HAMEG®
Instruments

Manual

Spectrum-Analyzer HM5012/14

Software SW5012

MANUAL•HANDBUCH•MANUEL

Spectrumanalyzer HM5012/HM5014

Subject to change without notice

Software SW5012

General information regarding 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 HZ72S 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.

December 1995
HAMEG GmbH

Subject to change without notice

KONFORMITÄTSERKLÄRUNG
DECLARATION OF CONFORMITY
DECLARATION DE CONFORMITE

$\mathsf{C}\mathsf{E}$

HAMEG ®
Instruments

Name und Adresse des Herstellers	**HAMEG GmbH**
Manufacturer´s name and address	**Kelsterbacherstraße 15-19**
Nom et adresse du fabricant	**D - 60528 Frankfurt**
	HAMEG S.a.r.l.
	5, av de la République
	F - 94800 Villejuif

Die HAMEG GmbH / HAMEG S.a.r.l bescheinigt die Konformität für das Produkt
The HAMEG GmbH / HAMEG S.a.r.l herewith declares conformity of the product
HAMEG GmbH / HAMEG S.a.r.l déclare la conformite du produit

Bezeichnung / Product name / Designation: Spektrum-Analysator/Spectrum Analyzer/Analyseur de spectre

Typ / Type / Type: **HM5012/ 5014**

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: 1993 / IEC (CEI) 1010-1: 1990 A 1: 1992 / VDE 0411: 1994
EN 61010-1/A2: 1995 / IEC 1010-1/A2: 1995 / VDE 0411 Teil 1/A1: 1996-05
Überspannungskategorie / Overvoltage category / Catégorie de surtension: II
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 /
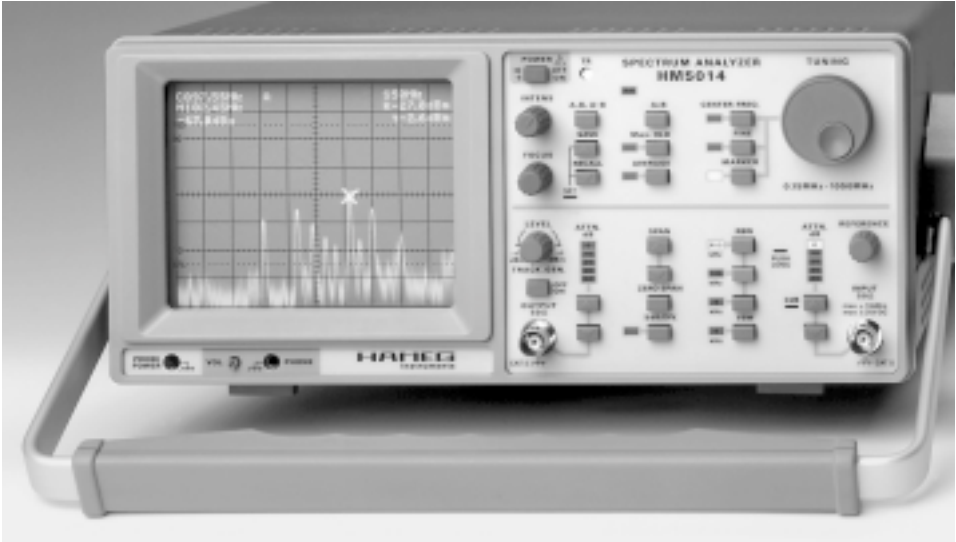
Fluctuations de tension et du flicker.

Datum /Date /Date

15.01.2001

Unterschrift / Signature /Signatur

E. Baumgartner
Technical Manager
Directeur Technique

HM5012 & HM5014, the Spectrum Analyzers for EMC Measurements

- ■ **Continuous frequency range from 150 kHz to 1050 MHz.**
- ■ **Amplitude range from –100 dBm to +13 dBm**
  (7 dBµV to 120 dBµV) 80 dB on-screen
- ■ **Resolution bandwidths of 9 kHz, 120 kHz, 400 kHz**
- ■ **Intermodulation-free dynamic range 75 dB**
- ■ **Save / Recall**

Technical Characteristics

The new spectrum analyzer HM5012 and HM5014 is based in general on the high frequency characteristics of the HM5010 and the HM5011 analyzers. The usable frequency range is therefore from 150 kHz to above 1 GHz. The available resolution bandwidths are 9kHz, 120kHz and 400 kHz. Completely new is primarily the processor-controlled operation and a digital signal display which works in real-time, and is resolved with up to 4,000 points over the entire screen. The screen will also display all selected frequency settings and the marker results.

The unique features of this spectrum analyzer are the extensive EMC measurement capabilities. These include the amplitude indication in Peak and Average modes. For the precise evaluation of the signals a marker is provided that will give a readout for amplitude and frequency on-screen.

An additional advantage is that newly acquired signals can be compared with the content of the reference storage. Complicated and repeatedly used equipment adjustments can be saved by use of the Save/Recall function.

HM 5014

The Model HM5014 includes a tracking generator that can be used to evaluate the frequency characteristics of 4-terminal devices, such as filters.

The Interface

The Analyzers are supplied with an RS-232 interface for PC communication and print-out. The optional HZ70 optoisolator with fiber-optics cable is available to isolate the spectrum analyzer from interference effects and ground loops.

The Software

The software for extended functions and for the evaluation of measurement results via PC is part of the spectrum analyzer and provides the following features:

Numeric indication of measurement values.
Average, peak and quasi peak values with
corresponding cursor.
Storage of reference spectra for comparison.
Freely definable limit lines.
Indication of above-limit signals.
Correction factors for antennas.
Script-control for automatic measurements.
Printout in tabular form (e. g. table calculations).
B/W or color printouts of the spectra with printer selection for all printers
supported by Windows ©.
On line "Help" function.

A manual for various EMC applications is provided.

Screen Dump of Software SW5012
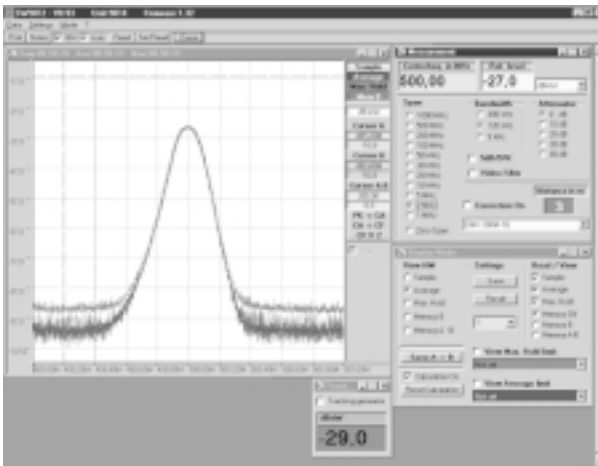
Specifications

Frequency

Frequency Range:	0.15 MHz to 1050MHz
Frequency Resolution displayed:	10kHz (5½ Digit in Readout)
Center Frequency Range	0.15 MHz - 1050 MHz
Accuracy:	±100kHz
Stability (Drift)**:**	<150kHz / hour
Span:	Zero span and 100kHz/Div to 100MHz/Div in steps of 1-2-5-10
Accuracy:	±5%
Marker:	absolute Marker
Marker Resolution (Frequency)	5½ digits
Marker Resolution (Level)	3½ digits
Marker Readout Accuracy:	±(0.1% span + 100kHz)
Resolution Bandwidth, RBW (3dB):	9kHz, 120kHz and 400kHz
Video Bandwidth, VBW:	4kHz
SWT (fixed)**:**	40ms, 320ms, 1s[1]

Amplitude

Measurement Range:	–100dBm to +13dBm
Displayed Average Noise Level:	–102dBm (120kHz RBW)
Frequency Response	
Relative to 500 MHz, ATTN 10 dB	±2 dB
Input Attenuator Range:	40 dB, 10 dB steps
Accuracy (reference level):	±1 dB
Maximum Safe Input Level	
Attenuator setting 20db:	+20 dBm (0,1W)
Attenuator setting 0dB:	+10 dBm
DC:	±25 V
Display Range:	40, 80 dB, 8 Divisions
Scale Units	dBm
Reference Level:	-99 to +13 dBm (+var.)
Resolution Bandwidth Switching Uncertainty:	±1dB
Spurious responses:	
Intermodulation (3rd Order)**:**	–75 dBc
(2 Signals, –27 dBm each, Frequency distance>3MHz)	
Harmonic Distortion (2nd, 3rd)**:**	<–75 dBc
Absolute Amplitude Accuracy:	±2.5 dB

Inputs / Outputs

Front Panel	
Input Connector	BNC (F) Impedance: 50Ω
Probe Power:	6V (Near field probes)
Tracking Generator Out (HM5014)	BNC (F) Impedance: 50Ω

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Special Functions

Average	32 measurements
SAVE/RECALL	9 complete Set-ups
Peak-Detection	
Max. Hold	
Hold	Trace stored on screen
Reference Curve	
AM-Demodulator	Ear Phones

Tracking Generator (only Model HM5014)

Output Frequency Range:	150 kHz to 1050 MHz
Output Power Level	–50dBm bis +1dBm
Output flatness (150 kHz to 1 GHz)	±1.0dB
Spurious Outputs	
Harmonic Spurs	>20dBc
Non-Harmonic Spurs	>20dBc

General

Temperature Range	
Operating	10°C to 40° C
Storage:	–40°C to 70° C
Power Requirements:	
Voltage	115 / 230V
Frequency	50-60Hz
Power consumption	approx. 43VA
CRT:	8 x 10cm
Protective System:	Safety Class I (IEC 1010-1)
Dimensions	**W** 285, **H** 125, **D** 380mm
Weight:	approx.: 6kg

1) only if EMC set-up is used
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Accessories supplied

Software for evaluation, Documentation and Remote Control. Power Cable, Operating Manual.

