CATV Terms and Terminologies

V 2.00

Introduction

CATV distribution networks are made up of a wide variety of technologies that help bring a multitude of channels and broadband internet access to the home. The network architecture starts with a headend and hub fiber optic rings and eventually makes its way down to RF distribution amplifiers. The RF amplifiers supply the signal to neighborhood homes. The current channel format in the United States, NTSC, has up to 136 channels ranging in frequency from 54 MHz to 870 MHz. This application note will focus on the terms and terminologies the CATV industry uses when specifying amplifiers and other components for their broadband RF networks. These are terms that are not often seen and understood by RF and microwave engineers.

dBmV

A common parameter widely used in the RF and microwave community is the decibel (dB). The decibel allows us to represent large power and voltage ratios as manageable numbers. The ratio of two power levels is as follows:

$$Ratio\ of\ P_1\ to\ P_2\ in\ dB = 10\log_{10}\left(\frac{P1}{P2}\right)$$

The ratio of two voltage levels is as follows:

$$Ratio\ of\ V_1\ to\ V_2\ in\ dB = 20\log_{10}\left(\frac{V1}{V2}\right)$$

In the RF and microwave world we like to define signal strength as a power ratio. The most common is dBm. dBm is the signal power relative to 1 milliwatt. The equation to convert dBm to milliwatts is as follows:

$$mW = 10^{\left(\frac{dBm}{10}\right)}$$

The CATV industry, however, prefers to define signal strength relative to 1 millivolt, or dBmV. If the system impedance Z is known there are two useful equations to convert dBm to dBmV and vice-versa. To convert dBm to dBmV:

$$dBmV = 10\log_{10}[Z \bullet 1000 \bullet 10^{\left(\frac{dBm}{10}\right)}]$$

Similarly, to convert dBmV to dBm:

$$dBm = 10\log_{10}\left[\frac{10^{\left(\frac{dBmV}{10}\right)}}{Z \bullet 1000}\right]$$

The system impedance in the CATV industry is usually 75 ohms. Figure 1 shows a conversion table for different signal levels in a 75 ohm system.

dBmV	dBm	mV	mW	dBmV	dBm	mV	mW
0	-48.8	1.0	0.0000	26	-22.8	20.0	0.0053
1	-47.8	1.1	0.0000	27	-21.8	22.4	0.0067
2	-46.8	1.3	0.0000	28	-20.8	25.1	0.0084
3	-45.8	1.4	0.0000	29	-19.8	28.2	0.0106
4	-44.8	1.6	0.0000	30	-18.8	31.6	0.0133
5	-43.8	1.8	0.0000	31	-17.8	35.5	0.0168
6	-42.8	2.0	0.0001	32	-16.8	39.8	0.0211
7	-41.8	2.2	0.0001	33	-15.8	44.7	0.0266
8	-40.8	2.5	0.0001	34	-14.8	50.1	0.0335
9	-39.8	2.8	0.0001	35	-13.8	56.2	0.0422
10	-38.8	3.2	0.0001	36	-12.8	63.1	0.0531
11	-37.8	3.5	0.0002	37	-11.8	70.8	0.0668
12	-36.8	4.0	0.0002	38	-10.8	79.4	0.0841
13	-35.8	4.5	0.0003	39	-9.8	89.1	0.1059
14	-34.8	5.0	0.0003	40	-8.8	100.0	0.1333
15	-33.8	5.6	0.0004	41	-7.8	112.2	0.1679
16	-32.8	6.3	0.0005	42	-6.8	125.9	0.2113
17	-31.8	7.1	0.0007	43	-5.8	141.3	0.2660
18	-30.8	7.9	0.0008	44	-4.8	158.5	0.3349
19	-29.8	8.9	0.0011	45	-3.8	177.8	0.4216
20	-28.8	10.0	0.0013	46	-2.8	199.5	0.5308
21	-27.8	11.2	0.0017	47	-1.8	223.9	0.6682
22	-26.8	12.6	0.0021	48	-0.8	251.2	0.8413
23	-25.8	14.1	0.0027	49	0.2	281.8	1.0591
24	-24.8	15.8	0.0033	50	1.2	316.2	1.3333
25	-23.8	17.8	0.0042	51	2.2	354.8	1.6786

Figure 1. Conversion Table

CTB and CSO

The distortion of the device is the most important parameter for the CATV industry. Lower distortion means fewer devices are needed to meet end-of-line performance. In the traditional RF and microwave world we often specify distortion in terms of 3rd order intercept point, or IP3. However, because of the large number of separate signals involved in CATV distribution systems, the CATV industry measures 3rd and 2nd order distortions in terms of Composite Triple Beat (CTB) and Composite Second Order (CSO) respectively.

