Society of Cable Telecommunications Engineers

ENGINEERING COMMITTEE
Interface Practices Subcommittee

AMERICAN NATIONAL STANDARD

ANSI/SCTE 126 2006

Test Method for Distortion of 2-way Amplifiers Caused by Insufficient Isolation of Built in Diplex Filter

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1.0 SCOPE AND DEFINITIONS

1.1 The purpose of this document is to establish the standard methodology to measure an amplifier's distortion caused by an upstream signal leaking through the diplex filter that is built inside of the amplifier of a Cable Telecommunications System (see Figure 1).

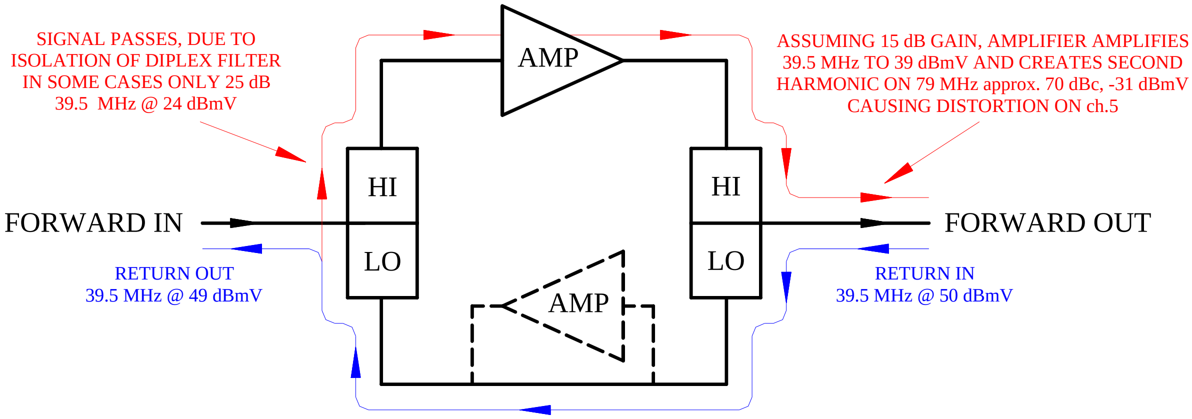

Figure 1

1.2 In a two way Cable Telecommunication Systems, amplifiers are commonly used to amplify downstream signals. These amplifiers, are designed as shown in Figure 1. They consist of two diplex filters with amplifier inserted in the high pass path, also known as the forward or downstream path. The low pass path (return or upstream) in most cases needs no amplification, and is used for upstream communication of modems, telephony, etc. In some cases, a return amplifier is used. Upstream communication uses high-level signals, reaching in some cases up to 55 dBmV. Serious problems with second harmonics can arise due to insufficient diplex filter isolation of amplifiers, as it can be seen in Figure 1. Diplex filter isolation is usually the worst at the end of the passband, for 5-40 MHz amplifiers at 38-40 MHz, for 5-42 MHz amplifiers at 41-42 MHz. If high-level signals are applied at these frequencies, second harmonics can be created causing distortion on the corresponding channel. If the amplifier also has a built in return amplifier, distortion problems can be even more serious, since the harmonic levels are higher by the gain of the return amplifier.

1.3 Measurement of this distortion is most practical by measuring the 2nd harmonic of a CW carrier, since signal generators and spectrum analyzers are commonly used in many other test procedures.

1.4 Please note that this procedure is a very unique procedure for testing 2-way amplifiers and distinguishes itself from other similar procedures in the following ways:

- It is designed for two-way Actives
- Measurement is Single Port, measures energy that leaks around the loop
- Injects reverse frequency into reverse input (forward output) and measure 2nd harmonic distortion at the same port
- Is designed to measure leakage due to insufficient isolation of built in diplex filter.
- The procedure requires measurements at multiple frequencies because this is a very frequency sensitive measurement.

For similar procedures, please reference the following:

- SCTE IPS TP 225: Test Method for Reverse Path (Upstream) Intermodulation Using Two Carriers
- SCTE IPS TP 227: Test Method for Second Harmonic Distortion of Passives Using a Single Carrier
- SCTE IPS TP 409: Test Method for Common Path Distortion

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 SCTE IPS TP 225: Test Method for Reverse Path (Upstream) Intermodulation Using Two Carriers

2.2 SCTE IPS TP 227: Test Method for Second Harmonic Distortion of Passives Using a Single Carrier

2.3 SCTE IPS TP 409: Test Method for Common Path Distortion

3.0 EQUIPMENT

Some test equipment is listed only as optional, and is used only if necessary as is explained in later sections.

