At 900 MHz carrier frequency equalizing the Doppler effect in M-QAM at 18dB gain

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Abstract—This paper describes the calculation and simulation results of the Doppler effect on a mobile car with the help of constellation diagram for 4 QAM modulation when the mobile car 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 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 5^0,45^0 and 85^0.

Keywords: *4 QAM modulation*, *LMS Linear equalizer*, *Rayleigh fading, Doppler effect, constellation diagram.*
aper format, publish, template, sample

I. INTRODUCTION

A. *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.

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.

B. M-Ary Quadrature Amplitude Modulation

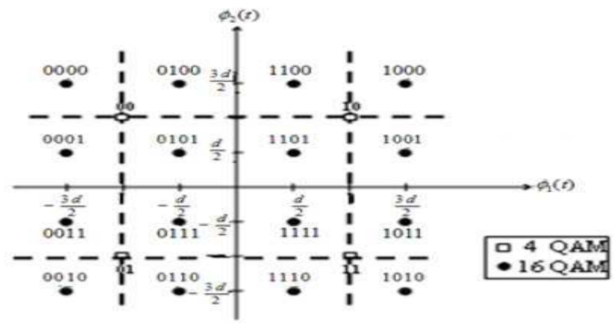

Fig.1. constellation diagram for 16 QAM

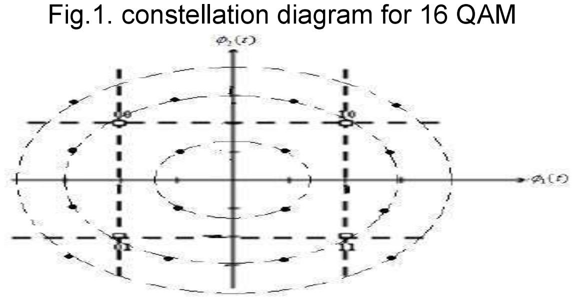

Fig.2. constellation diagram of 16-QAM with respective amplitude and phase

This constellation is known as square constellation. With an even number of bits per symbol, may have where L is a positive integer. Under this condition, an M-ary QAM square constellation can always be viewed as the Cartesian product of one dimensional M-ary PAM constellation with itself. Here L=4,so it is a figure of a Cartesian product of the 4-PAM constellation with itself. A few of the other constellations offer slightly better error performance, but with a much more complicated system implementation, like star constellation.

B. *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.

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

D. *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.

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".

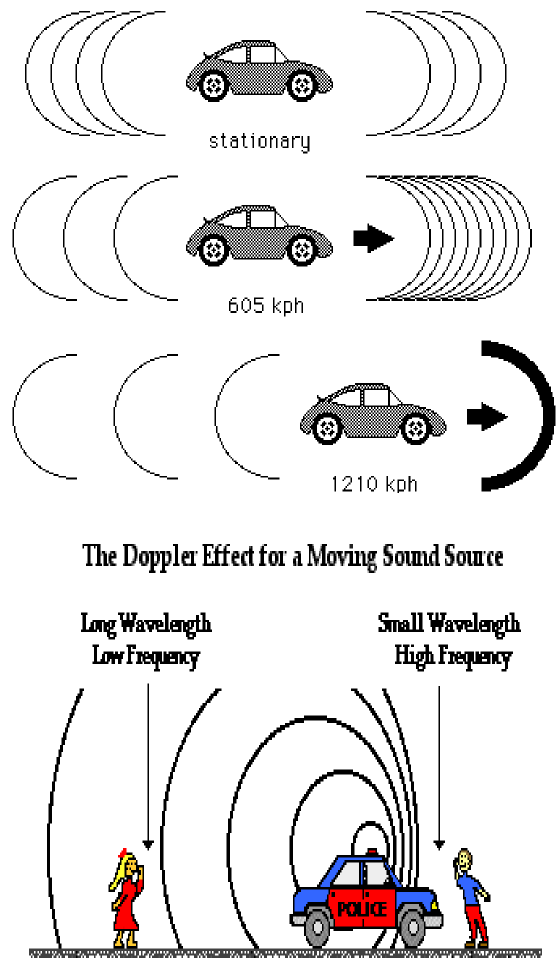

Fig.3. **Doppler Effect**

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.

