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QAM in Software Defined Radio for Vehicle Safety Application

MA Hannan, Muhammad Islam, S.A. Samad and A. Hussain

Department of Electrical, Electronic & Systems Engineering Faculty of Engineering, Universiti Kebangsaan Malaysia (UKM), 43600, Selangor, Malaysia.

Abstract: Automobiles crashes are becoming a source of increasing social concern, which instigates government bodies to impose stringent requirements on vehicle safety. The development of the embedded intelligent safety system (ISS) platform is a difficult task and involves many factors such as generation and interconnection of the hardware that support the execution of software. A Software Defined Radio (SDR) replaces the traditional fixed hardware radio with a system that may be reconfigured, both during operation to provide greater flexibility and by providing software upgrades to add new capabilities without requiring new hardware. SDR is computer based systems that emulate the behavior of traditional radio systems by processing digitized signals. Quadrature Amplitude Modulation (QAM) has fast become the dominant modulation mechanism for high speed digital signals. With increases in processing power, QAM as a part of SDR schema is now easily achievable. This paper is based on signal-space concepts to efficiently evaluate the performance of QAM schemes over an additive white Gaussian noise channel. This high order modulation technique is compared with respect to bit-error rate (BER) for vehicle safety.

Key words: Software Defined Radio, Vehicle Safety, Quadrature Amplitude Modulation, Bit-Error Rate.

INTRODUCTION

Automobile crashes cost billions each year and this does not include losses or defects due to fatalities and environmental effects .For that reason, crash data are being used to priorities functional performance objectives such as to provide collision warning and to extend driver's awareness of hazardous driving conditions using head-up display As a result, vehicle safety requirements for crash detection are gaining significant importance (Hannan *et al*., 2008; Hussain *et al.,* 2006). The public safety community shares this interest in Software Defined Radio (SDR), as exemplified by the formation of Public Safety Special Interest Group (PSSIG) within the SDR Forum in 2004 (Wang, *et al*., 2006).

A SDR is a radio whose function is defined by software, not by the design of the hardware. SDR provides radio users with much greater flexibility than is available from traditional hardware defined radio. When a new standard is developed, rather than replace the entire radio, only the software needs replacing (Islam et al., 2009). When two groups of people who normally use incompatible standards must work together, their radios could be loaded with software that allowed them to communicate with each other. Over the lifetime of a hardware design, new improved radio standards can be installed on the radio without requiring replacement hardware. SDR technology has been receiving considerable attention due to its potential benefits for addressing today's and future communications requirements (John *et al*., 2002).

Modern communication systems commonly use symmetric modulation schemes to transmit information across wireless channels. Modulated envelope, QAM signals are used to improve power efficiency, with added device cost for highly linear amplifiers. With standard QAM, symbols are positioned to form a square lattice in the complex plane. The constellation structures of these signals lend themselves to ambiguity in phase and are limited in their ability to adapt in dynamic environments (Liang et al., 2000).

Traditionally, the computation of the system BER of QAM scheme has been performed by either calculating the symbol error probability or simply estimating it using lower/upper bounds, or a combination of both (Sandeep et al., 1995; Tang *et al.,* 1999). This is because the exact analysis of the system BER is often complicated and usually results in nonclosed-form solutions which need to be evaluated numerically. However, the use of bounds cannot always guarantee sufficient accuracy, while the transformation from symbol

Corresponding Author: MA Hannan,Department of Electrical, Electronic & Systems Engineering Faculty of Engineering, Universiti Kebangsaan Malaysia (UKM), 43600, Selangor, Malaysia.

error rate to BER is in general not straightforward (Vitthaladevuni *et al.,* 2005; Markus *et al.,* 2009).

In this paper, we introduce a simple approach that is based on vehicle safety to evaluate the performance of QAM schemes over an additive white Gaussian noise channel. In particular, new bit error rate approximations shown to be in excellent results.

Methodology:

A communication link shown in Figure 1 consists of three components: the transmitter, the channel, and the receiver. The transmitter element processes an information signal in order to produce a signal most likely to pass reliably and efficiently through the channel. This usually involves coding of the information signal to help correct for transmission errors, filtering of the signal to constrain the occupied bandwidth and modulation of a carrier signal by the information signal to overcome channel losses. The transmission channel is defined as the propagating medium or electromagnetic path between source and destination, for example cable, optical fiber, or atmosphere. The channel, in wireless communication, is the atmosphere which may add attenuation, delay, distortion, interference, and noise to the transmitted signal. The receiver function is principally to reverse the modulation processing of the transmitter in order to recover the transmitted information signal, and attempts to compensate for any signal degradation introduced by the channel. This will normally involve, filtering, demodulation, and in general is a more complex task than the transmit process.

