Indian Journal of Science and Technology, *Vol 9(S1), DOI: 10.17485/ijst/2016/v9iS1/108288 December 2016*

*ISSN (Print) : 0974-6846*
*ISSN (Online) : 0974-5645*

# Comparative Analysis and Simulation of Various QAM Techniques as used in DVBT2

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## Abstract

**Objectives:** This paper proposes comparative performance analysis of QAM techniques as used in DVBT2 applied to random data base and also to images. **Methods/Statistical Analysis:** The proposed work uses MATLAB as the basic tool and applies DVBT2 techniques using 16 QAM and 64 QAM modulation techniques. The analysis is about observing the effect of increment in SNR on the corresponding BER. In case of image, the same has been verified visually by seeing the quality of reconstruction. **Findings:** The BER achieved is decreasing for an incremented value of SNR and there is a very well observed trade-off between these two, when 16 QAM and 64 QAM are applied in DVBT2. Also, it can be seen that images are better reconstructed in case when SNR is just little more than. **Improvements:** Dropping the probably less efficient 4 QAM, the potentially better 16 and 64 QAM is being targeted and results are obtained.

**Keywords:** BCH Coder, BER, Digital Video Broadcasting –Terrestrial (DVBT), Digital Video Broadcasting –Terrestrial – Second Generation (DVBT2) SNR, Low Density Parity Check - LDPC Coder, MIMO, OFDM, QAM, RS Encoder

## 1. Introduction

The paper describes Digital video broadcasting – Terrestrial standard as the one which actually is modifying the existing analog standards existing currently across the globe. The most important part of such standards is the retrieval of perfect signal at the receiver end excluding the effects of the channels it goes through and the noise and timing jitter. In the transmission being carried out, the data – either audio – video or any picture information or randomized data is processed for coded orthogonal frequency division multiplexing (COFDM) before they are modulated using QAM – Quadrature Amplitude Modulation constellation and mapped in the group of blocks. After formation of the blocks, IFFT – Inverse Fourier Transform is carried out with point 2048 or 8192, which will determine bandwidth requirement and number of subcarriers. Some of these subcarriers are kept in reserve to be used for the pilot symbols – much needed for efficient reception of the signals, whereas the others are to be used for guard bands as well[1,2].

**Limitations of DVBT:** Though there are many virtues of implementing DVB-T system, there are many shortcomings too of the same which cannot be neglected. The very first limitation and an important one too, is in the form of bit rates supported by it. They are limited and not compatible with the existing and rapidly changing wireless standards. For the transmission of HDTV – high-definition television and also for accommodating more channels for broadcasting, there was a strong need of new standard[3].

The second thing it lacked was interaction with the user which was needed to be upgraded.

The third limitation of the DVB-T system is its hugely inferior performance with portability or mobility which restricted its usages in moving vehicles. Last but not the least is regarding Single Frequency Networks – SFNs, where repeated signals create interference to their

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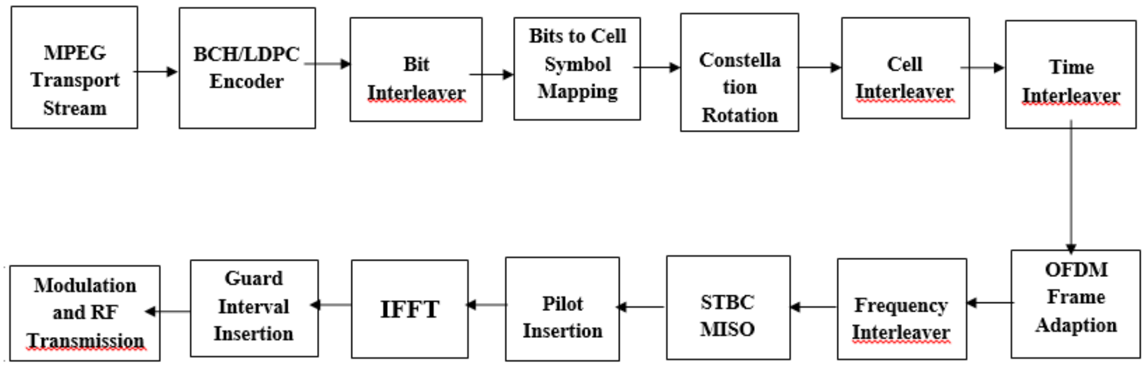


**Figure 1.** Functional Block Diagram of DVBT2.

own versions of the signal and damages the quality of reception[3].

