EE 352 Communications Systems

LAB 3 REPORT

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Conventional Amplitude Modulation

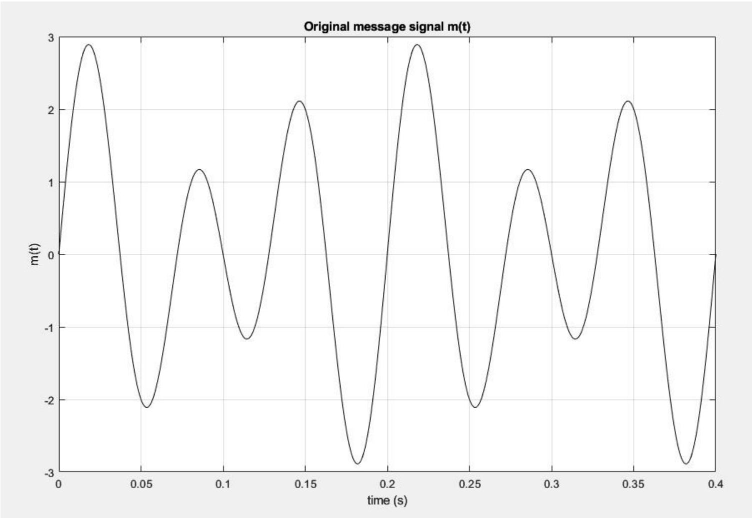

Figure 1: Construction and plot of the message signal m(t)

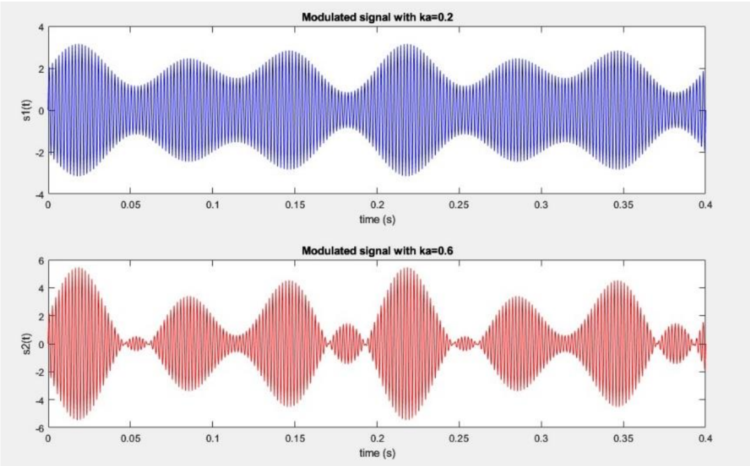

Figure 2: Modulation signal s(t) with different amplitude sensivity values

By using s(t) = (1+k*m(t))*c(t) (formula 1) , modulated signal is obtained depending on different amplitude sensivity (k_a) values. Element-wise operation is important to obtain true equation.

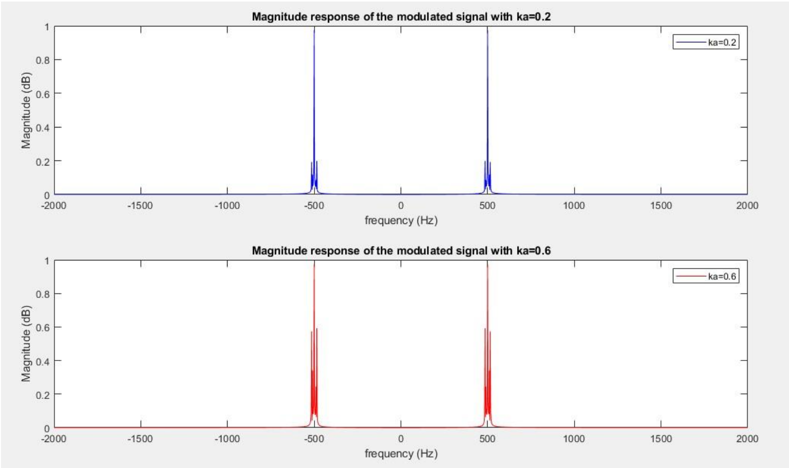

Figure 3: Magnitude responses of $s_1(t)$ and $s_2(t)$

By analyzing figure 3, it is obtained that magnitude response of $s_2(t)$ has more amplitude on the ridges near 500 Hz frequency. Since modulated signal $s_2(t)$ spends more energy, it is understood that it less power efficient than $s_1(t)$. According to the formula below:

$$\eta = \frac{\mu^2}{2+\mu^2} \times 100\%$$

where μ is modulation index.

Square-Law Envelope Detector

```
%% b
fcutoff=150;
% cut-off frequency is choosen according to the equation
% 2*fm < fcutoff < 2*fc also, for minimum phase delay between comparations
% fcutoff=150 Hz is available
[x,y]=butter(5,fcutoff/(Fs/2),"low");
%% c
s1filtered = sqrt(filter(x,y,term1));
s2filtered = sqrt(filter(x,y,term2));
%% d shifted and scaled signals from the step b in conv.AM
mt1prime=(s1filtered-Ac)/ka1;
mt2prime=(s2filtered-Ac)/ka2;
```

Figure 4: Missing parts of the lab sheet from MATLAB code

By following these steps:

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

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

(3) $\cos^2(2\pi f_c t) = (1+\cos(4\pi f_c t))/2$

(4) $s_{sq}(t) = (0.5)A_c^2(1+k_a*m(t))^2 + \underline{(0.5)A_c^2(1+k_a*m(t))^2\cos(4\pi f_c t)}$

These term is eliminated by low-pass filter because of the cut-off frequency is at $2f_c$.

