Frequency Division Multiplexing using Coherent and Envelope Detector

PREPARED BY:

1706136 SAMIN ZAWAD
1706162 SUDIPTA SAHA
1706170 ARPAN SUR
1706171 A.K.M. MOINUDDIN SIDDIQUE
1706182 FAHIM SHAHRIAR

SUBMITTED TO:

SUBMITTED ON:

COURSE:

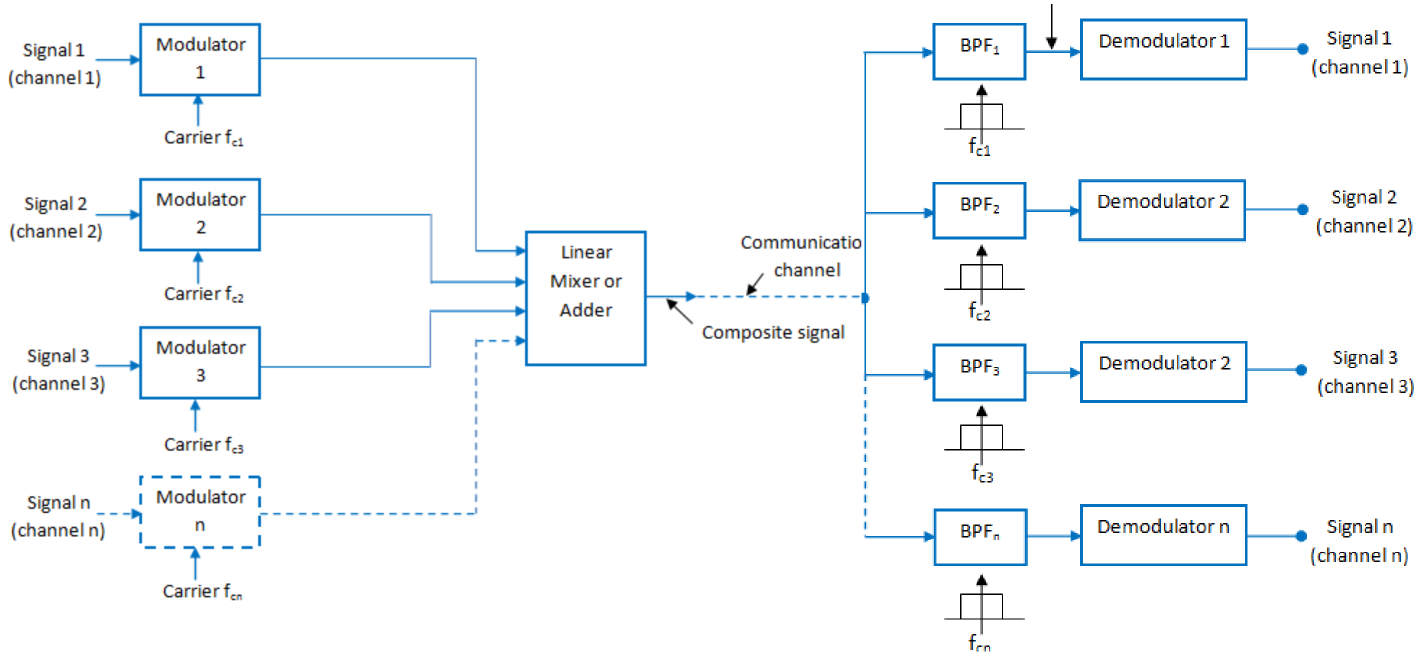
Introduction

This project implements AM DSB-WC in proteus.

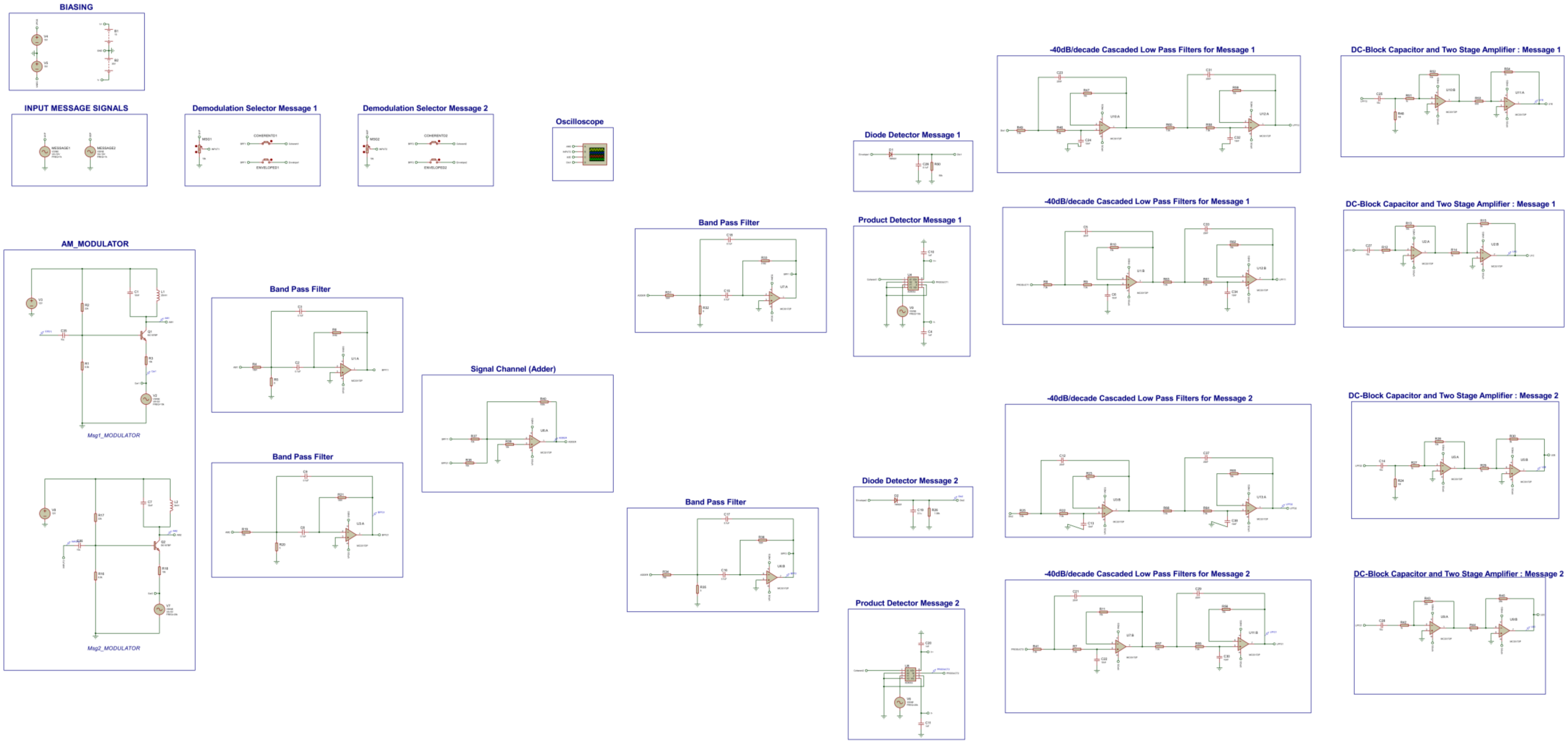
- There are multiple users at the input.
- Each user’s message is modulated with different carrier frequency.
- The modulated signals were sent signal through same transmission channel.
- At receiver side, the signals were demodulated for each user.
- Coherent and non-coherent detection is shown
- Controller is kept so that user can control the modulation index at which he wants to transmit the signal.
- User is able to properly demodulate signal at receiver side even if he uses overmodulation.

