301 SIGNALS AND SYSTEMS
Introducing to Simulink for simulating Modulation and Demodulation

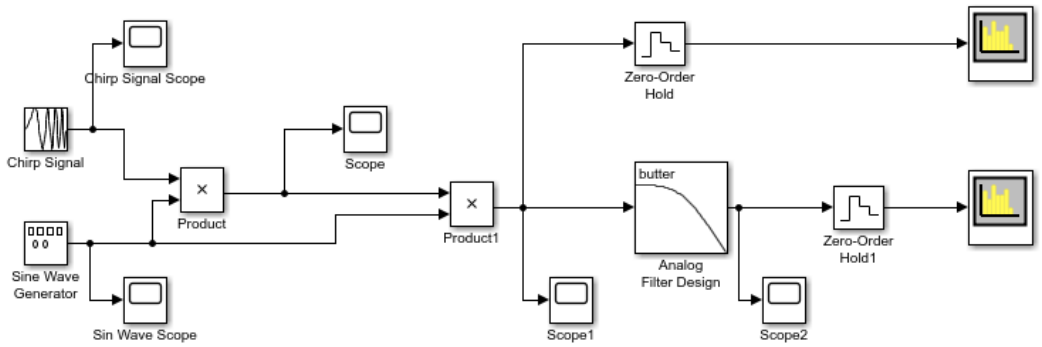
By Rushika Thandra

INTRODUCTION

In this experiment, we explore the amplitude modulation and demodulation application through the MATLAB Simulink toolbox.

EXPERIMENT

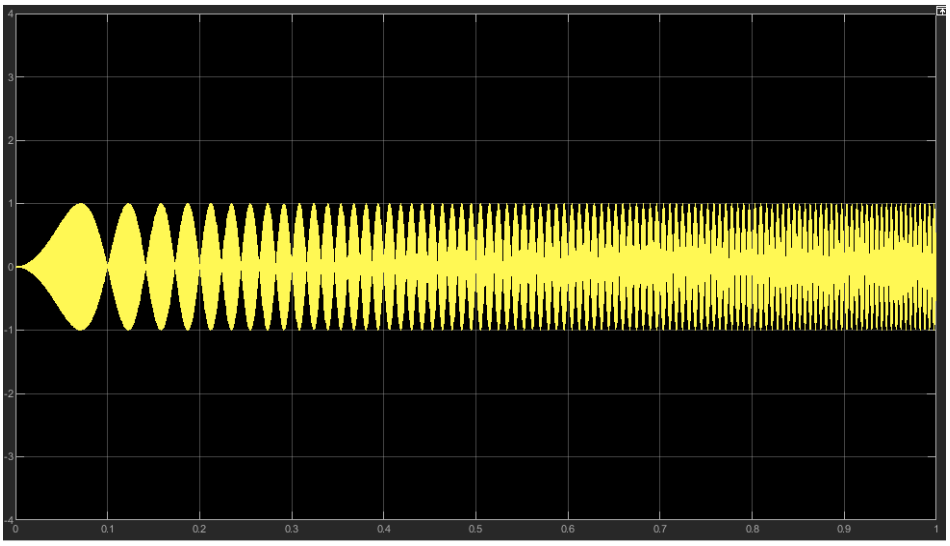
A chirp signal and 10khz sine wave are multiplied together in the circuit below in order to modulate the signal and add demodulation to it.



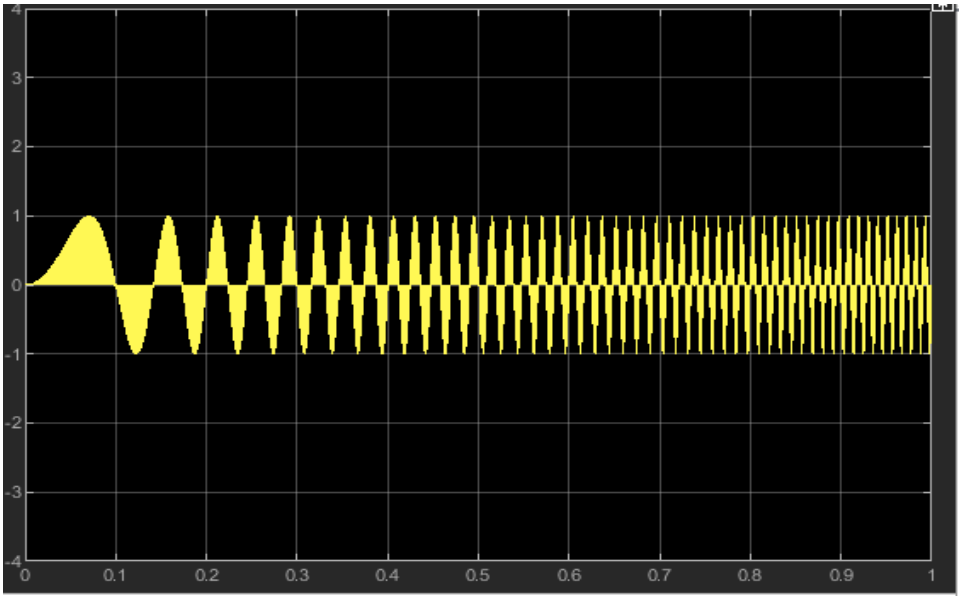
RESPECTIVE SCOPE OUTPUTS

Chirp signal was set to 0Hz initial frequency, target time 1 sec and frequency to 100Hz. The chirp signal was multiplied by using a 10KHz(2*pi*10e3) sine wave using the sine wave generator.

