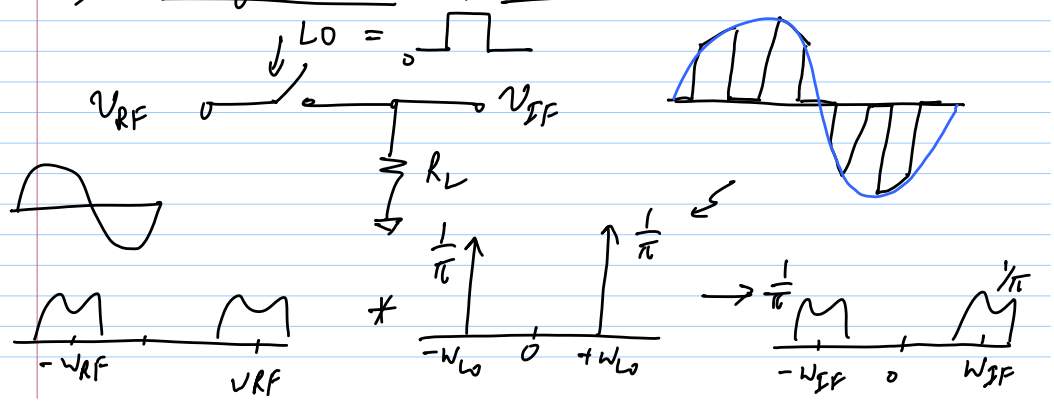
30/9/13

Lec 25

Passive Mixers – Refer Razavi 6.2

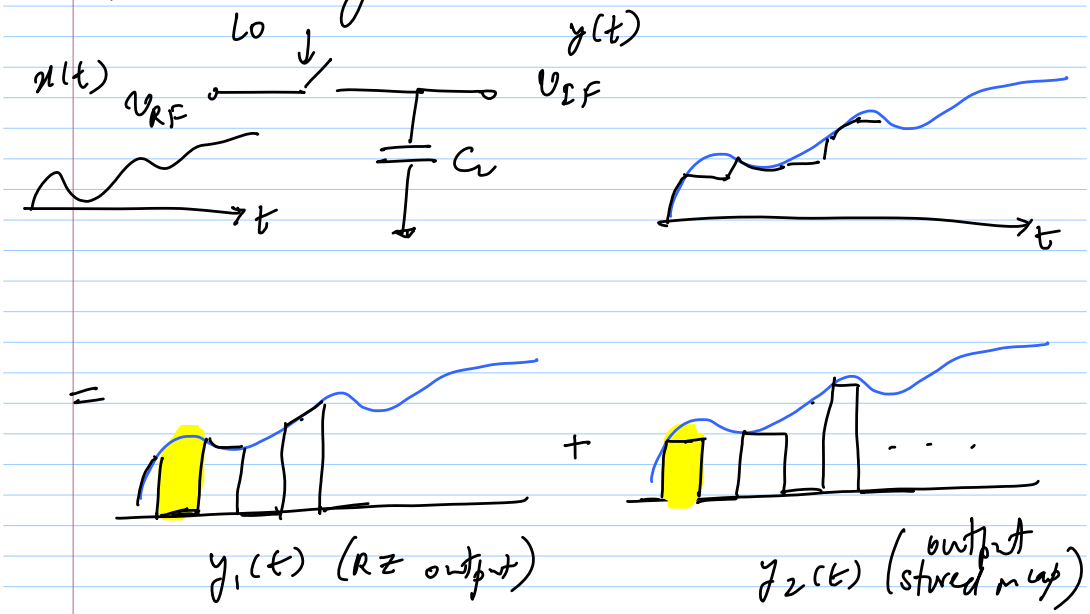
* Use mosfet as a passive switch, no ampl. devices

1) Voltage mode, RF mixer



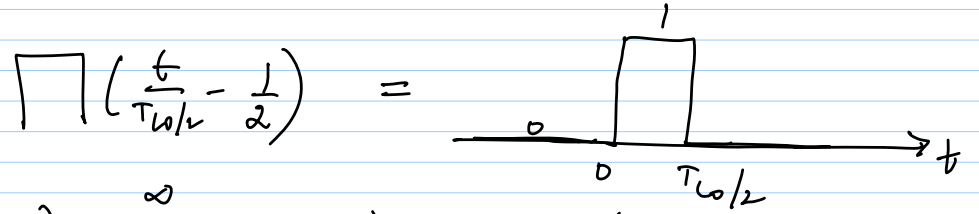
* $s_{LO}(t) = \frac{2}{\pi}\cos\omega_0 t$
* $G_C = \frac{1}{\pi} \approx -10dB$
* $s_{LO}(t)$ has avg. value = 0.5
  → v_{RF} appears @ IF port with gain = 0.5
  → even-order distortion causes IIP2 problems
* Single-balanced mixer has twice the gain $= \frac{2}{\pi} \approx -4dB$, & no dc component

