Measuring Cable System Distortions

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***Abstract* - The aim of this measurement is to exactly measure the video carrier level, and then just as exactly measure the average power of the distortion products in the video bandwidth. The difficult part of the measurement is precisely determining the level of the distortion products in the presence of noise and video modulation. The most exact method for measuring distortion requires the removal of the video modulation for CSO and the removal of the video carrier for CTB.**

***Keywords* – CSO (composite second order), CTB (composite triple beet), CATV, nonlinear products**.

I. Introduction

Each Cable television (CATV) system contains active devices: amplifiers, modulators, converters and etc. Under certain conditions [1], one or more devices go in nonlinear mode. Consequently in output subscriber`s outlets has been appear nonlinear products, which worse picture quality. The knowing and measuring these nonlinear products is important step to limitation and decrease to them.

When a distortion product is due to components of different order, and/or different order products occur within the bandwidth of the device used to measure the level of distortion products, then the measured level will not follow a standard level variation [2].

In principle, an infinite number of terms are necessary for a complete description of a non-linear characteristic. However, considering the standard level variation of terms of different order, the relative contribution of higher order terms increases with the level of input signals. Conversely, if signal levels are low enough, only a few of the lowest order terms will produce significant contributions at the output.

If all input signals are limited to a frequency band of less than one octave, the frequencies of all second order terms will fall outside the band limits. Signal frequencies can also be allocated in two or more non-contiguous bands in a manner that will place all second order products outside the bands.

Third order distortion products, in particular some of the products that occur at frequencies represented by $\omega_1 \pm \omega_2 \pm \omega_3$ cannot be kept out of the band that contains the input signals. The accumulation of third order distortion products may therefore be a limiting factor in the performance of a wideband multi-channel distribution system.

The video carrier must be at least 60 dB above any interfering signals, except in a system with harmonically related carriers (HRC). In an HRC system, the video carrier must be at least 56 dB above the distortion product that falls at the video carrier frequency (CTB). This higher level of distortion is allowed because the synchronous nature of the CTB in an HRC system is less objectionable to the viewer than the asynchronous beat in a non-HRC system [3], [4].

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II. System Performances

The system and equipment requirements are matched to each other in such a way that the minimum requirements for signal quality at the subscriber's outlet can be met with a minimum of technical effort. In addition, requirements that result from use of both analog and digital signal transmission have also been taken into account. The EN 50083 standards provide the network operator, planner and installer with concrete guidelines for network design and selection of appropriate network components.

When the amplifier is designed for sloped operation, measurements shall be carried out with sloped output.

The tests outlined are applicable to various categories of amplifiers as follows.

1. For wideband amplifiers intended for operation with more than 10 television channels in the range below 862 MHz: composite triple beat, composite second order and composite cross modulation.

   Note: Manufacturers may also publish second order and third order intermodulation performance.

2. For amplifiers intended for operation with less than 10 television channels in the range below 862 MHz, including return path amplifiers below 70 MHz: second order and third order distortion.

   Note: The maximum number of channels shall be clearly stated in the specification.

For all cases on distortions: *second* and *third order*, *composite triple beat (CTB)* and c*omposite second order (CSO)* shall be published the worst-case value as the output level in dBμV, that gives 60 dB signal to distortion ratio.

Note: For some amplifiers (e.g. feed forward) it may not be possible to measure 60 dB distortions. In these cases, the output level for a greater signal to distortion ratio may be stated.

III. Method for Measuring on CTB and CSO

A. Composite triple beat (CTB).

The method of measurement of composite triple beat using CW (continuous wave) signals is applicable to the measurement of the ratio of the carrier to composite triple beat at a specified point in a cable network. The method can also be used to determine the composite triple beat intermodulation performance of individual items of equipment.

When the input signals are at regularly spaced intervals (as is common in most allocations for TV channels), the various distortion products tend to cluster in groups, close to the TV channels. The number of different products in each cluster increases rapidly with the number of channels, and they combine in different ways, depending on the degree of coherence between generating signals, and the relative phases of the different distortion products.

The method described in this sub clause measures the non-linear distortion of a device or system by the composite effect of all the beats clustered within ±15 kHz of the video carrier of a TV channel. During the measurement, the video carrier of that channel shall be turned off, so that the composite triple beat measured is that generated by all the carriers except that of the measured channel.

