Texas A&M University
Department of Electrical and Computer Engineering

ECEN 620 – Network Theory (Broadband Circuit Design)

Fall 2020

Exam #2

Instructor: Sam Palermo

- Please write your name in the space provided below
- Please verify that there are **4** pages in your exam
- You may use one double-sided page of notes and equations for the exam
- Good Luck!

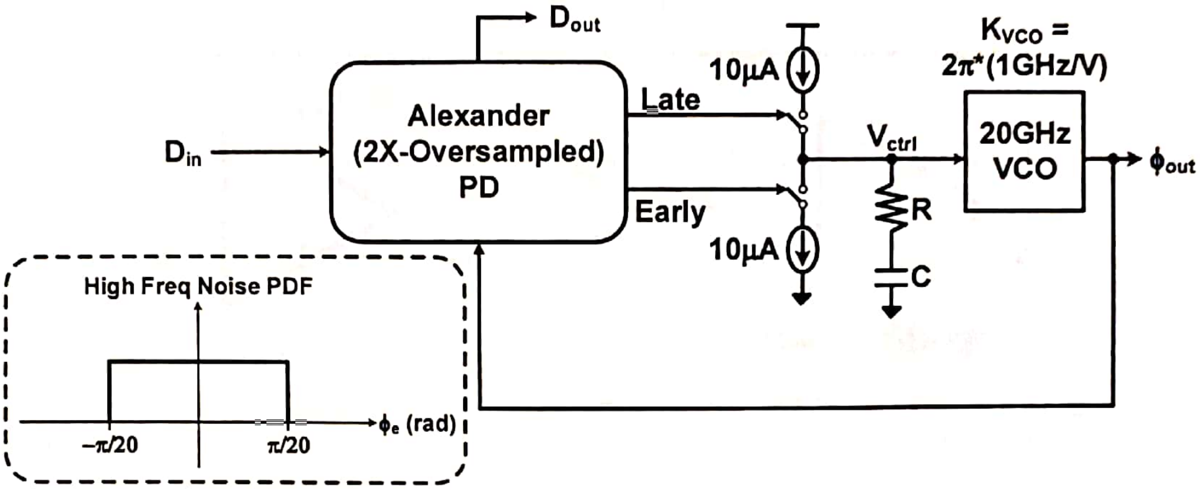
Problem	Score	Max Score
1		50
2		50
Total		**100**

Name: SAM PALERMO

UIN:

Problem 1 (50 points)

For the CDR shown below, assume that the incoming data has a **transition density TD = 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 $\zeta = 2$, $\omega_{3dB} = 2.48*\omega_n$.



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

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

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

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

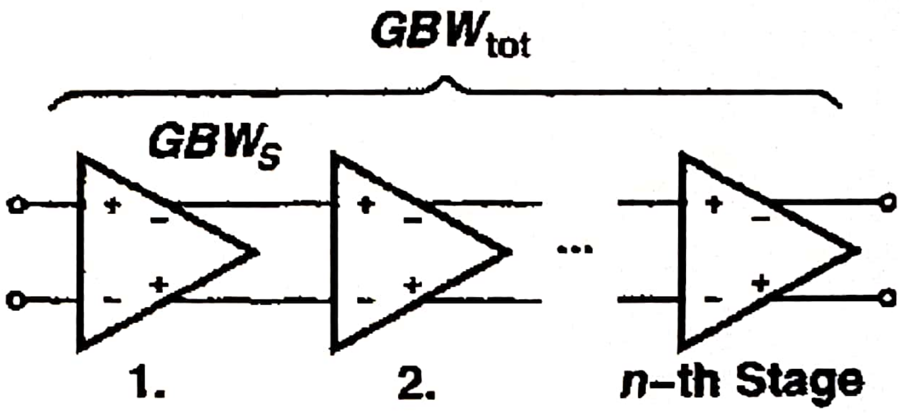
$$C = 109pF$$

$$R = \frac{2\zeta}{\omega_n C} = \frac{2\zeta(2.48)}{\omega_{3dB} C} = \frac{2(1)(2.48)}{(2\pi\ 20MHz)(109pF)} = 362\Omega$$

R = 362Ω

C = 109pF

Problem 2 (50 points)
Assume that the limiting amplifier below consists of cascaded identical single-pole amplifier stages, with gain A_{vs} and bandwidth ω_{3dBs}.



a) Design the limiting amplifier to achieve a 26dB total gain and 25GHz total bandwidth with the minimum per-stage gain-bandwidth product. Give the stage number and the per-stage gain and bandwidth. Also compute the per-stage gain-bandwidth product.

$n_{opt} = 2\ln(G_{tot}) = 2\ln(20) = 5.99 \Rightarrow 6$ stages

$A_{vs} = \sqrt[n]{G_{tot}} = \sqrt[6]{20} = 1.65$

$\omega_{3dBtot} = \omega_{3dBs}\sqrt{2^{1/n}-1} \Rightarrow \omega_{3dBs} = \frac{\omega_{3dBtot}}{\sqrt{2^{1/n}-1}}$

$\omega_{3dBs} = \frac{2\pi(25GHz)}{\sqrt{2^{1/6}-1}} = 449$ Grad/s

n = 6

A_{vs} = 1.65

ω_{3dBs} = 449 Grad/s (71.5GHz)

GBW_s = 741 Grad/s (118GHz)

b) Now let's use a more reasonable stage number. With **n=4** and for the same 26dB total gain and 25GHz total bandwidth, compute the per-stage gain and bandwidth. Also compute the per-stage gain-bandwidth product.

$A_{vs} = \sqrt[4]{20} = 2.11$

$\omega_{3dBs} = \frac{2\pi(25GHz)}{\sqrt{2^{1/4}-1}} = 361$ Grad/s

A_{vs} = 2.11

ω_{3dBs} = 361 Grad/s (57.5GHz)

GBW_s = 762 Grad/s (121GHz)

Scratch Paper