EE230: Experiment 4
Analog multiplier

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1 Overview of the experiment

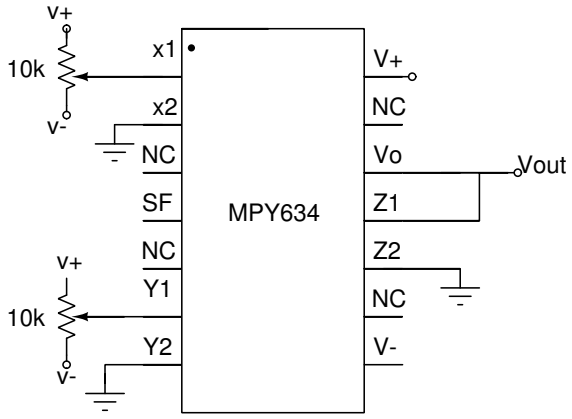
1.1 Aim of the experiment

In this experiment we try to study the applications of multiplier, how it can be used as Four quadrant multiplier, Squarer and square-rooter. It can also be used for the multiplication of phase shifted signals and to find out the true-RMS. It can also be used to modulate and demodulate signals.

1.2 Methods

To see the application of the multiplier we connect different input voltage on X1 and Y1 keeping x2and y2 grounded to obtain the multiplied signal. A signal can also be modulated by multiplier. We can also find its square root or RMS value.

