1

Application Note: Analyskop EZF/EZFU 6 kHz - 2700 MHz

Automatic Frequency and Time Analysis

COUNTER READOUT for all frequ. ranges

Sweep width > 20 MHz: freq. of adjustable marker
Sweep width ≦ 20 MHz: adjusted freq. (centre marker)
High tuning accuracy and setting accuracy

FUNCTION SETTING

Modes: frequency domain · time domain
LIN (26 dB) or LOG (80 dB) amplitude display · AM/FM demodulator

Programming switch: parameter selection
Sweep width, resolution and sweep time are ganged ■ A warning lamp lights if a switch of the EZF is in a wrcng position

Sweep time
Left: for frequency domain mode · right (for time domain mode): stepwise and continuous 0.12 – 400 msec

Frequency range, 6 bands without change of plug-in

EZF input: 6 kHz – 1.3 MHz/60 kHz – 13 MHz/0.1 – 130 MHz/150 – 170 MHz
EZFU input: 30 – 1400 MHz/1300 – 2700 MHz
Continuous tuning over all EZF/EZFU bands on EZFU
EZF can be tuned with ⬭ plug-in crystal or ○ external oscillator
Input sensitivity 0.1 – 0.5 µV, depending on selected band
Well-defined overdriving of the analyzer up to the actual limit of measurement possible thanks to automatic identification of spurious products

Adjustable level line
Electronically superimposed, no recalibration required · setting of reference level

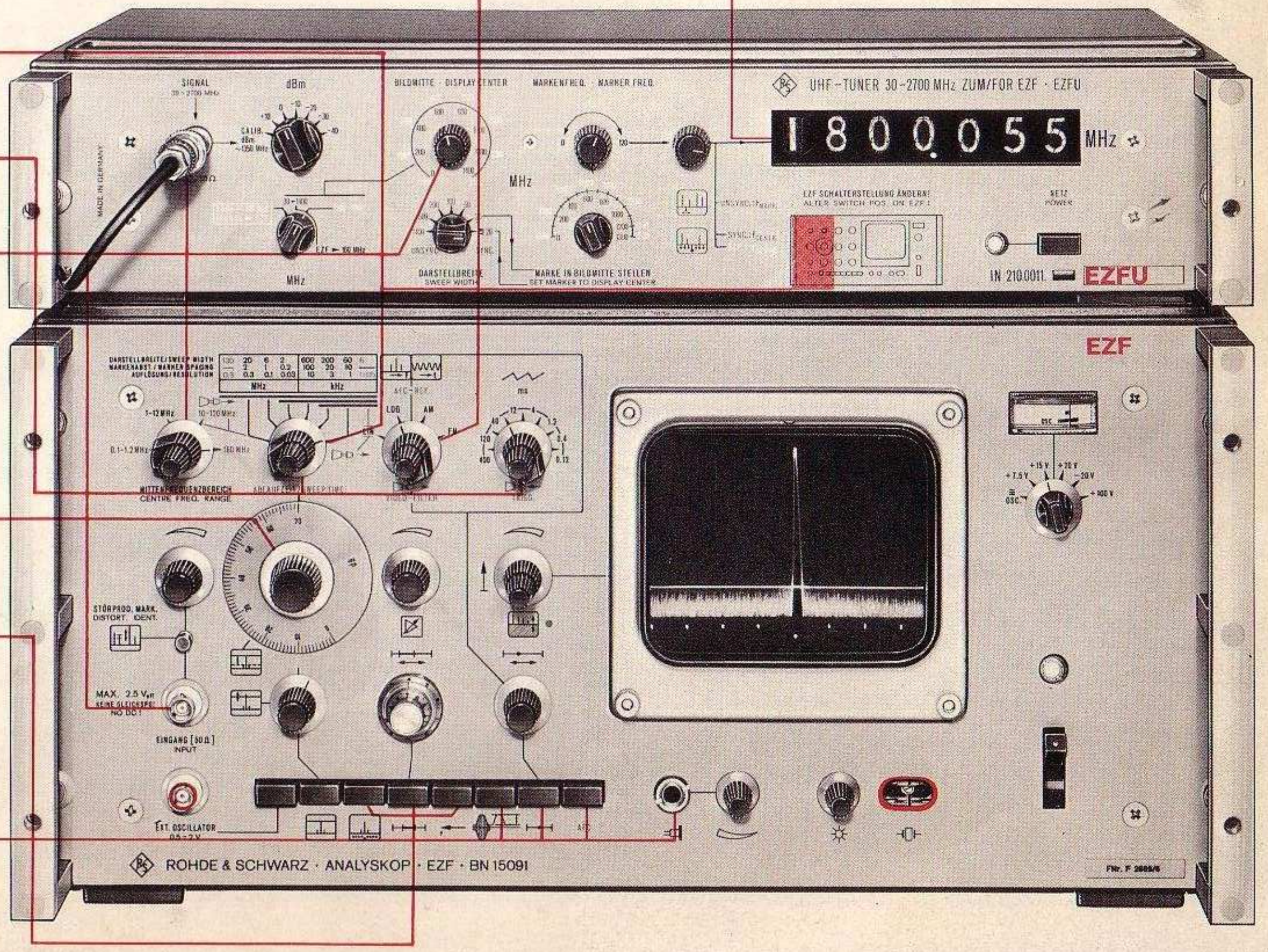
FREQUENCY DOMAIN MODE

Shifting of details · -reversal · -frequency markers

Shifting of subranges with crystal operation
Reversal of frequency axis – important for operation with a converter
Crystal-controlled linear frequency marker scale (interpolation possible)
Marker spacing ganged with sweep width · centre frequency marker is lower

TIME DOMAIN MODE

Sweep: stopped for display of modulation time function
Shiftable bright-up marker identifying the selected signal
Time display for AM and FM · aural monitoring of modulation content possible
Modulation-depth measurement · AFC, switch-selected video filter



