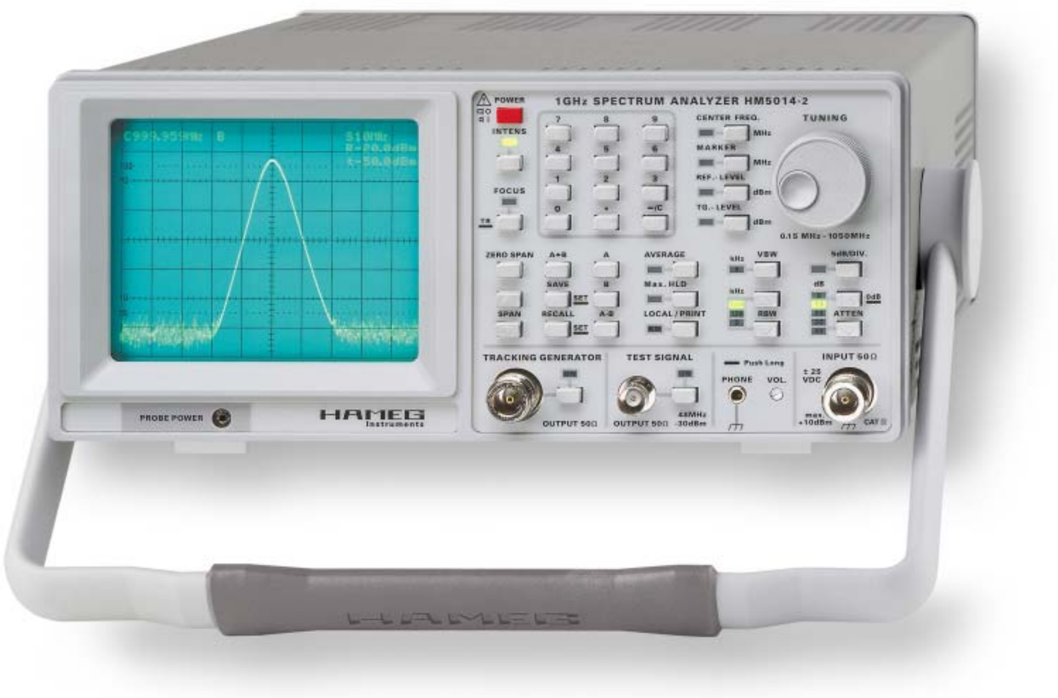
HAMEG Instruments

Spectrum-Analyzer HM5014-2

Manual



Hersteller HAMEG Instruments GmbH
Manufacturer Industriestraße 6
Fabricant D-63533 Mainhausen

KONFORMITÄTSERKLÄRUNG
DECLARATION OF CONFORMITY
DECLARATION DE CONFORMITE

HAMEG Instruments

Die HAMEG Instruments GmbH bescheinigt die Konformität für das Produkt
The HAMEG Instruments GmbH herewith declares conformity of the product
HAMEG Instruments GmbH déclare la conformite du produit

Bezeichnung / Product name / Designation:
Spektrumanalysator
Spectrum Analyzer
Analyseur de spectre

Typ / Type / Type: HM5014-2

mit / with / avec: –

Optionen / Options / Options: –

mit den folgenden Bestimmungen / with applicable regulations /
avec les directives suivantes

EMV Richtlinie 89/336/EWG ergänzt durch 91/263/EWG, 92/31/EWG
EMC Directive 89/336/EEC amended by 91/263/EWG, 92/31/EEC
Directive EMC 89/336/CEE amendée par 91/263/EWG, 92/31/CEE

Niederspannungsrichtlinie 73/23/EWG ergänzt durch 93/68/EWG
Low-Voltage Equipment Directive 73/23/EEC amended by 93/68/EEC
Directive des equipements basse tension 73/23/CEE amendée par 93/68/CEE

Angewendete harmonisierte Normen / Harmonized standards applied / Normes harmonisées utilisées

Sicherheit / Safety / Sécurité
EN 61010-1:2001 (IEC 61010-1:2001)

Messkategorie / Measuring category / Catégorie de mesure: I

Verschmutzungsgrad / Degree of pollution / Degré de pollution: 2

Elektromagnetische Verträglichkeit / Electromagnetic compatibility / Compatibilité électromagnétique

EN 61326-1/A1 Störaussendung / Radiation / Emission:
Tabelle / table / tableau 4; Klasse / Class / Classe B.

Störfestigkeit / Immunity / Imunitee: Tabelle / table / tableau A1.

EN 61000-3-2/A14 Oberschwingungsströme / Harmonic current emissions / Émissions de courant harmonique:
Klasse / Class / Classe D.

EN 61000-3-3 Spannungsschwankungen u. Flicker / Voltage fluctuations and flicker / Fluctuations de tension et du flicker.

Datum /Date /Date
15. 07. 2004

Unterschrift / Signature /Signatur

M. Roth

Manuel Roth
Manager

General information concerning the CE marking

HAMEG instruments fulfill the regulations of the EMC directive. The conformity test made by HAMEG is based on the actual generic- and product standards. In cases where different limit values are applicable, HAMEG applies the severer standard. For emission the limits for residential, commercial and light industry are applied. Regarding the immunity (susceptibility) the limits for industrial environment have been used.

The measuring- and data lines of the instrument have much influence on emmission and immunity and therefore on meeting the acceptance limits. For different applications the lines and/or cables used may be different. For measurement operation the following hints and conditions regarding emission and immunity should be observed:

1. Data cables
For the connection between instruments resp. their interfaces and external devices, (computer, printer etc.) sufficiently screened cables must be used. Without a special instruction in the manual for a reduced cable length, the maximum cable length of a dataline must be less than 3 meters and not be used outside buildings. If an interface has several connectors only one connector must have a connection to a cable.

Basically interconnections must have a double screening. For IEEE-bus purposes the double screened cables HZ73 and HZ72L from HAMEG are suitable.

2. Signal cables
Basically test leads for signal interconnection between test point and instrument should be as short as possible. Without instruction in the manual for a shorter length, signal lines must be less than 3 meters and not be used outside buildings.

Signal lines must screened (coaxial cable - RG58/U). A proper ground connection is required. In combination with signal generators double screened cables (RG223/U, RG214/U) must be used.

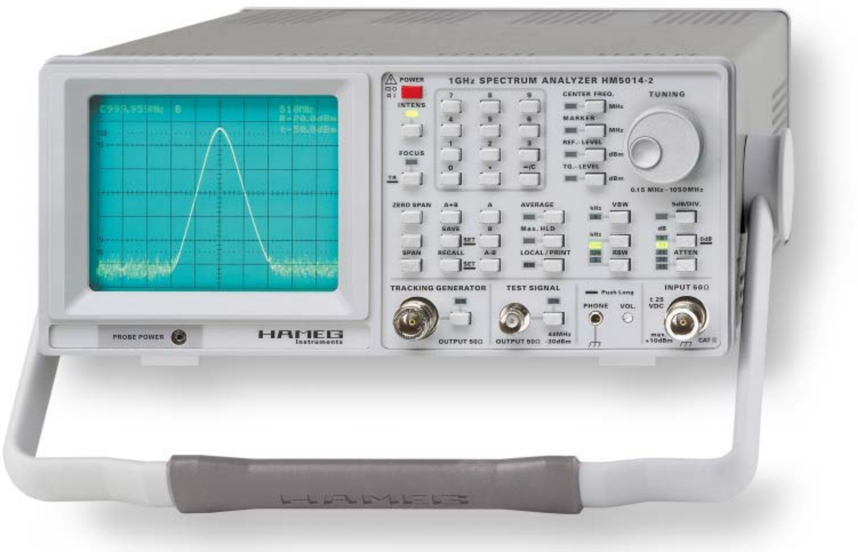
3. Influence on measuring instruments.
Under the presence of strong high frequency electric or magnetic fields, even with careful setup of the measuring equipment an influence of such signals is unavoidable.
This will not cause damage or put the instrument out of operation. Small deviations of the measuring value (reading) exceeding the instruments specifications may result from such conditions in individual cases.

4. RF immunity of oscilloscopes.
4.1 Electromagnetic RF field
The influence of electric and magnetic RF fields may become visible (e.g. RF superimposed), if the field intensity is high. In most cases the coupling into the oscilloscope takes place via the device under test, mains/line supply, test leads, control cables and/or radiation. The device under test as well as the oscilloscope may be effected by such fields.
Although the interior of the oscilloscope is screened by the cabinet, direct radiation can occur via the CRT gap. As the bandwidth of each amplifier stage is higher than the total –3dB bandwidth of the oscilloscope, the influence RF fields of even higher frequencies may be noticeable.

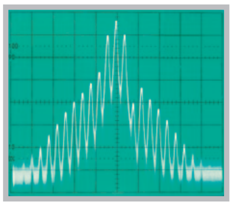
4.2 Electrical fast transients / electrostatic discharge
Electrical fast transient signals (burst) may be coupled into the oscilloscope directly via the mains/line supply, or indirectly via test leads and/or control cables. Due to the high trigger and input sensitivity of the oscilloscopes, such normally high signals may effect the trigger unit and/or may become visible on the CRT, which is unavoidable. These effects can also be caused by direct or indirect electrostatic discharge.

HAMEG Instruments GmbH

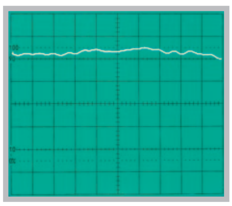
1 GHz Spectrum Analyzer HM5014-2



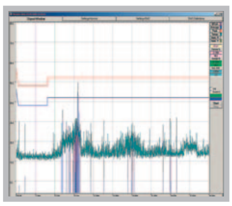
Amplitude-modulated RF Signal



Amplifier frequency response measured using a tracking generator



Measurement of line-conducted interference



Frequency range: 150 kHz to 1 GHz

Amplitude measurement range: – 100 dBm to + 10 dBm

Phase Synchronous, Direct Digital frequency Synthesis (DDS)

Resolution bandwidths (RBW): 9 kHz, 120 kHz and 1 MHz

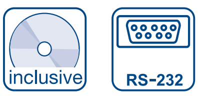
Pre-compliance EMI measurement

Serial interface for documentation and control

Software for documentation included

Additional measurement functions for EMI measurements with optional software

Tracking Generator with output amplitude from – 50 dBm to + 1 dBm



1 GHz Spectrum Analyzer HM5014-2

Valid at 23 °C after a 30 minute warm-up period

Frequency Characteristics

Frequency Range:	0.15 MHz to 1.050 GHz
Stability:	± 5 ppm
Ageing:	± 1 ppm/year
Frequency Resolution:	1 kHz (6½ digit in readout)
Center Frequency Range:	0 to 1.050 GHz
LO Frequency Generation:	TCXO with DDS (Digital Frequency Synthesis)
Span Setting Range:	Zero Span and 1 MHz - 1000 MHz (1-2-5 Sequence)
Marker:	
Frequency Resolution:	1 kHz, 6½ digit,
Amplitude Resolution:	0.4 dB, 3½ digit
Resolution Bandwidths (RBW) @ 6dB:	1 MHz, 120 kHz and 9 kHz
Video Bandwidth (VBW):	4 kHz
Sweep Time (automatic selection):	40 ms, 320 ms,1 s*)

Amplitude Characteristics (Marker Related) 150 kHz – 1 GHz

Measurement Range:	-100 dBm to +10 dBm
Scaling:	10 dB/div., 5 dB/div.
Display Range:	80 dB (10 dB/div.), 40 dB (5 dB/div.)
Amplitude Frequency Response (at 10 dB Attn., Zero Span and RBW 1 MHz, Signal – 20 dBm):	± 3 dB
Display (CRT):	8 x 10 division
Amplitude Scale:	logarithmic
Display units:	dBm
Input Attenuator Range:	0 - 40 dB (10 dB increments)
Input Attenuator Accuracy rel. to 10 dB:	± 2 dB
Max. Input Level (continuous)	
40 dB attenuation:	+20 dBm (0.1 W)
0 dB attenuation:	+10 dBm
Max. DC Voltage:	± 25 V
Max. Reference Level:	+10 dBm
Reference Level Accuracy rel. to 500 MHz, 10 dB Attn., Zero Span and RBW 1 MHz:	± 1 dB
Min. Average Noise Level:	approx. -100 dBm (RBW 9 kHz)
Intermodulation Ratio (3rd Order):	typical › 75 dBc (2 Signals: 200 MHz, 203 MHz, – 3 dB below Reference Level)
Harmonic Distortion Ratio (2nd harm.):	typical › 75 dBc (200 MHz, Reference Level)
Bandwidth Dependent Amplitude Error rel. to RBW 1 MHz and Zero Span:	± 1 dB
Digitization Error:	± 1 digit (0.4 dB) at 10 dB/div. scaling (Average, Zero Span)

