TANDBERG
Television

# A COMPANION GUIDE TO DVB-S2

# General Information

## About this Document

This document provides information relating to the DVB-S2 specification for satellite broadcasting. The aim is to give the reader a general understanding of what features are implemented in the specification – the reasons for the introduction of the features and the benefits they offer. This document does not aim to describe in detail how the features are implemented. For this detailed information there can be no better way to fully understand the inner workings of the DVB-S2 system than by reading the DVB-S2 specification itself.

Issues of this document are listed below:

| Issue | Date | Author | Comments |
|---|---|---|---|
| 1 | Dec 2004 | David Edwards | Initial Release |

The following associated documents are a useful accompaniment:

- EN302 307, Second Generation Framing Structure, Channel Coding and Modulation Systems for Broadcasting, Interactive Services, News Gathering and Other Broadband Satellite Applications – The DVB-S2 Specification
- EN300 421, Framing Structure, Channel Coding and Modulation for 11/12GHz Satellite Services – The DVB-S Specification
- EN301 210, Framing Structure, Channel Coding and Modulation for Digital Satellite News Gathering (DSNG) and Other Applications By Satellite – The DVB-DSNG Specification

## Acknowledgements

### General

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# 1 Introduction

For many years now there has been talk of new, improved, satellite transmission schemes. Much of the development was focussed on Turbo Codes and 8PSK modulation. From these varied and proprietary schemes came the need for a new international standard – DVB-S2. The DVB-S2 specification now exists and with the first products beginning to appear this paper aims to give a brief explanation of what DVB-S2 is and what it can deliver.

# 2 The Development Brief

The target for the DVB-S2 specification was to achieve a transmission standard that could achieve up to a 30% increase in spectral efficiency and be simple enough that consumer ASIC demodulator ICs would be commercially viable.

# 3 What is DVB-S2?

## 3.1 The FEC Scheme

As previously mentioned, the DVB-S2 specification originated from work on Turbo Code error correction schemes and the desire for improved efficiency.

Ironically, having evaluated all the error correction schemes submitted to the DVB-S2 group the best performing scheme of a Low Density Parity Check (LDPC) code concatenated with a Bose-Chaudhuri-Hocquenghem (BCH) code was chosen.

This new FEC scheme can be thought of as a replacement of the DVB-S convolutional coding with LDPC coding and Reed-Solomon encoding with a different BCH encoding. It is this new FEC scheme that forms the heart of the DVB-S2 standard.

## 3.2 Constellations

DVB-S2 has a range of constellations on offer. The existing standards of DVB-S and DVB-DSNG offered QPSK (DVB-S and DVB-DSNG), 8PSK and 16QAM (for DVB-DSNG). The new DVB-S2 standard allows the use of QPSK, 8PSK, 16APSK and 32APSK. The 16- and 32APSK constellations may be unfamiliar but can be though of as round QAMs. More detail on these modes will be given in due course.

## 3.3 Application Modes

The final tool set within DVB-S2 is a number of application modes, which are built around the use of the new FEC coding scheme. These modes give benefits to a number of different applications. These application modes are:

- Traditional Broadcast Mode
- Backward Compatible Broadcast Mode
- Interactive Mode

Again, more on these later.

# 4 DVB-S2 in Detail

## 4.1 The Modulation Scheme

The primary objective of DVB-S2 was to bring 8PSK within reach of consumer-sized satellite dishes and the increase in spectrum efficiency that 8PSK brings. With this work came the acceptance that real world transmission factors should be taken into account for the new system design. Rather than considering only the standard linear channel as with the previous DVB-S and DVB-DSNG specifications, the DVB-S2 specification recognises the following effects:

- Phase noise
- Non-linear magnitude and phase characteristics of a saturated transponder
- The fact that the transponder is power limited
- Group delay effects

This work led to the defined constellations to be optimised for the above conditions. The constellations that were chosen are shown below:

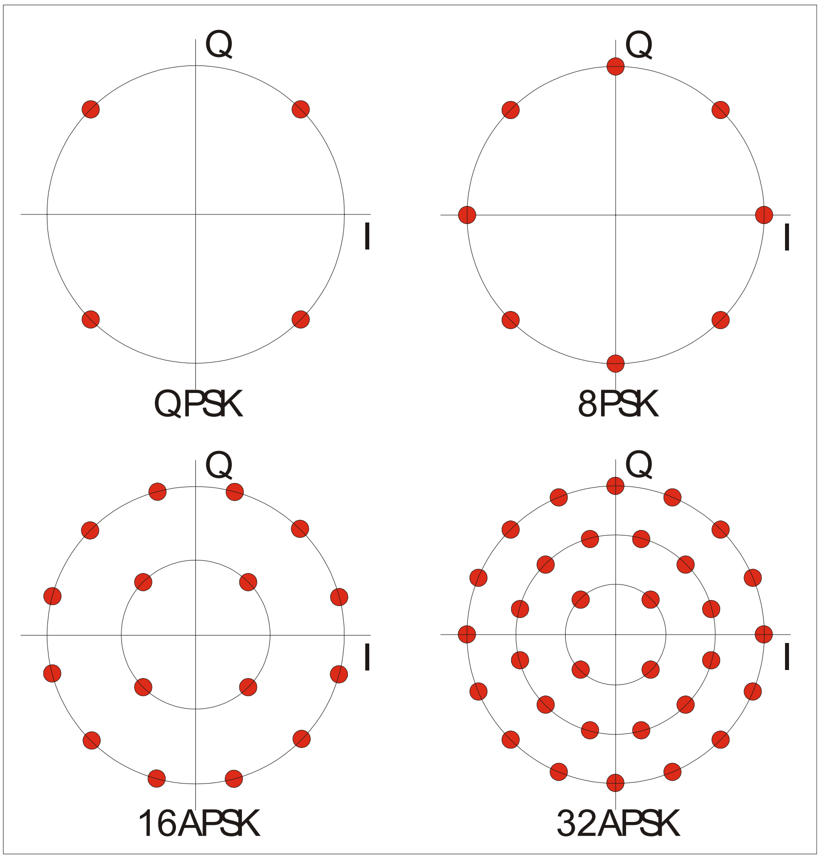


*Figure 1: DVB-S2 Constellations*

16APSK and 32APSK were chosen over the more familiar QAM constellations because their round shape makes them more power efficient in the power-limited channel that is a saturated satellite transponder. It is interesting to note that the ratio of the radii of the concentric circles for 16- and 32APSK changes slightly depending upon the FEC that is used in order to achieve maximum performance.

