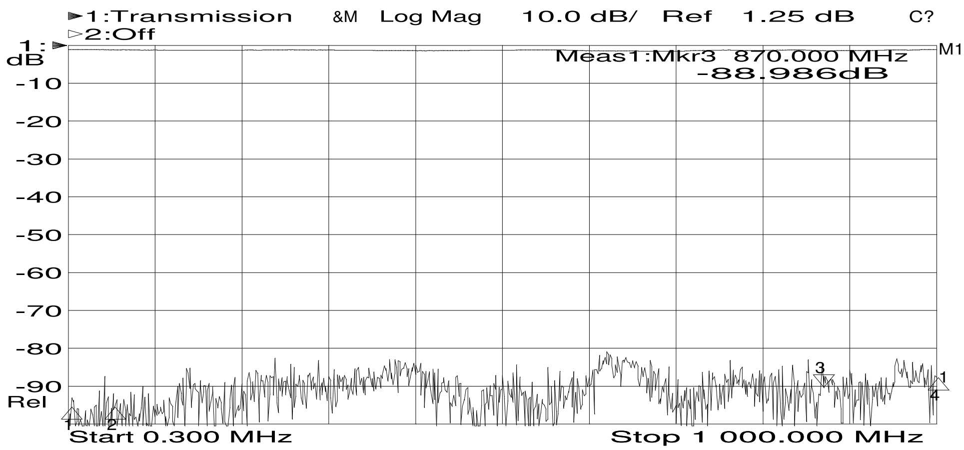


FIGURE 8: -30dBmV On Screen Display

If using a device such as a Spectrum analyzer or Signal Level meter having less Dynamic Range, the reference point can be established by using 20-40 dB of input attenuation during the –50 dBmV reference stage, and then removing the attenuation during the test phase. The received level will then be equal to the display plus the amount of attenuation removed. (Figure 9)

SPECTRUM ANALYZER DISPLAY

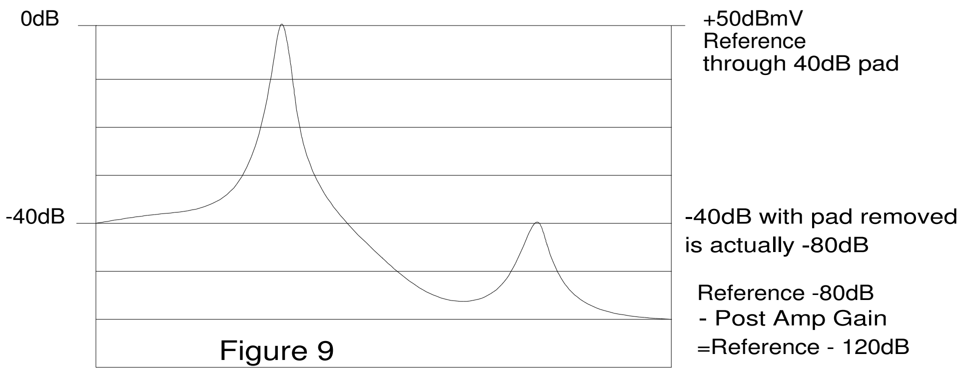


FIGURE 9: Spectrum Analyzer Display

For example: if the receive device has only 40 dB of dynamic range, then set the +50 dBmV reference through a 40 dB attenuator. When the attenuator is removed, the –40 dB display will be (+50 dBmV –40 dB –40 dB = -30 dBmV)

Connect the Probe to the Post Amplifier Input and connect the Post Amplifier output to the receive device. The –30 dBmV reference point is now 120 dB below the +50 dBmV reference.

7.2 PREVENTING FALSE READINGS

Connect the proposed transmission cable or connector to the signal transmission port.

(Figure 10)

