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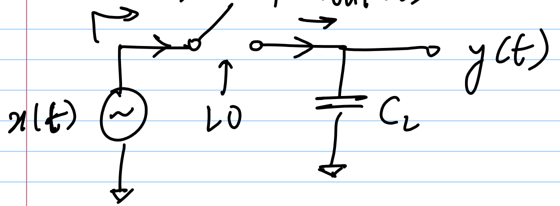
Lec 26

Input impedance of PM

1) Voltage-driven PM



* $i_{in}(t) = i_{out}(t)$
* $y(t) = y_1(t) + y_2(t)$
* $i_{out}(t) = C_L \dfrac{dy}{dt}$

$$I_{in}(f) = j\omega C_L Y(f)$$

* $x(t)$ is narrowband $\Rightarrow$ we are interested in freq. component of $I_{in}(f)$ corresponding to this

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

$$Y_2(f) = \left[X(f) * \frac{1}{T_{LO}} \sum_{k=-\infty}^{\infty} e^{-j\omega T_{LO}/2} \delta(f - kf_{LO})\right] \cdot \frac{1}{j\omega}\left(1 - e^{-j\omega T_{LO}/2}\right)$$

* Set $k=0$ for freq. component of interest

$$Y_1(f) \rightarrow \frac{X(f)}{2}$$

$$Y_2(f) \rightarrow \frac{1}{T_{LO}} \cdot X(f) \cdot \left[\frac{1}{j\omega}\left(1 - e^{-j\omega T_{LO}/2}\right)\right]$$

$$Y_{in}(f) = \frac{I_{in}(f)}{X(f)} = j\omega C_L \left[\frac{1}{2} + \frac{1}{j\omega T_{LO}}\left(1 - e^{-j\omega T_{LO}/2}\right)\right]$$

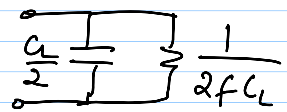
(TX)

a) $\omega \ll 2\pi f_{LO}$

$$Y_{in}(f) = j\omega C_L$$

b) $\omega = 2\pi f_{LO}$ (DCR): second term $= \dfrac{1}{j\pi}$

$$Y_{in}(f) = j\omega \frac{C_L}{2} + 2f C_L$$



c) $\omega \gg 2\pi f_{LO}$, second term is negligible

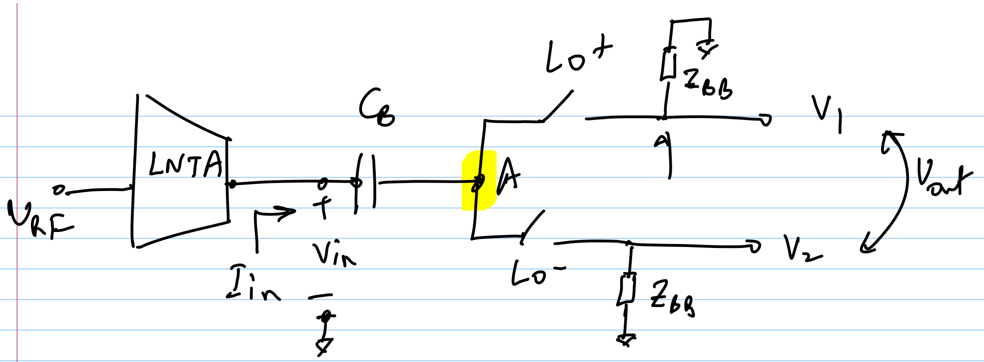
$$\Rightarrow Z_{in}(f) = j\omega \frac{C_L}{2}$$

Single-balanced PM, with $\omega \simeq \omega_{LO}$,

$$Z_{in_{SB}} = \frac{1}{2}\left[R_{SW} + \frac{1}{2f C_L + j\omega \frac{C_L}{2}}\right]$$

2) Current mode PM

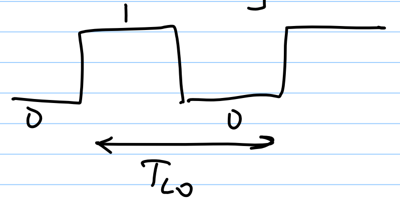
* Z_{in} would be different because the PM is time variant
* $Z_{in}(f) = \dfrac{V_{in}(f)}{I_{in}(f)}$



