EECS 142/242M

Integrated Circuits for Communication

Lecture 19: Introduction to Mixers

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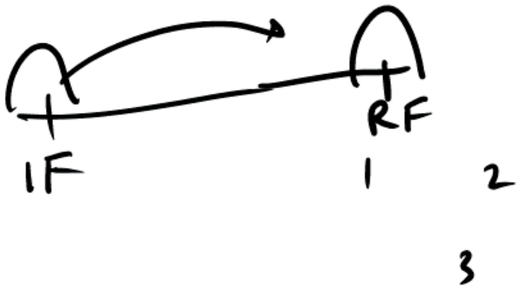
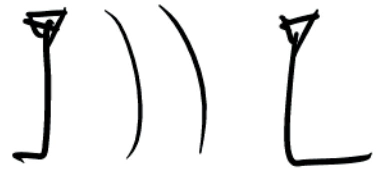
Mixers

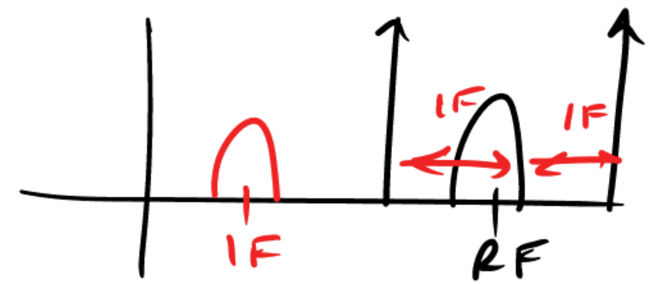




up-conversion

down conversion

Frequency Translation



$\omega_2-\omega_1$ ω_1 ω_2

- As shown a
  around one
  a higher R
  it's the inve
- We know t
  translation
  circuits or r

Ideal Multiplier

- Suppose that the input of the mixer is the RF and LO signal

$$v_{RF} = A(t)\cos\left(\omega_0 t + \phi(t)\right)$$

$$v_{LO} = A_{LO}\cos\left(\omega_{L0} t\right)$$

- Recall the trigonometric identity

$$\cos(A+B) = \cos A \cos B - \sin A \sin B$$

- Applying the identity, we have

$$\begin{aligned} v_{out} &= v_{RF} \times v_{LO} \\ &= \frac{A(t)A_{LO}}{2}\{\cos\phi\left(\cos(\omega_{LO}+\omega_0)t + \cos(\omega_{LO}-\omega_0)t\right) \\ &\quad -\sin\phi\left(\sin(\omega_{LO}+\omega_0)t + \sin(\omega_{LO}-\omega_0)t\right)\} \end{aligned}$$

$$\cos(A+B) = \cos A \cos B - \sin A \sin B$$

$$+ \quad \cos(A-B) = \cos A \cos B + \sin A \sin B$$

$$\cos(A+B) + \cos(A-B) = 2\cos A \cos B$$

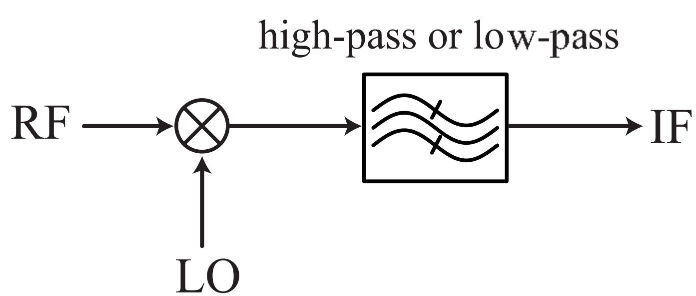
$$\cos \omega_1 t \cos \omega_2 t = \frac{1}{2}\left\{\cos(\omega_1 - \omega_2)t + \cos(\omega_1 + \omega_2)t\right\}$$

Ideal Multiplier (cont)