(5) $m'(t) = sqrt(s_{sq}(t)) = (0.707)A_c(1+k_a*m(t))$

Shift by carrier amplitude, scale by amplitude sensivity:

(6) $m''(t) = (m'(t) – A_c)/k_a$

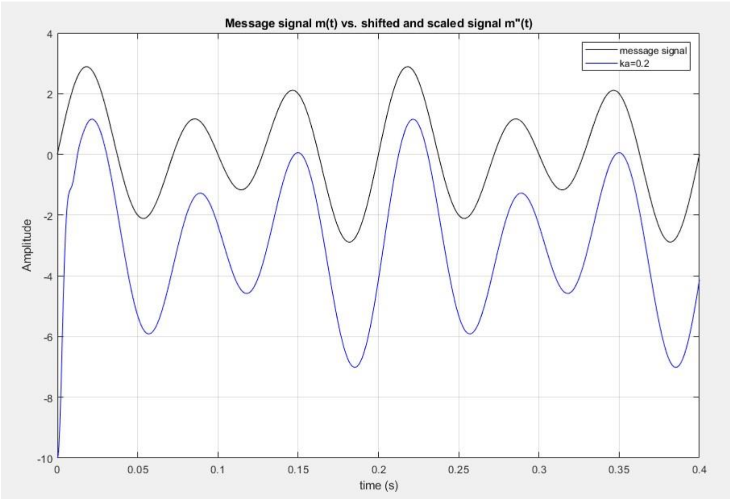

Figure 5: Reconstruction of the message signal by demodulating $s_1(t)$

Using the amplitude sensivity $k_{a1} = 0.2$, message signal is reconstructed by demodulation but with a non-negligible error.

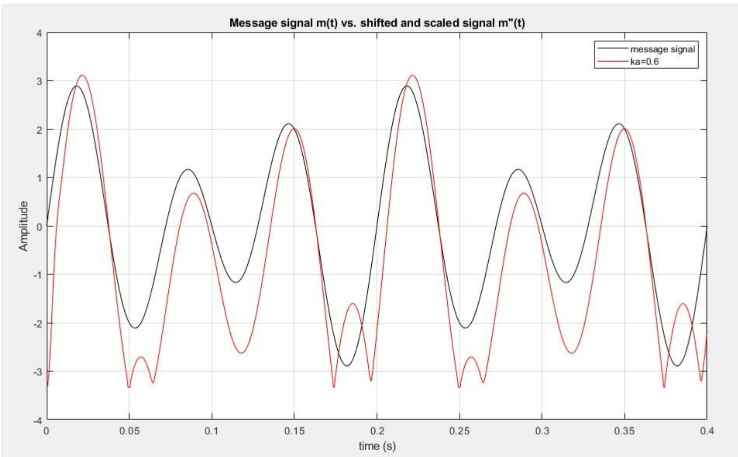

Figure 6: Reconstruction of the message signal by demodulating $s_2(t)$

Since $(1+k*m(t)) > 1$ according to the formula (1) before, demodulation of the signal is no accurate.

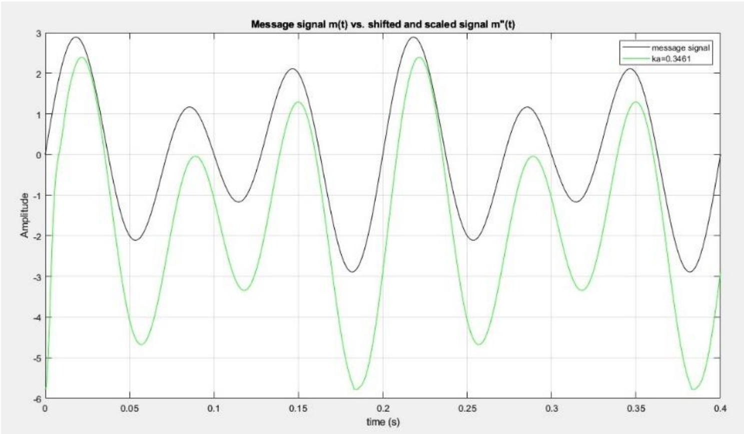

Figure 7: Reconstruction of the message signal by demodulating $s_3(t)$

```
%% Modulation Index
%% modulation index is u=ka*Am so,
Am=max(mt); % max value of message signal
u=1;
ka3=u/Am;

st3=(1+ka3*mt).*ct;
term3=st3.^2;
s3filtered = sqrt(filter(x,y,term3));
mt3prime=(s3filtered-Ac)/ka3;

figure(6)
plot(t,mt,"black");
grid on
legend("m(t)");
hold on
plot(t,mt3prime,"green");
xlabel("time (s)");
ylabel("Amplitude");
legend("message signal","ka=0.3461");
title("Message signal m(t) vs. shifted and scaled signal m''(t)");
```

Figure 8: Modulation index calculation

Modulation index u = ka*Am so, in order to obtain specified amplitude sensivity value (k_{a3} in figure 8), Am should be computed by the max() function. It is obtained that in figure 7, there is much smaller error in demodulation with this amplitude sensivity value than the demodulation calculations before. If u > 1, there would be a phase reversal like figure 6 above. It is possible to recover the message signal from a modulated signal that has phase reversals in conventional amplitude modulation (AM), although it may require some additional processing.

Conventional AM works by modulating the amplitude of a carrier signal with the message signal. This produces a modulated signal that varies in amplitude in proportion to the message signal. However, conventional AM does not preserve the original phase of the message signal, which can cause phase reversals in the modulated signal.

To recover the message signal from a modulated signal with phase reversals, you can use a synchronous detector or demodulator. This involves multiplying the modulated signal with a locally generated carrier signal that is synchronized in frequency and phase with the original carrier signal used for modulation. This process effectively removes the carrier and produces an output signal that is proportional to the original message signal.