Communication Theory Report 1

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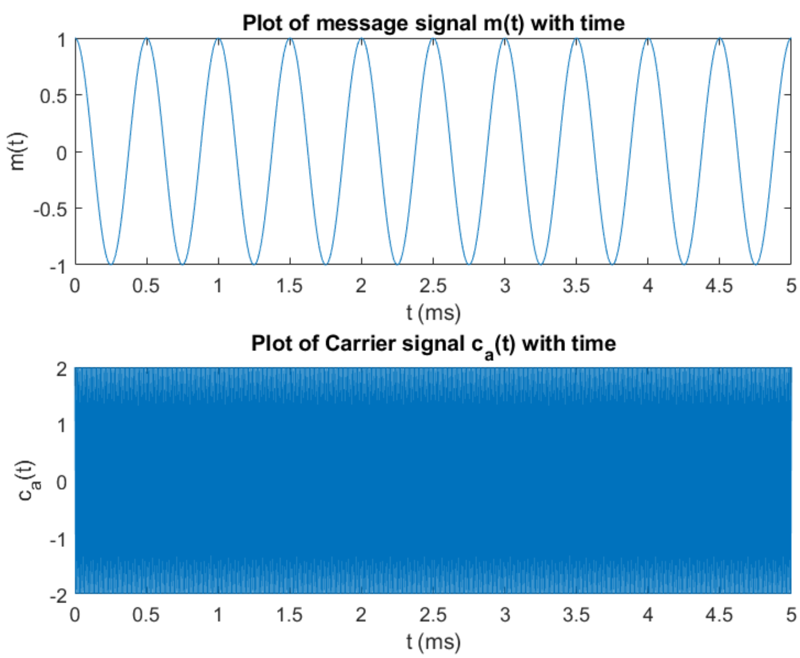
5 MATLAB simulation

5.1 (a)

The following signals were generated and plotted in Matlab.

1. Message signal
$$m(t) = 1\cos(2\pi(2\text{kHz})t)$$

2. Carrier Signal
$$ca(t) = 2\cos(2\pi(100\text{kHz})t)$$



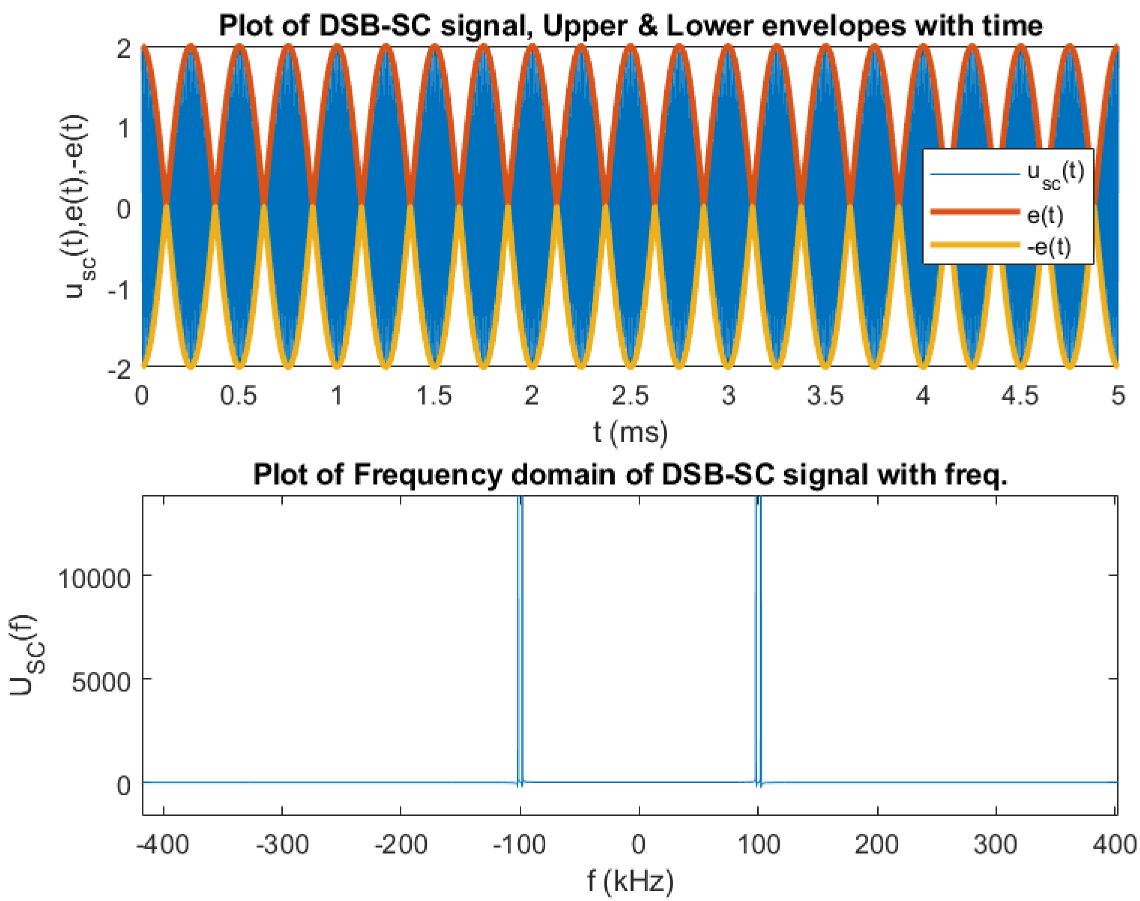
5.2 (b)

