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Analysis of Digital Video Broadcasting – Terrestrial with Different Encoding and Modulation Schemes

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Abstract: DVB-T is the most widely used standard for interactive television. DVB-T uses the MPEG-2 standard for coding the data, as well as Forward Error Coding, Reed Solomon Coding and Convolutional coding to make the signal robust against the high amount of error that comes with transmission. It also uses QPSK to modulate the signal, which makes the information be encoded in the phase instead of the amplitude, which also helps with making the signal robust enough for the channel. But due to increase in number of users and changing needs of users in the field of communications and entertainment, there are new challenges that the currents standards are not able to satisfy. So as the number of users increases the system complexity and interference also increases. The communication channel is not free from the effects of channel impairments such as noise, interference and fading. These channel impairments caused signal distortion and signal to ratio (SNR) degradation. This problem can be overcome by implementing the system with different modulation and error detection and correction schemes. So first design a DVB-T system with convolutional coding and OFDM transmitter. Then analyze this system with different modulation schemes such as 64-QAM and QPSK modulation, and find the best suited modulation scheme with lowest bit error rate. Then again analyze this system with different error detection and correction schemes such as Reed-Solomon (RS) encoding and Cyclic Redundancy Check (CRC) encoding to reduce the bit error rate and improves the performance of system.

Keywords: DVB-T, OFDM, BER, RS.

I. INTRODUCTION OF DVB-T

Digital Video Broadcasting (DVB) is a set of standards that define digital broadcasting using existing satellite, cable, and terrestrial infrastructures. In the early 1990s, European broadcasters, consumer equipment manufacturers, and regulatory bodies formed the European Launching Group (ELG) to discuss introducing digital television (DTV) throughout Europe. The ELG realized that mutual respect and trust had to be established between members later became the DVB Project. Today, the DVB Project consists of over 220 organizations in more than 29 countries worldwide. DVB-compliant digital broadcasting and equipment is widely available and is distinguished by the DVB logo. Numerous DVB broadcast services are available in Europe, North and South America, Africa, Asia, and Australia. The term *digital television* is sometimes used as a synonym for DVB. However, the Advanced Television Systems Committee (ATSC) standard is the digital broadcasting standard used in the U.S[2].

A fundamental decision of the DVB Project was the selection of MPEG-2, one of a series of MPEG standards for compression of audio and video signals. MPEG-2 reduces a single signal from 166 Mbits to 5 Mbits allowing broadcasters to transmit digital signals using existing cable, satellite, and terrestrial systems. MPEG-2 uses the lossy compression method, which means that the digital signal sent to the television is compressed and some data is lost. This lost data does not affect how the human eye perceives the picture. Two digital television formats that use MPEG-2 compression are standard definition television (SDTV) and high definition television (HDTV). SDTV's picture and sound quality is similar to digital versatile disk (DVD). HDTV programming presents five times as much information to the eye than SDTV, resulting in cinema-quality programming[3].

DVB uses conditional access (CA) systems to prevent external piracy. There are numerous CA systems available to content providers allowing them to choose the CA system that they feel is adequate for the services they provide. Each CA system provides a security module that scrambles and encrypts data. This security module is embedded within the receiver or is detachable in the form of a PC card. Inside the receiver, there is a smart card that contains the user's access information. The following describes the conditional access process:

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(a). The receiver receives the digital data stream.
(b). The data flows into the conditional access module, which contains the content provider's unscrambling algorithms.
(c). The conditional access module verifies the existence of a smart card that contains the subscriber's authorization code.
(d). If the authorization code is accepted, the conditional access module unscrambles the data and returns the data to the receiver. If the code is not accepted, the data remains scrambled restricting access.
(e). The receiver then decodes the data and outputs it for viewing.

For years, smart cards have been used for pay TV programming. Smart cards are inexpensive allowing the content provider to issue updated smart cards periodically to prevent piracy. Detachable PC cards allow subscribers to use DVB services anywhere DVB technology is supported.

DVB is an open system as opposed to a closed system. Closed systems are content provider-specific, not expandable, and optimized only for television. Open systems such as DVB allow the subscriber to choose different content providers and allows integration of PCs and televisions[6]. DVB systems are optimized for not only television but also for home shopping and banking, private network broadcasting, and interactive viewing. DVB offers the future possibilities of providing high-quality television display in buses, cars, trains, and hand-held devices. DVB allows content providers to offer their services anywhere DVB is supported regardless of geographic location, expand their services easily and inexpensively, and ensure restricted access to subscribers, thus reducing lost revenue due to unauthorized viewing.

