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DVB-SH-A TRANSMISSION IN GAUSSIAN AND MOBILE FADING CHANNELS

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Abstract

Nowadays, the development and improvement of the digital broadcasting techniques and video compression methods have big demand in the television and telecommunication market. In case of mobile terminals and phones the DVB-H and DVB-SH standards define the video reception. In case of the DVB-SH standard the key feature is that it is a hybrid satellite-terrestrial system that will allow using a satellite to achieve large coverage area. In this paper we survey the existing work and the general introduction about DVB-SH standard.

Keywords: DVB-T2, DVB-T, DVB-H, DVB-SH, OFDM, BER, PER, LMS, QoS.

1. INTRODUCTION

Demands for mobile reception of high quality video, audio and data broadcasting services are rapidly increasing. In an era of digital TV broadcasting there exist several types of DVB (Digital Video Broadcasting) standards, which define the methods of framing, coding and modulation of the broadcasted TV. In case of mobile TV, the standards DVB-H (Handhelds) and DVB-SH (Satellite to Handhelds) have been developed. DVB-H and DVB-SH are the leading global technology standards for the transmission of digital TV to handheld receivers such as mobile and smart phones, terminals and PDAs.[8]

Mobile TV is already booming on existing cellular infrastructures in point-to-point mode. However this mode is not optimized to deliver the same content of broadcasted stream to many users at the same time. More precisely, in areas where the reception of the transmitted information is bad, especially in urban areas; the classical DVB-H

(Handheld) does not support the optimal solution. For this situation the data stream, transmitted in DVB-SH system is optimal. [2]

DVB-SH is the name of a mobile broadcast standard designed to deliver video, audio and data services to small handheld devices such as mobile telephones, and to vehicle-mounted devices. The key feature of DVB-SH is the fact that it is a hybrid satellite/terrestrial system that will allow the use of a satellite to achieve coverage of large regions or even a whole country. In areas where direct reception of the satellite signal is impaired, and for indoor reception, terrestrial repeaters are used to improve service availability. The DVB-SH system provides an efficient and flexible mean of carrying broadcast services over a hybrid satellite and terrestrial infrastructure operating at frequencies below 3 GHz to a variety of portable, mobile and fixed terminals having compact antennas with very limited or no directivity. This configuration of system is optimal for the battery-powered devices (PDAs and mobile phones), vehicle-mounted (laptops) and stationary terminals (set-top boxes). The key feature of DVB-SH is the fact that it is a mentioned hybrid satellite/terrestrial system that will allow the use of a satellite to achieve coverage of large regions. Whenever a line of sight between terminal and satellite does not exist, terrestrial gap fillers are employed to provide the missing coverage. OFDM (Orthogonal Frequency Division Multiplexing) is the natural choice for the terrestrial modulation as it has been already selected for DVB-T/H systems.[2]

With focus on mobile and portable TV implementation aspects it is most important to determine the reception environment. The "portable" means that the device can easily be carried or taken from one point to another. The "mobile" means reception while moving at high speeds in cars, trains, etc. In the context of DVB-H/SH, portable antenna reception is defined as the reception at no speed very low speed (approx. 3km/h, e.g. walking speed) and mobile antenna reception is defined as the reception at medium to high speed (approx. between 30 km/h and 100 km/h in vehicular traffic).[8]

The DVB-SH system coverage is obtained by combining a Satellite Component (SC) and, if required, a Complementary Ground Component (CGC) to ensure service continuity in areas where the satellite alone cannot provide the required Q.o.S. The SC ensures wide area coverage while the CGC provides cellular-type coverage. All types of environment (outdoor, indoor, urban, sub-urban and rural) can then be served. It should be noted that the area served by a beam of currently planned multibeam satellites is in the order of 600 000 Km².

For the satellite transmission, two modulations have been selected, which leads to two reference architectures within the variety of possible hybrid satellite/terrestrial system architectures:

- SH-A (for OFDM terrestrial and OFDM satellite transmission mode) and
- SH-B (for OFDM terrestrial and TDM satellite transmission mode).