Inputs / Outputs

Measuring Input:	N socket
Input Impedance:	50 Ω
VSWR: (Attn. ≥ 10 dB)	typ. 1.5:1
Tracking Generator Output (HM5014-2):	N-socket
Output Impedance:	50 Ω
Test Signal Output:	BNC socket
Frequency, Level:	48 MHz, -30 dBm (± 2 dB)
Supply Voltage for Probes (HZ 530):	6 V DC
Audio Output (phone):	3.5 mm Ø jack
RS-232 Interface:	9-pin / Sub-D

Functions

Keyboard Input:	Center Frequency, Reference Level, Tracking Generator Level
Rotary Encoder Input:	Center Frequency, Reference Level, Marker, Tracking Generator Level
Max. Hold Detection:	Peak Value Acquisition
Quasi-Peak Detection:*	Quasi-Peak Valuation
Average:	Mean Value Acquisition
Ref. Spectrum Memory:	2 k x 8 bit
SAVE / RECALL:	Save and Recall of 10 Instrument Settings
AM demodulation	for audio
LOCAL:	RS-232 Remote Control OFF
Readout:	Display of various Measurement Parameters

Tracking Generator

Frequency Range:	0.15 MHz to 1.050 GHz
Output Level:	–50 dBm to +1 dBm
Frequency Response (0.15 MHz – 1 GHz)	
+1 dBm to -10 dBm:	± 3 dB
-10.2 dBm to -50 dBm:	± 4 dB
Digitization Error:	± 1 digit (0.4 dB)
Spurious Outputs:	better than 20 dBc

General information

CRT:	D14-363GY, 8 x 10 cm with internal graticule
Acceleration Voltage:	approx. 2 kV
Trace Rotation:	adjustable on front panel
Ambient Temperature:	10° C to 40° C
Power Supply:	105-253 V, 50 / 60 Hz ± 10 %, CAT II
Power Consumption:	approx. 35 W at 230 V/50 Hz
Safety Class:	Safety Class I (EN61010-1)
Dimensions (W x H x D):	285 x 125 x 380 mm
Weight:	approx. 6.5 kg

*) in combination with software AS100E only

Accessories supplied: Line Cord, Operators Manual, HZ21 Adapter Plug (N-plug with BNC socket) and Software for Windows on CD-ROM
Optional accessories:
HZ70 Opto-Interface (with optical fiber cable)
HZ520 Antenna
HZ530 Near Field Probe Set for EMI Diagnosis

Important hints

Immediately after unpacking, the instrument should be checked for mechanical damage and loose parts in the interior. If there is a damage of transport, first the instrument must not to be put into operation and second the supplier have to be informed immediately.

Used symbols

⚠ ATTENTION - refer to manual

⚠ Danger - High voltage

⏚ Protective ground (earth) terminal

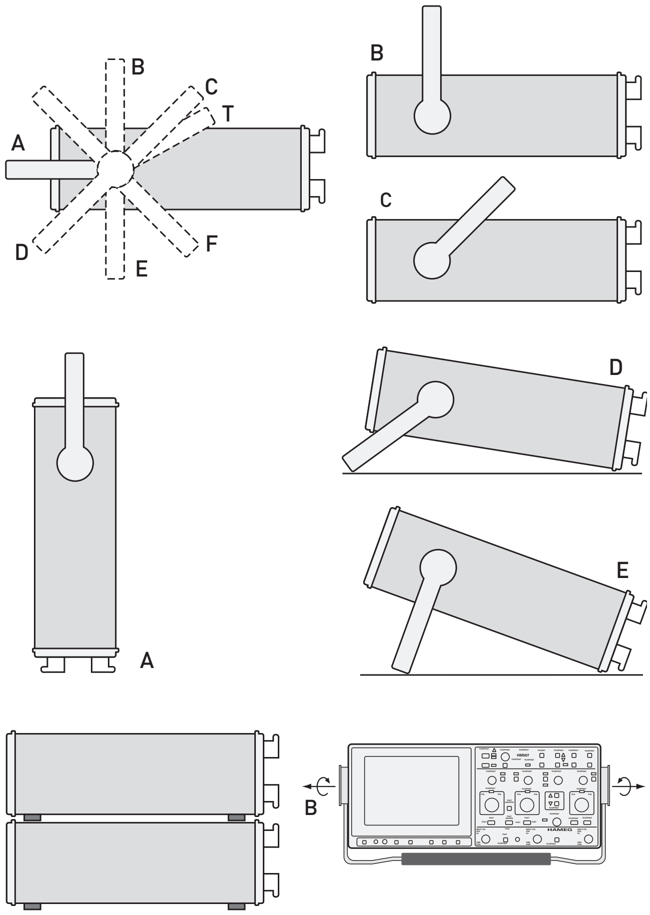
☞ Important note1

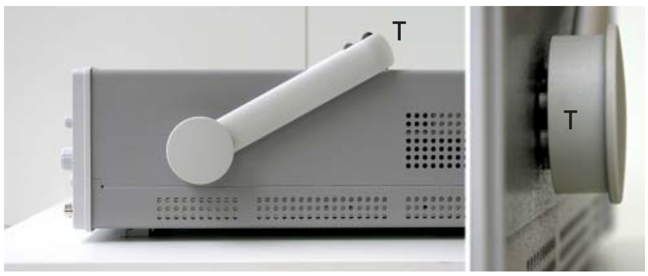
Positioning the instrument

As can be seen from the figures, the handle can be set into different positions:

A = carrying
B = handle removal and horizontal carrying
C = horizontal operating
D and E = operating at different angles
F = handle removal
T = shipping (handle unlocked)

☞ **Attention!**
When changing the handle position, the instrument must be placed so that it can not fall (e.g. placed on a table). Then the handle locking knobs must be simultaneously pulled outwards and rotated to the required position. Without pulling the locking knobs they will latch in into the next locking position.





Handle mounting/dismounting

The handle can be removed by pulling it out further, depending on the instrument model in position B or F.

Safety

This instrument has been designed and tested in accordance with IEC Publication 1010-1 (overvoltage category II, pollution degree 2), Safety requirements for electrical equipment for measurement, control, and laboratory use.

The CENELEC regulations EN 61010-1 correspond to this standard. It has left the factory in a safe condition. This instruction manual contains important information and warnings that have to be followed by the user to ensure safe operation and to retain the instrument in a safe condition.
The case, chassis and all measuring terminals are connected to the protective earth contact of the appliance inlet. The instrument operates according to Safety Class I (three conductor power cord with protective earthing conductor and a plug with earthing contact).

The mains/line plug must be inserted in a socket outlet provided with a protective earth contact. The protective action must not be negated by the use of an extension cord without a protective conductor.

The mains/line plug must be inserted before connections are made to measuring circuits.

The grounded accessible metal parts (case, sockets, jacks) and the mains/line supply contacts (line/live, neutral) of the instrument have been tested against insulation breakdown with 2200 V_{DC}.

Under certain conditions, 50 Hz or 60 Hz hum voltages can occur in the measuring circuit due to the interconnection with other mains/line powered equipment or instruments. This can be avoided by using an isolation transformer (Safety Class II) between the mains/line outlet and the power plug of the device being investigated.

Most cathode ray tubes develop X-rays. However, the dose equivalent rate falls far below the maximum permissible value of 36pA/kg (0.5mR/h).

Whenever it is likely that protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation. The protection is likely to be impa-ired if, for example, the instrument shows visible damage, fails to perform the intended measurements, has been subjected to prolonged storage under unfavourable conditions (e.g. in the open or in moist environments), has been subject to severe transport stress (e.g. in poor packaging).

Operating conditions

This instrument must be used only by qualified experts who are aware of the risks of electrical measurement. The instrument is specified for operation in industry, light industry, commercial and residential environments.

Due to safety reasons the instrument must only be connected to a properly installed power outlet, containing a protective earth conductor. The protective earth connection must not be broken. The power plug must be inserted in the power outlet while any connection is made to the test device.

The instrument has been designed for indoor use. The permissible ambient temperature range during operation is +10°C (+50°F) ... +40°C (+104°F). It may occasionally be subjected to temperatures between +10°C (+50°F) and -10°C (+14°F) without degrading its safety. The permissible ambient temperature range for storage or transportation is 40°C (-40°F) ... +70°C (+158°F). The maximum operating altitude is up to 2200 m (non operating 15000 m). The maximum relative humidity is up to 80%.

If condensed water exists in the instrument it should be acclimatized before switching on. In some cases (e.g. extremely cold instrument) two hours should be allowed before the instrument is put into operation. The instrument should be kept in a clean and dry room and must not be operated in explosive, corrosive, dusty, or moist environments. The instrument can be operated in any position, but the convection cooling must not be impaired. The ventilation holes may not be covered. For continuous operation the instrument should be used in the horizontal position, preferably tilted upwards, resting on the tilt handle.

The specifications stating tolerances are only valid if the instrument has warmed up for 20 minutes at an ambient temperature between +15°C (+59°F) and +30°C (+86°F). Values without tolerances are typical for an average instrument.

Warranty and repair

HAMEG instruments are subjected to a rigorous quality control. Prior to shipment each instrument will be burnt in for 10 hours. Intermittent operation will produce nearly all early failures. After burn in, a final functional and quality test is performed to check all operating modes and fulfilment of specifications. The latter is performed with test equipment traceable to national measurement standards.

Statutory warranty regulations apply in the country where the HAMEG product was purchased. In case of complaints please contact the dealer who supplied your HAMEG product.

Maintenance

The exterior of the instrument should be cleaned regularly with a dusting brush. Dirt that is difficult to remove on the casing and handle, the plastic and aluminium parts, can be removed with a moistened cloth (99% water +1% mild detergent). Spirit or washing benzine (petroleum ether) can be used to remove greasy dirt. The screen may be cleaned with water or washing benzine (but not with spirit (alcohol) or solvents), it must then be wiped with a dry clean lint free cloth. Under no circumstances must the cleaning fluid get into the instrument. The use of other cleaning agents can attack the plastic and paint surfaces.

Protective Switch Off

This instrument is equipped with a switch mode power supply. It has both over voltage and overload protection, which will cause the switch mode supply to limit power consumption to a minimum. In this case a ticking noise may be heard.

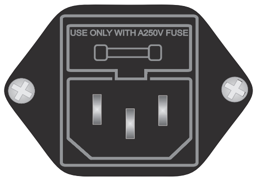
Power supply

The instrument operates on mains/line voltages between 105 V_{AC} and 250 V_{AC}. No means of switching to different input voltages has therefore been provided.