Optional accessories

Optical Interface (RS232)	**HZ 70**
Telescope Antenna	**HZ 520**
Transient Limiter	**HZ 560**
Near Field Probes (E, H, High Imp. Probe)	**HZ 530**
LISN (EMC)	**HM 6050**

HZ530 EMI Near Field Sniffer Probe Set (Optional accessories)

The HZ530 is the ideal toolkit for the investigation of **RF electromagnetic fields**. It is indispensible for **EMI pre-compliance testing** during product development, **prior to third party** testing. The set **includes 3 hand-held probes** with a built-in pre-amplifier covering the frequency range from **10 kHz** to **1000 MHz** depending on probe type. The set includes one **magnetic field** probe, one **electric field** probe and one **high impedance** probe. All have high sensitivity and are matched to the 50Ω inputs of **spectrum analyzers**. The power can be supplied either from the batteries or thrugh a power cord directly connected to an HM5012/14 series spectrum analyzer. Signal feed is via a 1.5m BNC-cable. When used in conjunction with a spectrum analyzer or a measuring receiver, the probes can be used to locate and **qualify EMI sources**. They are especially suited to locate **emission "hot spots"** on PCBs and cables, as well as evaluate EMC problems at the **breadboard** and **prototype level**. They enable the user to evaluate radiated fields and perform **shield effectivity comparisons**. Mechanical screening performance and immunity tests on cables and components are easily performed. Faulty components and **poor bonding locations** can be isolated.

The **magnetic probe** incorporates a high degree of rejection of both stray and direct electric fields, and provides far greater repeatability than with conventional field probes. Measurements can be made on the **very near field area** that is close to components or radiation sources. The electric field (mono-pole) probe has the **highest sensitivity** of all three probes. It can be used to check screening and **perform pre-compliance** testing on a comparative basis. The high impedance probe is used to measure **directly on the components** under test or at the conductive trace of a PC board. It has an **input capacitance** of only 2pF and supplies **virtually no electrical charge** to the device under test.

Specifications

Frequency

Frequency range:	0.1MHz to 1000MHz
	(lower frequency limit
	depends on probe type)
Output impedance:	50 Ω
Output connector:	BNC-jack
Input capacitance:	2pF
	(high imped. probe)
Max. Input Level:	+10dBm
	(without destruction)
1dB-compression point:	-2dBm
	(frequency range dependent)
DC-input voltage:	20V max.
Supply Voltage:	6V DC
	4 AA size batteries

Supply-power of HM5012/5014

Supply Current:	8mA (H-Field Probe)
	15mA (E-FieldProbe)
	24mA(High imp.Probe)
Probe Dimensions:	40x19x195mm (WxDxL)
Housing:	Plastic; (electrically
	shielded internally)

Package contents:	Carrying case
	1 H-Field Probe
	1 E-Field Probe
	1 High Impedance Probe
	1 BNC cable (1.5m)
	1 Power Supply Cable
(Batteries or Ni-Cads are not included)	

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General Information

The HM5012/14 spectrum analyzer is easy to operate.The logical arrangement of the controls allows anyone to quickly become familiar with the operation of the instrument, however, experienced users are also advised to read through these instructions so that all functions are understood. Immediately after unpacking, the instrument should be checked for mechanical damage and loose parts in the interior. If there is transport damage, the supplier must be informed immediately. The instrument must then not be put into operation.

Symbols

⚠ **ATTENTION** - refer to manual

⚠ **Danger** - High voltage

⏚ **Protective ground** (earth) terminal

Tilt handle

To view the screen from the best angle, there are three different positions (C, D, E) for setting up the instrument. If the instrument is set down on the floor after being carried, the handle automatically remains in the upright carrying position (A). In order to place the instrument onto a horizontal surface, the handle should be turned to the upper side of the Spectrum Analyzer (C). For the D position (10° inclination), the handle should be turned to the opposite direction of the carrying position until it locks in place automatically underneath the instrument. For the E position (20° inclination), the handle should be pulled to release it from the D position and swing backwards until it locks once more. The handle may also be set to
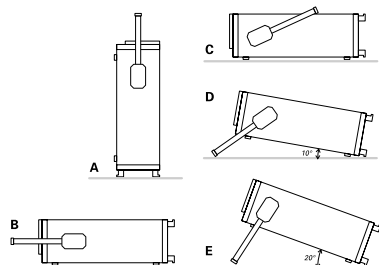
a position for horizontal carrying by turning it to the upper side to lock in the B position. At the same time, the instrument must be lifted, because otherwise the handle will jump back.

Safety

This instrument has been designed and tested in accordance with **IEC Publication 1010-1, 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 which have to be followed by the user to ensure safe operation and to retain the Spectrum Analyzer 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 shall only 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 should 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 2200V DC. Under certain conditions, 50Hz or 60Hz hum voltages can occur in the measuring circuit due to the inter-connection 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 shall be made inoperative and be secured against any unintended operation. The protection is likely to be impaired 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).

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Operating Conditions

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 (+14°F) ... +70°C (+158°F).

The maximum operating altitude is up to 2200m. 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. instrument extremely cold) 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 spectrum analyzer can be operated in any position, but the convection cooling must not be impaired. 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 60 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

HAMEG warrants to its Customers that the products it manufactures and sells will be free from defects in materials and workmanship for a **period of 3 years**. This warranty shall not apply to any defect, failure or damage caused by improper use or inadequate maintenance and care. HAMEG shall not be obliged to provide service under this warranty to repair damage resulting from attempts by personnel other than HAMEG representatives to install, repair, service or modify these products.
In order to obtain service under this warranty, Customers must contact and notify the distributor who has sold the product.

Each instrument is subjected to a quality test with 10 hour burn-in before leaving the production. Practically all early failures are

detected by this method. In the case of shipments by post, rail or carrier it is recommended that the original packing is carefully preserved. Transport damages and damage due to gross negligence are not covered by the waranty.

In the case of a complaint, a label should be attached to the housing of the instrument which describes briefly the faults observed. If at the same time the name and telephone number (dialing code and telephone or direct number or department designation) is stated for possible queries, this helps towards speeding up the processing of waranty claims.

Maintenance

Various important properties of the spectrum analyzer should be carefully checked at certain intervals. Only in this way it is certain that all signals are displayed with the accuracy on which the technical data are based.

The exterior of the instrument should be cleaned regularly with a dusting brush. Dirt which 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 may the cleaning fluid get into the instrument. The use of other cleaning agents can attack the plastic and paint surfaces.

Selecting the Line Voltage

The spectrum analyzer operates at mains/line voltages of 115V AC and 230V AC. The voltage selection switch is located on the rear of the instrument and displays the selected voltage. The correct voltage can be selected using a small screwdriver.

Remove the power cable from the power connector prior to making any changes to the voltage setting. The fuses must also be replaced with the appropriate value (see table below) prior to connecting the power cable. Both fuses are externally accessible by removing the fuse cover located above the 3-pole power connector.

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The fuseholder can be released by pressing its plastic retainers with the aid of a small screwdriver. The retainers are located on the right and left side of the holder and must be pressed towards the center. The fuse(s) can then be replaced and pressed in until locked on both sides.

Use of patched fuses or short-circuiting of the fuseholder 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 **5 x 20** mm; 250-Volt AC; must meet IEC specification 127, Sheet III (or DIN 41 662 or DIN 41 571, sheet 3).
Time characteristic: **time-lag**
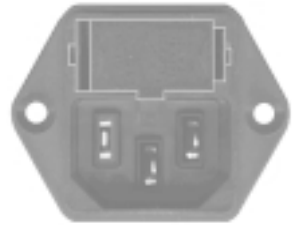
Line voltage **115V~** ±10%:   Fuse rating: **T 630mA**
Line voltage **230V~** ±10%:   Fuse rating: **T 315mA**
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Introduction

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 analyzer works according to the triple superhet receiver principle. The signal to be measured (fin = 0.15MHz to 1050MHz) is applied to the 1st mixer where it is mixed with the signal of a variable voltage controlled oscillator (fLO 1350MHz - 2350MHz). 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 1350MHz. It then enters an amplifier, and this is followed by two additional mixing stages, oscillators and amplifiers. The second IF is 29.875MHz and

the third is 2.75MHz. In the third IF stage, the signal can be selectively transferred through a filter with 400kHz or 20kHz bandwidth before arriving at an AM demodulator. The logarithmic output (video signal) is transferred directly, or via a low pass filter to another amplifier. This amplifier output is connected to the Y deflection plates of the CRT.

The X deflection is performed with a ramp generator voltage. This voltage can also be superimposed on a dc voltage which allows for the control of 1st LO. The spectrum analyzer scans a frequency range depending on the ramp height. This span is determined by the scanwidth setting. In ZERO SCAN mode only the direct voltage controls the 1st LO.

The HM5014 also includes a tracking generator. This generator provides sine wave voltages within the frequency range of 0.15 to 1050MHz. 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 paragraph "**Safety"** including the instructions prior to operating the HM5012/14. No special knowledge is necessary for the operation of the HM5012/14. 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.

Attention!

The most sensitive component of the HM5012/HM5014 is the input section of the spectrum analyzer. It consists of the signal attenuator and the first mixer. Without input attenuation, the voltage at the input must not exceed +10dBm (0.7Vrms) AC or ±25 volt DC. With a maximum input attenuation of 40dB the AC voltage must not exceed +20dBm.

These limits must not be exceeded

**otherwise the input attenuator and/or the first mixer would be destroyed.**

When measuring via a LISN (line impedance stabilization network) the input of the Spectrum Analyzer must be protected by means of a transient limiter (HZ560).

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 (1000MHz). The user should also consider the possibility of excessively high signal amplitudes outside the covered frequency range, although not displayed (e.g. 1200MHz). The frequency range of 0Hz to 150kHz is not specified for the HM5012/14 spectrum analyzer. Spectral lines within this range would be displayed with incorrect amplitude. A particularly high intensity setting shall be avoided. The way signals are displayed on the spectrum analyzer 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 0Hz. 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.

