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SIMULATION OF ATSC DIGITAL TELEVISION 8 QAM MODULATION USING MATLAB WITH SIMULINK

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Abstract
Advanced Television System Committee (ATSC) and 8V**SB** modulation is used primarily in North America. In this work the ATSC digital television transmission and reception was presented , 8VSB design, and a 8QAM modulation scheme were adapted to it , to check out the performance of the system. A simulation with the aid of MATLAB with SIMULINK was established and the comparison and analysis of the design were conducted. The ATS is designed to transmit high-quality video, audio, and ancillary data within a single 6 MHz terrestrial television broadcast channel.

Keywords-QAM; VSB; ATSC and MPEG2

I. INTRODUCTION

The original TV technology is called **analog**. It is also called **NTSC** (National Television System Committee), which is the committee that defined it. The NTSC spec was created in 1946, updated for colour in 1953, and updated for stereo in 1984. Both of these updates were backward compatible, rendering nobody's TV set obsolete. But the new digital standard is totally different. The only thing it has in common with NTSC is the 6 megahertz channel width.[1]
ATSC is the name of the technical standard that defines the digital TV (DTV) that the FCC has chosen for terrestrial TV stations. ATSC employs **MPEG-2**, a data compression standard. MPEG-2 typically achieves a 50-to-1 reduction in data. It achieves this by not retransmitting areas of the screen that have not changed since the previous frame.
Digital cable TV systems and DBS systems like DirecTV have devised their own standards that differ somewhat from ATSC. Their high-definition set top boxes (STBs) conform to ATSC at their output connectors. Those systems use MPEG-2 or MPEG-4.

II. ATSC System Layers

The ATSC systems is made of 4 main layers which are Transmission layer with 6 MHZ of bandwidth per channel (This is the layer that will be mainly discussed in this work), Transport layer (This layer is also briefly discussed) , compression layer and the Picture & sound layer as shown in Fig 1.[6]

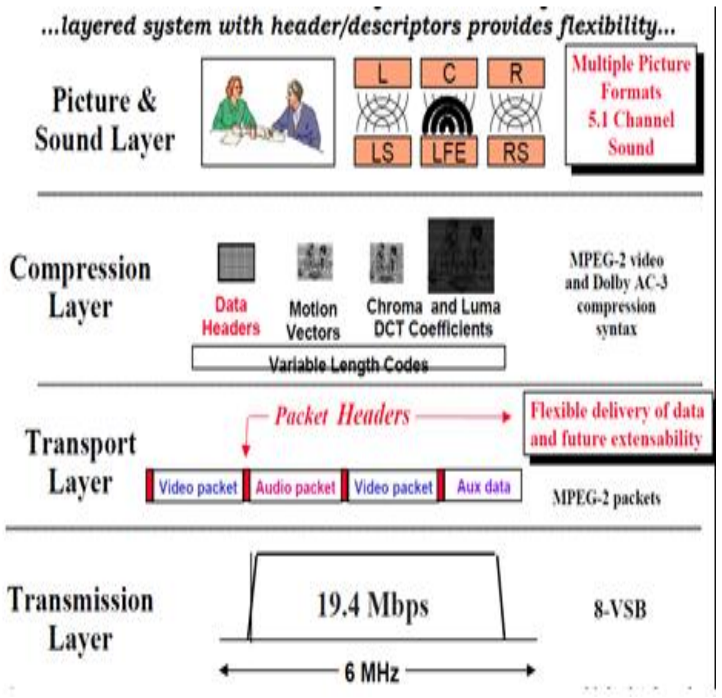

Fig 1. ATSC Sytem Layers

III. ATSC Transmission and Reception

A- ATSC Transmission

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Vestigial sideband modulation (VSB) is a modulation method which attempts to eliminate the spectral redundancy of pulse amplitude modulated (PAM) signals.

A modulation method specifies how the radio signal fluctuates to convey information. ATSC and DVB-T specify the modulation used for over-the-air digital television; by comparison, QAM is the modulation method used for cable. The specifications for a cable-ready television, then, might state that it supports 8VSB for broadcast TV.[4]

The trellis-coded 8-VSB-transmitter block diagram is shown in Figure 2. The transmitter, which includes the channel encoder and exciter, receives the incoming data packets (188 B/packet of interspersed video, audio, and ancillary data), and thoroughly randomizes the data so that the transmitted signal has a flat, noise-like spectrum. Random data is important for all the receiver recovery loops to work optimally, and minimizes interference into analog NTSC. The Reed–Solomon encoding, known for its good burst noise correction capability and data overhead efficiency, adds the 20 parity bytes to the end of each MPEG data packet before data bytes are convolutionally interleaved (spread out) over 52 data segments, to a depth of 1/6 of a data frame (4 ms). Segment and frame syncs are not interleaved. Data byte interleaving helps protect against the effects of burst noise/interference that occurs during transmission. In the trellis-coded 8-VSB terrestrial system, the trellis encoder adds additional redundancy to the signal in the form of more (than four) data levels, creating the multilevel (eight-level) data symbols for transmission. The added redundancy allows further error correction in the receiver through the cascaded forward error correction made up of Reed–Solomon block
coding and convolutionally coded trellis-coded modulation (2/3 rate, four-state Ungerboeck code).[3]

