FRAUNHOFER INSTITUTE FOR INTEGRATED CIRCUITS IIS

DVB-S2X DEMODULATOR IP FOR PROFESSIONAL EQUIPMENT

Technical Fast Facts

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DVB-S2X Demodulator IP for Professional Equipment

DVB-S2 is widely adopted in satellite broadband (»satellite internet«) for the user downlink and in many interactive or professional peer-to-peer networks. Compared to DVB-S2 developed and specified in the early 2000s, DVB-S2X is a state-of-the-art, backwards-compatible extension and superset, providing higher spectral efficiencies and new features to enable or promote new applications in the professional receiver and modulator/demodulator (MODEM) market.

Satellite communications is a multi-billion market, with dozens of satellites being launched each year, providing terabytes of capacity worldwide. The lion's share of this capacity is used in direct-to-home (DTH) broadcast, followed by the emerging satellite broadband market using high-throughput satellites (HTS). Professional equipment is used in these mainstream markets in some cases like in-flight entertainment and connectivity and in the military domain (MILCOM). The remainder of the professional market is typically on bandwidth-lease transponders and used for a plurality of applications, including remote site connectivity, backhauling, news and data gathering.

With DVB-S2X replacing DVB-S2 and becoming a »must have«, the subsequent section provides further insight into

- why to upgrade an existing professional MODEM platform to support DVB-S2X;
- where DVB-S2X is demanding in terms of resources and implementation effort; and
- how DVB-S2X technology and IP available at Fraunhofer IIS may be advantageously used in a product design.

Special attention is on the needs of equipment manufactures active in satellite and non-satellite communication markets, currently evaluating why, where and how to add DVB-S2X support into their products.

Why DVB-S2X for Professional MODEMs?

Satellite communication can be anything from a tiny communication link into the middle of nowhere to the backbone technology for direct-to-home (DTH) TV broadcast or internet access. Compared to competing terrestrial or wireless technologies, satellite communication has its unique advantage whenever alternative infrastructure is technically not feasible, not yet deployed or incurs prohibitive investment cost per site.

For these markets, the advantages from using DVB-S2X are twofold:

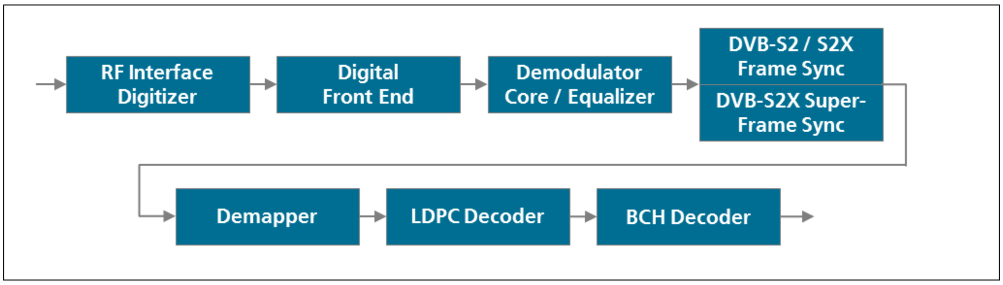
- **Improved performance and spectral efficiency**, squeezing more sellable capacity out of the same amount of spectrum, or, vice versa, lowering cost per bit.
- **Additional features**, allowing more robust communication and enabling new applications and use cases.

Furthermore, especially the industrial and MILCOM markets demand for standardization and mix and match of equipment from different vendors. Midterm, »DVB-S2« equipment will require the new »DVB-S2X« label or runs the risk of being disqualified in a tender.

For a professional equipment vendor, DVB-S2X is both an opportunity for selling additional and replacement MODEMs, but also a challenge and burden of getting one more technology implemented and products validated and supported. Sooner or later this leads to the decision to make or buy following the assessment of risk, investment cost, time-to-market and market opportunity.

Where's the difference in a DVB-S2X MODEM?