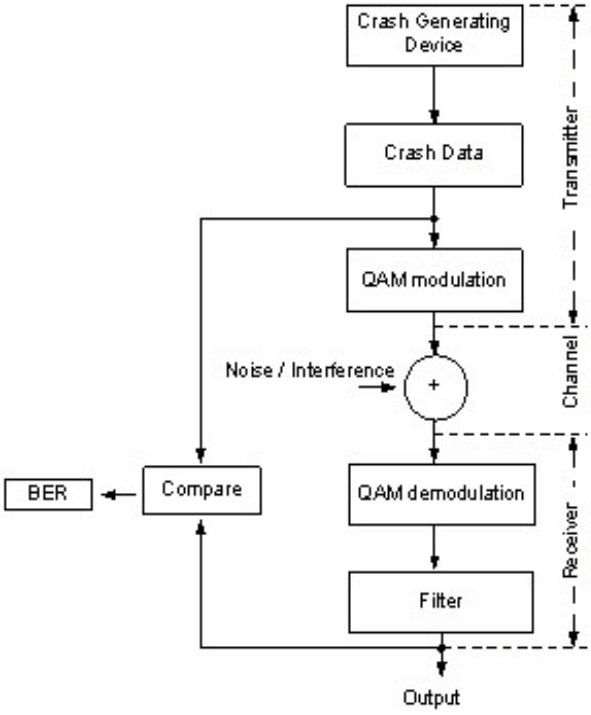

Fig. 1: Communication Link of Software Defined Radio.

A. Digital Modulation:

In digital modulation, the information signals, whether audio, video, or data, all are digital. As a result, the digital information modulates an analog sinusoidal waveform carrier. The sinusoid has just three features that can be modified to carry the information: amplitude, frequency, and phase.

If the amplitude, frequency, or phase of the carrier is altered by the digital information, then the modulation scheme is called amplitude shift keying (ASK), frequency shift keying (FSK), or phase shift keying (PSK), respectively.

Before Modulation the crash generating device generate data as shown in Figure 2. Modulation is the process where generating data amplitude, frequency, or phase is changed in order to transmit crash data. QAM digital modulations is used in this paper for communication.

B. Quadrature Amplitude Modulation (QAM):

QAM is a method for sending two separate (and uniquely different) channels of information. The carrier is shifted to create two carriers namely the sine and cosine versions. The outputs of both modulators are algebraically summed, the results of which is a single signal to be transmitted, containing the In-phase (I) and Quadrature (Q) information. The set of possible combinations of amplitudes, as shown on an x-y plot, is a pattern of dots known as a QAM constellation as shown in Figure 2.

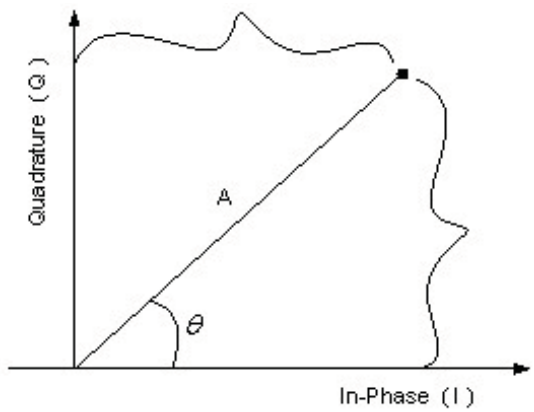

Fig. 2: IQ Constellation Diagram

Channel:

The channel is the propagating medium or electromagnetic path connecting the transmitter and the receiver. For a wireless channel, the characteristics are typically determined by the specific geography, atmospheric effects, objects in the channel, multipath effects, etc. The transmitter and receiver in this research are assumed to be fixed and communicate under line of sight (LOS) conditions, which means the transmitter and receiver are not moving and have a direct, unobstructed view of one another.

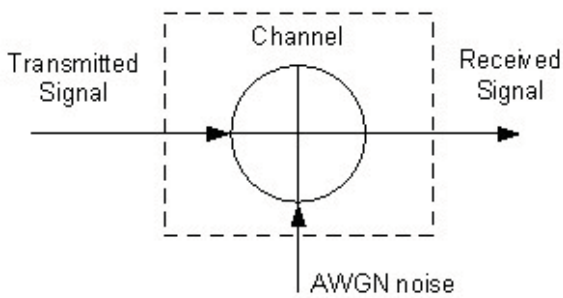

Fig. 3: AWGN channel model.

A reasonable assumption for a fixed, LOS wireless channel is the additive white Gaussian noise (AWGN) channel, which is flat and not "frequency-selective" as in the case of the fading channel. Particularly fast, deep frequency-selective fading as often observed in mobile communications is not considered in this paper, since the transmitter and receiver are both fixed. This type of channel delays the signal and corrupts it with AWGN. The AWGN is assumed to have a constant PSD over the channel bandwidth, and a Gaussian amplitude probability density function. This Gaussian noise is added to the transmitted signal prior to the reception at the receiver as shown in Figure 3.

It can be seen from Figure 4 that the noise causes symbols to "scatter" around the ideal constellation points. Since Gaussian noise samples are independent, the effect on the detection process of a channel with AWGN is that the noise affects each transmitted symbol independently.

