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Efficient Validation/Verification of a Robust DVB-H Link Layer

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***Abstract*—Currently, various semiconductor manufacturers develop silicon solutions for DVB-H receivers. One of the key functions in a DVB-H receiver is the link layer. In order to differentiate, manufacturers can choose between basic or advanced link-layer implementation concepts, resulting in modest or excellent performance. This paper presents the required validation and verification tools for evaluating the DVB-H link-layer robustness, capable of generating and analyzing extreme signal conditions. Furthermore, we also discuss an advanced analysis tool required to inspect the output IP-based data, Service Information and Program Specific Information of the link layer. The earlier simulation results for improved link-layer performance presented by the tools are validated from a newly developed silicon implementation.**

I. INTRODUCTION

Mobile television applications will soon become available because of increased consumer interest and availability of the associated standards such as DVB-H [1], which is specifically tailored to mobile communication. Basically, the DVB-H standard is an extension to the DVB-T standard with extra features added to the physical layer and link layer. The link layer is equipped with Multi Protocol Encapsulation (MPE) sections, which carry a single Internet Protocol (IP) datagram, and is enhanced with Forward Error Correction (FEC) parities. Both data types are inserted into well-known MPEG-2 Transport Stream (TS) packets [2][3]. The received IP-datagrams and Reed-Solomon parity data are stored in an MPE-FEC frame, onto which FEC decoding is applied. To improve the Quality-of-Service (QoS) performance of the basic implementation, advanced DVB-H link-layer concepts [4][5] have been applied. Fig. 1 indicates a DVB-H receiver, operating on an antenna signal and basically delivering IP-datagrams, Service Information (SI) and Program Specific Information (PSI) as output data. Testing an embedded link layer, such as from Fig. 1, requires a cumbersome verification and validation process, to cover the extreme signal conditions. Available transmission equipment uses one sub-set of the available syntax making them unsuitable for verification purposes. Verification of a link-layer requires a test concept such that each individual syntax element is addressable and is available in erroneous and non-erroneous condition. More specifically, the error location and position, MPE-FEC frame, MPE section or TS level are individually controlled. Reference data is required to analyze the link-layer output data on its correctness. This paper addresses an elegant solution, for the generation of error-free and error-prone DVB-H link-layer test sequences and the analysis of the received information afterwards. On top of this, our solution provides the possibility to validate various link-layer de-encapsulation approaches, and Reed-Solomon erasure decoding concepts, prior to the implementation phase.

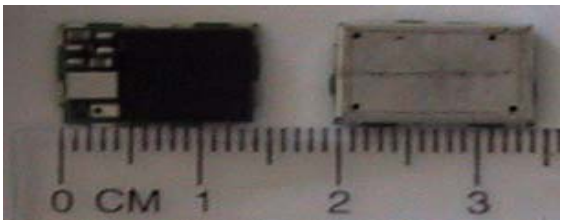

Fig. 1. At the right side an unshielded and at the left side the shielded version of a DVB-H receiver.

II. SYSTEM ASPECTS OF DVB-H LINK LAYER STREAM GENERATOR AND ANALYZER

The generator and analyzer system aspects are based on the link-layer architecture to be validated. Five functional blocks are distinguished in the DVB-H link-layer architecture: MPEG-2 demux, MPE-FEC decoding, IP-filters, queue management and link-layer control [4]. Four of the five blocks are directly influenced by the incoming TS, whereas the MPE-FEC decoder is only indirectly addressable. The link-layer functional blocks impose the following system requirements on the DVB-H TS generator:

- **MPEG-2 demux.** The generator must be able to generate error-free and error-prone TSs, thereby exploring the syntax variations according to [2][3].
- **MPE-FEC decoding.** This block operates on the MPE-FEC frame, using erasure information derived by the MPEG-2 demux block [4].
- **IP-filter.** The generator must be able to create error-free or error-prone IPv4 or IPv6 traffic, with uniform or non-uniform destination addresses [5].
- **Queue management.** The generator must be able to generate error-free or error-prone SI/PSI traffic for average signal conditions up to worst-case timing conditions, maximum section sizes and parallel or consecutive IP-based services based on different MPE-FEC dimensions.
- **Link layer control.** The generator must be able to generate time-sliced and dispersed elementary streams either with or without FEC.

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- **Reference data.** The generator must deliver the reference data for the analyzer to perform SI/PSI and IP-data comparison.