2 Four quadrant multiplier



. X1	y1	output
4	8	3.24
4	-8	-3.28
-4	8	-3.19
-4	-8	3.24

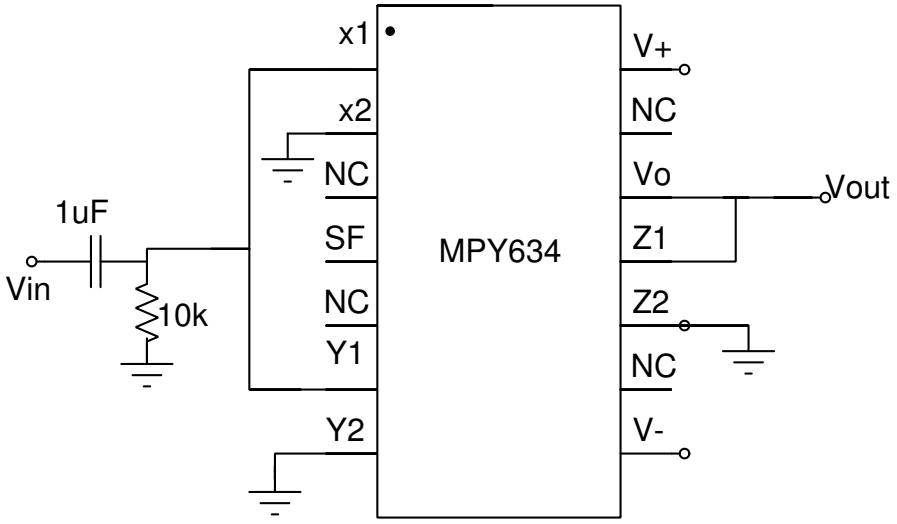
Four quadrant multiplier

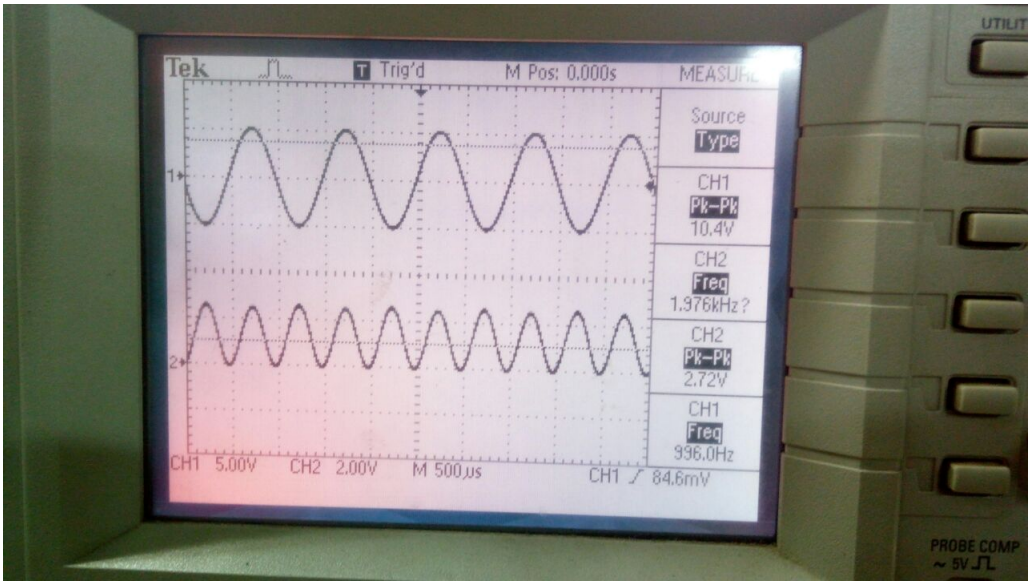
Here we can see that the readings of the multiplier are accurate. It also correctly shows the sigh of the desired output

3 Squarer and square-rooter

Use same formatting as the section above. Answer the questions asked in handout.

3.1 Squarer

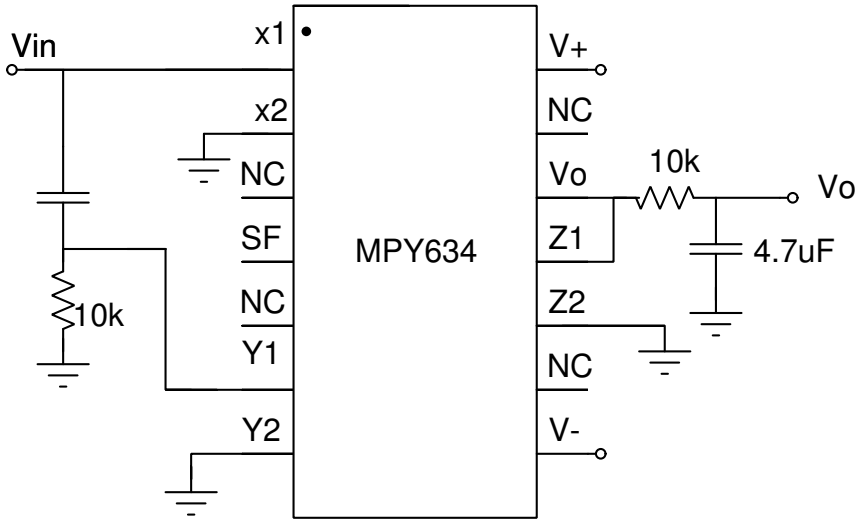




Why does Vout have a DC offset? .

$Vout = \frac{[5sin(2\pi 1000t)]^2}{10}$ which can be simplified to $Vout = \frac{25(1-cos(4\pi 1000t)}{20}$ thus there is an Dc offset of 1.25 v

