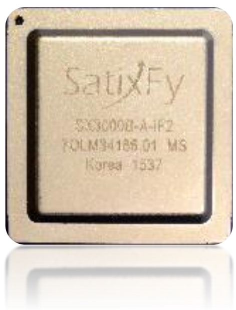
SatixFy Technology Impact On HTS Ground Infrastructure

White Paper

December 2015



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Introduction

The introduction of the SatixFy SX 3000B chip generates significant opportunities for HTS Satellite operators and service providers. The SX 3000B supports the DVB S2X standard including all optional modes and profiles. SX 3000B supports single carrier wideband operation up to 500Msps rate when coupled with 5% roll-off can up to doubling the throughput of a wideband transponder (minimal back-off required for single carrier). The time-slice operation (DVB S2X Annex M) enables multiple service providers working with multiple equipment providers on a single carrier enabling significant increase of capacity of satellite efficiency. The SX 3000B fully supports superframes (DVB S2X Annex E) that enable additional features and capabilities, among which is beam hopping and VLSNR operation. Using SX 3000B provides forward compatibility with future Beam Hopping based satellites that maybe placed in the same orbital location.

Remote terminal based on SatixFy chips and IDUs prices is significantly reduced and will be reduced even further after introduction of our next generation SX 3000A.

HTS satellite operators and service providers enjoy reduced price VSAT, together with many state-of-the art technologies such as single wideband carrier transponder utilization, time slice hub platform with inter-operability between service providers and equipment providers over a single carrier and future compatibility with future Beam Hopping satellites through over-the-air software download.

DVB S2X versus DVB S2

[2, 3] DVB-S2X is based on the well-established DVB-S2 specification. It uses the proven and powerful LDPC Forward Error Correction (FEC) scheme in combination with BCH FEC as outer code and introduces the following additional elements:

- Smaller roll-off options of 5% and 10% (in addition to 20%, 25% and 35% in DVB-S2)
- MODCOD and FEC upgrades: more granularity, adding 64, 128 and 256APSK, improving FECs & MODCODs
- New constellation options for linear and non-linear channels
- Wideband implementation (single 500 MHz carrier)
- Additional standard scrambling options for critical co-channel interference (CCI) situations
- Channel bonding of up to 3 channels
- Very Low SNR operation down to -10 dB SNR to support mobile applications (land, maritime, aeronautical, trains, etc.)
- Time-slice operation (DVB S2X Annex M) for multi-service networks over satellite
- Super-frame (DVB S2X Annex E) option for Beam Hopping support

This results in significant improvement of spectral efficiencies for DVB-S2X compared to DVB-S2 (see *Figure 1* below), all supported and improved by the SX 3000B superset chip. For example SX 3000B support 500 Msps, RoF down to 1% and VLSNR down to -30 dB, which are exceeding the standard definition.

