DVB-T Test Receiver EFA-T

Innovative measurement functions for terrestrial digital TV

DVB-T Test Receiver EFA-T (FIG 1) features a multitude of measurement functions for the complex characteristics of OFDM signals, thus helping to locate transmission channel problems. Some of these innovative methods are already described in detail in [1]. A number of new features now allow classification and analysis of DVB-T signal quality.

FIG 1 DVB-T Test Receiver EFA-T – now with enhanced functionality for terrestrial digital TV

OFDM modulation

DVB-T employs OFDM (orthogonal frequency-division multiplex) modulation in accordance with standard ETS 300744 [2]. Depending on the transmission mode, 1705 or 6817 mutually orthogonal carriers are sent simultaneously in a transmission channel (6 MHz, 7 MHz or 8 MHz bandwidth). Each single carrier is 4QAM, 16QAM or 64QAM modulated. At exactly defined intervals, individual carriers, called pilots, are emitted unmodulated with 0° or 180° phase angle, depending on the carrier number, and at power boosted by a factor of 16/9. These pilots allow direct assessment of the quality of the transmission channel (linear distortion).

Linear distortion

EFA-T calculates the theoretical, expected phase values of the pilots. At the same time, the actual phase values and amplitudes of the received pilots are determined. The quotients of the theoretical to actual values are a measure of linear distortion in a transmission channel at a specific frequency. All values of the pilots together give the channel transmission function. The special point about this method is that all calculations are complex (ie with real and imaginary components), yielding complex results. So EFA-T outputs not only the amplitude response of a transmission channel but also its phase response. The frequency axis is freely selectable, and the amplitude/phase axis automatically adjusts to the range of values obtained (FIG 2). Group delay can now be determined by means of a simple conversion function of EFA-T.

Polar plot in complex plane

The conditions prevailing in a transmission channel can be assessed at a glance by representing the complex values of pilots in the complex plane. While this representation is not referenced to frequency, it offers straightforward phase and amplitude information in a single diagram (FIG 3).

Channel impulse response

The channel transmission function and the channel impulse response are linked to each other via the Fourier transform. EFA-T performs an inverse Fourier transform (IFFT) to determine the channel impulse response, whose main signal (at t = 0) and echoes are graphically displayed (FIG 4). This measurement is performed with very high precision, so the zoom function of the receiver is particularly valuable in this case, allowing highly detailed presentation of results.

This measurement is used on the one hand to show the channel impulse response, caused for example by reflections from buildings, mountains and other obstacles. But it also serves for monitoring synchronization in single-frequency networks (SFNs). The SFN technique allows network operators to operate all transmitters at the same frequency for broadcasting a DVB-T signal from several sites. This requires highly precise time synchronization of the different transmitters however. To verify synchronization, EFA-T can present channel impulse response as a function of both time and distance (conversion to kilometers or miles).

Amplitude distribution of nonlinear distortions

DVB-T signals displayed on an oscilloscope cannot be distinguished from Gaussian noise. These signals are known for their very high crest factor. Monitoring the amplitude distribution of these signals is particularly important for the transmitter operator for two reasons, which should be carefully weighed up against each other. On the one hand, (nonlinear) limitation of the transmitted signals increases spurious emissions because of intermodulation between the OFDM carriers, so adjacent TV channels may be affected. For this reason, a high crest factor of the transmitted signal is aimed at. On the other hand, too high a crest factor in conjunction with effective use of the available transmitter power can considerably reduce the lifetime of transmitter output stages. For this reason, precisely specified limitation is chosen, ie reduced crest factor.

FIG 5 illustrates the amplitude distribution of a DVB-T transmitter, showing the relative frequency of the amplitudes in a 1 dB amplitude window. The rms value of the transmitted signal is used as the basis to which all other values are referred. Noteworthy is the very high inherent crest factor of more than 15 dB of EFA-T, which offers a comfortable margin for this type of measurement.

Since the theoretical amplitude distribution characteristic can be exactly calculated with DVB-T, it is included in the diagram (dotted lines above columns).

