TV Test Receiver EFA, Models 40/43 (DVB-T)

Comprehensive analysis/demodulation/monitoring of digital terrestrial TV signals

- All DVB-T modes supported according to ETS 300 744
- High-end demodulator
- High-end test receiver
- Standard test receiver
- Areas of application: production, single frequency network installation and adjustment, monitoring, coverage, research and development, service
- Comprehensive measurement and monitoring functions
- Simple, user-friendly operation
- Modular design – easy retrofitting of options
- IEC/IEEE bus and RS-232-C interface
- MPEG2 decoder option

ROHDE & SCHWARZ

EFA – the test reference for terrestrial digital TV

After the successful launch of the first European DVB-T network (Digital Video Broadcasting – Terrestrial) in Great Britain involving over 1 000 000 subscribers (as of December 2000), DVB-T is gaining ground in Europe at an ever faster pace. In this context, the new DVB-T models of the EFA family of test receivers meet the demand for high-precision reception measurements. Compact in design and featuring comprehensive automatic test functionality, the instrument is ideal for R&D, modulator production testing and in-service monitoring of TV signals.

Standard test receiver (model 40)

- ◆ Selective receiver
- ◆ Typical use in the field where adjacent channels need to be filtered
- ◆ High-end synthesizer with low phase noise
- ◆ Excellent price/performance ratio

High-end demodulator (model 43)

- ◆ Wideband input (non-selective receiver), tunable
- ◆ Typically used for transmitter testing
- ◆ Outstanding SNR, excellent intermodulation characteristics
- ◆ High-end synthesizer with extremely low phase noise

High-end test receiver (model 43 + option EFA-B3)

- ◆ Outstanding SNR and improved intermodulation characteristics
- ◆ Rejection of image frequency and IF
- ◆ Two additional selective RF inputs (50 Ω and 75 Ω)
- ◆ Extended frequency range from 4.5 MHz to 1000 MHz

Models and options for DVB-T

			Standard test receivers			High-end demodulators			High-end test receivers			
		Models ⇨	40	12	78	43	33	89	43	33	89	Slots needed
Option	**Designation**	**Order No.**	DVB-T	B/G	D/K or I	DVB-T	B/G	D/K or I	DVB-T	B/G	D/K or I	
EFA-B2	NICAM Demod./Decod. Std B/G or D/K	2067.3610.02	–	❍	❍	–	❍ 2)	❍ 2)	–	–	–	1
EFA-B2	NICAM Demod./Decod. Std I	2067.3610.04	–	–	❍	–	–	❍ 2)	–	–	–	1
EFA-B3	RF Preselection	2067.3627.02	–	–	–	❍	❍ 2)	❍ 2)	◆	◆	◆	1
EFA-B4	MPEG2 Decoder	2067.3633.02	❍	❍ 1)	❍ 1)	❍	❍ 1)2)	❍ 1)2)	❍	–	–	1
EFA-B6	Video Distributor	2067.3656.02	–	–	–	❍ 3)	❍	❍	❍ 3)	❍	❍	0
EFA-B7	Switchable Video Bandwidth	2067.3710.02	–	❍	–	–	❍	–	–	❍	–	1
EFA-B8	RPC Measurement	2067.3727.02	–	❍	❍	–	❍	❍	–	❍	❍	0
EFA-B10	OFDM Demodulator	2067.3740.02	✔	❍	❍	✔	❍	❍	✔	❍	❍	1
EFA-B11	6 MHz SAW Filter	2067.3691.00	❍	❍ 1)	❍ 1)	❍	❍ 1)	❍ 1)	❍	❍ 1)	❍ 1)	0
EFA-B12	7 MHz SAW Filter	2067.3591.00	❍	❍ 1)	❍ 1)	❍	❍ 1)	❍ 1)	❍	❍ 1)	❍ 1)	0
EFA-B13	8 MHz SAW Filter	2067.3579.02	❍	❍ 1)	❍ 1)	❍	❍ 1)	❍ 1)	❍	❍ 1)	❍ 1)	0
ZZT-314	Transportation Bag for 3 HU high units	1001.0523.00	❍	❍	❍	❍	❍	❍	❍	❍	❍	0

Each basic unit has three free slots to take up options.

✔ Included in basic unit ◆ Must be ordered with basic unit ❍ Available – Not applicable

1) Can be retrofitted if option EFA-B10 is built in.

2) EFA-B2 or EFA-B3 or EFA-B4: only one choice possible.

3) Can be retrofitted if option EFA-B4 is built in.

Common to all models
- In-depth measurement capabilities
- Simple, user-friendly operation
- Modular design – easy retrofitting of options
- General measurement functions for
  - RF input level
  - carrier frequency offset
  - bit rate offset
  - BER (before Viterbi, before and after Reed-Solomon)
- MPEG2 transport stream output (serial or parallel)
- Alarm messages for measurement functions, internal storage
- IEC/IEEE bus and RS-232-C interface

MPEG2 decoder (option EFA-B4)
- Realtime analysis to ETR 290
- Error report
- Video and audio output

Video distributor (option EFA-B6)[1)]
- Provides four video outputs (two on front and two on rear panel)

6 MHz SAW filter (option EFA-B11)
- Adjacent-channel rejection
- Meets US requirements

7 MHz SAW filter (option EFA-B12)
- Designed to DVB-T standards
- Adjacent-channel rejection
- Meets European and Australian standards

8 MHz SAW filter (option EFA-B13)
- Designed to DVB-T standards
- Adjacent-channel rejection
- Meets European standards

Analog and digital functions in one instrument

EFA models 40/43 belong to the EFA family. Using the OFDM demodulator option (EFA-B10), even analog EFA TV test receivers (models 12 and 78) and demodulators (models 33 and 89) can be upgraded to dual-mode versions: analog and digital in one unit.

