Test Receiver R&S EFA
ATSC/8VSB – ITU-T J.83/B – M/N Analog TV

Comprehensive analysis/demodulation/monitoring of digital and analog TV signals

- Standard test receiver
- High-end test receiver
- High-end demodulator
- Multistandard digital and analog platform for terrestrial and CATV applications
- Application areas: production, monitoring, coverage, service, research and development
- Comprehensive measurement and monitoring functions
- Modular design — easy retrofitting of options
- SDTV MPEG2 analyzer/decoder option
- IEC/IEEE-bus and RS-232-C interface
- Simple, user-friendly operation

ROHDE & SCHWARZ

The EFA Family

The TV Test Receiver and Demodulator Family EFA offers outstanding performance features and excellent transmission characteristics. The instruments provide high-precision reception and demodulation of vestigial sideband AM signals (analog TV signals) as well as of digitally modulated TV signals. They measure a comprehensive range of transmission parameters and are therefore ideal for measurement and monitoring applications in cable networks, TV transmitter stations and development labs.

The complete EFA family at a glance

Standard test receivers

- Model 50: digital TV, ATSC/8VSB
- Model 70: digital TV, ITU-T J.83/B
- Model 90: analog TV, standard M/N

High-end test receivers

- Model 53 incl. option EFA-B3: digital TV, ATSC/8VSB
- Model 73 incl. option EFA-B3: digital TV, ITU-T J.83/B
- Model 93 incl. option EFA-B3: analog TV, standard M/N

High-end demodulators

- Model 53: digital TV, ATSC/8VSB
- Model 73: digital TV, ITU-T J.83/B
- Model 93: analog TV, standard M/N

Standard test receiver

- Model 40: digital TV, DVB-T

High-end test receiver

- Model 43 incl. option EFA-B3: digital TV, DVB-T

High-end demodulator

- Model 43: digital TV, DVB-T

Data sheet No.
PD 0757.5514.xx

Standard test receivers

- Model 60: digital TV, DVB-C
- Model 12: analog TV, standard B/G
- Model 78: analog TV, standard D/K or I

High-end test receivers

- Model 63 incl. option EFA-B3: digital TV, DVB-C
- Model 33 incl. option EFA-B3: analog TV, standard B/G
- Model 89 incl. option EFA-B3: analog TV, standard D/K or I

High-end demodulators

- Model 63: digital TV, DVB-C
- Model 33: analog TV, standard B/G
- Model 89: analog TV, standard D/K or I

Data sheet No.
PD 0757.2421.xx

Wide variety of models

The TV Test Receiver Family EFA from Rohde & Schwarz is a versatile and high-performance TV test receiver and demodulator platform, which can be optimally configured for any application, whether digital or analog.
Three frontends are available:

standard selective,
high-end selective and
high-end non-selective.

The high-end models have an even better signal-to-noise ratio than the standard models and offer excellent intermodulation characteristics. This, coupled with minimum inherent frequency response, guarantees extremely accurate measurements.

The approach described in the following will help you find the right EFA model for your application:

- If the application mainly concerns measurements in cable networks or on terrestrial signals, a receiver model that selects the channel to be measured is the appropriate choice. Adjacent-channel signals, which impair measurement results, are filtered out by high suppression. Then, a choice has to be made between the standard selective and the high-end selective version. As with the other criteria, this choice depends on the application.
- Measurements on modulators or TV transmitters, where only one TV signal is involved, are performed with one of the demodulator models with the high-end non-selective frontend, which guarantees extremely low measurement uncertainty without preselection.
- The last selection criterion is the TV demodulator used, and whether it is analog and/or digital

The EFA test receivers can be configured for digital signals and for the analog TV standard M/N (option EFA-B30).

Operation involving a mix of analog and digital channels is becoming more widespread. In addition to the analog models, the digital demodulator option offers complete digital measurement functionality:

– For terrestrial applications, this task is performed by the digital

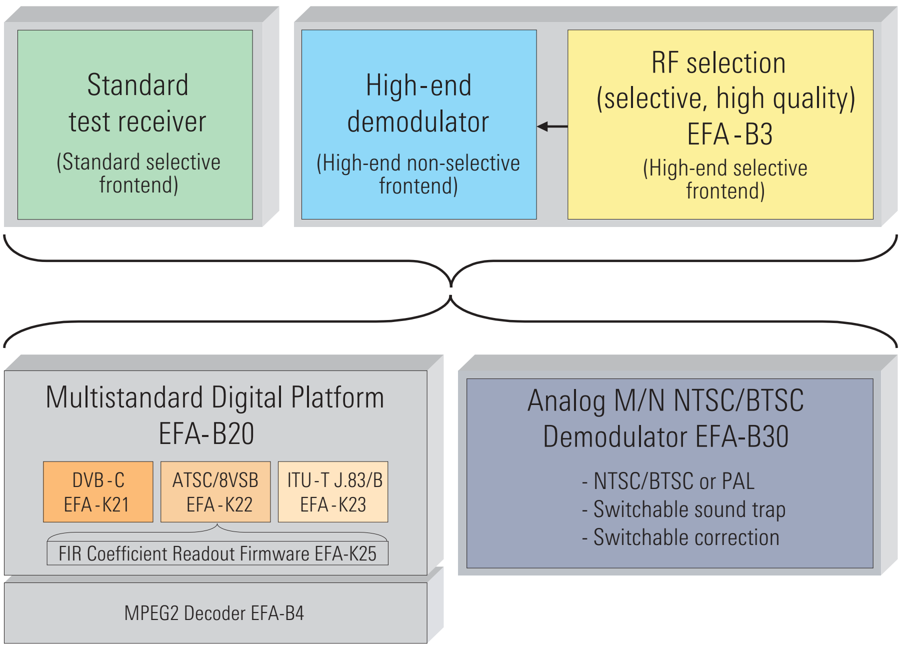
ATSC/8VSB demodulator
(options EFA-B20 + EFA-K22)

– In cable networks, this is handled by the QAM demodulator option for the

ITU-T J.83/B standard
(options EFA-B20 + EFA-K23) or
DVB-C standard
(options EFA-B20 + EFA-K21)

– For baseband analysis, the SDTV MPEG2 analyzer/decoder (option EFA-B4) rounds off the EFA product line.

EFA model selection concept



The EFA Family

EFA — realtime signal analysis

EFA's powerful digital signal processing provides fast and thorough analysis of the received digitally modulated TV 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 video and audio reproduction.

Due 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 and as yet unequalled time. Because of its high-speed data acquisition, the TV Test Receiver EFA is the ideal choice not only for R&D but also for production environments where short measurement cycles are essential.

Standard test receiver (EFA models 50/70/90)

- 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 (EFA models 53/73/93)

- 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 (EFA models 53/73/93 + 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

