TV Test Transmitter R&S SFQ

New coder for DVB-S/-DSNG and DVB-C standards

With a new coder, the TV Test Transmitter R&S SFQ (FIG 1) now supports the satellite standard DVB-S/-DSNG (digital satellite news gathering), which meets the growing demand for more transmission capacity. The coder also matches the DVB-S and DVB-C standards. It stands for a considerably extended symbol rate range and enhanced quality. The future-proofness of the universal R&S SFQ modulation platform and the versatile capabilities of the new coder are not at least due to high-efficiency Turbo coding.

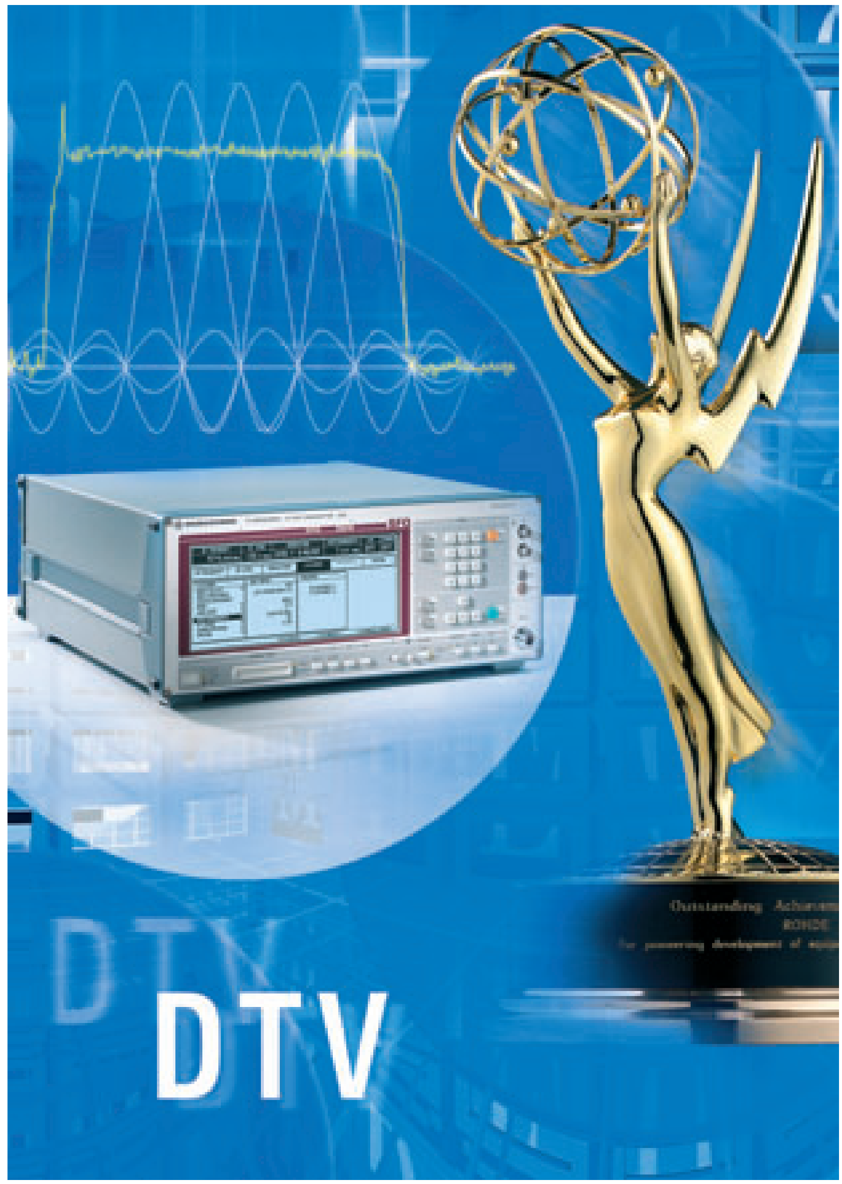

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FIG 1 The National Academy of Television Arts and Sciences awarded Rohde&Schwarz an EMMY for the TV Test Transmitter R&S SFQ. The signal source was commended for its unique capabilities and contribution to the further development of digital television.