In the condition where the DVB-S2 transmission is used on a saturated satellite transponder, the shape of the constellations will be distorted by the non-linear phase and magnitude characteristics of the saturated amplifier in the transponder. The distortion that occurs will have the effect of degrading the downlink margin of the received signal. This problem of non-linear distortion is most acute for the 16- and 32APSK constellations. For QPSK and 8PSK the problem is mostly negated by the carrier recovery loop in the demodulator. For 16APSK and 32APSK however, the DVB-S2 specification recommends that dynamic pre-correction techniques such as TANDBERG's Prekor™ system be employed.

### 4.1.1 Cycle Slips, Phase Noise and Pilot Tones

The choice of round constellations makes the carrier recovery of the received signal more difficult. With QPSK and in DVB-DSNG 16QAM there were "corners" to the constellations, which reduced the number of possible valid phase rotations and thus reduced the chance of the carrier recovery inadvertently slipping from one orientation to another. Such an event is called a cycle-slip and has the effect of momentarily producing a burst of uncorrected errors on the decoded transport stream.

Cycle slips tend to occur when there is too much phase noise (rotational noise) on the received constellation. The rotational noise upsets the carrier recovery loop and causes a momentary, erroneous slip in the rotation of the received constellation. Traditionally the maximum phase noise thought to be acceptable has been taken from an Intelsat standard IESS-308. The DVB-S2 group reviewed the likely aggregate phase noise levels for a typical consumer direct to home installation and have specified a system capable of withstanding that level of phase noise.

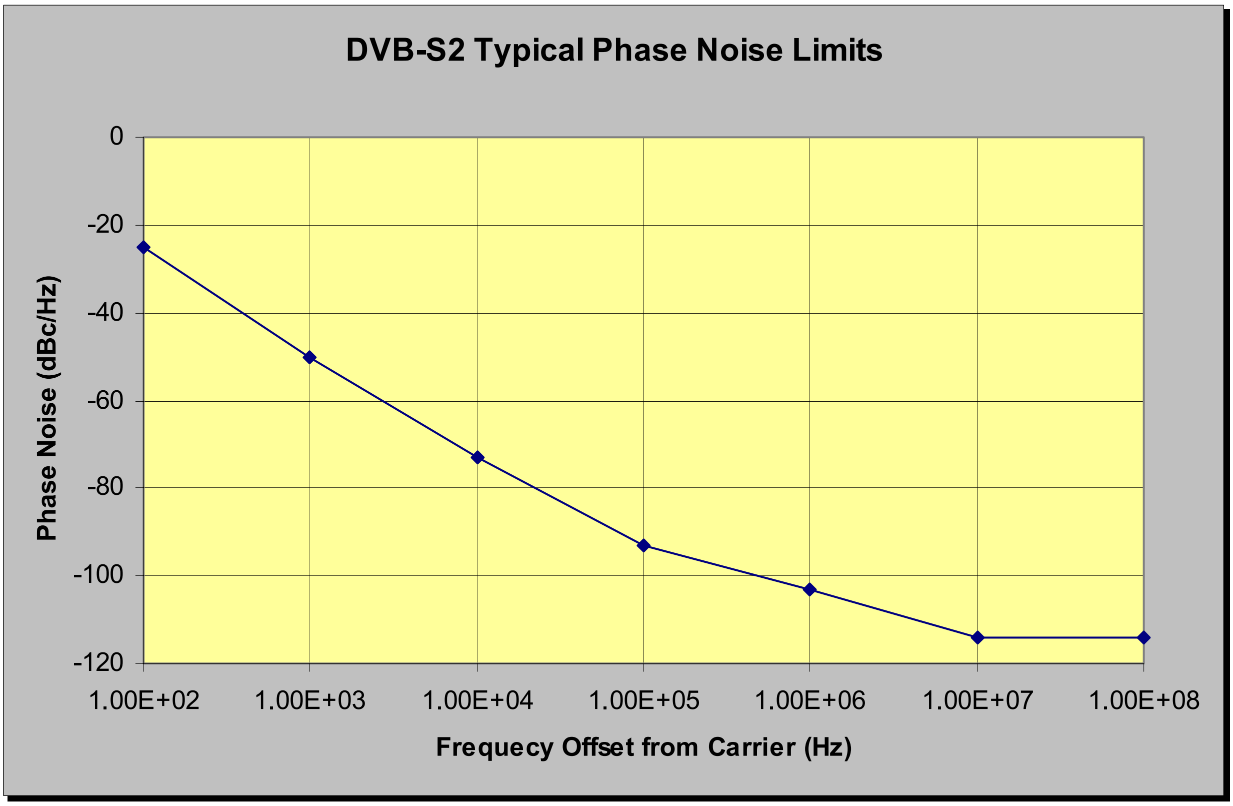


Figure 2: DVB-S2 Typical Aggregate Phase Noise Limits

To overcome the problem of phase noise induced cycle-slip events; DVB-S2 allows the option of inserting bursts of pilot tones at regular intervals. These pilot tones are effectively BPSK bursts and because these BPSK bursts have a strong phase component they prevent the carrier recovery system from cycle-slipping and failing prematurely. Whilst the use of pilot tones prevent the carrier recovery failing before the FEC fails the insertion of the tones reduces by a fraction the data rate throughput. The pilot tones are not necessary for every modulation format/FEC but where used they reduce the throughput by approximately 2.6%.

