Society of Cable Telecommunications Engineers

ENGINEERING COMMITTEE
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AMERICAN NATIONAL STANDARD

ANSI/SCTE 109 2010

Test Procedure for Common Path Distortion (CPD)

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1.0 Scope

1.1 The purpose of this document is to establish the standard methodology used to measure Common Path Distortion (CPD) in Cable Telecommunications Systems.

1.2 Please note that this procedure is a very unique procedure for measuring Common Path Distortion and distinguishes itself from other similar procedures in the following ways:

- Single port measurement, measures reflected energy
- Inject two forward carriers separated by 6 MHz and measure return beat at 6 MHz
- Used to verify performance of single port passives such as terminators or passives with all other ports terminated. Designed to be consistent with the mechanisms that cause common path distortion in outside plant.

For similar procedures, please reference the following:

- ANSI/SCTE 115 2006 : Test Method for Reverse Path (Upstream) Intermodulation Using Two Carriers
- ANSI/SCTE 145 2008: Test Method for Second Harmonic Distortion of Passives Using a Single Carrier
- ANSI/SCTE 126 2006: Test Method for Distortion of 2-way Active Amplifier Caused by Insufficient Isolation of Built in Diplex Filter

Each of these procedures targets a different measurement for a unique purpose. They are independent, are specifically applicable to the device being measured, use the test equipment commonly available at the manufacturing sites used to make the device being tested, and directly measure the impairment that must be controlled. The key differences are whether they are designed for actives or passives and whether they are single port or two port measurements. Other differences are the types of distortion products being measured and the filters required to do so.

2.0 INFORMATIVE REFERENCES

The following documents may provide valuable information to the reader but are not required when complying with this standard.

2.1 ANSI/SCTE 115 2006: Test Method for Reverse Path (Upstream) Intermodulation Using Two Carriers

2.2 ANSI/SCTE 145 2008: Test Method for Second Harmonic Distortion of Passives Using a Single Carrier

2.3 ANSI/SCTE 126 2006: Test Method for Distortion of 2-way Active Amplifier Caused by Insufficient Isolation of Built in Diplex Filter

3.0 NORMATIVE REFERENCES

The following documents contain provisions, which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreement based on this standard are encouraged to investigate the possibility of applying the most recent editions of the documents listed below.

3.1 ANSI/SCTE 144 2007: Test Method for Insertion Gain and Loss, Frequency Response and Bandwidth

4.0 COMPLIANCE NOTATION

"SHALL"	This word or the adjective "REQUIRED" means that the item is an absolute requirement of this specification.
"SHALL NOT"	This phrase means that the item is an absolute prohibition of this specification.
"SHOULD"	This word or the adjective "RECOMMENDED" means that there may be valid reasons in particular circumstances to ignore this item, but the full implications should be understood and the case carefully weighted before choosing a different course.
"SHOULD NOT"	This phrase means that there may exist valid reasons in particular circumstances when the listed behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.
"MAY"	This word or the adjective "OPTIONAL" means that this item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because it enhances the product, for example; another vendor may omit the same item.

5.0 DEFINITIONS AND ACRONYMS

CPD – Common Path Distortion is intermodulation distortion of downstream signals due to nonlinearities found at metallic junctions. The distortions are manifest as a series of beats (caused by analog downstream channels) or a band(s) of noise (caused by digital downstream channels) most noticeably in the upstream path. CPD may also be present in the downstream path, but since it adds with other downstream distortions (i.e. CTB and CSO), caused by active components, it is difficult to differentiate between the two. The nonlinear behavior found at passive junctions may be due to a number of reasons including corrosion, typically from exposure to the elements, dissimilar metals, contact pressure, and junctions involving connectors contaminated with carbonaceous materials.

