Bob's TechTalk #3
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Decibels (Part III of IV):

Simple dB Calculations

In Bob's TechTalk #2 we discussed decibels and how they allow you to express ratios of power (and voltage and current when you follow the rules!) This month you're going to learn some practical techniques so you can estimate dB conversions right in your head. Problems like those that follow can be answered within reasonable approximation with no calculator needed!

"How many dB gain is an amplifier that has an input of one watt and an output of 400 watts?" or:

"A microwave transmitter has a specified power output of 37 dBm. How many watts is that?" or:

"You have a 150 foot run of RG-8 that you are feeding with your 100 watt transceiver. How much power reaches the antenna when you're on the 10 meter net? (Assume RG-8 has a loss of 3.33 dB per 100 feet at an SWR of 1.5:1 on 10 meters)"

In the first part of this series we talked about powers of ten. You know that every 10 dB represents a ratio of 10 times the power (or one-tenth the power if it is a loss). The following are all referenced to 1 watt (dBw):

+30 dBw =	1,000 watts
+20 dBw =	100 watts
+10 dBw =	10 watts
+0 dBw =	1 watt
-10 dbw =	0.1 watt
-20 dBw =	10 mW
-30 dBw =	1 mW = 0 dBm

Now that's easy! But what happens when numbers other than multiples of tens are used? Here's one to memorize:

+3 dB represents doubling the power and inversely -3 dB represents halving the power.

This simple approximation can often get us close. Remember that adding dB is the same as multiplying power. Therefore:

6 dB = 3 dB + 3 dB = twice times twice or 4 times the power.

9 dB = 3 dB + 3 dB + 3 dB or eight times the power.

12 dB = 3 dB + 3 dB + 3 dB + 3db or sixteen times the power.

In a similar manner, other values can be quickly calculated by remembering that subtracting dB is the same as dividing power:

4 dB = 10 dB - 6 dB or 10 / 4 times, or 2.5 times the power.

7 dB = 10 dB - 3 dB or 10 / 2 times, or 5 times the power.

5 dB = 12 dB - 7 dB or 16 / 5 times or 3.2 times the power.

2 dB = 12dB - 10 dB = 16 / 10 or 1.6 times the power.

With a bit more difficulty of calculation:

8 db = 4 dB + 4 dB = 2.5 x 2.5 or 6.3 times the power.

Finally, you can calculate 1 dB:

1 dB = 10 db - 9 dB = 10 / 8 = 1.25 times the power.

Table One lists these approximate values as the approximate gain and loss along with the more accurate calculated gain value and percentage error. Our answers are pretty close, with all except 5 dB having less than a one percent error!

Now let's solve the problems at the beginning of this article:

One watt in and 400 watts out is a gain of 400. 20 dB is a gain of 100. Three dB more would double the 100 watts to 200 watts and another 3 dB would give us 400 watts. 20 + 3 + 3 = 26 dB. If you calculate it out using the formula you get 26.02 dB. Our answer is quite close!

A microwave transmitter has an output of +37 dBm, which is 37 dB greater than one milliwatt. Thirty dB represents one thousand times, so 30 dB is 1,000 milliwatts or 1 watt and 40 dB is 10 watts. Since the value is 3 dB less than 10 watts it is half of ten watts or 5 watts. (1 milliwatt + 30 dB + 10 dB - 3 dB, or 1 milliwatt x 1,000 x 10 / 2 or 5 watts). The calculated answer is 5.01 watts.

	Approximate		Calculated	
dB	**Gain**	**Loss**	**Gain**	**Error**
1	1.25	0.8	1.2589	0.71%
2	1.6	0.6	1.5849	0.95%
3	2.0	0.5	1.9952	0.24%
4	2.5	0.4	2.5118	0.47%
5	3.2	0.32	3.1622	1.19%
6	4.0	0.25	3.9811	0.48%
7	5.0	0.2	5.0118	0.24%
8	6.3	0.16	6.3095	0.94%
9	8.0	0.12	7.9432	0.71%
10	10.0	0.1	10.0000	0.00%

Table One

Finally, since your antenna feed line is 150' the loss is 3.33 dB times 1.5 or 4.99 dB. We'll round it to 5 dB. From the table we know 5 dB is 3.2 times. Since it is a loss, we must divide. 100 / 3.2 is about 31, so 31 watts reaches the antenna, and 69 watts is lost in the coax. If you don't have the table handy remember that a 6 dB loss leaves you with one quarter of the power or 25 watts. Five dB is one dB less or 25 watts x 1.25 or 31 watts! The calculated answer is 31.26 watts. It's wizardry! But you might want to invest in better coax or shorten the run.