II. 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 I 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

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

III. SIMULATED RESULTS

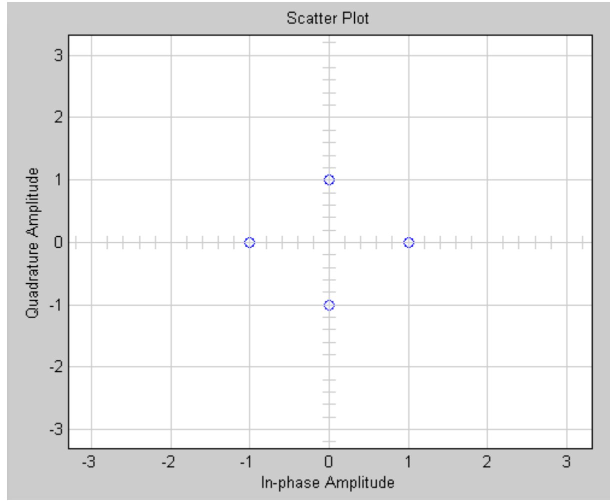

Fig.4. Constellation diagram of 4 QAM when mobile car is not experienced any fading & dopper effect

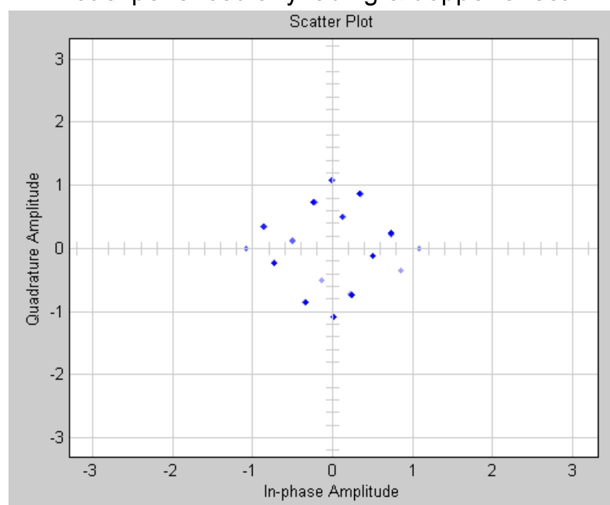

Fig.5. Mobile Car having speed 30m/sec on freeway for angle 5° (4 QAM) without equalizer

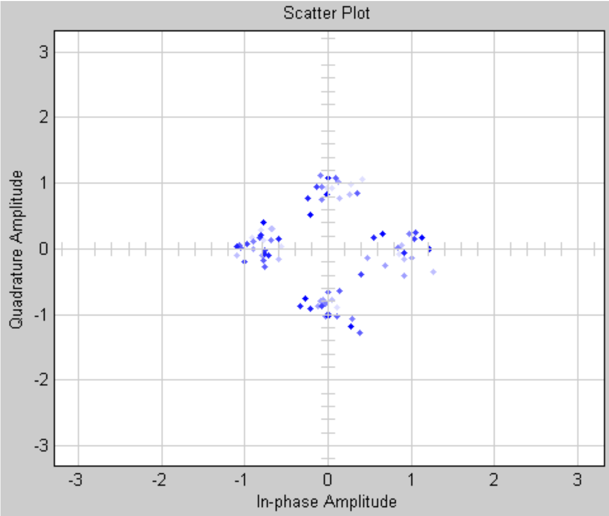

Fig.6. Mobile Car having speed 30m/sec on freeway for angle 5° (4 QAM) with equalizer

