##### ECOMMS Final Exam May 9, 2019

#### Spring 2019 10:30 – 12:30

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**Student’s Name**:

**DIRECTIONS**: This exam consists of **three** parts – Part A, Part B and Part C. Answer **all** questions in all **three** parts. This exam is **OPEN TEXTBOOK/NOTES, CLOSED COMPUTER/WEB**. Calculators are permitted. Remember to specify UNITS for all answers. Use proper NOTATION. Show ALL WORK.

**Part A** (4 questions @ 10 points each = 40 points)

1. Write down Shannon’s Theorem, describing each term. Discuss the trade-offs that this theorem allows us to calculate, for the goal of achieving an ideal communications system.
2. Describe the similarities and differences between analog-bandpass and digital-bandpass communications systems. Why are the latter superior to the former?
3. Given a discrete source with messages of varying probability, describe the principle and the advantage of encoding these messages with a variable length code. Comment, in particular, on the nature of the encoded bitstream in terms of the entropy of the encoded discrete source.
4. Draw a funny picture.

**Part B**

1. Draw a block diagram for generating the following band-limited signal:



For each block, provide equations for describing the input and output, and sketch the spectrum.

Extend the block diagram so that is frequency-translated by 100 kHz.

Suppose is sampled at a rate of 100 kHz. Sketch the spectrum of the sampled waveform; provide an equation describing it.

(20 points)

**Part C**

1. *Software Defined Radio*

The Software Defined Radio (SDR) uses DSP modules, embedded cores, FPGAs and software to create modulated signals for transmission and to demodulate signals at the receiver. The advantage of this system is that new receivers can be configured just by downloading code – no reassembly of the system hardware is required. The block diagram of a typical SDR receiver is shown below.

ADC/DSP

Receiver RF Front End

YOUR CODE HERE!

SDRs have found applications mainly in the military and cell phone services, where there is constant demand for reconfigurable communications due to changing radio protocols. The bottleneck that prevents widespread use of this system in the commercial sector is the expense of Analog-to-Digital-Converter hardware to process signals modulated with GHz carrier frequencies (some ADCs cost thousands of dollars).

Propose solutions to this problem by frequency-downshifting the input RF signal so that it can be processed by cheaper/lower frequency ADC/DSP modules. In particular, speculate how such frequency translation can occur by exploiting the effect of signal sampling (refer to your solution for the last question in Part B). Provide block diagrams, equations and a convincing argument in favor of your solution. Also discuss its limitations.

(40 points)