

Comparative Performance Evaluation of DVB-T using Advance Design System (ADS)

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Abstract
Wireless technologies have brought a rapid growth to digital video broadcasting and as such, has played (and still playing) a vital role in communication systems. Orthogonal frequency division multiplexing (OFDM) has also become so popular in wireless communication systems reason been that it has high spectral efficiency, high throughput, high data capacity and resilience to multipath fading. In addition to these, it is very robust to channel impairment; a quality which has made it preferable and ideal in wireless communication systems. This paper evaluates DVB and compares its performance across three different channels (AWGN, Rayleigh and Ricean) and three different modulation techniques (QPSK, 16 QAM and 64 QAM) is employed. DTV_DVB in 2K Mode carriers is transmitted across AWGN, Rayleigh and Ricean and a comparison of BER performance of the different modulation schemes was considered. At the end of the simulation results and analysis, it was found that AWGN in 16QAM carrier modulation is considered the best modulation technique for DVB_T.
Keywords: modulation, channel, digital television, digital video broadcasting.

1. Introduction

Today's systems of communication is focused on information transmission from point A to point B through a channel. The quest for digital transmission of multimedia across wireless mediums has gained recognition and as such becomes very relevant with each passing day. Because of the high demand for high-speed wireless services, wireless digital communication has become prevalent and most sort after. Digital Video Broadcasting has shown to provide this services with improved performance and high spectral efficiency. Along with the DVB-T2, OFDM systems have been demonstrated (seen) in Digital Video Broadcasting for optimum bit error rate [1].

With the advent of the wireless technology, television, radio, mobile telephone and communication satellites have witnessed a great boom. Due to constant and rapid growth in digital communication systems, wireless connectivity to the internet is way outstripping other means of access already and mobile users are now getting the same level of service quality as wireline users. This could be attributed to its superior bandwidth and integration of both voice and data communication. Digital video now provides high quality with low bandwidth because of its new compression algorithm with high compression rate as compared with analogue. Video over wireless is the resultant effect of the combination of digital video compression and digital wireless communication [2].

1.1 Statement of the problem

DVB is now used as the standard for digital television in many places; reason been that it gives many benefits when compared with the analogue standardisation and has brought television forward due to its technology. It is imperative to note that a high number of persons desires to have access to DVB services while on the go. Modern day development in DVB is an efficient/effective communication technology for broadcasting television. It is based on this background that the motivation for this research arises from the need of proposing a modulation technique that is best for Digital Video Broadcasting.

1.2 Aim of the study

The aim of the study is to propose a modulation technique for digital video broadcasting system using Advance Design System (ADS).

2. Literature review

2.1 Digital television

Digital Television has to do with the transmission of video and audio by a multiplexed and digitally processed signal aimed at supporting several programs within the same channel bandwidth. The emergence of digital television appeared as a natural transition of analog TV. Shortly before now, some phases constitutes the production of a television program. These phases include; shooting (the scene, editing, and video storage), broadcasting (generation of video composite, modulation, amplification, radio transmission), reception (signal capture by antenna, television set receiver demodulation and presentation of sound and image to the viewers) of the signal were analog [3]. The reverse is the case with the modern day wireless transmission as information is now digitally generated. All processes are digital with digital television such that, sound, image and other information are generated, transmitted and received via digital form. By so doing, best definition for image and sound is achieved [4].

2.2 Digital video broadcasting (DVB)

Digital video broadcasting is used interchangeably with digital television. As such, it has become a synonym for it. The term 'DVB' stands for a suite of an open standard for digital television that is accepted internationally [5]. As a result of the increasing demand for mobile television services, digital video broadcasting has become well known; the reason been credited to its effective use of lower radiated power and frequency spectrum when compared to the analog transmission system. This, as a result, makes DVB works in the same area as do analog systems only that with the former, there is a reduction in radiated power and frequency spectrum utilisation is efficient. Digital Video Broadcasting is an international standard for all digital television set up/maintained by DVB project group. It comprises of the 8k, 4k and 2k mode with differences in useful symbol length and the number of sub-carriers [6].