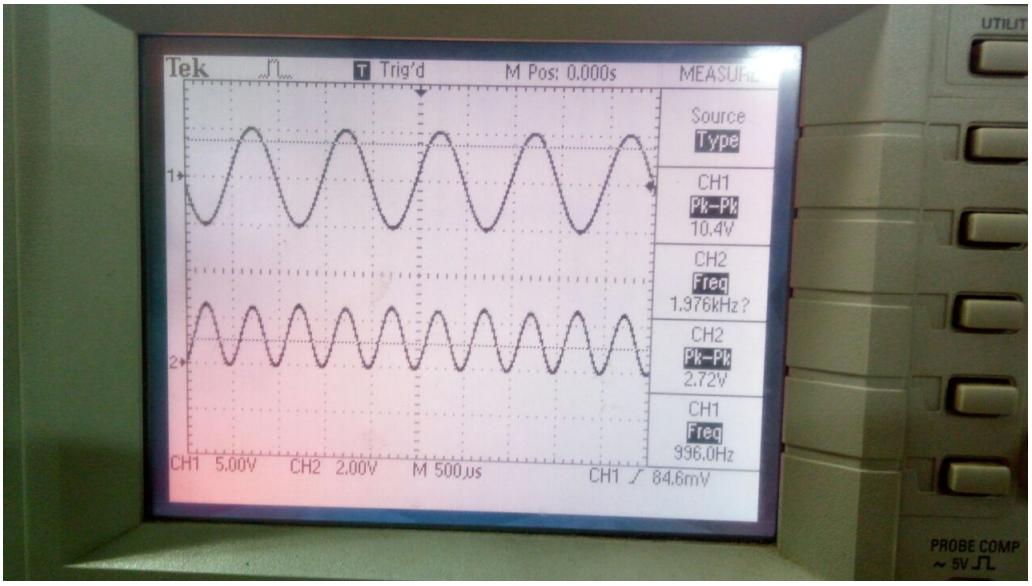
3.2 Multiplication of phase shifted signals



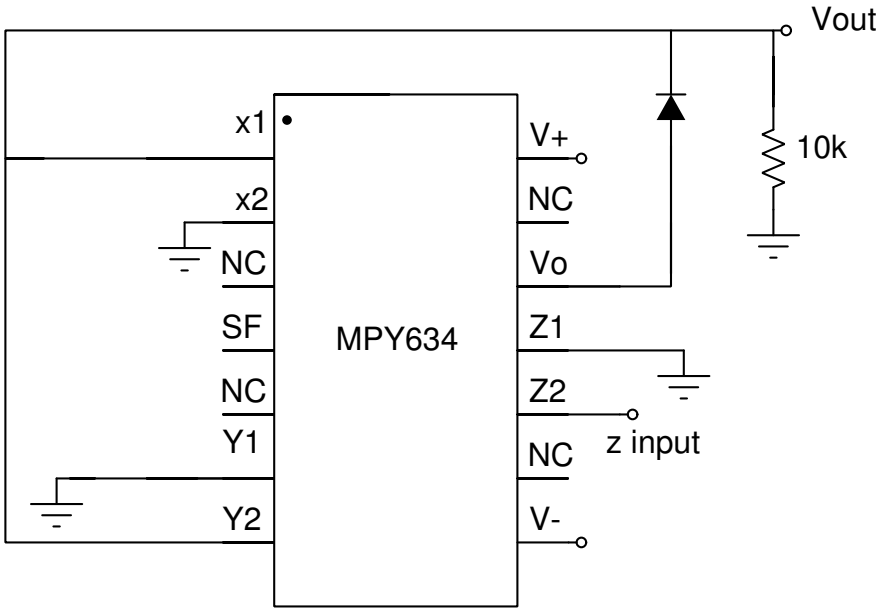
Calculated phase difference = 84.28 degree ($tan^{-1}(\frac{1}{2\pi F*RC})$
Observed Phase difference : 68 degree
Write the expression for the output of the multiplier Vout .

$X_1 = 5Sin2\pi 1000t$
$I_m = \frac{V_{in}}{10K - i10^5}$
$Y_1 = 10K * I_m$
$= \frac{10K*V_{in}}{10K-i10^5}$
$V_o = \frac{X_1*Y_1}{10}$
$X_c(4.7uf) = -i212.76$
$V_{out} = \frac{V_o*X_c}{10K-X_c}$

Verify the values of the DC component Vo, amplitude and frequency of the AC component of the output voltage Vout and phase relation between the two inputs with their calculated values.



