



***Society of Cable
Telecommunications
Engineers***

**ENGINEERING COMMITTEE
Interface Practices Subcommittee**

AMERICAN NATIONAL STANDARD

ANSI/SCTE 16 2001R2007

**Test Procedure for
Hum Modulation**

NOTICE

The Society of Cable Telecommunications Engineers (SCTE) Standards are intended to serve the public interest by providing specifications, test methods and procedures that promote uniformity of product, interchangeability and ultimately the long term reliability of broadband communications facilities. These documents shall not in any way preclude any member or nonmember of SCTE from manufacturing or selling products not conforming to such documents, nor shall the existence of such standards preclude their voluntary use by those other than SCTE members, whether used domestically or internationally.

SCTE assumes no obligations or liability whatsoever to any party who may adopt the Standards. Such adopting party assumes all risks associated with adoption of these Standards or Recommended Practices, and accepts full responsibility for any damage and/or claims arising from the adoption of such Standards or Recommended Practices.

Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken with respect to the existence or validity of any patent rights in connection therewith. SCTE shall not be responsible for identifying patents for which a license may be required or for conducting inquiries into the legal validity or scope of those patents that are brought to its attention.

Patent holders who believe that they hold patents which are essential to the implementation of this standard have been requested to provide information about those patents and any related licensing terms and conditions. Any such declarations made before or after publication of this document are available on the SCTE web site at <http://www.scte.org>.

All Rights Reserved

© Society of Cable Telecommunications Engineers, Inc. 2001, 2007

140 Philips Road

Exton, PA 19341

Table of Contents

1.0	Scope	1
2.0	Definitions	1
3.0	Background	1
4.0	Equipment	2
5.0	Setup	3
6.0	1 dB Delta Measurement Procedure	6
7.0	Differential Voltage Measurement Procedure	7
Figure 1	Hum Modulation Test Setup	9
Appendix 1	Hum Modulation Derivation	10
Appendix 2	Derivation of the 100m VDC Delta Calibration	11
Appendix 3	Conversion of the Hum Modulation from dB to percent (%)	12
Table 1	Hum Modulation Conversion Chart	13
Appendix 4	Time Domain vs. Frequency Domain Measurements	14
Appendix 5	Hum Modulation Test Methods	15
Appendix 6	Troubleshooting Guide	17
Appendix 7	Special Test Conditions/Considerations	18

1.0 SCOPE

To define and measure hum modulation in active and passive broadband **RF** telecommunications equipment and sub-assemblies. This procedure presents two methods for measuring hum modulation in the time domain, with a sensitivity exceeding -80 dB. These methods are referred to as the 1 dB delta and the differential voltage method. A mathematical relationship between time domain and frequency domain measurement methods is also provided.

2.0 DEFINITIONS

- 2.1. Hum Modulation: The amplitude distortion of a signal caused by the modulation of the signal with components of the power source. It is the ratio, expressed in dB, of the peak to peak variation of the carrier level caused by AC power line frequency products (and harmonics up to 1 kHz) to the peak voltage amplitude of the carrier.
- 2.2. Peak Voltage Amplitude: The maximum voltage amplitude of the carrier.
- 2.3. Percent Hum Modulation: Hum Modulation may also be expressed as a percentage of the peak to peak variation of the carrier level to the peak voltage amplitude of the carrier. See Appendix 3 for a derivation of percent Hum.

3.0 BACKGROUND

In a coaxial telecommunications system, where AC power and radio frequency (RF) signals exist on the same conductor, hum modulation of a television signal is measured as a comparison between the modulation envelope (created by line power distortions of the RF carriers), and the peak voltage of the sync tips of the video signal.

In a laboratory test environment, the video signal is replaced with a sine wave RF carrier. Under these conditions, the only modulation existing on the carrier is the line power related distortion (created by the device under test) of that carrier. Hum modulation is determined as a function of the line frequency current passing through the device by comparing the peak to peak modulation envelope of the power line distortion to the peak voltage of the carrier by utilizing a diode detector.

Due to the non-linear characteristics of any diode detector, it is inaccurate to simply compare the AC modulation voltage and the rectified DC carrier voltage directly due to the voltage drop across the diode. Instead, the modulation voltage is compared to a calibrated change in the rectified carrier.

There are two time-domain methods for measuring hum modulation in a laboratory environment, which are detailed in this procedure. These methods are commonly referred to as the 1 dB delta method, and the differential voltage method. These methods are described in Appendix 5.

4.0 EQUIPMENT

4.1. The general equipment required for this test is shown in Figure 1. The Test Procedures Introduction document, ANSI/SCTE 96 2004, describes and specifies this equipment.

4.2 The signal generator for this test must have (minimum) the characteristics listed below.

- 4.2.1 5 MHz – 1.002 GHz (minimum) single carrier signal generation capability.
- 4.2.2 0.2% minimum AM modulation index capability.
- 4.2.3 < 0.01% residual hum.
- 4.2.4 Suggested Equipment: Hewlett Packard ESG-4000A Signal Generator or equivalent.

4.3 Two AC/RF Power Combiners/Inserters:

- 4.3.1 Hum modulation < -80 dB at desired test current and voltage.
- 4.3.2 Return loss: > 22 dB.
- 4.3.3 Power Combiners/Inserters must possess RF only input/output capability, i.e. AC blocking incorporated into design.
- 4.3.4 Current carrying capacity of at least 50% greater than desired test currents.

