ROHDE&SCHWARZ
BROADCASTING DIVISION

# Digital TV
# Rigs and Recipes
# Part 3
# DVB-S

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**Contents**

## 3 Introduction

For optimal transmission, data not only has to be coded to MPEG2 (Motion Picture Experts Group), which reduces the data rate of the ITU-R BT.601 interface from 270 Mbit/s to typically 3 Mbit/s to 5 Mbit/s, but also subjected to a special type of modulation (see "Digital TV Rigs and Recipes" – Part 1 "ITU-R BT.601/656 and MPEG2"). A comparison of analog modulation with the modulation used in digital video broadcasting (DVB) reveals that DVB modulation yields a flat spectrum with a constant average power density across the channel bandwidth.

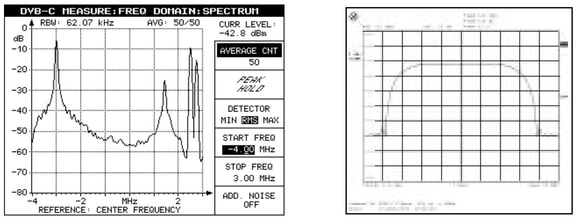



Fig. 3.1 Comparison of B/G PAL spectrum and DVB-S spectrum

This modulation mode results in optimal utilization of the transmission channel in all DVB modes, i.e. DVB-C (cable), DVB-S (satellite) and DVB-T (terrestrial). In this chapter, the special characteristics of DVB-S will be discussed.

### 3.1 DVB-S Modulation (Satellite)

to EN 300 421

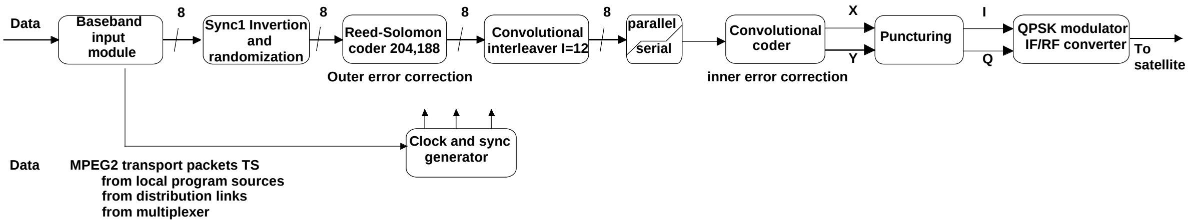



Fig. 3.2 Block diagram of DVB-S modulator/converter

#### 3.1.1 Baseband Input Module

The MPEG2 transport stream (TS) packets are routed to the "DVB room" of the "digital TV house" via one of the following interfaces (see also "Digital TV Rigs and Recipes" – Part 1 "ITU-R BT.601/656 and MPEG2", "Introduction"):

SPI (synchronous parallel interface)
ASI (asynchronous serial interface)
SSI (synchronous serial interface)
SDTI (serial digital transport interface)
HDB3 (high density bipolar of order 3)
ATM (asynchronous transfer mode)

The baseband input module reconstructs the original TS data, optimizes return loss, and corrects amplitude and phase response versus frequency. It supplies all the required information to the clock and sync generator block, which acts as a central clock generator for all blocks of the DVB modulator. Information includes, for example, the data rate, which is derived from the incoming TS data, and in the case of the SPI interface, also sync byte signalling for the TS packet and data valid signalling via the data valid line. The reconstructed TS packets are taken from the baseband input module to the next block, i.e. sync word inversion and randomization.

#### 3.1.2 Sync Word Inversion and Randomization for Energy Dispersal

After the input module, the TS packets undergo the first processing step: sync word inversion and randomization for energy dispersal.
Data randomization – or rather scrambling – ensures a constant average output level of the modulator signal.

The PRBS polynomial $1 + x^{14} + x^{15}$ disperses the data, but not the sync words (0x47), of the TS packets (for TS packet structure refer to "Digital TV Rigs and Recipes" – Part 1 "ITU-R BT.601/656 and MPEG2", section 1.8 "Transport Stream (TS)"). The polynomial has a length of 1503 bytes. This exactly corresponds to eight TS packets minus the bitwise inverted sync word of the first TS packet, whose value is now 0xB8. The 15-bit PRBS register is loaded with the sequence 100101010000000 after each 8-packet cycle. The inverted sync word marks the beginning of the randomized sequence.

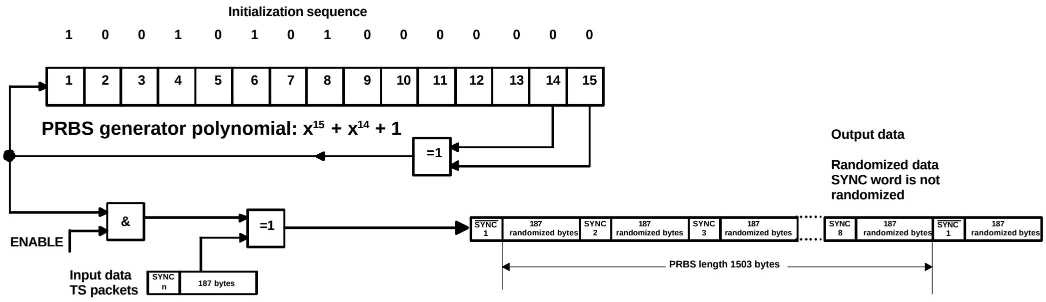



Fig. 3.3 Sync 1 inversion and randomization

This TS processing step is identical for the three DVB systems, cf Part 2 "DVB-C" and Part 4 "DVB-T".