1) only possible with model EFA 43 and if option EFA-B4 (MPEG2 decoder) is fitted

Fully compatible to ETS 300 744

Characteristics

DVB-T Test Receiver EFA, fully compatible with the ETS 300 744 standard, receives, demodulates, decodes and analyzes OFDM (orthogonal frequency division multiplex) signals. All key parameters for demodulating the receive signal can be selected automatically or manually:

- 6 MHz, 7 MHz or 8 MHz operating bandwidth
- 2K or 8K OFDM modulation
- QPSK, 16QAM or 64QAM constellation diagram
- 1/2, 2/3, 3/4, 5/6 or 7/8 code rate
- 1/4, 1/8, 1/16 or 1/32 guard interval
- α=1, 2 or 4 hierarchical demodulation
- Reed-Solomon error correction 204/188
- 6 MHz, 7 MHz or 8 MHz SAW filter bandwidth (selectable)

The operating principle of the receiver is basically the same as that of the other receivers from the EFA family, except for certain functions specified in standards.

Realtime signal analysis

EFA's powerful digital signal processing provides fast and thorough analysis of the received DVB-T signal. Analysis is performed simultaneously with, but independently of, demodulation and decoding. The MPEG2 transport stream is permanently available for decoding as well as for vision and sound reproduction.

Thanks to its realtime analysis capability, the high number of measured values necessary for the complex calculation and display processes are made available for subsequent mathematical/statistical processing in an extremely short, as yet unequalled, time. Because of its high-speed data acquisition, Test Receiver EFA is the ideal choice not only in R&D but also in production environments where short measurement cycles are essential.

Features (see figures page 6 to 9)

EFA-T, even the basic version, features a wide range of innovative measurement functions, allowing comprehensive, in-depth signal analysis. As well as measuring general parameters (Fig. 1) such as bit error ratio (BER), more thorough analysis includes:

- I/Q constellation diagrams (Fig. 2): the number of symbols to be displayed is user-selectable, range: 1 to 999 999 symbols
- Calculation of I/Q parameters: amplitude imbalance, quadrature offset and carrier suppression, phase jitter, SNR and MER (modulation error ratio) (Fig. 3)
- Frequency domain displays, e.g. MER(f), I|Q(f) or interferer (Figs 4, 5 and 6)
- Amplitude, phase and group-delay/frequency response displays (Fig. 7)
- Amplitude spectrum, including automatic shoulder attenuation measurement to ETR 290 (Fig. 8)
- Long-term monitoring of dedicated parameters through the history function (Fig. 9), monitoring time is selectable from 60 seconds to 1000 days
- Linearity analysis from amplitude distribution histogram or CCDF (Figs 10 and 11)
- Received impulse response within the guard interval – including zoom function (Fig. 12)

