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Study Of BER In DVB-S2 Satellite Implemented in Matlab

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Abstract—Satellite broadcasting has been considered lately as a promising media for IP streaming due to their wide coverage and high reliable bandwidth. Long propagation delay in GEO satellite system will affect the adaptive algorithms in DVBS-2/RCS systems. Long feedback delay will cause improper physical layer selection of modulation and coding (ModCod). This paper aims to provide an algorithm for physical layer selector in DVB-S2/RCS satellite systems. This algorithm will makeless ModCod switching of the adaptive coding and modulation (ACM) usingreduced number of ModCod combinations. We conclude that the number of ModCods in ACM algorithm can be relatively adjusted to maximize DVB-S2system stability.

Keywords-component; ACM; PHYSICAL layer;DVB-S2/RCS,GEO satellite;

I.INTRODUCTION

Satellite broadcasting has been considered lately as a promising media for IP streaming due to their wide coverage and high reliable bandwidth .Digital Video Broadcasting- Second Generation/ Return Channel via Satellite (DVB-S2/RCS), presents high spectrum efficiency using dynamic adaptation of transmission parameters. This leads to a 30% [1] improvement in channel efficiency comparing to its ancestor DVB-S using the same power and bandwidth.

Adaptive coding and modulation (ACM) as a key feature in DVB-S2/RCS systems, exploits fade mitigation techniques (FMT) to tackle atmospheric effects on satellite systems. Time variant nature of channel states of a Ka band channel which affects severelyperformance of a satellite link, necessitates a dynamic adjustment of ModCods. This dynamic adjustment is considered in an adaptive coding and modulation algorithm augmented in DVB-S2 systems deploying a feedback link via DVB-RCS terminals. ACM algorithm uses instantaneous Channel State Information (CSI) sent by DVB-RCS return link from individual Earth Stations (ES) to gate way so called Network Control Center(NCC).NCC is responsible of making the proper selection of ModCodsaiming best spectrum efficiency and the desired bit error rate(BER) at the same time.

The problem arises in satellite system, GEO system in particular, resulted from the long propagation delay in these systems. The time a DVB-RCS terminal observes an on/outgoing fade event and send the request for a suitable ModCodsto the NCC, to the time NCC receives it and sets appropriate transmissionModCods,is too long. This long delay results in an improper selection of transmission rates following by performance degradation of the channel.

S.Murakami et al in [2], used a strong transmission power control component. By dynamically varying transmission power in a way to match instantaneous channel states, they achieved higher channel efficiency. In one hand a too efficient transmission rate, indeed, may cause a limitation of a useful data rate; on the other hand inefficient one will encompass higher bit error rates. Although this approach guarantees the transmission in terms of bandwidth, higher transmission powers may endanger channels by adding co-channel interference resulting in increased packet error rates.

Indeed, the more concrete algorithm to gain spectrum efficiency includes the modulation and code rates adapted in a way to match the channel condition, as proposed in DVB-S2 standard [3]. In [4], the authors proposed aselection scheme of ModCodstaking to account average spectral efficiency. Authors in this research obviously ignored the delay involved with a return channel in satellite systems.

To compensate the delay effect, D. Moad et al [5] presentedpredictive channel estimation. In this approach they used prediction of channel state (e.g SNR) based on Least Mean Square (LMS) algorithm that uses a gradient-based mode for steepest decent [6]. They showed that their prediction algorithm exhibits lower BER about 10.73% less comparing to the conventional approaches which use instantaneous SNR values, and through put increasing by approximately 4.65%. Taking to account, they used FTP sources in their analysis which differ slightly from real time transmissions though.

D. Paradas et al, in [7] showed that the delay of ACM reaction to fade changes resulted from rain events affects quality of service (Qos) of real time streaming severely. They produced a shifted threshold which is useful to tackle the high packet error rates introduced by ACM's long switching delay. An adequate threshold selection can bring same PER reduction as the use of strong high level codes can, but with better bandwidth efficiency. Their goal to develop an algorithm to compute the threshold, that produces the optimal quality in terms of video streaming, was achieved deploying a shifted threshold of the standardized ACM. This was also followed by data loss avoidance when attenuation is increasing. They also considered superframe (SF) durations as an effective parameter in transmission quality of a real time stream. They showed that static threshold offsets are suboptimal, as a result dynamic selection of threshold offsets, potentially, will improve the video quality significantly.Extra payloads and loss of efficiency resulted from data over-protection when attenuation is decreasing has not been addressed in this study.

