ROHDE&SCHWARZ

BROADCASTING DIVISION

APPLICATION NOTE

RF Level Measurement Accuracy of DTV Test Receivers

Products:

TV Test Receivers,	***EFA***
DVB-C	
DVB-T	

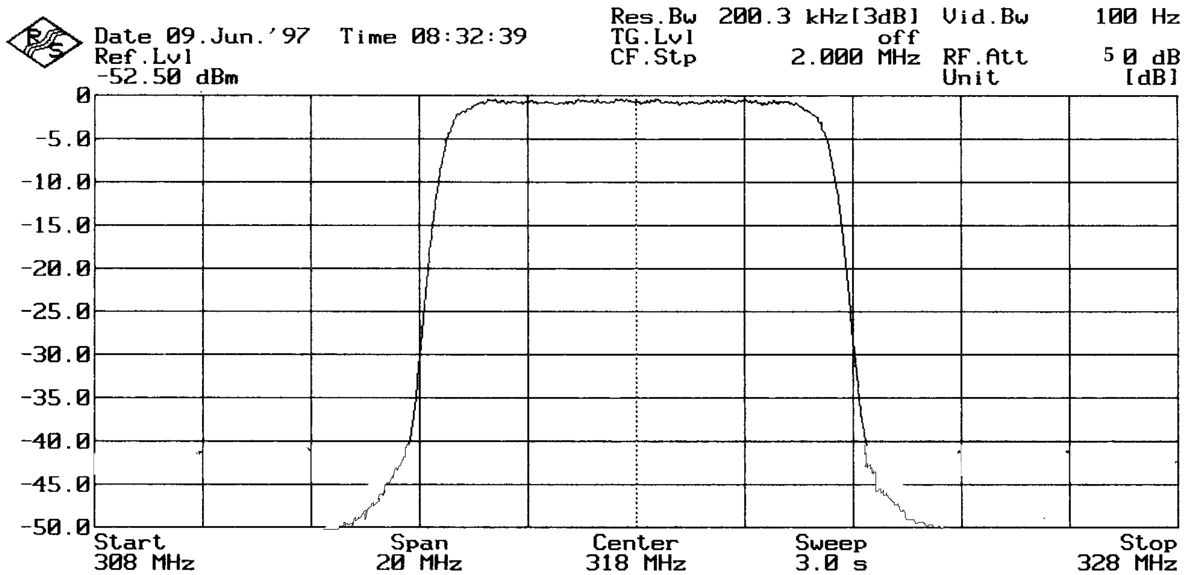
7BM12_0E

RF Level Measurement Accuracy of DTV Test Receivers

One of the most important parameters for determining the transmission quality in an RF channel is the receive level. In analog TV, the peak level of the sync base line is measured for this purpose. As a precondition, the resolution bandwidth must be sufficiently wide to allow all filters to settle during the 4.7-µs base line period. The resolution bandwidth should be at least 1 MHz. The power distribution in the transmission channel is of no importance here. In any case, there will be maximum and constant power in the region of the sync base line. Nominal amplitudes are as follows:

300 mV, sync amplitude
700 mV, white amplitude
1124 mV, $CCVS_0$ amplitude
(corresponding to residual carrier of 11%).

This is different in the case of QAM or QPSK modulation. Due to energy dispersal in the digital modulator, constant power density is obtained throughout the channel width. Consequently, the average channel power is to be measured. The plot below shows a typical power distribution in a 8-MHz cable channel:



Power distribution in an 8-MHz channel with 64QAM modulation

If this broadband measurement is performed with a normal spectrum analyzer, a consi-derable amount of extra calculation has to be done if a maximum bandwidth of 1 to 3 MHz is involved. If the amplitude frequen-cy response in the transmission band is flat, the average channel power can be deter-mined by way of a simple conversion with only one measurement. The average power P_m is:

$P_m = P_{RB} + 10 \log_{10} (NB/RB)$ dBm

where

P_{RB} is the power measured at the resolution bandwidth,

NB is the Nyquist bandwidth and

RB is the resolution bandwidth.

