DVB-T Modulator SDB-M

Start into digital terrestrial TV

Almost simultaneously with the adoption of the new terrestrial TV standard Rohde & Schwarz is introducing a matching digital modulation source: DVB-T Modulator SDB-M which is equally suitable for use with high-power TV transmitters and as a test transmitter in laboratories and production.

The high demands to be met by the terrestrial digital TV transmission standard DVB-T [1] are manifold: high program capacity is required in conjunction with excellent picture quality as well as transmission of data for supplementary services. Other requirements are highly reliable transmission even at low receiving field strengths and an excellent frequency management that leaves sufficient room for other radio services of the present and the future. All this is achieved by processing source-coded MPEG2 signals, adding a highly efficient error correction code, which takes into account the characteristics of the transmission channel, and the use of OFDM (orthogonal frequency division multiplexing) permitting single-frequency networks with widely spaced transmitters.

DVB-T Modulator SDB-M (FIG 1) was developed for use in high-power TV transmitters and as a test transmitter in the development and production of DVB-T components. Its distinguishing **characteristics and parameters** are:

- functions fully compatible with ETS 300 744 [2],
- LVDS (low voltage differential signalling) input interface with data rates from 5 to 40 Mbit/s depending on selected transmission parameters,
- code rates 1/2, 2/3, 3/4, 5/6 or 7/8 selectable,
- modulation modes QPSK, 16QAM or 64QAM selectable,
- optional hierarchical modulation,

FIG 1 DVB-T Modulator SDB-M and solid-state TV Transmitter NH520 – ideal partners for terrestrial digital TV Photo 42 961/1

- OFDM with 2k or 8k mode,
- guard intervals of 1/4, 1/8, 1/16 or 1/32 of symbol period selectable,
- digital I/Q modulation to prevent phase errors,
- 12-bit digital/analog converter with 27.43 MHz sampling frequency,
- analog IF output for driving high-power transmitters,
- optional upconverter with output frequency adjustable from 47 to 860 MHz and 0 dBm output level,
- SFN (single-frequency network) option for time and frequency synchronization in SFNs, including MIP (megaframe initialization packet [3]) decoder for optional automatic configuration of modulator via data input,
- integrated PRBS (pseudo random binary sequence) generator for BER (bit error rate) measurements,
- test mode permitting energy dispersal, Reed-Solomon coder, bit interleaver and frequency interleaver to be disabled individually,
- parallel interface with floating contacts for signalling or integration in interlock circuits,
- serial interface for configuration via standard PC using the convenient user interface supplied.

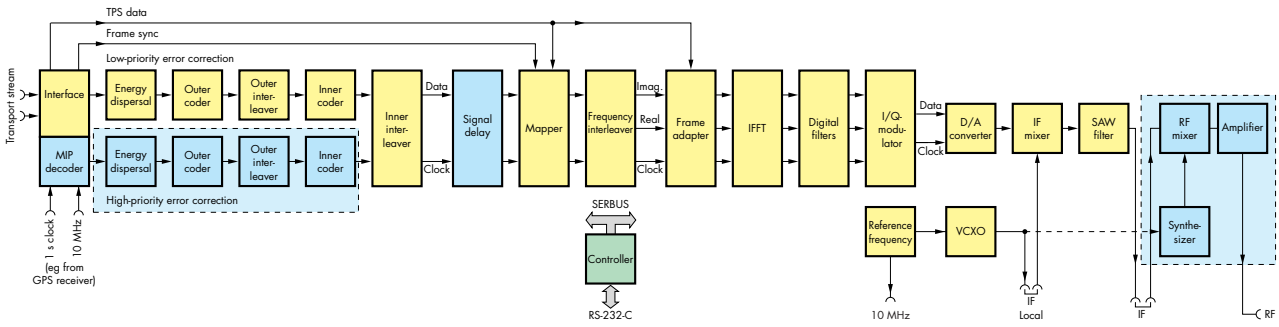

FIG 2 Block diagram of DVB-T Modulator SDB-M (options in blue)

Function

The MPEG2 data and control signals at the **LVDS input interface** are regenerated and the required clock frequencies derived for further processing (FIG 2). The transport packet may have a length of 188 or 204 bytes. An **optional MIP decoder** separates the data of the megaframe initialization packet and forwards them to the system controller for further processing.

For **energy dispersal** the data are linked to a PRBS sequence so that an even power distribution is obtained in the transmission channel. The **outer coder** uses a shortened Reed-Solomon code (204, 188, t = 8) which adds 16 bytes to each transport packet for error control, allowing up to eight errored bytes to be corrected in each transport packet. A convolutional interleaver distributes the data in the form of bytes to twelve blocks to improve correction of several successive errors. The **inner coder** operates bit by bit and generates a punctured convolutional code with code rates of 1/2, 2/3, 3/4, 5/6 or 7/8.

Two sets of the mentioned error correction blocks are available for **hierarchical coding** (option) allowing the different data (programs) of the MPEG2 transport stream to be transmitted with either high error correction and low data rate (high priority) or with low error correction and high data rate (low priority).

