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Energy Efficient Transmission in Wireless Sensor Network Based on GMSK and Reed-Solomon Code

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Abstract: **Transmission of Energy efficient mechanism is a significant issue in Wireless Sensor Network to prolong its lifetime. This paper examines a coded Gaussian Minimum Shift Keying (GMSK) system which uses Reed-solomon (RS) codes in AWGN, Rayleigh, Rician, Nakagami channels. It is essential to provide a proper error control scheme to reduce the bit error rate (BER). Indeed, the challenging choice of suitable modulation scheme with the proper Error Correcting code (ECC) played a vital role to obtain better energy conservation. In this work, we aim to evaluate the performance analysis of GMSK modulation with different coding scheme and analysis of Bit Error Rate (BER) and energy consumption. The BER against the SNR is analyzed in this paper. This paper derives an expression for the distance measurement of the energy consumption per bit of decoder equals the energy savings per bit due to coding gain of transmitter compared to uncoded modulation scheme. The survey also analyses the role of modulation and coding technique apply to different channel conditions to improve the lifetime of the wireless sensor network.**

Keywords: **Energy Efficient, wireless network, GMSK, RS, AWGN, Rayleigh, Rician, Nakagami, BER.**

I. INTRODUCTION

Wireless communication is the fastest growing segment. It has achieved the attention of the media and the public. Exponential growth of cellular systems is experienced over the last decade and currently around two billion users worldwide are using it. Cellular phones emerge as an important business tool for everyday life in most developed countries like US, UK, etc. Before the signal is sending out to the air interface, the signal will pass through the modulator. Modulation is the process of encoding information from a message source in a manner suitable for transmission. There have two types of modulation which is analogue modulation and digital modulation. Analogue modulation includes Amplitude Modulation, Angle Modulation and Frequency Modulation. For digital modulation which is Quadrature Phase Shift Keying, Minimum Shift Keying, Frequency Shift Keying, Quadrature Amplitude Modulation and so on. Depending on need our goal is to raise the performance of GMSK modulation for uncoded as well as coded systems under different simulation software to raise performance of system for improvement in the overall energy conservation within wireless sensors.

II. RELATED WORK

Manish Bhardwaj et al. (2002) achieved the fundamental limits of energy-efficient collaborative data-mining by implementing system having a better lifetime of increasingly sophisticated sensor networks.[1]

Gopinath Balakrishnan et al. (2007) analysed on the performance of various error control codes related to their BER performance and power consumption on distinctive platforms by transmitting randomly generated data over a Gaussian channel. On the basis of study and comparison of the three distinctive error control codes such as RS code, BCH code and convolution code, it is verified that binary-BCH codes having ASIC implementation were best suitable for WSNs. [2]

Soltan and Pedram (2007) focused on a wireless sensor network with mobile overlays, having a mobility-aware multi-hop routing scheme for optimization of the network lifetime, delay, and local storage size.[3]

Sanjeev Kumar et al. (2011) gives the performance analysis of Reed-Solomon code used for encoding the data stream for digital communication. The evaluation is done by applying it to binary phase shift keying modulation scheme with symmetric Additive White Gaussian Noise channel. After evaluation it is concluded that the BER performance is improved as the code rate is decreased and the simulations also verify that the BER performance is also improved.[4]

Sami H. O. Salih et al. (2011) specifies the use of an Adaptive Modulation and Coding for Wireless technologies to yield higher throughputs for long distance coverage. Furthermore, implemented AMC features in WiMAX and the role of BPSK, QPSK, 16 QAM and 64 QAM with RS codes in the physical layer design Optimal selection can be applied to various Wireless Sensor Network for achieving better energy consumption at the transceiver.[5]

M.SheikDawood et al. (2012) analyzed the modulation schemes transmission approach for improvement regarding to bandwidth and efficient energy transmission for fault tolerance over landslide area. The total energy consumes for both the transmitter and the circuit is studied. The comparison of different modulation schemes is given related to consumptions of energy for different node. The authors analyzed the modulation schemes for improvement of the energy efficiency and bandwidth efficiency in a wireless sensor network.[7]

Kun Yang et al. (2012) analyzed the performance of relay networks. BPSK, QPSK, 16QAM, 64QAM with convolutional coding is used for achieving a better system performance where, the two source nodes adaptively choose the proper modulation scheme and coding depends on the information from the feedback which ensure the block error rate (BLER) of the system under the system requirement. And also, derived expressions related to the system performances for Rayleigh Channels which includes average spectral efficiency and average BLER.[8]

