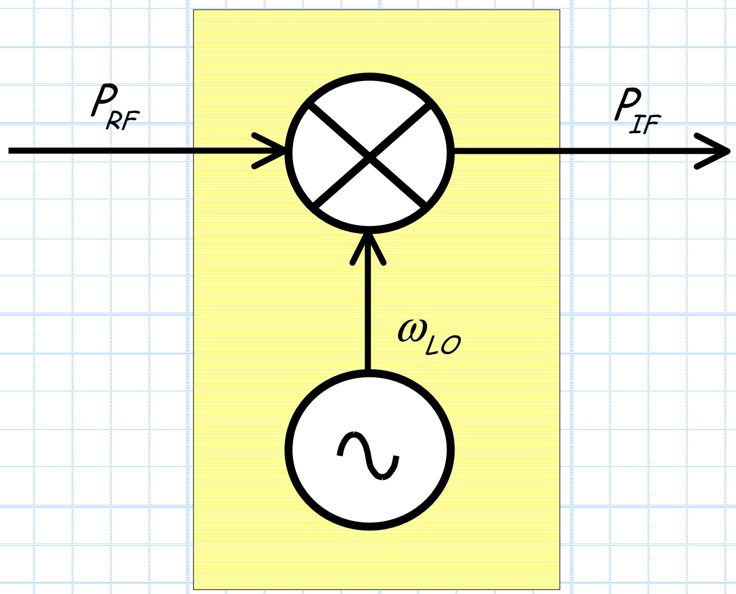
Mixer Compression and Intercept Points

Recall that we discussed the **1 dB compression point** and the **3rd order intercept point** for amplifiers.

The same concepts are also valid for **mixers**!

Instead of the values P_{in} and P_{out}, consider now P_{RF} and P_{IF}.



We can thus define the "gain" of the mixer (from RF port to IF port) as:

$$\begin{aligned}\text{"Gain"(dB)} &= 10 \log_{10}\left(\frac{P_{IF}}{P_{RF}}\right) \\ &= -\text{Conversion Loss (dB)}\end{aligned}$$

E.G., if the conversion loss of a mixer is 6 dB, then its "gain" is -6 dB.

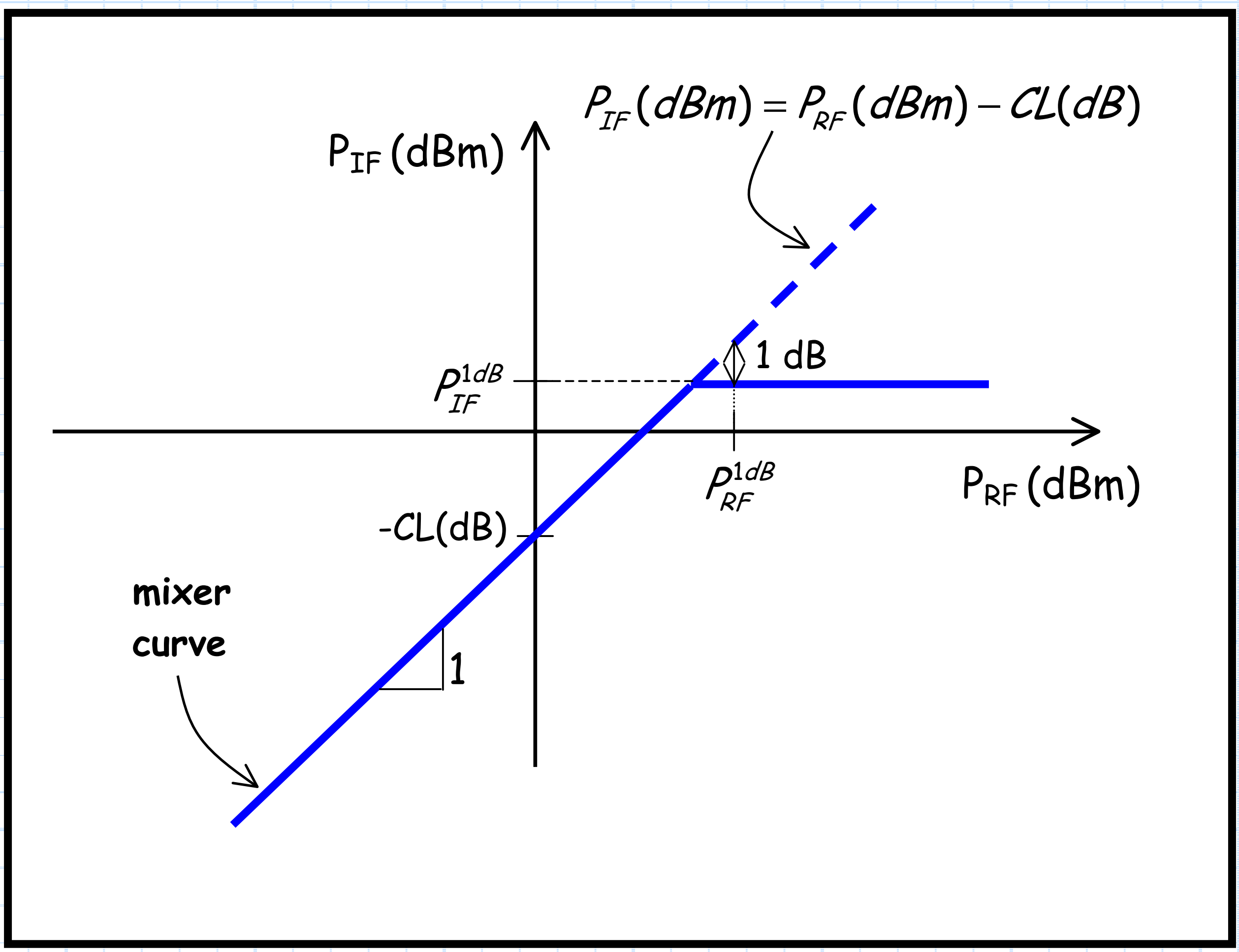
For **small** values of P_{RF}, this gain (conversion loss) is **constant** with respect to RF power.