Control Elements
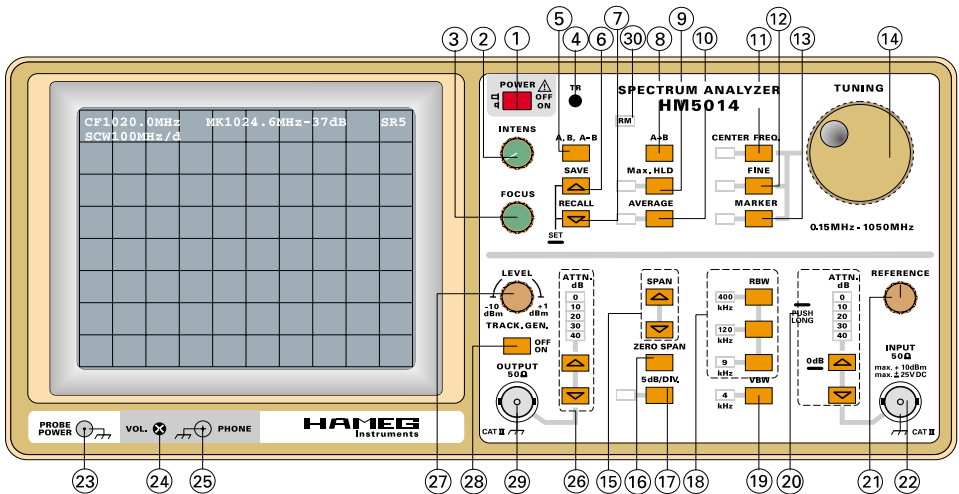
(1) POWER
After about 10 sec. the noise level will appear on the bottom base line.

(2) INTENS: Beam intensity adjustment.

(3) FOCUS: Beam sharpness adjustment.

(4) TR:
Trace Rotation - In spite of Mumetal-shielding of CRT, effects of earth's magnetic field on the horizontal trace position cannot be completely avoided. A potentiometer accessible through an opening can be used for correction. Slight pincushion distortion is unavoidable and cannot be corrected.

(5) A/B/A-B:
The instrument has two memories, memory A and memory B. Actual measurement results are always stored in A, whereby memory B can only accept copies of memory A results. Function A-B allows for the subtraction of B results from updated measuring results stored in A.

Retrieve:
Displays of memory A, B and balance of memory results (A-B) can be achieved by quickly pushing the A/B, A-B button. The readout on the screen will inform the user which storage space is being displayed on screen.

Remark:
After copying A to B, memory of B is displayed. By pushing button „A/B, A-B" short it switches to A-B, and another short push to display A. The readout will show if „A", „B" or „A-B" is currently displayed.

(6) SAVE:
For storing of up to 10 configuration settings. If a setup was saved, it can be retrieved via the RECALL button. Frequently used settings can be reenacted quickly and error-free. The saved information is retained also when the unit is separated from power or switched off.

How to choose the SAVE memory location:To choose memory location quickly push SAVE repeatedly up to number 9 location, and to return back to 0 location push RECALL button.

Storing:
After selection of memory location push SAVE long to save setting and to leave SAVE function.
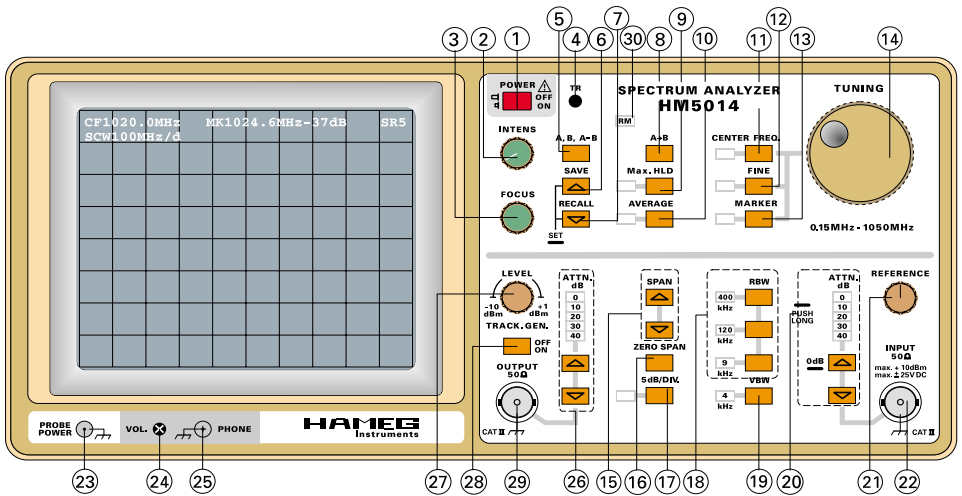
Remark:

Functions AVERAGE and MAX.HLD cannot be part of a storage operation, meaning that SAVE cannot be performed if these functions are activated. An acoustic signal will alert the user in this case.

Interrupt:

If no instrument setting is to be saved the SAVE setting will automatically be deactivated after 3 sec.

(7) RECALL

This function allows to RECALL stored instrument settings from SAVE.

To activate: Press RECALL long.

Remark:

The RECALL function can not be performed if AVERAGE or MAX.HOLD are activated. An acoustic signal will alert the user in this case.

Choose memory location:

To choose memory location quickly push SAVE repeatedly up to number 9 location, and to return back to 0 location push RECALL button.

To call-up: After selecting desired memory location, push RECALL long and instrument will display stored parameter settings.

Interrupt: If no instrument setting is to be saved the SAVE setting will automatically be deactivated after 3 sec.

(8) A➜B:
Allows for temporary storage of settings from memory A to memory B for comparison purposes. Push short to store the actual contents of A in B. The instrument will automatically display stored B memory. To get back to the actual signal, push „A/B/A-B" two times. If pushed one time, „A➜B" will be displayed.

Memory contents of B will be deleted when power is turned off.

(9) Max.HLD. (Maximum Hold)
This function allows the automatic storage of maximum signal level readings of the instrument. The display of the measurement results will only be updated if the measured value exceeds previously gathered values. Any smaller as previously recorded measurements will not be displayed. This function therefore accurately records maximum signal values of pulsating RF signals. Therefore, prior to taking measurement readings it should be made sure that measurement result display has been maximized.

Remark:
Pulsating signals should be recorded in lowest-possible SPAN, highest-possible Bandwidth and with video filter turned off in order to prevent transient response errors of the filters. If settings of span and RBW are set in certain ways, something can be gained by the slower sweep speed, active in some settings.

Pull-up: Push Max. HLD. The respective LED will light to show function is activated.

Remark:
To erase display of a measurement (Max.HLD), function Max.HLD has to be terminated and re-activated to be used again. Switching to AVERAGE directly will not affect the memory contents of Max. HLD.

Interrupt: Push Max.HLD. Respective LED will turn off and indicate interruption of Max.HLD function.

(10) AVERAGE
This function allows the automatic storage of average signal level readings of the instrument. Using the AVERAGE function the displayed noise band can be reduced. Thus, signals that would

otherwise not be visible due to the noise floor on screen, can be observed clearly. The AVERAGE function is activated by pushing the AVERAGE button a short time. The respective LED will light to show function is activated.

Remark:
The noise reduction (digital) using the AVERAGE function will not affect amplitude accuracy even for bigger spans, as would the video filter. So digital averaging doesn't have the response time limitation that a video filter possesses.

Pull-up: Push AVERAGE. The respective LED will light to show function is activated.

Remark:
To erase display of a measurement (AVERAGE), function AVERAGE has to be terminated and re-activated to be used again. Switching to MAX. HLD. will not affect the memory contents of AVERAGE.

Interrupt: Push AVERAGE. Respective LED will turn off and indicate interruption of AVERAGE function.
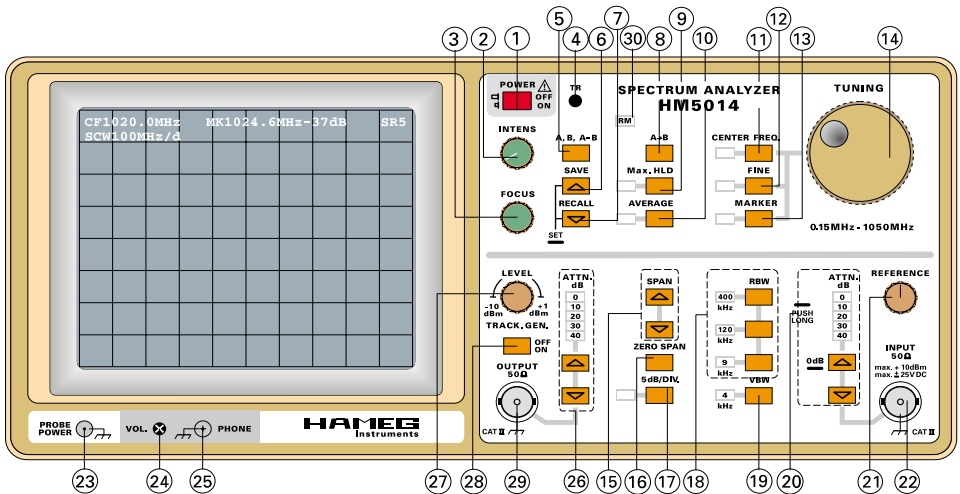
(11) CENTER FREQ.
By pushing CENTER FREQ. Button, input for center frequency is being enabled and respective LED is lit. Now Center Frequency can be adjusted via tuning knob (14). The frequency is displayed in the upper left-hand corner behind the letter „C".

Remark:

Is center frequency near lower end or SPAN increased, a spectral line might be visible, possibly even without a signal connected. It is commonly referred to as „Zero Frequency marking" (ZERO Peak) and is not unusual to be seen in analyzers using the superhet principle. What is observed is the carrier of the 1st LO (1st Oscillator) to become visible when the frequency comes within the transmission range of the 1st IF filter. The level of the ZERO peak mark may be different in each instrument and cannot be used as calibration level.

(12) FINE

If the FINE button is pushed (LED is lit), frequency inputs (with LED CENTER FREQ. lit) or Marker movements (LED MARKER is lit) is performed in very small steps.

