EEE/ECE F311
Communication Systems
Tutorial-5

Date : 04/09/2025
Date : 09/09/2025

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1. A transmitter transmits an AM signal with a carrier frequency of 1500 kHz. When a super heterodyne radio receiver (which has a poor selectivity in its RF-stage bandpass filter) is tuned to 1500 kHz, the signal is heard loud and clear. The same signal is also heard (not as strongly) when tuned to another carrier frequency setting within the AM range of 590-1605 kHz. State, with reasons, at what frequency you will hear this station. The IF is 455 kHz.

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Solution 1

if the receiver is tuned to 590 kHz, the same channel will be listened.

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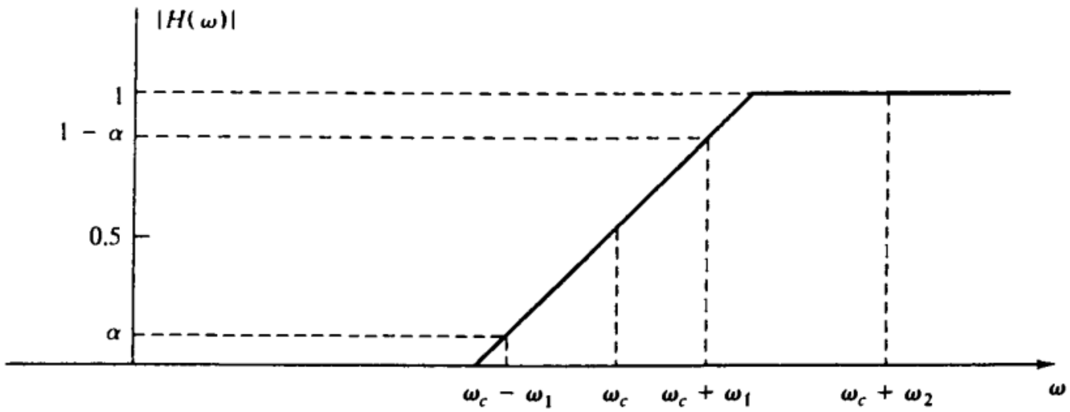
2. The frequency response H(ω) of a VSB filter is shown below.



Find the VSB signal $x_{VSB}(t)$ when

$$m(t) = a_1 \cos \omega_1 t + a_2 \cos \omega_2 t$$

Also, show that $x_{VSB}(t)$ can be demodulated by the synchronous demodulator.

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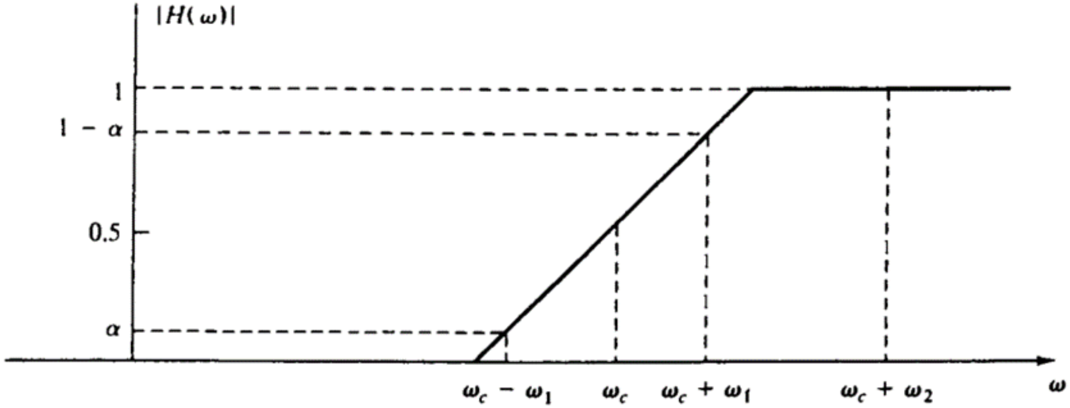
Solution 2

$$x_{\mathrm{DSB}}(t) = m(t)\cos\omega_c t$$

Signal will be passed through the VSB filter which has gains as per the diagram.



$$x_{\mathrm{VSB}}(t) = \tfrac{1}{2}a_1\alpha\cos(\omega_c - \omega_1)t + \tfrac{1}{2}a_1(1-\alpha)\cos(\omega_c + \omega_1)t + \tfrac{1}{2}a_2\cos(\omega_c + \omega_2)t$$

