Last name: Andrews **First name:** Josh

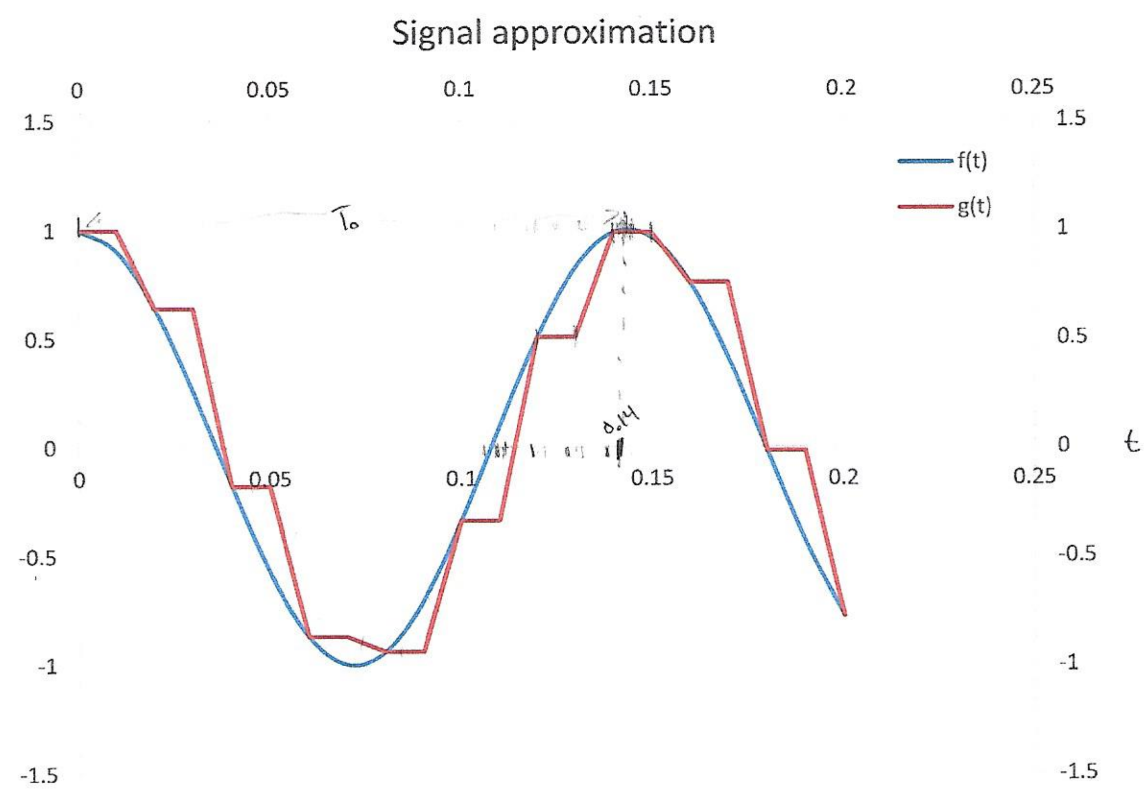
ECE 484: Communications Engineering

Midterm Examination – Spring 2018

Instructor: Dr. Ali Abedi, Professor of ECE

Important notes: Please write your name with pen on top of all pages. This exam is open book and notes and has 4 questions, one per page. Please only use the space provided for your answers, no additional pages are allowed. Phone or internet use is not allowed. Each student is expected to complete this test alone during the time allocated.

Question-1: Consider a periodic sinusoidal signal, f(t), and its approximated staircase signal, g(t) as illustrated in the figure below. **(a)** Write an equation representing f(t), determine its period, and carrier frequency. **(b)** Are these two signals, energy signal or power signal? **(c)** find the power or energy of both signals. **(d)** Determine percentage error in approximating f(t) using g(t). Enter all your final answers in the table below and show your work on the next page.



f(t)= $\cos(14.28\pi t)$	T= 0.14	f_c= 7.14 Hz	
☒Power or □Energy	P_f= 1/2	P_g=	% error =

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Question-1 (cont.): Show your work on this page.