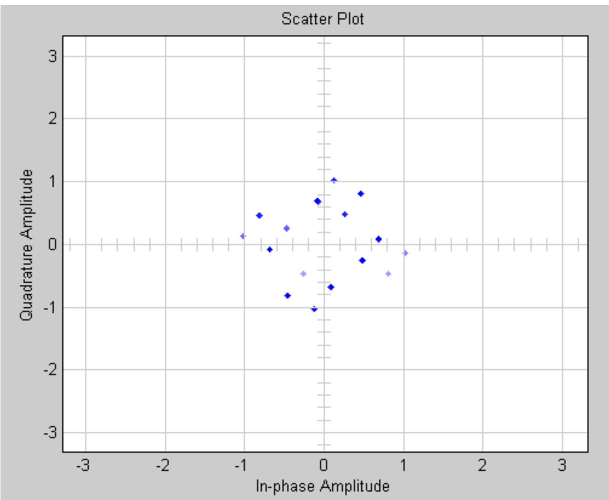

Fig.7. Mobile Car having speed 30m/sec on freeway for angle 45° (4 QAM) without equalizer

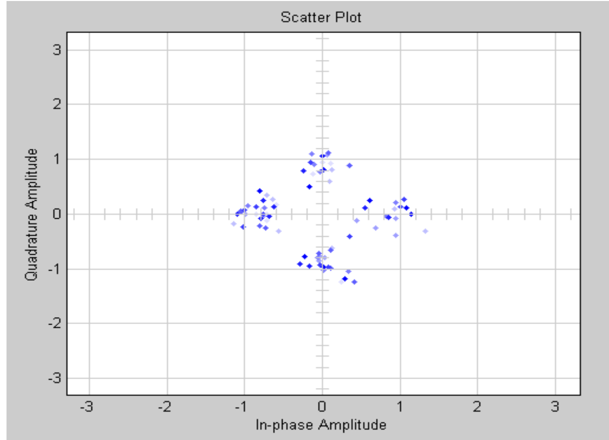

Fig.8. Mobile Car having speed 30m/sec on freeway for angle 45° (4 QAM) with equalizer

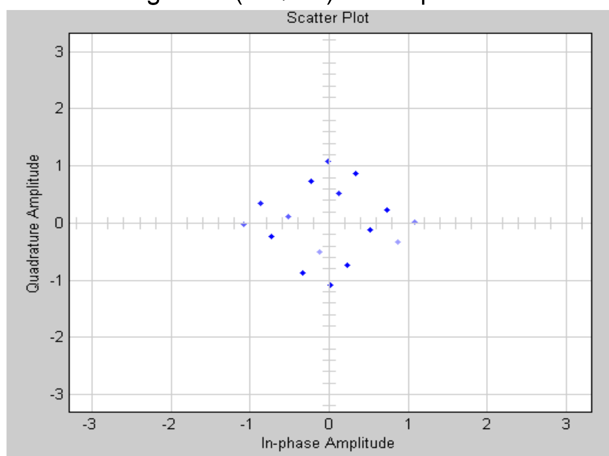

Fig.9. Mobile Car having speed 30m/sec on freeway for angle 85° (4 QAM) without equalizer

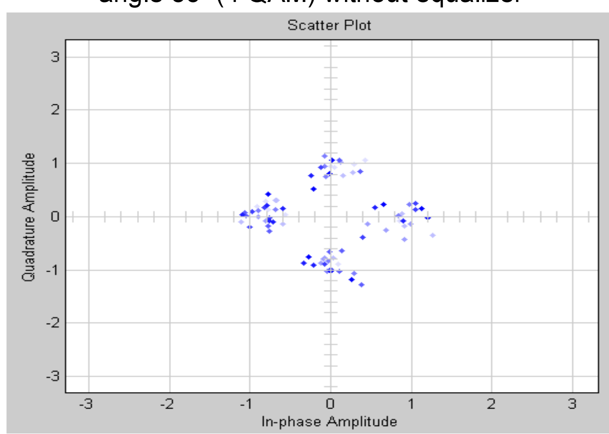

Fig.10. Mobile Car having speed 30m/sec on freeway for angle 85° (4 QAM) with equalizer

IV. CONCLUSION

This paper show the calculation and simulation results of the Doppler effect on a mobile car with the help of constellation diagram for 4 QAM modulation when the mobile car experienced the Rayleigh fading. And 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 constalletion point because of Doppler effect when gain is taken 18 dB and carrier frequency is 900 MHz (i.e. U.S. digital cellular syatem) for each observation. And also the LMS Linear equalizer equalize those distorted constellation point for optimizing the Doppler effect for every 5^0,45^0 *and* 85^0**.**

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