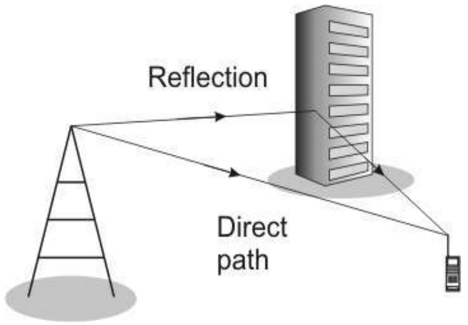

Figure 2: Depicting LOS (Direct Path) and NLOS (Reflected Path)

4. Doppler Shift

When a Base Station or transmitter and receiver is/are moving, the frequency of the received signal will not be the same as that of the transmitted signal. This is called Doppler's Shift. When they are moving towards each other or only mobile user is moving towards the Base station, the frequency of the received signal is higher than the transmitted signal frequency. However, the frequency of received signal will be lower than that of the transmitted signal, when either both of Mobile user and Base station are moving towards each other or only Mobile user is moving towards the base station. The total signal at receiver tends to fade or distort. For proper decoding of received signal, we must have the correct frequency [5]. Such change in frequency can be understood from Doppler's effect depicted in Fig. 3 below. The same is applicable to wireless communications.

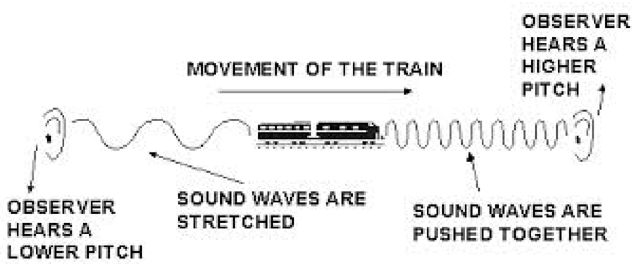

Figure 3: Dopplers Effect

Received Signal frequency f_r, is given by following equation,

$$f_r = f_c \pm f_d \quad (3)$$

where 'f_c' is the source carrier frequency and 'f_d' is the doppler's shift in frequency. Doppler's shift will be positive or negative depending on whether the mobile is moving towards or away from the BS. Therefore, f_d will be added to f_c when mobile is moving towards BS and subtracted from f_c when mobile is moving away from BS.

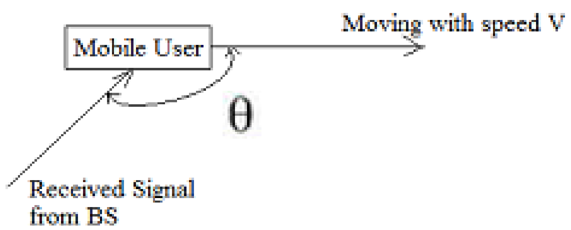

Figure 3: Mobile User

For Mobile user moving with speed v, receiving signal from Base Station at an certain angle Θ, the doppler shift is given by following equation,

$$f_D = \frac{V}{\lambda} \cos\theta \quad (4)$$

5. Simulation Results

Simulation Approach - Suppose a continuous wave is sent at frequency 'f_1' and it undergoes fading i.e. the received signal strength is lowered than the strength of transmitted signal. We have taken the scatter plots of received signal and analyzed the constellation for 16 symbols of 16 QAM to decide whether fading effects can be removed or not. Let at this frequency 'f_1', the fading effects can be removed i.e. ISI between 16 symbols of QAM is less. Now with the increased transmitted signal frequency, say from 'f_1' to '$f_1+\Delta f$', the received signal constellation is again analyzed. The same process has been repeated until a certain frequency 'f_2' at which the effects of fading cannot be removed. Then this gives us the range 'f_1 –to- f_2' between which we can de-correlate the effects of fading and recover the transmitted signal. All the following readings have been taken for a fixed SNR, taken as 21db. Extensive Matlab simulations were conducted to evaluate the performance of WiMAX communication system. Following are the simulation results,