## 4.2 System Performance and FEC Choice

At the heart of the DVB-S2 system is the LDPC, BCH FEC engine. DVB-S2 allows for two different LDPC block sizes – a short 16k block or the normal 64k block. Systems using the 16k short block codes are expected to perform 0.2 to 0.3 dB worse than those employing the normal 64k block codes.

The output of the FEC engine is an FECFRAME. The FECFRAME is always of constant length, either a 16k or 64k block depending on the choice of a normal or short FEC system. The amount of real data carried by each FECFRAME is dependent upon how much overhead the chosen FEC code uses.

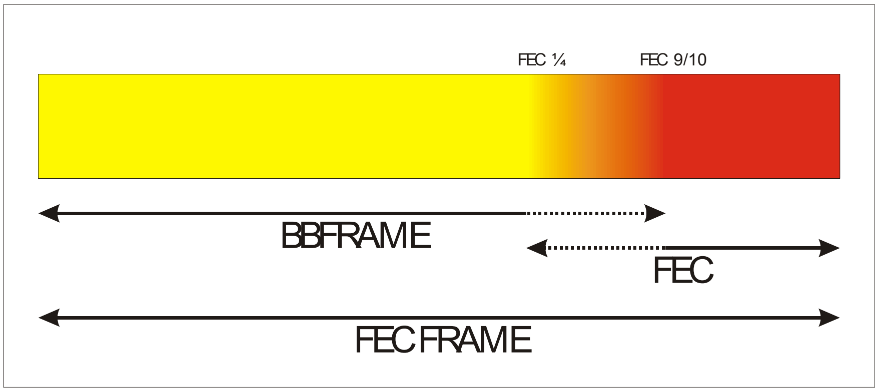


*Figure 3: An FEC Frame*

The FEC rates defined for use within DVB-S2 are shown in the following table along with the modulation formats for which they are valid.

| FEC | QPSK | 8PSK | 16APSK | 32APSK |
|---|---|---|---|---|
| 1/4 | ✓ | ✗ | ✗ | ✗ |
| 1/3 | ✓ | ✗ | ✗ | ✗ |
| 2/5 | ✓ | ✗ | ✗ | ✗ |
| 1/2 | ✓ | ✗ | ✗ | ✗ |
| 3/5 | ✓ | ✓ | ✗ | ✗ |
| 2/3 | ✓ | ✓ | ✓ | ✗ |
| 3/4 | ✓ | ✓ | ✓ | ✓ |
| 4/5 | ✓ | ✗ | ✓ | ✓ |
| 5/6 | ✓ | ✓ | ✓ | ✓ |
| 8/9 | ✓ | ✓ | ✓ | ✓ |
| 9/10 | ✓ | ✓ | ✓ | ✓ |

*Table 4.1: FEC Rates Applicable to the Various Modulation Formats*

> Note
>
> FEC 9/10 is not available for the Short FEC block size.

The performance of the DVB-S2 system is defined at the quasi error-free (QEF) point. This is the level at which the system is nearly but not quite failing - where decoded picture or sound errors are so infrequent as to prove unnoticeable.  Officially the QEF point for DVB-S2 is defined as a packet error ratio of 1E-7.

In the previous DVB-S and DVB-DSNG schemes the QEF point was defined as a post Viterbi error ratio of 2E-4. Obviously, since DVB-S2 does not use Viterbi error correction this definition is not applicable to DVB-S2.

Unfortunately, the rate of uncorrectable errors for DVB-S2 at QEF is not equivalent to the rate of uncorrectable errors for DVB-S or DSNG. It is therefore not possible to make a direct comparison between the $E_b/N_0$ performance quoted in the DVB-S/DSNG specifications with the DVB-S2 quoted performance.

To add to the comparison difficulties the DVB-S and DVB-DSNG specifications include in their quoted performance figures some allowance for modem implementation margin. There is no such allowance included in the DVB-S2 performance figures.

Further, it is also rather difficult to interpret the 16APSK and 32APSK performance figures – and for that matter 16QAM in DVB-DSNG when applied in single saturated carrier per transponder applications. This is because the performance $E_b/N_0$ figures reference average power. When used in single saturated carrier per transponder it is the peak power of the constellation that should be used as the reference (to saturation).

### 4.2.1 DVB-S, DSNG and S2 Performance Figures

In order to give a clear comparison between the previous DVB-S and DVB-DSNG standards and the new DVB-S2 standard the following table has been produced. The data shown evaluates all the various modes based on their theoretical performance – i.e. no modem implementation margin included. The QEF point is referenced to the DVB-S2 definition for all modulation formats – DVB-S and DVB-DSNG included. The peak-to-mean power ratios are also taken into account. In recognition of satellite links being non-linear power systems the performance is quoted as a $C/N_0$ rather than $E_b/N_0$, which is only relevant to linear channels.