- We can see from the graph that $T = 0.14$
  that gives a $f = \frac{1}{T} = 7.14\,Hz$ $\Rightarrow f(t) = \cos(2\pi 7.14 t)$

- because it is a periodic signal $\Rightarrow E = \infty$
  but $0 < \lim_{T\to\infty} \frac{1}{T}\int_{-T/2}^{T/2} |f(t)|^2\,dt < \infty$ $\Rightarrow$ it is a power signal
  g(t) as well

- ~~$P_f = \frac{1}{T}\int_{-T/2}^{T/2} |\cos(14.28\pi t)|^2\,dt$~~

$f(t)$ is also $= \dfrac{e^{j14.28\pi t} + e^{-j14.28\pi t}}{2}$ now apply parseval's

$P_f = |\tfrac{1}{2}|^2 + |\tfrac{1}{2}|^2 \Rightarrow \underline{P_f = 1/2}$

I'm not sure what to do with the stair function, can see it changes every 0.01 t but I dont know how to get the power or extract error from it.

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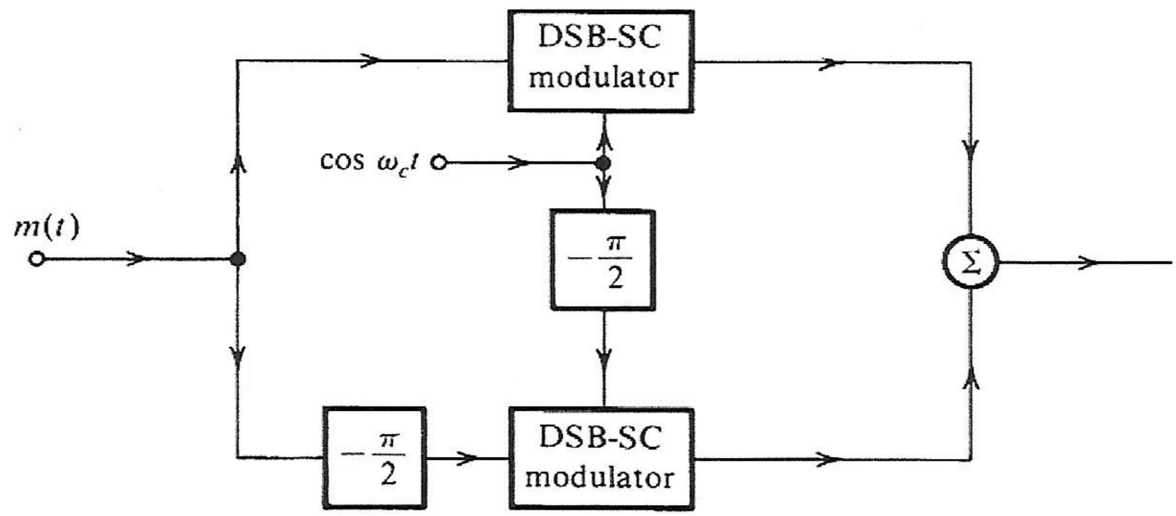
Question-2: Consider the following block diagram. **(a)** what is the function of this communication system? **(b)** If m(t) is a 1 KHz tone, determine the output of the system in time and frequency assuming that carrier frequency in the system below is 100 KHz. Write down both time and frequency equations and plot them on a labeled graph. Enter all your final answers in the table below and show your work and plot the output signal in time and frequency on the next page.



Function of this system is	The function of the system is to convert m(t) into a SSB signal. This system uses phase shifting modulation in order to do so.
Output in time domain is	$\varphi_{SSB}(t) = \cos\left(2\pi(100kHz) \pm 2\pi(10kHz)\right)t$ $\varphi_{USB}(t) = \cos(2\pi \cdot 100K + 2\pi \cdot 10K)t$ $\varphi_{LSB}(t) = \cos(2\pi \cdot 100K - 2\pi \cdot 10K)t$
Output in frequency domain is	$\Phi_{SSB}(f) = 0.5[\delta(f-90kHz) + \delta(f-110kHz) + \delta(f+90kHz) + \delta(f+110kHz)]$

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Question-2 (cont.): Show your work and out signal time and frequency plots on this page.

