The Power of the Decibel

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One of the questions asked by many is how much power makes a difference in transmit range in either HF or VHF/UHF frequencies? This question more likely comes up when looking for an amplifier to boost the transmit power of the base power of a transceiver. Another item might be the gain of an antenna. With respect to a transmitter 3 dB will double the transmit power. Going from a basic 100 Watt level to 200 Watts produce 3 dB of gain. The same can be said of an antenna: Using an antenna with 3 db of gain will effectively double the transmit power. The gain can be equal all around the antenna if it is an omnidirectional array. A directional array may produce 3 dB of gain in one basic direction. An example of directional antennas would be a yagi; a log periodic, a corner reflector, a Moxon, etc. Antenna gain is usually referenced to an imaginary point source called isotropic. Thus, many antennas are labeled with gain referenced to dBi, or Decibel referenced to an isotropic source. Practically an antenna can be measured referenced to a dipole antenna. Such an antenna is labeled as gain referenced to dBd, or Decibel referenced to a dipole. The difference between an isotropic source and a dipole source is 2.15 dB. To make the math easier the reference can be just 2 dB. Therefore, an antenna with a gain of 6 dBi can be looked as 4 dBd; referenced to a real world dipole antenna. (In actuality, the gain is 6 dBi – 2.15 dB = 3.85 dBd.)

I) <u>Calculating (converting) transmitter power (Watts) into dB.</u>

Going back to the transceiver example doubling the transmit power by 3 dB will produce 200 Watts. How will this show as gain on a receiver. By convention, an S-Unit equals 6 dB. So, going from 100 Watts to 200 watts will show an increase of ½ an S-Unit. To get a full S-Unit the transmitter needs to be increased by another 3 dB, or 6 dB in total. To get a full S-Unit increase the 100 Watt transmitter would need to be 400 Watts. This is why many manufactures claim that a 600 Watt HF amplifier is the best bang for the buck. So how much gain is 600 Watts over a 100 Watt level. The Wattage figures need to be converted to db, then the difference in db needs to converted back to Watts.

There are two reference levels for VHF/UHF transmitters: 1) dBW: db referenced to a Watt, and 2) dBm: dB referenced to 1 milliwatt. (Note, in the broadcast industry transmit levels are referenced to dBk, or db referenced to 1 Kilowatt.) The most common reference is dBm. To calculate dBm use formula (b) where 100 Watts equals 50 dBm. For 600 Watts dBm = 10log(600/0.001); equals 10log(600,000); equals 10(5.7781513); equals 57.781513 dBm. Going from 100 watts to 600 Watts has a gain of 7.778 dB, which is slightly more than 1 S-Unit.

Watts to dBW = 10log(Pwr/1) **(a)**

100 Watts = 10log(100/1)
= 10(2)
= **20 dBW**

Watts to dBm = 10log(Pwr/.001) **(b)**

100 Watts = 10log(100/.001)
= 10log(100,000)
= 10(5)
= **50 dBm**

Many hams have a 1 KW amplifier and would like the ability to go for the legal limit of 1.5 KW. What gain advantage will there be.

1,000 Watts = 10log(1,000/0.001)
= 10log(1,000,000)
= 10(6)
= 60 dBm

1,500 Watts = 10log(1,500/0.001)
= 10log(1,500,000)
= 10(6.1760913)
= 61.760913 dBm

Going from 1,000 Watts to 1,500 Watts produces a gain of 1.76 dB. You be the judge.

Formula (c) is used to calculate Watts from dBm.

dBm to Watts = 0.001 * 10$^{(dBm/10)}$ **(c)**

50 dBm = 0.001 * 10$^{(50/10)}$
50 dBm = 0.001 * 10$^{(5)}$
50 dBm = 0.001 * 100,000
= **100 Watts**

II) Calculating (converting) microvollts (µv) into dBm.

To calculate the gain or loss of a received signal knowing the µv level, the µv value needs to be converted into dBm. Formula (d) shows the formula to calculate dBm from µv value. From the example it is shown that 0.35 µv is equal to -116.10834 dBm. What is the difference from 0.35 µv to 0.5 µv? Using formula (d)

µv to dBm = 20log((µv/7.0710678)-120)+30 **(d)**

0.35µv = 20log(.35/7.0710678)-120+30
= 20log(0.0494975)-120+30
= 20(-1.305417)-120+30
= (-26.108339-120)+30
= -146.10834+30
= **-116.10834 dBm**

0.5 µv = 20log((0.5/7.0710678)-120)+30
= 20log(0.0707107)-120+30
= 20(-1.150515)-120+30
= (-23.0103)-120+30
= -143.0103+30
= -113.0103 dBm

From the calculations going from 0.35µv to 0.5µv is a loss of 3.0980401 dB. Conversely, going from 0.5µv to 0.35µv is a gain of 3.0980401 dB. That is a change of ½ an S-Unit.

Formula (e) shows the calculation to convert dBm to µv. The example below shows the calculation to convert -116 dBm to υv. From the example below -116 dBm is equal to 0.3543929 µv.

dBm to µv = $10^{(dBm/20)+6)}$ * SQRT(0.05) **(e)**

$= 10^{((-116/20)+6)}$ * SQRT(0.05)
$= 10^{((-116/20)+6)}$ *0.2236068)
$= 10^{(-5.8 + 6)}$ * 0.2236068)
$= 10^{(0.2)}$ * 0.2236068
= 1.58848932 * 0.2236068
= **0.3543929 µv**