R&S SFQ offers all major standards

Satellite transmission to DVB

The R&S SFQ supports satellite transmission to DVB-S (EN 300 421) and DVB-DSNG (EN 301 210) standards. All code rates are user-selectable. The digital modulation formats QPSK, 8PSK and 16QAM can be chosen. QPSK corresponds to the DVB-S format.

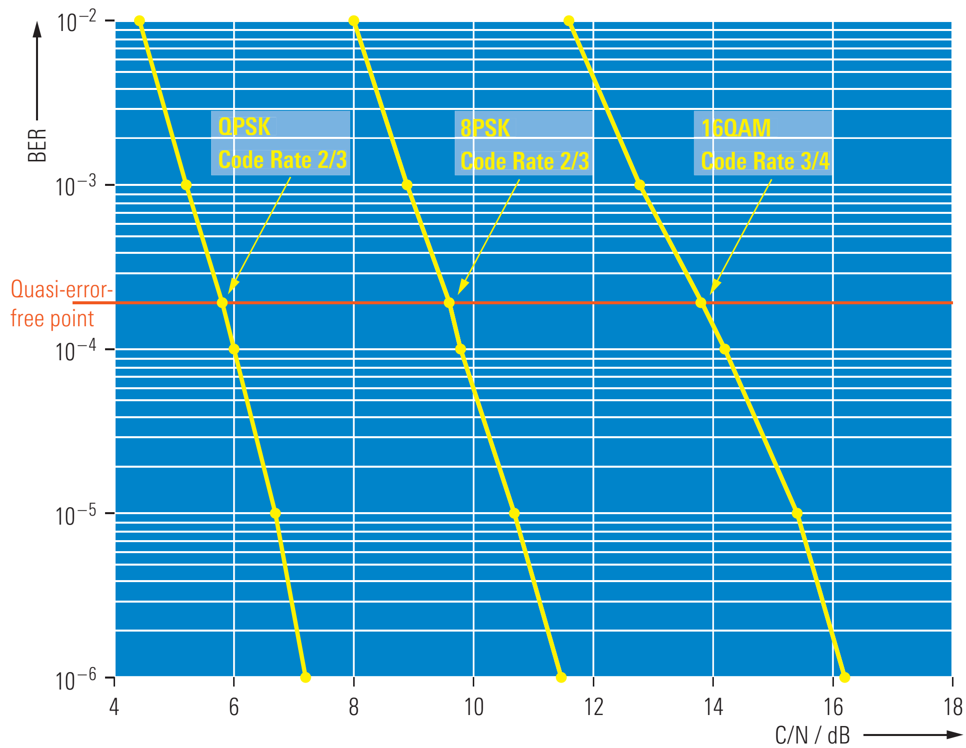


FIG 2 BER versus C/N ratio in DVB-S and DVB-DSNG (rate 27.5 Msymb/s)

Enormous range of symbol rates

When it comes to DVB-S, the new coder bursts the previous bounds. All symbol rates between 0.1 and 80 Msymb/s can be set without any restrictions to the input data rate, so all transponder bandwidths can be covered. In tuner production, this will allow testing and specifying components to well beyond the required operating range.

DVB cable transmissions

Like the previous coder, the new coder is in line with the DVB-C standard (EN 300 429). 16 / 32 / 64 / 128 and 256QAM modulation can be selected. And like the satellite standard, the range of symbol rates was extended at both ends to produce 0.1 through 8 Msymb/s.

Satellite transmission with Turbo coding

What makes Turbo coding/decoding attractive is the fact that the bit error rate (BER) versus C/N ratio comes very close to the Shannon limit (coding gain, FIG 2) [1]. Given a stable transponder bandwidth, the gain produced by Turbo coding can be used for a higher net data rate, or the same net data rate can be transmitted with smaller parabolic antennas or lower output power.

Turbo methods for digital TV broadcasting are not yet finally specified and fully standardized. But by advance implementation of a proprietary Turbo method (France Telecom / ST Microelectronics), Rohde & Schwarz was able to prove that the R&S SFQ with its programmable logic ICs (FPGAs) can be rapidly adapted to market requirements.

