ELP 725 Wireless Communication Laboratory

Experiment 2

"Channel Fading countermeasures by diversity schemes"

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1. INTRODUCTION.

(a) Diversity combining of independently fading signal path is one of the most powerful techniques to mitigate the effect of fading which induces a very lare power penalty on the performance over the wireless channels.

(b) Diversity combining exploits the fact that independent signal paths have a low probability of experiencing deep fades simultaneously. Thus, the idea behind diversity is to send the same data over independent fading paths. These independent paths are combined in such a way that the fading of the resultant signal is reduced

(c) **Space Diversity**. It is one of the methods in which multiple transmit or receive antennas, also called an antenna array, where the elements of the array are separated in distance. Independent fading paths are realized without an increase in transmit signal power or bandwidth.

(d) **Frequency diversity**. It is achieved by transmitting same narrow band signal at different frequencies.

(i) **Selection Combining** . In selection combining (SC), the combiner outputs the signal on the branch with the highest SNR. This is equivalent to choosing the branch with the highest if the noise power is the same on all branches. Because only one branch is used at a time, SC often requires just one receiver that is switched into the active antenna branch. However, a dedicated receiver on each antenna branch may be needed for systems that transmit continuously in order to monitor SNR on each branch simultaneously.

(ii) **Switch and Stay Combining**. Selection combining for systems that transmit continuously may require a dedicated receiver on each branch to continuously monitor branch SNR. A simpler type of combining, called threshold combining, avoids the need for a dedicated receiver on each branch by scanning each of the branches in sequential order and outputting the first signal whose SNR is above a given threshold . Once a branch is chosen, the combiner outputs that signal as long as the SNR on that branch remains above the desired threshold. If the SNR on the selected branch falls below the threshold, the combiner switches to another branch. With only two-branch diversity this is equivalent to switching to the other branch when the SNR on the active branch falls below threshold. This method is called switch-and-stay combining (SSC)

2. OBJECTIVES.

(a) Design Transmitter and receiver module for 2x1 space diversity on SDR.

(b) Realize Frequency Diversity: Selection Combining, Switch and Stay Combining.

3. EQUIPMENT USED.

(a) Two Hack RF and one RTL SDRs, Laptop.

(b) Laptop for programming the SDR

4. EXPERIMENTAL SETUP.

Frequency Diversity.

In frequency diversity, the same signal is sent through different carrier frequencies and coherently received at the receiver. Then various combining techniques are used to get back the original signal. In this experiment,” selection combining” and ”switch and stay combining” is used.

(a) At the transmitter side, the signal is modulated and multiplied with two different carrier frequencies (100 Khz and 50 Khz) the results are added. The outcome is sent to a single antenna through osmocom sink.

(b) At the receiver side, the output from osmocom source is multiplied with the carrier frequencies separately for coherent detection, then passed through a low pass filter to retain the baseband signal.

(c) Baseband signal is sent to MPSK SNR Estimator block. Depending on the outputs, the results of selection combining or switched combining is displayed.

(d) For selection combining, the received signal with the highest SNR is chosen. For switched combining, a random strong signal is selected first. When its SNR drops below a certain threshold, the receiver switches to another signal.

(e) A simple Python block is used the achieve the above techniques. A control message is generated, which is used in the Selector block.

(f) At the transmitter side, carrier signal amplitude is varied to simulate varying channel conditions and observe an increase/decrease in SNR.

Space Diversity

In space diversity, same message signal is sent through many transmitters to simulate different channel coefficients.

(a) At the transmitter side, two different antennas (osmocom sink) are set up to carry the same random source signal.

(b) At the receiver side, a generic QPSK receiver (osmocom source) is set up to receive multiple copies of the same signal.

(c) For simulation, two different channel models are used to emulate different channel coefficients in space diversity.

5. Requirements.

(a) Frequency Diversity .

I. The simulation of frequency diversity was done using the both analog and digital modulation techniques.

II. The Analog modulation frequency Diversity was simulated using the two different carriers at frequencies 100KHz and 50 KHz and demodulated at the receiver using the same frequencies.

III. The switch and stay and selection combiner block has been programmed using python block (named as S.S.Combining) which selects the received signal after comparing the SNR (SNR higher is selected) in selection combiner and also implements the Switch and stay considering threshold value (given value of the SNR).