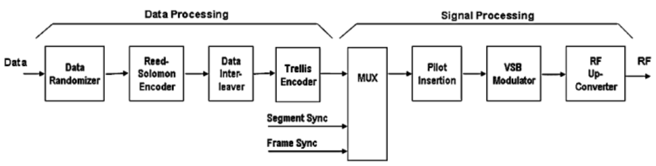

Fig 2. ATSC Transmitter

B- Reception

The VSB receiver block diagram is illustrated in Figure 3, The DTV signal, using the existing 6-MHz RF channel allocations, is converted by the VSB receiver's tuner to the IF frequency (typically 44 MHz) prior to channel decoding. After appropriate IF filtering (root-raised cosine) and automatic gain control (AGC), the pilot signal can be used to synchronously detect the VSB signal while simultaneously removing FM sidebands and low-frequency phase noise inherent in low-cost consumer tuners. The clock synchronizer recovers the 10.762-MHz symbol clock from the received signal as well as synchronizes the various following loops (interleaver, trellis and Reed–Solomon decoders, and randomizer) so that further VSB processing can be accomplished. The equalizer is the workhorse of the DTV receiver removing any linear distortion due to multipath propagation or imperfect filtering. Any remaining high-frequency tuner phase noise is removed by the phase tracker. The remaining data processing circuits perform the concatenated forward error correction (short four-state trellis decoding with minimal error propagation followed by a T=10 Reed–Solomon decoder that can correct up to ten byte errors/MPEG packet). A convolutional de-interleaver reassembles the interleaved (dispersed) data bytes while dispersing (spreading out) contiguous burst errors to maximize Reed–Solomon error correction. Finally, the de-randomizer recreates the original data bytes for the transport multiplexer to deliver to the video and audio decoders.[3]

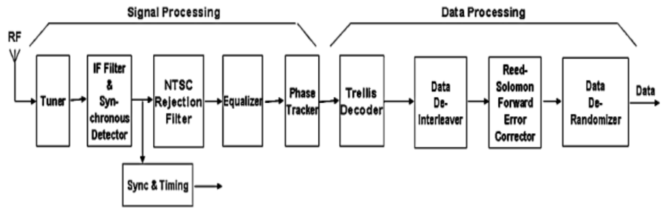

Fig 3. 8-VSB receiver

IV. Design and Simulation

The ATSC Transmission and Reception system is implemented using Simulink as shown in Fig. 4

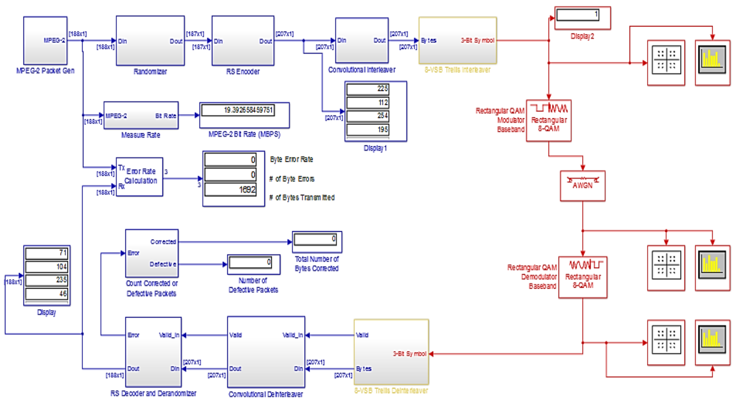

Fig 4. Simulation block diagram in Matlab with Simulink

- MPEG-2 Data Source

The MPEG-2 Transport Packet is a randomly generated 188-byte vector with the first byte replaced by the sync byte 0x47 (Hexadecimal).

- Randomizer

The MPEG-2 sync byte should not be randomized and encoded, and hence is thrown away before the XOR operation. The pseudo random byte sequence that scrambles input data bytes is re-initialized at the beginning of each Data Field. In this model, each Data Field consists of 312 Data Segments because the Data Field Sync segment is not modelled**.**

- The Modulator

In the baseband interface, the input transport stream synchronizes to the MPEG-2 188-byte packet structure by means of a sync byte.
The 188 bytes include the transport stream packet header with the sync byte, which has a constant value of 0x47.