Case 1: When Mobile User is moving towards the Base Station

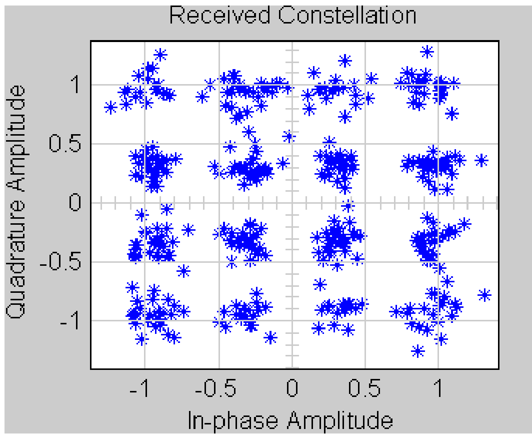

Figure 4(a): f_D=10Hz BER = 0.00013

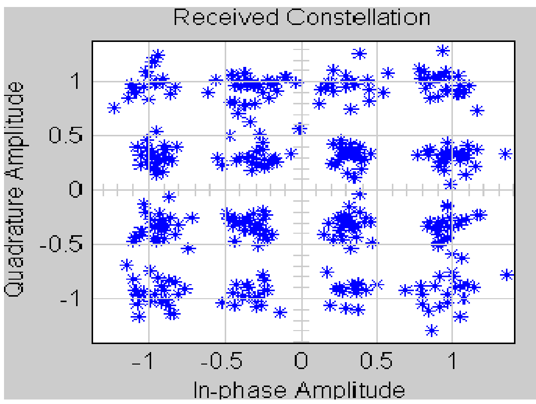

Figure 4(b): f_D=100Hz BER = 0.00037

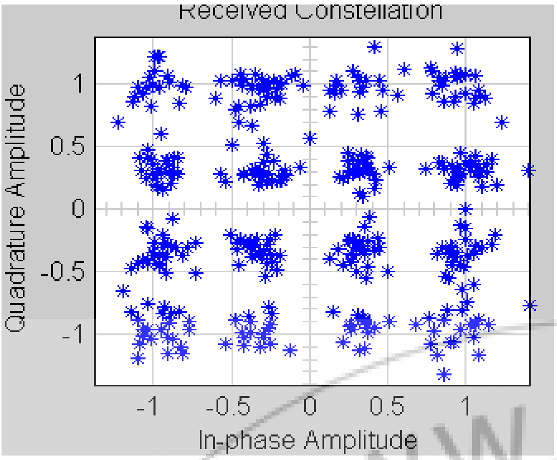

Figure 4(c): f_D=200Hz BER = 0.00047

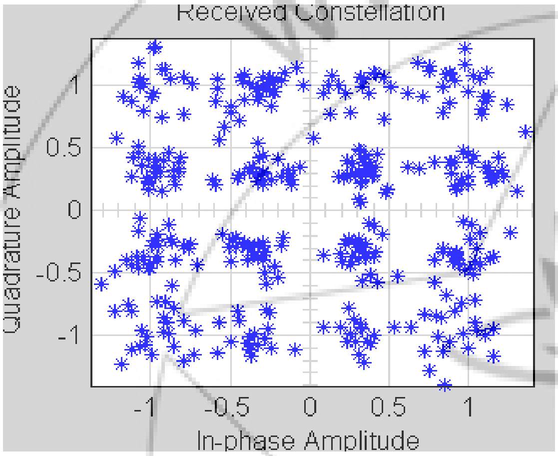

Figure 4(d): f_D=400Hz BER = 0.00088

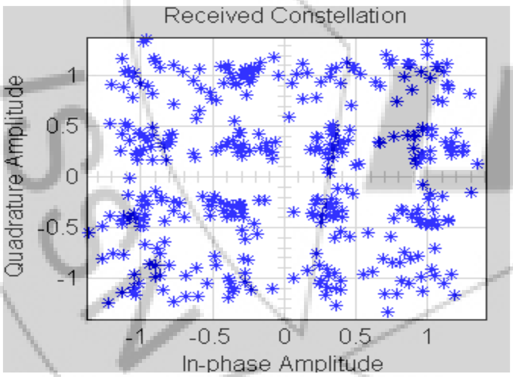

Figure 4(e): f_D=600Hz BER = 0.02892

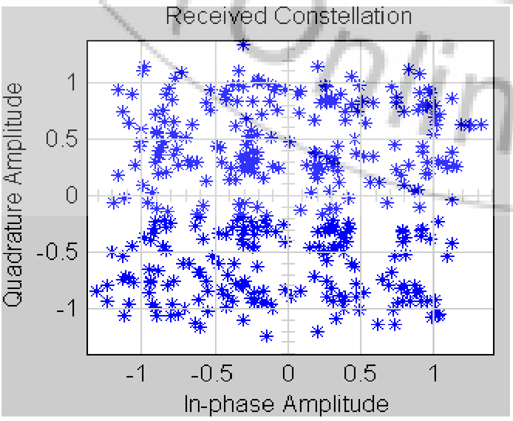

Figure 4(f): f_D=800Hz BER = 0.08053

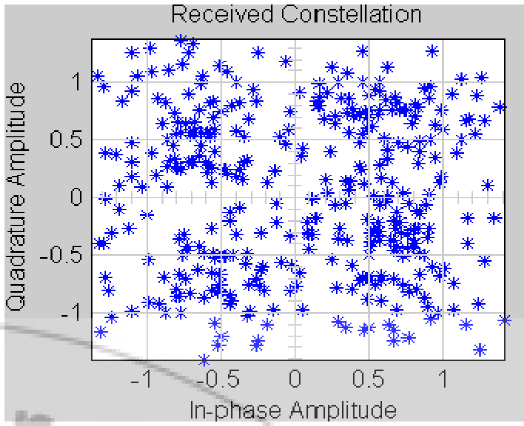

Figure 4(g): f_D=1000Hz BER = 0.09061

Figure 4: Received signal Constellations for Case1

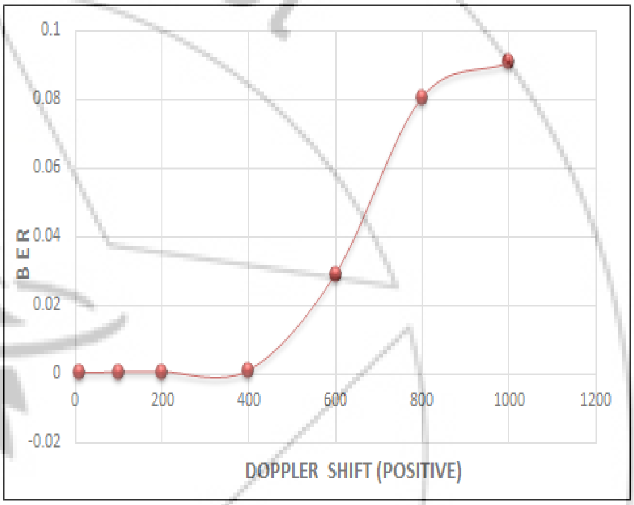

Figure 5: BER Curve for Doppler Shift for Case 1

Case 2 - When Mobile User is moving away from the Base Station

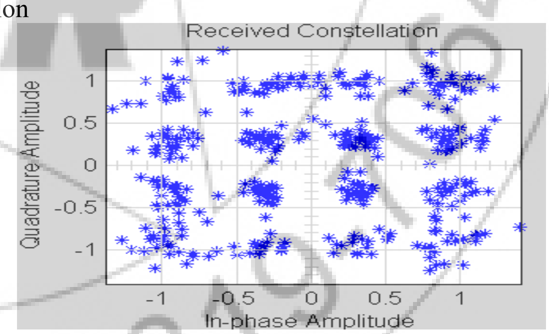

Figure 6(a): f_D=10Hz BER = 0.000125

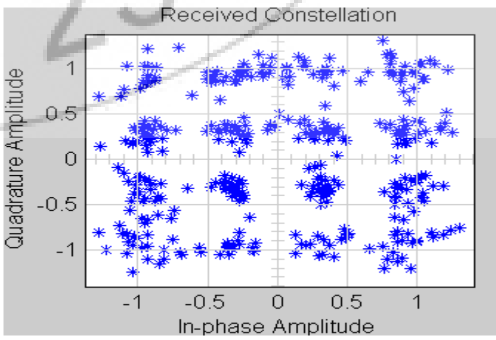

Figure 6(b): f_D=100Hz BER = 0.000218

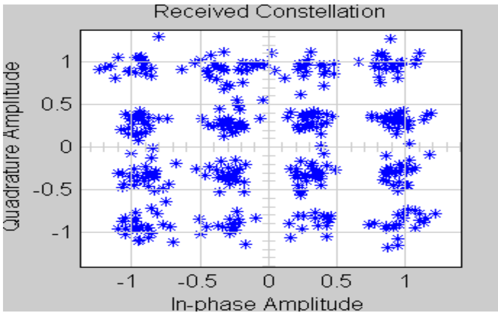