$f_c = 100\text{ KHz}$ $f_m = 1\text{ KHz}$ $\omega_c = 2\pi f_c$ $\omega_m = 2\pi f_m$

$m(t) = \cos 2\pi f_m t$ and $m_h(t) = \sin 2\pi f_m t$

So

$$\varphi_{SSB}(t) = m(t)\cos\omega_c t + m_h(t)\sin\omega_c t$$

$$\varphi_{SSB}(t) = \cos 2\pi f_m t \cos 2\pi f_c t + \sin 2\pi f_m t \sin 2\pi f_c t = \cos(2\pi f_c \pm 2\pi f_m)t$$

$$= \cos(2\pi \cdot 100k \pm 2\pi \cdot 10k)t$$

Now shifting to frequency domain and $\varphi_{LSB} + \varphi_{USB} = \varphi_{SSB}$

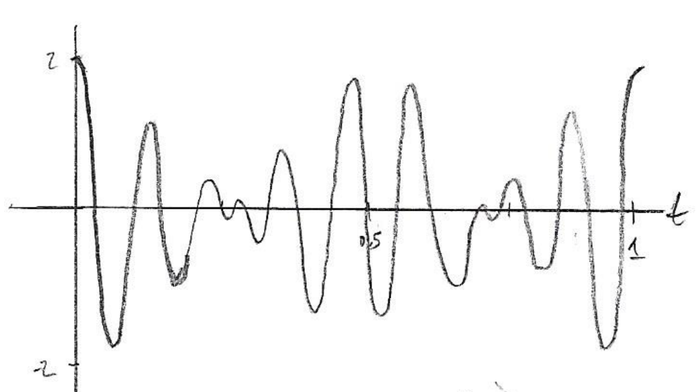
We know $\cos 2\pi f_0 t \Leftrightarrow 0.5[\delta(f+f_0) + \delta(f-f_0)]$

And after substituting & summing $\varphi_{SSB}(t)$ cos terms

$$\Phi_{SSB}(f) = 0.5\left[\delta(f-(f_c+f_m)) + \delta(f-(f_c-f_m)) + \delta(f+(f_c+f_m)) + \delta(f+(f_c-f_m))\right)$$

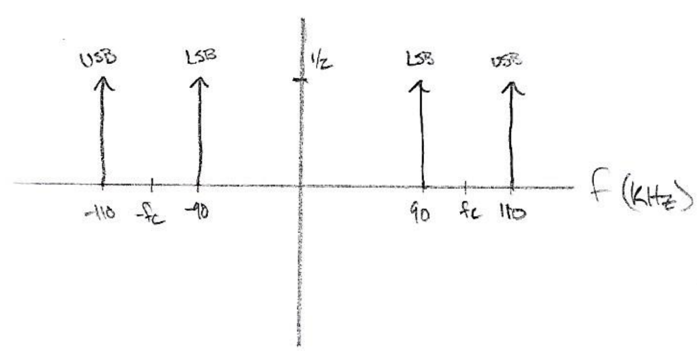
and to plot

$\varphi_{SSB}(t)$



(not the best sketch)
Sum of LSB and USB signals

$\Phi_{SSB}(f)$



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Question-3: Draw block diagram of *Armstrong* indirect modulator and explain each block separately in 1-2 sentences. What is the advantage of using this system over direct FM modulator? Draw block diagram on the next page and enter explanations on the table below.

