Simulation of Noise Effects on Signals and Demodulation Techniques

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Introduction

This lab report aims to simulate the effect of noise on different types of modulated signals and to demonstrate the use of filters and demodulators for signal recovery. MATLAB is used to generate and analyze the signals in both the time and frequency domains.

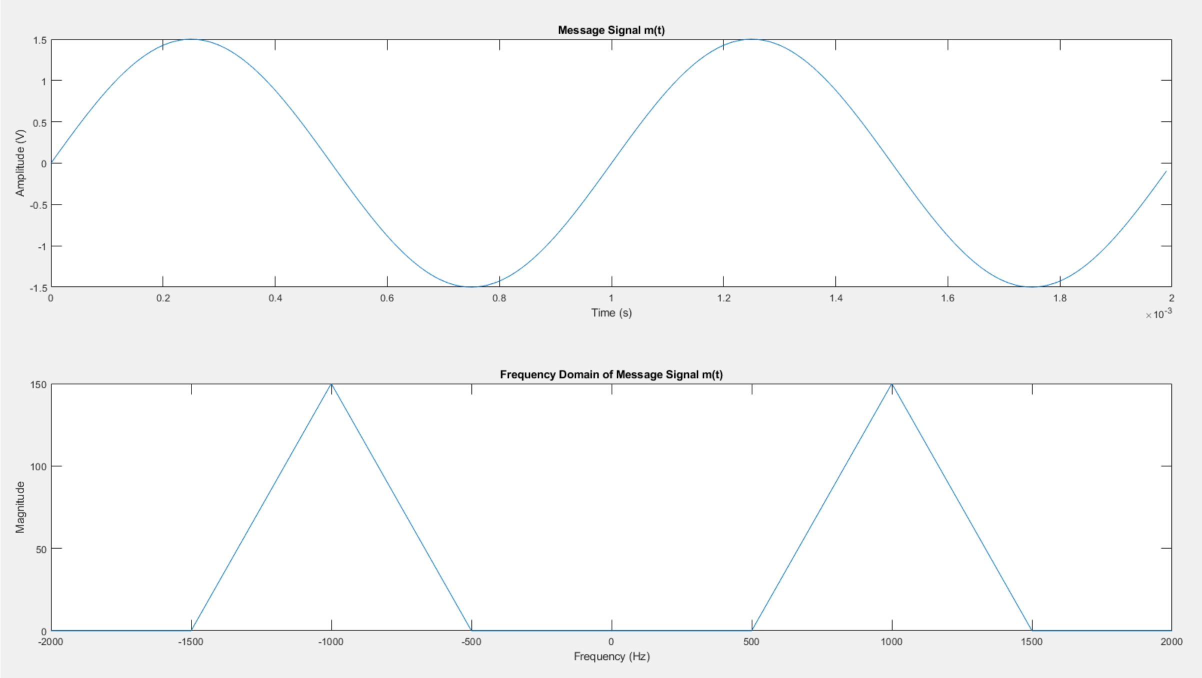
Theory

In signal processing, noise is an unwanted component that can affect the quality of the signal. Different types of modulated signals such as AM, DSB-SC, and FM can be used to transmit information over a communication channel. However, the presence of noise can distort the signal and make it difficult to recover the original message signal. To simulate the effect of noise, we add additive white Gaussian noise (AWGN) to the original signal. The signal-to-noise ratio (SNR) is used to control the amount of noise added to the signal. A higher SNR means less noise, while a lower SNR means more noise. To recover the original message signal, we use filters and demodulators. A bandpass filter is used to filter out unwanted frequencies and isolate the modulated signal. For AM and DSB-SC signals, a product modulator is used to recover the message signal. For FM signals, a linear demodulator is used to detect the frequency variations in the signal and recover the message signal.

Plots And Observations

<u>Objective 1</u>: To generate a message signal, add AWGN and plot the signals of two cycles in both time and frequency domains using MATLAB.

1. Generate a message signal m(t) with a frequency of 1 kHz and amplitude of 1.5 V. Here, we assume sampling frequency to 100 kHz.