- AWGN Channel

The AWGN Channel block uses the Signal to noise ratio SNR mode. The SNR is set to 10 dB, which produces a byte error rate of approximately 0.003857. The block diagram of Fig 4 above is used to investigate and compare the ATSC modulation 8 PAM based to our suggested 8 QAM modulation scheme. In 8 QAM, each three bits input alters the phase and amplitude of the carrier to derive eight unique modulation states.

The result obtained after simulation is as follows:

a) Before 8QAM modulation the constellation and the spectrum of the signal is of the form shown in Fig 5.

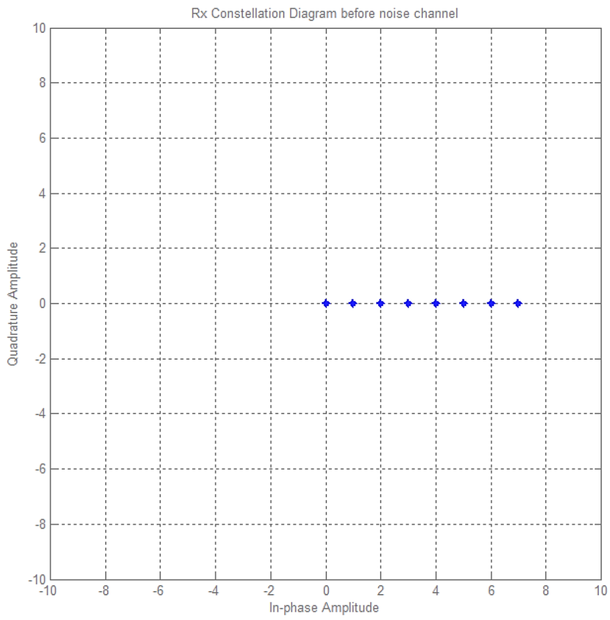

Fig 5. Constellation diagram generated after simulation

The above figure shows the constellation diagram obtained after simulation consisting of 8 Eight
equidistant constellation point distributed along the I axis.
The 8VSB baseband signal has eight discrete amplitude modulation levels. First, however, an 8ASK signal is generated (ASK: amplitude shift keying) as shown in Figure 5.
Note that the ASK signal is a staircase signal seen in Figure 6. The bit information to be transmitted is contained in the step height. One step width corresponds to one symbol or symbol duration; three bits can be transmitted per symbol. The reciprocal of the step width is the symbol rate. The ASK staircase signal is amplitude-modulated on a sinusoidal carrier. As a result, a double-sideband spectrum is obtained.[6]

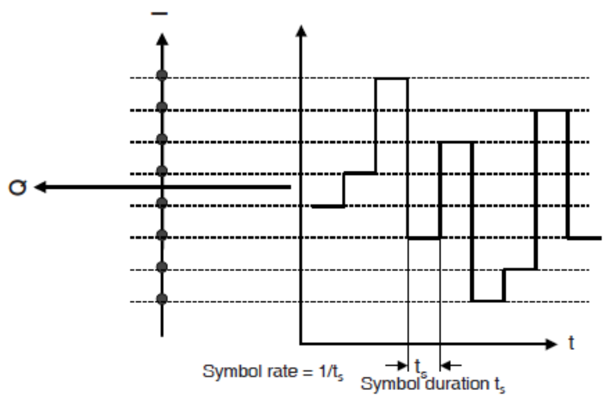

Fig 6. 8VSB /8ASK baseband signal

The resulting spectrum is as shown in Fig 7.

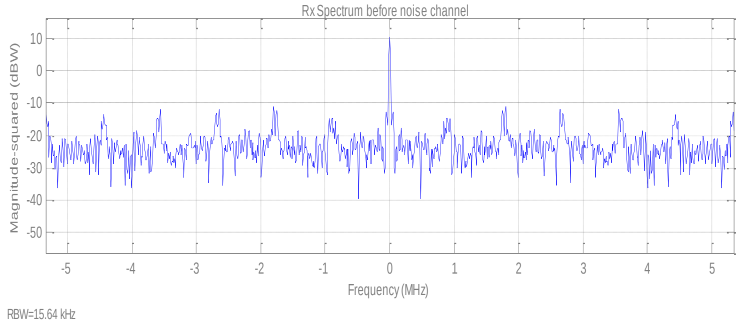

Fig 7. 8VSB/8ASK Spectrum before channel AWGN

The Spectrum in Figure 7, shows double sided 8VSB with a peak magnitude-squared value of about -13.836 dbW

b) After the AWGN Channel the result is as shown in Fig 8.
The constellation diagram is filled with noise from channel introduced by the Gaussian noise in the AGWN channel setting.