| Modulation | FEC | $C/N_0$ (dB) for Failure | Bits/sym (No Pilots) | Bits/Sym (With Pilots) |
|---|---|---|---|---|
| **DVB-S QPSK** | 1/2 | 2.69 | 0.921569 | |
| | 2/3 | 4.36 | 1.228758 | |
| | 3/4 | 5.46 | 1.382353 | |
| | 5/6 | 6.53 | 1.535948 | |
| | 7/8 | 7.24 | 1.612745 | |
| **DVB-DSNG 8PSK** | 2/3 | 8.12 | 1.843137 | |
| | 5/6 | 10.42 | 2.303922 | |
| | 8/9 | 11.22 | 2.457516 | |
| **Multi-Carrier Per Transponder** | | | | |
| **DVB-DSNG 16QAM** | 3/4 | 11.43 | 2.764706 | |
| | 7/8 | 13.12 | 3.22549 | |
| **Single Carrier Per Transponder** | | | | |
| **DVB-DSNG 16QAM** | 3/4 | 13.99 | 2.764706 | |
| | 7/8 | 15.68 | 3.22549 | |
| **DVB-S2** | | | | |
| **DVB-S2 QPSK** | 1/4 | -2.35 | 0.490243 | 0.47767267 |
| | 1/3 | -1.24 | 0.656448 | 0.639616 |
| | 2/5 | -0.3 | 0.791874 | 0.77156954 |
| | 1/2 | 1 | 0.988857 | 0.96350169 |
| | 3/5 | 2.23 | 1.188303 | 1.15783369 |
| | 2/3 | 3.1 | 1.322251 | 1.28834713 |
| | 3/4 | 4.03 | 1.487472 | 1.44933169 |
| | 4/5 | 4.68 | 1.587195 | 1.54649769 |
| | 5/6 | 5.18 | 1.654662 | 1.61223477 |
| | 8/9 | 6.2 | 1.766451 | 1.72115738 |
| | 9/10 | 6.42 | 1.788612 | 1.74275015 |
| **DVB-S2 8PSK** | 3/5 | 5.5 | 1.779989 | 1.73434826 |
| | 2/3 | 6.62 | 1.980633 | 1.92984754 |
| | 3/4 | 7.91 | 2.228122 | 2.17099067 |
| | 5/6 | 9.35 | 2.47856 | 2.41500718 |
| | 8/9 | 10.69 | 2.646012 | 2.57816554 |
| | 9/10 | 10.98 | 2.679207 | 2.61050938 |

| Modulation | FEC | $C/N_0$ (dB) for Failure | Bits/sym (No Pilots) | Bits/Sym (With Pilots) |
|---|---|---|---|---|
| **Multi-Carrier Per Transponder** | | | | |
| **DVB-S2 16APSK** | 2/3 | 8.97 | 2.637197 | 2.56957656 |
| | 3/4 | 10.21 | 2.966726 | 2.8906561 |
| | 4/5 | 11.03 | 3.165621 | 3.08445123 |
| | 5/6 | 11.61 | 3.300181 | 3.21556097 |
| | 8/9 | 12.89 | 3.523142 | 3.43280503 |
| | 9/10 | 13.13 | 3.567341 | 3.47587072 |
| **Single Carrier Per Transponder** | | | | |
| **DVB-S2 16APSK** | 2/3 | 10.05 | 2.637197 | 2.56957656 |
| | 3/4 | 11.29 | 2.966726 | 2.8906561 |
| | 4/5 | 12.11 | 3.165621 | 3.08445123 |
| | 5/6 | 12.69 | 3.300181 | 3.21556097 |
| | 8/9 | 13.97 | 3.523142 | 3.43280503 |
| | 9/10 | 14.21 | 3.567341 | 3.47587072 |
| **Multi-Carrier Per Transponder** | | | | |
| **DVB-S2 32APSK** | 3/4 | 12.73 | 3.703293 | 3.60833677 |
| | 4/5 | 13.64 | 3.951568 | 3.85024574 |
| | 5/6 | 14.28 | 4.119537 | 4.01390785 |
| | 8/9 | 15.69 | 4.397854 | 4.28508851 |
| | 9/10 | 16.05 | 4.453027 | 4.33884682 |
| **Single Carrier Per Transponder** | | | | |
| **DVB-S2 32APSK** | 3/4 | 14.775 | 3.703293 | 3.60833677 |
| | 4/5 | 15.685 | 3.951568 | 3.85024574 |
| | 5/6 | 16.325 | 4.119537 | 4.01390785 |
| | 8/9 | 17.735 | 4.397854 | 4.28508851 |
| | 9/10 | 18.095 | 4.453027 | 4.33884682 |
| | | | | |
| | | | Indicates pilot tones recommended | |

*Table 4.2: DVB-S2 Performance Figures for 64k Block Codes*

### 4.2.2 DVB-S, DSNG, S2 Performance Curves

The values in the above table can be plotted graphically to allow easier interpretation of the figures. The following graphs – one for the single carrier per transponder and one for the multi-carrier scenario allow the reader to easily evaluate the possibilities of moving to DVB-S2. The graph can be interpreted by reading a change in the X-axis C/N or in the Y-axis spectral efficiency. For example, for a satellite link running DVB-S, QPSK, FEC rate 5/6, one has the choice of keeping the same spectral efficiency (data rate) and by moving along the X-axis – to the left. From the QPSK 5/6 point, one hits the DVB-S2, QPSK 3/4 point. This change results in the satellite link gaining approximately 2.5 dB extra downlink margin.

Alternatively and probably more advantageously, by moving along the Y-axis from the same DVB-S, QPSK, FEC rate 5/6 point upwards to the DVB-S2, 8PSK, rate 2/3 point, one gains an extra 0.5 bits/symbol increase in data rate whilst maintaining the same downlink margin on the satellite link.

This game can be played for just about any combination of scenarios that one cares to think of.

