Products 2005





HAMEG® Instruments

HAMEG
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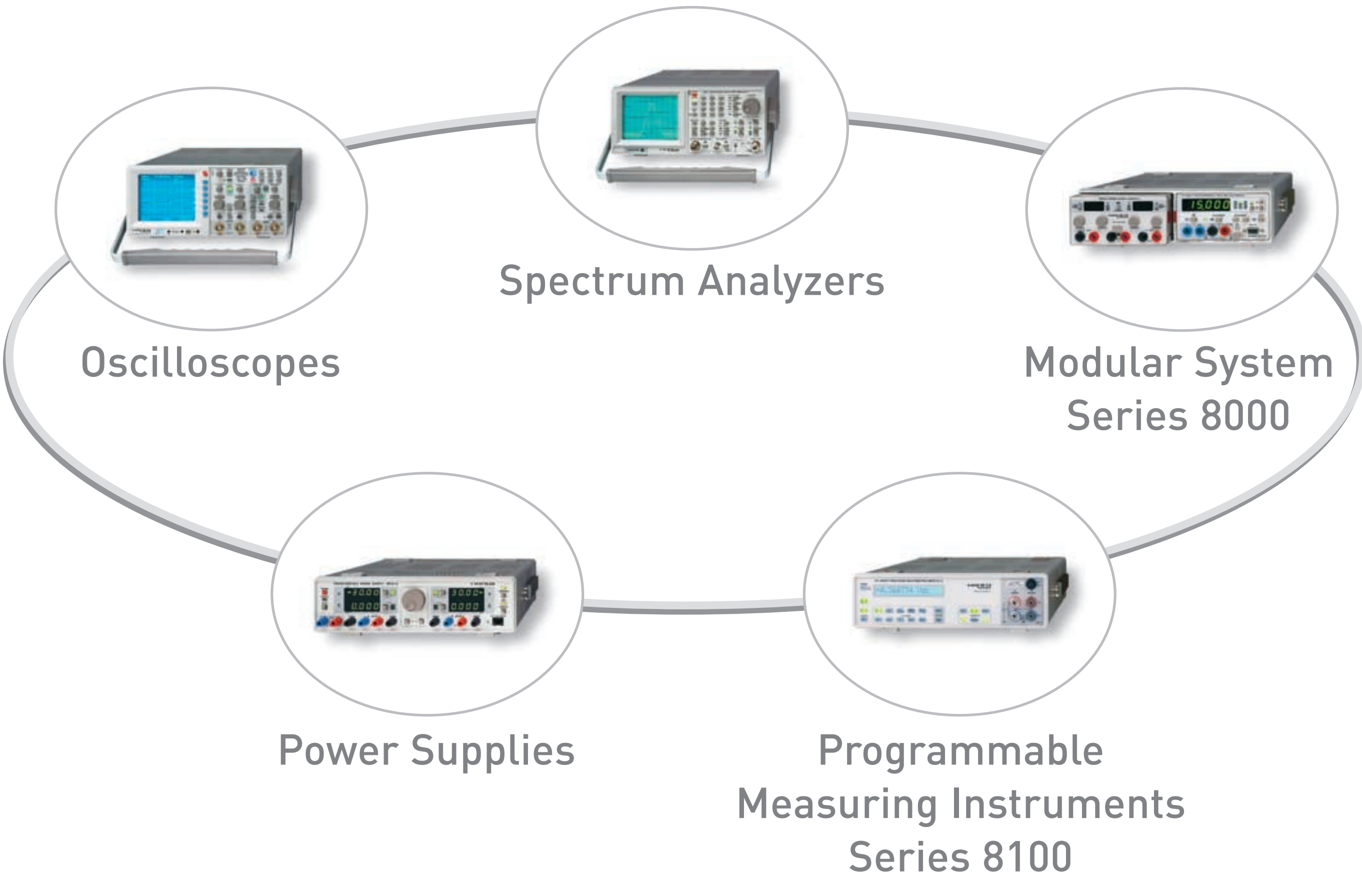