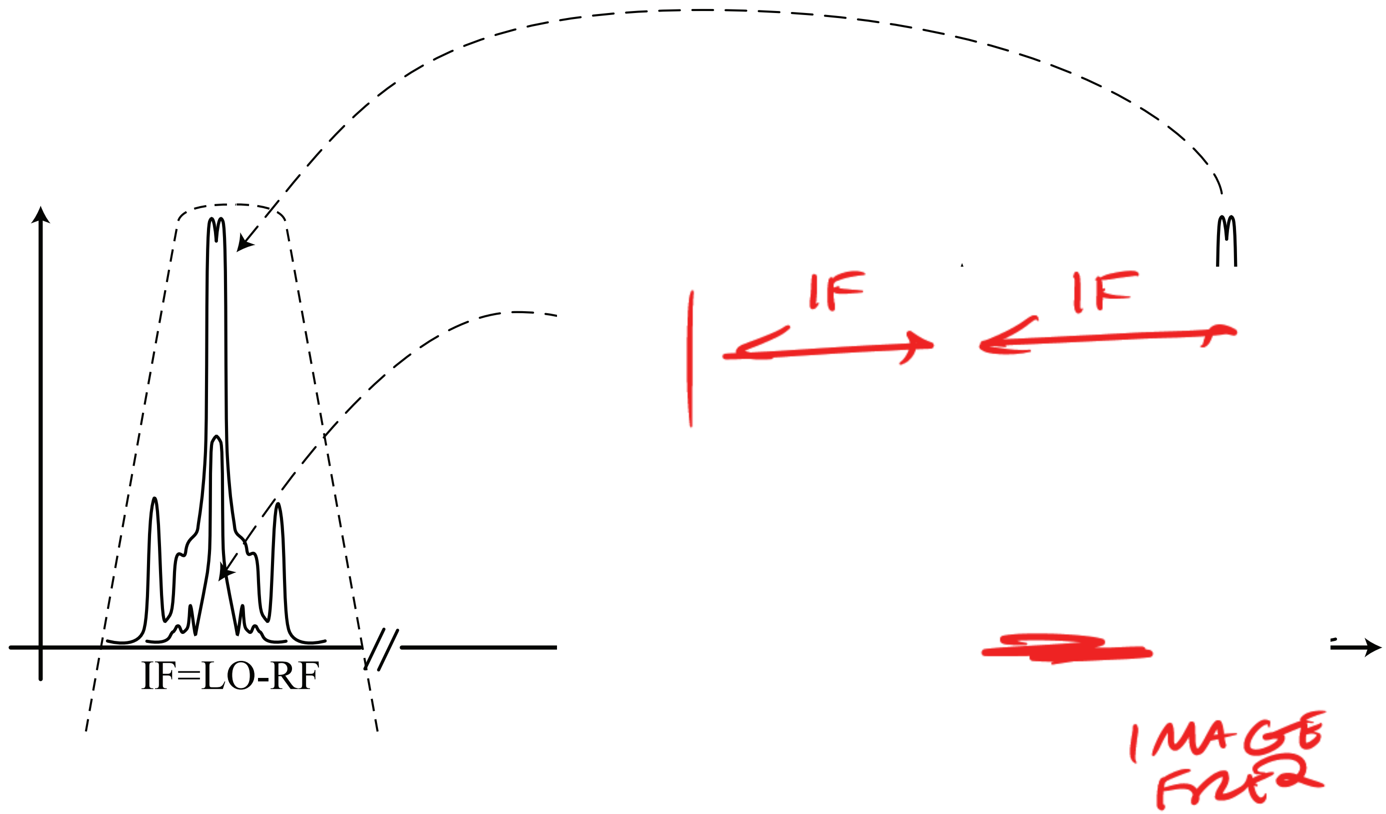
- Grouping terms we have

$$v_{out} = \frac{A(t)A_LO}{2} \quad \{\cos\left((\omega_{LO} + \omega_0)t + \phi(t)\right) + \\ \cos\left((\omega_{LO} - \omega_0)t + \phi(t)\right)\}$$

- We see that the modulation is indeed translated to two new frequencies, $LO + RF$ and $LO - RF$. We usually select either the upper or lower "sideband" by filtering the output of the mixer

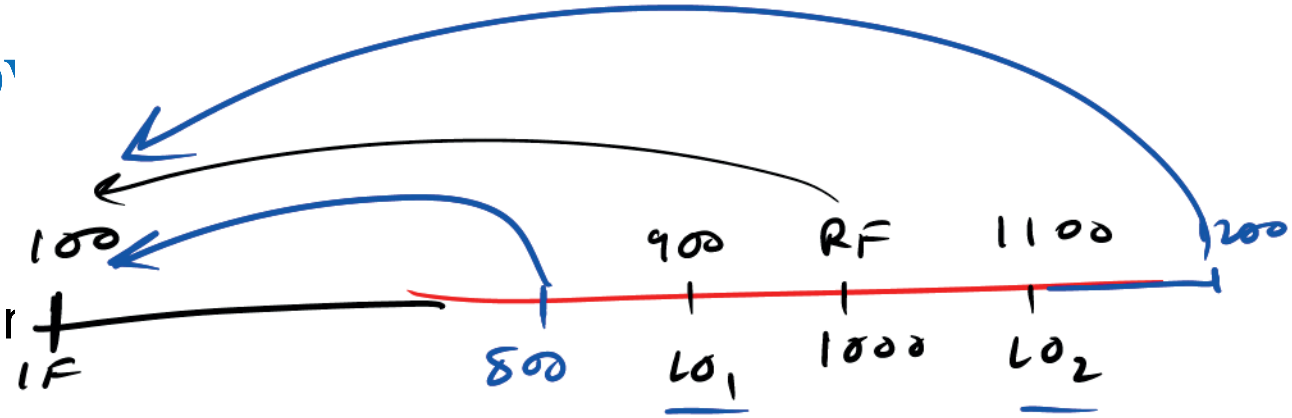


Mixer + Filter



- Note that the LO can be [illegible] tion) or above the RF (high side [illegible]
- Also note that for a giver [illegible] verted to the same IF frequency. [illegible]

Upper/Lo

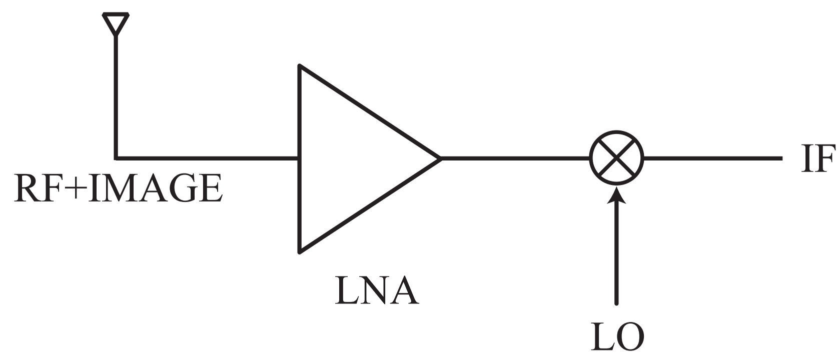


- Example: Downcor

Let’s say we choos

That means that ar
downconverted to t

Receiver Application



- The image frequency is the second frequency that also down-converts to the same IF. This is undesirable becuase the noise and interferance at the image frequency can potentially overwhelm the receiver.
- One solution is to filter the image band. This places a restriction on the selection of the IF frequency due to the required filter Q