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.
The dB value is calculated by taking the log of the ratio of the measured or calculated power \( P_2 \) with respect to a reference power \( P_1 \).

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

\[
\text{dB} = 10 \log_{10} \frac{P_2}{P_1}
\]

It can be modified to provide a dB value based on the ratio of two voltages. By using the power relationship \( P = \frac{V^2}{R} \)

\[
\text{dB} = 10 \log_{10} \frac{P_2}{P_1} = 10 \log_{10} \frac{\frac{V_2^2}{R}}{\frac{V_1^2}{R}} = 20 \log_{10} \frac{V_2}{V_1}
\]
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.

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

- \( P = 1 \text{mW}, \quad P(\text{dBm}) = ? \)
- \( P = 0.1 \text{mW}, \quad P(\text{dBm}) = ? \)
- \( P = 10 \text{W}, \quad P(\text{dBW}) = ? \)
- \( P = 1 \text{W}, \quad P(\text{dBm}) = ? \)
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

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

- Where \(G_{\text{sys}}\) 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, \(T_{\text{sys}} = T_1 + \frac{T_2}{G_1} + \frac{T_3}{G_1 G_2} + \ldots\)
- \(T_0\) is ambient room temperature (290K).

- Signal-to-noise ratio is defined as

\[
\text{SNR} = \frac{\text{Signal Power}}{\text{Noise Power}}
\]
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

\[ P_r (\text{dBm}) = \text{SNR} + (-119.5) = -89.5 \text{ dBm} \]

If the propagation loss is 100 dB, what is the minimum transmit power?