Pushing FINE again will cause the more coarse steps to be active again. The FINE LED will be unlit.

(13) MARKER

In order to evaluate measurement curves, the instrument is equipped with a running Marker (X). The Marker can be moved in X-orientation via the tuning dial and follows the measurement curve in Y-orientation. To activate the Marker, the Marker has to be activated (LED lit) by pushing MARKER. The numeric indication of marker frequency and amplitude is displayed on-screen (i.e.: M 100.00MHz –29dBm). Push CENTER to leave MARKER mode

Remark:

The FINE function also affects the input for the Marker position.

(14) Tuning Dial:

The tuning dial either selects Center Frequency or Marker position, depending on CENTER FREQ. or MARKER being activated.

(15) SPAN

The span of sweep of the analyzer is set via the two SPAN buttons. The SPAN is displayed in the upper right-hand corner of the screen and is marked with the letter „S". At full SPAN (1000MHz) the frequency axis is scaled in 100MHz steps per (vertical) graticule line. Moving from the center graticule line towards the right screen edge, the frequency increases by 100MHz per each line. Therefore, the frequency of a displayed spectral line would be 500MHz + 5x100MHz = 1000MHz. The frequency reduces

accordingly when moving towards the left screen edge. The outermost left line therefore corresponds to 0MHz.
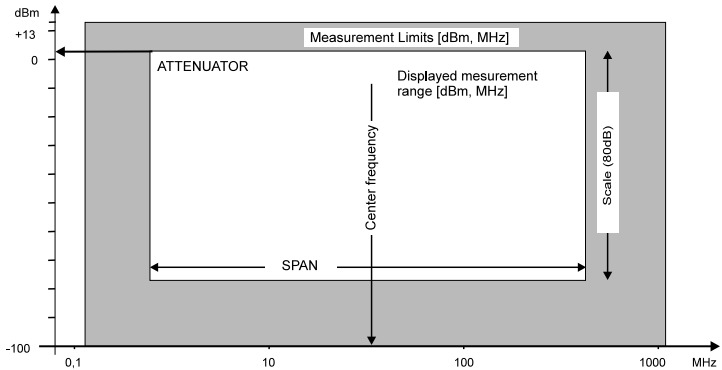
(16) ZERO SPAN:
With the ZERO SPAN button a SPAN of 0 Hz is being selected. If a SPAN of 0Hz is selected, the analyzer performs as a selective level meter, which can be calibrated via the Center Frequency (CENTER FREQ.). The display of the measured level is displayed via a horizontal line. The ZERO SPAN mode is activated by pushing the ZERO SPAN button. Press again to revert to previous span.

Above illustration explains the terms SPAN, Center Frequency, Extent of Scale, and Attenuator. The gray area shows the maximum measuring range of the HM5012, whereby the white area shows the area which can be displayed on screen. The height of the „window" is limited to 80dB due to the extent of the scale, however, the display range can be shifted up and down by switching on or off the attenuators and by setting another reference level. The width of the displayed range is set via the SPAN of the analyzer, which may comprise of the entire gray area or only part of it. The location of this range is set via the Center Frequency (CENTER FREQ.). It is always advisable to select the precise Center Frequency and the SPAN as low as possible (resolution of display) so the signal can be viewed easily. An unnecessarily high SPAN has a rather negative effect.

Remark:
The HM5012/5014 spectrum analyzer is internally programmed for always choosing the appropriate sweep time related to the span, resolution bandwidth and video bandwidth, wherever possible. The UNCAL indicator in the readout will be visible in

order to prevent possible measuring errors due to insufficient transient response time.

(17) 5dB/Div.
Py pushing the 5 dB/Div. button, the vertical scale is set to 5 dB/ Div. The respective LED will then be lit. To enter again in 10 dB/ Div. mode, push 5 dB/Div. again.

(18) RBW (Resolution Bandwidth):
The instrument is equipped with resolution filters of 9kHz, 120kHz, and 400kHz, which can be selected via the „RBW" buttons. The respective LED will indicate which bandwidth is selected.

Remark:
A maximum measuring bandwidth and the Max.HLD function should be selected for pulsed signals.
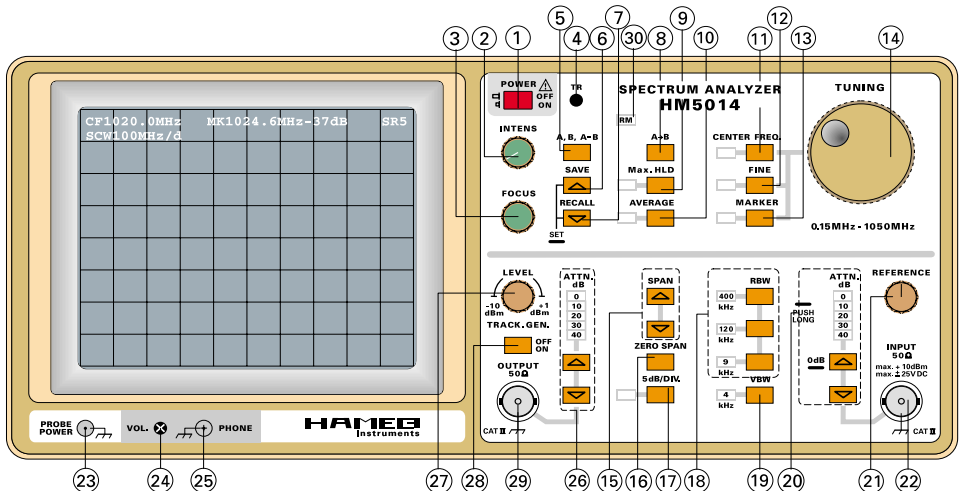
(19) VBW-Video Filter:
The Video Filter has the purpose of reducing video and noise bandwidth and therefore reducing noise distribution. When measuring low level values, which are situated within the regular noise level, the Video Filter (low pass) can be used to reduce the noise level. This allows for the detection of even small signals which might otherwise not be visible.

Remarks:
Please note that if frequency range (SPAN) is too high and Video Filter is active, amplitude readings might be wrong (too small)

(UNCAL display). In this case, SPAN needs to be reduced. With the aid of the Center Frequency (CENTER FREQ.) setting, first the signal to be tested needs to be centered on screen, then the SPAN can be reduced.

If SPAN is reduced without the signal to be tested centered it is possible for the signal to end up outside of the screen.

The Video Filter should not be used - if possible - when pulsed signals are measured in order to prevent measuring errors (transient response time).

(20) ATTN:
The buttons to set the input attenuation are marked ATTN. By pushing the UP and DOWN buttons, the attenuation can be set from 0 dB to 40 dB in 10 dB steps.

To enter 0 dB attenuation, it is neccessary to push button long, this is for protection of the input stage, so this setting can't be set accidentally.

Remark:
For reasons of protection of the input stage, the instrument will always set an attenuation of 10 dB when switched on.
It needs to be pointed out again that the maximum allowable input voltages may not be surpassed. This is especially important, as it may be possible that the spectrum analyzer will display only part of a signal under test, if other input signals are present but not visible at current span.

(21) REFERENCE
With rotary knob REFERENCE the so called reference level is set, to this level all amplitude readings on screen are referenced. The reference level is always at the topmost horizontal graticule line. Depending also on attenuator setting, the reference level may be set between –99.8 dBm and +13 dBm.

(22) INPUT:
50 Ω Input of Spectrum Analyzer. Without attenuation of input signal the maximum allowable input voltage is ±25V DC or +10dBm AC respectively. With a maximum attenuation of the input signal (40dB) +20dBm is allowed. These values may not be exceeded, otherwise the input stages will be damaged.
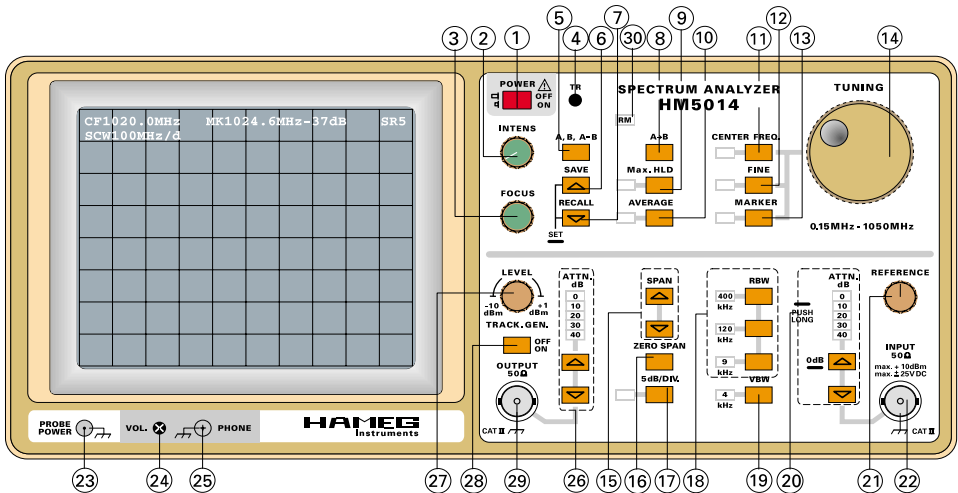
(23) PROBE POWER:
PROBE POWER is used solely to supply power for the near field probes HZ530. The required special power cable is supplied with the probe set.

(24) VOL.: To regulate the volume for the head set.

(25) PHONE:
Connector for headset. The head set should be equipped with a 3.5mm stereo phone connector and have >8 Ohm of impedance.