3.1 Spectrum Analyzer

Agilent 8591C with 75 Ω input option and built in preamplifier, or equivalent. If a spectrum analyzer without a 75 Ω input option and preamplifier is used, an external preamplifier may be required.

3.2 Signal Generator

Variable frequency signal generator capable of delivering up to 60 dBmV (2nd harmonic distortion at least –40dBc), at frequencies 38 to 42 MHz, Agilent 8648C, or equivalent.

3.3 50 to 75 Ω matching circuitry, either transformer or Minimum Loss Pad (MLP)

3.4 Attenuator

Any 6 dB, 75 Ω attenuator can be used, such as Viewsonics FLN6-G or equivalent. The value can be lowered if the level at point ”A” (Figure 2) cannot reach the required level

3.5 Diplex Filter

Viewsonics’ VSREDP-40 or any equivalent diplex filter with the following specifications can be used:

High Pass Side	54-1000 MHz
Low Pass Side	5-42 MHz
Return Loss	> 16 dB

Isolation	> 45 dB
Pass band IL	< 1.5 dB

3.6 Low Pass Filter- Optional

This filter is used if the second harmonic distortion of the signal generator is too high and appears on spectrum analyzer when testing of the setup, described later in this document, is performed. The intention is to remove the second harmonic of the carrier; so any appropriate low pass filter with a passband of 5-42 MHz and a stopband 54-1000 MHz, and stopband attenuation of at least 30 dB can be used.

3.7 Band Pass or High Pass Filter- Optional

This filter is used if the diplex filter used does not have enough isolation to attenuate the main CW carrier in order not to overload the spectrum analyzer. Any high pass filter with a passband of 54-1000 MHz and a stopband 5-42 MHz, and stopband attenuation of at least 30 dB can be used, such as Viewsonics' VSHPF-40 or equivalent.

3.8 Amplifier - Optional

Required if the level out of the signal generator is not sufficient to reach the required level at the DUT.

3.9 For multiple output amplifier testing, the surge generator described in American National Standard procedure ANSI/SCTE 81 2003, formerly IPSTP210, is required.

4.0 SET-UP

4.1 Follow all manufacturer recommended calibration requirements for the spectrum analyzer and signal generator.

4.2 Connect all test equipment as shown in Figure 2, except for the connection between point “A” and the DUT.

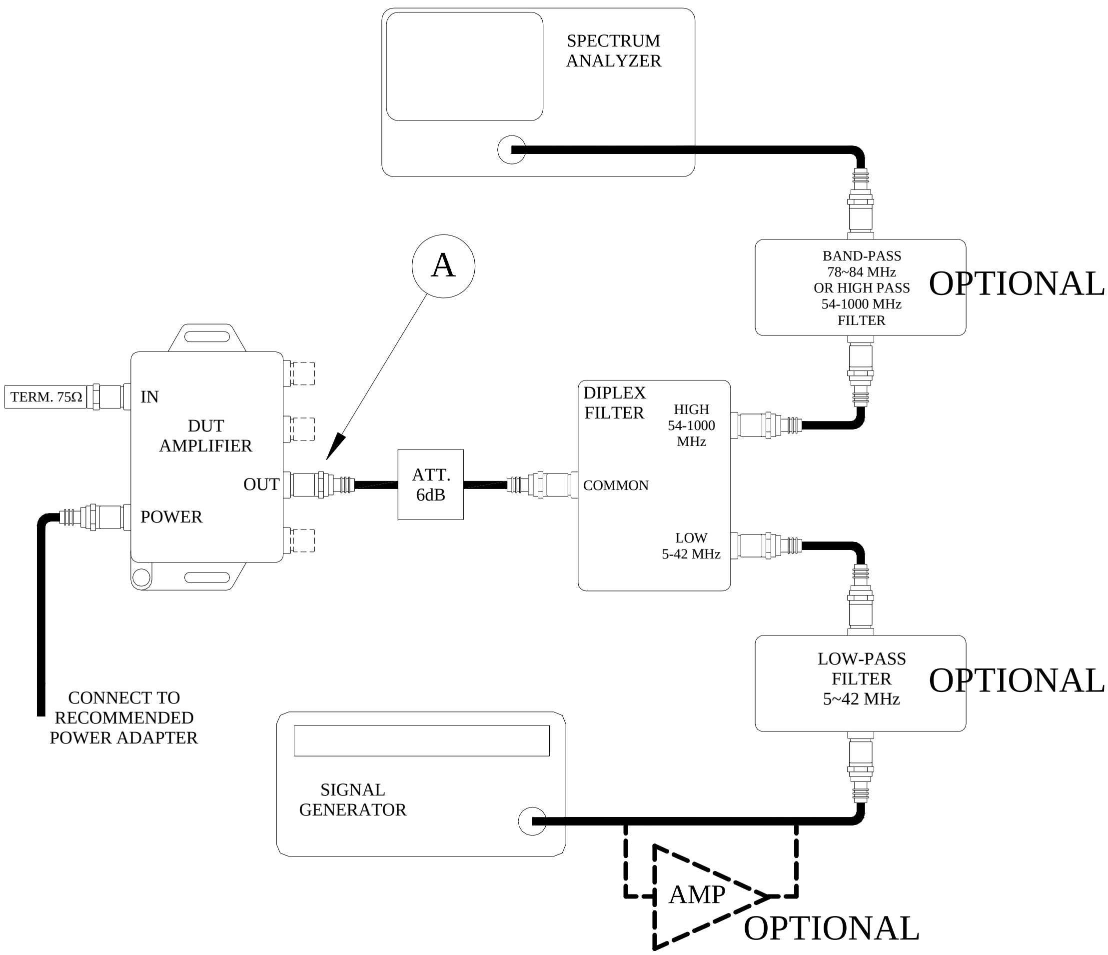
SPECTRUM
ANALYZER
BAND-PASS
78~84 MHz
OR HIGH PASS
54-1000 MHz
FILTER
OPTIONAL
A
TERM. 75Ω
IN
DUT
AMPLIFIER
OUT
POWER
ATT.
6dB
DIPLEX
FILTER
HIGH
54-1000
MHz
COMMON
LOW
5-42 MHz
LOW-PASS
FILTER
5~42 MHz
OPTIONAL
CONNECT TO
RECOMMENDED
POWER ADAPTER
SIGNAL
GENERATOR
AMP
OPTIONAL