The complexity and bandwidth of a DVB-S2X receiver is primarily defined by the maximum carrier size supported in the front end. Support for higher order modulations (e.g. 16APSK to 256APSK) requires careful control of the data path bit-widths to minimize quantization noise, including complex algorithms in the de-mapper for producing »soft« log-likelihood ratios (LLR) information for use in the subsequent LDPC decoder. LDPC decoding is an iterative process, where the decoder converges after a number of iterations, providing quasi-error free data. There are various implementation options for the LDPC decoder, including use of »early termination« strategies and internal parallelism to speed up the decoding process and to meet the required throughput.



Block diagram of a generic DVB-S2X receiver

- **Tuner, RF Interface and Digitizer.** This is the analog front end of the receiver, providing signal conditioning and optional frequency conversion and filtering. The complexity and bandwidth of this block is primarily defined by the maximum carrier size supported by the MODEM – independent of being used for DVB-S2, DVB-S2X or any other satellite communication standard.
- **Digital Front End.** This is the digital front end of the receiver, controlling the analog front end gain (analog AGC) and providing digital I/Q samples at its output. Optionally, this block may provide I/Q imbalance correction and down-conversion capabilities. Again the complexity of this block is primarily defined by range supported carrier sizes and bandwidth and not specific for DVB-S2X.
- **Demodulator Core including Equalizer.** This module includes a numerically controlled oscillator (NCO) and mixer, timing interpolation (including error detector and loop filter), matched filtering, channel equalization and optional gain control (digital AGC). The output of the demodulator is a digital I/Q symbol stream. This block is generic, and its complexity is largely independent of carrier size and bandwidth; however an implementation may be required to apply pipelining and parallel processing for higher throughput MODEMs. Support for higher order modulations (e.g. 16APSK to 256APSK) requires careful control of the data path bit-widths to minimize quantization noise.
- **DVB-S2 Synchronization.** This module implements DVB-S2 Physical Layer Header (PLHEADER) capture and decoding and provides frequency and phase tracking and correction using data-aided or pilot based algorithms. As DVB-S2X is backwards compatible to DVB-S2, this module is required for both receiver types. Furthermore, a DVB-S2X receiver requires modification in the PLHEADER decoding, interpreting the DVB-S2X specific signaling.

- **DVB-S2X Super-Frame Synchronization.** This module implements detection of the Start of Super-Frame (SOSF) field and decoding of the Super-Frame Format Indicator (SFFI). In formats supporting Super-Frame aligned pilots (SF-Pilots), frequency and phase tracking and correction is derived. This module is specific for DVB-S2X, providing robust synchronization in very-low signal-to-noise (VL-SNR) modes and improved channel estimation and co-channel interference mitigation. Some of the DVB-S2X super-frame modes tend being processing and resource intensive, e.g. for detecting and decoding the highly protected 900 symbol VL-SNR-Header.
- **De-Mapper.** This module implements the de-mapping of constellation points (I/Q symbols) into bits or log-likelihood ratios (LLR). DVB-S2X specifies additional modulation schemes, including BPSK and 64APSK to 256APSK. For DVB-S2, some receivers, especially used for DTH reception, are limited to QPSK and 8-PSK modulations; this allows a rather simple (e.g. table based) hard-decision de-mapping, without resulting in major implementation loss. However, support for the higher order modulations in DVB-S2 and DVB-S2X requires more complex algorithms, producing »soft« LLR information for use in the subsequent LDPC decoder. Depending on the target technology, the de-mapper may limit the MODEM throughput, leading to pipelined or multi-instance implementation for carrier sizes significantly above 100 MSps.
- **LDPC Decoder.** LDPC decoding is usually an iterative process, where the decoder converges after a number of iterations, providing quasi-error free data. The maximum allowed number of iterations defines the time spent in the LDPC decoder but also the »implementation loss« between actual decoder performance and the theoretical decoding threshold. There are various implementation options for LDPC decoders, including use of »early termination« strategies and internal parallelism to speed up the decoding process and improve throughput. Although DVB-S2X defines a number of additional coding and modulation schemes (MODCODs), LDPC decoders in DVB-S2 and DVB-S2X are largely identical. Depending on target technology, the LDPC decoder may limit the MODEM throughput; support for carrier sizes significantly above 100 MSps typically requires a combination of pipelining and multi-instance design. Due to the iterative nature in processing data, LDPC decoder implementation performance benefits from the availability of high-speed, multi-port RAM.
- **BCH Decoder.** Last but not least, DVB-S2 and DVB-S2X foresee a BCH decoder for correcting the last erroneous bits left over by the LDPC decoding process. A typical BCH decoder is of limited complexity, however contains long combinatorial paths – limiting the maximum clock speed and leading to multi-instance designs in high-throughput MODEMs.

