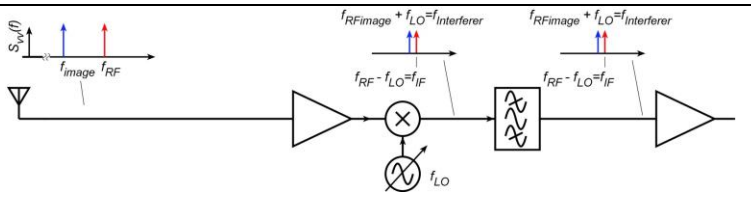
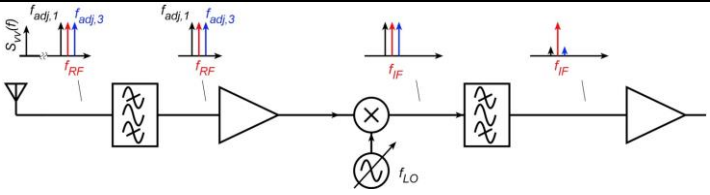
Problem set: mixers

Problem 1: If the radio receiver has a 10.7 MHz IF, and is tuned to receive an 108 MHz signal frequency, what are your two possible choices of LO frequency ? -

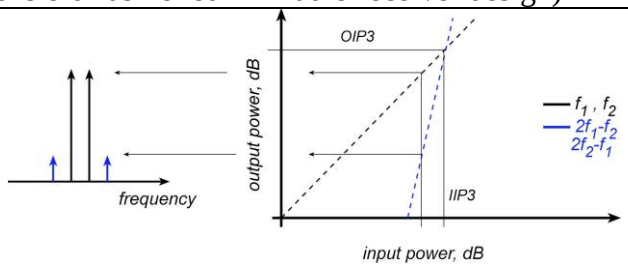


For each choice, what is the frequency of the image, i.e. what un-desired signal frequency at the antenna falls at the center of the IF pass band ?

Problem 2: continuing with the parameters of problem 1, if we choose an LO **below** the RF frequency, and wish to tune the 88-108 MHz RF band, will a 85-110 MHz bandwidth of a fixed-tuned RF front-end filter be sufficient if we wish to always reject the image response ? (This is old-fashioned FM radio receiver design)

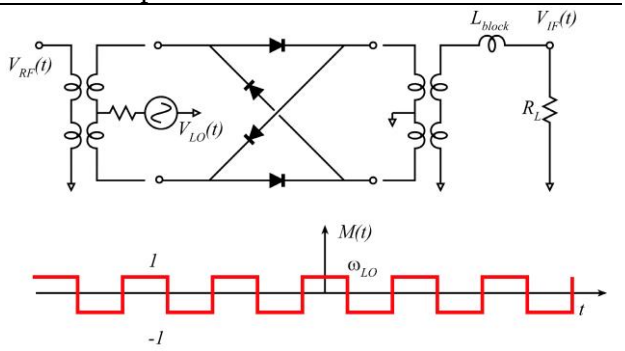


Problem 3: You are measuring an amplifier you have built. At -10 dB input power per tone, the output power at each of the input frequencies are 0 dBm, while the output signal powers at $(2f_1 - f_2)$ and $(2f_2 - f_1)$ are both -40 dBm. Find the amplifier gain and the input-referred and output referred third-order intercepts.

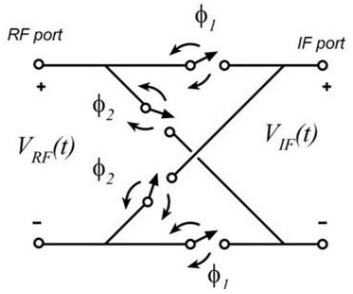


Problem 4: (**218B only**). A component has 10 dB gain and a 0 dBm input-referred third-order intercept. Tones of amplitudes -20 dBm and -40 dBm are input at signal frequencies f_1, and f_2 (0.99 GHz and 1.0 GHz). Ignoring responses near DC and near 3 GHz, find the frequencies and power levels of the output tones near 1 GHz.

Problem 5: We will model a diode bridge mixer as four ideal switches. The transformer ratios are all 1:1. The LO is a cosine wave at 10 GHz. The IF port is loaded in R_L =50 Ohms. $V_{RF}(t)$ is a 10.01GHz cosine wave of 1 mV peak amplitude. L_{block} is a short circuit at the 10 MHz IF frequency but an open circuit at any frequency above 1.0 GHz. (a) Find the Fourier amplitude (voltage) of the mixer output at 10 MHz. (b) (**218 B only**) find the mixer input impedance at the RF port. (You can do this by



computing the current at 10 MHz at the IF port and from this finding the current at 10.01 GHz at the RF port)



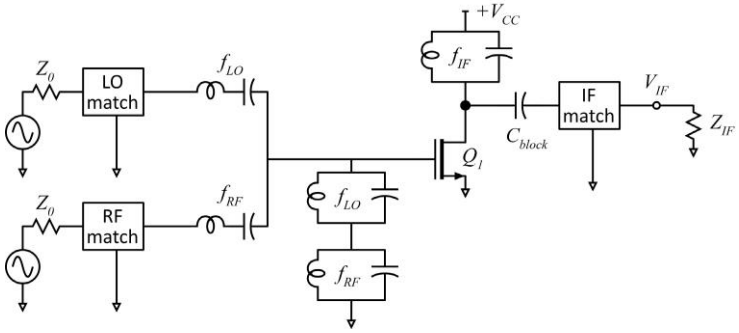
(c) If $V_{RF}(t)$ is a **30**.01 GHz cosine wave of 1 mV peak amplitude, what would be the Fourier amplitude (voltage) of the mixer output at 10 MHz ?

Problem 6: (**218 B only**)

The FET has

$$I_D = \begin{cases} K_\mu (V_{gs} - V_{th})^2 & V_{gs} > V_{th} \\ 0 & V_{gs} < V_{th} \end{cases}$$

With $K_\mu = 5\text{mA/V}^2$ and V_{th}=0.3V. LO and RF signals are applied to the FET with



$V_{gs}(t) = V_{th} + 2^{1/2} V_{LO,RMS} \cos(\omega_{LO} t) + 2^{1/2} V_{RF,RMS} \cos(\omega_{RF} t)$.

(a) Assuming $V_{RF,RMS}$=0 mV, first compute $g_m(t)$.

(b) Search the literature (or reliable internet references) to find the Fourier series of the resulting expression for $g_m(t)$, then find the magnitude of the Fourier compoenent of $g_m(t)$ at ω_{LO}.

(c) Assuming that $V_{RF,RMS}$ is small, such that $\delta I_D(t) = g_m(t) V_{RF}(t)$, compute the RMS magnitude of the drain current at $\omega_{RF} - \omega_{LO}$