Turbo coding – close to Shannon channel capacity

The use of Turbo codes allows what is currently the most powerful decoding method, also known as iterative decoding. Turbo codes result in a gain that increases transmission capacity to within a few tenths of a decibel of the channel capacity defined by Shannon. This method is based on two key innovations: parallel recursive convolutional coding and iterative decoding.

Principle of Turbo coding

Parallel recursive convolutional coders consist of two or more feedback encoders for block or convolutional codes (FIG 3). The top branch transmits the uncoded information and forms the systematic path x. An information block is fed to the first encoder C1 and coded (output y1). The original data block is written to an interleaver, whose output is the input for the second encoder C2 with output y2.

The right interleaver algorithm plays a big part in overall code performance. Pseudo-random block interleavers are used here, i.e. the information is writ-

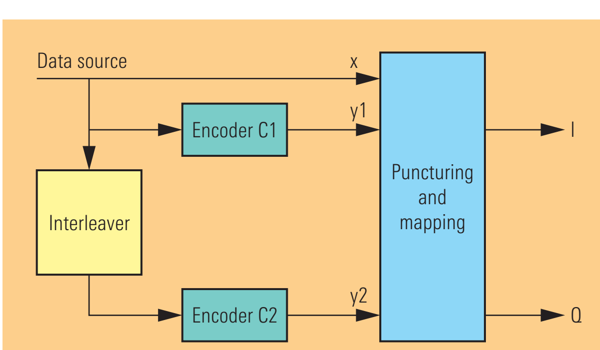


FIG 3
Structure of Turbo coder

Possible scenario for introducing Turbo code in digital television

Both the use of high-order modulation (8PSK, 16QAM) and Turbo coding create a major problem for satellite operators, because the new methods are not compatible with household set-top boxes. Necessary re-investment would considerably hinder acceptance of the new system.

So a procedure permitting gradual conversion to the new system would be desirable. With the backward-compatible mode [2] a solution is in view. Here the transport stream to be transmitted is split into a high-priority component (compatible with DVB-S) and a (non-compatible) low-priority component (FIG 5). The high-priority branch performs DVB-S channel coding, the non-compatible component is Turbo-coded.

The 2-bit output symbols from the DVB-S branch (QPSK) are combined with a 1-bit symbol from the Turbo branch in the mapper and then transmitted with 8PSK modulation.

The two constellation points of 8PSK modulation in the quadrant are now as close to each other as possible (FIG 4), so a conventional satellite receiver interprets them as a single point and

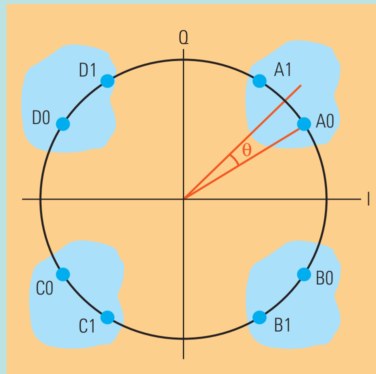


FIG 4 Constellation in backward-compatible mode [2]

therefore only decodes the high-priority branch. A modern set-top box is nevertheless able to demodulate 8PSK and produce the complete information. The latest set-top boxes can also decode entirely Turbo-coded 8PSK modulation. During a transitional period, the backward-compatible mode can be used. As soon as newer set-top boxes are being used by all viewers, a switchover can be made to pure 8PSK/Turbo coding and the full performance of the system utilized.

