

Analysis of Doppler Effect on constellation Diagram of 8-PSK Modulation

Sanjeev Kumar Shah, Vinay Negi, Sandeep Singh, Manish Kumar, Lalit Mohan

Abstract— This paper describes the calculation and simulation results of the Doppler effect on a mobile car with the help of constellation diagram for 8 PSK modulation when the mobile car experienced the Rayleigh fading. Here LMS Linear equalizer is used to optimize the Doppler effect when the mobile Car having speed 30 m/sec and the mobile car is assumed on freeway. The results are taken at three position of mobile car i.e. at an angle of 5° , 45° and 85° . The calculation and simulation results of the Doppler effect on a mobile car with the help of constellation diagram for 8 PSK modulation is simulated in MATLAB.

Index Terms— 8 PSK modulation, LMS Linear equalizer, Rayleigh fading, Doppler effect, constellation diagram..

1 INTRODUCTION

THE constellation diagram is a representation of a signal modulated by a digital modulation scheme such as quadrature amplitude modulation or phase-shift keying. It displays the signal as a two-dimensional scatter diagram in the complex plane at symbol sampling instants [1]. In a more abstract sense, it represents the possible symbols that may be selected by a given modulation scheme as points in the complex plane. Measured constellation diagrams can be used to recognize the type of interference and distortion in a signal.

By representing a transmitted symbol as a complex number and modulating a cosine and sine carrier signal with the real and imaginary parts (respectively), the symbol can be sent with two carriers on the same frequency. They are often referred to as quadrature carriers.

A coherent detector is able to independently demodulate these carriers. This principle of using two independently modulated carriers is the foundation of quadrature modulation. In pure phase modulation, the phase of the modulating symbol is the phase of the carrier itself [2].

As the symbols are represented as complex numbers, they can be visualized as points on the complex plane. The real and imaginary axes are often called the in phase, or I-axis and the quadrature, or Q-axis. Plotting several symbols in a scatter diagram produces the constellation diagram. The points on a constellation diagram are called constellation points. They are a set of modulation symbols which comprise the modulation alphabet.

Also a diagram of the ideal positions, signal space diagram, in a modulation scheme can be called a constellation diagram. In this sense the constellation is not a scatter diagram but a representation of the scheme itself. The example shown here is for 8-PSK, which has also been given a Gray coded bit assignment [3].

1.1 Interpretation

Upon reception of the signal, the demodulator examines the received symbol, which may have been corrupted by the channel or the receiver (e.g. additive white Gaussian noise, distortion, phase noise or interference). It selects, as its estimate of what was actually transmitted, that point on the con-

stellation diagram which is closest (in a Euclidean distance sense) to that of the received symbol.

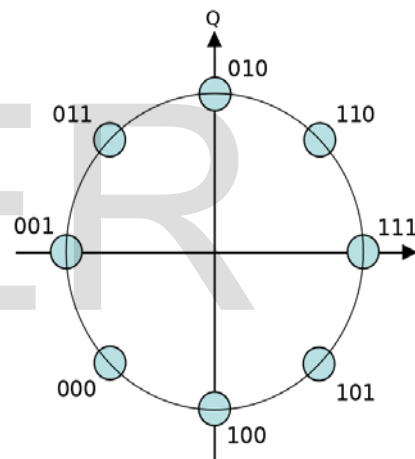


Fig.1 A constellation diagram for 8-PSK.

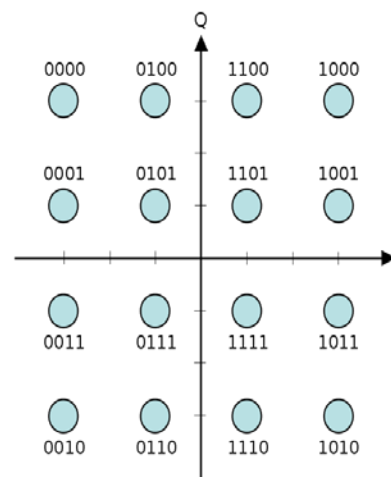


Fig.2 A constellation diagram for rect. 16-QAM.

