ENEL 471 – Winter 2020

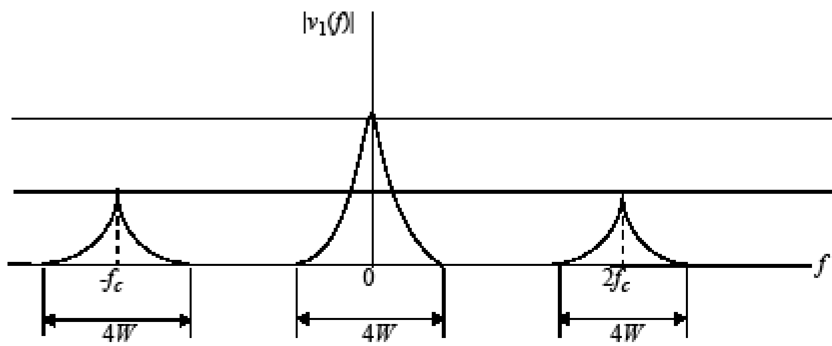
Assignment 3 - Solutions

Problem 3.7

The squarer output is

$$v_1(t) = A_c^2[1 + k_a m(t)]^2 \cos^2(2\pi f_c t)$$
$$= \frac{A_c^2}{2}[1 + 2k_a m^2(t)][1 + \cos(4\pi f_c t)]$$

The amplitude spectrum of $v_1(t)$ is therefore as follows, assuming that $m(t)$ is limited to the interval $-W \leq f \leq W$:



Since $f_c > 2W$, we find that $2f_c - 2W > 2W$. Therefore, by choosing the cutoff frequency of the low-pass filter greater than $2W$, but less than $2f_c - 2W$, we obtain the output

$$v_2(t) = \frac{A_c^2}{2}[1 + k_a m(t)]^2$$

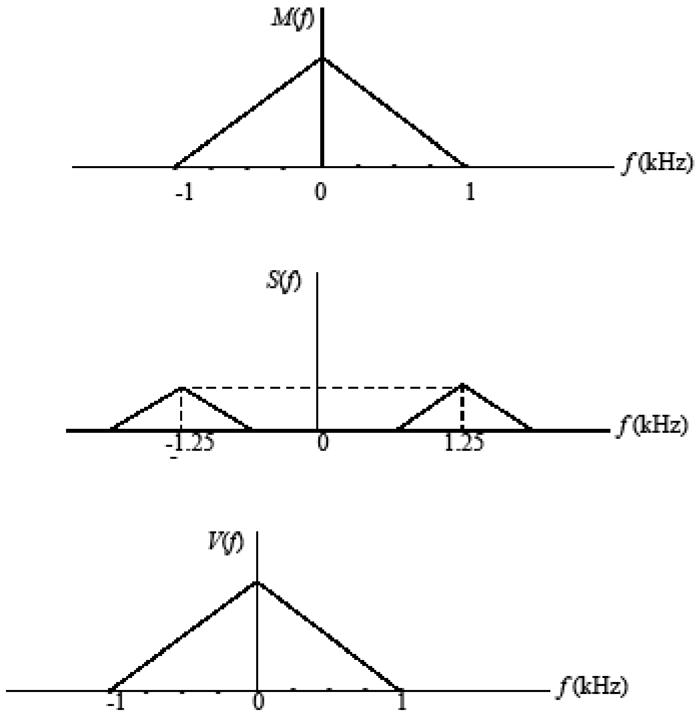
Hence, the square-rooter output is

$$v_3(t) = \frac{A_c}{\sqrt{2}}[1 + k_a m(t)]$$

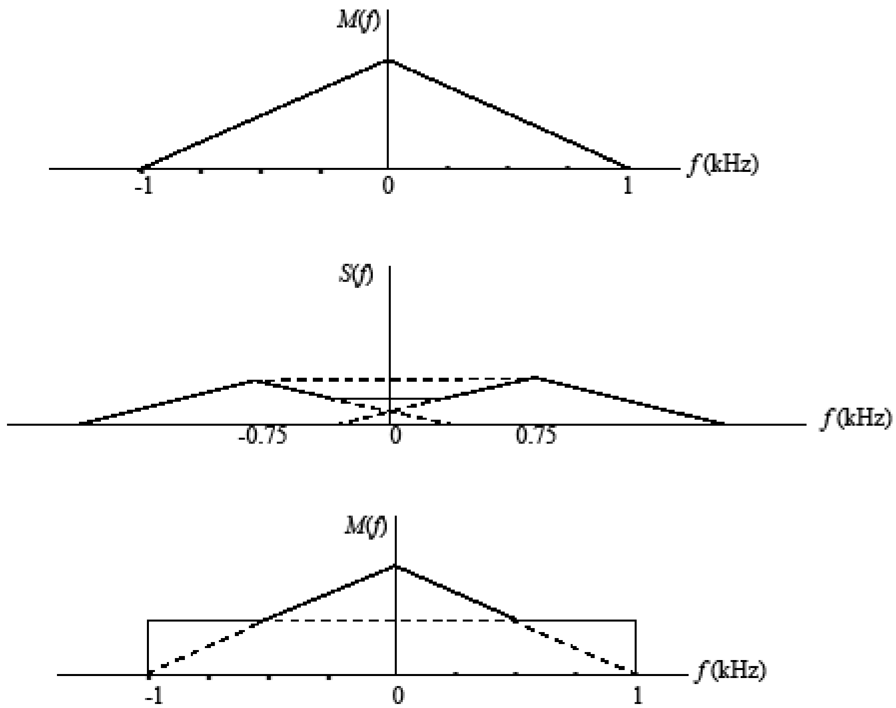
which, except for the dc component $\frac{A_c}{\sqrt{2}}$, is proportional to the message signal $m(t)$.

Problem 3.8

(a) For f_c = 1.25 kHz, the spectra of the message signal $m(t)$, the product modulator output $s(t)$, and the coherent detector output $v(t)$ are as follows, respectively:



(b) For the case when $f_c = 0.75$, the respective spectra are as follows:



To avoid sideband-overlap, the carrier frequency f_c must be greater than or equal to 1 kHz. The lowest carrier frequency is therefore 1 kHz for each sideband of the modulated wave $s(t)$ to be uniquely determined by $m(t)$.

Problem 3.9

The two AM modulator outputs are:

$$s_1(t) = A_c\left[1 + k_a m(t)\right]\cos(2\pi f_c t)$$
$$s_2(t) = A_c\left[1 - k_a m(t)\right]\cos(2\pi f_c t)$$

The output of the entire system is obtained by subtracting $s_1(t)$ from $s_2(t)$

$$s(t) = s_1(t) - s_2(t)$$
$$s(t) = 2A_c k_a m(t)\cos(2\pi f_c t)$$

In this output only the component including message signal around the carrier frequency is maintained. The carrier signal is cancelled out by the subtraction. This is a DSB-SC signal (the carrier is cancelled out before transmission).