RF Components and Basic Concepts
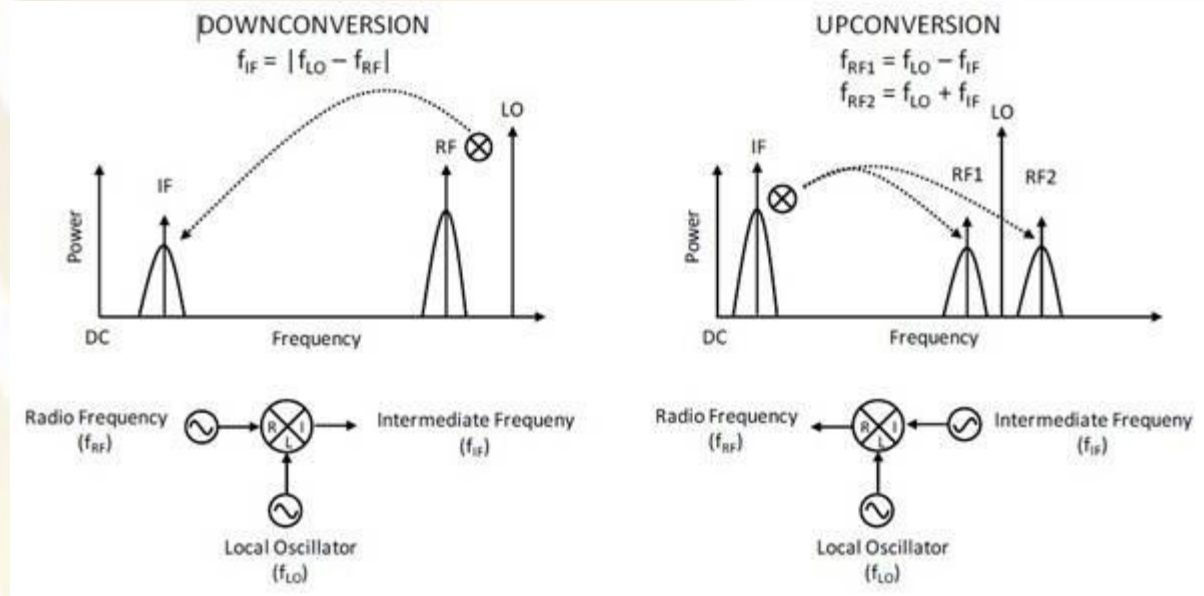## 1.9 - Mixer

Mixer

- An **RF mixer** is a three-port passive or active device that can modulate or demodulate a signal.

- The purpose is to change the frequency of an electromagnetic signal while preserving every other characteristic (such as phase and amplitude) of the initial signal.

Mixer

- UPCONVERSION

- DOWNCONVERSION

$$G(f) = \Im\{\cos(2\pi At)\} = \int\limits_{-\infty}^{\infty} \frac{e^{i2\pi At} + e^{-i2\pi At}}{2} e^{-i2\pi ft} dt$$

$$= \frac{1}{2}\left[\int\limits_{-\infty}^{\infty} e^{i2\pi At} e^{-i2\pi ft} dt + \int\limits_{-\infty}^{\infty} e^{-i2\pi At} e^{-i2\pi ft} dt\right]$$