2. BLOCK DIAGRAM OF DVB-SH-A

The structure of the transmitter follows common DVB-SH-A transmitter block diagram, as shown in Fig.1. Details of the following blocks are briefly described below. In the first step the input data sequence is generated. The constant length of one DVB-SH frame contains 12 282 bits. For the simulation in this project the length of this frame was shortened. The reason is that the time for turbo decoding is too long and the process of decoding is complex. The length of one data frame therefore equals to 2048 bits (2 kb).

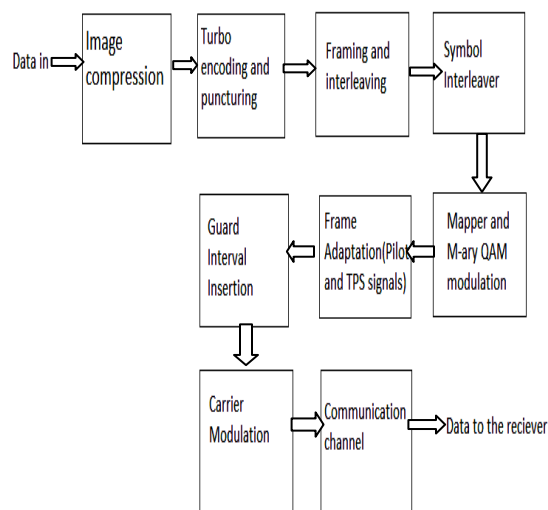


Figure 1 : Block diagram of DVB-SH-A transmitter

2.1 Image Compression

The input image is first compressed using 'spiht_3d' wavelet-based image compressing method. Set partitioning in hierarchical trees (SPIHT) is an image compression algorithm that exploits the inherent similarities across the subbands in a [wavelet decomposition](#) of an image. The algorithm codes the most important wavelet transform coefficients first, and transmits the bits so that an increasingly refined copy of the original image can be obtained progressively. For the efficient transmission of an image across a channel, source coding in the form of image compression at the

transmitter side & the image recovery at the receiver side are the integral process involved in any digital communication system. The wcompress command performs either compression or uncompression of grayscale or truecolor images.

2.2 Turbo encoding and puncturing

The next stage contains the turbo encoder and puncturing. The turbo encoder, as it was standardized by the 3GPP2 organization, shall be used for the DVB-SH. However, this type of turbo coder has several disadvantages from the perspective of simulation (complexity, time of encoding, problems with the methods for the turbo decoding). Therefore, for the simulation there was used a modified type of this coder [5]. Hence, the application is using PCCC (Parallel Concatenated Convolutional Code) turbo encoder. This type is preferred for a very low BER [7]. After the turbo encoding the puncturing of the encoded data is followed, as it is defined in [4]. Within a puncturing pattern, a "0" means that the symbol shall be deleted and a "1" means that a symbol shall be passed.

2.3 Framing and Interleaving

The interleavers are introduced to enhance the resistance of the waveform to short-term fading and medium-term shadowing impairments in satellite and terrestrial channels. Interleaving is frequently used in digital communication and storage systems to improve the performance of [forward error correcting codes](#). Many [communication channels](#) are not memoryless: errors typically occur in [bursts](#) rather than independently. If the number of errors within a [code word](#) exceeds the error-correcting code's capability, it fails to recover the original code word. Interleaving ameliorates this problem by shuffling source symbols across several code words, thereby creating a more [uniform distribution](#) of errors. Before the symbol interleaving, the input stream is demultiplexed (and mapped to output modulation symbols) into v sub-streams, depending of the modulation used: $v = 2$ for QPSK and $v = 4$ for 16QAM.

2.4 Symbol Interleaver

Symbol interleaving is performed as bit-wise interleaved substream. The purpose of the symbol interleaver is to map v bit words onto the 756 (1k mode) 1512 (2k mode), 3024 (4k mode) or 6048 (8k mode) active carriers per one OFDM symbol. The symbol interleaver acts on blocks of 756, 1512, 3024 or 6048 data symbols. After previously mentioned FEC blocks and interleavers are ready to modulate symbols into QPSK or 16QAM constellations.

2.5 Mapper and M-ary QAM modulation

QAM is more exacting in terms of the carrier frequency and phase or the requirement for a distortion-less transmission medium. QAM, when used for digital transmission for radio communications applications is able to carry higher data rates than ordinary amplitude modulated schemes and phase modulated schemes. As can be seen from the constellation plot that for SNR above 10 we get a more precise accurate signal. Hence we use QAM for DVB-SH-A transmission.