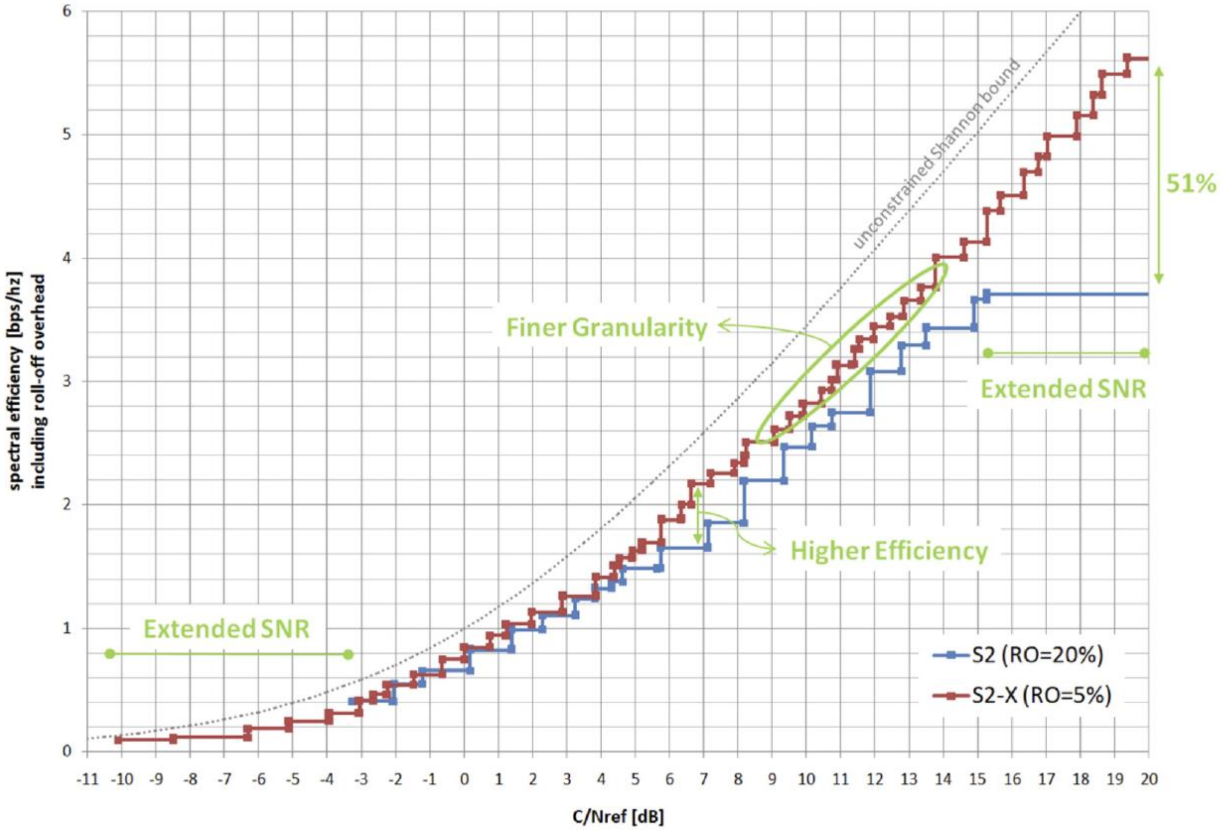


Figure 1- Spectral efficiencies for DVB-S2X Compared to DVB-S2

Wideband – Single Carrier Advantages

The DVB-S2X standard supports wideband transponders technology. The wideband implementation in DVB-S2X typically addresses satellite transponders with bandwidths from 72 MHz up to several hundred MHz (i.e. 500MHz on Ka-band, HTS). A single carrier utilizes the whole transponder bandwidth and allows it to be driven close to saturation.

Using traditional technology an operator needed to allocate several narrowband channels inside a wideband transponder, mandating the operation of the satellite transponder with reduced downlink power (OBO) and therefore at sub-optimal efficiency as illustrated in *Figure 2* below.

