Name: Dimple Kochar
Roll No.: 16D070010

This report is primarily to simulate the given optical circuit diaagram in simulink modelling it as an electric one. We can't go to the range of TeraHertz as step size of Simulink becomes way too small. But for Giga Hertz.
Circuit diagram from the paper:
Paper Name:
High-Performance Phase Locking of Wide Linewidth
Semiconductor Lasers by Combined Use of Optical
Injection Locking and Optical Phase-Lock Loop
A. C. Bordonalli, C. Walton, and Alwyn J. Seeds, Fellow, IEEE

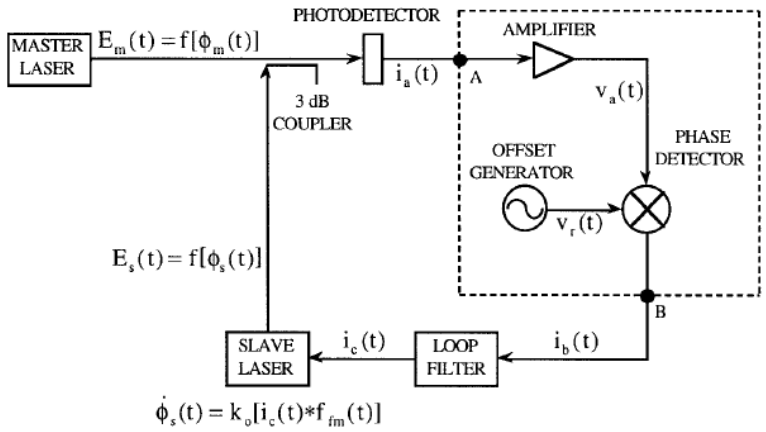
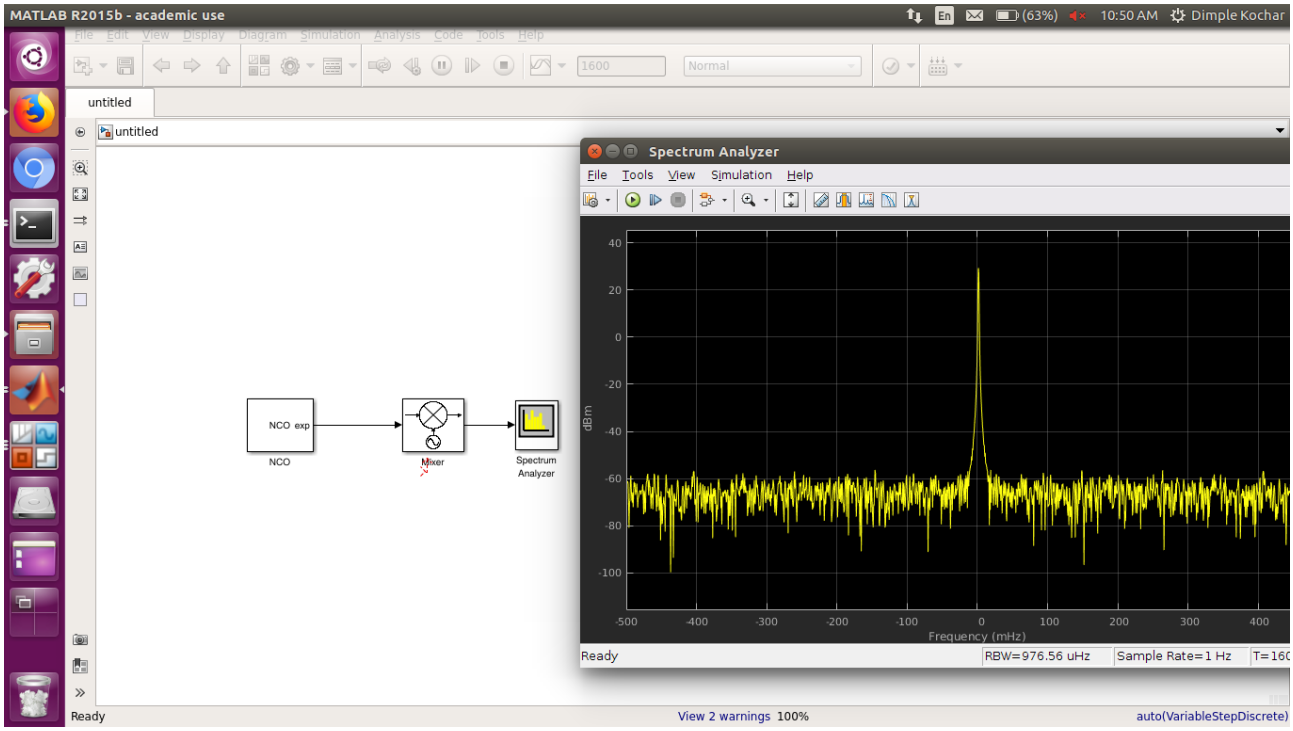
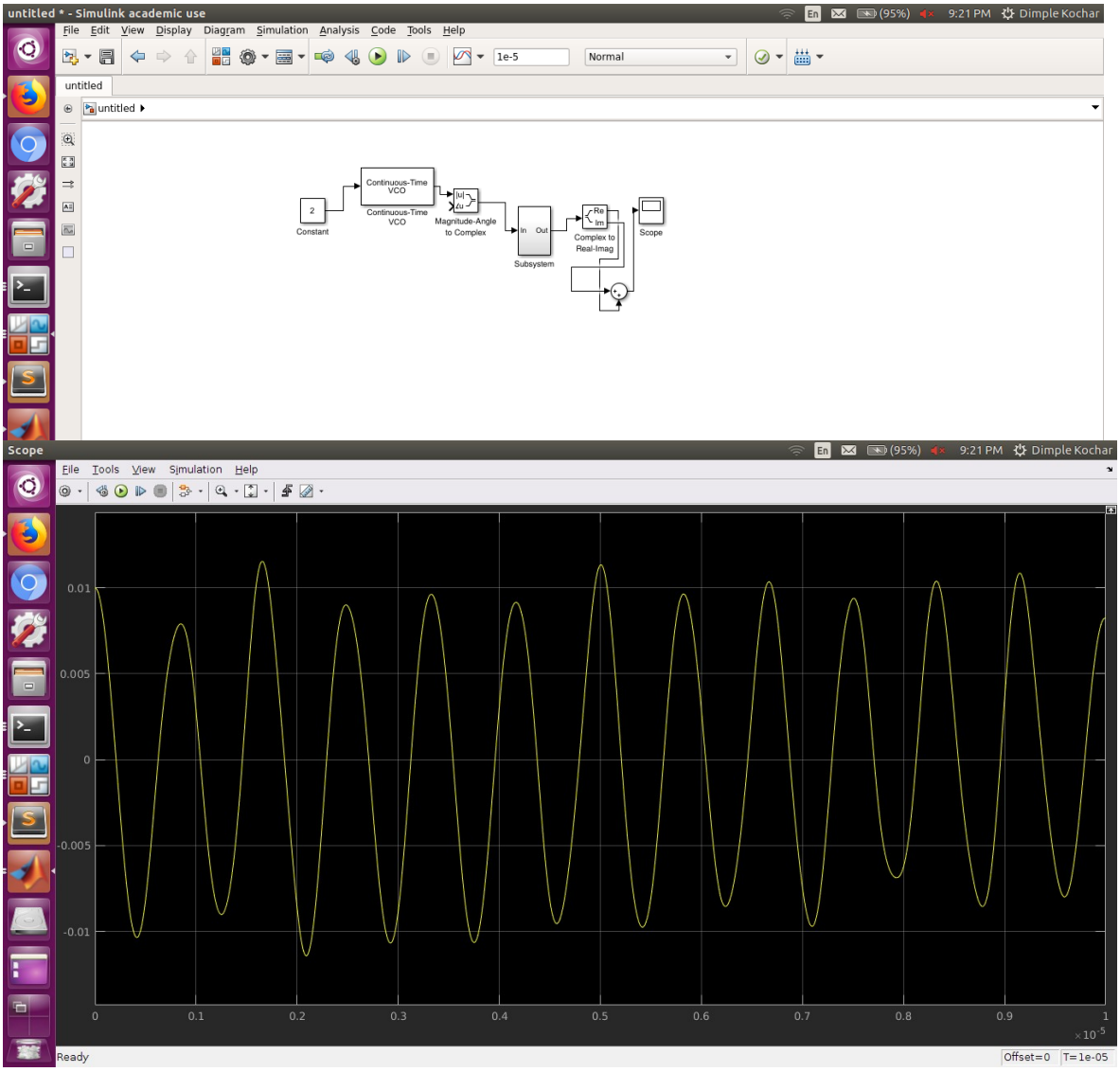