CSO – Composite Second Order

CTB – Composite Triple Beat

DUT – Device Under Test

6.0 EQUIPMENT REQUIREMENTS

Qty.	Description
1	spectrum analyzer, AGILENT 8568B or equivalent
1	network analyzer, AGILENT 8753E or equivalent
1	calibration kit, network analyzer
2	RF signal generators, AGILENT 8657B or equivalent
1	current clamp, to measure current passing through active DUT
1	environmental chamber, programmable, capable of -40 to 60°C, Tenney Engineering, Inc., Model TTC or equivalent
1	diplexer, low-pass ≤ 42 MHz, high-pass ≥ 54 MHz, Eagle EDPF-42/54 or equivalent
1	bi-directional amplifier, capable of amplifying signals below 42 MHz in one direction and signals above 54 MHz in the other, GI Starline 2000, BLE-86S or equivalent
1	splitter, 2-way, PCT-NGNII-2S or equivalent used for combining
1	power supply, AC (quasi-square-wave)
2	power inserters, Lindsay Electronics LHI100H or equivalent
1	power load, adjustable, to pull desired current through DUT
1	thermometer, Fluke 29 digital multimeter with Fluke 80TK thermocouple module and Fluke 80PK-1 or equivalent to measure chamber temperature
A/R	terminators
1	torque wrench, Mitutoyo 983-201 or equivalent

A/R – as required

Table 1 – Equipment Requirements

7.0 UPSTREAM PASSBAND CHARACTERIZATION

7.1 Calibrate the network analyzer for a transmission path measurement, from 5 to 42 MHz, per the manufacturer's instructions.

7.2 Set up the equipment as shown in Figure 1 and terminate any unused ports.

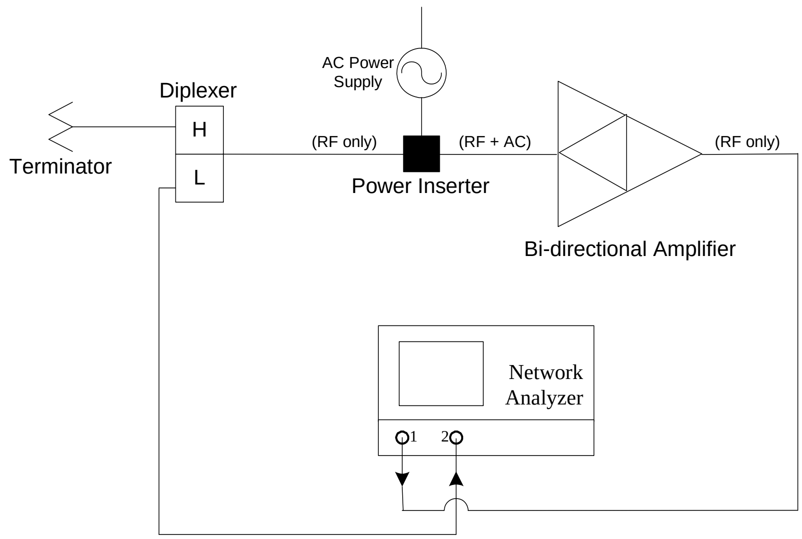

Figure 1 – Upstream passband characterization

Note: The bi-directional amplifier may be DC powered, eliminating the need for the AC power supply and power inserter.

7.3 Measure and record the frequency response and gain of the upstream passband from 5 to 42 MHz. (*Reference* ANSI/SCTE 144 2007: Test Method for Insertion Gain and Loss, Frequency Response and Bandwidth. This is defined as 'Gain.'

