SCTE · ISBE
STANDARDS

Interface Practices Subcommittee

AMERICAN NATIONAL STANDARD

# ANSI/SCTE 115 2019

# Test Method for Reverse Path (Upstream) Intermodulation Using Two Carriers

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# 1. Introduction

## 1.1. Executive Summary

Cable Communication Systems are two-way systems with signal generation and transmission in both forward and reverse directions. Test methods are required to determine the quality of the components used for this signal transmission in both directions.

This test procedure focuses on the reverse path and provides a method of measurement to evaluate the level intermodulation distortion generated by components used in the reverse path of the cable system.

## 1.2. Scope

This test procedure defines a method of measurement of intermodulation distortion in the reverse "upstream" path of Cable Telecommunications equipment.

This test procedure uses two signal sources (CW sources) at the input of the device under test and uses a spectrum analyzer to measure the discrete second and third intermodulation distortions generated by the device under test.

This procedure is a very unique procedure for reverse "upstream" measurements and is distinguished from other similar procedures in the following ways:

- Designed for two-way actives
- Two port measurement, reverse direction only
- Injects two reverse carriers and measure intermodulation distortion in the reverse band
- Used to verify performance of reverse path amplifier

For similar procedures, please reference the following:

- SCTE 145 2008: Test Method for Second Harmonic Distortion of Passives Using a Single Carrier
- SCTE 126 2006: Test Method for Distortion of 2-way Active Amplifier Caused by Insufficient Isolation of Built in Diplex Filter
- SCTE 109 2010: Test Method for Common Path Distortion

Each of these procedures is targeted at 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.

## 1.3. Benefits

This test procedure for Reverse Upstream Intermodulation, when executed per this procedure, will yield accurate and consistent measurements, for the device under test. Use of this test method provides users a means to verify manufacturer test reports and certificates of compliance when available. When the industry utilizes standard test methods, comparative analysis is more accurate.

### 1.4. Intended Audience

The intended audience for this test method, are manufactures and end-users with proper laboratories and equipment to perform this test.

### 1.5. Areas for Further Investigation or to be Added in Future Versions

At this time, there are no considerations being giving for further investigation.

## 2. Normative References

The following documents contain provisions, which, through reference in this text, constitute provisions of this document. At the time of Subcommittee approval, the editions indicated were valid. All documents are subject to revision; and while parties to any agreement based on this document are encouraged to investigate the possibility of applying the most recent editions of the documents listed below, they are reminded that newer editions of those documents might not be compatible with the referenced version.

### 2.1. SCTE References

- ANSI/SCTE 96 2013, Cable Telecommunications Testing Guidelines

### 2.2. Standards from Other Organizations

- No normative references are applicable.

### 2.3. Published Materials

- No normative references are applicable.

## 3. Informative References

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

### 3.1. SCTE References

- ANSI/SCTE 145 2015, Test Method for Second Harmonic Distortion of Passives Using a Single Carrier
- ANSI/SCTE 126 2013, Test Method for Distortion of 2-way Active Amplifier Caused by Insufficient Isolation of Built in Diplex Filter
- ANSI/SCTE 109 2016, Test Method for Common Path Distortion

### 3.2. Standards from Other Organizations

- No informative references are applicable.

### 3.3. Published Materials

- No informative references are applicable.

# 4. Compliance Notation

| | |
|---|---|
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# 5. Abbreviations and Definitions

## 5.1. Abbreviations

| | |
|---|---|
| ANSI | American National Standards Institute |
| BNNC | beat near noise correction factor |
| CW | continuous wave |
| dB | decibel |
| DUT | device under test |
| DSO | discrete second order |
| DSO1 | discrete second order frequency #1 |
| DSO2 | discrete second order frequency #2 |
| DTO | discrete third order |
| DTO1 | discrete third order frequency #1 |
| DTO2 | discrete third order frequency #2 |
| F1 | fundamental frequency #1 |
| F2 | fundamental frequency #2 |
| Hz | hertz |
| kHz | kilohertz |
| AIB | measured amplitude of intermodulation distortion beat |
| AF2 | measured amplitude at fundamental frequency #2 |
| ADSO1 | measured value of intermodulation beat at discrete second order frequency #1 |
| mHz | megahertz |
| NFCF | notch filter correction factor |
| Qty | quantity |
| SCTE | Society of Cable Telecommunication Engineers |