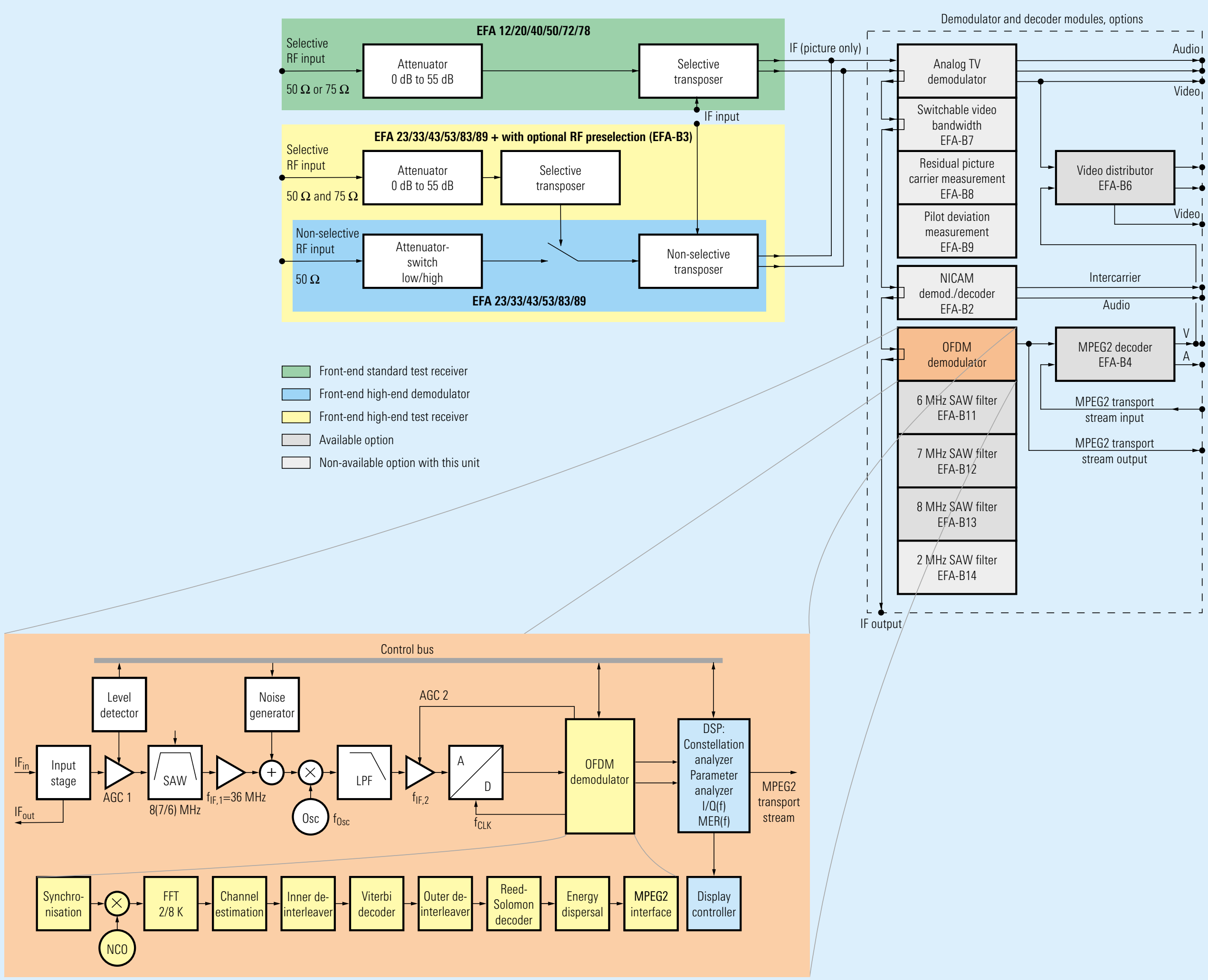
DVB-T: OFDM modulation for terrestrial broadcasting of digital TV signals

The DVB-T standard employs OFDM (orthogonal frequency division multiplex) modulation. This modulation is applied to the downconverter module (selective or non-selective, depending on the model) which converts the signal to a 36 MHz IF. It can then be filtered by different SAW filters (depending on the occupied bandwidth), and Gaussian noise can be internally added for margin measurements.

The IF signal is converted to the baseband using a numeric control oscillator. A Fast Fourier Transform (2k or 8k) translates the signal from the time domain to the frequency domain. Then, channel estimation is used to correct the signal's amplitude, phase and delay (continuous and discrete pilots are used for this task) to eliminate most of the degradation introduced during RF transmission.

Data packets are then applied to the Viterbi convolutional decoder, data de-interleaver (outer de-interleaver), Reed-Solomon decoder and data de-randomizer (energy dispersal). Finally, the MPEG2 interface feeds the demodulated MPEG2 transport stream to the hardware output interface (TS SPI or TS ASI). (see Fig. below).

Block diagram of TV Test Receiver EFA, models 40/43 (DVB-T)



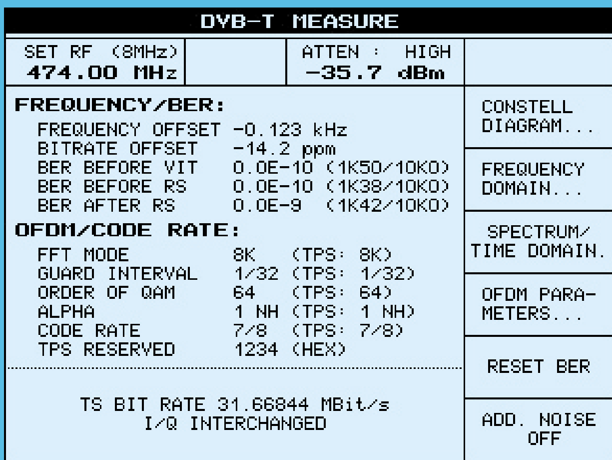


Fig. 1: Main measurement menu

All parameters for the demodulated DVB-T channel are displayed on a single screen and can be checked at a glance:

- the three BERs (bit error ratio) – before Viterbi decoder, before and after Reed-Solomon decoder – give a fast quality overview of the demodulated signal
- the frequency offset of the central carrier
- whether the transmitted TPS pilots are correct (compared with the internal demodulator settings)

Hint: The internal noise generator can be activated to perform END (equivalent noise degradation) measurements or noise margin measurements which are based on the BER measurement.