M. Sheik Dawood, R. Aiswaryalakshmi and G. Athisha (2013) analyzed the performance of MSK modulation with error control codes in base station controlled Dynamic Clustering Protocol architecture of WSN.[10]

Nitha V Panicker and Sukesh Kumar A (2014) analyzed the BER is maximum for Rayleigh and Ricean channels. In AWGN channel, Rayleigh fading channel and Rician channels OQPSK and BPSK gives best performance than all other digital modulation schemes.[11]

III. SYSTEM MODEL

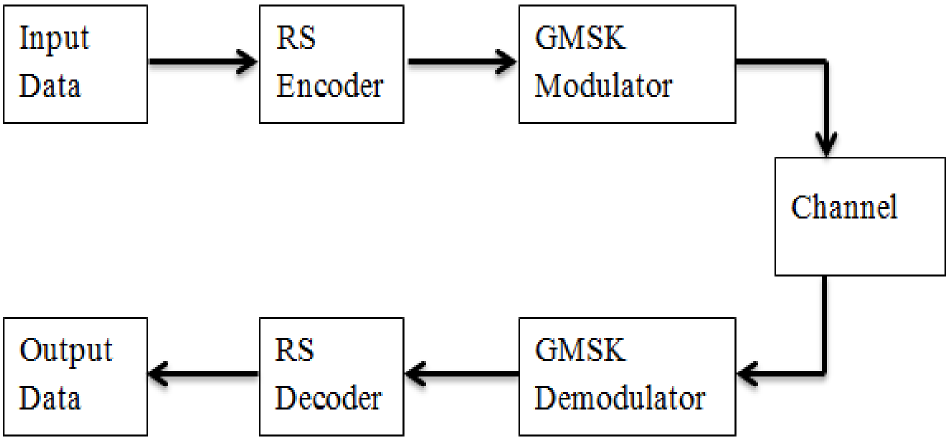


Fig3.1: Block diagram of GMSK and RS Code

The system model used is shown in Fig. 3.1. The data to be transmitted over the channel was randomly generated and was in the uncoded form. This data is coded by using RS encoder. After the coded bit sequence has been obtained, it is applied to a GMSK modulator. This modulated waveform is transmitted over the channel in the presence of AWGN, Rayleigh, Rician and NAKAGAMI. The received signal is demodulated and decoded where the error detection and correction is held. The various blocks used in this model is described below.

3.1 REED-SOLOMON CODE:

A nonbinary block code and binary block code has similar properties: it consists of K bits of information which is divided into N length codeword. This N codeword symbols are chosen within a nonbinary alphabet having size $q > 2$. Thus, codeword has any value from the subset $\{0, 1 \ldots, q-1\}$. Geerally q = 2k therefore k information bits can be divided into one codeword symbol.

One of the Nonbinary block codes is Reed Soloman code which is used over a large range of applications. RS codes have N = 2k−1 and K = 1, 2, . . .,N −1. The K indicates the error correction capability related to the code. RS code can correct upto T = 0.5(N − K) codeword symbol errors. codes The minimum distance between codewords in nonbinary code is defined by the number of codeword symbols which differ. Minimum distance dmin = N − K + 1. This is the largest possibility of minimum distance between codewords with the encoder input and output block lengths for linear block code.

3.2 GMSK:

In GMSK, data signals are passed through a low-pass filter before entering the phase modulation. The integral of the impulse response of a Gaussian filter output is quite smooth which causes the phase of the modulated signal to vary in a continuous manner.

GMSK has a low out of band power characteristic and a constant envelope which makes it a desirable choice for usage in the wireless mobile communications. The effect of the filter brings out the suppression of the out of band power by its sharp cut-off property.

GMSK finds a wide range of usage due to its spectral efficiency. As GMSK is a type of MSK scheme, it has a modulation index of 0.5. The Gaussian filter concentrates the energy on a desired band allowing for low out of band power characteristic. Widely known advantages of GMSK, that are narrow bandwidth and constant envelope modulation, make the GMSK suitable for both coherent and incoherent detection. Due to the constant envelope scheme, that is a property of GMSK, makes it less susceptible to fading environments than amplitude modulation and it requires inexpensive class-C amplifiers to be utilized for this scheme.

