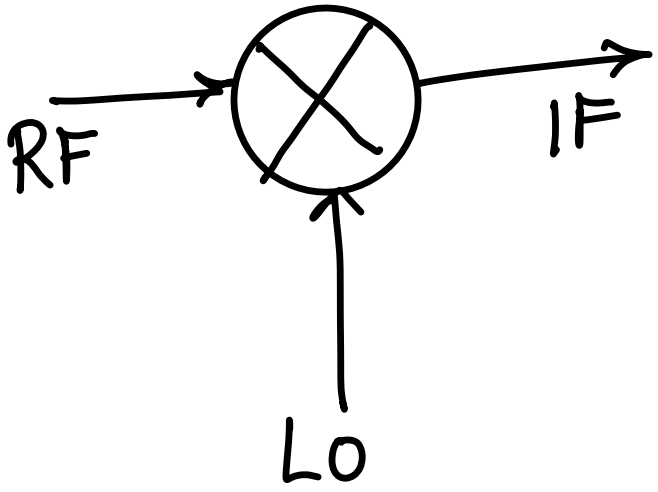
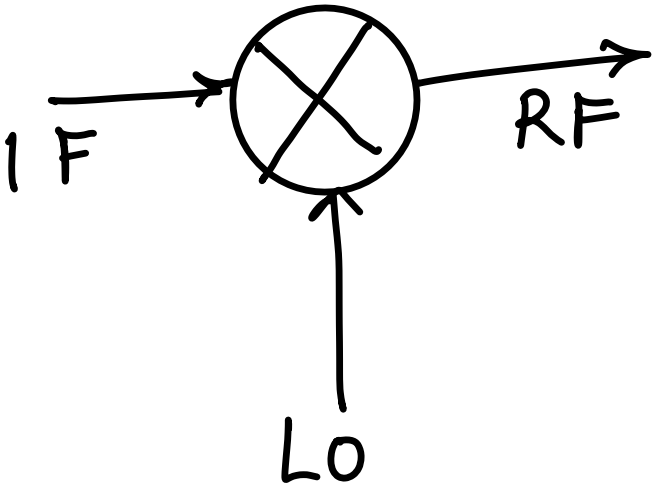
RF Mixers



Down conversion



Up conversion.

$$v_{RF} = A_{RF} \cos(\omega_{RF} t)$$

$$v_{LO} = A_{LO} \cos(\omega_{LO} t)$$

$$v_{IF} = \underbrace{v_{RF} v_{LO}}_{\text{ideal mixer}} = \frac{A_{RF} A_{LO}}{2} \left[\cos(\omega_{RF} - \omega_{LO})t + \cos(\omega_{RF} + \omega_{LO})t \right]$$

