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Simulation of Coastal Line Surveillance System and Comparative Study of Digital Modulation Techniques using GNU Radio

Aditya Patial[1], B. Druva Ram Narayana[2], B. Nikshith Kumar[3], Dhanesh G Kurup[4], Braj Bhushan Jha[5]

Student, Electronics & Comn Engineering Department, Amrita School of Engineering, Bangalore, India[1,2,3]

Professor, Electronics & Comn Engineering Department, Amrita School of Engineering, Bangalore, India[4,5]

Abstract- GNU Radio is a free and open-source simulation software that provides signal processing blocks to simulate Software Defined Radio (SDR) and other communication systems. GNU Radio companion library has a large number of signal processing blocks and new signal processing blocks can also be created for specific system simulation requirements using Python or C++ code. For this paper, GNU Radio has been used to simulate Trans-Receive chain of the communication system for Coastal Line Surveillance. The comparative study of the effect of Additive White Gaussian Noise (AWGN) on DBPSK, DQPSK & D8PSK modulation techniques have also been carried out.

Keywords- GNU Radio, DBPSK, DQPSK, D8PSK, AWGN, IFF, Coastal Surveill

I. INTRODUCTION

Security situation along India's seashore has been causing concern especially when unidentified boats/ships enter Indian waters. The 2008 terrorist attacks in Mumbai were coordinated shooting and bombing attacks lasting 4 days across the city, killing hundreds of people and leaving many wounded. The attackers who were involved in this incident entered our land through the sea. In order to minimize such incidences, there is a requirement of very effective coastal line surveillance system which can identify and locate boats and small ships approaching Indian waters and shores. As of now, the Naval and Coast guard RADARS are already deployed along the seashore, which detect presence of boats and ships along with their exact location in the sea near Indian shore. To supplement the information provided by RADAR, in this system we proposed a coastal surveillance system in which a Base station at the shore collects information from all friendly boats and ships about their identity and location and shared the collected information in real time with Navy and Coast Guard for centrally coordinating the coastal security.

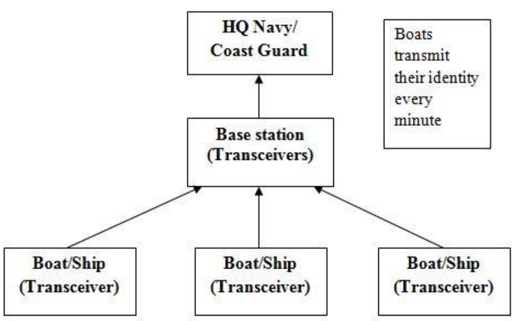

Fig.1- Basic data flow

The basic trans-receive chain is shown below :

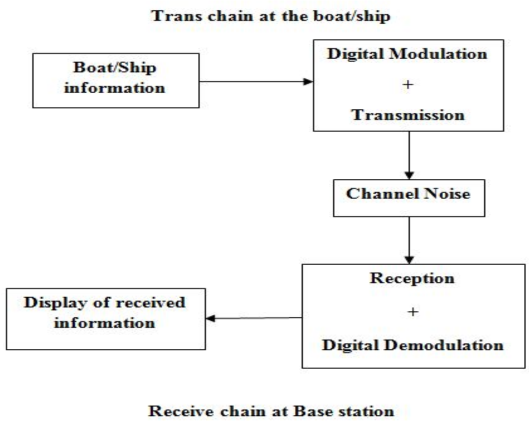

Fig.2 - Trans and Receive Chain Block Diagram

II. GNU RADIO

GNU Radio Companion library has a large number of signal processing blocks such as Source, Sink, Modulator, Filters, Operators etc. New signal processing blocks in GNU Radio can also be created according to the requirements using Python or C++ code.

1. Source: Source block is used for providing input for processing. Vector Source Blocks have been used in this simulation.
2. Vector to Stream: This block converts multiple vector inputs into a single stream.
3. Stream Mux: This block merges multiple streams into a single stream.
4. Modulator: In this block, the given input sequence can be modulated according to the requirement.
5. Demodulator: This block demodulates the received signal added with the noise.

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6. Noise : Additive White Gaussian Noise block has been used to simulate channel noise.
7. Sink: The blocks which are used in this project are scope sink and constellation sink to view the signal and data.