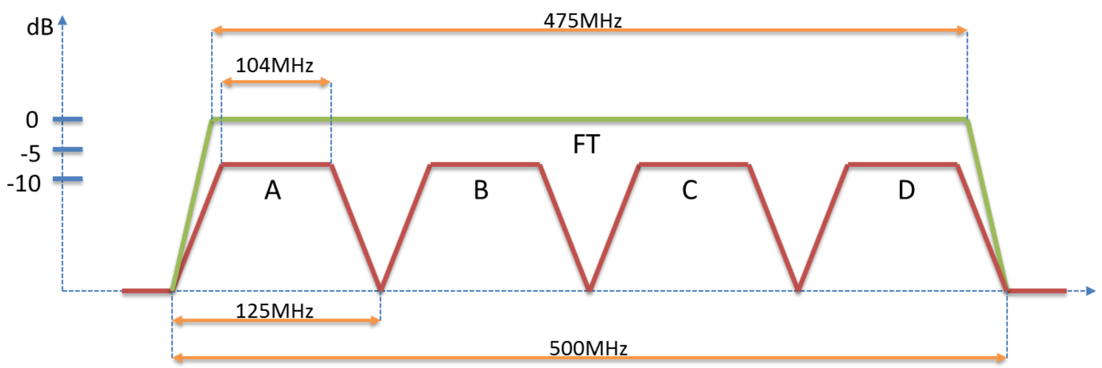


Figure 2- Wideband Carrier vs. Multiple Carriers

Table1 below taken from [3] summarizes the optimized OBO for various MODCODs when allocating a single wideband carrier capturing the whole transponder. This example considers the use of RoF of 0.05.

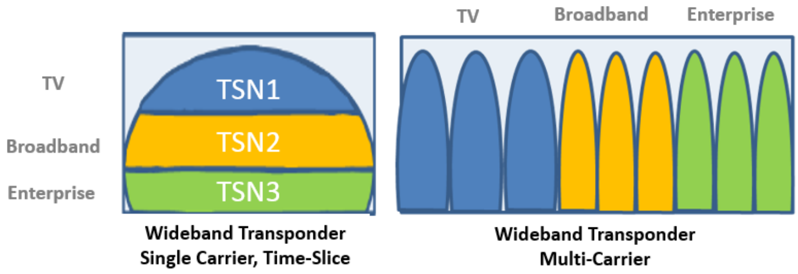
Table 1- Optimized OBO for Physical Layer Simulations

Modulation	QPSK	8PSK	16APSK	32APSK
OBO [dB]	0.39	0.52	1.61	2.28

The DVB-S2X demodulator will receive the complete wideband signal up to 500 Msps resulting in a very high data rate. The introduction of the wideband technology adds significant efficiency gain.

Time slice versus frequency slice. Shared carrier

DVB-S2/S2X Annex M offers an optional transmission format for high symbol-rate satellite carriers for broadcasting, professional and interactive services. This format can be adopted for wideband satellite transponders, where the transmission of a single or few wide-band carriers is preferable to the transmission of a multiplicity of narrow-band carriers, for power and efficiency optimization or other needs. The time-slice format is intended to permit the operation of time-slicing receivers, which are characterized



by real-time high-speed coherent-demodulation and PL-Header processing capabilities, but FEC decoding speed significantly lower than that of the wideband carrier. In order to allow such receivers to select and decode a specific stream carrying one or more service(s) within its performance capabilities, while discarding the other streams and services of the wide-band carrier, the transmitter maps the input services into streams (identified by a specific Time Slice Number, TSN). Such streams are transmitted in time-slices (i.e. bursts) suitably spaced in time. A time-slicing burst (identified by a specific TSN) corresponds to one PL-Frame, as shown in *Figure 3* below.

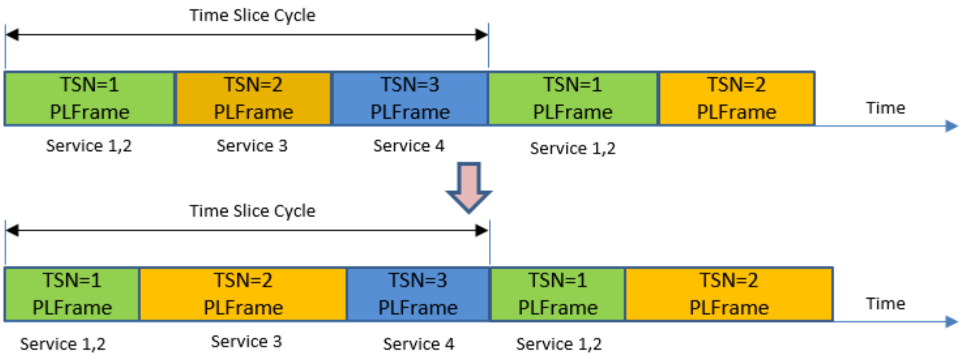


Figure 3- Time-Slice Format (Example)

The time-slice format enables the sharing of ground station equipment and the satellite space segment utilization between several different service providers (ISPs).