Block diagram of TV Test Receiver EFA

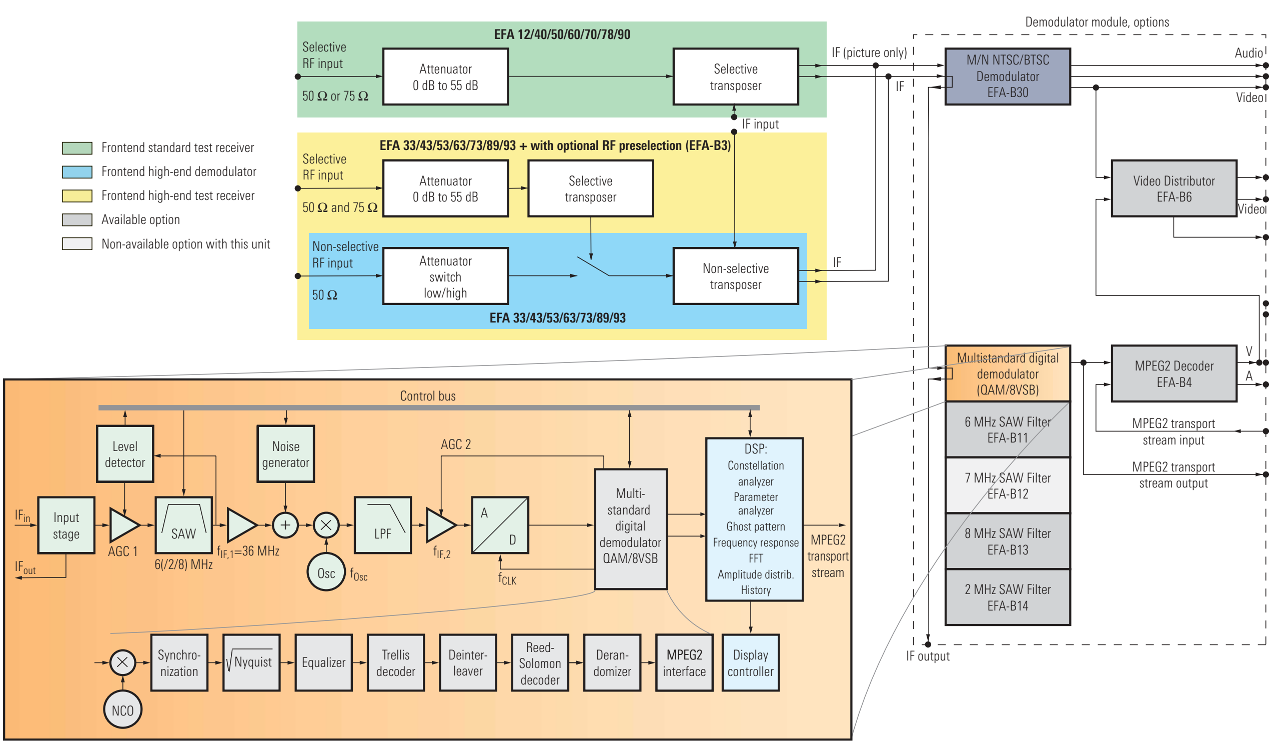


Table of available EFA models & options

			Standard test receivers				High-end demodulators				High-end test receivers				
		Models	50	60	70	90	53	63	73	93	53	63	73	93	Slot needed
Option	Designation	Order No.	8VSB	DVB-C	J.83/B	M/N	8VSB	DVB-C	J.83/B	M/N	8VSB	DVB-C	J.83/B	M/N	
EFA-B3	RF Preselection	2067.3627.02	–	–	–	–	❍	❍	❍	❍	◆	◆	◆	◆	1
EFA-B4	MPEG2 Decoder	2067.3633.02	–	❍	❍	❍ 1)	–	❍	❍	❍ 1)	–	❍	❍	❍ 1)	1
EFA-B6	Video Distributor	2067.3656.02	–	–	–	–	❍ 3)	❍ 3)	❍ 3)	❍	❍ 3)	❍ 3)	❍ 3)	❍	0
EFA-B11	6 MHz SAW Filter	2067.3691.00	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	0
EFA-B13	8 MHz SAW Filter	2067.3579.03	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	0
EFA-B14	2 MHz SAW Filter	2067.2562.00	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	0
EFA-B20	Digital Demodulator Platform	2067.3585.02	✔	✔	✔	❍ 2)	✔	✔	✔	❍ 2)	✔	✔	✔	❍ 2)	1
EFA-B30	M/N NTSC/BTSC Demodulator	2067.3556.02	❍	❍	❍	✔	❍	❍	❍	✔	❍	❍	❍	✔	1
EFA-K21	DVB-C / J.83/A/C (QAM) Firmware	2067.4000.02	❍	✔	❍	❍	❍	✔	❍	❍	❍	✔	❍	❍	0
EFA-K22	ATSC/8VSB Firmware	2067.4017.02	✔	❍	❍	❍	✔	❍	❍	❍	✔	❍	❍	❍	0
EFA-K23	J.83/B Firmware	2067.4023.02	❍	❍	✔	❍	❍	❍	✔	❍	❍	❍	✔	❍	0
EFA-K25	FIR Coefficient Readout Firmware	2067.4046.02	❍ 4)	❍ 4)	❍ 4)	❍ 4)	❍ 4)	❍ 4)	❍ 4)	❍ 4)	❍ 4)	❍ 4)	❍ 4)	❍ 4)	0
ZZT-314	Carrying Bag for 19" units, 3 HU	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-B20 is built in.

2) Must be ordered with min. one firmware option (EFA-K21 or EFA-K22 or EFA-K23).

3) Requires EFA-B4 or EFA-B30

4) Requires models EFA.50/53 or option EFA-B20 + EFA-K22

Common to all models

- In-depth measurement capabilities
- Simple, user-friendly operation
- Modular design — easy retrofitting of options
- Alarm messages for measurement functions, internal storage
- IEC/IEEE-bus and RS-232-C interface

Digital options

Digital Demodulator Platform EFA-B20

- Retrofit of analog instruments
- Multistandard demodulator platform supporting DVB-C demodulation (with EFA-K21), ATSC/8VSB demodulation (with EFA-K22), ITU-T J.83/B demodulation (with EFA-K23)
- Included in basic EFA 50/53/60/63/70/73 models
- MPEG2 transport stream output (serial or parallel)
- General measurement functions for
  - RF input level
  - carrier frequency offset
  - bit rate offset
  - BER (before and after Reed-Solomon)

MPEG2 Decoder EFA-B4

- MPEG2 syntax analysis according to DVB standard
- SDTV decoding, 625L or 525L supported, SDI output, PAL / SECAM / NTSC video out

6 MHz SAW Filter EFA-B11

- Adjacent-channel rejection
- Meets US requirements

8 MHz SAW Filter EFA-B13

- Adjacent-channel rejection
- Meets European and US standards, recommended for spectrum measurements

2 MHz SAW Filter EFA-B14

- Adjacent-channel rejection
- Meets channel return requirements (in cable applications)

DVB-C Firmware EFA-K21

- Analysis, demodulation and monitoring of DVB-C signals according to ETS 300 429 standard
- Included in basic EFA 60/63 models

ATSC/8VSB Firmware EFA-K22

- Analysis, demodulation and monitoring of ATSC/8VSB signals according to ATSC Doc. A/53
- Included in basic EFA 50/53 models
- Additional SMPTE310M MPEG2 TS output

ITU-T J.83/B Firmware EFA-K23

- Analysis, demodulation and monitoring of American digital cable signals according to ITU-T J.83/B standard
- Included in basic EFA 70/73 models

FIR Coefficient Readout Firmware EFA-K25

- Calculation of FIR filter coefficients for linear precorrection of digital signals
- Only available for the ATSC/8VSB models

Analog option

M/N NTSC/BTSC Demodulator EFA-B30

- Meets FCC requirements (group delay correction)
- Switchable sound trap
- Switchable group delay correction
- Switchable synchronous or envelope detector
- Integrated BTSC/MTS decoder
- Retrofit of digital instruments

ATSC/8VSB

EFA models 50/53 – all measurement functions for ATSC digital TV standard

EFA 50/53 characteristics

The ATSC/8VSB Test Receiver EFA, fully compatible with the ATSC Doc. A/53 standard, receives, demodulates, decodes and analyzes 8VSB (eight-level vestigial sideband) signals. All key parameters for demodulating the received signal can be automatically or manually selected:

- 8VSB modulation
- Trellis decoder (code rate 2/3)
- Fixed symbol rate for normal use (10.762238 Msymbols/s)
- Variable symbol rate for special modulator tests and lab analysis (2 Msymbols/s to 11 Msymbols/s)
- Reed-Solomon error correction 207/187/10
- Optional SAW filter bandwidths: 6 MHz, 8 MHz and 2 MHz
- Input of any IF frequency with the aid of the EFA-B3 option: frequency range continuously tunable from 5 MHz to 1000 MHz
- Special function: invert spectrum feature

Features

The new test receiver, even the basic version, features a wide range of innovative measurement functions, allowing comprehensive, in-depth signal analysis. In addition to measuring general parameters (Fig. 1) such as bit error ratio (BER), more thorough analysis includes:

- I/Q constellation diagrams (Fig. 2) with user-selectable number of symbols to be displayed, range: 1 to 999 999 999 symbols
- Frequency spectrum, including automatic shoulder attenuation measurement to FCC recommendation (Fig. 3),
- Complex channel transmission function (Fig. 4)
- Received echo signals (ghost pattern, Fig. 5)
- Histogram I (Fig. 6) with user-selectable number of symbols to be displayed, range: 1 to 999 999 999 symbols
- Modulation error ratio (MER), error vector magnitude (EVM), phase jitter and signal-to-noise ratio (Fig. 7)
- Linearity analysis from amplitude distribution histogram and CCDF referred to the RF signal (Figs 8 and 9)
- History function: long-term monitoring of transmission parameters (Fig. 10)
- Alarm monitoring window (Fig. 11) and alarm statistics (Fig. 12)
- Permanent MPEG2 transport stream demodulation (independent from the selected measurement task)
- Integrated noise generator

Any failures and degradations are immediately visible in the constellation diagram. Effects of interest can be located more precisely by varying the number of symbols represented. The integrated spectral analysis function enables simple examination of the signal type and its spectrum. One can see immediately, for example, whether there is a marked frequency offset, or if the pilot carrier level matches the specification. An optional filter with 8 MHz channel bandwidth covers spectral components outside the 6 MHz user channel while effectively suppressing more distant components. The shoulder attenuation according to the FCC recommendation can be measured with this optional 8 MHz SAW filter.

