PLL Demodulation

Topic	Student Name	Date	Course Leader
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This laboratory exercise expands the characteristics of the PLL linear demodulation.

Introduction

PLL (else, phase locked loop) is a type of control system that is able to generate a sort of output signal with a phase that is in a way similarly related to the phase of our input signal of course they are not the same. In electronics there are different types of PLL's, one of the most common and simples is an electric circuit that is simply an oscillator of variable frequency and a phase detector that is in the feedback loop therefore whenever the oscillator generates a signal the detector acts and compares to the phase of signal with input in affect it adjusts the oscillator.

Measurements

All measurements for this experiment were simulated using the program LT Spice. Loaded onto the sheet is a modulator and a series of properties as instructed in manual.

To begin I have constructed the same circuit used in the PLL modulation file. Please see the below circuit presenting our modulator.

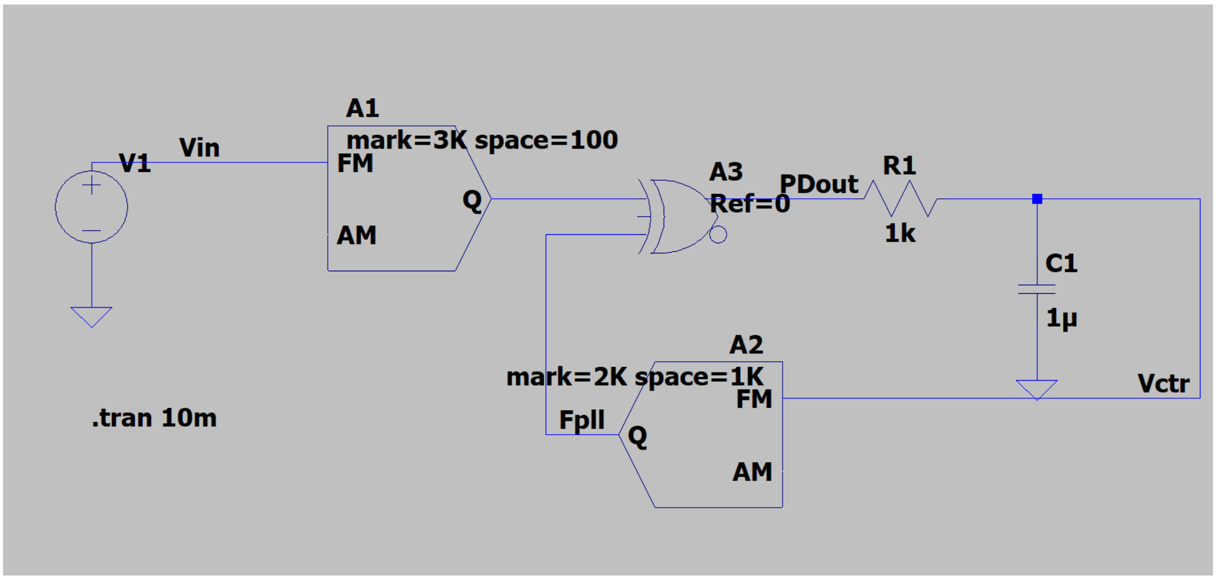

Figure 1 Presents modulator circuit from PLL modulation report

Since we are demodulating and not modulating this will not be our final circuit. As stated in the instructions I have recreated the following circuit in figure 1 in and inputted some modifications as shown in the figure in the PLL demodulation instruction manual. Please see figure 2 below presenting said circuit. As seen there were many alterations to the original circuit and a lot of values have changed.