II. SYSTEM MODEL OF DVB-T

It is the DVB European-based consortium standard for the broadcast transmission of digital terrestrial television that was first published in 1997 and first broadcast in the UK in 1998. This system transmits compressed digital audio, digital video and other data in an MPEG transport stream, using coded orthogonal frequency-division multiplexing (COFDM or OFDM) modulation. It is also the format widely used worldwide (including North America) for Electronic News Gathering for transmission of video and audio from a mobile newsgathering vehicle to a central receive point. It is also used in the US by Amateur television operators.

Rather than carrying one data carrier on a single radio frequency (RF) channel, COFDM works by splitting the digital data stream into a large number of slower digital streams, each of which digitally modulates a set of closely spaced adjacent sub-carrier frequencies. In the case of DVB-T, there are two choices for the number of carriers known as 2K-mode or 8K-mode. These are actually 1,705 or 6,817 sub-carriers that are approximately 4 kHz or 1 kHz apart. DVB-T offers three different modulation schemes (QPSK, 16QAM, 64QAM).

DVB-T as a digital transmission delivers data in a series of discrete blocks at the symbol rate. DVB-T is a COFDM transmission technique which includes the use of a Guard Interval. It allows the receiver to cope with strong multipath situations. Within a geographical area, DVB-T also allows single-frequency network (SFN) operation, where two or more transmitters carrying the same data operate on the same frequency. In such cases the signals from each transmitter in the SFN needs to be accurately time-aligned, which is done by sync information in the stream and timing at each transmitter referenced to GPS[11].

The length of the Guard Interval can be chosen. It is a trade-off between data rate and SFN capability. The longer the guard interval the larger is the potential SFN area without creating intersymbol interference (ISI). It is possible to operate SFNs which do not fulfill the guard interval condition if the self-interference is properly planned and monitored.
The digital TV system called DVB-T is designed to allow optimum use of the available frequency spectrum with a structure of broadcast data enough to accommodate numerous services: multiplex of up to 8 video programs in a 8 MHz bandwidth, multi-language stereo/surround channels, etc. The architecture of the DVB-T network consists in: program coder, multiplexer, SFN network adapter, COFDM (Coded Orthogonal Frequency Division Multiplex) modulator, up converter and transmitter. It specifies all the process to use terrestrial transmission channels: channel coding and modulation[9].

The figure 1. describes the block diagram of the DVB-T system. These blocks form the channel codification and the modulation scheme that is used by the system. The channel coding uses the Forward Error Correction (FEC) after the signal pass the transmission channel. Moreover, the modulation scheme showsthe transmission type OFDM (Orthogonal Frequency Division Multiplex). The combination of this one with the error correction and the multi-carrier modulation is the COFDM transmission type.

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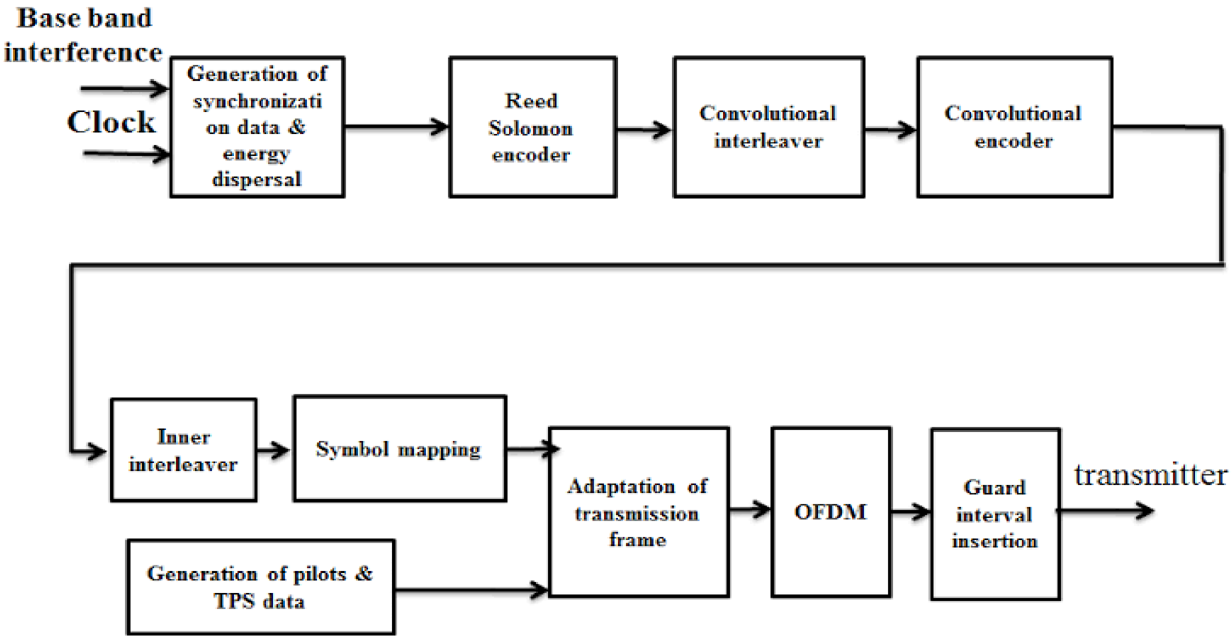