3.3 Square-rooter



Z1(V)	Vout(V)
1.98	4.46
2.99	5.45
4.08	6.37
4.96	7.02
5.99	7.71
7	8.62
8	8.63
9	8.62

We can see that after 7 volts v_{out} saturates.This signifies that the operating range of this amplifier as an squarerooter is about 7 volts. we can see that the $Vout = \sqrt{10 * Z1}$

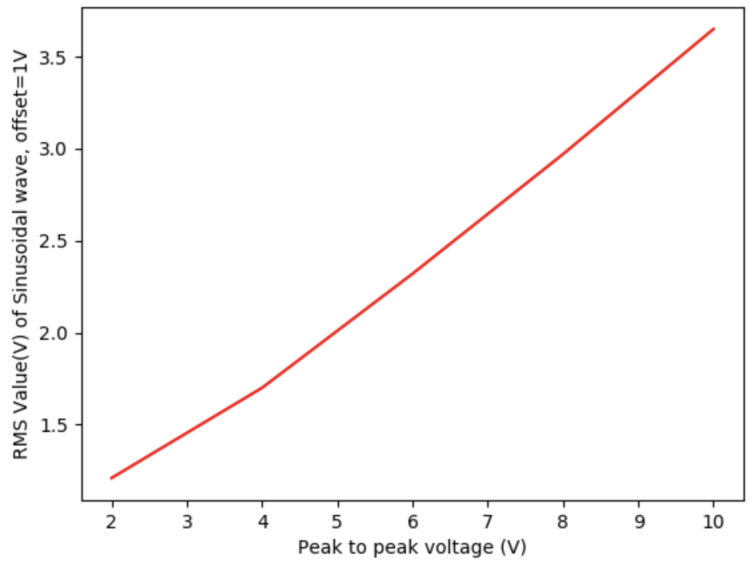
3.4 True-RMS measurement

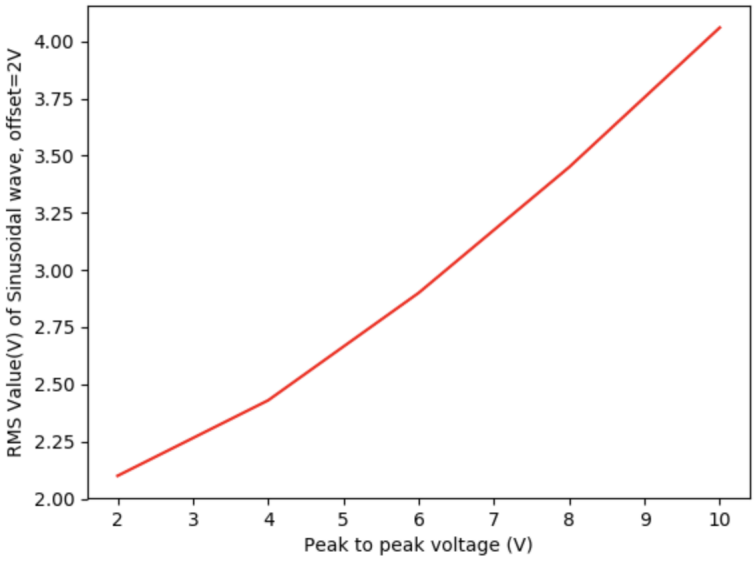
For offset = 1v

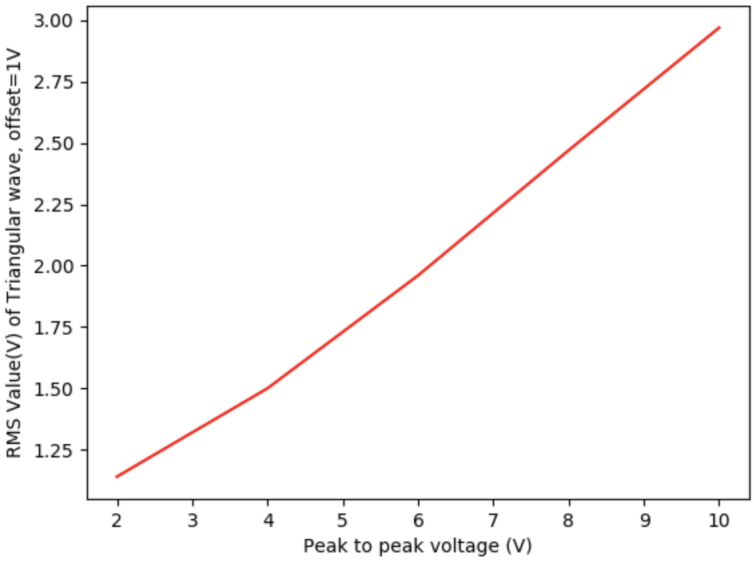
. Vpp(V)	sine wave	triangular
10	3.65	2.97
8	2.97	2.47
6	2.32	1.96
4	1.7	1.5
2	1.21	1.14