Compared to a demodulator the resources required in a modulator scale more gracefully with supported carrier size and MODEM throughput. Moreover, DVB-S2X reuses the physical layer frame structure and signaling fields from DVB-S2 and carries DVB-S2X super-frame data in DVB-S2 data frames. Thus, the DVB-S2X specific signaling and spanning of a super-frame structure mainly affects higher (software) layers of the MODEM.

Deciding on the right implementation solution

Besides resource and performance, a DVB-S2X implementer is usually concerned about selecting the right features for a product and the target market. Although of only medium complexity and size, implementing the DVB-S2X standard may be complicated by the variety of different target applications and services and the richness in features – normative, optional or not applicable depending on target application and service.

Therefore, a professional receiver maker not only has to decide on the supported feature set to be implemented and tested, but also on the trade-off between throughput, complexity and price of the platform, while keeping the implementation loss at a minimum. There is no one size fits all solution, and a professional receiver supporting 100 Mbps on a bandwidth-lease transponder using a high-gain ground antenna should be different from a mobile receiver using a low aperture dish. Both receivers will be very different from a receiver designed for processing a 500 MHz carrier and handling in excess of 2 000 Mbps under high SNR conditions.

DVB-S2X chips available on the market today are designed for use in DTH receivers. As such, they are limited in output, throughput and the number of service streams made available. As for DVB-S2, the offer in pure MODEM chips is declining, as the satellite MODEM has become part of a larger system on chip (SoC). Optimization for high volume technically and commercially complicates the integration of such a SoC into a professional product.

Besides readymade silicon, DVB-S2X IP for integration into FPGA is the alternative way to go. Many professional MODEMs are already »software defined«, using configurable FPGA hardware for physical layer processing. There is some limited offer in DVB-S2X IP on the market today; however, the true challenge is to fit such IP to the requirements of the product and the available resources on the MODEM without sacrificing throughput and performance.

DVB-S2X: Be smart, get it right and get it done

Thorough understanding of DVB-S2X technology, the market needs and the constraints of the target application is vital for the right selection of the features and for building a unique and successful product. Thus, as a professional equipment manufacturer, benefit from Fraunhofer IIS' background and know-how when evaluating DVB-S2X as an extension to your product portfolio and when drafting the product's DVB-S2X features and capabilities in detail.

Implementing DVB-S2X easily consumes person-years of effort, not even counting functional validation and tuning the decoder performance. Adoption of a validated and field tested implementation minimizes technical and schedule risks. Contact us for an evaluation of a field tested FPGA receiver implementation. Discuss customizations, throughput scaling and evaluate with us how DVB-S2X fits and performs on an existing hardware platform.

Time-to-market is essential staying ahead of competition and for timely return of investment. Fraunhofer IIS offers a readily available DVB-S2X receiver implementation using Annex E, format 4 (super-framing) that can be quickly tailored for different products and throughput ranges, up to the maximum spectral efficiency supported by DVB-S2X on wideband carriers. Different licensing options are available on request.