8.0 STIMULUS SETUP

8.1 Calibrate the spectrum analyzer per the manufacturer's instructions.

8.2 Set up the equipment as shown in Figure 2. Make sure to use the same cables used in Section 7.2.

8.3 Set the resolution bandwidth of the spectrum analyzer to 30 kHz.

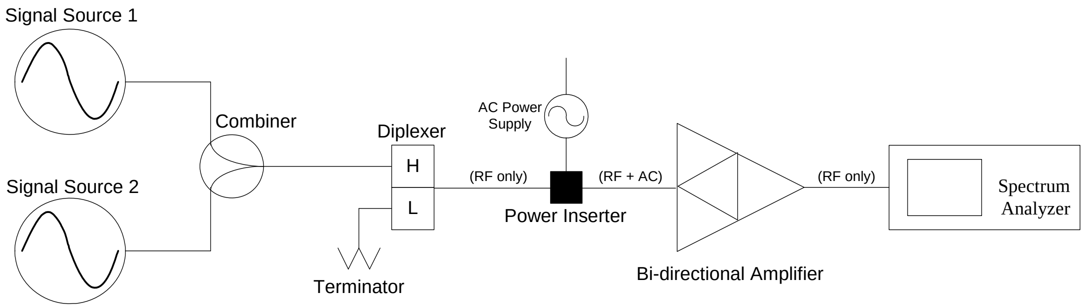

Figure 2 – Stimulus setup

8.4 Set Signal Source 1 and Signal Source 2 to two adjacent video carrier frequencies, 6 MHz spacing, within the downstream passband (54 to 1002 MHz). Make sure to select frequencies that are within the downstream passband of the bi-directional amplifier.

8.5 Adjust the output of each signal source to 50 dBmV at the spectrum analyzer. This is defined as the 'Y carrier.'

9.0 EQUIPMENT SETUP (PASSIVE DEVICE)

9.1 Set up the equipment as shown in Figure 3.

9.2 Set the spectrum analyzer as follows:

Start Frequency:	5 MHz
Stop Frequency:	42 MHz
RBW:	30 kHz
VBW:	1 kHz
Attenuation:	0 dB
Reference Level:	0 dBmV

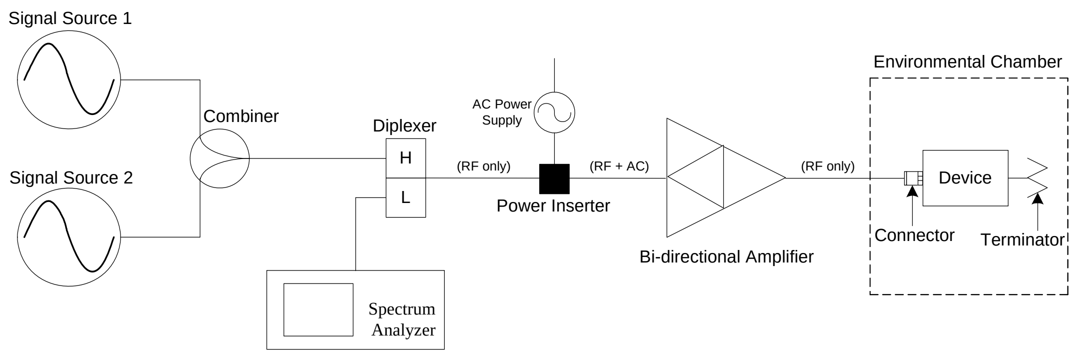

Figure 3 – Test setup for passive device

10.0 EQUIPMENT SETUP (POWER PASSING DEVICE)

10.1 Set up the equipment as shown in Figure 4. (NOTE: To avoid damaging equipment, make sure that AC power is not present on cables going to or from RF test equipment prior to connecting the equipment.)

10.2 Set the spectrum analyzer as follows:

Start Frequency:	5 MHz
Stop Frequency:	42 MHz
RBW:	30 kHz
VBW:	1 kHz
Attenuation:	0 dB
Reference Level:	0 dBmV

