Cairo University
Faculty of Engineering
Electronics & Communication
Department.

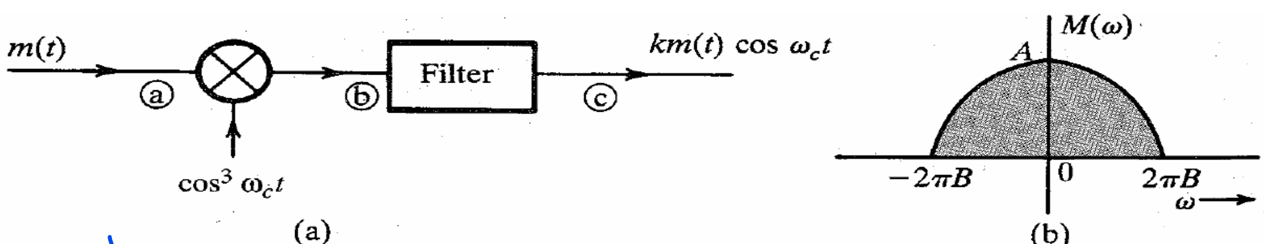
Sheet 2

1-For each of the following baseband signals: (i) $m(t) = \cos 1000t$; (ii) $m(t) = 2\cos 1000t + \cos 2000t$; $m(t) = \cos 1000t \cos 3000t$:

a) Sketch the spectrum of $m(t)$
b) Sketch the spectrum of the DSB-SC signal $m(t)\cos 10000t$.
c) Identify the upper sideband (USB) and the lower sideband (LSB) spectra.
d) Identify the frequencies in the baseband, and the corresponding frequencies in the DSB-SC USB, and LSB spectra. Explain the nature of frequency shifting in each case.

2-You are asked to design a DSB-SC modulator to generate a modulated signal $km(t) \cos \omega_c t$, where m(t) is a signal band limited to B Hz. The figure shows an available DSB-SC modulator. The carrier generator available generates not $\cos \omega_c t$ but $\cos^3 \omega_c t$. Explain whether you would be able to generate the desired signal using only this equipment. You may use any kind of filter you like.

a) what kind of filter is required?
b) Determine the signal spectra at points b and c, and indicate the frequency bands occupied by these spectra.
c) What is the minimum usable value of ω_c.
d) Would this scheme work if the carrier generator output were $\cos^2 \omega_c t$? Explain.
e) Would this scheme work if the carrier generator output were $\cos^n \omega_c t$ for any integer $n \geq 2$?



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3- A given AM (DSB-LC) transmitter develops an unmodulated power output of one KW across a 50-ohm resistive load. When a sinusoidal test tone with a peak amplitude of 5.0 V is applied to the input of the modulator, it is found that the spectral line for each sideband in the magnitude spectrum for the output is 40% of the carrier line. Determine the following quantities in the output signal:

a) The modulation index
b) The peak amplitude of the lower sideband.
c) The ratio of total sideband power to carrier power.
d) The total power output.
e) The total average power in the output if the peak amplitude of the modulation sinusoid is reduced to 4.0 V.

4- Consider the two amplitude-modulated signals, where $\omega_c >> \omega_m$,

$$\Phi_1(t) = (\,2 + E_1 \cos \omega_m t\,) \cos \omega_c t$$
$$\Phi_1(t) = E_2 \cos \omega_m t \;\; \cos \omega_c t$$

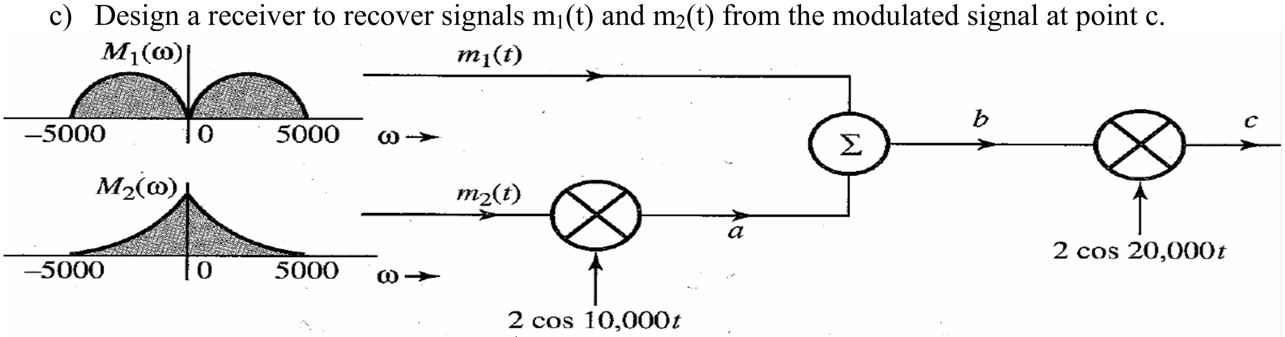
a) Sketch the spectral density of each signal.
b) Determine the required numerical values of E_1 and E_2, to produce 100% modulation in the large carrier signal and the same average power in both signals.
c) Find the ratio of the respective outputs when these signals are applied to a synchronous detector.