FDM Theory

Fdm theory

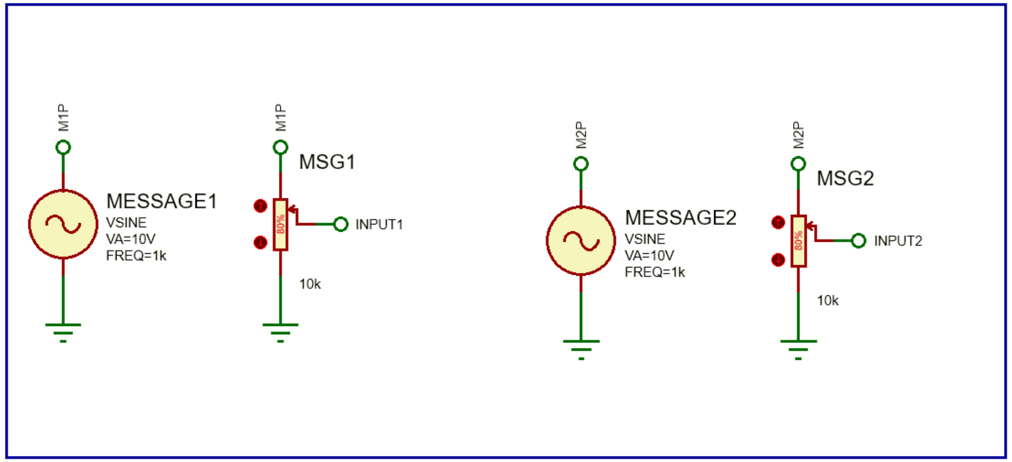


Proteus Circuit

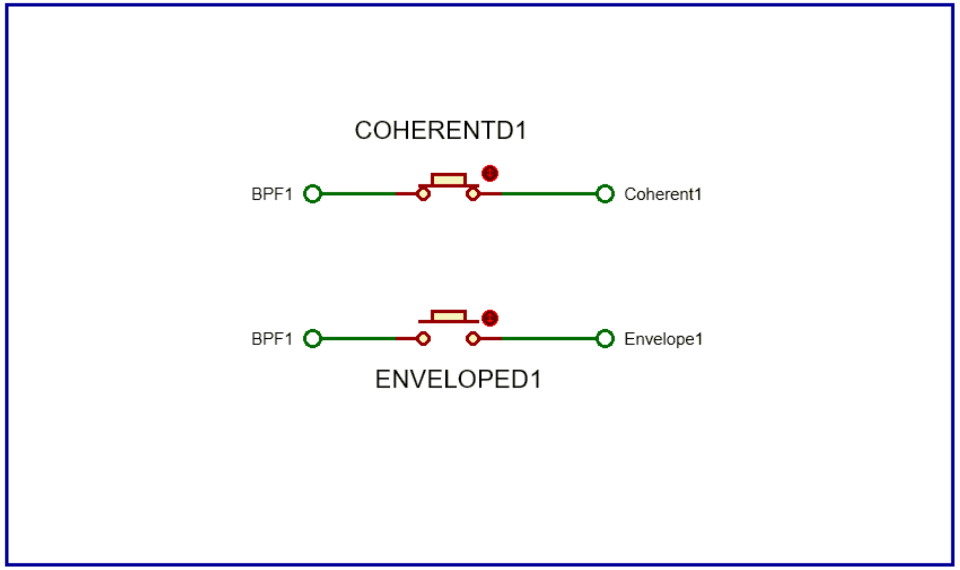


User Guide

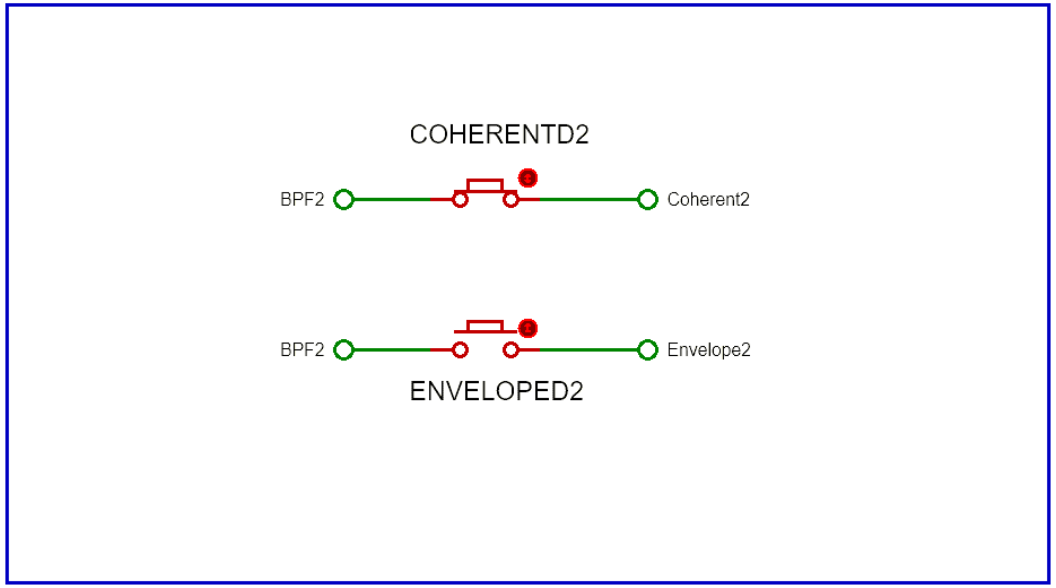
INPUT MESSAGE SIGNALS



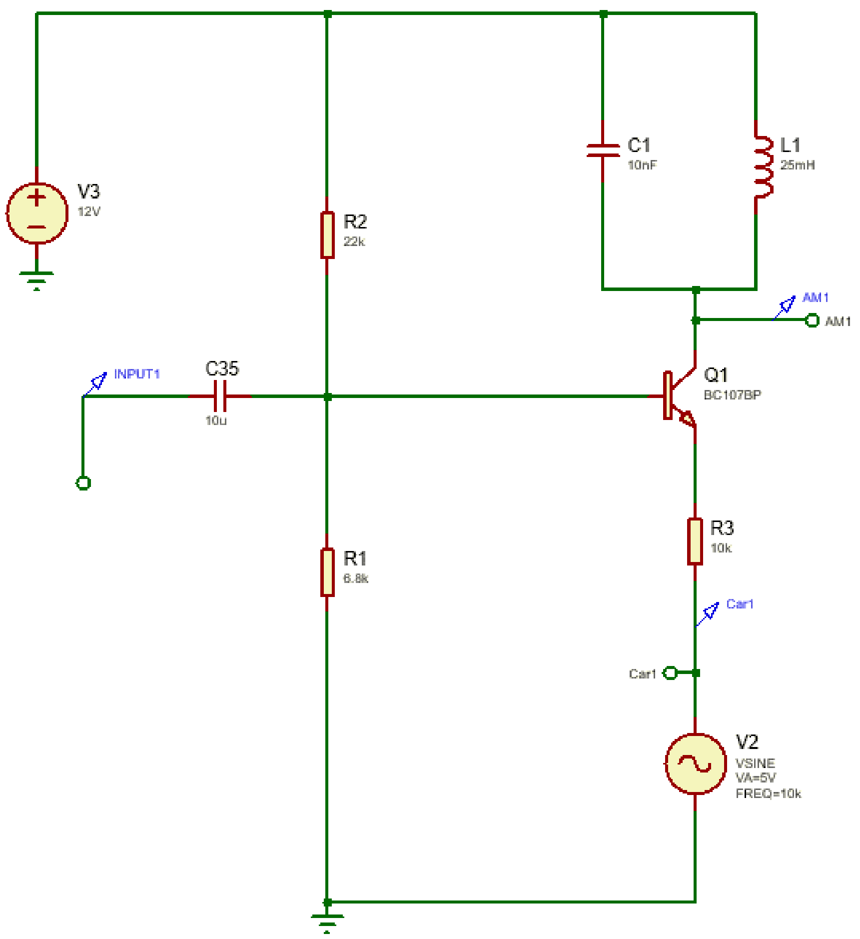
Demodulation Selector Message 1



Demodulation Selector Message 2



Amplitude Modulator : Class C Amplifier



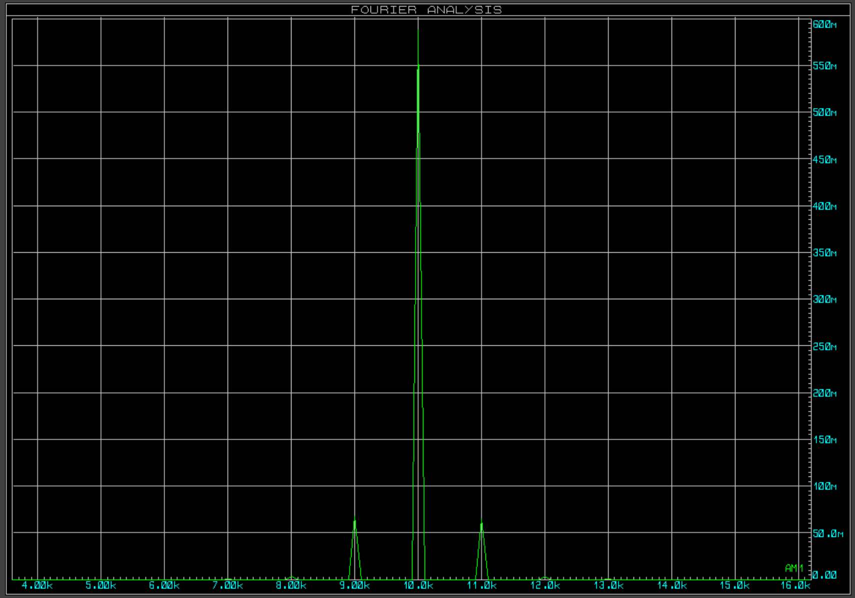