In unicasting ACM applications, where the slice structure follow the traffic requirements, "on the fly" allocation of resources (in dynamic mode) offer the best efficiency and flexibility.

The time-slice option is supported by multiple chip and equipment vendors.

Beam Hopping

Beam hopping is a technique applicable to multi-beam systems whereby communications (Tx/Rx) takes place to a small number of beams at a time, out of the large set of beams covering the entire area (coverage beams). The technique is applicable for interactive services, where unicasts or limited multicasts are used.

The greatest disadvantage of existing HTS MSB satellite is the coupling of the capacity to physical area. Beam hopping is coming to decouple this constraint. A multi-spot beam communication payload with many PAs allows the switching of each PA to the corresponding active beam and maximizing the capacity utilization to 100%. This concept was not deployed yet due to lack of supportive ground equipment. NOW, after the introduction of SX 3000B it becomes feasible.

Advantages of beam hopping:

- Adaptation to varying traffic demand and non-uniform distribution
- Lower number of amplifiers and Tx channels
- Reduced inter-beam interference
- Reduced payload power consumption

Disadvantages of beam hopping:

- Need for burst receivers at the terminals
- Total capacity is limited by the number of available beams.

A study made by ESA [5] Compares by simulation the performance of a beam hopping technique to a variety of non-hopped techniques, including conventional (where all beams are illuminated), and flexible wherein power and spectrum allocation may vary between beams using single port of multi-port power amplifiers. The scenario used for simulation is of non-uniform traffic distribution of 70 beams over Europe (see *Figure 4*). The main conclusions are that beam hopping shows a clear advantage over conventional fixed multi-beams and some advantages over non-hopped flexible systems in terms of "unmet system capacity" and payload power consumption. Refer to *Appendix A* to learn more about superframe and beam hopping options and advantages.

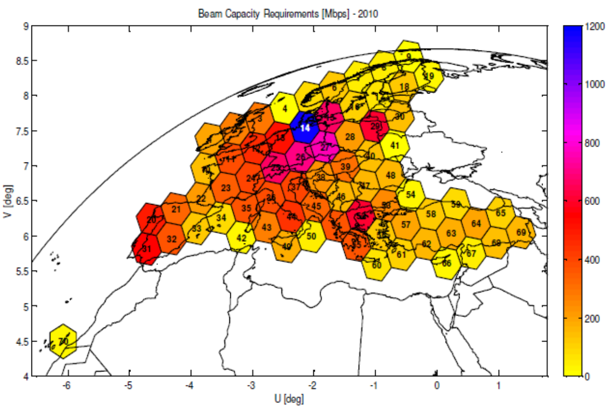


Figure 4- Multi-beam Coverage and Capacity, Density and Distribution

The Pricing of VSATs

Very Small Aperture Terminal (VSAT) systems have been for many years and are still providing low cost communication solutions for users in very wide coverage areas, which outspans the coverage of terrestrial technologies such as cellular and land-line technologies. Recently, many service providers are enabling broadband services through VSATs over HTS satellites.

One of the main drawbacks of the VSAT solution is the relatively high cost of the terminal, requiring a large antenna, RF and typically a non-standard modem which is implemented using costly and high power components. This disadvantage makes the solution inadequate for many applications. Even though prices have dropped dramatically over the year to 30% of the cost every 10 years, prices of VSATs are still in the $300 range and represent a significant obstacle to wide adoption.

In order to compete effectively with terrestrial alternatives, the cost of VSAT is yet to be reduced. The idea of low cost VSAT has been discussed over the years, where the definition of “low cost” has always been half or less of the, then current, price. Recently, prices have reached a point close to $300, which is very good for enterprise applications but not good enough for users who want consumer broadband service (where in ADSL and cable modem – terminal price is around $100).

