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Enhancement of GSC Using OFDM and QAM Over Reiyleign Fading Channel: A Review

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

As indispensable as communication has been to human endeavors, geographical and physical distance would have been a barrier to its effective deployment if not for the advent of wireless mobile communication. In the world today, most of the developments we see in all spheres of our modern life are influenced by communication technologies. However, the performance of each modulation scheme deployed in the communication system dictates the Quality of Service (QoS), effective cost management, efficient power, available bandwidth, Bit Error Rate (BER), and Signal to Noise Ratio (SNR). Extensive research has been done with different authors proffering wide-ranging solutions for generalized selection combining (GSC) algorithms in the presence of noise and interfering signals. Some of the reported approaches include varying modulation schemes, changing the channel, and using different equalizing techniques. Many of these proposed solutions worked effectively in some areas while they understandably left other areas untouched, others show better performance by analyzing the channel using; Log-likelihood Ratio (LLR), integral expression, and multiple-mode transmission scheme which in turns proof to be of better performance with a good result. Despite all the efforts, overcoming the issue of noise interference in the communication

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channel has still been somewhat elusive. Conclusively, to reduce noise to the barest minimum in mobile/cellular communication, this review proposes modulation scheme synchronization with combined diversity technique over an improved channel that is less prone to noise.

Keywords: Generalized Selection Combining (GSC); Orthogonal Frequency-Division Multiplexing (OFDM); Bit Error Rate (BER); Quadrature Amplitude Modulation (QAM).

1 INTRODUCTION

An efficient communication system is the main criterion for the evolution and improvement of the world at large. Without this technology, the world would be negatively impacted. An electrical communication system involves the processing, sending, and receiving of information by electrical means. This system encompasses three basic stages which are the source (transmitter), the medium (channel), and the destination (receiver). Each stage is characterized by various processing techniques of the information signal. The processes at the transmitting end are sampling (which involves obtaining samples of the analogously varying signal), quantization (breaking the analogously varying signal into a set of discrete values), encoding (representation of information in bits of ones and zeros), and modulation (transforming the information into suitable signal waveforms that can be carried in the channel dedicated for communication. However, since mobile communication uses electromagnetic waves for information transmission from one point to the other, it is therefore faced with the challenge of multipath propagation. Multipath propagation is a phenomenon whereby a transmitted signal is split (either by atmospheric ducting, ionospheric reflection, or objects on earth surface such as high hills and skyscrapers buildings) into several signals causing the split signals to take different paths hence reaching the receiving antenna separately at different time delay so also accompanied by channel noise. As a result of this phenomenon and several other time-varying impairments such as noise, interference, etc. There is variability in the signal received.

As good and advantageous wireless communication is to the world at large, noise and interference pose a major problem to achieve better performance in communication network at large, which in turns reduce Quality of Service. Several methods have been proposed by different authors to tackle noise and interference. Some of the techniques are varying modulation schemes, changing channels, and using different equalizing techniques. In the comparative analysis of digital modulation techniques in 4G systems, ([1]) proposed a modulation scheme variation to select a scheme that is less prone to noise. In ([2]), the BER performance of OFDM system over correlated Nakagami-m fading channel using maximal - combing diversity at the receiver was analytically evaluated. The result showed that the received signals are correlated when the antennas are closely spaced and that more than two MRC (M ¿ 2) considered at receiver gives a better BER performance of the OFDM system. In the performance analysis of OFDM based cooperative communication over Nakagami fading channel, ([3]) derives the carrier to noise interference ratio (CNIR) and average bit error rate (BER) for OFDM based amplify and forward (AF) and decode and forward (DF) scheme over Nakagami fading channel.

However, all techniques mentioned above proved abortive since they cannot provide a lasting solution to noise and interference in the communication network. This review, therefore, reveals different techniques that are available in the open literature. Different methods used in mitigating these effects in other to attain a good performance of the signal at the receiver are logically discussed to know the problems solved and area of limitation.

2 NOISE AND INTERFERENCE

2.1 Noise

One of the major disturbances against useful information signals in the communication system is noise. This noise can be natural or man-made, it is the aggregate of unwanted or any form of disturbing energy. Examples are (SNR) signal-to-noise ratio,(SIR) signal-to-interference. Noise and interference are two different things in communication, noise is not also the same thing as distortion. Distortion is unwanted systematic signal waveform alteration by the communication equipment. Examples are (SINAD) signal-to-noise and distortion ratio and (THD+N) Total harmonic distortion plus noise, ([4, 5]). The various categories of noise are discussed below.

