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Adaptive Modulation with Customised Core Processor

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Abstract

Objectives: To develop an automatic modulation detection. **Methods/Statistical Analysis:** A single system having the antenna transmits and receives multiple signals. Autonomous modulation techniques avoid the multipath fading, delay and bandwidth limitation. Transmitter selects the modulation from group based on the receiver location and selected modulation gives maximum accuracy. Findings: This approach avoids the size limitation because of parallel relay terminal structure acceptance. This research work focuses on different set of modulation schemes in virtual logic channel implemented in low power consuming hardware and also be customized. Application/Improvements: Proposed work is a large number low power hardware used in more secured manner.

Keywords: FL2440, GNU, Modulation/Demodulation, Node/Network Security, WSN

1. Introduction

The objectives of the work include but not limited to Multiple modulation and demodulation with switching ability at any condition, Choosing a best fit modulation based on efficiency and also maintain the BER and SNR value, Filtering the channel noise and automatically identify the corresponding demodulator at receiver and ensuring security good for the system without scalability issues. The demonstrated modulation and demodulation schemes include^{1,2}:

- **ASK**
- **CPFSK**
- D8PSK
- QAM8
- **QASK**
- **DQPSK**
- **SUNDE**
- **QAM 16**
- **QAM 64**
- **QAM 256**

shown along with the channel in Figure 1. Transmitter shows in Figure 2. Modulation / Demodulation blocks are shown in Figure 3³.



Figure 1. Communication transmission via channel.

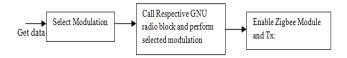


Figure 2. Selected modulation transmitted using Zigbee module.

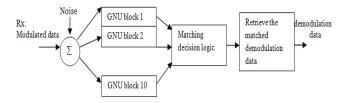


Figure 3. Modulate/Demodulate data using GNU blocks.

Communication Model

The communication between transmitter and receiver is

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3. Modulation Detection

In this work, Automatic modulation detection extracts seven parameters (Features based on amplitude, frequency and phase) for identification of different modulation techniques namely: ASK2, ASK4, FSK2, FSK4, PSK2, PSK4, QAM16 and QAM64. All the different parameter have been calculated in during the real time process, based on statistics of the signal condition the parameter are selected cautiously. The parameters selected are^{4,5}:

3.1 Absenv

$$absEnv = \frac{1}{N} \sum_{i=1}^{N} [A_{cn}[i]]$$

3.2 AbsPhase

$$absPhase = \frac{1}{C} \sum_{A_n[i]>a_t} |\emptyset_c[i]|$$

3.3 rEnv

$$rEnv = \frac{1}{N} \sum_{i=1}^{N} \frac{|A[i] - m_a|}{m_a}$$

3.4 absEnv2

$$rEnv2 = \frac{1}{N} \sum_{i=1}^{N} |B_{cn}[i] - m_b|$$

$$B_{cn}[i] = |A_{cn}[i]|$$

$$m_b = \frac{1}{N} \sum_{i=1}^{N} B_{cn}[i]$$

3.5 absFreq

$$absFreq = \frac{1}{C} \sum_{A_n \text{El} > a_t} \left| \frac{f[i] - f_a}{Fsym} \right|$$
$$f_a = \frac{1}{C} \sum_{A_n \text{El} > a_t} f[i]$$

3.6 absFreq2

$$absFreq2 = \frac{1}{C} \sum_{A_n \in \mathbf{I} > a_t} \left| f_2[i] - \frac{1}{C} \sum_{A_n[j] > a_t} f_2[j] \right|$$
$$f_2[i] = \left| \frac{f[i] - f_a}{Fsym} \right|$$

3.7 absPhase2

$$absPhase2 = \frac{1}{C} \sum_{A_n \in \mathbf{I} > a_t} \left| \mathbf{Ø_2}[i] - \frac{1}{C} \sum_{A_n \in \mathbf{I} > a_t} \mathbf{Ø_2}[j] \right|$$
$$\mathbf{Ø_2}[i] = \left| \mathbf{Ø_C}[i] \right|$$

The method of classification as mentioned above is based on the threshold value and is calculated for various modulation techniques. Based on the flow chart shown in Figure 4 the type of modulation transmitted to the receiver is identified⁶.

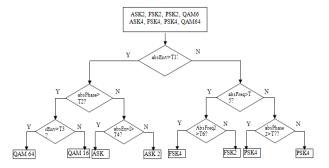


Figure 4. Modulation identifier Algorithm.

4. Hardware Implementation

The implementation uses two hardware nodes (ARM 9 and above based architecture with "GNU Radio" LINUX drivers installed)⁷.

- Transmitter board consisting of all the modulation blocks
- Receiver board consisting of all the demodulation blocks

4.1 Transmitter Block

The transmitter board consists of carrier generator, various modulation blocks, modulation selection switch, noise generator, DAC converter as shown in Figure 5. The User selects one of the modulations using the "modulation selection switch". Based on the selected modulation scheme, necessary software blocks are activated like data, carrier and noise. Working function for the software blocks are data block is used to modulate data, carrier block is used to generate carrier and noise block is used to generate the noise as well as control the noise. The modulated wave is transmitted which is converted to in an analog signal using on board DAC and the signal is transmitted using antenna^{8,9}.