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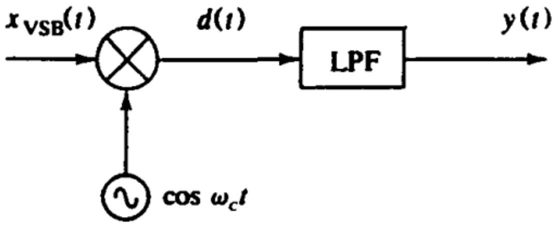
Solution 2

Considering the synchronous demodulation we have,



Using low-pass filtering to eliminate the double-frequency terms, we obtain

$$y(t) = \frac{1}{4}(a_1 \cos \omega_1 t + a_2 \cos \omega_2 t) = \frac{1}{4} m(t)$$

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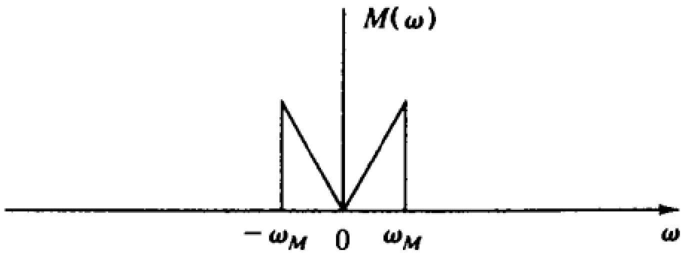
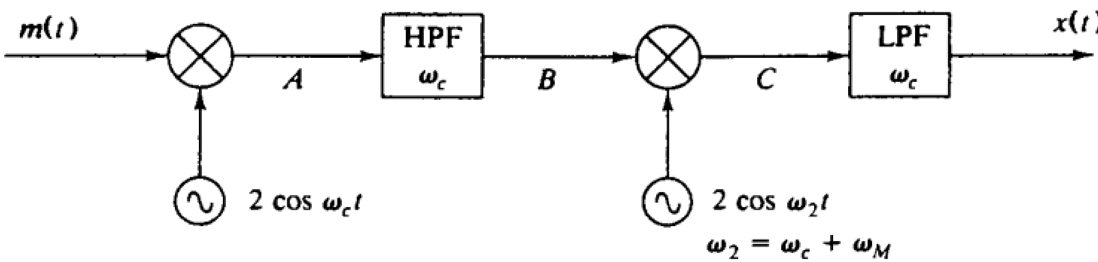
3. The spectrum of a message signal m(t) is shown below. To ensure communication privacy, this signal is applied to a system (known as a scrambler) shown below. Analyze the system and sketch the spectrum of the output x(t).



(a)



(b)

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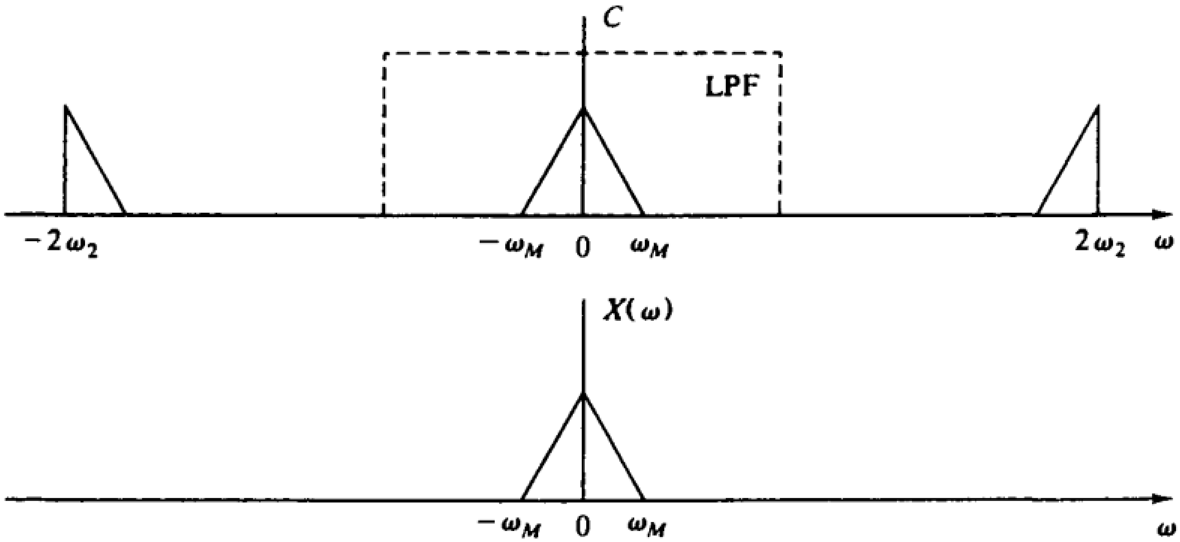
Solution 3