(26) ATTN. (not included in HM5012)
The TG output attenuator HM5014 has 5 positions,which can be chosen via the UP/DOWN-buttons. The output attenuator is used for reducing the output level of the Tracking Generator.
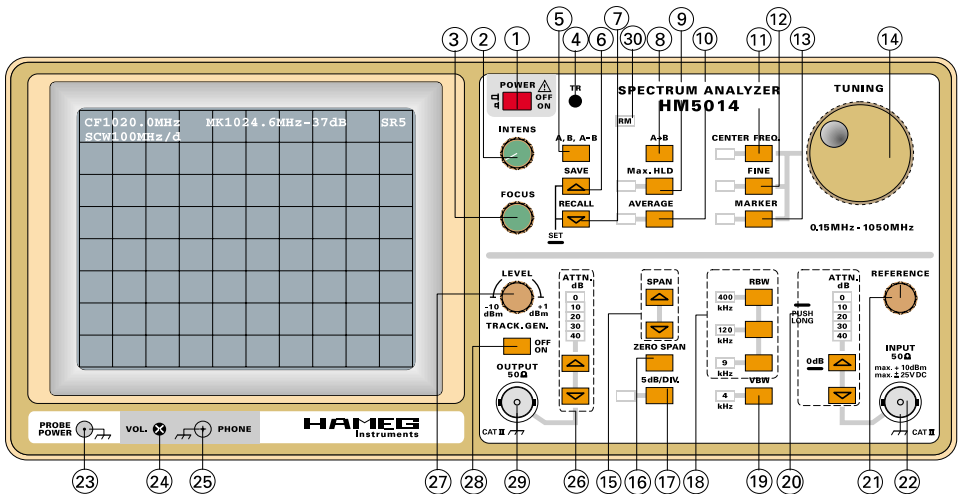
(27) LEVEL (not included in HM5012)
With the LEVEL knob the output level of the Tracking generator can be varied in steps of 0.2 dB. The range for level settings is 11 dB. The output level is shown in the readout, also dependent on the attenuator setting.

Attention:
If Tracking Generator is not activated, the output level can be still varied, this is visible in the readout. For having this signal appliued to the output, the Tracking generator must be activated. This is a security measure to prevent damages to sensitive loads.

(28) Tracking Generator (not included in HM5012)
After switching on the instrument, the Tracking generator will be inactive. This is a security measure to protect any loads connected. In the readout this is shown by the minuscule „t". By pushing TRACK. GEN., the Tracking Generator is activated. Now a capital „T" will appear in the readout, and one of the attenuator LEDs (26) will be lit. By again pushing TRACK. GEN., the Tracking Generator is deactivated.

(29) Output (not included in HM5012)
50 Ω output of Tracking Generators. The output level is set using the rotary knob LEVEL (27) and the attenuator buttons (26). The output level can be set between +1 dBm and –50 dBm.

(30) RM (Remote) LED
The RM-LED indicates that the instrument is controlled via the serial interface. If the LED is lit, it is not possible to use controls on front panel. This state can either be ended via a serial commando, or by switching off the instrument. The remote-mode can be activated only by a serial command via the interface.

Operation - first steps

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 maximum amplitude is below +20 dBm.

ATTN. :
As a protective measure the attenuation should be set to 40 dB
(LED „40" is lit).

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

Bandwidth:
For the first measurements the 400 MHz filter should be selected,
and video filter off.

If the noise band moves upward on screen when decreasing input
attenuation, this indicates a possible other high-amplitude input
signal present but not visible in the chosen frequency range. If no
signal is visible, the attenuation can be consecutively decreased.

In any case the attenuator setting must be in correspondence 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. Previous to this, the center frequency has to be set so
the signal is at center of screen. Then span can be reduced.
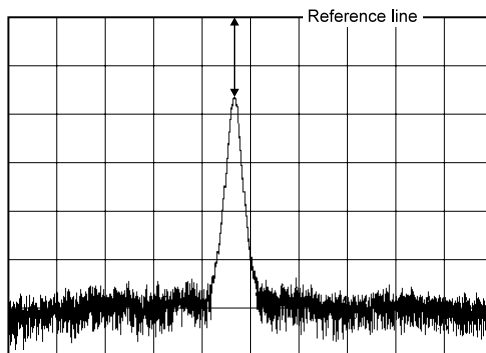
Then the resolution bandwidth can be decreased, and the video
filter used if neccessary. The warning „uncal" in the readout must
not be displayed, otherwise measurement results may be incorrect.

Obtaining values:

For a numerical value of a measurement result the easiest way is the use of the marker. The marker frequency is set by the rotary dial, if necessary, use the fine step mode. Then, read the value for the amplitude, which is shown in the readout. The amplitude is automatically corrected for the attenuator setting.

If a value is to be measured without using the marker, then measure the difference of the reference line to the signal. Observe 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 neccessary to make a correction afterwards.

The signal shown in the picture shows an amplitude difference of about –16 dB to the reference line. Assuming that the reference level is –27 dBm, and the scale 10 dB/Div.

Thus the signal has an amplitude of (–27 dBm) + (–16 dB) = -43dBm. In this value the setting of the input attenuator is already included. It is not necessary for the user to correct the value for any attenuator setting.

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 which 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 permits 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 superheterodyne type. A trf analyzer consists of a bandpass 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 dont usually have constant bandwith, 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 bandpass filter instead of sweeping the filter through the spectrum. The analyzer is basically a narrowband receiver which is electronically tuned in frequency by applying a saw-tooth voltage to the frequency control element of a voltage tuned local oscillator. This same saw-tooth voltage is simultaneously applied to the horizontal deflection plates of the CRT. The output from the receiver is synchronously applied to the vertical deflection plates of the CRT and a plot of amplitude versus frequency is displayed.

The analyzer is tuned through its frequency range by varying the voltage on the LO (local oscillator). The LO frequency is mixed with the input signal to produce an IF (intermediate frequency) which can be detected and displayed. When the frequency difference between the input signal and the LO frequency is equal to the IF frequency, then there is a response on the analyzer. The advantages of the superheterodyne technique are considerable. It obtains high sensitivity through the use of IF amplifiers, and many decades in frequency can be tuned.

Also, the resolution can be varied by changing the bandwidth of the IF filters. However, the superheterodyne analyzer is not real-time and sweep rates must be consistent with the IF filter time constant. A peak at the left edge of the CRT is sometimes called the "zero frequency indicator" or "local oscillator feedthrough". It occurs when the analyzer is tuned to zero frequency, and the local oscillator passes directly through IF creating a peak on the CRT even when no input signal is present. (For zero frequency tuning, $F_{LO}=F_{IF}$). This effectively limits the lower tuning limit.

Spectrum Analyzer Requirements

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

1. Wide tuning range
2. Wide frequency display range
3. Stability
4. Resolution
5. Flat frequency response
6. High sensitivity
7. Low internal distortion

Frequency Measurements

The frequency scale can be scanned in three different modes full, per division, and zero scan. The full scan mode is used to locate signals because the widest frequency ranges are displayed in this mode. (Not all spectrum analyzers offer this mode).

The per division mode is used to zoom-in on a particular signal. In per division, the center frequency of the display is set by the Tuning control and the scale factor is set by the Frequency Span or Scan Width control. In the zero scan mode, the analyzer acts as a fixed-tuned receiver with selectable bandwidths.

Absolute frequency measurements are usually made from the spectrum analyzer tuning dial. Relative frequency measurements require a linear frequency scan. By measuring the relative separation of two signals on the display, the frequency difference can be determined.

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 which 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. Long term stability is characterized by the frequency drift of the analyzers LOs. 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 3dB bandwidth of the IF filter. The ratio of the 60dB bandwidth (in Hz) to the 3dB bandwidth (in Hz) is known as the shape factor of the filter. The smaller the shape factor, the greater is 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 offband 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 10kHz then the nearest any two signals can be and still be resolved is 10kHz. 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 bandwdith infinitely, 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 10kHz, then the narrowest bandwidth that can be used to distinguish a single input signal is 10kHz. 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 nonthermal noise. Thermal noise power can be expressed as:

$$P_N = k \times T \times B$$

where:

P_N = Noise power in watts
k = Boltzmanns Constant
(1.38 · 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. Nonthermal noise accounts for all noise produced within the analyzer that is not temperature dependent. Spurious emissions due to nonlinearities of active elements, impedance mismatch, etc. are sources of nonthermal noise. A figure of merit, or noise figure, is usually assigned to this nonthermal 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 bandwith it is important, when comparing the sensitivity of two analyzers, to compare sensitivity specifications 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 passband. 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 HM5012/14) +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 which 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 nonlinearly 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 HM5012/5014 these distortions are typically 70dB below the input signal level for signal levels not exceeding –27dBm 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 exeed –27dBm, or the analyzer distortion products may exceed the specified 70dB range. This 70dB 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 can 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 70dB down for –27dBm at the input mixer". Then, determine that adequate sensitivity exists. For example, 70dB down from –27dBm is –97dB. 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 the spurious-free measurement range can be extended by reducing the level at the input mixer. 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.

1.The largest input signal does not exceed the optimum input level of the analyzer (typically –27dBm with 0dB input attenuation).

2.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 nonlinear. For accurate amplitude measurements, a spectrum analyzer 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 Generators

The tracking generator (**HM5014 only**) is a special signal source whose RF output frequency tracks (follows) some other signal beyond the tracking generator itself. In conjunction with the spectrum analyzer, the tracking generator produces a signal whose frequency precisely tracks the spectrum analyzer tuning. The tracking generator frequency precisely tracks the spectrum analyzer

tuning since both are effectively tuned by the same VTO. This precision tracking exists in all analyzer scan modes. Thus, in full scan, the tracking generator output is a start-stop sweep, in zero scan the output is simply a CW signal.

The tracking generator signal is generated by synthesizing and mixing two oscillators. One oscillator is part of the tracking generator itself, the other oscillator is the spectrum analyzer's 1st LO. The spectrum analyzer/tracking generator system is used in two configurations: open-loop and closed-loop. In the open-loop configuration, unknown external signals are connected to the spectrum analyzer input and the tracking generator output is connected to a counter. This configuration is used for making selective and sensitive precise measurement of frequency, by tuning to the signal and switching to zero scan.