The main novelty of DVB-S2/RCS system is the adaptive approach in physical layer to select different coding and modulation considering the channel states. DVB-S2/RCS standard offers different combinations of coding and modulations schemes. Each of which supporting a spectrum efficiency guaranteeing an expected BER level. Amongst available combinations of 11 coding rates and 4 modulations, only 28 of them are addressed in DVB-S2 standard. A higher order modulation and a slight coding rate will higher the efficiency in a clear sky. Lower order modulation and lower coding rate will increase robustness to face channel losses in rain event. The over-protection of data when attenuation is decreasing is the main reason for throughput degradation. The delay in return link will cause late selection of ModCods, and in case of decreasing attenuation, extra payloads will reduce channel throughput. As a result, recovery of the ACM from a rain event is important in terms of maintaining link's throughput.

II.SYSTEM MODEL

In this paper we consider a hybrid satellite and terrestrial network. As depicted in Fig 1. A transparent GEO satellite is responsible of video stream broadcasting via DVB-S2/RCS terminals. Since the terrestrial portion of the network has no impact on satellite links (e.g. down link), we consider the satellite link in terms of video transmission quality in rain event which is the most effective parameter in a Ka band satellite link.

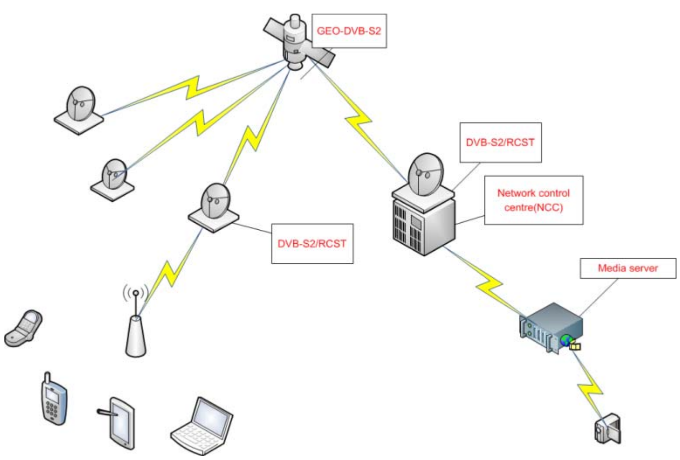

Fig. 1.Transparent satellite network

To study the impact of Eb/No, on BER levels of different ModCods, we used discretesimulator based on ETSI standard [3]. In this standard physical layer is defined as functional blocks shown in Fig. 2.

Following the standard we modeled the system function blocks as shown in Fig.3.

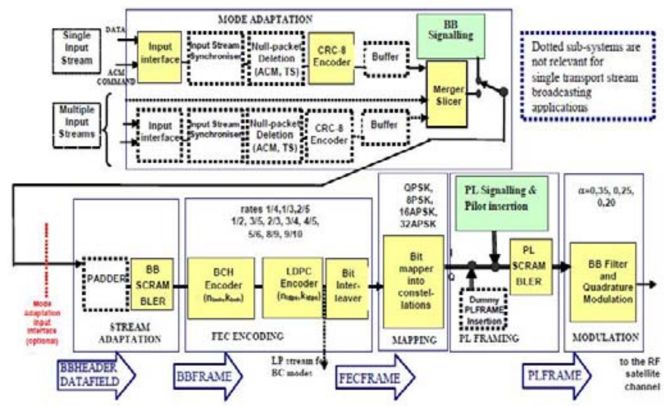

Fig.2Functional block diagram of the DVB-S2 System

-BBFRAME BUFFERING/UNBUFFERING:The buffering function block will receive the input stream that includes BBHEADER and by data field at transmitter and its counterpart, un buffering block, will produce MPEG-TS at the receiver as its output.

