EECS 622: Homework #16

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Problem 1

The power available at the input of a two-port matched device is:

$$dBm\,[P_{avl}] = -50.0$$

while the power absorbed by a matched load at its output is:

$$dBw\,[P_{abs}] = -60.0$$

Express the power gain of this device in decibels.

Solution:
These need to be of the same scaling, I'll choose set both in dBm. Power absorbed is then -30 dBm, since dBm scales the same as dBw with an offset of 30 dB. Gain is defined as:

$$G \equiv \frac{P_{abs}}{P_{avl}}$$

In logarithmic scaling, this is instead division;

$$G = -30 + 50 = 20\ \text{dB}$$

Problem 2

An oscillator generates an output signal of 100 mW .
Unfortunately, it also produces a 50 micro-Watt spurious signal.
Express the spurious signal power:

A. with the dBw operator.

Solution:

dBw normalizes to 1 W.

$$50\mu\text{W} = -10\log_{10}\left(\frac{50\ \mu\text{W}}{1\ \text{W}}\right) = 43\ \text{dBw}$$

B. with the dBm operator.

Solution:

dBm normalizes to 1 mW.

$$50\mu\text{W} = -10\log_{10}\left(\frac{50\ \mu\text{W}}{1\ \text{mW}}\right) = 13\ \text{dBm}$$

C. with the dBc operator.

Solution:

dBc normalizes to the output signal power.

$$50\mu\text{W} = -10\log_{10}\left(\frac{50\ \mu\text{W}}{100\ \text{mW}}\right) = 33\ \text{dBc}$$

An oscillator generates an output carrier signal with power:

$$dBm\,[P_{\text{out}}] = 10.0$$

Unfortunately, it also produces a first harmonic with power of -40 dBm, and a second harmonic at $-50dBm$. Express:

A. the power of the first harmonic in dBc.

Solution:

This is normalized to the fundamental:

$$-40\ \text{dBm} = 10^{-40/10}\ \text{mW} = 0.1\mu\text{W}$$
$$10\ \text{dBm} = 10\ \text{mW} = 10\ \text{mW}$$

Then the first harmonic will have a value normalized to the fundamental:

$$-10\log_{10}\left(\frac{0.1\ \mu\text{W}}{10\ \text{mW}}\right) = -50\ \text{dBc}$$

B. the power of the second harmonic in dBW.

Solution:

Similarly

$$-50 \text{ dBm} = 0.01 \ \mu\text{W}$$

$$-10 \log_{10} \left(\frac{0.01 \ \mu\text{W}}{1 \text{ W}} \right) = 80\text{dBw}$$

C. the total harmonic power (i.e., the combined power of the two harmonics) in dBm.

Solution:

I already went through the effort to get these in μW, where they can be added before applying the dBm operator.

$$0.1 \ \mu\text{W} + 0.01\mu\text{W} = 0.11 \ \mu\text{W} = -10 \log \left(\frac{0.11 \ \mu\text{W}}{1 \text{ mW}} \right) = 39.59 \text{ dBm}$$