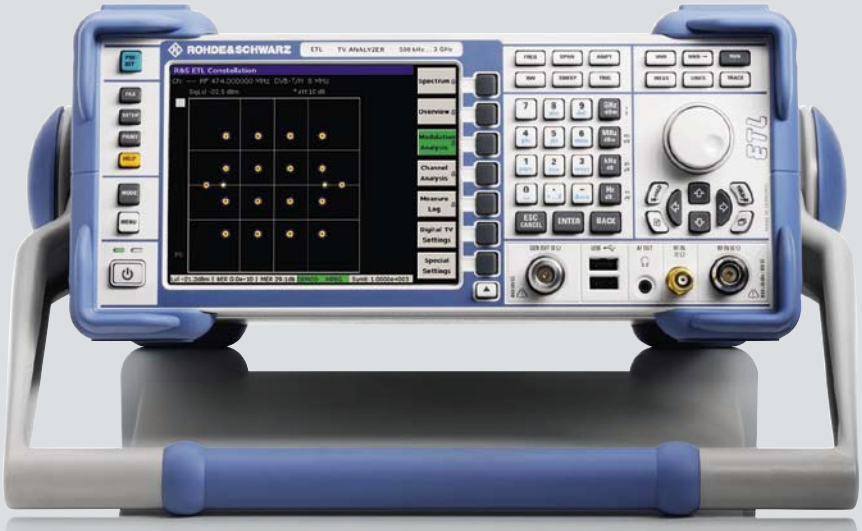
Optimizing DVB-T/-H single-frequency networks with the R&S®ETL TV analyzer

Keeping a DVB-T/-H single-frequency network (SFN) running smoothly not only requires that every single TV transmitter in the network functions properly – network performance criteria in the coverage area also have to be strictly complied with. Offering an extensive range of easy-to-operate analysis functions, the R&S®ETL TV analyzer helps operators to ensure that the required high level of transmission quality is maintained both at the transmitter stations and in the coverage area.

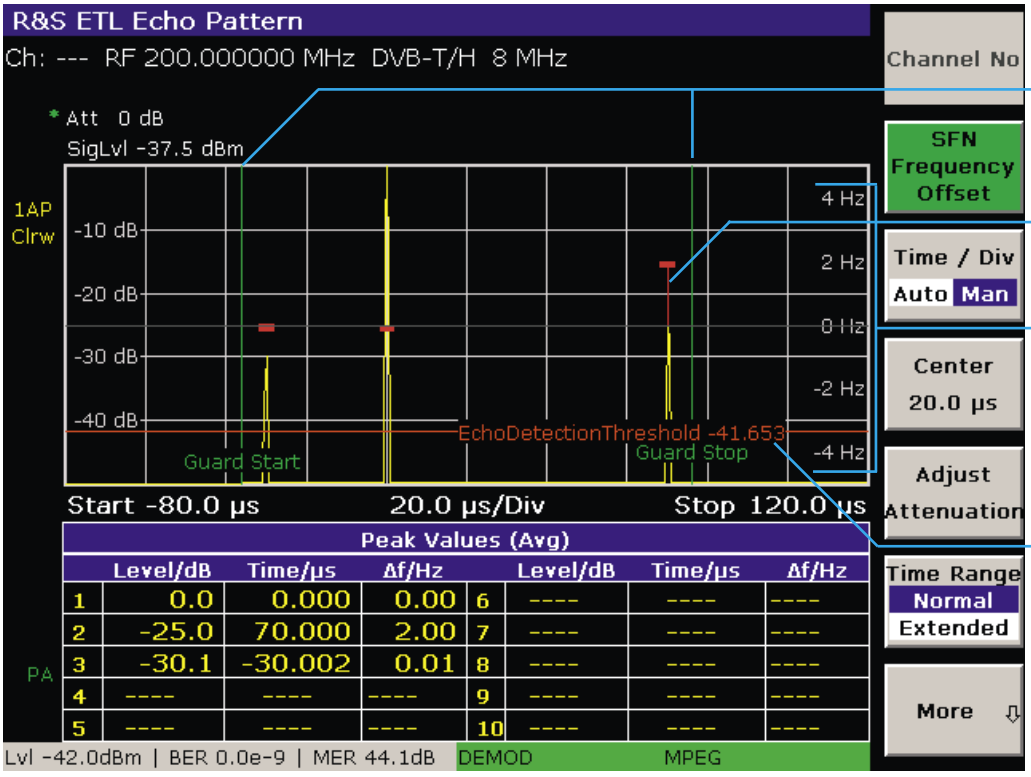
Precisely defined performance criteria in single-frequency networks

The principal advantage of OFDM-based digital TV transmission standards is that they allow a TV transmitter network to be operated as a single-frequency network. SFNs provide enhanced reliability of coverage especially in densely populated areas. To ensure trouble-free operation within an SFN, certain criteria have to be precisely met. For example, all DVB-T / DVB-H transmitters in a network must broadcast their signals at exactly the same frequency, with permissible deviation not exceeding 1 Hz (VHF / UHF). Greater deviations will result in time-variant channels in the area of reception, with the consequence of a poorer bit error ratio (BER) in the case of stationary receivers, accompanied by a decrease in range.