Sync word inversion and randomization

| | |
|---|---|
| PRBS polynomial | $x^{15} + x^{14} + 1$ |
| Initialization of PRBS register | 100101010000000 |
| Length of polynomial | 1503 bytes |
| Length of randomized sequence | 1503 bytes + inverted sync byte = 8 TS packets |
| Sync word | 0x47 |
| Bitwise inverted sync word | 0xB8 |

Table 3.1

### 3.1.3 Reed-Solomon (RS) Forward Error Correction (FEC)

Following randomization, 16 error control bytes are appended to the TS packets, which are thus enlarged to 204 bytes.

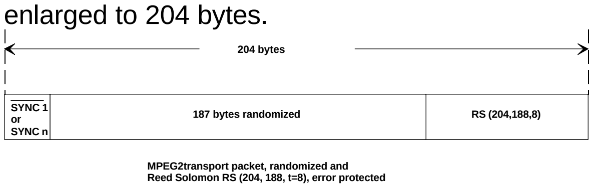



Fig. 3.4 204, 188, t = 8 Reed-Solomon error control coding

Using Reed-Solomon (204, 188, t = 8) error control coding, up to eight errored bytes per TS packet can be corrected in the receiver/decoder. Moreover, a bit-error ratio (BER) of $2*10^{-4}$ can be corrected to obtain a quasi-error-free (QEF) data stream with residual BER of $<1*10^{-11}$.

*Note:*
*The BER of $2*10^{-4}$ is used as a reference in all quality measurements in digital TV (DTV).*

This TS processing step, too, is identical for the three DVB systems, cf Part 2 "DVB-C" and Part 4 "DVB-T".

RS FEC

| | |
|---|---|
| TS packet length | 188 + 16 = 204 bytes |
| Correction | Up to 8 errored bytes per TS packet |
| Corrective capacity | BER of $2*10^{-4}$ to $1*10^{-11}$ |

Table 3.2 Reed-Solomon forward error correction

### 3.1.4 Convolutional Interleaver

Transmission errors usually corrupt not only a single bit but many bits following it in the data stream. Consequently the designation error burst, which may comprise up to several hundred bits. The bits may even be deleted. The Reed-Solomon correction capacity of eight bytes per TS packet is insufficient in such cases. So an interleaver is used to insert at least 12 bytes (the convolutional interleaver has 12 branches, see Fig. 3.5) and at most 2244 bytes from other TS packets between neighbouring bytes of a TS packet. This allows burst errors of max. 12 x 8 = 96 bytes to be corrected if only eight or fewer errored bytes per TS packet occur after the deinterleaver in the receiver/decoder.

Interleaver

| | |
|---|---|
| Branches | I = 12 |
| Memory depth of FIFOs | M = 17 ( = 204 / I) bytes |
| Sync bytes | Always routed in branch 0 |

Table 3.3

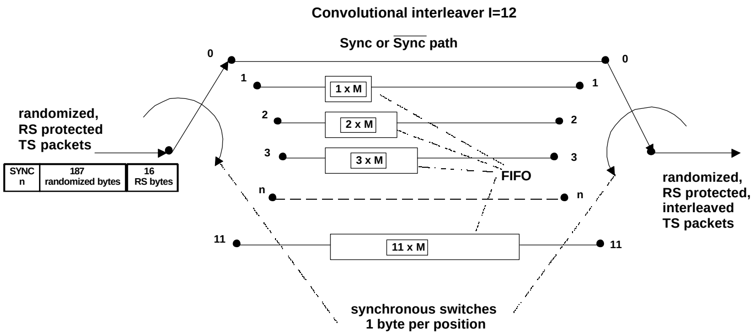



Fig. 3.5 Convolutional interleaver

This TS processing step, too, is identical for the three DVB systems, cf Part 2 "DVB-C" and Part 4 "DVB-T".

After the convolutional interleaver, TS processing is different for the different DVB standards.

### 3.1.5 Convolutional Coder

In DVB-S, further error protection is added to the TS data by means of convolutional coding and (Viterbi) decoding. This additional forward error protection is necessary because DVB-S signals are subject to additional interference during transmission in the form of atmospheric disturbances. Unlike DVB-C transmission, which relies on a fixed cable network with constant conditions, DVB-S transmission quality may be seriously impaired, for example by rain clouds gathering or a thunderstorm coming up. Yet, DVB-S should provide a clearly better reception quality than analog satellite systems. This is achieved through the second FEC, which is implemented by means of the convolutional coder in the DVB-S modulator.
The convolutional coder has the following characteristics:

| | |
|---|---|
| Length (constraint length) | k = 7 |
| Generator polynomials | G1 = 171 OCT (X) and G2 = 133 OCT (Y) |

Table 3.4 Data of convolutional coder

The generator polynomials determine the outputs at the shift register with k = 7.