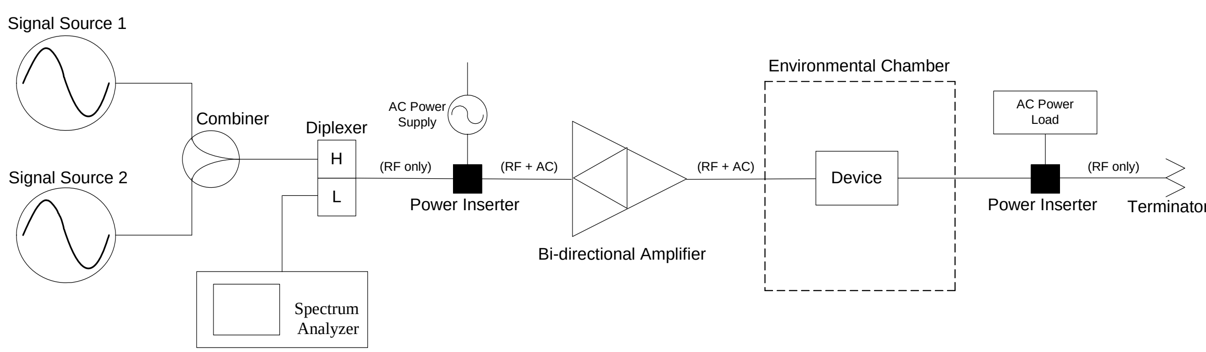

Figure 4 - Test setup for power passing device

Note: The bi-directional amplifier may be DC powered, allowing the AC power supply and power inserter to be placed between the bi-directional amplifier and the device under test (DUT), if desired.

10.3 Adjust the AC Power Load for the desired current.

11.0 TEST PROCEDURE

11.1 Measure and record the spectral response from 5 to 42 MHz. If available, use a software program to capture the spectrum analyzer trace point by point.

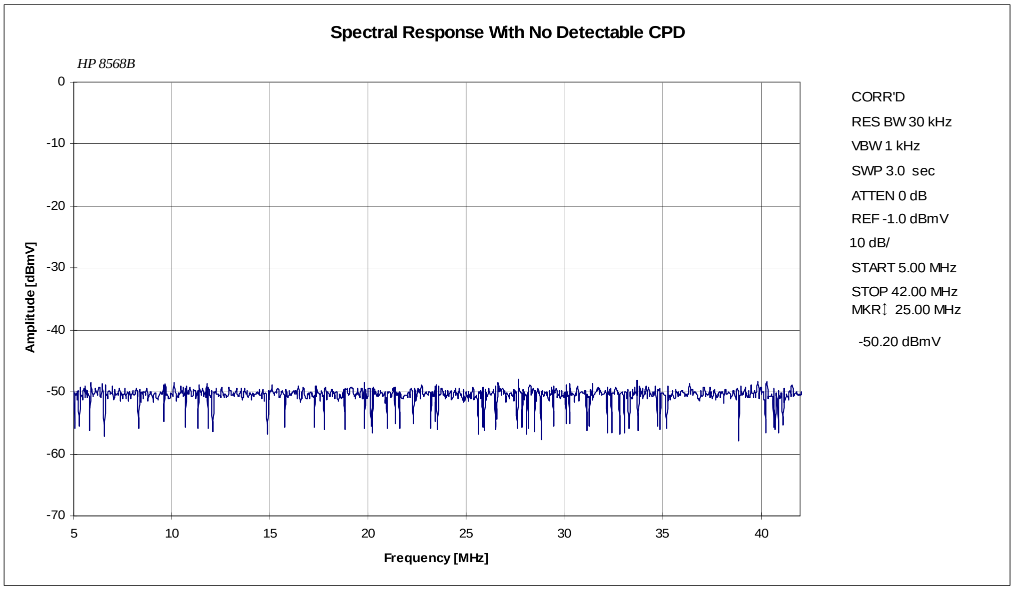

Figure 5 – Spectral response with no apparent CPD

11.2 Program the environmental chamber to cycle from -40 ±1°C or mfr. specified minimum operating temperature to 60 ±1°C or mfr. specified maximum operating temperature, with 2 hour dwell times at each temperature extreme and 1 hour ramp times between temperature extremes, for a period of 14 days.

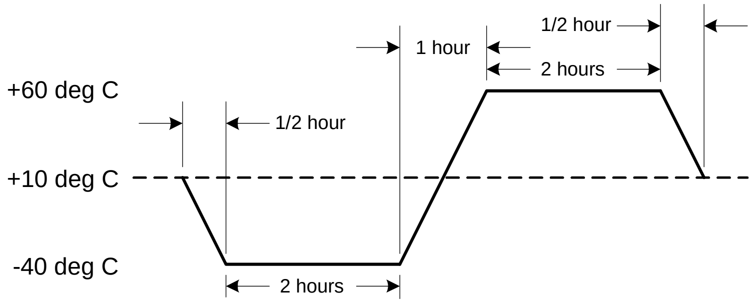

Figure 6 - Thermal cycle profile

11.3 Measure and record the spectral response from 5 to 42 MHz twice daily for 14 days of thermal exposure. Make one measurement at minimum and one measurement at maximum temperatures. Use spectrum analyzer "peak hold" function to capture worse case data.