Composite triple beat is defined as the ratio (in decibels) of the peak video carrier power to the peak of the aggregate distortion signal lying at the video carrier frequency. In essence, CTB represents the composite of many 3rd order IMD products. In a heavily loaded cable system, the number of 3rd order beats can be in the thousands causing nonlinear distortion effects during amplification. CTB is essentially an extreme case of typical two-tone, 3rd order IMD. The United States uses the NTSC channel plan, which places TV signals at 6 MHz intervals. The carrier frequencies, which contain most of the energy of the AM signals, are found at

$$f_c = 6 \bullet n + 1.25\ MHz$$

where n is an integer greater than 9

The CTB products fall at:

$$f_{CTB} = 6 \bullet (n \pm m \mp p) + 1.25\ MHz,\ 6 \bullet (n - m - p) - 1.25\ MHz$$

where n, m and p are integers greater than 9

This puts the CTB beats directly on the carrier as well as 1.25 MHz below the channel edge. The beats below the channel edge are very few in number and do not contribute much distortion. The beats that fall directly on the carrier frequencies can cause considerable distortion in the amplifier. The distribution of the beats is a gradual curve, with the largest number of beats falling near the center of the frequency band. However, because the distortion performance tends to decline with frequency, and because CATV amplifiers normally operate with an uptilted response, the worst CTB readings are usually found in the upper half of the frequency band.

Similarly, the CATV industry is concerned with CSO, which are the second order distortion products of the form:

$$f_{sum} = 6 \bullet (n+m) + 2.5\ MHz$$

$$f_{difference} = 6 \bullet (n-m)\ MHz$$

where n and m are integers greater than 9

Thus, the sum frequencies fall 1.25 MHz above a carrier and the difference frequencies 1.25 MHz below a carrier. In an NTSC system the carrier is 1.25 MHz above the lower edge of a channel, thus the difference frequencies fall in the border between two channels and are not thought to contribute to video interference. However, in other channel plans this may not be the case and the difference beats need to be considered. The number of sum beats increases with increasing frequency, so the composite power of beats falling 1.25 MHz above a carrier (high side CSO) increases for channels high in the frequency band. The difference beats (low side CSO) pile up at the low end of the frequency band. Figure 2 shows where the CTB and CSO beat frequencies fall in a standard NTSC channel.

XMOD

Cross modulation (XMOD) is a specification often seen in CATV industry specifications. Cross modulation is defined as the ratio of the peak-to-peak amplitude of the modulation on the test carrier (caused by the signals on other carriers), to the peak level of the carrier. Essentially XMOD is the unwanted modulation of any particular video carrier on the other channels in the system. The largest frequency component in a television signal is the horizontal sweep rate. For NTSC channels this is 15.75 kHz. This becomes the most noticeable component for cross modulation. This distortion is seen as a windshield wiper effect on the picture.

Hot Coring

A final specification that is not familiar to most RF and microwave engineers is hot coring. Hot coring is a phenomena that happens when technicians splice new amplifiers into existing infrastructure. To save time, the splicing is done when the lines are AC live, or “hot”. During the process, a coring tool is used to extract the insulation from the end of the cable. When this is done, the metal blades of the coring tool short the coaxial cable’s center conductor to the outer shield. This process causes sudden transients in AC voltage levels between +60 V and 0 V or –60 V and 0V. The energy from this is transferred to the RF band. CATV components need to be able to withstand this high energy level. Figure 3 shows a typical hot coring application in the field.