5- A given DSB-SC broadcast station transmits a total power output of 50 KW and uses a modulation index of 0.707 for sine wave modulation. Calculate:

a) The carrier power.
b) The transmission efficiency.
c) The peak amplitude of the carrier f the antenna is represented by a 50-ohm resistive load.
d) F the amplitude of the modulating tone is reduced until the power is 45 KW and assuming that the carrier power remained constant, compute the new modulation index and transmission efficiency.

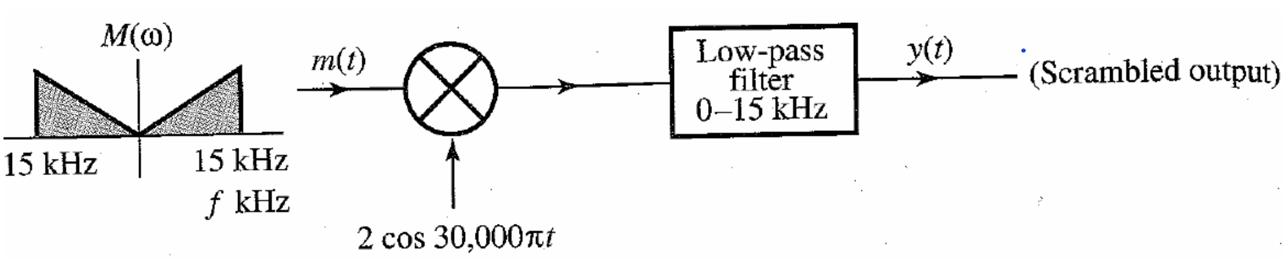
6-Two signals $m_1(t)$ and $m_2(t)$, both band limited to 5000 rad/s, are to be transmitted simultaneously over a channel by the multiplexing scheme shown in the figure. The signal at point b is the multiplexed signal, which now modulates a carrier of frequency 20000 rad/s. The modulated signal at point c is transmitted.

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.

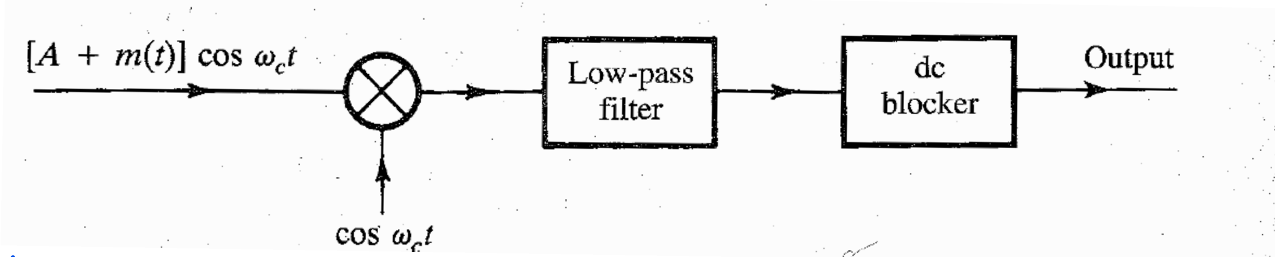


7- System shown in figure is used for scrambling audio signals. The output $y(t)$ is a scrambled version of the input signal $m(t)$

a) Find the spectrum of the scrambled signal y(t)
b) Suggest a method of descrambling the signal y(t) to obtain m(t)



8-The figure shows a scheme for coherent demodulation. Show that this scheme can demodulate the AM signal $[A+m(t)]\cos \omega_c t$ regardless of the value of A.