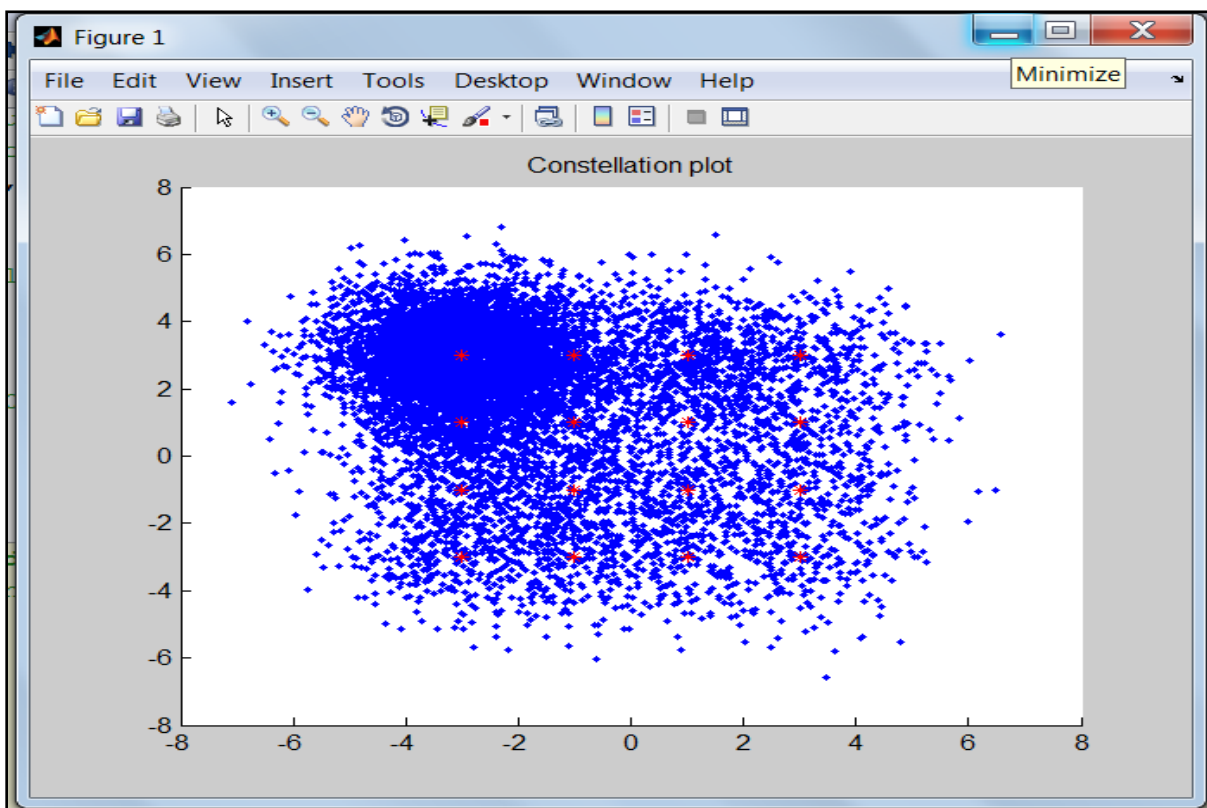


Figure.2: Constellation plot for SNR 5

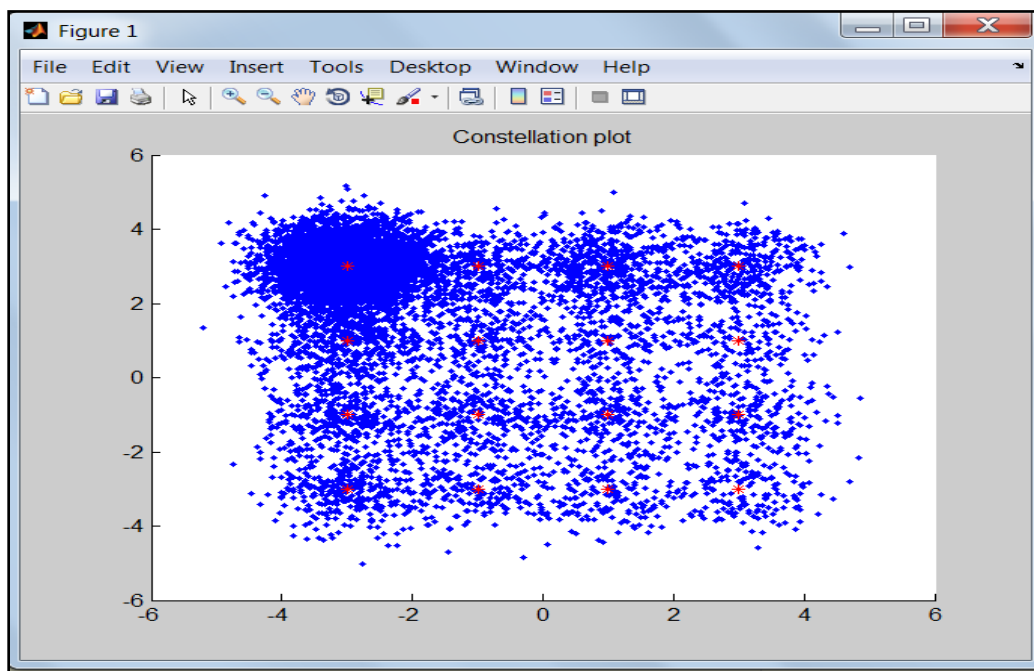


Figure.3: Constellation plot for SNR 10

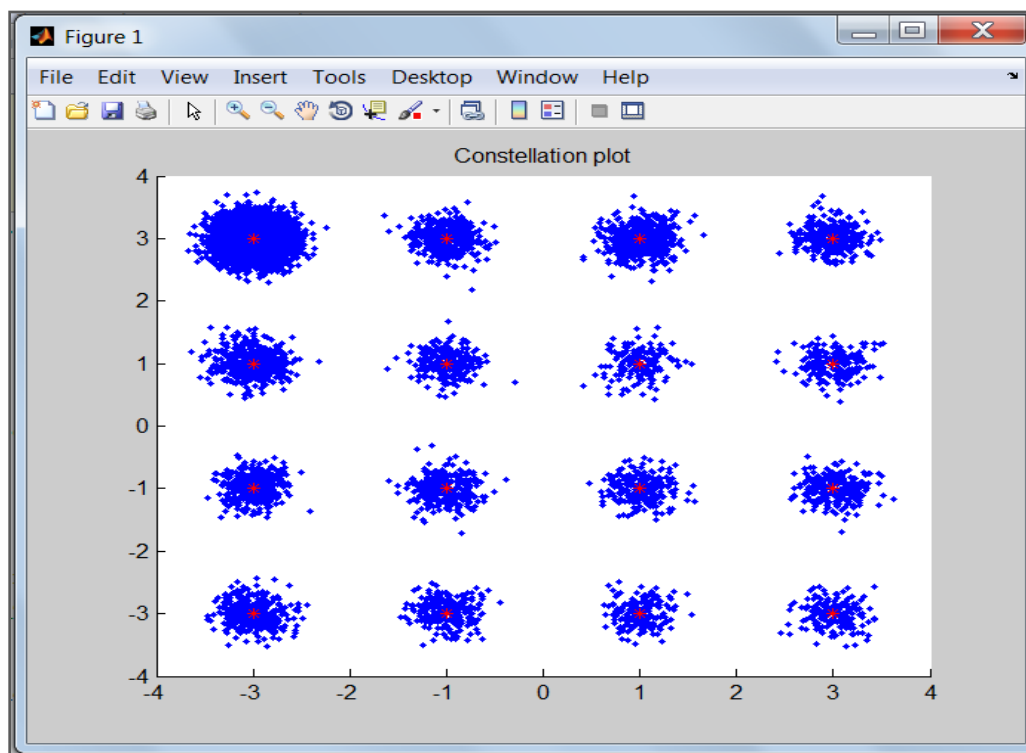


Figure.4: Constellation plot for SNR 20

MATLAB functions and tools support some cases for the modulation and demodulation. In the developed application the `modem.qammod (M)` function was used from Communication Toolbox. This function also enables set up of which symbols will be mapped.

2.6 Frame Adaptation

Transmission frame adaptation block has to divide modulated stream, carrying useful data, into OFDM symbols and adds the TPS, scattered, pilot and zero carriers. This block is simple, as the only purpose is to rearrange the data and insert special carriers on their defined positions.

