HIERARCHICAL MODULATION AND DVB-S2

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ABSTRACT

DVB-S2 is the recently defined successor to the current DVB-S standard [4] and DVB-DSNG standard (EN 301210); enabling new services via significantly higher data rates and allowing for a long-term migration. For unicasting applications, the DVB-S2 system includes Adaptive Coding and Modulation (ACM) techniques [1], in order to differentiate the error protection according to the propagation condition experienced by each specific customer.

In Hierarchical (H-Mod) two separate data streams are modulated onto a single DVB-S2 stream. Hence the new DVB-S2 receivers may receive both data streams, whereas DVB-S receivers shall remain backward compatible.

The novel approach employed in this paper extends 'Traditional' H-Mod systems [2] which apply a shift in phase (theta) upon existing modulation schemes to incorporate alternative constellations for the Low Priority Data stream. This new approach provides a foundation for new concepts and techniques in Receiver Design. These techniques have been simulated in software over time varying channels, and implemented using Field Programmable Gate Arrays (FPGA). The results from this research are individually discussed and presented.

1. INTRODUCTION

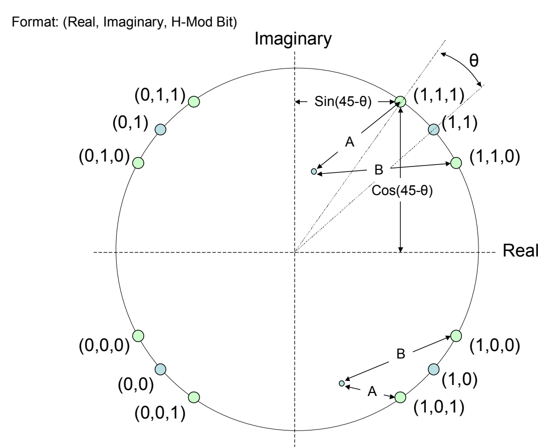
Since the DVB-S2 specification has been recently frozen, there is much interest in research activities for optimizing Receiver and Transmitter design with regards to utilizing the inherent ACM schemes in order to enable the transmission of additional channels.

There are already many millions of DVB-S receivers deployed all over the world. DVB-S2 is designed to benefit from technology advances to meet the more exacting requirements of satellite broadcasting today. Providing 30 % greater efficiency than DVB-S; an increased range of applications and techniques such as ACM. Due to the vast number of DVB-S receivers deployed, there is a strong requirement for backward compatibility, allowing transmission of additional services over the transponder, used for the conventional DVB-S2 services. This assumes that the users with the conventional DVB-S receivers still be able to receive DVB-S services, while users with the new "luxury" receivers will be provided with the extra 30% more services.

This paper simulates the effects of Hierarchical Modulation (H-Mod) upon DVB-S2; pursuing the goal to find the method for H-Mod to enable the maximum information throughput for DVB-S2 users, yet most importantly still remaining backwardly compatible for existing DVB users.

1.1 What Is H-Mod?

H-Mod provides a means of increasing the data throughput of a Modulation scheme. This increase in throughput is obtained by the shifting of encoded bits due to the extra bit "H-Mod Bit". The diagram below illustrates graphically how this can be used upon the QPSK Constellation.



This "conventional method" of applying H-Mod is often used since the radii for all the transmitting bits are the same, hence providing a consistency in SNR for all the bits transmitted.

This method will be used as a reference for other results we have obtained by non-conventional methods.

These alternative methods are discussed within Chapter 2.

1.2 High And Low Priority Data Streams

The data streams of hierarchical modulation vary in susceptibility to noise, which in turn can affect service coverage areas. The better-protected data steam (*within DVB-S2, this is the existing DVBS services)* is referred to as the High-Priority (HP) stream; the other one is referred to as the Low-Priority (LP) stream (*addition services*).

For an M-point signal constellation with minimum distance d_{min}, the probability of error for the ML detector on the AWGN channel is bounded by:

$$P_e \le (M-1)Q\left[\frac{d_{\min}}{2\sigma}\right].$$

When H-Mod is applied to a constellation since d_{min} is reduced the probability of error increases.

In order to limit the signal degradation upon the High Priority Data Stream it is imperative to keep the H-mod phase angle (theta) and hence the shift in constellation point as small as possible; which in turn shall limit the performance of the Low Priority Data Stream. This has been a limitation that has meant that H-Mod to date has not utilized in many Satellite Broadcasting applications.