Thus it will demodulate incorrectly if the corruption has caused the received symbol to move closer to another constellation point than the one transmitted.

This is maximum likelihood detection. The constellation diagram allows a straightforward visualization of this process imagine the received symbol as an arbitrary point in the I-Q plane and then decide that the transmitted symbol is whichever constellation point is closest to it.

For the purpose of analyzing received signal quality, some types of corruption are very evident in the constellation diagram. For example:

1. Gaussian noise shows as fuzzy constellation points
2. Non-coherent single frequency interference shows as circular constellation points
3. Phase noise shows as rotationally spreading constellation points
4. Attenuation causes the corner points to move towards the center.

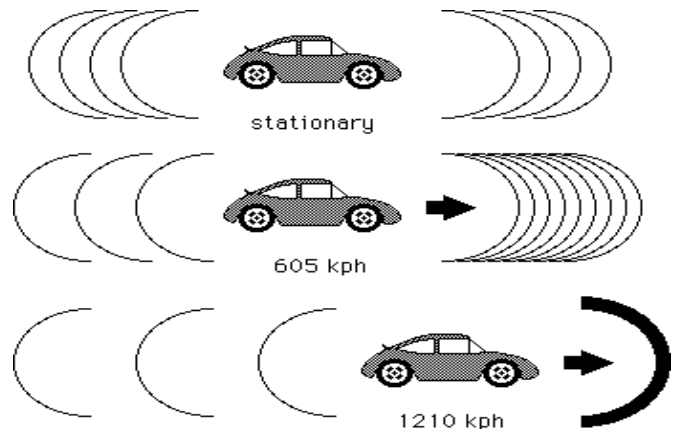
1.3 Doppler Effect

The Doppler Effect (or Doppler shift), is the change in frequency of a wave (or other periodic event) for an observer moving relative to its source. It is commonly heard when a vehicle sounding a siren or horn approaches, passes, and recedes from an observer. The received frequency is higher (compared to the emitted frequency) during the approach, it is identical at the instant of passing by, and it is lower during the recession [4].

The relative changes in frequency can be explained as follows. When the source of the waves is moving toward the observer, each successive wave crest is emitted from a position closer to the observer than the previous wave.

Therefore each wave takes slightly less time to reach the observer than the previous wave. Therefore the time between the arrivals of successive wave crests at the observer is reduced, causing an increase in the frequency. While they are travelling, the distance between successive wave fronts is reduced; so the waves "bunch together".

Conversely, if the source of waves is moving away from the observer, each wave is emitted from a position farther from the observer than the previous wave, so the arrival time between successive waves is increased, reducing the frequency. The distance between successive wave fronts is increased, so the waves "spread out".



The Doppler Effect for a Moving Sound Source

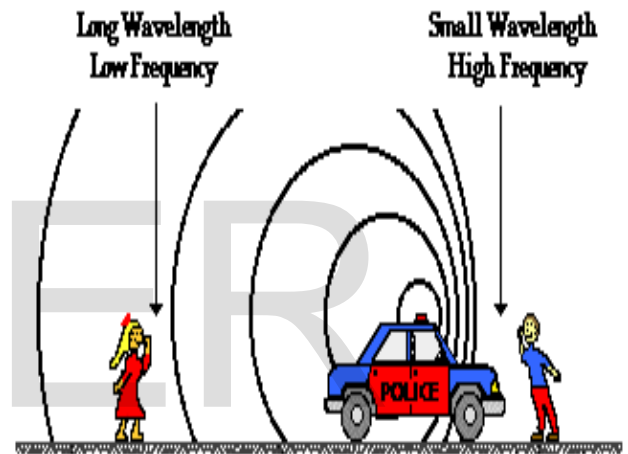


Fig.3 Doppler Effect

For waves that propagate in a medium, such as sound waves, the velocity of the observer and of the source is relative to the medium in which the waves are transmitted. The total Doppler Effect may therefore result from motion of the source, motion of the observer, or motion of the medium. Each of these effects is analyzed separately. For waves which do not require a medium, such as light or gravity in general relativity, only the relative difference in velocity between the observer and the source needs to be considered.