Additive White Gaussian Noise (AWGN): Is a noise structure used to partially represent the resultant effect of processes that occur randomly in nature. AWGN channel is represented linearly as the addition of white noise or wideband with specific/regular spectral density alongside amplitude of Gaussian distribution. As stated earlier, the source of a Gaussian Noise could result from natural phenomena like a short noise, thermal vibrations of atoms embedded in antennas, black body radiations emitted from a warm object and so on.

Rayleigh fading: In an environment where there is no Line-Of-Sight (LOS) interaction in between the transmitter and the receiver, objects in such environment could diffract, refract, reflect or attenuate signals before getting to its final destination (receiver). It is this phenomena that is known as Rayleigh fading [7]. With the Raleigh channel, it is assumed that the signal magnitude which passes through a communication channel varies differently or fade with respect to Rayleigh distribution.

Rican fading: Ricean fading occurs when a resulting envelope amplitude, is an output of some multiple reflective rays together with a considerable none- faded Line –of Sight component to make up for a received signal. In other words, when a dominant non-faded stationary signal component is present, such as a propagation path for Line-of-Sight, the small scale fading envelope distribution is what is known as Ricean [8].

Channel coding: When there are impairments in channels along a transmission path, errors may abound in the received signal. The fundamentals of channel coding are to represent the source information in a way that reduces the probability of errors in the decoding [9] and for the sole aim of challenging multiple degrading effects of that channel [10]. The focus of channel coding is that, with a given desired uncertainty of bit error, needed amount of energy per bit Eb across noise power density N0 (Eb / N0) is minimised [11].

Modulation technique: Modulation is the process of mapping digital information into analog form so it can be transmitted over a channel. The data bits are entered serially into the constellation mapper after bit interleaving. The constellation multiplies a constant c in other to achieve equal average power. Table 1 shows the mandatory channel coding per modulation.

Table 1: Mandatory channel coding modulation [12]

Rate ID	Modulation block size	Uncoded size (bytes) Bytes	Coded block coding rate	Overall	RS Code	CC code rate rate
0	QPSK	24	48	1/2	(32,24,4)	2/3
1	QPSK	36	48	3/4	(40,36,2)	5/6
2	16-QAM	48	96	1/2	(64,48,8)	23
3	16-QAM	72	96	3/4	(80,72,4)	5/6
4	64-QAM	96	144	23	(108,96,6)	¾
5	64-QAM	108	144	3/4	(120,108,6)	5/6

3. Simulation model

The model for this system as designed by the authors is divided majorly into three parts and these parts are further divided into subsections as could be seen in the diagram in fig.1. The major parts includes:

3.1 The transmitter (Source)
3.2 The channel (AWGN, Rayleigh and Ricean)
3.3 The receiver

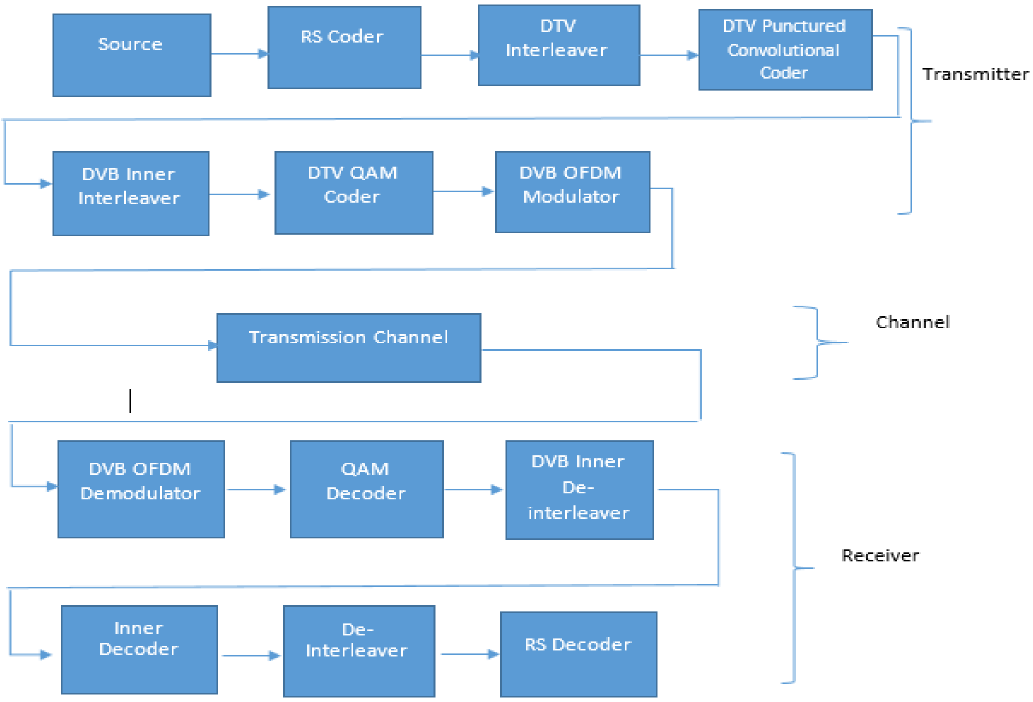

Figure 1: System model simulation block diagram

3.1 The transmitter (source)

At the transmitter, the data is first generated by a random source, consisting of various ones and zeros. The input bit data are then converted to a symbol vector via modulation. The size of the data generated, rest solely on the block size used and since transmission is done block wise, forward Error Correction (FEC) is employed. The generated data is then moved to FEC block which is the next stage [13].

Forward error correcting codes are then employed to the sequence of convolutional code as well as interleaved convolutional code sequence. The reason for using error correcting codes at this stage is to do away with a long sequence of ones and zeros since generated data are randomised. Encoding of the irregular data is done with rear biting convolutional codes (CC) with a code rate of ½. Randomization ease carrier recovery at the receiver.

3.2 The Channel

hannel here is the transmission path between the transmitter and the receiver. When there are impairments in channels along a transmission path, errors may abound in the received signal. The fundamentals of channel coding are to represent the source information in a way that reduces the probability of errors in the decoding [14] and for the sole aim of challenging multiple degrading effects of that channel [15]. The focus of channel coding is that, with a given desired uncertainty of bit error, needed amount of energy per bit Eb across noise power density N0 (Eb / N0) is minimised [11].

3.3 The receiver

The receiver performs the inverse operation that was carried out at the transmitter but will also include some other vital part such as tracking, carrier frequency estimation and timing. In other words, the receiver is responsible for the demodulation of bit streams. In other to synchronise itself with DVB transmitter base station, will first of all boots up its needs to identify some transmission parameters used by the transmitter.

