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Simulation of a Combat Platform Identification System and Comparative Study of Digital Modulation Techniques using GNU Radio and Python

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Abstract: GNU Radio is a free and open-source simulation software that provides signal processing blocks to simulate communication systems. It can be used with readily-available low-cost external RF hardware to create software defined radios, or without hardware in a simulation-like environment. It is used to support both wireless communications research and real-world radio systems. For this paper, GNU Radio has been used to simulate a trans-receive chain of a communication system for Combat Platform Identification System to minimize the incidence of fratricide among friendly forces during war. Also, comparative study of the effect of Additive White Gaussian Noise (AWGN) on DBPSK, DQPSK and GMSK modulation techniques have been carried out.

Keywords: GNU Radio, CPIS, Flowgraphs, RSA Algorithm, SHA-224 hash, DBPSK, DQPSK, GMSK

I. INTRODUCTION

In a military combat zone, there are various types of military combat platforms such as Tanks, Armoured Personnel Carriers, Artillery Guns, Troops-carrying Vehicles, Helicopters and slow moving or low flying aircrafts. Many times, it is difficult to identify all combat platforms in a military combat zone, either as friendly or enemy combat platforms. This becomes more difficult, in case of a joint operation undertaken along with forces of some friendly countries. This situation becomes even more complex in dynamic battlefield situations. There have been incidents of fratricide in previous battles resulting in death of friendly soldiers and destruction of friendly military platforms. This is a serious problem that is being faced in combat zones in the present times.

To overcome or minimise the occurrence of the above problem, one of the possible solutions is to have a "Combat Platform Identification System (CPIS)" on each military platform in the Combat zone to act as an Identification Friend or Foe (IFF) system For this paper, trans-receive chain of Combat Platform Identification System (CPIS) has been simulated using the Simulation Software GNU Radio. The trans-receive chain has been simulated by applying Encryption, Modulation, Error Detection and Demodulation techniques in the presence of AWGN. The comparative study of DBPSK, DQPSK and GMSK modulation techniques in the presence of AWGN has been carried out.

II. COMBAT PLATFORM IDENTIFICATION SYSTEM (CPIS)

CPIS is a friendly platform identification system designed to be utilized on combat platforms to be able to locate friendly combat platforms during war time or in a war zone.

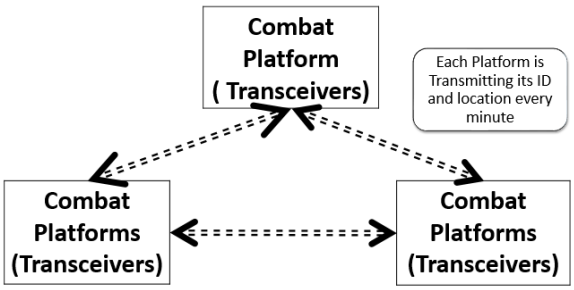

Figure 1:CPIS Basic block diagram.

The communication between the combat platforms is expected to be two way communication, with each platform broadcasting its unique identity over an encrypted channel so that there isn't any mis-utilization of information that is being broadcast. Each platform transmits its identity and location every minute. A simple block diagram of the CPIS transceiver chain has been given below.

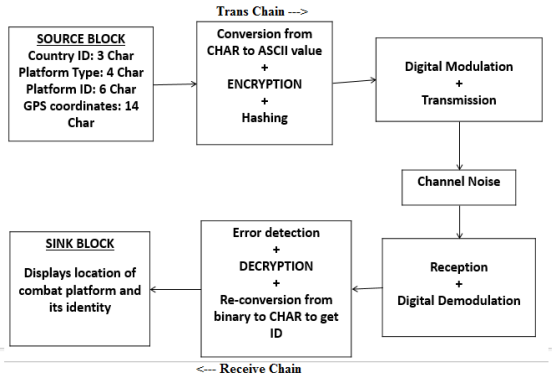

Figure 2:CPIS Basic block diagram.

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III. GNU RADIO

GNU Radio is a free and open-source simulation software that provides signal processing blocks to implement software radios. It can be used with readily-available low-cost external RF hardware to create software-defined radios, or without hardware in a simulation-like environment. It is widely used in academic and commercial environments to support both wireless communications research and real-world radio systems.GNU Radio applications are primarily written using the Python programming language, while the supplied, performance-critical signal processing path is implemented in C++ using processor floating point extensions, where available. Thus, the developer is able to implement real-time, high-throughput radio systems in a simple-to-use,rapid-application-development environment. The basic signal processing blocks in GNU Radio are,

1. *Source*: It is used for signal generation and consists only output ports.
2. *Sink*: It consists only input ports and used to observe the output.
3. *General Block*: It consists of both input ports and output ports. The main signal processing occurs in this block.