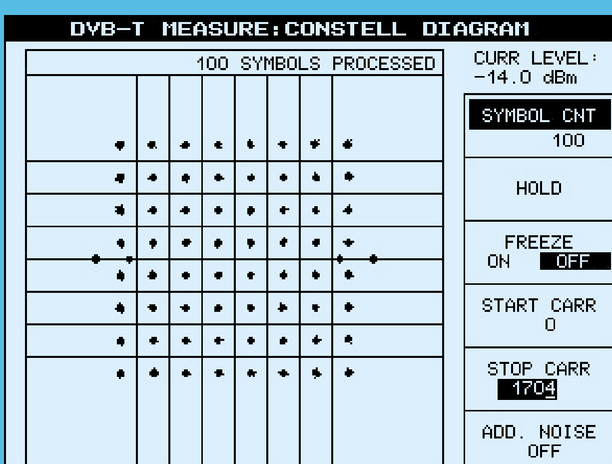


Fig. 2: Constellation diagram

The constellation diagram is always the best way to represent digital modulation. It is also the best visual tool for interpreting measurement results, for example from carrier suppression or I/Q amplitude imbalance measurements. For in-depth analysis, adjustment of the displayed number of symbols is possible (100 symbols are shown in this example). If required, the EFA can set the number automatically to obtain an optimal refresh rate.

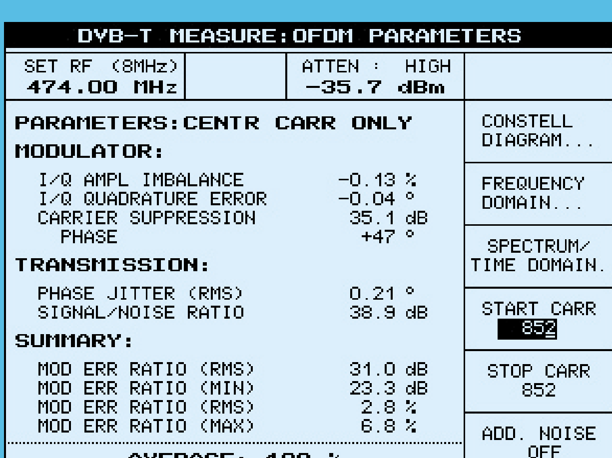


Fig. 3: OFDM parameters

All OFDM parameters are calculated from the constellation diagram for the selected carriers. It is then very easy to measure for example the suppression of the RF central carrier of a modulator in 2K mode (carrier 852 – discrete pilot) even in 8K mode (carrier 3408 – continuous pilot).

Fig. 4: MER as a function of frequency
MER as a function of the frequency is one of the most powerful measurements that the EFA can perform. It displays the MER for every QAM modulated carrier of the OFDM signal. At a glance, you can measure the overall quality of the transmitter under test.

With 'START CARR' and 'STOP CARR', you can quickly locate any impaired QAM carrier in the OFDM signal. Co-channel interference can also be measured and displayed when an interference measurement is performed (interference-to-carrier measurement).

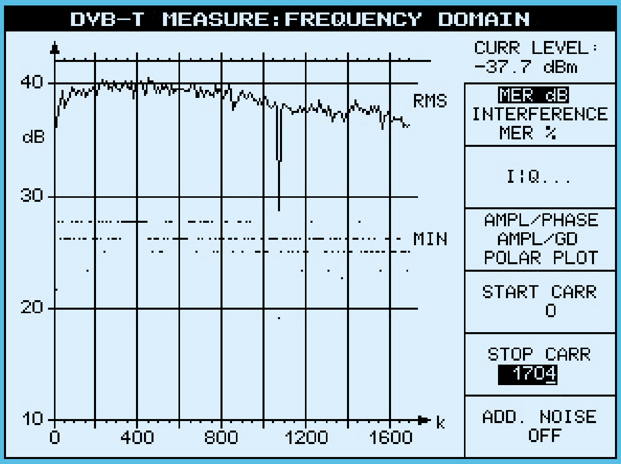


Fig. 5: I/Q versus frequency
This diagram shows symbols versus frequency. In other words, the quadrature (Q) and the in-phase (I + 90°) information of the constellation diagram are displayed for a complete symbol.

A glance at the constellation diagram immediately shows any errors or degradations.

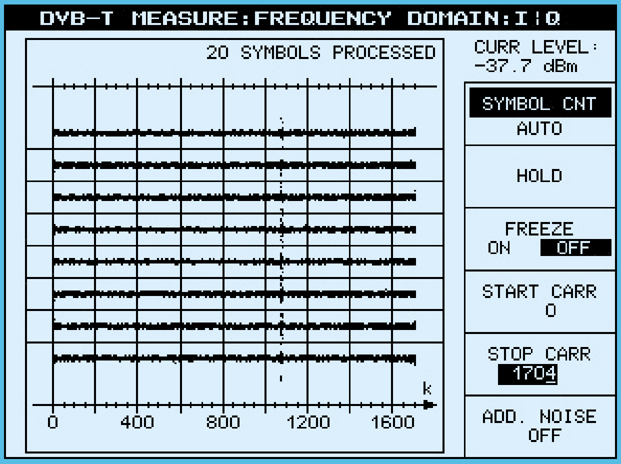
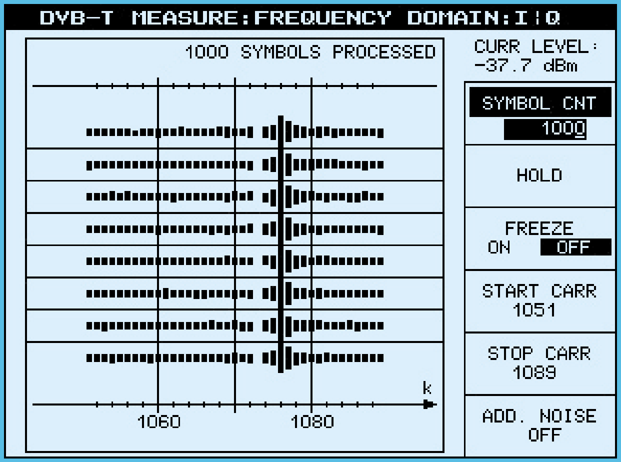


Fig. 6: I/Q versus frequency (zoom)
Effects of interest can be located more precisely by varying the number of symbols and carriers that are displayed. Any impairment (carrier 1076 is clearly marked on display) can then be localized quickly and easily.