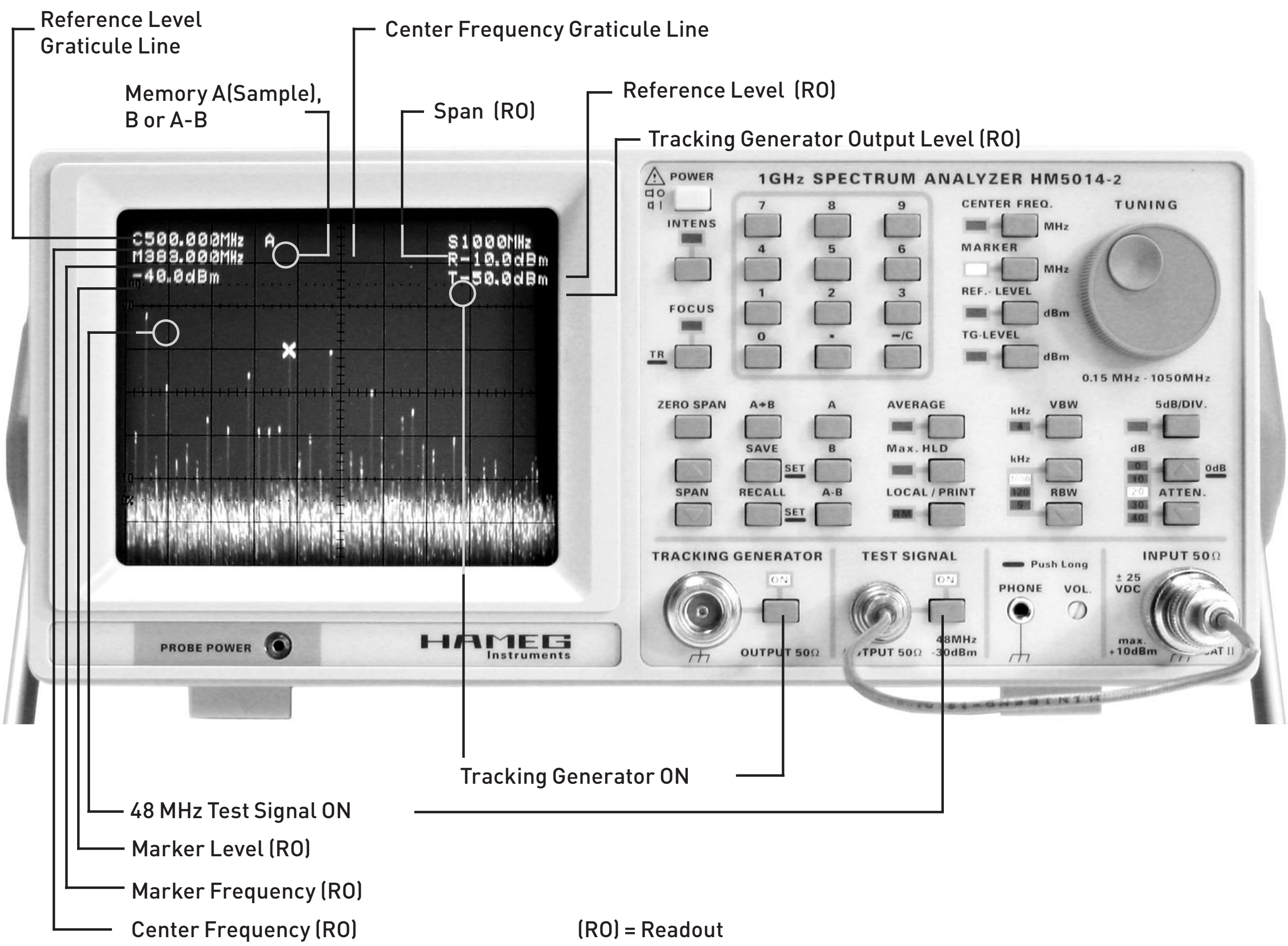
The power input fuse is externally accessible. The fuse holder and the 3 pole power connector is an integrated unit. The power input fuse can be exchanged after the rubber connector is removed. The fuse holder can be released by lever action with the aid of a screwdriver. The starting point is a slot located on contact pin side. The fuse can then be pushed out of the mounting and replaced.

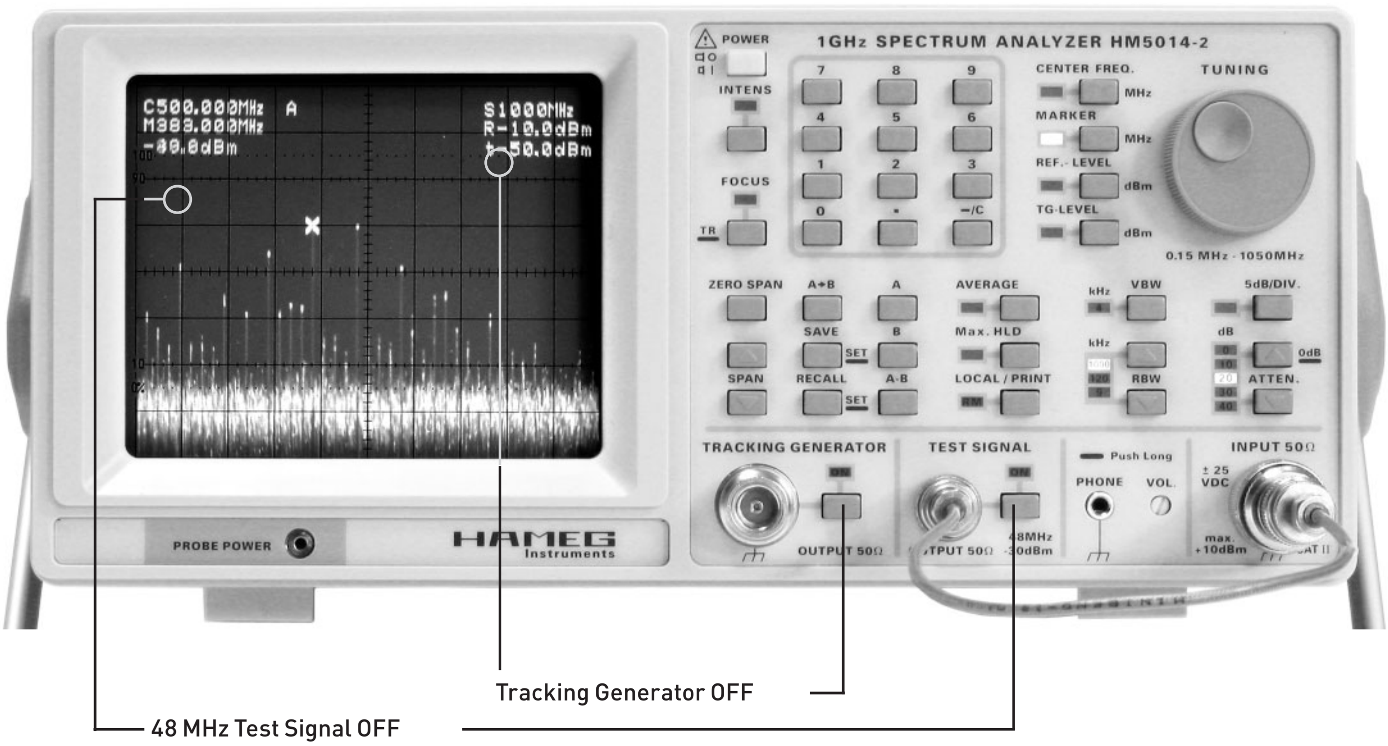
The fuse holder must be pushed in against the spring pressure and locked. Use of patched fuses or short circuiting of the fuse holder is not permissible; HAMEG assumes no liability whatsoever for any damage caused as a result, and all warranty claims become null and void.

Fuse type:
Size 5x20mm; 0.8A, 250V AC fuse;
must meet IEC specification 127,
Sheet III (or DIN 41 662
or DIN 41 571, sheet 3).
Time characteristic: time lag.



Test Signal Display





Functional principle

The spectrum analyzer permits the detection of spectrum components of electrical signals in the frequency range of 0.15 to 1050MHz. The detected signal and its content have to be repetitive. In contrast to an oscilloscope operated in Yt mode, where the amplitude is displayed on the time domain, the spectrum analyzer displays amplitude on the frequency domain (Yf). The individual spectrum components of a "signal" become visible on a spectrum analyzer. The oscilloscope would display the same signal as one resulting waveform.

The spectrum analyser works according to the double superhet receiver principle. The signal to be measured (fin = 0.15 MHz to 1050 MHz) is applied to the 1st mixer where it is mixed with the signal of a variable voltage controlled oscillator (fLO 1350,7 MHz – 2400,7 MHz). This oscillator is called the 1st LO (local oscillator). The difference between the oscillator and the input frequency (fLO - fin = 1st IF) is the first intermediate frequency, which passes through a waveband filter tuned to a center frequency of 1350,7 MHz. It then enters an amplifier, a second mixing stage, oscillator and the second IF amplifier (10.7 MHz). In the latter, the signal can be selectively transferred through a filter with 1000 kHz, 120 kHz or 9 kHz bandwidth before arriving at an AM demodulator. The logarithmic output (video signal) is transferred directly, or via a low pass filter to an A/D converter and the signal data are stored in a RAM. The lowest frequency of a span is stored at the lowest address and the highest frequency at the highest address. Then the next span starts the same procedure once again. This means that the signal data are continuously updated.

In addition the signal data are read and converted by a D/A converter into an analogue signal. The latter controls the Y amplifier and the Y deflection plates of the CRT. With increasing signal level (amplitude) the beam is deflected from the bottom (noise) to the top of the screen.

During the continuous read process the RAM becomes addressed from the lowest to the highest address. The addresses become D/A converted and consequently generate a saw tooth signal which controls the X deflection. The sweep starts with the lowest frequency (address) at the trace start (left) and ends with the highest frequency (address) at the trace end (right). The stored spectrum data can be transferred to a PC via the built in serial interface.

Note: While Zero-Span-Mode the measuring frequency does not change and the X-deflection is a time depending function.

The HM5014-2 also includes a tracking generator. It provides sine wave voltages within the frequency range of 0.15 to 1050 MHz. The tracking generator frequency is determined by the first oscillator (1st LO) of the spectrum analyzer section.

Spectrum analyzer and tracking generator are frequency synchronized.

Operating Instructions

It is very important to read the instructions including the chapter „Safety" prior to operate the HM5012-2/HM5014-2. The straightforward front panel layout and the limitation to basic functions, guarantee efficient operation immediately. To ensure optimum operation of the instrument, some basic instructions need to be followed.

Prior to examining unidentified signals, the presence of unacceptable high voltages has to be checked. It is also recommended to start measurements with the highest possible attenuation and a maximum frequency range (Span 1000M Hz). The user should also consider the possibility of excessively high signal amplitudes outside the covered frequency range, although not displayed (e.g. 1200 MHz). The frequency range of 0 Hz to 150 kHz is not specified for the HM5014-2 spectrum analyser. Spectral lines within this range would be displayed with incorrect amplitude.

High intensity settings should be avoided. The way signals are displayed on the spectrum analyser typically allows for any signal to be recognized easily, even with low intensity. Due to the frequency conversion principle, a spectral line is visible at 0 Hz. It is called IF feedthrough. The line appears when the 1st LO frequency passes the IF amplifiers and filters. The level of this spectral line is different in each instrument. A deviation from the full screen does not indicate a malfunctioning instrument.

First measurements

Settings:
Before an unknown signal is applied to the input of the instrument, it should be verified that the DC component is smaller than ±25V and the signal level below +10 dBm.

ATTN:
As a protective measure the attenuation should initially be set to 40 dB.

Frequency setting:
Set CENTER FREQ. to 500 MHz (C500MHz) and choose a span of 1000 MHz (S1000 MHz).

Vertical scaling:
For maximum display range choose 10dB/div scaling.

RBW (resolution bandwidth):
At the start of a measurement it is recommended to select 1000 kHz (IF) bandwidth and to switch the video filter (VBW) off.

If under these conditions only the noise band (frequency base line) is visible the input attenuation can be reduced to enable the measurement and display of lower signal levels. Bear in mind that at full span, very narrow, high level signals may low intensity and thus difficult to see, and should be carefully sought before reducing attenuation. If the frequency base line shifts to the top, this may be caused by a high level spectra outside the measuring range. In any case the attenuator setting must correspond to the biggest input signal (not Zero-peak). The correct signal level is achieved if the biggest signal („0 Hz" - 1000 MHz) just touches the reference line. If the signal surpasses the reference line, the attenuation must be increased, or an external attenuator (of suitable power rating and attenuation) must be used.

Measuring in full-span mode serves mostly as a quick overview. To analyze the detected signals more closely, the span has to

be decreased. Before decreasing the span, make sure that the center frequency is set so the signal is at exact center of screen. Then span can be reduced.
Then the resolution bandwidth can be decreased, and the video filter used if necessary. Note that if the warning „uncal" is displayed in the readout, measurement results are incorrect.

Measurement reading: For a numerical value of a measurement result the easiest way is by the use of the marker. The marker frequency, and hence the marker symbol position, can be set by the TUNING knob (on condition the MARKER LED is lit) on a spectrum line. Then the frequency and the level can be read from the readout. For the level value the reference level (REF.-LEVEL) and the input attenuator setting (ATTN) are automatically considered.

