## Problem 3.17

(a) We are given

$$c(t) = A_c \sin(2\pi f_c t)$$

and

$$m(t) = A_m \sin(2\pi f_m t)$$

Invoking the definition of AM wave

$$s(t) = [1 + k_a m(t)]c(t)$$

we now write

$$s(t) = A_c [1 + k_a A_m \sin(2\pi f_m t)] \sin(2\pi f_c t)$$
  
=  $A_c \sin(2\pi f_c t) + \mu A_c \sin(2\pi f_m t) \sin(2\pi f_c t)$  (1)

where

$$\mu = k_a A_m$$

is the modulation factor. Next, we use the trigonometric identity

$$\sin A \sin B = \frac{1}{2} [\cos(A - B) - \cos(A + B)]$$

Hence, we may rewrite Eq. (1) as

$$s(t) = A_c \sin(2\pi f_c t) + \frac{1}{2} \mu A_c [\cos(2\pi (f_c - f_m)t) - \cos(2\pi (f_c + f_m)t)]$$
 (2)

The spectrum of the AM wave s(t) consists of three components:

(i) Carrier:

$$A_c \sin(2\pi f_c t)$$

(ii) Lower side-frequency: 
$$\frac{1}{2}\mu A_c \cos(2\pi (f_c - f_m)t)$$

(iii) Upper side-frequency: 
$$-\frac{1}{2}\mu A_c \cos(2\pi(f_c + f_m)t)$$

This spectrum is depicted in Fig. 1.

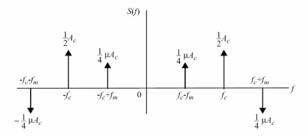


Figure 1

- (b) Comparing the AM spectrum of Fig. 1 with the corresponding AM spectrum of Fig. 3.3(c) on page 105 of the text, we may make two observations:
  - · The frequency locations of the spectral components of these two AM waves are identical.
  - The only difference between them is that the upper side-frequency  $f_c + f_m$  in Fig. 1 is the negative of the upper side-frequency  $f_c + f_m$  in Fig. 3.3(c).

**Note:** The following correction in the first printing of the book should be made. The modulating wave should read as follows:

$$m(t) = A_m \sin(2\pi f_m t)$$

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