2 Mathematical Analysis

1) Phase change in Rx signal $(\Delta\phi) = 2\pi\Delta l / \lambda = (2\pi v \Delta t / \lambda) * \cos\theta$

2) Doppler shift $(fd) = \Delta\phi / 2\pi\Delta t = (v / \lambda) * \cos \theta = v fc / c * \cos \theta$

Table 1
 Mobile Car having speed 30m/sec on freeway (fd1)

Angle(θ) (Deg)	Gain(db)	fc(MHz)	fd1(Hz)	Velocity(v) m/sec
5	18	900	91.6	30.79
30	18	900	80	30.79
45	18	900	65.32	30.79
60	18	900	46.18	30.79
85	18	900	8.05	30.79
90	18	900	No doppler shift	30.79

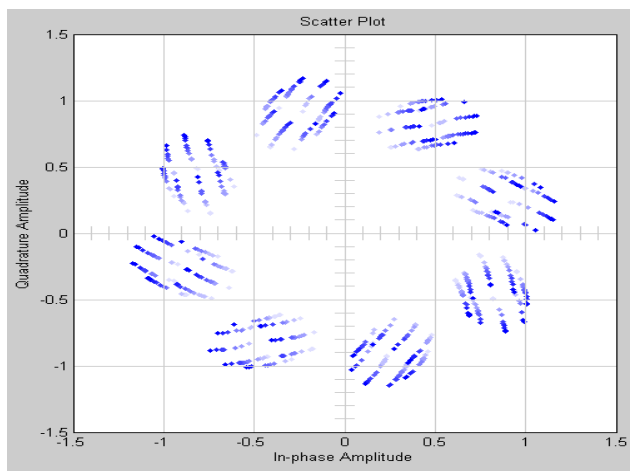


Fig.5 Mobile Car having speed 30m/sec on freeway for angle 5° (MPSK, M=8) without equalizer

Rayleigh fading is a reasonable model when there are many objects in the environment that scatter the radio signal before it arrives at the receiver. The central limit theorem holds that, if there is sufficiently much scatter, the channel impulse response will be well-modeled as a Gaussian process irrespective of the distribution of the individual components [5]. If there is no dominant component to the scatter, then such a process will have zero mean and phase evenly distributed between 0 and 2π radians. The envelope of the channel response will therefore be Rayleigh distributed.

3 Simulated Results

The constellation for the mobile Car having speed 30 m/sec and the mobile car is assumed on freeway at an angle of 5° , 45° and 85° is simulated in MATLAB for 8-PSK are shown in fig.4 to fig. 10.

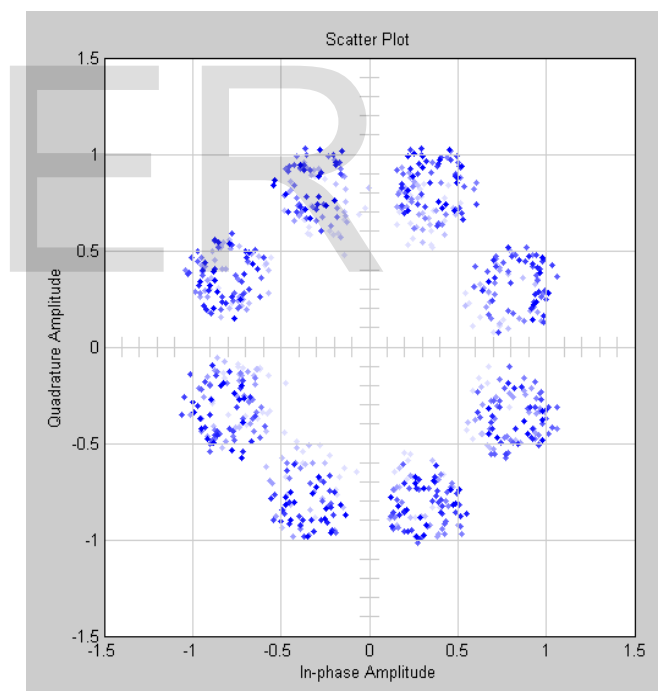


Fig.6 Mobile Car having speed 30m/sec on freeway for angle 5° (MPSK, M=8) with equalizer