Figure 1. Transmitter of DVB-T.

III. DVB-T PERFORMANCE ANALYSIS

Simulation of Digital Video Broadcasting-Terrestrial (DVB-T) system is done in Simulink tool of MATLAB. The simulation results are plotted in term of the performance of DVB-T system that is Bit Error Rate (BER). First the DVB-T system is analyzed with different modulation schemes such as 64-QAM and QPSK. and the Bit Error Rate (BER) of DVB-T system with these modulation schemes is calculated to check the system performance.

Analysis was done by observing the simulation result and tabulating the analysis results to make it more convenient to be read. In the performance analysis of DVB-T system the transmitted signal, received signal, scattered plot and bit error rate of the systems are analyzed.

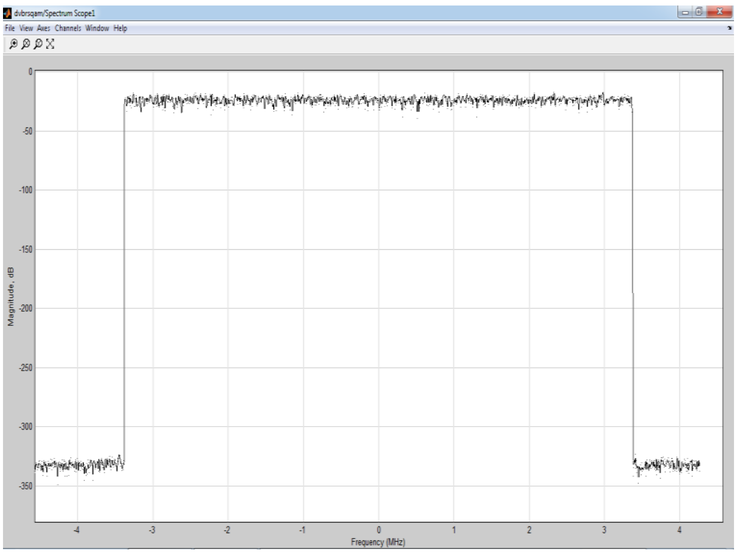

Figure 2. Transmitted Signal of DVB-T with RS Encoder.

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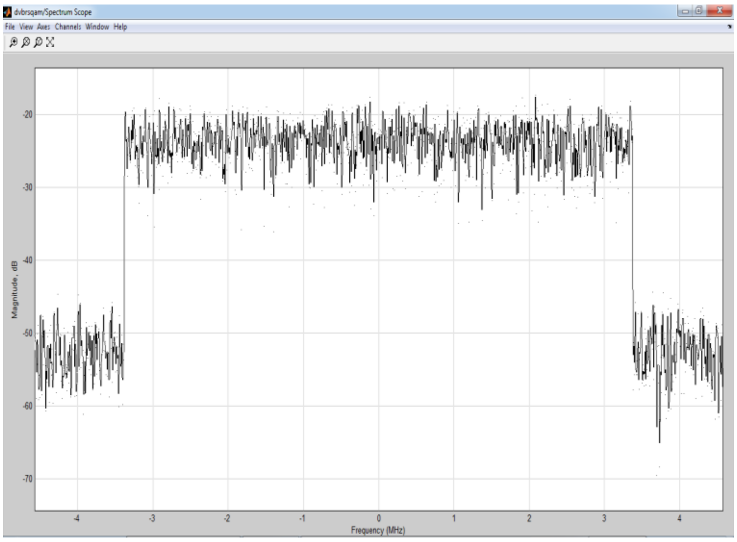

Figure 3. Received Signal of DVB-T with RS Encoder.