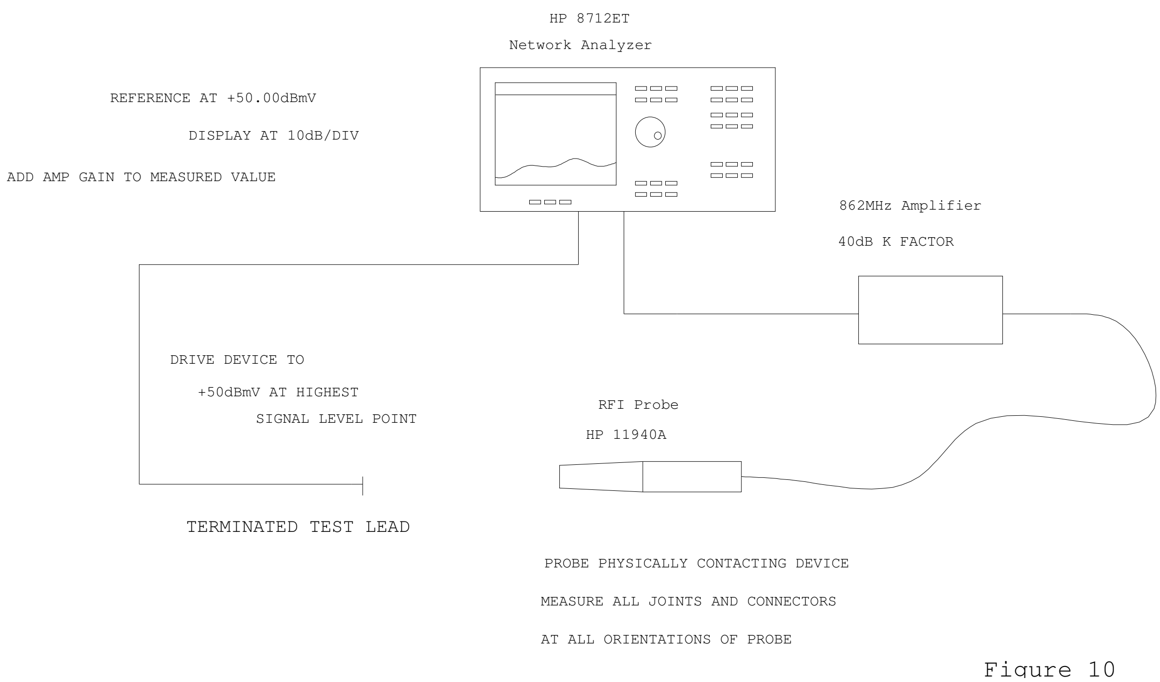


FIGURE 10: Typical Scalar Test Setup

Bring the Probe near the open end of the transmission cable and note that significant signal is received. This is a quick determination that the system is operating correctly. An example is seen as the upper trace in Figure 11B.

Terminate the transmission cable, and move the Probe tip all over the transmission cable, connectors, test equipment face, and power cords, and note that no signals are received higher than the –30 dBmV reference. This will establish that the system is not generating leakage prior to device testing. If signals above the –30 dBmV level are noted, replace cables and connectors, or extend cables to move the transmission equipment further away from the test area.