If a value is to be measured without using the marker, then measure the difference of the reference line to the signal. Note that the scale may be either 5 dB/Div. or 10 dB/Div. In the reference level value, the setting of the input attenuator is already included; it is not necessary to make a correction afterwards. The level of the 48 MHz test signal (shown on the page „Test Signal Display") is approx. 2.2 div below the reference level graticule line of –10 dBm. In combination with a scaling of 10 dB/div, 2.2div equals 22 dB and consequently the signal level is –10 dBm – (22 dB) = –32 dBm.

Introduction to Spectrum Analysis

The analysis of electrical signals is a fundamental problem for many engineers and scientists. Even if the immediate problem is not electrical, the basic parameters of interest are often changed into electrical signals by means of transducers. The rewards for transforming physical parameters to electrical signals are great, as many instruments are available for the analysis of electrical signals in the time and frequency domains.

The traditional way of observing electrical signals is to view them in the time domain using an oscilloscope. The time domain is used to recover relative timing and phase information that is needed to characterize electric circuit behavior. However, not all circuits can be uniquely characterized from just time domain information. Circuit elements such as amplifiers, oscillators, mixers, modulators, detectors and filters are best characterized by their frequency response information. This frequency information is best obtained by viewing electrical signals in the frequency domain. To display the frequency domain requires a device that can discriminate between frequencies while measuring the power level at each. One instrument which displays the frequency domain is the spectrum analyzer.

It graphically displays voltage or power as a function of frequency on a CRT (cathode ray tube). In the time domain, all frequency components of a signal are seen summed together. In the frequency domain, complex signals (i.e. signals composed of more than one frequency) are separated into their frequency components, and the power level at each frequency is displayed. The frequency domain is a graphical
representation of signal amplitude as a function of frequency. The frequency domain contains information not found in the time domain and therefore, the spectrum analyzer has certain advantages compared with an oscilloscope.

The analyzer is more sensitive to low level distortion than a scope. Sine waves may look good in the time domain, but in the frequency domain, harmonic distortion can be seen. The sensitivity and wide dynamic range of the spectrum analyzer is useful for measuring low-level modulation. It can be used to measure AM, FM and pulsed RF. The analyzer can be used to measure carrier frequency, modulation frequency, modulation level, and modulation distortion. Frequency conversion devices can be easily characterized. Such parameters as conversion loss, isolation, and distortion are readily determined from the display.

The spectrum analyzer can be used to measure long and short term stability. Parameters such as noise sidebands on an oscillator, residual FM of a source and frequency drift during warm-up can be measured using the spectrum analyzer's calibrated scans. The swept frequency responses of a filter or amplifier are examples of swept frequency measurements possible with a spectrum analyzer. These measurements are simplified by using a tracking generator.

Types of Spectrum Analyzers

There are two basic types of spectrum analyzers, swept-tuned and real time analyzers. The swept-tuned analyzers are tuned by electrically sweeping them over their frequency range. Therefore, the frequency components of a spectrum are sampled sequentially in time. This enables periodic and random signals to be displayed, but makes it impossible to display transient responses. Real time analyzers, on the other hand, simultaneously display the amplitude of all signals in the frequency range of the analyzer; hence the name "real time". This preserves the time dependency between signals which permit phase information to be displayed. Real time analyzers are capable of displaying transient responses as well as periodic and random signals.

The swept tuned analyzers are usually of the TRF (tuned radio frequency) or super heterodyne type. A TRF-analyzer consists of a band pass filter whose center frequency is tunable over a desired frequency range, a detector to produce vertical deflection on a CRT, and a horizontal scan generator used to synchronize the tuned frequency to the CRT horizontal deflection. It is a simple, inexpensive analyzer with wide frequency coverage, but lacks resolution and sensitivity. Because trf analyzers have a swept filter they are limited in sweep width depending on the frequency range (usually one decade or less). The resolution is determined by the filter bandwidth, and since tunable filters do not usually have constant bandwidth, it is dependent on frequency.

The most common type of spectrum analyzer differs from the trf spectrum analyzers in that the spectrum is swept through a fixed band pass filter instead of sweeping the filter through the spectrum. The analyzer is basically a narrowband receiver which is electronically tuned in frequency by a local oscillator (1^{st} LO). The LO signal is the first of two inputs applied to the first mixer. The complete input spectra (the analyzer input) is the second signal for the first mixer. A front panel controllable attenuator (adjacent to the input socket) can be used to reduce the input signal level in 10dB steps. At the first mixer output, the following four signals appear:

a) The signal of the first local oscillator (1st LO).
This is always 1350.7 MHz higher then the input signal frequency. For an input frequency of 0kHz the 1st LO is set to 1350.7 MHZ (0 kHz + 1350.7 MHz). At 150 kHz it is

1350.85 MHz (150 kHz + 1350.7 MHZ) and for an input signal of 1050 MHz the 1st LO must oscillate at 2400.7 MHz (1050 MHz + 1350.7 MHz).

b) The complete input spectra as present at the analyzer input. After having passed through the attenuator, this is also present at the mixer output.

c) The mixing product sum of the 1st LO and the complete input spectra. For 150 kHz the 1st LO frequency is 1350.85 MHz which results in a sum of 1351 MHz. In case of 1050 MHz input frequency the 1st LO frequency is 2400.7 MHz and the sum is 3450.7 MHz.

d) The mixing product difference of the 1st LO and the complete input spectra. At 150 kHz the 1st LO frequency is 1350.85 MHz so that the difference (1350.85 MHz – 150 kHz) is 1350.7 MHz. Tuned to 1050 MHz the 1st LO frequency is 2400.7 MHz and the difference is 1350.7 MHz (2400.7 MHz – 1050 MHz).

After the mixing stage these signals enter a band pass filter (IF filter) with a center frequency of 1350.7 MHz. Except for one special condition, only the mixing product difference can pass the filter and is displayed after further processing. The exception is the 1st LO signal which is 1350.7 MHz if the analyzer is tuned to 0 kHz.

Note:
This 1st LO signal at „0 kHz" is named Zero Peak, or local oscillator feedthrough and is unavoidable. It can be seen at the left of the display. Its presence can be disturbing on frequencies between 150 kHz and approx. 2.5 MHz if e.g. 1 MHz resolution bandwidth (RBW) is selected. To avoid such problems a lower resolution bandwidth should be selected.
Depending on whether measurements are made with or without SPAN, the following conditions occur.

In ZERO SPAN mode the 1st LO generates a frequency that must be 1350.7 MHz higher than the selected input frequency. The analyzer then displays only the input frequency and those frequency fractions that can pass the IF filter, depending on the actual resolution bandwidth (RBW) setting.

In normal frequency span conditions (ZERO SPAN not selected), a frequency range is displayed dependent on the SPAN setting. In the condition that the center frequency is 500 MHz and a span of 1000 MHz (full span) is chosen, the measurement starts with 0 kHz at the left side of the display and ends with 1000 MHz at the right side. This means that the 1st LO frequency is increased repeatedly from 1350.7 MHz to 2400.7 MHz. After each sweep is performed, a new one starts.

There is a relationship between the frequency range to be analyzed (SPAN setting dependent) and the resolution bandwidth that can cause the display of erroneous (too low) signal levels. Such errors occur if the measuring time does not meet the requirements of the IF and/or Video Filter settling time, which is the case if the measuring time is too short. A warning of this state is indicated by the readout displaying „uncal".

Spectrum Analyzer Requirements

To accurately display the frequency and amplitude of a signal on a spectrum analyzer, the instrument itself must be properly adjusted. A spectrum analyzer properly designed for accurate frequency and amplitude measurements has to satisfy many requirements:

a) Wide tuning range
b) Wide frequency display range
c) Stability
d) Resolution
e) Flat frequency response
f) High sensitivity
g) Low internal distortion

Frequency Measurements

A Spectrum Analyzer allows frequency measurement whether SPAN mode is present or not (ZERO-SPAN).
In „full span" (1000MHz) mode, the complete frequency range is displayed and a signal frequency can roughly be determined. This frequency then can be input as center frequency and displayed with less SPAN. The measurement display and MARKER accuracy increases with less SPAN and smaller resolution bandwidth (RBW). In combination with „ZERO SPAN", a signal which is not modulated is displayed as a straight horizontal line. To determine the signal frequency, the center frequency should be adjusted so that the signal line moves up the screen to the maximum top position (maximum level). Then the frequency can be read from the readout. In the zero scan mode, the analyzer acts as a fixed tuned receiver with selectable bandwidths.

Relative frequency measurements can be made by measuring the relative separation of two signals on the display. It is important that the spectrum analyzer be more stable than the signals being measured. The stability of the analyzer depends on the frequency stability of its local oscillators. Stability is usually characterized as either short term or long term. Residual FM is a measure of the short term stability that is usually specified in Hz peak-to-peak. Short term stability is also characterized by noise sidebands which are a measure of the analyzers spectral purity.

Noise sidebands are specified in terms of dB down and Hz away from a carrier in a specific bandwidth. The frequency drift of the analyzer's Local Oscillators characterizes long term stability. Frequency drift is a measure of how much the frequency changes during a specified time (i.e., Hz/min. or Hz/hr).

Resolution

Before the frequency of a signal can be measured on a spectrum analyzer it must first be resolved. Resolving a signal means distinguishing it from its nearest neighbours. The resolution of a spectrum analyzer is determined by its IF bandwidth. The IF bandwidth is usually the 3 dB bandwidth of the IF filter. The ratio of the 60 dB bandwidth (in Hz) to the 3 dB bandwidth (in Hz) is known as the shape factor of the filter. The smaller the shape factor, the greater the analyzer's capability to resolve closely spaced signals of unequal amplitude. If the shape factor of a filter is 15:1, then two signals whose amplitudes differ by 60dB must differ in frequency by 7.5 times the IF bandwidth before they can be distinguished separately. Otherwise, they will appear as one signal on the spectrum analyzer display.

The ability of a spectrum analyzer to resolve closely spaced signals of unequal amplitude is not a function of the IF filter shape factor only. Noise sidebands can also reduce the resolution. They appear above the skirt of the IF filter and reduce the off band rejection of the filter. This limits the resolution when measuring signals of unequal amplitude.

The resolution of the spectrum analyzer is limited by its narrowest IF bandwidth. For example, if the narrowest bandwidth is 9 kHz then the nearest any two signals can be and still be resolved is 9 kHz. This is because the analyzer traces out its own IF band pass shape as it sweeps through a CW signal. Since the resolution of the analyzer is limited by bandwidth, it seems that by reducing the IF bandwidth indefinitely, infinite resolution will be achieved.

The fallacy here is that the usable IF bandwidth is limited by the stability (residual FM) of the analyzer. If the internal frequency deviation of the analyzer is 9 kHz, then the narrowest bandwidth that can be used to distinguish a single input signal is 10 kHz.

Any narrower IF-filter will result in more than one response or an intermittent response for a single input frequency. A practical limitation exists on the IF bandwidth as well, since narrow filters have long time constants and would require excessive scan time.

Sensitivity

Sensitivity is a measure of the analyzer's ability to detect small signals. The maximum sensitivity of an analyzer is limited by its internally generated noise. This noise is basically of two types: Thermal (or Johnson) and non thermal noise. Thermal noise power can be expressed as: **PN = k x T x B**

where: PN = Noise power in watts
k = Boltzmanns Constant (1.38 x 10^{-23} Joule/K)
T = absolute temperature, K
B = bandwidth of system in Hertz

As seen from this equation, the noise level is directly proportional to bandwidth. Therefore, a decade decrease in bandwidth results in a 10dB decrease in noise level and consequently 10dB better sensitivity. All noise produced within the analyzer that is not temperature dependent is known as non thermal noise. Spurious emissions due to non linearities of active elements, impedance mismatch, etc. are sources of non thermal noise. A figure of merit, or noise figure, is usually assigned to this non thermal noise which when added to the thermal noise gives the total noise of the analyzer system. This system noise which is measured on the CRT, determines the maximum sensitivity of the spectrum analyzer. Because noise level changes with bandwidth, it is important when comparing the sensitivity of two analyzers, to compare sensitivity speci-fications for equal bandwidths. A spectrum analyzer sweeps over a wide frequency range, but is really a narrow band instrument. All of the signals that appear in the frequency range of the analyzer are converted to a single IF frequency which must pass through an IF filter; the detector sees only this noise at any time. Therefore, the noise displayed on the analyzer is only that which is contained in the IF pass band. When measuring discrete signals, maximum sensitivity is obtained by using the narrowest IF bandwidth.

