EQUALIZATION USING LMS LINEAR EQUALIZER FOR DOPPLER EFFECT USING M-ARY (M=2) PAM

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Abstract — ***This paper describes the calculation and simulation results of the Doppler effect on a mobile user while walking with the help of constellation diagram for 2 PAM modulation when the walking user experienced the Rayleigh fading. And the equalizer is used to optimize the Doppler effect. Here LMS Linear equalizer is used to optimize the Doppler effect when the walking user having speed 1.5 m/sec. and the walking user is assumed on freeway. The results are taken at three position of mobile user i.e. at an angle of 5^0,60^0 and 85^0 using MATLAB.***

***Index Terms* — 2 PAM modulation, LMS Linear equalizer, Rayleigh fading, Doppler effect, constellation diagram.**

1. Introduction

In a wireless mobile communication system due to multipath propagation there occurs rapid fluctuations in the amplitude, phases or angle of arrival of a radio signal referred to as multipath fading. The important effects are rapid changes in signal strength over a short travel distance or time interval, random frequency modulation due to varying Doppler shifts on different multipath signals, and time dispersion caused by multipath propagation delays.

Rayleigh fading is a statistical model for the effect of a propagation environment on a radio signal, such as that used by wireless devices. Rayleigh fading models assume that the magnitude of a signal that has passed through such a transmission medium will vary randomly, or fade, according to a Rayleigh distribution — the radial component of the sum of two uncorrelated Gaussian random variables. Rayleigh fading is viewed as a reasonable model for tropospheric and ionospheric signal propagation as well as the effect of heavily built-up urban environments on radio signals.[1][2] Rayleigh fading is most applicable when there is no dominant propagation along a line of sight between the transmitter and receiver. If there is a dominant line of sight, Rician fading may be more applicable.

2. Constellation Diagram

A 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. 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 [1].

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 [2]. In pure phase modulation, the phase of the modulating symbol is the phase of the carrier itself.

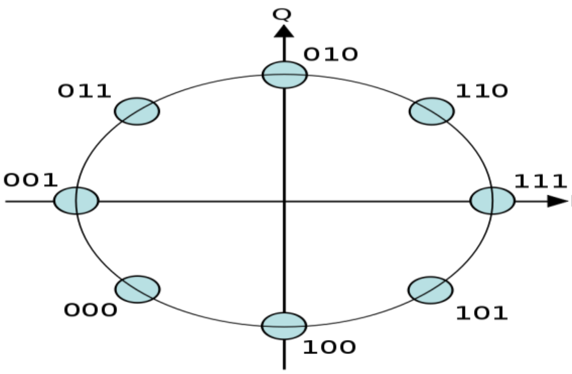


Figure 1 A constellation diagram for 8-PSK.

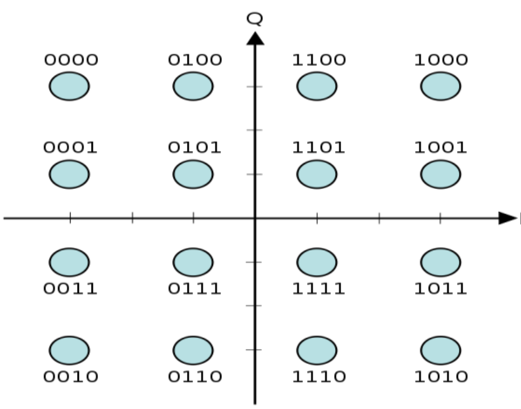


Figure 2 A constellation diagram for rect. 16-QAM.

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.

2. 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 constellation diagram which is closest (in a Euclidean distance sense) to that of the received symbol. Thus it will demodulate incorrectly if the corruption has caused the received symbol to move closer to another constellation point than the one transmitted [3].

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

3. Least Mean Square Algorithm

Introduced by Widrow and Hoff in 1959, LMS algorithm is an adaptive algorithm which uses a gradient based method of steepest descent. Least mean squares (LMS) algorithms are a class of adaptive filter used to mimic a desired filter by finding the filter coefficients that relate to producing the least mean squares of the error signal (difference between the desired and the actual signal). It is a stochastic gradient descent method in that the filter is only adapted based on the error at the current time. It incorporates an iterative procedure that makes successive corrections to the weight vector, w(n), in the direction of the negative of the gradient vector which eventually leads to the minimum mean square error.

The basic idea behind LMS filter is to approach the optimum filter weights by updating the filter weights in a manner to converge to the optimum filter weight. The algorithm starts by assuming a small weights (zero in most cases), and at each step, by finding the gradient of the mean square error, the weights are updated. That is, if the MSE-gradient is positive, it implies, the error would keep increasing positively, if the same weight is used for further iterations, which means we need to reduce the weights. In the same way, if the gradient is negative, we need to increase the weights. So, the basic weight update equation is :

$$W_{n+1} = W_n - \mu \Delta \varepsilon[n],$$

where ε represents the mean-square error. The negative sign indicates that, we need to change the weights in a direction opposite to that of the gradient slope.

