The diaBolical dB

Understanding Logarithmic Scales And The deciBel

Blame your ears if you are having trouble dealing with decibels (dB). The dB was originally defined as a measure of relative acoustic power as perceived by the human ear, and the ear has a logarithmic response. The original unit of measure was defined as the Bel after Alexander Graham Bell. In practice the deci-Bel , 1/10 of a Bel, is used as defined in the following equation:

$$\mathbf{dB} = 10\log_{10}\left(\frac{P_2}{P_1}\right)$$

Based on this definition some common power ratios are:

P_2/P_1	dB
2:1	3
4:1	6
10:1	10
100:1	20
1:2	-3
1:4	-6
1:10	-10
1:100	-20

The logarithmic scale provides the best view of wide dynamic range measurements. As an example consider the FFT analysis of the waveform in figure 1. The lower trace is the power spectrum, displayed

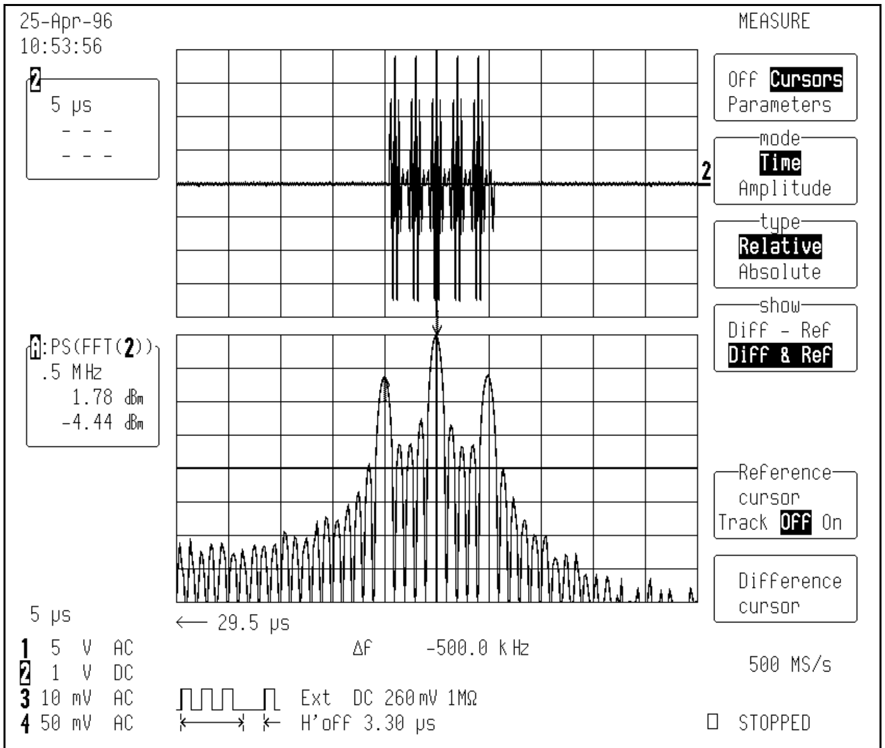

Figure 1

using a logarithmic scale. It covers an amplitude range of 100:1 or 40 dB in power. The dB scale overlays a linear grid on the logarithmic scale. This grid makes it easy to see data separated by common multiplicative factors. For example a 2:1 steps show up as 3 dB increments, 10:1 steps are 10 dB increments.

If you're given the relative power levels in dB you can calculate the ratio using:

$$\frac{P_2}{P_1} = \mathrm{antilog}\left(\frac{dB}{10}\right) = 10^{\frac{dB}{10}}$$

In many applications specific reference levels of power are used. In LeCroy oscilloscopes and most rf spectrum analyzers the power measurements are referenced to 1 milliwatt. The power spectrum display, in figure 1, has a vertical axis calibrated in dBm, that is dB relative to 1 milliwatt. The reference cursor, reading the spectral amplitude at the center of the display, reads 1.78 dBm. The absolute power can be calculated as:

$$\frac{P_2}{1mW} = anti\log\left(\frac{1.78}{10}\right)$$

$$= 10^{\frac{1.78}{10}} = 1.51$$

$$P2 = 1.51mW$$

Voltage ratios can also be expressed in dB. If you express power in the form of V^2/R with R the same for both measurements, then the definition of dB becomes:

$$\mathbf{dB = 10\log_{10}\left(\frac{V_2^{\,2}/R}{V_1^{\,2}/R}\right)}$$

$$\mathbf{= 10\log_{10}\left(\frac{V_2}{V_1}\right)^2}$$

$$\mathbf{= 20\log_{10}\left(\frac{V_2}{V_1}\right)}$$

Commonly used voltage ratios are:

V_2/V_1	dB
2:1	6
4:1	12
10:1	20
100:1	40
1:2	-6
1:4	-12
1:10	-20
1:100	-40

Given a voltage ratio in dB you can calculate the ratio of the voltages using:

$$\mathbf{\frac{V_2}{V_1} = anti\log\left(\frac{dB}{20}\right) = 10^{\frac{dB}{20}}}$$

The unit dBV refers to dB relative to 1 Volt. It simply means that V_1 in the voltage ratio equation is replaced by 1 Volt. So that 6 dBV has an absolute value of 2 Volts. Similarly dBµV is dB relative to a microvolt.

Relative levels in signal generators are often described in units of dBc, or decibels relative to the carrier level. For example an arbitrary waveform generator specification for non-harmonic spurious is < -60dBc. This means that spurious signals are 60 dB below (1/1000th) the current carrier voltage level.

Many other “specialized” reference levels are in use with the dB scales but these are the most commonly encountered when dealing with LeCroy oscilloscopes and signal generators.