IV. The simulation GNU block for digital modulation frequency diversity is given below.

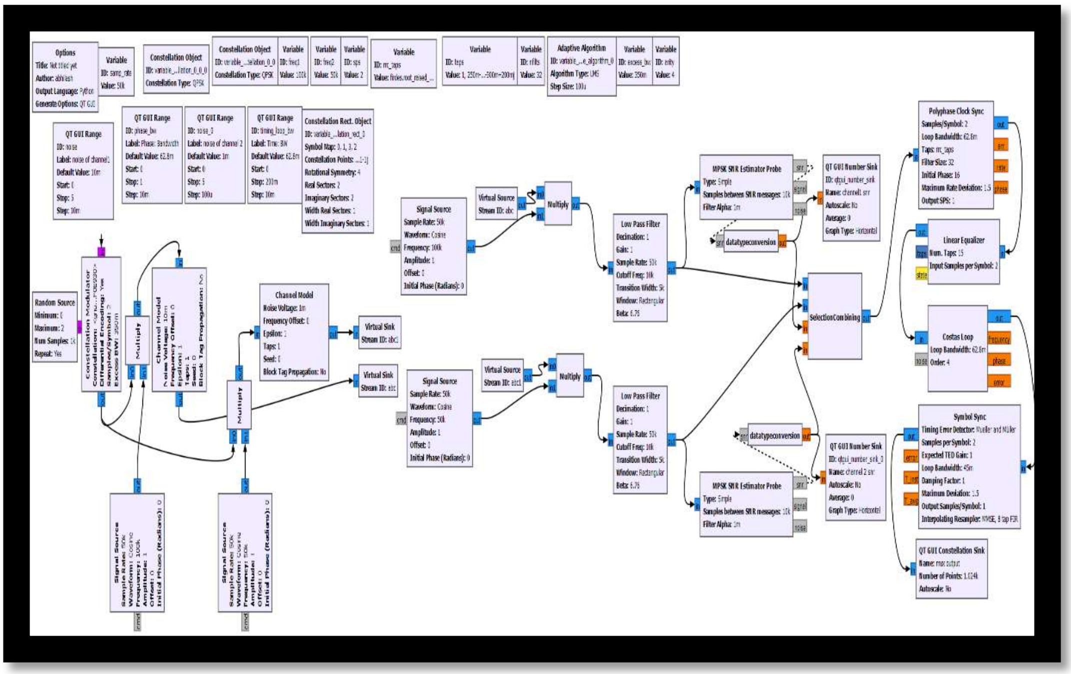


Figure 1-FREQUENCY DIVERSITY SELECTION COMBINING

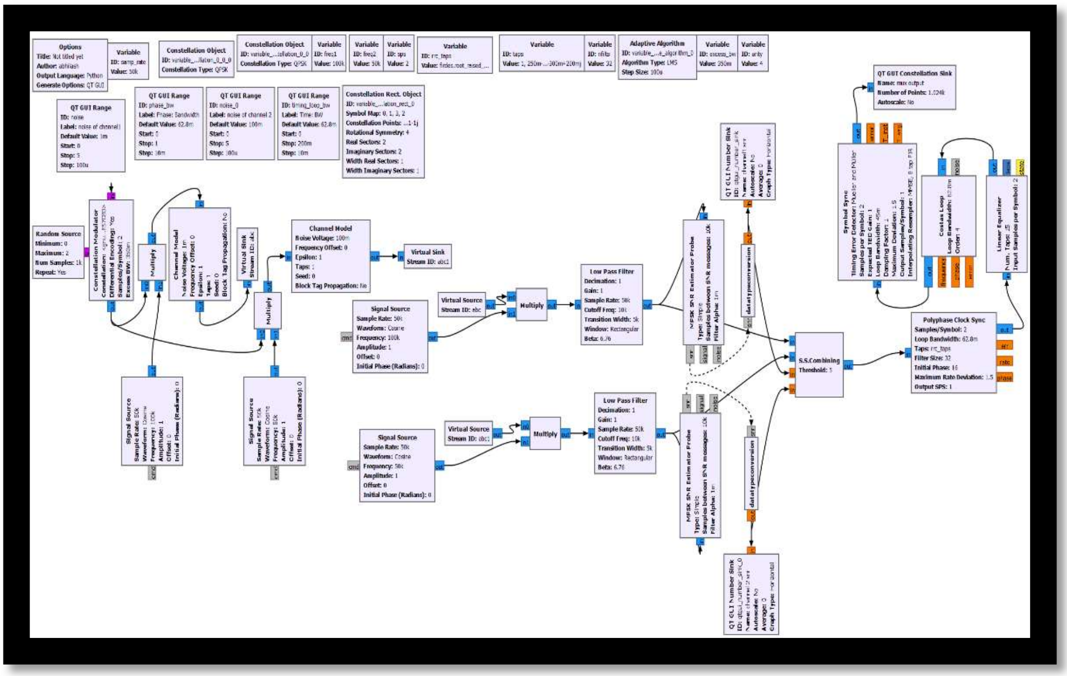


Figure 2-Frequency Diversity Switch & stay Combining.