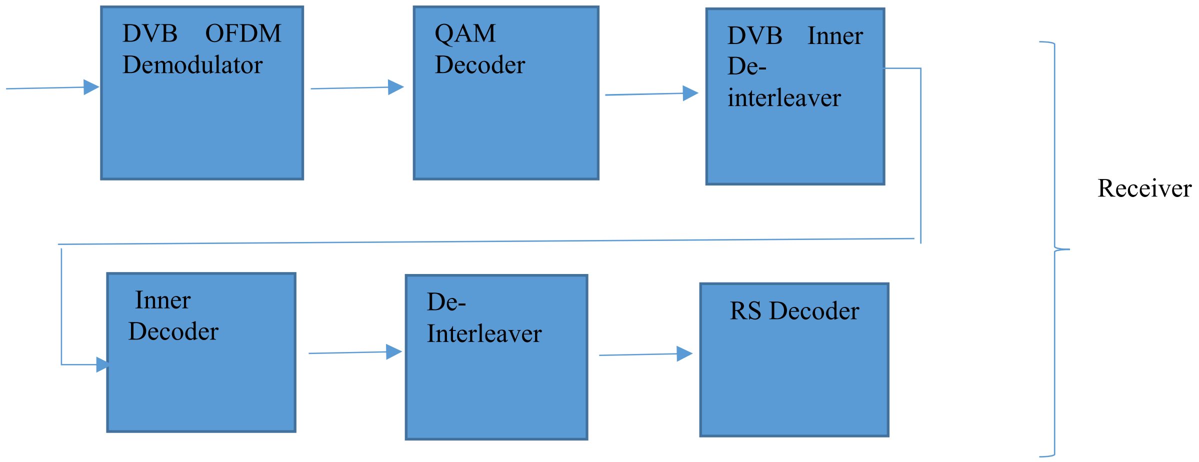

Figure 2: System model of a DTV_DVB receiver

4.0 Simulation analysis and result

The simulations were performed with the Agilent's Advance Design System (ADS) 2011 simulator. The ADS simulator is an electronic design automation software platform used by Engineers in the designs of Radio Frequency electronic products like the mobile phones, wireless and satellites network communications. The ADS supports the layouts of schematic capture, time and frequency domain, circuit and electromagnetic field simulation as well as design rule checking. In addition to the simulation environment, the following were also used: Microsoft Core i7, Microsoft Windows 8.1, ADS 2011 simulator.

The core objective of this research is to carry out a simulation analysis and result in order to propose the best modulation technique for DVB and to do this, the following areas of DTV – DVB in accordance to QPSK, 16-QAM and 64-QAM modulation schemes were simulated and appropriate analysis was carried out. This includes:

1. Bit Error Rate (BER) performance of Gaussian, Ricean and Rayleigh channel with respect to carrier – to-noise ratio (C/N).
2. Comparative analysis of QPSK, 16QAM and 64QAM.
3. Measurement of BER vs. CN

4.1 Performance analysis of AWGN, Ricean and Raleigh channels

With effect to channels and considering AWGN, Ricean and Rayleigh, a comparative analysis is presented in terms of BER and Carrier-to-noise ratio. The plot of BER vs C/N with the help of the Advanced Design System (ADS) 2011 is drawn. Simulation results in fig (5) shows the performance of AWGN, Ricean and Rayleigh in QPSK modulation.

Table 2: General system simulation parameters

Parameter	Value
Data	1512
Number of Carriers	1705
FFT Size	2048
IFFT Oder	11
FFT Oder	11
OFDM Mode	2K Mode
Coding	Reed-Solomon, Punctured Convolutional Coding (PCC)
Code Rate	PCC (1/2)
Constraint Length	7
MaxDelay	2047
CN	5dB
Modulation	QPSK, 16-QAM, 64-QAM
Noise Channel	AWGN, Ricean and Rayleigh

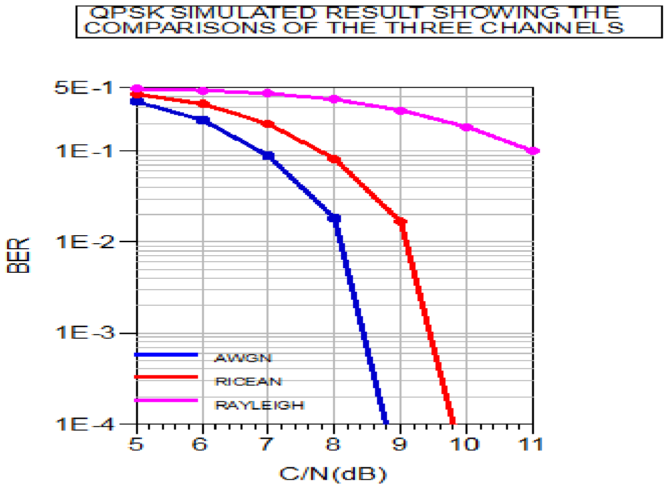

Figure 3: BER of QPSK via AWGN, Ricean and Rayleigh

In fig. (3), the BER performance of AWGN, Ricean and Rayleigh in QPSK carrier modulation was studied with a code rate of ½ in OFDM adaptation [16]. From the simulation carried out, in terms of BER, the path affected most by noise is the Rayleigh channel with BER at 5E-1 (0.5) reason been that Rayleigh has deep multipath fading which is why the ratio of error is high in Rayleigh and lowest in AWGN. AWGN gives a good result at lower C/N of 6.90 dB and BER of 1E-1 (0.1) [17].