III. MODULATION AND NOISE

A. *Modulation*

Modulation is the process of varying some parameter of a periodic waveform in order to use that signal to convey a message. Normally a high-frequency sinusoidal waveform is used as carrier signal. The design of a communication system is application oriented and is dependent on the type of the signal. The digital communication technique provides larger immunity to noise compared to analogue counterpart, although at the price of larger bandwidth requirement [1]. Hence, digital communication techniques DBPSK, DQPSK and D8PSK have been used in the simulation and their performance in the presence of noise has been compared

B. *Noise*

In communication systems, the noise is a summation of unwanted or disturbing energy from natural and sometimes man-made sources in the communication channel, which affects error-free reception of the useful information. Noise is, however, typically distinguished from interference, (e.g. Cross-talk or other unwanted electromagnetic interference from specific transmitters).

Additive White Gaussian Noise (AWGN) is a basic noise model used in Information theory to mimic the effect of many random processes that occur in nature. AWGN is used as a channel model in which the only impairment to communication is an addition of white noise with a constant spectral density (expressed as watts per hertz of bandwidth) and a Gaussian distribution of amplitude.

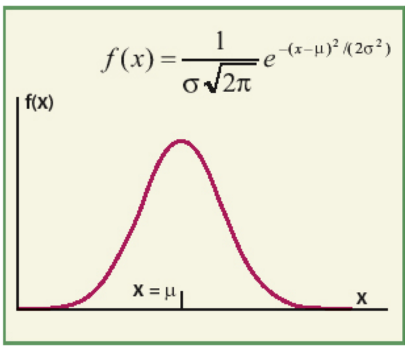

Fig.3 - Gaussian Bell Curve

A normal distribution is

$$f(x, \mu, \sigma) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

The parameter μ in this definition is the *mean* or *expectation* of the distribution (and also its median and mode). The parameter σ is its standard deviation; its variance is therefore σ^2. A random variable with a Gaussian distribution is said to be normally distributed and is called a normal deviate.

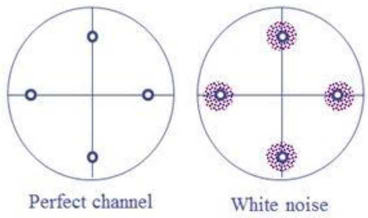

Fig.4 Effect of AWGN on a DQPSK Modulated channel

IV. SIMULATION

Step 1: Giving the inputs using 5 Vector Sources:

1. Country ID (2 characters)

2. Platform Type (2 characters)

3. Boat/Ship ID (6 characters)

4. GPS Location **(**Latitude(7 characters) and longitude(7 characters)**)**

For example, in 5 vector sources we give input as

91 – Country ID

01 – Platform type

123456 – Boat/Ship ID

1212581 – Latitude(Last digit 1 represents North)

3445782 **-** Longitude(Last digit 2 represents East)

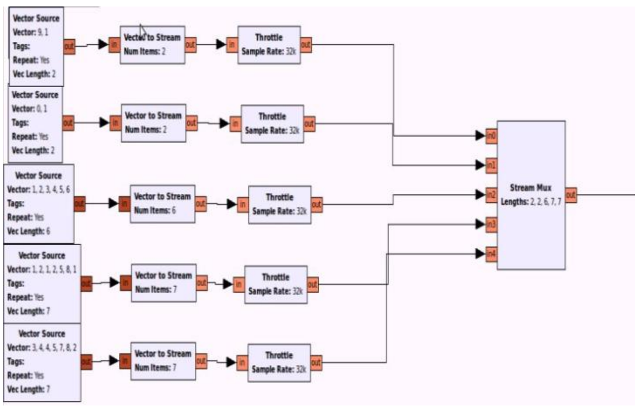

Fig.5 - Data Input for transmission

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The waveform after Stream Mux is shown below:

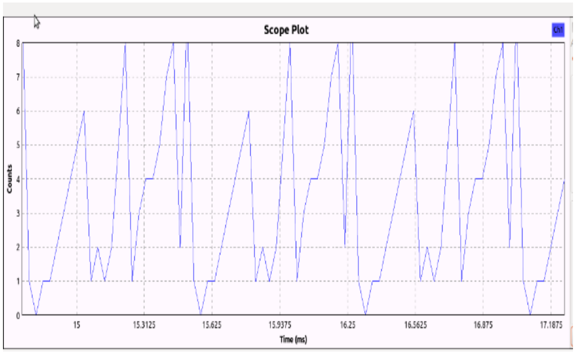

Fig.6 - Input waveform

Step 2: This step includes modulating the given waveform using the chosen modulation technique (Refer to book 1) and adding noise. This noise added signal is demodulated using respective demodulation algorithm.

