**ENGR 4323/5323: Digital and Analog Communication**

**HW 3\_Ch4**

**1)** Determine and sketch the spectrum of the signal

 *φ*(t) = 2*m*1(*t*)cos(1200π*t*) + *m*2(*t*)cos(2400π*t*)

Where we know that *m*1(*t*) = 10 sinc2(200π*t* - 50π) *m*2(*t*) = 5 sinc(240π*t*)

**2)** You are asked to design a DSB-SC modulator to generate a modulated signal *Am*(*t*)cos *ωct* with the carrier frequency *fc* = 300 kHz (*ωc* = *2π* x 300,000). The following equipment is available in the stockroom: **(i)** a sinwave generator of frequency 100 kHz; **(ii)** a ring modulator; **(iii)** a bandpass filter with the tuning range of 100 kHz to 500 kHz

1. Show how you can generate the desired signal.
2. Explain how to tune the bandpass filter.
3. If the output of the modulator must be 400*m(t)* cos *ωct,* what should be the amplifier gain to be used on the input *m*(*t*) to obtain the desired modulator output signal amplitude?

**3)** Two signals *m*1(*t*)and *m*2(*t*)*,* both band-limited to 5000 Hz, are to be transmitted simultaneously over a channel by the multiplexing scheme shown below. The signal at point *b* is the multiplexed signal, which now modulates a carrier of frequency 20,000 Hz. The modulated signal at point *c* is transmitted over a channel.

1. Sketch signal spectra at points *a, b,* and *c.*
2. What must be the bandwidth of the distortionless channel?
3. Design a receiver to recover signals *m*1(*t*) and *m*2(*t*) from the modulated signal at point *c.*



**4)** A slightly modified version of the scrambler below was first used commercially on the 25-mile radio-telephone circuit connecting Los Angeles and Santa Catalina island, for scrambling audio signals. The output *y*(*t*)is the scrambled version of the signal *m*(*t*).

* 1. Find the spectrum of the scrambled signal *y*(*t*).
	2. Suggest a method of descrambling *y*(*t*) to obtain *m*(*t*).



**5)** a) Sketch the AM signal [*B* +*m*(*t*)]cos(*ωct*)for the message signal *m*(*t*) shown below corresponding to the modulation index by selecting a corresponding *B*: (a) *μ* = 0.5; (b) *μ* = 1; (c) *μ* = 2; (d) *μ* = ∞· Is there any pure carrier component for the case *μ* = ∞? How do you interpret the case *μ* = ∞?



b) For *μ* = 2, find the amplitude and power of the carrier.

c) For *μ* = 2, find the sideband power and the power efficiency *η*.

**6)** In the early days of radio, AM signals were demodulated by a crystal detector followed by a low-pass filter and a dc blocker, as shown below. Assume a crystal detector to be basically a squaring device. Determine the signals at points *a, b, c,* and *d.* Point out the distortion term in the output *y*(*t*). Show that if *A* >>|*m*(*t*)|, the distortion is small.



**7)** A modulating signal *m*(*t*)is given by:

1. *m*(*t*)= cos 100π*t* + 2 cos 300π*t*
2. *m*(*t*) = sin 100π*t* sin500π*t*

In each case:

1. Sketch the spectrum of *m*(*t*).
2. Find and sketch the spectrum of the DSB-SC signal 2*m*(*t*)cos(1000π*t*).
3. From the spectrum obtained in part (ii), suppress the LSB spectrum to obtain the USB spectrum
4. Knowing the USB spectrum in part (ii), write the expression *ϕ*USB(*t*) for the USB signal.
5. Repeat (iii) and (iv) to obtain the LSB signal *ϕ*LSB(*t*) in both time and frequency domains.
6. Use the equation 4.20 in textbook to determine the time domain expressions *ϕ*LSB(*t*) and *ϕ*USB(*t*).

**8)** A vestigial filter *Hi*(*f*)shown in the transmitter below has a transfer function as shown below. The carrier frequency is *fc* = 10 kHz and the baseband signal bandwidth is 4 kHz. Find the corresponding transfer function of the equalizer filter *H*0(*f*)shown in the receiver below.





**9)** A transmitter must send a multimedia signal *m*(*t*) with bandwidth of 450 kHz. Its assigned bandwidth is [2.3 MHz, 2.8 MHz]. As shown in the transmitter diagram of figure below, this is an ideal BPF *HT*(*f*) at the transmitter.



1. Complete the design of the VSB system for carrier frequency of 2.354 MHz in the above figure by specifying the carrier frequency and a detailed receiver system block diagram.
2. For distortionless detection, derive and plot the receiver filter frequency response needed at the front end of the demodulator.