## 2. Evolution of DVBT2

A new standard which provides enhanced capacity and also the required sturdiness in the terrestrial scenario is the second generation standard of DVBT, popularly known to be DVB-T2. It was basically designed in such a way that it can support the fixed receptors but was also equipped with required mobility. It was designed in such a way as to maintain the spectrum characteristics of its ancestor standard – i.e. DVBT. Figure 1 shows the functional block diagram of a DVB-T2 transmitter[4]. The most important change made is in its strategy of correcting errors, which has been inherited from DVBS2. A combination of LDPC – Low Density Parity Check code and BCH - Bose-Chaudhuri-Hocquenghem code improves the performance by great amount giving the robustness in receiving the signal efficiently. The FEC – forward error check coding techniques are way better than Convolution Codes used in DVBT to achieve the same purpose. As far as the modulation technique is concerned, DVBT2 uses the same – OFDM as used in DVBT, but it uses this modulation technique introducing longer symbols with 16K and 32K carriers so that an increment in the length of the guard interval can be carried out without damaging the spectral efficiency. The second generation provides combination of different numbers of carriers and guard interval lengths and hence it become a very flexible standard and can be used for any of the multiple combinations[5].

A very important modification offered by DVBT2 is the presence of 8 different pilot patterns in the scattered format, whose choice would be made by the parameters of current transmission. Because of all these minute changes made and modulation techniques too updated, a new standard has emerged giving the best possible spectral efficiency[6]. In the block diagram, it can be observed that interleaving is carried out in multi-folds – bit inter-leaver – time inter-leaver and then frequency inter-leaver to avoid the bursts of errors as much as possible and giving a way to the randomised error pattern within the frame of LDPC[7].

The Bit Error Rate as obtained from the internal decoder is taken into account for all results compared in this article. For the justified comparison to be made between DVBT and DVBT2, a quasi-error free (QEF) of $BER=2{\cdot}10^{-4}$ and $BER=10^{-7}$ must be considered for DVB-T and DVB-T2 after convolutional and LDPC decoders, respectively[8]. If these QEF reference values are considered, for an additive white Gaussian noise (AWGN) channel model - a gain of 6 dB can be obtained between the two standards and in a Rayleigh channel - nearly 4 dB[9].

## 3. DVBT2 as Applied to Random Data - BER vs. SNR

The research paper includes the study related to DVBT2 technique as modified from DVBT using LDPC coding method and BCH codes which is verified on random stream of data[10].

After achieving the results of reconstruction as the results expected or desired for, this particular technique is applied on color image and the results of 4, 16 and 64 QAMs are compared.

It can be seen from the given graphs that in 16 QAM technique used as the basic modulation technique in DVBT2, the graph shows the value of BER for given value of SNR. The gradual betterment achieved in the BER (by betterment, here reduction is referred.)

The permissible generalized value of BER taken as 10e-5 is achieved in 16 QAM using/providing/maintaining the SNR at approx. 7.5 dB. It can be seen in the graph in Figure 2.

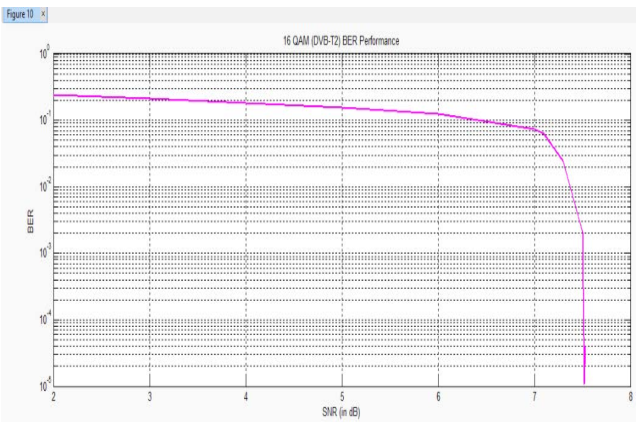


Figure 2. BER vs. SNR in DVBT2 using 16 QAM.

