Labwork

In this experiment, you will modulate a message signal using conventional amplitude modulation and apply Square-Law Envelope Detector to recover the message signal. As you may notice, the modulator block diagram given in experiment preliminaries is valid for a simple unit amplitude sinusoidal message signal m(t). In this experiment, the carrier signal will be modulated by a message signal which is given as sum of two sinusoidal signals with different amplitude values. Therefore, you should use the following notation to represent amplitude modulated signal: $s(t) = A_c(1 + k_a m(t))cos(2\pi f_c t)$ where k_a is amplitude sensitivity, A_c is carrier amplitude, f_c is carrier frequency and $m(t)$ is the message signal. In this notation, modulation index μ is defined as $\mu = k_a m_p$ where m_p is the peak message signal with the relation $-m_p \leq m(t) \leq m_p$. In order to detect the envelope without a distortion $|k_a m(t)| < 1$ relation should hold.

Conventional Amplitude Modulation

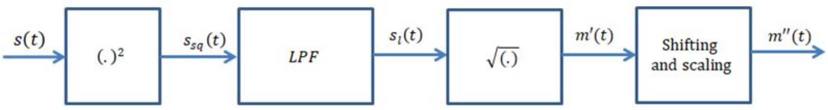
a. Construct a message signal $m(t) = A_1 sin(2\pi f_1 t) + A_2 sin(2\pi f_2 t)$ and carrier signal $c(t) = A_c sin(2\pi f_c t)$ with following parameters: $A_1 = 1, A_2 = 2, A_c = 2$ $f_1 = 10, f_2 = 15, f_c = 500$, sampling frequency Fs=4kHz, signal duration is 0.4 seconds. Plot the message signal on the time axis.

b. Obtain two different amplitude modulated signal ($s_1(t)$ and $s_2(t)$) for amplitude sensitivity $k_a = 0.2$ and $k_a = 0.6$ and plot them using 2x1 subplot.

c. Obtain the magnitude response of the amplitude modulated signals ($s_1(t)$ and $s_2(t)$) using fft() command and plot them using 2x1 subplot(). You can use the signal length as fft size.

   Report - Comment on the power efficiency of these two modulation results considering the magnitude responses in your report.

Square-Law Envelope Detector



$$s(t) = A_c\big(1 + k_a m(t)\big)\cos(2\pi f_c t)$$

$$s_{sq}(t) = A_c^2\big(1 + k_a m(t)\big)^2 \cos^2(2\pi f_c t)$$

$$, where\ cos^2(2\pi f_c t) = \frac{1 + \cos(4\pi f_c t)}{2}$$

$$LPF\left(s_{sq}(t)\right) = s_l(t) = \boxed{}$$

$$m'(t) = \boxed{}$$

$$\text{Estimated Signal } m''(t) = \boxed{}\ m'(t)$$

Complete the derivation of Square-Law Envelope Detector shown in the figure where LPF stands for low pass filter. *Hint: While finding the estimated signal $m''(t)$ in the final step of the derivation, take the $m'(t)$ expression that you derive one step above and just express $m(t)$ in terms of $m'(t)$*

Report - Write the missing parts in your report.

Apply demodulation to modulated signals ($s_1(t)$ and $s_2(t)$) using the following steps: **(You must follow these steps EXACTLY, a change in the process will not let you get any score from the respective part)**

a. Take square of the modulated signals ($s_1(t)$ and $s_2(t)$).

b. Construct a LPF with n = 5 by using the command butter(). Select a proper the cut off frequency considering message signal and carrier frequencies.

c. Apply the low pass filter and take square root of the low pass filter output.

d. Convert $m'(t)$ signal that you obtained in the previous step to the estimated message signal $m''(t)$ using the $m''(t) - m'(t)$ relation that you derive.

e. Plot the initial message signal $m(t)$ and estimated message signal $m''(t)$ on the same axis using *hold on* command.

Modulation Index

Compute the amplitude sensitivity (k_a) value that corresponds to modulation index $\mu = 1$ using the peak message signal. Apply the modulation step for this (k_a) value as well.

Report - Can we recover the message signal correctly for $\mu > 1$ using an envelope detector method. Are there any other way to recover the signal for $\mu > 1$.

Note - Your report should include answers to the questions given with the -*Report*- mark as well as the figure outputs and your comments on each figure output.