Block Name	**Description**
1. NBFM –	The NBFM Generator converts a m(t) input
2. Multiplier M_1 –	Consists of frequency doublers, triplers, etc. first stage frequency multiplication, affects f_c & Δf
3. Frequency Mixer –	Shifts the entire spectrum by f_{LO} which alters f_{c3} but not Δf_3. Used to reach desired f_c and Δf out.
4. Local oscillator –	Generates a f_{LO} frequency by which to shift the spectra. Value depends on desired output and the input
5. BPF @ f_{c3} –	Used to filter out noise at new shifted spectra
6. Multiplier M_2 –	Second stage multiplier, similar to first stage
7.	
8.	
9.	
10.	
11.	
Advantages over direct modulation	The advantage is that indirect modulation has much better frequency stability

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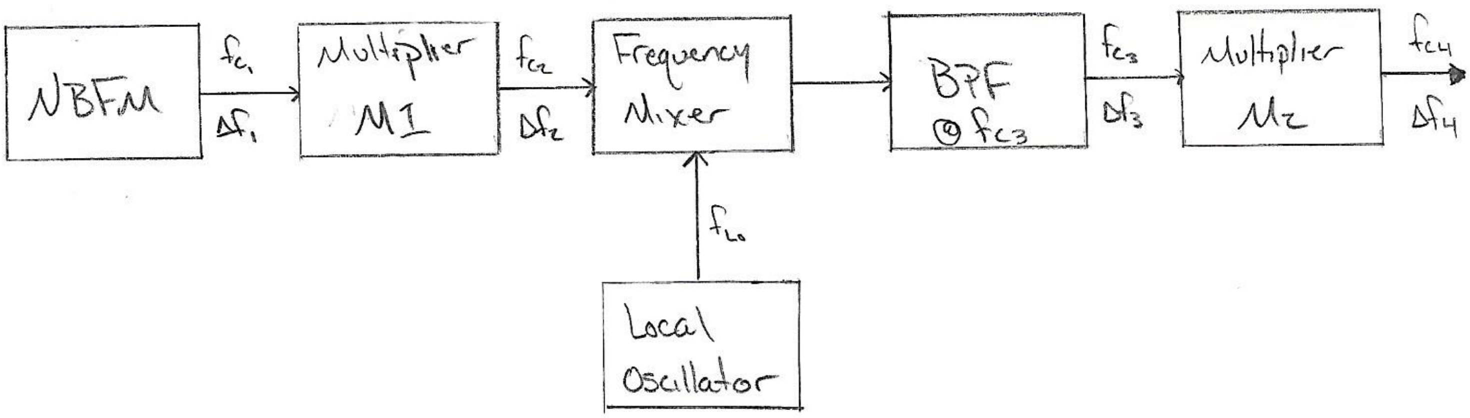
Question-3 (cont.): Draw block diagram on this page.



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Question-4: Draw block diagram of an FM stereo transmitter and an FM mono receiver. Explain how a mono receiver (single channel) can detect and demodulate a stereo signal (2 channel). Enter your explanations on this page and block diagram on the next page.

A mono receiver can detect a stereo signal due to the FCC ruling that the stereo transmitter had to be able to be received by a mono receiver. Stereo FM had to keep same $B = 200kHz$ and $\Delta f = 75kHz$.

Because the stereo transmitter still keeps the L+R signal at the base frequency, the mono receiver is able to detect that L+R signal and demodulate it. It will just be absent of the stereo effect