The mean-square error, as a function of filter weights is a quadratic function which means it has only one extrema, that minimises the mean-square error, which is the optimal weight. The LMS thus, approaches towards this optimal weights by ascending/descending down the mean-square-error vs filter weight curve.

4. Pulse Amplitude Modulation

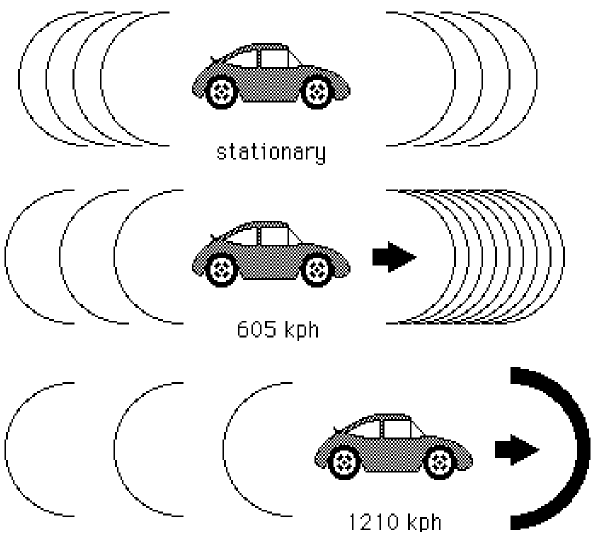
In PAM, in proportion to the corresponding sample values of a continuous message signal, the amplitudes of regularly spaced pulses are varied. These pulses can either be of rectangular form or some other appropriate shape. Pulse-amplitude modulation (PAM), is a form of signal modulation where the message information is encoded in the amplitude of a series of signal pulses. It is an analog pulse modulation scheme in which the amplitudes of a train of carrier pulses are varied according to the sample value of the message signal.

The signal is sampled at regular intervals and each sample is made proportional to the magnitude of the signal at the instant of sampling. These sampled pulses may then be sent either directly by a channel to the receiving end or may be made to modulated using a carrier wave before transmission. For the generation of a PAM signal we use a flat top type PAM scheme because during the transmission, the noise is interfered at top of the transmission pulse which can be easily removed if the PAM pulse in flat top.PAM is also useful for demodulation of PWM These are all come under pulse amplitude modulation..

4. 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.

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.



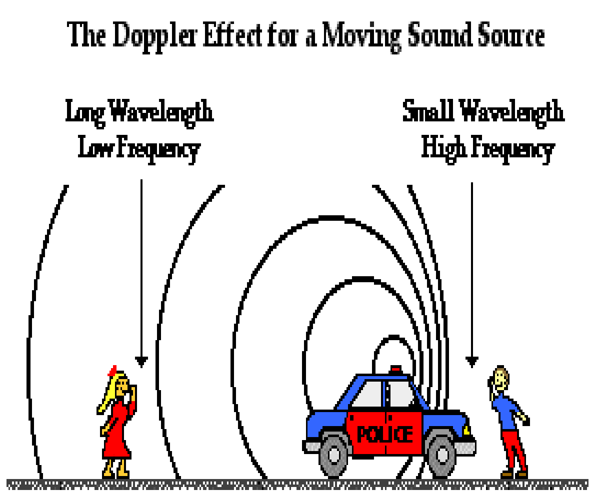


Figure 3 Doppler Effect

4. Mathematical Analysis for Simulation Results

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 1.1 Mobile user having Walking speed of 1.5 m/sec on freeway (fd2)

Angle(θ) (Deg)	Gain(db)	fc(MHz)	fd2(Hz)
5	18	900	4.62
30	18	900	4
45	18	900	3.28
60	18	900	2.32
85	18	900	0.40
90	18	900	No doppler shift

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-modelled as a Gaussian process irrespective of the distribution of the individual components. 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.

