Implementation of communication subsystem, Ground station subsystem and Back-up subsystem

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Abstract__ Developing a space vehicle is a complex and detailed process. A reliable communication system using GNU-Radio & Hack RF one to a complete transceiving mode. usage of this system to transfer a pay load (camera) which may be photo or video as well as transferring telemtry of satellite. The modulation methodology used (TQAM) to enhance power resources and bit error performance. Satellite links are currently being developed to provide higher data rates and improved power efficiency, but in other hand there is a main problem which is the increasing of bit error rate due to using higher order modulation techniques. Showing a comparison between methodologies of modulation, to get the optimum modulation type to satisfy the needed requirements.Secondly, establishing a GUI subsystem for the ground station, showing the satellite's telemetry by telemetry gauges.GUI subsystem is presented using web development. Thirdly, the alternate methodology is to use node MCU (Wi-Fi module) in emerging situations of communication interruption using a backup subsystem.
Keywords:QAM , Traingular constellation ,GUI, MCU ,Back-up .

INTRODUCTION

Our goal is to advance a reliable communication system that transfers a payload by a camera using QAM modulation, so A triangular lattice provides the most compact QAM constellations, i.e., the constellation points closest to the origin [1]. For a given minimum Euclidean distance between signal points, the more compact the constellation, the better the power efficiency; the contributions of this paper are as follows. Clarify the concept of both SQAM and TQAM[2]. Implementation of 16-TQAM and 16-SQAM modulation and demodulation using GNURADIO. Comparing the performance of each modulation. First, SQAM and then TQAM are introduced. Second, the implementation of 16-R-TQAM using GNU-radio is discussed. Finally, web design was born. In its infancy, web design was heavily restricted by technology and hardware, with a web presence being little more than black text on a white background. HTML and CSS are the key components for building web pages and sites[7].

The ground station's home page enables the operator to watch parameters and gives orders to the satellites through buttons to observe the satellite's status and telemetry gauges of the satellite. thirdNode MCU is an open source development board and firmware based on the widely used ESP8266 -12E Wi-Fi module. An access point (AP) is a device that provides access to Wi-Fi network to other devices (stations) and connects them further to a wired network. ESP8266 can provide similar functionality, except it does not have an interface to a wired network. The User Datagram Protocol (UDP) is the simplest transport layer communication protocol available in the TCP/IP protocol suite. It involves the minimum amount of communication mechanism[13].

1-communication subsystem

I.MODELLING

A. SQAM methodology

Modulation is the process of changing the parameters of the carrier signal. Parameters can be amplitude(ask), phase(psk) ,frequency(fsk) or hybrid of two parameters like amplitude and phase in QAM mapped of b bits into symbols. M-ary SQAM (where M is the signal level) have its signal constellation points ordered in square lattice. Different formats of SQAM constellation diagram is shown in Fig.1[9]. As seen as modulation order increases, the distance between the points decreases so small amount of noise can corrupt the data. As the noise level increases the area covered by a point on the constellation increases. For some systems the order of the modulation format is fixed, but in others where there is a two-way link, it is possible to adapt the order of the modulation to obtain the best throughput for the given link conditions[4].
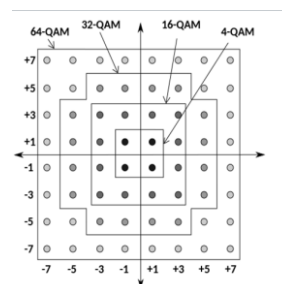

Fig.1: Different SQAM techniques[9]

B. SQAM in AWGN channels

Higher modulation order achieves higher data rates and spectral efficiency, but Reducing the order of the QAM modulation enables lower bit error rates, reducing the amount of error correction required. This way, the throughput can be maximized for the prevailing link quality. We must meet the prevailing link quality and ensure the optimum data throughput, balancing transmitter power, QAM order, forward error correction, etc[3].
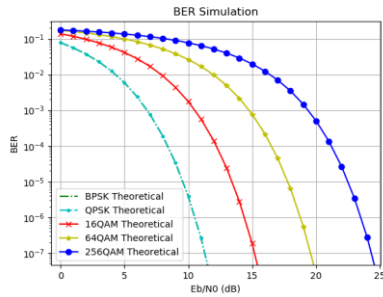
Fig.2 : BER performance for SQAM

II.Triangle QAM

For a given minimum Euclidean distance between signal points, the more compact the constellation, the better the power efficiency; the demodulation is done by following as we could divide the constellation into vertical regions. Then the received point is located inside a region, and the closest constellation point is found within this region[5].
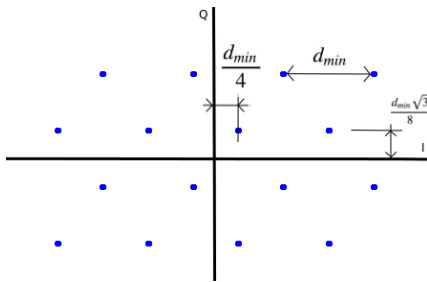
A. RTQAM constellation diagrams