Fig. 1. Optical phase-lock loop. Dotted lines enclose additional components required for heterodyne operation.

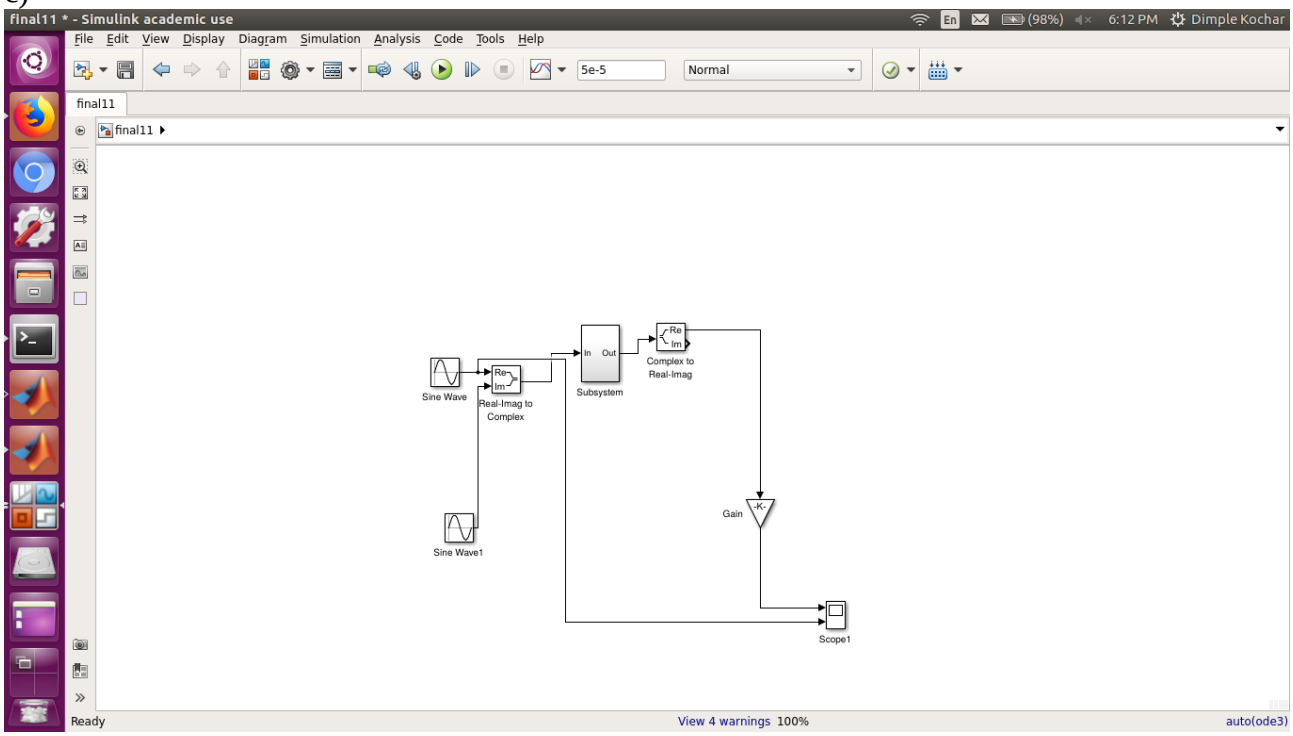
So, instead of master laser we use an electrical signal. Initially, we don't model anything for the photodetector, later we use a magnitude block. Phase detector is constructed. Slave laser is modelled as a VCO.
Bare beginnings:
First task was to learn how to add noise to the signal
Attempts:
a) Using the phase noise block. But it gave errors when the final circuit was made.

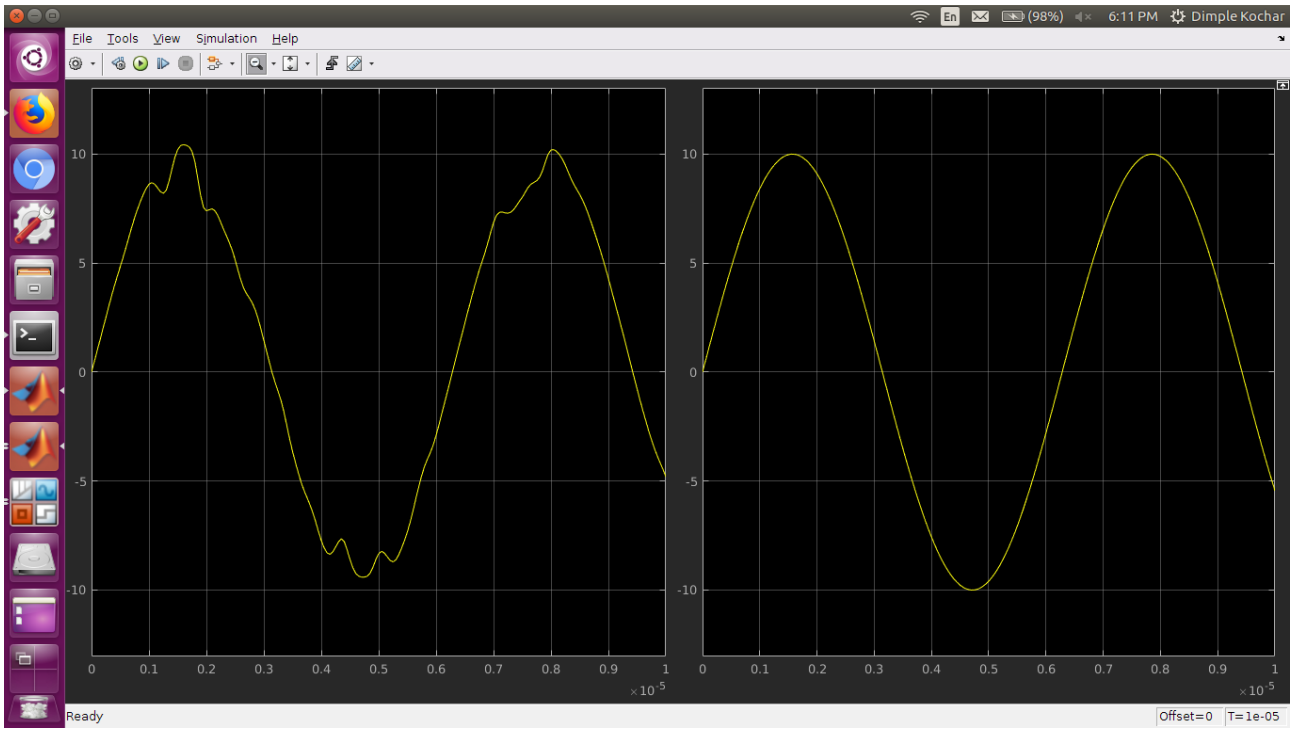

MATLAB R2015b - academic use
Dimple Kochar
untitled
Spectrum Analyzer
File Tools View Simulation Help
NCO exp
NCO
Mixer
Spectrum Analyzer
dBm
Frequency (mHz)
Ready
RBW=976.56 uHz
Sample Rate=1 Hz
View 2 warnings 100%
auto(VariableStepDiscrete)