The same method can be used for all frequency domain measurements – for example MER versus frequency or the polar plot.



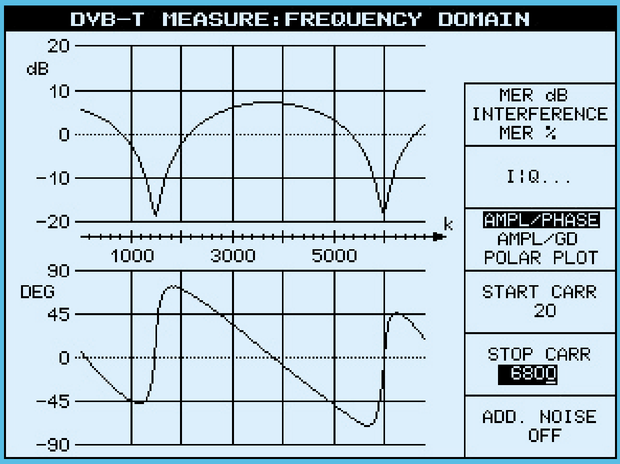


Fig. 7: Channel estimation
In the OFDM demodulation chain, channel estimation compensates for frequency, phase and delay degradations that have been introduced during DVB-T transmission. It is then easy for the EFA to output the amplitude response, the phase response and the group delay, displaying the channel estimation coefficients versus frequency.

The polar plot may also help to interpret very fast echoes (difficult to visualize with impulse response measurements).

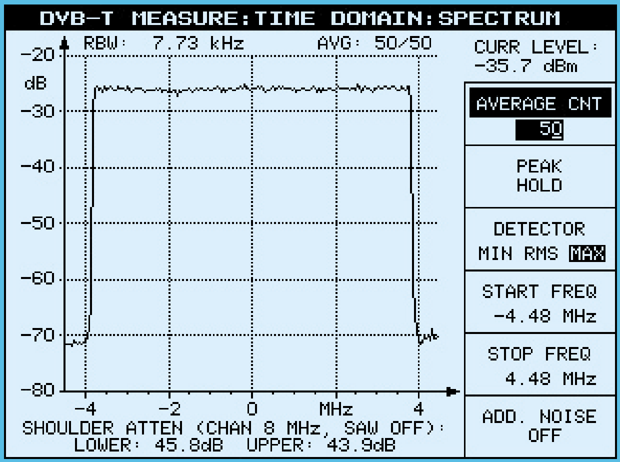


Fig. 8: Spectrum analysis
Thanks to this integrated feature, you will not need a separate spectrum analyzer anymore. All basic spectrum analyzer functions are provided, for example start/stop frequency (or center/span) as are several detection and averaging modes.

The automatic shoulder attenuation measurement (strictly meets ETR 290), makes checking the performance of any DVB-T transmitter child's play.

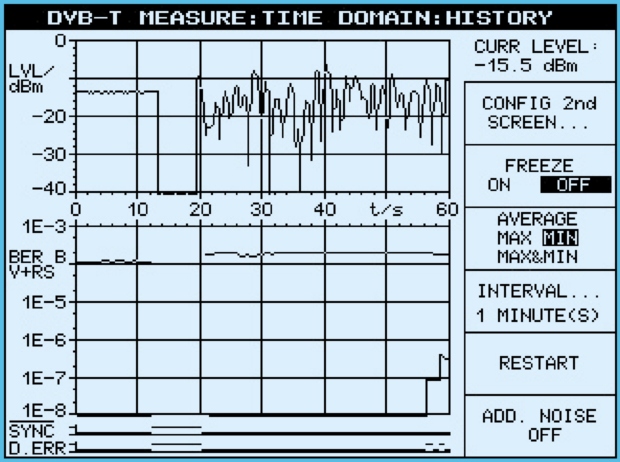


Fig. 9: History function
This measurement is just what is required for long-term DVB-T transmitter monitoring. Most key parameters (level, MER/dB, MER/%, BER and synchronization information) are, therefore, displayed in graphical form. This mode can also display all values numerically (average, max, min, current). BER and level measurements run continuously and are independent of other measurements.

Hint: Results are easy to read from a remote location.

Fig 10: Amplitude distribution function

The measurement function for displaying the amplitude distribution or the CCDF (complementary cumulative distribution function) is used to detect nonlinear distortions. The frequency distribution of the DVB-T signal is divided into several 1 dB windows to determine the amplitude distribution. Information on the crest factor is obtained from the frequency distribution and displayed in the upper right-hand corner of the graph.