2.7. Guard Interval Insertion

Once we have OFDM symbols assembled, guard interval can be inserted. According to the DVB-SH specification the options are 1/4, 1/8, 1/16 and 1/32 of the symbol period. End part of each symbol is copied to the beginning of the previous symbol.

2.8. Carrier Modulation

Now, complete OFDM signal in the frequency domain is transferred into the time domain by using IFFT (Inverse Fast Fourier Transformation) function. Real $\text{Re}(t)$ as well as imaginary $\text{Im}(t)$ part of the OFDM signal is upsampled and filtered with Raised Cosine filter with roll-off factor equals to 0.35.

2.9. Channel Simulation

At this point we have now prepared DVB-SH-A signal, which can be transmitted by using transmission channel model. There exist several types of channel models (AWGN, Rice, Rayleigh) in MATLAB Communication Toolbox, which can we used for the examination how the signal behaves in the transmission environment. In this paper for the simplified simulation there was chosen AWGN channel, which characteristics are simulated by using the MATLAB function `awgn`.

3. SIMULATION

The complete functional scheme of the DVB-SH-A transmitter has been described and it has been implemented in MATLAB. The method of the FEC, used in the DVB-SH was described in [4]. On the other hand, the turbo code decoding process is not described. Decoding systems are based on a SISO (Soft-Input Soft-Output) decoding or LLR (Log Likelihood Ratios) and other methods [7]. In this paper for the turbo decoding

of received data the SISO method was used. For the simulation of the DVB-SH channel encoder and decoder there was used following settings:

- mode: 1k (satellite),
- code ratio: 1/5 and 2/9 (robust transmission),
- non-hierarchical modulation: QPSK, 16QAM,
- transmission channel: Gaussian (AWGN),
- turbo decoding method: SISO.
- number of iterations: 1 and 2

4. RESULTS

The figure 4 shows the image of transmitted and received image with SNR 7 .The constellation diagram shows modulated and demodulated signal points. The frequency plot shows the OFDM signal. For the simulation purpose the image is transmitted. The image is read, compressed and converted into binary data. The resulting signal is turbo encoded, interleaved, OFDM modulated. At the receiver side Turbo decoding, demodulation and uncompression is done and the signal is received.