Video Filtering

Measuring small signals can be difficult when they are approximately the same amplitude as the average internal noise level of the analyzer. To facilitate the measurement, it is best to use video filtering. A video filter is a post-detection low pass filter which averages the internal noise of the analyzer. When the noise is averaged, the input signal may be seen. If the resolution bandwidth is very narrow for the span, the video filter should not be selected, as this will not allow the amplitude of the analyzed signals to reach full amplitude due to its video bandwidth limiting property.

Spectrum Analyzer Sensitivity

Specifying sensitivity on a spectrum analyzer is somewhat arbitrary. One way of specifying sensitivity is to define it as the signal level when signal power = average noise power.

The analyzer always measures signal plus noise. Therefore, when the input signal is equal to the internal noise level, the signal will appear 3dB above the noise. When the signal power is added to the average noise power, the power level on the CRT is doubled (increased by 3dB) because the signal power=average noise power.

The maximum input level to the spectrum analyzer is the damage level or burn-out level of the input circuit. This is (for the HM5014-2) +10dBm for the input mixer and +20dBm for the input attenuator. Before reaching the damage level of the analyzer, the analyzer will begin to gain compress the input signal. This gain compression is not considered serious until it reaches 1dB. The maximum input signal level that will always result in less than 1dB gain compression is called the linear input level. Above 1dB gain compression, the analyzer is considered to be operating non linearly because the signal amplitude displayed on the CRT is not an accurate measure of the input signal level.

Whenever a signal is applied to the input of the analyzer, distortions are produced within the analyzer itself. Most of these are caused by the non linear behavior of the input mixer. For the HM5014-2 these distortions are typically >75dB below the input signal level for signal levels not exceeding –30dBm at the input of the first mixer. To accommodate larger input signal levels, an attenuator is placed in the input circuit before the first mixer. The largest input signal that can be applied, at each setting of the input attenuator, while maintaining the internally generated distortions below a certain level, is called the optimum input level of the analyzer. The signal is attenuated before the first mixer because the input to the mixer must not exceed –30dBm, or the analyzer distortion products may exceed the specified 75dB range. This 75dB distortion free range is called the spurious free dynamic range of the analyzer. The display dynamic range is defined as the ratio of the largest signal to the smallest signal that can be displayed simultaneously with no analyzer distortions present. Dynamic range requires several things then. The display range must be adequate, no spurious or unidentified response must occur, and the sensitivity must be sufficient to eliminate noise from the displayed amplitude range.

The maximum dynamic range for a spectrum analyzer can be easily determined from its specifications. First check the distortion spec. For example, this might be „all spurious products >75dB down for –30dBm at the input mixer". Then, determine that adequate sensitivity exists. For example, 75dB down from –30dBm is –105dB.

This is the level we must be able to detect, and the bandwidth required for this sensitivity must not be too narrow or it will be useless. Last, the display range must be adequate.

Notice that reducing the level at the input mixer can extend the spurious free measurement range. The only limitation then, is sensitivity. To ensure a maximum dynamic range on the CRT display, check to see that the following requirements are satisfied.

a) The largest input signal does not exceed the optimum input level of the analyzer (typically –30dBm with 0dB input attenuation).
b) The peak of the largest input signal rests at the top of the CRT display (reference level).

Frequency Response

The frequency response of an analyzer is the amplitude linearity of the analyzer over its frequency range. If a spectrum analyzer is to display equal amplitudes for input signals of equal amplitude, independent of frequency, then the conversion (power) loss of the input mixer must not depend on frequency. If the voltage from the LO is too large compared to the input signal voltage then the conversion loss of the input mixer is frequency dependent and the frequency response of the system is non linear. For accurate amplitude measurements, a spectrum analyzer's response should be as flat as possible over its frequency range. Flatness is usually the limiting factor in amplitude accuracy since it is extremely difficult to calibrate out. And, since the primary function of the spectrum analyzer is to compare signal levels at different frequencies, a lack of flatness can seriously limit its usefulness.

Tracking Generator

A tracking generator is a sine wave generator that is frequency controlled by a spectrum analyzer in such a way that the generator frequency and the spectrum analyzer receiving frequency are always equal. In ZERO SPAN mode the tracking generator provides a discrete sine wave frequency equal to the center frequency. In SPAN mode the tracking generator frequency precisely tracks the spectrum analyzer.

The tracking generator can be used for frequency response (amplitude vs. frequency) measurement on amplifiers, attenuators and filters. The generator output voltage should be applied to the input of the device under test, and the device output connected to the analyzer input. In this configuration, the spectrum analyzer/tracking generator becomes a self contained, complete (source, detector, and display) swept frequency measurement system. An internal leveling loop in the tracking generator ensures a leveled output over the entire frequency range.

RS-232 Interface – Remote Control

Attention:
All terminals of the RS-232 interface are galvanically connected with the instrument and subsequently with protective (safety) earth potential.

Measurement on a high level reference potential is not permitted and endangers operator, instrument, interface and peripheral devices. In case of disregard of the safety warnings contained in this manual, HAMEG refuses any liability regarding personal injury and/or damage to equipment.

Operation
The spectrum analyzer is supplied with a serial interface for control purposes. The interface connector (9 pole D SUB female) is located on the rear of the instrument. Via this bi-directional port, the instrument can be controlled and the parameter settings and signal data can be received from a PC.

RS-232 Cable
The maximum connecting cable length must be less then 3 meters and must contain screened lines connected 1 : 1. The instrument RS-232 connection (9 pole D SUB female) is determined as follows:

Pin
2 Tx data (data from instrument to external device)
3 Rx data (data from external device to instrument)
5 Ground (reference potential - connected via the instrument power cord with protective earth)
9 +5V supply for external device (max. 400mA).

The maximum voltage swing at pin 2 and 3 is ± 12 Volt.

RS-232 protocol N-8-1 (no parity bit, 8 data bits, 1 stop bit)

Baud Rate Setting
After switching the instrument on, the default setting of the RS-232 port is always 4800 baud. It can be changed thereafter to 9600, 38400 or 115200 baud by a command listed below.

Data Communication
After switching on the instrument it always automatically transmits HM5014-2 with 4800 baud. A data carrier with a program executable under Windows 95, 98, Me, NT 4.0 (with actual service pack), 2000 and XP is part of the delivery. Updates can be found on the Internet under www.hameg.de.

Commands from PC to HM5014-2

General description: Each query/command must be introduced with „#" (23 hex = 35 dec) followed by respective characters, i.e. TG for Tracking Generator, and further followed by parameter, which are explained in detail below. Each command is executed by pushing the „Enter" key (hex: 0x0d). No differentiation is made between capital and lowercase letters (i.e. TG = tg). Units of measurement are always definite (i.e. span value given in MHz) and are therefore not indicated.

Setting Commands:

(E)	=	stands for keyboard Enter
(CR)	=	Carriage Return pushbutton
#kl0(E)	=	Key-Lock off
#kl1(E)	=	Key-Lock on (RM (Remote) -LED is lit)

The following commands are executed only if „kl1" has been sent before, so that REMOTE is on.

#tg0(E)	=	tracking generator off
#tg1(E)	=	tracking generator on
#vf0(E)	=	video filter off
#vf1(E)	=	video filter on
#tl+01.0(E)	=	tracking generator level of +1.0 dBm
#tl-50.0(E)	=	up to -50.0 dBm in 0.2 dB steps
#rl-30.0(E)	=	reference level of -30.0 dBm
#rl-99.6(E)	=	up to -99.6 dBm, in 0.2dB steps
#at0(E)	=	attenuator 0 (10, 20, 30, 40) dB
#bw1000(E)	=	bandwidth 1000 (120, 9) kHz
#sp1000(E)	=	Span 1000 MHz, selectable between 1000MHz and 1MHz in 1-2-5 sequence
#sp0(E)	=	zero span
#db5(E)	=	5 dB/Div. scaling
#db10(E)	=	10 dB/Div. scaling
#cf0500.000(E)	=	center frequency in xxxx.xxx MHz
#dm0(E)	=	detect mode off (average, max. hld)
#dm1(E)	=	detect mode on (average, max. hld)
#sa(E)	=	stores signal A in memory B
#vm0(E)	=	display signal A
#vm1(E)	=	display signal B (stored signal)
#vm2(E)	=	display A – B (A (actual) minus B (stored signal))
#vm3(E)	=	display average mode detected signal
#vm4(E)	=	display max. hold mode detected signal
#br4800(E)	=	baud rate 4800 (9600, 38400, 115200) Baud
#bm1(E)	=	signal data transfer in 2048 byte block, 2001 signal byte, 3 check sum byte and hex: 0x0d
#rc0(E)	=	recall (0 to 9) saved instrument settings
#sv0(E)	=	save (0 to 9) instrument settings

Special commands for emc measurement (only possible in combination with zero span):

#es0(E)	=	„1 second measurement" off
#es1(E)	=	prepares for a „1 second measurement" (1second measuring time; zero span activated and suitable resolution band width selected)
#ss1(E)	=	starts a „1 second measurement" at current center frequency and transfers data of the previous measurement.

Note: After a command has been received and executed the spectrum analyser returns „RD" (CR).

Example (emc measurement):
#es1(CR) (prepares for „1 second measurement), #cfxxxx.xxx(CR), #ss1(CR) (1. measurement, data invalid), #cfxxxx.xxx(CR), #ss1(CR) (2. measurement, transfer of 1. measurement data), #cfxxxx.xxx(CR), #ss1(CR), ... , #es0(CR) (1 second measurement off).

Parameter Query (list of query commands):
The following queries are always answered even if the instrument is not in remote condition (Remote Off; KL0).

Syntax:

#xx(E)	=	transfer parameter (xx = tg, tl, rl, vf, at, bw, sp, cf, db, kl, hm, vn, vm, dm, uc)

Note: With the exception of

#hm(E)	=	query for instrument type
#vn(E)	=	query for firmware version
#uc(E)	=	query for measurement condition (uncalibrated, calibrated)

other commands have been listed under „Setting Commands".

1st Example:
„#uc(E) (uncalibrated)": PC transmits #uc(CR). Instrument reply: UC0(CR) (calibrated) or UC1(CR) (uncalibrated)

2nd Example:
„#tl(E)", PC query for tracking generator level: PC transmits #tl(CR). Instrument reply: e.g. TL-12.4 (CR)

3rd Example:
„#vn(E)", PC query for firmware version: PC transmits #vn(CR). Instrument reply: x.xx(CR) (e.g. x.xx = 1.23)

4th Example:
„#hm(E)", PC query for instrument type: PC transmits #hm(CR). Instrument replies with:
5014-2 (CR) or 5012-2

5th Example:
PC transmits a command sequence to the analyzer:

#kl1(E)	=	switch „Remote" on
#cf0752.000(E)	=	sets center frequency to 752 MHz
#sp2(E)	=	sets a span of 2 MHz
#bw120(E)	=	selects a resolution bandwidth of 120 kHz
#kl0(E)	=	switches from remote to manual operation

Unknown or unrecognised commands do not cause a response to the PC.