2.1.1 Thermal noise

One of the unavoidable random motion thermal electron charge carriers that generated noise in an electrical conductor irrespective of the applied voltage is thermal noise. The power spectral density of thermal noise is approximately equal all through the frequency spectrum which makes it to be regarded as white, and a communication system that thermal noise effect is modeled as Additive White Gaussian noise channel (AWGN), since the amplitude of is almost Gaussian probability density function.

2.1.2 Flicker noise

When a frequency spectrum of a signal or process falls off steadily into higher frequencies, with a pink spectrum is known as flickers noise, this occurs in practically all electronic device as a result from diversity effects.

2.1.3 Burst noise

At casual and irregular times, sudden step-like transitions between two or more discrete voltage or current levels, of high as many as a hundred microvolts are known as burst noise. The current/voltage offset shift lasts for some milliseconds to seconds. The popping sound produced in the audio circuit makes it also be known as popcorn noise ([6]).

2.1.4 Transit-Time Noise

If the time required for an electron to move from emitter to collector in a transistor can be compared to the time it is required for a signal to be amplified with a very high frequency above, there will be a decrease in noise input impedance of the transistor and the transit time effect will take place. There is an increase in frequency compared to the frequency at which the effect becomes noticeable and this rapidly takes over the other sources of noise.

2.1.5 Coupled noise

Some noise may be generated in the electronic circuit, and other noise energy might be from outside environment coupled inside the circuit either by the capacitive or inductive coupling or via the antenna of the receiver radio.

2.1.6 Intermodulation noise

When a non-linear medium is being shared by signals of different frequencies then an intermodulation noise is experienced. There are several categories of intermodulation noise, they are:

1. Crosstalk: This occurs when there is undesired interference from a transmitted signal from one channel or circuit against another signal in another channel or circuit.
2. Atmospheric noise: This is a natural form of noise caused by lightning discharge in a thunderstorm and electrical disturbance that occur naturally. It is also known as static noise ([7]).
3. Industrial Noise: These are majorly caused by any form of industrial operation, discharge from fluorescent lamps and high voltage wires also cause industrial noise.
4. Solar noise: This is the form of noise that originates from the sun, due to the solar cycle there is variability in the intensity of solar noise over time, though under the normal condition there is constant radiation from the sun due to its high temperature. Additional noise can be experienced through electrical disturbances such as corona discharge, as well as sunspots.

5. Cosmic Noise: Noise generated by a distant star is known as cosmic noise; the stars when too far away can individually affect the terrestrial communication system, but their large number collectively cause appreciable effects. Cosmic noise is in the frequency range of 8 MHz-1.43 GHz which is about 21 cm hydrogen lines. It is the strongest noise aside from man-made noise with a component range of about 20 -120 MHz.

2.2 Interference

Any form of disruptive modification effect on a signal in telecommunication as it travels from source to receiver is known as interference, it can also be referred to as an additional unwanted signal to a useful signal. Common examples are cross-talk or co-channel interference (CCI), Inter-symbol interference (ISI), Adjacent-channel interference (ACI), Inter-carrier interference (ICI), caused by Doppler shift in modulating OFDM (multi-tone modulation) Electromagnetic interference (EMI) Common mode interference (CMI) Conducted interference (CI) ([8]).

3 NOISE REDUCTION TECHNIQUES

3.1 Varying Modulation Scheme Solution

An OFDM simulation model using the interactive environment of Matlab/Simulink tool allows studying the OFDM system and it can be enlarged easily because of the modular structure. Using this model, the OFDM system performance is analyzed for the duo typical digital modulation techniques, namely M-ary Phase Shift Keying (PSK) and M-ary Quadrature Amplitude Modulation (QAM). The results obtained for BER versus SNR graphs confirm low BER values for a larger value of SNR, as expected. It is also observed that although spectrum efficiency increases due to the high value of M, these modulation schemes are easily affected by noise and there is no diversity technique considered at the receiving end to mitigate against noise. Thus, OFDM systems having high M-ary modulation schemes may be used for great capacity application but with the rate of an increase in BER ([9, 10]). The OFDM system performance under the Rayleigh fading channel has also been considered. Simulation results show that the receiver requires channel estimation and equalizing blocks, with a cost of complexity, for satisfactory performance. In the Simulink model proposed, according to actual needs, a suitable channel estimation algorithm can be added. Although this will increase the complexity, preferring the LMMSE estimator is advised because there is a great degradation in the performance of the receiver especially under the 5-tap Rayleigh channel and it will provide better performance ([11]). Authors in ([12]) employed Rayleigh Channel as a medium of transmission while analyzing the Bit Error Rate (BER) of three dissimilar Digital Modulation Techniques in an OFDM System BPSK, QPSK, and QAM. The model was designed using MATLAB/SIMULINK block. The simulation of the BPSK has lower BER values followed by the QPSK and QAM. Conclusively, the binary scheme of BPSK is better of as compared to the M-ary scheme of QPSK and QAM as shown in Table 1.

