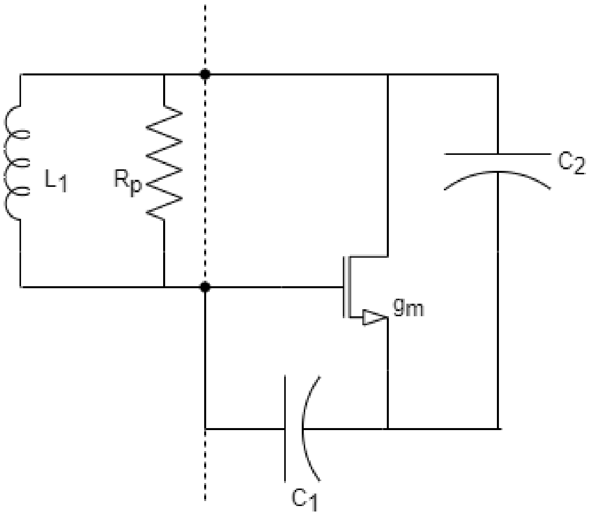
# EE 619

# Radio Frequency Microelectronic Chip Design

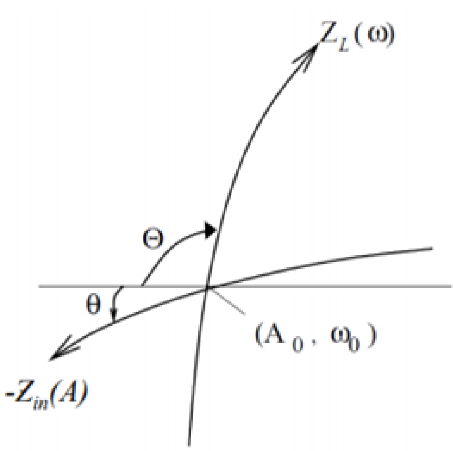
# Endsem Exam

4th May 2021, 3.00pm-6.00pm

1. For the given collpits oscillator, prove that the condition of oscillation is $g_m.R_P=4$ and $C_1=C_2$ **(3 M)**




2. For oscillation stability prove that Θ+Θ is between 0 and 180 degree. **(3 M)**

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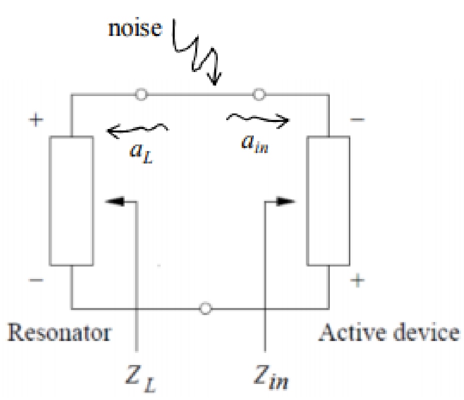
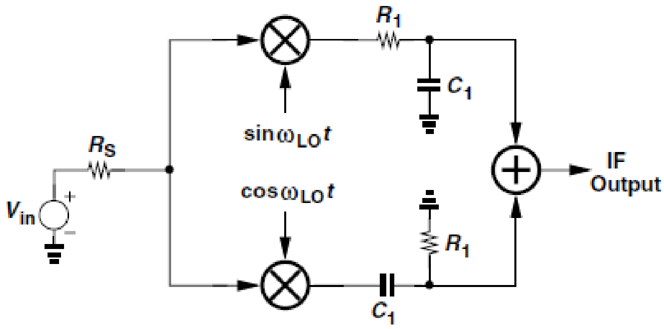
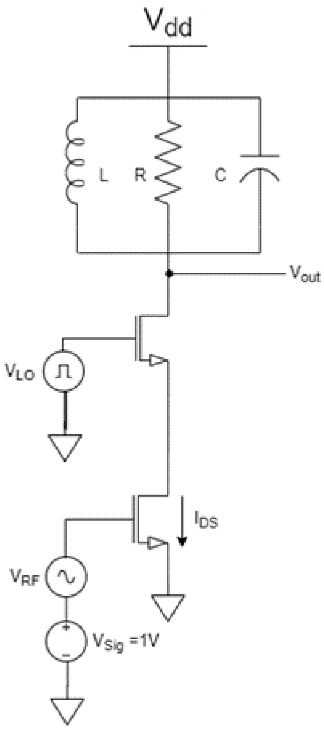



**<u>Model of Oscillator</u>**

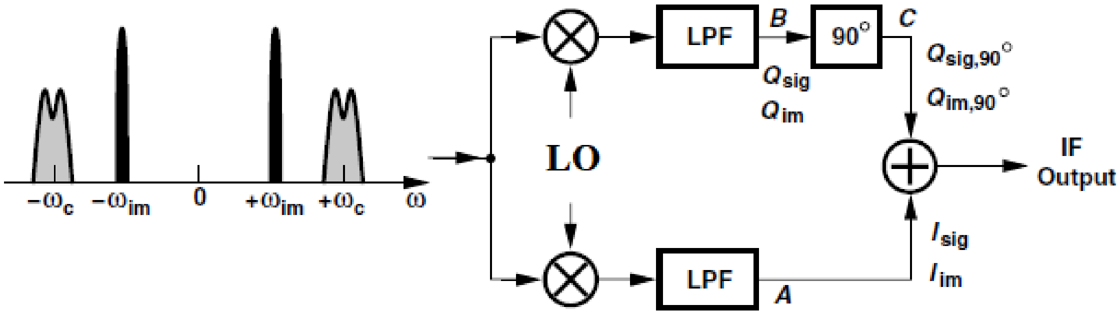
3. The simplified Hartely architecture shown incorporates mixers having a voltage conversion gain of $A_{mix}$ and infinite input impedance. Taking into account only the noise of the two resistors, compute the noise figure of the receiver with respect to a source resistance of $R_S$ at an IF of $1/R_1C_1$. **(3 M)**