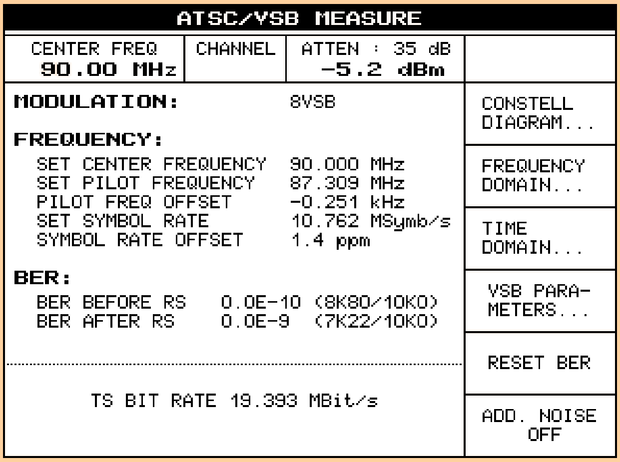


Fig. 1: Measurement menu

All parameters for the demodulated ATSC/8VSB channel are displayed on a single screen and can be checked at a glance:

– Level of the input signal
– Two BERs (bit error ratio) — before and after Reed-Solomon decoder — provide a fast quality overview of the demodulated signal
– Pilot frequency offset
– Symbol rate offset

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

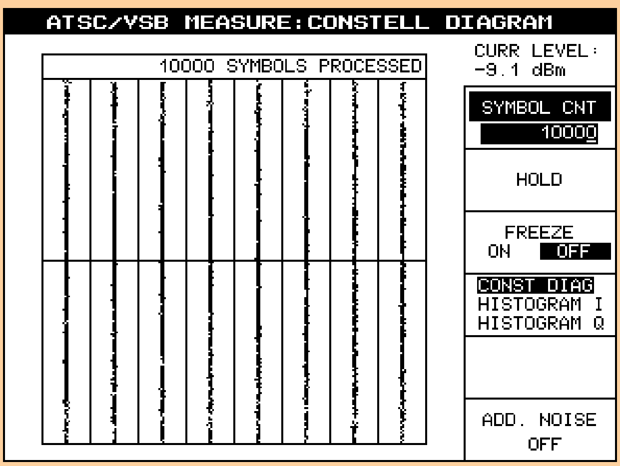


Fig. 2: Constellation diagram

The constellation diagram is always the best way to represent digital modulation. It is also the best visual tool for interpreting measurement results such as pilot amplitude error. For in-depth analysis, adjustment of the displayed number of symbols is possible (10 000 symbols are shown in this example).

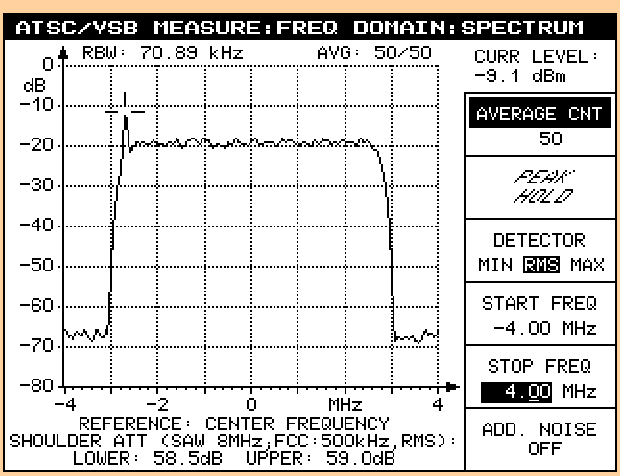


Fig. 3: Spectrum analysis

Thanks to this integrated feature, a separate spectrum analyzer is not required anymore.

All basic spectrum analyzer functions are provided: start/stop frequency (or center/span) and several detection and averaging modes.

The automatic shoulder attenuation measurement (strictly compliant to FCC recommendations) makes checking the performance of any ATSC/8VSB transmitter a child's play.

Fig. 4: Amplitude and phase frequency response

The coefficients of the equalizer are used to display the amplitude and phase frequency response (shown here), the group delay (not shown here) and the polar plot representation.

In the 8VSB demodulation chain, the equalizer compensates for frequency, phase and delay degradation that may have been introduced during the 8VSB transmission. It is then easy for the EFA to output the amplitude response, phase response and group delay, displaying the equalizer coefficients over the frequency by means of FFT.

The polar plot representation — which is the complex representation of amplitude and phase — may also help to interpret very short echoes (that are difficult to visualize on the ghost pattern).

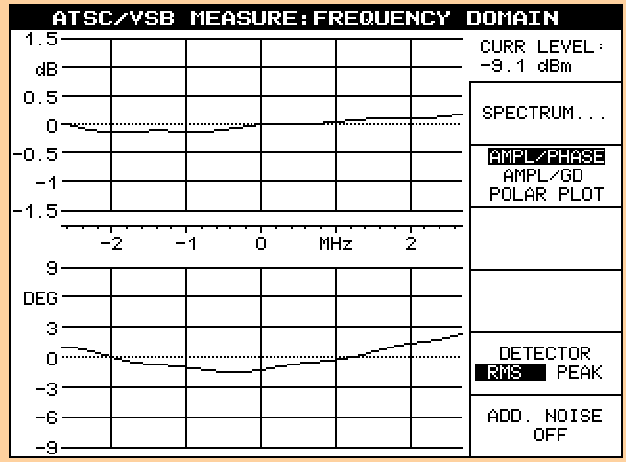


Fig. 5: Ghost pattern

The ghost pattern measurement allows the main ATSC/8VSB signal (0 dB relative), echoes and pre-echoes to be visualized and measured (numeric values).

The range function allows the visualization of the short echoes that may occur in urban areas (reflections from buildings).

The units of the X axis and of the numeric values can be changed from µs to km or even miles, depending on the application.

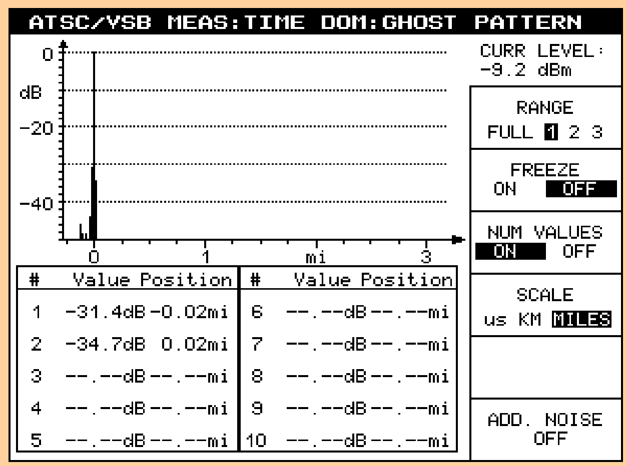
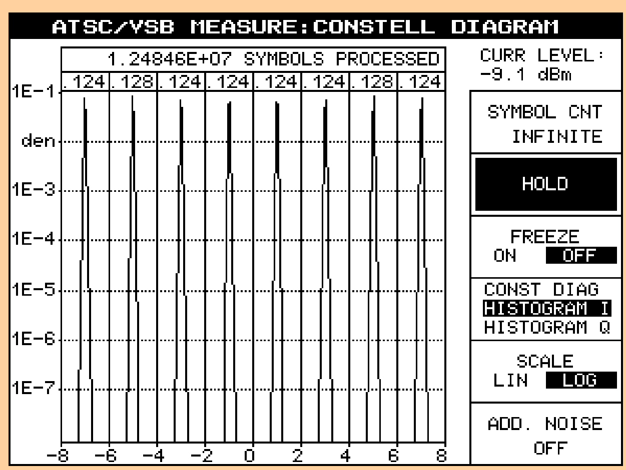


Fig. 6: Histogram I

Histogram I represents the distribution of the eight-level vestigial sideband modulation (8VSB) on the X axis, and can be expressed in a linear or logarithmic scale.