Oscilloscopes

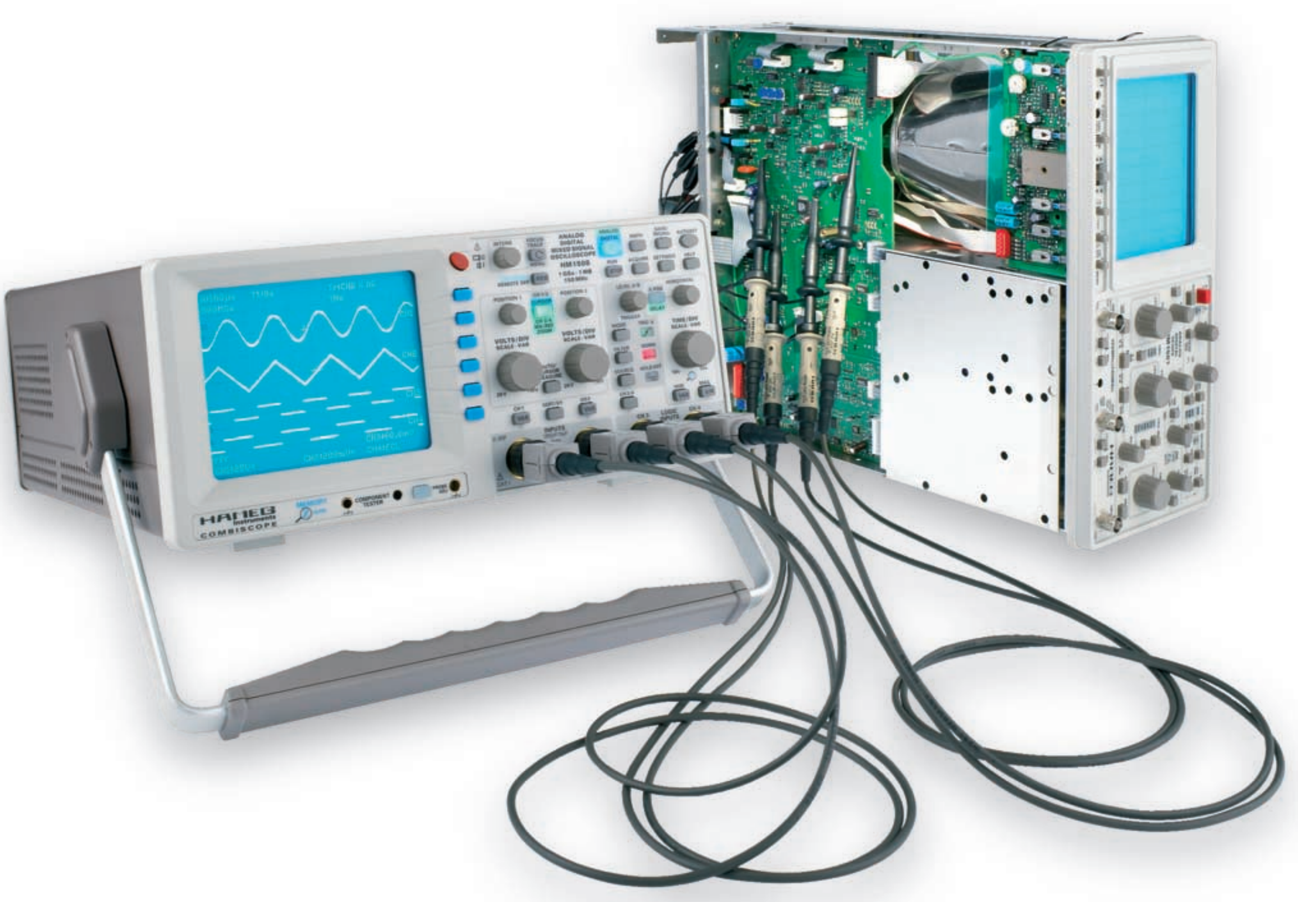
HAMEG Oscilloscopes

Oscilloscopes cannot be replaced by any other measuring instruments ...

... because only oscilloscopes give a full representation of the measuring signal.

... because only oscilloscopes display signals versus time.

The importance of waveform representation becomes obvious when comparing oscilloscopes with alternatives to oscilloscopes: multimeters and frequency counters. Both offer a much higher measuring accuracy, but the lack of waveform representation may obscure erroneous measurements.

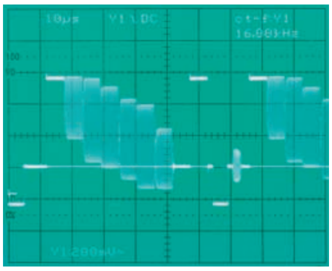


As an example, erroneous measuring results will be obtained if pulse signals are being measured with duty cycles not exactly 1:1. This is especially the case when there are complex signals.

Comparable problems exist when measuring frequency, too. True measurements are based on the assumption that the signals are nearly ideal sine waves, triangles or square waves. Again complex signals will also lead to erroneous results.

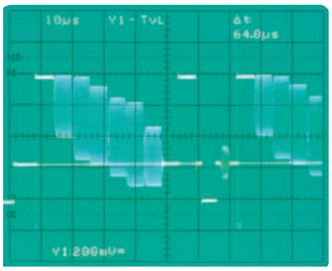
A typical example of such a complex signal is a composite video signal. It contains 50 Hz field sync pulses, 15.625 kHz line sync pulses and the video signal with frequencies of a few Hertz up to about 5 MHz.

If a frequency counter is used to analyze such a signal, the accidental selection of the trigger level will determine which of the many frequencies will be displayed. Depending on the choice of trigger level, either the frequency of the sync pulses or of the video signal will be displayed. This can be easily demonstrated with the oscilloscopes HM504 or HM507. These instruments not only display the signal, they also contain a frequency counter. The choice of the trigger level is the same for oscilloscope and frequency counter, but if the frequency counter is used, the trigger level will not be visible.