In the closed-loop configuration, the tracking generator signal is fed into the device under test and the output of the device under test is 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. The specific swept measurements that can be made with this system are frequency response (amplitude vs. frequency), magnitude only reflection coefficient, and return loss. From return loss or reflection coefficient, the SWR can be calculated. Swept phase and group delay measurements cannot be made with this system; however, it does make some unique contributions not made by other swept systems, such as a sweeper/network analyzer, a sweeper/spectrum analyzer, or a sweeper/detector oscilloscope.

Precision tracking means at every instant of time the generator fundamental frequency is in the center of the analyzer passband, and all generator harmonics, whether they are generated in the analyzer or are produced in the tracking generator itself, are outside the analyzer passband. Thus only the tracking generator fundamental frequency is displayed on the analyzer's CRT. Second and third order harmonics and intermodulation products are clearly out of the analyzer tuning and, therefore, they are not seen. Thus, while these distortion products may exist in the measurement set-up, they are completely eliminated from the CRT display.

Appendix A

The 1dB gain compression level is a point of convenience, but it is nonetheless considered the upper limit of the dynamic range. The lower limit, on the other hand, is dictated by the analyzer sensitivity which, as we know, is bandwidth dependent. The narrowest usable bandwidth in turn is limited by the tracking generator residual FM and any tracking drift between the analyzer tuning and the tracking generator signal.

CODES for serial interface RS232
Spectrum Analyzer HM5012 / HM5014

RS232 parameters when unit is turned on:

4800 baud, 8 data bits, 1 stopbit, no parity
Receive following information when unit is turned on:
HAMEG   HM5012 V___, or
            HM5014 V___ respectively.

Commands to HM5012 / 5014 via PC:

To be noted: First symbol of any command is „#" (0x23) which is followed by the respective characters, i.e. TG for Tracking Generator, and further followed by additional symbols, which are explained in detail below. Each command is executed by pushing the „Enter" key (hex: OxOd). No differentiation is made between capital and lower-case letters (i.e. TG = tg). Units of measurement are always definite (i.e. span value given in MHz) and are therefore not indicated.

(E) = „enter" key

#kl0 (E)	=	Key-Lock off
#kl1 (E)	=	Key-Lock on (Remote-LED lit)
#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 Level of +1.0 dB
#tl-50.0 (E)	=	Tracking Level to -50.0 dB in 0.2 dB steps
#rl-27.0 (E)	=	Reference Level of -27.0 dB
#rl-99.6 (E)	=	Reference Level to -99.6 dB in 0.4 dB steps
#at0 (E)	=	Attenuator 0 (10, 20, 30, 40) dB
#bw400 (E)	=	Bandwidth 400 (120, 9) kHz
#sp1000 E)	=	Span 1000 (500, 200, . . . 5, 2, 1) MHz
#sp0 (E)	=	Zero Span
#db5 (E)	=	5 dB/div.
#db10 (E)	=	10 dB/div.
#cf0500.00(E)	=	Center Frequency in xxx.xx MHz

Subject to change without notice

#dm0 (E)	=	Detect mode off
#dm1 (E)	=	Detect mode on
#sa (E)	=	Save signal A as signal B
#vm0 (E)	=	View mode: Signal A
#vm1 (E)	=	View mode: Signal B (stored signal)
#vm2 (E)	=	View mode: Signal A - B
#vm3 (E)	=	View mode: Average
#vm4 (E)	=	View mode: Max. Hold
#br4800 (E)	=	baudrate 4800 (9600, 19200, 38400, 115200) Bd
#bm1 (E)	=	transfer signal in block mode (2048 bytes) 2044 signal bytes, 3 checksum bytes and (0x0D)
#rc0 (E)	=	Recall (0 to 9)
#sv0 (E)	=	Save (0 to 9)

Special commands for emc measurement in combination with zero-span:

#es0 (E)	=	1 second sweep disable
#es1 (E)	=	1 second sweep enable (measuring time 1 second; select zero-span and bandwidth 9/120/400 kHz)
#ss1 (E)	=	Start 1 second sweep at a selected center frequency
#ss2 (E)	=	Start 1 second sweep at a selected center frequency (i.e 100MHz) + frequency step(s) (i.e. 100.12MHz, 100.24MHz, ...). step = bandwidth: 400, 120, 10 (9) kHz

After receiving and processing the command, the instrument transmitts „RD(hex: 0x0d)".

Polling of Parameters:

Syntax:

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

1st example:
#uc (uncalibrated): PC transmitts #uc (E), instrument replies:
uc0 (calibrated), uc1 (uncalibrated)

2nd example:

#tl (E)	=	PC query for Tracking Level: PC transmitts #tl(E), instrument replies: TL-12.4(E)

3rd example: sequence control via external computer:

#kl1 (E)	=	switches to remotes status, RM LED is lit

#cf0752.00(E)	=	sets Center Frequency to 752 MHz
#sp2 (E)	=	sets Span to 2 MHz
#bw120 (E)	=	sets RBW to 120 kHz
#kl0 (E)	=	switches back to keyboard mode

4th example:

| #vn | = | PC query for software version, i.e. „1.00". |

5th example:

| #hm | = | PC query for instrument type, i.e. (5012 or 5014) |

HAMEG
Instruments

Manual
Software
SW5012
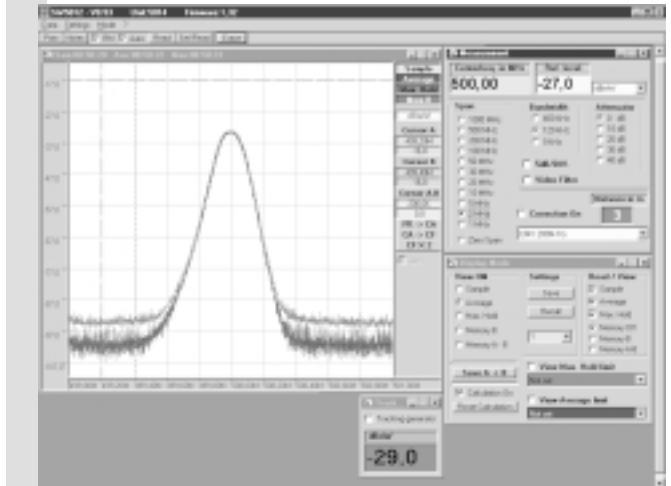
Software package SW5012

Functions and set-up.
Menu overview.

Pulldown Menu 1:

Data

Load
Save

Settings   Load and Save set-up information for the instrument
Measurement Load and Save measurement data

New/Copy
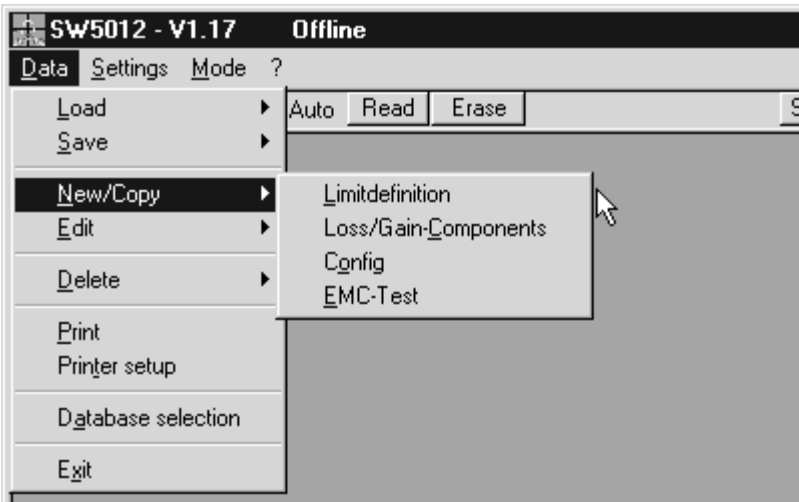
Edit
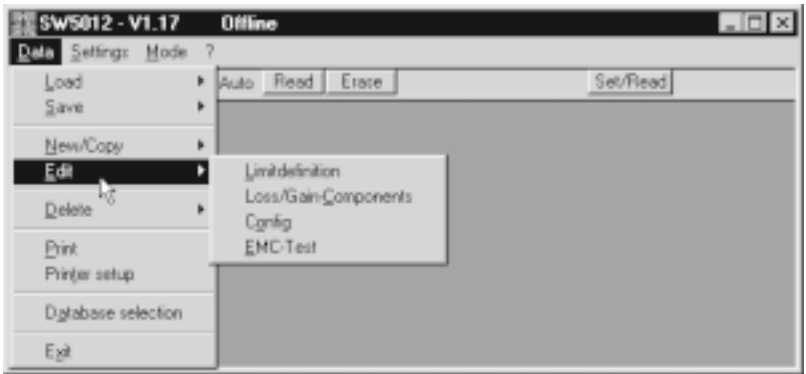
Delete
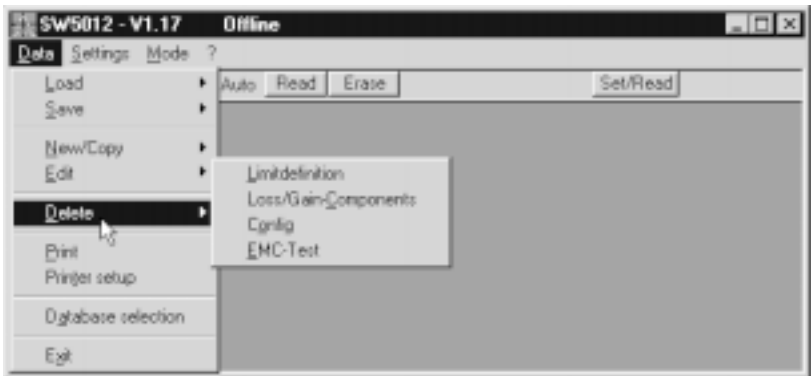
New, Copy, Edit, Delete regarding to the following items:

Limit Definition
Definition of limit lines

Loss/Gain Components
Set-up of the correction curves for amplifiers, cables etc., acquired
    by measured data (damping curve).

Config
Set-up for used equipment and DUT, attachment of correction
    curves of amplifiers and cables for calculation purposes.