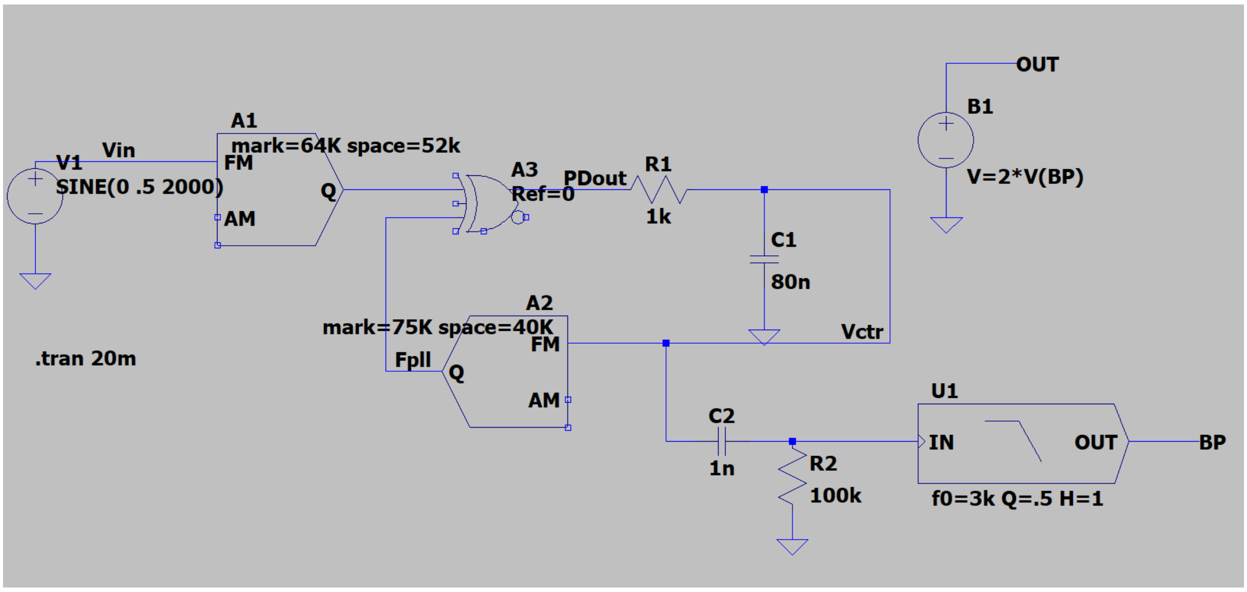

Figure 2 Presents PLL demodulation circuit

As seen in the screengrab above the demodulation circuit from instruction manual has been made. My first mistake was that I set a normal voltage source instead of behavioral voltage source, however this was corrected. Another thing I noticed is that in the first screengrab in manual we have 2k frequency set to voltage gate 1, later in manual it states that frequency should be changed to 1kHz – this has been done.

The simulation has been ran at a stop time set to 5ns. Maximum time step has been set to 100n. Please see the figure below presenting our signals.

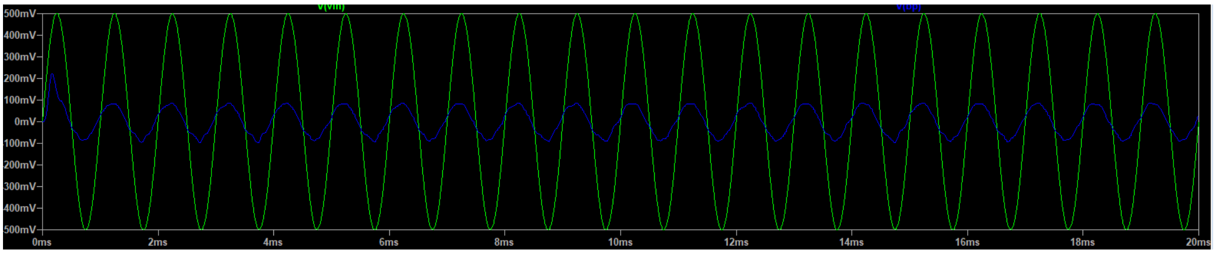

Figure 3 Presents the input and output signals from simulation mentioned in the above

We see that the simulation is working, we have a sinusoidal signal going through the input and filter