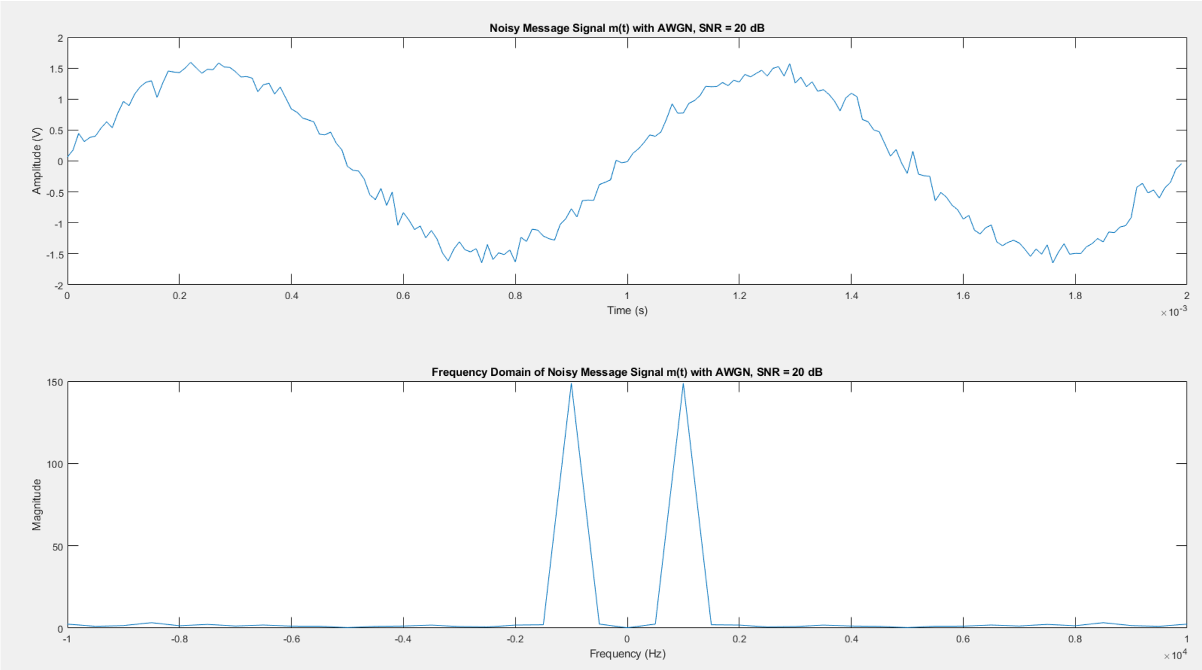


2. Add AWGN to the message signal with a signal-to-noise ratio (SNR) of 20 dB.
   Pm = MSE of power of message signal
   Pn = Pm / 10^(SNR/10) where SNR is 20 as given
   Noise Signal = (Pn^(0.5)) * randn(size of message signal)
   Here, we have added noise signal (AWGN) to the main signal and plots are displayed in 3^{rd} part.

3. Plot the message signal and the noisy signal in both time and frequency domains.

(a) In the time domain, plot the signals as a function of time with appropriate labels for the axes.

(b) In the frequency domain, plot the signals using the Fourier transform with appropriate labels for the axes.



<u>Objective 2</u>: To simulate the effect of noise on a DSB-SC modulated signal, and to demonstrate the use of a bandpass filter and product modulator for demodulation.

1. Generate a message signal m(t) with a frequency of 10 Hz and amplitude of 2 V.
   Here, we assume sampling frequency to 100 kHz.
2. Modulate the message signal using DSB-SC modulation with a carrier frequency of 1 kHz and a carrier amplitude of 4 V.
   Similar as q1.
3. Add AWGN to the modulated signal with a signal-to-noise ratio (SNR) of 10 dB.
   Pm = MSE of power of message signal
   Pn = Pm / 10^(SNR/10) where SNR is 20 as given
   Noise Signal = (Pn^(0.5)) * randn(size of message signal)
4. Pass the noisy modulated signal through a bandpass filter.
   This part is done by using butter function with carson bandwidth (2 * (kf+fm)).
5. Demodulate the filtered signal using a product modulator.
   This part is done by using filter function.