Tank Circuit Parameters

$$fr = \frac{1}{2\pi\sqrt{LC}}$$

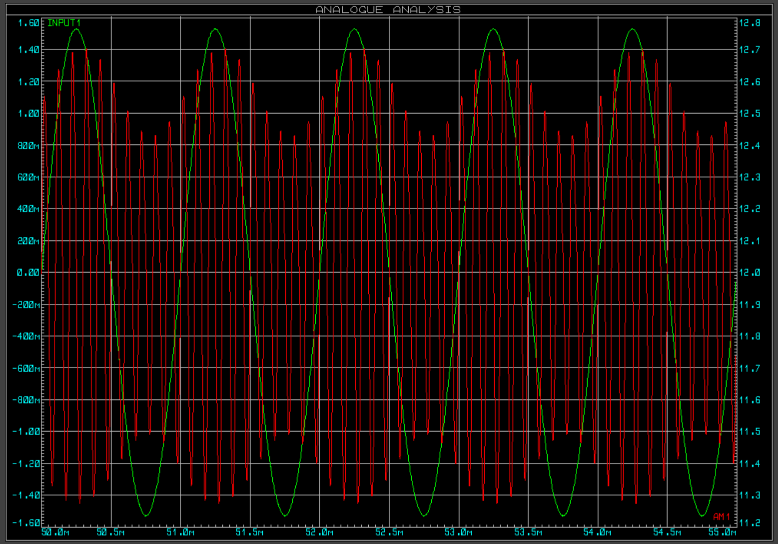
Carrier Frequency, f_c = *Resonant Frequency*, f_r

Theoretical Efficiency: 90%
Power Consumption: Very Low

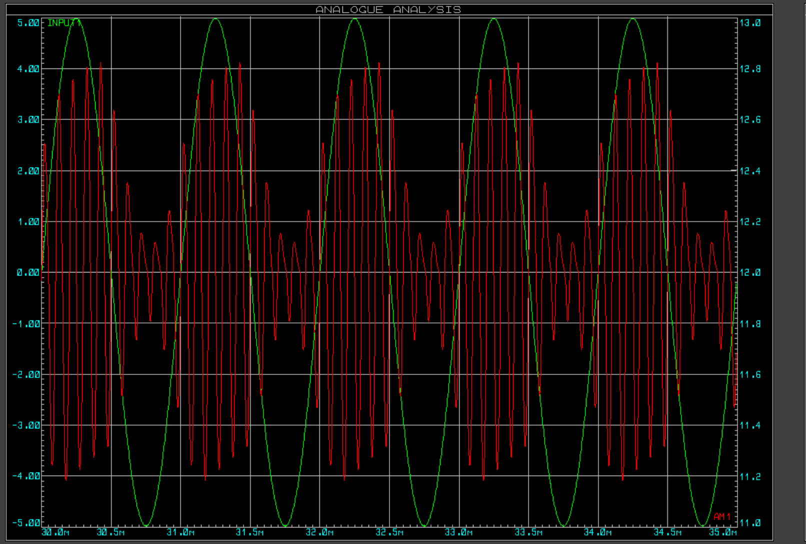
Amplitude Modulation FFT and Outputs



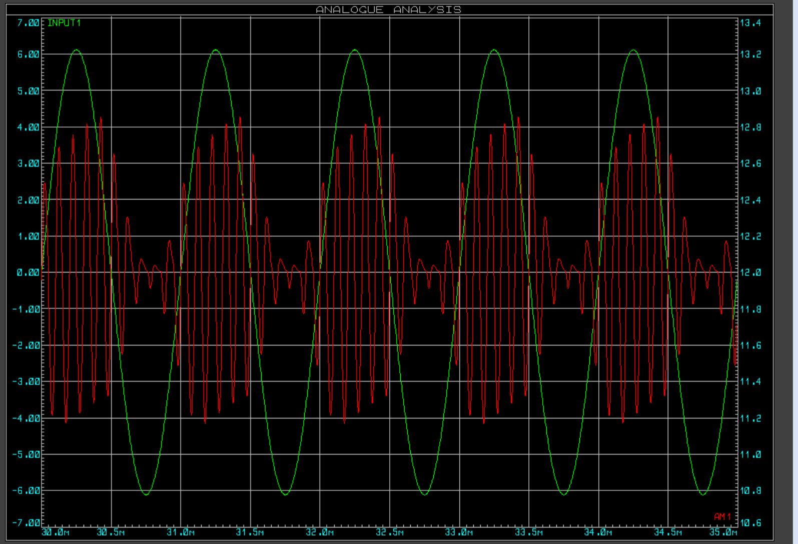
F_c=10kHz
Sidebands:
(F_c - F_m) at 9kHz
(F_c + F_m) at 11kHz



UNDERMODULATED (m = 0.3)