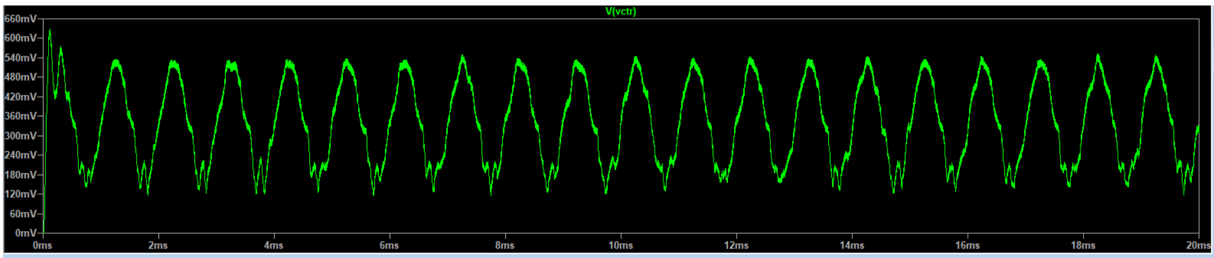

Figure 4 Presents VCTR signal measured by probe

Here we see the distortion in the VCTR signal

Next step of this report is to change the amplitude from -1 to 1v with a step of 0.1V.

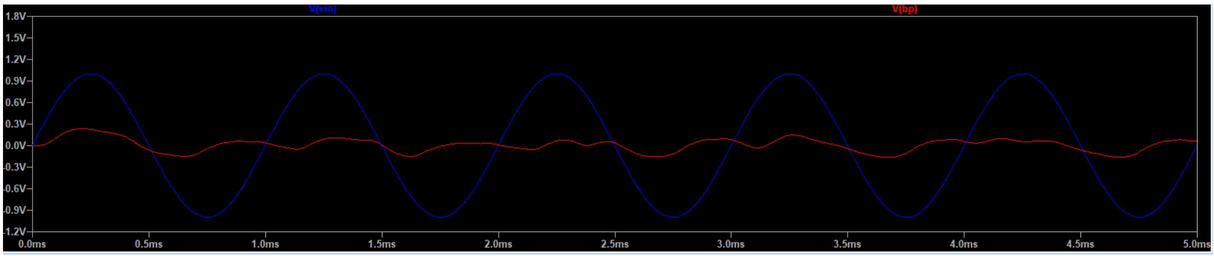

Figure 5 Presents the input and output after changes

He we can see in close depth how the input signal looks like vs. what the BP signal looks like after modifications

Amplitude has been set to half of the maximal amplitude value.

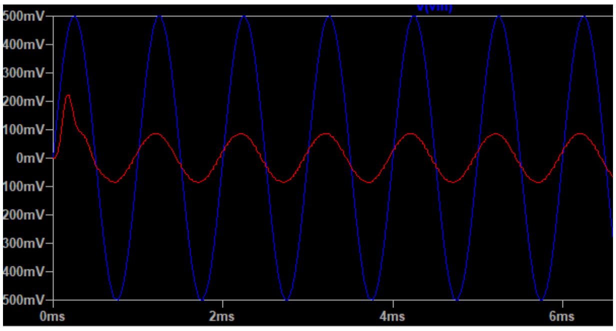

Figure 6 Presents the change of amplitude

Using the maximal value the amplitude has been reduced leaving signal as shown in figure below.

Frequency has been changed from 100Hz to 3100Hz with a step of 100Hz. Bandwidth of PLL FM demodulator.
Below please see the BP probe

Frequency [Hz]	Amplitude [V]
100	0.1863
200	0.1901
300	0.1943
400	0.1983
500	0.2022
600	0.2061
700	0.2103
800	0.2151
900	0.2184
1000	0.2221
1100	0.2260
1200	0.2300

1300	0.2320
1400	0.2375
1500	0.2404
1600	0.2430
1700	0.2442
1800	0.2480
1900	0.2490
2000	0.2493
2100	0.2489
2200	0.2445
2300	0.2442
2400	0.2367
2500	0.2373
2600	0.2237
2700	0.2225
2800	0.2182
2900	0.2153
3000	0.2090