6. Plot the following signals in both time and the frequency domain:

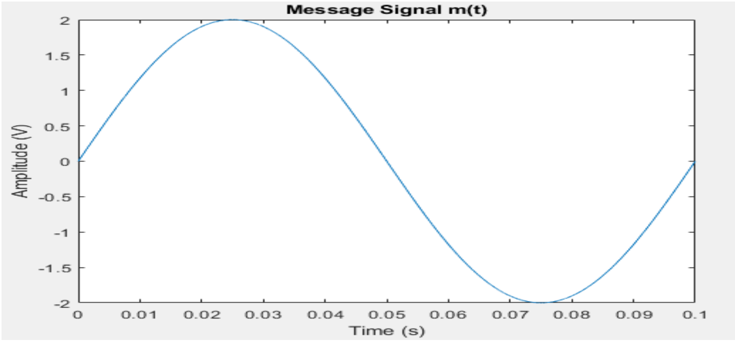
   (a) Original message signal for two cycles

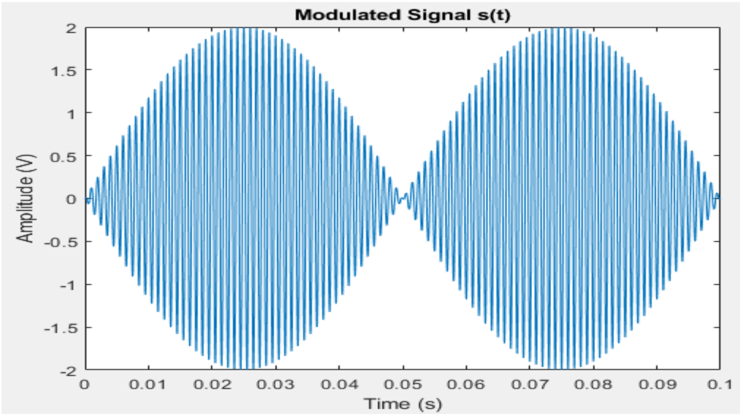
   (b) DSB-SC modulated signal

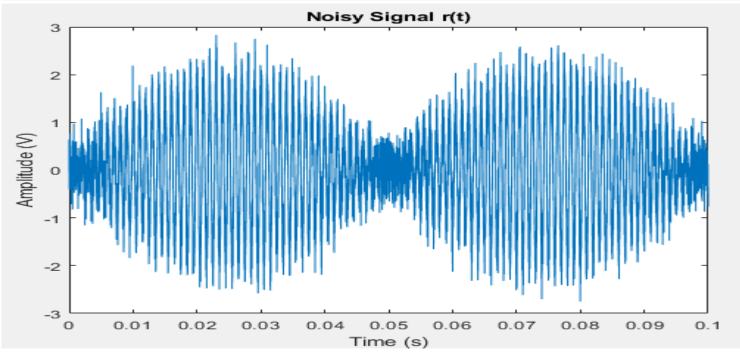
   (c) Noisy modulated signal

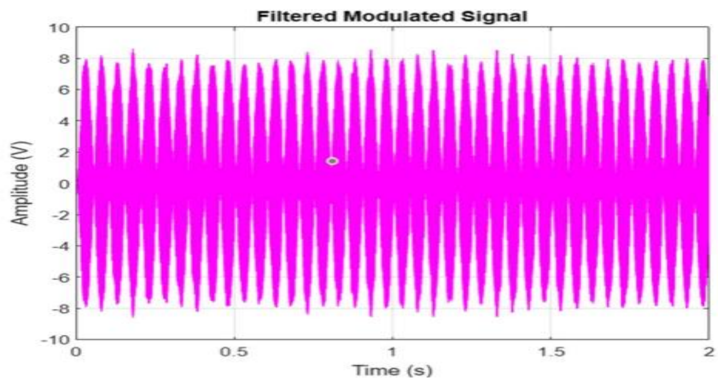
   (d) Filtered modulated signal

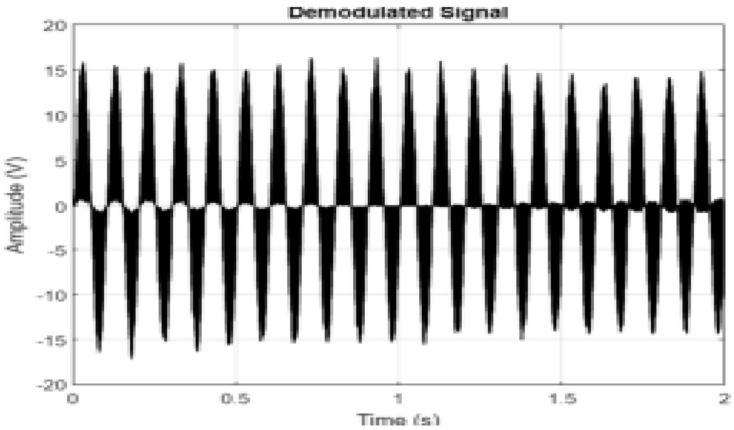
   (e) Demodulated signal

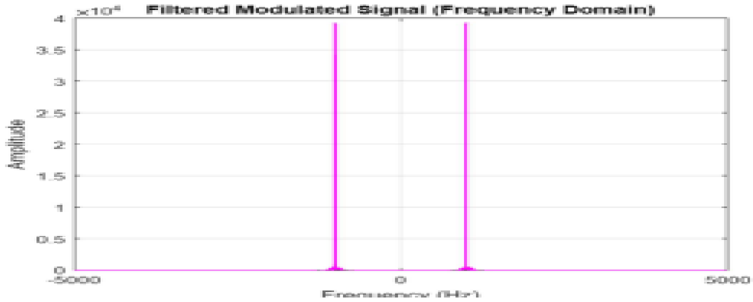

Message Signal m(t)
Amplitude (V)
Time (s)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1


Modulated Signal s(t)
Amplitude (V)
Time (s)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1


Noisy Signal r(t)
Amplitude (V)
Time (s)
3
2
1
0
-1
-2
-3
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1


Filtered Modulated Signal
Amplitude (V)
Time (s)
10
8
6
4
2
0
-2
-4
-6
-8
-10
0
0.5
1
1.5
2





Objective 3: To simulate the effect of noise on a frequency modulated (FM) signal, and to demonstrate the use of a bandpass filter and linear demodulator for demodulation.

1. Generate a message signal m(t) with a frequency of 5 Hz and amplitude of 5 V. Here, we assume sampling frequency to 100 kHz.
2. Modulate the message signal using FM modulation with a carrier frequency of 100 Hz and kf = 30π.
   It is done with message signal passed in cumsum function.
3. Add AWGN to the modulated signal with a signal-to-noise ratio (SNR) of 20 dB.
   Similarly AWGN signal with SNR=20 is passed here.
4. Pass the noisy modulated signal through a bandpass filter use the Carson bandwidth rule for cutoff frequency.
   This part is done by using butter function with carson bandwidth (2 * (kf+fm)).
5. Demodulate the filtered signal using a linear demodulator.
   This part is done by using filter function.