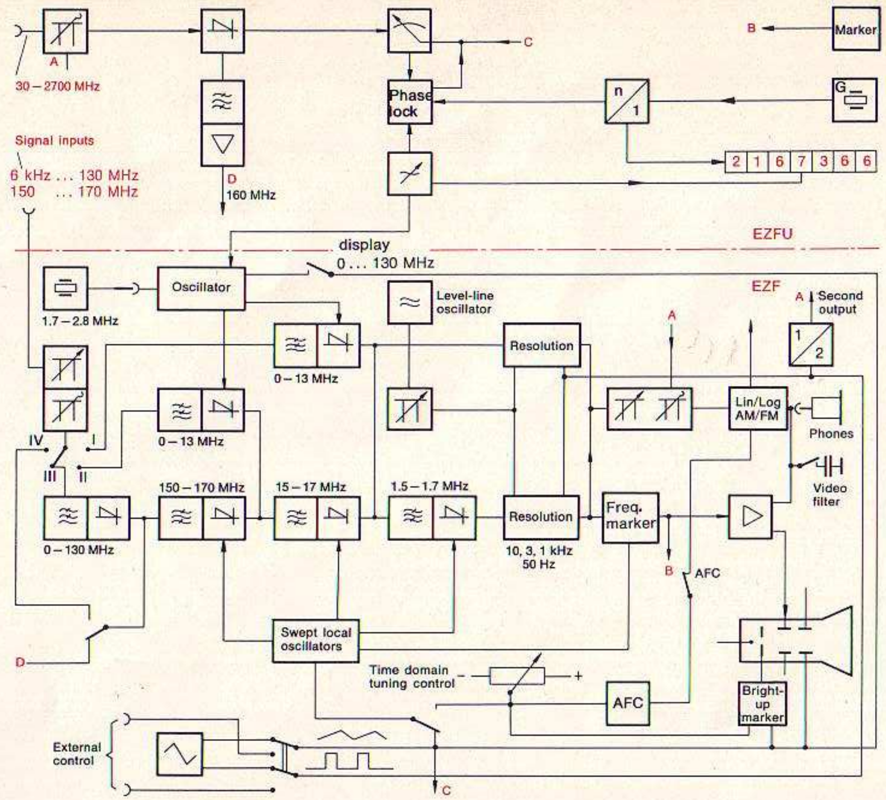
2

Principle-Uses

MEASUREMENT

Automatic analyzer with visual display of frequency and time functions
Distortion and noise measurements:
harmonic and intermodulation distortion; signal-to-noise ratio
noise and spurious signals
Modulation measurements:
modulation with AM, FM, PM; modulation depth, modulation frequency, pulse width, pulse repetition frequency
Laboratory measurements: Q's of resonant circuits
Radio monitoring:
station identification, checks on band occupation and out-of-band radiation

TEST ASSEMBLY

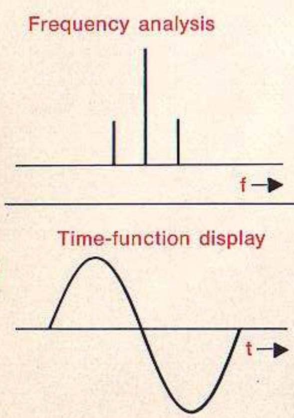


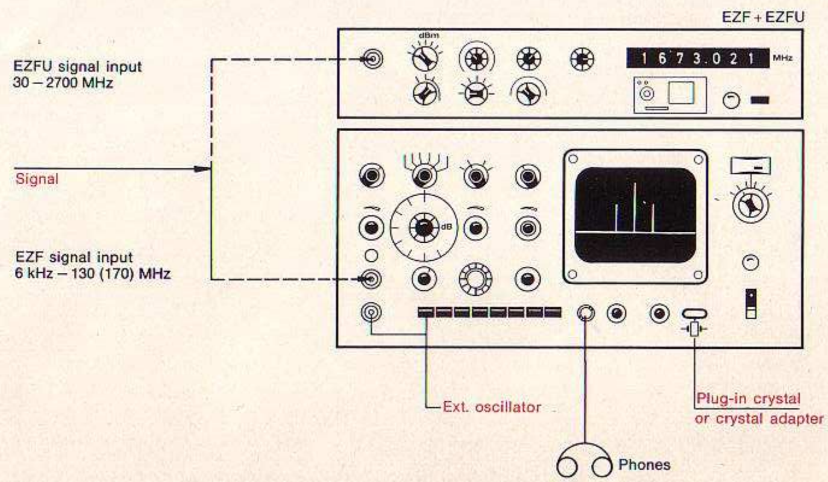
FEATURES

Low phase noise, high frequency accuracy due to crystal-controlled oscillator
Sharp-cutoff filters $B_{3\,dB}/B_{60\,dB} = 1/2.5$
Digital readout in the whole range of 6 kHz – 2.7 GHz
Automatic marking of inherent spurious products caused by overdriving
Operating errors are widely precluded
Time-domain display for AM and FM
Resolution (50 Hz – 300 kHz) ganged with sweep width
Superimposed frequency markers; level line adjustable with calibrated shift control
Built-in reference level generator
Operation from AC supply 50 – 400 Hz; 100 VA; battery operation possible

Setting EZF + EZFU

Hint for operation





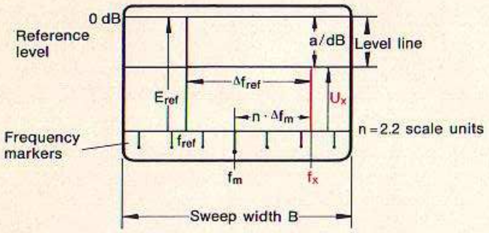
Frequency selection f→
Basic Unit EZF alone:
1st possibility: plug-in crystal or crystal adapter
2nd possibility: external oscillator
Basic Unit EZF + UHF Tuner EZFU (3rd possibility)
Frequency setting on EZFU for all subranges from 6 kHz to 2.7 GHz
Seven-digit frequency readout with automatic shifting of decimal point
Sweep width selection
EZF alone: max. 130 MHz · EZF + EZFU: max. 1400 MHz, min. 6 kHz
Spectrum evaluation: see applications

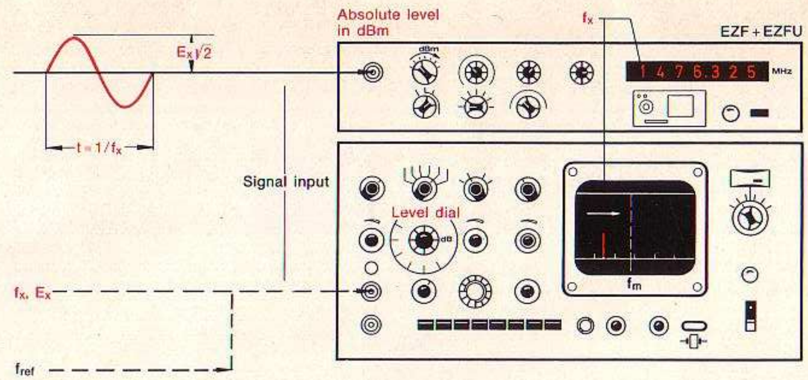
t→
Select the desired signal in the spectrum with the bright-up marker
Select the desired type of modulation (AM, FM)
The demodulated signal is displayed as a function of time
The modulation content can simultaneously be monitored via headphones

Frequency and Amplitude Measurement

Measurement of signal frequency and amplitude

Evaluation of pattern, methods 1 b, 2 a





Frequency measurement

1. Reference: centre-frequency marker f_m

a) Most subtle method using EZF/EZFU combination: bring signal f_x to coincide with centre frequency f_m, reduce sweep width B stepwise to obtain the desired resolution. Read frequency f_x on counter

b) Without EZFU counter. Read from the screen display (see diagram in the left column): $f_x = f_m\,(\pm)\,n\,\Delta f_m$

2. Reference: reference signal f_{ref}; a) read from the screen display (see diagram in the left column): $f_x = f_{ref}\,(\pm)\,\Delta f_{ref} = f_{ref} + m\,\Delta f_m$

b) Zero-beat method: $f_x \rightarrow f_{ref}$

Amplitude ratio

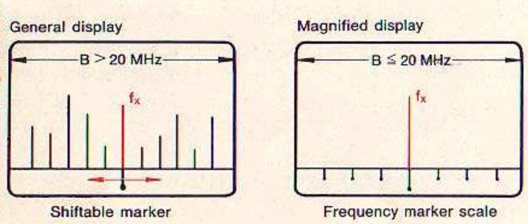
Absolute in dB_m: direct on EZFU attenuator