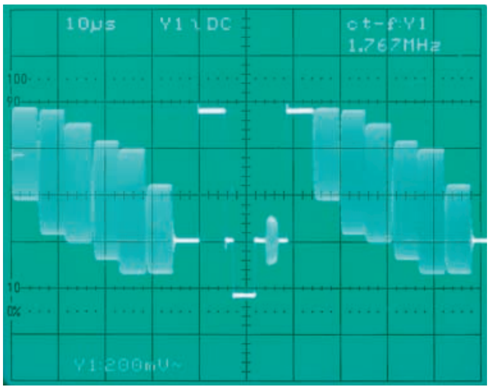
Picture 1: Composite video signal displayed on a HAMEG oscilloscope

Picture 1 displays a composite video signal. The trigger symbol is visible on the left of the display. In this example the trigger level was chosen at the level of the sync pulses. A frequency counter can neither determine nor display the trigger level; this is also true for the frequency counter in the oscilloscope mentioned. The result of the frequency measurement is displayed in the top right corner as (16.00 kHz); the correct result would be 15.625 kHz (line frequency). The causes of this difference are the equalizing pulses preceding and following the field sync pulses and the half line offset of the frame sync pulses. If the cursors are used as demonstrated in picture number 2 the correct time for one line of 64.0 µs and that the correct line frequency of 15.625 kHz are obtained.



Picture 2: Time measurement with cursor lines (HAMEG oscilloscope)

If the trigger level is moved into the area of the video rather than the line content the differences will increase. Depending on the trigger level various different measurement results will be obtained. In picture 3 1.767 MHz are displayed, even though for this signal the frequency 4.43 MHz dominates. This erroneous measurement is caused by the fact that the 4.43 MHz color signal is not constantly available. In fact this signal is interrupted by sync pulses and other signals. Also in this case a correct result can only be obtained if the waveform is displayed with the cursors set to the correct points.



Picture 3: Frequency counter shows 1.76 MHz (HAMEG oscilloscope)

Without oscilloscope control of the signal to be measured, the measuring results of multimeters and frequency counters are not reliable especially in the case of complex signals. This concerns even "simple" signals such as a 50 Hz line (mains) frequency which may become superimposed by noise and transients and thus be converted to complex signals.

The importance of signal wave form representation is consequently immense and with it the importance of oscilloscopes.

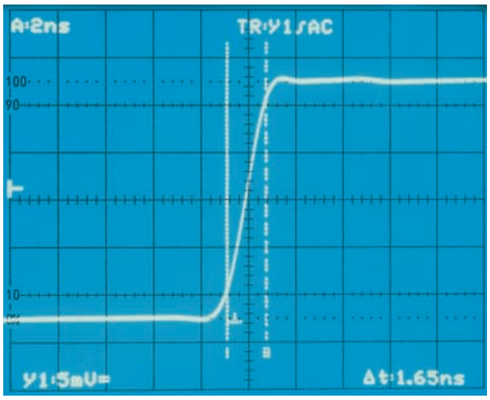
Main purpose of oscilloscopes

The duty of an oscilloscope is to display a signal as faithfully as possible as it is present at the point of measurement.

Unfortunately, this requirement is fundamentally unrealizable, but HAMEG engineers succeed in creating instruments that give a fairly truthful representation of the signals. The main criteria that an oscilloscope has to fulfill are listed in the following.

Rise time

The manufacturing costs of an oscilloscope are mainly influenced by the bandwidth or risetime of the instrument. As a rule the risetime of an oscilloscope should be less than one third of the risetime of the fastest signal to be measured. If the signal is very much faster than the oscilloscope, the oscilloscope will display its own risetime which is shown in picture 4.



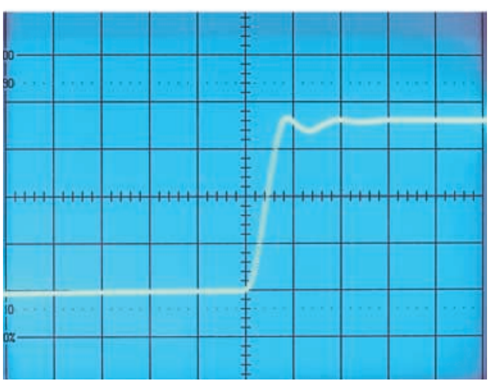
Picture 4: Square wave with risetime of less than 1 ns displayed on a HAMEG oscilloscope

Overshoot

Faithful signal display requires that the oscilloscope does not contribute distortions like overshoots, ringing etc to the signal itself. In order to test the transient behavior of an oscilloscope a very fast, clean square wave signal is used.

Picture 5 shows the display of such a signal on an oscilloscope from an East Asia company.

The user of such an oscilloscope has no way to discriminate whether the signal distortion is inherent in the measuring signal or whether it is caused by the oscilloscope.