The same is applied using 64 QAM techniques as the basic modulation technique in DVBT2, the graph shows the value of BER for given value of SNR. The gradual betterment achieved in the BER can be observed. The resulting graph can be observed in Figure 3.

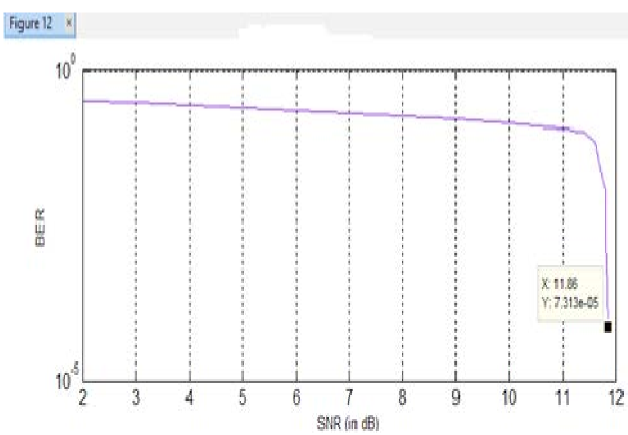


Figure 3. BER vs. SNR in DVBT2 using 64 QAM.

The permissible generalized value of BER taken as 10e-5 is achieved in 64 QAM using/providing/maintaining the SNR at approx. 11.86 dB.

The Figure 4. for both the techniques, the graphs of BER vs. SNR are plotted so that a closed comparison can be made and the required technique can be chosen.

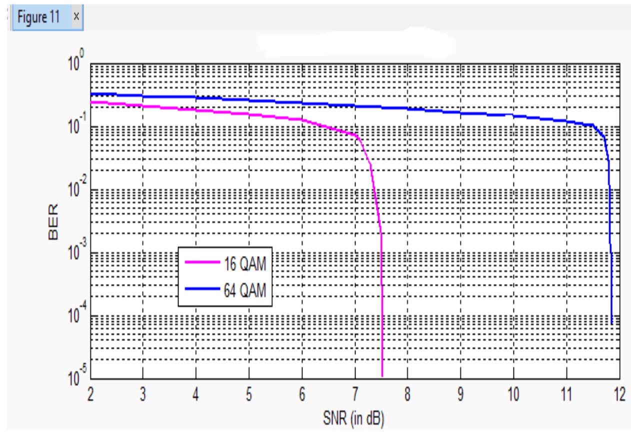


Figure 4. BER vs. SNR in DVBT2 using 16 and 64 QAM.

## 4. Simulation Results

The proposed research work was to carry out to find the best and optimized method of implementing DVBT2 using the most efficient and promising QAM technique and also the optimized value for SNR for an acceptable value of BER[11]. This entire work actually is carried out in order to further obtain the same results on video signals and later to implement them to Digital Video Broadcasting-Hand Held – also becoming popular DVBH.

Figure 5. shows how in 4 QAM (very much similar in results and performance to QPSK) it can be seen the good – better – the best reconstruction of the image for the values of SNRs taken 1.92 d B, 1.95 d B and 1.98 d B respectively.

Figure 6. shows that in 16 QAM, it can be seen the good – better – the best reconstruction of the image for the values of SNRs taken 7.65 d B, 7.68 d B and 7.81 d B respectively[11].

Figure 7. shows that in 64 QAM, it can be seen the good – better – the best reconstruction of the image for the values of SNRs taken 11.79 d B, 11.81 d B and 11.86 dB respectively[11].

Table 1. shows the comparison of DVBT with DVBT2 keeping the major points into account. It shows how minutely the second generation shows improvement.