Figure 7 Presents the amplitude data used in figure 8

Amplitude in each point and amplitude graph in function of frequency

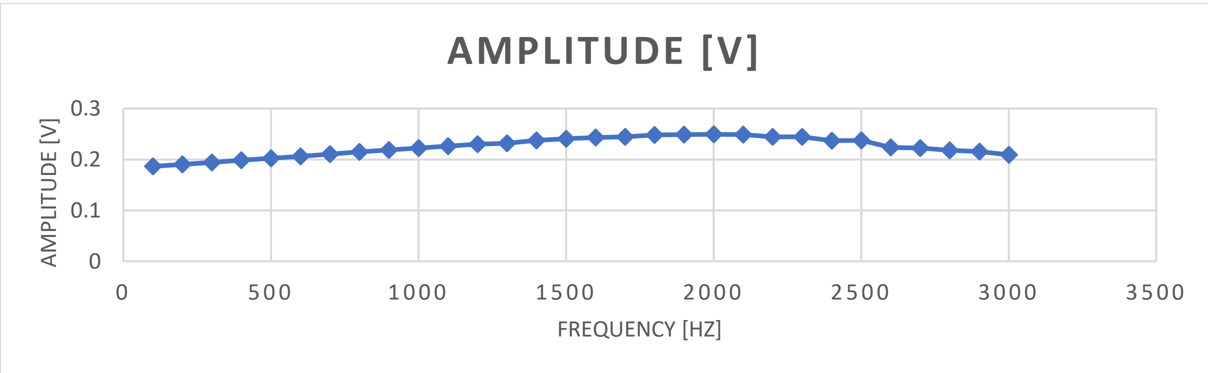

Figure 8 Presents the plot of data from figure 7

The frequency has been now set to 1500Hz.

The next step of our laboratory is to prepare another formula, to do so we follow instructions provided in the manual so by opening the spice directive we place our formula label and insert the formula found in the figure below.

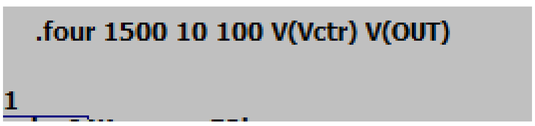

Figure 9 Presents mentioned formula in directive

Below please find a figure presenting data from simulation with stop time set to 100ms and data saving set to 1ms.

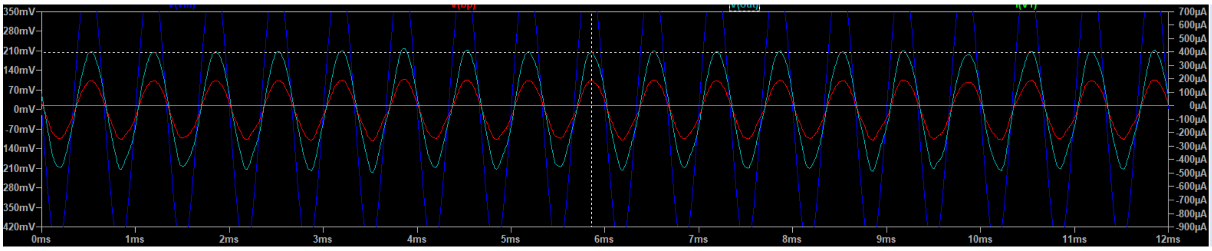

Figure 10 Presents all viable sources during simulation

As we can see the blue line is the output signal and is very clear in comparison to the VCRT output probe

Below please see part of the Spice error log, the figure presents the total harmonic distortion of signals from which we could potentially asses the quality of our modulation and demodulation.

```
N-Period=100
Fourier components of V(out)
DC component:3.01834e-006
```

Harmonic Number	Frequency [Hz]	Fourier Component	Normalized Component	Phase [degree]	Normalized Phase [deg]
1	1.500e+03	2.051e-01	1.000e+00	165.77°	0.00°
2	3.000e+03	4.566e-03	2.226e-02	144.20°	-21.57°
3	4.500e+03	1.423e-03	6.937e-03	-5.94°	-171.72°
4	6.000e+03	1.449e-03	7.063e-03	-127.26°	-293.03°
5	7.500e+03	6.512e-04	3.175e-03	-152.33°	-318.11°
6	9.000e+03	5.077e-04	2.475e-03	-109.29°	-275.06°
7	1.050e+04	2.020e-05	9.850e-05	156.18°	-9.60°
8	1.200e+04	7.183e-05	3.502e-04	-71.40°	-237.17°
9	1.350e+04	4.520e-05	2.203e-04	-26.83°	-192.60°
10	1.500e+04	4.194e-05	2.045e-04	16.32°	-149.45°

```
Total Harmonic Distortion: 2.469830%(5.301924%)
```