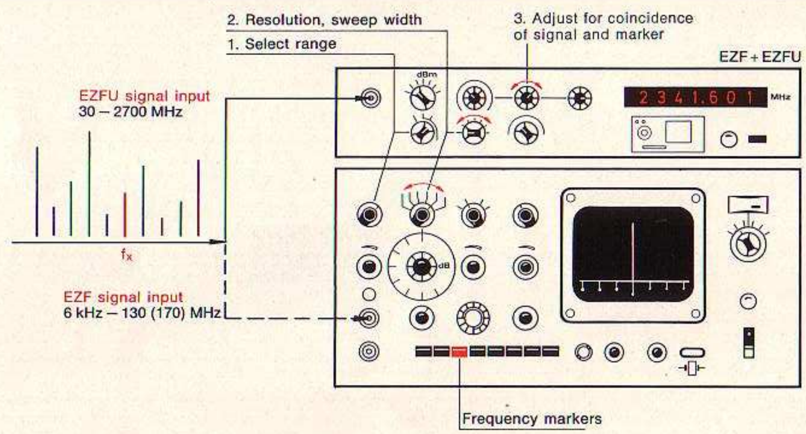
Relative: the level reading "a" in dB (on level dial) is used to calculate the voltage ratio

$$\frac{E_x}{E_{ref}} = 10^{\frac{-a}{20}} \quad \text{or power ratio} \quad \frac{P_x}{P_{ref}} = 10^{\frac{-a}{10}}$$

Selective frequency measurement with:

several simultaneous signals, low signal levels, modulated test signals





High tuning accuracy and counter resolution

Counter resolution EZF: 10 Hz/ – /1 kHz depending on subrange EZF/EZFU: 1 kHz

Advantage over direct-reading frequency meter: individual frequency components of a spectrum can be exactly selected and measured

Measurement (see diagrams in the left column)

General display: coarse location of signal

Reduce sweep width stepwise to obtain the desired reading accuracy, e. g. B = 60 kHz; accuracy ± 10 kHz at max. 2.7 GHz

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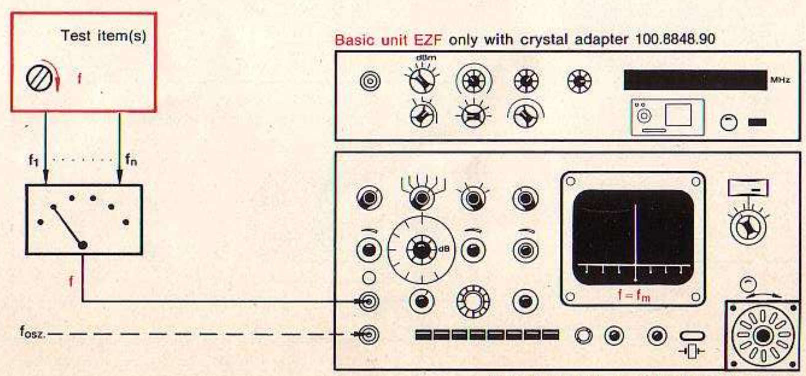
Measurements at fixed frequencies

Typical applications in test departments:

- IF measurement/adjustment of radiotelephone receivers
- Video signal: vision and sound carriers, colour subcarrier

Long-term frequency recording



Crystal adapter, complete with 12 crystals

Easy setting and rapid changing of nominal frequency ($f_{nom} = f_m$) with the selector switch of the crystal adapter allows short checking and adjusting times. Max. 12 crystal frequencies ($f_Q = k \times f_m$) can be selected; k = 1, 0.1, 0.01, depending on range

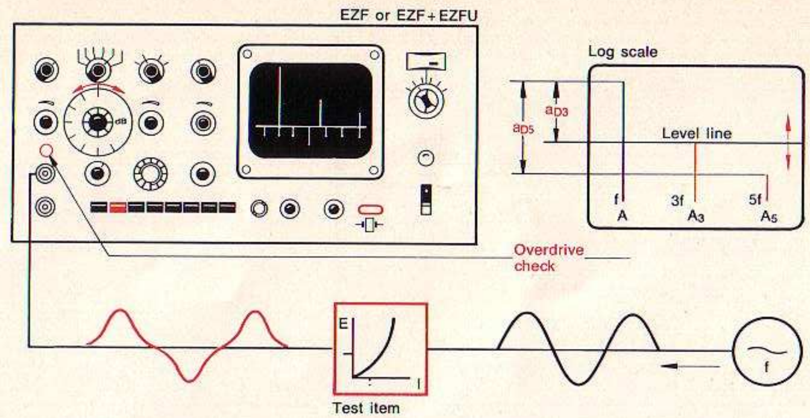
Dashed in the diagram: second possibility of fixed-frequency tuning, with highly stable external oscillator f_{osc}; suitable for precise long-time frequency recording (EZF + recorder)
The EZF + EZFU combination allows continuous tuning by EZFU with digital readout

Harmonic Measurement

MEASUREMENT / TEST ASSEMBLY / FEATURES

Measurement of harmonic ratio and distortion factor (single-tone method)

Example: range up to 130 MHz



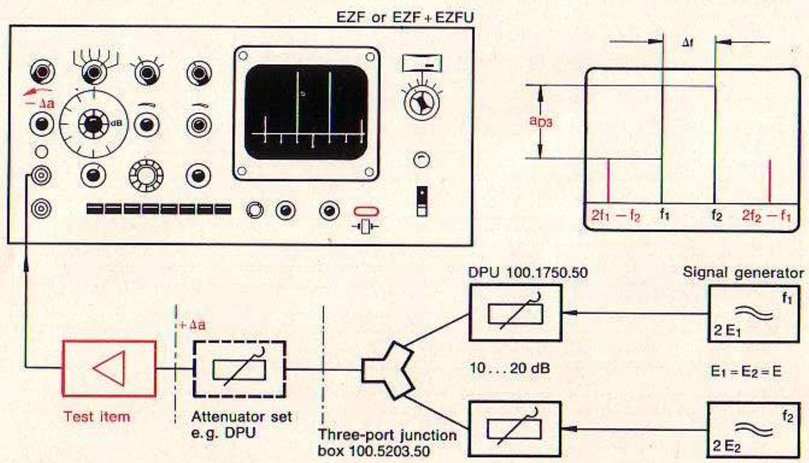
At a glance: amplitudes and distribution of harmonics
No switching of resolving bandwidth when changing from LIN to LOG display (sharp-cutoff filters)
Harmonic ratio a_{Dn} can be directly measured with calibrated adjustable level line
Definition: $a_{Dn}/dB = -20 \log D_n$
Distortion factor of individual component: $D_n \approx A_n/A$

Overdriving does not lead the user to misinterpret the display: inherent spurious products are displayed with half the sweep frequency; their amplitude A_n changes by n dB according to the order n when the OVERDRIVE CHECK button is depressed ($\Delta A_3 = -3$ dB; $\Delta A_5 = -5$ dB; etc.)