V. Results . The simulated results of the Analog frequency diversity and digital frequency diversity is as follows.

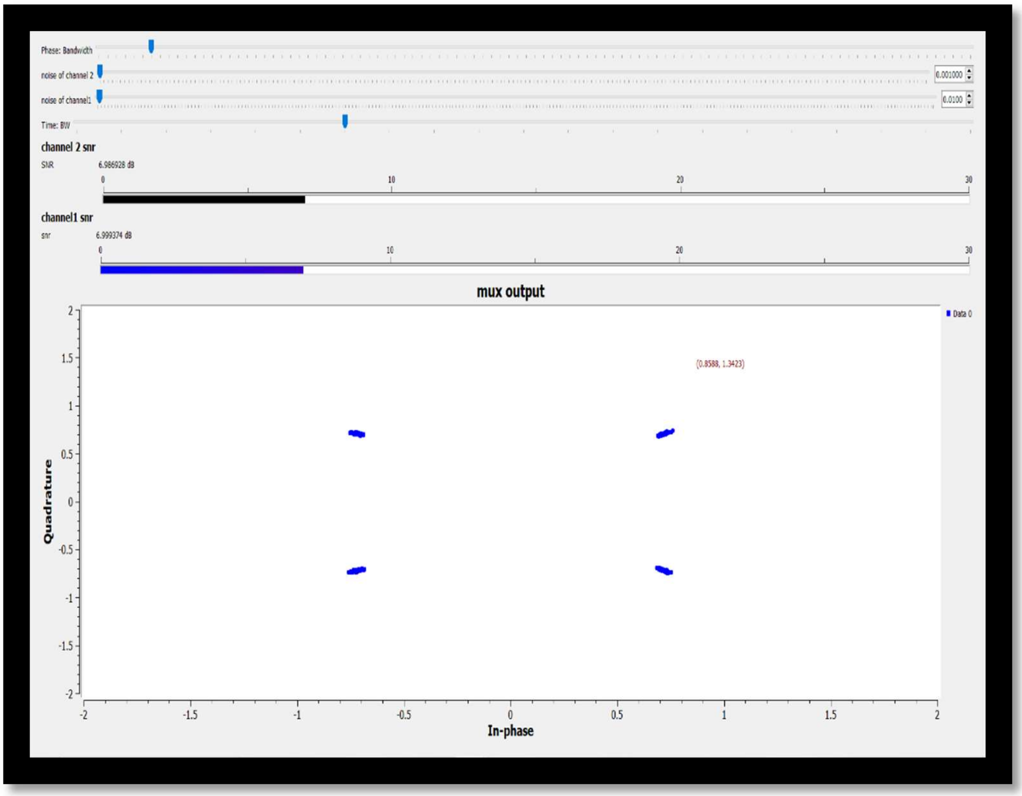


Figure 3 Frequency Selection Combining

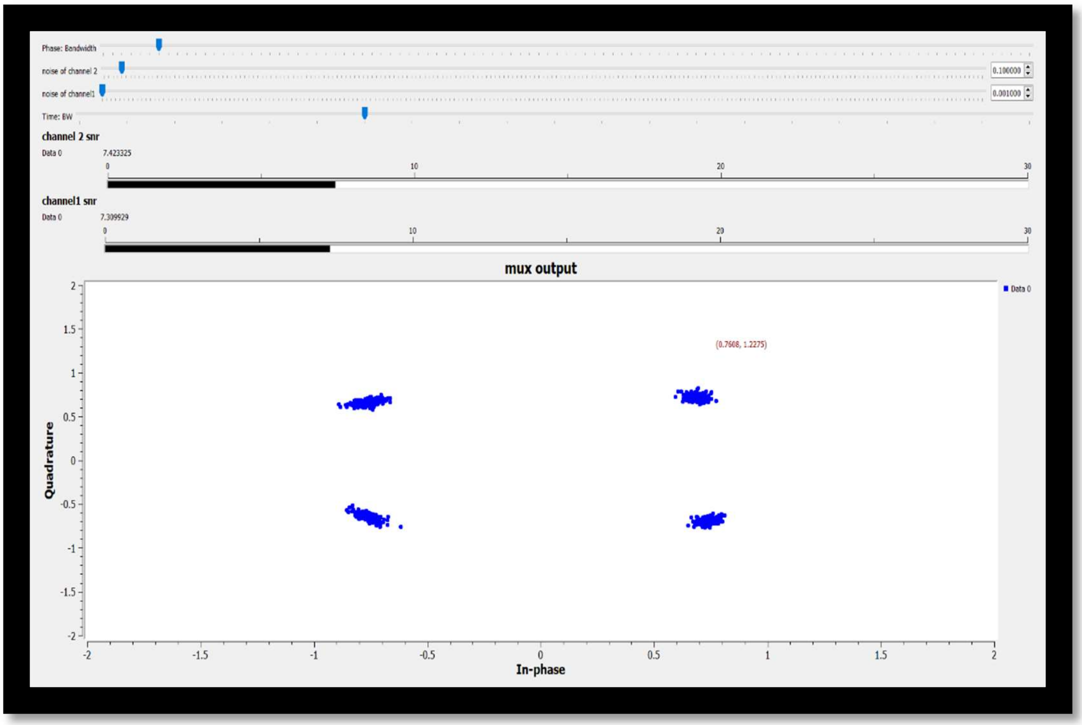


Figure 4-Frequency Diversity Switch and Stay

(b) <u>Space Diversity .</u>

I. The Space diversity has been simulated using the different channel conditions. The GNU block diagram for 2X1 MISO is as under .

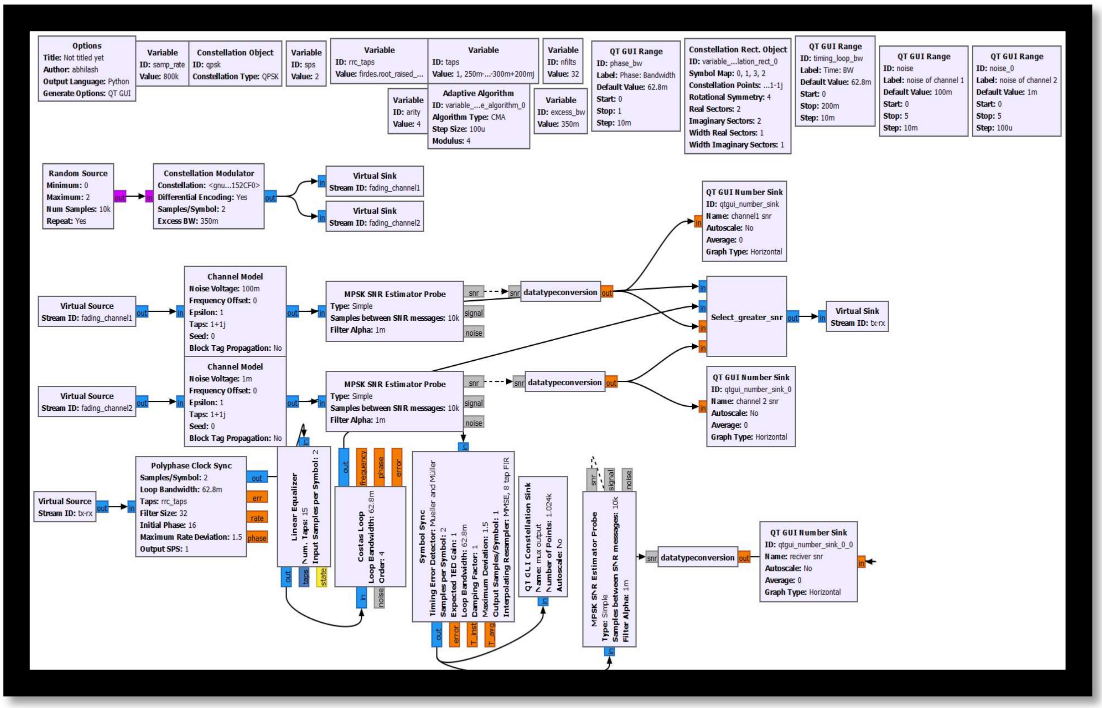


Figure 5-MISO

II. The space diversity was also simulated using the SISO under one of the above channel conditions. The GNU block diagram is as under.