Figure 2

4.3 2nd Harmonic Distortion Verification

4.3.1 Use setup described in figure 2.

* Disconnect Spectrum Analyzer from the high-pass port of the diplex filter (or from optional band-pass filter) and terminate the filter with a 75 Ω termination. Disconnect the cable from the DUT at point "A"and connect to the spectrum analyzer.
* Adjust the signal generator to the required test frequency.
* Adjust the signal generator power to get the specified Power Level "PL" at point "A". If the signal generator does not have enough output power, the optional amplifier must be used.

Caution: Be sure to use the appropriate spectrum analyzer attenuator setting to avoid damaging the spectrum analyzer

4.3.2 Adjust spectrum analyzer as follows:

Center Frequency:	2x the test frequency of signal generator
Span:	20 kHz
RBW:	1 kHz
VBW:	30 Hz
Attenuation:	0 dB
Internal Amplifier:	ON
Scale	10 dB/div
Reference Level	0 dBmV (provides >=80dB display range)

4.3.3 Connect a 75 Ω terminator to the 6dB attenuator at point "A". There should be no second harmonic distortion visible on spectrum analyzer. If the second harmonic distortion is visible, optional filters depicted in figure 2 should be installed.

4.4 Determination of Correction Setup Constant (CSC)

In order to get accurate readings during measurements, the insertion loss of the test setup from point "A" to the spectrum analyzer must be known and if an internal amplifier is used, the gain of the internal amplifier must be known. Inserting a known signal at the point "A" and reading the level of this signal on spectrum analyzer can determine this. The following procedure can be used:

4.4.1 Connect the signal generator directly to the spectrum analyzer; adjust signal generator frequency to 80 MHz.

4.4.2 Adjust spectrum analyzer as described in 4.3.2, except with a center frequency of 80 MHz and Internal Amplifier “OFF”.

4.4.3 Adjust the signal generator level to get a reading of –30 dBmV on spectrum analyzer.

4.4.4 Apply this level of the signal generator to the 6dB attenuator at point “A” of the test setup in figure 2, and read the value on spectrum analyzer adjusted exactly as described in 4.3.2 with center frequency 80 MHz and connected as seen in figure 2. If the internal amplifier is being used, make sure it is on.

4.4.5 The difference between the value read and –30 dBmV is the Correction Setup Constant “CSC”, and must be used in calculations of second harmonic distortion.

CSC [dB] = -30 dBmV - Value read [dBmV]

4.4.6 Determination of the test setup correction constant can be done at different frequencies if there is a suspicion that the response of diplex filter and/ or optional filters vary greatly between 40 MHz and the test frequency.

