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DVB-S2X based Non-Linear Distortion Cancellation using 64-APSK for Satellite Forward Link

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Abstract

Objective: This paper aims at designing DVB-S2X based satellite forward link with higher order modulation scheme for achieving large data transmission with less prone to distortion. **Method:** The 64-APSK modulation scheme is used to design this forward link with MATLAB Simulink version 17. **Findings:** The high quality end-to-end transmission with less design complexity is achieved with addition of phase noise at user terminal, satellite transponder with IMUX, OMUX filter response and TWTA characteristics. The analysis of channel performance can be done through constellation diagram. **Application**: It enables traffic demand and bandwidth-demand adaptation benefits for large area coverage

Keywords: Satellite Forward Link, DVB-S2X, 64-APSK, OMUX, TWTA

1. Introduction

Due to the evolution of digitizing the multimedia broadcasting, the first standard DVB-S was introduced. In addition to this, DVB-RCS (Return Channel Satellite) and DVB-S2 projects were initiated for second generation. These improved generation technology uses Forward Error Correction technique and higher order modulation[1]. The DVB-S2 extension (DVB-S2X) is having good SNR threshold with wideband operation, higher order modulation schemes[2]. It can be used for the applications includes HTS satellite service, DTH receiver due to its ability to handle co-channel interference. With the benefit of improved granularity, it can minimize the unwanted margin level and coding[3].

2. Research Methodology

The DVB-S2X will handle the detection of symbol in[4] with non-linear distortion cancellation and interference compensation. An iterative receiver is modelled in[5] to handle non-linear distortion noise cancellation. The multicarrier pre-distortion helps in eliminating non-linear distortion effect and handle the adjustment of transmitted symbol by making distortion vector drive towards zero in[6]. The characteristics of BER for DVB-S2 channels with minimum symbol error probability using mapping and constellation were analysed in[7]. The DVB-S2 channel that follows new iterative methodology to handle higher order modulation with pre-distortion algorithm is designed[8]. For each interaction, the updating of pre-distorted symbol and significant reduction of distortion, mean square error is done[9] with bandwidth efficiency improvement using optimization technique of 64-APSK constellation. Different sensitivity due to unequal error protection of data is achieved. The soft limiter channel[10] which uses higher order modulation schemes with symbol error rate, bit error rate calculations are done in the region of entire SNR.

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On considering these reference works, 64-APSK modulation is used in this paper to eliminate the non-linear distortion. Here, the received constellation diagram helps to analyse distortion level and transmitted data level.

3. Satellite System Model

Figure 1 represents the block diagram for the satellite transmission chain in the forward link.

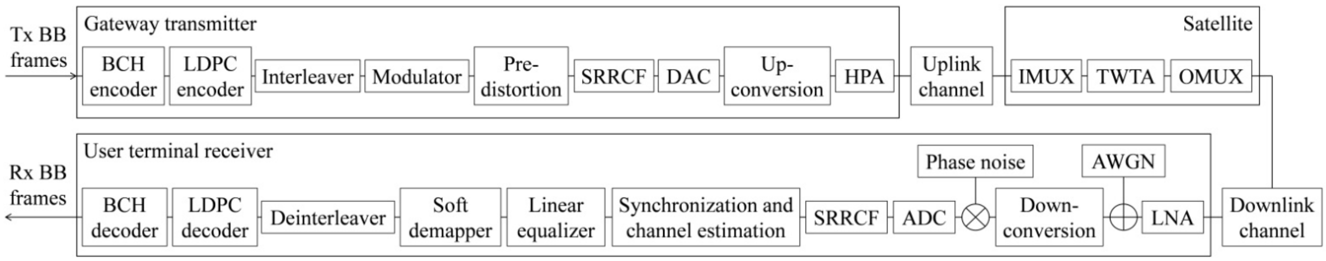

Figure 1. Satellite transmission chain forward link.