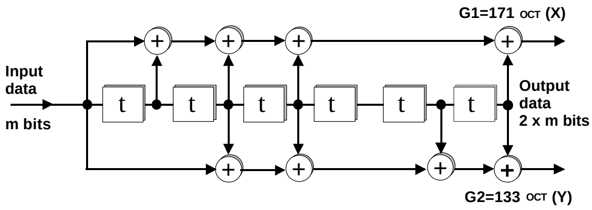



Fig. 3.6 Convolutional coder in DVB

From k bit input data, 2 x k bit output data is obtained, i.e. the useful data rate decreases by a factor of 2. To reduce this high redundancy at least in part, the output data is punctured, i.e. defined bits of the output data are deleted to reduce the output data rate.

### 3.1.6 Puncturing Scheme

The bit-serial data is doubled between the input and the output of the convolutional coder. The scheme shown below illustrates what bits of the X or Y output are deleted, how the remaining bits are sorted into two continuous data streams applied to the I and Q inputs of the DVB-S QPSK (quadrature phase shift keying) modulator, and the code rate P (also referred to as puncturing rate).

The Viterbi decoder of the DVB-S receiver can improve the BER based on the remaining redundancy. The code rate indicates the ratio of input data rate to output data rate. Possible values are given in Fig. 3.7. The combined use of Viterbi FEC and RS FEC permits an input BER of about $2 \ast 10^{-2}$ at the DVB-S receiver, depending on the code rate.

The Viterbi decoder corrects the bit error ratio to BER $\leq 2*10^{-4}$
and
the RS FEC to BER $\leq 1*10^{-11}$

*Note:*
*The BER of $2*10^{-4}$ before RS FEC is the reference value in all measurements of transmission quality.*

Up to this point, the processing steps for DVB-S and DVB-T are almost the same. Both use a convolutional coder. The difference is in the sorting of the punctured bits: with DVB-S the two outputs are directly applied to the I and Q inputs of the modulator, whereas the DVB-T coder has a bit-serial output.

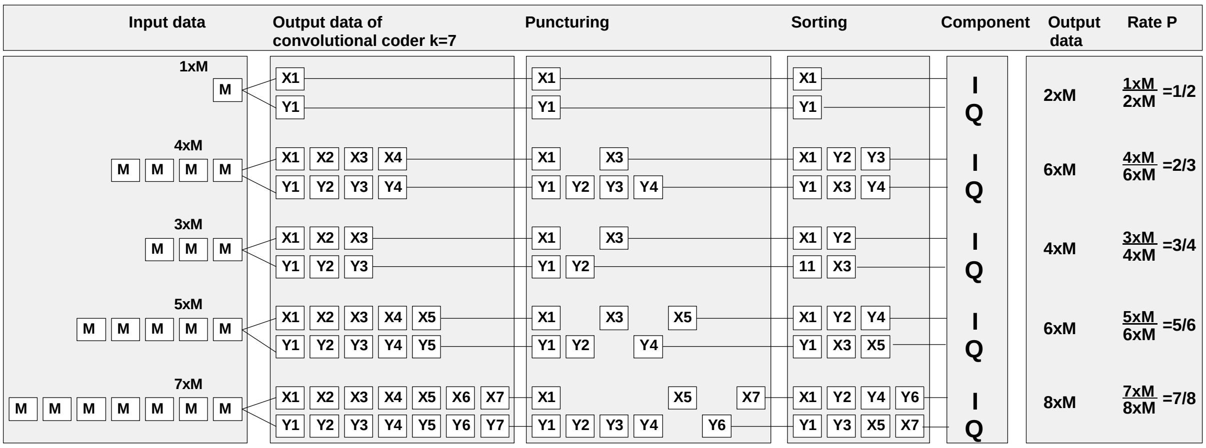



Fig. 3.7 DVB-S puncturing scheme

### 3.1.7 I and Q Components

Two bits – of the I and Q output data streams of the puncturing block – are mapped into a DVB-S symbol. This means that each symbol carries two bits of information. Gray coding is used to allocate the bits to the respective points of the constellation diagram. This is illustrated by the figure below:

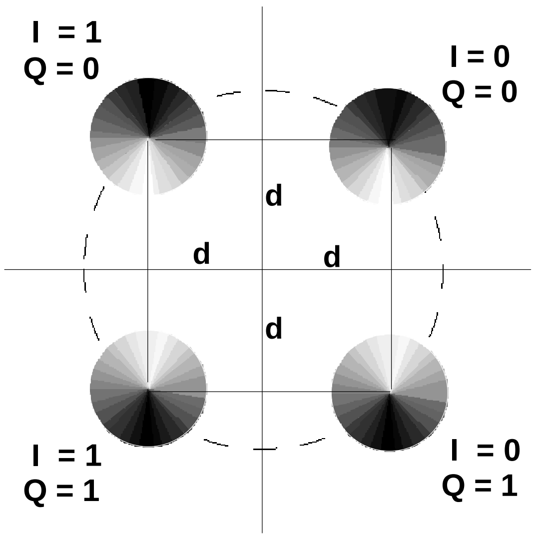



Fig. 3.8 QPSK constellation diagram

The symbols at the output of the DVB-S modulator are $\sqrt{\cos}$ roll-off filtered analog pulses with a spectrum approximating a sin (x)/x function and two amplitude levels each for the I and the Q component. The resulting signals, therefore, have a defined flat spectrum (see Fig. 3.1, right, and section 3.3 "QPSK Spectrum for DVB-S").

A symbol consists of a pair of I and Q values arranged orthogonally through modulation. "I" stands for the inphase and "Q" for the quadrature component.