The functional blocks of the link layer impose the following system requirements on the DVB-H analyzer:

- **Erasure information.** The analyzer must have the knowledge about erasure-location information and its usage by the FEC decoder to determine the FEC decoder result.
- **MPE-FEC frame.** The analyzer must have knowledge about the transmitted MPE-FEC frame.
- **IP-filter settings.** The analyzer must have knowledge of the IP-filter settings to determine which IP-datagrams are to be expected.
- **SI/PSI sections.** The analyzer must have knowledge on all SI/PSI sections, their position in time, the SI/PSI filter settings and the DVB-H receiver reception mode.

III. IMPLEMENTATION CONCEPT

The DVB-H TS-generator/analyzer system aspects result in a DVB-H TS-generator concept according to Fig. 2. The MPE-FEC frame generator creates an MPE-FEC frame including erasure-location information, which is also used as a reference frame by the analyzer, to avoid the need for a full link-layer reference model. Erasure positions are explicitly indicated or obtained/extended via back annotation. Error

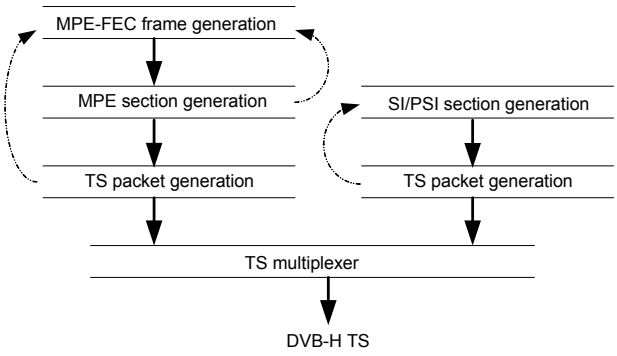

Fig. 2. DVB-H generator, with at the left side the IP-flow and at the right side, the SI/PSI flow. The generators at the top also generate the reference data. Via back annotation, dashed lines, the generators are informed of errors on purposely inserted during encapsulation resulting in an MPE-FEC frame equipped with erasure information or absence of SI/PSI sections in the reference set.

expansion is caused by the TS packet generation and considers the target link-layer de-encapsulation scheme. The DVB-H analyzer uses the original MPE-FEC frame and the associated erasure-location information to predict which IP-datagrams are to be delivered by the DVB-H link layer of the Device Under Test (DUT). The selection of useful IP-datagrams is guided by a FEC erasure information conversion. The SI/PSI generator delivers a section reference set in the form of time-stamped sections. From this reference set, the DVB-H analyzer predicts which sections should appear at the DVB-H link-layer output of the DUT, using the DVB-H link-layer section filter settings and reception mode. Taking into account the fact that the DVB-H generator allows error insertion at all stages of the encapsulation process, an error-trace derived from a specific channel model can be used to insert errors at the TS-packet level. Such an approach allows validation of various de-encapsulation algorithms and FEC erasure-conversion concepts to be evaluated prior to actual implementation.

IV. EXPERIMENTS AND CONCLUSIONS

The embedded DVB-H link layer from Fig. 1 has been subjected to a test to validate the IP-de-encapsulation

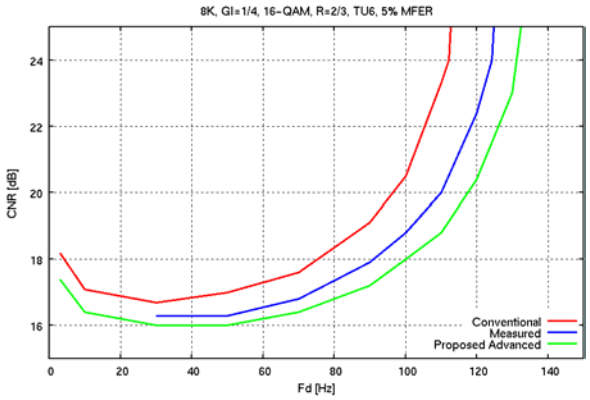

Fig. 3. Measured 5% MFER performance for a TU6 channel.

performance, in order to determine the 5% MFER QoS indicator using *error-traces* of a TU6 channel. The measured graph (middle) of Fig. 3 indicates a performance that is slightly worse than the proposed advanced curve (lower) [5], but it still provides a good Doppler performance (Fd) and additionally, it offers a small gain in sensitivity (0.5 - 4 dB) when compared to the conventional curve (upper). The proposed link-layer generator concept is an efficient approach to generate a DVB-H test sequence and at the same time derive the corresponding data reference set for testing. The proposed tool for generating error-free or error-prone DVB-H test sequences encompasses extreme syntax situations for receiver link-layer verification and error-prone sequences according to various channel profiles for validation purposes.

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