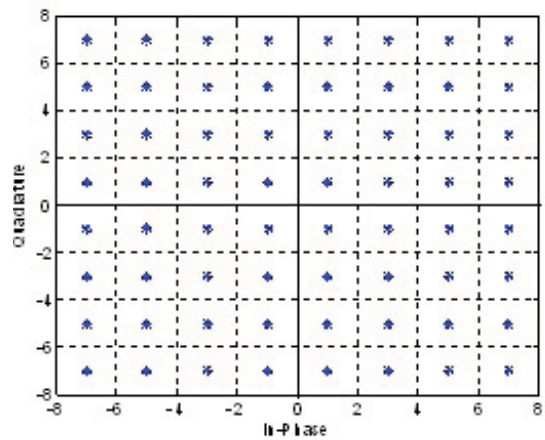

Fig. 4: The Scatter Plot of 16-QAM Signal Corrupted by AWGN

Demodulation:

Since the information is carried in the phase and amplitude of the modulated carrier for the QAM signal, the receiver is assumed to be able to generate a reference carrier whose frequency and phase are identical to those of the carrier at the transmitter. When the receiver exploits knowledge of the carrier's phase to detect the signals, the process is called coherent demodulation/detection. The out of the demodulation is passed through a lowpass filter (LPF). The LPF removes the high-frequency components. These LPFs also perform as matched filters whose impulse responses are matched to the transmitted signal to provide the maximum signal-to-noise ratio (SNR) at their output. Then demodulation decides which of the possible signal waveforms was transmitted from the output of the LPFs.

RESULTS AND DISCUSSION

The vehicle crash data obtained from crash generating device, is shown in Figure 5. Using software defined radio described above; we run several simulations to compare the performance. The input signal is modulated before passing the channel. When the signal passed to the channel, noises from various sources are interference the input signal. A simple filter is required to remove atmosphere noise. The accuracy of the software defined radio is shown in Figure 6. In the interest of verifying the usefulness of the above method, we compare the analytical results, which are obtained through the use of the developed BER expressions, which are indicate the exact BER performance of QAM is shown in Figure 7.

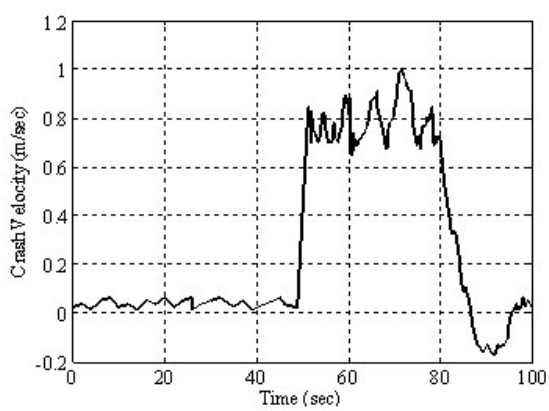

Fig. 5: Vehicle Crash Input Data.

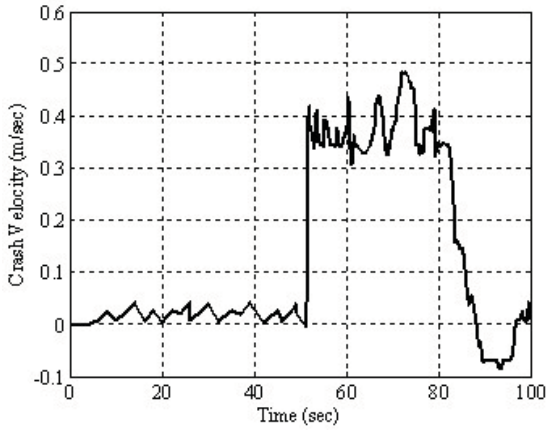

Fig. 6: Output Data using Software Defined Radio.

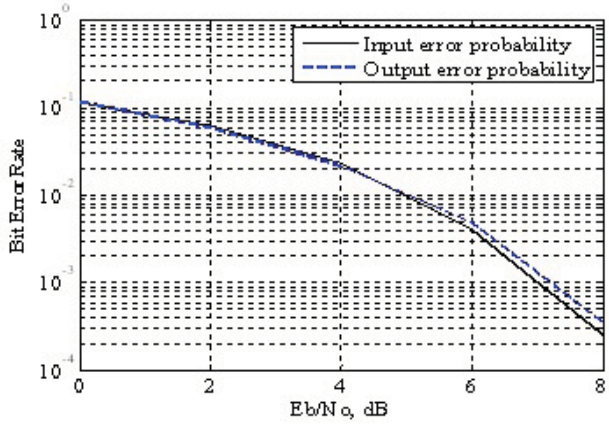

Fig. 7: BER Performance of Software Defined Radio

Conclusion:

In this paper a SDR based vehicle safety is designed. The system has been designed for the QAM modulation only because the simplicity of the hardware used for the safety devices. In general, the system's data transmission ability is approximately 95 percent and above for SNR greater than 8 dB. Hence the performance of the system is quite accurate in terms of SNR versus BER. Thus it can be concluded that SDR can provide enough security to the vehicle without any hardware complexity, increased error rate and bandwidth.

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