B. Composite second order (CSO)

Practically everything called for CTB have a bearing on CSO except that the second order beats are not clustered (±15 kHz) about the exact carrier frequencies but may be clustered (±10 kHz) at ±0,75 MHz or ±0,25 MHz from them. The carrier/composite second order distortion ratio can be read directly off the screen of the spectrum analyzer.

For composite second order it is also necessary to measure the beats close to the channel at 48,25 MHz or, where this is not possible with the equipment under test, at the lowest frequency available. Although it is not essential to have the carrier present at this frequency, it may be useful for reference purposes. In this case, the second order beats are clustered around 48,00 MHz ±10 kHz and so again may be read directly off the screen of the spectrum analyzer.

The worst case maximum output level giving the required signal to composite second order distortion ratio shall be noted for publication.

C. Measurement procedure

The measurement procedure comprises the following steps:

1. Connect point A directly to point B and disconnect the band pass (BP) filter (see Fig.1). Adjust the level of each generator for an output level at point A equal to that, which will be present when the system or device under test (DUT) is connected.
2. Adjust the spectrum analyzer as follows:
   - IF bandwidth 30 kHz
   - Video bandwidth 10 Hz
   - Scan width 5 kHz/div
   - Vertical scale 10 dB/div
   - Scan time 0,2 s/div.
3. Tune the spectrum analyzer so that the video carrier of the channel in which the measurement is to be made is centered on the display screen.
4. Adjust the sensitivity of the spectrum analyzer together with its internal and external input attenuator (75Ω/step 1 dB) in such a way that the response to the video carrier corresponds to a full-scale reference.

   At the same time the noise level shall be at least 10dB lower than the distortion level expected.
5. Insert the band pass filter corresponding to the channel to be measured and adjust the input attenuator to correct for the attenuation of the filter.
6. Disconnect the generator for the channel to be measured and terminate the combiner with its nominal impedance.
7. Verify that the intermodulation products generated in the spectrum analyzer over the entire channel are at least 20 dB below the distortion ratio required. If this is not the case, disconnect the band pass filter and repeat the steps 4 to 7 of this procedure with decreased sensitivity of the spectrum analyzer.
8. Note the setting of the sensitivity control.
9. Connect the signal generator again and repeat steps 3 to 8 of this procedure for all channels.
10. Connect the device to be tested between points A and B and reset the signal generators (SG) to obtain the required output levels at point B.
11. Adjust the center frequency of the spectrum analyzer as in step 3 and insert the appropriate band pass filter.
12. Adjust the input attenuator (internal or external) to return the response of the spectrum analyzer to the video carrier to full scale with the appropriate setting of its sensitivity control (see step 8).
13. Disconnect the generator for the channel to be measured and terminate the combiner with its nominal impedance.
14. The composite triple beats are clustered within ±15 kHz of the video carrier, so the signal/composite triple beat ratio can be read directly off the screen of the spectrum analyzer.
15. Adjust the attenuator Al of Fig. 1 to obtain the required signal/composite triple beat ratio and compensate for the change in output level by using attenuator A2.
16. Measure the signal level at the output of the device under test.
17. Repeat the steps 11 to 16 of this procedure for every channel used in this test.
18. The worst case maximum output level giving the required signal to composite triple beat ratio shall be noted for publication.

IV. EXPERIMENTAL SETUP

Fig.2 shows the experimental setup, where SGi have been replacing with signals from Head end's up-converters. DUT is CATV system on Technical University of Sofia. Channel number is 47. First channel is 49,75 MHz and last channel is 495,25 MHz.

Spectrum analyzer is PROMAX AE-476.

TABLE I presents experimental results for CTB and CSO by carrier frequencies from channel allocation on CATV system.

Fig.3, Fig. 4 and Fig.5 present the results from measurements of signals for channel 12 (223.25 MHz, standard D/K) and put him non-linear distortions.