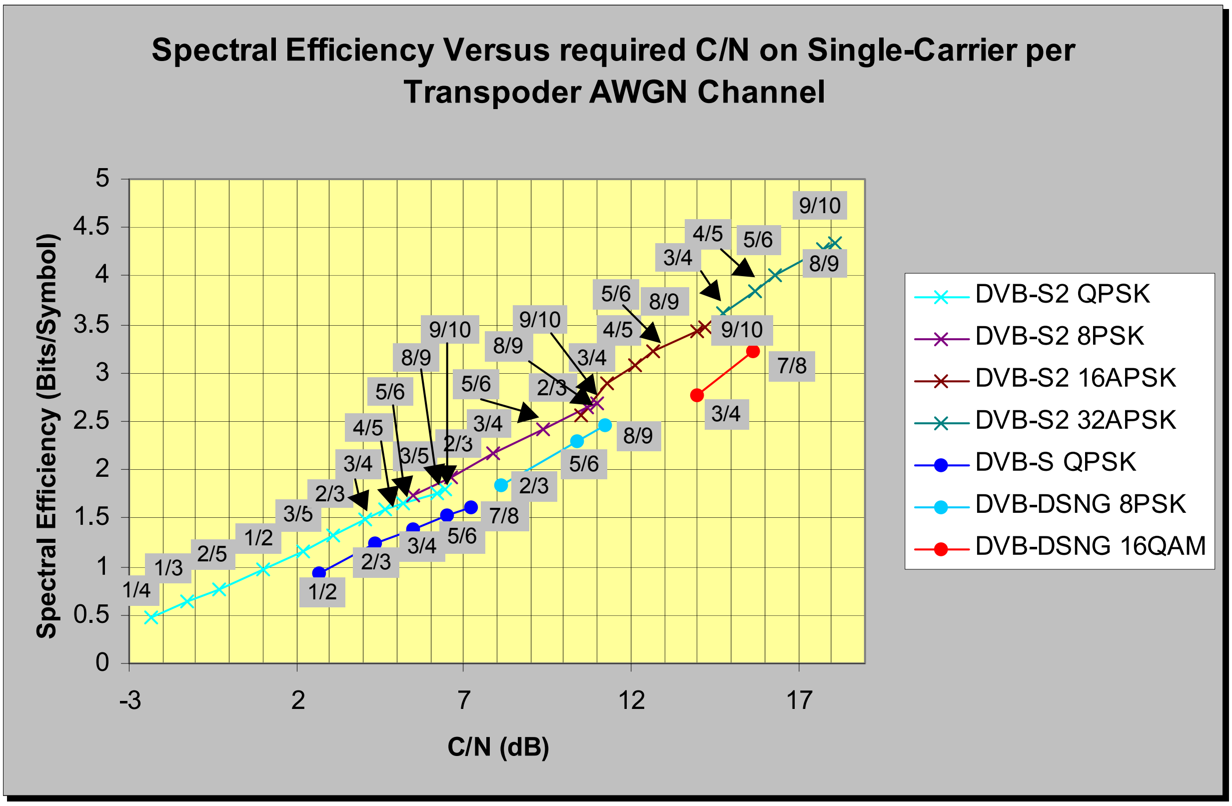


*Figure 4: DVB-S2 Performance Graph for Single Carrier per Transponder Operation Using Pilot Tones as Recommended*

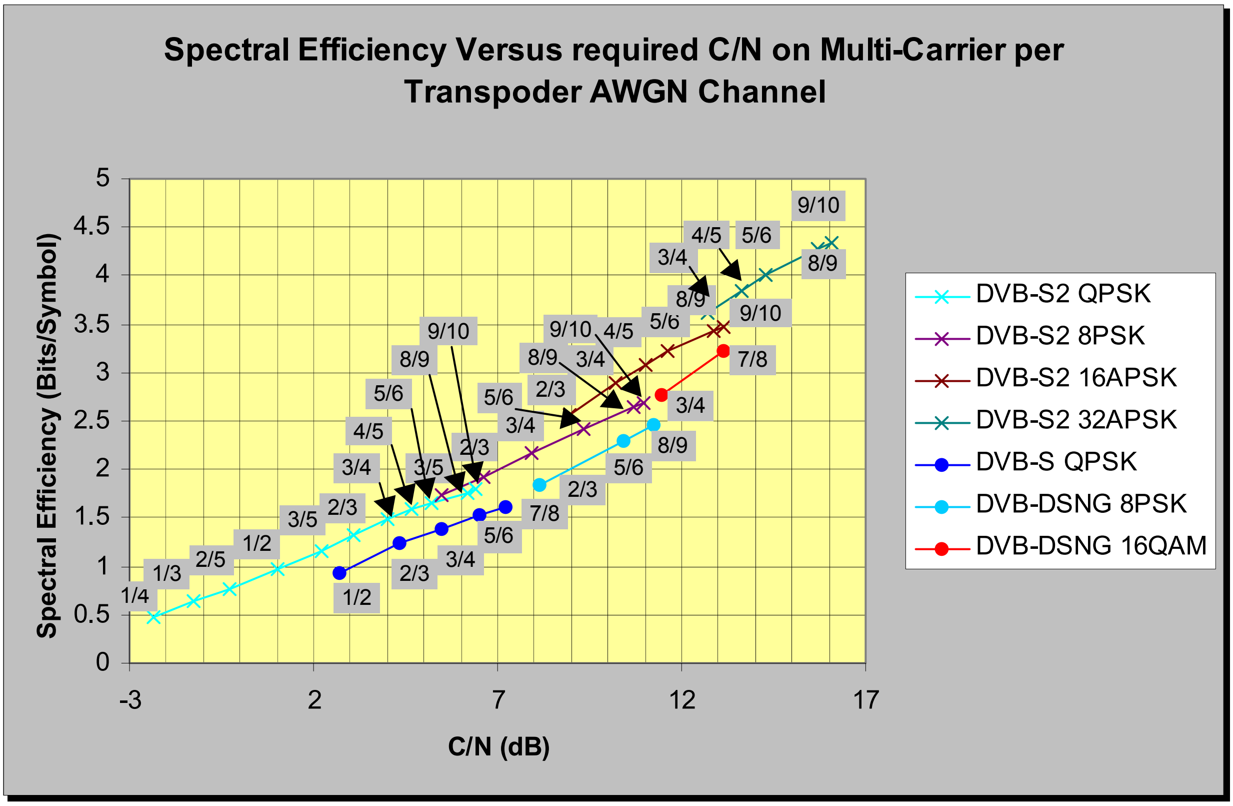


*Figure 5: DVB-S2 Performance Graph for Multi-Carrier Carrier per Transponder Operation Using Pilot Tones as Recommended*

The multi-carrier per transponder graph above differs from the single carrier per transponder graph for the 16QAM, 16APSK and 32APSK C/N figures. In the single carrier per transponder case, the constellation has to be reduced in power by its peak-to-mean power ratio to ensure that the outer constellation points do not over-saturate the transponder. The reduction required in power by the peak-to-mean power ratio directly affects the C/N threshold for QEF.