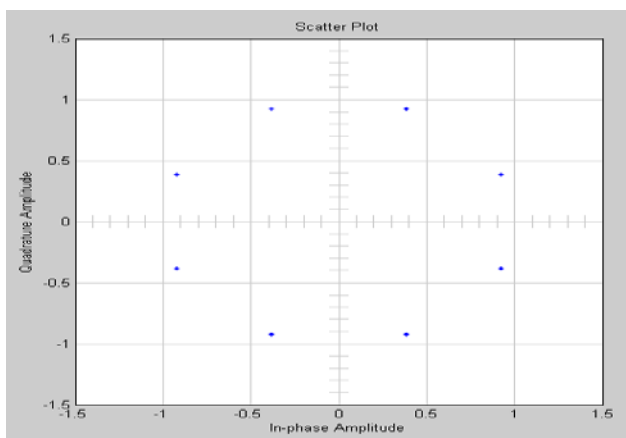


Fig.4 Constellation diagram of 8-PSK , No fading & dopper effect

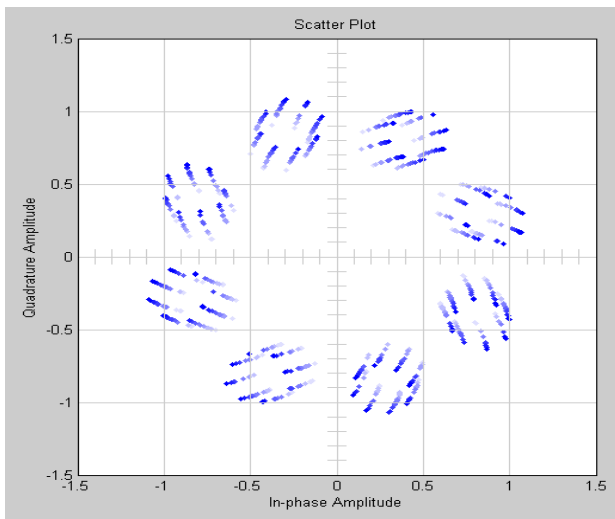


Fig.7 Mobile Car having speed 30m/sec on freeway for angle 45° (MPSK,M=8) without equalizer

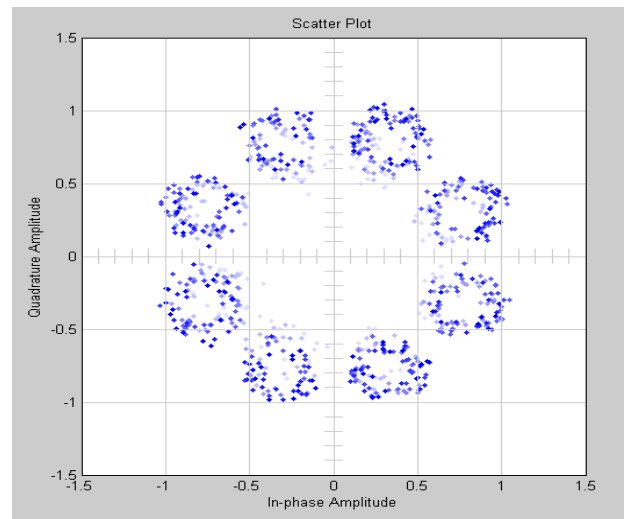


Fig.10 Mobile Car having speed 30m/sec on freeway for angle 85° (MPSK,M=8) with equalizer