Problems:

Here are four problems for you to work out. Three of the four are multiple choice. Write your answers in the boxes supplied. You'll know if your answers are correct!

1. Two thousand watts output is how many dBm?
   - (a) 63 dBm
   - (b) 33 dBm
   - (c) zero dBm
   - (d) 1000 dBm
   - (e) 220 volts
   - (f) none of the above

2. Your feed line has a small loss of just 1 dB. How much of the 125 watt transmitter output power is lost in the feed line?
   - (a) 1 watt
   - (b) 1.25 watts
   - (c) 99 watts
   - (d) 50 watts
   - (e) 156 watts
   - (f) 25 watts

Your highly accurate inline wattmeter measures 20 watts when placed between the output connector of your 70 CM rig and the feed line. When moved to the other end of the feed line, so it is in line between the feed line and the antenna, it reads 5 watts. Write the feedline loss in dB in box 3.

4. John's new VHF "brick" amplifier produces 60 watts of output when excited with his 3 watt handheld. What is the gain in dB of the "brick"? What is 60 watts in dBw?

(a) 20 dB and 38 dBw
(b) 43 dB and about 13 dBw
(c) 13 dB and a bit under 18 dBw
(d) 13 dB and about 38 dBw
(e) 20 dB and just over 18 dBw
(f) 43 dB and about 13 dBw

Put your answers in the boxes provided:

1	2	3	4

By now you should have a good feel for converting between dB and power ratios. You might want to copy Table One and keep it handy in your shack.

Accuracy:
Ten dB is exactly a power gain of ten; however 3 dB is not exactly equal to a power gain of two. The correct value is closer to 1.9952, an error of just under one-quarter of a percent. Thus a small error is introduced in our calculations each time 3 dB is used. Our approximation for 9 dB uses three dB three times, thus an error of about 0.72% should be expected. A look at the error column can give you a good clue as to how many times the 3 dB approximation is used for determining that gain value.

Answers:

Problem 1: (A)
Two thousand watts is 10 x 10 x 10 x 2 watts or 10 + 10 + 10 + 3 dBw = 33 dBw. However the questions asks for dBm (referenced to milliwatts) and 0dBw = 30 dBm. Thus the correct answer is 63 dBm.

Problem 2: (F)
A one-dB loss in the cable will result in a loss that allows only 0.8 times the power to reach the antenna. (0.8 = 1 / 1.25)

0.8 x 125 watts = 100 watts.

Thus 25 watts or 20% of the power is lost in the feedline.

Problem 3: (6)
You are feeding 20 watts into the feedline and only 5 watts, or one-quarter of the power appears at the far end. If half the power made it through the loss would be 3 dB, but only half of half of the power arrives so the loss is 3 dB + 3 dB or 6 dB.

The 'S' Meter:
In an earlier part of this series I mentioned the S-meter. Only on the most expensive commercial grade communications receivers does the S-meter read the actual signal voltage. On most ham equipment the S-meter can only give relative signal strength readings. In the fifties some manufacturers claimed an S–9 reading represented a specific received signal strength, though the value varied from company to company. A commonly heard reference is that each S–unit increase represents twice the signal strength (voltage) which relates to four times the power. (i.e. 6 dB) and that S9 represents a signal level of 50µV. How good is your S–meter? You can find out by building a step attenuator. In next month's Tech Talk we're going to look at attenuators and some of the things they can be used for.

Problem 4: (C)
John's amplifier has a power gain of 60 / 3 or 20. A gain of ten is 10 dB, so a gain of 20 would be twice that or 3 dB more, giving 13 dB.

Sixty watts takes a little thought. Fifty watts is 5 times 10 watts or 7 + 10 dB. To add one more dB multiply 50 by 1.25 and you get 62.5W for 18 dBw. Thus you can approximate that 60 watts is a bit under 18 dBw (The correct answer is 17.78 dB - an error of just over 1.2%).

73, from AF6C

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Answers to the Quiz
from Bob's TechTalk #3