5.0 TEST PROCEDURE

5.1 Connect equipment as specified in figure 2. The signal Power Level “PL” must be adjusted as specified in paragraph 4.3.1.

5.2 Adjust the signal generator to the test frequency and the spectrum analyzer to the same setup as described in 4.3.2

5.3 Use the “Peak Search” function of the analyzer to read the Second Harmonic Level “SHL”. The “SHL” must be corrected using the Correction Setup Constant determined in 4.4.5

CSHL [dBmV] =SHL [dBmV] + CSC [dB]

In case the CSHL level is 10 dB or less above the noise floor of the spectrum analyzer, do the following: Record the Noise Floor Level as the level of the noise floor in a flat portion of the spectrum displayed on the SA. Compute Noise Floor Delta = CSHL Level – Noise Floor Level. If the Noise Floor Delta is less than 2 dB, it is recommended that the optional post-amplifier be added to the system. The measurement should then be made again. If, however, the Noise Floor Delta remains less than 2 dB, refer to ANSI/SCTE 96 2003, Section 8.2 for the proper Noise-Near-Noise Correction. If the Noise Floor Delta is greater than 2 dB, the following Noise Floor Correction Factor should be calculated:

$$\textit{Noise Floor Correction Factor}: 10 * \left|\log\left(1 - 10^{-\left(\frac{\text{Noise Floor Delta}}{10}\right)}\right)\right|$$

A table of values calculated from this equation is presented in ANSI/SCTE 96 2003, Section 8.2.
Compute Corrected CSHL as:
Noise-adjusted CHSL = CHSL + Noise Floor Correction Factor

5.4 For comparison reasons, it is important to also calculate the relative value of Second Order Distortion (SOD) with reference to input Power Level (PL) as follows:

SOD [dBc] = PL [dBmV] – CSHL [dBmV]

Use either CHSL or Noise-adjusted CHSL as appropriate as calculated in section 5.3

5.5 Suggested test frequencies, power levels, and recording tables are described in section 7, “RESULTS RECORDING, TEST FREQUENCIES AND LEVELS”.

6.0 AMPLIFIERS WITH INTEGRAL OUTPUT SPLITTERS

In addition to creating second harmonic distortion as described in section 1.0, multiple output amplifiers that utilize splitters at the output of the final stage of amplification create second harmonic distortion also due to nonlinearity of the ferrites used in splitter. This nonlinearity is caused either by magnetizing of the ferrites, or poor ability of the ferrites to handle high-level signals. The second harmonic distortion determined in this test is either caused by insufficient isolation of diplex filter, or nonlinearity of ferrites, or combination of both. For these reasons, in order to get the worst-case test results; the multiple output amplifiers must be exposed to magnetization currents of the specified surge for the product, as described in American National Standard procedure ANSI/SCTE 81 2003, formerly IPSTP210. There is no need to surge the amplifier with the full surge test as described in section 4.4 of IPSTP210, since this is not a surge withstand test, but a ferrite magnetization stimulation. Each output port must be exposed to 4 alternate ± 1kV 0.5 µs-100 kHz surges as defined in the standard mentioned above. The test procedure is then exactly the same as described in section 5.0, Test Procedure. Unused ports of the multiple output amplifier must be properly terminated during testing.

7.0 RESULTS RECORDING, TEST FREQUENCIES AND LEVELS

7.1 The table below shows the suggested test frequencies and power levels for measuring amplifier's distortion caused by diplex filter isolation with passband 5-40 MHz.*

Test Frequency f [MHz]	Power Level adjusted at "A" PL [dBmV]	2nd Harmonic Frequency f [MHz]	Correction Setup Constant CSC [dB]	Second Harmonic Level SHL [dBmV]	Corrected Second Harmonic Level CSHL [dBmV]	Second Order Distortion SOD [dBc]
38.5	50					
39.0	50					
39.5	50					
40.0	50					
38.5	55					
39.0	55					
39.5	55					
40.0	55					

7.2 The table below shows the suggested test frequencies and power levels for measuring amplifier's distortion caused by diplex filter isolation with passband 5-42 MHz.*

Test Frequency f [MHz]	Power Level adjusted at "A" PL [dBmV]	2nd Harmonic Frequency f [MHz]	Correction Setup Constant CSC [dB]	Second Harmonic Level SHL [dBmV]	Corrected Second Harmonic Level CSHL [dBmV]	Second Order Distortion SOD [dBc]
40.5	50					
41.0	50					
41.5	50					
42.0	50					
40.5	55					
41.0	55					
41.5	55					
42.0	55					

*Required power levels and test frequencies should be obtained from the specifications