3.1 Transmitter

The output from Bernoulli sequence generator is the frame (1504 bits). This received frame is buffered to produce Base Band FRAME (BBFRAME). It is then given to BCH encoder. It is mainly related in terms of coding rate. The Forward Error Correction technique deals with minimization of bit error rate during transmission. It can be modelled using polynomials. The output size of this BCH encoder should matches with the output size of LDPC encoder which is responsible for linear error control coding[11]. Resulting FEC frame is about 64800 bits. The next block is bit interleaver. It produces metric format. After that modulation block will process the interleaved vector. In this paper, 64-APSK modulation scheme is used. The modulator block is followed by raised cosine filter block, DAC, HPA.

3.2 Satellite Channel

The OMUX and IMUX filters are responsible for linear distortion. The equalization process helps to handle it. Travelling Wave Tube Amplifier (TWTA) block is responsible for non-linear distortion.

3.3 User Terminal Receiver

The output from the satellite channel is the given to the LNA block at receiver side. It is followed by AWGN block. The distorted down converted signal is then allowed to pass through ADC and matched SRRCF. After performing the synchronization process, linear distortion is handled with linear equalizer. Input for the decoding stage is given after the process of de-interleaving. Then the reverse processes are done with de-interleaver, LDPC decoder and BCH decoder in accordance with transmitter.

3.4 Channel Compensation Technique

The problem of spectral regrowth can be handled effectively with Pre-distortion techniques[11-12].

4. 64-APSK Characteristics and Construction

The need of more bits per symbol transmission with high possibility to pre-distort the signal and easy separation of states from each other, APSK modulation become more suitable for satellite communication. On going with higher order modulation like 64-APSK, distortion resistance can be achieved with less retransmission. In addition to this bandwidth has to be efficiently preserved. The construction procedure for building 64-APSK is explained in Figure 2. This design includes QPSK, BPSK and HPA.

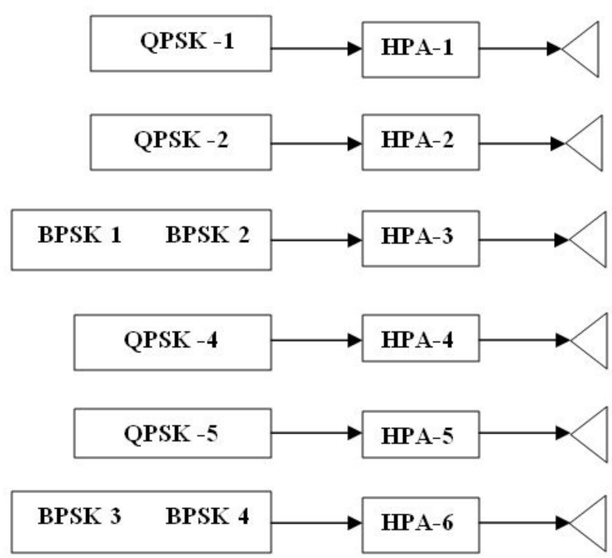

Figure 2. . Construction of 64-APSK.

5. Results and Discussions

The design of 64-APSK modulator using simulink is shown in Figure 3.