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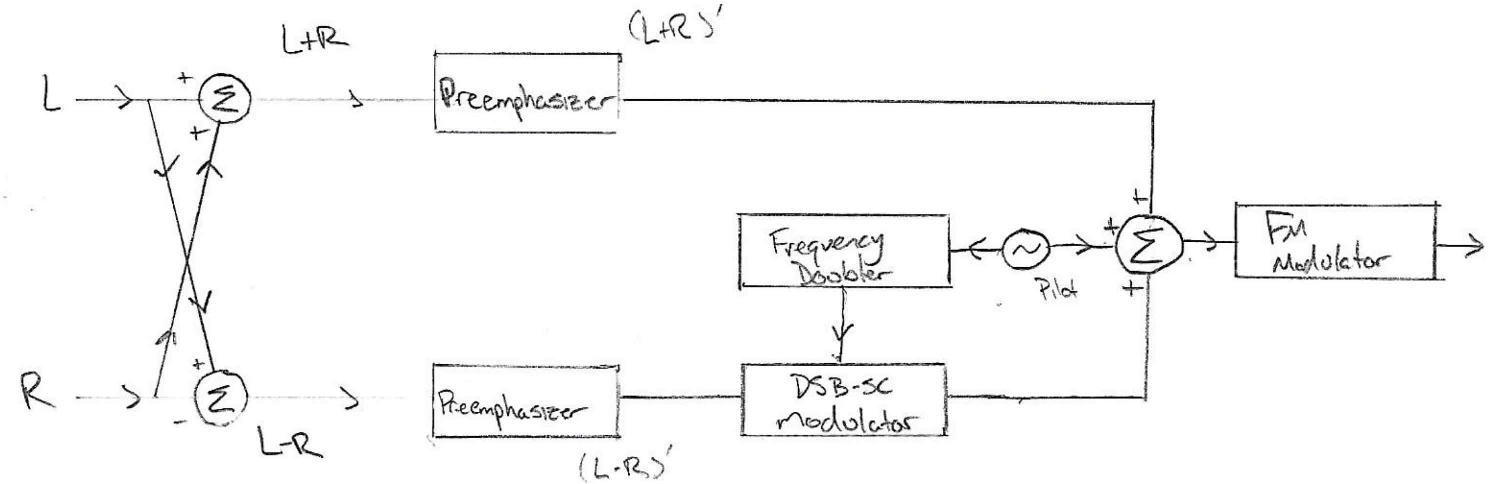
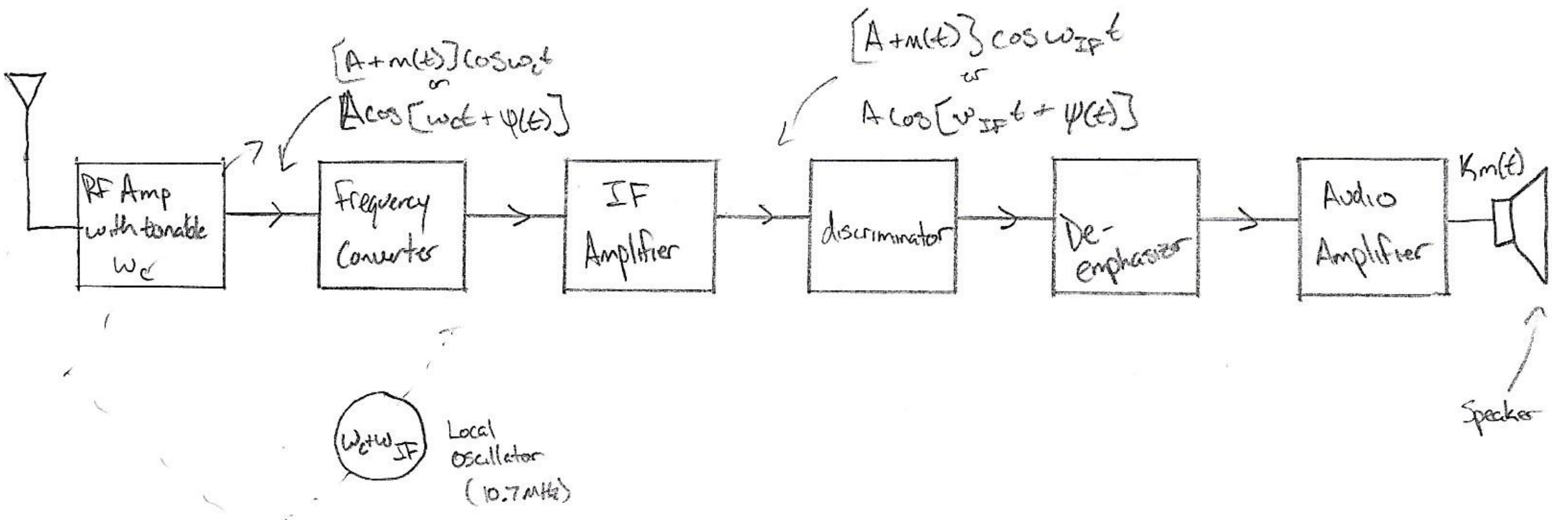
Question-4 (cont.): Draw the block diagrams on this page.

FM stereo transmitter



FM Mono Rx



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