RF Circuit Design **Prof. Salvatore Levantino**

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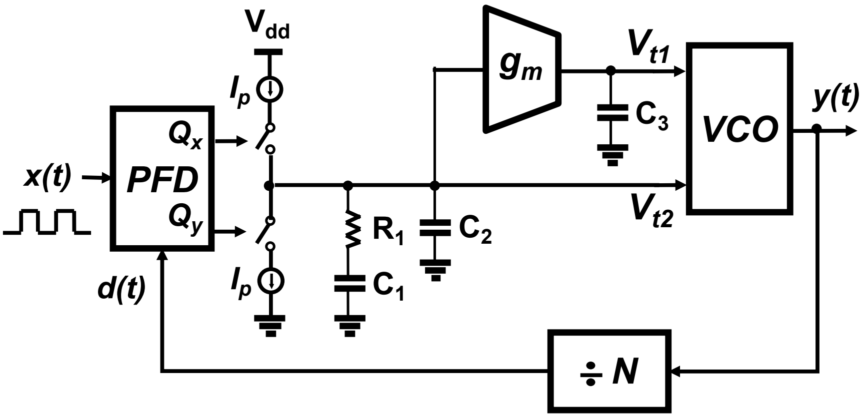
Mid-term Test

Problem #1

Assume that $x(t)$ and $d(t)$ are square-wave signals between 0V and V_{dd} = 2.5V, with $x(t)$ being a 20-MHz signal. The VCO has 1-GHz free-running frequency and two tuning nodes V_{t1} and V_{t2}, which vary the frequency linearly when their voltages are swept from 0V to V_{dd}.



Let R_1 = 3kΩ, C_1 = 1nF, C_2 = 27pF, N = 60, g_m = 10μS, $K_{vco,1}$ = 1.3 Grad/(sV) (from V_{t1}) and $K_{vco,2}$ = 330 Mrad/(sV) (from V_{t2}).

a) Calculate the **values of I_p and C_3** to have the loop-gain crossover frequency at 500kHz with 60-degree phase margin. **How do the crossover frequency and phase margin change at g_m = 0?**

b) Calculate the values of the **tuning voltages V_{t1} and V_{t2} at steady-state**.

c) Assume that the stand-alone VCO has $1/f^3$ phase noise such that $\mathcal{L}_{VCO}$(1kHz) = -40dBc/Hz. For **both cases (g_m = 10μS and g_m = 0)**, calculate the **value of the output phase noise $\mathcal{L}_y$(1kHz)**.

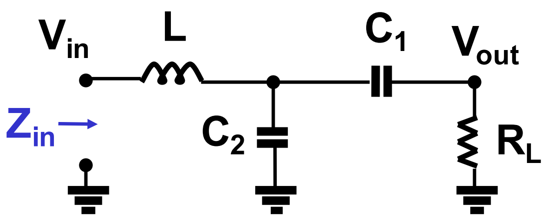
[Sol.: a) C_3 = 71pF, I_p = 1.2mA; f_u = 500kHz, PM = 70deg; b) V_{t1} = 0.97V, V_{t2} = 0V; c) $\mathcal{L}_y$ = -167dBc/Hz (g_m = 10μS), -128dBc/Hz (g_m = 0)]

Problem #2

The circuit in figure is used to transform the load impedance R_L = 50Ω to have an input impedance of Z_{in} = 10Ω + j0Ω at f_0=5GHz frequency.

a) Find the **values of the inductance L and the capacitance C_1 = C_2**.

b) Calculate the **gain V_{out}/V_{in} at $f = f_0$** (magnitude and phase), and estimate the **shape** of the frequency response of V_{out}/V_{in}.



[Sol.: a) C_1 = C_2 = 0.63pF, L = 0.96nH; b) |V_{out}/V_{in} | = √5 = 2.23, Phase(V_{out}/V_{in}) = -26deg, bandpass]