Picture 5: The same square wave displayed on a competitive oscilloscope which causes overshoot

As can be seen in picture 6, a HAMEG oscilloscope with the same bandwidth, displaying the same signal as in picture 5, shows a perfectly clean step. Consequently, if a signal displayed on a HAMEG oscilloscope shows any distortion, the user will know that this distortion was not caused by the oscilloscope.

Jitter

In picture 7 taken from the screen of a competitor's instrument, the jitter on the rising portion of the signal is obvious. The user can not discern whether this jitter was inherent in the signal or whether it is caused by the oscilloscope. However, in many applications the information about the jitter is important.

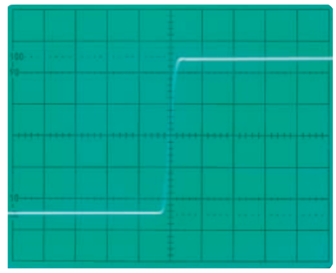
Of course, some jitter will be unavoidable, and in oscilloscopes jitter is caused e.g. by noise, trigger comparators and the time base generator. Picture 8 illustrates that there is no visible Jitter with the same signal displayed on a HM2005 as in picture 7.

Noise

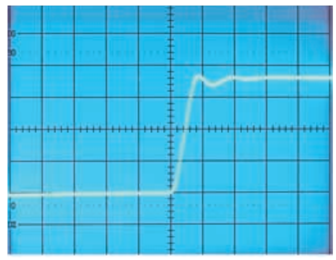
Residual noise of the oscilloscope amplifiers is of great concern, and HAMEG oscilloscopes are known for their very low intrinsic noise. This is of major concern especially with all digital storage oscilloscopes (DSOs).

HAMEG combination analog-/digital-oscilloscopes excel by their extremely low noise. This is achieved by using 8 bit flash A/D converters. Often, it is not discernible from the display whether the HAMEG oscilloscope is operating in the analog or digital mode. Picture 10 shows the display of a HAMEG oscilloscope with no signal displayed; there is practically no noise visible. Simple and low cost DSOs particularly display strong noise as shown in picture 9.

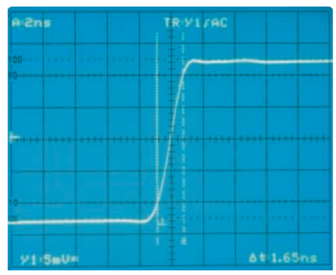
Naturally, one can get rid of noise by averaging. However, one thereby also eliminates the information about the actual noise of the signal source.



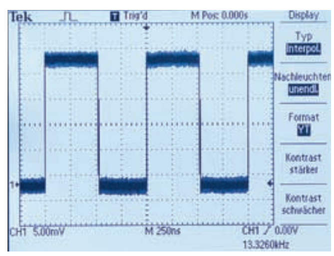
Picture 6: Step response of an excellent amplifier (HAMEG oscilloscope)



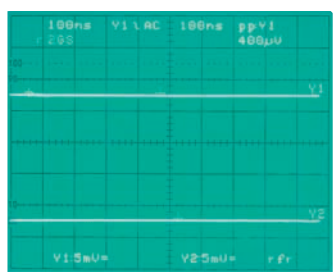
Picture 7: Competitor's oscilloscope display jitter



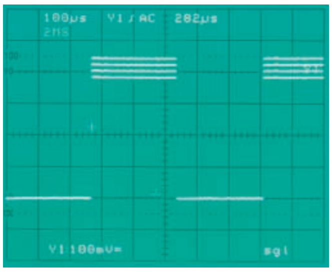
Picture 8: The same signal displayed on a HAMEG oscilloscope shows that there was no jitter in the signal



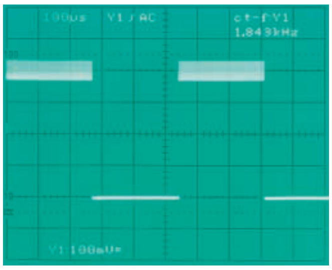
Picture 9: Noise of a competitor's DSO with CCD AD-Converter



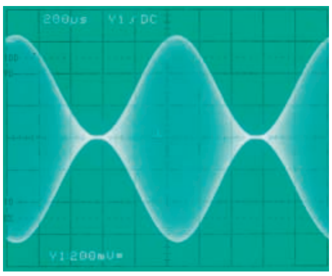
Picture 10: Practically no noise visible on a HAMEG due to flash AD-Converter



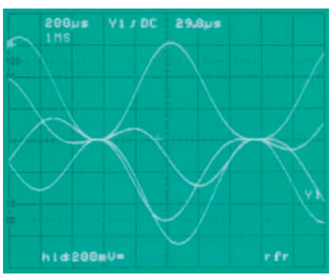
Picture 11: HAMEG oscilloscope operating in the digital mode: seemingly low frequency superposition on a signal