In the multi-carrier case, because the satellite transponder is not run at saturation but backed off a few dBs into a linear region, there is no longer any danger of the outer constellation points, which are of greater power than the mean power of the constellation, over-saturating the transponder. And so the C/N failure point is as defined for a linear channel in the DVB-DSNG and S2 specifications.

### 4.2.3 Examples of the DVB-S2 Improvement

As specific examples of what can be achieved from DVB-S2, some worked examples are included here. The examples are for some of the most common modulation parameters utilising pilot tones where appropriate.

**Replacement for QPSK 27.5Msym/s FEC 2/3 System**

| | Option 1 | Option 2 | Option 3 |
|---|---|---|---|
| Transmission Standard | DVB-S2 | DVB-S2 | DVB-S2 |
| Modulation | QPSK | QPSK | QPSK |
| Symbol Rate | 27.5 | 28 | 27.5 |
| FEC | 3/4 | 3/4 | 4/5 |
| Rolloff | 35% | 25% | 35% |
| Bit Rate (Ru188) | 40.91 | 41.65 | 43.65 |
| Bit Rate Increase | 7.11 | 7.86 | 9.86 |
| % Increase | 21% | 23% | 29% |
| Link Margin Change | +0.33 | -0.05 | -0.32 |

*Figure 6: Replacement for QPSK 27.5 Msym/s FEC 2/3 System*

**Replacement for QPSK 22Msym/s FEC 5/6 System**

| | Option 1 | Option 2 | Option 3 |
|---|---|---|---|
| Transmission Standard | DVB-S2 | DVB-S2 | DVB-S2 |
| Modulation | QPSK | 8PSK | 8PSK |
| Symbol Rate | 22 | 23 | 22 |
| FEC | 9/10 | 3/5 | 2/3 |
| Rolloff | 35% | 25% | 35% |
| Bit Rate (Ru188) | 39.25 | 39.89 | 42.46 |
| Bit Rate Increase | 5.56 | 6.1 | 8.66 |
| % Increase | 16% | 18% | 26% |
| Link Margin Change | +0.11 | +0.54 | -0.09 |

*Figure 7: Replacement for QPSK 22.5 Msym/s FEC 5/6 System*

**Replacement for 8PSK 27.5Msym/s FEC 5/6 System**

| | Option 1 | Option 2 | Option 3 |
|---|---|---|---|
| Transmission Standard | DVB-S2 | DVB-S2 | DVB-S2 |
| Modulation | 16APSK | 16APSK | 8PSK |
| Symbol Rate | 27.5 | 29 | 29 |
| FEC | 3/4 | 2/3 | 8/9 |
| Rolloff | 35% | 25% | 25% |
| Bit Rate (Ru188) | 79.5 | 5 | 76.7 |
| Bit Rate Increase | 16.1 | 11.2 | 13.4 |
| % Increase | 26% | 18% | 21% |
| Link Margin Change | -0.87 | -0.16 | -0.8 |

Figure 8: Replacement for 8PSK 27.5 Msym/s FEC 5/6 System

As can be seen from these examples, DVB-S2 gives between 20% and 30% increase in bit rate for approximately the same link budget as can be achieved from the DVB-S and DVB-DSNG specifications.

## 4.3 Nyquist Filter Roll-off

DVB-S specifies the sole use of a 35% roll-off Nyquist filter whilst DVB-DSNG gives the option of either a 25% or 35% filter. DVB-S2 gives the option of a 20%, 25%, 35% filter.

The Nyquist filter consists of two half (or root) Nyquist filters. One half is implemented in the modulator, the other half in the demodulator. The roll-off of the filter allows the bandwidth of the modulated spectrum to be constrained within a certain bandwidth – the tighter the filter roll-off the more constrained the bandwidth.

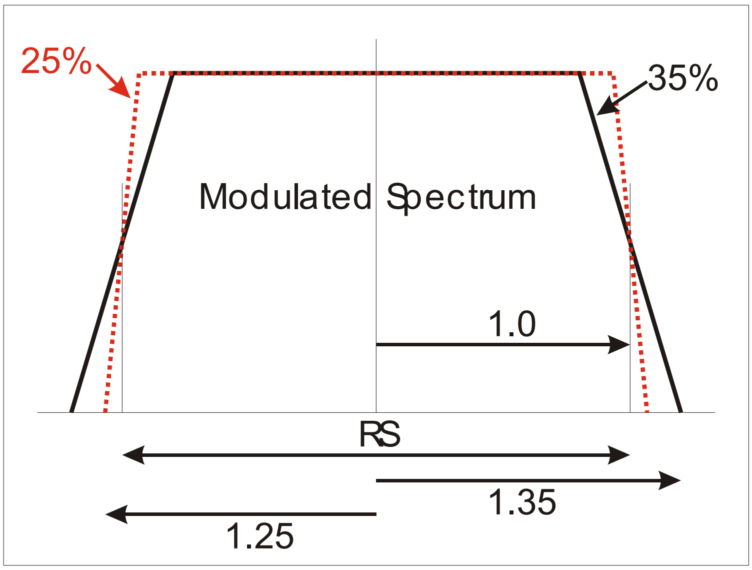


*Figure 9: Nyquist Filter Roll-off*

A tight roll-off such as 20% allows carriers to be closely spaced in a multi-carrier environment or to achieve maximum symbol rate within a transponder in a single carrier per transponder environment. Either way, it leads to maximum bandwidth efficiency. The downside is that a tighter roll-off can introduce more inter-symbol interference and power loss in the non-linear channel that is the satellite. This extra degradation is however fairly small – in the region of 0.3 dB when moving from 35% to 25% roll-off.