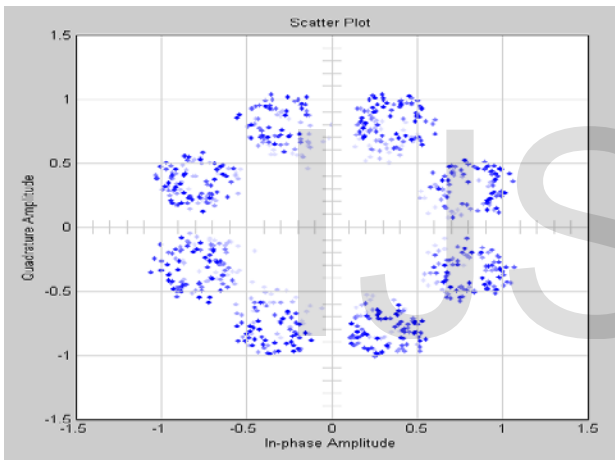


Fig.8 Mobile Car having speed 30m/sec on freeway for angle 45° (MPSK,M=8) with equalizer

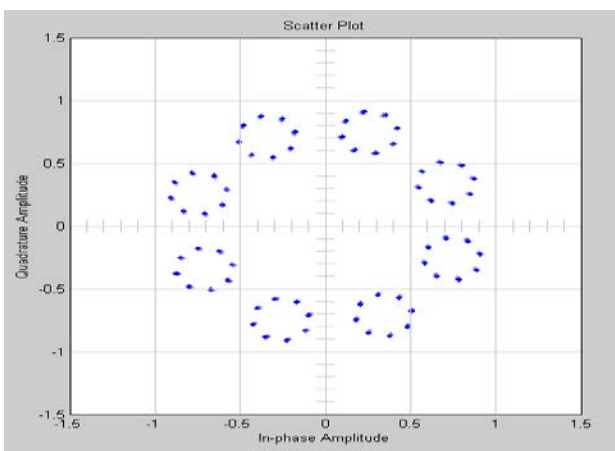


Fig.9 Mobile Car having speed 30m/sec on freeway for angle 85° (MPSK,M=8) without equalizer

4 CONCLUSION

This paper shows the calculation and simulation results of the Doppler effect on a mobile car with the help of constellation diagram for 8 PSK modulation when the mobile car experienced the Rayleigh fading. The LMS Linear equalizer is used to optimize the Doppler effect when the Mobile Car having speed 30 m/sec. and the mobile car is assumed on freeway. The results shows that the distorted constellation point because of Doppler effect when gain is taken 18 dB and carrier frequency is 900 MHz (i.e. U.S. digital cellular system) for each observation. And also the LMS Linear equalizer equalize those distorted constellation point for optimizing the Doppler effect for every 5°, 45° and 85°.

REFERENCES

- [1] BER Performance of Reed-Solomon Code Using M -ary FSK Modulation in AWGN Channel, *International Journal of Advances in Science and Technology*, Vol. 3, No.1, 2011.
- [2] Difference Threshold Test for M-FSK Signaling With Reed-Solomon Coding and Diversity Combining in Rayleigh Fading Channels, *IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY*, VOL. 54, NO. 3, MAY 20045.
- [3] Performance Analysis of Combined Transmit Selection Diversity and Receive Generalized Selection Combining in Rayleigh Fading Channels Xiaodong Cai, *Member, IEEE*, and Georgios B. Giannakis, *Fellow, IEEE*, *IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS*, VOL. 3, NO. 6, NOVEMBER 2004.
- [4] Bit-Error Probabilities of 2 and 4DPSK with Nonselective Rayleigh Fading, Diversity Reception, and Correlated Gaussian Interference, Pooi Yuen Kam, *IEEE TRANSACTIONS ON COMMUNICATIONS*, VOL. 45, NO. 4, APRIL 1997 .
- [5] T.S. Rappaport Wireless Communication. Prentice-hall, Upper Saddle River, N.J, 1996.