2. DVB-S2 H-Mod Simulation

In order to investigate the implications of H-Mod on DVB-S2 Bit Error Rates (BER) the System Block Diagrams (figures 2 & 3), were implemented as C++ link libraries.

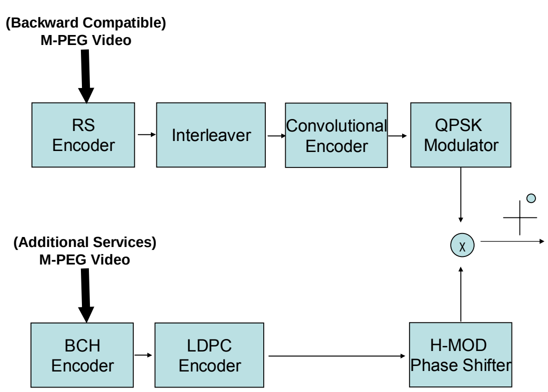


Fig.2. DVB-S2 H-Mod Encoder & Modulator System Diagram

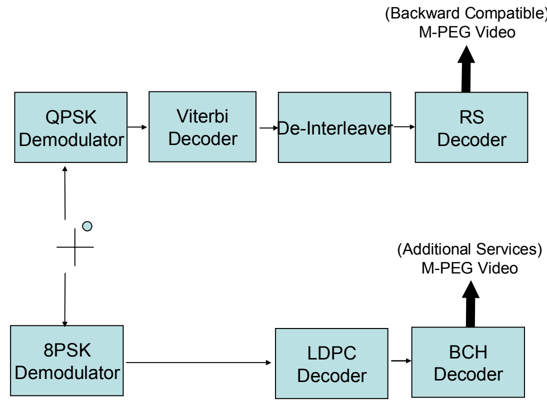


Fig.3. DVB-S2 H-Mod Decoder & Demodulator System Diagram

As shown within Fig.2, the Backward Compatible, High Priority Data stream is coded and modulated as within the DVB-S standard [3]. Forward error correction is built around two error-correcting codes: a Reed-Solomon (outer code) and a Viterbi decoder (inner code). The Reed-Solomon (204, 188) decoder corrects up to 8 erroneous bytes among the N (204) bytes of one data packet. A convolutional de-interleaver (I=11) is located between the Viterbi output and the Reed-Solomon decoder input. The de-interleaver and Reed-Solomon decoder are automatically synchronized according to a frame synchronization algorithm that uses the sync pattern present in each packet.
The rate 1/2, Constraint length K = 7 (with G1 = 171_8 and G2 = 133_8) Viterbi Decoder was used within these simulations.
The convolutional interleaving process is based on the Forney approach which is compatible with the Ramsey type III approach, with I = 12. The interleaved data bytes shall be composed of error-protected packets and shall be delimited by inverted or non-inverted MPEG-2 sync bytes (preserving the periodicity of 204 bytes).

The Low Priority Data stream is coded as specified within the DVB-S2 standard [4]. The powerful FEC system is based on the concatenation of Bose-Chaudhuri-Hocquenghem (BCH) with Low Density Parity Check (LDPC) inner coding. This results in performance that is at times only 0.7dB from the Shannon limit.

The H-Mod Phase Shifter alters the High Priority stream's QPSK DVBS modulation by forming "H-Mod" 8-PSK. Plotting BER performance curves obtained for a range of phase shift (theta) values of this H-Mod Phase Shifter enables determination of:

(i) The maximum distance between the H-Mod constellation points that can provide a pre-defined BER for the High Priority Data Stream (Backward Compatible Existing Services)

(ii) The minimum distance between H-Mod constellation points, which can provide a predefined BER for the Low Priority Data Stream (new DVB-S2 Services)

Results obtained and there implications are explained within the Section 3.

3. DVB-S2 H-MOD SIMULATION RESULTS

The simulation results displayed below obtained for the conventional H-Mod methods have been by a C program simulation.

