

- 1) Please attempt each problem on a new page.
- 2) Please write only on one side of the page.
- 3) Show all your work clearly.

Problem 1 (35 Points)

1. Consider the message signal $m(t)$ whose spectrum is shown in Figure 1. This signal together with the carrier wave $A_c \cos(2\pi f_c t)$ is applied to a product modulator producing a DSB-SC waveform $s(t)$. The modulated waveform $s(t)$ is then applied to a coherent demodulator. Assuming perfect synchronism between the carriers of the modulator and demodulator, determine the spectrum of the demodulator's output when

- (a) $f_c = 4$ kHz.
- (b) $f_c = 7.5$ kHz.

What is the lowest carrier frequency f_c for which $m(t)$ can be obtained by demodulating the modulated wave $s(t)$.

2. Repeat the above for the waveform $m(t)$ whose spectrum is shown in Figure 2.

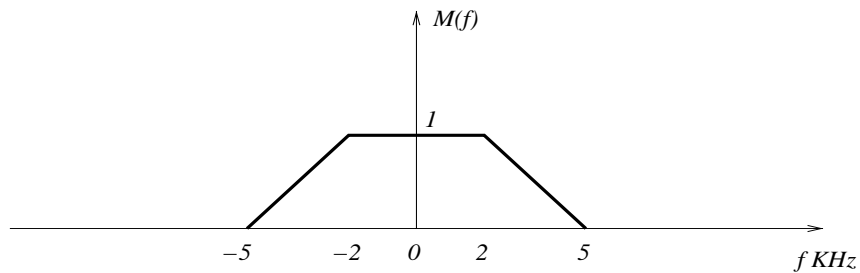


Figure 1

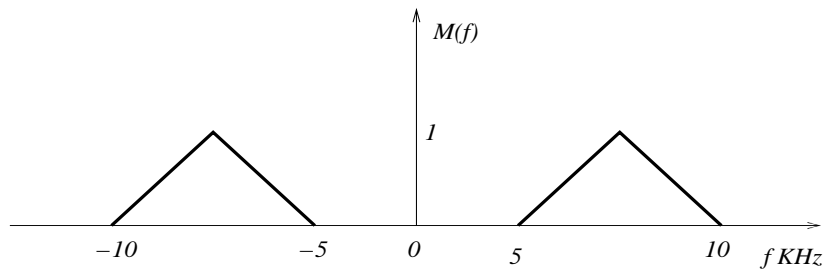


Figure 2

Problem 2 (30 Points)

A message signal $m(t)$ is DSB-SS modulated using the carrier signal $A_c \cos(2\pi f_c t)$.

1. The received signal is coherently demodulated using a local oscillator that produces the signal $A_r \cos(2\pi f_c t + \phi)$. In other words there is a phase offset ϕ between the oscillators in the transmitter and the receiver. Find the output of the detector in the receiver and comment on the effect of ϕ on the detected signal.
2. The received signal is coherently demodulated using a local oscillator that produces the signal $A_r \cos[2\pi(f_c + \Delta f)t]$. In other words there is a frequency offset Δf between the oscillators in the transmitter and the receiver. Find the output of the detector in the receiver and comment on the effect of Δf on the detected signal.

Problem 3 (35 points)

A carrier wave of frequency 105 MHz is frequency modulated by a sine wave of amplitude 5 V (volts) and frequency 15 kHz. The frequency sensitivity, k_f , of the modulator is 10 kHz/V.

1. Determine the approximate bandwidth of the FM wave using the Carson's rule.
2. Determine the bandwidth if we only transmit those side-frequencies with amplitudes that exceed 1% of the unmodulated carrier amplitude. You can use the universal curve provided below.
3. Repeat parts (1) and (2) above assuming that the amplitude of the modulating wave is doubled.
4. Repeat parts (1) and (2) above assuming that the frequency of the modulating wave is doubled.

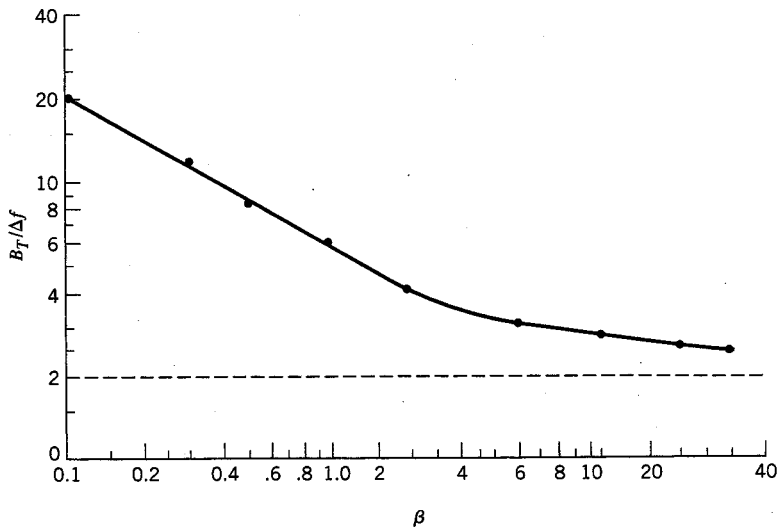


FIGURE 2.26 Universal curve for evaluating the 1 percent bandwidth of an FM wave.