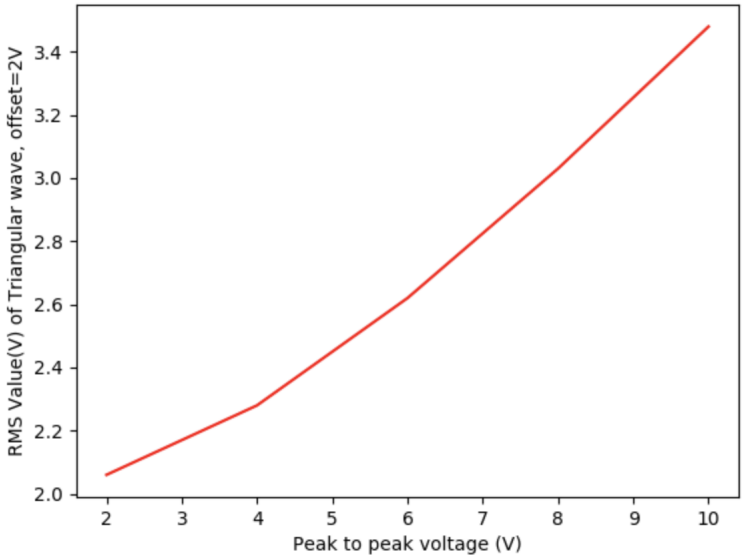
For offset = 2v

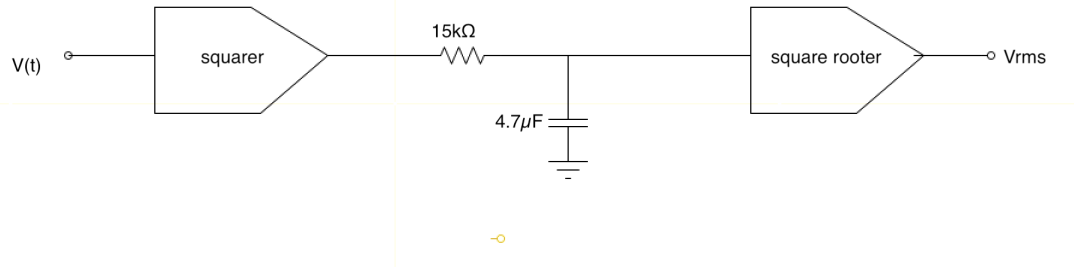
. Vpp	sine wave	triangular
10	4.06	3.48
8	3.45	3.03
6	2.9	2.62
4	2.43	2.28
2	2.1	2.06


RMS Value(V) of Sinusoidal wave, offset=1V
3.5
3.0
2.5
2.0
1.5
2
3
4
5
6
7
8
9
10
Peak to peak voltage (V)


RMS Value(V) of Sinusoidal wave, offset=2V
4.00
3.75
3.50
3.25
3.00
2.75
2.50
2.25
2.00
2
3
4
5
6
7
8
9
10
Peak to peak voltage (V)


RMS Value(V) of Triangular wave, offset=1V
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
2
3
4
5
6
7
8
9
10
Peak to peak voltage (V)