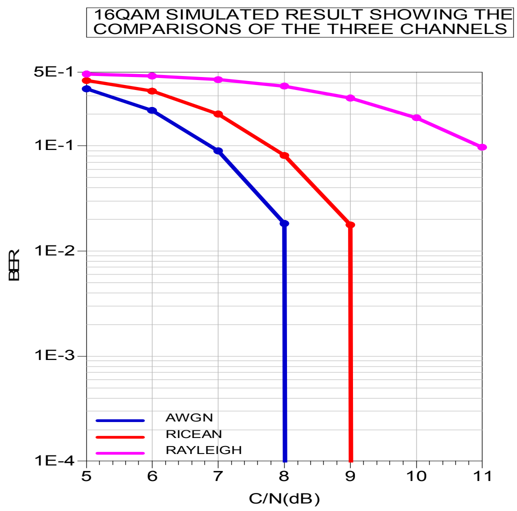

Figure 4: BER of 16QAM via AWGN, Ricean and Rayleigh

Looking at the performance of the three channels in 16QAM carrier modulation, and comparing them in terms of BER and C/N, it could be seen that at BER of 1E-1 (0.1), C/N is 6.90 dB for AWGN, 7.90 dB for Ricean and 10.90 dB for Rayleigh. From these result, we can evidently see that the higher the C/N, the lower the BER. The graph shows that at C/N of 5dB, the percentage that received bit could be in error is 99.9% in Rayleigh channel. But in Ricean, this error is reduced by almost 20%. The reason could be attributed to the fact that one or some of the wave are in the strong line of sight (LOS) [17]. In addition to this, it is observed from the above graph that the highest BER occurs at the lowest C/N of 5dB for Rayleigh. From this comparison of the three channels in 16QAM carrier modulation, AWGN channel coding is considered best in 16QAM modulation as compared to Ricean and Rayleigh [18].

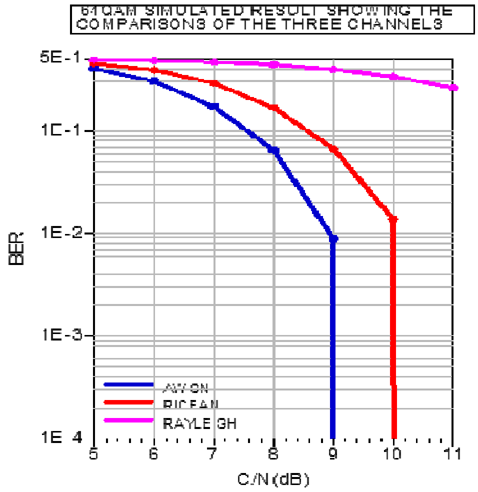

Figure 5: BER of 64QAM via AWGN, Ricean and Rayleigh

The performance of Rayleigh channel, in this case, is totally different from what we have seen in QPSK and 16QAM carrier modulation. In QPSK and 16QAM, we made our BER reading at 1E-1 (0.1) for the three channels (AWGN, Ricean and Rayleigh) but in this case, we cannot take the reading for Rayleigh from 1E-1 because it does not make an intersection with 1E-1; instead, we make our reading for Rayleigh at 5E-1 (0.5) making the performance of Rayleigh channel the worst of all the channels as BER of Rayleigh has been much affected by noise under the 64QAM carrier modulation [18].

4.2 Performance comparison of 16QAM and 64QAM (AWGN)

Like we did compare the performance of the three different channels above, we also compare the performance of the modulation scheme (16QAMs and 64QAMs).