## 5.2. Definitions

| | |
|---|---|
| Intermodulation Distortion | Nonlinear distortion beats generated by a device that are linear combinations of the fundamental frequencies injected at the input of the device. |
| Discrete Second Order (DSO) | Discrete intermodulation distortion beats generated by the sum and/or difference of one or two carriers that pass through a non-linear component. |
| Discrete Third Order (DTO) | Discrete intermodulation distortion beats generated by the sum and difference three carriers that pass through a non-linear component. |

# 6. Equipment

Only equipment specific to this procedure is described in detail here. The Cable Telecommunications Testing Guidelines, ANSI/SCTE 96 2013, should be consulted for further information on all other equipment.

## 6.1. Required Equipment:

- Signal Generators, Qty 2: Used to generate the two CW carriers at the input to the device under test.
- Spectrum Analyzer: Used to measure the intermodulation distortion and requires a bandwidth equal to or greater than the return path bandwidth of the device under test.
- 2-way signal splitter/combiner: Combines the two signal sources and requires a bandwidth equal to or greater than the return path bandwidth of the device under test.
- Notch filter: This is used to notch the first fundamental carrier frequency at the output of the device under test. The center frequency of the notch shall be equal to fundamental frequency #1. The rejection at the center of the notch shall be > 70 dB. The passband shall encompass fundamental frequency #2 and all measured intermodulation frequencies. The flatness of the passband should be < 1.0 dB Peak-to Peak.
- 6 dB Pad: Used to isolate the notch filter from the DUT and provide a proper output load to the DUT.
- Network Analyzer: Used to measure the insertion loss of the notch filter to determine insertion loss correction factors at each intermodulation frequency to be measured and at fundamental frequency #2.

# 7. Setup

## 7.1. Test Frequency Determination

Prior to starting this test, a determination of the two fundamental frequencies, F1 and F2, desired at the input of the device under test and calculation of the intermodulation frequencies to be measured at the output of the device are required.

The intermodulation distortions to be measured at the output of the device under test consist of DSO intermodulation beats and DTO intermodulation beats: The frequencies of the beats are calculated as follows:

- Fundamental Frequency #1 = $F_1$ (1)
- Fundamental Frequency #2=$F_2$, where $F_2 > F_1$ (2)
- Discrete second order (DSO) beats to be measured:

- $DSO_1 = F_1 + F_2$ (3)
- $DSO_2 = F_2 - F_1$ (4)
- Discrete third order (DTO) intermodulation beats to be measured:
  - DTO1 = 2*F1 - F2 (5)
  - DTO2 = 2*F2- F1 (6)

The two fundamental frequencies and calculated DSO and DTO intermodulation beats shall be in the passband of the device under test.

Recommended fundamental frequencies are 13 MHz and 19 MHz which correspond to return channels T8 and T9.

- Fundamental Frequency #1, F1 = 13 MHz
- Fundamental Frequency #2, F2 = 19 MHz
- Discrete Second order beats:
  - DSO1 = 13 MHz + 19 MHz = 32 MHz, (7)
  - DSO2 = 19 MHz - 13 MHz = 6 MHz (8)
- Discrete third order beats:
  - DTO1 = 2*13 MHz - 19 MHz = 7 MHz (9)
  - DTO2 = 2*19 MHz - 13 MHz = 25 MHz (10)

### 7.2. Equipment Connection

Following the equipment manufacturer's recommendations, perform the appropriate warm-up and calibration procedures.

Prior to connecting the DUT in Figure 1, set the signal generators to the frequencies determined in 7.1 and to appropriate output levels for the device under test.