Note: AC/RF Power Combiners/Inserters may not be required for certain DUT applications. Refer to Appendix 7 for special test considerations.

4.4 Resistive Load Bank: capable of dissipating desired test power.

4.5 Display Devices:

- 4.5.1 Power analyzer capable of measuring rms current and voltage simultaneously.
- 4.5.2 Oscilloscope must have a minimum deflection sensitivity of 2.0 mV/div.
 - 4.5.2.1 Suggested Equipment: Tektronix TDS724A Digitizing Oscilloscope with Tektronix ADA400A Differential Preamplifier or equivalent (recommended, preamplifier not used in differential mode).
 - 4.5.2.2 The oscilloscope used for the test must possess signal averaging capability.

4.6 Power supply:

- 4.6.1 Ferro-resonant quasi-square wave (trapezoidal wave with < 100 V/ms slew rate).
- 4.6.2 AC voltage output (50/60 Hz) at desired test voltage.
- 4.6.3 Rated current output of at least 30% greater than the desired test current.

4.7 Low Pass Filter: DC – 1 kHz(minimum)

- 4.7.1 Shielded.
- 4.7.2 High Impedance (5 k Ω or greater).

- 4.7.3 > 30 dB attenuation above 30 kHz.
- 4.7.4 This filter may be contained in the differential preamplifier used in the test.
- 4.8 AM Detector:
 - 4.8.1 75 Ω Input Impedance.
 - 4.8.2 Frequency Range: 200 kHz to 1.002 GHz.
 - 4.8.3 Maximum VSWR: 1.2:1 to 1.002 GHz.
 - 4.8.4 Suggested Equipment: Trilithic CD-75 or equivalent.
- 4.9 Required inter-connect cables and connectors.
 - 4.9.1 Quad-shield 75 Ω coaxial cable, for RF only paths.
 - 4.9.2 Rigid or semi-rigid 75 Ω coaxial cable (1/2" diameter or greater), for RF and AC common paths, with a current carrying capacity of at least 50% greater than desired test currents.
 - 4.9.3 Suggested Equipment: Gilbert interconnect cables or equivalent.
- 4.10 Isolation Transformer
 - 4.10.1 115 – 120 VAC Input : 115 – 120 VAC Output.
 - 4.10.2 50/60 Hz.
 - 4.10.3 > 1,000 VA.
 - 4.10.4 Suggested Equipment: Xentek EIT 1.0-31
- 4.11 RF Amplifier
 - 4.11.1 5 MHz – 1 GHz (two amplifiers may be used to encompass this frequency range).
 - 4.11.2 Gain $\cong$ 25 dB.
 - 4.11.3 Noise Figure $\leq$ 10 dB.
- 4.12 RF Attenuators
 - 4.12.1 Maximum VSWR: 1.2:1 to 1 GHz.
 - 4.12.2 75 Ω Switchable Attenuators.
 - 4.12.2.1 0.1 dB steps, 0 – 1 dB range, $\pm$ 0.05 dB tolerance.
 - 4.12.2.2 1.0 dB steps, 0 – 10 dB range, $\pm$ 0.1 dB tolerance.
 - 4.12.2.3 10.0 dB steps, 0 – 70 dB range, $\pm$ 0.2 dB tolerance.
 - 4.12.3 75 Ω fixed attenuators: 10 dB values, $\pm$ 0.05 dB tolerance.

5.0 SETUP

- 5.1. Follow all calibration requirements recommended by the manufacturers of the test equipment, including adequate warm-up and stabilization time.
- 5.2. Connect the test equipment as shown in Figure 1.

Note: AC/RF Power Combiners/Inserters may not be required for certain DUT applications. Refer to Appendix 7 for special test considerations.

5.3. Set the oscilloscope to the following settings:

Vertical Scale	As required for waveform display
Horizontal Scale	1 ms/div
Input Impedance	1 M Ω
AC Coupled Mode	On
Measurement Mode	V pk-pk
Signal Averaging	Off
Trigger	External

Note: A pre-amplifier is recommended to increase the vertical resolution of the oscilloscope, and extend the noise floor.

5.4. Determine RF levels:

5.4.1. Connect DUT into test setup.

5.4.2. Set the signal generator to a frequency within the operating range of the device.

5.4.3. Adjust the signal generator RF output level, while monitoring the RF test point, to set the RF output level of the DUT to it's typical operating levels.

5.4.4. Adjust the step attenuator preceding the RF post amplifier until the voltmeter displays approximately 0.9 VDC. If this voltage cannot be obtained, the gain of the RF post amp will need to be increased. This will ensure operation in the linear region of the AM detector.

Note: Section 5.4 establishes the calibration voltage while maintaining the DUT at it's rated output level (achieved by monitoring the test point). This prevents possible compression of the DUT while obtaining the calibration voltage.

5.5. Calibration:

5.5.1. Add 1.0 dB of attenuation from the input attenuator and note the voltage change on the voltmeter.

5.5.2. Fine tune the amplitude of the signal generator until a 1.0 dB switchable attenuator change causes a 100 mVDC deflection on the voltmeter. When a 100 mVDC delta is achieved, record the DC voltage at the higher signal level as the detector dc operating point or calibration voltage.(see Appendix 2)