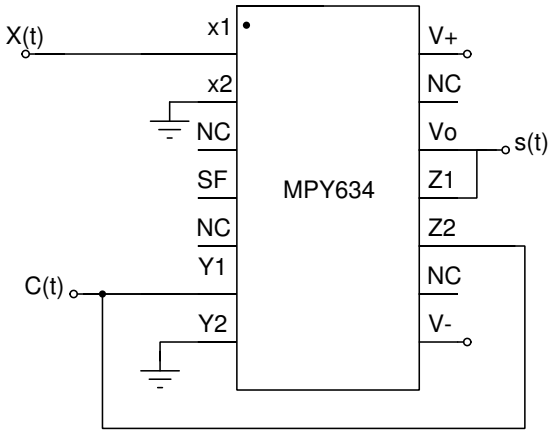

RMS Value(V) of Triangular wave, offset=2V
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
2
3
4
5
6
7
8
9
10
Peak to peak voltage (V)



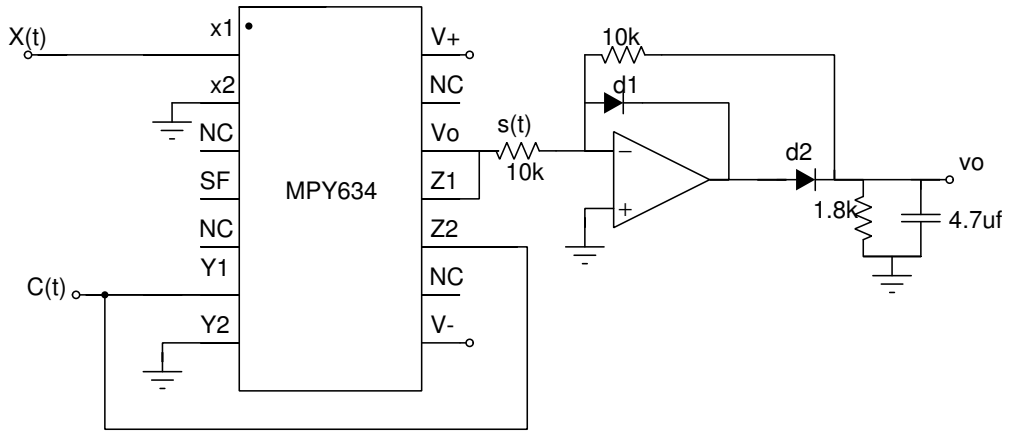
RMS value of half wave rectified signal is