**Figure 5.** 4QAM as applied to an image.


**Figure 6.** 16QAM as applied to an image.

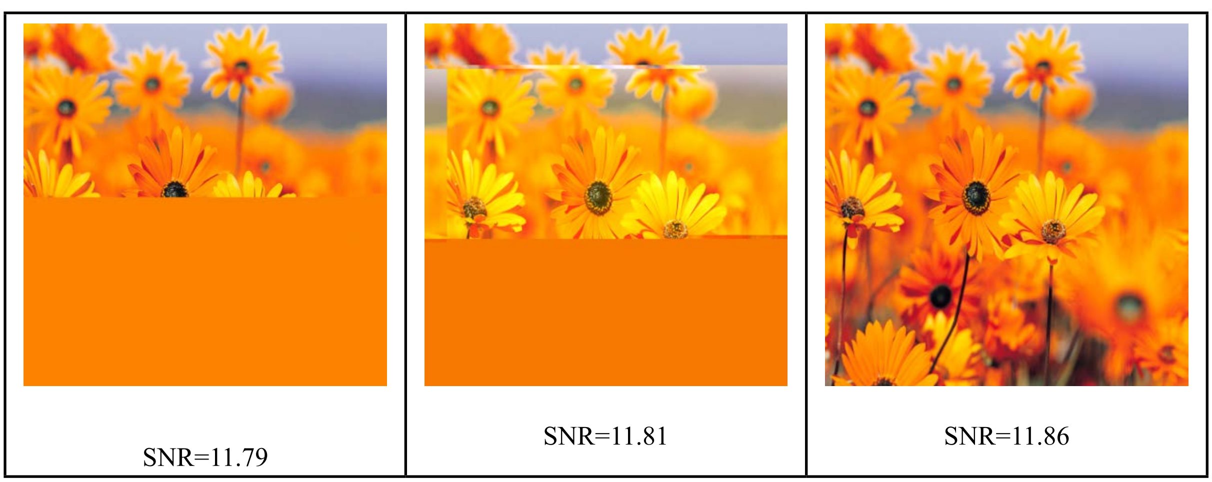


**Figure 7.** 64QAM as applied to an image.

**Table 1.** Comparison of DVBT with DVBT2

| DVBT | DVBT2 |
|---|---|
| FEC carried out by REED SOLOMON & Convolutional codes | FEC carried out by LDPC & BCH codes |
| Modes are QPSK, 16QAM, 64QAM | QPSK,16QAM, 64QAM, 256QAM |
| Guard intervals 1/4, 1/8, 1/16, 1/32 | 1/4, 19/256, 1/8, 19/128, 1/16, 1/32, |
| FFT size 2K, 8K | FFT size 1K, 2K, 4K, 8K, 16K, 32K |
| Scattered pilots 12% | Scattered pilots 1% |
| Continual pilots 2.6% | Continual pilots 0.35% |

Table 2. shows the comparison of 16 QAM and 64 QAM as applied to random data bits generated applying DVBT2 and taking the results of achieved BER for gradually increasing values of SNR.

**Table 2.** Comparison of DVBT2 using 16 and 64 QAM techniques

| | DVBT2 -16 QAM | | DVBT2 -64 QAM | |
|---|---|---|---|---|
| | SNR | BER | SNR | BER |
| 1 | 7.5 dB | $10^{-5}$ | 11.86 dB | $10^{-5}$ |
| 2 | 4 dB | $0.8 \times 10^{-2}$ | 7.5 dB | $0.5 \times 10^{-1}$ |
| 3 | 2 dB | $10^{-1}$ | 2 dB | $0.5 \times 10^{-1}$ |

## 5. Conclusion

DVB-T2 provides much higher data rates as compared to DVB-T (for the equal amount of sturdiness) -between approximately 50% to almost double.

- The constellation are revolves/rotated
- Larger SFN – pilot pattern supported.
- Greater choice for guard interval Higher FFT modes (number of carriers)
- Forward Error Check highly improvised.

This definitely makes it the first choice when HD services are to be included to the terrestrial platform. However, accurate definition of the key parameters of the DVB-T2 system is more critical in planning DVB-T2 networks than it is for DVB-T.

Another important conclusive point is using 64 and 16 QAM respectively, the similar value of accepted BER can be achieved by applying higher SNR.

The benefit of choosing the higher order formats is - there are more points included within the constellation – so, it is possible to transmit more bits per symbol. The shortcoming is that the constellation points are closer together and so the link is more susceptible to noise. As a result, higher order versions of QAM are only used when there is a sufficiently high signal to noise ratio.

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