## 3.2 DVB-S Signal Bandwidth

The symbols are $\sqrt{\cos}$ roll-off filtered analog pulses similar to a sin (x)/x function with a 3 dB bandwidth B in Hz corresponding to half the symbol rate S in symbols/s. The roll-off factor for DVB-S is r = 0.35. After double-sideband modula-tion, the signal bandwidth is obtained as the symbol rate in Hz.

The bit rate R in Mbit/s of the TS packets can be converted to the symbol rate of a QPSK system by the following equation:

$$S = R * \frac{204}{188} * \frac{1}{2} * \frac{1}{P} \ \mathbf{Msymb/s} \qquad \text{Equation 3.1}$$

The factor 204/188 takes into account Reed-Solomon error control coding; P takes into account the effect of puncturing.
In satellite transmission, the bit rate

$$R = 38.014706 \text{ Mbit/s}$$

is frequently used. This results in a Nyquist bandwidth $f_N$ of

$$f_N = S = 27.5 \text{ MHz}$$

for the QPSK symbols, applying the code rate of P = 3/4 commonly used in DVB-S.

The required bandwidth $B_T$ for the transponder channel is calculated from the symbol rate and the roll-off factor as follows:

$$B_T = S * (1 + r) \ \mathbf{MHz}$$

For a roll-off factor of 0.35, the following transponder bandwidth is obtained:

$$B_{transponder} = 27.5 * 1.35 = 37.125 \text{ MHz}$$

The new 1E generation of Astra satellites offers 36 MHz transponder bandwidth. This extends the 33 MHz bandwidth of Astra satellites 1A to 1D by 3 MHz, but still does not match the preferable DVB-S symbol rate of 27.5 Msymb/s. Investigations were, therefore, carried out with the aim of reducing the roll-off factor. It was found that a roll-off factor of 0.28 or 0.25 in the DVB-S modulator has hardly any impact on the demodulated signal in the DVB-S receiver. For this reason, a roll-off factor of 0.27 is mostly used today.

Applying a roll-off factor of 0.27, the following transponder bandwidth is obtained:

$$B_{transponder} = 27.5 * 1.27 = 34.925 \text{ MHz}$$
$$\text{i.e. } < 36 \text{ MHz}$$

For the 33 MHz transponders, lower symbol rates are defined. The maximum possible symbol rate in compliance with DVB-S specifications is:

$$S = 33 / 1.35 = 24.444 \text{ Msymb/s}$$

## 3.3 QPSK Spectrum for DVB-S

The European Standard EN 300 421 defines the tolerances of the DVB-S spectrum as follows:

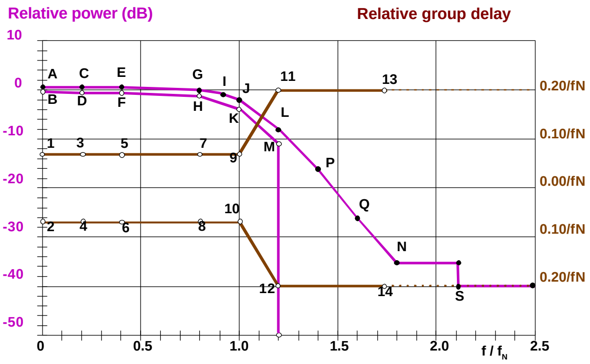



Fig. 3.9 DVB-S spectrum

Definition of points shown in Fig. 3.9

| Relative power, upper tolerance limit | | |
|---|---|---|
| Point | Frequency | Relative power (dB) |
| A | 0.0 $*f_N$ | +0.25 |
| C | 0.2 $*f_N$ | +0.25 |
| E | 0.4 $*f_N$ | +0.25 |
| G | 0.8 $*f_N$ | +0.15 |
| I | 0.9 $*f_N$ | -0.50 |
| J | 1.0 $*f_N$ | -2.00 |
| L | 1.2 $*f_N$ | -8.00 |
| P | 1.4$*f_N$ | -16.00 |
| Q | 1.6 $*f_N$ | -24.00 |
| N | 1.8 $*f_N$ | -35.00 |
| S | 2.12 $*f_N$ | -40.00 |
| Relative power, lower tolerance limit | | |
| B | 0.0 $*f_N$ | -0.25 |
| D | 0.2 $*f_N$ | -0.40 |
| F | 0.4 $*f_N$ | -0.40 |
| H | 0.8 $*f_N$ | -1.10 |
| K | 1.0 $*f_N$ | -4.00 |
| M | 1.2 $*f_N$ | -11.00 |

| Relative group delay *), upper tolerance limit | | |
|---|---|---|
| Point | Frequency | Relative group delay |
| 1 | 0.0 $*f_N$ | +0.07 / $f_N$ |
| 3 | 0.2 $*f_N$ | +0.07 / $f_N$ |
| 5 | 0.4 $*f_N$ | +0.07 / $f_N$ |
| 7 | 0.8 $*f_N$ | +0.07 / $f_N$ |
| 9 | 0.9 $*f_N$ | +0.07 / $f_N$ |
| 11 | 1.0 $*f_N$ | +0.07 / $f_N$ |
| 13 | 1.2 $*f_N$ | +0.2 / $f_N$ |
| Relative group delay *), lower tolerance limit | | |
| 2 | 0.0 $*f_N$ | -0.07 / $f_N$ |
| 4 | 0.2 $*f_N$ | -0.07 / $f_N$ |
| 6 | 0.4 $*f_N$ | -0.07 / $f_N$ |
| 8 | 0.8 $*f_N$ | -0.07 / $f_N$ |
| 10 | 0.9 $*f_N$ | -0.07 / $f_N$ |
| 12 | 1.0 $*f_N$ | -0.07 / $f_N$ |
| 14 | 1.2 $*f_N$ | -0.2 / $f_N$ |

*) The numerical values are expressed as (group delay $* f_N$), i.e. for a "normal" satellite channel with 27.5 Msymb/s the group delay of $\tau \leq 5.1$ ns is defined up to the Nyquist frequency.

