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TUTORIAL 808

CATV dBm, dBmV, and dBµV Conversions

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Abstract: Cable television systems are based on 75Ω interfaces, while most RF test equipment is 50Ω impedance. This paper presents the needed conversions between power and voltage levels in the two environments. Two tables are provided for easy look-up of the appropriate conversion factor.

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Introduction

CATV circuits operate in a 75Ω environment. Most RF laboratories equipped with standard test instruments employ 50Ω as the standard interface impedance.

In this application note, it will be shown that:

$dBmV = 46.9897 + dBm_{50\Omega}$
$dBmV = 48.7506 + dBm_{75\Omega}$
$dB\mu V = 60 + dBmV$
$dB\mu V = 106.98 + dBm_{50\Omega}$
$dB\mu V = 108.75 + dBm_{75\Omega}$

dBmV and dBµV

Most CATV measurements are referenced to voltage and measured in dBmV or dBµV. In the classic definition, dBmV is referenced to $1mV_{RMS}$ and output voltage (V_{OUT}) is measured in mV_{RMS} (Equation 1). Since Equation 1 is a ratio of voltage, it can also be measured in mV_{P-P} referenced to $1mV_{P-P}$ or any voltage unit as long as the same units are used.

$$dBmV = 20\log_{10}\left(\frac{V_{OUT}}{1mV}\right); (V_{OUT} \text{ in mV}) \qquad \text{(Eq. 1)}$$

Inspection of Equation 1 shows dBmV to be independent of impedance.

In the classic definition, dBµV is referenced to $1\mu V_{RMS}$ and output voltage (V_{OUT}) is measured in μV_{RMS} (Equation 2). Since Equation 1 is a ratio of voltage, it can also be measured in μV_{P-P} referenced to $1\mu V_{P-P}$ or any voltage unit as long as the same units are used.

$$dB\mu V = 20\log_{10}\left(\frac{V_{OUT}}{1\mu V}\right); (V_{OUT} \text{ in } \mu V) \quad \text{(Eq. 2)}$$

Inspection of Equation 2 shows dBµV to be independent of impedance.

Conversion of dBm to dBmV

dBm is defined in Equation 3.

$$dBm = 10\log_{10}\left(\frac{P_{OUT}}{1mW}\right) \quad \text{(Eq. 3)}$$

P_{OUT} is measured in mW. The dBm is referenced to 1mW. Equation 3 does depend on impedance of the load as shown in Equation 4. Most RF equipment has a 50Ω load or input impedance. Equation 3 is still valid for any load impedance including 75Ω.

Power depends on load impedance. Equation 4 equates power to voltage and load impedance.

$$P_{OUT} = \frac{V_{OUT}^2}{R} \quad \text{(Eq. 4)}$$

Rearranging terms,

$$P_{OUT} \times R = V_{OUT}^2 \quad \text{(Eq. 4.1)}$$

Solving Equation 3 for P_{OUT},

$$P_{OUT} = (1 \times 10^{-3})10^{\left(\frac{dBm}{10}\right)} \quad \text{(Eq. 3.1)}$$

Solving Equation 1 for V_{OUT},

$$V_{OUT} = (1 \times 10^{-3})10^{\left(\frac{dBmV}{20}\right)} \quad \text{(Eq. 1.1)}$$

Substituting Equation 3.1 and Equation 1.1 into Equation 4.1,

$$R(1 \times 10^{-3})10^{\left(\frac{dBm}{10}\right)} = \left((1 \times 10^{-3})10^{\left(\frac{dBmV}{20}\right)}\right)^2 \quad \text{(Eq. 5)}$$

Solving for dBmV in terms of dBm,

$$dBmV = 10\log_{10}\left(\frac{R}{1 \times 10^{-3}}\right) + dBm \quad \text{(Eq. 5.1)}$$

Using R = 50Ω,

$$dBmV = 46.9897 + dBm_{50\Omega} \quad \text{(Eq. 5.2)}$$

Equation 5.2 is valid for 50Ω measurement equipment.

Solving Equation 5.1 using R = 75Ω,

$$dBmV = 48.7506 + dBm_{75\Omega} \quad \text{(Eq. 5.3)}$$

Equation 5.3 is valid for 75Ω measurement equipment.

Using the same technique it can be shown that the relationship for dBµV to dBmV is

$$dB\mu V = 20\log_{10}\left(\frac{1 \times 10^{-3}}{1 \times 10^{-6}}\right) + dBmV \qquad \text{(Eq. 6)}$$

$$dB\mu V = 60 + dBmV \qquad \text{(Eq. 6.1)}$$

Table 1 and **Table 2** show conversions between dBmV, dBµV and dBm in a 50Ω and 75Ω environment.