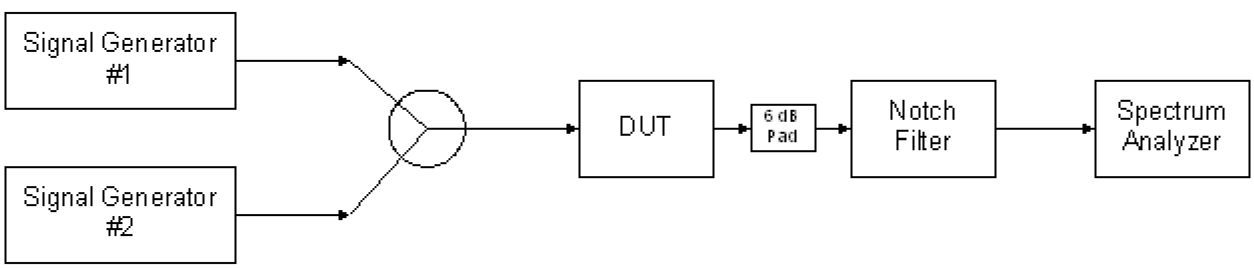


Figure 1 - Reverse Path Intermodulation Test Setup

## 8. Test Procedure

### 8.1. Notch Filter Correction Factor

With the network analyzer, measure and record the insertion loss of the notch filter at F2 and at each intermodulation frequency to be measured, DSO1, DSO2, DTO1, DTO2.

Calculate and record the notch filter correction factor (NFCF) for each intermodulation frequency:

- NFCF (dB) = Insertion loss at F2 – Insertion Loss at Intermodulation Frequency (11)

1) Set the Spectrum Analyzer as follows:
   - Center Frequency: $F_2$, Fundamental which is not notched.
   - Span: 1 MHz
   - Resolution Bandwidth: 30 kHz
   - Video Bandwidth: 30 Hz
   - Input Atten: 0 dB (unless carrier is higher than maximum reference level)

1. Perform a peak search to put the marker at the peak of F2
2. Set the reference level equal to the amplitude of F2
3. Measure the level of F2 on the spectrum analyzer and record the value and record as AF2.
4. Set the center frequency equal to DSO1. Perform a peak search and record the amplitude of the intermodulation beat at DSO1 (ADSO1).
5. Move the marker off the carrier and measure the Noise Floor Level as the level of the noise floor in the flat portion of the spectrum displayed on the spectrum analyzer.
6. Noise Floor Delta = ADSO1 – Noise Floor Level.
   (12)
7. For intermodulation beats that are within 10 dB of the noise floor level, a beat near noise correction factor is required. Calculate the beat near noise correction factor by using equation 13.

$$\text{Beat Near Noise Correction (dB)} = \left| 10\log\left(1 - 10^{\frac{\text{-Noise Floor Delta}}{10}}\right) \right| \text{dB} \qquad (13)$$

Note: Corrections for any beat near noise deltas less than 2.0 dB are subject to significant potential errors. For beat near noise deltas less than 2.0 dB, it is recommended that a 4.3 dB correction factor be used and the result be expressed as “less than” (<) -x dB.

8. Compute the corrected intermodulation distortion as:

   Intermodulation Distortion (dBc) =AF2 – AIB + BNNC – NFCF (14)

   Where: AF2 = Measured Amplitude of $F_2$
   AIB = Measured Amplitude of Intermodulation Distortion Beat
   BNNC = Beat Near Noise Correction Factor
   NFCF = Notch Filter Correction Factor

Note: This is a positive number, expressed in – dBc. Refer to the Definitions and Acronyms section of ANSI/SCTE 96 2008 for a discussion of these units.

9. Repeat steps 6 through 10 for each intermodulation frequency (DSO1, DSO2, DTO1, DTO2) to be measured.

# Appendix A: Test Report

Device under test

| Equipment Type: | | Manufacturer: | |
|---|---|---|---|
| Model Number: | | Serial number: | |

Test equipment

| Description | Manufacturer | Model Number | Serial Number | Calibration Date |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |

Test Frequencies

| Fundamental Frequency 1, $F_1$ | Fundamental Frequency 2, $F_2$ | DSO1 | DSO2 | DTO1 | DTO2 |
|---|---|---|---|---|---|
| | | | | | |

Test Results

| Freq | Notch Filter Insertion Loss (Step 8.1.1) | Notch Filter Correction Factor (step 8.1.2) | $AF_2$ (step 8.5) | Beat Amplitude (step 8.6) | Noise Floor Level (step 8.7) | Noise Floor Delta (step 8.8) | Beat near Noise Correction Factor (step 8.9) | Inter-modulation Distortion (dBc) (step 8.10) |
|---|---|---|---|---|---|---|---|---|
| F2 | | - | | - | - | - | - | - |
| DSO1 | | | - | | | | | |
| DSO2 | | | - | | | | | |
| DTO1 | | | - | | | | | |
| DTO2 | | | - | | | | | |

| Tested by | Date |
|---|---|
| | |