a) Using DBPSK Modulation:

Modulated waveform is shown below :

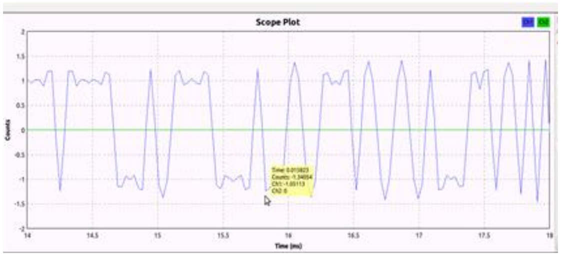

Fig.7- DBPSK modulated waveform

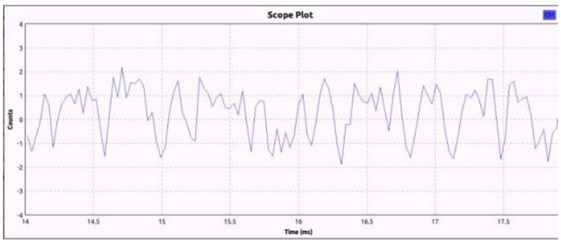

Fig.8 - Noise added DBPSK Modulated Waveform

Demodulated waveform of DBPSK modulation is same as the input waveform

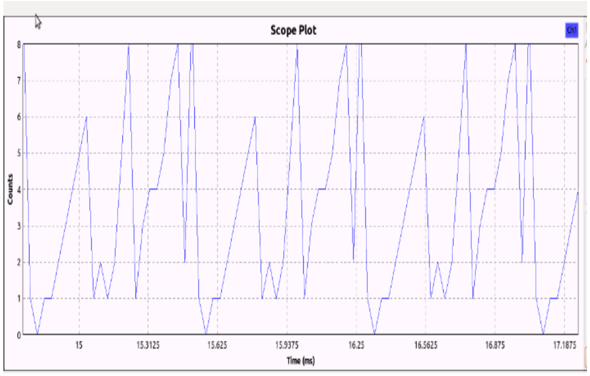

Fig.9 - Demodulated Waveform

b) Using DQPSK Modulation: Modulated waveform of input wave is shown below

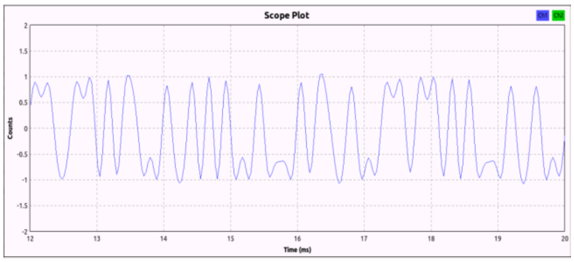

Fig.10 - DQPSK Modulated Waveform

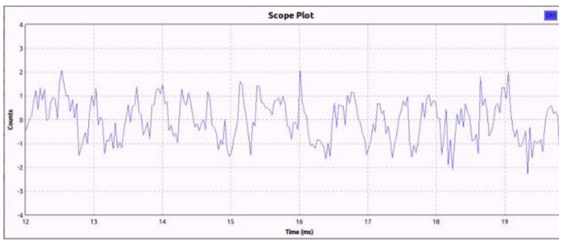

Fig.11 - Noise added DQPSK modulated waveform

c) Using D8PSK Modulation: Modulated waveform of input wave is shown below

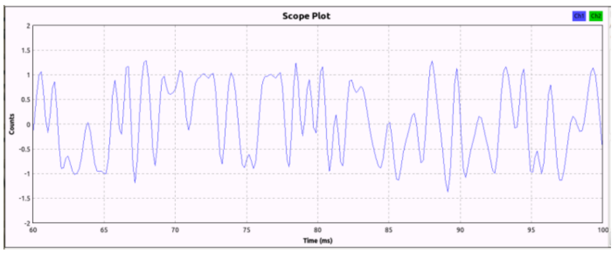

Fig.12 - D8PSK modulated waveform

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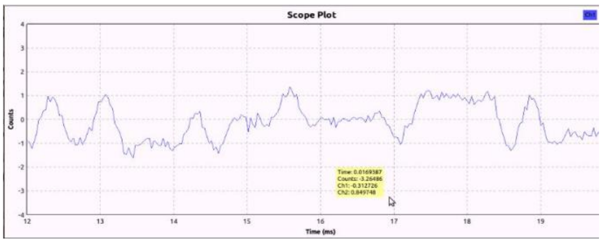

Fig.13 - Noise added D8PSK modulated waveform

V. RESULTS AND ANALYSIS

Comparative Performance of DBPSK, DQPSK and D8PSK modulation techniques in the presence of AWGN has been shown at Table 1. It can be inferred from the data in the table that DBPSK has the maximum noise immunity compared to DQPSK and D8PSK.