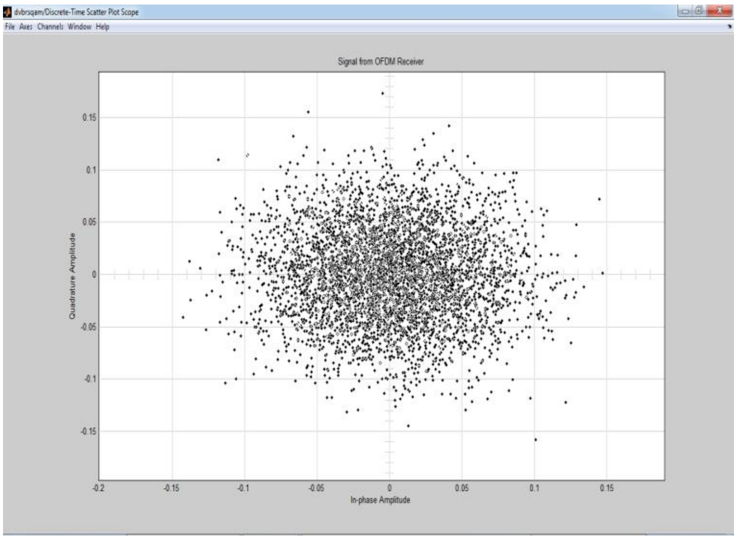

Figure 4. Scatter Plot of DVB-T Transmitted Signal with RS Encoder and QAM Modulation.

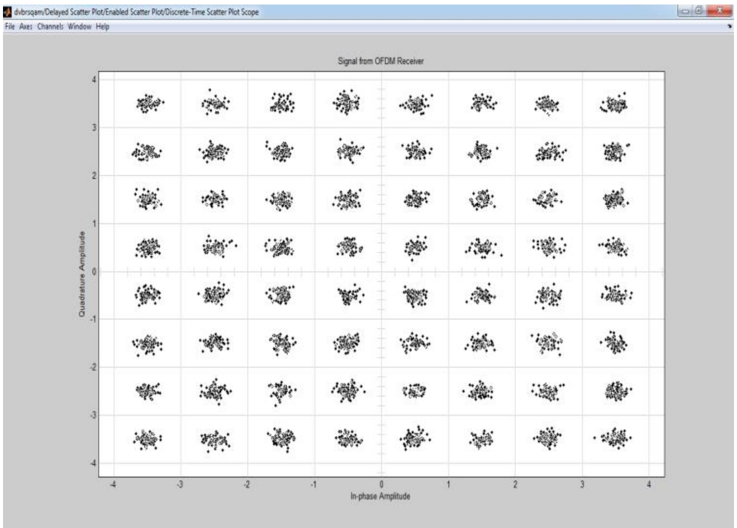

Figure 5. Scatter Plot of DVB-T Received Signal with RS Encoder and QAM Modulation.

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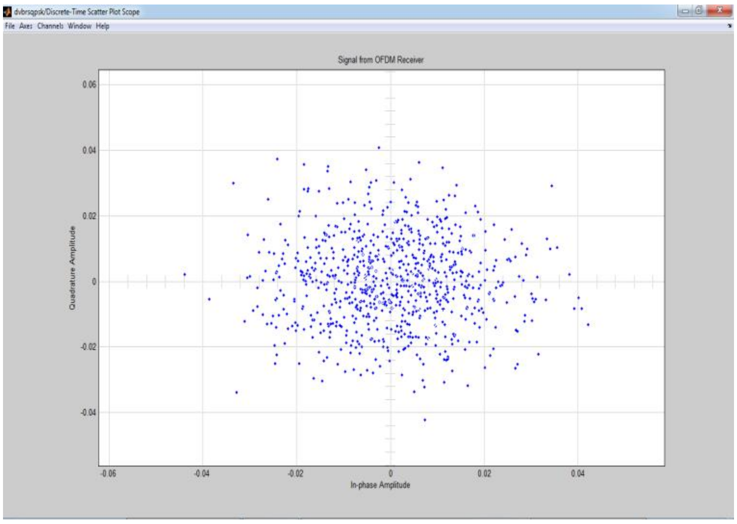

Figure 6. Scatter Plot of DVB-T Transmitted Signal with RS Encoder and QPSK Modulation.