The **inner interleaver** distributes these data to a maximum of six serial bit streams (bit interleaving) depending on modulation and code rate: two (QPSK), four (16QAM) or six (64QAM) bit streams with non-hierarchical coding, or two (QPSK) streams for high-priority data plus two (16QAM) or four (64QAM) for low-priority data with hierarchical coding. From these serial bit streams, words with a width of two,

IFFT mode	8k	2k
Number of subcarriers	6817	1705
Symbol period	896 µs	224 µs
Carrier spacing	1116 Hz	4464 Hz
Useful bandwidth	7.61 MHz	7.61 MHz

TABLE 1
OFDM parameters for 2k and 8k mode

Modulation	Code rate	Guard interval			
		1/4	1/8	1/16	1/32
QPSK	1/2	4.98	5.53	5.85	6.03
	2/3	6.64	7.37	7.81	8.04
	3/4	7.46	8.29	8.78	9.05
	5/6	8.29	9.22	9.76	10.05
	7/8	8.71	9.68	10.25	10.56
16QAM	1/2	9.95	11.06	11.71	12.06
	2/3	13.27	14.75	15.61	16.09
	3/4	14.93	16.59	17.56	18.10
	5/6	16.59	18.43	19.52	20.11
	7/8	17.42	19.35	20.49	21.11
64QAM	1/2	14.93	16.59	17.56	18.10
	2/3	19.91	22.12	23.42	24.13
	3/4	22.39	24.88	26.35	27.14
	5/6	24.88	27.65	29.27	30.16
	7/8	26.13	29.03	30.74	31.67

TABLE 2
Input data rates in Mbit/s with non-hierarchical coding depending on modulation, code rate and guard interval (values rounded to two digits)

IFFT mode	8k				2k			
Guard interval	1/4	1/8	1/16	1/32	1/4	1/8	1/16	1/32
Symbol period	896 µs				224 µs			
Guard interval	224 µs	112 µs	56 µs	28 µs	56 µs	28 µs	14 µs	7 µs
Symbol period + guard interval	1120 µs	1080 µs	952 µs	924 µs	280 µs	252 µs	238 µs	231 µs

TABLE 3 Values for symbol period and guard interval

four or six bits are formed, which determine the vector of a subcarrier. In 2k mode, 1512 of these words form a symbol (6048 in 8k mode) and their position within the symbol will be scrambled (symbol interleaving).

In SFNs, the different delays of the transport stream feeders to the transmitters can be compensated by means of an optional **signal delay.** Differences of up to 1000 ms with 100 ns resolution can be compensated manually or automatically by comparing the time stamp in the transport stream with an external 1 Hz reference.

In the **mapper,** the words are Gray-coded and represented at the constellation points of the complex level. The **frame adapter** adds 176 (701) subcarriers as sync information in 2k mode (8k mode) and 17 (68) subcarriers as control information so that a total number of 1705 (6817) carriers is obtained (TABLE 1).

Inverse fast Fourier transform (IFFT) converts the subcarriers represented at the complex level from the frequency to the time domain. During the guard interval of 1/4, 1/8, 1/16 or 1/32 of the symbol period, the beginning of the symbol is repeated with the respective length.

After forming a spectrum by means of **digital filters** and subsequent **digital I/Q modulation,** the time signal is applied to the **D/A converter** where it is converted to an IF of 35.764 MHz.

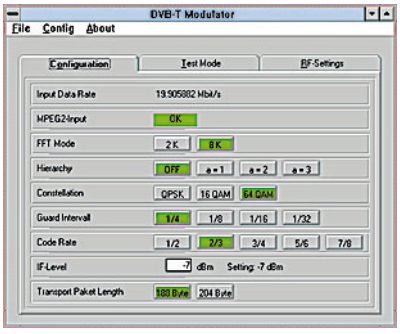

FIG 3 User interface of DVB-T Modulator SDB-M

The required local frequency is generated internally but can be locked to a frequency standard or applied from an external source.

A synthesizer with upconverter is used for optional **conversion to an RF output frequency.** It converts the 7.61 MHz wide OFDM signal to an adjustable center frequency from 47 to 860 MHz at an excellent S/N ratio.

Selection of operating parameters and operation

The input or net data rate is determined by setting code rate, modulation and guard interval. The selection of code rate and modulation enables a trade-off between the added error correction code and the useful transmission capacity (TABLE 2). Selection of IFFT mode and guard interval depends on the network structure and is dictated by multipath reception (echo signals, SFN transmitter at any distance to the receiver) for which the delay differences must be shorter than the guard interval (TABLE 3) [4].

The integrated controller configures the individual modules of DVB-T Modulator SDB-M power-failure-proof, monitors their operation and provides information at a parallel and a serial interface. At the serial interface this information can be called up under Windows™ using a standard PC and the convenient user interface supplied (FIG 3). Moreover, any parameter can be modified at this interface.

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REFERENCES

[1] Lauterjung, J.: DVB-T, the new terrestrial TV standard. News from Rohde & Schwarz (1997) No. 155, pp 31–32

[2] ETS 300 744: Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital terrestrial television (DVB-T). ETSI (March 1997)

[3] ETS 101 191: Digital Video Broadcasting (DVB); DVB mega-frame for single frequency network (SFN) synchronization. ETSI (April 1997)

[4] Acts Validate: Implementation Guideline for DVB-T; Transmission aspects. Draft (April 1997)

Condensed data of DVB-T Modulator SDB-M

Input data rate	5 to 40 Mbit/s, depending on operating mode
IFFT mode	2k and 8k
Modulation	QPSK, 16QAM or 64QAM
Guard interval	1/4, 1/8, 1/16 or 1/32
Inner code rate	1/2, 2/3, 3/4, 5/6 or 7/8
Inputs	
Transport stream	MPEG2, LVDS, 25-contact sub-D, female, 100 Ω
Reference frequency	10 MHz, –10 to +10 dBm, BNC, 50 Ω
Outputs	
IF, COFDM	35.764 MHz, –7 dBm, BNC, 50 Ω
or RF (option)	band I to V, 0 dBm, BNC, 50 Ω
SFN mode (option)	to SFN-DS
MIP data	read-out via serial interface
TS delay	<1000 ms, automatic or manual setting
Reference pulse input	1 Hz, TTL, BNC
Interfaces	serial RS-232-C, 15-contact parallel sub-D

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