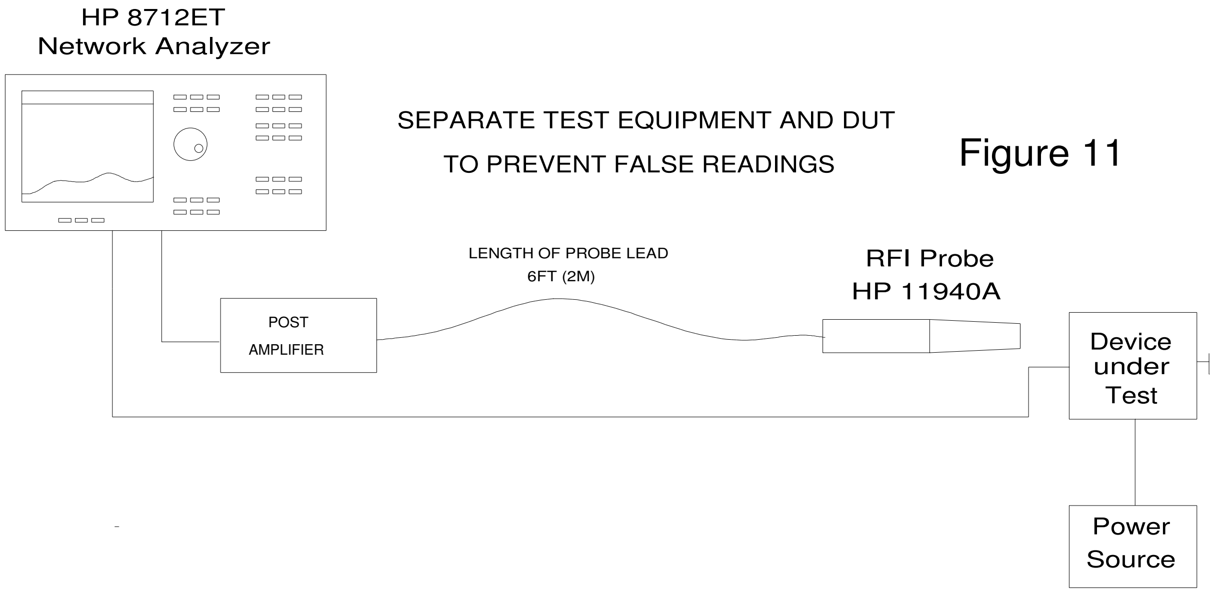


FIGURE 11: Physical Separation to prevent False Readings

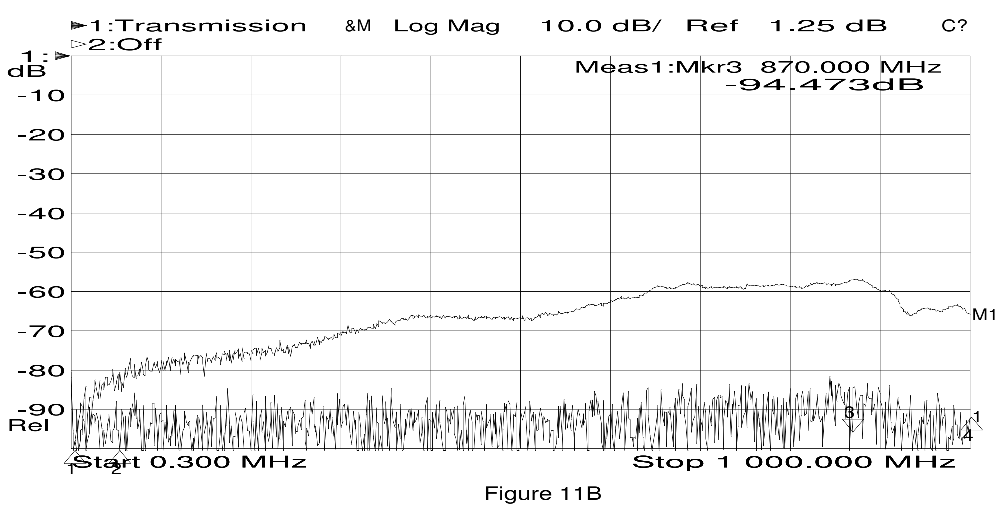


FIGURE 11B: Operational Check

Once the test setup is established with no readings above the –30 dBmV reference, we now have a 120 dB capable measurement setup.

7.3 DETERMINING THE DEVICE UNDER TEST (DUT) MAXIMUM SIGNAL LEVEL POINT

This test involves driving the DUT so as to achieve a signal level of +50 dBmV at the highest level point within the device. This signal level will not harm conventional cable telecommunication system actives or passive devices, but Ultra Low Noise or Optical devices may be damaged. Before performing this test on such devices, approval of the equipment supplier should be obtained.

The highest signal level point in the DUT can be determined from the block diagram or schematic. It is the intent of this test procedure to apply an input signal level that will drive the highest signal point to +50 dBmV. Some examples are:

7.3.1 Splitter

The Highest Level Point in a passive splitter is the input port. Figure 12

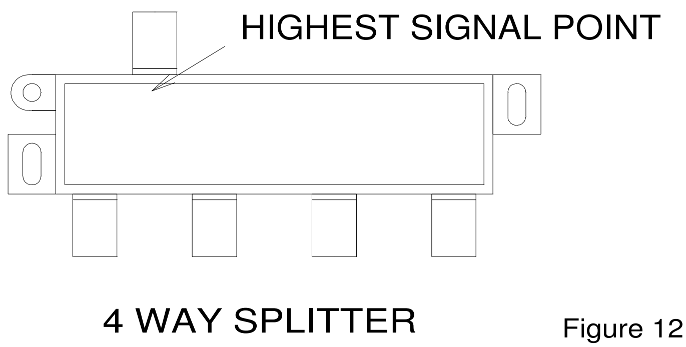


FIGURE 12: Indoor Splitter

7.3.2 Four Port Drop Amplifier

The Highest Level Point is the output of the gain stage prior to the output splitter (Figure 13)

