(updated 2019-4-12)

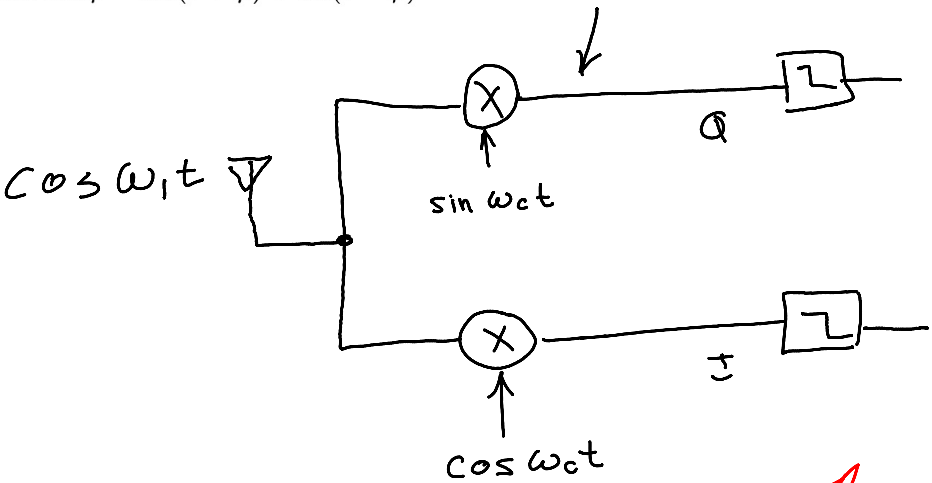
RF Design - Receiver Architectures

Exercise 1: A zero-IF receiver is tuned to a center frequency of 100 MHz. The input contains a signal at 101 MHz. What components are present at the input, after the mixers and after the low-pass filters? Give the frequencies, amplitudes and phases of the components.

Let:
$\omega_1 = 101$ MHz
$\omega_c = 100$ MHz

$2\cos\theta\cos\varphi = \cos(\theta-\varphi) + \cos(\theta+\varphi)$
$2\sin\theta\sin\varphi = \cos(\theta-\varphi) - \cos(\theta+\varphi)$
$2\sin\theta\cos\varphi = \sin(\theta+\varphi) + \sin(\theta-\varphi)$

$\frac{1}{2}\left(\sin(\omega_1+\omega_c)t + \sin(\omega_1-\omega_c)t\right)$ (removed by LPF)

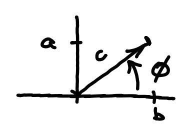


$\frac{1}{2}\left(\sin(\omega_1-\omega_c)t\right)$ 90°

$\frac{1}{2}\left(\cos(\omega_1-\omega_c)t\right)$ 0°

$\frac{1}{2}\left(\cos(\omega_1-\omega_c)t + \cos(\omega_1+\omega_c)t\right)$ (removed by LPF)

Exercise 2: What is the baseband spectrum if we add the I and Q branches above? What is the spectrum if the two branches have unequal gains? What if a DC offset is added to a mixer output?



$$a\sin x + b\cos x = c\sin(x+\varphi)$$

$\phi = \text{atan2}(a, b)$

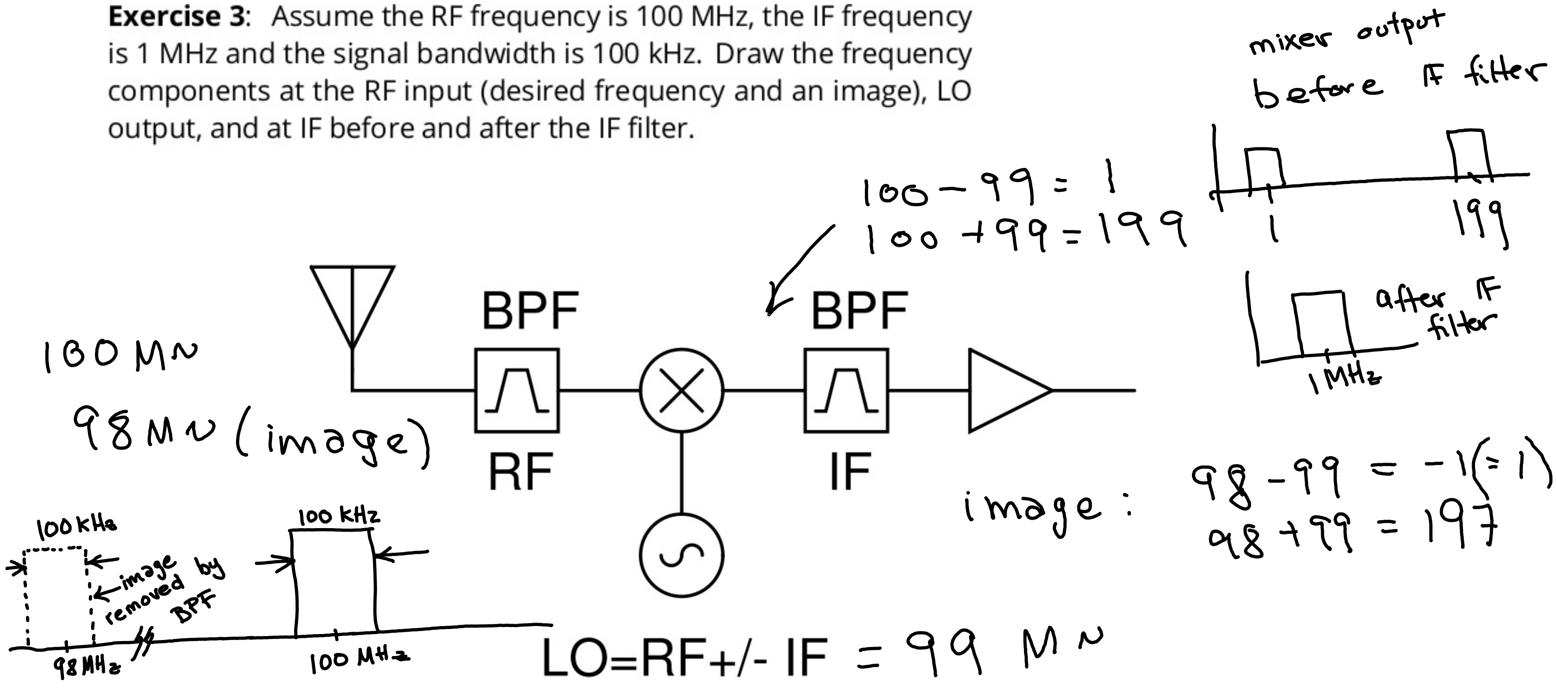
$c = \sqrt{a^2+b^2}$

sum is: $\frac{1}{\sqrt{2}}\sin\left((\omega_1-\omega_c)t + \phi\right)$

if $a \neq b$ get phase error

a DC offset appears in output at DC
($LO = k + \cos\omega_c t \rightarrow k$)

Exercise 3: Assume the RF frequency is 100 MHz, the IF frequency is 1 MHz and the signal bandwidth is 100 kHz. Draw the frequency components at the RF input (desired frequency and an image), LO output, and at IF before and after the IF filter.



Exercise 4: Draw the block diagram of an RF-sampling receiver.