Table 3.5 DVB-S spectrum

## 3.4 $\sqrt{\cos}$ Filtering

The symbols shaped by $\sqrt{\cos}$ filters in the transmitter and the receiver yield a spectrum similar to a sin (x)/x function with a constant amplitude- and group-delay frequency response.

$\sqrt{\cos}$ filtering in the transmitter and the receiver, therefore, produces spectrum edges as shown in Fig. 3.11 "Spectrum obtained by cos roll-off filtering". The degree of approximation to an ideal sin (x)/x spectrum depends on the selected roll-off factor. The smaller this factor, the better the approximation to an ideal sin (x)/x spectrum.

Plotting the level along a linear scale, the following theoretical spectrum is obtained at the output of the DVB-S modulator:

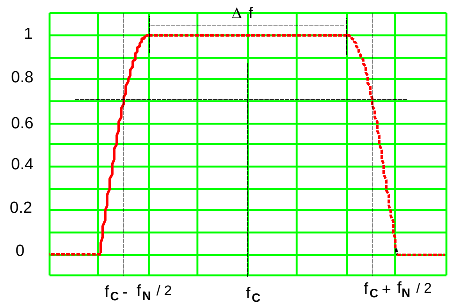



Fig. 3.10 Spectrum obtained by $\sqrt{\cos}$ filtering

Clearly discernible are the steep edges at low levels at the left and right boundaries of the spectrum produced by $\sqrt{\cos}$ filtering. Attenuation at the Nyquist frequencies of $f_C \pm f_N/2$ is 3 dB. The roll-off factor r is the ratio of the Nyquist bandwidth to the flat "rooftop" of the spectrum.

$$r = \frac{f_N}{\Delta f} - 1$$

$\sqrt{\cos}$ filtering in the transmitter and the receiver yields the cos roll-off edges:

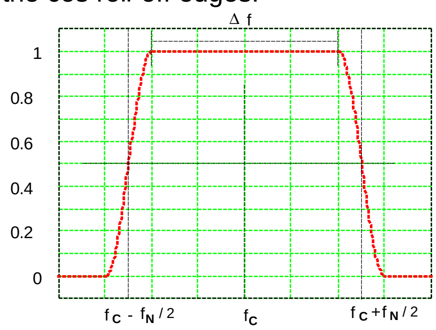



Fig. 3.11 Spectrum obtained by cos roll-off filtering

It can be seen that after cos filtering the edges at low levels at the left and right boundaries of the spectrum are flatter and rounder. Attenuation at the Nyquist frequencies of $f_C \pm f_N/2$ is now 6 dB.

To illustrate this, Fig. 3.12 shows the $\sqrt{\cos}$ and cos filter edges in greater detail:

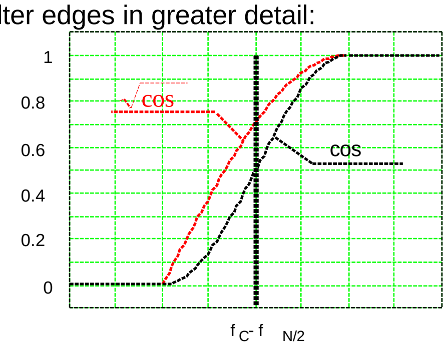



Fig. 3.12 Edges obtained with $\sqrt{\cos}$ roll-off and cos roll-off filtering

The combined filtering in the transmitter and the receiver serves two purposes:

1. optimal approximation to an ideal sin (x)/x spectrum and thus a flat useful spectrum;
2. signal filtering in the receiver and thus useful channel selection.

## 3.5 DVB-S Key Data

| | | |
|---|---|---|
| Modulation | | QPSK |
| Symbol form | | similar to sin (x)/x, $\sqrt{\cos}$ roll-off filtered |
| Roll-off factor | | 0.35 (0.28, 0.25) |
| Most frequently used bit rate R | Mbit/s | 38.014706 |
| Symbol rate S | Msymb/s | $S = R * \frac{204}{188} * \frac{1}{2} * \frac{1}{P}$ |
| Most frequently used symbol rates S | Msymb/s | 27.5 (at 36 MHz bandwidth)<br>24.44 (at 33 MHz bandwidth) |

Table 3.6

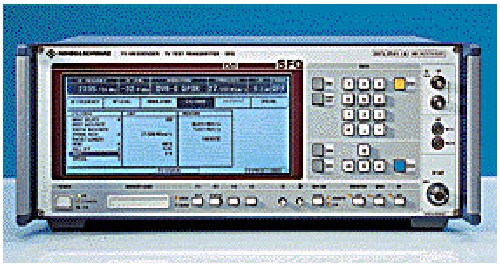
### 3.6 Measurements in DVB-S Systems

An MPEG2 multiplexer or MPEG2 generator supplies video, audio and other data in the form of TS (transport stream) packets with a defined data rate R.