Fig. 3. Constellation Diagram of 16-RTQAM.

the 16-TQAM can be calculated as follows

$$E_{s16} = 10d^2, \qquad (1)$$
$$E_{t16} = 9d^2. \qquad (2)$$

From (1) and (2) we can find the power gain PG_{16} of the 16-TQAM against the 16-SQAM becomes

$$PG_{16} = 10log_{10}\left(\frac{E_{s16}}{E_{t16}}\right) = 0.46dB \qquad (3)$$

To get this compatable effenciency detected in details we must have bit stream mapping .
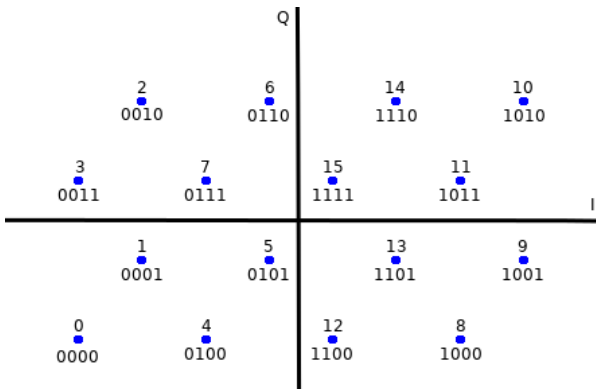
A. Bit stream mapping

Fig.4 .Bit stream constellation

To minimize the number of bit errors Gray code is used in which only one bit differs between adjacent signal points. To show this difference the difference must be calculated .

B. BER performance

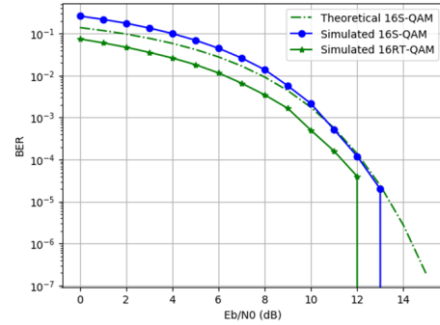The BER performance comparison between 16-SQAM and 16-RTQAM over an additive white gaussian noise is shown in the Fig

Fig.5 . BER performance for RTQAM

C. GNU-Radio implementation

GNU-Radio blocks where developed using python programming language, implementing 16-TQAM modulator and demodulator as shown in Fig. 6 and Fig. 7[3].

Fig.6 .16RTQAM modulator   *Fig.7.16RTQAM demodulator*

We will transmit and receive photo by using various modulation technique like BPSK and QPSK and QAM the flowing graph of transmit and receive photo .
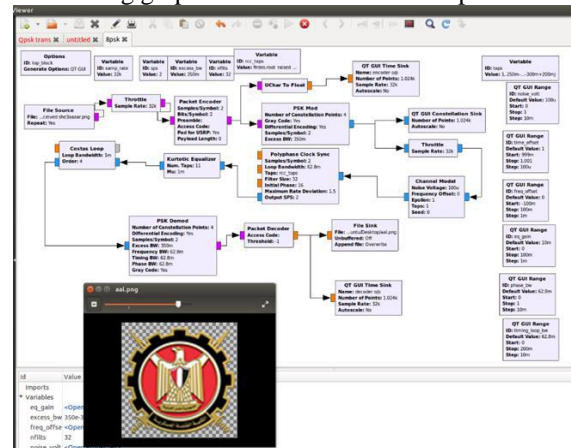

Fig.8 . SQAM implementation

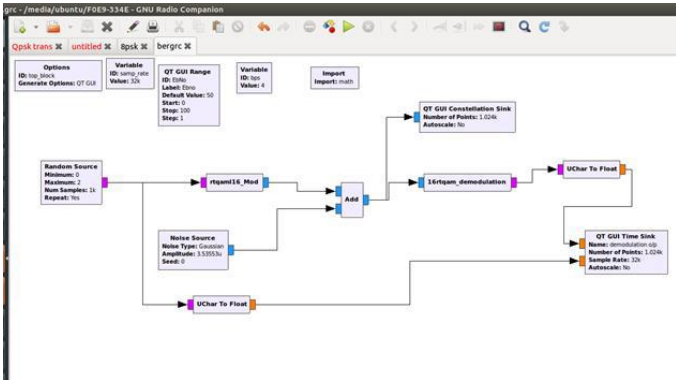For implementing RTQAM using GNU-Radio using the following Fig