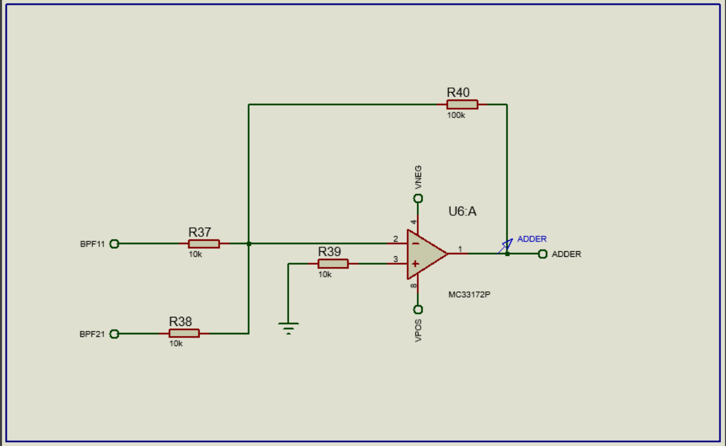


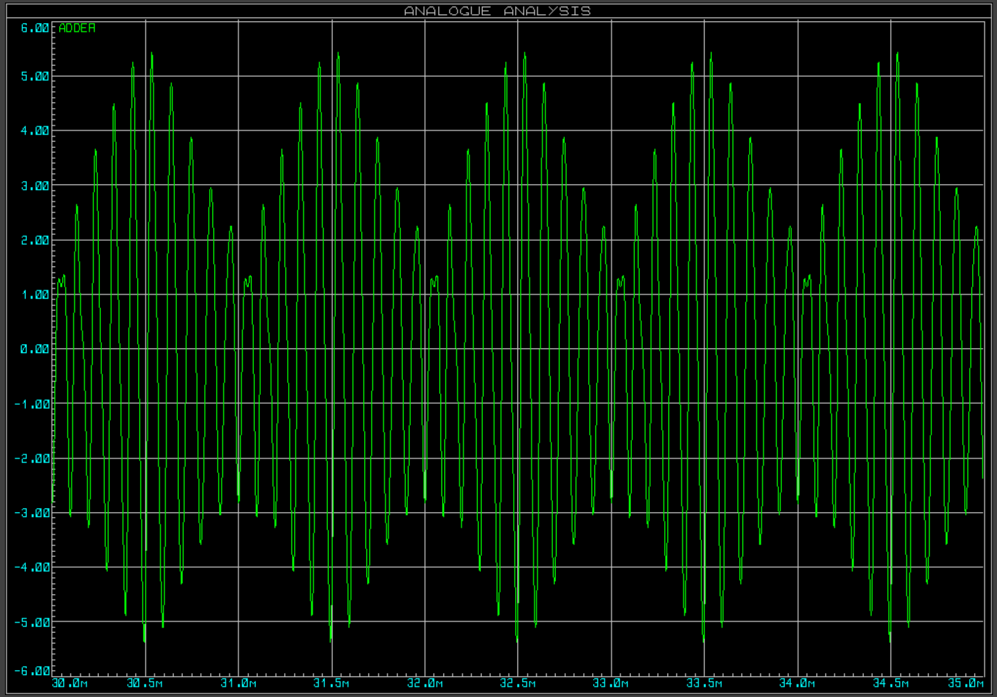
FULLY MODULATED (m = 1.0)



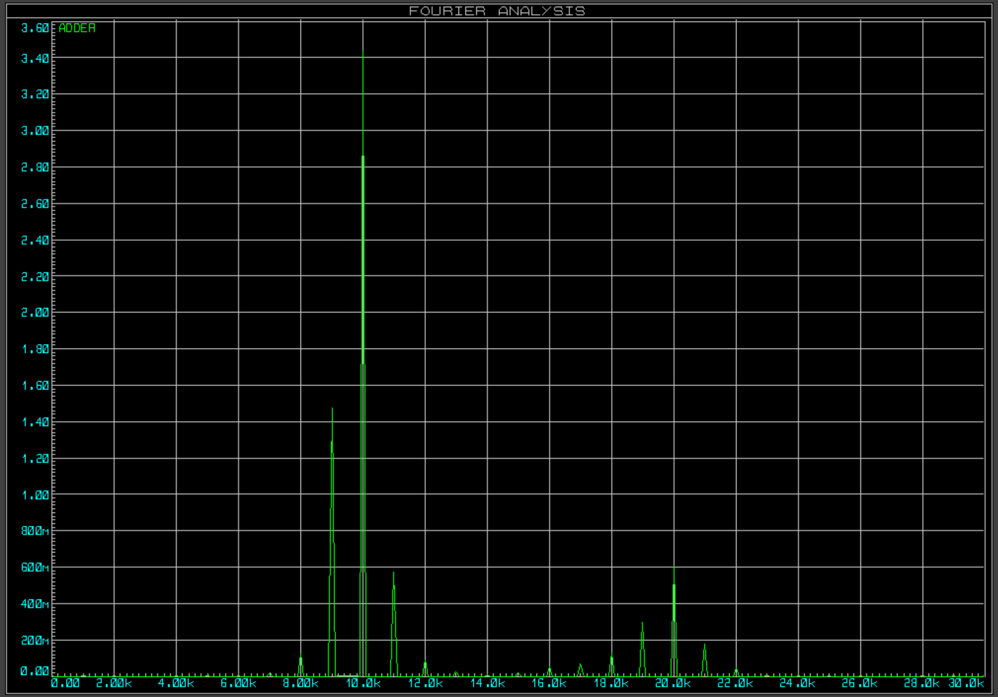
OVERMODULATED (m = 1.22)