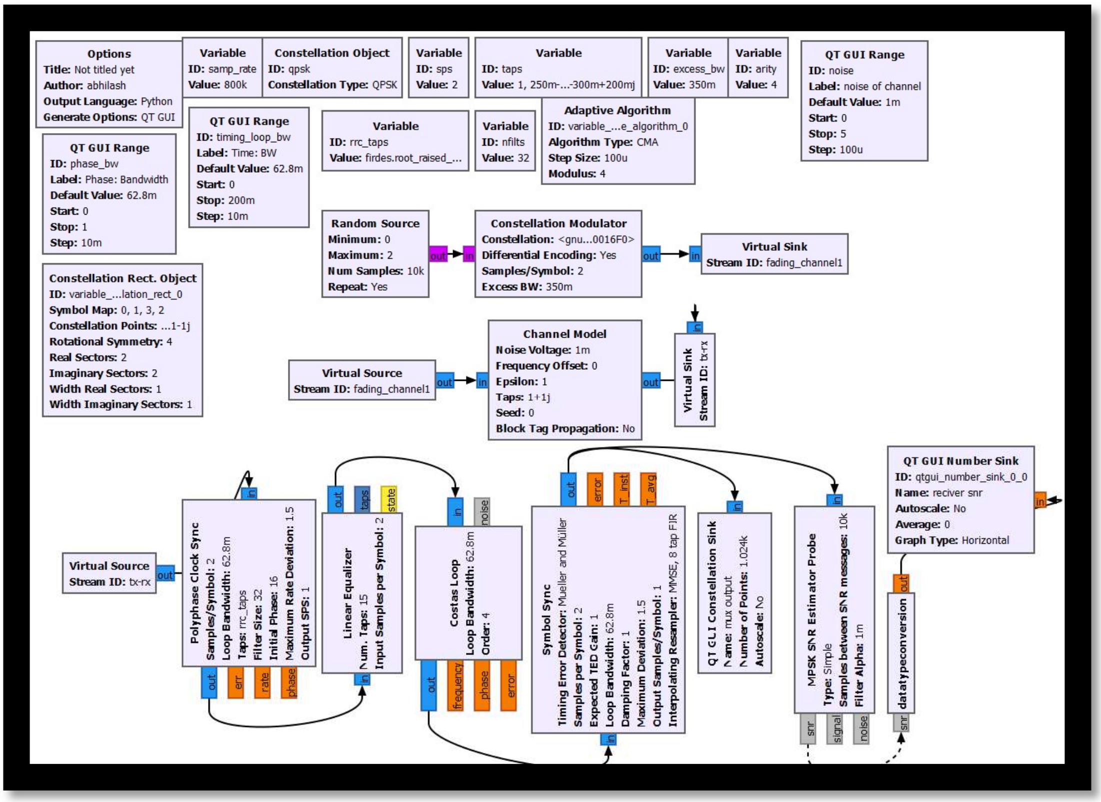


Figure 6- SISO

III. **Results**. The simulated results of the space diversity for MISO and SISO is as follows.

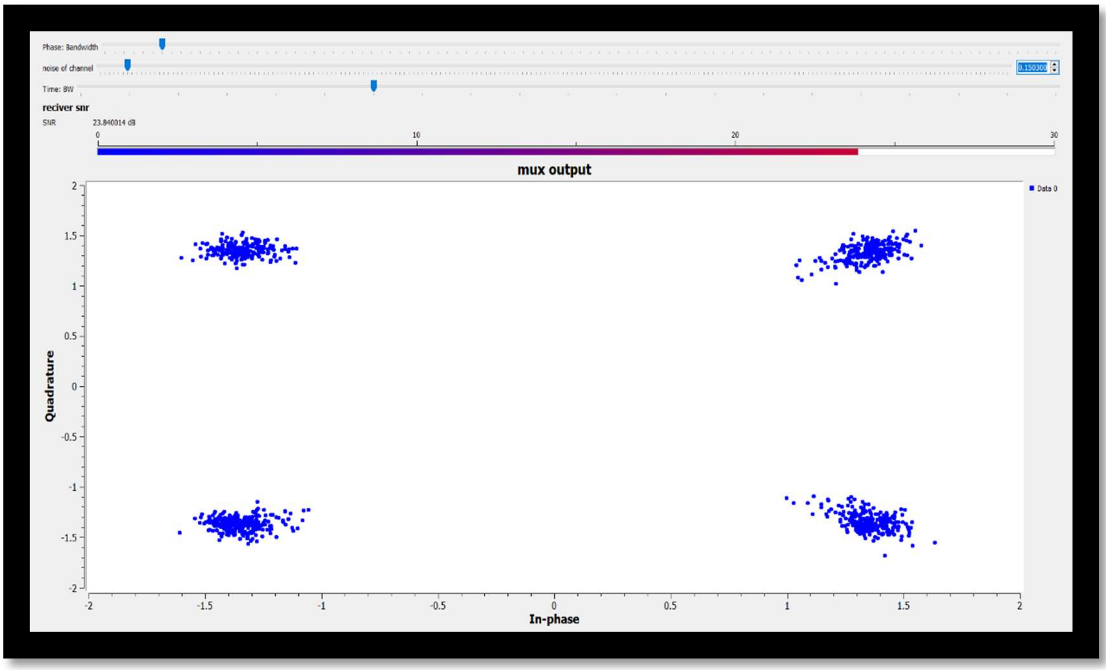


Figure 7 SISO

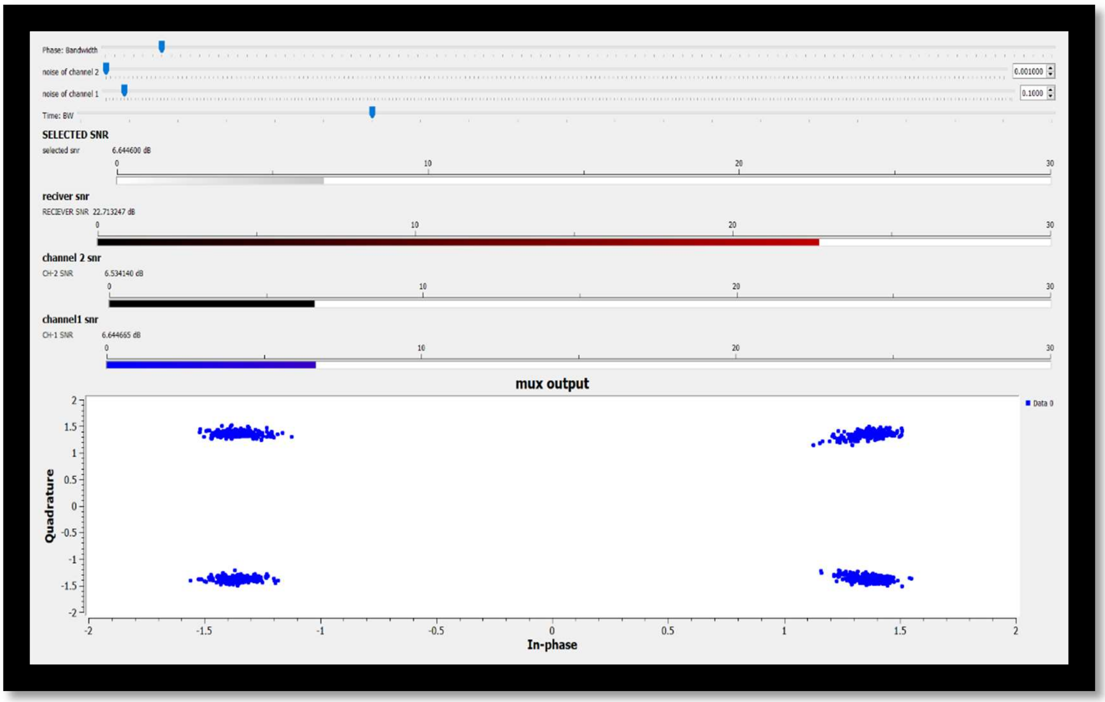


Figure 8-MISO

6. Hardware Implementation using GNU radio

Frequency Diversity. The frequency diversity was implemented using GNU radio. The screen shots are as under