TABLE I

Frequency MHz	CTB dB	CSO dB
49.75	61	64
119.25	62	62
175.25	61	61
191.25	62	62
207.25	62	62
223.25	63	63
231.25	61	66
247.25	61	63
263.25	62	63
287.25	62	64
311.25	61	63
327.25	61	61
343.25	60	61
359.25	60	61
375.25	61	63
391.25	62	63
407.25	62	63
479.25	61	62
495.25	62	61

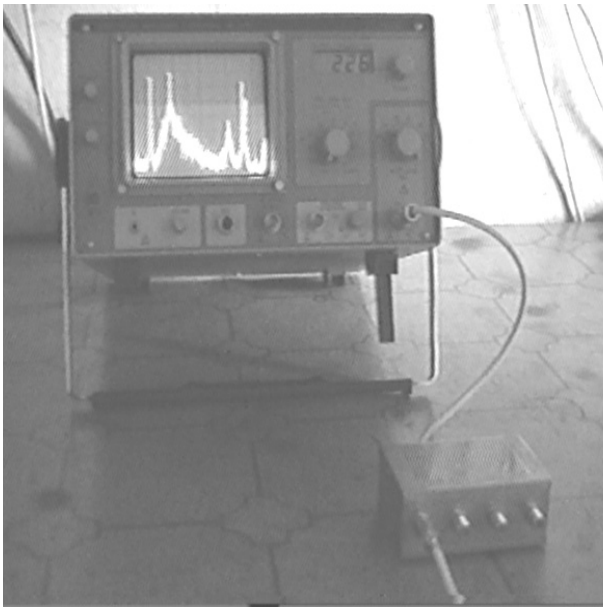

Fig.2. Measurement setup with a screen image of signals channel 12 (223.25 MHz, standard D/K)

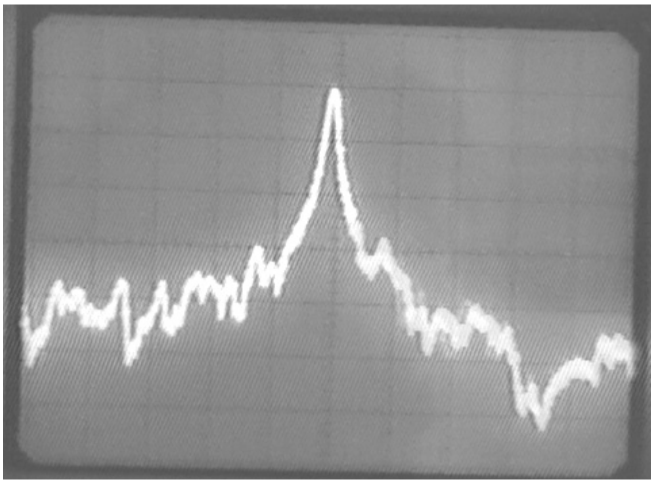

Fig.3.AM video signal (channel 12,D/K) with put non-linear products. Span 1 MHz, input level 80 dBμV, step 10 dB/div

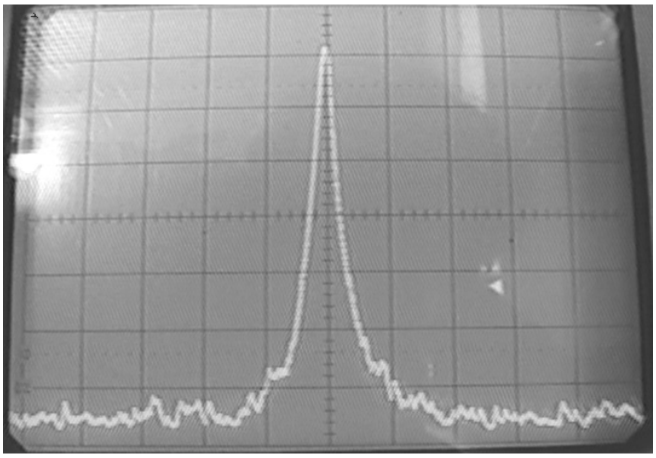

Fig.4. Videocarrier (223.25 MHz, D/K) with CSO and noise. AM absent

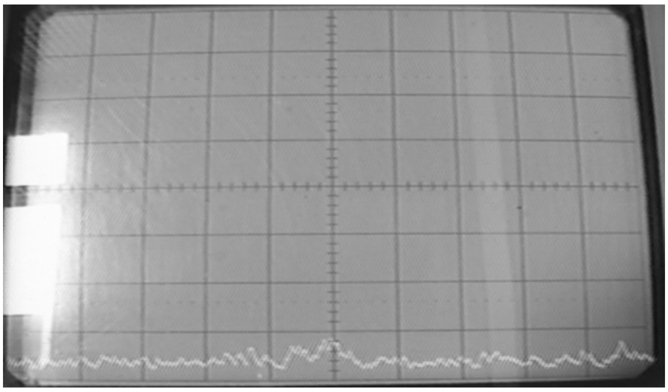

Fig.5. CTB and noise (channel 12,D/K). Videocarrier absent

V. CONCLUSION

The method is used to support a specification of the following general format:

The composite triple beat ratio for groups of carriers in channel (A) at (B) dBμV is (C) dB, where

(A) Designates the channel in which the test is made. If omitted, the specification is understood to be a minimum specification for measurements at all the channels specified by the list of carriers.