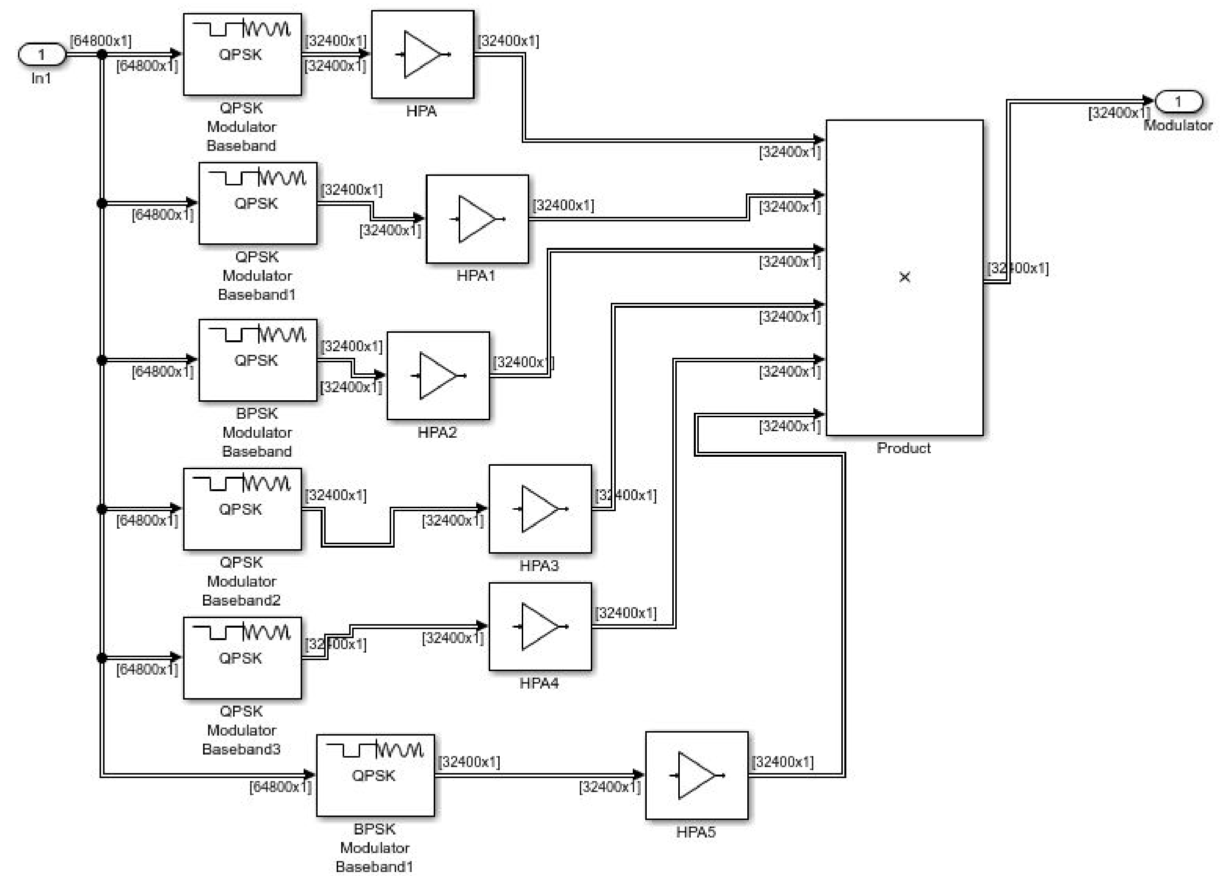

Figure 3. Design of 64-APSK using BPSK and QPSK.

The design of satellite system model with 64-APSK as modulator using Simulink is shown in the Figure 4.