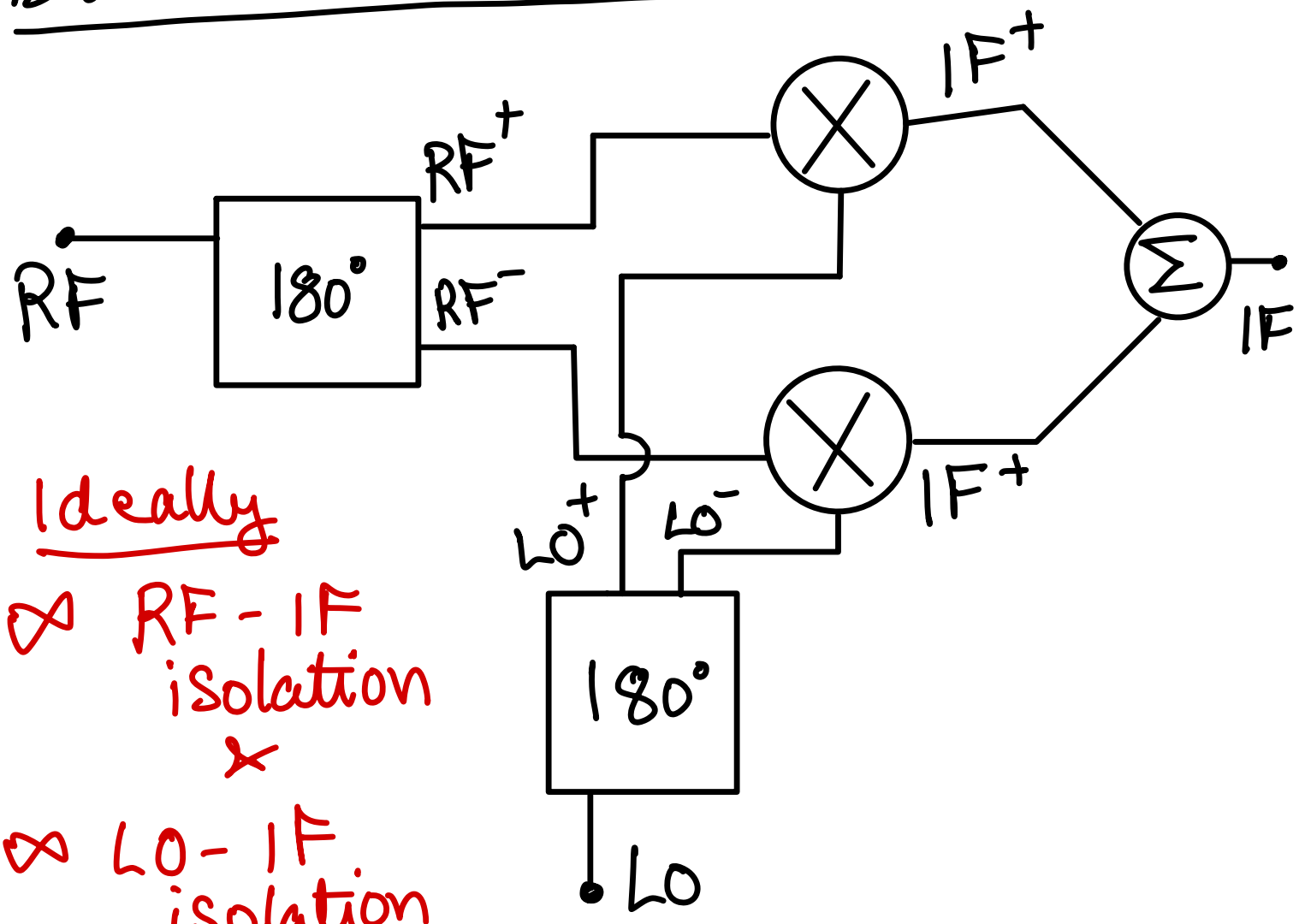
ideal mixer $\longrightarrow$ $\omega_{RF} \pm \omega_{LO}$

Practical mixer (real) $\longrightarrow$ $m\omega_{RF} + n\omega_{LO}$ where $m, n \in \mathbb{Z}$

Specifications

1) Frequency range of RL, LO, IF.
2) Conversion loss/Gain at a specific LO drive/power.
3) Port isolation (LO - IF, LO - RF, RF - IF) } Balanced Mixing or Filters.
4) Max. power rating
5) Linearity (RF ⟷ IF)
6) Noise Figure (SSB, DSB) → revisit
7) P_{DC}
8) Matching/VSWR
9) Conversion phase or Group delay.

Balanced Mixers (Double Balanced)



Ideally

∞ RF - IF isolation

×

∞ LO - IF isolation

-40dB isolation ✓ → -60dB.