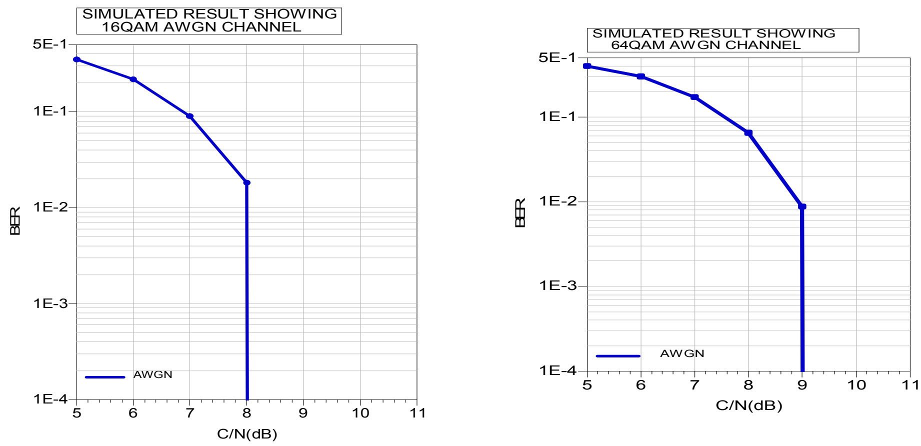

Figure 6: Comparison between 16QAM and 64QAM BER for AWGN channel

As the mapping methods increases, the chances for error occurring increases likewise; this could be seen from the two graphs above (fig. 6) for 16QAM and 64QAM AWGN. While C/N for 16QAM is at 6.90 dB, C/N for 64QAM is at approximately 7.80 dB; reason been that diminishing duration of symbol and huge data rate could result to Inter Symbol Interference (ISI) [17].

4.3 Performance Comparison of QPSK, 16QAM and 64QAM (RICEAN)

Here, we compared the performance of all three modulation scheme through the Ricean channel

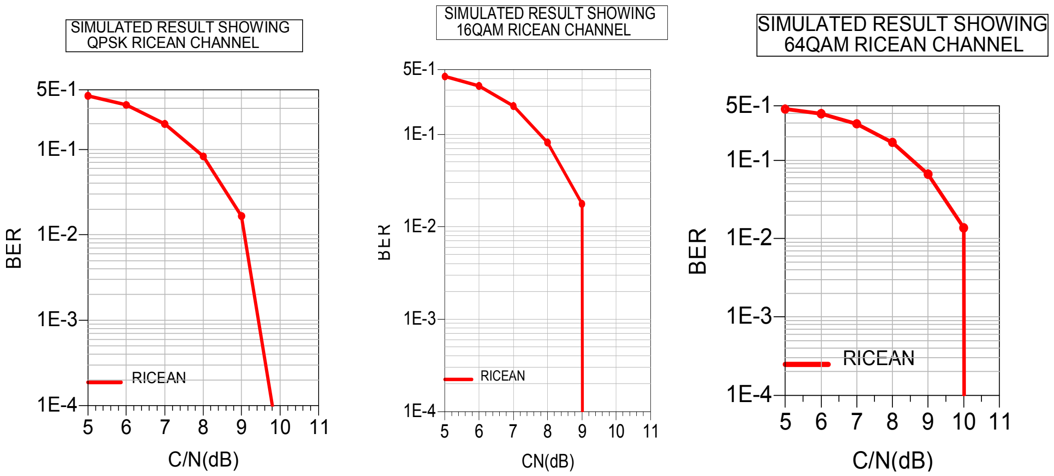

Figure 7: Performance comparison of QPSK, 16 and 64QAM via Ricean channel

Like we see from fig (7) of QPSK, 16QAM and 64QAM via Ricean, the performance of Ricean channel in QPSK modulation is better than that of 64QAM modulation and best in 16QAM modulation. This is because BER is seen to be higher in 64QAM than in QPSK and lower in 16QAM [18].