The modified DSB-SC waveform $u_{sc}(t)$ was created like so:

$$u_{sc}(t) = m(t) \times ca(t) = 2\cos(2\pi(2\text{kHz})t)\cos(2\pi(100\text{kHz})t)$$

and its Fourier transform $U_{SC}(f)$ was generated and plotted

$$U_{SC}(f) = \mathcal{F}\{u_{sc}(t)\} = \frac{1}{2}\sum \delta((\pm 100 \pm 2)\,\text{kHz} - f)$$



5.3 (c)

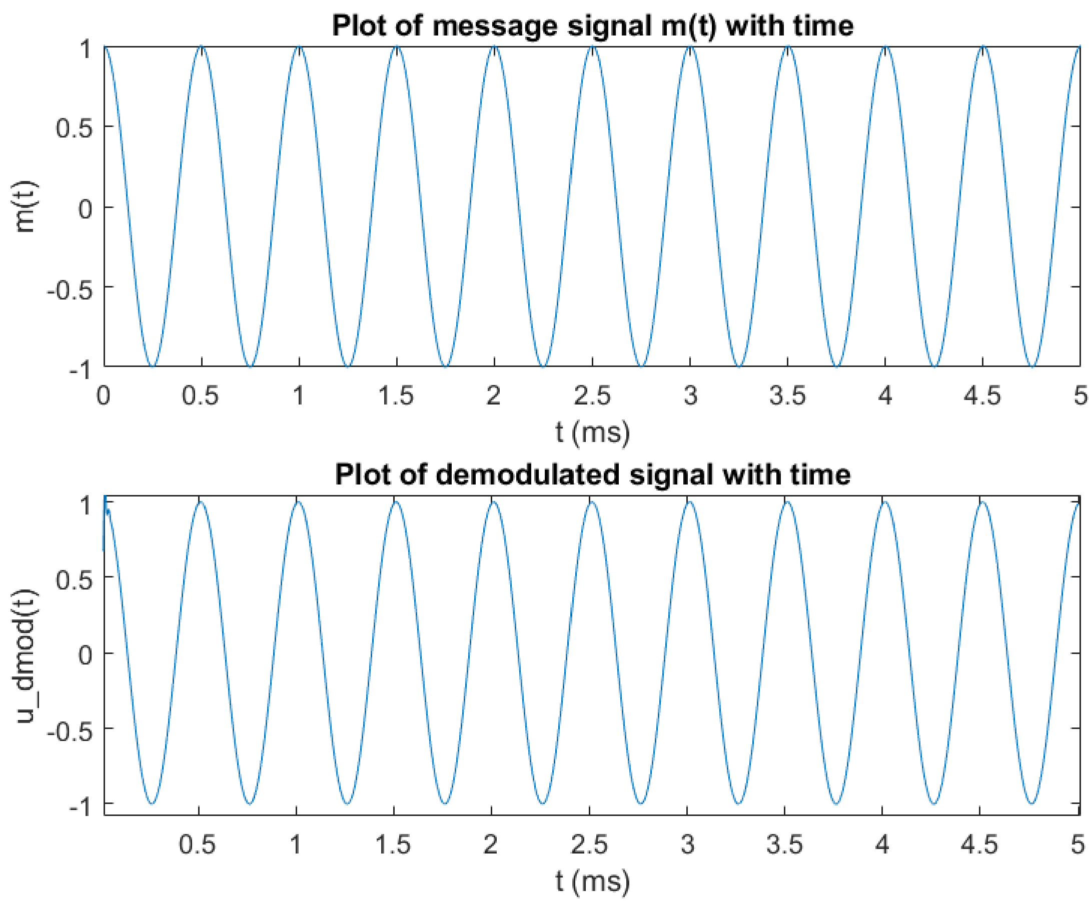
Then, the signal $u_{sc}(t)$ was demodulated by multiplying it again with a sinusoid of carrier frequency and appropriate Amplitude and then passing the corresponding output signal into a Low-pass filter.

