Texas A&M University
Department of Electrical and Computer Engineering

ECEN 620 – Network Theory (Broadband Circuit Design)

Fall 2025

Exam #2

Instructor: Sam Palermo

- Please write your name in the space provided below
- Please verify that there are **5** pages in your exam
- You may use one double-sided page of notes and equations for the exam
- Good Luck!

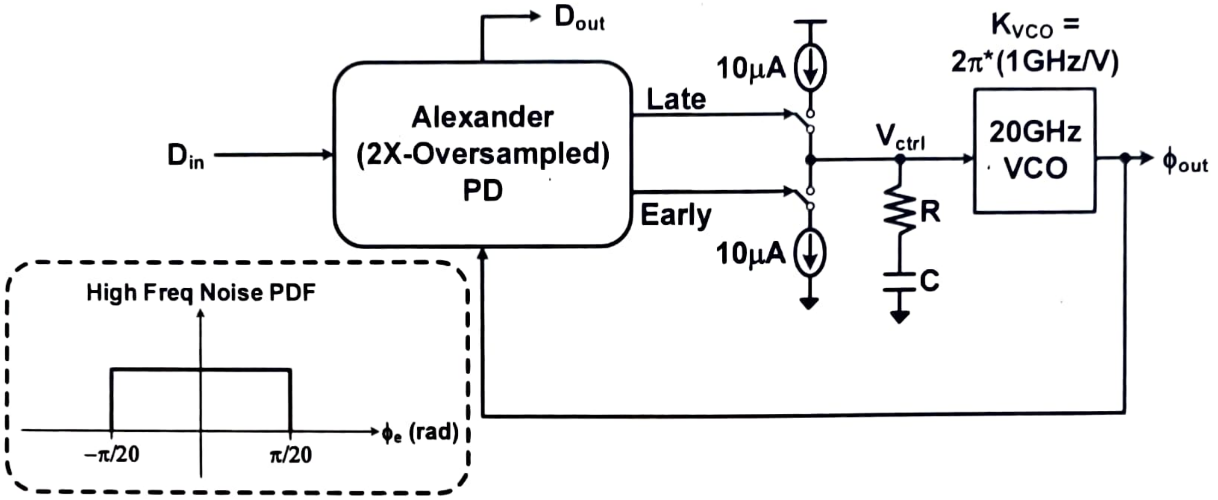
Problem	Score	Max Score
1		50
2		50
Total		**100**

Name: SAM PALERMO

UIN: ______

Problem 1 (50 points)

For the CDR shown below, assume that the incoming data has a **transition density** $\boldsymbol{TD} = \mathbf{0.7}$. Assume that high-frequency phase noise, given by the uniform PDF below, is present and linearizes the system. Design the loop filter components to yield $\zeta = 1$ and $\omega_{3dB} = 2\pi*(20MHz)$. Note, for $\zeta = 1$, $\omega_{3dB} = 2.48*\omega_n$.



Closed-Loop CDR Transfer Function

$$H(s) = \frac{2\zeta\omega_n\left(s + \frac{\omega_n}{2\zeta}\right)}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

where $\omega_n = \sqrt{\dfrac{K_{PD} I_{cp} K_{vco}}{C}}$ and K_{PD} is the linearized

$$K_{PD} = \frac{2}{\phi_{PP}}(TD) = \frac{2}{\frac{\pi}{10}}(0.7) = \frac{14}{\pi}$$

$$\zeta = \frac{\omega_n}{2} RC$$

$$C = \frac{K_{PD} I_{cp} K_{vco}}{\omega_n^2} = \frac{K_{PD} I_{cp} K_{vco}(2.48)^2}{\omega_{3dB}^2} = \frac{\left(\frac{14}{\pi}\right)(10\mu A)(2\pi\, 1GHz/V)(2.48)^2}{(2\pi\, 20MHz)^2} = 109pF$$

$$R = \frac{2\zeta}{\omega_n C} = \frac{2(1)(2.48)}{(2\pi\, 20MHz)(109pF)} = 362\Omega$$