5. SIMULATED RESULTS

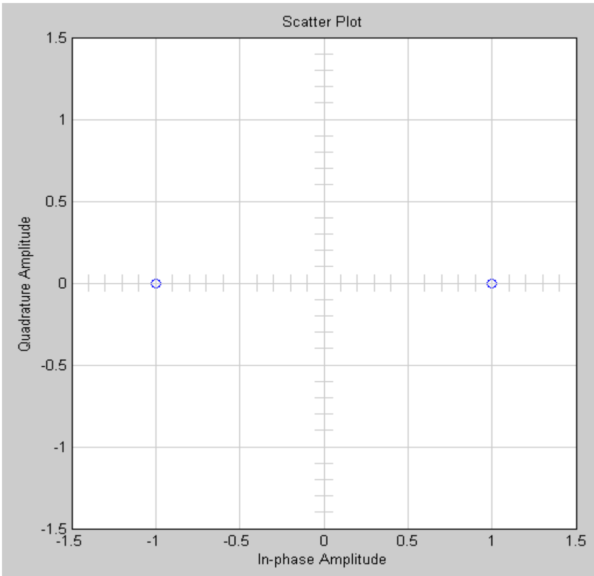


Figure 4 Constellation diagram of 2 PAM when mobile walking user is not experienced any fading & Doppler effect

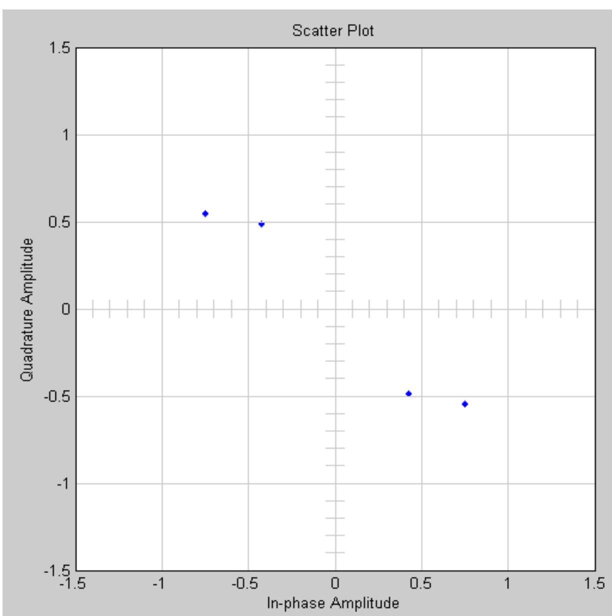


Figure 5 mobile walking user having speed 1.5 m/sec on freeway for angle 5° (2 PAM) without equalizer

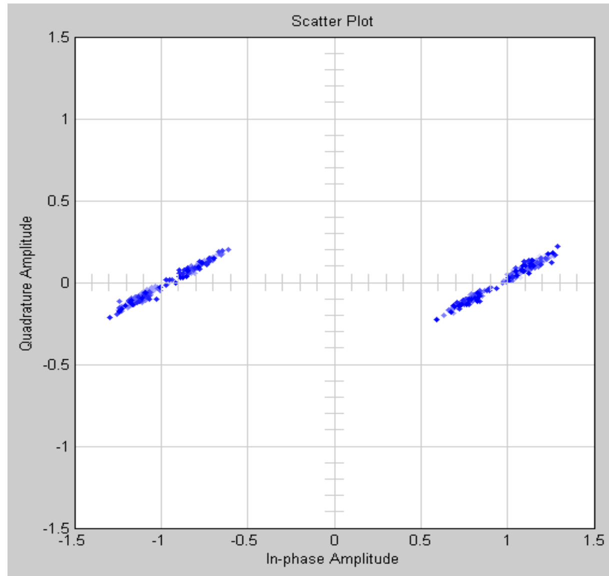


Figure 6 mobile walking user having speed 1.5 m/sec on freeway for angle 5° (2 PAM) with equalizer

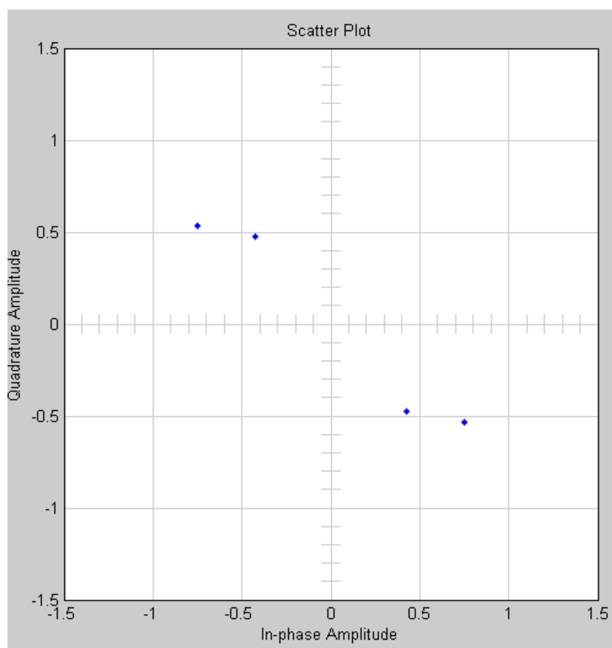


Figure 7 Mobile walking user having speed 1.5 m/sec on freeway for angle 60° (2 PAM) without equalizer