The VSAT paradigm Shift

It’s true that the manufacturing technologies improved, new materials have been used and new RF components are used inside the ODU active elements (LNB and BUC), which led to price drop over the years. It is certain that the evolution path through the SX 3000B/A will make it possible to reduce the total cost of a VSAT terminal to within $100 range, as shown in *Figure 5* below.

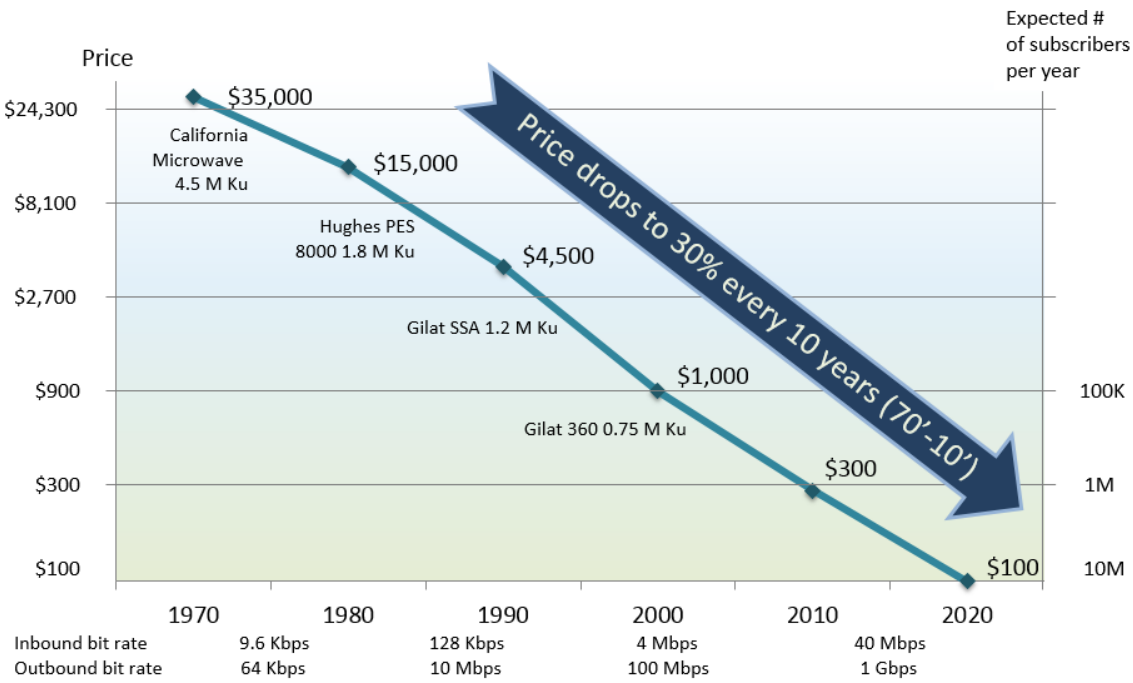


Figure 5- VSAT Terminal Pricing Trend

The main building blocks for such a solution are based on new silicon SoCs for complete baseband modem system as well as evolution of very low cost antenna, and new technologies for the RF part such as single conversion ICs or direct RF sampling ADCs and DACs.

SatixFy IDU

The small form factor of the IDU PCB based on the SX 3000B enables small, low cost, low power IDUs. The terminal is highly integrated due to the inclusion of Modulator, Demodulator, DSP, CPU, ADC, DAC and other functions and accelerators on a single SX 3000B chip.

An example of such a board is attached coupled with a sample industrial design of such IDU which is about 10 cm in diameter.

This small sized IDU is capable of processing a wideband carrier of 500MHz with/without Time Slice and transmit a SCPC/MF-TDMA return link.

SX 3000A: Low cost, Low Power Consumption/IoT chip

The SX 3000A is a lower cost and lower power version of the SX 3000B product. It is intended for the high volume consumer broadband and M2M/IoT markets. The chip is a subset of our proven SX-3000B chip and includes a highly efficient power management scheme. This will enable low cost, extremely low power terminals operating with superframe and low power saving method.