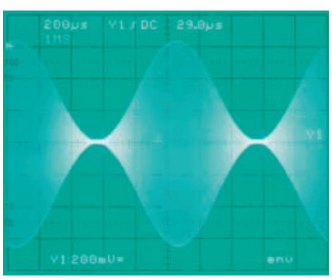
Picture 12: HAMEG oscilloscope in analog mode displays the true nature of the disturbance: the superposed signal is a high frequency signal



Picture 13: HAMEG oscilloscope in analog mode: signal with AM 100 %



Picture 14: HAMEG oscilloscope in the digital mode: the same signal



Picture 15: HAMEG oscilloscope in the digital mode, envelope display

Signal acquisition

The frequency of signal acquisition is a further criterion of the quality of an oscilloscope.
The higher the signal acquisition and display frequency, the better are the chances of acquiring additional information. The signal frequency and time base settings of the oscilloscope determine the frequency of signal acquisition and display. In the analog mode 500,000 to 2.5 million signal displays are standard. This is only possible by analog signal processing; no graphic display or any LCD can come close to the performance of a cathode ray tube.

In the digital mode the signal must first be acquired and then processed within the instrument.
While the instrument is busy with processing a signal captured previously it can not acquire any other signal. Pictures 11 and 12 show the vital difference in signal display between digital and analog modes.

The next example (picture 13) illustrates a still clearer statement of the facts: an amplitude modulated signal is displayed in analog mode. Without any difficulty one can read from the signal display that the modulation degree is 100 % and the modulation frequency is 1 kHz. In contrast, in digital mode it is difficult even to recognize that we are dealing with an amplitude-modulated signal (picture 14).

If the digital signal acquisition of the AM signal takes place in envelope mode, the problem of the signal recognition seems to be resolved, as illustrated in picture 15. However, this is valid only when the modulation degree and modulation frequency do not change, because in envelope mode the once acquired maximum value is always displayed. Therefore envelope mode is also no solution for the measurement of modulated signals.

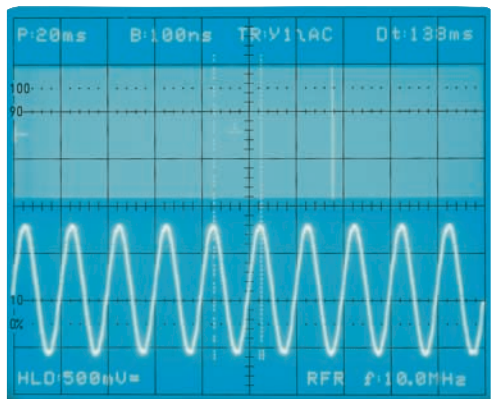
The drawbacks of the digital mode described here apply to competitors whose "only digital" oscilloscopes do not allow any switchover to analog operation. HAMEG oscilloscopes excel by the possibility of selecting the analog and digital modes whichever is more useful for the application intended.

Focus and intensity

The requirements of a good display are focus and intensity, even at 2 kV acceleration voltage reasonable focus and intensity can be obtained, and such a cathode ray tube is used in the HM303-6, HM504 and HM507 oscilloscopes.

The oscilloscopes HM1004-3, HM2005 and HM1507-3 have even superior characteristics, since they are equipped with cathode ray tubes that work with 2,000 volt acceleration voltage and 12,000 volt post-acceleration voltage, providing a very high intensity reserve. This is important for a visible display of signals with a very low repetition frequency and with oscilloscopes with a second time base which allows the display of selected signal portions.

The second time base of a HM1507-3 is also available for digital mode and enables the 200,000-fold X-expansion of a 10 MHz sine wave signal (see picture 16), which is displayed with the A time base at 20 ms/cm and with the B time base at 100 ns/cm. An expansion to such a degree only makes sense in the digital mode as here the trace intensity will not decrease with increasing expansion. The display of an analog only oscilloscope under such conditions would hardly be visible.



Picture 16: Signal in intensified sector displayed with 200,000 fold magnification.

Resolution

The limits of resolution for analog oscilloscopes are predetermined only by the visual acuity of the viewers, because the electron ray can be deflected in every position of the screen. Restrictions on the X or Y-resolution consequently do not exist.

In contrast, the resolution for digital oscilloscopes is limited in principle. Most oscilloscopes use 8 bit analog/digital converters. Consequently, there are only 256 possible positions in vertical direction of which 200 positions are visible on the graticule.

This corresponds to 25 possible signal positions per centimeter of raster. The graphic display number one on the right hand side of this page shows the 8 x 10 centimeter graticule and graphic display 2 shows the same graticule, where one raster unit has been enlarged. With the exception of very small sized battery operated digital oscilloscopes, the 25 dot resolution in vertical direction is the standard because of their 8 bit A/D converters.

For horizontal resolution the situation is different, as the physical characteristics of the display determine the resolution.