b)


untitled * - Simulink academic use
Dimple Kochar
File Edit View Display Diagram Simulation Analysis Code Tools Help
Constant
Continuous-Time VCO
Magnitude-Angle to Complex
Subsystem
Complex to Real-Imag
Scope
Scope
File Tools View Simulation Help
Ready
Offset=0
T=1e-05

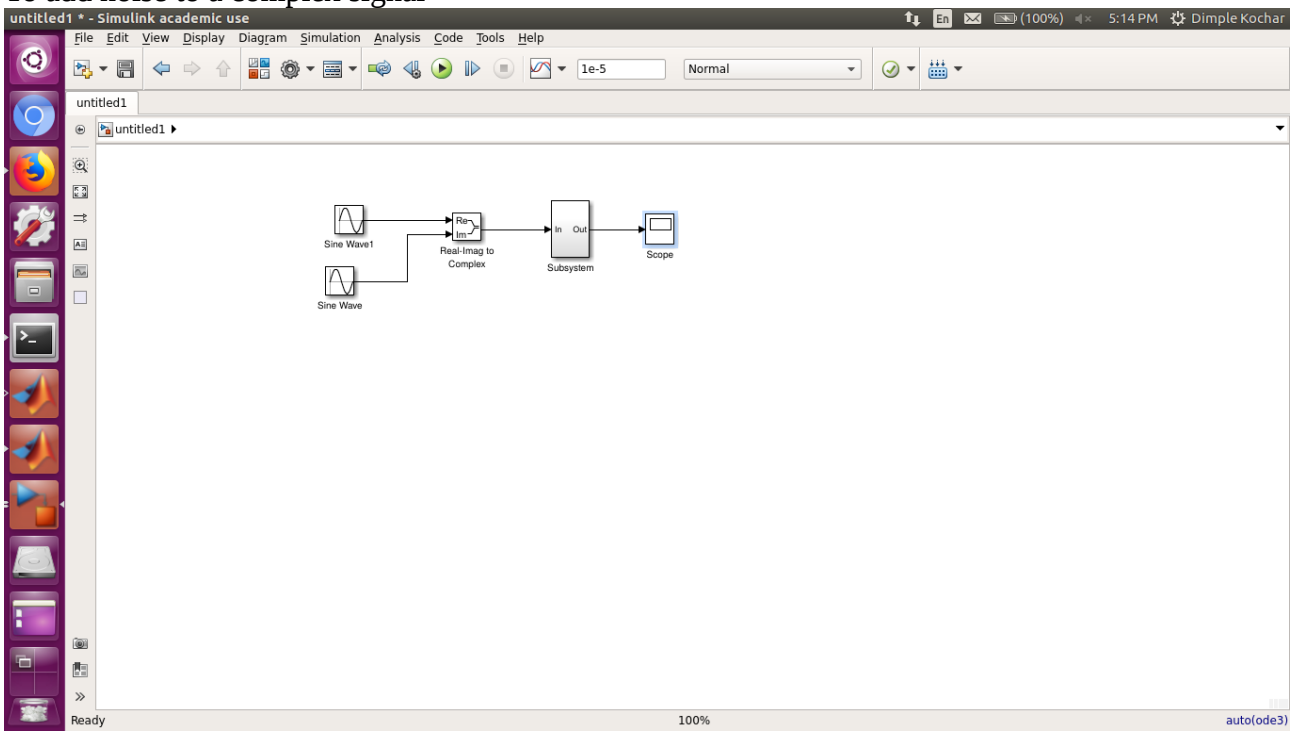
c)


final11 * - Simulink academic use
File Edit View Display Diagram Simulation Analysis Code Tools Help
5e-5
Normal
final11
Sine Wave
Real-Imag to Complex
In Out
Subsystem
Complex to Real-Imag
Gain
Sine Wave1
Scope1
Ready
View 4 warnings 100%
auto(ode3)

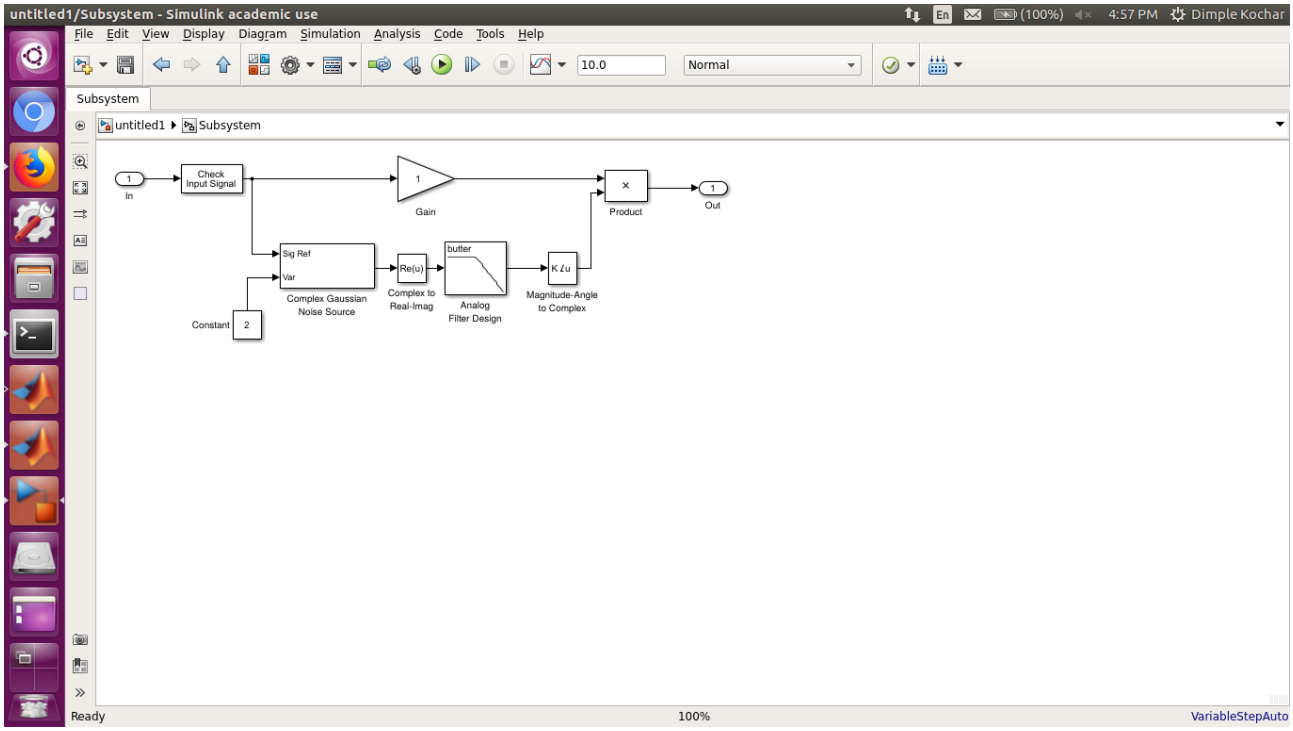

File Tools View Simulation Help
10
5
0
-5
-10
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
×10^-5
Ready
Offset=0
T=1e-05

d) Attempt used: Adding noise to a signal to pass the resultant and the original signal through a phase detector.

