Lec 26
Input impedance of PM

1) Voltage-driven DM
\[ \text{Input: } u(t) \quad \text{Output: } y(t) \]
\[ x(t) \to \frac{1}{L_0} \frac{1}{C_L} \frac{d}{dt} y(t) \]
\[ y(t) = y_1(t) + y_2(t) \]
\[ x(t) = \frac{1}{L_0} \frac{1}{C_L} \frac{d}{dt} y(t) \]
\[ y_1(t) = X(f) \ast \left[ \frac{1}{jW} \left( 1 - e^{j2\pi f L_0} \right) \right] \]
\[ y_2(t) = \left[ X(f) \ast \sum_{k=-\infty}^{\infty} e^{j2\pi f L_0} \delta(f - k f_L) \right] \cdot \frac{1}{jW} \left( 1 - e^{-j2\pi f L_0} \right) \]
* Set \( k=0 \) for frequency component of interest
\[ Y_1(f) = X(f) \frac{1}{jW} \left( 1 - e^{j2\pi f L_0} \right) \]
\[ Y_2(f) = \frac{1}{jW} \cdot X(f) \left[ \frac{1}{jW} \left( 1 - e^{-j2\pi f L_0} \right) \right] \]

2) \( W \gg 2\pi f_L \), second term is negligible
\[ Z_{in}(f) = \frac{jW C_L}{2} \]

a) \( W \ll 2\pi f_L \)
\[ Y_{in}(f) = jW C_L \]

b) \( W = \frac{2\pi f_L}{2} \) (DCR): second term = \( \frac{1}{jW} \)
\[ Y_{in}(f) = jW C_L + 2f C_L \]

3) Current mode PM
* \( Z_{in} \) could be different because the PM is time variant
\[ Z_{in}(f) = \frac{V_{in}(f)}{I_{in}(f)} \]
\[ V_i(f) = [\text{In}(f) \ast \text{S}(f)] \cdot Z_{BB}(f) \]

- In(f) convolved with 1st harmonic of \( S(f) \) - key translation to \( I_\text{f}(f) \)
- \( V_i(f) = I_\text{f}(f) \cdot Z_{BB}(f) \)
- \( V_i(t) \) & \( V_\text{s}(t) \) are multiplied with \( S(t) \) - up-converted to RF

\[ V_\text{IF}(f) \]

- RF voltage spectrum is shaped by \( Z_{BB}(f) \)
  - Lowpass - becomes Bandpass at RF
- Noise & linearity of current mode PM are better - because the mixer's in series with input current source
- PM to swing as large as possible (not a problem @ moderate freq)
  - 50% duty cycle

\[ \text{Vin at input mode A} \]

- \( Z_{BB}(f) \)
  - Upconversion
  - \( 0 \)
  - \( V_i(f) \)
duty cycle = \( d \) \rightarrow \text{maximise} \quad I_{Sp}(t) = \frac{2}{\pi} \frac{\sin (d \cdot t)}{2d} \quad \text{I.R.F. at} \quad I_{Sp}

best case — impulse sampling
— generating impulses is difficult
-5% duty cycle is easy to generate
— gives 3dB (\( \sqrt{2} \) times) more gain
— \( I_c = \frac{2 \sqrt{2}}{\pi} \) for \( d = 0.25 \)
— \( I_0, I_{0101}, \text{and} \quad I_{090} \quad \text{and} \quad I_{027} \) are

not on simultaneously — lower noise @ NL