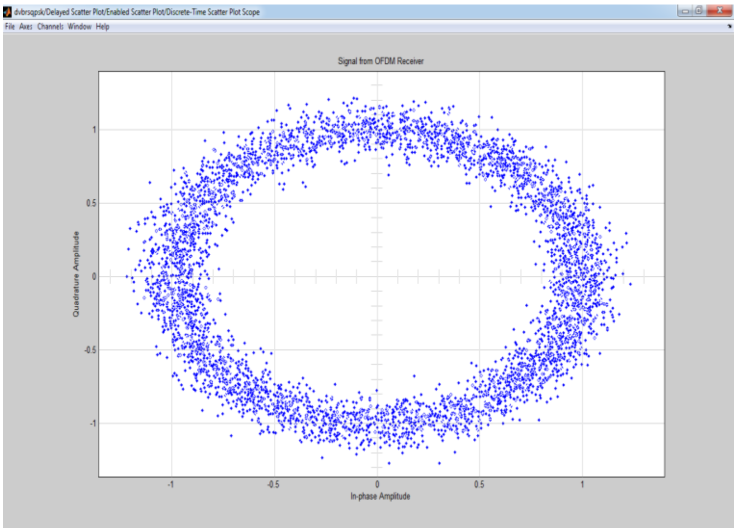

Figure 7. Scatter Plot of DVB-T Received Signal with RS Encoder and QPSK Modulation.

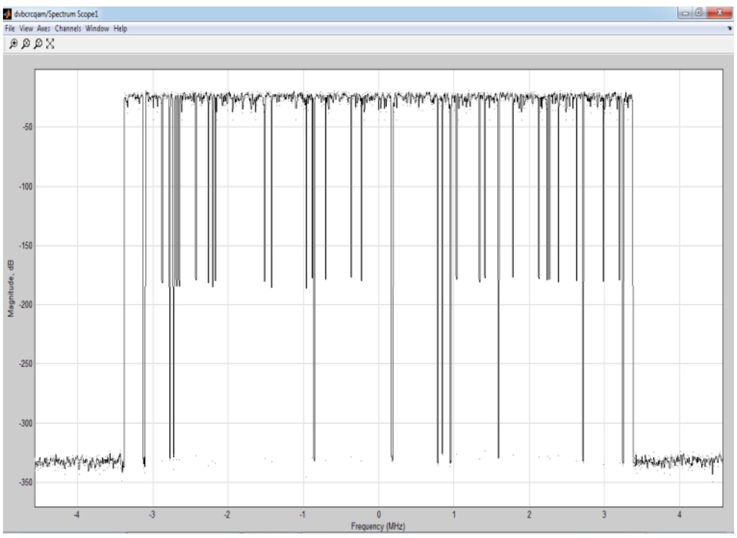

Figure 8. Transmitted Signal of DVB-T with CRC Encoder.

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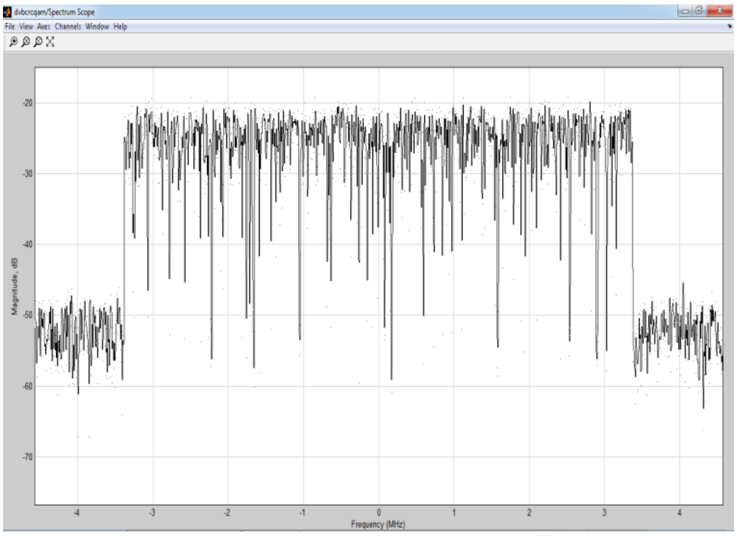

Figure 9. Received Signal of DVB-T with CRC Encoder.