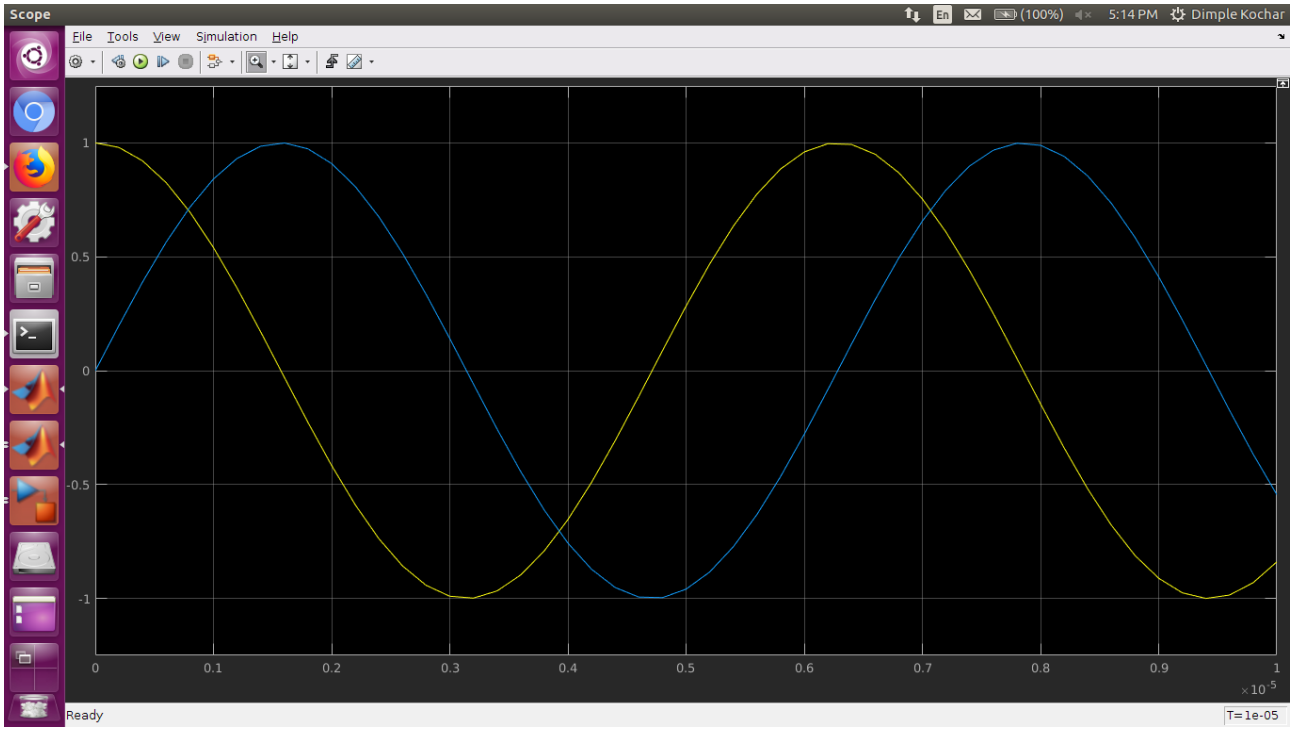
To add noise to a complex signal-



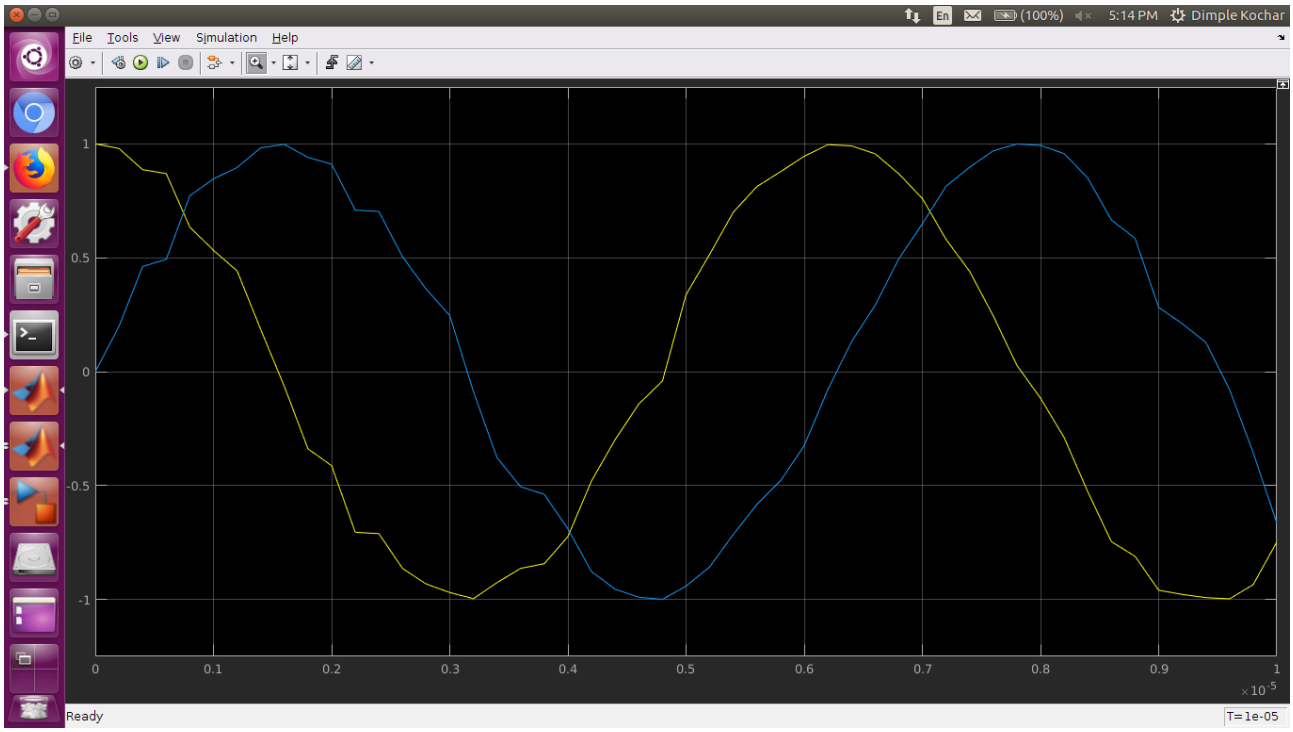
That was modelled as:



If we set the constant value input to the Gaussian Noise as 0, we get the noiseless signal:

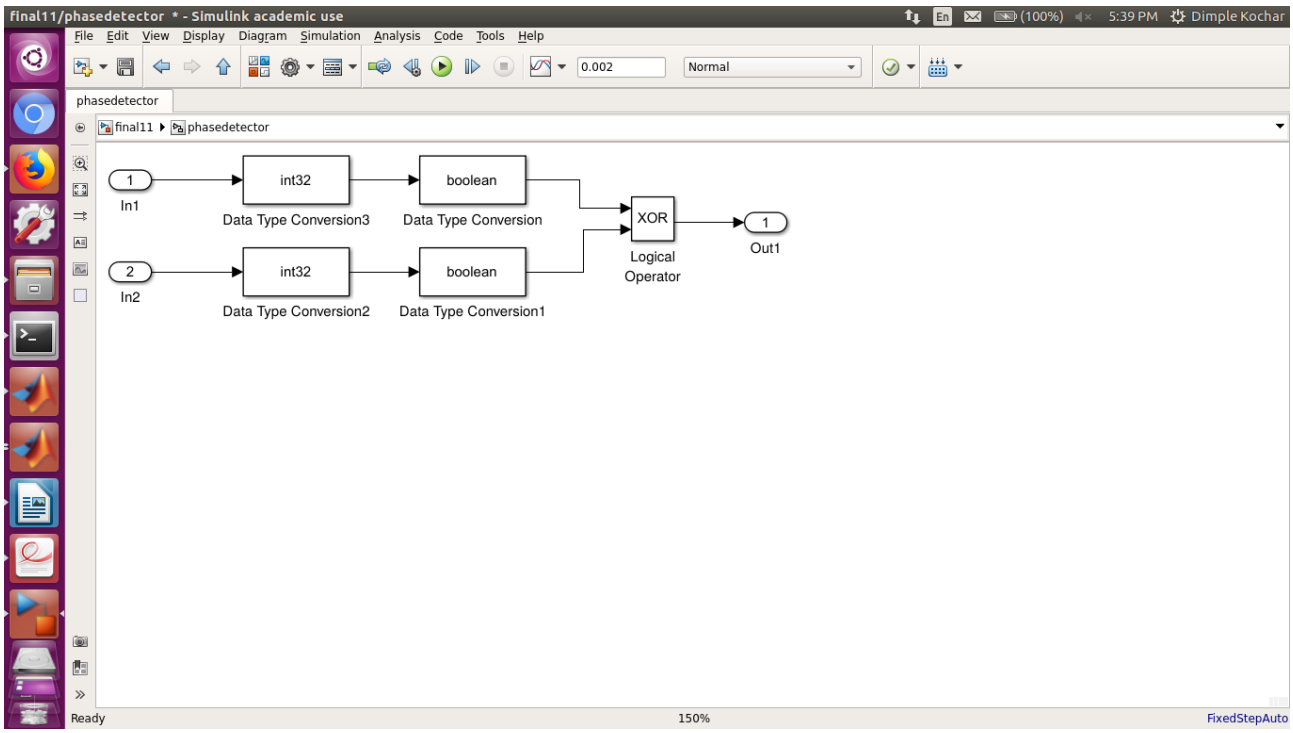


But if we set the constant to say a value of 0.001, we get something like



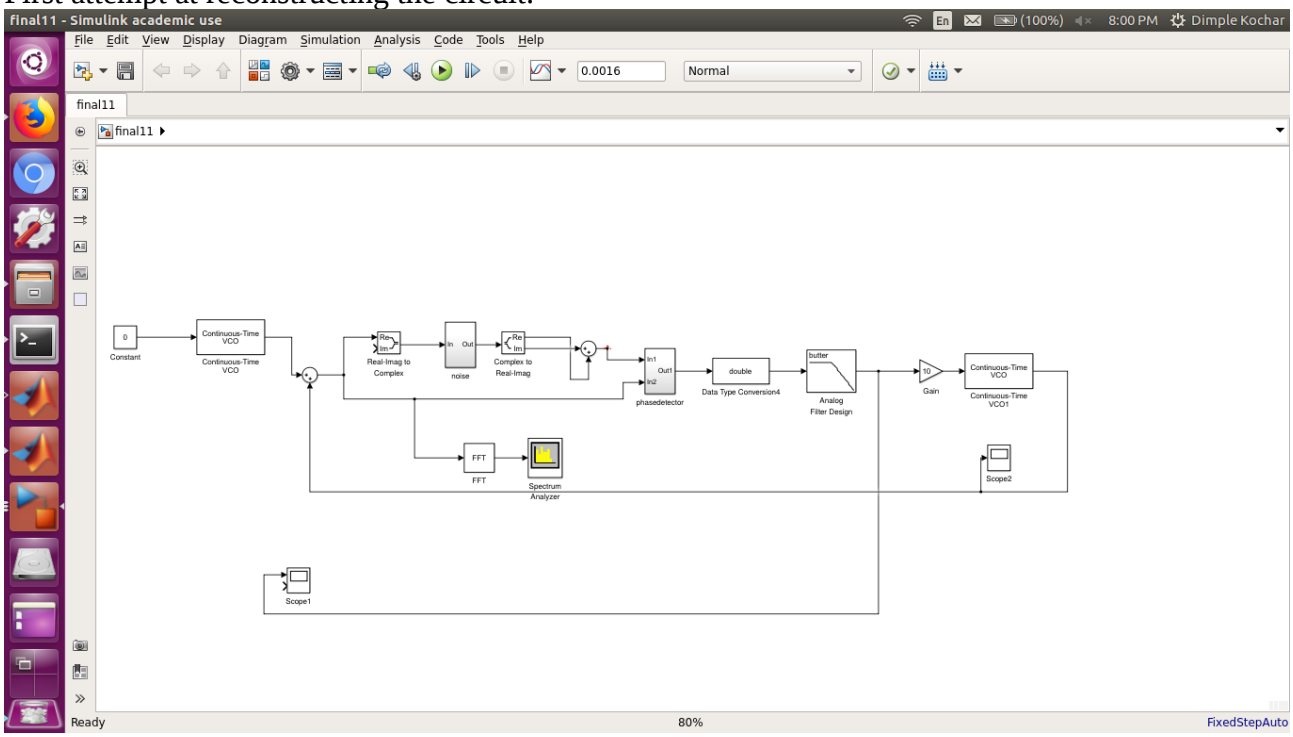
High values of the constant input are not recommended as the signal gets distorted considerably.