Signal Channel Simulation Using Adder





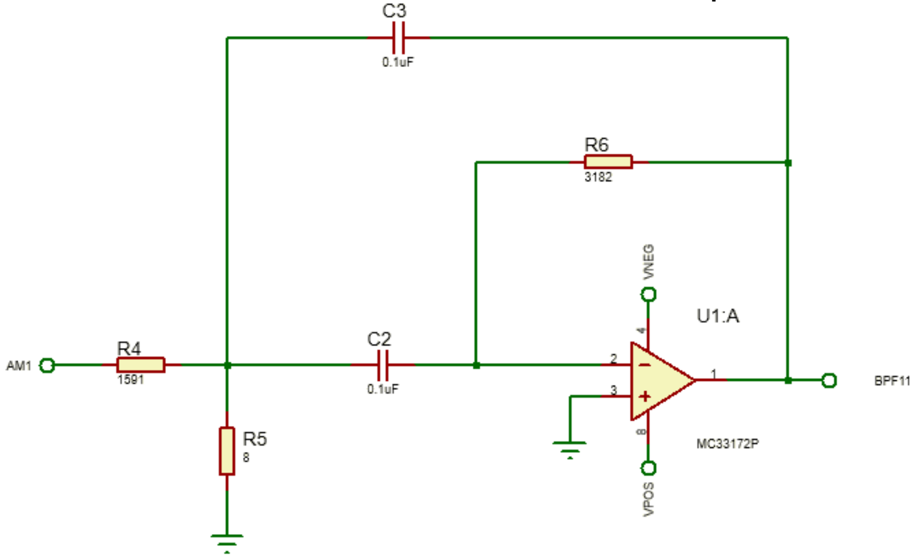
ADDER OUTPUT FOR 2 MODULATED INPUT SIGNALS



FFT SHOWS 2 x DSB-WC at 10kHz and 20kHz

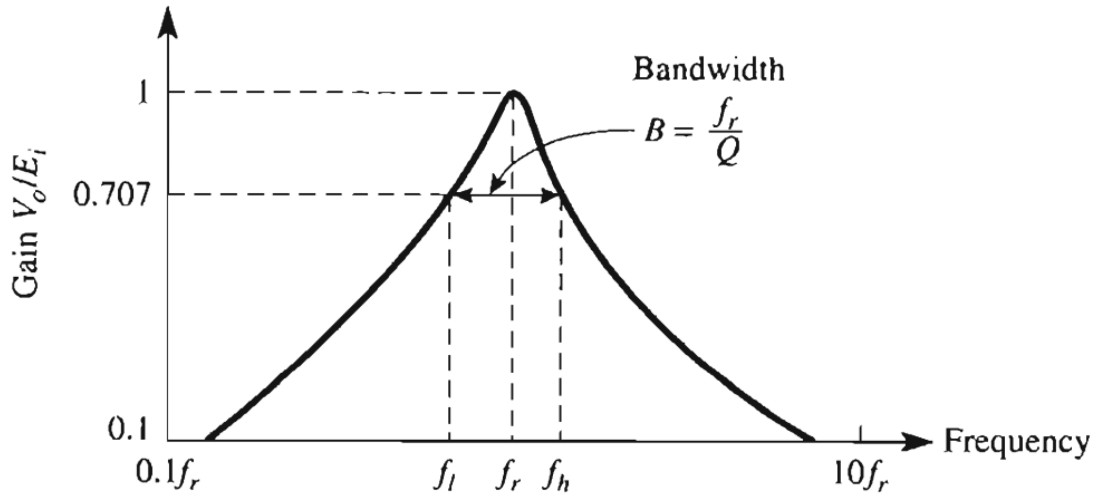
Filters Used in Project

NARROW BANDPASS FILTER WITH f_r= 10kHz



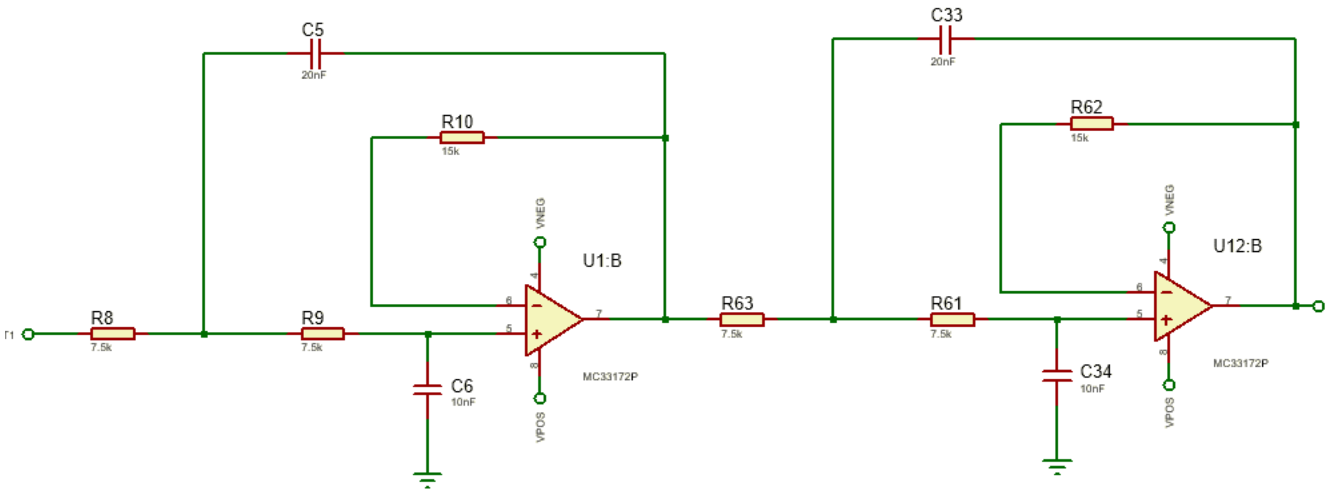
$$B = \frac{0.1591}{RC} = \frac{fr}{Q}, \qquad Rr = \frac{R}{2Q^2 - 1}$$

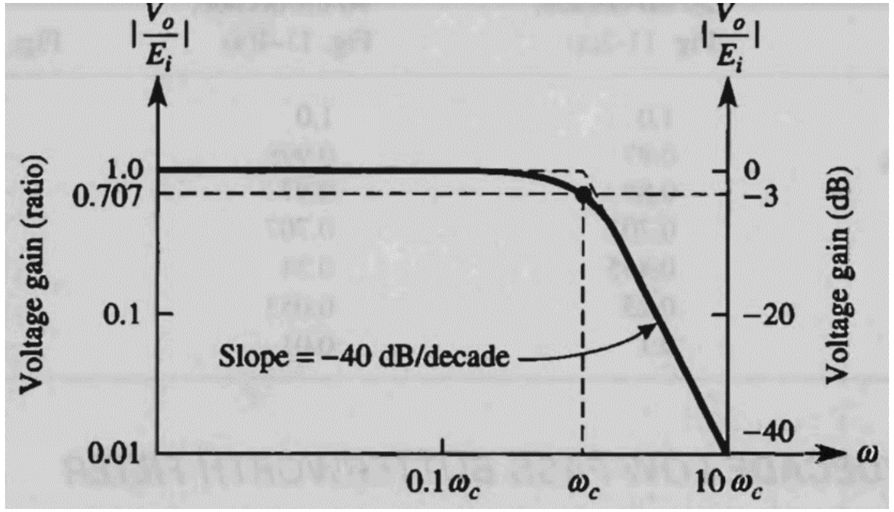
Quality Factor, Q = 10
Bandwidth, B = 1kHz