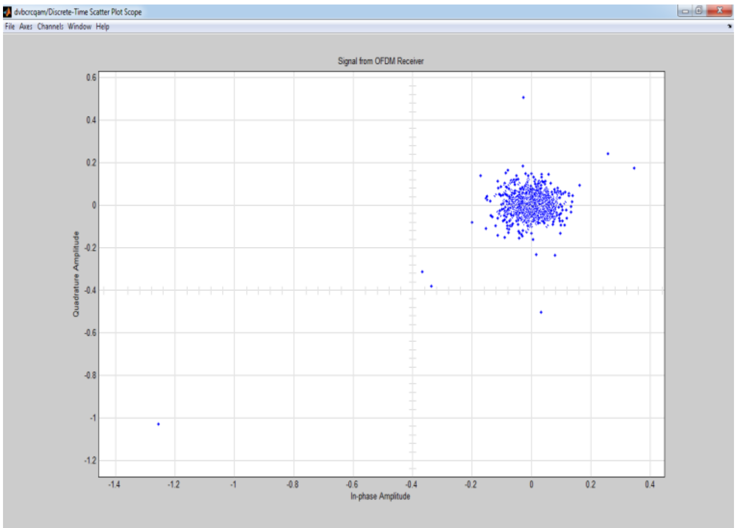

Figure 10. Scatter Plot of DVB-T Transmitted Signal with CRC Encoder and QAM Modulation.

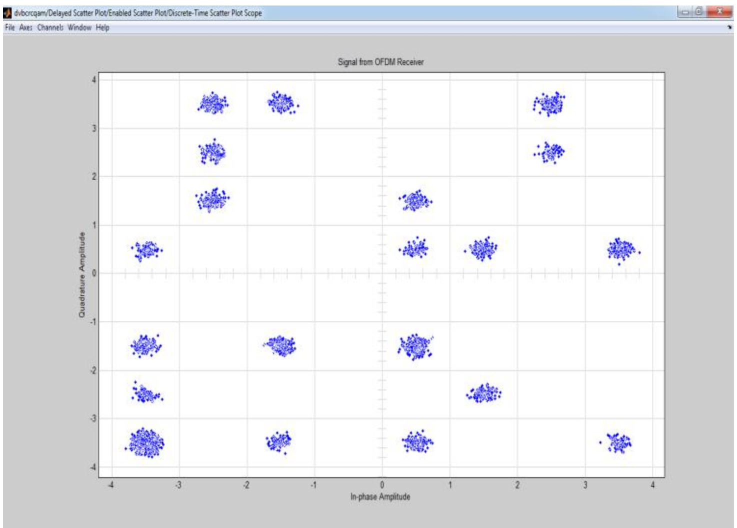

Figure 11. Scatter Plot of DVB-T Received Signal with CRC Encoder and QAM Modulation.

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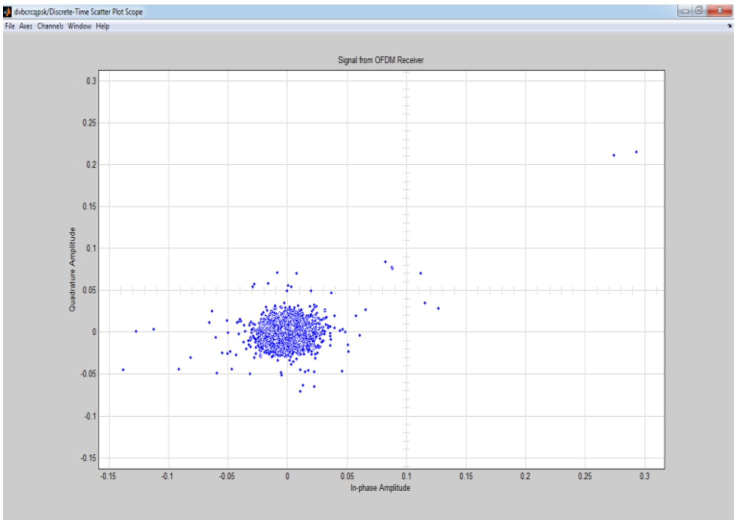

Figure 12. Scatter Plot of DVB-T Transmitted Signal with CRC Encoder and QPSK Modulation.

