Bob's TechTalk #1
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Decibels (Part I of IV):

The Logarithm

Decibels are commonly used in the field of radio. They are used to indicate signal strength, antenna performance, gain and loss, and even power output. Microwave transmitters commonly used to transmit signals from point to point often have power ratings expressed in decibels instead of watts. How is your knowledge of decibels? This series of articles will help you gain a better understanding of what expressions like 40 dB over S9 really means.

Decibels are logarithmic in nature, so in part-one lets look at the concept of logarithms and why they're important. We'll do this with as little math as possible, and use only simple math when needed. Occasionally there will be sidebars for those who enjoy math, but you won't need to understand them to proceed.

Many hams have junk boxes, and in the junk box they usually have an assortment of common carbon resistors. Resistors are used in almost every electronic circuit and come in numerous shapes and sizes. They also come in a very large number of values. Common 5% film and carbon resistors are available from 1 ohm to 22 Meg (22,000,000) ohms in over 170 standard values. Let's say we want to plot these standard resistor values along the bottom of a graph. If the distance between where we plot the one ohm point and the two ohm point is a just one-tenth of an inch, the length of the graph would have to be over 34 miles! That's impracticable, especially since there are six standard values that need to be plotted between the one and two ohm points. Also, the next to the last standard value (20 Meg) ohm would be over three miles from the last point.

The solution is to use a logarithmic scale. This scale is based on powers of ten. Look at the following numbers; they are powers of ten:

10 =	10	$= 10^1$
10 X 10 =	100	$= 10^2$
10 X 10 X 10 =	1,000	$= 10^3$
10 X 10 X 10 X 10 =	10,000	$= 10^4$

(etc.)

In each case tens are multiplied together a different number of times to get the value shown. The expression on the right is a different way to express that value; the number in the superscript is just the number of tens used and is referred to as the exponent. Ten with an exponent of zero (10^0) is less intuitive. By definition it is one.

$$10^0 = 1$$

Not only can exact powers of ten be expressed in this manner. All the numbers in between them can also be expressed using decimal exponents. For example:

$$5 = 10^{0.7}$$
$$20 = 10^{1.3}$$
$$200 = 10^{2.3}$$
$$5000 = 10^{3.7}$$

Don't worry about calculating these exponents. It is difficult, and is the reason books containing "Tables of Logarithms" used to be common. Today the simple scientific calculator has replaced the need for extensive books of log tables.

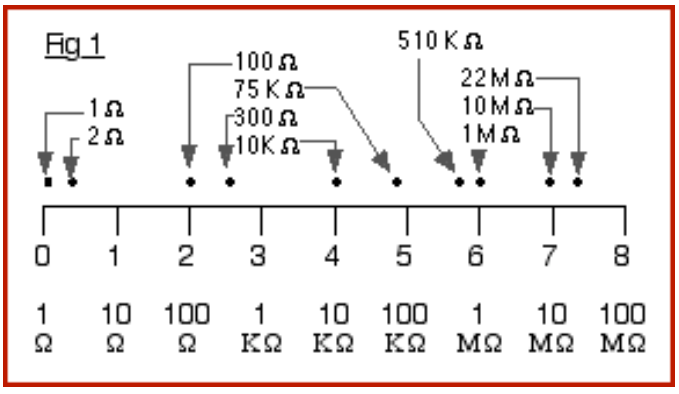
Numbers between zero and one can also be expressed by using negative exponents. Now we're dividing by ten instead of multiplying:

$$0.1 = 1/10 = 10^{-1}$$
$$0.01 = 1/10 \text{ X } 1/10 = 10^{-2}$$

So what is a logarithm? It is just a way to express one number with another number based on the exponent of the power of ten. Why use logarithms? It allows you to express a large range of numbers with small numbers. To show this, let's go back to our example of plotting standard resistor values. Here are ten standard resistor values and their logarithms:

1 ohm	0.0
2 ohms	0.3
100 ohms	2.0
300 ohms	2.5
10,000 ohms	4.0
75,000 ohms	4.88
510,000 ohms	5.71
1 Meg ohms	6.0
10 Meg ohms	7.0
22 Meg ohms	7.34

Figure 1 shows the resistors plotted by value logarithmically. Usually only the value is given on plots, as in figure two. Since the values increase by multiples of ten on each large division of the plot, the plot can be distinguished as being logarithmic. Just about every *A.R.R.L. Handbook* since before 1944 has a reactance chart that uses logarithmic scales for the frequency and reactance axes.



Notice in the table that orders of ten each take up the same amount of room on the bottom scale. The same axis space is given to values between 1Ω and 10Ω as between 100KΩ and 1MΩ. Thus the space between 1Ω and 2Ω is the same as the space between 1MΩ and 2MΩ.

Logarithms - some interesting facts:

- Logarithms can use base numbers other than ten. The mathematical value "e", (2.71828...) which has certain properties only a mathematician can enjoy, is a common base. Logarithms based on "e" are called natural logarithms.
- Negative numbers do not have logarithms.
- While very small numbers can be expressed easily with logarithms, zero cannot.
- Numbers can be multiplied together by adding their logarithms.
- Numbers can be divided by subtracting the logarithm of the denominator from the logarithm of the numerator.
- These last two principles are the basis of the slide rule.

73, from AF6C

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