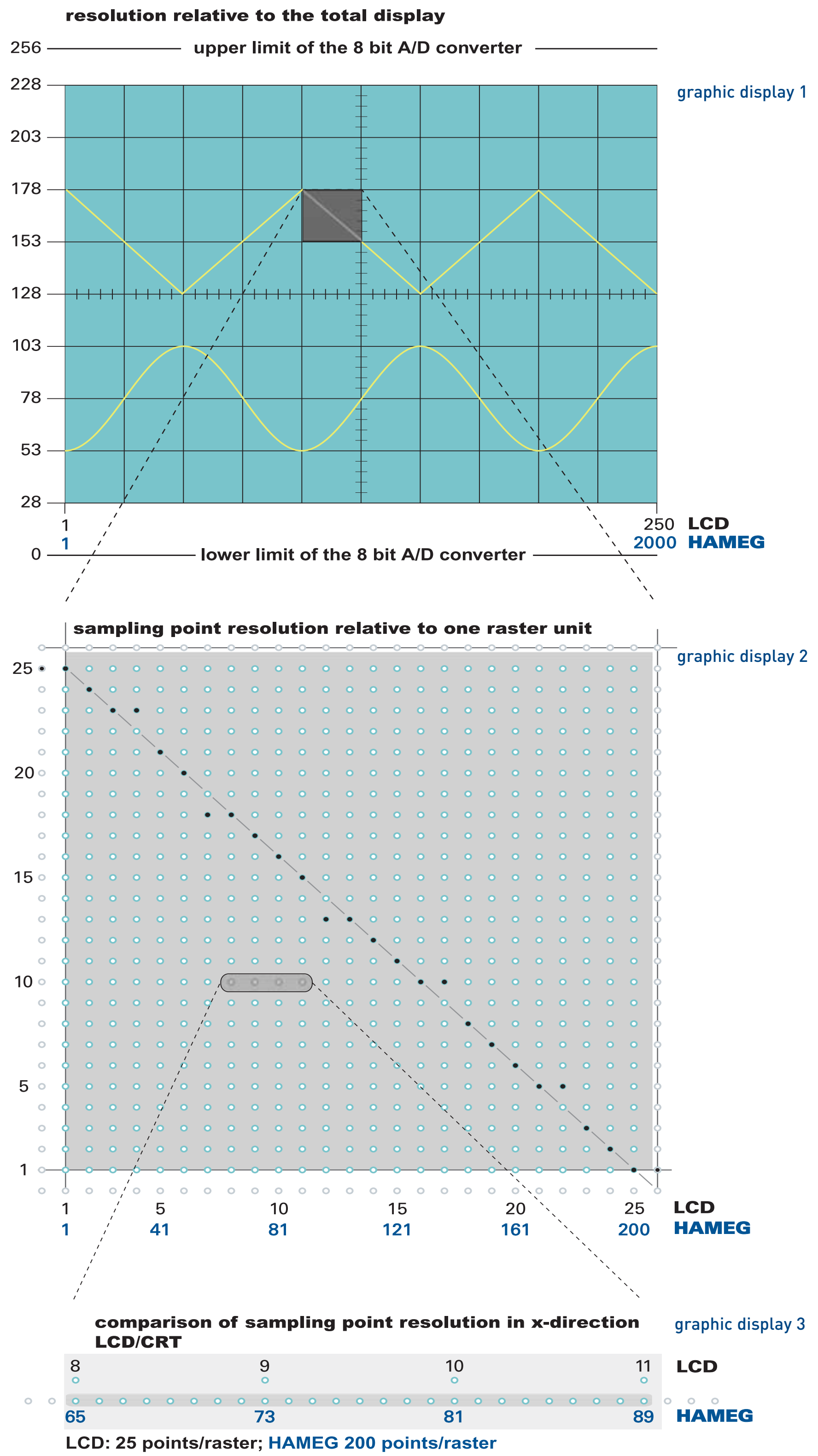
A LCD normally allows for 250 dot resolution for the complete signal display in horizontal direction. This means that only 25 dots (samples) can be displayed in horizontal direction. Graphic display 2 shows this resolution.

Monitor tubes feature a resolution of about 50 points in X-direction and 25 points in Y-direction, however, but they do not reach the resolution which HAMEG oscilloscopes feature in the digital mode.

An oscilloscope CRT allows a complete display of the memory of 2,000 sampling points. The resolution per raster is about 200 points in X and 25 points in the Y direction. As shown in the graphic display 3 on the right hand side the resolution in X-direction is better by a factor of 8 compared to LCDs. Of course, in order to make use of the higher resolution the sampling rate should also be higher by the same factor.

Memory, resolution and sampling rate

These three parameters stand in direct relationship to each other. As mentioned the memory capacity of HAMEG analog-/digital



graphic display 1: full display

graphic display 2: one raster unit with 25 points in Y- and 25 points in X-direction (LCD)

graphic display 3: 8 times higher resolution = smaller sampling intervals oscilloscopes is 2,000 sampling points (per channel) which are all displayed. This means that the memory depth and the display resolution are identical. This is very important to note, as there are competitive instruments that can store more than 2,000 samples but they display only every tenth sample. This is equivalent to only one tenth of the sampling rate specified.