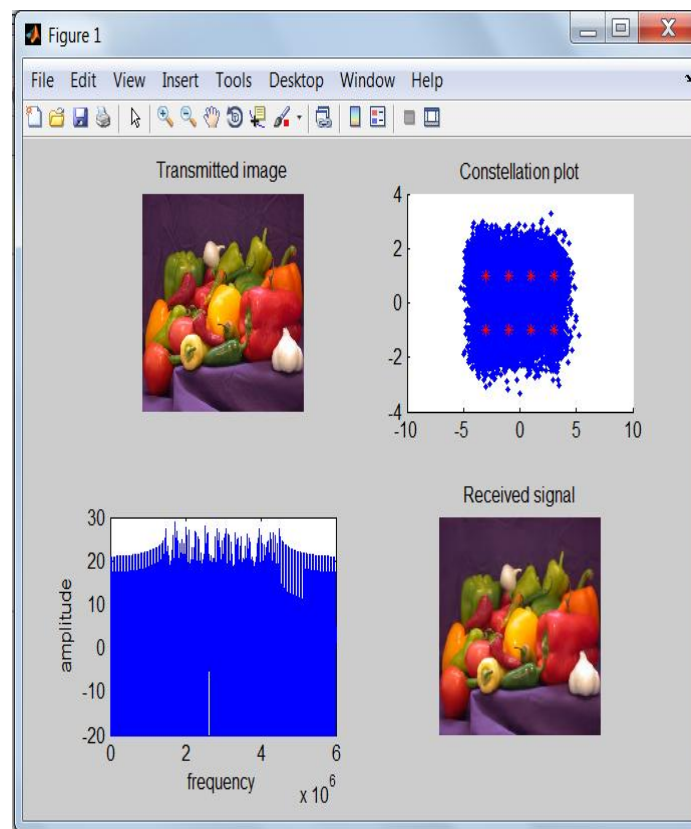


Figure 4: Transmitted and Received image with SNR 7

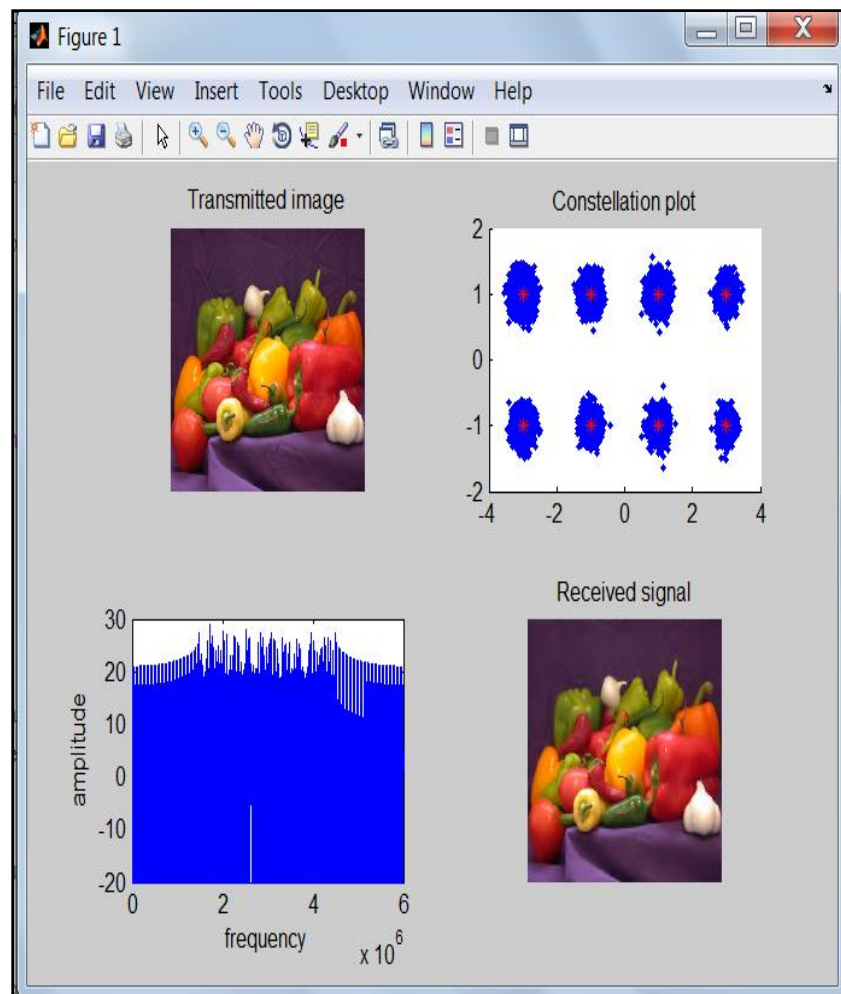


Figure 5: Transmitted and Received image with SNR 20

The fig 5 shows the transmitted and received image when the SNR value is 20. The received image is of better quality and all the information is recovered. In *digital transmission*, the number of bit errors is the number of received *bits* of a *data stream* over a *communication channel* that have been altered due to *noise*, *interference*, *distortion* or *bit synchronization* errors. The BER may be improved by choosing a strong signal strength (unless this causes cross-talk and more bit errors), by choosing a slow and robust *modulation* scheme or *line coding* scheme, and by applying *channel coding* schemes such as redundant *forward error correction* codes.

The figure 6 shows the comparison of BER for different modulation techniques.

For 4-QAM the BER is 0 for SNR values above 5.

For 8 QAM the BER is 0 above 10 SNR value.

For 16 QAM the BER is 0 above 15 SNR value.

For 32 QAM the BER is 0.000123 for 20 SNR value

For 256 QAM the BER is 0.072935 for 20 SNR value.

Hence we prefer using 8 QAM modulation technique as BER is 0 for high SNR value.