IV. ENCRYPTION AND ERROR DETECTION

A. *Encryption*

The Encryption is an important part of any communication occurring over free space as there is always a fear of information being sniffed and data going into the wrong hands. For encryption, we shall utilize an Asymmetric Key Encryption standard, known as Rivest Shamir Adleman Algorithm (commonly known as RSA Algorithm). The RSA Algorithm is a two way cryptographic hash function. It utilizes the public key of a two way communication to encrypt the data that is being sent and uses the private key to decrypt the data that is received by the end user.

For this paper, we have employed a few changes in the algorithm to strengthen the integrity of the message.

B. *Error Detection*

The purpose of Error Detection is very important in a noise prone channel. The authenticity of a message always needs to be verified. To verify the integrity of our received message, we utilize the Cryptographic Hash Function called the Secure Hashing Algorithm-224, which has a block size of 512. The weakness of SHA-224 have been theoretically proven, however, there is no practical breaking of SHA-224 that has taken place till today.

V. MODULATION TECHNIQUES

Living in the era of communication everything may be video, audio or any information in the form of electrical signal is termed as data and there is an enormous requirement of data transfer between two or more point through the world wide web, every moment of the clock, which is a big threat to the existing communication systems because of the problems like spectral congestion, severe adjacent and co-channel interference problems and noise corrupted data reception etc. We have made comparative study using three modulation techniques in the presence of AWGN in this paper.

A. *Differential Binary Phase Shift Keying*[4][iv]

BPSK (also sometimes called PRK, phase reversal keying, or 2PSK) is the simplest form of phase shift keying (PSK). It uses two phases which are separated by 180° and so can also be termed 2-PSK. It does not particularly matter exactly where the constellation points are positioned, and in this figure they are shown on the real axis, at 0° and 180°. This modulation is the most robust of all the PSKs since it takes the highest level of noise or distortion to make the demodulator reach an incorrect decision. It is, however, only able to modulate at 1 bit/symbol and so is unsuitable for high data-rate applications.

B. *Differential Quadrature Phase Shift Keying*[4][iv]

Sometimes this is known as *quadriphase PSK* or 4-PSK. QPSK uses four points on the constellation diagram, equispaced around a circle. With four phases, QPSK can encode two bits per symbol, shown in the diagram with Gray coding to minimize the bit error rate (BER) — sometimes misperceived as twice the BER of BPSK.

The mathematical analysis shows that QPSK can be used either to double the data rate compared with a BPSK system while maintaining the same bandwidth of the signal, or to *maintain the data-rate of BPSK* but halving the bandwidth needed. In this latter case, the BER of QPSK is *exactly the same* as the BER of BPSK - and deciding differently is a common confusion when considering or describing QPSK. The transmitted carrier can undergo numbers of phase changes.

C. *Gaussian Minimum Shift Keying*

Minimum Shift Keying is a special type of continuous phase frequency shift keying. The peak frequency deviation of MSK can be given as ¼ th the bit rate.

Even though MSK's power spectrum density falls quite fast, it does not fall fast enough so that interference between adjacent signals in the frequency band can be avoided. To take care of the problem, the original binary signal is passed through a Gaussian shaped filter before it is modulated with MSK.

VI. SIMULATION

A. Source Block

The Source block input contains the following data.

Country ID – 3 Characters
Platform Type – 4 Characters
Platform ID – 6 Characters
Latitude and Longitude – 14 characters

Figure 3a: Input Block.

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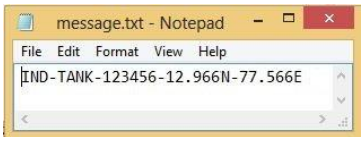

Figure 3b: Source File

B. Encryption and Error Detection Block

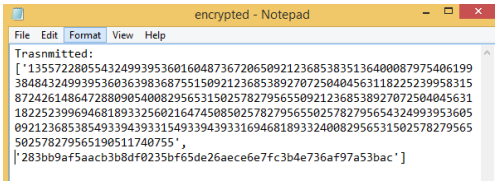

Figure 4. Data after Encryption

C. GNU Radio Flowgraph

i.. DBPSK

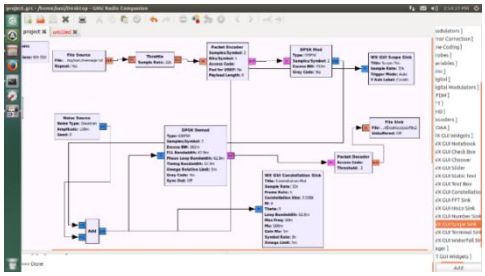

Figure 4a: Graphical representation of BPSK output.