EMC Test
Test procedure set-up (single test): start frequency, stop frequency,
    correction curve, filter settings, etc.

Print

Print preview and start of printing.
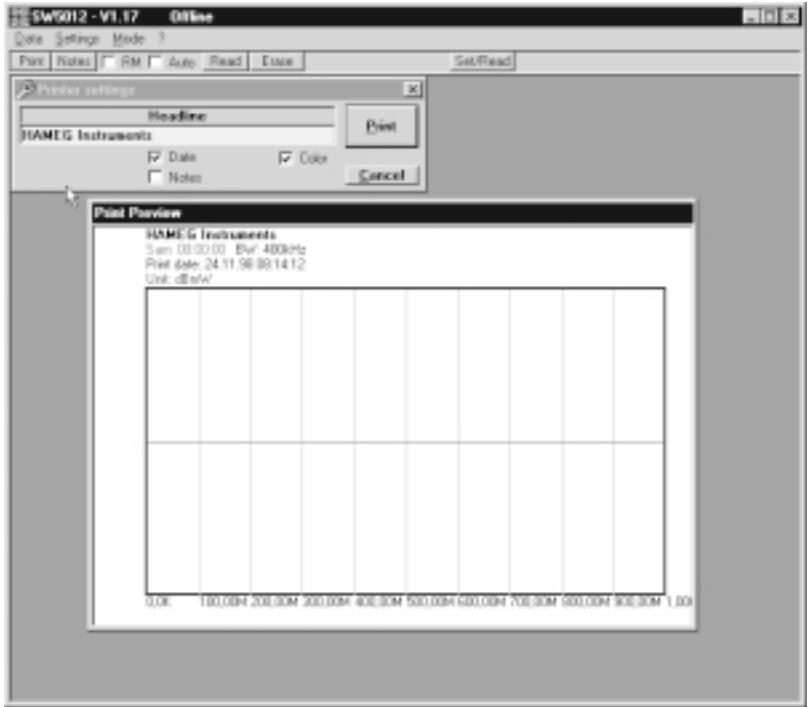
Printer Setup

Set-up for the printer being attached to the PC

Database Selection

Selection of the database to be used.

           Exit   Exit program.

Pulldown Menu 2: (Command Mode Normal)

Settings
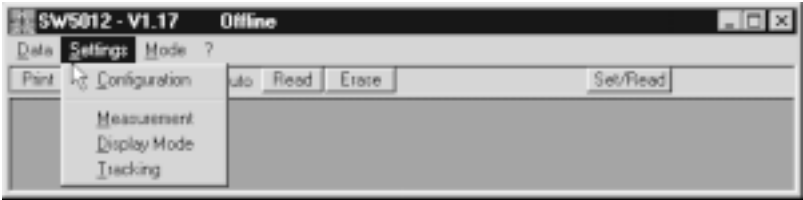
Configuration

Set-up of the serial interface, set COM port and transfer rate; possibility of automatic rate identification.

Measurement

Opens window for instrument set-up and a waveform graph to display the actual measurement data.

Display Mode

Two areas are defined: Spectrum Analyzer and graphic display on the PC's screen.

Tracking

Window for controlling the Tracking Generator (appl. only for HM5014).

Pulldown Menu 3:

Mode
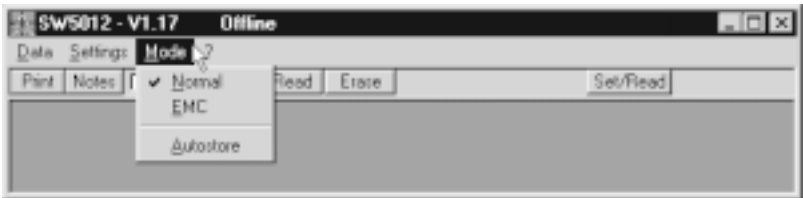
Normal   Remote operation of the Spectrum Analyzer via PC. Acquisition, analysis and storage of data on the PC.

EMC   Extended operating procedures for measuring emitted radiation with an antenna including correction for antenna gain, damping characteristics of cables and amplifiers, etc.).

Autostore

Timer controlled measurement in Normal Mode with automatic storage in the PC's memory/hard disk.

Operating Modes:

Normal Mode

This mode of man-machine-interface corresponds one-to-one to the functions available on the instrument's front panel.

A mouse click on **"Normal"** enables the user to remotely control the functions of the Spectrum Analyzer from the measurement window. The "Remote" indicator (visible in the second bar of the window) has to be activated first (RM) by a mouse click on the related button (a small hook is visible after activation).

When Remote has been activated any center frequency within the allowed range may be selected by typing in the desired numeric value, closed by a carriage return.

The indication for RevLevel is actualized automatically according to any modification in the attenuator settings. A dedicated window allows the selection of the unit in which the signal level values shall be indicated. Furthermore one can configure the set-up for span, filter bandwidth, scaling, and video filter.

Correction on

Single spectral lines can be analyzed in mode **"EMC"** in menu **"Function Correction"**. When **"Correction on"** is activated all correction data according to the selected EMC settings will be used during the calculations. Limit line data can be loaded at any time and graphically displayed in the window.

Calculation on

The Display Mode window is split into two areas: the left one ("Analyzer" and "Settings") is directly related to the instrument, the other one ("Read/View") belongs to the representation on the PC's screen.

Using function Save A → B the data of the actual curve A will be transferred into the reference memory.

Subject to change without notice

In the "Settings" window ten different instrument set-ups can be saved and recalled. This responds directly to the front panel function of the instrument.

There are three different modes to display data after acquisition by the Spectrum Analyzer: **"Sample"** (actual curve A), **"Reference B"** or **"A-B"**. When the function "Calculation" is activated one of the following curves may be indicated: **"Max. Hold"** or **"Average"**. The **"Max. Hold"** and **"Average"** curves are calculated in real-time. After a mouse click on button "Reset Calculation" the sampling will be started anew. The window in the right area (**"Read/View"**) enables the user to select the data type to be transferred from the instrument to the PC and the curve(s) to be displayed on the screen. The attached colors are explained at the right edge of the window, the time stamp for the last acquisition is indicated at the upper edge. The calculation of the curve data is switched off with **"Calculation off"**. Neither the **"Max. Hold"** nor the **"Average"** curve will be actualized in this state since data acquisition inside the instrument is switched off. The displayed curves may be erased by a mouse click on button **"Erase"**. After modifying the value for center frequency the curves will be erased automatically and calculated anew during the next data transfer from the instrument to the PC.

EMC Mode Functions, Software tasks

The EMC Mode enables the user to integrate the Spectrum Analyzer as one device into a pre-compliance EMC test system. Normally a test system like this is an assembly of several devices. The software package supports the definition of dedicated test procedures as well as the configuration of the attached devices.

A typical test system is a composition of:
LISN, BNC cable and receiver (Spectrum Analyzer) or
Antenna, amplifier, BNC cable and receiver.

Supported by integrated procedures the user is able to define an entire EMC test system including all attached components. The spectral response of each single component can be used for correction calculations. The frequency response data of each single component is stored in a dedicated database and used for correction calculations according to a test system set-up, which - in a dedicated window - can be defined in a pipeline arrangement of components and then stored as an entire EMC test system procedure.

Furthermore the software package includes quasi peak and average calculations. In its operating mode 'zero span' the instrument acquires data over a period of 1 s, followed by the averaging of the data. Also, the quasi peak values are calculated by applying digital filter calculations.

Several ways exist to configure the software program:

1. The frequency response curve of each component must be available and stored inside the PC. There is no limit for the number of components; nevertheless the data files must have different names
2. An arrangement of devices as EMC test system is given an evident file name and stored as desired. A maximum of five components might be arranged to build up a single configuration, which seems to be sufficient for ordinary applications. An ideal cable is used to simulate nonexistent components. There is no limit for the number of arrangements; nevertheless the filenames must be different.
3. According to the regulations certain signal levels may not be exceeded. Thus limit lines have to be defined before they can be displayed on the screen. Any number of limit lines can be defined, as long as they are given different file names. A maximum of two limit lines can be displayed in one window.
4. After the completion of these steps a test system can be arranged by using the limit lines and the component configurations. At least it is necessary to enter the values for start frequency, stop frequency, bandwidth, damping, and the measuring procedure to be used.

After the set-up as described the system is ready to perform complex EMC test procedures, which - in most applications - can be executed automatically.

Definition of new components

To add a new component select the menu called **Data New/ Copy** and then **Loss/Gain-Components**. The according window will appear. A field to be filled in with the name of a new component is located in the upper area. A maximum number of 80 characters may be entered, including space characters. Each entry must be closed by a carriage return. After a mouse click on **Add New** the new component will be added to the database.

By using the **Copy** function data of an existing component can be copied to define a new component. This procedure is recommended if only few data are different.

Subject to change without notice

In the next step – for example - the frequency response of a component has to be defined. First make a mouse click on button **View limit definition** or, after closing this window, select **Data/ Edit/** (**Loss/Gain-Components**). After the appearance of the window, select the component type: antenna, loss component or amplifier. The frequency response of an antenna always is related to the distance of measurement, thus the field **Distance (m)"** has to be filled in with meter units.
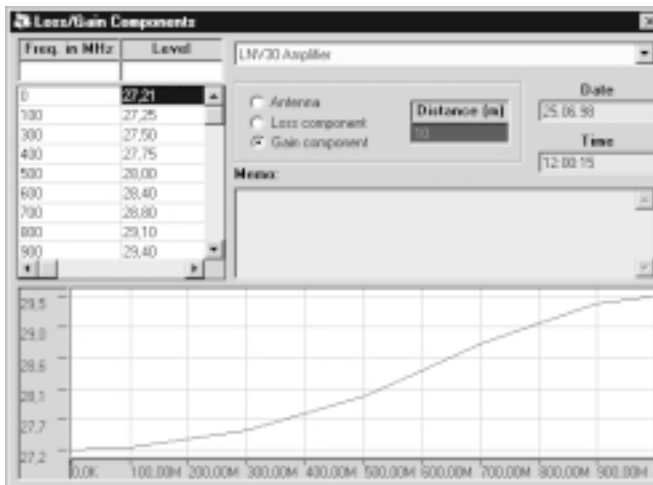
Now the system is ready to accept **"Freq. in MHz"** and **"Level"** (correction, in dB) values in the appropriate fields, each one followed by a carriage return to add the value to the table. The software automatically sorts the data in an ascending order for the frequency.