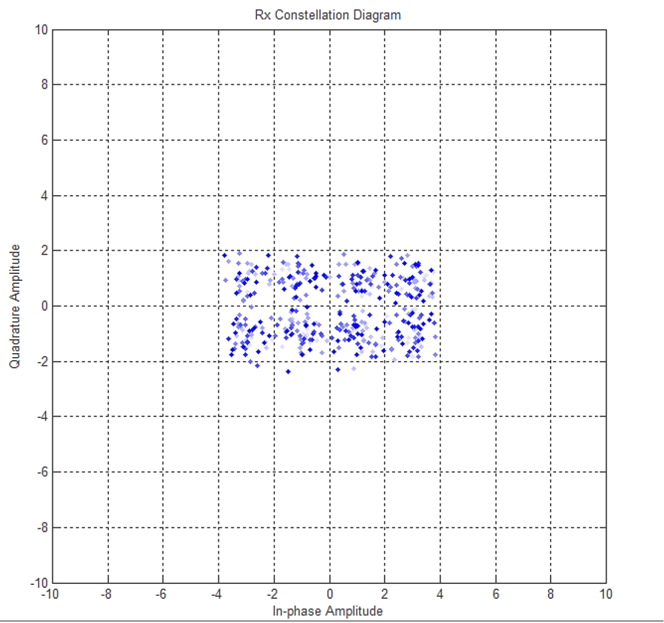

Fig 8. Constellation Diagram at the channel

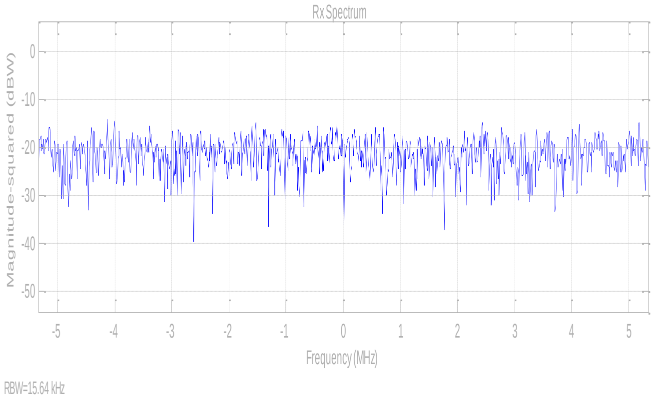

Fig 9. Spectrum at the AGWN Channel after 8QAM Modultion

The signal exhibit a different spectrum pattern and quite improvement of the signal as shown in figure 9.

The AGWN which is a communication channel that adds white Gaussian noise to the input signal parameters is set to suppress more noise so that a clear idea of the 8 QAM modulation constellation can be considered as shown in the Figure 10

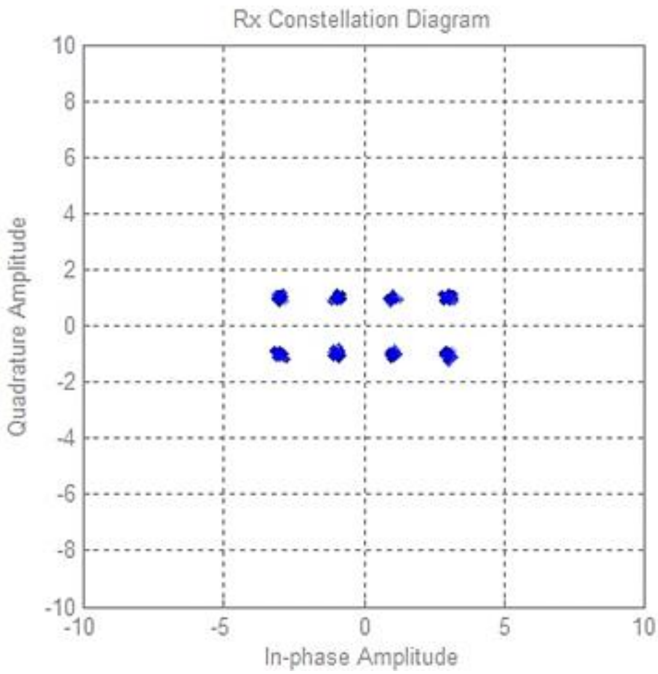

Fig 10. 8 point constellation as the result of 8QAM Modulation

Conclusion

MATLAB/Simulink is a very powerful tool that can be used for simulation in communication, control, DSP, etc. This paper comparing the modulation technique used by ATSC PAM with QAM technique. The Result of the simulation shows that for 5.095E+04 bytes transmitted gives rise up to 1965 error bytes, which counts for Bytes Error Rate of approximately 0.03857 . Therefore ATSC system can be implemented using 8 QAM modulation technique but will suffer a little higher bit error rate. Further error reduction could be achieved by using 16 QAM and 64 QAM modulation .

V. References

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