12.0 CALCULATING CPD

12.1 Use the following formula to calculate CPD.

$$CPD = X_{CPD} - Gain - Y_{Carrier} \quad (1)$$

Where:

CPD – common path distortion [dBc]
X_{CPD} – signal level of CPD [dBmV]
Gain – return path gain [dB]
$Y_{Carrier}$ – signal level of carrier at input to DUT [dBmV]

NOTE: If common path distortion (CPD) is less than 10dB above the noise floor of the analyzer, additional adjustments may be needed to compensate for the noise floor of the analyzer.

12.2 Example calculation

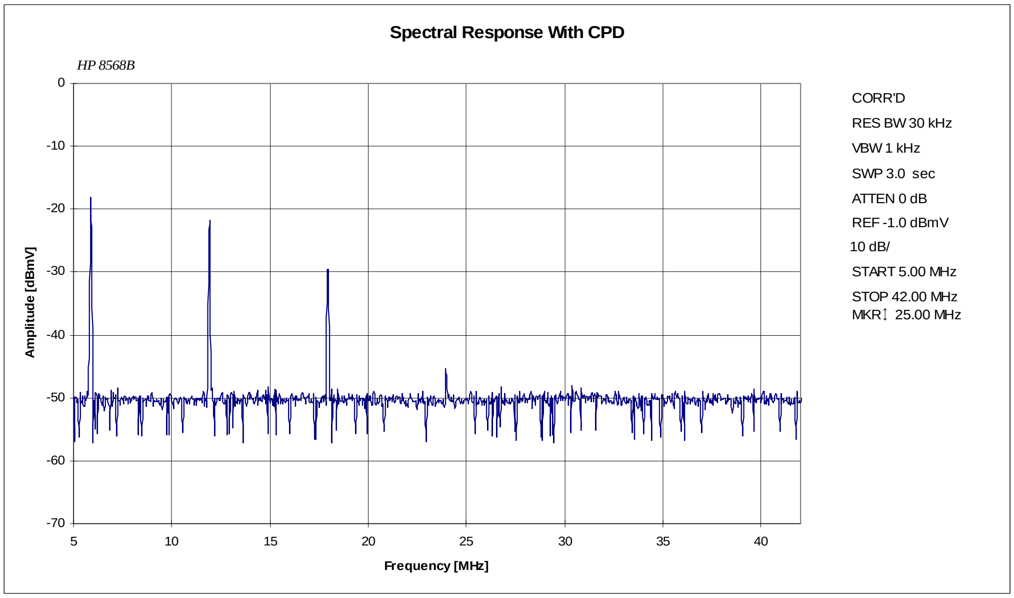

Figure 7 – Spectral response with CPD

Consider the plot with CPD in Figure 7. The level of X_{CPD} is indicated by the highest level in the spectral response.

signal level of Signal Source 1 and 2 at DUT = 50 dBmV
signal level of X_{CPD} at 6 MHz = -18 dBmV
return path gain at 6 MHz = 14 dB

$$\text{CPD at 6 MHz [dBc]} = -18\ \text{[dBmV]} - 14\ \text{[dB]} - 50\ \text{[dBmV]}$$
$$= -82\ \text{dBc}$$

APPENDIX A: DATA RECORDING TEMPLATE

Signal Source 1: Frequency [MHz] = ____________, Amplitude [dBmV] = ____________

Signal Source 2: Frequency [MHz] = ____________, Amplitude [dBmV] = ____________

Date	DUT	Chamber Temperature [°C]	CPD Frequency [MHz]	Level of CPD [dBc]