The DVB-T / -H standard further defines guard intervals with durations depending on the selected transmission mode. DVB-T / DVB-H receivers can compensate differences in delay between the SFN transmitter signals received via the direct path and those received via multiple paths due to reflections. This is possible on condition that the differences in delay between the individual transmitters do not exceed the duration of the guard interval. Measures taken to optimize SFNs include defined delays being set on each transmitter to ensure that the guard interval will be maintained at any location within the network. Violation of the guard interval in the order of a few microseconds can cause problems similar to those encountered in the case of deviations from the transmit frequency, especially in large coverage areas.



The R&S®ETL TV analyzer is a versatile platform that has been mainly designed for installing, putting into operation and servicing TV transmitters, for carrying out coverage measurements on terrestrial TV networks, and for performing measurements on cable headends (see News from Rohde&Schwarz No. 195 (2008), pp 48–55).



Guard interval after automatic positioning of the FFT window.

Frequency deviation of a signal relative to the selected main transmitter.

Frequency axis for the display of the frequency deviation.

Signal paths above this threshold are taken into consideration when determining the position of the FFT window.

FIG 1 The DVB-T / -H SFN frequency offset option indicates deviations from the center frequency with high precision; the option expands the echo pattern (amplitude) graph by displaying frequency deviation in addition.

Moreover, the receive level must be high enough to yield a signal-to-noise ratio sufficiently large to ensure error-free reception. The R&S®ETL offers precise analysis functions for each of the three criteria – transmitter frequency, differences in delay and receive level – and presents results in a single measurement window.

SFN analysis at a glance

The R&S®ETL's *Echo Pattern* measurement window (FIG 1) reveals at a glance whether the above criteria are complied with in an SFN. It provides straightforward time-domain display of the individual single-frequency transmitters and of reflections. Two green lines mark the beginning and the end of the selected guard interval. A zoom and center function facilitates navigation within a trace, allowing even extremely narrow pulses and pulses located closely together to be analyzed in detail. In addition, up to four markers can be activated to compare performance characteristics of the individual transmitters, e.g. different transmitter delays, in the time domain. A particularly valuable aid is the result table displayed below the diagram. It lists up to ten pulses according to level or delay. Level values are displayed as relative values referenced to a user-selected main pulse. As the absolute levels of echo signals at the site of reception are also of interest, especially in the case of coverage measurements, the R&S®ETL allows you to choose between relative or absolute level display.

DVB-T / DVB-H signals contain scattered pilots that support channel estimation in the receiver. These pilot carriers are unmodulated and, after interpolation in the time domain, are available on average at every third OFDM carrier as reference points in the frequency domain. The echo pattern is created by means of an inverse fast Fourier transform (IFFT) that transforms the channel frequency response into the time domain. Since a reference point is available only at every third OFDM carrier, the echo pattern displayed in the time domain extends only over one third of the OFDM symbol duration. Pulses with delays outside this range – which may occur in the case of overshoot – are subsampled in the