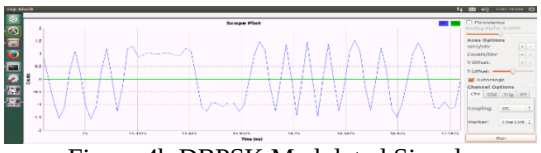

Figure 4b:DBPSK Modulated Signal.

Figure 4c:DBPSK Modulated Signal with noise.

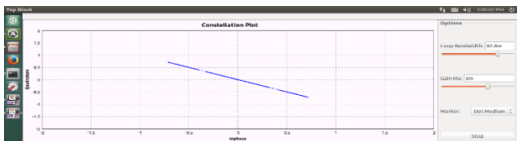

Figure 4d:DBPSK Constellation Plot.

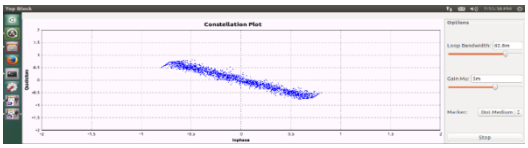

Figure 4e:DBPSK Constellation Plot with noise.

ii. DQPSK

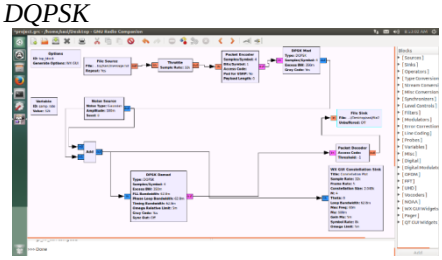

Figure 5a:DQPSK Flowgraph.

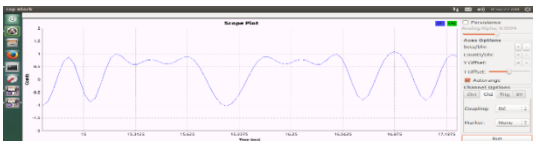

Figure 5b:DQPSK Modulated Signal.

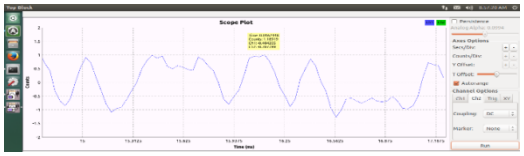

Figure 5c:DQPSK Modulated Signal with noise.

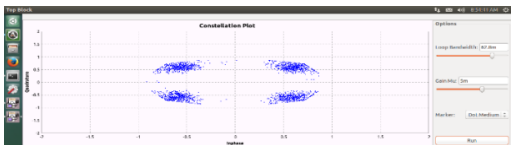

Figure 5d:DQPSK Constellation Plot.

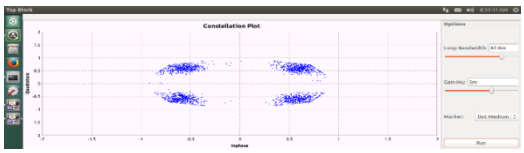

Figure 5e:DQPSK Constellation Plot with noise.

iii. GMSK

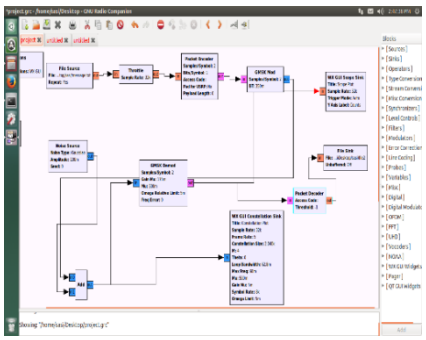

Figure 6a:GMSK Flowgraph.

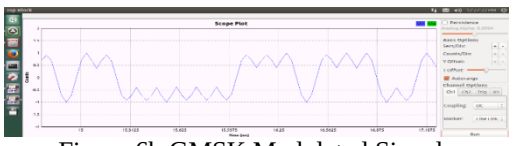

Figure 6b:GMSK Modulated Signal.