Figure 11 Presents the total harmonic distortion

Distortion is relatively low, meaning that our simulation is somewhat accurate however we cannot fully say it is accurate due to the distortion still existing in our simulation.

Below please see the input method as specified in instruction manual of loading the .wav file included with this task.

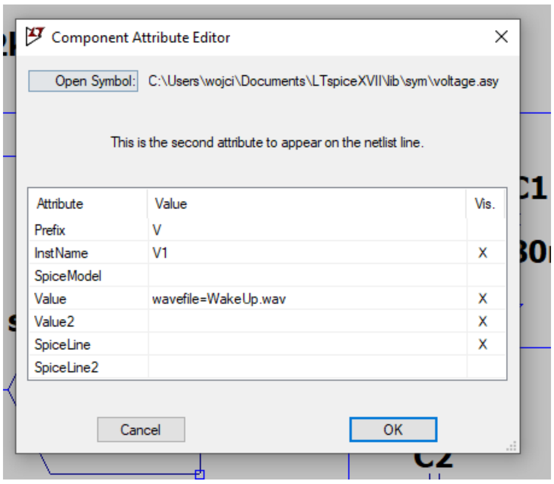

Figure 12 Presents the editor wakeup.wav loading screen

Below please find the used directives to conduct our simulation

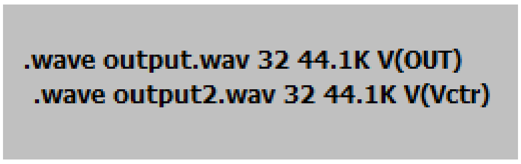

Figure 13 Presents the directives mentioned above

Below please see our final circuit built for this simulation.

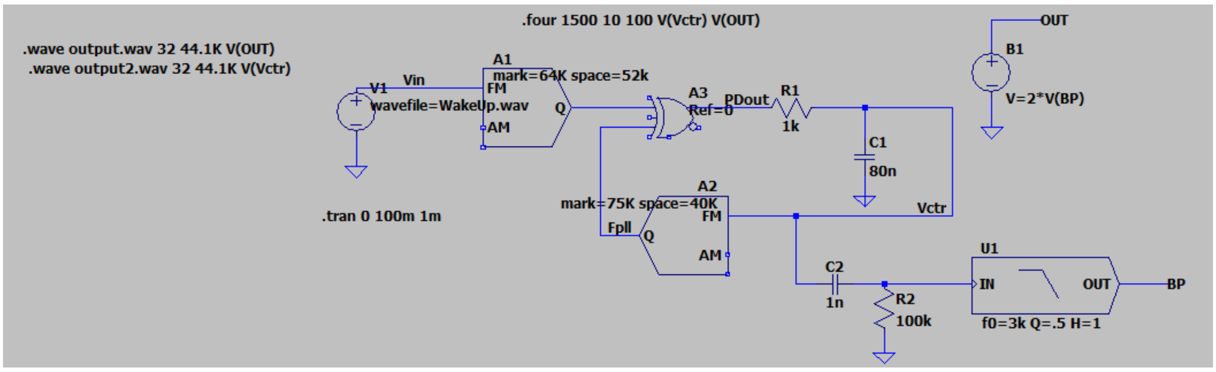

Figure 14 Presents the final circuit

Below please see the output channels of our simulation.

