# Instantaneous Dynamic Range

**Q:** *So, let's make sure I have the right—**any** input signal with power exceeding the receiver sensitivity but below the saturation point **will** be adequately demodulated by the detector, right?*

**A:** Not **necessarily!** The **opposite** is true, any signal with power **outside** the receiver dynamic range **cannot** be properly demodulated. However, signals **entering** the receiver within the proper dynamic range will be properly demodulated **only** if it **exits** the receiver with the proper **power**.

The reason for this is that **demodulators**, in addition to requiring a **minimum** ***SNR*** (i.e., $SNR_{min}$), likewise require a certain amount of **power**.

If the signals enters the receiver with power greater that the MDS, then the signal will **exit** the receiver with **sufficient SNR**. However, the signal **power** can be **too large** or **too small**, depending on the overall receiver gain $G$.

**Q:** ***How*** *can the exiting signal power be too large or too small? What would **determine** these limits?*

**A:** Recall that the signal **exiting** the receiver is the signal **entering** the detector/demodulator. This **demodulator** will have a **dynamic range** as well!

Say the signal **power** entering the **demodulator** (i.e., exiting the receiver) is denoted $P_D$. The **maximum** power that a demodulator can "handle" is thus denoted $P_D^{max}$, while the **minimum** amount of power required for proper demodulation is denoted as $P_D^{min}$.

Thus, every **demodulator** has its own dynamic range, which we call the **Instantaneous Dynamic Range** (IDR):

$$IDR = \frac{P_D^{max}}{P_D^{min}} \quad or \quad IDR\,(dB) = P_D^{max}\,(dBm) - P_D^{min}\,(dBm)$$

**Typical** IDRs range from 30 dB to 60 dB.

To differentiate the Instantaneous Dynamic Range from the receiver dynamic range, we refer to the **receiver** dynamic range as the **Total Dynamic Range** (TDR):

$$TDR = \frac{P_{in}^{sat}}{MDS} \quad or \quad TDR\,(dB) = P_{in}^{sat}\,(dBm) - MDS\,(dBm)$$

**Q:** *How do we insure that a signal will exit the receiver within the dynamic range of the demodulator (i.e., with in the IDR)?*

**A:** The relationship between the signal power when **entering** the receiver and its power when **exiting** the receiver is simply determined by the **receiver gain** $G$ :

$$P_D = G\,P_s^{in}$$

We simply need to design the receiver gain such that $P_D$ lies within the IDR for **all** signals $P_s^{in}$ that lie within the TDR.

**Big Problem** → We find that typically TDR >> IDR. This can make setting the receiver gain $G$ very complicated!