The SX 3000A has several operational modes for transmit, receive and standby. All the circuitry not required in a certain mode is being turned off to minimize the power leakage. While in operation the dynamic power consumption is optimized as well according to the use case. The advanced power management enables the use of solar and battery operated devices.

The ASIC can act as store and forward communication channel for sensors, operate at a very low duty cycle and wake up with traffic demand via data coming through interfaces to the sensors or on a fixed receive frame algorithm to check if there is a need for a fully wake-up cycle (see Figure 6 below).

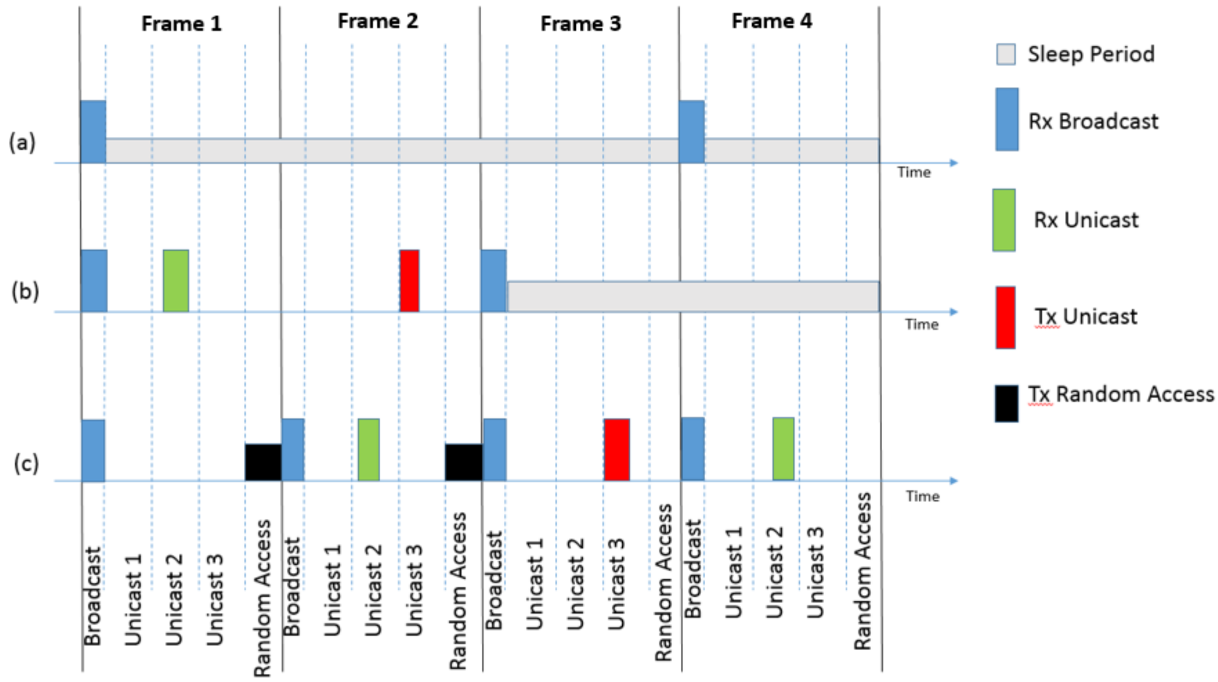


Figure 6- Framing Structure for Low-power/IoT Applications

The modem was designed to withstand Doppler shifts of mobile vehicles, either ground, aerial or maritime or MEO/LEO constellations and has powerful DSP to process signals coming from small aperture antennas.

SX-3000A includes a baseband modem with high speed analog front end which supports a wide-band DVB-S2/S2X forward channels (capturing up to 600MHz) and DVB-RCS2/DVB-S2X return channel. The chip takes full advantage of Adaptive Coding Modulation (ACM) with a very wide variety of MODCOD options to optimize the efficient utilization of the Satellite link.

