ECEG-3174: Introduction to Communication Engineering
Worksheet II

Linear Modulation Techniques

Q#1

The output signal from an AM modulator is $S(t) = [20 + 2Cos(3000\pi t) + 10Cos(10000\pi t)]Cos(2\pi 10^5 t)$ Determine

(a) The (voltage) spectrum of S(t)
(b) Determine the modulation index and the bandwidth of the modulated signal.
(c) The power spectral density of S(t).
(d) Determine the ratio of the power in the sidebands to the power in the carrier and the power efficiency.
(e) What type of demodulator will be used to demodulated S(t).

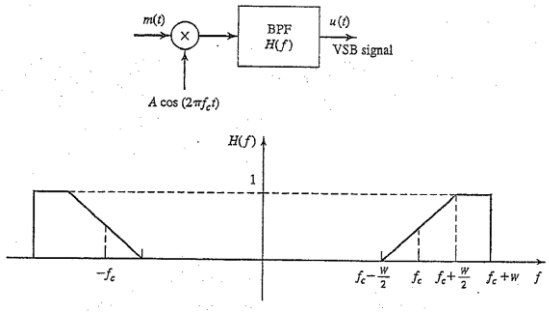
Q#2

A SSB AM signal is generated by modulating an 800 KHz carrier by the message signal $m(t) = Cos(2000\pi t) + 2Cos(2000\pi t)]$. The amplitude of the carrier is Ac = 100. Determine

(a) The signal of $\hat{m}(t)$
(b) Determine the (time domain) expression for the lower sideband of the SSB AM signal.
(c) Determine the magnitude spectrum of the lower sideband SSB signal.

Q#3

A vestigial sideband modulation system is shown in Figure 1. The bandwidth of the message signal $m(t)$ is W and the transfer function of the band pass filter is shown in the figure.

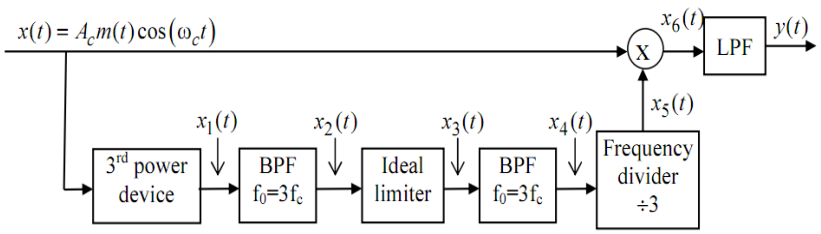


(a) Determine $h_l(t)$, the lowpass equivalent of $h(t)$, where $h(t)$ represents the impulse response of band pass filter.
(b) Derive the expression of the modulated signal $u(t)$.

Figure 1

Q#4

If Figure below shows the probable design of DSB-SC demodulator:



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a) Find $X_1(t)\ upto\ X_6(t)\ and\ y(t)$. Is it a demodulator? Why?
b) Consider a special case of $m(t) = Sin(\omega_m t)$ $\omega_m << \omega_c$ and sketch $m(t)$ and $y(t)$ on the same graph. Are they the same? Assume that the amplitude of $y(t)$ is 1.

Note: 3rd power device has the following input-output characteristic: $X_{out}(t) = {X_{in}}^3(t)$ and the Ideal limiter input-output characteristic is $X_{out}(t) = sgn(X_{in}\ (t))$.

Q#5

Consider the DSB-SC modulated wave $m(t) = A_m Cos(2\pi f_m t)$ obtained by using the sinusoidal modulating wave and the carrier wave $c(t) = A_c Cos(2\pi f_c t + \varphi)$

The phase angle denoting the phase difference between and at time is variable. Sketch this modulated wave for the following values and Comment on your results.

(a) $\varphi = 0°$ (b) $\varphi = 45°$ (c) $\varphi = 90°$ (d) $\varphi = 135°$

Q#6

(a) Explain how you could transmit two independent baseband information signals by using SSB on a common carrier frequency.
(b) (b) Can an information signal have a higher frequency than that of the carrier signal? What would happen if a 1-kHz signal amplitude-modulated a 1-kHz carrier signal?

Angle (Nonlinear) Modulation Techniques

Q#1

An angle-modulated signal with carrier frequency $\omega_c = 2\pi * 10^6$ is described by the equation:

$$S(t) = 10\cos(\omega_c t + 20\sin(1000\pi t) + 10\sin(2000\pi t))$$

a. Find the power of the modulated signal.
b. Find the max frequency deviation and max phase deviation β.
c. Estimate the bandwidth of S(t).
d. What power will this FM wave dissipate in 10Ω resistive wire.

Q#2

A carrier is FM modulated by a sinusoidal modulating signal $m(t)$ of frequency 2 KHz, it results in frequency deviation of 5KHz. Find the BW occupied by the FM waveform. The amplitude of the modulating sinusoid is increased by a factor of 3 and its frequency lowered by 1KHz. Find the new BW.

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Q#3

In single tone FM modulation, the modulated signal s(t) is given by $S(t) = A\,Cos\,(w_c t + \beta \sin w_m t)$ where $\beta \ll 1$, the modulation can be considered as Narrowband frequency Modulation.

a. Determine the spectrum of this NBFM signal
b. Compare the results with the spectrum of that of a single tone Amplitude modulated signal.
c. Discuss the importance of frequency modulation over amplitude modulation.

FDM and TDM

Q#1

A 4 KHz band-limited signal $m_1(t)$ and two other signal signals $m_2(t)$ and $m_3(t)$ band-limited to 2 KHz are to be transmitted by means of time division multiplexing.

a. Design a (TDM) commutator switching system so that each signal is sampled at its Nyquist rate.(**clearly indicate the transmitter channel BW and Sketch TDM transmitted signal**)
b. Design a (TDM) so that each signal is sampled at its Nyquist rate and obtain minimum transmission BW.

Q#2

Two signals $\boldsymbol{m_1(t)\ and\ m_2(t)}$, both band-limited to 5000 Hz, are to be transmitted simultaneously over a channel by multiplexing scheme shown in Figure 3. 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.

a. Sketch signal spectra at points a, b, and c.
b. What must be the bandwidth of the channel?
c. Design a receiver to recover signals $m_1(t)\ and\ m_2(t)$ from the modulated signal at point c.

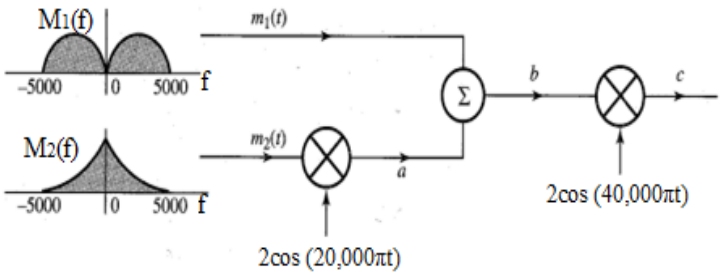

Figure3