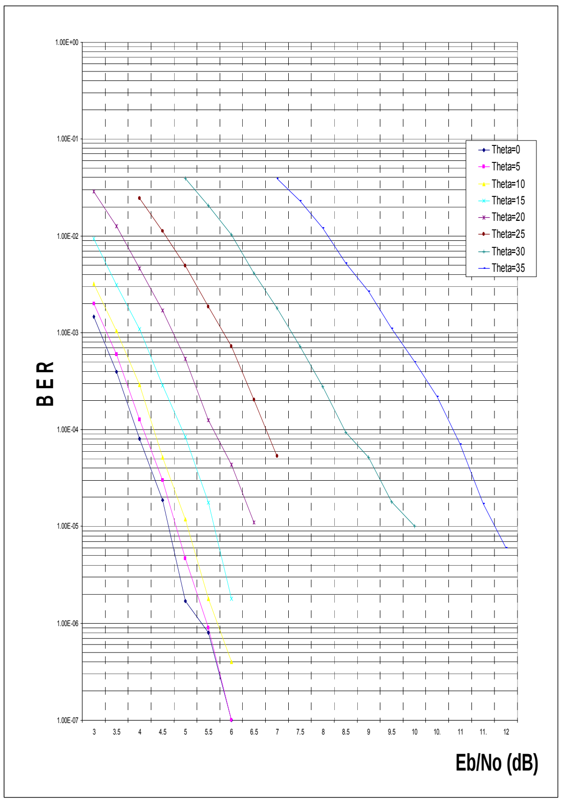


Fig.3. Simulations results for High Priority “Backward Compatible”channel with varying values of theta (For H-Mod QPSK)

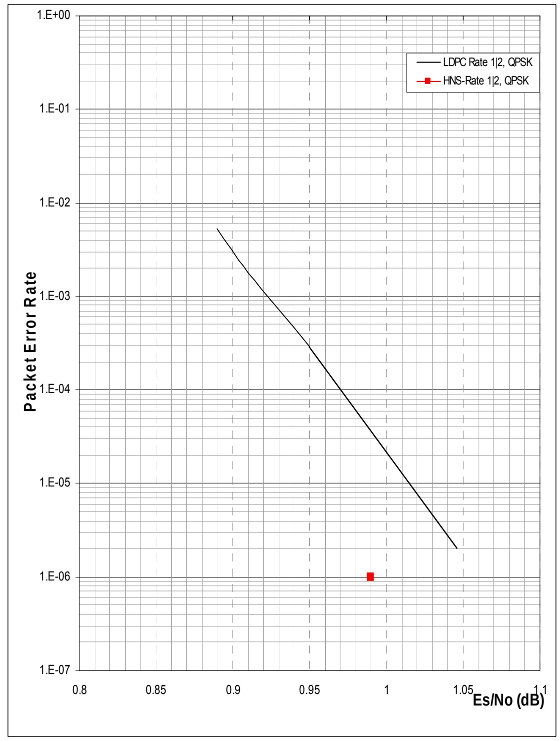


Fig.4. Comparison of QPSK results obtained with Hughes Network System (HNS)

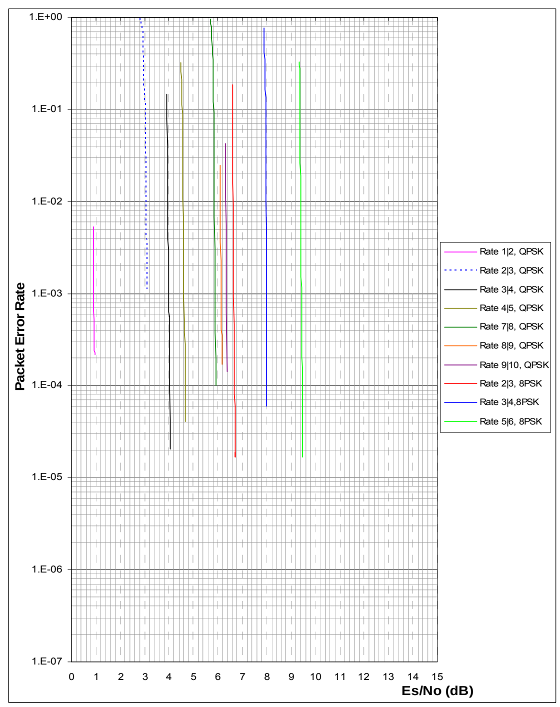


Fig.5. Simulation results at specified DVB-S2 code rates

5. SUMMARY AND CONCLUSIONS

The results obtained within Fig. 3. Illustrate that even with theta at 10 degrees; the performance degradation is relatively small. Further work is being continued into obtaining results illustrating how the DVBS-2 Low Priority channel will perform at these varying values of Theta. These results shall allow broadcasters the capability of utilizing the ACM inherent within DVB-S2.

5. REFERENCES

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