2) Sampling Mixer



$$y(t) = y_1(t) + y_2(t)$$

$$y_1(t) = x(t) \cdot \left[\Pi\left(\frac{t}{T_{LO}/2} - \frac{1}{2}\right) * \sum_{k=-\infty}^{\infty} \delta(t - kT_{LO}) \right]$$



a) $\sum_{-\infty}^{\infty} \delta(t - kT) \longleftrightarrow \frac{1}{T}\sum_{-\infty}^{\infty} \delta\left(f - \frac{k}{T}\right)$

b) $x(t - T) \longleftrightarrow e^{-j\omega T} X(f)$

c) $\prod\left(\frac{t}{T/2}-\frac{1}{2}\right) \longleftrightarrow \frac{1}{jw}\left(1-e^{-jwT/2}\right)$

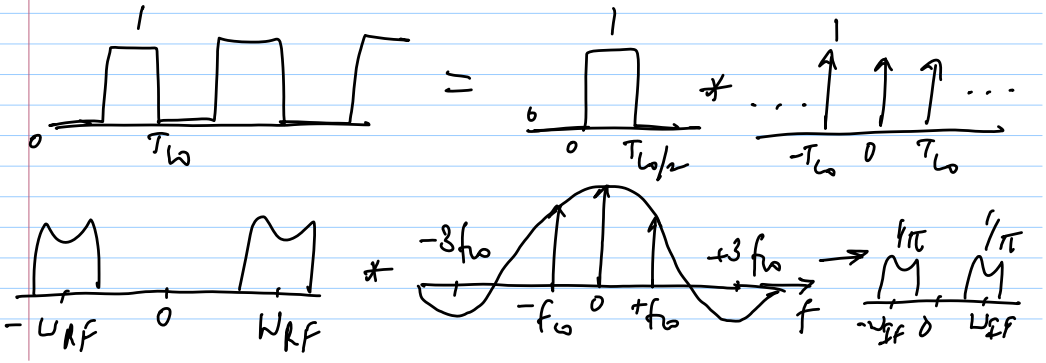
$$Y_1(f) = X(f) * \left[\frac{1}{jw}\left(1-e^{-jwT_{LO}/2}\right) \cdot \frac{1}{T_{LO}}\sum_{k=-\infty}^{\infty}\delta\left(f-\frac{k}{T_{LO}}\right)\right]$$

set $k = \pm 1$ gives IF spectrum

$$Y_1(f)\Big|_{IF} = X(f) * \left[\pm\frac{T_{LO}}{j\pi}\cdot\frac{1}{T_{LO}}\delta(f \pm f_{LO})\right]$$

$$Y_1(f) = \frac{X(f-f_{LO})}{j\pi} - \frac{X(f+f_{LO})}{j\pi}$$

as expected $\angle H_C\big|_{Y_1(f)} = \frac{1}{\pi}$ phase shift of 90°



$y_2(t)$ = impulse train sampling the input convolved with a square pulse

$$= \left[x(t)\cdot\sum_{k=-\infty}^{\infty}\delta\left(t-kT_{LO}-\frac{T_{LO}}{2}\right)\right] * \prod\left(\frac{t}{T_{LO}/2}-\frac{1}{2}\right)$$

$$Y_2(f) = \left[X(f) * \frac{1}{T_{LO}}\sum e^{-jwT_{LO}/2}\cdot\delta(f-kf_{LO})\right] \cdot \frac{1}{jw}\left(1-e^{-jwT_{LO}/2}\right)$$

set $k = \pm 1$ to determine IF output

$$Y_2(f)\Big|_{IF} = \frac{1}{T_{LO}}\left[-X(f-f_0)-X(f+f_0)\right] \cdot \frac{1}{jw}\left[1-e^{-jwT_{LO}/2}\right]\Big|_{w=w_{IF}}$$