# 5 The Modes of DVB-S2

DVB-S2 has three modes of operation designed to cater for different types of applications. This following section describes the modes, uses and analyses their usefulness.

## 5.1 Traditional Broadcast Mode

This mode of operation can be thought of very much like DVB-S or DVB-DSNG with improved performance and a wider range of FEC rates to choose from. This mode of operation represents the driving force behind the creation of the DVB-S2 standard – the need for broadcasters to gain an extra 30% increase in bandwidth for no penalty to their link budget.

The operation of the modulation and demodulation equipment in a larger system will be exactly as before. Any control system for the equipment will of course need updating to reflect the new FECs that are available and the relationship between bit rate and symbol rate.

The use of DVB-S2 to enable an extra 30% capacity for no change in downlink margin is very valuable, allowing a great deal of extra data e.g. more TV channels to be transmitted. This extra "free" capacity coupled with new advanced encoding schemes such as MPEG4 can greatly increase the number of available TV channels within a transponder. Alternatively, a move to HD programming can be achieved by applying DVB-S2 and Advanced Coding techniques, yielding approximately the same number of TV channels per transponder as is currently achievable for SD programming when utilising DVB-S and MPEG 2.

As DVB-S is the most widely used satellite transmission scheme and the majority of DVB-S transmissions are utilised for TV broadcasts, it follows that it is this mode of DVB-S2 which is likely to prove the most popular.

## 5.2 Backward Compatible Broadcast Mode

The backward compatible mode has been devised to give a migration route for a gradual upgrade to new IRDs/STBs – useful if there are large receiver populations out in the field. The mode is a hierarchical modulation technique where both DVB-S and DVB-S2 signals are simultaneously transmitted on the same frequency. The system is illustrated in the diagram below.

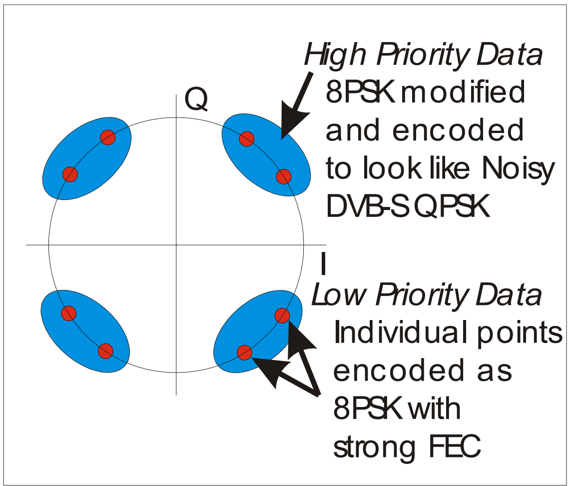


*Figure 10: Backward Compatible Hierarchical Constellation*

This hierarchical system involves the processing and combined modulation of two separate transport streams. The High Priority data would be the existing QPSK transmission – actually constructed from two closely spaced 8PSK constellation points. These two closely spaced 8PSK points would look to a conventional DVB-S QPSK receiver like noisy QPSK. A new DVB-S2 enabled receiver would however resolve the individual 8PSK constellation points to reconstruct the Low Priority transport steam giving an additional service.

The advantage of the backward compatible system is that the existing QPSK transmission can be maintained whilst an upgrade to the receiver population is implemented to migrate to DVB-S2. New DVB-S2 receivers can decode the extra Low Priority stream to offer extra data. At the point where the receiver population has been completely upgraded the DVB-S QPSK encoding can be switched off and the transmission changed to a non-hierarchical DVB-S2 8PSK transmission giving the promised 30% data rate increase that DVB-S2 can achieve over DVB-S.

The backward compatible system does though have its problems. Example analysis of common implementations shows that the effects on link budgets can be quite large.

**For a 27.5Msym/s DVB-S, QPSK, FEC 3/4, 38Mbits/s legacy system**

Using an FEC 1/4 DVB-S2 Hierarchical code for the low priority data

Low Priority data rate = 6 Mbits/s

> Imposing the criteria that the legacy High Priority signal and new Low Priority signal must have the same C/N failure point
>
> > *Implies a 1 dB loss of down-link margin to the legacy system*
>
> Imposing the criteria that the legacy system is degraded by only 0.5 dB
>
> > *Results in the Low Priority data requiring a doubling of receive dish size to maintain downlink margin.*

For many, such a large impact on link budget may make the scheme impractical to implement.

The greatest pull factor for DVB-S2 currently is the requirement to implement HD services. As HD services need new IRDs to decode the high definition pictures, the need to observe any backward compatibility is often removed. The combined link budget penalties and the pull factor to HD mean that the backward compatibility mode is unlikely to prove particularly popular.

## 5.3 Interactive Mode

The interactive mode has the potential to introduce something of a revolution to some specific satellite transmission applications. All satellite systems are currently designed with some downlink margin to ensure that the link is available during rain fade conditions. The result of this mode of operation is that in clear sky conditions the system is not performing as optimally as it could.

DVB-S2 has introduced two modulation techniques to help improve the efficiency of the satellite link.

### 5.3.1 Adaptive Coding and Modulation - ACM

The ACM mode allows both the modulation mode (QPSK, 8PSK, etc) and FEC to be changed "on the fly" on a frame-by-frame basis. The ability to do this, combined with a return channel from the receiver to the transmission site allows the receiver to indicate back to the uplink site current signal conditions so that the modulation and FEC can be tailored to the current signal conditions at the receive site. The type of return channel for signalling reception conditions is not defined but could be DVB-RCS or a simple modem connection through a telephone line.