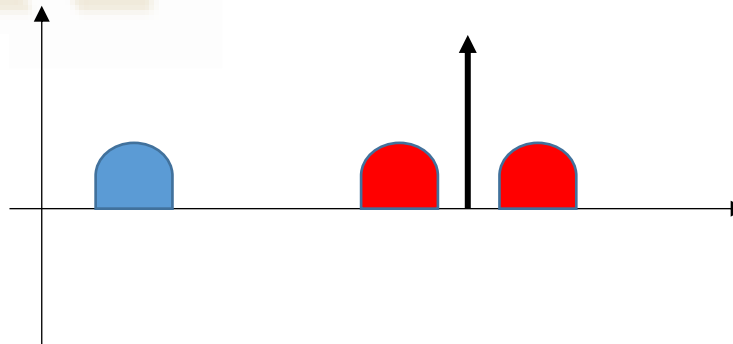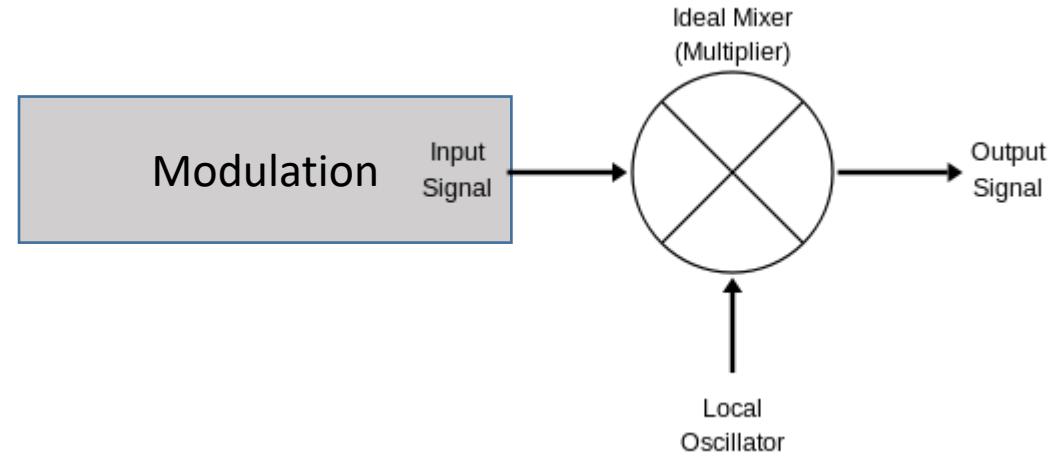$$= \frac{1}{2}\left[\delta(f - A) + \delta(f + A)\right]$$
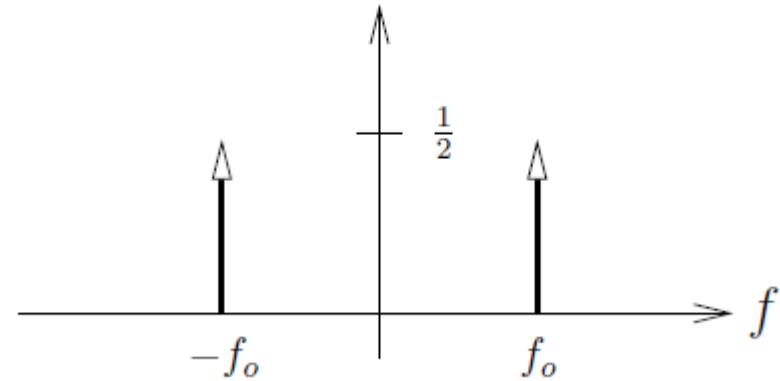
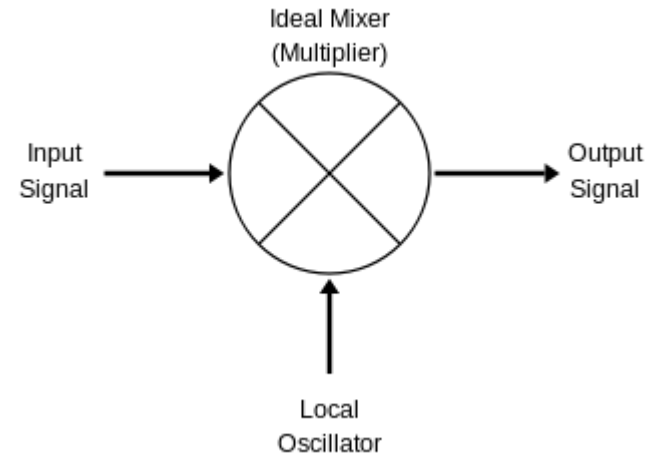# Mixing

$$Output(t) = Input(t) \times \cos 2\pi f_0 t$$

FT:

$$Output(f) = [Input(f - f_{IF}) + Input(f + f_{IF})] * \frac{1}{2}[\delta(f - f_0) + \delta(f + f_0)]$$

$$Output(f) = \frac{1}{2}[Input(f - f_{IF} - f_0) + Input(f - f_{IF} + f_0) + Input(f + f_{IF} - f_0) + Input(f + f_{IF} + f_0)]$$

Ideal Mixer
(Multiplier)

Modulation | Input Signal → → Output Signal

Local Oscillator

Example

- $Input = \cos 2\pi f_1 t$
- $Carrier = \cos 2\pi f_c t$
- $f_1 = 100 MHz$ and $f_c = 2GHz$

Ideal Mixer
(Multiplier)

Input
Signal

Output
Signal

Local
Oscillator

$$\cos a \times \cos b = \frac{1}{2}[\cos(a+b) + \cos(a-b)]$$

$$\cos 2\pi f_1 t \times \cos 2\pi f_c t = \frac{1}{2}[\cos 2\pi(f_1 + f_c)t + \cos 2\pi(f_c - f_1)t]$$

f_1

$f_c - f_1$ f_c $f_c + f_1$