If $w_{IF} << 2w_{LO}$,

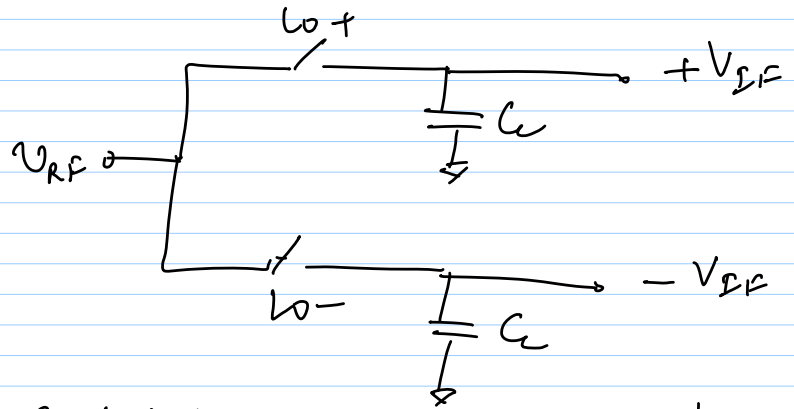
$$e^{-jw_{IF}T_{LO}/2} \simeq \left(1 - j^{w_{IF}}\frac{T_{LO}}{2}\right)$$

$$Y_2(f)\Big|_{IF} \simeq \frac{-X(f-f_{LO}) - X(f+f_{LO})}{2}$$

$$|Y(f)|_{IF} = \left|Y_1(f) + Y_2(f)\right|_{IF}$$

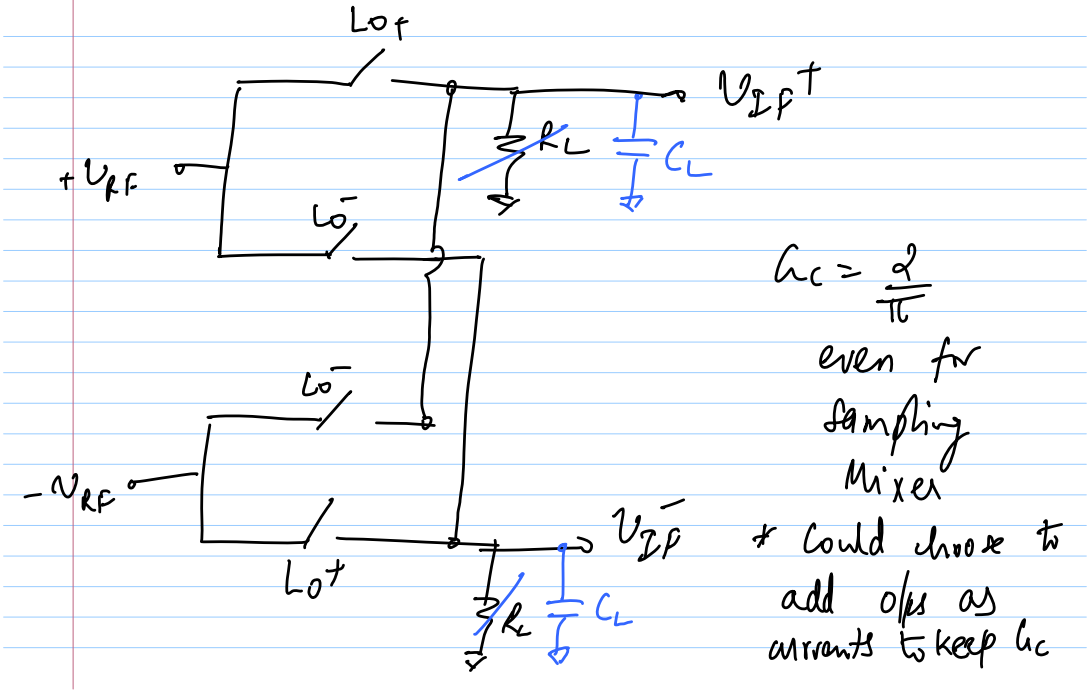
$$= \sqrt{\frac{1}{\pi^2} + \frac{1}{4}} \cdot \left[|X(f-f_{LO})| + |X(f+f_{LO})|\right]$$

$G_c = 0.593$



Single balanced passive mixer has

$G_c = 1.18 = 1.48\,dB$



$G_c = \frac{2}{\pi}$

even for sampling mixer

* could choose to add o/ps as currents to keep G_c

Current mode passive mixers