$$u_{filter}(t) = u_{sc}(t) \times \cos(2\pi(100\text{kHz})t)$$

Now we pass u_{filter} through a Butterworth low-pass filter with impulse response $h_{butter}(t0$ with just enough cutoff to filter in only the 2kHz component. Thus we finally have

$$\hat{m}(t) = h_{butter}(t) * u_{filter}(t)$$

The following plot shows $m(t)$ and $\hat{m}(t)$. Here, $u_{dmod}(t) = \hat{m}(t)$ (u_{dmod} represents the demodulated signal)



5.4 (d)

The effect of frequency and phase offset were studied in this following section. The de-modulator is modelled to be slightly buggy, i.e., the frequency of the multiplier is not exactly equal to the carrier and there is an additional phase shift as well.

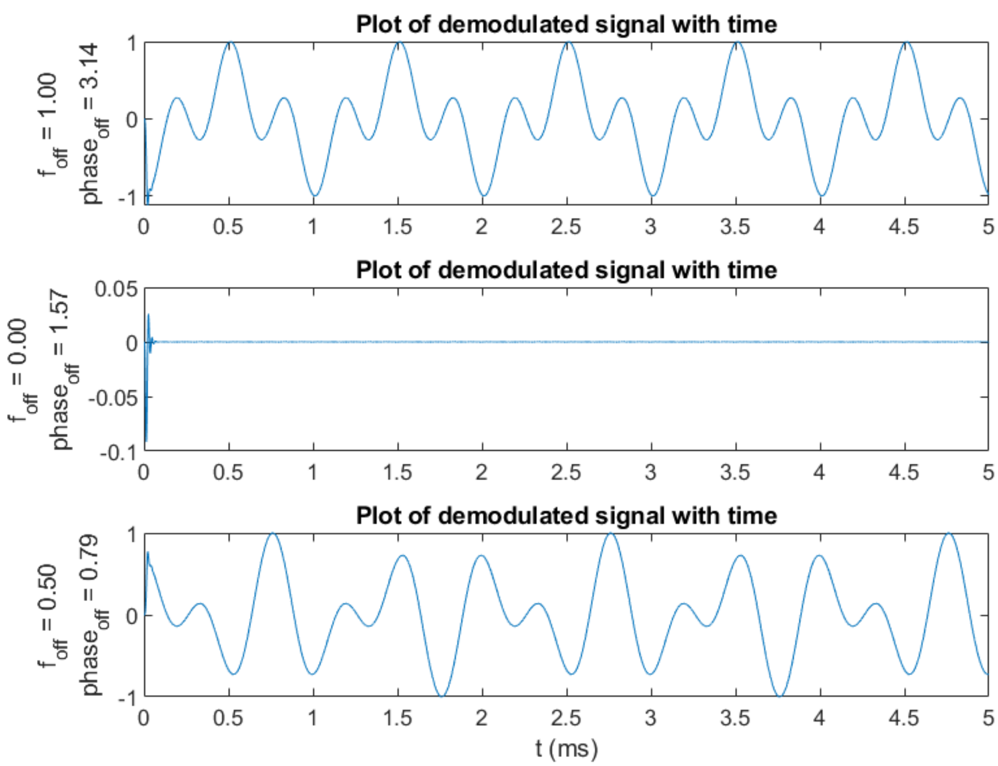
The demodulated signal thus has the form