Fig.9 . 16 RTQAM implementation

III. Results

Now implementing the flow graphs of tests of implementing and simulation of transmitting and receiving the telemetry text of the cube sat and its resultو the simulation assumes random bit stream. we see that the original stream of bits at the input of the modulator is the same as the bit stream out of the demodulator as well as the constellation points at the correct position indicates the correct operation of the blocks[6].
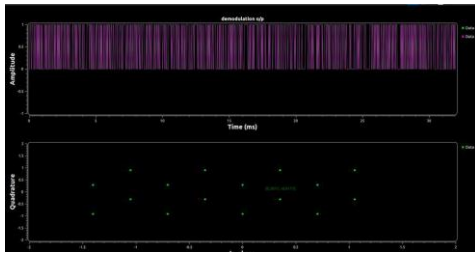

Fig.10. 16RTQAM constellation

Using a basic component for implementation like HACK-RF one shown in the Fig

Fig.11 . HACK-RF one

2-Ground station subsystem
A. Basic structure of webpage

Web design was born. In its infancy, web design was heavily restricted by technology and hardware, with a web presence being little more than black text on a white background. Thankfully, technology and web design have reached a far more creative and imaginative stage in their evolutions. Skipping past frames, tables, and animated GIFs, web design has become far more sophisticated and will continue to grow and develop. HTML and CSS are the key components for building web pages and sites – without them, the web as we know it would not exist. Provided JavaScript is a loosely typed scripting language with simple uses for tasks like form data validation or minor page embellishments, such as rollover buttons[7].

B. Implementation of ground station

The operator can watch parameters and gives orders to the satellites through buttons and observe the status and the telemetry gauges of the satellite shown in fig.13.

Fig.12 .Home page of ground station

As a home page through it can reach any subsystem and manage it , for telemetry web page

Fig.13 .Telemtry page

C. Back-up subsystem

Node MCU is an open source development board and firmware based in the widely used ESP8266 -12E Wi-Fi module. It allows you to program the ESP8266 Wi-Fi module with the simple and powerful LUA programming language or Arduino IDE in It can be used as access point and/or station, host a web server or connect to internet to fetch or upload data[5].

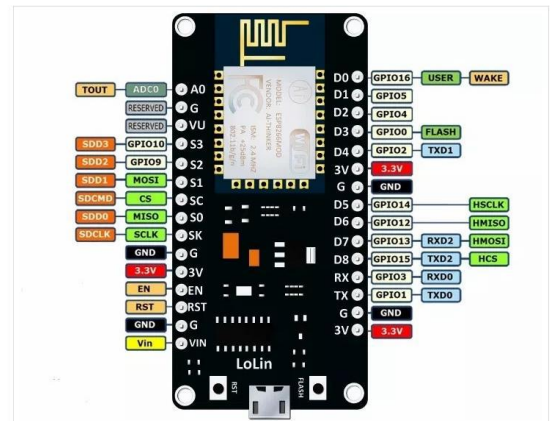The basic structure for the the ESP8266 is shown in the following Fig

Fig.14 ESP pins layout

D. Layout

An access point (AP) is a device that provides access toWi-Fi network to other devices (stations) and connects themvfurther to a wired network. ESP8266 can provide similar functionality except it does not have interface to a wired network. Such mode of operation is called soft access point(soft-AP). The maximum number of stations connected to the soft-AP is five[13].
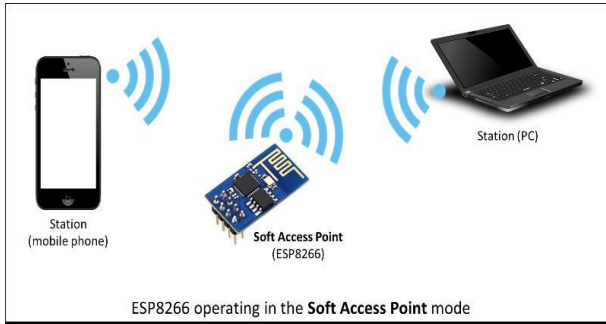

Fig.15 . ESP operating Access point

The soft-AP mode is often used and an intermediate step before connecting ESP to a Wi-Fi in a station mode. This is when SSID and password to such network is not known up front.

A. User Datagram protocol

The User Datagram Protocol (UDP) is simplest Transport Layer communication protocol available of the TCP/IP protocol suite[8]. It involves minimum amount of communication mechanism. UDP is said to be an unreliable transport protocol but it uses IP services which provides best effort delivery mechanism. the receiver does not generate an acknowledgement of packet received and in turn, the sender does not wait for any acknowledgement of packet sent. This shortcoming makes this protocol unreliable as well as easier on processing , but it uses complicated codes flushing the memory but at least the node can afford it , here the used codes for the multi-uses

Fig.16 .UDP implementation

3-Conclusion

A quick introduction to communication system and the used type of modulation and signal processing , full description for the main languages used for coding GNU Radio and building the web pages and how we could make the full use

of these languages and employ them to construct the modulation type and webpages Showing the relationship between subsystems and the communication between the subsystems having the interface between subsystems .

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