It allows an estimate of the interferer's origin (interferer, Gaussian noise, etc).

Hint: Check the position of the sync pulse (±5), and check the impact on the distribution.



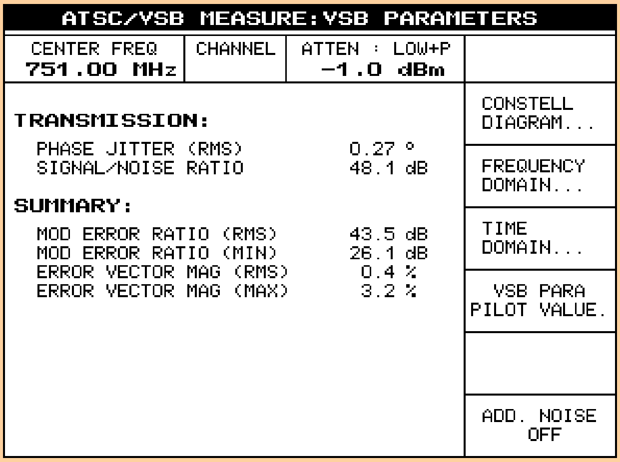


Fig. 7: 8VSB modulation parameters

All 8VSB parameters are calculated from the constellation diagram:

- Phase jitter
- Signal-to-noise ratio
- MER (modulation error ratio), RMS and Min
- EVM (error vector magnitude), RMS and Max...

... and the pilot parameters (not shown here):

- Pilot value
- Data signal to pilot ratio
- Pilot amplitude error

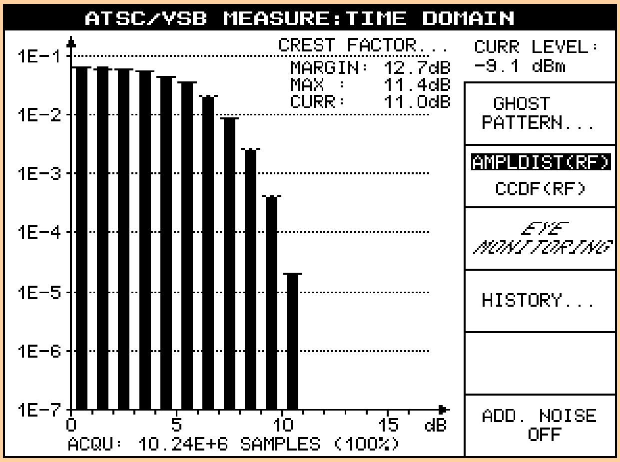


Fig. 8: Amplitude distribution function

The measurement function for displaying the amplitude distribution or the CCDF (complementary cumulative distribution function) is used to detect nonlinear distortion.

The frequency distribution of the 8VSB 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.

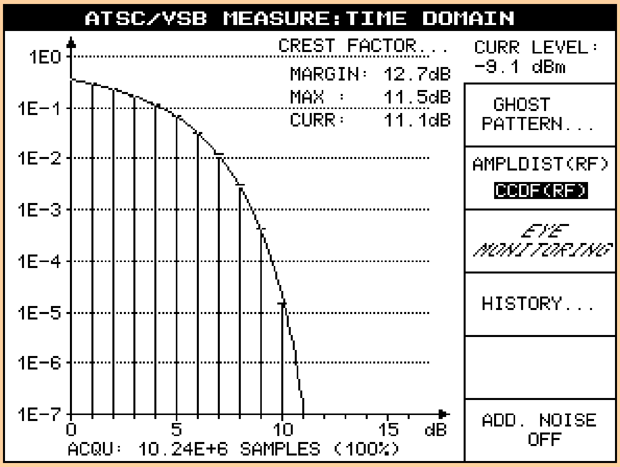


Fig. 9: Complementary cumulative distribution function (CCDF)

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 8VSB 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.

ATSC/8VSB

Fig. 10: History function

This measurement is just what is required for long-term ATSC/8VSB transmitter monitoring and does not require any additional tools.

The key parameters (level, synchronization information, MER/dB, MER/%, EVM/%, BER before and after Reed-Solomon decoder, synchronization and MPEG2 TS data error) 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. The user can configure a monitoring interval from 60 seconds (shown here) to 1000 days.

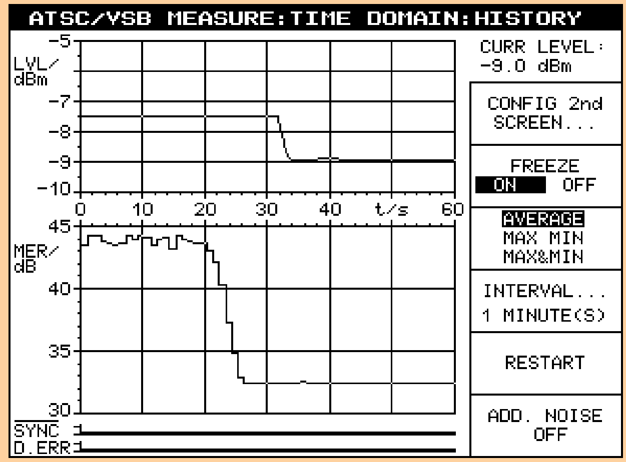
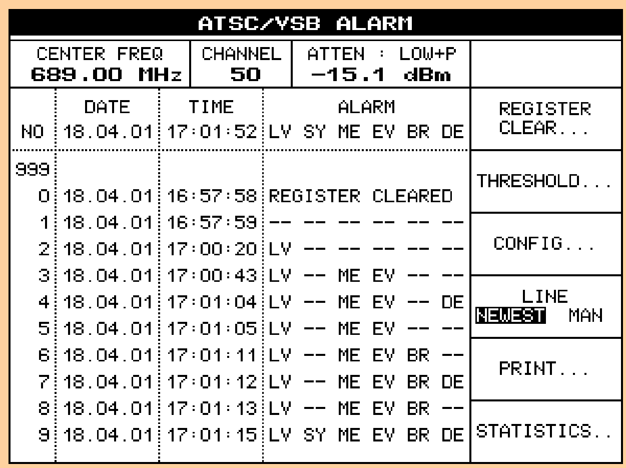


Fig. 11: Monitoring/Alarm register

The EFA checks the input level (LV), 8VSB synchronization (SY), modulation error ratio (ME), error vector magnitude (EM), bit error ratio before Reed-Solomon decoder (BR) and MPEG2 data errors (DE) of the 8VSB signal at a rate of once per second.

All alarm messages are stored in the alarm register together with the date and time.

Up to 1000 entries can be stored.