6. Plot the following signals in both the time and frequency domains:

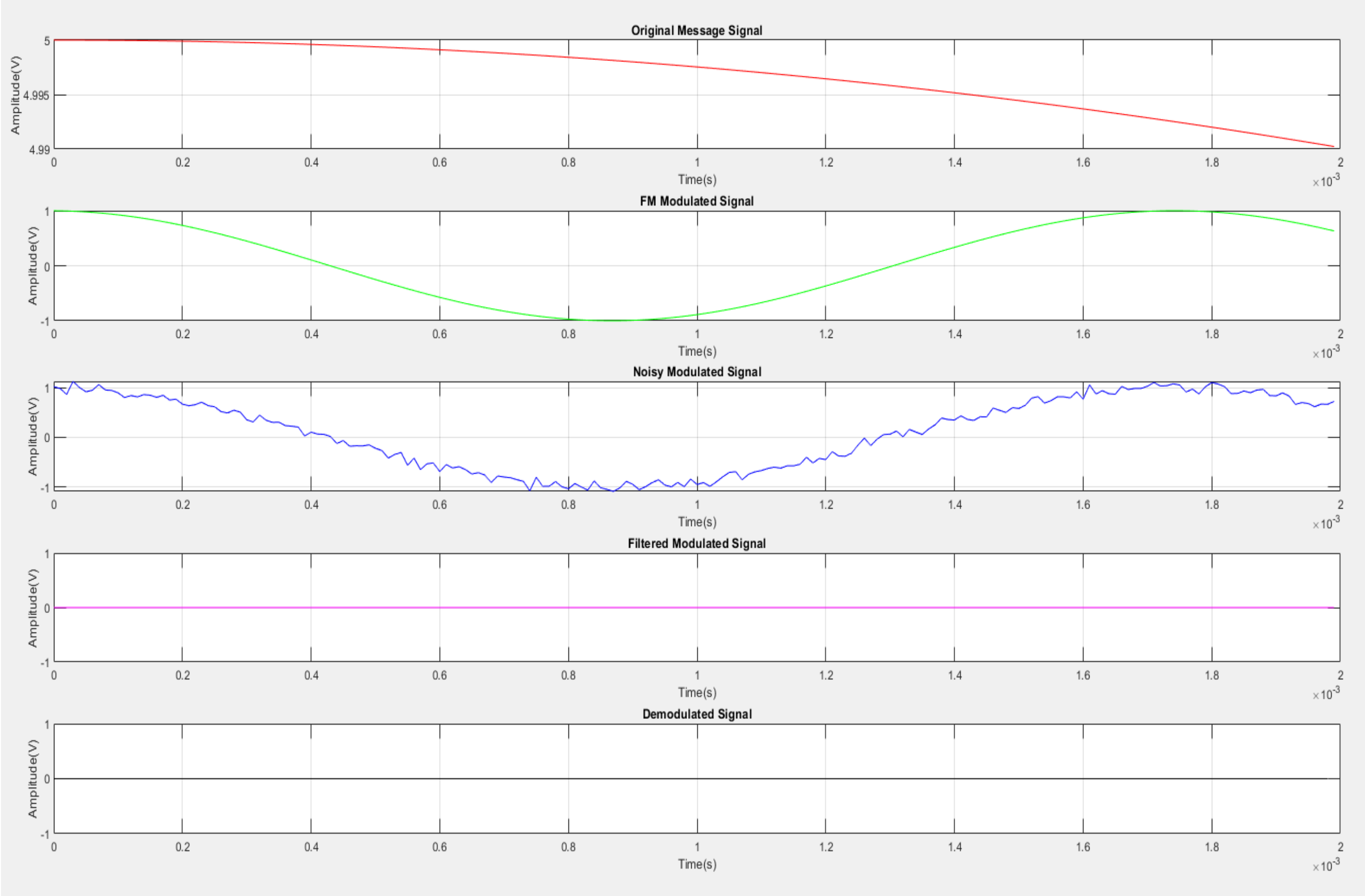
   (a) Original message signal of two cycles

   (b) FM modulated signal

   (c) Noisy modulated signal

   (d) Filtered modulated signal

(e) Demodulated signal



Conclusion

In this lab report, we have demonstrated the effect of noise on different types of modulated signals and the use of filters and demodulators for signal recovery. By adding AWGN to the original signal, we have shown how noise can affect the signal quality and make it difficult to recover the message signal. The use of filters and demodulators has shown how we can recover the original message signal from the noisy modulated signal. Overall, this lab report provides a practical demonstration of the importance of noise reduction and signal recovery techniques in communication systems.