Trimming

18 Mixers

$$V_{RF} = A_{RF}(t)\cos\left(\omega_{RF}t + \phi_{RF}(t)\right)$$

$$V_{LO}^{I} = \cos(\omega_{RF}t)$$

$$\downarrow \text{mix \& LPF}$$

$$V_{IF}^{I}(t) = \frac{A_{RF}(t)}{2}\cos\left(\phi_{RF}(t)\right)$$

$$V_{LO}^{\theta} = -\sin(\omega_{RF}t)$$

$$V_{IF}^{\theta}(t) = +\frac{A_{RF}(t)}{2}\sin\left(\phi_{RF}(t)\right)$$

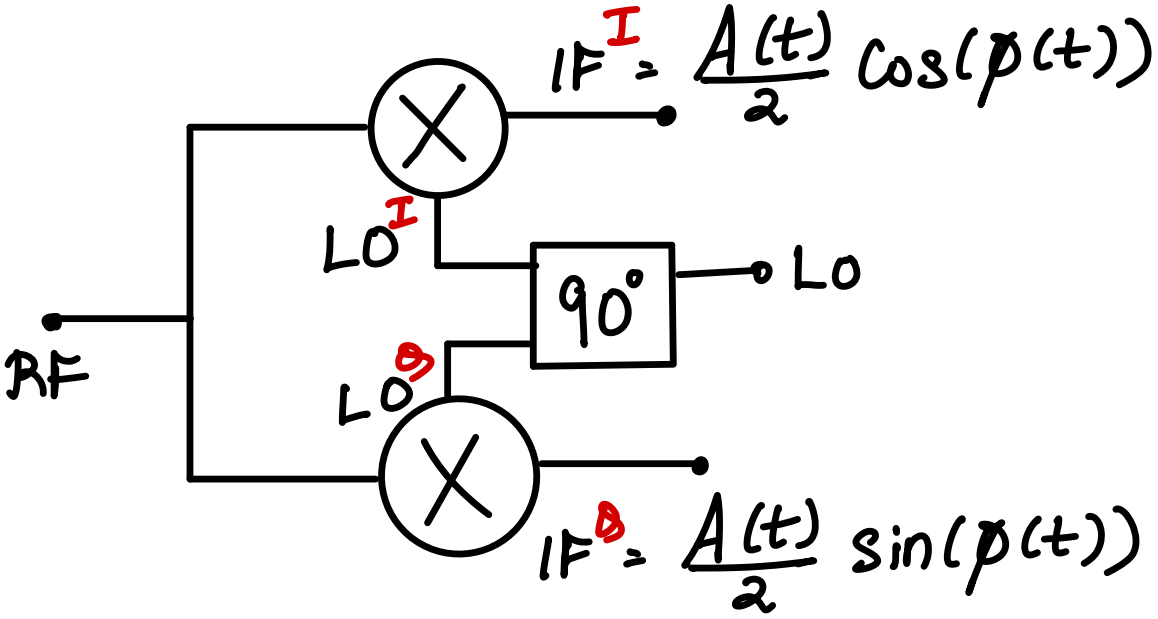
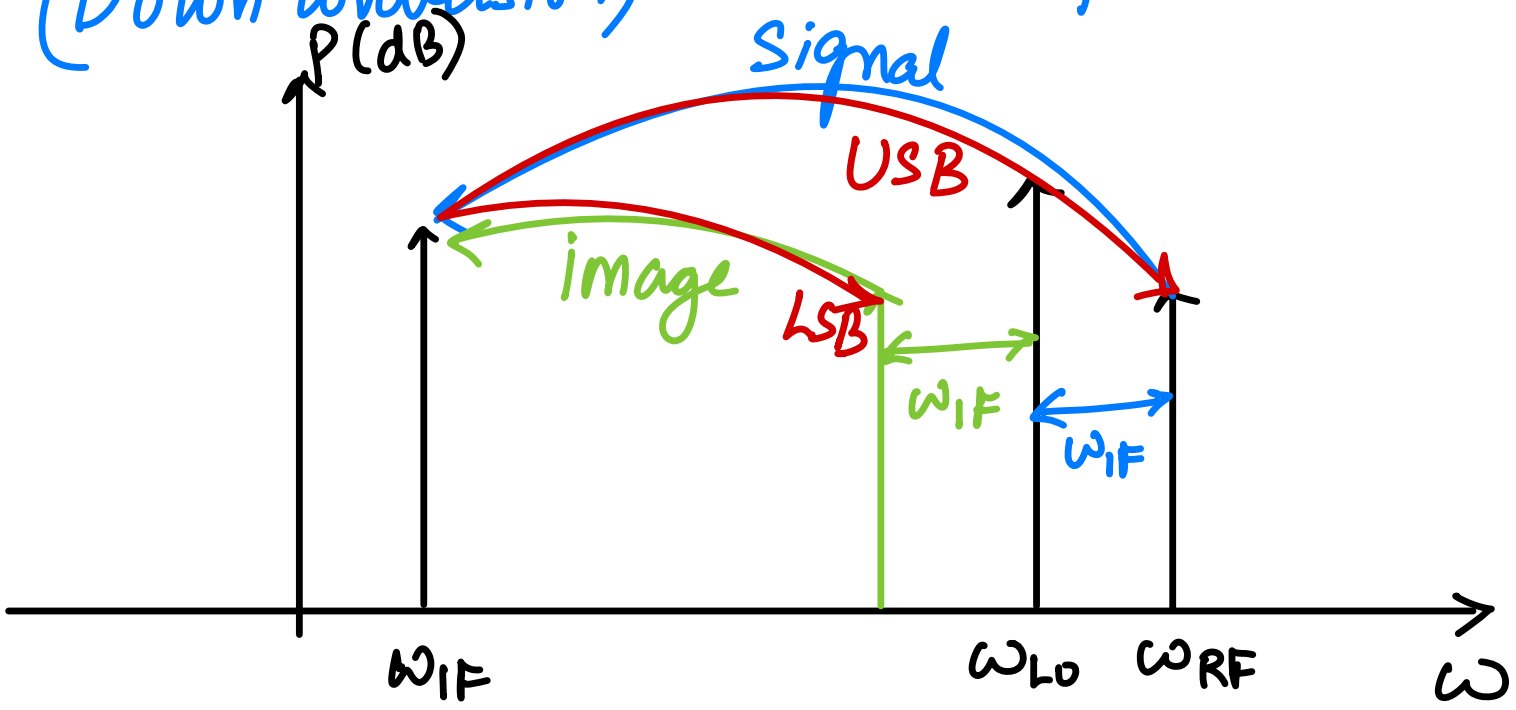
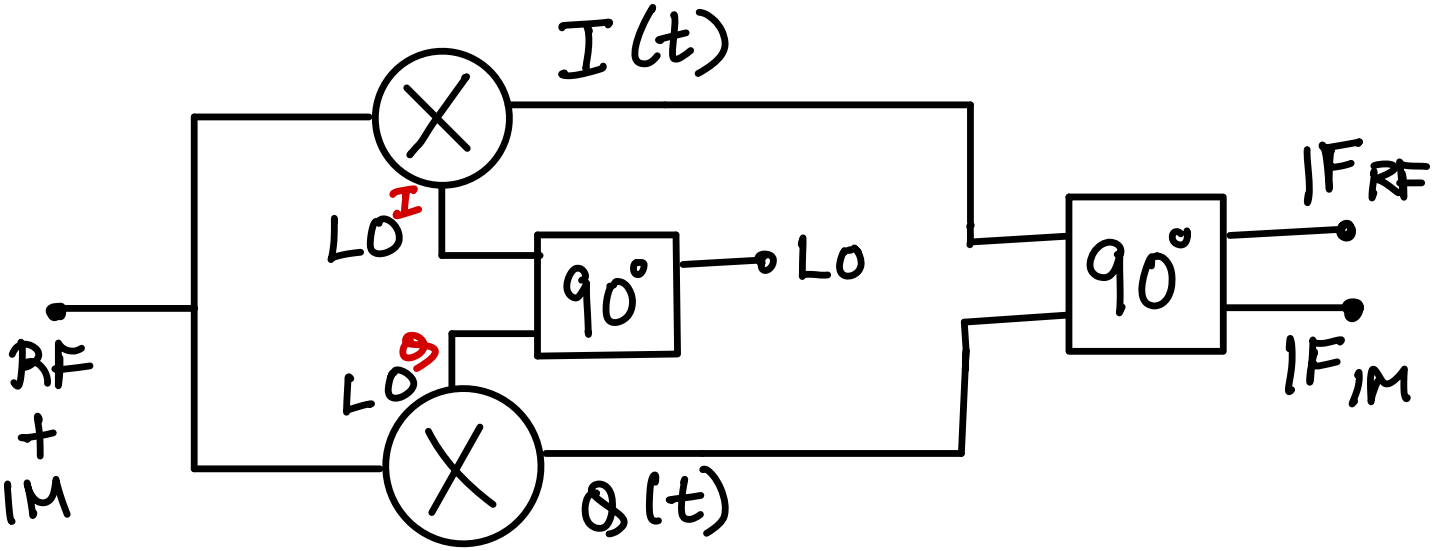