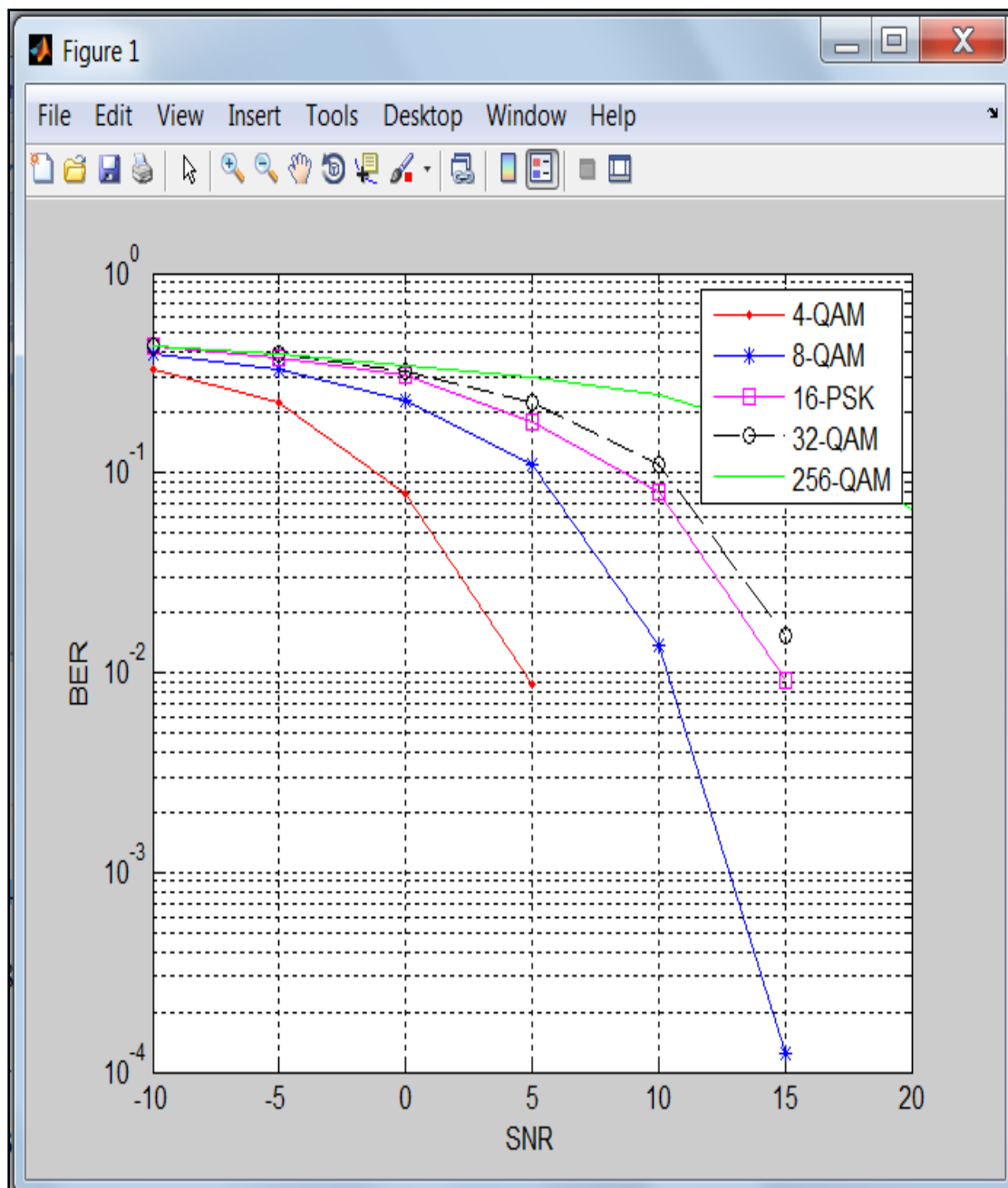


Fig 6: BER of different modulation techniques

5. CONCLUSION

The application that allows simulation of the DVB-SH standard (in fact DVB-SH-A) transmission was developed and briefly described in the project. Features of this standard i.e, turbo encoding, OFDM mode 1k, turbo decoding were modified for the simulation and they were implemented in MATLAB. While transmitting the image, the image is first compressed and then is turbo encoded and modulated at transmitter side and the image is demodulated, turbo decoded and uncompressed at the receiver side. The DVB-SH offers a very good solution for the mobile TV broadcasting. On the other hand, mobile phones, which are available in the market, should be compatible with DVB-SH standard.

This work will continue by finishing the MATLAB application with GUI (Graphical User Interface) and then by improving the turbo encoder/decoder and transmission channel model used in this application.

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