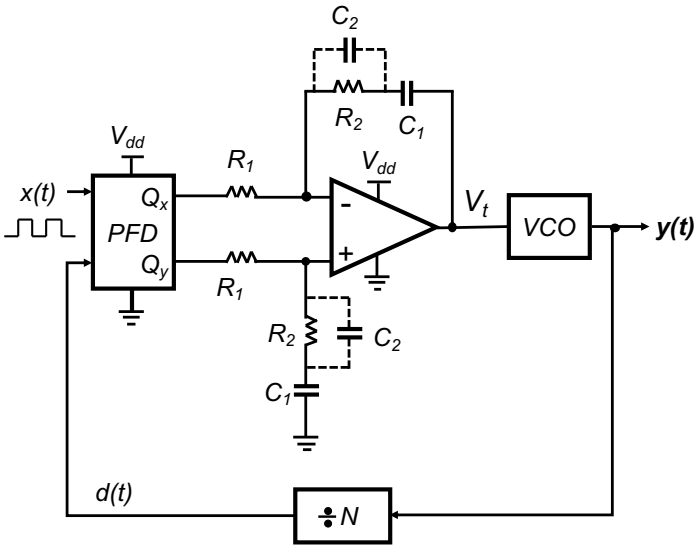
RF Circuit Design **Prof. Salvatore Levantino**

Available time: 120 minutes April 22nd, 2021

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 20MHz signal. The VCO has 5GHz free-running frequency and 500MHz linear tuning range from 0V to V_{dd}. Let R_2 = 1kΩ, N = 261.



a) Neglect the capacitors C_2 (C_2=0) and **calculate the values of R_1 and C_1** to have 50kHz loop bandwidth and maximally flat response from input to output.

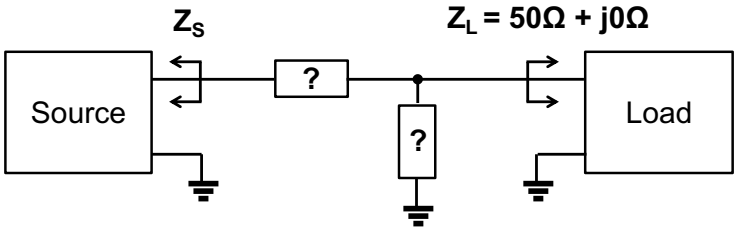
b) If the Op-Amp has input-referred voltage offset of 100mV, calculate **the value of the capacitor C_2** which is needed to keep the level of the reference spur at -50dBc.

c) Assuming that the Op-Amp has an input-referred voltage noise of 20nV/√Hz, calculate the **value of the output phase noise $\mathcal{L}_y$ at 1kHz offset from the carrier**.

[Sol.: a) C_1 = 4.5nF, R_1 = 4.3kΩ; b) C_2 = 670pF; c) $\mathcal{L}_y$ (1kHz) = -101dBc/Hz]

Problem #2

The two unknown elements in the circuit are used to create conjugate matching from source to load at f_0=2.5GHz frequency (for maximum power transfer) and lowpass transfer function.



a) Find **the types and the values of the two unknown elements**, when Zs = 23Ω + j0Ω.

b) Find **the types and the values of the two unknown elements**, when Zs = 23Ω + j11.5Ω.

c) What is the **value of the voltage gain from input to output** at f_0 in the circuits found in b).

[Sol.:
a) Z_{in} = 23Ω, Z_1 is an inductor L = 1.58nH, and Z_2 is a capacitor C = 1.38pF;
b) Z_{in} = 23Ω-j11.5Ω, Z_1 is an inductor L = 0.85nH, and Z_2 is a capacitor C = 1.38pF;
c) Re{Z_{in}} = 28.7Ω, $|V_{out}/V_{in}| = \sqrt{(Re\{Z_L\}/Re\{Z_{in}\})} = 1.32$]