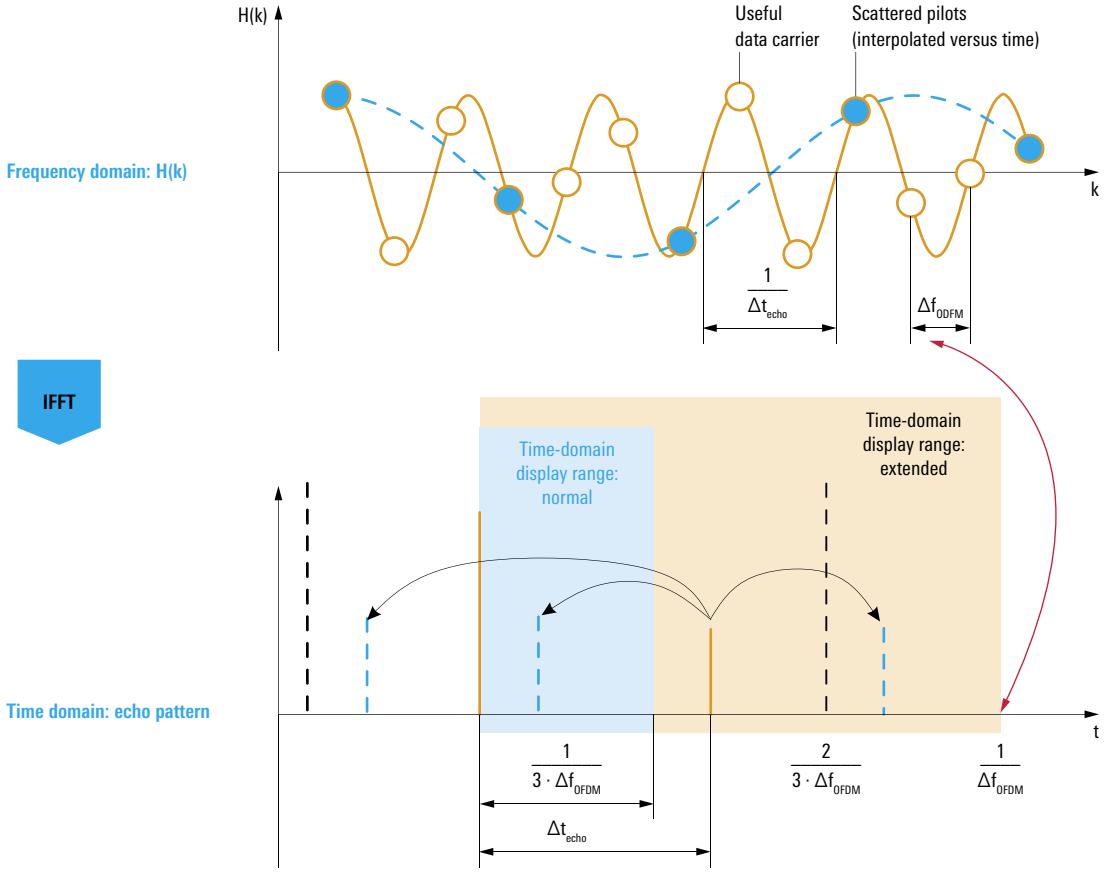
frequency domain by the pilot carriers (aliasing). This usually leads to a pulse with a short delay (image pulse) being erroneously displayed in the echo pattern (FIG 2). The R&S®ETL offers, as a special feature, time domain display of the echo pattern up to the OFDM symbol duration (patent application for Rohde&Schwarz filed). The extended display range allows low-level pulses caused by overshoot to be correctly displayed as post-echoes. Problems resulting from overshoot can thus be clearly identified and echoes unambiguously allocated.

Immediate detection of frequency deviations

To ensure that all transmitters within an SFN operate at exactly the same frequency, each transmitter of the network is locked to a GPS reference signal. To verify whether all transmitters actually transmit at the same frequency, it was previously necessary to measure the frequency at each and every transmitter location – a time-consuming method. The test receiver used for this purpose was itself required to be locked to a precision reference frequency to ensure that measurements were performed with the stipulated accuracy. A patented method developed by Rohde&Schwarz now provides the solution to this problem. The R&S®ETL-K241 DVB-T / -H SFN frequency offset option indicates, for each signal, the frequency deviation relative to the main pulse with an accuracy of <0.3 Hz (FIG 1). As the frequency deviation is determined as a relative value, a reference frequency is not necessary, which greatly facilitates measurements. The R&S®ETL will immediately indicate, at an arbitrary reception site in the coverage area, whether the frequency of one or more transmitters in the network deviates from that of the main transmitter.

FIG 2 Subsampling of the channel frequency response by the scattered pilots (blue) in the DVB-T / DVB-H signal, caused by an echo pulse with a very long delay. This normally leads to the distant echo being misinterpreted as a near echo. A special method implemented in the R&S®ETL complements the channel frequency information by including reference points at all OFDM carriers. This expands the time-domain display range for the echo pattern up to the OFDM symbol duration (orange).

Display of post-echoes on the R&S®ETL



Stable synchronization even under adverse reception conditions

In-depth analysis of a DVB-T / DVB-H signal is possible only if the TV analyzer is reliably synchronized. The R&S®ETL features a special DVB-T / DVB-H demodulator developed by Rohde&Schwarz. Based on a novel concept, the demodulator ensures stable synchronization even under adverse reception conditions. To extract the OFDM carriers, the FFT window is customarily placed such that the start of the guard interval coincides with a symbol changeover of the main pulse or the first pre-echo. With dynamically changing reception conditions, however, this may quickly lead to a loss of synchronization.

This is different in the case of the R&S®ETL: The TV analyzer continuously and automatically defines a decision threshold as to where the FFT window should be placed. This is done as a function of the signal quality and the selected receive mode (*Fast/SFN* or *Mobile*). The decision threshold is inserted as a red line in the echo pattern diagram (*EchoDetectionThreshold*, see FIG 1). All echo paths with signal powers above the threshold are considered in the decision. Based on this decision, the R&S®ETL positions the FFT window with equidistant spacing, i.e. such that the distance between the symbol changeover of the earliest echo path relative to the start of the guard interval and the distance between the symbol change of the last echo path relative to the end of the guard interval are identical (FIG 3). This greatly enhances reliability of synchronization even in busy signal scenarios. This exceptional feature makes the R&S®ETL an ideal choice also for mobile measurements.

The R&S®ETL TV analyzer again proves that it offers, in a single box, all the test functionality required to optimize your single-frequency network.

Werner Dürport; Martin Hofmeister

FIG 3 The R&S®ETL features an innovative method for positioning the FFT window, which ensures that the analyzer always remains synchronized even under adverse reception conditions.

Positioning of the FFT window on the R&S®ETL