(B) Is the reference level at which all the carriers should be set during the measurement, unless otherwise specified. If all the carriers are not at the same level, the specification should clearly indicate the level of each carrier relative to the reference level.

(C) Is the composite triple beat ratio, usually given as a minimum specification.

Because of the large variety of frequency plans in use throughout Europe and the need to compare readily performance specifications of different manufacturer's equipment, the measurement shall be made with the carriers listed in Annex C, [2]. The carriers are all in an 8 MHz raster.

The video carrier frequencies are arranged in groups and only complete groups shall be used, except as stated below:

- Group A for amplifiers specified up to 450 MHz.
- Groups A and B shall be used if specified up to 550 MHz.
- Groups A, B, C, D and E shall be used if specified up to 862 MHz.

Group A also can be used in part, dependent on the specified bandwidth of the equipment under test. The frequencies deleted shall be stated. For all pass bands, the performance shall be quoted for the maximum possible number of complete groups. The manufacturer may, in addition, provide a performance figure for a larger number of carriers. The frequencies deleted shall be stated.

REFERENCES

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[2] European standard "EN 50083-3", aug.1998.

[3] http://www.gemini-inc.com

[4] Catalog "Hirschmann" , 2003.

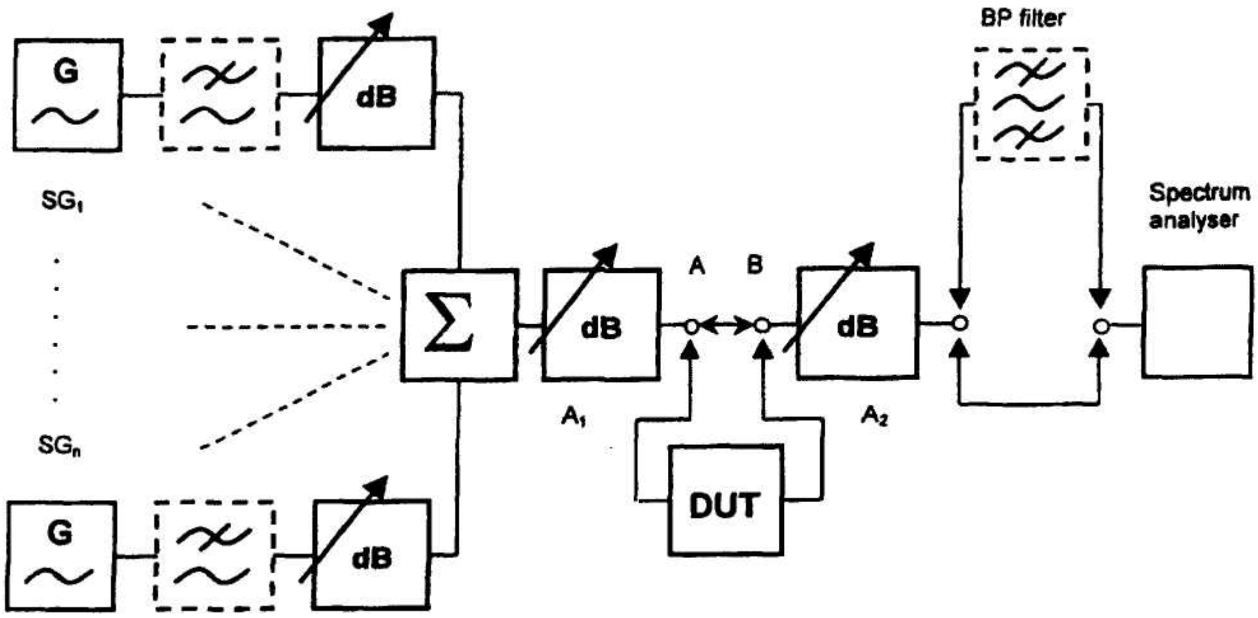

Fig.1. Connection of test equipment for the measurement of non-linear distortion by composite beat