TV Test Transmitter SFQ modulates this data as required for the following standards:
DVB-C (digital video broadcasting – cable),
DVB-S (digital video broadcasting – satellite),
DVB-T (digital video broadcasting – terrestrial),
ATSC with 8VSB (advanced television systems committee with eight-level trellis-coded vestigial sideband)
and the American cable standard
ITU-T Rec. J.83/B.

TV Test Transmitter SFL was designed specially for applications in production. It comes in five models tailored to the above standards:
SFL-C for DVB-C (EN 300 429)
SFL-S for DVB-S (EN 300 421, EN 301 210)
SFL-T for DVB-T (EN 300 744)
SFL-V for ATSC/8VSB
SFL-J for ITU-T Rec. J.83/B

To optimally adapt to the TS signal parameters, TV Test Transmitters SFQ and SFL measure the data rate of the input transport stream and convert it to the current symbol rate as appropriate for the modulation mode used, or the data rate is calculated from a predefined symbol rate. Then the data is modulated in compliance with the DTV (digital television) standard in question and transposed to the RF.
For measurements to the DTV standards, SFQ and SFL modulate the TS data stream strictly in accordance with DTV specifications. Apart from this, defined modulation errors can be introduced into the ideal signal, so creating reproducible signal degradation. Such stress signals are indispensable in DTV receiver tests to determine system limits.



TV Test Transmitter SFQ

Condensed data of SFQ

| | |
|---|---|
| Frequency range | 0.3 MHz to 3.3 GHz |
| Level range | -99.9 dBm to +4 dBm |
| MPEG2 inputs | ASI<br>SPI<br>TS PARALLEL |
| Error simulation | |
| I/Q amplitude imbalance | ±25 % |
| I/Q phase error | ±10 ° |
| Residual carrier | 0 % to 50 % |
| Special functions | scrambler, Reed-Solomon, all interleavers can be switched off |
| DVB-C | |
| Modulation | 16QAM, 32QAM, 64QAM, 128QAM, 256QAM |
| DVB-S | |
| Modulation | QPSK |
| Code rate | 1/2, 2/3, 3/4, 5/6, 7/8 |
| DVB-T | |
| Modulation | QPSK,16QAM, 64QAM<br>non-hierarchical, hierarchical |
| FFT mode | 8k and 2k |
| Bandwidth | 6 MHz, 7 MHz, 8 MHz |
| Puncturing | 1/2, 2/3, 3/4, 5/6, 7/8 |
| ATSC | |
| Modulation | 8VSB |
| Bandwidth | 6 MHz |
| Data rate | 19.392658 Mbit/s ±10 % |
| Symbol rate | 10.762 Msymbol/s ±10 % |
| Internal test signals | null TS packets,<br>null PRBS packets<br>PRBS ($2^{23}$ - 1 and $2^{15}$ - 1) |
| Options | fading simulator,<br>noise generator,<br>input interface,<br>BER measurement,<br>turbocoding |

Condensed data of SFL-S

| | |
|---|---|
| Frequency range | 0.3 MHz to 3.3 GHz |
| Level range | -140 dBm to 0 dBm |
| MPEG2 inputs | ASI<br>SPI<br>TS PARALLEL |
| Error simulation | |
| I/Q amplitude imbalance | ±25 % |
| I/Q quadrature offset (phase offset) | ±10 ° |
| Residual carrier | 0 % to 50 % |
| Special functions | scrambler, Reed-Solomon, all interleavers can be switched off |
| Modulation | QPSK, 8PSK, 16QAM |
| Internal test signals | null TS packets,<br>null PRBS packets<br>PRBS ($2^{23}$ -1 and $2^{15}$ -1) |
| Options (on request) | noise generator (SFL-N),<br>turbocoding |


TV Test Transmitter SFL-S

### 3.6.1 Important Requirements To Be Met By DVB-S Test Transmitter

This section deals in particular with the requirements to be met by TV Test Transmitter SFQ in DVB-S measurements. The statements made below also apply to TV Test Transmitter SFL-S.

Test transmitters are needed to simulate potential errors in the DTV modulator and distortions in the transmission channel. From the two types of signal degradation it is determined to what extent a receiver still operates correctly when non-standard-conforming signals are applied. For tests on a DVB-S set-top box (STB), for example, the test transmitter should be capable of producing defined deviations from the standard in addition to the common parameter variations of, for example, Tx frequency or output level.

STBs have to undergo function tests in at least three frequency ranges:

- in the lowest RF channel,
- in a middle RF channel, and
- in the highest RF channel.

TV Test Transmitter SFQ is capable of setting any frequency between 0.3 MHz and 3.3 GHz, thus offering a frequency range by far exceeding the range presently defined for DVB-S. Frequencies of interest can also be stored in the form of a channel table.

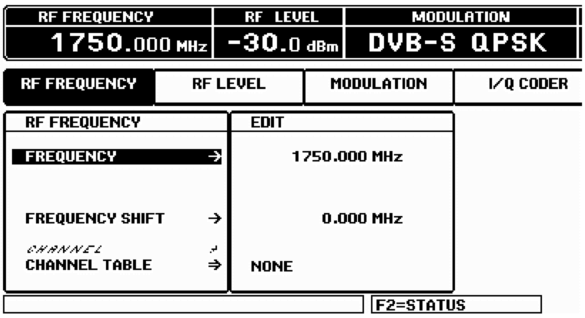



Fig. 3.13 Frequency setting on SFQ

Another test is for verifying error-free reception at a minimum level of typically -70 dBm. SFQ features a setting range between +6 dBm and -99 dBm, which in any case includes the required minimum level.