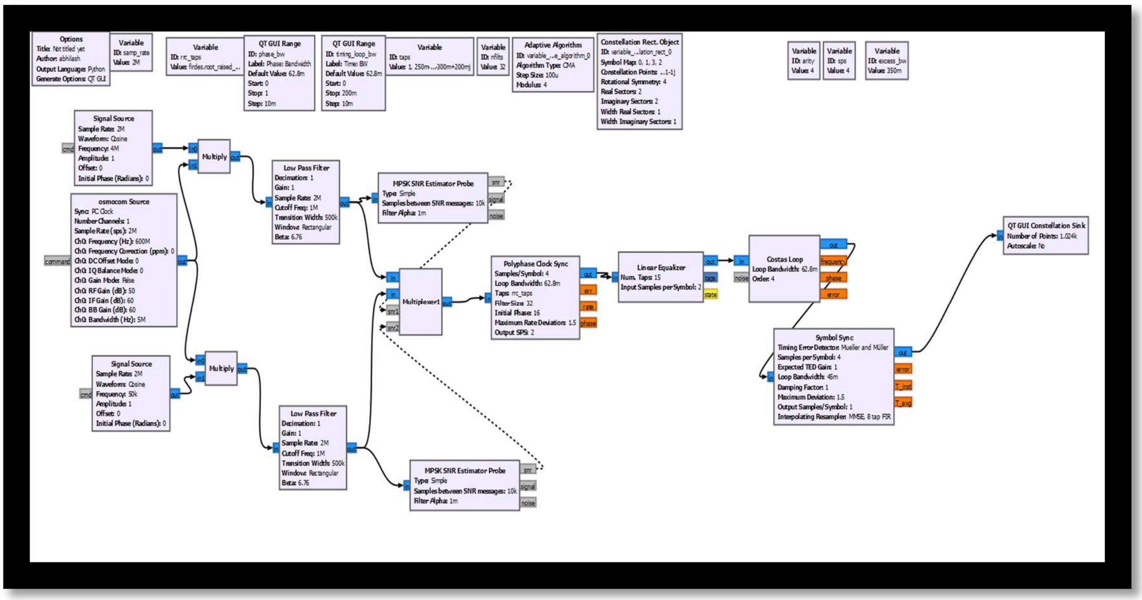


Figure 9 Frequency Diversity SDR implementation RX

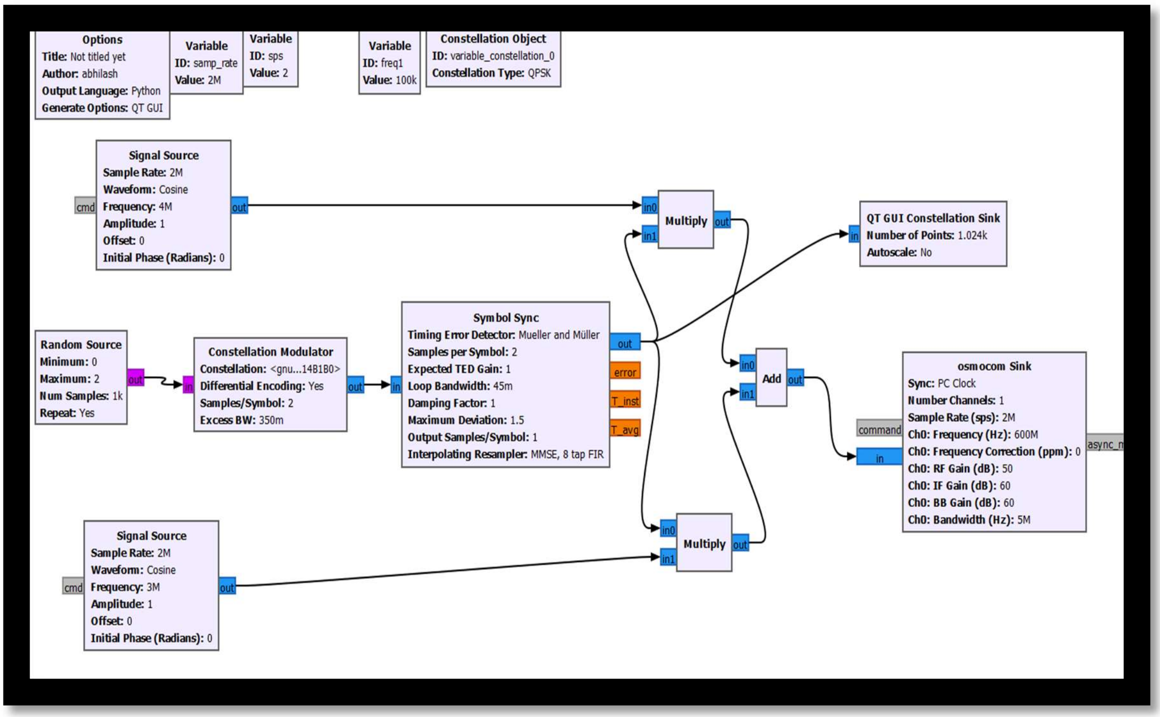


Figure 10 Frequency Diversity TX

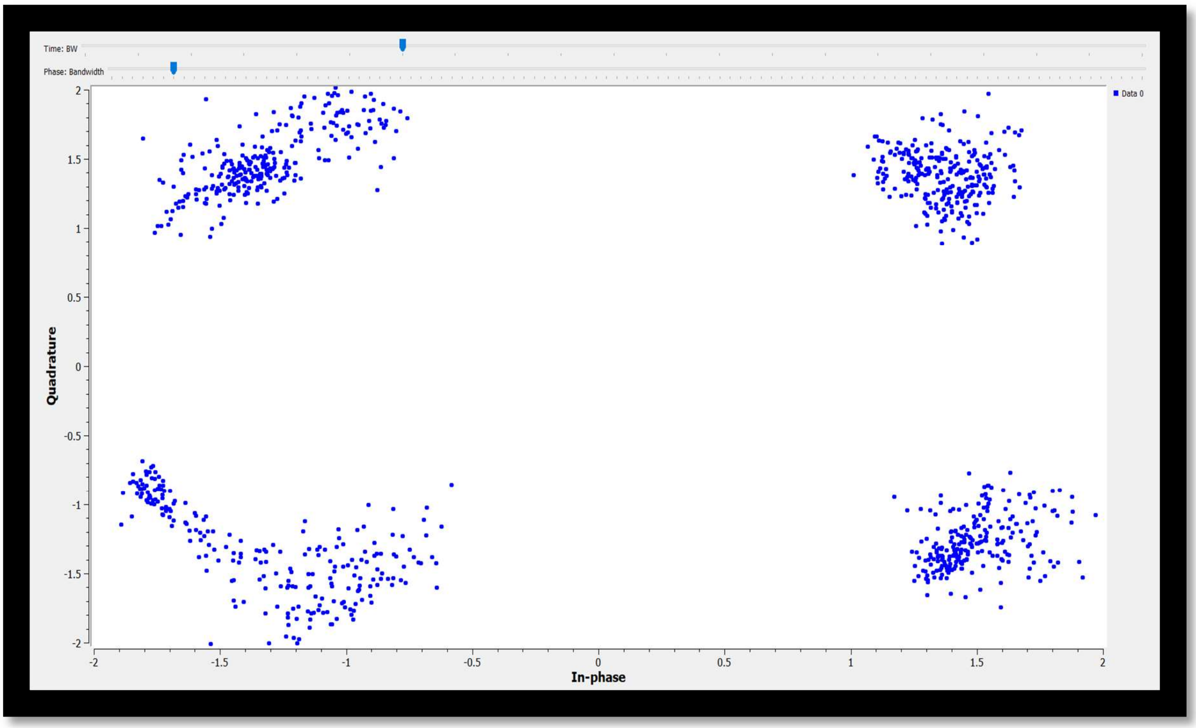


Figure 11 Frequency Diversity SDR result

<u>Spatial Diversity</u>. The spatial diversity was implemented using MISO and SISO model using SDR. The screen shots of the block and result are shown below.