Data field size is depending on Forward Error Correction (FEC) rate and can be calculated as follows [3]:

$$\text{Data field}=K_{bch}-80 \tag{1}$$

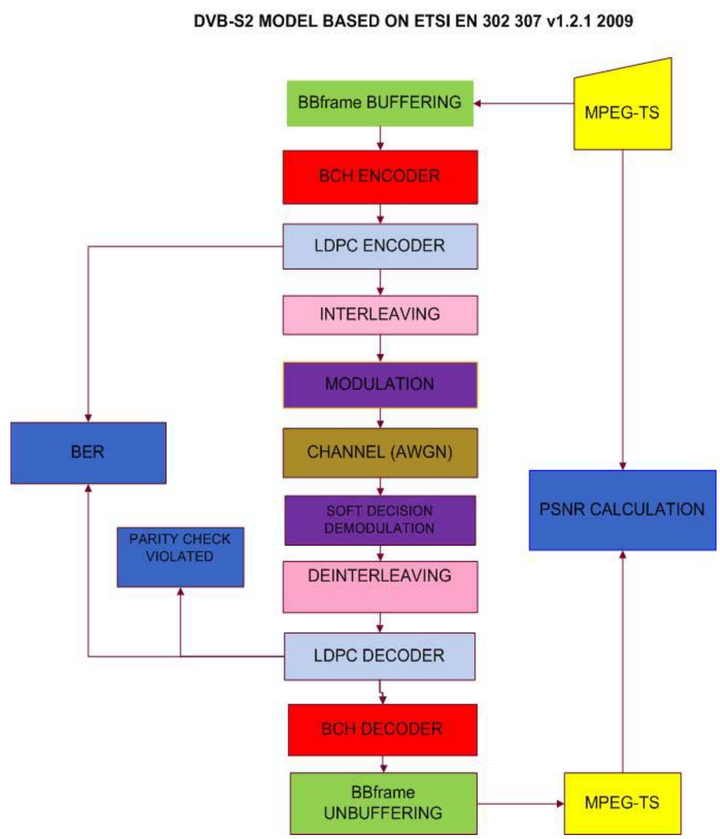

Fig.3. DVB-S2 LINK--level implementation in Matlab

Where K_{bch} is the input length for BCH encoder in the next step and 80 is the header size in bits.

-BCH ENCODER/DECODER: At decoder the BBFRAME will be encoded by outer encoder,BCH encoder will receive BBFRAME as input and the parity check bits will be added with respect to the coding rate to create a FECFRAME with the length of n_{ldpc} bits. At the receiver the BCH decoder is responsible for decoding the input received from LDPC decoder and error correction the output of this module will be sent to un buffering function.

-LDPC ENCODER/DECODER:Inner coding with the use of Low Density Parity Check (LDPC) method will be applied on the receivedK_{ldpc}bits to produce the n_{ldpc}bit FECFRAME. The parameters for a normal FECFRAME with the size of 64800 bits are given in the ETSI standard as shown in table 1.[3] .

Table 1:Coding Parameters for normal FECFRAME [3]

LDPC code	BCH Uncoded Block K_{bch}	BCH coded block N_{bch} LDPC Uncoded Block k_{ldpc}	BCH t-error correction	LDPC Coded Block n_{ldpc}
1/4	16 008	16 200	12	64 800
1/3	21 408	21 600	12	64 800
2/5	25 728	25 920	12	64 800
1/2	32 208	32 400	12	64 800
3/5	38 688	38 880	12	64 800
2/3	43 040	43 200	10	64 800
3/4	48 408	48 600	12	64 800
4/5	51 648	51 840	12	64 800
5/6	53 840	54 000	10	64 800
8/9	57 472	57 600	8	64 800
9/10	58 192	58 320	8	64 800

-INTERLEAVER/DEINTERLEAVER: The output of LDPC encoder (FECFRAME) shall be interleaved before sending to modulationpart. And at the receiver deinterleaving shall be applied to demodulator output to be decoded in LDPC decoder.