Detailed description of #bm1 command

#BM1(CR) = block mode (transfers 2048 data byte via RS-232 interface)

The transfer data consist of 2048 byte: trans_byte [0] up to trans_byte [2047]
The 2048 data byte contain 2001 signal byte, the center frequency parameter and a check sum for the signal byte.
The signal data allocate the following transfer data byte.
trans_byte[n] = sig_data[n] (n = 0 bis n = 2000):
trans_byte[0] = sig_data[0]
trans_byte [2000] = sig_data[2000]

The check sum is a 24 bit value (= 3 Bytes) and generated as follows:
Checksum = sig_data[0] +sig_data[1] + ... sig_data[1999] + sig_data[2000] (sum of all signal data)
The 24 bit check sum allocates the following transfer data byte:
trans_byte[2044] = 1.Byte of checksum [MSB]
trans_byte[2045] = 2.Byte of checksum
trans_byte[2046] = 3.Byte of check sum [LSB]

The center frequency parameter is allocated to the following transfer data byte:
trans_byte [2016] = 'C'; trans_byte [2017] = 'F'; trans_byte [2018] = 'x';
trans_byte [2019] = 'x'; trans_byte [2020] = 'x'; trans_byte [2021] = 'x';
trans_byte [2022] = '.'; trans_byte [2023] = 'x'; trans_byte [2024] = 'x';
trans_byte [2025] = 'x'; (x= '0' to '9') Example: CF0623.450
(These bytes are not being used for check sum calculation)

The last sign is always CR (Carriage Return)
trans_byte[2047] = 0D hex (Carriage Return)
All unused bytes are set to „00 hex".

Reference between signal data and screen display

The signal data are the result of 2001 analog/digital conver-si-ons during one sweep.

X-Position: The analog value of the first byte „sig_data[0]" is displayed at the trace start position (left). The following values are displayed linearly until sig_dat[2000] is reached, which is

displayed at the trace end position (right). The frequency of each signal data (sample) can be calculated from center frequency and span.
Frequency (x) = (Center Frequency – 0.5 * Span) + Span * x/2000
X = 0... 2000 (Position of sample = sig_data[x])

Y-Position: The 8 bit value (hex: 00 bis FF) of each memory location for sig_data[x] has the following relation to the screen:
1C hex (28 dec) coincides with the lowest horizontal graticule line.
E5 hex (229 dec) coincides with the upmost (reference level) graticule line.
The a/d converter dependent resolution allows for 25 different Y positions/div.
In combination with 10dB/div the resolution is 0.4 dB and in case of 5dB/div it is 0.2dB.
The level (y) of a signal position can be calculated:
For y< 229 (Ref-Level position):
Level in dBm (y) = ref-level (dBm) – ((229-y) x 0.4 dB) at 10dB/Div
For y > 229 (Ref-Level position):
Level in dBm (y) = ref-level (dBm) + ((y-229) x 0.4 dB) at 10dB/Div

Control elements

① **POWER** (power switch)

② **INTENS** (Intensity)

③ **FOCUS / TR** (Trace Rotation)

④ **Keyboard**

⑤ **CENTER FREQ.** (center frequency)

⑥ **MARKER**

⑦ **REF.-LEVEL** (reference level)

⑧ **TG.-LEVEL** (Tracking Generator level)

⑨ **TUNING**

⑩ **5dB/DIV.** (vertical scaling)

⑪ **ATTN.** (input attenuator)

⑫ **RBW** (resolution bandwidth)

⑬ **VBW** (video bandwidth)

⑭ **AVERAGE** (arithmetic mean value)

⑮ **Max. HOLD** (storing of the maximum level values automatically)

⑯ **LOCAL/PRINT**

⑰ **B** (display of memory B)

⑱ **A – B** (displays the difference of memory A and B)

⑲ **A** (display of memory A)

⑳ **RECALL/SET** (calls the settings of the instrument)

㉑ **SAVE/SET** (saves the settings of the instrument)

㉒ **A>B** (copies signal from memory A to memory B)

㉓ **SPAN** (changes the measurement range values)

㉔ **ZERO SPAN** (measurement range at zero)

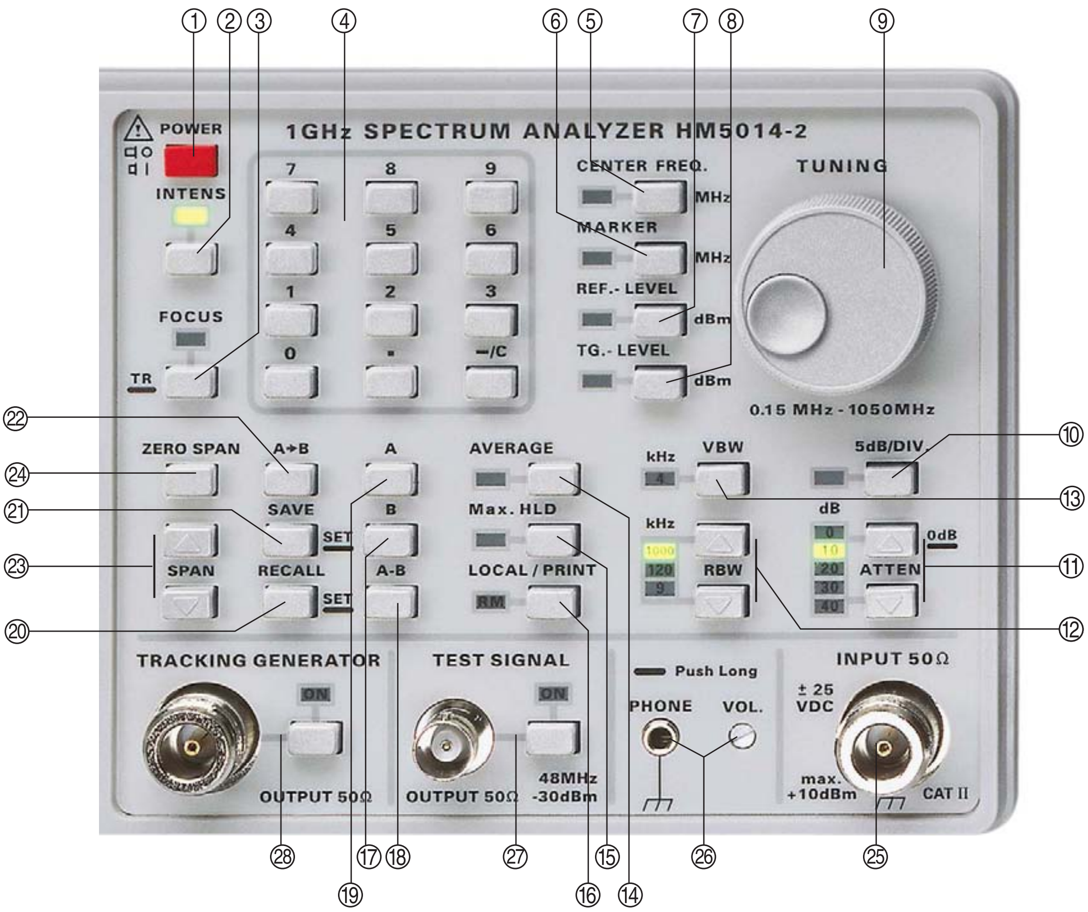
㉕ **INPUT 50 Ohm**

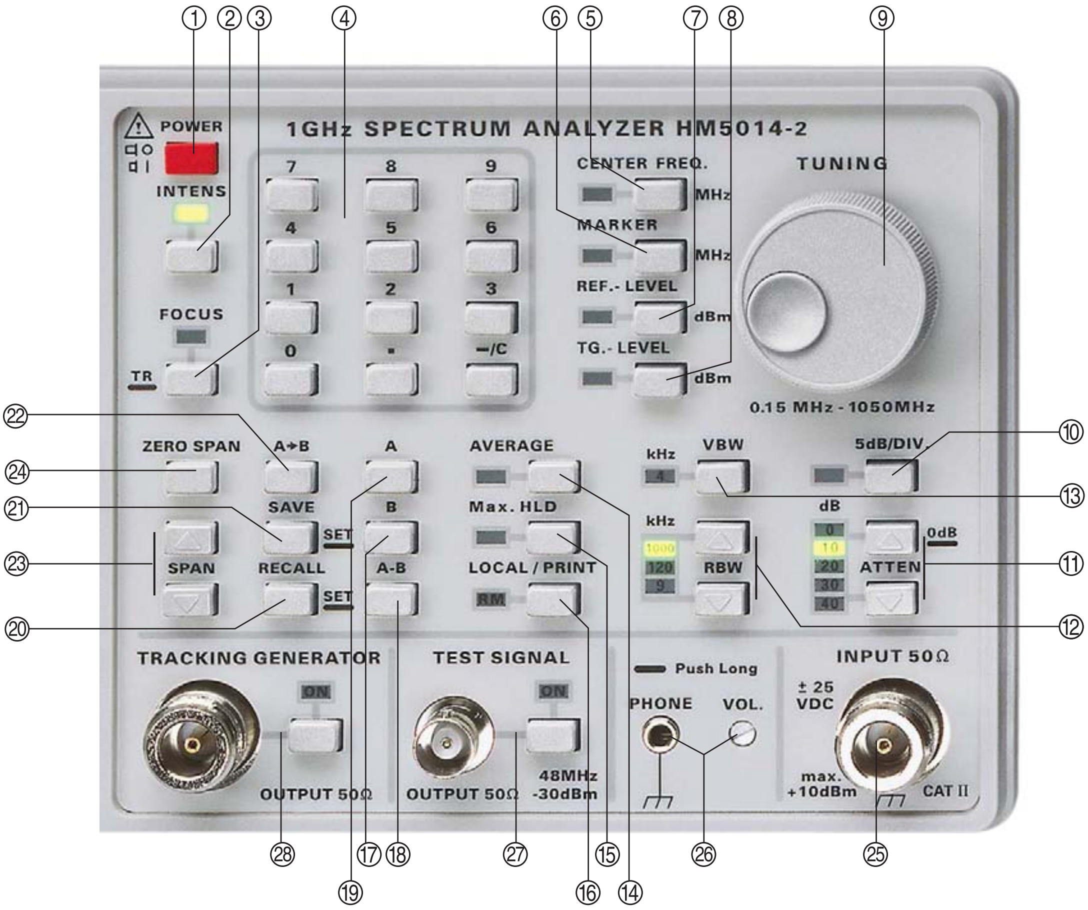
㉖ **PHONE** (headphone connector)

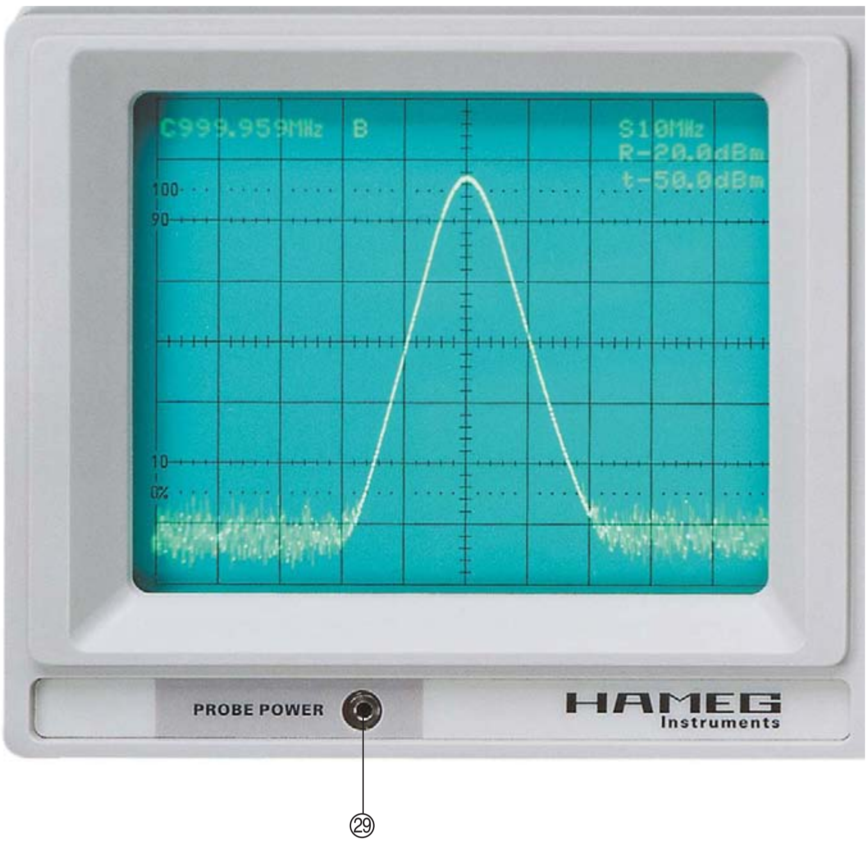
㉗ **TEST SIGNAL**

㉘ **TRACKING GENERATOR**

㉙ **PROBE POWER**




1GHz SPECTRUM ANALYZER HM5014-2
POWER
INTENS
FOCUS
TR
7 8 9
4 5 6
1 2 3
0 . –/C
CENTER FREQ.
MHz
MARKER
MHz
REF.- LEVEL
dBm
TG.- LEVEL
dBm
TUNING
0.15 MHz - 1050MHz
ZERO SPAN
A→B
A
AVERAGE
kHz
VBW
5dB/DIV.
SAVE
SET
B
Max. HLD
kHz
1000
120
9
RBW
dB
0
10
20
30
40
ATTEN
0dB
SPAN
RECALL
SET
A-B
LOCAL / PRINT
RM
TRACKING GENERATOR
ON
OUTPUT 50Ω
TEST SIGNAL
ON
48MHz
OUTPUT 50Ω -30dBm
Push Long
PHONE
VOL.
INPUT 50Ω
± 25 VDC
max. +10dBm
CAT II
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28


C999.959MHz B
S10MHz
R-20.0dBm
t-50.0dBm
100
90
10
0%
PROBE POWER
HAMEG
Instruments
29

Controls and readout

① **POWER**
Pushbutton and symbols for ON (I) and OFF (◯) – Depressing the POWER pushbutton into the ON position activates the display of the HAMEG logo after a few seconds, followed by the firmware version. At this time the intensity is set to a default value and cannot be changed. After the firmware version goes off, the baseline (noise) becomes visible at the graticule bottom and some instrument setting parameters appear at the top.