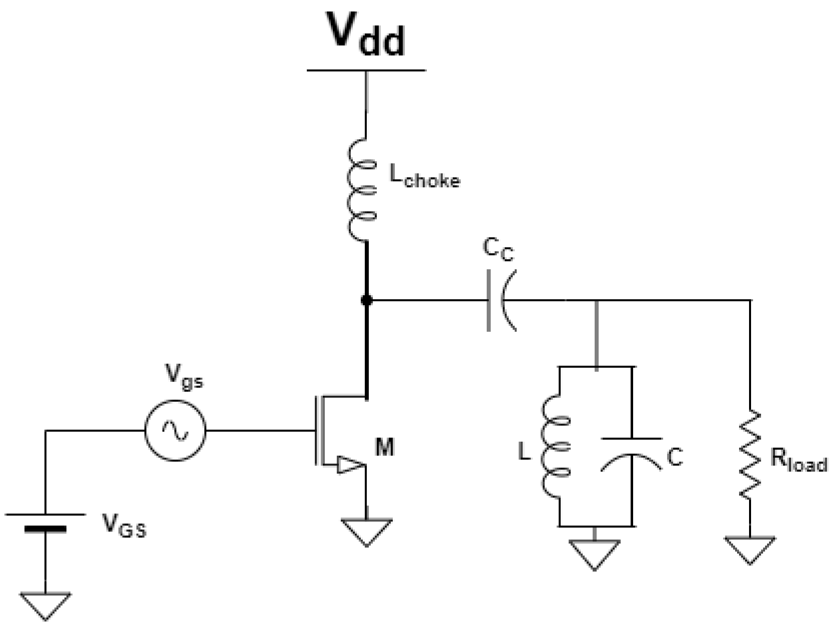

4. In the given figure, find the voltage conversion gain ($A_{VC}$) of the mixer in dB. Assume that the resonant tank circuit (LRC) will sufficiently allow the ($\omega_{RF}$ - $\omega_{LO}$) frequency component and reject others. Given, $g_m$ of the MOSFETS is 2mS, R=3KΩ, $V_{bias}$=1V, $V_{thn}$=0.5V, Amplitude of the square wave of LO=1.2V,(LO oscillated between 0 and 1.2 with frequency $\omega_{LO}$). (Assume VDD = 1.2V) **(3 M)**



5. For the given architecture, derive the expression of **I**mage **R**ejection **R**atio (IRR) as a function of ε and ΔΘ. Hence prove that IRR$\approx\frac{4}{\varepsilon^2+\Delta\theta^2}$ if ΔΘ<<1rad and ε<<1rad.(Assume one LO waveform is expressed as sin$\omega_{Lo}$t and the other as (1+ε).cos($\omega_{Lo}$t+ ΔΘ) due to mismatches) **(4 M)**




6. Design a class-B RF power amplifier to deliver an output power of 5.1dBm at $f_0$=2.45GHz. The bandwidth is 500MHz.Assume $V_{DD}$=1.8V, $V_{th}$=0.6V (Threshold voltage of NMOS) $\mu_n C_{ox}$=200µA/V$^2$.(Assume input AC source $v_{gs}$=0.2cos(ωt). Tabulate the values of $R_{load}$, L, C, W/L of transistor M. Draw the voltage waveform at $R_{load}$ and current waveform $I_d$ of transistor M of at least one cycle. Clearly label the amplitudes.
**(6 M)**



7. A Hilbert transform of a signal m(t) ←→$m_h(t)$ with the relation **(2 M)**

$m_h(t) = \frac{1}{\pi}\int_{-\infty}^{+\infty}\frac{m(t)}{t-\tau}d\tau$ and $M_H(f)$=-$jsgn(f).M(f)$ show that for a upper sideband modulated signal resulting from m(t) and $\cos(2\pi f_c t)$ is given by $s(t)=\frac{1}{2}[m(t)\cos(2\pi fct) - mh(t)\sin(2\pi fct)]$

8. The below figure shows the concept of Heterodyne Transmitter. Signal conversion happens in two steps as shown. The frequency of up-conversion is $f_0$=5GHz. Units in spectrum are in MHz. Assume that $f_1$=1GHz and $f_2$=4GHz . The spectrum of I signal is real. The Q spectrum is 90 degrees phase shifted version of I spectrum (Imaginary). The I and Q signals are at base band(Close to DC). Our goal is to have final PA transmitter spectrum at 5GHz.
    a. Draw the 3D spectrum at A,B,C, and D **(4M)**
    b. Sketch the characteristics of the desired BPF?(Center frequency & Stopband) **(2M)**