If the measurement is made with the NOISE marker, which indicates power density in dBm/Hz, the resolution bandwidth is 1 Hz. The Nyquist bandwidth must be specified accordingly in Hz.
As set out above, this applies only if the amplitude frequency response in the channel is flat. The two methods described do not however satisfy the accuracy requirements for measurements of this kind.
Another method of determining the power in a channel is by measuring the power between two selectable frequencies. The big advantage of this method is that the amplitude frequency response between the two frequencies is irrelevant. The spectrum analyzer used for the measurement determines the level characteristic over the selected frequency range, eg across a 64QAM-modulated 8-MHz channel. Since new analyzers perform all measurements digitally, power measurement is actually effected by calculating the partial power for each frequency step and integrating the results. This method yields very accurate results, provided the frequency steps are small enough, ie the spectral resolution in the channel is high enough. Absolute accuracy is less than 0.5 dB lower than the absolute accuracy of the analyzer. An example of this is Spectrum Analyzer FSE from Rohde & Schwarz, whose overall tolerance for this type of measurement is only 1.5 dB in the range f < 1 GHz.

Level measurement with
TV Test Receiver EFA Mod 20, 23, 60, 63

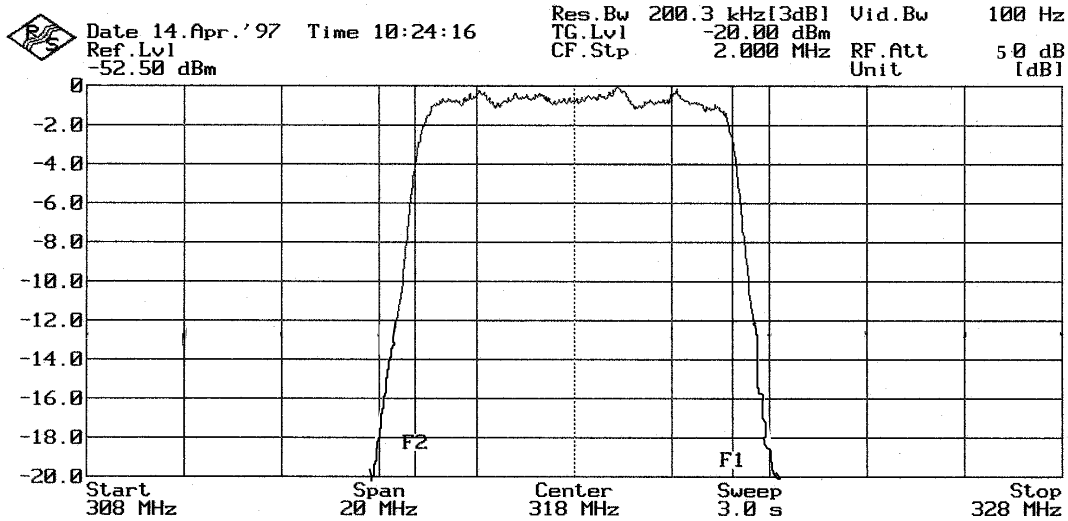
TV Test Receiver EFA uses a simple but highly accurate method for channel power measurement. This method however presupposes that the crest factor remains constant while the amplitude frequency response varies. The crest factor is the ratio of peak voltage to rms voltage of a signal. If it can be assumed that the symbol frequency with n QAM modulation (n = 4, 16, 32, 64, 128, 256) is evenly distributed across the frequency range under test, the crest factor will be different for the different orders of QAM but will be constant. The time interval for evaluating the crest factor must be long enough to have a sufficient number of symbols for evaluation. EFA performs level measurements at intervals of approx. 1 s so that the above assumption is valid.
The correctness of the above assertion is substantiated by the explanations given in the following and the subsequent series of tests.

The ready-to-send transport stream TS from the output of the TS multiplexer is applied to the input of a QAM/QPSK modulator. After the input module of the QAM/QPSK modulator, the signal passes a section that is important in this context: energy dispersal with the associated sync word inversion. Energy dispersal uses the polynomial $x^{15} + x^{14} + 1$ and generates from the input data a PRBS-like sequence. It is thus ensured that symbol frequency is evenly distributed and amplitude distribution is constant across the channel width depending on the order of QAM. From this it follows that the crest factor is constant, also depending the order of QAM, even with amplitude frequency response of whatever kind.
The average power of the QAM channel can therefore be determined with high accuracy by measuring the peak voltage of the QAM-modulated signal by means of a rectifier specially developed for this task. The crest factors for the different orders of QAM must of course be taken into account.
QAM Demodulator EFA operates exactly in this way. To underline the above theoretical considerations, the subsequent test series was performed where the average channel power was determined with a precision Power Meter NRV from R&S as well as with EFA. Amplitude frequency response was simulated through echoes of different delay and level.