Figure 6(c): f_D=200Hz BER = 0.000526

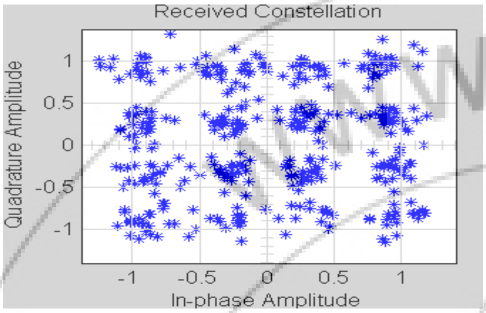

Figure 6(d): f_D=400Hz BER = 0.003138

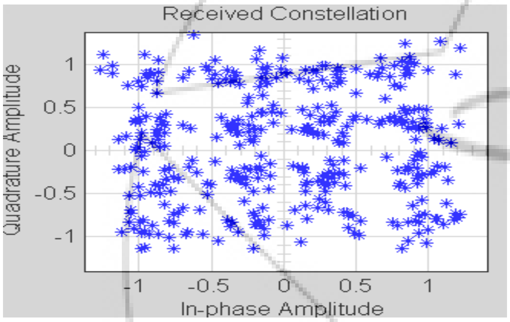

Figure 6(e): f_D=600Hz BER = 0.03062

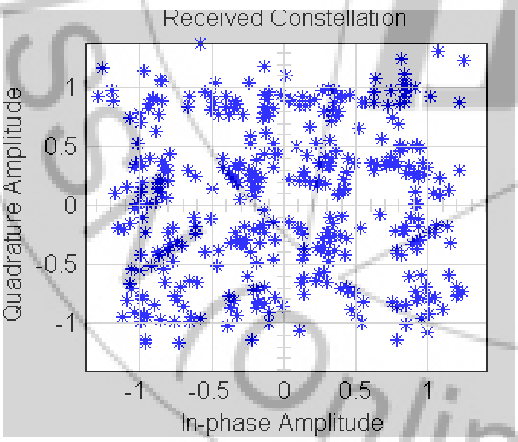

Figure 6(f): f_D=700Hz BER = 0.04846

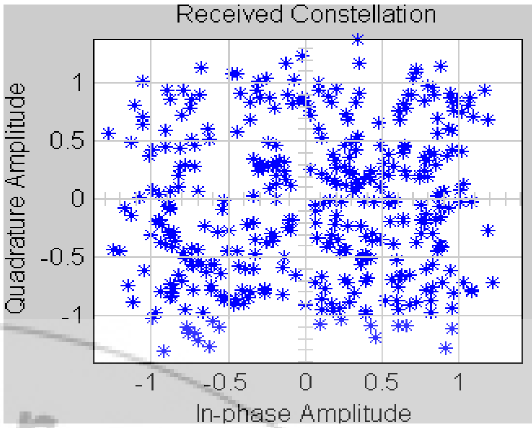

Figure 6(g): f_D=800Hz BER = 0.06840

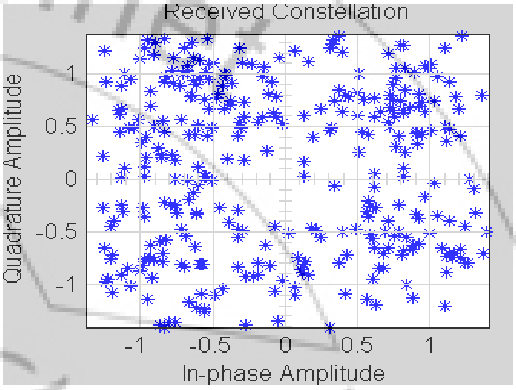

Figure 6(h): f_D=850Hz BER = 0.09830

Figure 6: Received Signal Constellations for Case 2

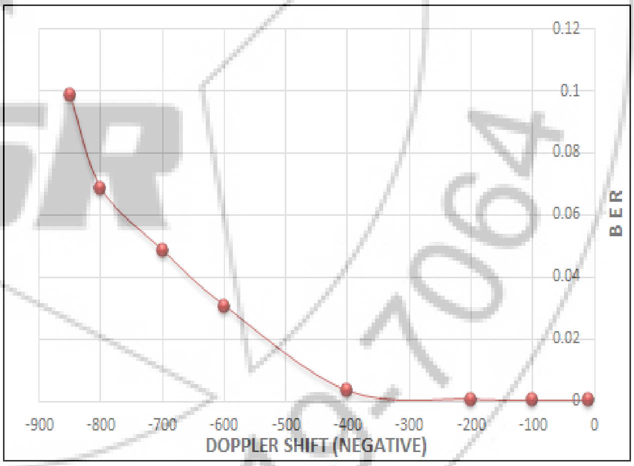

Figure 7: BER Curve for Doppler shift for Case 2

6. Conclusion

Fig. 5 concludes that when Mobile user moves towards the Base Station, BER increases with increase in Doppler Shift**.** The received signal constellations in Fig. 4 suggest that for Doppler Shifts beyond around 400Hz, the Inter Symbol Interference starts severely affecting the received signal strength for the chosen WiMAX profile (i.e. for operation at 3.5GHz). Thus, the de-correlation of fading effects from received signal beyond 400Hz (approximately) becomes inconvenient for the receiver.