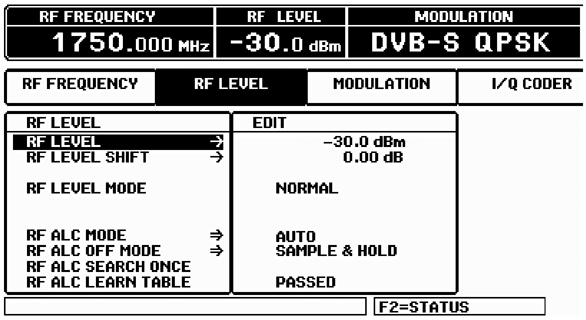



Fig. 3.14 Level setting on SFQ

In the DVB-S modulation mode, modulator- and transmission-specific settings can be made, including noise superposition and the generation of fading profiles. SFQ is thus capable of simulating all signal variations and degradations occurring in a real DVB-S system. The degraded signal generated by the "stress transmitter" SFQ is used for testing the STB's susceptibility to errors and interference.

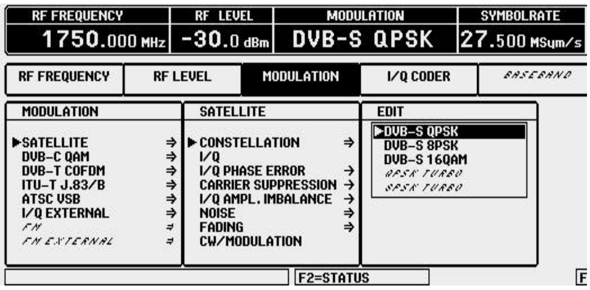



Fig. 3.15 Setting of modulator- and transmission-specific parameters in DVB-S mode

Detailed information on the above parameters will be found in section 3.6.3 "Error Sources in DVB-S".
Further important settings for the DVB-S system can be made in the "I/Q CODER" menu. Here the TS (transport stream) parameters for the modulator can be selected.

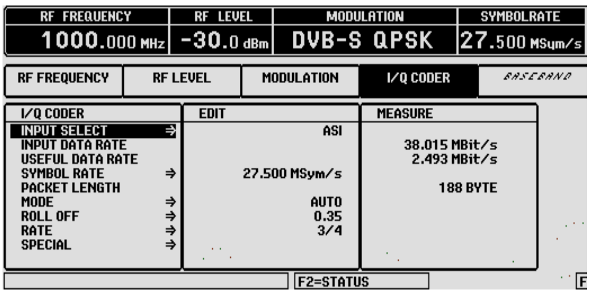



Fig. 3.16 DVB-S settings in I/Q CODER menu

### 3.6.2 Power Measurement

Measurement of the output power of a DVB transmitter is not as simple as that of an analog transmitter. In the analog world, the actual power of the sync pulse floor is measured at a sufficiently large bandwidth and displayed as the actual sync pulse peak power. A DVB signal, by contrast, is characterized by a constant power density across the Nyquist bandwidth (see Fig. 3.17), which results from energy dispersal and symbol shaping in the DVB modulator. Consequently, only the total power in a DVB channel is measured.

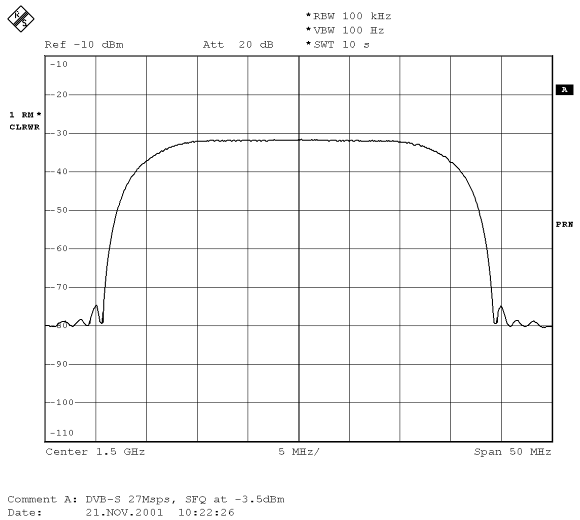



Fig. 3.17 Constant power density in a DTV channel (the $\sqrt{\cos}$ roll-off filter edges are clearly discernible)

The measurement bandwidths (resolution bandwidths - RBWs) of a spectrum analyzer are very small compared to the Nyquist bandwidth of a DVB-S signal. Information about the channel power can be gained by converting the measurement bandwidth to the signal bandwidth, taking into account the analyzer-specific correction factor. This method is, however, complicated and involves a considerable degree of inaccuracy.

