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Migration from DVB-S to DVB-S2 and Related Efficiencies

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Introduction

Digital Video Broadcasting-Satellite (DVB-S), as specified by ETSI EN 300 421, has been successfully deployed throughout the world with outstanding results.

DVB-S2 (the second generation of DVB-S), as specified by ETSI EN 302 307, provides an increase in spectral efficiency and advanced operational features. The improvement of DVB-S2 over DVB-S translates to one of the following:

- An increase in bandwidth with no change to satellite parameters (antenna, carrier power, etc.) within the same spectral configuration

- Or -

- A reduction in satellite bandwidth, if no increase in user throughput is desired

The migration from DVB-S to DVB-S2 provides greater spectral efficiency (bits/Hz) due to improvements in Forward Error Correction (FEC) coding. Adding Low Density Parity Check (LDPC) with Bose-Chaudhuri-Hocquenghem (BCH) results in an optimization that closely approaches the Shannon Limit. Both DVB-S and DVB-S2 Constant Coding and Modulation (CCM) support a static configuration, using a single modulation and coding (MODCOD) configuration for a given carrier.

The DVB-S2 specification introduces a concept known as Variable Coding and Modulation (VCM), which is a static version of the Adaptive Coding and Modulation (ACM) feature. The introduction of ACM/VCM allows support for multiple MODCODs within the same carrier. ACM/VCM allows receivers of a given carrier to decode any MODCOD that operates above the decoding threshold. Any MODCOD below the decoding threshold is ignored.

In a DVB-S or DVB-S2 CCM environment, the MODCOD is chosen so the worst-case site (the site with the lowest ERIP) can close the link budget with an appropriate margin to achieve quasi-error free (QEF) operation. As a result, the weakest site limits the overall efficiency (and throughput) of the common carrier configuration.

However, by introducing ACM/VCM, the carrier can be configured so that sites on the fringe of the satellite's footprint (lowest EIRP) can be configured with heavier FEC coding, while sites in the center of the beam (higher EIRP), can be configured with less FEC coding while operating simultaneously in the same carrier. ACM/VCM opens a new dimension for optimizing power, bandwidth and throughput over the link.

A typical satellite footprint with EIRP contours is shown in Figure 1.

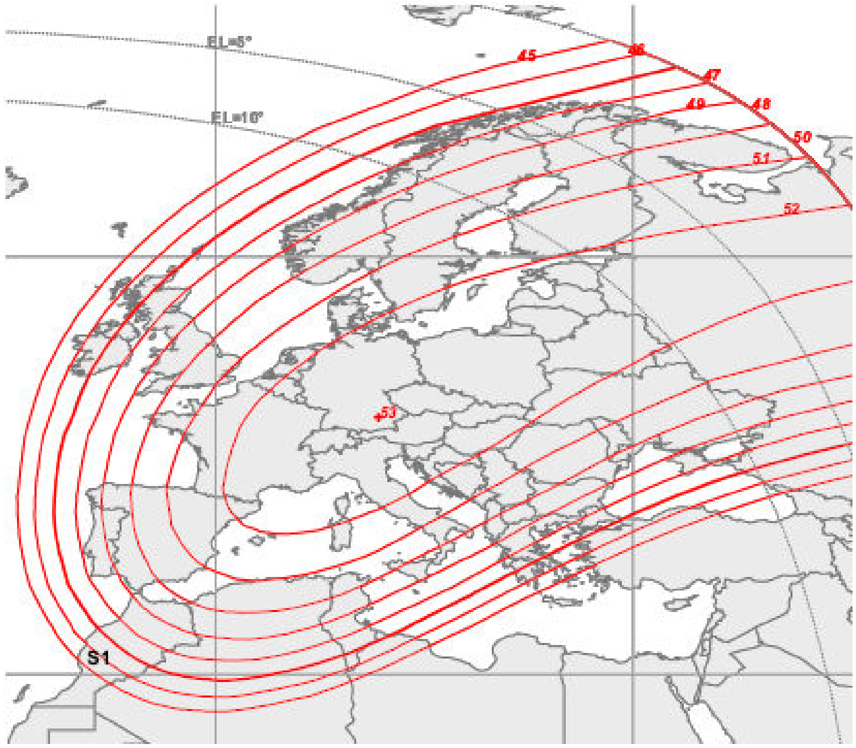

Figure 1. Sample Satellite Contour

The inner contours of the satellite footprint radiate a higher EIRP (50 – 53 dB), so earth stations located here can operate higher code rate FEC and higher order modulation to achieve optimal power and bandwidth performance. Sites on the fringe require lower code rate FEC and lower order modulation, costing more bandwidth or needing larger antennas and amplifiers to compensate for the lower EIRP.