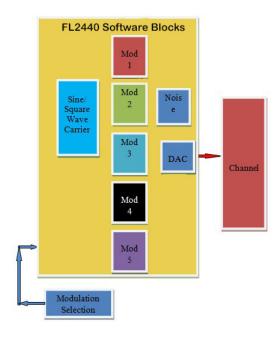


Figure 5. Transmitter board consisting of all the modulation blocks.

4.2 Receiver Block

The receiver board consists of carrier generator, various demodulation blocks, noise generator, ADC converter as shown in Figure 6. The modulated signal is sampled through Analog to Digital convertor at a high sampling rate. The digitized signal is then noise filtered by the noise filtering software block. The algorithm is applied in data sample by the detected modulation scheme, applicable software blocks are applied in the data results get demodulated data¹⁰.

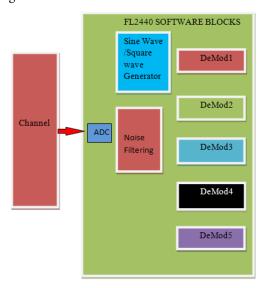


Figure 6. Receiver board consisting of all the demodulation block.

Case (i) 16 QAM Implementation details

16 QAM, commonly used in radio networks and microwave digital radios, offers four values for 'I' and four values for 'Q', yielding 16 possible states, as shown in Figure 7. 16 QAM sends four bits per symbol. The signal can transition from any state to any other state11. 16 QAM is more spectrally efficient than BPSK, QPSK, OQPSK, and $\pi/4$ - DQPSK. The QAM approach transmitter and receiver path have the nonlinearity path with noise, here one symbol is interpreted with another symbol that may cause error¹². This approach decrease the inter symbol interference problems so its give the better result compare with other modulation techniques. The 16 QAM implementation, shows a flow chart in which it import the GNU radio blocks, select the defaults values (provided by GNU blocks) and provide the modulation/demodulation for 16 QAM process Figure 8^{13,14}.

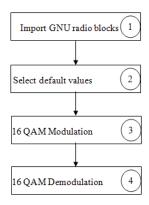


Figure 7. 16 QAM implementation block.



Figure 8. Hardware Implementation.

Case (ii) PSK Implementation

The digital modulation technique here phase shift keying is by changing the data with carrier reference signal. PSK implementation blocks shows Figure 9. PSK has unique pattern, respectively unique pattern have equal number of bits form the result of encoder. The phase is represented by the particular symbol its received form the unique pattern. To implementing process of PSK is quite good, but in order to improve the process to go for DPSK^{15,16}. The process simplified because the omitting the one section because it is no need for demodulator, reason is reference signal and unique pattern bit symbol represent exact phase of the received signal. In Figure 10 imported GNU blocks generate gray code constellation for different M-PSK values, convert the code and receive demodulation for PSK¹⁷.

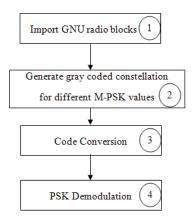


Figure 9. PSK implementation block.

```
5:QASK
6:QPSK
7:Sunde
8:QAM16
9:QAM64
10:QAM256
enter your choice
10
****QAM256****

Total = 2393 bytes
constellation with 256 arity
[QAM256 Modulation] - Start QAM256 modulation
[QAM256 Modulation] - Finish QAM25
```

Figure 10. QAM256 Modulation/demodulation process.

5. Results and Discussion

In this work, the results have been found out based on linux and hardware correlation, where related to modulation choices have been provided and chosen the QAM256. It shows the constellation with 256 arity and the start and end of the modulation status. It shows the status of port number also (Figure 10). The QAM code detection output is shown in Figure 11.

```
QASK code not matched
[DQPSK Demodulation] - Start DQPSK Demodulation
[DQPSK Demodulation] - Finish DQPSK Demodulation
                                                                not matched with modulations
 DOPSK code not matched
[Sunde Demodulation] - Start Sunde Demodulation
[Sunde Demodulation] - Finish Sunde Demodulation
 0 E 4
 Sunde code not matched
[QAM16 Demodulation] - Start QAM16 Demodulation
[QAM16 Demodulation] - Finish QAM16 Demodulation
 QAM16 code not matched
[QAM64 Demodulation] - Start QAM64 Demodulation
[QAM64 Demodulation]
                         - Finish QAM64 Demodulation
 QAM64 code not matched
[QAM256 Demodulation] - Start QAM256 Demodulation
[OAM256 Demodulation] - Finish OAM256 Demodulation
                                    Code Matched for QAM256
QAM256 code matched -
****QAM256 DETECTED****
```

Figure 11. QAM code detection output.

6. Conclusion

In this work, multiple modulation techniques to automatically identify an unknown modulation using different set of modulation are used. This technique is practically implemented and tested for ten modulation types with hardware implementation on FL2440 ARM9 Embedded core. The hardware implementation takes low power. Additionally, the Modulation Identification Technique is implemented with a Scheduler and optimize performance based on the priority of a node, availability of the modulation and channel. The error detection and correction at receiver also implemented using ARM9 core.

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