Two more precise methods of measuring DVB-S signal power are known to date:

#### 3.6.2.1 Mean Power Measurement with Power Meter NRVS and Thermal Power Sensor

Condensed data of Power Meter NRVS with Thermal Power Sensor NRV-Z51

| | |
|---|---|
| **NRVS** | |
| Frequency range | DC to 40 GHz |
| Level range | 100 pW to 30 W (depending on sensor) |
| Readout | |
| Absolute | W, dBm, V, dBmV |
| Relative | dB, % W or % V, referred to a stored reference value |
| Remote control | IEC 625-2/IEEE 488.2 interface |
| Max. input voltage | 50 V |
| **NRV-Z51** | |
| Power sensor | thermal |
| Impedance | 50 O |
| Connector | N type |
| Frequency range | DC to 18 GHz |
| Level range | 1 µW to 100 mW |

Thermal power sensors supply the most accurate results if there is only one DVB channel in the overall spectrum.
Plus, they can easily be calibrated by performing a highly accurate DC voltage measurement, provided the sensor is capable of DC measurement. To measure the DVB power, however, the DVB signal should be absolutely DC-free.

#### 3.6.2.2 Mean Power Measurement with Spectrum Analyzer FSEx, FSP or FSU

If a conventional spectrum analyzer is used to measure power, its maximum measurement bandwidth will not be sufficient for a satellite channel. State-of-the-art spectrum analyzers, by contrast, allow broadband power measurements between two user-selected frequencies. The large Nyquist bandwidth of DVB transmission channels poses therefore no problems. Moreover, all kinds of amplitude frequency response that may occur in a satellite channel are taken into account, whether these are just departures from flat or caused by echoes. Based on this principle, the Rohde & Schwarz Spectrum Analyzers FSEx, FSP and FSU measure mean power in a DVB channel with an accuracy of ≤ 1.5 dB.

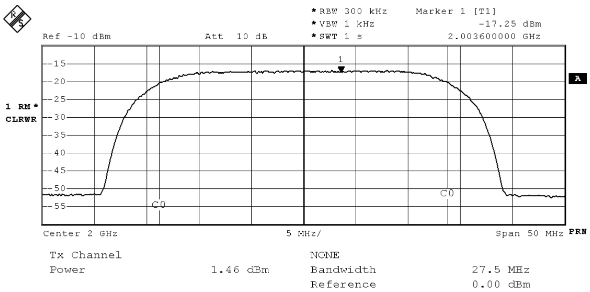



Fig. 3.18 a Power measurement with frequency cursors, Nyquist channel power (BW = 27.5 MHz)

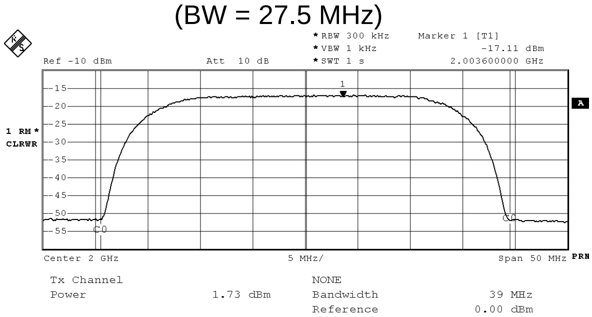



Fig. 3.18 b Power measurement with frequency cursors, total channel power (BW = 39 MHz)

A frequency cursor (C0) is placed on the lower and another one on the upper frequency of the DVB-S channel. The spectrum analyzer calculates the power for the band between the cursors. The method provides sufficient accuracy as long as the transponder channels are sufficiently spaced from each other in frequency and thus clearly separated. Given the normal DVB-S transponder assignment, i.e. without guard channels, results may be falsified however.

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## SPECTRUM ANALYZER FSP

Condensed data of FSP

| | |
|---|---|
| Frequency range (FSP3/7/13/30) | 9 kHz to 3/7/13/30 GHz |
| Amplitude measurement range<br>Amplitude display range | -140 dBm to +30 dBm<br>10 dB to 200 dB<br>in steps of 10 dB, linear |
| Amplitude measurement error | <0.5 dB up to 3 GHz,<br><2.0 dB from 3 GHz to 13 GHz,<br><2.5 dB from 13 GHz to 20 GHz |
| Resolution bandwidth | 1 Hz to 30 kHz (FFT filters),<br>10 Hz to 10 MHz in 1, 3 sequence<br>EMI bandwidths:<br>200 Hz, 9 kHz, 120 kHz |
| Detectors | Max Peak, Min Peak<br>Auto Peak, Quasi Peak,<br>Sample, Average, RMS |
| Display | 21 cm (8.4") TFT LC colour display,<br>VGA resolution |
| Remote control | IEC 625-2/IEEE 488.2<br>(SCPI 1997.0) or RS232C |
| Dimensions (W x H x D)<br>Weight (FSP3/7/13/30) | 412 mm x 197 mm x 417 mm<br>10.5/11.3/12/12 kg |

## SPECTRUM ANALYZER FSEx

Condensed data of FSEA/FSEB

| | |
|---|---|
| Frequency range<br>Amplitude measurement range<br>Amplitude display range | 20 Hz/9 kHz to 3.5/7 GHz<br>-155/-145 dBm to +30 dBm<br>10 dB to 200 dB<br>in steps of 10 dB |
| Amplitude measurement error | <1 dB up to 1 GHz,<br><1.5 dB above 1 GHz |
| Resolution bandwidth | 1 Hz/10 Hz to 10 MHz<br>in 1, 2, 3, 5 sequence |
| Calibration<br>Display | amplitude, bandwidth<br>24 cm (9.5") TFT LC colour or monochrome display, VGA resolution |
| Remote control | IEC 625-2/IEEE 488.2<br>(SCPI 1997.0) or RS232C |