Measurement of intermodulation distortion ratio a_{dn}
(signal amplitude* $E_1 = E_2 = E$)
The method is particularly suitable for selective test items when signal frequency and interference frequency are close to each other

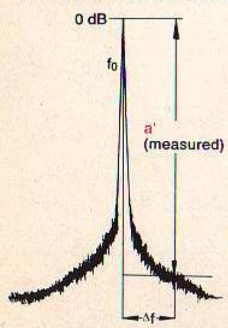
Example: intermodulation distortion ratio a_{d3} (3rd-order intermodulation product) of an amplifier

* For the intermodulation method: $E_1 > E_2$



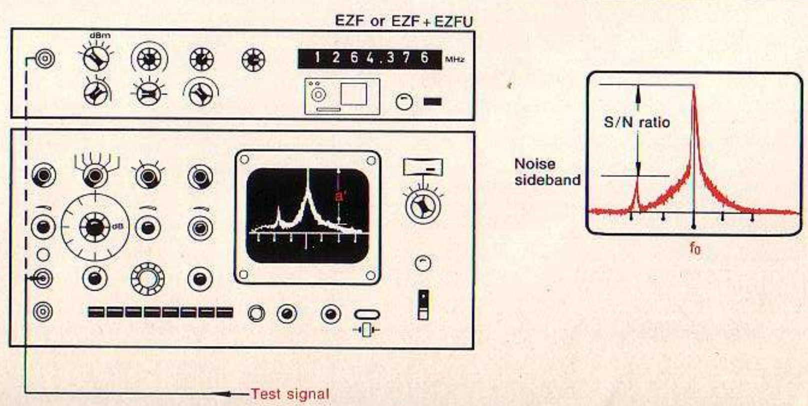
Short sweep time with high selectivity
Hint for setting: sweep width 60 kHz, resolution 1 kHz, $f_2 - f_1 \geq 10$ kHz
Take the reading at $a_{d3}/dB = -20 \log d_3$
Test hint: When the test item has a broadband input, connect a lowpass filter into the signal path to suppress the generator harmonics $2f_1$ ($2f_2$)
Poor decoupling of the signal generator results in intermodulation distortion ahead of the test item: upon variation of the attenuator setting, a_{d3} remains constant
If a_{d3} test item $> a_{d3}$ analyzer ($>$70 dB, automatic check), extension of dynamic range by accurately defined overdriving of test item
Relation: with a linear increase of the signal level Δa by n dB, a_{d3} decreases by 2n dB

Measurement of S/N ratio and noise sidebands



Definition
S/N ratio a' is measured in dB at distance Δf from signal f_0 with bandwidth B. Equivalent S/N ratio referred to 1 Hz bandwidth:

$$\frac{a}{dB/Hz} = \frac{a'}{dB} + 10 \log \frac{B}{Hz}$$



High inherent S/N ratio of internal oscillators: 110 – 130 dB/Hz at 10 kHz from f_0, depending on selected subrange

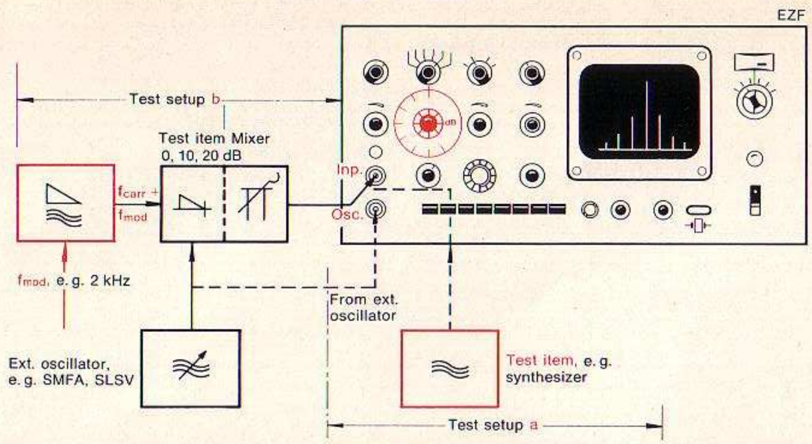
Example (for definition see Measurement column): resolution (bandwidth) B = 1 kHz, marker spacing Δf = 10 kHz, sweep time 0.6 sec. Measured S/N ratio a' = 70 dB
Equivalent S/N ratio:

$$\frac{a}{dB/Hz} = 70\ dB + 10 \log \frac{1000\ Hz}{1\ Hz} = (70 + 30)\ dB = 100\ dB$$

5

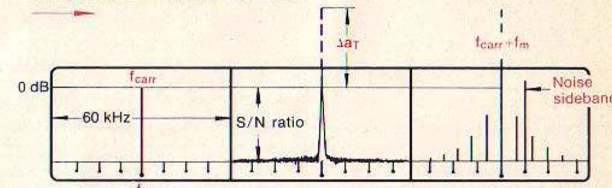
Measurement of extremely high S/N ratios; noise sidebands down 130 dB/Hz at 10 kHz from carrier

1. at 1 MHz (EZF with crystal adapter) or at 160 MHz (EZF only, no input oscillator operating)
2. test setup a, range 60 kHz – 13 MHz, 10 kHz – 130 MHz (EZF with low-noise external oscillator)
3. test setup b (EZF with Mixer Ident No. 111.8915.02 and external oscillator) for adjacent-channel measurement of radio-telephone systems



Test setup a is suitable for checking high-quality frequency sources for spectral purity in the range 10 kHz – 130 MHz
Test setup b allows analysis of noise sidebands, e.g. measurement of adjacent-channel cross-modulation

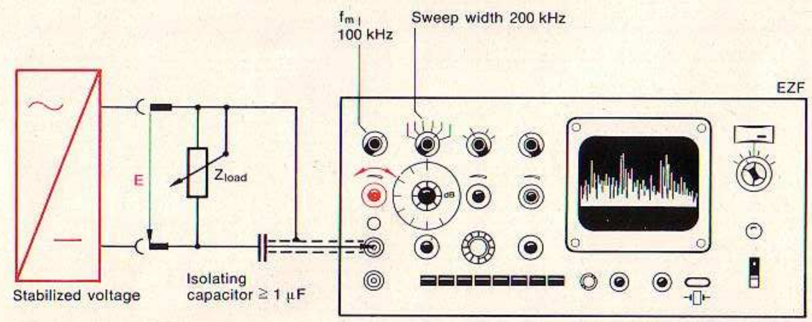
Schematic of measurement:



1. f_{carr} alone; calibrate signal level a_{carr}
2. f_{carr} alone; increase level a_{carr} by Δa_{carr}
3. $f_{carr} + f_{mod}$; measure spectral components in adjacent channel

Analysis of noise spectra in stabilized supply voltages

This analysis is particularly useful when a noise spectrum superimposed on a stabilized supply voltage risks to impair the performance of the circuit being operated (Z_{load}), e.g. a voltage-tuned oscillator