. offset	RMS value
0	1.3
1	1.62
2	1.90

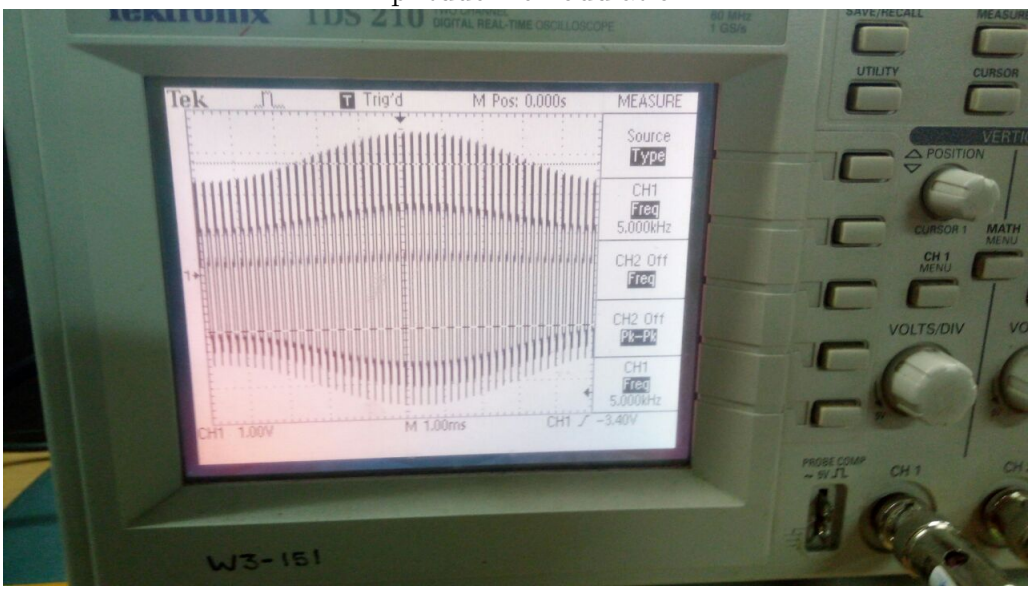
4 Amplitude modulation and demodulation



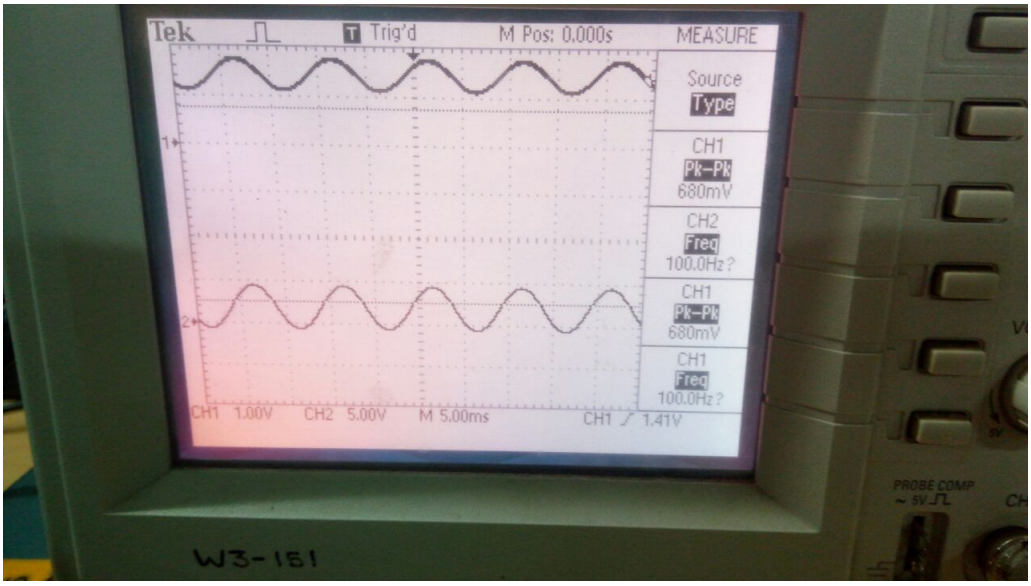
Amplitude-Modulation



Amplitude-Demodulation



Modulation signal



Demodulated signal

The multiplier circuit is used to modulate two waves of different frequencies F_c and f_m

5 Questions for reflection

1. Read up on Gilbert cell mixers. On page 4 of the handout that shows block diagram of the MPY634, you would probably guess that one of the blocks includes a Gilbert cell. Which block is it? What function is the "Voltage reference and bias" block serving? i.e. what circuit element in the Gilbert cell do you think it controls?
Ans. The multiplier block has the Gilbert Cell.
Gilbert cell has current mirror,and the the voltage reference block is used to fix the reference current.

2. When you performed your experiments, did you notice any offset at the output? (You would not have noticed any offset if you did your experiments with the DSO in AC coupled mode). Did the offset change when you changed the input frequency? Do your observations tally with the feedthrough plots on page 4 of the MPY634 datasheet available on TI website? Write down your guess-timate.
Ans.No I did not get any offset as my frequency was well below 10 khz

3. Based on whatever you have learnt so far in both Analog and Digital courses, which technique is best for signal multiplication - analog or digital? Explain your answer in your own words.
Ans. I think analog will be a better and faster technique to multiply two signals. If we use a digital multiplier then first we have to use a ADC to convert it into digital and then perform the multiplication .As the frequency increases the cost required for the multiplication through digital multiplier increases as we have to take more samples.whereas on case of analog we do not have to convert the signal thus it is fast. However if we want to store the signal then we have to convert it into digital fram anyways