The reference values are marked by short horizontal lines.

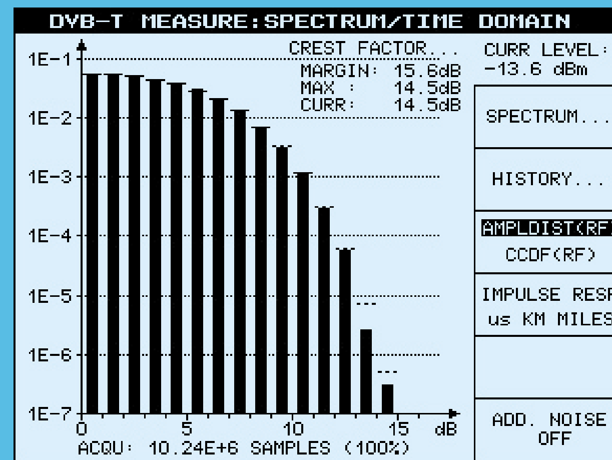


Fig 11: Complementary cumulative distribution function (CCDF)

In contrast to the amplitude distribution, each trace point indicates how often a certain voltage level is attained or exceeded.

The ideal frequencies are displayed as short, horizontal lines at 1 dB intervals (reference values) so that the amplitude distribution of the applied signal can be compared with that of an ideal DVB-T signal. Any deviation from the ideal distribution is then identified by the deviations of the column heights and the value of the crest factor, for example due to clipping in the transmitter output stage.

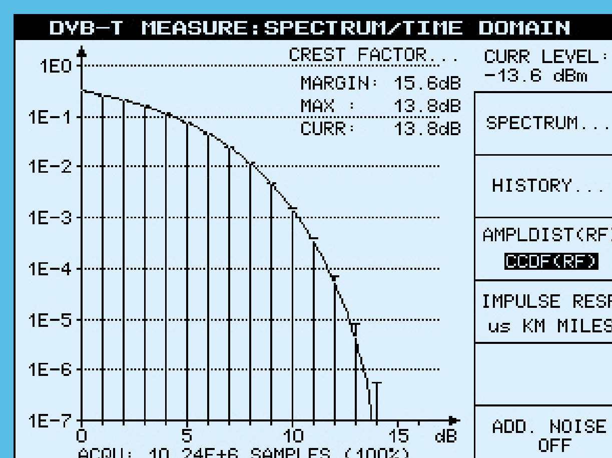
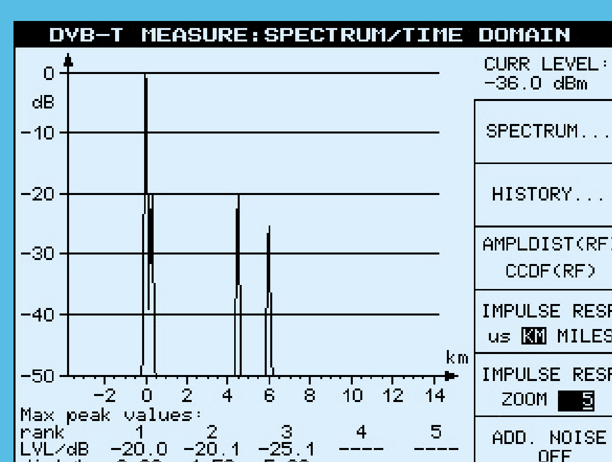


Fig 12: Impulse response

The impulse response measurement (within the guard interval) is very useful. Especially so for single frequency network (SFN) adjustment. The measurement lets you visualize and measure (numeric values) the main DVB-T signal (0 dB, reference), echoes and pre-echoes. The zoom function lets you visualize fast echoes that may occur in urban areas (reflections from buildings).

To suit the application, the X axis unit and scale can be changed, for example from µs to km or even miles.



Typical applications

Production testing on modulators and transmitters (calibration and test)

EFA's analysis capabilities make it possible to pinpoint problems such as interferers and inadequate carrier suppression: the constellation diagram shows the symbols, but only if a single carrier is affected – the difficulty is localization. This is exactly what the I/Q measurement function does: symbols are displayed as a function of carriers (frequency domain) to locate the problem in the spectrum display. Once the interferer is localized, the constellation display can be used for further evaluation. This approach can also be used with the MER-vs-frequency measurement function.

Transmitter installation and adjustment of single frequency networks (SFN)

The time domain analysis extends EFA's range of applications to SFN installation and adjustment – an area where spectrum and impulse-response analysis are very useful. The impulse response function makes it possible to visualize the delay between two transmitters at a reception point. This measurement function can be used to optimize the delay between the transmitters. The zoom function makes it possible to see fast echoes, for example direct reflections from a building, mountain etc.

Coverage measurements on terrestrial signals (see photo above)

To allow measurements to be performed under even the worst reception conditions, a single keystroke will optimize the OFDM demodulator for mobile reception (where a lot of impairments affect transmission quality) or stationary reception. The algorithms for speed and channel equalization are optimized, as is internal level control.