Table 1- Comparative Performance of DBPSK, DQPSK and D8PSK in the presence of AWGN

AWGN Level	DBPSK	DQPSK	D8PSK.
0.1	Correctly Received	Correctly Received	Correctly Received
0.15	Correctly Received	Correctly Received	Correctly Received
0.2	Correctly Received	Correctly Received	Data Corrupted
0.25	Correctly Received	Data Corrupted	Data Corrupted
0.3	Correctly Received	Data Corrupted	Data Corrupted
0.35	Correctly Received	Data Corrupted	Data Corrupted
0.4	Correctly Received	Data Corrupted	Data Corrupted
0.45	Correctly Received	Data Corrupted	Data Corrupted
0.50	Data Corrupted	Data Corrupted	Data Corrupted

Comparison between Constellation plots for DBPSK, DQPSK and D8PSK modulation techniques is shown at Figure 14. The effect of AWGN is clearly visible in these Constellation plots.

From the Constellation plots, it can be seen that in DBPSK the distribution is only in two angles (45 and -45).Whereas in DQPSK the distribution is a cloud roughly in 4 angles (45, 135, -135, -45) and in D8PSK the distributions are sparsely distributed over 360 degrees. Hence, it can be seen that DBPSK can be transmitted and received at receiver with the signal being correctly received compared to DQPSK and D8PSK.

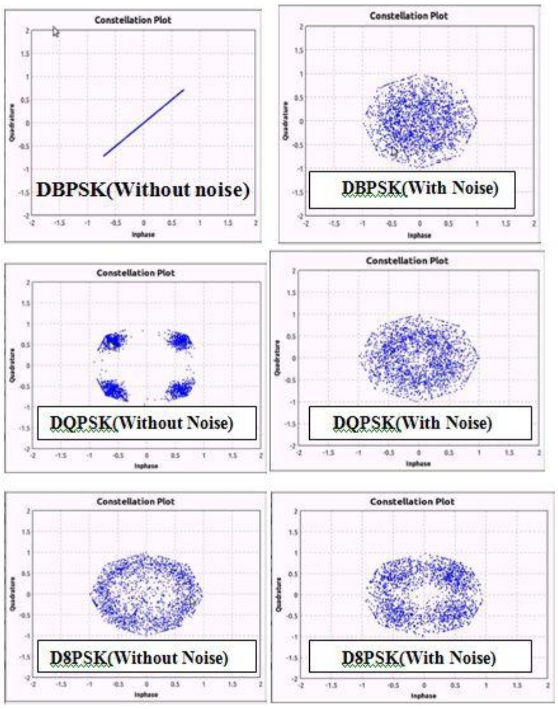

Fig.14 - Comparison of DBPSK, DQPSK and D8PSK in Constellation Plots

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BIOGRAPHY

Aditya Patial is a student pursuing Electronics & Communication Engineering at Amrita Vishwa Vidyapeetham University, Amrita School of Engineering, Bangalore, India.

B Druva Ram Narayana is a student pursuing Electronics & Communication Engineering at Amrita Vishwa Vidyapeetham University, Amrita School of Engineering, Bangalore, India.

B Nikshith Kumar is a student pursuing Electronics & Communication Engineering at Amrita Vishwa Vidyapeetham University, Amrita School of Engineering, Bangalore.

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Dr. Dhanesh G Kurup is a Professor in Electronics & Communication Engineering Department at Amrita Vishwa Vidyapeetham University, Amrita School of Engineering, Bangalore. His research interests are RF Engineering, Signal processing and Wireless systems.

Braj Bhushan Jha is a Professor in Electronics & Communication Engineering Department at Amrita Vishwa Vidyapeetham University, Amrita School of Engineering, Bangalore. His research interests are Command Control and Communication Networks and Network Management Systems.