ATSC/VSB ALARM

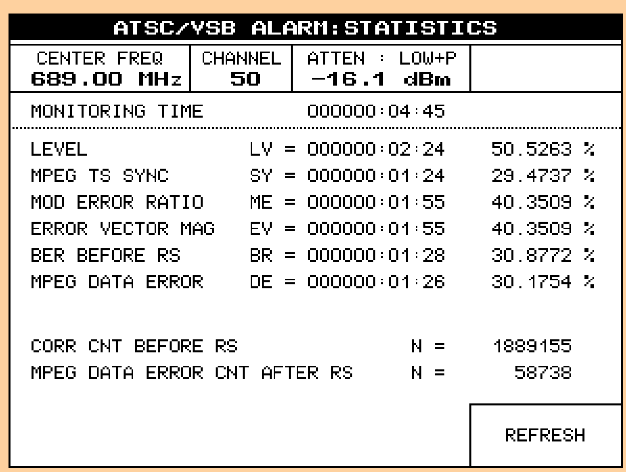
CENTER FREQ 689.00 MHz | CHANNEL 50 | ATTEN : LOW+P −15.1 dBm

NO	DATE 18.04.01	TIME 17:01:52	ALARM LV SY ME EV BR DE
999			
0	18.04.01	16:57:58	REGISTER CLEARED
1	18.04.01	16:57:59	-- -- -- -- -- --
2	18.04.01	17:00:20	LV -- -- -- -- --
3	18.04.01	17:00:43	LV -- ME EV -- --
4	18.04.01	17:01:04	LV -- ME EV -- DE
5	18.04.01	17:01:05	LV -- ME EV -- --
6	18.04.01	17:01:11	LV -- ME EV BR --
7	18.04.01	17:01:12	LV -- ME EV BR DE
8	18.04.01	17:01:13	LV -- ME EV BR --
9	18.04.01	17:01:15	LV SY ME EV BR DE

REGISTER CLEAR... / THRESHOLD... / CONFIG... / LINE NEWEST MAN / PRINT... / STATISTICS..

Fig. 12: Statistics function

The alarm messages can be called up at a keystroke (in the alarm menu), providing the user with an overview of downtimes.



ATSC/VSB ALARM:STATISTICS

CENTER FREQ 689.00 MHz | CHANNEL 50 | ATTEN : LOW+P −16.1 dBm

MONITORING TIME 000000:04:45

LEVEL	LV =	000000:02:24	50.5263 %
MPEG TS SYNC	SY =	000000:01:24	29.4737 %
MOD ERROR RATIO	ME =	000000:01:55	40.3509 %
ERROR VECTOR MAG	EV =	000000:01:55	40.3509 %
BER BEFORE RS	BR =	000000:01:28	30.8772 %
MPEG DATA ERROR	DE =	000000:01:26	30.1754 %

CORR CNT BEFORE RS N = 1889155

MPEG DATA ERROR CNT AFTER RS N = 58738

REFRESH

Typical applications

EFA-ATSC/8VSB for production of modulators and transmitters

The EFA's analysis capabilities permit in-depth testing of the transmitter's performance thanks to the outstanding MER/EVM dynamic range, amplitude distribution measurement and spectrum analysis - integrating the automatic shoulder attenuation measurement according to FCC recommendations.

Monitoring of ATSC/8VSB transmitters and transposers

The EFA is the perfect solution for monitoring ATSC/8VSB signals. An alarm is triggered if one of the selected parameters exceeds the set threshold (all thresholds can be individually configured): incident level, ATSC/8VSB synchronization, MER (modulation error ratio), EVM (error vector magnitude), BER before Reed-Solomon decoder and MPEG2 TS data error can be checked in realtime independently of other measurements and decoding. If an error occurs, a 1000-line register is available for recording the date, time and description of the event.

EFA ATSC/8VSB as relay receiver

For this special application, the EFA is simply optimized for reception at a keystroke — adding a special filter in order to remove any analog M/N co-channel interferers. This allows reception even under adverse operating conditions. The user is also able to configure the bandwidths of the main amplitude- and phase-controlled loops.

EFA as a multistandard digital and analog platform

Since the analog terrestrial standard M/N is still in use, and broadcasters need a future-proof solution for their short- and long-term investment based on an EFA ATSC/8VSB receiver, an analog M/N NTSC/BTSC demodulator can optionally be implemented. It covers all application areas from R&D to field measurements. Furthermore, to protect your investment, the unit can be updated by means of options to demodulate and analyze the ITU-T J.83/B and DVB-C digital cable standards. These unique features make the new EFA family members THE measurement devices for the present and the future.

Summary of measurements required for the various ATSC/8VSB applications

ATSC/8VSB application	Level	BER	MER/EVM	SNR	Pilot parameters	Phase jitter	Constellation diagram	Frequency spectrum - shoulder attenuation	Amplitude (f) - phase (f) - group delay (f)	Amplitude distribution - CCDF	Ghost pattern	History	Alarm	Statistics
Production of modulators and transmitters	✔	✔	✔	✔	✔	✔	✔	✔	✔	!	✔	✔		
Transmitter installation	✔	✔	✔		✔		✔	!	✔			✔		
Coverage measurement of terrestrial signals	✔	!	✔				✔	✔			✔	✔	✔	✔
Monitoring of TV transmitters and transposers	✔	✔	✔		✔		✔			✔	✔	!	✔	✔
Research and development	✔	✔	!	✔	✔	✔	✔	✔	✔	✔	✔	✔		
Service	✔	✔	✔	✔	✔	✔	!	✔	✔	✔		✔	✔	✔

! most important measurement ✔ required measurement

ITU-T J.83/B

EFA models 70/73 – all measurement functions for ITU-T J.83/B digital CATV standard

Besides the deployment of the worldwide digital terrestrial TV network and the already established digital video broadcasting over satellite, digital cable TV still represents an alternative for many consumers worldwide. Additionally, cable technology provides a return channel within the same physical layer (coax cable), allowing the consumer to send back information to the cable headend for versatile applications (full Internet access, video-on-demand and more). The boundary between data communications and TV networks has never been so narrow!

EFA 70/73 characteristics

Fully compatible with the ITU-T J.83/B standard, the EFA 70/73 models receive, demodulate, decode and analyze 64 QAM or 256 QAM (quadrature amplitude modulated) signals. All key parameters for demodulating the received signal can be automatically or manually selected:

- 64 QAM or 256 QAM modulation
- Trellis decoder (code rate 14/15 for 64 QAM and 19/20 for 256 QAM)
- Fixed symbol rate for normal use (5.056941 Msymbols/s for 64 QAM and 5.360537 Msymbols/s for 256 QAM)
- Variable symbol rate for special modulator tests and lab analysis (1 Msymbols/s to 6999 Msymbols/s)
- Reed-Solomon error correction 128/122/3
- Optional SAW filter bandwidth: 6 MHz, 8 MHz and 2 MHz
- Input of any IF frequency with the aid of the EFA-B3 option: frequency range continuously tunable from 5 MHz to 1000 MHz
- Special function: invert spectrum feature

Features

The new test receiver, even the basic version, features a wide range of innovative measurement functions, allowing comprehensive, in-depth signal analysis. In addition to measuring general parameters (Fig. 13) such as bit error ratio (BER), more thorough analysis includes:

- I/Q constellation diagrams (Fig. 14) with user-selectable number of symbols to be displayed, range: 1 to 999 999 999 symbols
- I/Q parameters, modulation error ratio (MER), error vector magnitude (EVM), phase jitter and signal-to-noise ratio (Fig. 15)
- Frequency spectrum (Fig. 16)
- Complex channel transmission function (Fig. 17)
- Received echo signals: echo pattern (Fig. 18)
- Histogram I (Fig. 19) and Q (Fig. 20) with user-selectable number of symbols to be displayed, range: 1 to 999 999 999 symbols
- Linearity analysis from amplitude distribution histogram and CCDF referred to the RF signal (Figs 21 and 22)
- History function: long-term monitoring of transmission parameters (Fig. 23)
- Alarm monitoring window (Fig. 24)

Any failures and degradations are immediately visible from the constellation diagram. Effects of interest can be located more precisely by varying the number of symbols represented. The integrated spectral analysis function enables simple examination of the signal type and its spectrum.