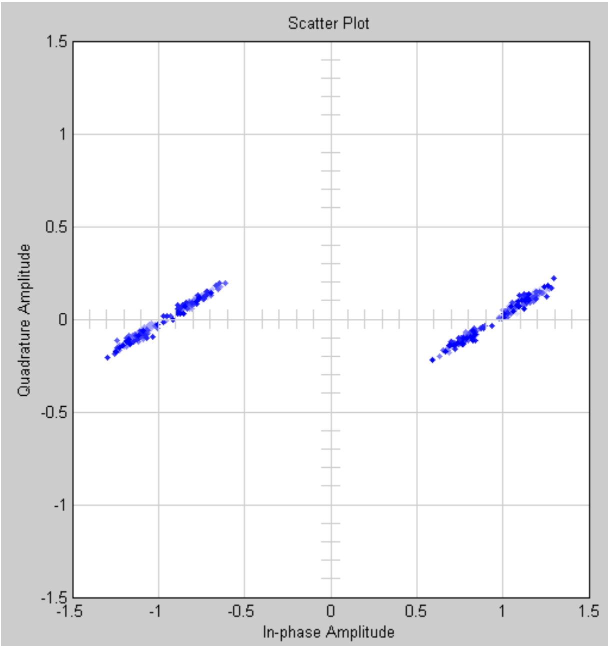


Figure 8 Mobile walking user having speed 1.5 m/sec on freeway for angle 60° (2 PAM) with equalizer

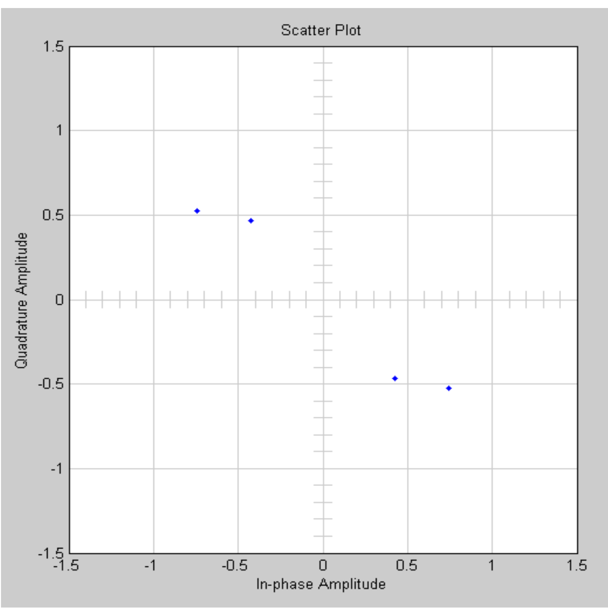


Figure 9 Mobile walking user having speed 1.5 m/sec on freeway for angle 85° (2 PAM) without equalizer

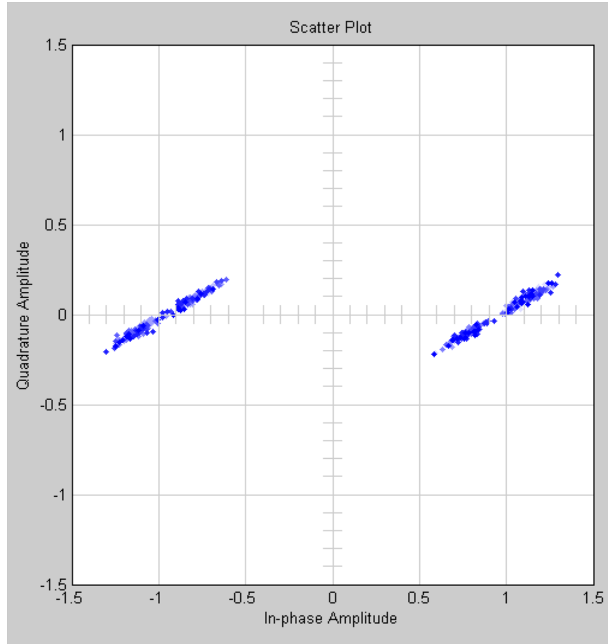


Figure 10 Mobile walking user having speed 1.5 m/sec on freeway for angle 85° (2 PAM) with equalizer

6. CONCLUSION

This paper shows the calculation and simulation results of the Doppler effect on a mobile walking user with the help of constellation diagram for 2 PAM modulation when the mobile walking user experienced the Rayleigh fading. And the LMS Linear equalizer is used to optimize the Doppler Effect. When the mobile walking user having speed 1.5 m/sec. and the mobile walking user 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 5^0,60^0 *and* 85^0**.**

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