② **INTENS**
Pushbutton with double function and associated LED. Briefly depressing this pushbutton switches the INTENS LED on and activates the TUNING knob as an intensity control. Turning this knob clockwise increases the intensity and vice versa. It must be noted that a higher intensity increases the beam diameter and reduces the sharpness. This mainly occurs at the graticule border lines and can be minimized to some degree by FOCUS ③ correction. Therefore the intensity should not be set higher than required by ambient conditions.

③ **FOCUS / TR**
Pushbutton with two functions and associated LED.

FOCUS
This function is activated by briefly depressing the pushbutton so that the LED is lit. Then the TUNING ⑨ knob can be used for focusing.

The beam diameter increases with higher intensity settings which may cause a reduced focus. The focus also depends on the beam deflection. If the focus optimum is set for the screen center, it decreases with increasing distance from the center. The function is cancelled and the LED unlit if another function pushbutton (2, 5, 6, 7 or 8) is called.

TR
Pressing and holding the pushbutton switches off the spectrum and parameter display and the FOCUS LED. A rectangle with horizontal and vertical center lines is then displayed. It should be tilted using the knob TUNING ⑨, so that the horizontal center line is parallel to the graticule line. This adjustment depends on the orientation of the instrument to the Earth's magnetic field. Slight pincushion distortion is unavoidable and cannot be corrected.

After use, the TR-function can be switched off by briefly depressing the FOCUS/TR-pushbutton or any other pushbutton (with associated LED) in the upper half of the front panel.

④ **Keyboard**
The keyboard contains 10 decimal keys, a decimal point key and –/C key. The following functions are available: CENTER FREQ ⑤, REF.-LEVEL ⑦, TG.-LEVEL ⑧. Alternatively, these may also be adjusted with the knob TUNING ⑨. The MARKER ⑥ frequency can only be set by the knob TUNING ⑨.

The available function have to be active, before entering a value. E.g. the REF.-LEVEL-LED have to be lit if a new reference level can be entered. Then the reference level is able to be entered unsigned or with negative sign. As soon as the first value or the negative sign has been input, two additional lines are displayed by the readout. They are located on the left below the previous information. The first line shows the actual function (e.g. CENTER:MHz) and below, the first keyboard entry.

After complete entry, the new value is accepted, (if the value corresponds with the specifications and range limits) by pressing the active function pushbutton once again; otherwise „Range?" will be displayed. Input errors can be corrected by pressing the „–/C" pushbutton, followed by a new input. Pressing and holding the „–/C" pushbutton deletes the complete keyboard entry and the readout function display.

⑤ **CENTER FREQ.**
Pushbutton with associated LED – Briefly depressing this pushbutton switches the CENTER FREQ. (frequency) LED on. A new center frequency can then be set with the knob TUNING ⑨ or via keyboard ④. The center frequency is displayed by the readout (e.g. „C:054.968 MHz").

After the center frequency has been changed, it must be confirmed by pressing the CENTER FREQ. pushbutton. The center frequency spectrum is displayed at the center of the horizontal axis.

⑥ **MARKER**
Pushbutton with associated LED – The MARKER is switched on by briefly depressing this pushbutton so that the LED is lit and the MARKER symbol (x) is displayed on the spectrum. Below the center frequency, the readout now also shows the MARKER frequency display (e.g. „M086.749 MHz") and beneath the MARKER level display (e.g. „–35.2dBm") of the signal.
The MARKER frequency and level display relates to the actual MARKER symbol (x) position, which follows the signal when being shifted to the right or left by the knob TUNING ⑨.

The keyboard ④ is not activ when the MARKER function is switched on. In ZERO SPAN mode the MARKER is automatically set to the screen center and cannot be altered as only one frequency is measured.

⑦ **REF.-LEVEL**
Pushbutton with associated LED – The function is selected by pressing the pushbutton, the LED will light up. The value can be chosen either with the knob TUNING ⑨ or by entering it using the keyboard ④ and pressing the pushbutton again. The display will show e.g. R-34.8 dBm.

The REF.-LEVEL can be set for ease of reading, shifting a spectrum line to a suitable graticule position. The reference level setting will not change the input sensitivity. If the noise band is in the lowest screen position, the REF.-LEVEL value can only be decreased but not increased. Additionally the noise band is shifted to the screen top, so that the dynamic range becomes smaller.

The noise band is no longer visible when the ref. level is in the lowest position and 5 dB/div. ⑩ scaling is switched on. It can be made visible again by reducing the reference level by 40 dB (e.g. from –30 dBm to –70 dBm).

⑧ **TG-LEVEL**
Pushbutton with associated LED – The tracking generator output level can be set by keyborad ④ entry or by using the knob TUNING ⑨. The selected level is displayed by the readout as the third line in top right position (e.g. „txxxdBm" or „TxxxdBm"). The small letter „t" indicates that the TRACKING GENERATOR OUTPUT is switched off. The ON-condition is indicated by the capital letter „T".

⑨ **TUNING**
The knob TUNING can be used to change all functions with pushbuttons and associated LEDs in the upper sector of the front panel. They are: INTENS, FOCUS, TR, CENTER FREQ., MARKER, REF.-LEVEL and TG-LEVEL.

⑩ **5 dB/DIV.**
Pushbutton with associated LED – Pressing this pushbutton switches the vertical scale from 10 dB/Div. (LED dark) to 5 dB/Div. (LED lit) and vice versa, without changing the reference level setting. With 5 dB/Div. selected, the display range is 40 dB instead of 80 dB.

Note:
Switching over to 5dB/Div. can cause the noise band to „disappear" from the screen, but it can be made visible again by changing the REF.-LEVEL ⑦.

⑪ **ATTN.**
Pushbuttons with associated LEDs. – Pressing one of the pushbuttons switches the attenuator in 10 dB steps from 0 dB to 40 dB resp. from 40 dB to 10 dB. The measuring range depends on the attenuator setting. If 10dB/div. is set (80dB scale), the following measuring ranges are available:

Attenuator setting	Reference Level	approx. Noise Level
40 dB	+10 dBm	–60 dBm
30 dB	0 dBm	–70 dBm
20 dB	10 dBm	–80 dBm
10 dB	20 dBm	-90 dBm

Pressing and holding the upper pushbutton causes switch over from 10 dB to 0 dB. Due to the high sensitivity of the input stage, this measure has been taken to protect the input stage from being set to 0 dB inadvertently.

IMPORTANT:

It must be emphasized once again that the maximum permissible input voltages must not be exceeded. This is of high importance as the analyzer may only display a part of the spectrum and high signal levels outside the measuring range may cause measuring errors or in worst case destruction of the input section.

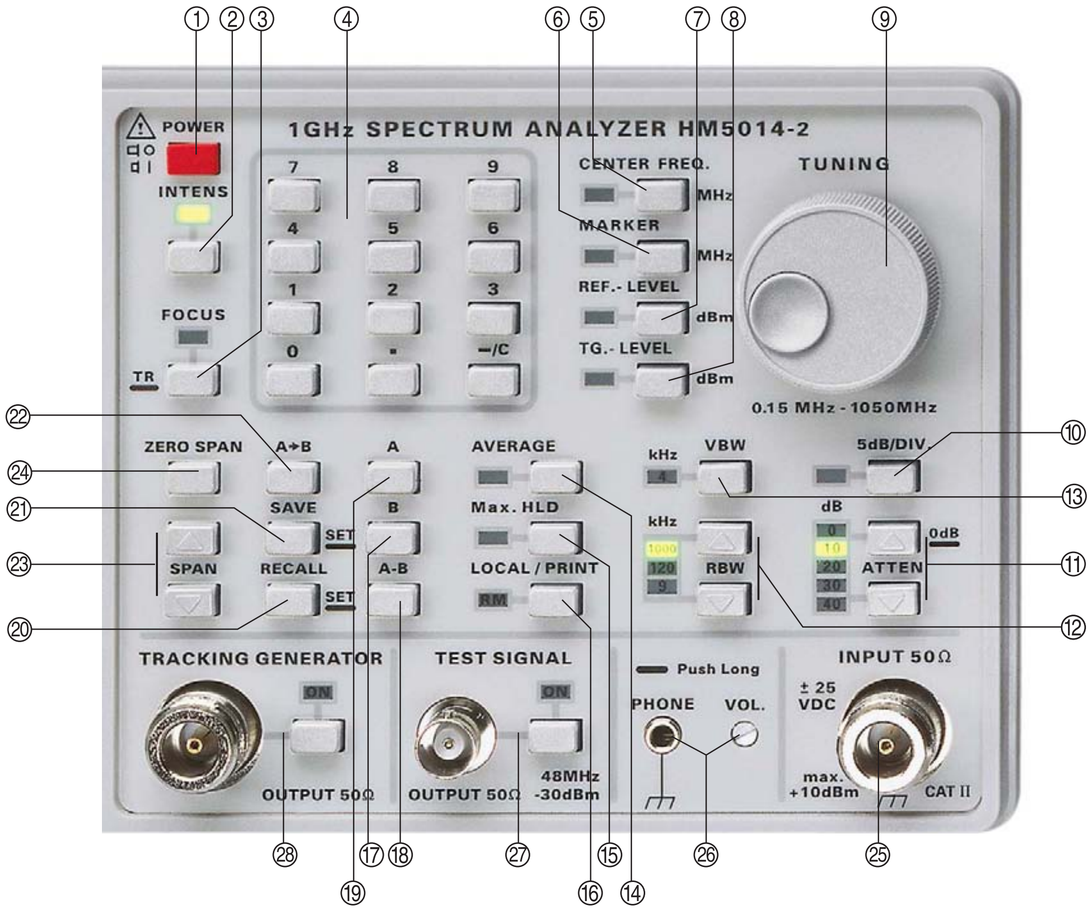
⑫ **RBW**
Pushbuttons with associated LEDs. – The pushbuttons allow you to select one of three IF bandwidths. A lit LED indicates the actual bandwidth setting.
With the exception of ZERO SPAN, the curve of the selected IF filter is displayed when a signal passes the IF filter causing the beam to be deflected to the screen top, depending on the signal strength. It depends on the IF bandwidth (RBW=Resolution Bandwidth) whether two different sine wave signals with minor frequency distance can be displayed separately. For example, two sine wave signals with 40 kHz signal difference and equal amplitude can be identified as two different signals if 9 kHz RBW is selected. With 120 kHz or 1 MHz RBW selected, the two signals are displayed as one signal only.

A smaller IF bandwidth shows more details, but has the disadvantage that the building up time is higher. If due to high SPAN setting there is not enough time for building up, the spectrum analyzer automatically increases the time for a SPAN. This becomes visible by a reduced measurement repetition rate.