$$u_{dm}(t) = u_{np}(t) * h_{butter}(t)$$

where

$$u_{np}(t) = u_{sc}(t) \times cos(2\pi(100\text{kHz} + \delta f) + \delta\theta)$$

The following plot shows the Demodulated signals for carious frequency and phase offsets. The second subplot shows the Quadrature null effect (where $\delta f = 0$ and $\delta\theta = \frac{\pi}{2}$). The entire signal goes to zero, hence NULLING has occured due to the phase shift.



5.5 (e)

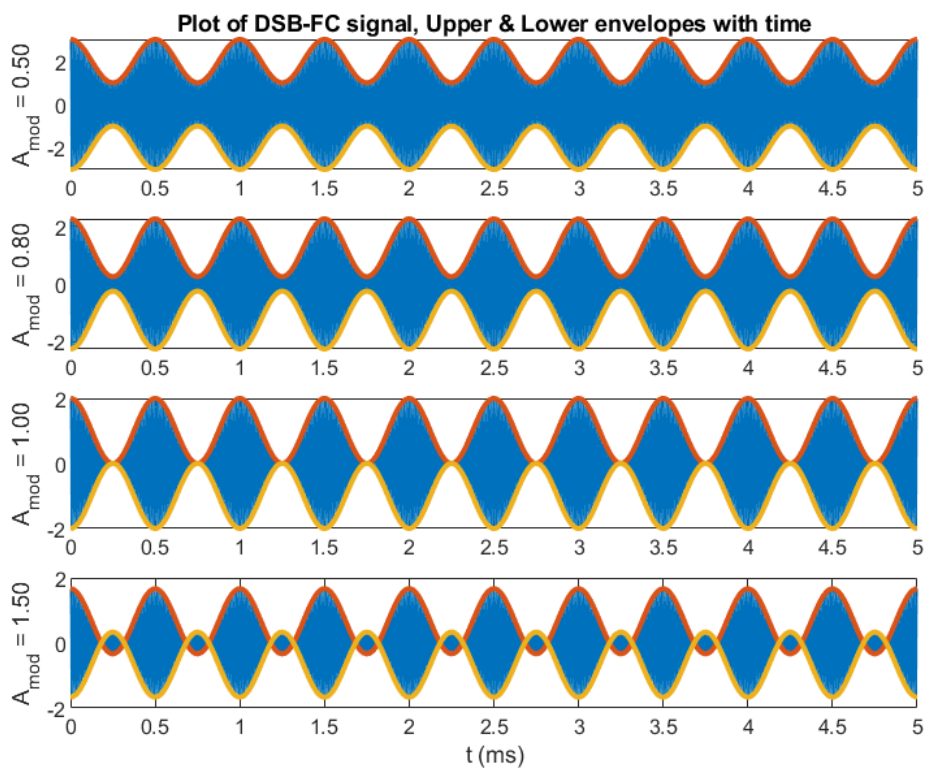
Now the DSB-FC (Conventional AM) signal was created like so:

$$u_{fc}(t) = (m(t) + B)\cos(2\pi(100\text{kHz})t)$$

The value B represents the Amplitude of the Carrier wave.It also determines the modulation index A_{mod}.