3.2 Analysis Using Different Equalizing Technique

Correlated Nakagami-m fading channel system has been analyzed with OFDM system using maximal ratio combining (MRC) diversity at the receiver. A closely spaced antenna at the receiver gives correlated received signals which cannot be independently considered. ([2]) used a novel approach for BER analysis of correlated Nakagami-m fading channel l and OFDM system using maximal - combing diversity at the receiver as shown in Table 1.

Table 1. Summary of Reviewed Works on Noise Reduction Techniques

[9]	The BER Performance of OFDM System in Rayleigh Fading Channel Using Cyclic Prefix	The research focused on the use MATLAB software in analyzing the performance of OFDM scheme simulation technique under various modulation schemes.	One channel was considered.
[1]	Comparative Analysis of Digital Modulation Techniques in LTE 4G Systems	The research concentrated on Bit Error Rate as performance metric with diverse modulation schemes to know the best configuration that gives better utilization of bandwidth. Each modulation scheme performance is measured Matlab simulation to estimate the probability of error produced by noise and interference induced in the channel.	Error-correction techniques, such as convolution coding and turbo coding, which helps to improve the system performance is not used.
[3]	Performance Analysis of OFDM Based Cooperative Communication over Nakagami Fading Channel	The research focused on and using the theorectical analysis to carry out the result for carrier to noise interference ratio (CNIR) and average bit error rate for OFDM based amplify and forward (AF) and decode and forward (DF) scheme over Nakagami fading channels.	Other fading channel is not considered.
[2]	Improved BER Analysis of OFDM Communication System on Correlated Nakagami-m Fading Channel	The research analysed OFDM systems behavior using maximal ratio combining (MRC) diversity at the receiver. over correlated Nakagami fading channel	Other diversity measure is not used
[13]	Bit Error Rate Analysis Of Different Digital Modulation Schemes In Orthogonal Frequency Division Multiplexing Systems	The research fixated on analyzing bit error rate (BER) behavior of the OFDM system over two fading channels and different FFT points to determine the effect of this factor on the performance of the system using Matlab	Implementation of the proposed MIMO-OFDM system on hardware is not focused on.
[14]	SER Performance of M-ary QAM OFDM System under AWGN Channel	The research capitalized on performance and effect of AWGN in terms of Symbol Error Rate. Analysis of diverse modulation scheme and technique on wireless communication systems using Matlab simulation to carry out the result.	The use of adaptive modulation which can improve BER performance is not considered.
[15]	BER Analysis of QAM with Transmit Diversity in Rayleigh Fading Channels	The focus of this research was the use of a log-likelihood ratio (LLR) approach to analyze the bit error rate (BER) performance of a modulation scheme on a fading Channel without and with transmit diversity.	Multiple transmit antenna is not considered.
[13]	Performance Analysis of Spatial Modulation over Weibull Fading Channels	The research studies the operation of SM to derived suboptimal receiver over fading channel and used exact integral expressions for the SER performance of M-QAM.	One fading channel was considered.
[12]	BER Comparative Analysis in BPSK, M-PSK and M-QAM Modulation of OFDM System in a Multipath fading channel using Simulink.	The research focused on measuring the BER of different digital modulation in an OFDM system. Matlab simulation was used to carry out the result.	Clarkes Model where by a Doppler shift can be included into the Rayleigh Channel Model is not considered for further improvement
[16]	Multiple-Mode Orthogonal Frequency Division Multiplexing With Index Modulation	The research focused on the OFDM framework based scheme Performance analyses and computer simulations have been conducted to carry out the result.	The analysis performance and ICI mitigation for this case is not put into consideration

4 PRESENT AND FORTHCOMING CHALLENGES

The review above shows that there different ways to eradicate or reduced noise to a minimum bearable level in mobile/cellular communication. Many of the techniques used seem to work efficiently in some areas of operation, especially in line with the proposed intention of the author, while others focus on other strong areas of application. Some of the techniques are paperwork model that has not been tested on field application. This abounds to be the only current challenge, and future challenges lie in technology advancement in mobile/cellular communication.

5 CONCLUSION

Among the reviewed technique of reducing noise, OFDM has wider application and the result shows good performance. However, to consider noise in current and future mobile/cellular communication, synchronization of modulation scheme over an improved channel that is resilient to noise will be of better performance with good result. This can be achieved through the enhancement of GSC using OFDM and QAM over Reiyleign Fading Channel by mitigating against noise using the combined diversity technique at the receiving end.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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