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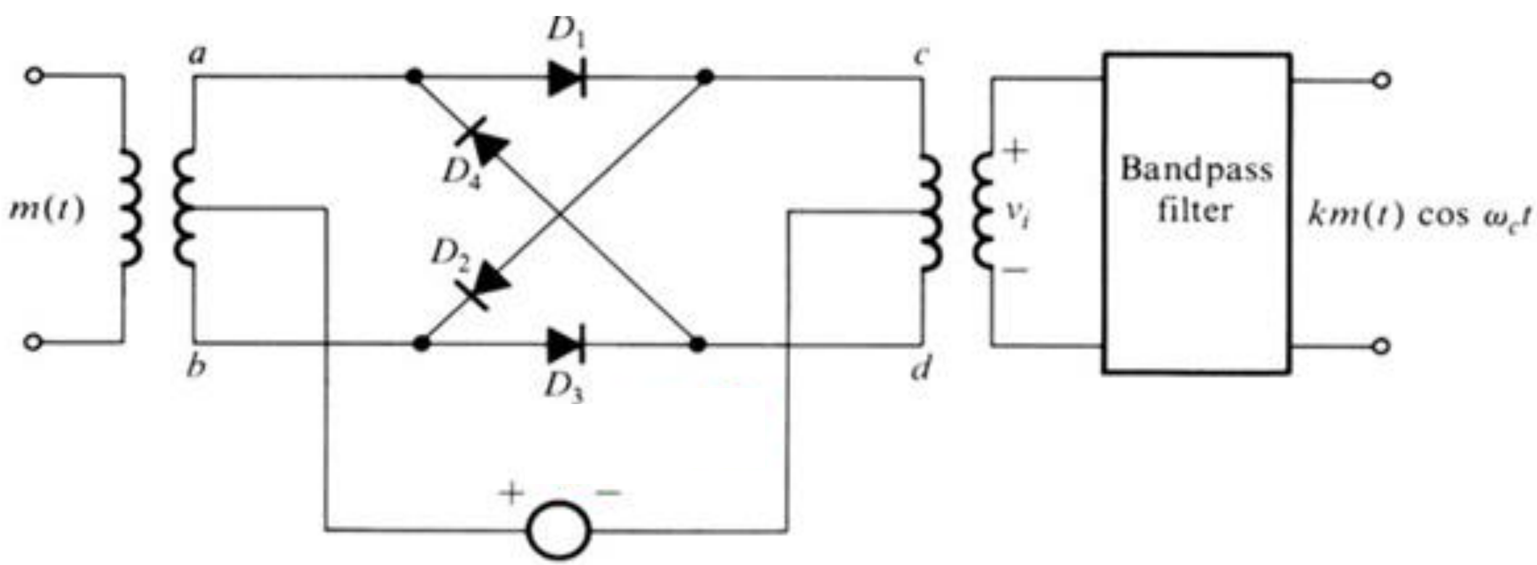
4. Design a DSBSC modulator to generate a modulated signal $km(t)\cos\omega_c t$ with the carrier frequency f_c = 300 kHz ($\omega_c = 2\pi X300{,}000$). The following equipment is available in the stock room: (i) a signal generator of frequency 100 kHz; (ii) a ring modulator (as shown in figure given below); (iii) a band pass filter tuned to 300 kHz.

(a) Show how can you generate the desired signal.

(b) If the output of the modulator is $km(t)\cos\omega_c t$, find k.