However, if the RF input power becomes **too large**, then the mixer will begin to **saturate** (i.e., compress)—just like an amplifier!

When in saturation, an increase in P_{RF} will **not** result in a proportionate increase in P_{IF}! I.E.:

$$P_{IF}(\text{dBm}) < P_{RF}(\text{dBm}) - \text{Conversion Loss(dB)}$$

We therefore can **plot** a behavior that reminds us of an **amplifier**:



There is **one** (and only one!) point on the mixer curve that satisfies the equation:

$$P_{IF}(\text{dBm}) = P_{RF}(\text{dBm}) - \text{Conversion Loss(dB)} - 1 \text{ dB}$$

This point is the **1 dB compression point** of the mixer!

* At the **1 dB compression point**, the conversion loss appears to be **1 dB greater** than its normal (i.e., low power) value.

* We define the RF power at this compression point as P_{RF}^{1dB}, and the IF power P_{RF}^{1dB}.

* We can conclude that P_{IF}^{1dB} is the **maximum output power** of the mixer (for second-order signals).

* The largest RF signal power that should ever be put **into** the mixer is therefore P_{RF}^{1dB}.

* Typically, mixer manufactures will specify the compression point in terms of the **input RF signal power** (i.e., P_{RF}^{1dB}).

* Note that this is in distinct **contrast** with amplifiers, as manufactures of those components specify the compression point in terms of **output** power (i.e., P_{1dB}), as opposed to the input power (i.e., P_{in}^{max}).

* **Typical** mixer compression points range from **0 to 15 dBm**.

3rd Order Intercept Point

Manufactures also typically specify a **third-order intercept** point (generally in dBm). This is actually a parameter describing "**two-tone**" intermodulation distortion—that is, the RF input includes two (or more) signals at dissimilar frequencies:

$$v_{RF} = a\cos\omega_1 t + a\cos\omega_2 t$$

In addition to the desired IF signals at frequencies $|\omega_1 \pm \omega_{LO}|$ and $|\omega_2 \pm \omega_{LO}|$, the two input signals combine to form **third order** intermodulation distortion products at frequencies $|(2\omega_1 - \omega_2) \pm \omega_{LO}|$ and $|(2\omega_2 - \omega_1) \pm \omega_{LO}|$.

* Being third order products, the power of these IF signals are proportional to the RF power **cubed**.

* Theoretically, if the power of the RF input is large enough, the these third order intermodulation terms can become **equal** in power to the "fundamental" signals $|\omega_1 \pm \omega_{LO}|$ and $|\omega_2 \pm \omega_{LO}|$.

* Of course, this 3rd order intercept point is a **theoretical** value, as the mixer IF output will **saturate** before the 3rd order intermodulation terms can get that large.

* However, the mixer 3rd order intercept power does provide an indication of the mixers intermodulation **distortion performance**.

* Just like an amplifier, the **higher** the two-tone 3rd order intercept point, the **better**.

* **Typically**, the two-tone 3rd order intercept point of a mixer is **10 to 20 dB** greater than its **1 dB compression point**.