Similar to CCM, a VCM site is statically configured for a given MODCOD, depending on where the site falls in the footprint of the satellite. In an ACM environment, sites can be dynamically moved from one MODCOD to another as conditions at the remote site change (improve or degrade).

Sites that fall below the 48 dBW contour are assumed to use larger antennas to compensate for the lower EIRP. This is a reasonable assumption, since most sites that fall near the edges of the satellite's footprint are typically in lower density populated locations.

This paper will focus on the benefits of DVB-S2 CCM and VCM operation as compared to DVB-S.

DVB-S to DVB-S2 Migration

DVB-S defines support for one modulation format (QPSK) and five FEC codes 1/2, 2/3, 3/4, 5/6 and 7/8, but DVB-S2 defines support for 28 combinations of modulation and codes (MODCODs) ranging from 1/4 QPSK to 9/10 32-APSK. The spectral efficiency of DVB-S and DVB-S2 are shown in Figure 2.

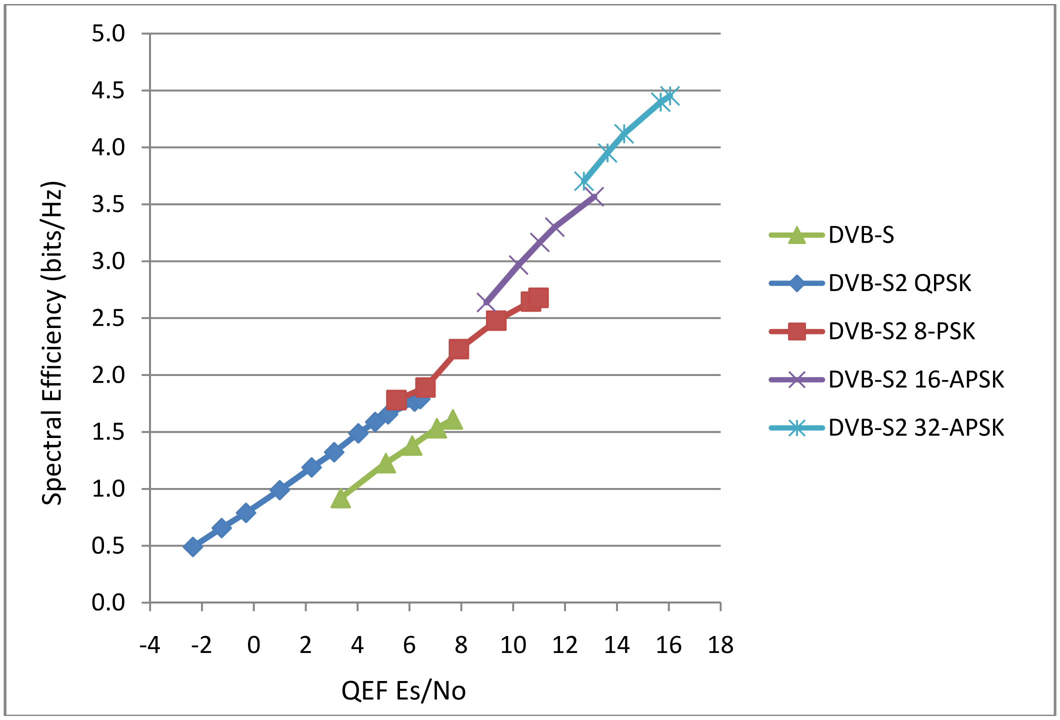

Figure 2. DVB-S verses DVB-S2 Spectral Efficiencies

Comparing similar spectral efficiencies between DVB-S and DVB-S2, an increase of QEF Es/No verses spectral efficiency demonstrates that an increase can be realized. Observing efficiency at 1 bits/Hz shows there is an increase of approximately 30% when comparing DVB-S to DVB-S2 QPSK. From an academic point of view, the bandwidth efficiency of migrating from DVB-S to DVB-S2 will provide approximately 30% greater efficiency due to improvements in the error coding for similar Es/No. The migration from DVB-S to DVB-S2 may be applied to an operational scenario where the operating expense (OPEX) can be applied as shown in Example 1.