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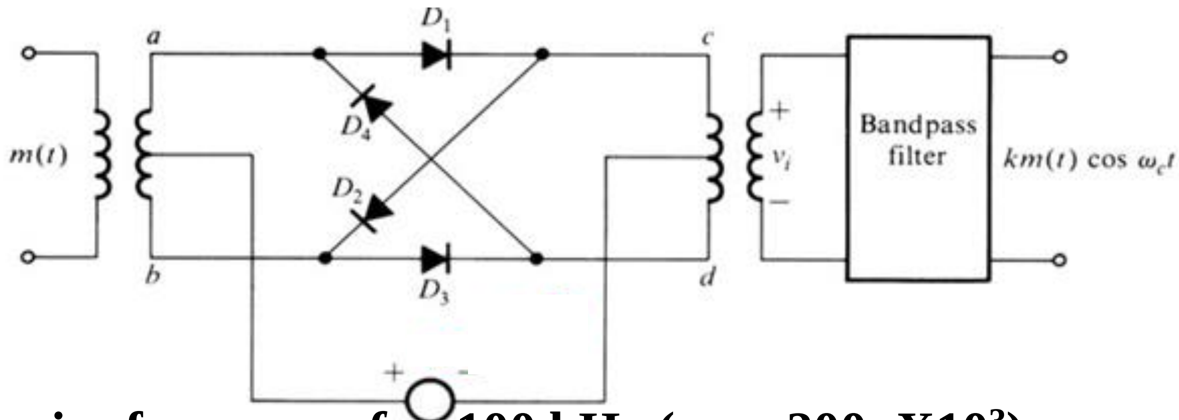
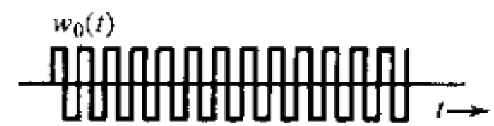
Solution 4



(a)

Given: The carrier frequency f_c = 100 kHz ($\omega_c = 200\pi X10^3$)
The output band pass filter centered at f_c = 300 kHz



The output $v_i(t)$ is found as $v_i(t) = m(t)\, w_0(t)$
$v_i(t) = 4/\pi\ [m(t)\cos\omega_c t - 1/3\, m(t)\cos 3\omega_c t + 1/5 m(t)\cos 5\omega_c t + \ldots]$

k=- $4/3\pi$

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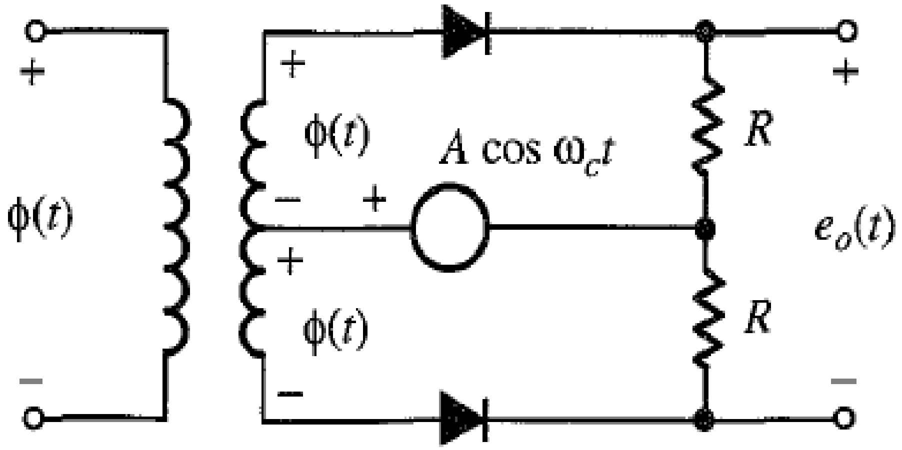
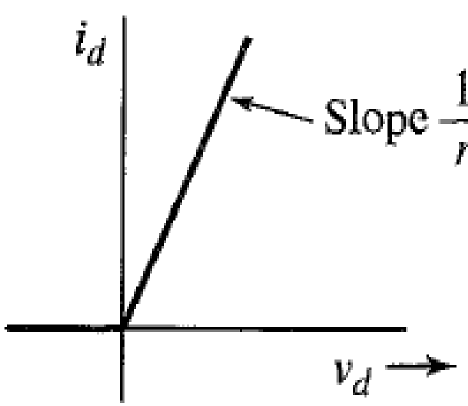
5. In the figure given below, the input φ(t) = m(t), and the amplitude A ≥ $|\phi(t)|$.
The two diodes are identical with a resistance r ohms in the conducting mode and infinite resistance in the cutoff mode. Show that the output *$e_o(t)$* is given by

$$e_0(t) = \frac{2R}{R+r} w(t) m(t)$$

Where *w(t)* is the switching periodic signal with period $2\pi/\omega_c$ seconds.
(a) Hence, show that this circuit can be used as a DSBSC modulator.
(b) How would you use this circuit as a synchronous demodulator for DSB-SC signals





