CARLETON UNIVERSITY

FINAL
EXAMINATION
December 2013

DURATION 3 HOURS No. of Students 12

Department Name & Course Number: Electronics ELEC 5705
Course Instructor(s): Prof. John W. M. Rogers

AUTHORIZED MEMORANDA	Calculators, Course Notes

Students MUST count the number of pages in this examination question paper before beginning to write, and report any discrepancy immediately to a proctor. This question paper has 5 pages.

This examination question paper MAY **be taken from the examination room.**

Information and Instructions:

1. Attempt all questions.
2. Show all analysis.
3. The exam marks total 100.

Potentially Useful Equations:

$$v_{DS\,Sat} = v_{GS} - V_T,\ V = IR,\ C = \frac{q}{V},\ i_D = \frac{1}{2}\left(\mu C_{ox}\right)\left(\frac{W}{L}\right)\left(v_{GS} - V_T\right)^2$$

$$v_{DS\,Sat} = v_{GS} - V_T = \sqrt{\frac{2i_D}{\mu C_{ox}\left(\frac{L}{W}\right)}},\ E = mc^2, c = \frac{1}{\sqrt{\mu\varepsilon}}$$

$$r_{DS} = \frac{1}{\lambda I_{DS}}, i_{nd}{}^2 = 4kT\left(\frac{2}{3}\right)g_m,\ \text{kT} = 4\cdot10^{-21}\text{W/Hz at T=290K, q} = 1.6\cdot10^{-19}\text{C}$$

$$g_m = \sqrt{2\mu C_{ox}\left(\frac{W}{L}\right)I_{DS}},\ \Gamma = \frac{Z_L - Z_o}{Z_L + Z_o},\ \nabla\times\vec{E} = -\mu\frac{\partial\vec{H}}{\partial t}$$

$$a = \frac{dv}{dt} = \frac{d^2x}{dt^2},\ Money = Power = VI = I^2R = \sqrt{Evil},\ R_{on} = R\cdot\frac{L}{W}$$

$$\alpha = \frac{1}{(1+\Delta A)\cos(\phi_e)},\quad \Delta A = \frac{-2(Q_dQ_{im} + I_dI_{im})}{I_d{}^2 + Q_d{}^2},\quad \phi_e = 2\tan^{-1}\left[\frac{Q_dI_{im} - I_dQ_{im}}{Q_d{}^2 + I_d{}^2}\right]$$
$$\beta = -\tan(\phi_e)$$
,

Question 1 (Total 25 Marks)

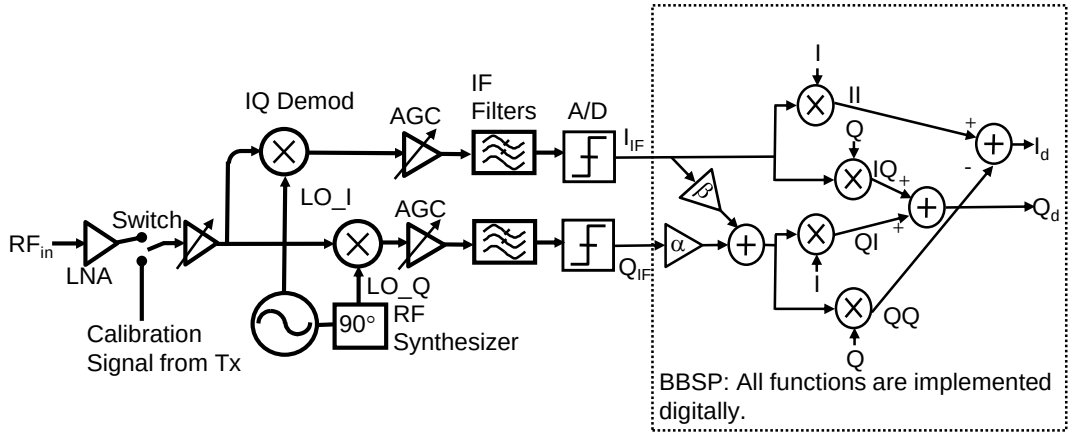
(a) Write an expression to describe an amplifier that has a gain of 10dB, an IIP2 of 20dBm, and an IIP3 of -10dBm.

(b) Write an expression for a 2GHz LO with a 1V peak amplitude and a phase noise of -80dBc/Hz at all offset frequencies.