With all DSOs the effective sampling rate depends on the memory depth and the time base setting. The user can only select the time base setting. Consequently, as the time base is set to slower sweep speeds this sampling rate must be decreased, and is done automatically, but very few oscilloscopes on the market do display the actual sampling rate on the screen.

If for example the memory depth is 2,000 sampling points and is completely displayed on a CRT, the X resolution is 200 points per raster. If the time base is adjusted, for example, to 10 µs/cm (per raster), this means that 200 samples must be acquired within 10 µs. The sampling interval is then 10 µs : 200 = 50 ns; this means that the signal is sampled in 50ns intervals. Consequently the sampling rate is 1/50 ns = 20 MSa/s (20 million samples per second). The duration of one samples is very short compared to the sampling interval. Of course, any signal changes between two samples will be ignored.

In contrast, LCDs can often display only 25 samples per raster. If 10 µs/cm as time base setting is also required, then the sampling interval is 10 µs : 25 = 400 ns. This however corresponds to a sampling frequency of only 2.5 MSa/s. This will be the case irrespective of the maximum sampling rate specified for the instrument.
A shorter memory as well as a lower resolution will thus lead to a lower sampling rate.

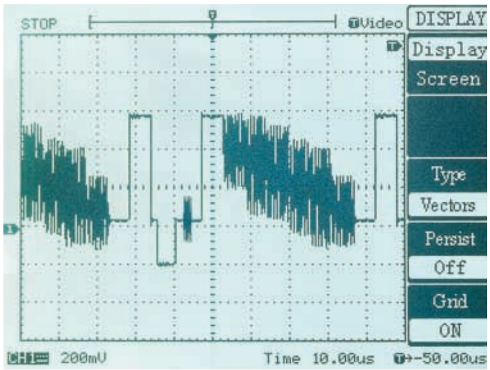
The repercussions in practice are shown by the following example, whereby the following facts are to be considered:

1. The period duration of the measuring signal defines the time base setting.

2. If sine wave signals are acquired, at least 10 samples per signal period will be necessary otherwise it will be impossible to discriminate between sine wave and triangle signals.

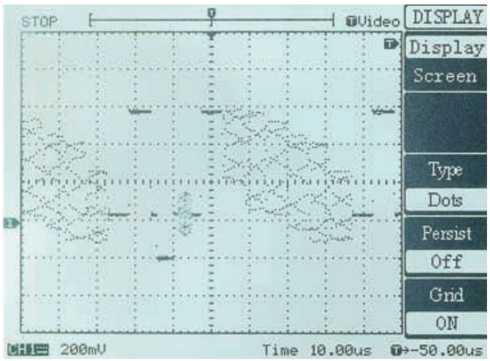
As a result, the sampling rate for the acquisition of a 5 MHz sine signal must at least be 50 MSa/s (sampling frequency 50 MHz). If signals with a low repetition rate, containing signals of very high frequencies, are sampled at a low rate, serious distortions and aliasing will result.

An example of this is a composite video signal which contains signals up to 5 MHz, even though the half frame frequency is only 50 Hz and the line frequency only 15.625 kHz (64 µs period). In order to display a complete line, the time base setting must be 10 µs/cm. For an "only digital" oscilloscope with LCD, as shown in picture 17, the sampling rate will then be 2.5 MHz.



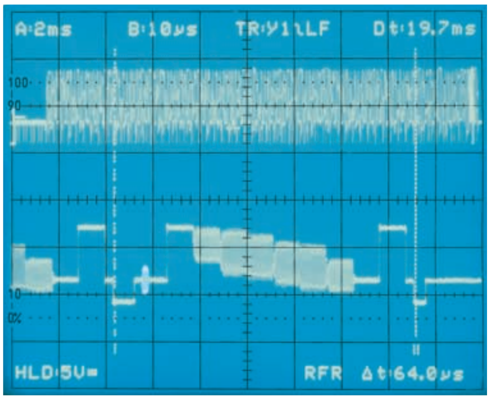
Picture 17: Composite video signal displayed with LCD (competitor's instrument, vector display)

Consequently the highest signal frequency may only be 250 kHz. Picture 18 displays the



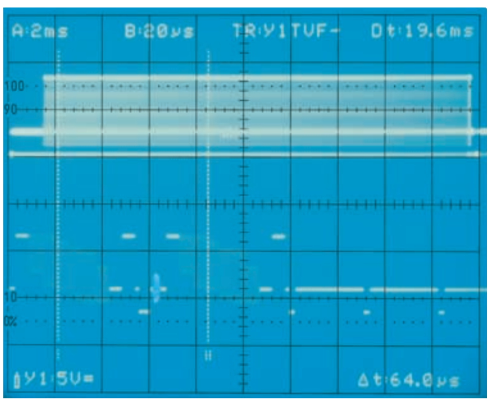
Picture 18: LCD displays composite video signal, only the sampled points are shown (competitive instrument)

same signal where only the sampling points are displayed. Obviously this display is of no relevance or use whatsoever.