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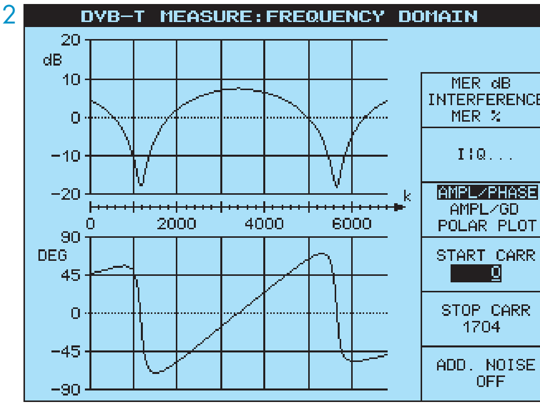

FIG 2 Linear distortion in transmission channel (here due to strong fading), top: amplitude frequency response, bottom: phase frequency response; frequency axis marked with carrier number k of OFDM signal

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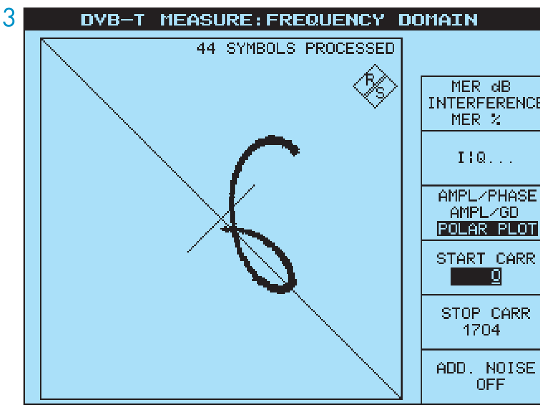

FIG 3 Linear distortion as polar plot; real component represented along long diagonal, imaginary component along short diagonal

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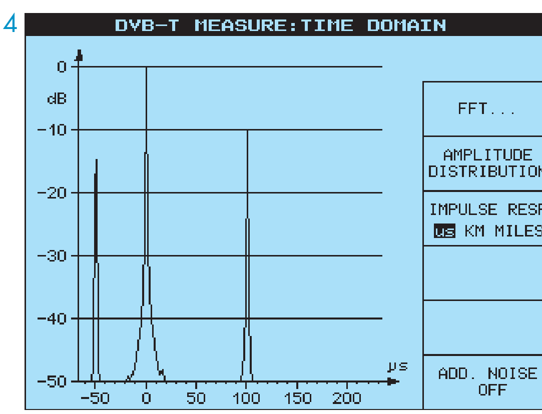

FIG 4 Channel impulse response; useful signal at t = 0; post-echo with –10 dB at t = 100 μs; pre-echo with –15 dB at t = –50 μs. Signal is generated by DVB-T Test Transmitter SFQ fitted with fading simulator option

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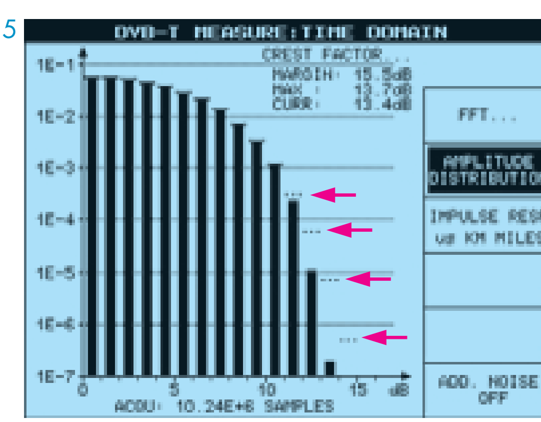

FIG 5 Amplitude distribution of DVB-T transmitter. Theoretical (ideal) distribution is shown by dotted lines. Limiting effect of power amplifier is clearly discernible (red arrows)

You can see at a glance if and how the signal is limited in amplitude.

Summary: reference class

EFA-T offers further functions not described here, such as spectrum analysis (FFT) and history. So it is no wonder that the test receiver has rapidly become a reference in the class of realtime instruments. All functions and graphical displays are of course available also via the remote-control interface. Great ease of operation and extremely fast measurement cycles round off the comprehensive and innovative functionality of EFA-T.

Christoph Balz

REFERENCES
[1] Balz, Christoph; Leutiger, Mathias: DVB-T Test Receiver EFA-T – The test reference: now for terrestrial digital TV too. News from Rohde&Schwarz (1999) No. 164, pp 4–7
[2] Digital systems for television, sound and data services. Framing structure, channel coding and modulation for digital terrestrial television. ETS300744, European Telecommunications Standards Institute, ETSI

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