(c) A signal is modulated with BPSK and has an RF bandwidth of 1MHz. What is the BER if -104dBm of power is received in a radio with a 5dB NF?

Question 2 (Total 25 Marks)

A low IF radio is shown below.



The radio must be able to handle signals from -80 to -30dBm with an SNR of 15dB. The A/D should have a 1V input signal. Received signals in the band of 2GHz with a bandwidth of 5MHz. The IF is at 10MHz. Fill in the following table so that the radio will operate properly:

Component	Parameters
LNA	Gain: 15 dB NF: _____dB
RF Mixers	Voltage Gain: 5 dB NF: 10 dB IIP3:_____dBm
AGC	Voltage Gain Range: _____ dB AGC gain mismatch: 1%
IF Amplifier	Voltage Gain Range: _____ dB NF: 15 dB IIP3: -20dBm
ADC	Input voltage: 1Vpp Sampling frequency: 40MHz Number of Bits: _____ Clock timing jitter: _____
LO	LO Frequency: 1.9-2GHz LO Step Size: 5MHz LO Phase noise: _____@ _____KHz offset IQ phase mismatch: 3degrees
BBSP	α: _____ β: _____

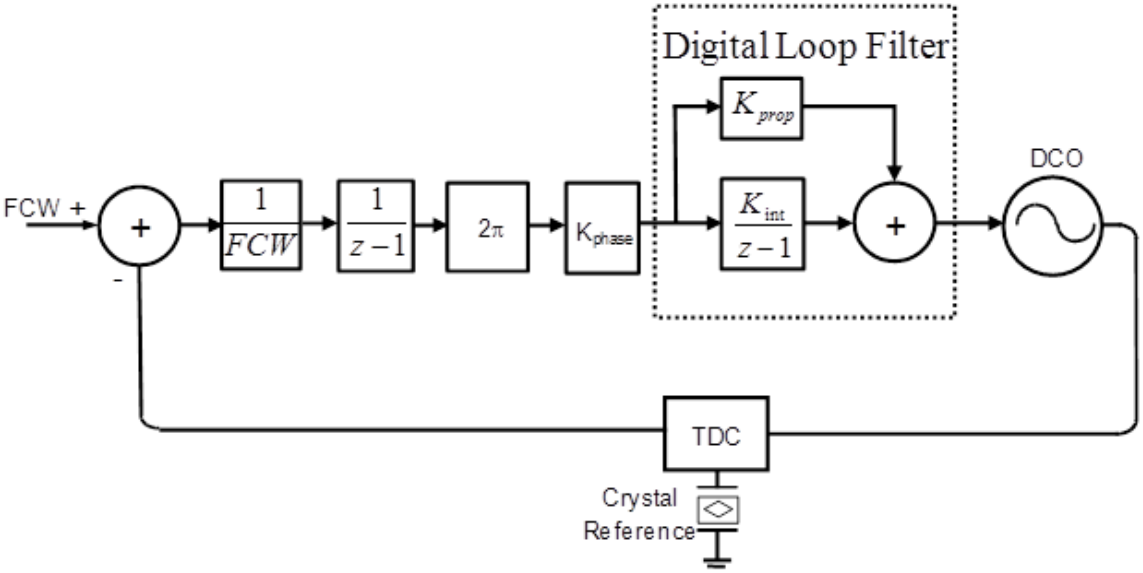
Question 3 (Total 25 Marks)

A transmitter is required to provide 20dBm of output power. It uses 16QAM OFDM modulation with 64 subcarriers. The RF bandwidth is 1MHz.

(a) What distance will the link work over if an SNR of 15dB is required?
(b) What is the linearity required to provide an ACPR of 40dB?
(c) What in band phase noise is required for an EVM of 15dB?
(d) What is the required linearity of the PA?
(e) How would we fix the EVM caused by phase shift through the base band filter as discussed in class? Give a word answer only.

Question 4 (Total 25 Marks)

(a) Design a fractional N frequency synthesizer with a KVCO = 200MHz/V a CP current of 1mA and a XTAL frequency of 10MHz to produce an output frequency of 1.5GHz with a natural frequency of 300kHz and a damping constant of 0.707.
(b) What is the settling time of the synthesizer assuming no cycle slip?
(c) Now change the fractional N synthesizer into a ADPLL like the one shown below.



(d) At what frequency step size will your ADPLL start to cycle slip?
(e) If the TDC resolution is 10ps estimate the phase noise of your design.