1. Echoes with 1000 ns and 50 dB Attenuation

Level measured with	NRV	EFA
	-35.08 dBm	-35.2 dBm

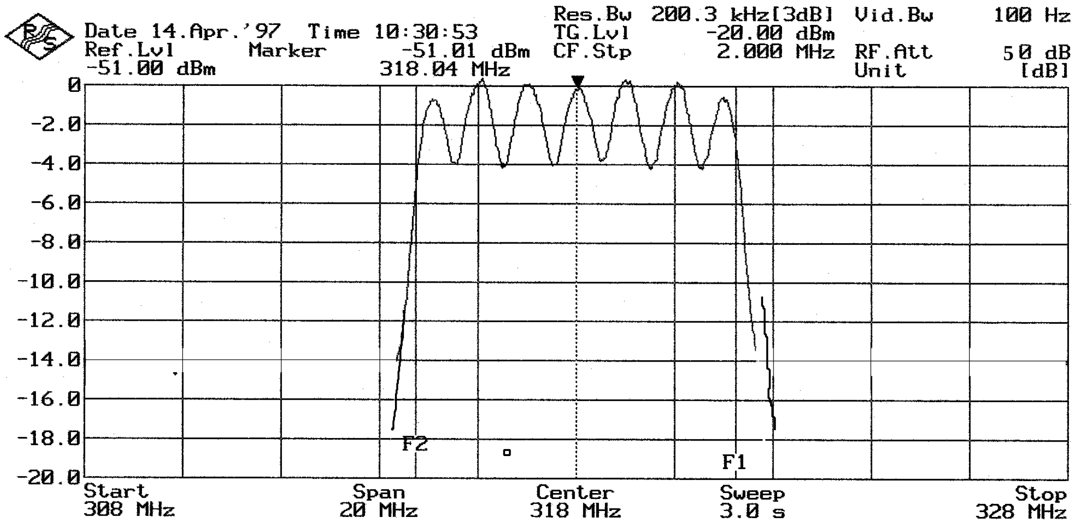
Associated amplitude frequency response



2. Echoes with 1000 ns and 10 dB Attenuation

Level measured with	NRV	EFA
	-34.58 dBm	-34.5 dBm

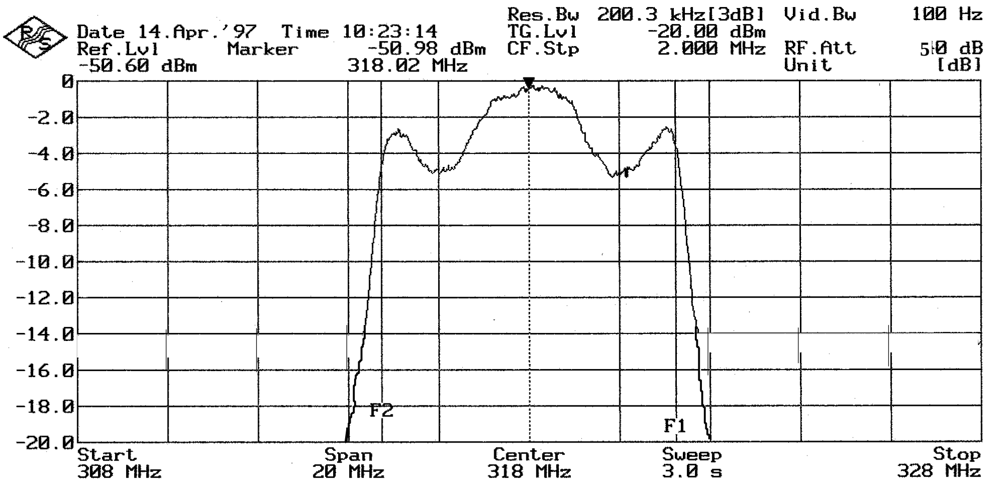
Associated amplitude frequency response



3. Echoes with 250 ns and 10 dB Attenuation

Level measured with	NRV	EFA
	-35.13 dBm	-35.0 dBm

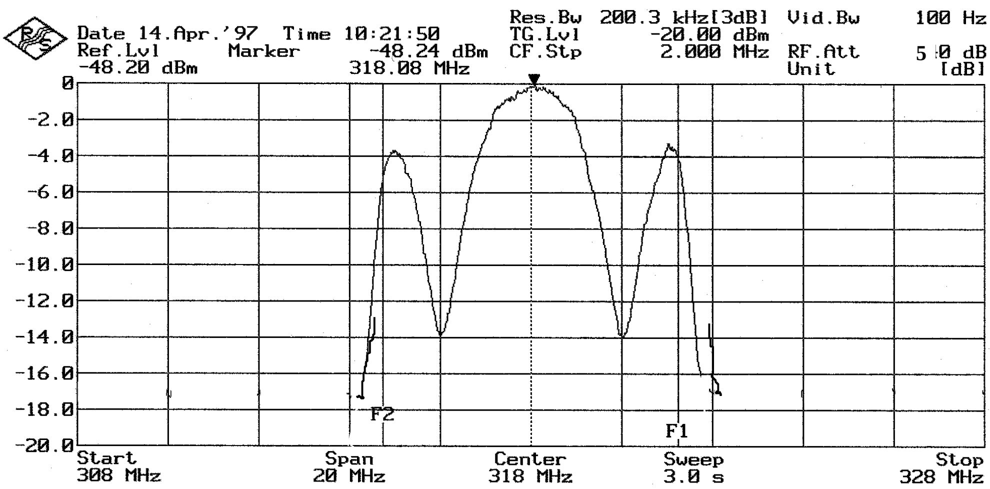
Associated amplitude frequency response