R = 362Ω

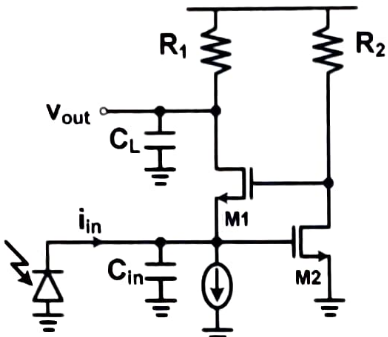
C = $109pF$

Problem 2 (50 points)

For the TIA shown below, assume that all transistors are operating in saturation with $r_o=\infty$. Obtain expressions for the following:

a) Low-Frequency Transimpedance.

b) The TIA's input bandwidth. Note, it's OK to neglect the transistor capacitors here.



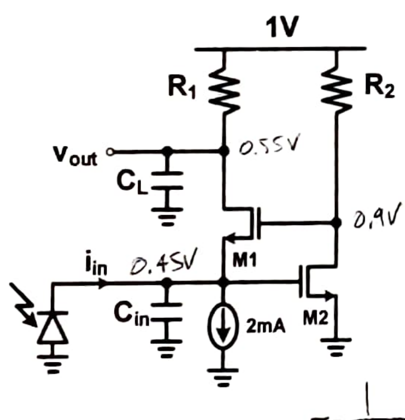
a, $R_T = R_1$

b, $R_{in} = \dfrac{1}{g_{m1}(1+g_{m2}R_2)}$

$W_{in} = \dfrac{1}{R_{in}C_{in}} = \dfrac{g_{m1}(1+g_{m2}R_2)}{C_{in}}$

c) Now assume that the TIA works with a 1V supply and 2mA bias in the input stage. Assume that all the transistors have an overdrive voltage of 100mV. What is the minimum input resistance and maximum transimpedance that can be achieved, while still keeping all transistors in saturation? Use the following NMOS parameters.

$KP_N=\mu_n C_{ox}=600\mu A/V^2$, $V_{TN}=0.35V$, $\lambda_N=0V^{-1}$



$g_{m2} = \dfrac{2I_2}{V_{OD}}$ $R_2 = \dfrac{100mV}{I_2}$

$g_{m2}R_2 = \left(\dfrac{2I_2}{V_{OD}}\right)\left(\dfrac{100mV}{I_2}\right) = 2$

$g_{m1} = \dfrac{2(2mA)}{100mV} = 40mA/V$

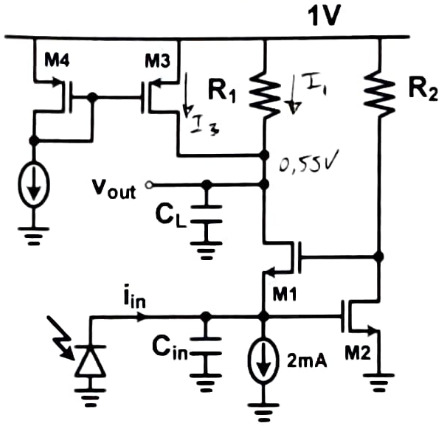
$R_{in,min} = \dfrac{1}{40mA/V(1+2)} = 8.33\Omega$

$R_{T,max} = \dfrac{1V-0.55V}{2mA} = 225\Omega$

$R_{in,min}$ = 8.33Ω

$R_{T,max}$ = 225Ω

d) Now assume that the circuit is modified as shown below. Assuming the same NMOS bias conditions as part (c), how much current should flow through M3 to allow the TIA to achieve 60dBΩ transimpedance?



$R_1 = 1k\Omega$

$I_1 = \frac{1V - 0{,}55V}{1k\Omega} = 450\mu A$

$I_3 = 2mA - 450\mu A = 1.55mA$

$I_{M3} = 1.55mA$