3.3 ADDITIVE WHITE GAUSSIAN NOISE:

In communications, the additive white Gaussian noise channel model is a single impairment which is a linear addition of wide band or white noise with a constant spectral density that is expressed as watts per hertz of bandwidth besides having a Gaussian distribution of amplitude. The model does not work for fading, interference, nonlinearity, frequency selectivity or dispersion. It does not s suffer from fading which means does not have to worry about distortion that a carrier-modulated telecommunication signal experiences over certain propagation media. However, it produces simple and tractable mathematical models which are useful for gaining insight into the behaviour of a system. Wideband Gaussian noise comes from many natural sources, such as the thermal vibrations of atoms in antennas or referred to as thermal noise, shot noise, black body radiation from the earth and other warm objects.

3.4 RAYLEIGH FADING CHANNEL:

Rayleigh fading is a model which causes effect of a propagation environment. The magnitude will vary randomly which is passed through such a transmission medium. The radial component is the sum of uncorrelated Gaussian random variables. When there is no dominant propagation Rayleigh fading is most applicable along a line of sight between the transmitter and receiver. If there is a dominant line of sight, rician fading may be more applicable.

3.5 RICIAN FADING CHANNEL:

It occurs in a LOS as well as in non-LOS path between the transmitter and receiver. The signals comprises on both the direct and scattered multipath waves.

3.6 NAKAGAMI CHANNEL:

It is used in various applications. It is also called m-distribution and proves as a better channel than Rayleigh and Rician distributions. It will be a better tool to model fading conditions.

IV. SIMULATION RESULTS

a) Energy used vs SNR for AWGN channel without RS:

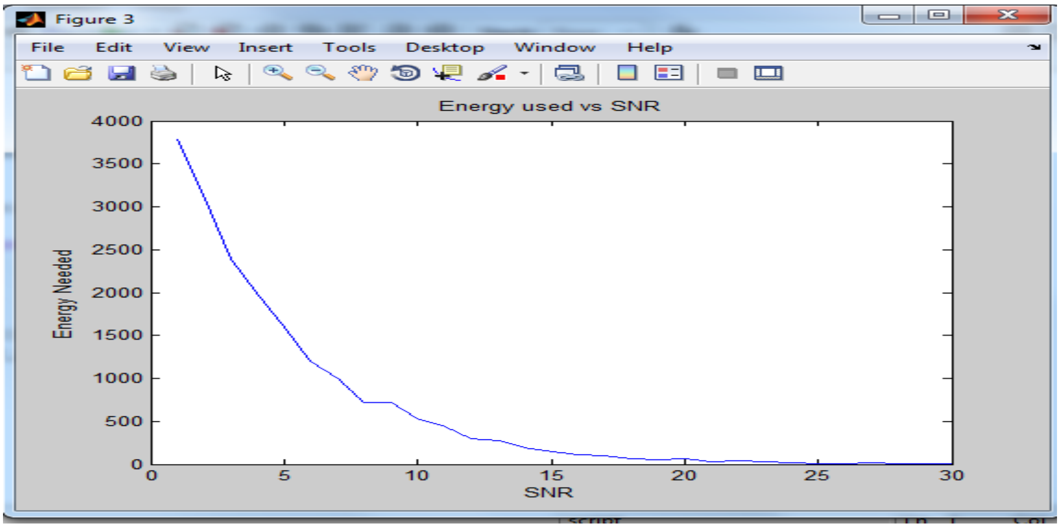


Fig.4.1: Energy used vs SNR over AWGN noise channel

For GMSK modulation the channel can be modelled where y is the received signal at the input of the BPSK receiver, x is the modulated signal transmitted through the channel and 'a' is the amplitude scaling factor for the transmitted signal usually assumed as unity. 'n' is the Additive Gaussian White Noise random variable with zero mean.

b) Energy used vs SNR for AWGN channel with RS:

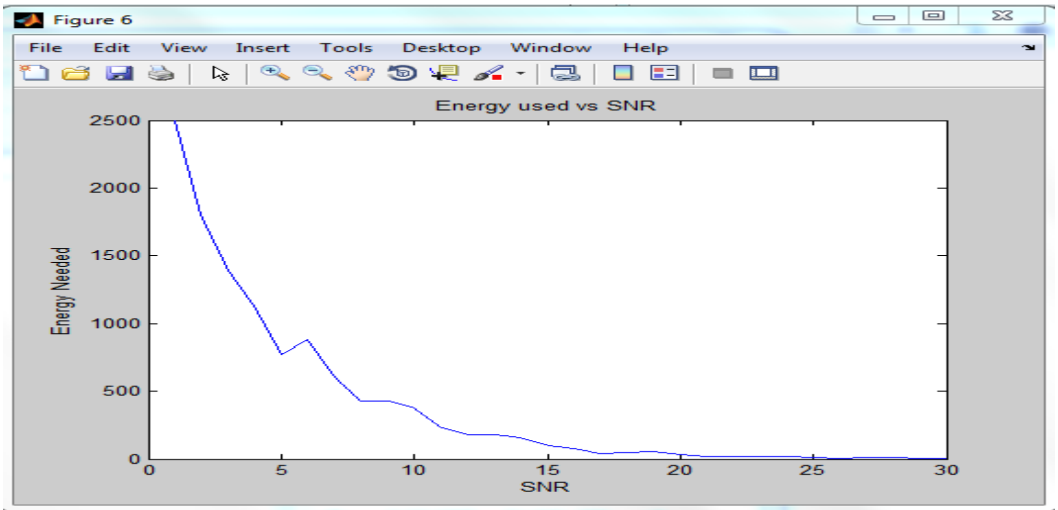
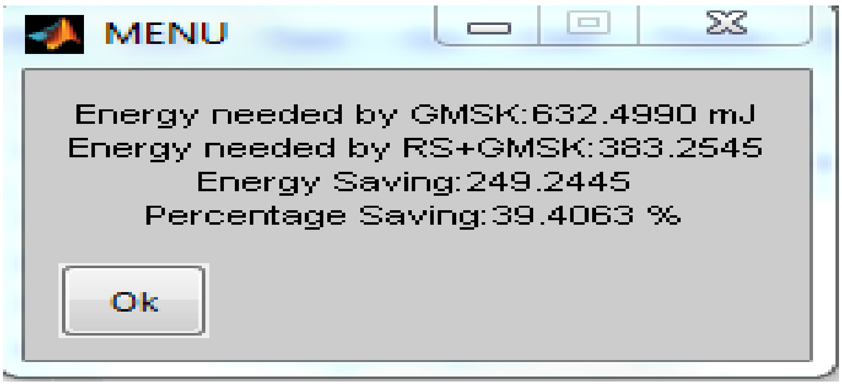


Fig.4.2: Energy used vs SNR over AWGN noise channel

c) Energy saving and lifetime using RS code for AWGN channel:



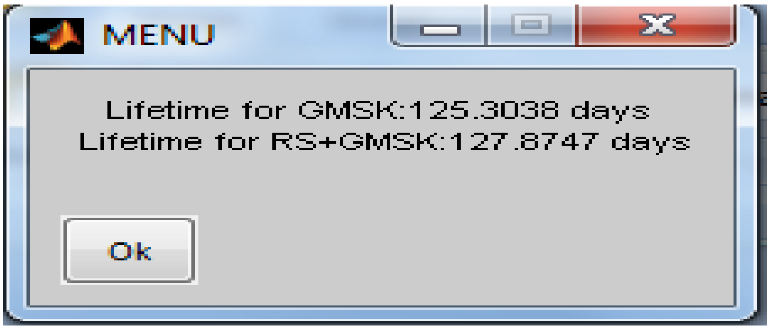


Fig.4.3: Energy Saved and lifetime of AWGN noise channel with RS

From above 3 diagram it is clear that energy saving and lifetime of signals in GMSK model with reed solomon code is more than GMSK model without reed solomon code.

d) Energy saving and lifetime using RS code for different channel:

Channel	Samples	Energy for GMSK(mJ)	Energy for GMSK +RS(mJ)	Energy saving %	Lifetime for GMSK(days)	Lifetime for GMSK+RS (days)
AWGN	100	6413	3301	48	660	1282
	200	12904	6555	49.35	1387	2565
Rayleigh	100	398	249	37.36	49	79
	200	665	422	36	84	133
Rician	100	374	253	32.21	50	74
	200	766	457	40	91	153
Nakagami	100	50026	28010	44	5602	10005
	200	1000079	52974	47	10594	20015

Above table specifies that the energy saving and lifetime of signal of rician, rayleigh, AWGN and NAKAGAMI without RS code is less than with RS code.

V. CONCLUSION

In this work, the performance analysis of GMSK modulation scheme with error control channel approach is studied under various channel conditions such as AWGN, Rayleigh, Rician, Nakagami channels to improve the energy efficiency and lifetime of a Wireless sensor network. Simulation results shows that GMSK modulation scheme with reed-solomon code achieves energy consumption that can be greatly reduced. This paper shows that GMSK with RS- code AWGN & Nakagami channel is more energy efficient than other channel conditions. It is analysed that performance of GMSK in AWGN channel is further competent than a other channel.

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