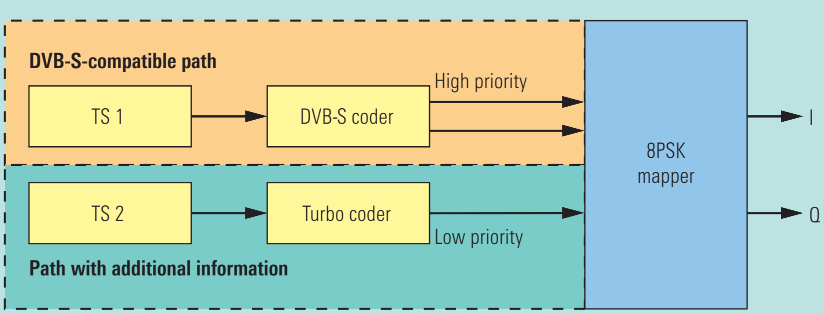


FIG 5 Backward-compatible mode

ten in line by line but read out in a quasi-random sequence. Separate decoding probabilities can thus be determined for each path by the decoders in the receiver.

The interleaver also ensures that the set of code words generated by the encoders is of favourable weight. That reduces the probability of the decoder determining incorrect code words.

The original data block in the systematic path x and the outputs from the encoders y1 and y2 are multiplexed, punctured and transmitted in the traffic channel.

Principle of Turbo decoding

Turbo decoding is an iterative method involving several soft-in-soft-out decoders. Part of the soft output is forwarded to the next decoding stage after each iteration step. Splitting the decoding into a number of iterative operations considerably increases the coding gain and at the same time reduces decoder complexity.

Flexible adaptation by options

The coder hardware only need be purchased once. Further transmission standards can subsequently be activated by buying a software option and entering an enable code, without opening the unit (FIG 6).

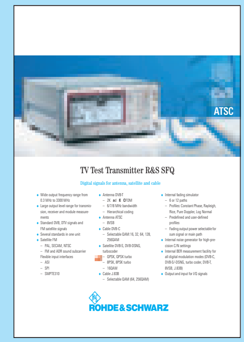
Option -B23 or -B24 must be installed first to operate the Satellite Turbo -B25 software option (enable code).

Günter Huber; Franz-Josef Zimmermann

Major innovations in the new coder for the R&S SFQ

- **Satellite modulation enhanced by 8PSK and 16QAM**
- **Expanded range of symbol rates**
  DVB-S: 0.1 to 80 Msymb/s
  DVB-C: 0.1 to 8 Msymb/s
- **Minimum setting time, i.e. fast settling**
  A VCO (voltage-controlled oscillator) is tuned with the aid of a DDS (direct digital synthesis) chip in a fast loop. Fine tuning is performed by controlling the fill state of the FIFO. This ensures fast settling of the module even in the case of considerable symbol rate variations. This is a decisive factor particularly in production, as fast switching operations shorten the time to test and thus reduce costs.
- **Linking of the symbol rate to the internal reference frequency**
  The symbol rate of internal signals is a function of the SFQ's internal reference frequency. The latter can also be coupled with an external reference frequency.
- **Optimized pulse filtering**
  More taps are available in the FIR (finite impulse response) filter for pulse filtering (root raised cosine rolloff) than in the coder previously used. Thus the rolloff could be better approximated and the shoulder attenuation improved at the same time. This eliminates effects of the transmit filter on the eye aperture, which can be quite noticeable when measuring the BER for 256QAM in the range 1×10^{-9} (ahead of the Reed-Solomon decoder).
- **Minimal symbol jitter**
  Thanks to the new oscillator concept, internal clock quality was substantially improved, which results in low phase jitter.

More information and data sheet at www.rohde-schwarz.com (search term: SFQ)



REFERENCES

[1] Berrou, C., Glavieux, A., Thitimajshima, P.: Near Shannon limit error-correcting coding and decoding: Turbo codes. Proc. IEEE International Conference on Communication (ICC), pp 1064–1070, Geneva, May 1993

[2] Morello, A., Mignone, V., Rai-CRIT: Backward compatible solutions for DVB-S2. DVB Technical Module, TM2638, February 2002

Option	Firmware	Hardware
R&S SFQ-B21	DVB-C	incl. coder hardware
R&S SFQ-B22	DVB-C	none
R&S SFQ-B23	DVB-S, DVB-DSNG	incl. coder hardware
R&S SFQ-B24	DVB-S, DVB-DSNG	none
R&S SFQ-B25	Satellite Turbo	none

FIG 6 Available options