If the lowest repetition rate is still not suitable for correct measurement, the readout displays „uncal", as under such circumstances the signal is displayed with too low a level. For proper measurement the SPAN must then be reduced until the „uncal" information is no longer displayed. For the ease of operation it is advisable to set the signal to the center before reducing the SPAN.

With the 4 kHz video filter activated, the bandwidth reduces once again. A smaller bandwidth reduces the noise and offers a higher sensitivity. This becomes evident when switching from 1000 kHz to 9 kHz RBW.

⑬ **VBW**
Pushbutton with associated 4-kHz-LED – Pressing this pushbutton switches the video filter on or off. In ON-condition the video filter reduces noise using a low pass filter. Weak signals, which normally get lost in the noise, may become visible when activating this function.



Note:
If the video filter is activated and the SPAN is too high, „uncal" is displayed by the readout, as the signal level(s) do not reach their real height on the screen.

In case of measuring pulses, the video filter should not be used.

⑭ AVERAGE
Pushbutton with associated LED – Pressing this pushbutton switches this function and the associated LED on or off. In Average mode, the spectrum recordings are continuously calculated and displayed as arithmetic mean value. Some functions cannot be called in AVERAGE mode and cause only an acoustic error message.

When the AVERAGE LED lit, briefly depressing the pushbutton switches LED and function off and erases the previous calculation result. AVERAGE also activates the Max. HLD ⑮ function (without displaying the result) to avoid waiting time and enable direct switch over from AVERAGE to Max. HLD (maximum hold).

⑮ Max. HLD
Pushbutton with associated LED – Pressing this pushbutton switches the Max. HLD (maximum hold) function and the associated LED on or off. Max.HLD stores and displays the maximum level values of the spectrum; values below the maximum get lost. In case of pulsating RF-signals the signal reading should not be made until the maximum signal height is present. Some functions cannot be called in Max. HLD mode and cause an acoustic error signal.

When Max. HLD is activated and the associated LED lit, briefly depressing the pushbutton switches LED and function off and erases the Max. HLD values. Max. HLD also activates the AVERAGE ⑭ function (without displaying the result) to avoid waiting time and enable direct switch over from Max. HLD to AVERAGE mode.

⑯ LOCAL/PRINT
Pushbutton with two functions and associated LED.

LOCAL function
Remote mode can be switched on or off via the built in serial interface. In remote condition the RM LED is lit and with the exception of the LOCAL/PRINT pushbutton all other controls are deactivated. Briefly depressing the LOCAL/PRINT pushbutton switches over from remote (RM) to LOCAL operation, so that all controls become operative again.

PRINT function
On condition that the RM-LED is not lit (LOCAL mode), documentation via a PC printer can be started if the following conditions are required:

1st The serial interface of the spectrum analyzer must be connected with a serial PC (COM) port.
2nd The provided PC software must be activated and the software COM port setting must comply with the hardware connection.

⑰ B
Pushbutton – The spectrum analyzer contains a second signal and parameter memory that is called „B". This memory is volatile and switching the instrument off will lose its content. Memory „B" can only be activated with the instrument on, after a spectrum has been previously stored by A→B-function; otherwise an acoustic error message is audible.

Briefly depressing the B pushbutton switches over to B display which is indicated by the readout (top left position) on the right of the center frequency display.

⑱ A – B
Pushbutton – This function can be called only if a spectrum has previously been stored in memory B. Then the result of the actual recorded spectrum minus the content of memory B is displayed. On the right on the center frequency the readout shows A - B.
The A–B-function eases the perceptibility of changes in signal level, frequency and shape when adjustments are made (if the previous setting had been stored in memory B). When switching the A–B-function on, the reference level is automatically changed for better reading. A manual correction overrides the automatic setting.

⑲ A
Pushbutton – The spectrum analyzer contains 2 memories named A and B. The memory A content is the actual signal at the spectrum analyzer input that is continuously refreshed. When the A pushbutton is pressed, only the actual spectrum is written into the memory, read and displayed. The letter A indicates this state after the CENTER FREQUENCY information in the readout.

⑳ RECALL/SET
Pushbutton with double function. – **Note:** The RECALL function cannot be activated as long as AVERAGE or Max. HLD is present.

RECALL: The instrument has a memory for 10 instrument parameter settings that can be called by this function.

Pressing the RECALL pushbutton calls the function so that e.g. „Recall9" is displayed by the readout where the SPAN was previously indicated. As long as „Recall .." is displayed (approx. 2 seconds) the RECALL and SAVE ㉑ pushbuttons can be used to select the memory location with ciphers between 0 and 9. Each time the memory location setting is changed by pressing the SAVE or RECALL pushbutton, the (approx.) 2 seconds for the memory location display time starts again.

SET (push long): Calling an instrument setting first requires that the memory location be displayed, which is called by briefly pressing the pushbutton. Pressing and holding the pushbutton while the memory location is displayed, causes the instrument to accept the settings from the selected memory location to the front panel. The take over is acknowledged by a double beep.

Function break off: After approx. 3 seconds waiting time the RECALL function is left automatically if it has been called inadvertently or not used. The Recall memory location display is then switched off.

㉑ SAVE / SET
Pushbutton with double function. – **Note:** The SAVE function cannot be activated as long as AVERAGE or Max. HLD is present.
SAVE: This function allows you to store up to 10 instrument settings in a non volatile memory, which can later be called by RECALL. This allows you to quickly call repeated instrument settings.

Pressing the SAVE pushbutton calls the function so that e.g. „Save5" is displayed by the readout where the SPAN was indicated before. As long as „Save .." is displayed (approx. 2

seconds) the SAVE and the RECALL ⑳ pushbuttons can be used to select the memory location with ciphers between 0 and 9. Each time the memory location setting is changed by briefly depressing the SAVE or RECALL pushbutton, the (approx.) 2 seconds for the memory location display time starts again.

SET (push long): Saving the instrument setting first requires that the memory location be displayed, which is called by briefly pressing the pushbutton. Pressing and holding the pushbutton while the memory location is displayed causes the instrument to save the instrument settings in the selected memory location. The take over is acknowledged by a double beep.

Function break off: After approx. 3 seconds waiting time the SAVE function is left automatically if it has been called inadvertently or not used. The „Save..“ memory location display is then switched off.

㉒ **A→B**
Pushbutton – When the readout displays the letter A at the right of the center frequency, the actual spectrum present at the input is displayed. After processing the spectrum is digitized stored into A memory, converted back to analog and displayed on the screen.

Pressing the pushbutton A→B stores the contents of memory A into the B memory and additionally switches over to display the content of memory B. The readout now indicates the letter B in the position where previously A was shown.

After the actual spectrum has been transfered from memory A to B the transfered signal is displayed continuously (without change) until switching either to memory A ⑲ (causing the actual input spectrum to be displayed) or A–B (where the actual input spectrum minus the memory B content is shown). The spectrum in memory B is lost after turning off the instrument.

㉓ **SPAN**
Pushbuttons. – The pushbuttons allow you to increase (upper pushbutton) or reduce (lower pushbutton) the SPAN. It can be selected in a 1-2-5 sequence between 1 MHz and 1000 MHz (full span) and defines the start and stop frequency in combination with the center frequency setting.

Example: In combination with a center frequency of 300 MHz and a span of 500 MHz, the start frequency (trace start, left) is 50 MHz (300 MHz – Span/2) and the stop frequency (trace end, right) is 550 MHz (300 MHz + Span/2).

Note: The instrument has been programmed to optimize the sweep time, considering the span, resolution bandwidth (RBW) and video filter (VBW). If not possible the readout shows „uncal“ to indicate that the spectrum level values are incorrect.

㉔ **ZERO SPAN**
Pushbutton – Pressing this pushbutton switches this mode on or off. In order to exit ZERO SPAN, by pressing one of the SPAN pushbuttons, the instrument will return to the SPAN selected before entering ZERO SPAN.

In ZERO SPAN mode the readout shows ZERO-SP instead of the SPAN setting. This mode enables measurement on a discrete frequency that is determined by the center frequency setting. ZERO SPAN can also be turned off by pressing one of the SPAN ㉓ pushbuttons.

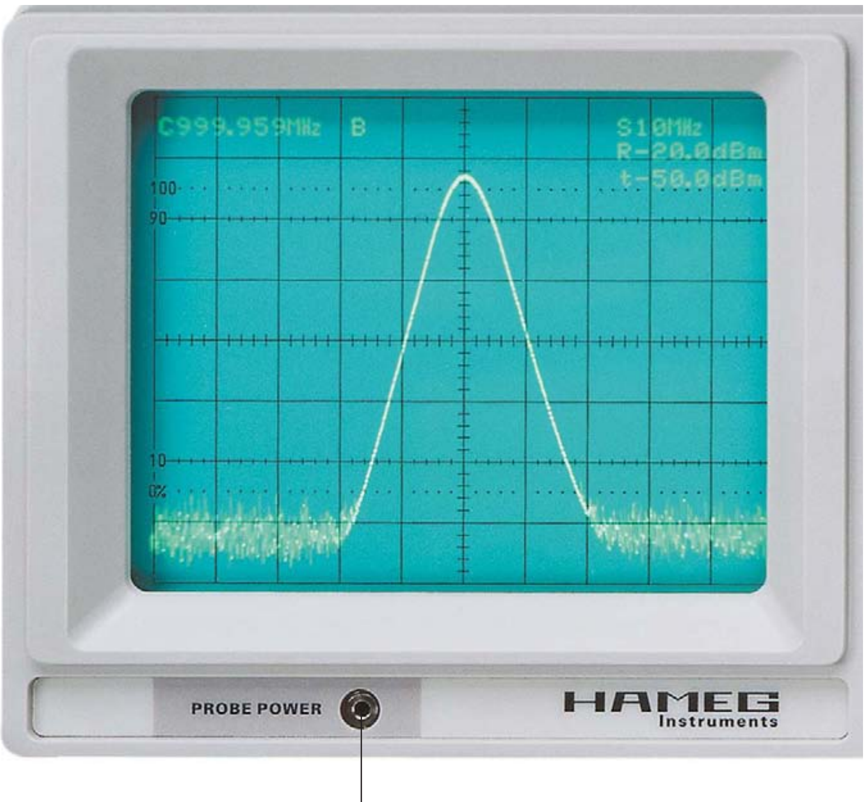
㉕ **INPUT 50 Ω**
N-socket – Measurement input, max. 25 V_{DC} resp. max. +10 dBm HF. With the attenuator set to –40 dB the maximum input HF-signal is +20 dBm. Higher levels may destroy the input stage.

The N connector is directly connected to the chassis and thus with the safety earth of the power plug!

㉖ **PHONE**
Headphone output connector, Ø 3.5 mm. – This output is destined for headphones with an impedance of ≥8 Ω. The volume can be varied with a screwdriver using the VOL. control.

The signal at this socket originates from the AM demodulator and eases the identification of signals. E.g. If an antenna is connected to the spectrum analyzer input in ZERO SPAN mode, the instrument can be tuned to a discrete transmitter frequency. Please consider that using this function must be within the limits of the law.

㉗ **TEST SIGNAL**
BNC socket with pushbutton and associated LED. – Even if the LED is not lit, the BNC socket serves always as a broadband signal source with many spectra even though the 48 MHz signal is absent. It can be connected to the spectrum analyzer input via a 50 Ω cable and used for function check of the input.



㉙

If the output is switched on (LED lit) a 48 MHz signal with a level of approx. –30dBm is additionally connected to the test signal output. Please note „Test Signal Display"!

㉘ **TRACKING GENERATOR**
N-socket and OUTPUT pushbutton with ON LED. – For protection of devices connected to the tracking generator it is always in off condition after switching the instrument on. This state is indicated by the letter „t" displayed by the readout and the LED is not lit. Depressing the pushbutton switches the tracking generator on, the LED lights, and the readout now displays the capital letter „T" in front of the tracking generator level. Depressing the pushbutton once again switches the tracking generator off.

A sine wave output signal is provided at the N socket with a source impedance of 50 Ohm. The sine wave signal frequency is always identical to the spectrum analyzer receiving frequency.

㉙ **PROBE POWER**
The jack has a diameter of 2.5mm and may be used only for supply of HZ530 near field probes. The inner connector (+6V) and outer connector (galvanically connected with Protective Earth) can supply a maximum current of 100mA.