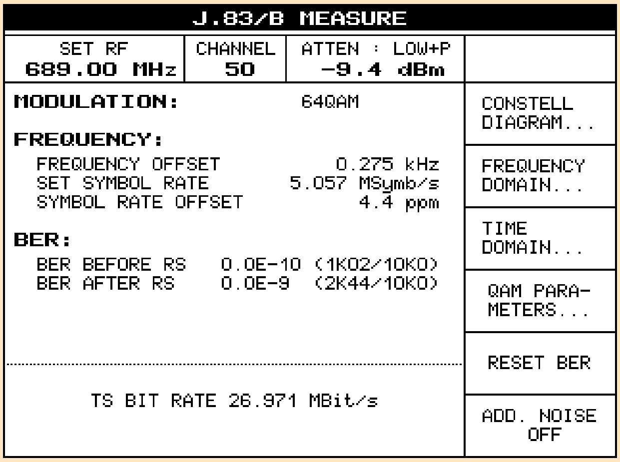


Fig. 13: Measurement menu

All parameters for the demodulated ITU-T J.83/B channel are displayed on a single screen and can be checked at a glance:

– Level of the input signal
– Two BERs (bit error ratio) — before and after Reed-Solomon decoder — provide a fast quality overview of the demodulated signal
– Demodulated symbol rate
– Symbol rate offset

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

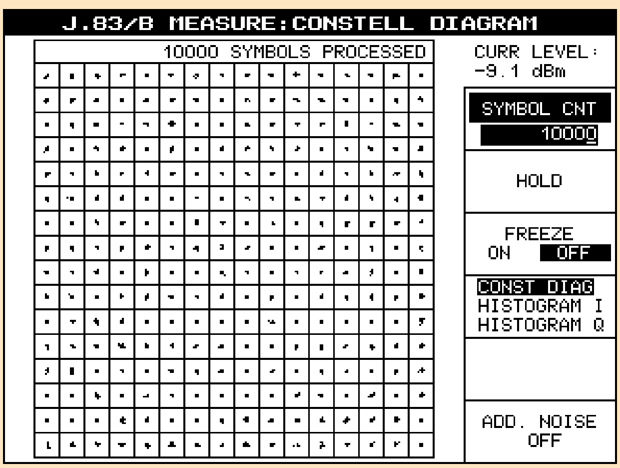


Fig. 14: Constellation diagram

The constellation diagram is always the best way to represent digital modulation. It is also the best visual tool for interpreting measurement results like I/Q amplitude imbalance or carrier suppression. For in-depth analysis, adjustment of the displayed number of symbols is possible (10 000 symbols are shown in this example).

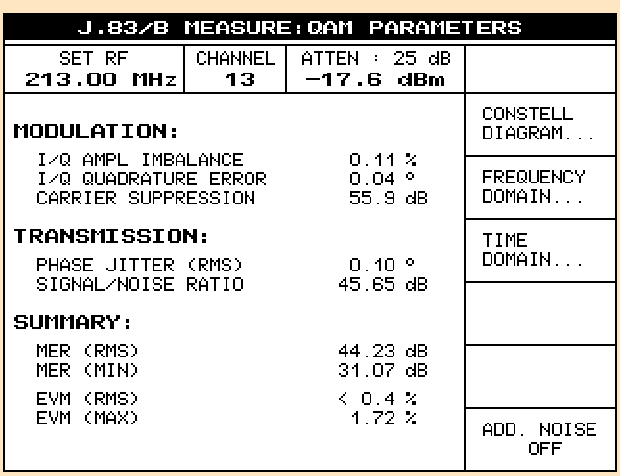


Fig. 15: QAM modulation parameters

All QAM parameters are calculated from the constellation diagram:

– I/Q amplitude imbalance
– I/Q phase error
– Carrier suppression
– Phase jitter
– Signal-to-noise ratio
– MER (modulation error ratio), RMS and Min
– EVM (error vector magnitude), RMS and Max

ITU-T J.83/B

Fig. 16: Spectrum analysis

Thanks to this integrated feature, a separate spectrum analyzer is not required anymore.

All basic spectrum analyzer functions are provided: start/stop frequency (or center/span) and several detection and averaging modes.

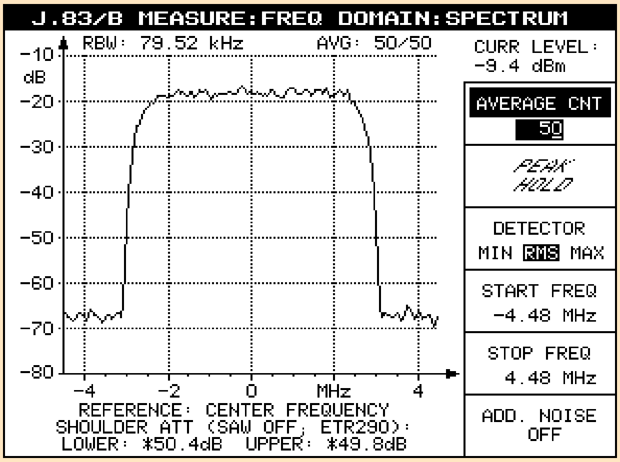


Fig. 17: Amplitude and phase frequency response

The coefficients of the equalizer are used to display the amplitude and phase frequency response (shown here), the group delay (not shown here) and the polar plot representation.

In the ITU-T J.83/B demodulation chain, the equalizer compensates for frequency, phase and delay degradation that may have been introduced during the QAM transmission. It is then easy for the EFA to output the amplitude response, phase response and group delay, displaying the equalizer coefficients over the frequency by means of FFT.

The polar plot representation — which is the complex representation of amplitude and phase — may also help to interpret very short echoes (that are difficult to visualize on the echo pattern).

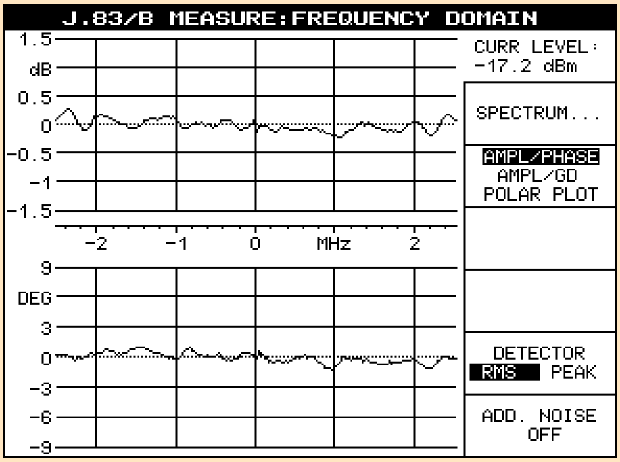
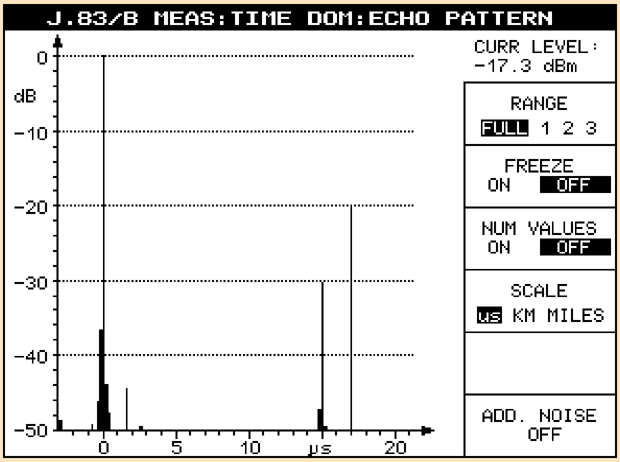


Fig. 18: Echo pattern

The echo pattern measurement allows the main QAM signal (0 dB relative), echoes and pre-echoes to be visualized and measured (numeric values).

The range function allows the visualization of the reflections.

The units of the X axis and of the numeric values can be changed from µs to km or even miles, depending on the application.



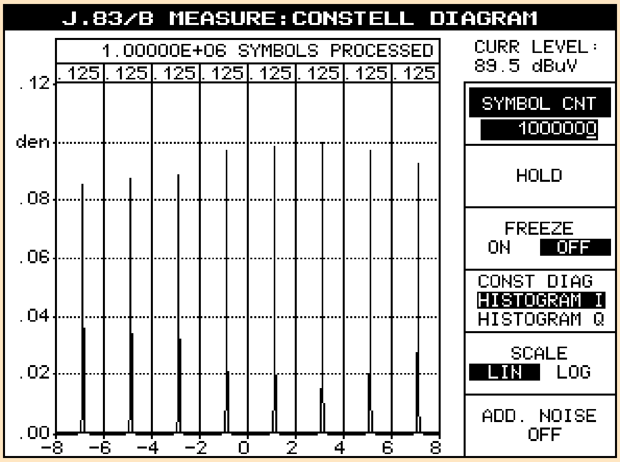


Fig. 19: Histogram I

Histogram I represents the distribution of the quadrature amplitude modulated (QAM) signal on the X axis (I for inphase), and can be expressed in a linear or logarithmic scale.