-MODULATOR/DEMODULATOR: For the modulation part we used soft decision demodulator at the receiver as the LDPC decoder will only accept Log-Likelihood Ratios (LLR) as input to be decoded. The LLRof received signal shall be calculated using this formula[8]:

$$L(b) = \log\left[\frac{P_r\left(b=0 \middle| r=(x,y)\right)}{P_r\left(b=1 \middle| r=(x,y)\right)}\right] \quad (2)$$

Where r represents the coordinates of received signal and Pr(b) represents the probability of being 0 or 1 for the received bit.

-CHANNEL(AWGN) : In transmission part we used Additive White Gaussian Noise (AWGN) fading model that uses input signal power(Eb/No,Es/No) and Signal To Noise Ratios(SNR) to model a transmission. The relationship between Eb/No,Es/No and SNR is as follows[8]:

$$E_s/N_o = \left(T_{sym}/T_{samp}\right).SNR \quad (3)$$

$$E_s/N_o = E_b/N_o + 10\log_{10}(k) \quad (4)$$

Where Es represents signal energy,Eb represents bit energy, No represents noise power,T_{sym} is the symbol period ,k is number of info bits and T_{samp} is the sample time.
-BER :Bit Error Rates(BER) are calculated at LDPC level by the mean of dividing the number of correctly transmitted info bits by number of transmitted bits(Kbch).

III.SIMULATION AND RESULTS

We run simulation for different values of Eb/No ranging from -5 to 20 dB and for each ModCod. The LDPC decoder was set to have 50 iteration and normal frame size (64,800 bits) is used.Simulation parameters and settings are presented in table 2. At the LDPC decoder output we calculate BER and number of violated parity check.

Table 2: Simulation parameters and settings

SIMULATION PARAMETERS AND SETTINGS	
Frame size	Normal (64800 bits)
LDPC encoder input type	Bit
LDPC decoder output type	Information part
LDPC encoder decision type	Hard decision
LDPC encoder number of iterations	50
Modulator input type	bit
Modulator symbol order	Gray
Demodulator output type	Bit
Demodulator decision type	Soft decision
LLR algorithm	Approximate LLR
Channel noise factor	Eb/No in dB (-5 to 20)

Simulation result in Figure 4 shows 6 regions of different ModCods with almost the same BER performance have made. It can be clearly be seen that instead of using all combinations of ModCods which will result in too much switching in ModCod selector, we can use the combination with the greatest spectrum efficiency in each region. In

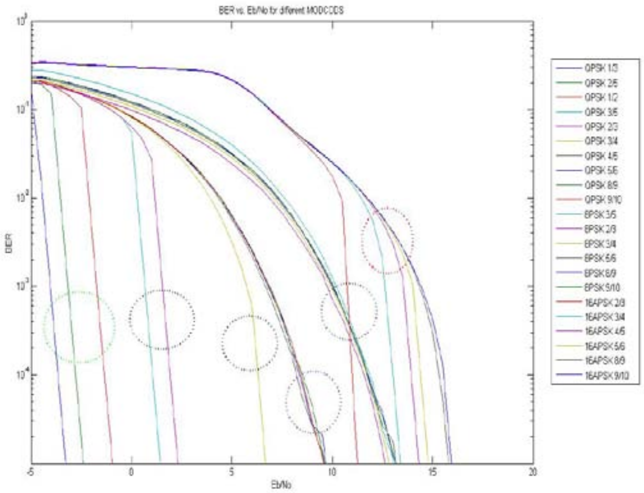

Fig. 4 BER vs. Eb/No for different MODCODS

this way we can avoid unnecessary switching which will lead to system instability and performance oscillations [5].

According to BER results we draw new threshold offsets to be used in ACM algorithm for a more stable switching on physical layer selector,shown in table 3.

Table 3: Threshold offsets for physical layer selector

Eb/No	ModCod
Eb/No < 0	QPSK 2/5
0< Eb/No<3	QPSK 2/3
3< Eb/No<6	QPSK 3/4
6< Eb/No<10	QPSK 9/10
10< Eb/No<14	8 PSK 9/10
14< Eb/No	16APSK 8/9

III.CONCLUSION

In this paper, we proposed a DVB-S2 model using Matlab simulator to study BER performance of different ModCods. Considering simulation results we draw a new threshold offset for physical layer selector with a reduced set of ModCods to avoid extra switching in ACM algorithm which will introduce oscillations resulting in system instability.

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