Example 1 (DVB-S to DVB-S2)

Our goal is to support every user in the satellite footprint from the center of the footprint at 53 dBW down to the 45 dBW contour with a DVB-S carrier. All users are to be supported on a satellite transponder that is shared by multiple carriers (multi-carrier transponder) at a cost of $4,000/MHz per month. Assuming an availability of 99.9%, a FEC code of 2/3 is required. It must be noted, that sites below the 48 dBW contours must have improved hardware, e.g. larger antennas or higher quality LNBs to operate. If we assume the current DVB-S carrier operates at 13.33 Msps and occupies 18.0 MHz of bandwidth, the OPEX per month is $72,000 for 18 MHz, and provides 16.4 Mbps of total throughput with an efficiency of 0.91 bits/Hz. Migrating to DVB-S2 for the same spectral requirement for DVB-S2 QPSK 4/5 FEC to meet with the same Es/No requirements provides an increase in available bandwidth from 16.4 Mbps to 21.2 Mbps operating in the same 18.0 MHz, resulting in an increase of 29.3% additional user throughput with no increase in OPEX. The overall efficiency increases from 0.91 bits/Hz to 1.18 bits/Hz, reducing the monthly OPEX from $4,395 per Mbps to $3,390 per Mbps.

DVB-S2 CCM to VCM

Figure 1 shows contours of the satellite's footprint for an EIRP of 53 dBW in the center of the beam to as low as 45 dBW, a spread of 8 dB between the best and worst coverage areas for the satellite. If we assume that sites that fall below the 48 dBW contour have larger antennas or higher performance electronics to compensate for the lower performance, and then all sites in the 48 dBW to 53 dBW contours have the same hardware. Moving to DVB-S2 VCM shows increased performance may be realized.

A resulting link budget for each contour demonstrates the following MODCODs may be supported for a 13.33 Msps carrier occupying a partial transponder as shown in Table 1:

Table 1. DVB-S2 MODOCDs for Sample Satellite Contours

EIRP/Contour dBW	MODCOD	Data Rate	Site Type
52	2/3 16-ASPK	35.2 Mbps	C1
51	3/4 8-PSK	29.7 Mbps	C2
50	2/3 8-PSK	26.4 Mbps	C3
49	8/9 QPSK	23.5 Mbps	C4
48	4/5 QPSK	21.2 Mbps	C5+C6+C7+C8

Table 1 demonstrates that each contour band is assigned to a given MODCOD, ranging from 2/3 16-APSK, supporting 35.2 Mbps down to 4/5 QPSK supporting 21.2 Mbps. An example of how the bandwidth is distributed is shown in Table 2.

Table 2. VCM Bandwidth Distribution over Five MODCODs

EIRP/Contour dBW	MODCOD	Data Rate	Site Type	Division of Bandwidth	Resulting Bandwidth
52	2/3 16-ASPK	35.2 Mbps	C1	1/5	7.0 Mbps
51	3/4 8-PSK	29.7 Mbps	C2	1/5	5.9 Mbps
50	2/3 8-PSK	26.4 Mbps	C3	1/5	5.3 Mbps
49	8/9 QPSK	23.5 Mbps	C4	1/5	4.7 Mbps
48	4/5 QPSK	21.2 Mbps	C5+C6+C7+C8	1/5	4.2 Mbps
				Total	27.2 Mbps

By spreading the bandwidth over five MODCODs, the resulting increase in overall throughput has increased as follows:

- DVB-S to DVB-S2 (CCM): 16.4 Mbps to 21.2 Mbps – 29.3% increase in efficiency
- DVB-S2 (CCM to VCM): 21.2 Mbps to 27.2 Mbps – 28.3% increase in efficiency
- DVB-S to DVB-S2 (VCM): 16.4 Mbps to 27.2 Mbps – 65.8% increase in efficiency

The migration from DVB-S to DVB-S2 VCM may be applied to an operational scenario where the operating expenses (OPEX) can be applied as shown in Example 2:

Example 2 (DVB-S to DVB-S2 VCM Mode)

Assume 18 MHz at $4,000 per MHz on a multi-carrier transponder would result in a monthly cost of $72,000. If we utilize five MODCODs as shown in Table 2 and allocate the available bandwidth by 1/5 to each type of site, the resulting increase in bandwidth from DVB-S2 CCM of 21.2 Mbps to 27.2 Mbps provides an increase of 6.0 Mbps at no additional increase in OPEX. The resulting efficiency goes from 1.18 bits/Hz to 1.51 bits/Hz, resulting in a monthly OPEX from $3,390 per Mbps to $2,649 per Mbps.

Conclusion

DVB-S paved the way for a unified satellite transmission standard that has proven to be a viable architecture and embraced by the broadcast industry. DVB-S2 provides a significant improvement in efficiency (bits/Hz) and has features such as VCM to further improve utilization of bandwidth resulting in additional improvement in OPEX. Further, by segmenting the carrier into to discrete MODCOD bins allows sites assigned to the inner contours to more efficiently utilize bandwidth, resulting in higher overall efficiency of the allocated bandwidth. As demonstrated in this paper, with proper design consideration and Comtech EF Data products, the network provider can increase bandwidth efficiency with no increase in OPEX, or reduce OPEX with no additional increase in service level.

Please contact Comtech EF Data Sales for more information about this innovative technology.

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