Image Reject Mixers or Single Sideband Mixers

(Down conversion)

(Up conversion)





$$RF(t) = A_{RF}\cos(\omega_{RF}t + \phi_{RF}) + A_{IM}\cos(\omega_{IM}t + \phi_{IM})$$

$$LO^I = \cos(\omega_{LO}t) \qquad LO^Q = -\sin(\omega_{LO}t)$$

$$I(t) = \frac{A_{RF}}{2}\cos\left(\underbrace{(\omega_{RF}-\omega_{LO})}_{\omega_{IF}}t + \phi_{RF}\right)$$

$$+ \frac{A_{IM}}{2}\cos\left(\underbrace{(\omega_{IM}-\omega_{LO})}_{-\omega_{IF}}t + \phi_{IM}\right)$$

$$= \frac{A_{RF}}{2}\cos\left(\omega_{IF}t + \phi_{RF}\right)$$

$$+ \frac{A_{IM}}{2}\cos\left(\omega_{IF}t - \phi_{IM}\right)$$

$$Q(t) = \frac{A_{RF}}{2}\sin\left(\omega_{IF}t + \phi_{RF}\right)$$

$$- \frac{A_{IM}}{2}\sin\left(\omega_{IF}t - \phi_{IM}\right)$$

$$IF_{RF}(t) = \frac{A_{RF}}{2}\cos\left(\omega_{IF}t + \phi_{RF}\right)$$

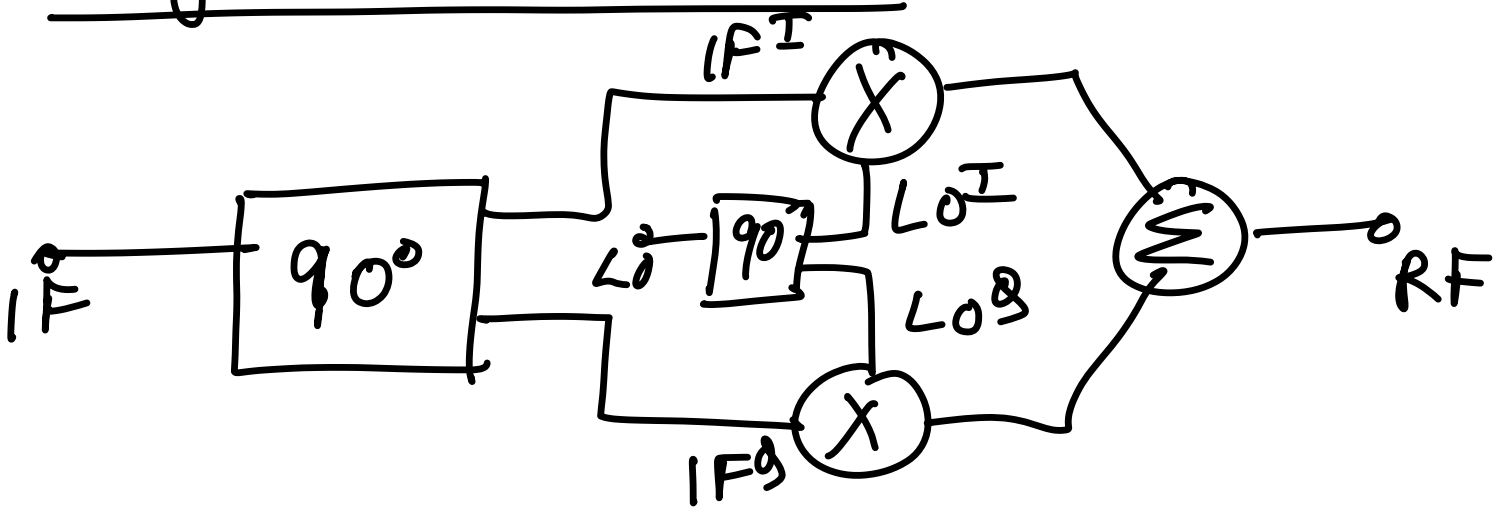
$$+ \cancel{\frac{A_{IM}}{2}\cos\left(\omega_{IF}t - \phi_{IM}\right)}$$

$$+ \frac{A_{RF}}{2}\cos\left(\omega_{IF}t + \phi_{RF}\right)$$

$$- \cancel{\frac{A_{IM}}{2}\cos\left(\omega_{IF}t - \phi_{IM}\right)}$$

$$\boxed{IF_{RF}(t) = A_{RF}\cos\left(\omega_{IF}t + \phi_{RF}\right)}$$

Single Sideband Mixer



Double Balanced SSB Mixer