Summary

HTS is a game changing technology for consumer broadband networks over satellite. In order to take full advantages of HTS technology and provide affordable service to needed areas, the ground segment should both support the technology to its extent and provide the most cost effective terminal BOM.

SatixFy's SX 3000B provides in a single package almost the entire functionality of a VSAT, making the terminal highly integrated and cost effective. The chip also supports all the newest standards DVB-S2X, DVB-RCS2. The SX 3000B supports single carrier wideband operation up to 500 Msps, time-slice operation (DVB S2X Annex M) and the superframes (DVB S2X Annex E) which brings opportunities for new systems deployment with significantly improved system performance and utilization.

Appendix A: Superframes, Beam Hopping and its implementation on SatixFy chips

Purpose of Super-Framing

In the DVB-S2X standard [2], a design the superframes structure (Annex E) as enablers for various techniques applicable for multi-beam satellites.

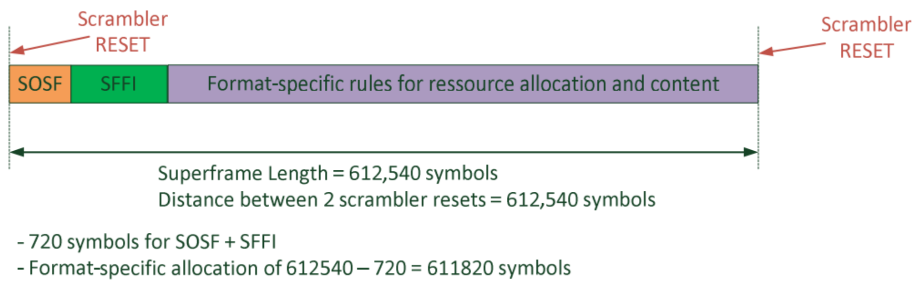


Figure 7- Superframe General Format

For beam hopping, formats 2 and 3 ("bundled PLFRAMES" for normal and short frames respectively) are recommended. These formats include:

- SOSF and SFSI (start of superframe and Superframe Format Specification Indication common to all superframe formats.
- Bundled PLFRAMES, which are groups of frames with the same MODCOD, repeated PL-headers (PLH) for better acquisition
- Regularly distributed pilots
- Special pilot signals, of the same constellation as the frame (P2)
- Additional dummy signals at the end of the superframe.