Filters Used in Project

Two -40dB/decade Low Pass Butterworth Filters (Cascaded) f_c= 1.5 kHz



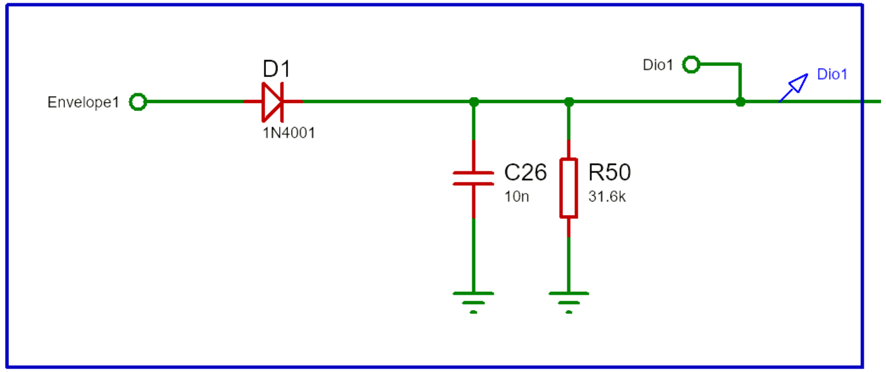


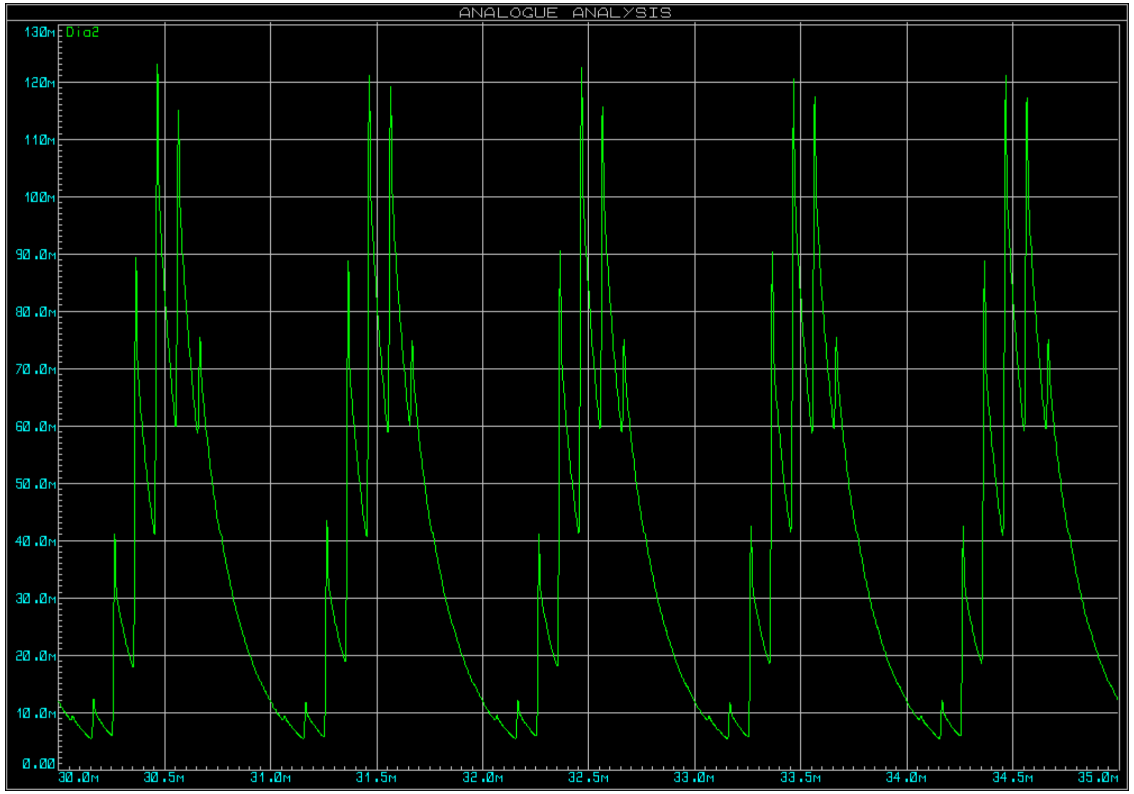
$$fc = \frac{0.707}{2\pi RC}$$

Cutoff Frequency (*fc*) = 1.5kHz

Envelope Detector Details

Diode Detector Message 1



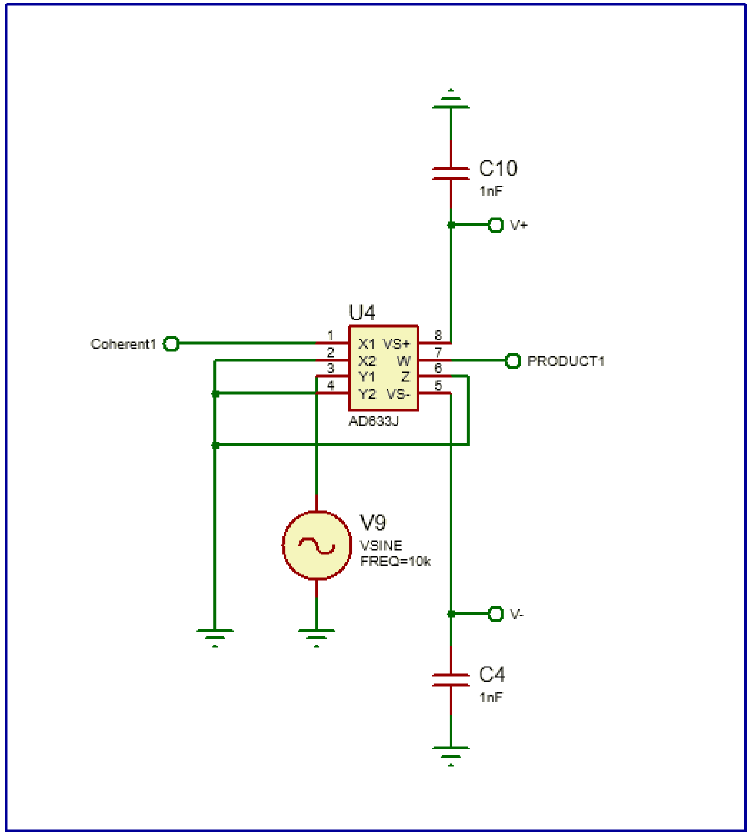


The Envelope Detector's output shows a distorted waveform containing high frequency components which will later be filtered by the Low Pass Filter and amplified by a 2-stage op-amp.

RC is the Inverse of Geometric Mean of fc and fm.

$$RC = \frac{1}{\sqrt{fc.fm}}$$

Product Detector Details

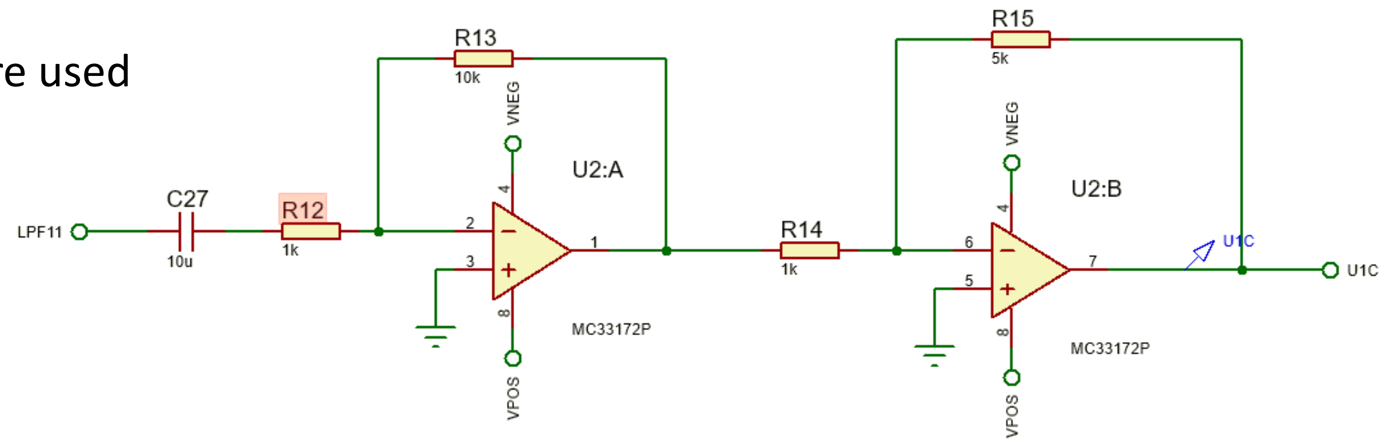


$$Output(W) = \frac{(X1 - X2)(Y1 - Y2)}{10} + Z$$

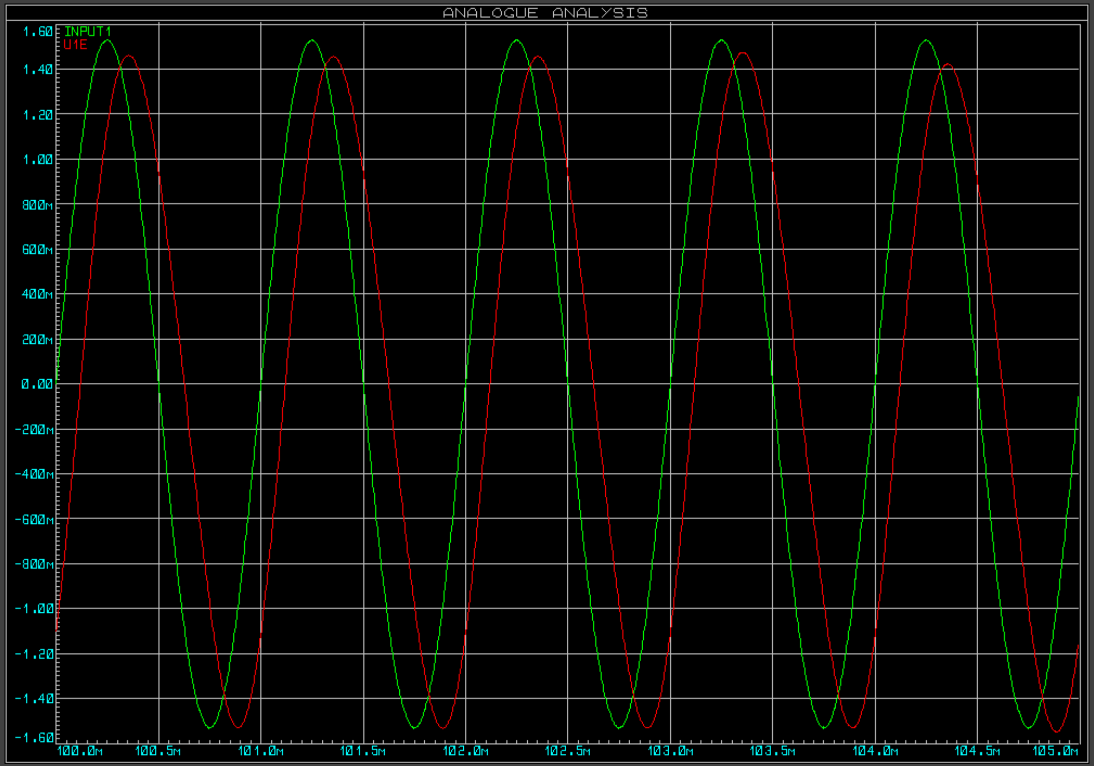
DC Block Capacitor and 2 Stage Amplifier