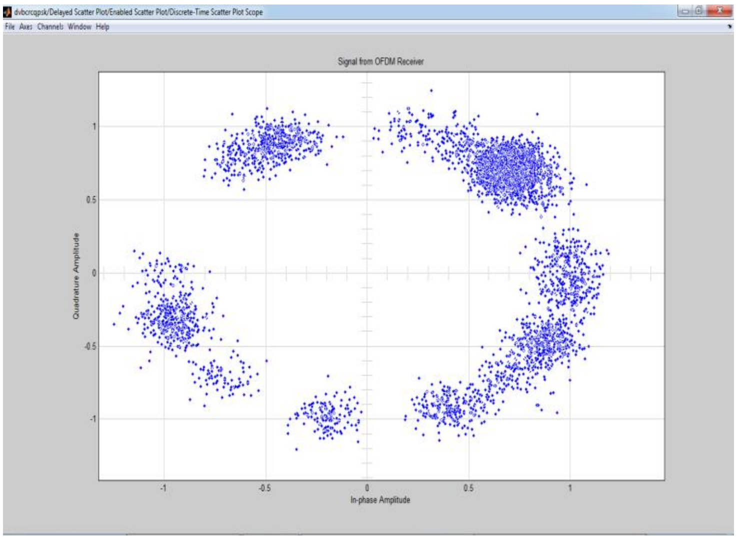

Figure 13. Scatter Plot of DVB-T Received Signal with CRC Encoder and QPSK Modulation.

The Figure shows the transmitted and received signal of DVB-T system. To plot these signals spectrum scope is used. The Spectrum Scope block computes and displays the periodogram of the input. From the plot of transmitted and received signal it is clear that the received signal is so much distorted as comparison to transmitted signal due to channel. The simulation results are plotted in term of the performance of DVB-T system that is transmitted, received signal. Now the Bit Error Rate (BER) of DVB-T system is analyzed. First calculate the BER for the DVB-T system with different modulation schemes such as 64-QAM and QPSK. The BER is calculated with error rate calculation block. In this block the transmitted and received signals are compared to calculate the BER.

Table 1. BER of DVB-T with RS Encoding.

For 64-QAM Modulation	
Bit Error Rate	0.5
Total Error Bits	15180000
Total Bits	30370000
For QPSK Modulation	
Bit Error Rate	0.5
Total Error Bits	15180000
Total Bits	30370000

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Table 2. BER of DVB-T with CRC Encoding.

For 64-QAM Modulation	
Bit Error Rate	0.4603
Total Error Bits	13980000
Total Bits	30370000
For QPSK Modulation	
Bit Error Rate	0.4980
Total Error Bits	15120000
Total Bits	30370000

From these tables it is clear that while analyzing the different modulation schemes of DVB-T system with different encoding schemes, the 64-QAM modulation with CRC encoding gives better bit error rate as compare to other schemes.

IV. CONCLUSION

The digitalisation of television signals today is a well-known and widely implemented process. It consists basically of the representation of a picture - and the accompanying sound - by a binary bit-stream, a series of '0's and 'l's. However, compression and transmission of these signals through a communications channel- satellite, terrestrial or cable- becomes practical only after the raw digital data has been subject to a series of processes. And therefore, if it is wished to be able to interconnect digital TV equipment from different suppliers, or to receive such transmissions satisfactorily, different modulation and error detection schemes are used. So DVB-T system is designed to withstand with interference and fading in communication channel. Channel coding and modulation is needed for a system in order to sustain in any type of environment especially in multipath fading channel. Here DVB-T system is first analyzed with RS encoding and different modulation schemes i.e. 64-QAM and QPSK modulation. The bit error rate with both the modualtion schemes is same with RS encoding. Then DVB-T system is again analyzed with CRC encoding and different modulation schemes. It is concluded that 64-QAM modulation with CRC encoding is best suited scheme for proposed system with 0.4603 BER.

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