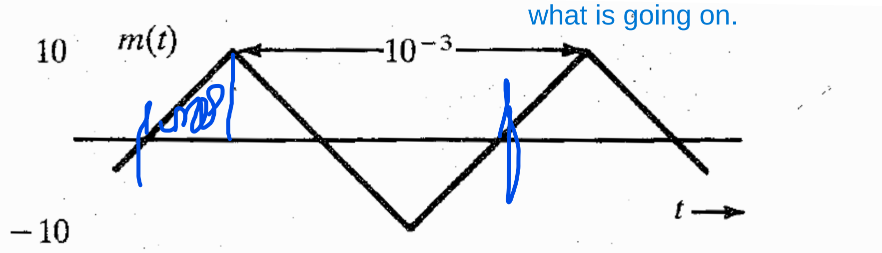
9-Sketch the AM signal $[A+m(t)]\cos \omega_c t$ for the periodic triangle signal m(t) shown in figure corresponding to the modulation index: a) μ=0.5; b) μ=1; c) μ=2; d) μ=∞. How do you interpret the case μ=∞.

For the AM signal with μ=0.8:

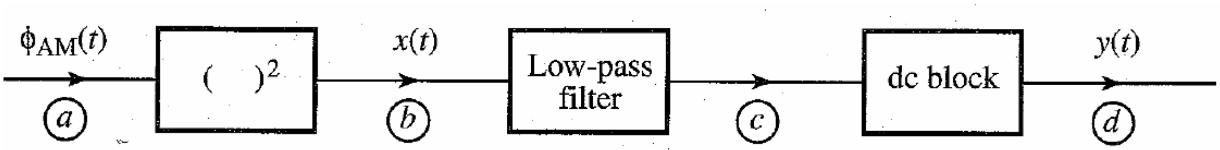
a) Find the amplitude and the power of the carrier.

b) Find the sideband power and the power efficiency η.

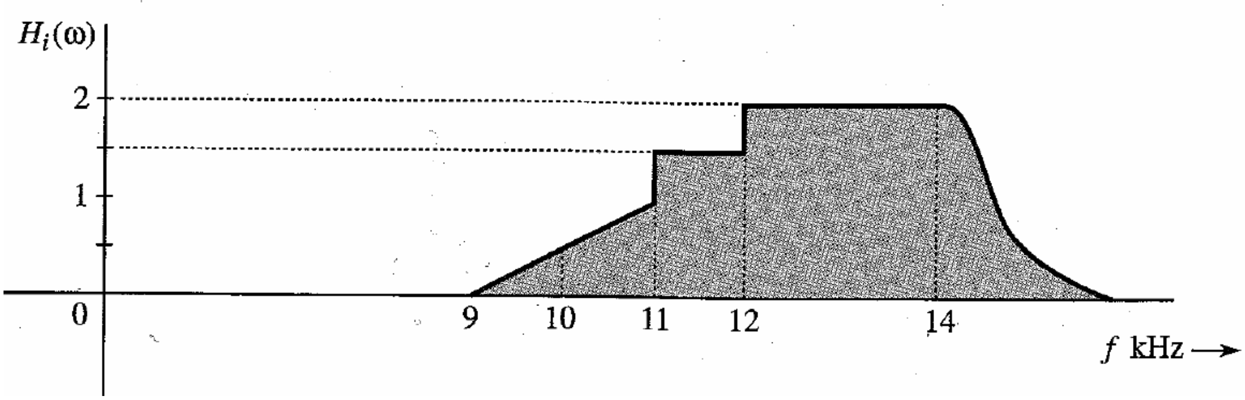
advice: solve the same 2 questions for all values of u to ensure that you understand what is going on.



10-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 in the figure. 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 $A \gg |m(t)|$, the distortion is small.



11-A vestigial filter $H_i(\omega)$ used in the transmitter has a transfer function as shown in figure. The carrier frequency f_c=10 kHz and the baseband signal bandwidth is 4 kHz. Find the corresponding transfer function of the equalizer filter $H_o(\omega)$ used in the receiver.



12- A transmitter transmits an AM signal with a carrier frequency of 1500 kHz. When an inexpensive radio receiver (which has a poor selectivity in its RF-stage band pass filter) is tuned to 1500 kHz, the signal is heard loud and clear. This same signal is also heard (not as strong) at another dial setting. State, with reasons, at what frequency you will hear this station. The IF frequency is 455 kHz.