Fig. 7 concludes that when Mobile user moves away from the Base Station, BER increases with increase in Doppler Shift. The received signal constellations in Fig. 6 suggest that for Doppler Shifts beyond around -400Hz, the Inter Symbol Interference starts severely affecting the received signal strength for the chosen WiMAX profile (i.e for operation at 3.5GHz). Thus, the de-correlation of fading effects from received signal beyond -400Hz (approximately) becomes inconvenient for the receiver.

References

[1] Mathworks Whitepaper, 2006, "Creating an Executable Specification for WiMAX Standard"

[2] Bernard Sklar. Rayleigh Fading Channels in Mobile Digital Communication Systems Part 1: Characterization. IEEE Comm., 1997, v35, n7, pp.90-100.

[3] J.G Andrews, A Ghosh, R Muhamed, Fundamentals of WiMAX, Understanding Broadband Wireless Networking.

[4] S. M. Alamouti, "A simple transmit diversity technique for wireless communications," IEEE Journal on Selected

[5] Areas in Communications, Vol. 16, No. 8, Oct. 1998, pp. 1451-1458.

[6] Theodore S. Rappaport, “Wireless Communications”, Prentice Hall, Second Edition, 17th Printing, March 2008.

Author Profile

Dr. Amita Soni: received her B.E. degree in Electronics and Communication, Masters in Engineering degree in Electronics and Ph.D. in Wireless Communication from PEC University of Technology, Chandigarh-India. She is currently working as Assistant Professor in PEC University of Technology, Chandigarh. Her research interests include Wireless Communication.

Navgeet Singh: is a PG scholar, currently pursuing Masters in Engineering in Electronics at PEC University of Technology, Chandigarh- India. He received his B.Tech in Electronics and Communication Engineering from Jaypee University of Technology, Solan in 2011. He has worked with Infosys Ltd (from Aug 2011 – July 2012) as a Systems Engineer in the Financial Services and Insurance division to develop enterprise applications for Bank of America. His research interests include Wireless Communication and Nano Technology