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SIMULATION OF COMINT RECEIVER USING MATLAB AND SIMULINK

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Abstract—- **Electronic Warfare (EW) refers to any action involving the use of electromagnetic (EM) spectrum. Electronic Support Measures (ESM) is the division of EW that involves intercept, locate, and immediately identify sources of enemy electromagnetic radiations. A branch of ESM is COMINT (Communication intelligence). COMINT generally includes military communication signals rather than commercial broad casting communication signals. The existing COMINT systems are operator dependent and manual interpretation of identified parameters of intercepted signal is common practice. Our project focuses on the automation of COMINT system and virtual implementation of COMINT signal processor. The Processor is capable of extracting the parameters of received signals such as centre frequency, symbol rate and modulation type. The processor can recognize 8 types of modulation schemes using higher-order moments. COMINT processor to be designed in this project will be using state of the art algorithms to estimate different unknown parameters such as centre frequency, symbol rate and Modulation scheme. The processor will be designed in MATLAB and also a SIMULINK model will be designed for the simulation of demodulation of different modulation schemes.**

Keywords— COMINT, MATLAB, higher-order moments

I. INTRODUCTION

Electronic Warfare (EW) refers to any action concerning the usage of electromagnetic (EM) energy to control the electromagnetic spectrum (EMS) or to attack the opponent. The purpose of EW is and guarantee friendly unhindered access to the electromagnetic environment. Communication EW deals with communication signals which are generally continuous in nature. The transmitter and receiver are geometrically and geographically separated.

While the conventional HF communication band covers 3 to 30 MHz, the HF band used for tactical communications begins with 1.5 MHz and goes up to 30 MHz The VHF band which is known to 30 to 300 MHz becomes 20 to 400 MHz when it comes for tactical communication.

II. METHODOLOGY

A. Estimation of Frequency

Initially the received IQ data is normalised in order to reduce the error vector magnitude. Multiple iterations of the same is seldom done in order to reduce the error vector magnitude to a negligible level or in order to eliminate it completely. Also, normalization helps in easier computations and also normalization of the signal amplitude is designed to compensate the unknown channel attenuation.

After normalization, Discrete Fourier Transform (DFT) is taken of the samples. Here, FFT (Fast Fourier Transform) algorithm is used to implement DFT. The FFT calculates the cross correlation of an input signal with sine and cosine functions (basis functions) at a set of frequencies that are evenly spaced. The real part of the output is the cross-correlation of the input signal with cos (2*pi*Fc*t) and the imaginary part is the cross-correlation of the input signal with sin(2*pi*Fc*t). To accommodate for phase mismatches between the input signal and the fundamental functions, the input signal is coupled with sin and cos functions. We now calculate these bins and then plot the magnitude of FFT versus the graph containing the frequency bins of the FFT. This results in a plot that gives us the centre frequency of the received signal.

B. Estimation of Symbol Rate

The algorithm employed to estimate symbol rate is very similar to that of estimation of frequency, as symbol rate is related to the range of frequencies. After normalization, Discrete Fourier Transform (DFT) is taken of the samples. Here, FFT (Fast Fourier Transform) algorithm is used to implement DFT. The FFT calculates the cross correlation of an input signal with sine and cosine functions (basis functions) at a set of frequencies that are evenly spaced. Now the magnitude of the FFT signal is taken. This magnitude is now plotted against the frequency bins plot to achieve symbol rate of the algorithm.

C. Modulation Classification Algorithm

We look at the problem of modulation classification in the presence of carrier frequency offset in this project. Several methods for blind classification in the presence of frequency offset have recently been described, based on higher-order cumulants of differently processed received signals and cyclic cumulants of the received signal. Because the variance of these feature estimations is significant, effective classification performance demands more data and/or a high SNR. We employ the received signal's moments and differentially processed received signal to identify the modulations hierarchically in this research. For wide classification, we utilise second-order moments of differentially processed received signal, and for tighter classification, we utilise fourth-order moments of received and differently processed received signal.

III. SIMULATION RESULTS

We have conducted this project by taking inputs received signals as real time IQ data. These inputs were generously shared with us by a start-up firm that focusses on producing hardware devices that improve the SNR ratio of the received signals in real time.

The outputs of all the simulations in MATLAB and SIMULINK are included below.

TABLE I. SIMULATION RESULT OF CFE ALGORITHM

S.No	Modulation Type	Original Frequency	Estimated frequency
1	BPSK	70.35 MHz	70.351 MHz
2	BPSK	70.20 MHz	70.206 MHz
3	QPSK	70.00 MHz	70.06 MHz
4	8-PSK	70.50 MHz	70.51 MHz
5	16-QAM	70.20 MHz	70.28 MHz
6	16-QAM	70.00 MHz	70.04 MHz
7	32-QAM	70.65 MHz	70.71 MHz
8	64-QAM	70.35 MHz	70.41 MHz

TABLE II. SIMULATION RESULT OF SRE ALGORITHM

S.No	Modulation Type	Original Symbol Rate	Estimated Symbol Rate
1	BPSK	6.25 msps	6.21 msps
2	BPSK	5 msps	5.01 msps
3	QPSK	2.08 msps	2.1 msps
4	16-QAM	6.25 msps	6.23 msps
5	16-QAM	1 msps	0.87 msps
6	64-QAM	6.25 msps	6.23 msps

From Table I, we can infer that the frequency estimation algorithm works well in case of PSK. The accuracy of the algorithm reduces as the order of QAM increases. This observation can be associated with the fact that our algorithm uses a distance metric approach and higher the order, lesser the distance between points on a constellation diagram.

Observations from Table II establish that the symbol rate estimation algorithm works well in most of the cases.

In case of result of the modulation classification algorithm, the result of the simulation is displayed in a histogram-style and the algorithm so proposed using the higher-order moments worked very efficiently.

IV. CONCLUSION

Our project focuses on the automation of COMINT system and virtual implementation of COMINT signal processor. The Processor is capable of extracting the parameters of received signals such as centre frequency, symbol rate and modulation type. The algorithms we have chosen for the implementation of this project have an edge over the aforementioned algorithms either in terms of accuracy or simplicity or robustness or computational requirements The COMINT signal processor thus designed was able to demodulate AM and FM signals among the intercepted signals. The processor was designed to recognize 8 types of modulation schemes among which two of them are analog modulation schemes i.e. Amplitude Modulation and Frequency Modulation and six digital schemes (BPSK, QPSK, 8PSK, 16QAM, 32QAM, and 64QAM).

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