4.4 performance comparison of QPSK, 16QAM and 64QAM (Rayleigh)

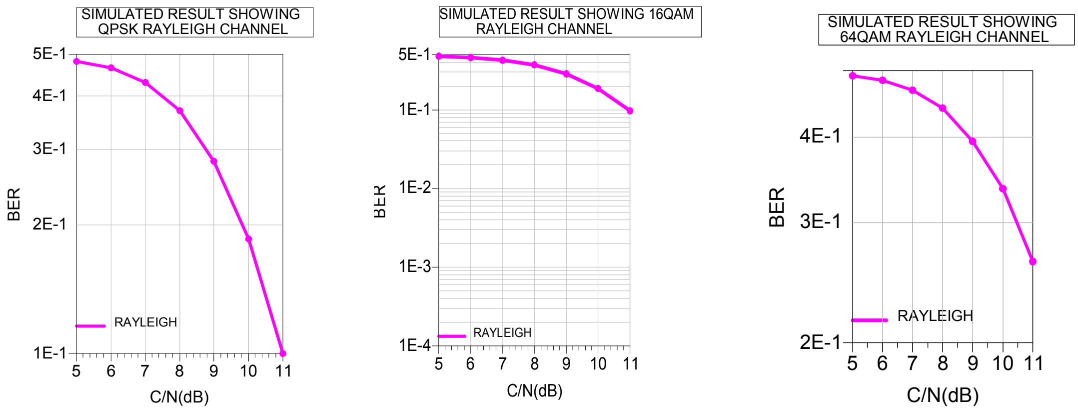

Figure 8: Performance comparison of QPSK, 16 and 64QAM via Rayleigh channel

The performance of Rayleigh channel is seen to be the worst from all the channels and in all three modulation schemes. BER is seen to be higher in 64QAM than in QPSK and highest in 16QAM. This invariably means that the performance of the 64QAM is not as good as that of the QPSK and that 16QAM is more error prone than the QPSK but this does not mean that 16QAM is not good. All the above results are in order because according to [19], the required carrier-to-noise ratio (C/N) in DVB_T is between 0 to 16.7 dB and looking at the C/N of this simulation we have not exceeded that. Results for BER and C/N performances is shown for the case of QPSK, 16-QAM and 64-QAM modulation schemes via AWGN, Rayleigh and Ricean channels. Another result shown is the Comparative analysis of the different channels and schemes and it has been seen from these results that AWGN in 16QAM is the suitable modulation technique for DVB_T with a C/N of 6.9 db.

5. Conclusion

Right from the beginning of this research, the focus has been on DVB Systems with a view of proposing the best modulation technique. Evolution of digital television and digital video broadcasting, transmitters, channels (AWGN, Rayleigh, and Rican), receivers, modulation techniques, and the simulation model used for the research analysis were all discussed appropriately. Simulation with Advance Design Systems (ADS) 2011 was carried out in order to investigate the performance of DVB transmission under different channels. 2k mode DVB-T was chosen and simulation parameters were set up. From the channel modulations, three channel models were analysed and below is the analysis/conclusions derived:

1. In terms of BER, it shows that there is a decrease in BER as Carrier–to Noise Rate (C/N) increases making BER performance the best in AWGN channel.
2. QPSK modulation seems to be more robust as regard to interference and permit the utilisation of only 2

bit
per symbol as distance increases. At a low C/N, fading tends to be more and signal strength reduces.
3. A better result is gotten with 16QAM as compared with QPSK and 64-QAM.
4. At high C/N, 64-QAM gives the worst result when compared with QPSK and 16-QAM.

Rayleigh fading channel has the worst performance from among the three channels as C/N has been most affected by noise under QPSK, QAM 16 and 64.

Ricean fading channel performance is worst when compared with AWGN channel and better when compared with Rayleigh fading channel. This is because the BER of Ricean fading channel is higher than that of AWGN channels and lower than that of Rayleigh fading channel. It could be seen that the BER of this channel has not been greatly affected by noise under QPSK, 16QAM and 64QAM.

Future work will be on digital television terrestrial (DTT) (although DTV networks are built on DVB_T and on DVB_T2) with a view of making sure that DTT networks have sufficient capacity to support service offer that is in HD quality, data service and also ultra HDTV and 3DTV .

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