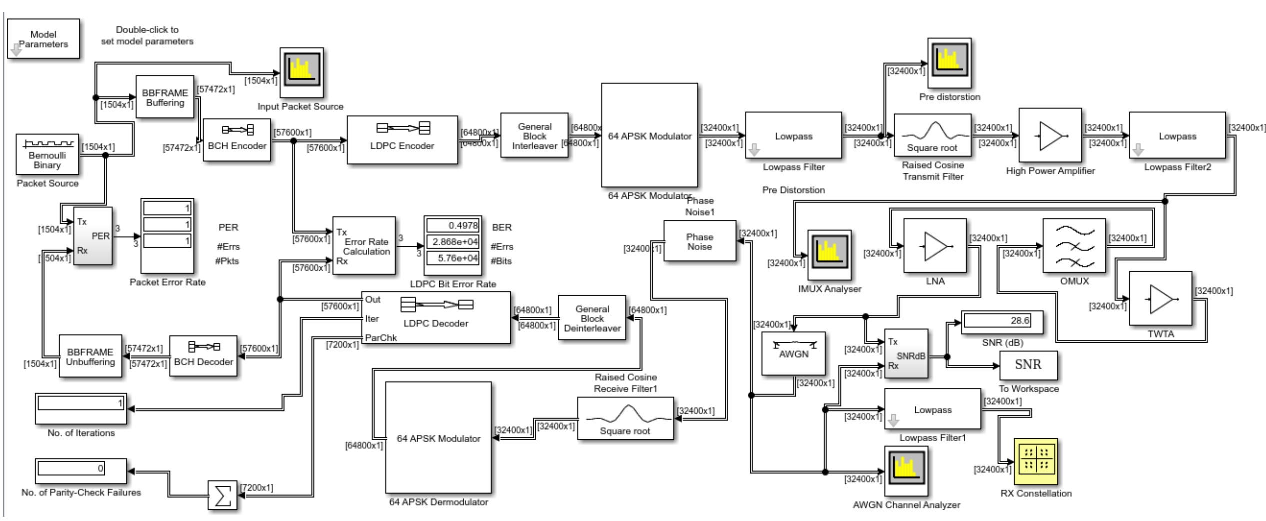

Figure 4. Satellite transmission chain forward link using 64-APSK modulator.

Continuous monitoring and measurement for the received signal should be done and then the signal is given to pre-distortion circuitry. Some parameter value used for designing this model is shown in the Table 1.

Table 1. Parameters for designing satellite forward link

Parameters	Values
No. of Information bits per Codeword	31584
TWTA	Saleh Model
Interleaver order	[64800 * 1 double]
Low Pass Filter Structure Format	Direct Form II SOS
Parity check matrix of LDPC	[32400 * 64800 logical]
SRRCF input processing	Columns as channel (frame based)
Phase Noise Sample Rate	1024
Noise Variance Estimation	0.5617
LDCP Number of Iterations	50
Phase Offset	0.7854
Bit Period	3.1662e-05

The usage of TWTA and solid state power amplifiers enhances energy level and improves spectral efficiency at satellite transmission. The BER value plays a major role in accessing the performance level gateway transmitter, channel, user terminal receiver. In order to attain better throughput, high data rate transmission with less retransmission, there is in need to maintain high SNR value. For this forward link with 64-APSK as modulator, the SNR value of 28.6 dB and BER value of 0.4978 is achieved.

The parameters like power, bandwidth, harmonics, distortion, frequency level can be analysed from electrical signal spectrum using spectrum analyser block, which cannot be detected easily in time domain waveform. The signal spectrum of input packet source, AWGN channel, IMUX analyser and Pre-distortion stage are shown in the Figures 5-8.

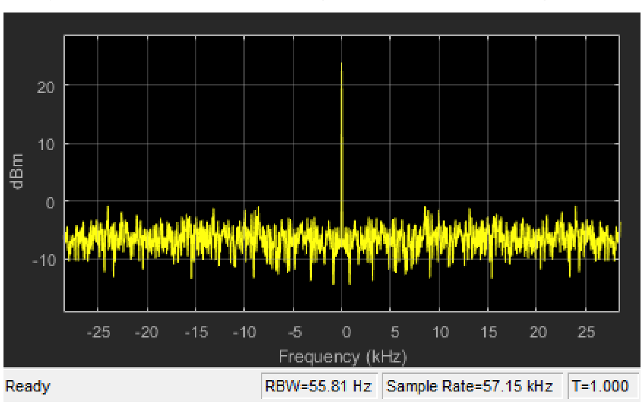

Figure 5. Spectrum at input packet source.

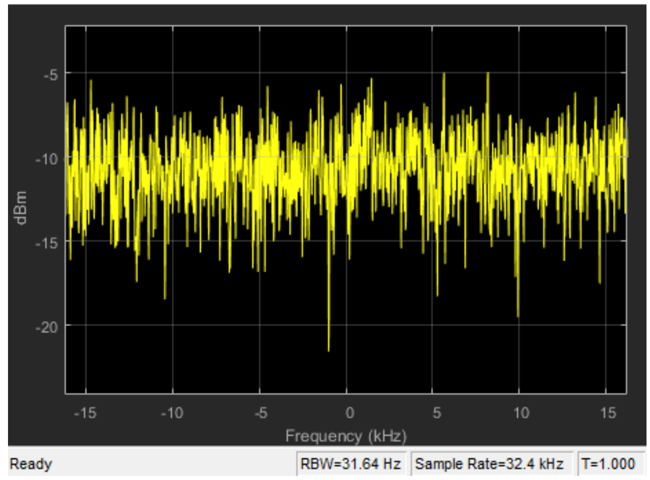

Figure 6. Spectrum at AWGN channel.

