Problem 3.7

The coherent detector for the demodulation of DSB-SC fails to operate satisfactorily if the modulator experiences spectral overlap. Explain the reason for this failure.

Solution

The DSB-SC modulated wave is defined by

$$s(t) = A_c m(t) \cos(2\pi f_c t)$$

Spectral overlap occurs if the condition $f_c > W$ is violated, in which case the lower sideband overlaps with its image.

However, when $s(t)$ is applied to a coherent detector, the resulting output is

$$v(t) = s(t) \cos(2\pi f_c t)$$

$$= A_c m(t) \cos^2(2\pi f_c t)$$

$$= \frac{1}{2} A_c m(t)[1 + \cos(4\pi f_c t)]$$

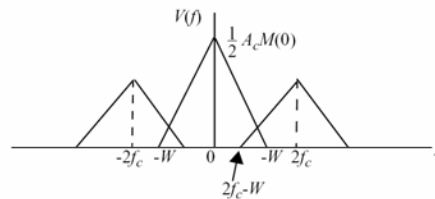The spectral description of $v(t)$ is shown in Fig. 1, assuming that $f_c < W$:

Figure 1

Recovery of the original signal is possible only if

$$2f_c - W > W$$

or

$$f_c > W$$

But this condition is being violated because of the spectral overlap.

Hence, once spectral overlap is permitted, no coherent detector can recover the original modulating signal.