4. Echoes with 250 ns and 2 dB Attenuation

Level measured with	NRV	EFA
	-33.79 dBm	-33.0 dBm

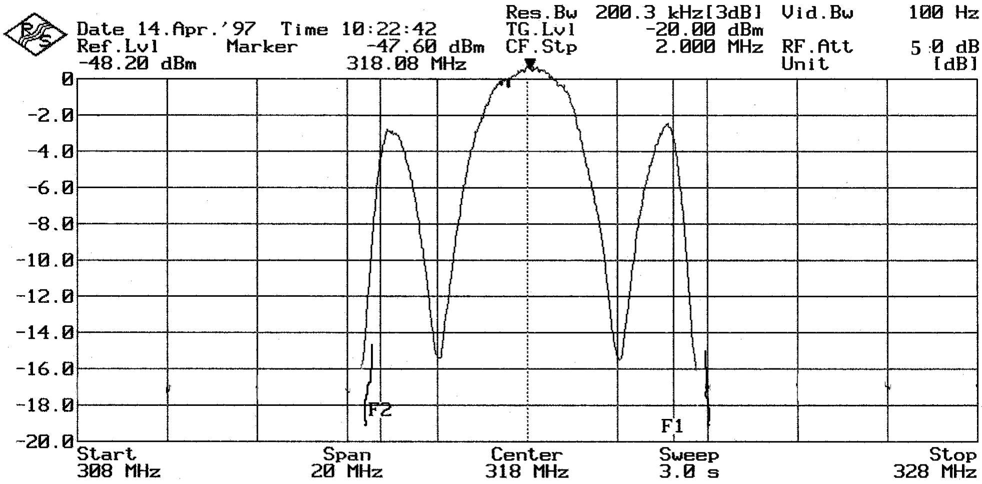
Associated amplitude frequency response



5. Echoes with 250 ns and 0 dB Attenuation

Level measured with	NRV	EFA
	-32.93 dBm	-32.0 dBm

Associated amplitude frequency response



The above diagrams show that the results obtained with NRV and EFA virtually coincide. This demonstrates the high precision of power measurements made with EFA in a QAM-modulated channel also under critical conditions.