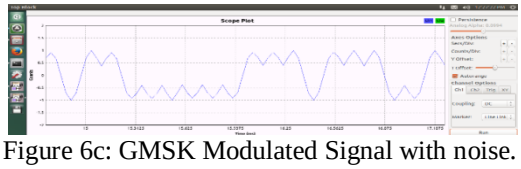

Figure 6c: GMSK Modulated Signal with noise.

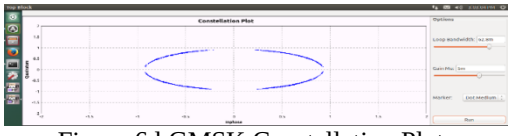

Figure 6d:GMSK Constellation Plot.

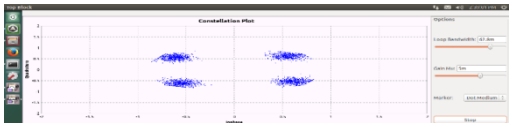

Figure 6e:GMSK Constellation Plot with noise.

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C. *SINK Block*

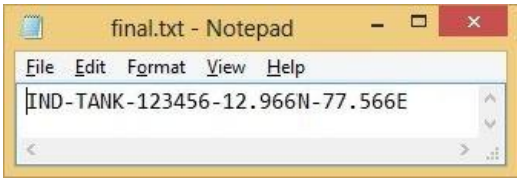

Figure 7:Final Output File.

VII. RESULT, ANALYSIS AND CONCLUSION

A. *Comparison based on Signal Constellation*

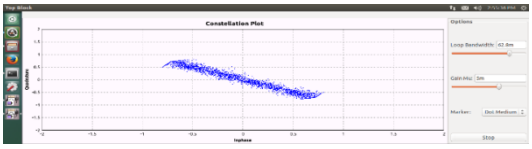

Figure 8a:DBPSK Constellation Plot with noise.

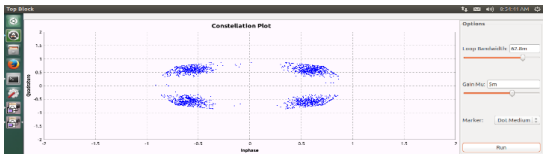

Figure 8b:DQPSK Constellation Plot with noise.

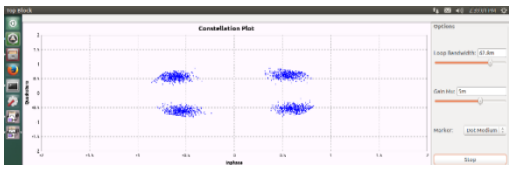

Figure 8c:GMSK Constellation Plot with noise.

In DBPSK the distribution is only in two angles (135 and -45).

In DQPSK the distributions are sparsely distributed over 360 degrees.

In GMSK the distribution is a cloud roughly in 4 angles (45, 135, -135 and -45).

Hence, it can be seen that DBPSK can be transmitted and received at receiver with the whole signal being easily received compared to DQPSK and GMSK.

B. *Comparison based on noise level*

Noise Level	DBPSK	DQPSK	GMSK.
0.1	Correctly received	Correctly received	Correctly received
0.15	Correctly received	Correctly received	No Output
0.2	Correctly received	Correctly received	No Output
0.25	Correctly received	No Output	No Output
0.3	Correctly received	No Output	No Output
0.35	Correctly received	No Output	No Output
0.4	Correctly received	No Output	No Output
0.45	Correctly received	No Output	No Output
0.49	No Output	No Output	No Output
0.5	No Output	No Output	No Output

It can be inferred that the DBPSK has more noise immunity compared to DQPSK and GMSK since till 0.45 amplitude of noise, we get the output in DBPSK.

ACKNOWLEDGMENT

We express a deep sense of gratitude to the developers of GNU Radio for providing it as a free and open source, valuable information and guidance. We take this opportunity to express our profound gratitude and deep regards to our guides Prof Braj Bhushan Jha and Dr. Dhanesh G Kurup for their guidance and support. The blessing, help and guidance given by them from time to time shall carry us a long way in the journey of professional life on which we are about to embark.

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[8] [iv] en.wikipedia.org/wiki/GNU RADIO

BIOGRAPHIES

Tanoy Bose is a student pursuing his B.Tech in Electronics & Communication Engineering at Amrita Vishwa Vidyapeetham University, Amrita School of Engineering, Bangalore, India. His research work is concentrated on Cyber Security, Cryptography and Network Security. His current research is on Encryption and improved usage of RSA Algorithm.

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