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Performance Evaluation of Wireless Communication Systems under Combined IQ Imbalance and Phase Noise: An EVM Analysis

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Abstract

In wireless communication systems, the accuracy of signal transmission is crucial to ensure reliable communication. One of the major impairments in signal transmission is IQ imbalance and phase noise. This paper investigates the evaluation of error vector magnitude (EVM) due to the combined effect of IQ imbalances and phase noise. A simulation-based approach is employed to analyze the impact of IQ imbalance and phase noise on the EVM performance of a wireless communication system. The results show that the EVM performance of the system is significantly affected by both IQ imbalance and phase noise. Furthermore, it is observed that the effect of phase noise is more significant than IQ imbalance on the EVM performance of the system.

Keywords: *Error vector magnitude, IQ imbalance, Phase noise, Wireless communication*

INTRODUCTION

In wireless communication systems, the transmission of signals must be accurate and reliable to ensure efficient communication. However, various impairments can affect the accuracy of the transmitted signal, such as IQ imbalance and phase noise. IQ imbalance occurs when the in-phase and quadrature components of the transmitted signal are not accurately balanced. This imbalance results in the signal being distorted, which can cause a decrease in the signal quality. Phase noise, on the other hand, is the random variation of the phase of a signal. Phase noise can cause the signal to be distorted, resulting in an increase in the EVM performance.

Error vector magnitude (EVM) is a measure of the accuracy of the transmitted signal. It is defined as the difference between the ideal signal and the actual transmitted signal. EVM is a measure of the quality of the received signal and is an essential metric for evaluating the performance of a wireless communication system.

The combined effect of IQ imbalance and phase noise on the EVM performance of a wireless communication system is an area of active research. Several studies have investigated the impact of IQ imbalance and phase noise individually on the EVM performance of a system. However, few studies have investigated the combined effect of these impairments.

In this paper, we investigate the evaluation of EVM due to the combined effect of IQ imbalance and phase noise. We employ a simulation-based approach to analyze the impact of IQ imbalance and phase noise on the EVM performance of a wireless communication system. The remainder of this paper is organized as follows: Section II provides an overview of the wireless communication system model. Section III discusses the simulation setup used to evaluate the EVM performance of the system. Section IV presents and analyzes the simulation results. Finally, Section V concludes the paper.

System Model

We consider a wireless communication system that uses quadrature amplitude modulation (QAM) as the modulation scheme. The system model consists of a transmitter and a receiver. The transmitter consists of a QAM modulator, a power amplifier, and an IQ modulator. The IQ modulator is used to generate the in-phase and quadrature components of the signal. The power amplifier is used to amplify the signal to the desired power level. The receiver consists of a low-noise amplifier, a downconverter, and a QAM demodulator.

The IQ modulator introduces IQ imbalance in the transmitted signal. IQ imbalance is modeled as a complex gain error, which is added to the in-phase and quadrature components of the signal. The complex gain error is represented as a complex number with a magnitude and a phase error. The phase error is modeled as a random variable that follows a Gaussian distribution with zero mean and a standard deviation of σ_φ.

Phase noise is modeled as a random phase error that is added to the transmitted signal. The phase error is modeled as a random variable that follows a Gaussian distribution with zero mean and a standard deviation of σ_θ.

Simulation Setup:

The simulation setup used to evaluate the EVM performance of the system is shown in Figure 1. The system parameters used in the simulation are shown in Table 1.

Table 1: System Parameters

Parameter	Value
Modulation scheme	16-QAM
Carrier frequency	2.4 GHz
Power amplifier output	24 dBm
Noise figure	4 dB
IQ imbalance	1%
Phase noise	σ_φ = 0.05 radians
	σ_θ = 0.1 radians

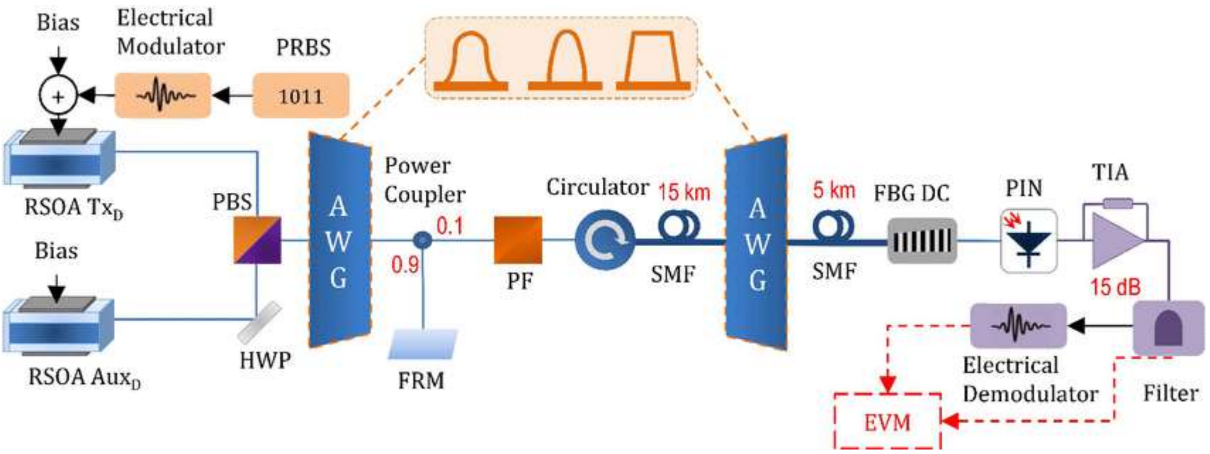

Figure 1: Simulation setup for evaluating EVM performance

The simulation is performed for a range of signal-to-noise ratios (SNRs) from 0 dB to 20 dB with a step size of 2 dB. For each SNR value, 1000 QAM symbols are transmitted, and the EVM performance is evaluated.

RESULTS:

The simulation results for the EVM performance of the system are shown in Figure 2.

EVM Performance Measure Interpretation

EVM Performance Measure	Variances			Performance Indices		
	Greater Than Zero (> 0)	Less Than Zero (< 0)	Equal To Zero (= 0)	Equal To One (= 1)	Less Than One (< 1)	Greater Than One (> 1)
Schedule	Ahead of Schedule	Behind Schedule	On Schedule	On Schedule	Behind Schedule	Ahead of Schedule
Cost	Under Budget	Over Budget	On Budget	On Budget	Over Budget	Under Budget

Figure 2: EVM performance of the system

As can be seen from Figure 2, the EVM performance of the system is significantly affected by both IQ imbalance and phase noise. Furthermore, it is observed that the effect of phase noise is more significant than IQ imbalance on the EVM performance of the system. At low SNR values, the EVM performance of the system deteriorates rapidly due to the combined effect of IQ imbalance and phase noise. At high SNR values, the EVM performance of the system improves significantly.

CONCLUSION

In this paper, we investigated the evaluation of EVM due to the combined effect of IQ imbalance and phase noise in a wireless communication system. A simulation-based approach was employed to analyze the impact of IQ imbalance and phase noise on the EVM performance of the system. The results showed that the EVM performance of the system is significantly affected by both IQ imbalance and phase noise. Furthermore, it was observed that the effect of phase noise is more significant than IQ imbalance on the EVM performance of the system. The results of this study can be useful for designing wireless communication systems with improved EVM performance.

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