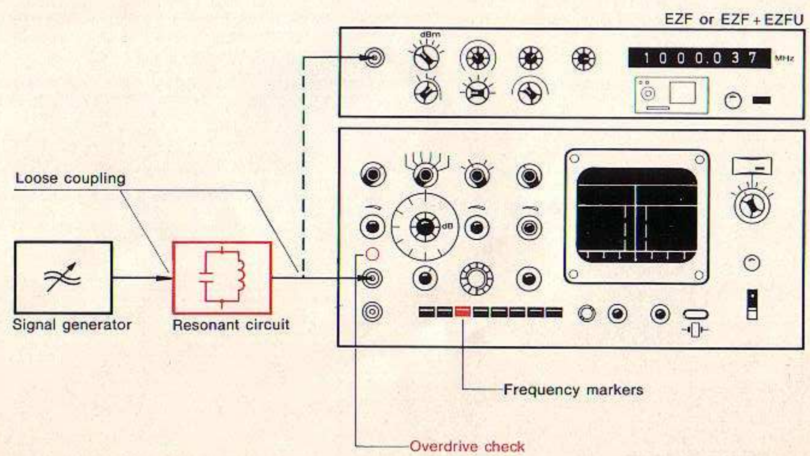


Full input sensitivity even at the lower frequency limit of 6 kHz thanks to low-noise oscillator
High selectivity with good noise bandwidth
Short sweep time

Note: Take care that the input control of the Analyskop is not set for full sensitivity when the test item is connected or disconnected, because of the resulting current surge!

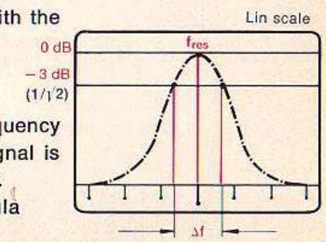
Q measurement

Precise Q measurement of resonant circuits ($Q > 1000$) in conjunction with a signal generator



A "by-product" of the automatic overdrive check facilitates the measurement: the 3-dB level-line jump. When the OVERDRIVE CHECK button is depressed, a double line representing the reference values 0 and −3 dB is displayed.

Measurement: Find maximum amplitude (f_{res}) and mark it with the 0 dB level line.
Switch overdrive check on.
(Double line 0/−3 dB.)
Vary signal generator frequency toward + and − until f signal is at the −3-dB line. Read Δf.
Calculate Q from the formula
$Q = f_{res}/\Delta f$

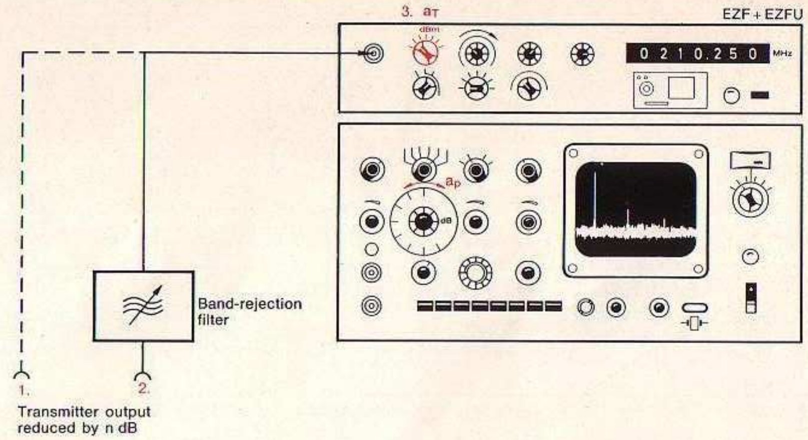


MEASUREMENT | TEST ASSEMBLY | FEATURES

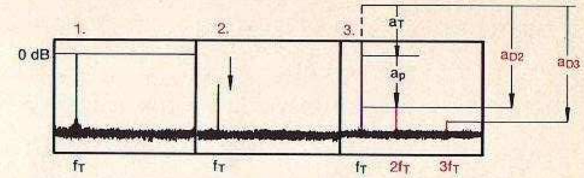
Measurement of harmonic radiation of broadcasting and TV transmitters up to 2.7 GHz

Example: TV transmitter for Band III, carrier power 20 kW
Permissible harmonic power ≦ 20 mW according to standard specifications

Harmonics measurements on Band V transmitters do not require a band-rejection filter since the fundamental and harmonics lie in different reception ranges of the Analyskop



High tuning accuracy allows harmonics measurements with small sweep width
Procedure →

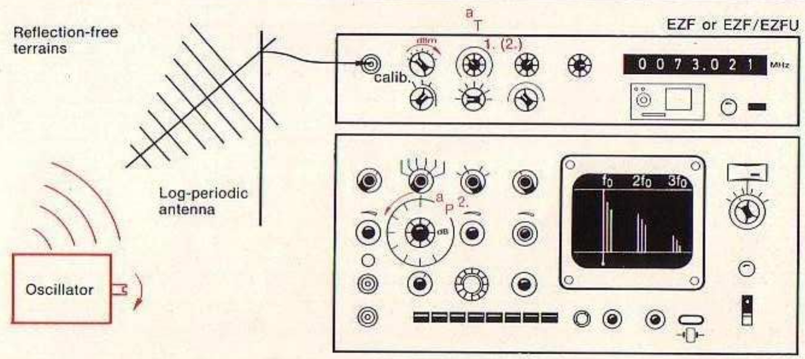


1. Adjust carrier alone to within level range of Analyskop
2. Tune band-rejection filter to carrier (carrier reduction ≈ 25 to 40 dB)
3. Reduce input attenuator by a_{carr}

Measure level ratio with level line
Example: Adjustment of attenuator $a_{carr} = -30$ dB, of level line $a_p = -36$ dB; $a_{D2} = a_{carr} + a_p = -66$ dB
With $P_{carr} = 20$ kW, harmonic power $P_{2carr} = 5$ mW

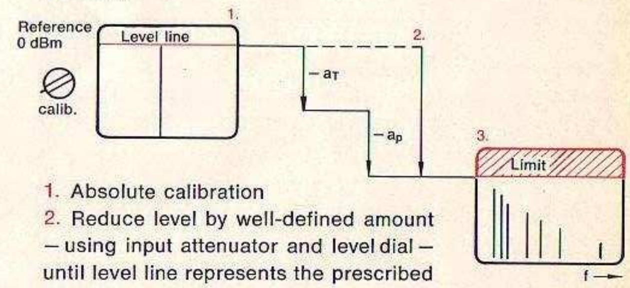
Reradiation measurement

Measurement of oscillator reradiation according to VDE 0871-9 (acceptance test)



Built-in standardizing oscillator for absolute level measurements in the range 30 – 2700 MHz

Procedure →



1. Absolute calibration
2. Reduce level by well-defined amount – using input attenuator and level dial – until level line represents the prescribed limit (e. g. – 46 dB)
3. Tune test item through range and observe display. The limit line must not be exceeded at any point