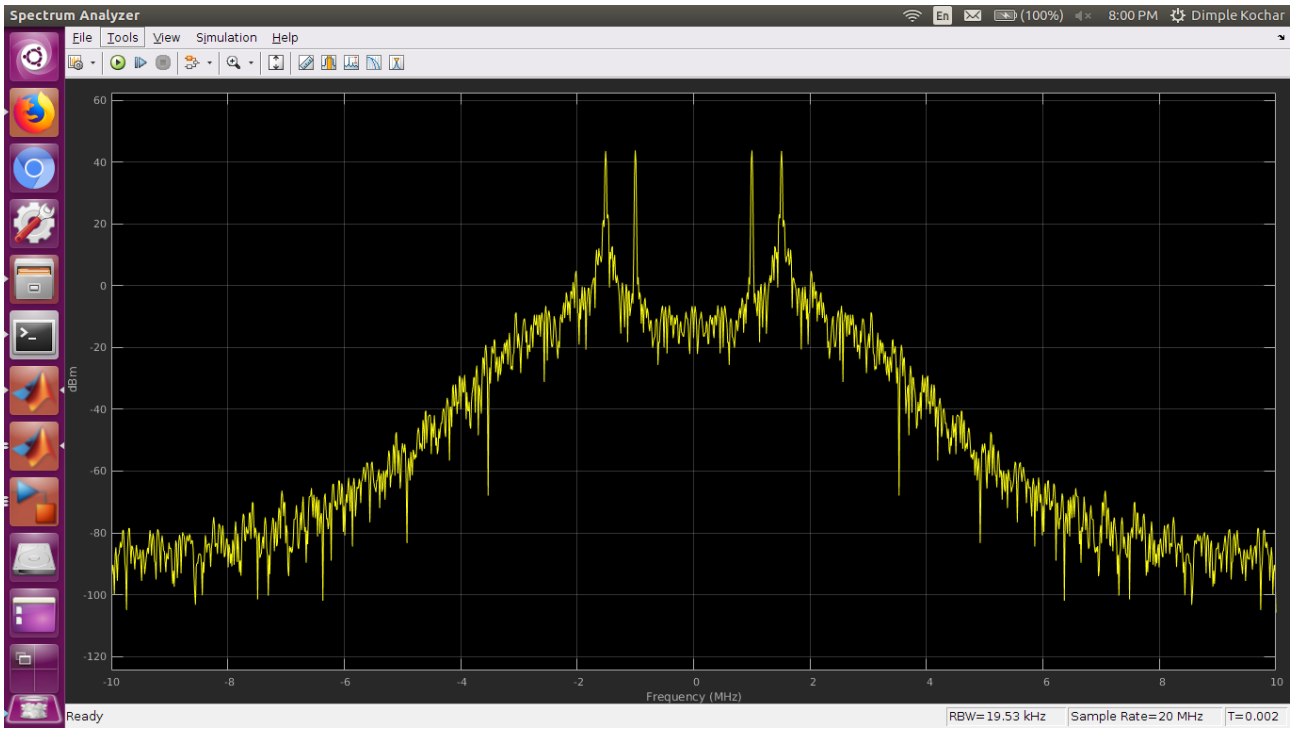
2) Phase detector



Since XOR is a digital block, it needs some data type conversion. And later, the output has to be reconverted too. Throughout the circuit, we've to take care if the blocks require a complex signal or a real signal and convert them accordingly.

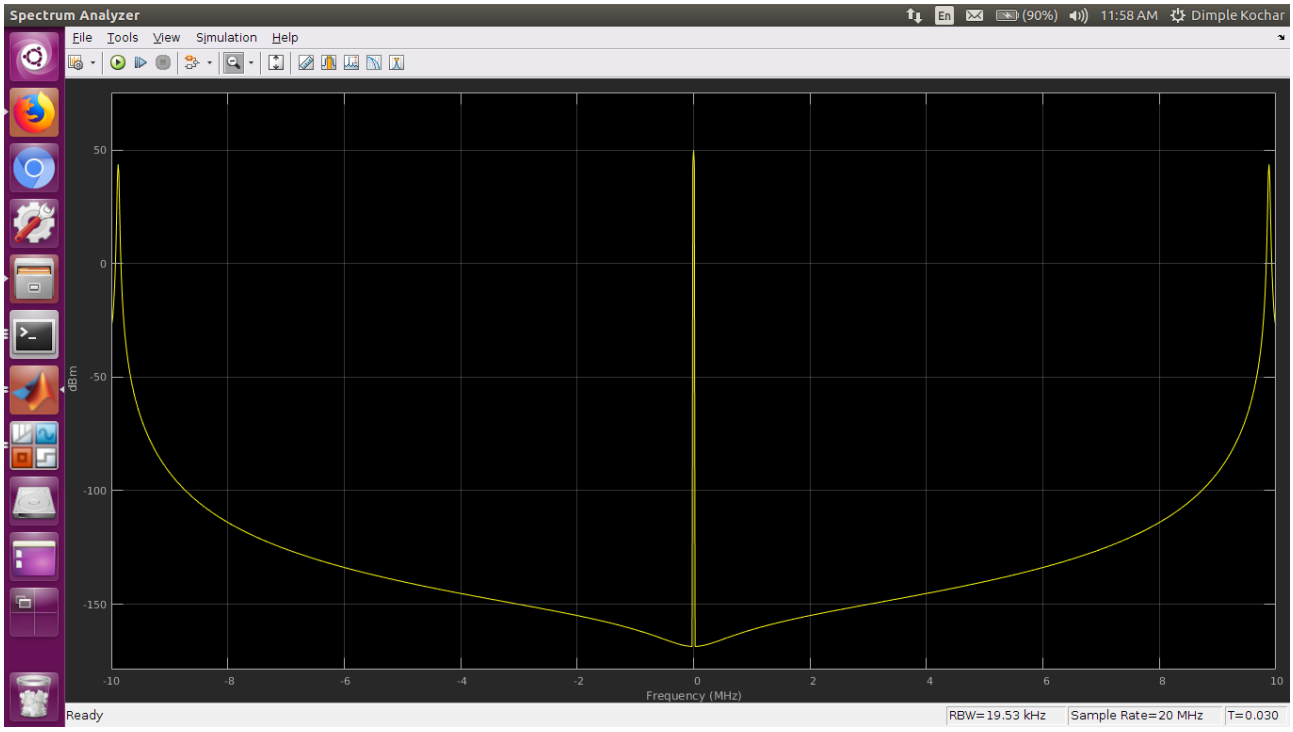
First attempt at reconstructing the circuit:



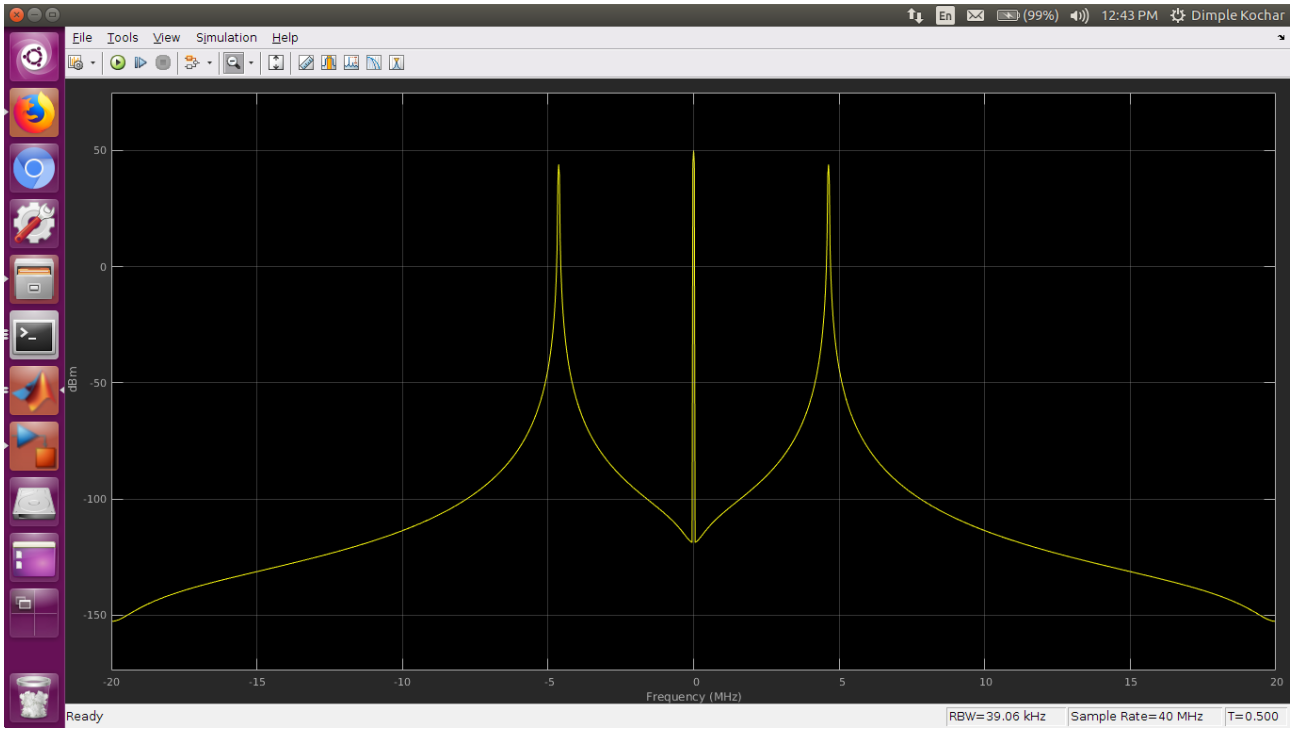


We can see that phase locking isn't taking place.

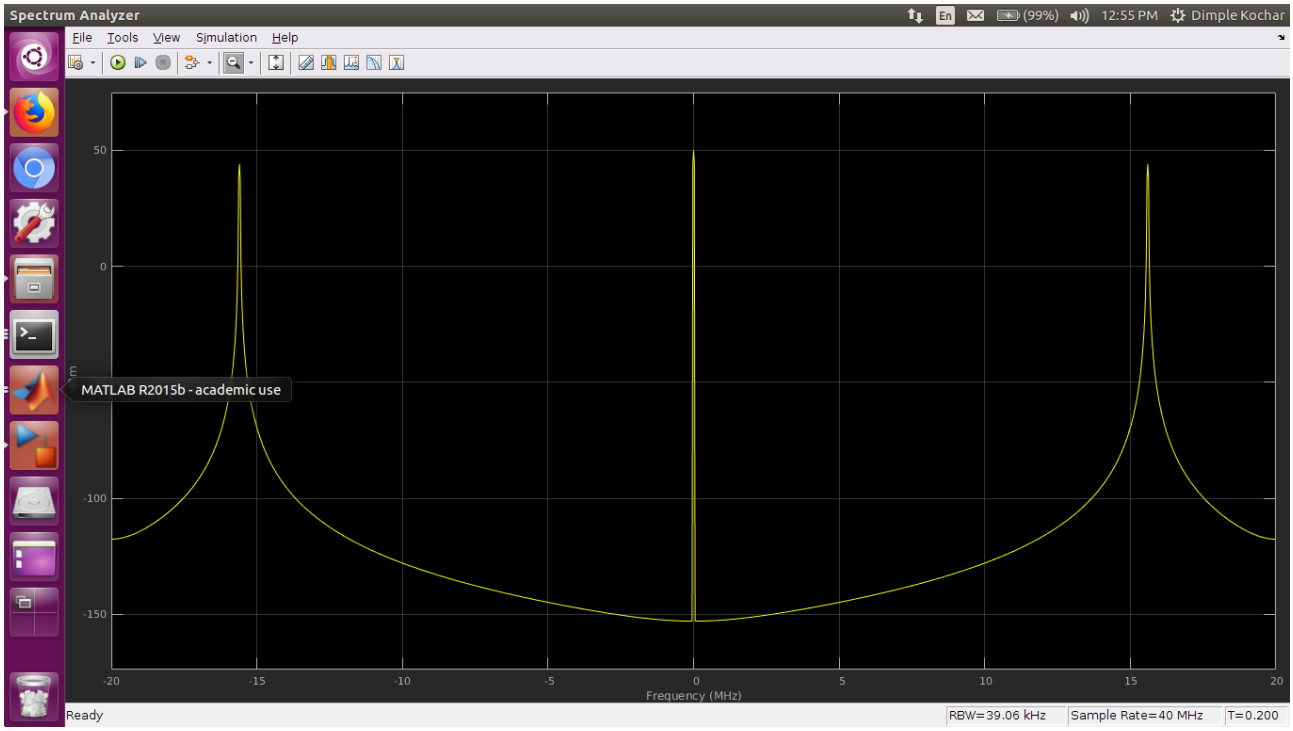
On setting master laser to 1e9, slave to 1.2e9, filter to 1e3, we get single peaks. Although there's a peak at 0, I don't know why. When we run it for longer time, the peak oscillates a bit but the oscillation amplitude decreases as we increase the time for which we run the simulation and it settles down:



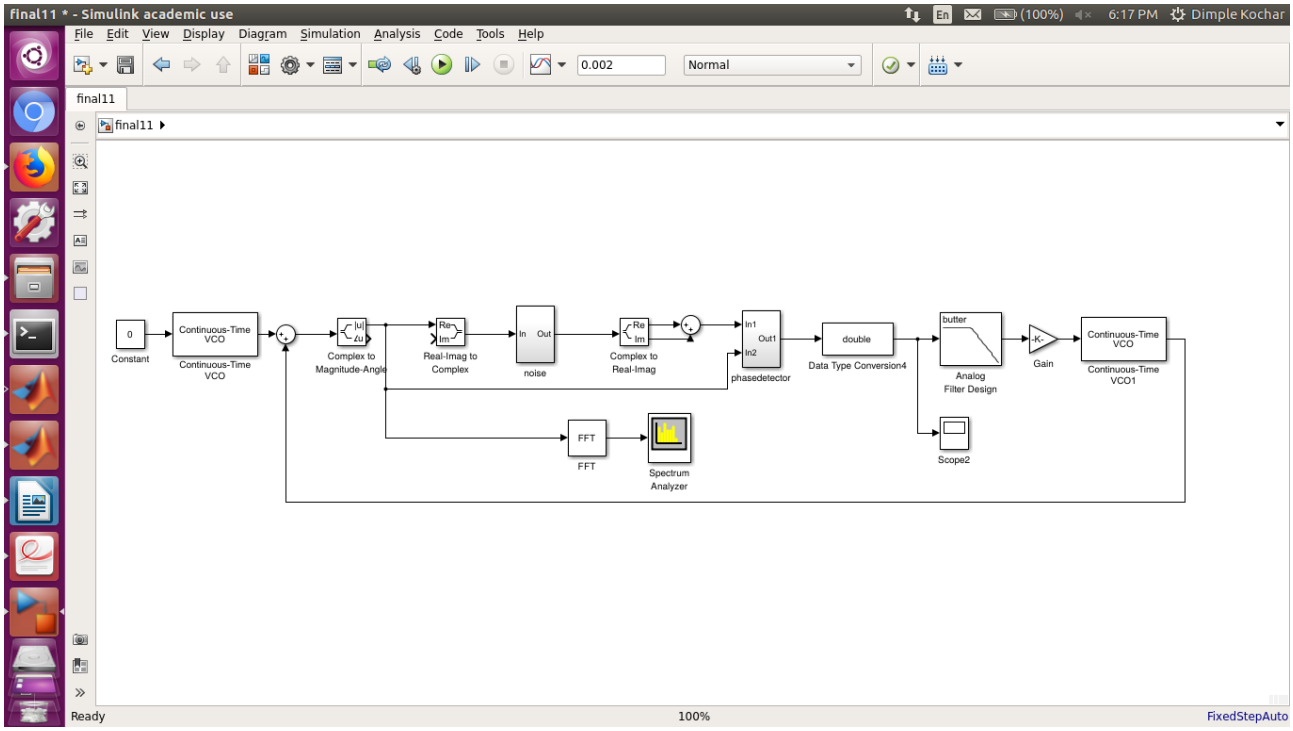
Running for ten times the time and halving the step size, the oscillations were hardly there, and it the peaks were settled:



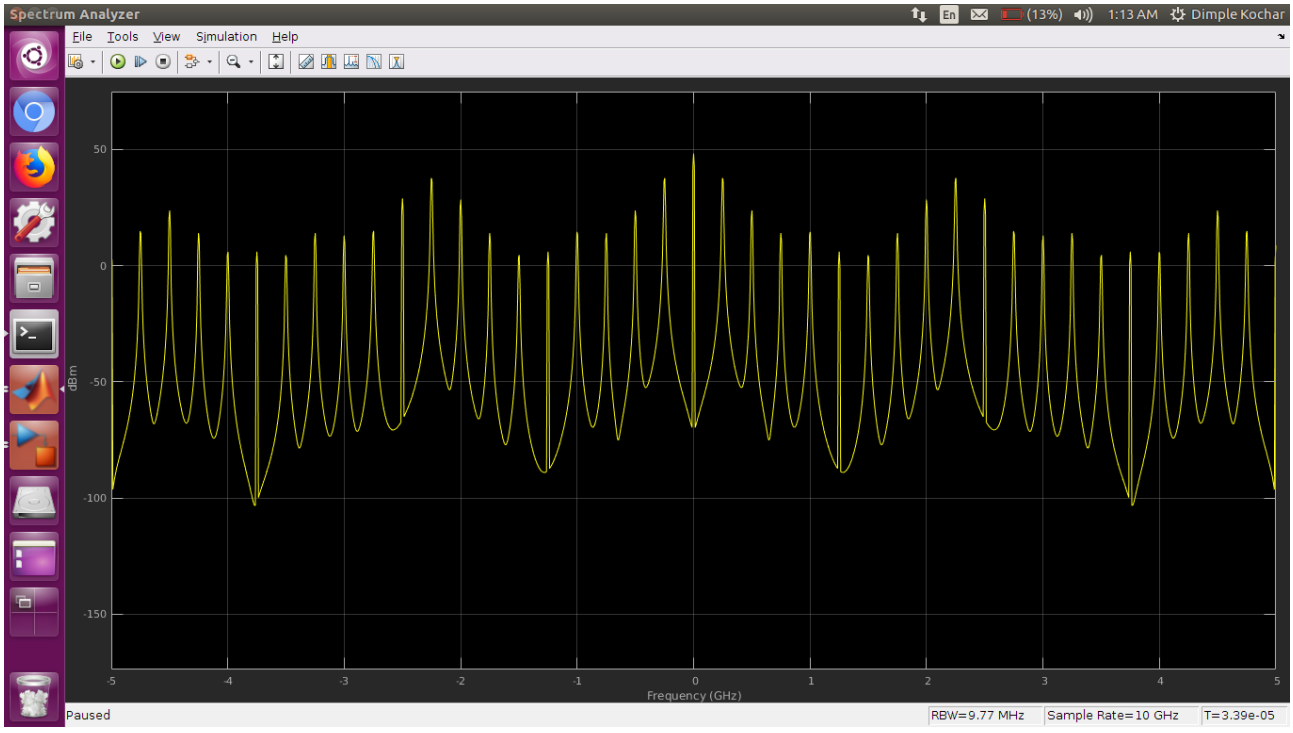
Changing the slave laser vco frequency to 1.5e9 from 1.2e9. Still got locking although at a different frequency.



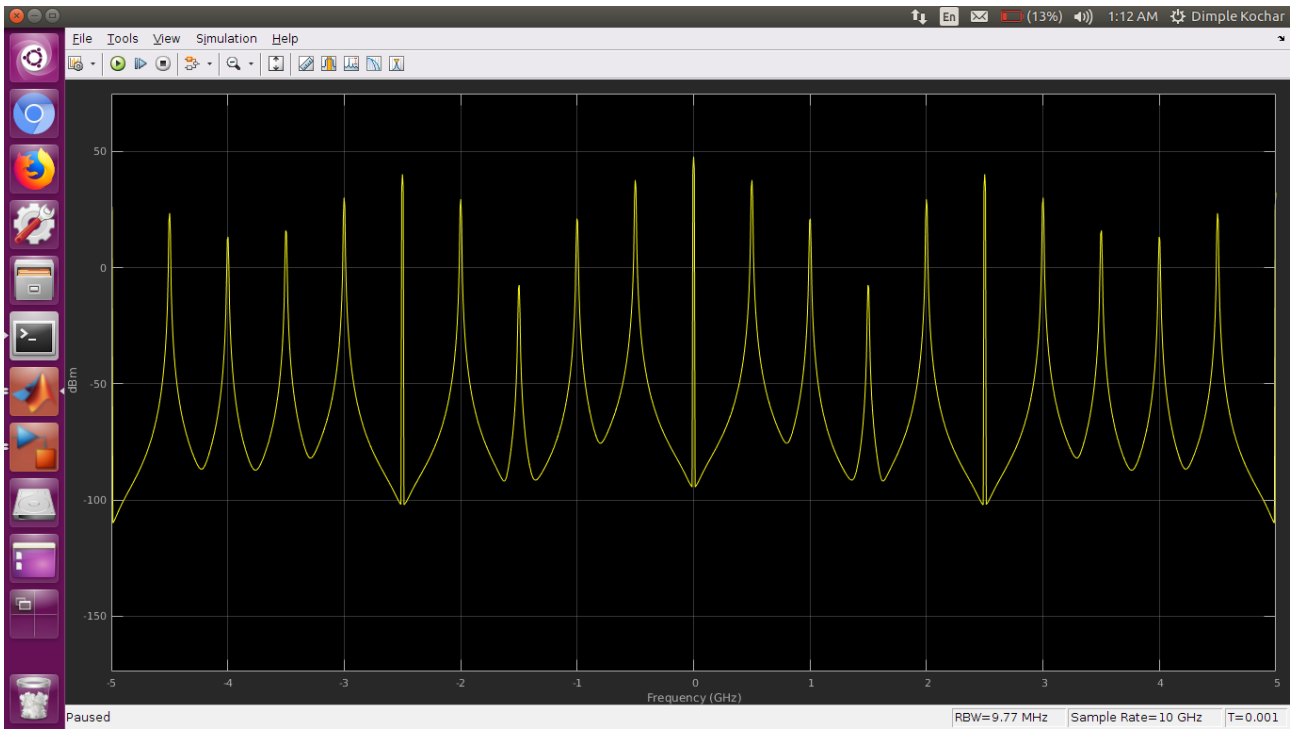
Now, we incorporate the phase detector as a magnitude block to get our final circuit:



Results:



1 and 1.25



1 and 1.5

When the frequency difference between the main signal and the VCO signal quiescent frequency is 0.5 GHz, I get peaks with separation of 0.5 GHz. When the difference is 0.25 GHz, I get peaks with separation of 0.25 GHz. When the difference is 0.1 GHz, I get peaks with separation of 0.1 GHz.