Understanding dB, dBc, and dBm
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The term dB and its derivatives dBc and dBm are widely used in the specification and measurement of electronic circuits, particularly crystals, oscillators, and filters. The term dB defines a mathematical relationship that is used to compress large ranges of numbers into a more convenient format. The dB is based on a logarithmic scale and to understand its nature it is necessary to have a basic understanding of logarithms.

The common logarithm ($\log_{10}$ or simply log) is based on multipliers of the number 10. Other logarithmic scales can be derived from any base number. To grasp the concept of the relationship it is convenient to use a chart as shown here:

Number	$\log_{10}$
1	0
10	1
100	2
1000	3
1000000	6

For numbers less than one the logarithm is negative:

Number	$\log_{10}$
1/10	-1
1/100	-2

The logarithm of a number is equal to the exponent of the multiples of 10 required to generate the number.

For example:

Number	$\log_{10}$
$10 = 10^1$	1
$100 = 10\text{x}10 = 10^2$	2
$10,000 = 10\text{x}10\text{x}10\text{x}10 = 10^4$	4

For numbers that are not exact multiples of 10 the logarithm will be some fraction that will fall between the numbers shown in the table.
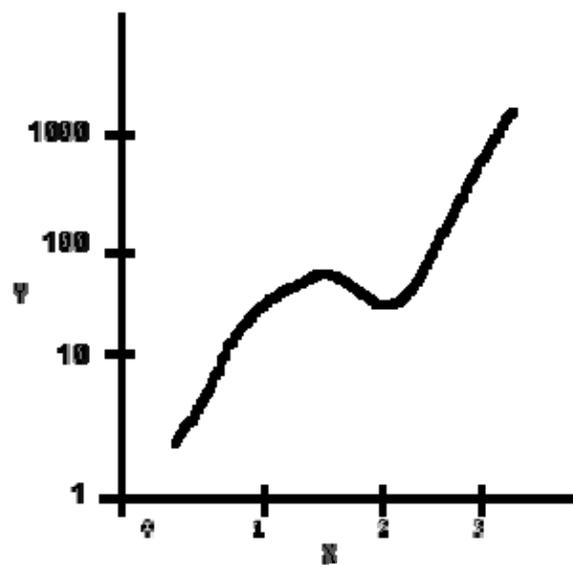
For example:

log 7 = 0.8451

log 250 = 2.3979

Before the advent of the hand held calculator, values for logarithms were printed in books (log tables) and their use required a considerable amount of arithmetic manipulation. Now with calculators readily available, logarithms can be easily looked up and used with the touch of a few buttons. Logarithmic scales are frequently used in graphs where a wide range of numbers are needed. The logarithmic scale expands the smaller numbers and compresses the larger numbers.

An example of the use in graphs is shown here where the x-axis uses a linear scale and the y-axis uses a logarithmic scale:

The decibel, based on logarithmic relationships, is widely used in electronic measurement and specifications.

The definition of the decibel as listed in the handbook *Reference Data for Radio Engineers* is:

"The decibel, abbreviated dB, is a unit used to express the ratio between two amounts of power, P_1 and P_2, existing at two points. By definition:

$$\text{number of dB} = 10 \log_{10} (P_1/P_2)$$

It is also used to express voltage and current ratios:

$$\text{number of dB} = 20 \log_{10} (V_1/V_2) = 20 \log_{10} (I_1/I_2)$$

It can be shown that all of these expressions represent equal conditions because power is proportional to the square of voltage or current. However, in using the unit dB, it is essential to define whether it is a power ratio or voltage/current ration.
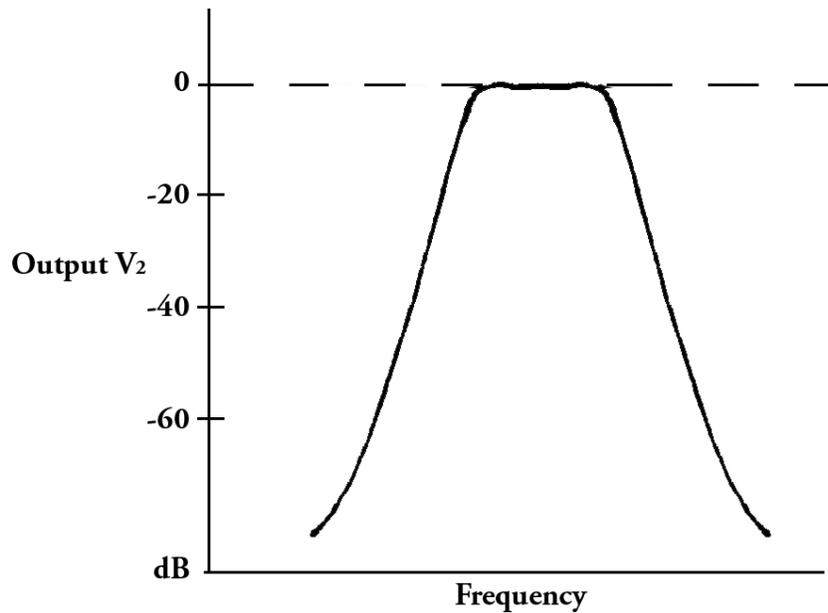
The decibel is normally used to define the frequency response of filters and also to describe the gain characteristics of amplifiers. In filters the frequency response is determined as follows:
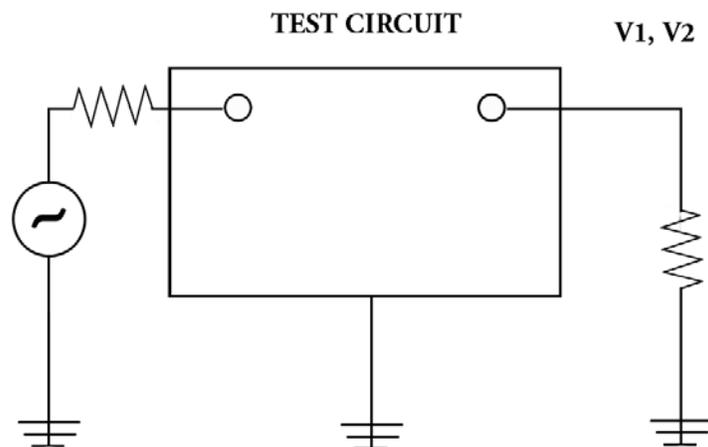
TEST CIRCUIT   V1, V2