It allows an estimate of the interferer's origin (interferer, Gaussian noise, etc). Linear scaling is used in this plot.

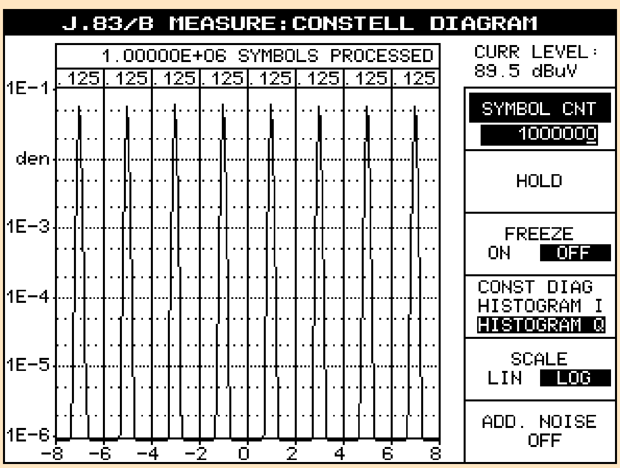


Fig. 20: Histogram Q

Same representation as Fig. 15 — but referring to the distribution of the Q component projected on the X axis (Q for quadrature). Logarithmic scaling is used in this plot.

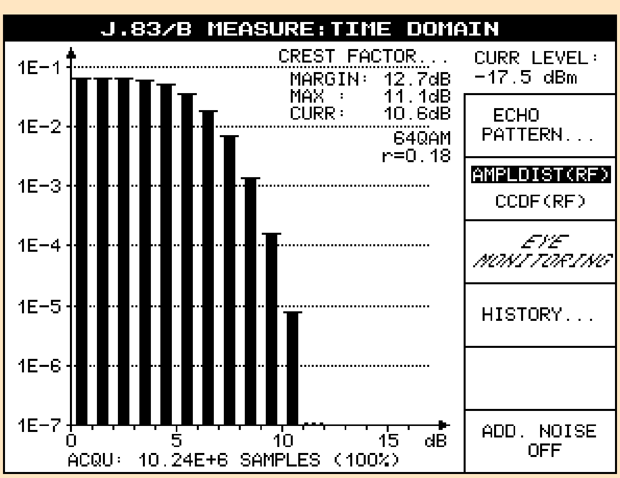


Fig. 21: Amplitude distribution

The measurement function for displaying the amplitude distribution or the CCDF (complementary cumulative distribution function) is used to detect nonlinear distortion.

The frequency distribution of the QAM 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. 22: 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 QAM 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 modulator output stage.

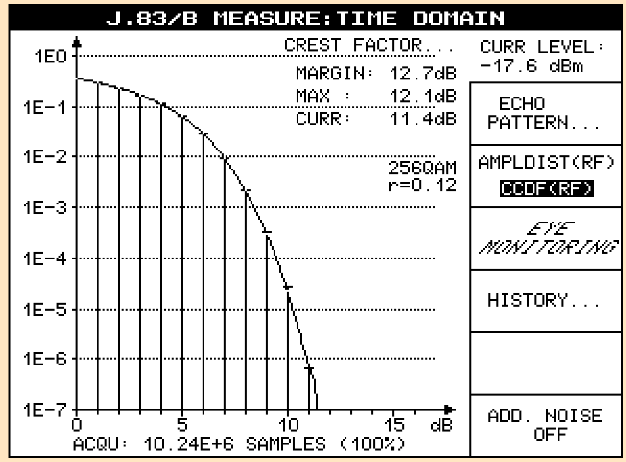


Fig. 23: History function

This measurement is just what is required for long-term ITU-T J.83/B modulator monitoring in cable headends, and does not require any additional tools.

The key parameters (level, synchronization information, MER/dB, MER/%, EVM/%, BER before and after Reed-Solomon decoder and MPEG2 TS data error) 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.

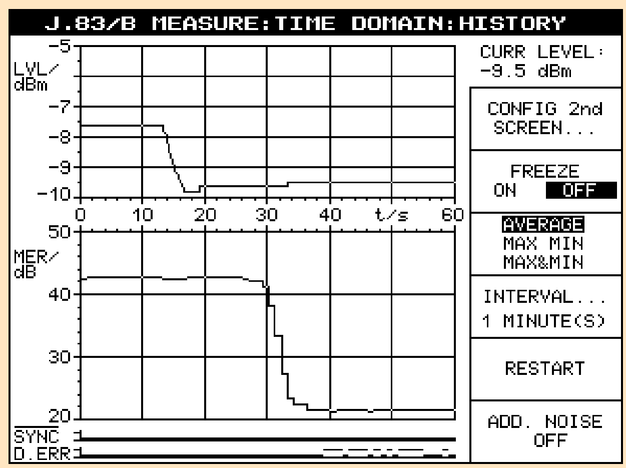
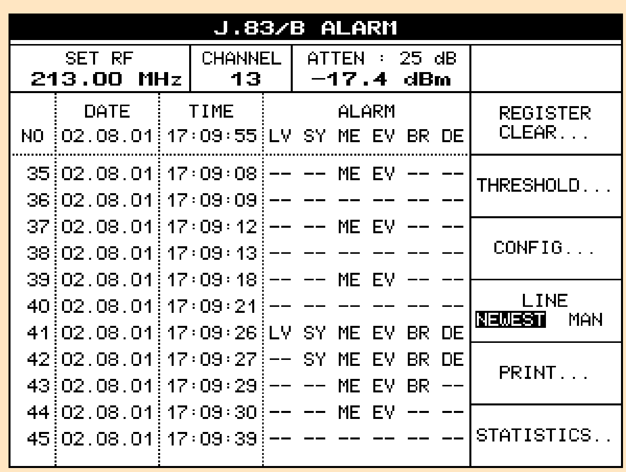


Fig. 24: Monitoring/Alarm register

The EFA checks the input level (LV), QAM synchronization (SY), modulation error ratio (ME), error vector magnitude (EV), bit error ratio before Reed-Solomon decoder (BR) and MPEG2 data errors (DE) of the ITU-T J.83/B signal at a rate of once per second.

All alarm messages are stored in the alarm register together with the date and time.

Up to 1000 entries can be stored.



Typical applications

EFA for production of modulators

The EFA's analysis capabilities permit in-depth testing of the cable modulator's performance thanks to the outstanding MER/EVM dynamic range, amplitude distribution measurement and spectrum analysis. Another feature is the Equalizer ON/FREEZE/OFF function, which is mandatory during the alignment phase of the modulators. Finally, the high accuracy and repeatability of the measurements makes the EFA ideally suited for the production of QAM modulators.

Cable headend monitoring

The capability of the EFA to handle multichannel reception with the spectrum measurement and the history functions (graphical measurement representation versus time) permit the unit to monitor cable headends. In addition, an alarm is triggered if one of the selected parameters exceeds the set threshold (all thresholds can be individually configured). Incident level, QAM synchronization, MER (modulation error ratio), EVM (error vector magnitude), BER before Reed-Solomon decoder and MPEG2 TS data error can be checked in realtime independently of other measurements and decoding. If an error occurs, a 1000-line register is available for recording the date, time and description of the event.

EFA in research and development laboratories

Thanks to the high-quality frontend design, the dynamic range of the modulation error ratio measurement (MER dynamic range better than 41 dB) allows the unit to be used as a reference demodulator in research and development laboratories.

EFA as a multistandard digital and analog platform

Since the analog standard M/N is still heavily in use, and broadcasters need a future-proof solution for their short- and long-term investment, an analog M/N NTSC/BTSC demodulator can optionally be implemented. It covers all application areas from R&D to cable headend measurements. Furthermore, to protect your investment, the unit can be updated by means of options to demodulate and analyze the ATSC/8VSB digital terrestrial and DVB-C digital cable standards. These unique features make the new EFA family members THE measurement devices for the present and the future.