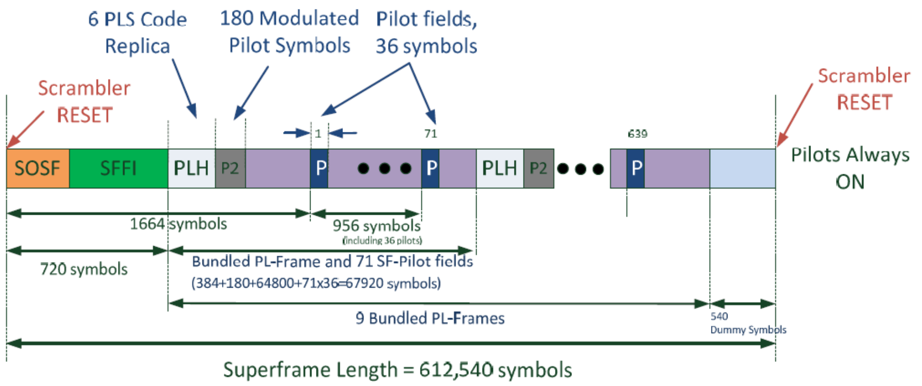


Figure 8- Superframe Format 2 for 64800 information symbols

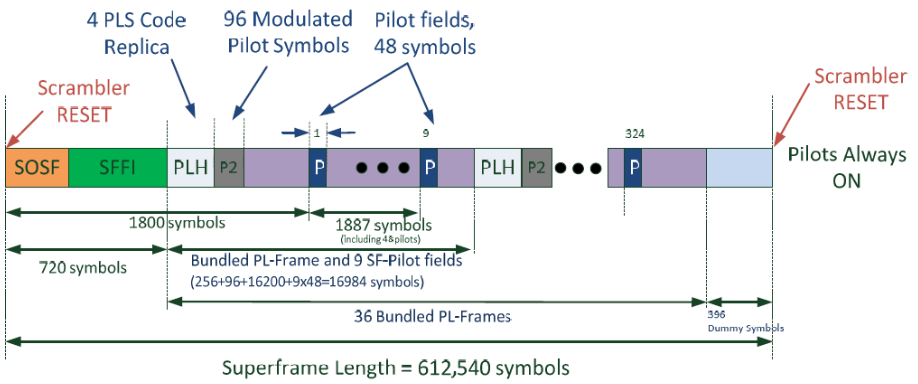


Figure 9- Superframe Format 3 for 16200 information symbols

The Superframe features enable:

- acquisition of the superframe and detection of the PL Headers in a burst and low SNR conditions
- phase, gain and non-linear distortion detection using the pilots and P2 pilots
- Time for beam switching at the end of each superframe.
- Forming a “fixed grid” in time, even if a variety of frame –lengths is needed for the whole coverage area.
- Disadvantages of the superframe structure:
- Delay as a function of superframe length (612540/Rs = 1.2msec for 500Msps)
- Some constraints for MODCOD allocations.

The use of Beam Hopping

Beam hopping can be used for a variety of platforms: GEO/MEO/LEO satellites or even high altitude platforms (HAP/ UAV…). While the principles might be similar, implementation might be very different according to the platform type, For GEO satellite it is expected that beams’ footprints on the ground are large (hundreds of km). They would include a large number of users, with large capacity demands. On the other hand with UAV types of platform, the footprints would be much smaller (20-50 km in diameter). When covering rural areas there might be very little traffic in a beam.

Beam Hopping ground terminal

Unlike traditional point-to-multipoint systems (including, cellular systems, single beam VSAT, and more) the terminal is not always illuminated by the downlink transmission, so it is required to perform “cold” acquisition per each received burst, including synchronization, frame acquisition and decoding. To allow for that, beam scheduling might be made such that minimum visiting time per terminal is assured, such that synchronization is possible.

In addition, the terminal is required to extract the frame designated to it out of the downlink superframe. This may put on the terminal the burden of decoding the entire superframe, or at least the bundle of frames with the expected MODCOD, and extracting the relevant packets from the bit stream. With the large symbol rate envisaged for the high throughput satellites, and high computation load of, e.g. LDPC decoding, this might result in unnecessary cost in computational and memory resources in the terminal. Another mechanism could be an indication by the hub to the location of the relevant frame within the superframe, or by using the Time-Slice mechanism of DVB=S2 (Annex M). However, none of the superframe formats defined so far include the mechanism.

The SX 3000B ASIC include all the capabilities required to operate in a beam switching network and a terminal built using the chip will be future proof.

References

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2 ETSI EN 302 307-2 V1.1.1: Second generation framing structure, channel coding and modulation systems for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications, Part 2: DVB-S2 Extension (DVB-S2X) (2014-10)

3 ETSI TR 102 376-2 V1.1.1: User guidelines for the second generation system for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications- Part 2: S2 eXtensions. (2015)

4 Rainish, D: First Satellite Software Defined Radio chip implementation, KA-2015 Conference

5. Anzalchi, J.; Couchman, A.; Gabellini, P.; Gallinaro, G.; D'Agristina, L.; Alagha, N.; Angeletti, P., "Beam hopping in multi-beam broadband satellite systems: System simulation and performance comparison with on hopped systems," Advanced satellite multimedia systems conference (asma) and the 11th signal processing for space communications workshop (spsc), 2010 5th, vol., no., pp.248,255, 13-15 Sept. 2010