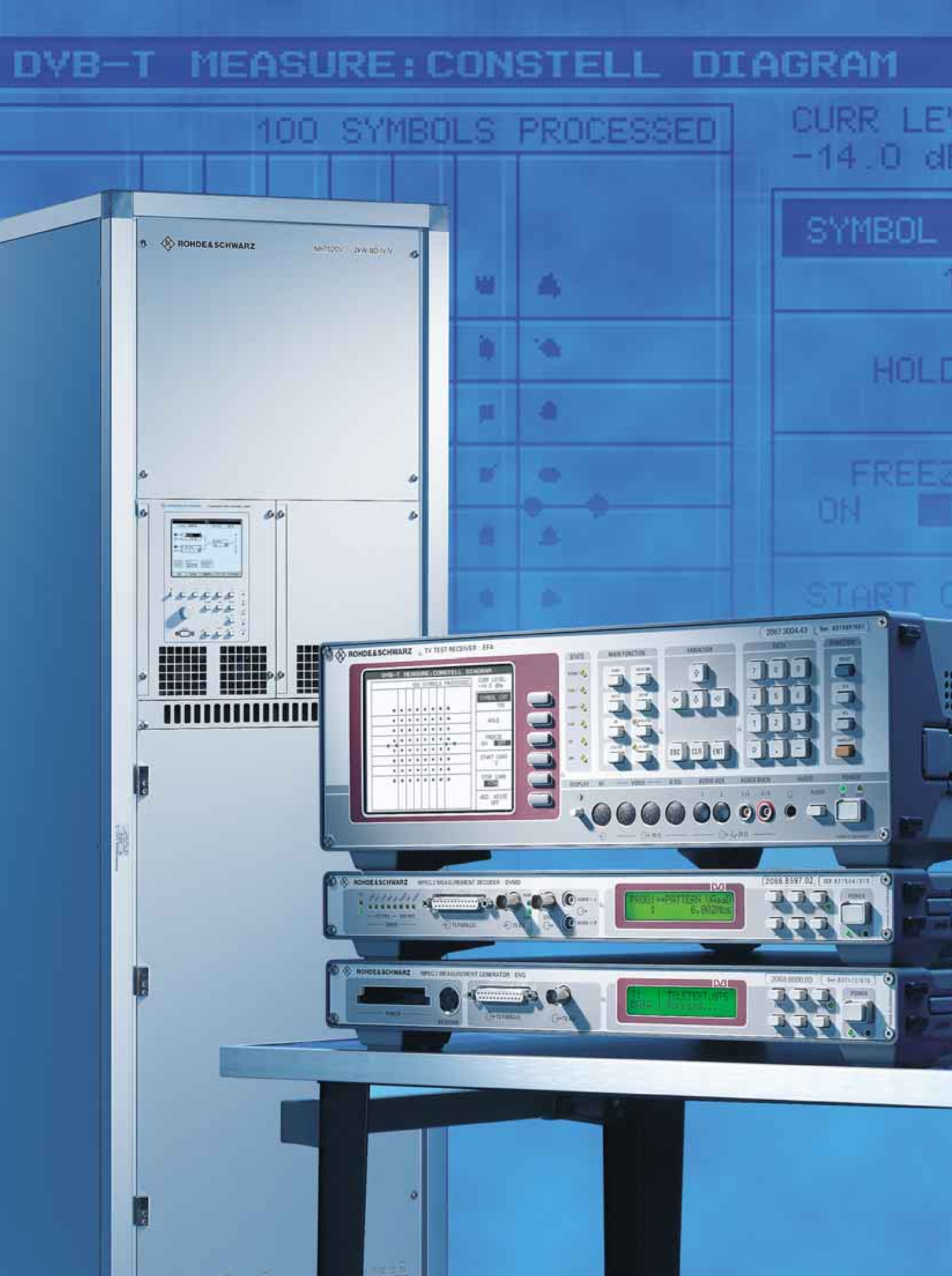
Monitoring TV transmitters and transposers

EFA is the perfect solution for DVB-T signal monitoring. An alarm is triggered if one of the selected parameters exceeds the threshold that has been set. The incident level, OFDM synchronization, MER (modulation error ratio), BER (before Viterbi and before Reed-Solomon decoders) and the MPEG2 transport stream output can be checked in realtime independent of other measurements and decoding. If an error occurs, a 1000-row register is available to record the date, time and designation of the event. The MPEG2 decoder option EFA-B4 extends monitoring capabilities. Realtime measurements to test specifications for DVB systems (ETR290 – priorities 1, 2 and 3) can be performed and make the EFA a complete DVB-T monitoring system.