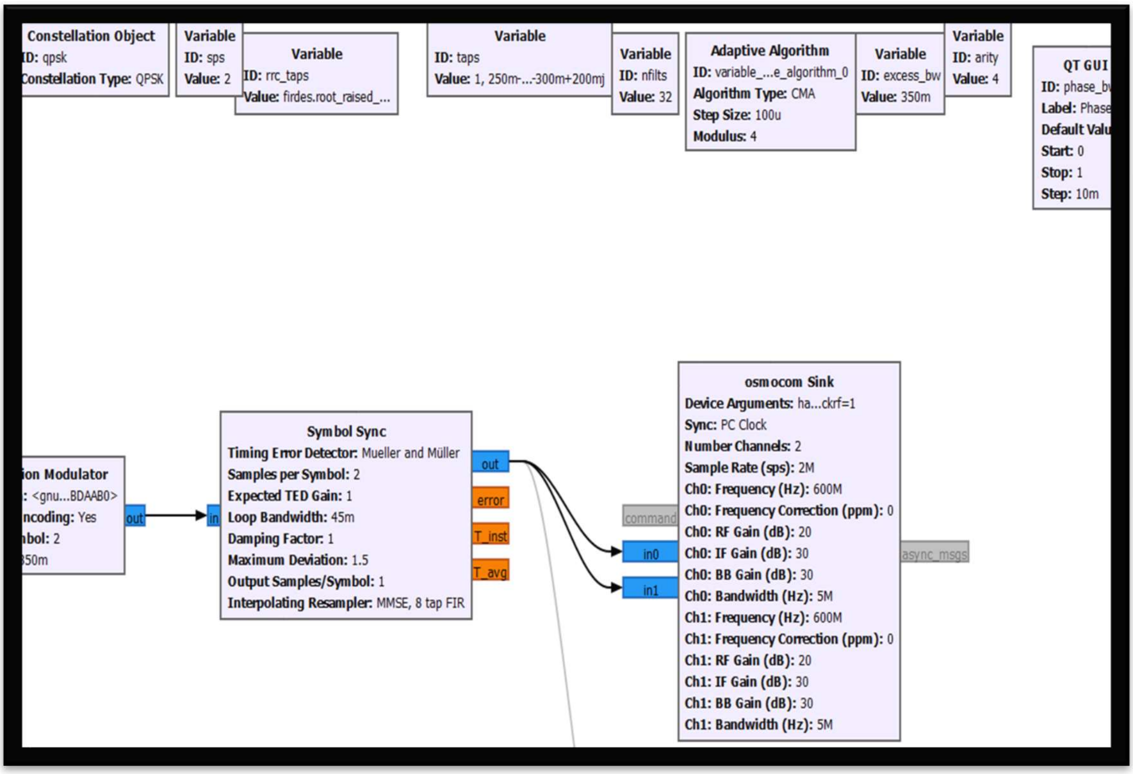


Figure 12- Spatial Diversity SDR TX MISO

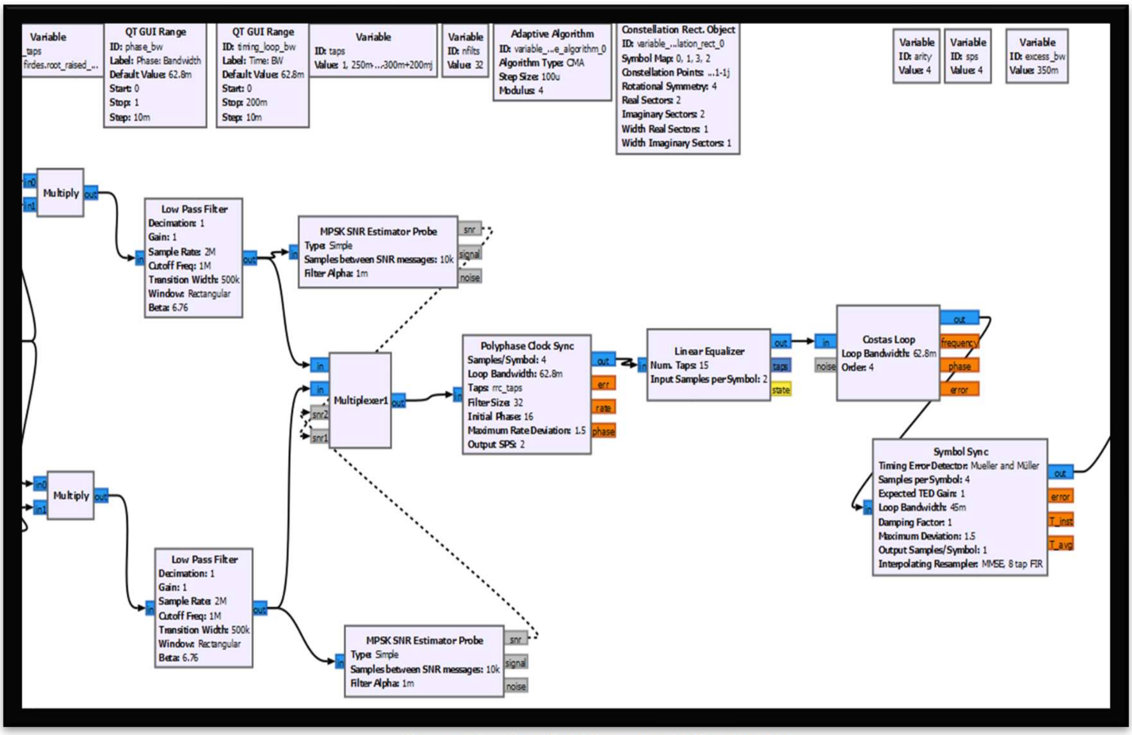


Figure13. Spatial Diversity MISO RX SDR

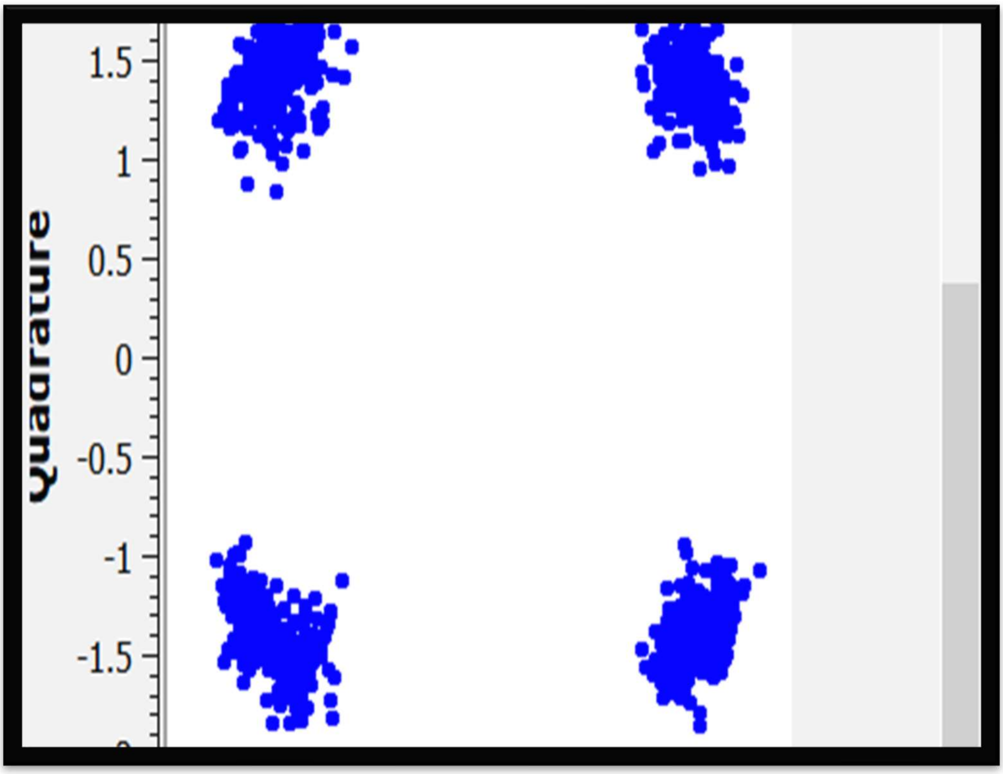


Figure 14- MISO RESULT SDR Constellation

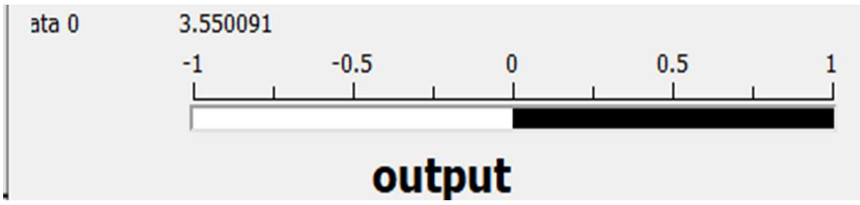


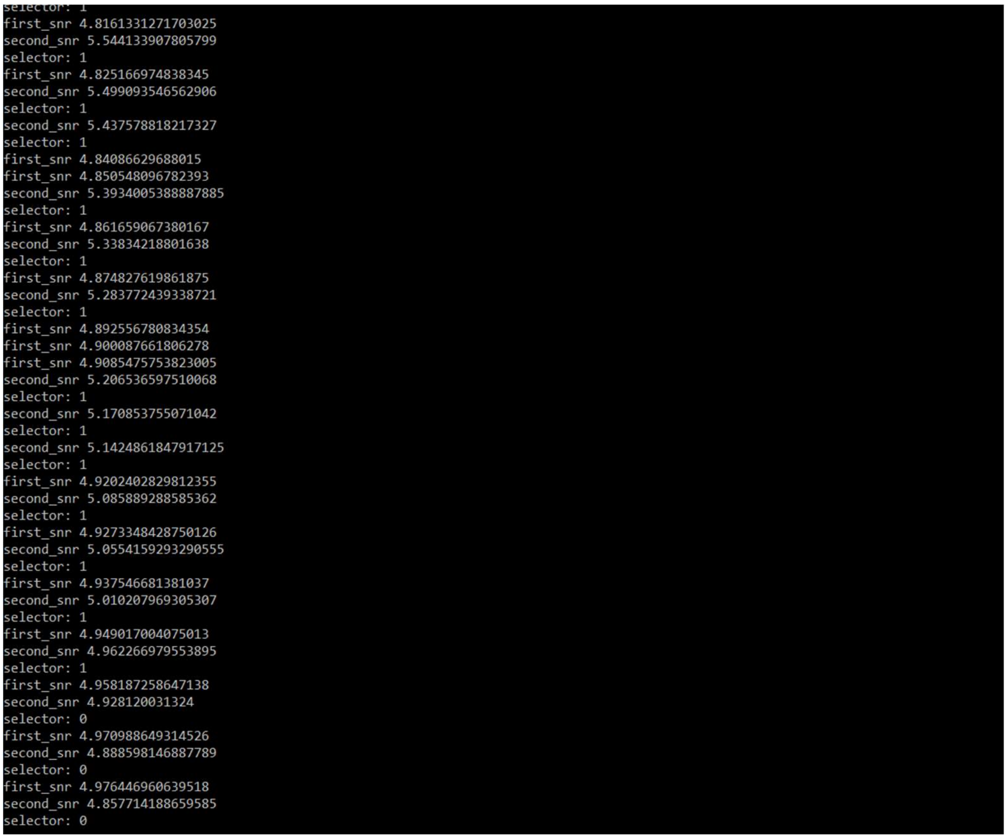
Figure 15- SNR output MISO

7.CONCLUSIONS.

(a) **Frequency Diversity.**

I. Frequency Diversity technique has been simulated using both selection combining and switch and stay combining.

II. Carrier amplitude of either signal on transmitter side is reduced and its effect on SNR is observed. Depending on this, a python block generates a select control message. This is used to perform selection or switch Combining.



```
selector: 1
first_snr 4.8161331271703025
second_snr 5.544133907805799
selector: 1
first_snr 4.825166974838345
second_snr 5.499093546562906
selector: 1
second_snr 5.437578818217327
selector: 1