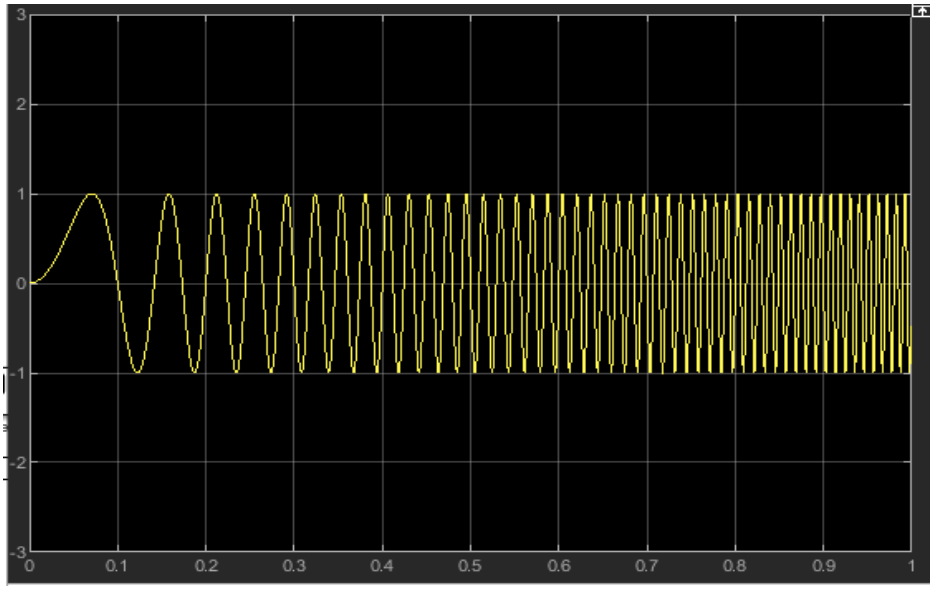
Output:



The signal is now demodulated by multiplying it by the identical sine wave that modulated it in the first place.

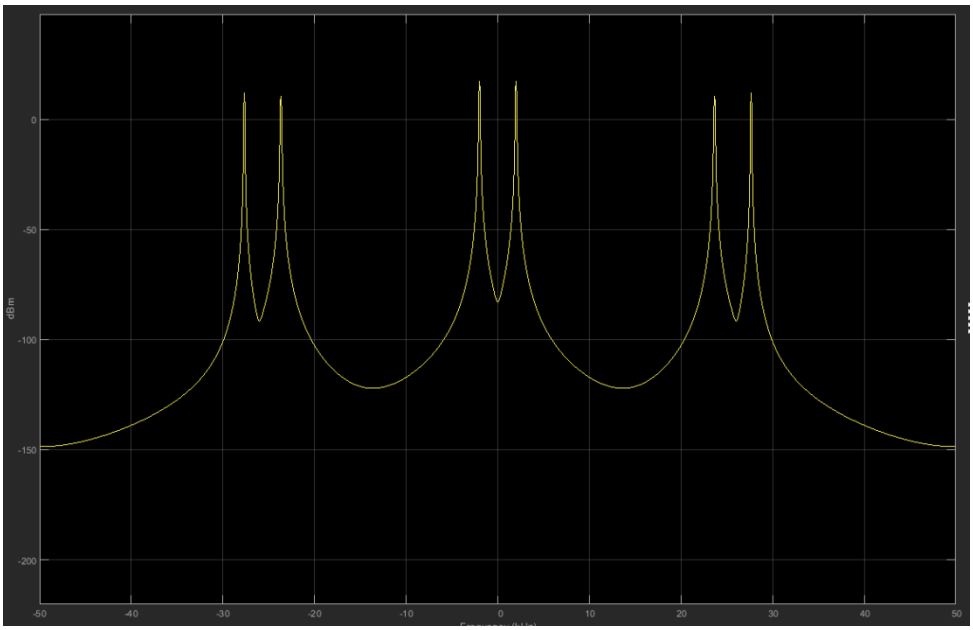


A demodulated signal is passed through a low pass Butterworth filter of 5th order and a cutoff frequency of 200Hz.



Running the signal through a 200hz cutoff low-pass butterworth filter produced the identical output signal.

Two zero order holds blocks were places with their sample time set to 1e10-5 corresponding to a sample rate of 100KHz. The spectrum analyzer was set as input to the signal and the output is shown below:


0
-50
-100
-150
-200
dBm
-50
-40
-30
-20
-10
0
10
20
30
40
50

Trignometry proof of concept

$A = 100(2\pi)t$ $\quad$ $B = 10{,}000(2\pi)t$

multiply A & B signal

$$\sin A \sin B = \frac{1}{2}\left[\cos(A-B) - \cos(A+B)\right] \rightarrow (1)$$

multiply result (1) by the demodulating signal.

$$= \frac{1}{2}\left[\cos(A-B) - \cos(A+B)\right] \sin B$$

$$= \frac{1}{2}\cos(A-B)\sin B - \frac{1}{2}\cos(A+B)\sin B$$

$$= \frac{1}{4}\left[\sin(B+A-B) + \sin(B-A+B)\right] -$$

$$\frac{1}{4}\left[\sin(B+A+B) + \sin(B-A-B)\right]$$

$$= \frac{1}{4}\sin(A) + \frac{1}{4}\sin(2B-A) - \frac{1}{4}\sin(2B+A) - \frac{1}{4}\sin(-A)$$

$$= \underbrace{\frac{1}{2}\sin(A)}_{\text{low frequency modulated signal}} + \underbrace{\frac{1}{4}\sin(2B-A) - \frac{1}{4}\sin(2B+A)}_{\text{High frequency modulated signal}}$$

CONCLUSION

In this experiment, the concept of AM modulation was performed using Simulink. The frequency behaviors and time domain of different settings were observed.