Z_{BB} has impulse response $h(t)$

$$V_1(t) = [i_{in}(t) \times s(t)] * h(t)$$

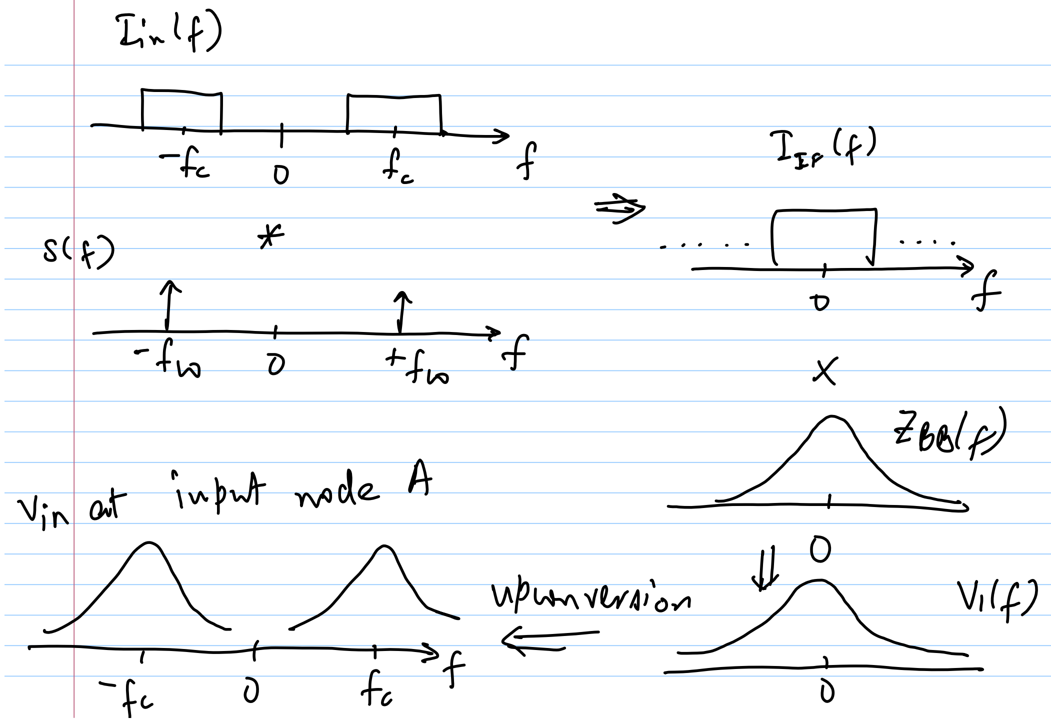
$s(t) =$



50% duty cycle

$$V_1(f) = [I_{in}(f) * S(f)] \cdot Z_{BB}(f)$$

- * $I_{in}(f)$ convolved with 1st harmonic of $S(f)$ — freq. translation to $I_{IF}(f)$
- * $V_1(f) = I_{IF}(f) \cdot Z_{BB}(f)$
- * $V_1(t)$ & $V_2(t)$ are multiplied with $s(t)$ — up-converted to RF



- * RF voltage spectrum is shaped by $Z_{BB}(f)$
  - → Lowpass — becomes Bandpass @ RF
- * Noise & linearity of current mode PM are better. — because the mixer is in series with input current source

PM LO swing

- — as large as possible (not a problem @ moderate freq.)
- — 50% duty cycle

duty cycle = d ← maximise

$$I_{IF}(t) = \frac{2}{\pi} \frac{\sin(\pi d)}{2d} I_{RF_0} \cos \omega_{IF} t$$

best case – impulse sampling

– generating impulses is difficult

25% duty cycle is easy to generate

– gives 3dB ($\sqrt{2}$ times) more gain

– $G_c = \frac{2\sqrt{2}}{\pi}$ for $d = 0.25$

– LO_0 & LO_{180} and LO_{90} & LO_{270} are

not on simultaneously – lower noise & NL