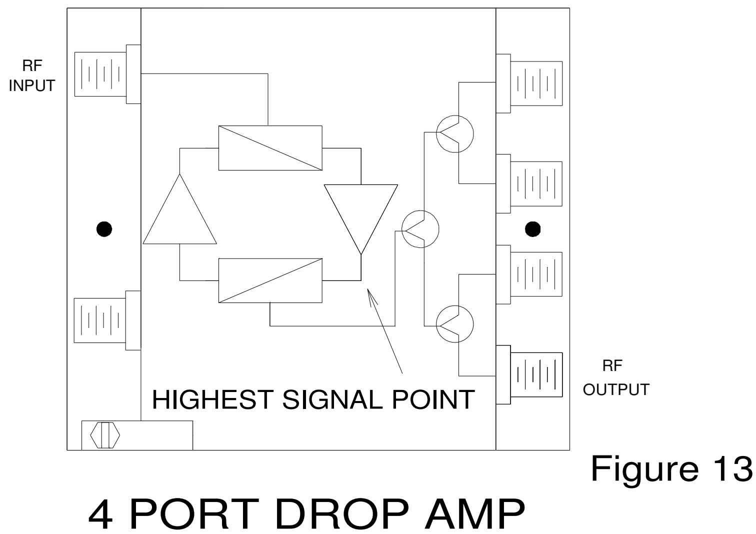


FIGURE 13: Four-Port Drop Amplifier

7.3.3 Line Amplifier

The Highest Level Point will be the output of the Post Amplifier hybrid prior to any diplex filtering or splitting. Figure 14

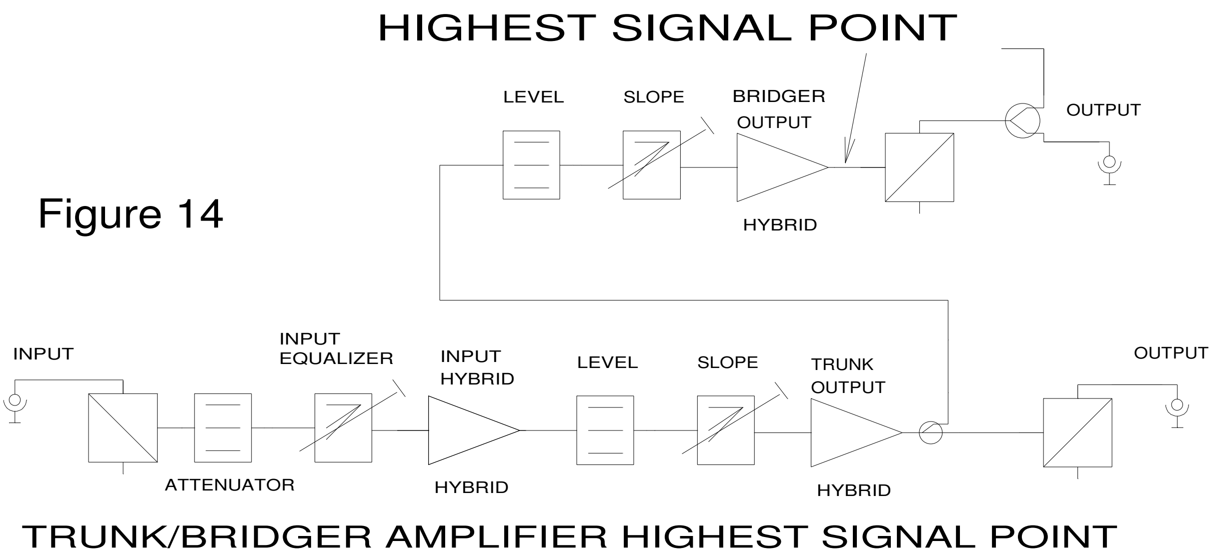


FIGURE 14: Trunk/Bridger Amplifier Highest Signal Point

7.4 Measurement Technique

Set equipment as in Figure 11. The Standard method is to have the non-conductive Probe tip in physical contact with the DUT. Should the particular user's test specification require spacing the Probe Tip some defined distance from the DUT, a non-metallic, non-conductive spacer may be fabricated from LEXAN or similar material, to ensure a consistent spacing. Such spacing should be noted in the final report form. An example of such spacer is shown in Appendix A.

7.4.1 Set the transmission level so as to drive the DUT Highest Level Point to +50 dBmV.

7.4.2 Probe all openings or potential leakage points on the device with particular attention to slots and seams, which are most likely to exhibit a "Slot Antenna" effect.

7.4.3 Use the Probe at all orientations but with specific attention to testing with the long edge of the probe parallel to any lengthwise openings or joints. Figure 15

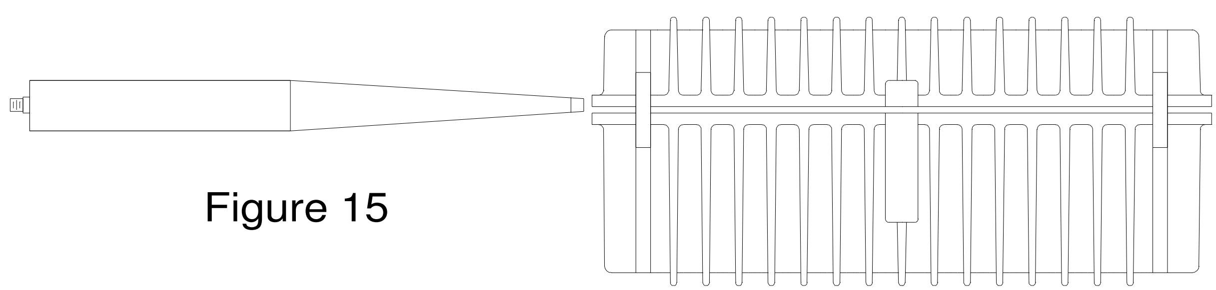


Figure 15

FIGURE 15: Shows the probe being held with the long tip edge parallel to an amplifier housing lid seal.