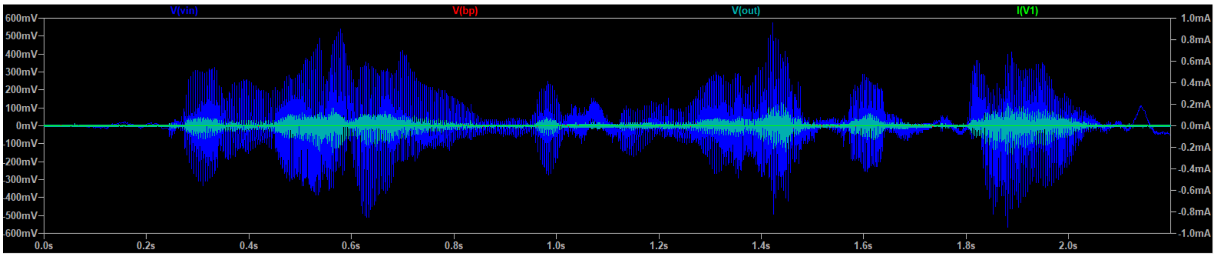

Figure 15 Presents all viable outputs

We see the input signal in dark blue and output in light blue. We see that the signal is not reconstructed as its original as the amplitude is drastically changed.

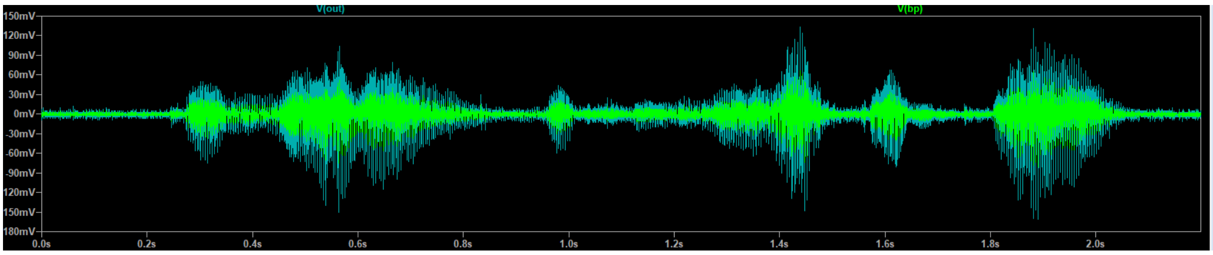

Figure 16 Presents the output and bp signals

Here we see even closed how the input signal changes during the demodulation stage.

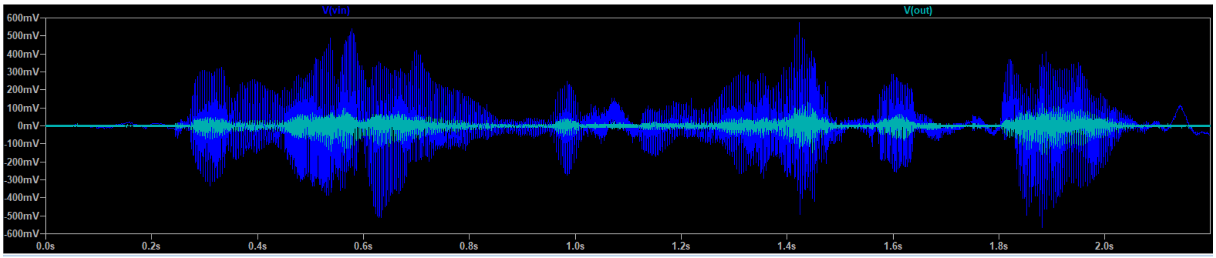

Figure 17 Presents the output signal

Here we just see a comparison between input and output similarly as to figure 15.

The phase locked loop demodulation as FM detector provides good performance and really is not using a lot of adjustments during building and producing. Another advantage is that we have demonstrated how easy it is to integrate it into a circuit with very limited components as well as costs – each component and filter will be costly. So the demodulator operated the loop in such manner that it will detect the instant incoming signal and our voltage oscillator with a loop will simply monitor the frequency of the signal – so it can be said that the VCO varies with the frequency of the signal a little hence why we receive a demodulated output of our modulated signal. The coincidence detector has many similarities to quadrature demodulation technique. It's similar to the integrated circuit but requires a coil to function and this might be a huge drawback due to the cost. The performance is excellent and provides very little levels of distortion and gives linearity in demodulated results.