! most important measurement ✔ required measurement

The table below summarizes the measurements required for the various DVB-T applications

DVB-T OFDM application	Level	BER	MER	SNR	Carrier suppression	Quadrature error	Amplitude imbalance	Phase jitter	Constellation diagram	MER(f)	I/Q(f)	Spectrum-shoulder attenuation	Amplitude(f)/phase(f)/group	Amplitude distribution CCDF	Impulse response	History
Production of modulators and transmitters	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	!		✔
Transmitter installation and SFN adjustments	✔	✔	✔						✔	✔	✔	✔			!	✔
Coverage measurement of terrestrial signals	✔	!	✔						✔			✔			✔	✔
Monitoring of TV transmitters and transposers	✔	✔	✔						✔					✔	✔	!
Research & Development	✔	✔	✔	✔	✔	✔	✔	✔	✔	!	✔	✔	✔	✔	✔	✔
Service	✔	✔	✔	✔	✔	✔	✔	✔	!	✔	✔	✔	✔	✔		✔


DVB-T MEASURE:CONSTELL DIAGRAM
100 SYMBOLS PROCESSED
-14.0
SYMBOL
ROHDE&SCHWARZ
TV TEST RECEIVER · EFA
ROHDE&SCHWARZ MPEG2 MEASUREMENT DECODER · DVMD
ROHDE&SCHWARZ MPEG2 MEASUREMENT GENERATOR · DVG

Fax Reply (TV Test Receiver EFA, Models 40/43 (DVB-T))

- ❑ **Please send me an offer**
- ❑ **I would like a demo**
- ❑ **Please call me**
- ❑ **I would like to receive your free-of-charge CD-ROM catalogs**

Others: ______________________________
____
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Name: ______________________________
Company/Department: ______________________________
Position: ______________________________
Address: ______________________________
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Country: ______________________________
Telephone: ______________________________
Fax: ______________________________
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Mobile reception with EFA models 40 and 43

When the EFA 40/43 is set to MOBILE mode (SPEC FUNC: SYSTEM OPTIMISATION), mobile reception is optimized. The firmware version 4.60 offers improved reception of faded signals. Although further software updates can improve the synchronization to faded signals, the 2K mode of the EFA 40/43 is better for receiving faded signals than the 8K mode. The following measurements provide current information about the performance of the EFA 40/43. These measurement results are valid for firmware 4.60.

2K mode

In the 2K mode, a faded signal simulating a typical urban (TU6) reception environment is fed to the EFA. The signal comprises 6 paths with wide delay dispersion and relatively strong power (see ETR 290, Annex K.3).

Tap number	Delay (µs)	Power (dB)	Doppler spectrum
1	0.0	–3	Rayleigh
2	0.2	0	Rayleigh
3	0.5	–2	Rayleigh
4	1.6	–6	Rayleigh
5	2.3	–8	Rayleigh
6	5.0	–10	Rayleigh

The EFA was set up as follows:
– Channel bandwidth = 8 MHz
– System optimization = mobile
– SAW filter bandwidth = 8 MHz
The Doppler frequency (which is a function of speed and radio frequency) was increased until the BER before the Reed-Solomon decoder was 2.0E-4 or until one MPEG data error occurred in 1 minute. The following table indicates the Doppler frequency in Hz.

Order of QAM	Code rate	Guard = 1/4	Guard = 1/8
QPSK	1/2	58	61
	2/3	40	42
	3/4	33	35
	5/6	28	26
	7/8	24	22
16QAM	1/2	30	26
	2/3	21	25
	3/4	14	9
	5/6	0.2	0.5
	7/8	0.4	0.2
64QAM	1/2	5	4
	2/3	0.2	0.2
	3/4	0.2	0
	5/6	0	0
	7/8	0	0

Order of QAM	Code rate	Guard = 1/16	Guard = 1/32
QPSK	1/2	60	67
	2/3	44	47
	3/4	36	39
	5/6	27	31
	7/8	23	25
16QAM	1/2	32	35
	2/3	24	24
	3/4	18	16
	5/6	7	5
	7/8	0.3	0.3
64QAM	1/2	1	1
	2/3	0	0
	3/4	0	0
	5/6	0	0
	7/8	0	0

8K mode

In the 8K mode, a 0 dB echo profile according to ETR290, Annex K.3, was fed to the EFA:

Tap number	Delay (µs)	Power (dB)	Doppler spectrum	Frequency ratio
1	0.0	0	pure Doppler	–1
2	½ T_G	0	pure Doppler	+1

The EFA was set up as follows:
– Channel bandwidth = 8 MHz
– System optimization = mobile
– SAW filter bandwidth = 8 MHz

The Doppler frequency (which is a function of speed and radio frequency) was increased until the BER before the Reed-Solomon decoder was 2.0E-4 or until one MPEG data error occurred in 1 minute. The following table indicates the Doppler frequency in Hz.

Order of QAM	Code rate	Guard = 1/4	Guard = 1/8
QPSK	1/2	23.1	21.0
	2/3	7.2	15.5
	3/4	0.5	10.9
	5/6	0	5.0
	7/8	0	0
16QAM	1/2	10.2	5.1
	2/3	0.2	3.4
	3/4	0	2.3
	5/6	0	0.1
	7/8	0	0
64QAM	1/2	0	1.8
	2/3	0	0
	3/4	0	0
	5/6	0	0
	7/8	0	0

Order of QAM	Code rate	Guard = 1/16	Guard = 1/32
QPSK	1/2	23.3	24.5
	2/3	17.0	17.0
	3/4	12.2	11.8
	5/6	7.2	7.6
	7/8	4.0	4.1
16QAM	1/2	8.8	8.8
	2/3	5.7	5.9
	3/4	4.8	5.1
	5/6	3.0	3.4
	7/8	1.0	2.3
64QAM	1/2	3.6	3.7
	2/3	1.8	2.0
	3/4	1.3	1.6
	5/6	0	0.8
	7/8	0	0

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