This rather clever mode of operation is feasible because of a number of properties new to DVB-S2. It is possible to signal the type of modulation and FEC in a field in the transmitted data. And because carrier recovery can be achieved independently of modulation format (QPSK, 8PSK, etc) with the use of pilot tones it is possible to change modulation format quickly. With these two tools the demodulator can always maintain lock onto the signal and decode the data appropriately.

The management of this mode of operation is performed by an ACM router and router manager. The combination of these two devices receive the quality of reception data from the remote receivers and instruct the modulator which modulation and FEC to use whilst managing the data rate flow into the modulator.

With the ability to signal current reception conditions and change the modulation mode on the fly to match those conditions, the satellite link can be reliably run with minimal downlink margin and hence maximum efficiency at the highest possible data rate whatever the current downlink conditions.

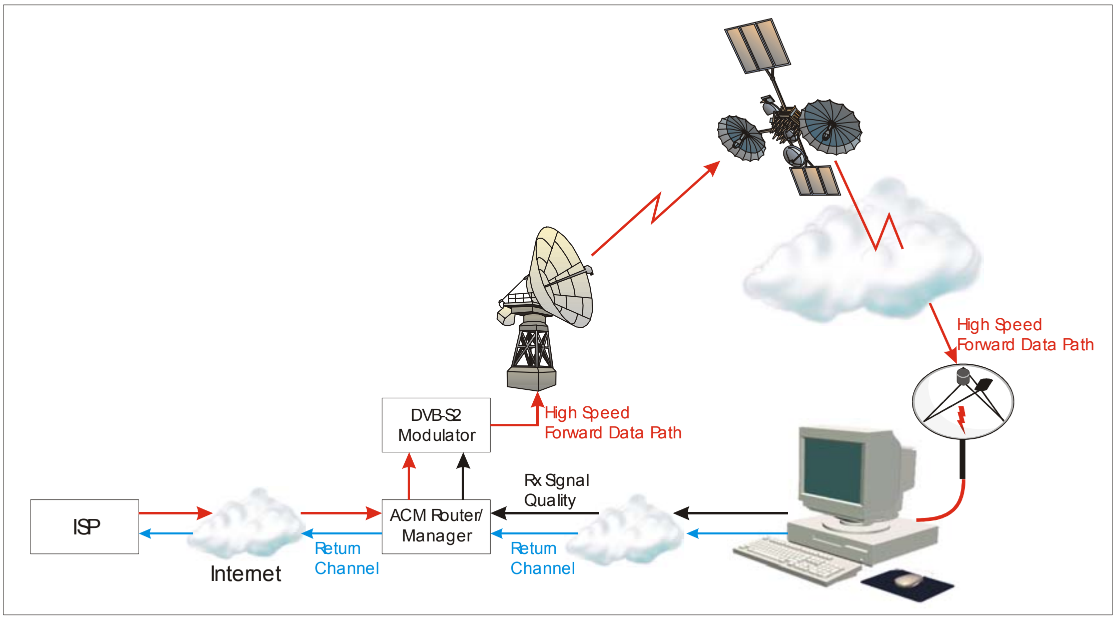


*Figure 11: An ACM System*

This mode is great for some applications but not so useful for others. ACM is extremely well suited to pure data applications such as direct to home Internet services. In these types of applications, achieving maximum data rate transfer is critical to the business model where a higher data rate transfer allows a higher number of users per MHz of bandwidth.

However this mode of operation is not very useful to traditional satellite TV broadcasters. It is highly likely that during rain fade conditions the reduction in data rate required to keep the link operational will result in an unacceptably low bit rate allocated to each TV channel through to the eventual possibility of having to drop some channels from the multiplex. Not very desirable!

### 5.3.2 Variable Coding and Modulation – VCM

VCM can be considered to be a subset of the functionality provided in the ACM mode, described above. The VCM mode does not provide a feedback path from receiver to uplink site and does not allow for modulation or FEC changes on the fly as with ACM. VCM does however provide the ability for some modulated frames of data to be regularly transmitted with a different FEC or modulation format. As with the ACM mode it is possible to detect the FEC and modulation format from data descriptor headers in the transmitted data.

As with the ACM mode, its usage will probably be most applicable to pure data transmissions rather than TV broadcasts. The ability to transmit some data with a different FEC and hence different data rate will most likely find a home in providing a lower data rate signal to users on the edge of the satellite footprint as a type of threshold extension. The penalty however is that by using some data frames to send lower rate data to edge of beam users those frames are not being efficiently used for the majority of near-centre beam users of the service.

This mode gives some extra flexibility which may be of use in some applications where receive dish size may be limited. The exact value of this mode will depend on individual business models.

# 6 Input Data Interfaces

DVB-S2 is not just restricted to MPEG Transport streams. DVB-ASI still sits happily within the new specification but the input data possibilities have been widened to allow generic non-packetised data streams to be accepted as well. This opens the way for IP-based data interfaces into the modulator such as Gigabit Ethernet connections, again reinforcing the improved ability of DVB-S2 to deal with pure data transmissions.

The backward compatible mode described earlier enables the transmission of high priority and low priority data simultaneously. The DVB-S2 specification defines that this be achieved by the use of two separate transport stream inputs, which are then combined within the modulator and processed into one hierarchical stream.

# 7 Benefits of DVB-S2

It can be seen from the information included in this document that DVB-S2 has some large benefits compared to what is achievable with the current DVB-S and DSNG standards. The commercial appeal of achieving up to 30% higher throughput can be enormous and for those happy with their current throughput the ability to improve one's downlink margin is almost always welcome.

DVB-S2 has been devised with real-world implementations in mind and so with the introduction of pilot tones to aid carrier recovery and modulation formats designed to withstand linear and non-linear degradations of the satellite transponder, an 8PSK or 16APSK DVB-S2 satellite link should be trouble-free to commission and install.