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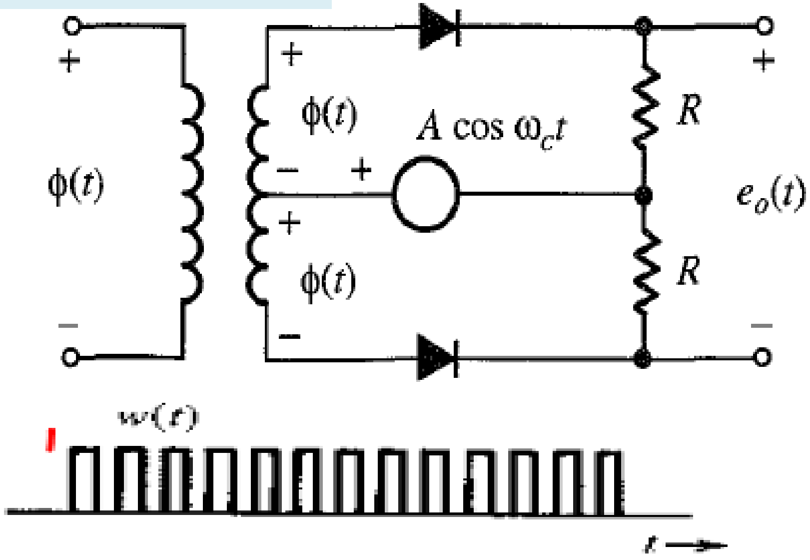
Solution 5



The output is:

$$e_0(t) = \frac{2R}{R+r} w(t) m(t)$$

(a) If we pass the output $e_0(t)$ through a band pass filter (centered at ω_c),

$$\frac{4R}{\pi(R+r)} m(t) \cos \omega_c t$$

At the output of demodulator

$$\frac{2R}{\pi(R+r)} m(t)$$

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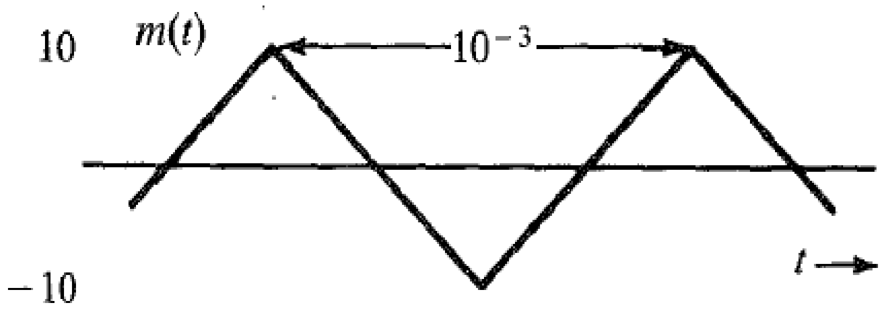
6. For the baseband message signal m(t) as shown in figure, an AM signal $[A+m(t)]\cos\omega_c t$ has been generated with modulation index of 0.8.



(a) Find the amplitude and power of the carrier.
(b) Find the sideband power and the power efficiency η.

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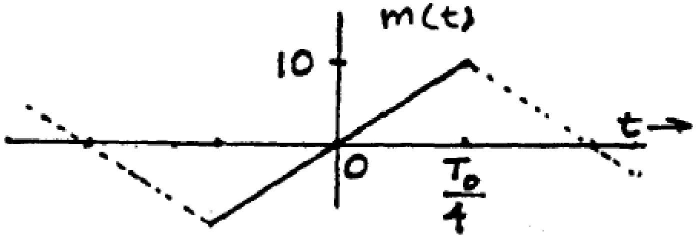
Solution 6

(a) Carrier amplitude is $A = m_p/\mu = 10/0.8 = 12.5$

The carrier power is $P_c = A^2/2 = 78.125$

(b) Sideband power is



$$P_s = \frac{1}{2}\overline{m^2(t)}$$

$$\overline{m^2(t)} = \frac{1}{T_0/4}\int_0^{T_0/4}\left[\frac{40t}{T_0}\right]^2 dt = 33.34$$

$$P_s = \frac{\overline{m^2(t)}}{2} = 16.67$$

$$\eta = \frac{P_s}{P_c + P_s} = \frac{16.67}{78.125 + 16.67} \times 100 = 19.66\%$$