To keep op-amp gain linear, two op amps were used

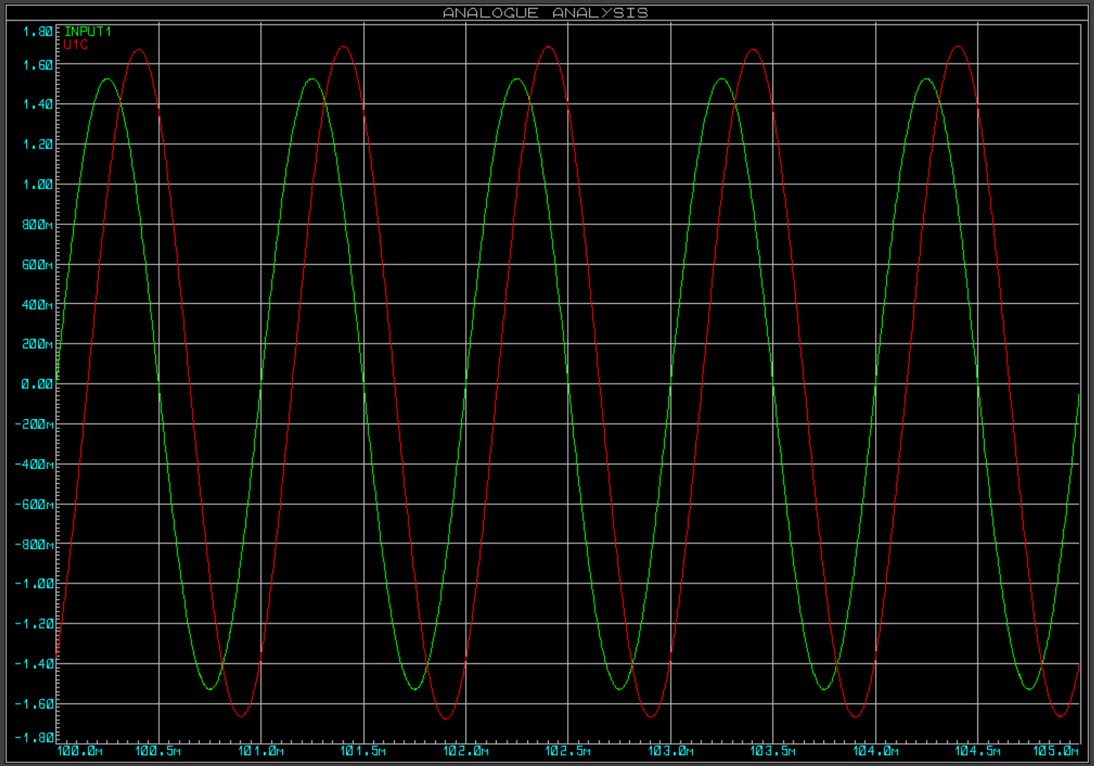
$$A_{CL} = -\frac{R_f}{R_i}$$



Message 1 Outputs

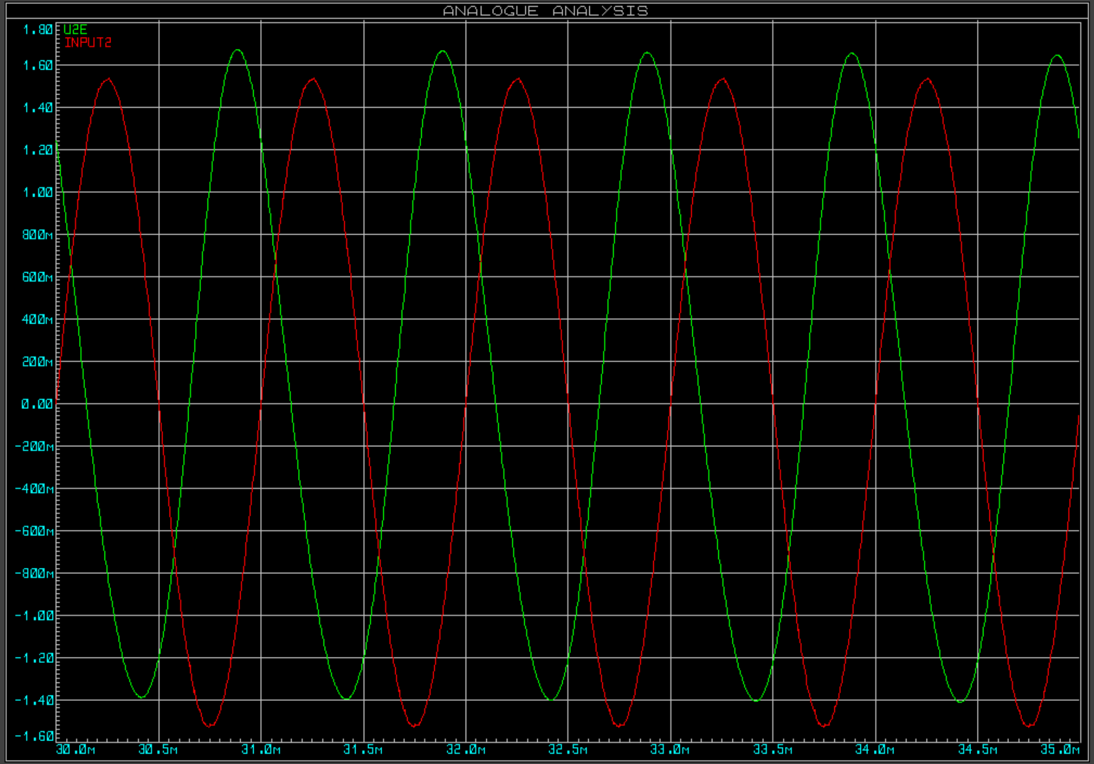


Msg 1 Input & Envelope Detector Output (m=0.3)

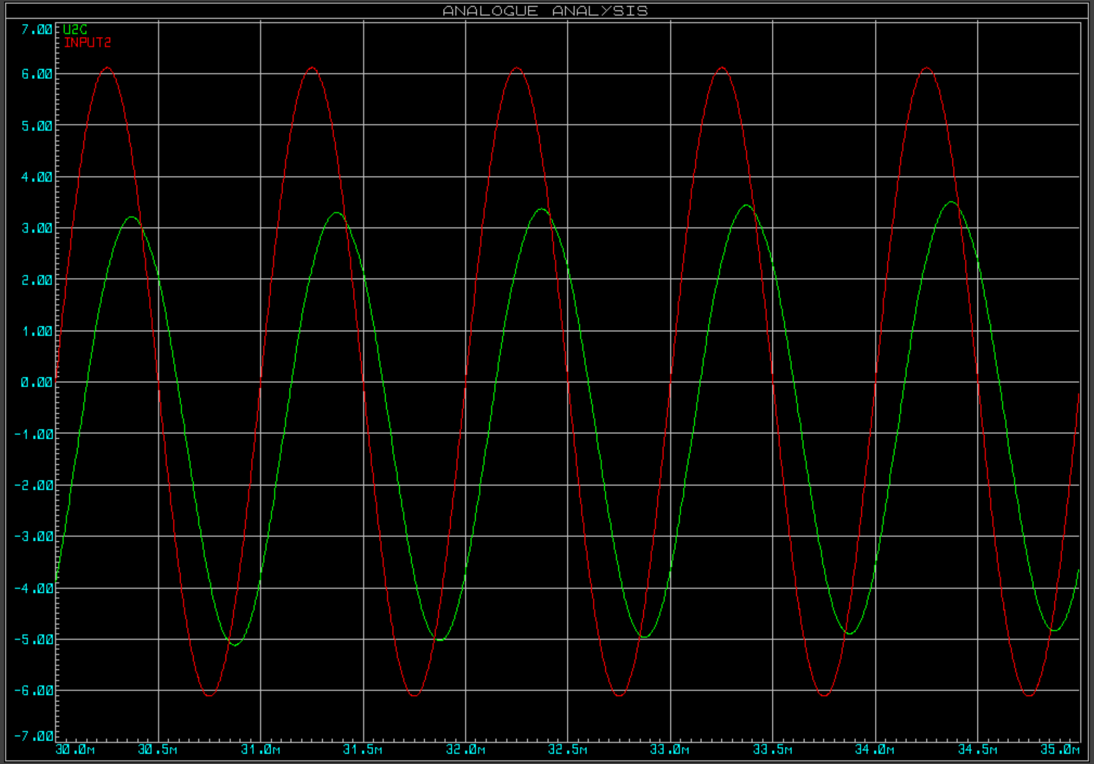


Msg 1 Input & Coherent Detector Output (m=1.22)