$$A_{mod} = \frac{|\min_t m(t)|}{B}$$

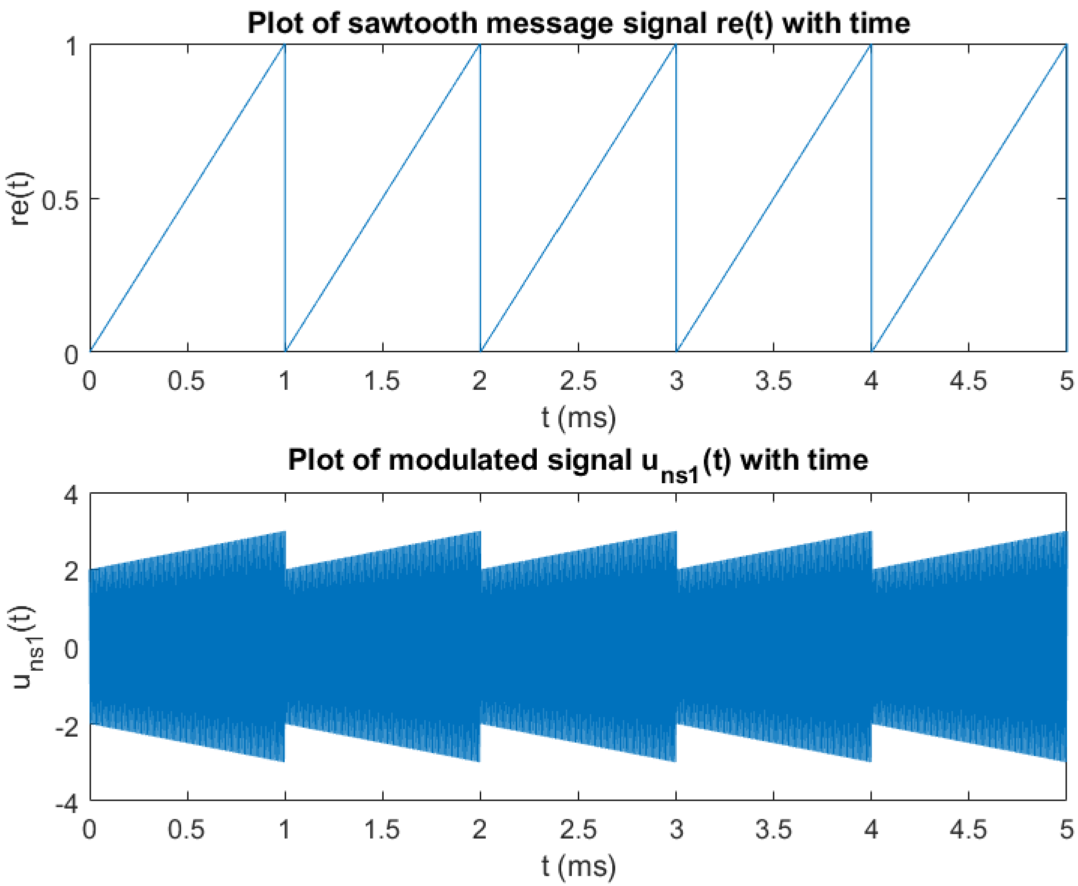
For different values of A_{mod}, the corresponding DSB-FC signal $u_{fc}(t)$ is plotted;



It is clear from the plots that once A_{mod} reaches the value of 1,the upper and lower envelopes just start to touch and once it crosses 1, they overlap. This makes it impossible to be read without error using an envelope detector. Thus if $A_{mod} \leq 1$, it is possible to reconstruct the envelopes and hence the message signal.

5.6 (f)

A sawtooth message signal $re(t)$ was created and this plot shows the signal plot and the DSB-FC modulated version $u_{ns1}(t)$.



5.7 (g)

The message signal $re(t)$ was modulated using two schemes, DSB-FC and DSB-SC to get modulated signals $u_{ns1}(t)$ and $u_{ns2}(t)$ repsectively. Their fourier transforms ($U_{NS1}(f)$ and $U_{NS2}(f)$) are plotted below.