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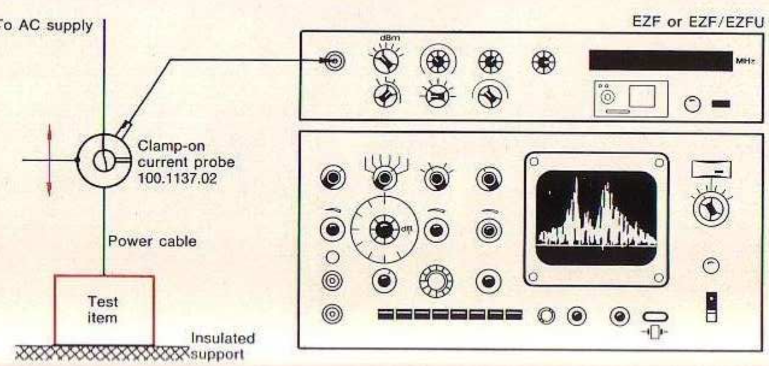
Direct measurement of spurious RF energy from 30 to 300 MHz transmitted from a (sine-wave) noise source through the power cable

Also: measurement of sheath currents in coaxial cables

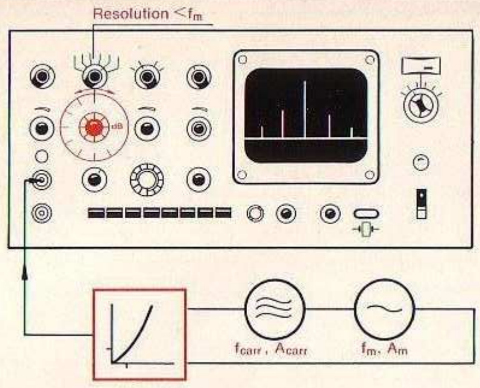


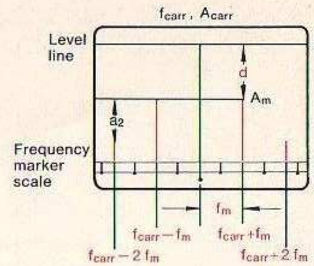
Adjust clamp-on current probe for maximum spurious energy
Weighted measurement of pulse interference is possible only by an integrating method

AM measurements on modulators

Suitable method: use of frequency spectrum for small modulation depths; using time domain mode for large modulation depths

Example: determination of small modulation depths from frequency spectrum of sinusoidal amplitude-modulated RF carrier





Modulation distortion directly measurable in dB below carrier amplitude by means of level line

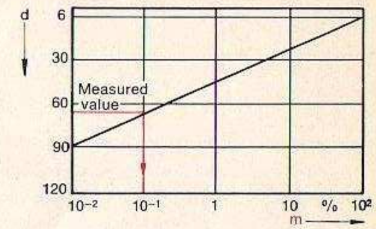
Modulation depth measurable down to $m = 0.02\,\%$

Example: measured $d = 66$ dB or $A_m/A_{carr} = 5 \times 10^{-4}$

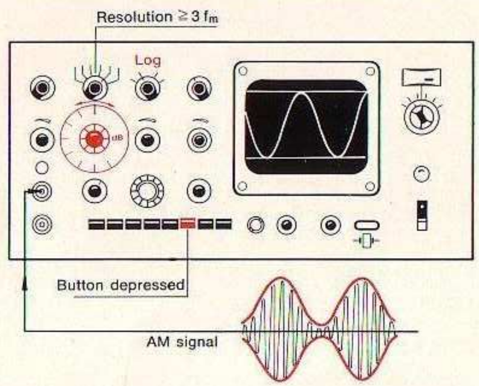
Calculation:

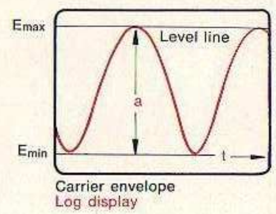
$$m = 10^{\frac{6-d}{20}} = \frac{2\,A_m}{A_{carr}} = 10^{-3} \text{ or } 0.1\,\%$$

General diagram



Example: determination of large modulation depths by the envelope method ($m > 0.9$)





Tracking level line for accurate measurement requiring no recalibration. The wide dynamic range of 70 dB allows modulation depths up to $m = 99.95\,\%$ to be measured.

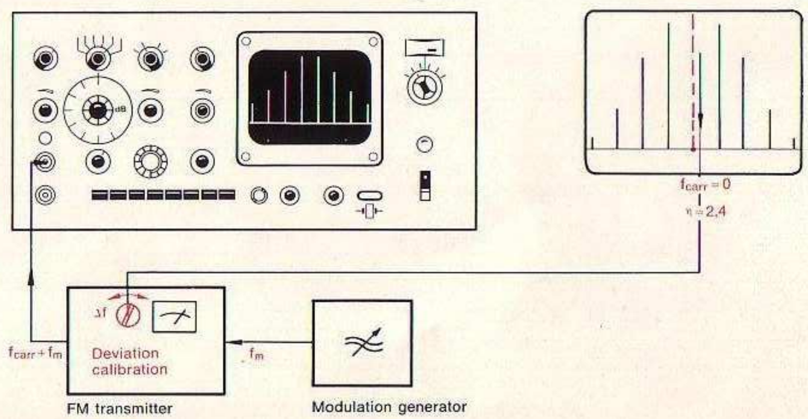
From the measured value a one calculates

$$\Delta x = E_{min}/E_{max} = 10^{-a/20};\quad m = \frac{1 - \Delta x}{1 + \Delta x} \approx 1 - 2\,\Delta x$$

Example: measured $a = 60$ dB; $\Delta x = 10^{-3}$ gives a modulation depth $m \approx 1 - 2 \times 10^{-3} \approx 0.998$ or $99.8\,\%$

FM measurement on signal generator

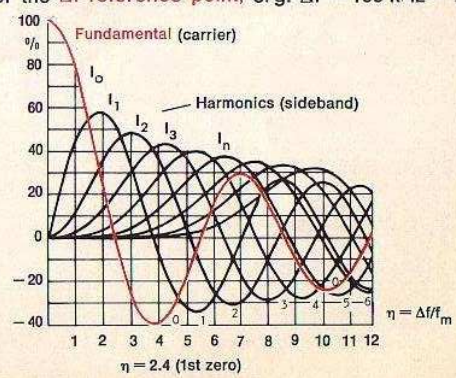
Deviation calibration of FM transmitter



Measurement: Take modulation index η from a zero of the Bessel function. Preferably choose 1st zero $\eta = 2.4$ of carrier since here the distortion of the modulation generator does not enter into the measurement

Calculate associated modulation frequency $f_m = \Delta f/\eta$ (Δf = predetermined deviation reference value) and adjust f_m. Vary deviation until carrier f_{carr} disappears. This zero is the criterion for the Δf reference point, e. g. $\Delta f = 100$ kHz = FS