Message 2 Outputs



Msg 2 Input & Envelope Detector Output (m=0.3)



Msg 2 Input & Coherent Detector Output (m=1.22)

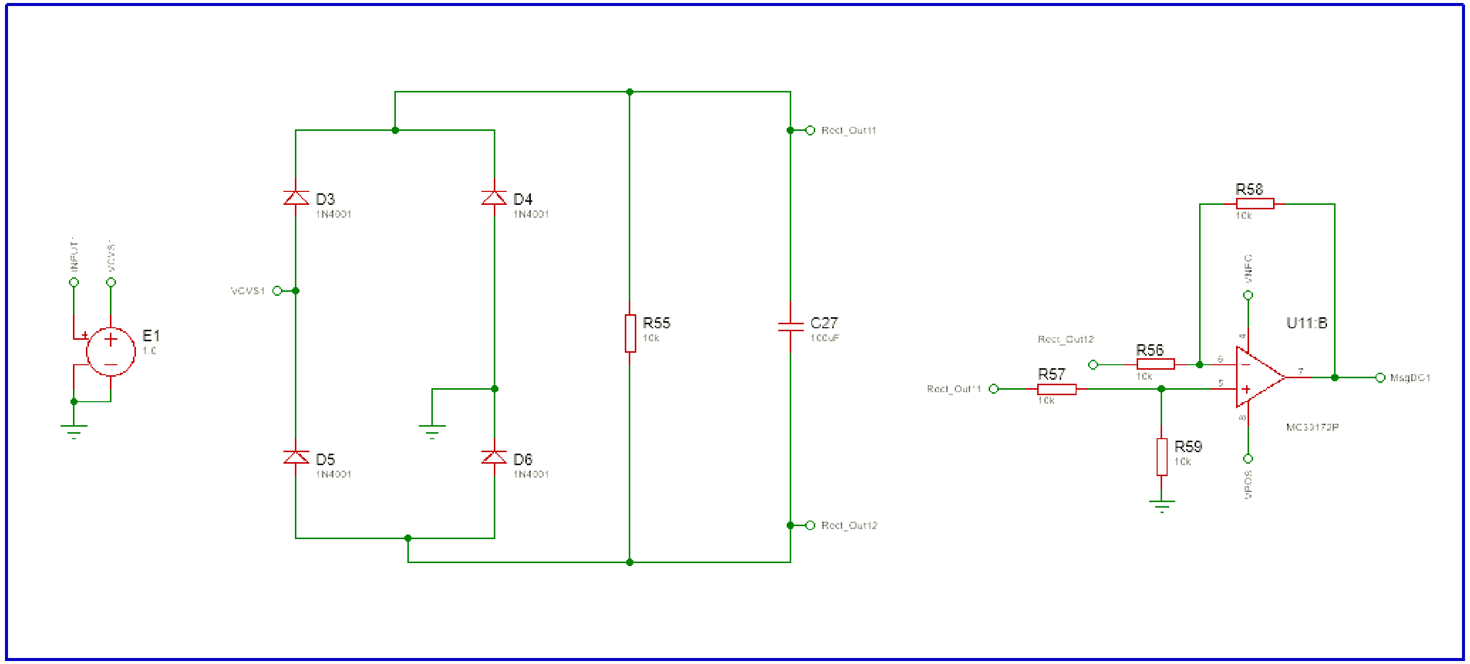
FFT Analysis: Envelope vs Coherent Detector

Envelope Detector Showing Low Amplitude Distortion at 2kHz frequency

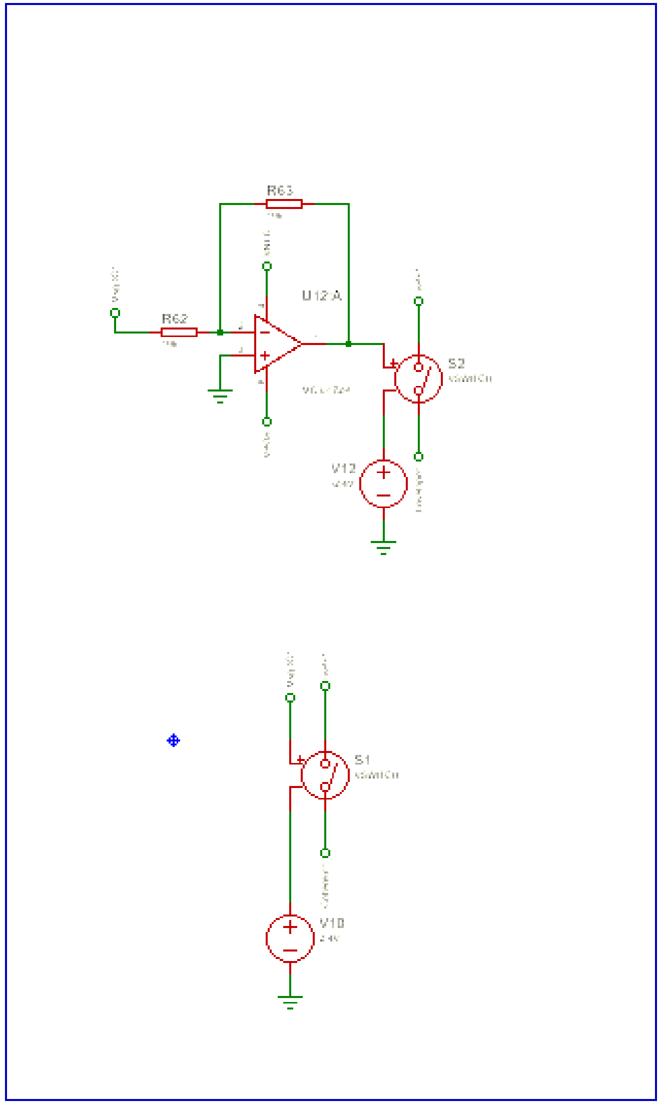
Coherent Detector Showing No Distortion

Smart Circuit Design: Automatic Demodulation Scheme Selector

Full Wave Rectifier and Voltage Comparator : Message 1



Automatic Coherent / Envelope Selector



Limitations:

1. Reconstructed Signal is phase shifted from the original due to capacitors, diodes and other components.
2. Op-Amp Slew Rate Problem: Due to high frequency of modulated signal, the output moves slower than input signal causing distorted output.
3. Due to op-amp limitations, the carrier frequency cannot be very high.

Conclusion:

1. Frequency Division Multiplexing is performed in a 2 user scenario
2. Message signal is recoverable regardless of modulation index value
3. Smart circuit has been designed that can take decision automatically based on modulation index

Project Contributions	
Topics	**ID**
Amplitude Modulator Circuit Design	1706162, 1706170, 1706136
Envelope (Non-Coherent) Detector	1706162, 1706171, 1706182
Product (Coherent) Detector	1706136, 1706182
Bandpass and Lowpass Filter Design	1706170, 1706171
Smart Circuit Idea and Implementation	All

THANK YOU!