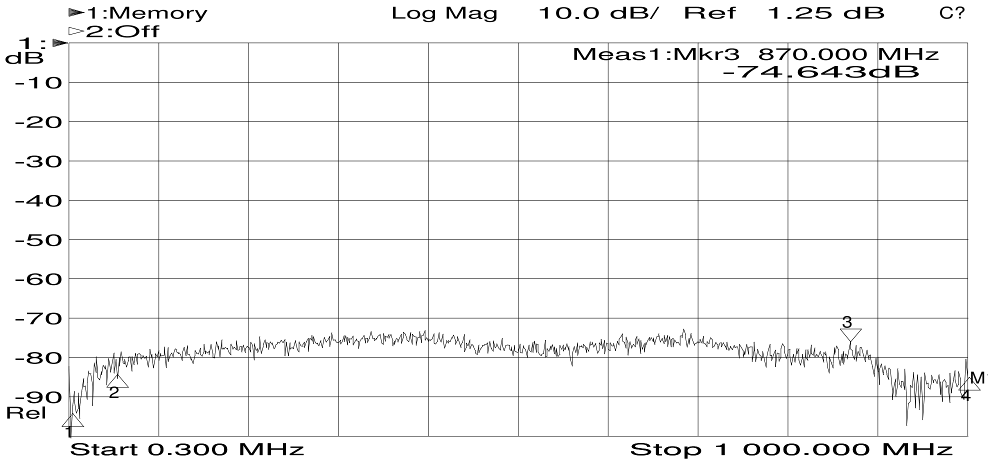


Figure 15B

FIGURE 15B: Shows a reading of –115 dB (-75 dB + 40 dB K factor)

If the device being tested incorporates a powering cord or lead, probe along the lead for at least 6 ft (2 m) from the device. The antenna effect of a cable can result in a leakage hot spot some distance from the device being tested. The Probe tip should be held parallel to the cable or cord as in Figure 16.

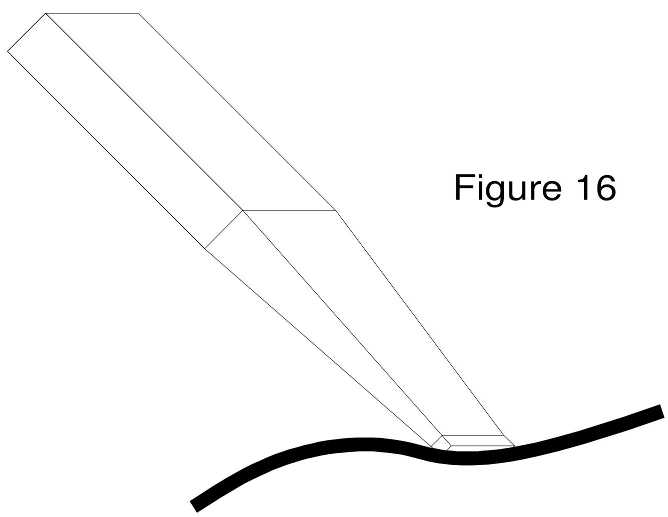


Figure 16

FIGURE 16: Probe Tip Held Parallel to cable/cord

Depending on the Test Equipment being employed, several items should be noted:

When employing a Tracking Generator or other slow sweep, the Probe should be held in each test location for one complete sweep across the frequency band.

When employing a Single Frequency test setup, the test should be repeated at 50MHz intervals across the frequency band.

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RFI Near Field Test Summary

Date	Tested By	Equipment Setup	
		Transmitter	
		Receiver	
		Post Amplifier	
		Post K Factor	
		DUT Max RF Level	
		Probe Tip Spacing	
		Probe Model Number	

Equipment under Test

Displayed RFI	Corrected RFI	RFI Location on DUT	Frequency

General Test Environment : Temperature, Relative Humidity and Altitude (ASL)

Sketch or Photo if Req,d

APPENDIX A

PROBE SPACER