Summary of measurements required for the various ITU-T J.83/B applications

ITU-T J.83/B application	Level	BER	I/Q parameters	SNR	Phase jitter	MER/EVM	Constellation diagram Histograms	Frequency spectrum	Amplitude (f) - phase (f) - group delay (f)	Amplitude distribution - CCDF	Echo pattern	History	Alarm	Statistics
Production of modulators	✔	✔	✔	✔	✔	!	✔	✔	✔	✔				
Cable headend monitoring	✔	✔				✔	✔	✔			✔	!	✔	✔
Research and development	✔	✔	✔	✔	✔	✔	!	✔	✔	✔	✔	✔		
Service	✔	✔	✔			✔	!	✔				✔	✔	✔

! most important measurement ✔ required measurement

EFA models 90/93 – new high-end M/N TV demodulator

Rohde & Schwarz provides a high-end measurement device that can cover all application areas from R&D to field measurements. This EFA model was created to offer the best performance and the most useful features to test standard M/N transmitters under optimal conditions. To accomplish this, a sound trap filter has been integrated in the unit as well as synchronous and envelope detectors, a BTSC audio decoder and additional features!

To further protect your investment, the unit can be updated by means of options to demodulate and analyze the upcoming digital TV standards ATSC/8VSB and ITU-T J.83/B. These unique features make the new EFA family members THE measurement devices for the present and the future!

EFA 90/93 characteristics

Fully compatible with the FCC standard, the EFA 90/93 models receive and demodulate any analog TV signals to standard M/N (NTSC/BTSC and PAL). All key parameters for demodulating the received signal can be automatically or manually selected:

- Switchable video bandwidth (sound trap)
- Switchable group delay correction
- Switchable envelope or synchronous (5 different modes) detector
- Demodulation using intercarrier method
- Balanced audio outputs
- Measurement functions for
  - vision/sound carrier power ratio
  - FM sound carrier and pilot deviation
- Measurement of video modulation depth and residual picture carrier
- Input of any IF frequency with the aid of the EFA-B3 option: frequency range continuously tunable from 5 MHz to 1000 MHz
- Special function: invert spectrum feature (with option EFA-B3)

Features

The EFA models 90/93 provide high-precision demodulated baseband signals (vision and sound) for measurements in various applications (TV transmitters, cable headends, coverage measurements, R&D). At the same time, all relevant RF parameters are measured at high speed and represented in a logically arranged way (Fig. 25). User-configurable alarm messages permit unattended monitoring of the received signals as well as switchover to alternative links in the event of a failure.

The high-end demodulator version is used for on-site measurements on TV transmitters. This version offers particularly low-distortion demodulation of the broadcast signal. It is perfectly suited for these types of measurements; its low measurement uncertainty permits optimal alignment as well as permanent quality control of the transmitter.

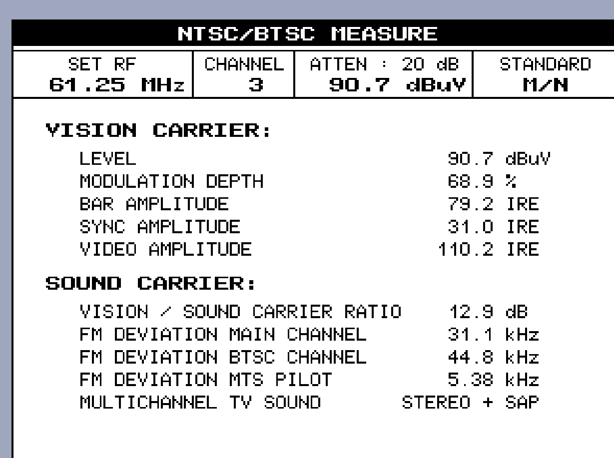


Fig. 25: Measurement window

All parameters for the demodulated standard M/N TV channel are displayed on a single screen and can be checked at a glance:

- Vision carrier level
- Video modulation depth
- Bar/sync/video amplitudes (expressed in IRE)
- Vision/sound level ratio
- Main and BTSC channel FM deviation
- FM deviation of MTS pilot
- Sound mode indication (Mono, Stereo, SAP)

Specification of intermodulation

In-channel distortion

In-channel distortion is determined by means of a modulated TV signal with a vision carrier (f_{VC}), a colour subcarrier (f_{SB}) and a sound carrier (f_{SC}). Modulation is chosen such that the vision carrier is lowered by 6 dB, the colour subcarrier by 14 dB and the sound carrier by 10 dB relative to the sync pulse level. The level of the intermodulation product is measured at the video output relative to the black-to-white transition of the video signal. Fig. 26 shows the signals involved and the reference level at the RF.

Out-of-channel distortion

The effect of signals outside the received channel is described by the 3rd-order intercept point (TOI). For the EFA family, this parameter is specified on the basis of a three-tone measurement with the following signals: a wanted carrier at the receive frequency f_{VC} and two unwanted carriers 14 MHz and 15 MHz above the receive frequency.

The unwanted frequencies are chosen to be within the bandwidth of the RF preselection but outside the bandwidth of the first IF filter. The effect of out-of-channel interference on the receiver can thus reliably be determined. It is assumed that each of the three signals has a level P = –33 dBm. The level of the intermodulation product ΔIM 1 MHz relative to the wanted carrier is measured (see Fig. 27, measurement at the RF). The 3rd-order intercept point is:

$$TOI/dBm = P/dBm + \frac{\Delta IM/dB}{2} + 3$$

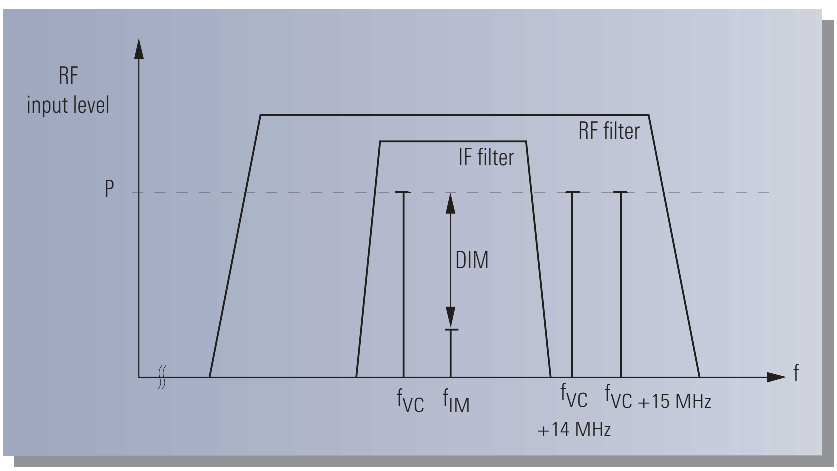


Fig. 26

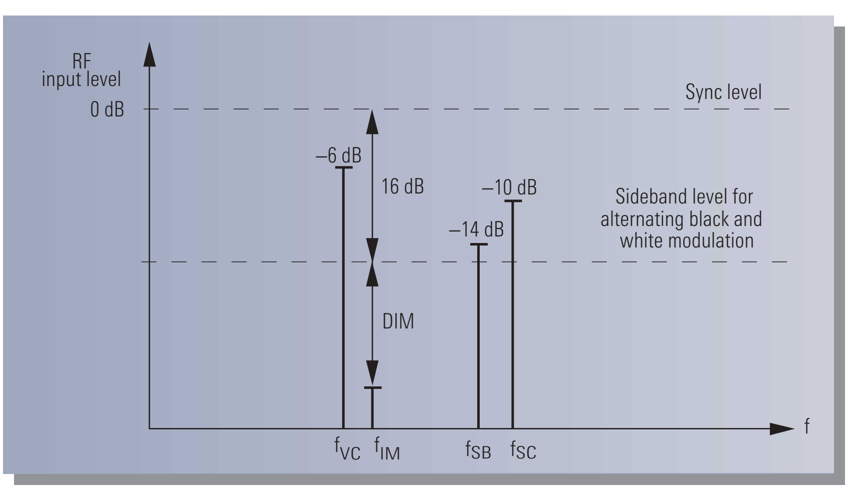


Fig. 27

Analog TV