Bessel function



Analysis of pulse-modulated carrier

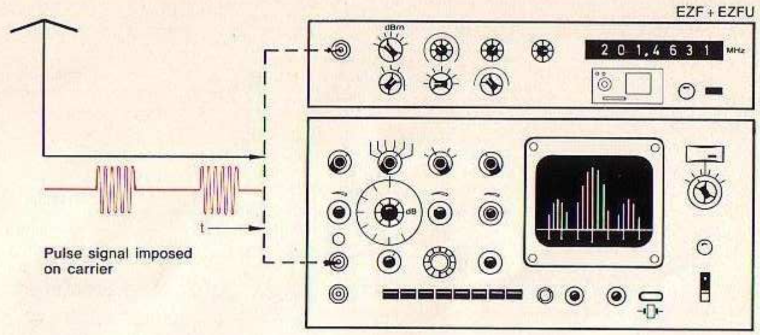
MEASUREMENT

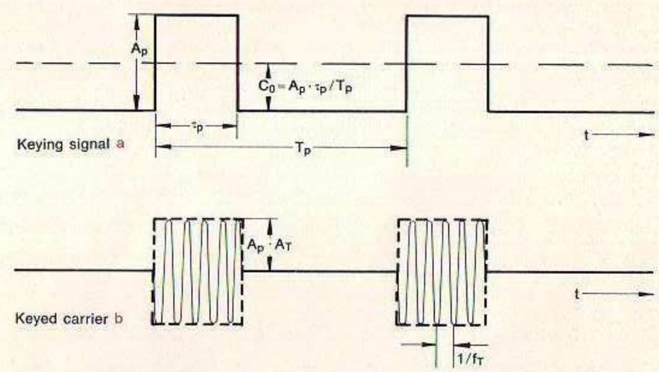
Evaluation of pulse-modulated carrier, i. e. determination of typical pulse data (time domain) from the spectrum displayed (frequency domain)

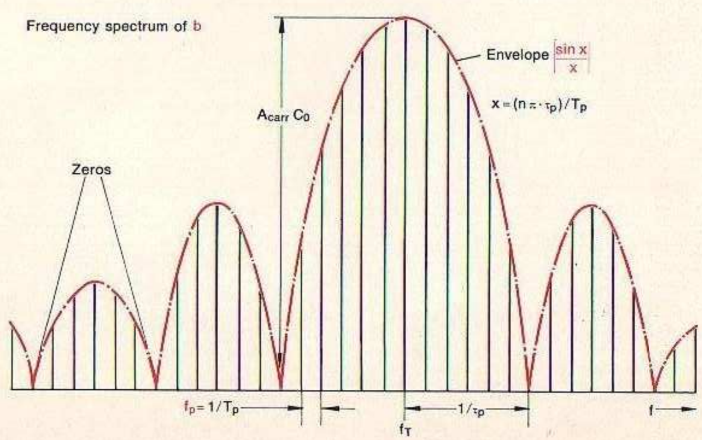
Quantitative evaluation of random noise, i. e. of non-periodic energy surges is possible only with integrating measurements

The analytical method of the Analyskop EZF/EZFU gives an uncalibrated survey of the noise intensity distribution or is used to check noise-reducing measures

TEST ASSEMBLY







FEATURES

High sweep speed together with high selectivity (sharp cut-off filters)

Resolution and sweep-width selection are ganged so that faulty settings are precluded

Frequency measurement: linear frequency marker scale (interpolation possible) with crystal-controlled centre marker

Amplitude measurement: superimposed level line, accurate without recalibration, adjustable with calibrated shift control covering > 80 dB

Test hint: For exact determination of pulse repetition frequency $f_p = 1/T_p$ select a detail (high resolution)

For determining pulse width τ_p select great sweep width

Quantitative evaluation of the spectrogram (valid also if the pulses are not of squarewave form):

1. Amplitudes of individual spectral lines. 2. Number of spectral lines up to the first zero is the duty cycle T_p/τ_p. 3. Distance between two neighbouring spectral lines corresponds to pulse repetition frequency f_p. 4. Zeros are at $f_{carr} \pm n/\tau_p$ (τ_p = pulse width)

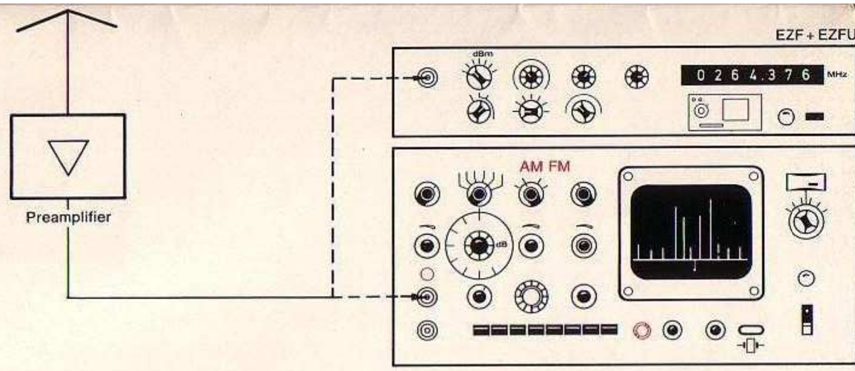
Qualitative evaluation of the envelope:

The total frequency range covered by spectral lines depends on the pulse width τ_p, e. g. $\tau_p = 0$; $\Delta f = \infty$. The area enclosed by the envelope represents the power distribution: the spectral lines between the first zeros ($f_{carr} \pm 1/\tau_p$) constitute the main contribution, the others mainly determine the waveform. Any asymmetry of the spectrum about f_{carr}, for example, indicates detuning of the transmitter-output circuit

Radio monitoring

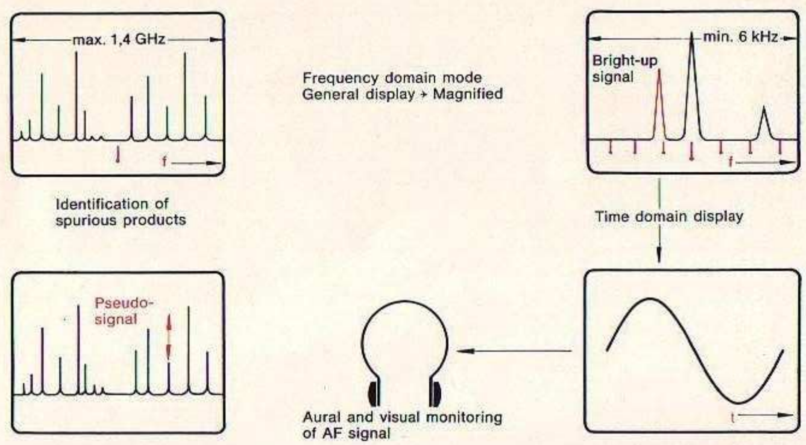
Radio monitoring of RF signals for:
- band occupation,
- type of modulation, modulation depth, frequency deviation, frequency stability, time-domain display of modulation

The Preamplifier Ident. No. 104.0458.90 is used to compensate for line losses and to increase sensitivity.