first_snr 4.84086629688015
first_snr 4.850548096782393
second_snr 5.3934005388887885
selector: 1
first_snr 4.861659067380167
second_snr 5.33834218801638
selector: 1
first_snr 4.874827619861875
second_snr 5.283772439338721
selector: 1
first_snr 4.892556780834354
first_snr 4.900087661806278
first_snr 4.9085475753823005
second_snr 5.206536597510068
selector: 1
second_snr 5.170853755071042
selector: 1
second_snr 5.1424861847917125
selector: 1
first_snr 4.9202402829812355
second_snr 5.085889288585362
selector: 1
first_snr 4.9273348428750126
second_snr 5.0554159293290555
selector: 1
first_snr 4.937546681381037
second_snr 5.010207969305307
selector: 1
first_snr 4.949017004075013
second_snr 4.962266979553895
selector: 1
first_snr 4.958187258647138
second_snr 4.928120031324
selector: 0
first_snr 4.970988649314526
second_snr 4.888598146887789
selector: 0
first_snr 4.976446960639518
second_snr 4.857714188659585
selector: 0
```

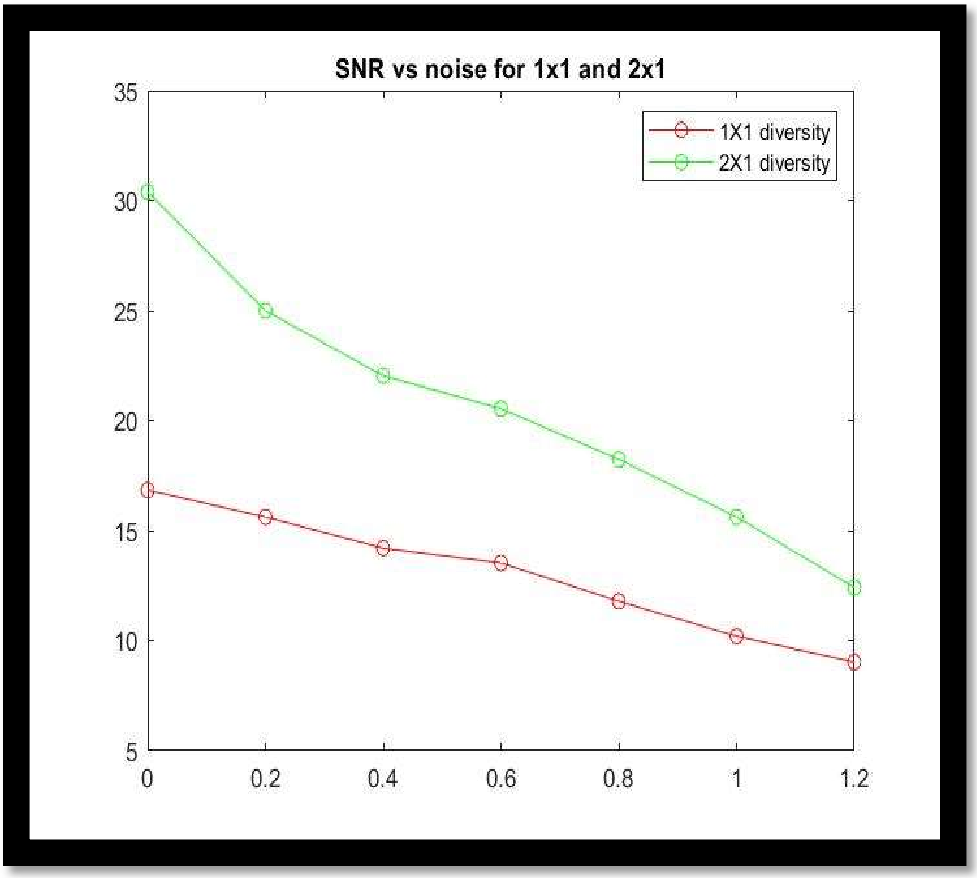
Figure 16- Result Showing Change of Channel with better SNR

III. The results of the simulation and hardware implementation is as under. The improved and better SNR has always been selected at the receiver.

IV. Frequency diversity led to the improved performance of the wireless communication system.

(b) **<u>Space Diversity .</u>**

I. The graph of the same is also plotted using MATLAB code as shown:



II. We have observed high SNR response in case of MISO compared to SISO. This is because in MISO, we have two multipath which will reduce the probability of signal getting in caught with the deep fade event as we have an alternative path which is absent in SISO. This is the advantage of spatial diversity method which combines the signals from several antennas to enhance the signal and lessen

8.References

[1] Goldsmith, A. (2005). Wireless Communications. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511841224

[2] https://www.gnuradio.org/