Table 1. Conversions of Power 50Ω

dBmV	dBµV	dBm 50Ω	mV_{RMS}	mW 50Ω
8	68	-38.99	2.51	1.3E-04
9	69	-37.99	2.82	1.6E-04
10	70	-36.99	3.16	2.0E-04
11	71	-35.99	3.55	2.5E-04
12	72	-34.99	3.98	3.2E-04
13	73	-33.99	4.47	4.0E-04
14	74	-32.99	5.01	5.0E-04
15	75	-31.99	5.62	6.3E-04
16	76	-30.99	6.31	8.0E-04
17	77	-29.99	7.08	1.0E-03
18	78	-28.99	7.94	1.3E-03
19	79	-27.99	8.91	1.6E-03
20	80	-26.99	10.00	2.0E-03
21	81	-25.99	11.22	2.5E-03
22	82	-24.99	12.59	3.2E-03
23	83	-23.99	14.13	4.0E-03
24	84	-22.99	15.85	5.0E-03
25	85	-21.99	17.78	6.3E-03
26	86	-20.99	19.95	8.0E-03
27	87	-19.99	22.39	0.010
28	88	-18.99	25.12	0.013
29	89	-17.99	28.18	0.016
30	90	-16.99	31.62	0.020
31	91	-15.99	35.48	0.025
32	92	-14.99	39.81	0.032
33	93	-13.99	44.67	0.040
34	94	-12.99	50.12	0.050
35	95	-11.99	56.23	0.063
36	96	-10.99	63.10	0.080

37	97	-9.99	70.79	0.100
38	98	-8.99	79.43	0.126
39	99	-7.99	89.13	0.159
40	100	-6.99	100.00	0.200
41	101	-5.99	112.20	0.252
42	102	-4.99	125.89	0.317
43	103	-3.99	141.25	0.399
44	104	-2.99	158.49	0.502
45	105	-1.99	177.83	0.632
46	106	-0.99	199.53	0.796
47	107	0.01	223.87	1.002
48	108	1.01	251.19	1.262
49	109	2.01	281.84	1.589
50	110	3.01	316.23	2.000
51	111	4.01	354.81	2.518
52	112	5.01	398.11	3.170
53	113	6.01	446.68	3.991
54	114	7.01	501.19	5.024
55	115	8.01	562.34	6.325
56	116	9.01	630.96	7.962
57	117	10.01	707.95	10.024
58	118	11.01	794.33	12.619
59	119	12.01	891.25	15.887
60	120	13.01	1000.00	20.000
61	121	14.01	1122.02	25.179
62	122	15.01	1258.93	31.698
63	123	16.01	1412.54	39.905
64	124	17.01	1584.89	50.238
65	125	18.01	1778.28	63.246
66	126	19.01	1995.26	79.621
67	127	20.01	2238.72	100.237
68	128	21.01	2511.89	126.191

Table 2. Conversions of Power 75Ω

dBmV	dBµV	dBm 75Ω	mV_{RMS}	mW 75Ω
8	68	-40.75	2.51	8.4E-05
9	69	-39.75	2.82	1.1E-04
10	70	-38.75	3.16	1.3E-04
11	71	-37.75	3.55	1.7E-04
12	72	-36.75	3.98	2.1E-04

13	73	-35.75	4.47	2.7E-04
14	74	-34.75	5.01	3.3E-04
15	75	-33.75	5.62	4.2E-04
16	76	-32.75	6.31	5.3E-04
17	77	-31.75	7.08	6.7E-04
18	78	-30.75	7.94	8.4E-04
19	79	-29.75	8.91	1.1E-03
20	80	-28.75	10.00	1.3E-03
21	81	-27.75	11.22	1.7E-03
22	82	-26.75	12.59	2.1E-03
23	83	-25.75	14.13	2.7E-03
24	84	-24.75	15.85	3.3E-03
25	85	-23.75	17.78	4.2E-03
26	86	-22.75	19.95	5.3E-03
27	87	-21.75	22.39	6.7E-03
28	88	-20.75	25.12	8.4E-03
29	89	-19.75	28.18	0.011
30	90	-18.75	31.62	0.013
31	91	-17.75	35.48	0.017
32	92	-16.75	39.81	0.021
33	93	-15.75	44.67	0.027
34	94	-14.75	50.12	0.033
35	95	-13.75	56.23	0.042
36	96	-12.75	63.10	0.053
37	97	-11.75	70.79	0.067
38	98	-10.75	79.43	0.084
39	99	-9.75	89.13	0.106
40	100	-8.75	100.00	0.133
41	101	-7.75	112.20	0.168
42	102	-6.75	125.89	0.211
43	103	-5.75	141.25	0.266
44	104	-4.75	158.49	0.335
45	105	-3.75	177.83	0.422
46	106	-2.75	199.53	0.531
47	107	-1.75	223.87	0.668
48	108	-0.75	251.19	0.841
49	109	0.25	281.84	1.059
50	110	1.25	316.23	1.333
51	111	2.25	354.81	1.679
52	112	3.25	398.11	2.113

53	113	4.25	446.68	2.660
54	114	5.25	501.19	3.349
55	115	6.25	562.34	4.216
56	116	7.25	630.96	5.308
57	117	8.25	707.95	6.683
58	118	9.25	794.33	8.413
59	119	10.25	891.25	10.591
60	120	11.25	1000.00	13.333
61	121	12.25	1122.02	16.786
62	122	13.25	1258.93	21.132
63	123	14.25	1412.54	26.604
64	124	15.25	1584.89	33.492
65	125	16.25	1778.28	42.164
66	126	17.25	1995.26	53.081
67	127	18.25	2238.72	66.825
68	128	19.25	2511.89	84.128

Related Parts		
MAX2165	Single-Conversion DVB-H Tuner	Free Samples
MAX3543	Multiband Analog and Digital Television Tuner	Free Samples
MAX3580	Direct-Conversion TV Tuner	Free Samples

More Information
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