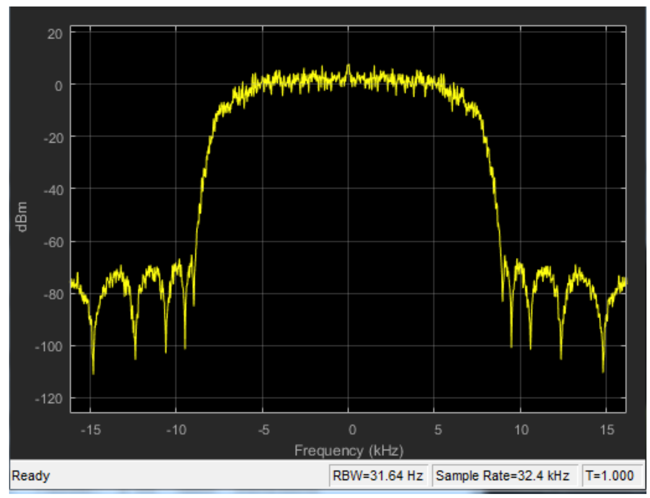

Figure 7. Spectrum of IMUX analyzer.

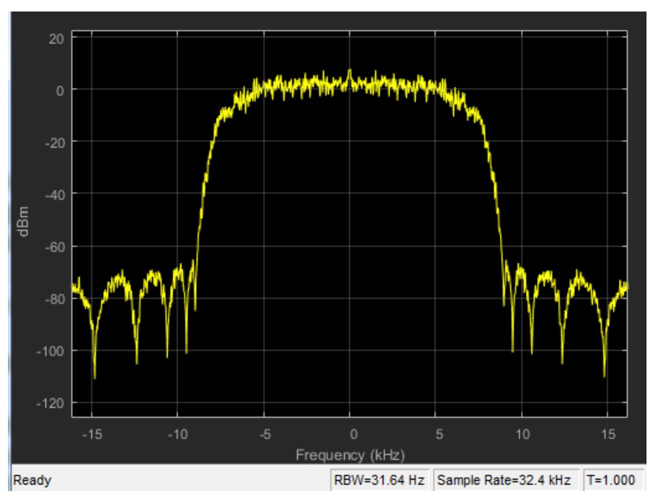

Figure 8. Spectrum at pre-distortion stage.

The constellation diagram helps to recognize the distortion level in the signal which creates a way to generate schemes for predicting and correcting the errors during transmission. The distortion level of signal for this designed satellite forward link is shown in the Figure 9.

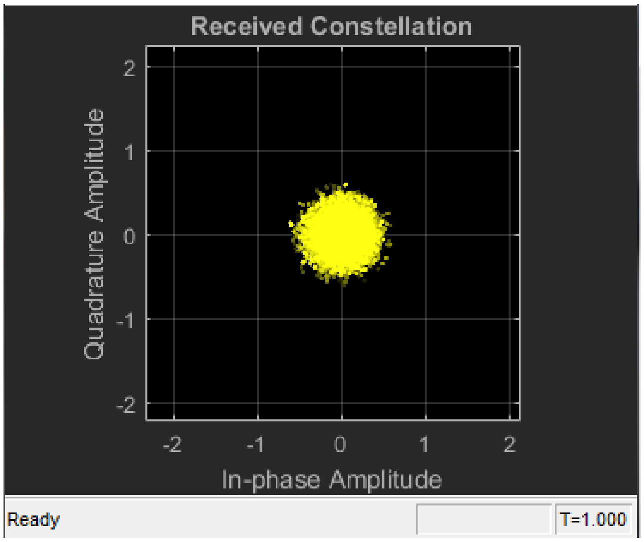

Figure 9. Received constellation for satellite forward link using 64-APSK as modulator.

6. Conclusion

Thus DVB-S2X based satellite forward link using 64-APSK is designed. The forward link with 64-APSK as modulator, the SNR value of 28.6 dB and BER value of 0.4978 is achieved. The constellation map shows that distortion level is low. Hence large amount of data transmission with less prone to error can be achieved through this model.

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