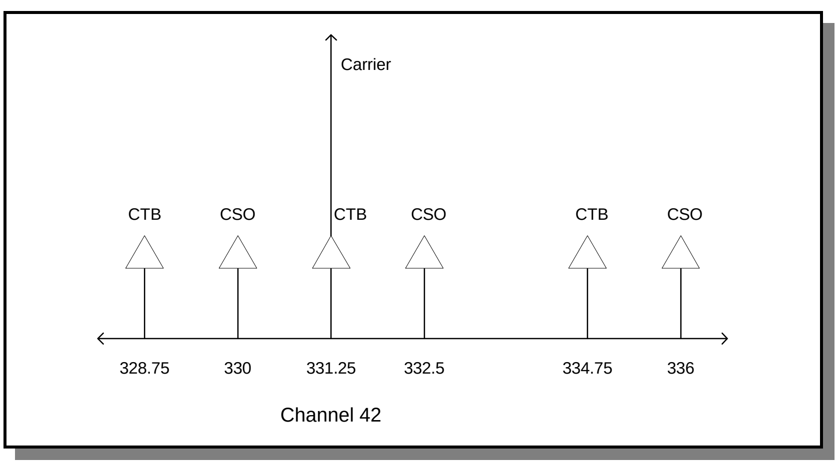

Figure 2. Carrier and Beat Frequencies for Standard NTSC Channel

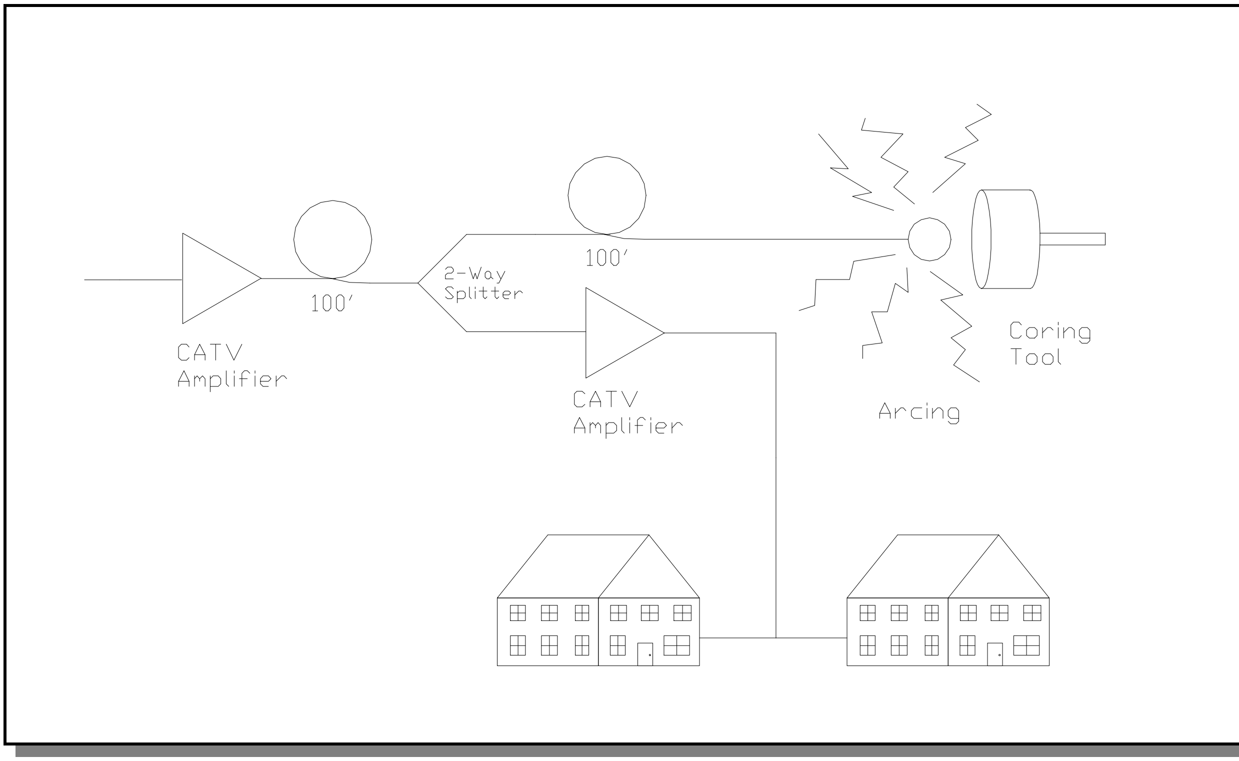

Figure 3. Hot Coring Application in the Field