dB in Communications

- The db (decibel) is a relative unit of measurement commonly used in communications for providing a reference for input and output levels.
  - Power gain or loss.
- Decibels are used to specify measured and calculated values in
  - audio systems, microwave system gain calculations, satellite system link-budget analysis, antenna power gain, light-budget calculations and in many other communication system measurements
  - In each case the dB value is calculated with respect to a standard or specified reference.

Calculation of dB

- The dB value is calculated by taking the log of the ratio of the measured or calculated power (P2) with respect to a reference power (P1).

- The result is multiplied by 10 to obtain the value in dB.

$$\mathrm{dB} = 10 \log_{10} \frac{P_2}{P_1}$$

- It can be modified to provide a dB value based on the ratio of two voltages. By using the power relationship $P = V^2/R$

$$\mathrm{dB} = 10 \log_{10} \frac{P_2}{P_1} = 10 \log_{10} \frac{V_2^2/R}{V_1^2/R} = 20 \log_{10} \frac{V_2}{V_1}$$

Definitions of dBm and dBW

- dBm indicates that the specified dB level is relative to a 1 milliwatt reference.

$$\text{dBm} = 10\log_{10}\frac{P_2}{0.001\text{W}}$$

- If Power is expressed in watts instead of milliwatts.
  - the dB unit is obtained with respect to 1 watt and the dB values are expressed as dBW.

$$\text{dBW} = 10\log_{10}\frac{P_2}{1\ \text{W}}$$

Examples

- Important Note: The decibel (dB) is "the logarithm of a power ratio" and NOT a unit of power;
- However, dBW and dBm are units of power in the logarithmic system of numbers
- Convert the following into dBm or dBW
- P=1mW, P(dBm)=?
- P=0.1mW, P(dBm)=?
- P=10W, P(dBW)=?
- P=1W, P(dBm)=?

Signal-to-Noise Ratio (SNR)

- The received signal should be greater than the average noise level at the receiver
- The average noise level is calculated by

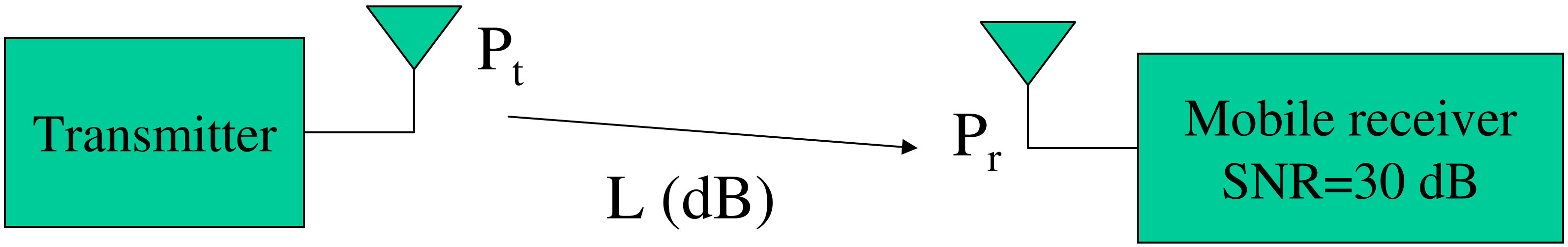
$$P_{out,noise} = G_{sys} F k T_0 B = G_{sys} k T_0 B \left(1 + \frac{T_e}{T_0}\right)$$

  - Where G_{sys} is the overall receiver gain due to cascaded stages
  - F is the noise figure of the receiver
  - k is Boltzmann's constant (1.38§10^{-23})
  - $T_e=(F-1)\,T_0$ is the effective noise temperature
  - For a cascaded system, $T_{esys} = T_1 + \frac{T_2}{G_1} + \frac{T_3}{G_1 G_2} + \ldots$
  - T_0 is ambient room temperature (290K)
- Signal-to-noise ratio is defined as

$$\text{SNR} = \frac{\text{Signal Power}}{\text{Noise Power}}$$

Example

- A mobile receiver system



- Determine the average signal strength at the antenna terminals to provide a SNR of 30 dB at the receiver output if the average noise level is -119.5 dBm.
- L is the propagation loss
- P_r(dBm)=SNR+(-119.5)=-89.5 dBm
- If the propagation loss is 100 dB, what is the minimum transmit power?