Sharp-cutoff resolution filters: high sweep speed with good selectivity, i. e. high pick-up probability for short-term signals
Rapid frequency access; high setting accuracy; automatic optimization of settings; measurement accuracy 10 kHz at 2.7 GHz; seven selectable resolving (monitoring) bandwidths from 300 kHz to 50 (70) Hz
For mobile use: battery operation 22 – 30 V, 100 W or operation from 400-Hz airborne supply system

Measurements and measuring facilities in frequency domain and time domain modes



Frequency domain mode

Magnified display: reliable identification of a signal for amplitude and frequency with electronically superimposed level line and crystal controlled frequency-marker scale
Spurious products are recognized; they are represented in the frequency display as spectral lines with fluctuating amplitude
Adjustable base line clipper

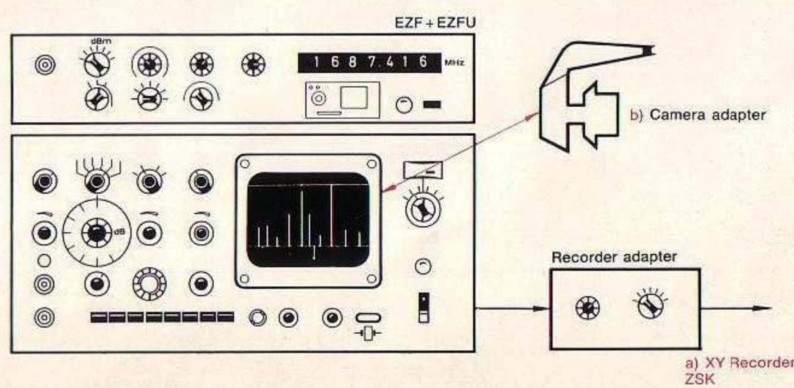
Time domain mode

Presetting for transition from frequency domain to time domain mode: shiftable bright-up marker identifies a selected signal in the spectrum
Simultaneous aural monitoring and visual display of demodulated information; AM, FM, AFC switch-selected

Recording

Recording of patterns, for example, of a particular band occupation

a) XY recorder e. g. ZSK, YT recorder e. g. ZSG 2 — with Recorder Adapter Ident. No. 103.5227.02
b) Camera adapter



a) Direct transition from EZF display to recording and vice versa
No problems of level adjustment and scale conversion for level line (staircase or line pattern), and frequency marker (marker scale displayed below zero line)
Pattern synchronous with recording; setting of starting level during observation of pattern. Sweep time ≦ 3 min, manual or remote sweep control also possible, single or periodic sweep

Specifications of Analyskop EZF Ident. No. 100.8831.52 in Conjunction with UHF Tuner EZFU Ident. No. 210.0011.02

Signal input

	EZF				EZFU	
Input frequency range, switch selected	I	II	III	IV	V	VI
Input frequency	6 kHz – 1.3 MHz	60 kHz – 13 MHz	100 kHz – 130 MHz	150 – 170 MHz	30 – 1400 MHz	1300 – 2700 MHz
Max. sweep width [1])	200 kHz	2 MHz	130 MHz	20 MHz	1400 MHz	1400 MHz
Sensitivity at 1 kHz resolution (signal + noise = 2x noise)	$\leq$ 0.5 µV	$\leq$ 1 µV	$\leq$ 1.5 µV	$\leq$ 1 µV	$\leq$ 1.5 µV	$\leq$ 1.5 µV
Input attenuator	continuous $\geq$ 60 dB				50 dB in 10-dB steps	
Level range	operating range 146 dB				absolute +10 to −122 dBm, calibrated	

Gain adjustment of IF attenuator . . . continuous > 100 dB; no influence on calibration, since level line follows

Dynamic range (spurious products appear in the basic noise) . . . with 1 kHz resolution: third-order intermodulation products better than −75 dB; automatic identification of inherent spurious products caused by overdriving

FUNCTIONAL SETTING

Input frequency tuning (centre frequency)

- by internal oscillator in UHF Tuner EZFU . . . for EZF ranges I, II, III — EZFU ranges V, VI
- by plug-in crystal or plug-in crystal adapter carrying 12 crystals . . . 1.7 – 2.8 MHz, EZF ranges I, II, III
- by external oscillator . . . for EZF ranges I, II, III; f_{osc} = 170 – 280 MHz, E_{osc} = 1 – 2 V

Amplitude display . . . lin 26 dB; log 80 dB; amplitude error over display range $\leq \pm 0.5$ dB

FREQUENCY DOMAIN

Sweep width	6 kHz	60 kHz	200 kHz	600 kHz	2 MHz	6 MHz	20 MHz	20, 50, 100, 200, 500, 1400 MHz
Resolution	50 Hz	1 kHz	3 kHz	10 kHz	30 kHz	100 kHz	300 kHz	ganged (300 kHz) or arbitrary
Frequency marker spacing	–	10 kHz	20 kHz	100 kHz	200 kHz	1 MHz	2 MHz	–
Minimum sweep duration, automatic	0.7/0.4 sec	600 msec	200 msec	60 msec	20 msec	20 msec	20 msec	20 – 200 msec

Frequency markers [2]) . . . for sweep widths $\leq$ 20 MHz: linear scale with centre marker; with EZFU at sweep widths > 20 MHz: shiftable single marker

Frequency axis . . . can be reversed: ←f

Frequency readout . . . on 7-digit counter of EZFU; sweep width > 20 MHz: shiftable marker; sweep width $\leq$ 20 MHz: tuned frequency (centre marker)

[1]) Also with crystal tuning, any sweep width can be selected and centred anywhere within the maximum sweep range (subrange limits) · [2]) Frequency markers: displayed below base line; extended centre-frequency marker; marker spacing ganged with sweep width

TIME DOMAIN MODE

Demodulation of AM and FM possible with all IF bandwidths (resolution)

Modulation-frequency range (AM, FM) . . . 10 Hz – 50 kHz

Time-base triggering . . . automatic from signal, can be switched off

Sweep time . . . in steps of 0.12/0.4/1.2/4/12/40/120/400 msec; continuously adjustable between steps

Video filter with AM demodulation . . . 1-kHz lowpass filter, improving S/N ratio of AF signals

Phones output ($Z \leq 100\ \Omega$) . . . for 4 kΩ load $E_{out\ max}$ = 6 V; for 1 kΩ load $E_{out\ max}$ = 2 V

Level line

Calibrated shift in the amplitude range . . . 0 to −70 dB

Range extension . . . over more than −80 dB

Error above 70 dB . . . $\leq$ 1 dB

Connectors

Input for external control functions

Outputs for XY signal, several pulse and DC voltages

RECORDER ADAPTER Ident. No. 103.5227.02

Perfect frequency and time analysis with recording. No level adjustment problem. No conversion of frequency scale. The Recorder Adapter is the appropriate interface between the Analyskop EZF and the recorder.
XY or YT recorders, evaluation units or laboratory voltmeters are used as peripherals.

Sweep control

Internal via sawtooth or potentiometer (manual tuning), external (tracking potentiometer), or by control voltage.
Single or recurrent sweep.
Sweep time: 30 – 50 sec or 100 – 150 sec adjustable on adapter.
Floating changeover contact for YT recorder.
Screen pattern synchronous with recording.
EZF frequency marker scale can be superimposed.

Level-line graticule or limit-value lines

1. Between two successive signal cycles: plotting of one level line. 2. After single cycle: plotting of complete level line graticule. 3. Quickest method (applicable also with YT recorders): before a single signal cycle: plotting of level lines in the form of a staircase. The desired step size, e.g. 10-dB steps, is selected for all three methods during the level-line period by adjusting the level dial of the EZF by an accurately defined amount.