Frequency Response

The voltage V_1 is defined as the level at the point of minimum loss, and V_2 is the voltage as a function of frequency. Because values for V_2 will be equal to or less than V_1 the scale will be negative.
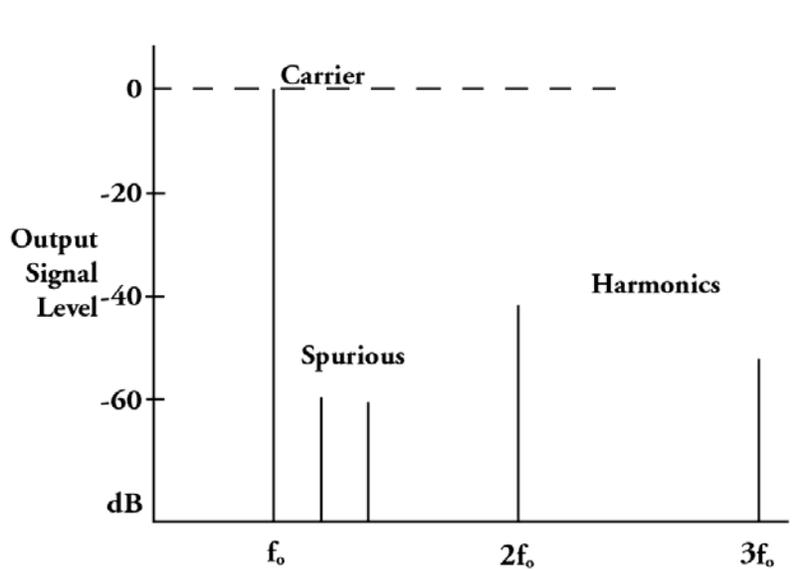
The decibel is also used to define the level of harmonic and spurious outputs in oscillators and VCO's. This is illustrated in the following diagram:

Harmonic and Spurious Signals in an Oscillator

Some examples of dB levels that are frequently specified are:

$-3dB = \frac{1}{2}$ power

$-6dB = \frac{1}{2}$ voltage

$-40dB = 1/100$ voltage

$-60dB = 1/1000$ voltage

To get a feel for the extremely low power levels specified in sideband noise for example:

$-100dBc = 1/1,000,000,000$ power

The term dBc stands for decibels below the carrier and is used in defining the sideband noise properties of oscillators. This is illustrated in the figure below:

Oscillator Sideband Noise Spectrum
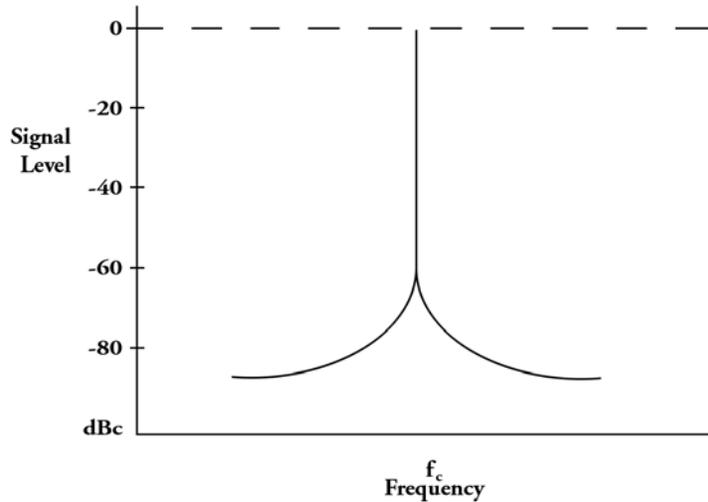
In this application the expression is a power ratio comparing the power in the carrier frequency of the oscillator to the power of the sideband noise contained in a one Hertz bandwidth. The scale of the y-axis will be in dBc.

The unit dBm was commonly used in the telephone industry as a reference power level and is defined as:

0 dBm = 1 mW of signal power

With this definition,

10 dBm = 10 mW
20 dBm = 100mW
30 dBm = 1 watt

-30 dBm = 1 microwatt

etc.