In case of an erroneous data input just select the wrong entry with a mouse click (highlighted) and delete it by pushing the DEL key. The entry will be removed from the table, the data sorted, and the graphic curve refreshed.

The table can be supplemented by a comment, for example: date of calibration, responsible technician, etc.

After entering all frequency response data of the components to be used, they are available for the following correction calculations.

Configuration of a test system

The menu "configuration" supports the definition of an entire test system by arranging several components.

To add a new configuration set-up, select **"Data/Edit/Config"** from the menu bar. A window called **"Configuration"** will be opened.

The way the signal takes from one device to the other during the test procedure is highlighted, starting at the signal source and walking on to the Spectrum Analyzer.

If an antenna is part of the test system it must be defined in the uppermost field –, as it is the component most closely located to the DUT. Of course only one antenna can be used in a test system, thus other components will follow, as there are:
Damping elements, amplifiers, and cables. In case a field is not used for a component it has to be defined as an ideal cable
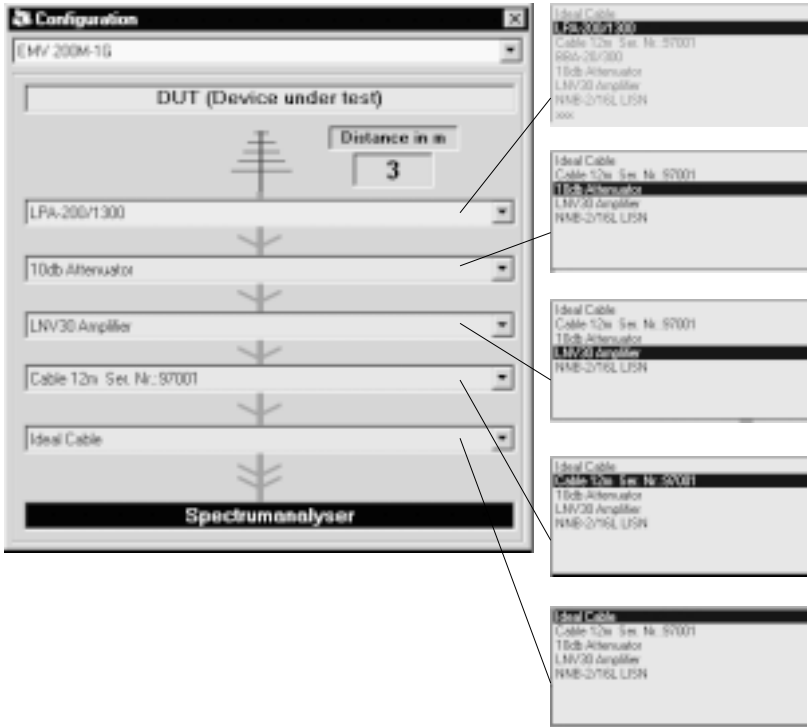
element. An ideal cable has absolutely no influence on the result of the measurement.

Definition of limit lines

Select **"Data/Edit/ Limit definition"** from the menu bar to open the window called **"Limit definition"**.

First chose the unit used for the limit levels. If it is a limit for radiated emission measurements then select field **"Radiated"** and enter the value for the distance.

If the limit line shall be defined in logarithmic scale then select field **"Logarithmic def."**. Enter the values for the frequency and the according level. A memo field is available for free use.
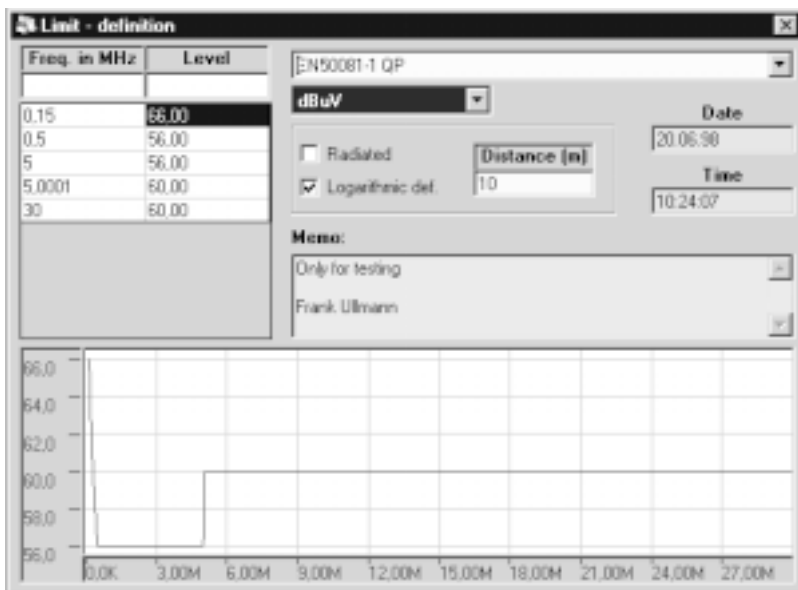
Define Test

Select **"Data/Edit/EMC Test"** to define a new test procedure. The window called **"Test Settings"** will be opened.

First select the desired configuration and the limit lines to be used. Then enter the values for the start and the stop frequency. Beginning with the start frequency the instrument will scan until the stop frequency has been reached considering the filter bandwidth. Please take care to enter the correct values for Revlevel and engineering unit. There may be no overriding at the instrument's input. To achieve reliable measurement results it is important to choose a suitable attenuation. Then select the desired filter bandwidth and the mode of signal detection.

At least the plane of polarization must be defined. If both, the horizontal and the vertical plane, have been selected the test will be performed first for the horizontal, then for the vertical plane. The maximum values of both measurements will be used for further analysis.

The next step to be defined is the mode of testing.

Step:
In this mode the signal level will be detected over a measuring period of 1 s (zero span). The test begins at the start frequency as defined, for further measurement steps the frequency is incremented according to the selected bandwidth and terminates at the stop frequency. In addition to the basic measuring period of 1 s the transfer time for the data from the instrument to the PC has to be taken into consideration. The entire period for one step might exceed 1.5 s to 2 s. The high accuracy of measurement is an advantage, at the price of a time consuming test procedure.

Sweep + Step:
In this mode the value for the span will be chosen as high as possible according to the selected bandwidth. When using the "Max. Hold" acquisition method the center frequency is modified between the start and the stop frequency until the complete frequency range will be covered by the measurement (sweep). The length of the acquisition

period for detecting the signal at each single center frequency value had been defined before in **"Meas. Time"** (in second units). If the signal level at certain frequencies exceeds the value for **"Lim. distance"**, measurement will be performed in step mode at all points of interest. The advantage of this procedure is a comparatively short test period, with extended testing at frequencies with critical signal levels.

EMC Test Procedure

To perform a complete EMC test procedure start mode "EMC" with a mouse click on EMC in the "Mode" menu. The window
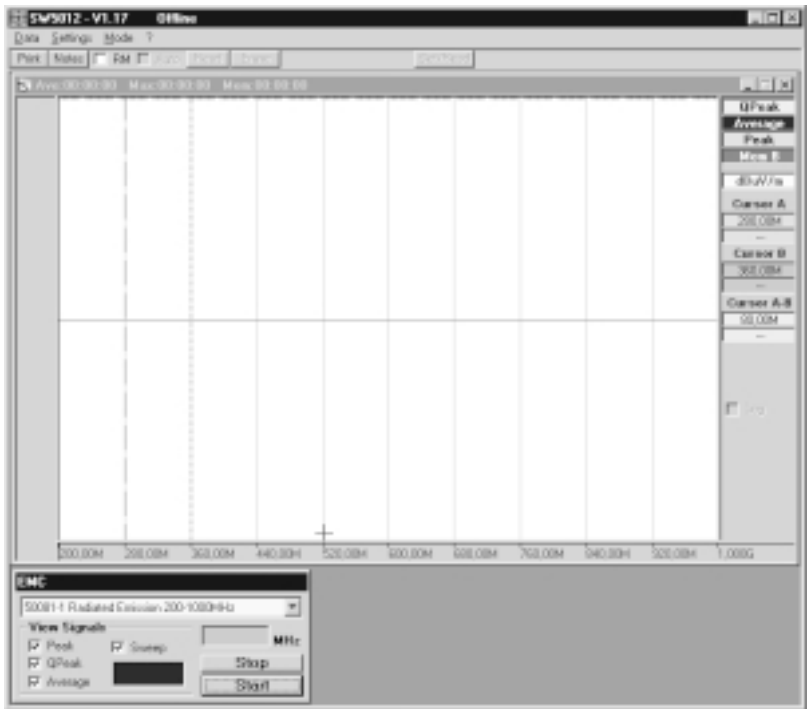
called "EMC" will appear on the screen.

Select the desired EMC test procedure and initiate the test with a mouse click on the **Start** button. A free definable file name can be entered now. Please take care of certain limitations, which might be given by the operating system you use. The test results will be stored in a file with the defined name. Please note: This file does not belong to the internal database of the system.

Now follow the steps as indicated on the screen. The procedure will differ according to the set-up of the test system.

Values indicated in field Peak, Qpeak, Average, and Sweep have no influence on the measurement procedure itself, but are used for a proper display of the results on the screen. The measurement itself is performed according to the test settings.

Repeatedly after every fifty steps the graphic display will be refreshed or, in sweep mode, after terminating the sweep.

At any time a scan can be stopped by a mouse click on the button **Stop**. There is no way to continue the scan after it has been stopped. Nevertheless it is possible to load, visualize, and print the measurement results at any time, if desired.

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