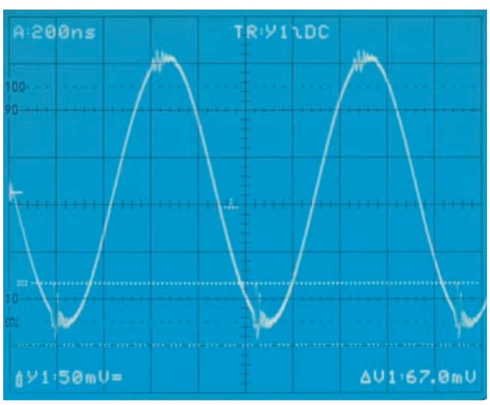


Picture 19: Composite video signal displayed on a CRT with a HAMEG oscilloscope

With the HAMEG oscilloscope, however, the resolution of 200 points/cm at 10 µs/cm yields a sampling rate of 20 MSa/s, which is still fairly adequate to display 2 MHz with 10 points per signal period. The top display in picture 19 shows half a frame with time base A. The lower display in picture 19 shows one line with time base B.



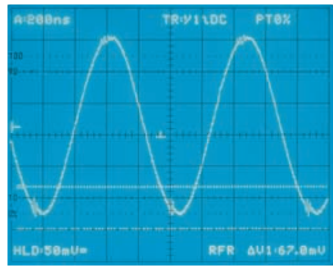
Picture 20: Optimum analog display of a composite video signal on a HAMEG oscilloscope



Picture 21: Analog display of superimposed noise on a HAMEG oscilloscope

Please note, that in sharp contrast to these principle shortcomings of any DSO if the HAMEG oscilloscope is operating in the analog mode, the full bandwidth of the instrument will be available at all sweep settings. Analog oscilloscopes always display the true signal itself and not a more or less distorted reconstruction of the signal.

Picture 21 shows a sine wave signal on which high frequency noise is superimposed. The picture was taken in the analog operating mode, and the amplitude of the superimposed noise is about 67 mV$_{PP}$. With the same signal displayed in digital operation mode, the noise will be displayed with a much lower amplitude, which is hardly discernible (picture 22).



Picture 22: Same display in digital mode shows distorted and reduced amplitude of noise

Summary

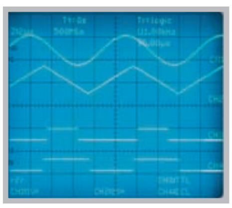
The characteristics described here are only a small part of the most important quality characteristics of an oscilloscope. It is definitely untrue that analog oscilloscopes are not "up to date".

Naturally, a digital oscilloscope offers advantages for single-event acquisition, the storage of very slow signals and the documentation of signals. Further advantages are the possibility of pre- and post-trigger and the feature of extremely high signal expansions in x-direction using the 2nd time base without a reduction in trace intensity. The disadvantages, however, are numerous and severe.

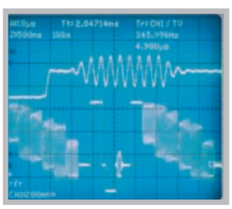
This is one reason why analog oscilloscopes in most applications are the technologically superior as well as more economical solution. The combination of analog and digital oscilloscopes — as offered by HAMEG — remains the optimum. Pressing a button is all it needs to change from analog to digital operating mode.

150 MHz Analog-/Digital Mixed Signal CombiScope HM1508

Digital Mode: Display of 4 signals (2 analog and 2 logic signals)



Digital Mode: One complete TV line and a ZOOM magnified sector (PAL Burst)



High fidelity even in digital mode: Low noise signals displayed without additional noise

Analog mode: see HM1500 (page 16)

4 Channels (2 Analog, 2 Logic)

1 GSa/s Real Time Sampling, 10 GSa/s Random Sampling

Pre-/Post-Trigger -100 % to +400 %

8-Bit Low Noise Flash A/D Converters

Time Base 50 s/cm – 5 ns/cm

1 MPts memory per channel allows zoom up to 40,000:1

Acquisition modes: Single Event, Refresh, Average, Envelope, Roll, Peak-Detect

RS-232 Interface, optional: RS-232/USB, IEEE-488, Ethernet

Signal display: Yt and XY;
Interpolation: Sinx/x, Pulse, Dot Join (linear)

See page 112 for technical specifications.

100 MHz Analog-/Digital CombiScope HM1008

Analog Mode: see HM1000 (page 17)

Two Channels

1 GSa/s Real Time Sampling, 10 GSa/s Random Sampling

8-Bit Low Noise Flash A/D Converters

Pre-/Post-Trigger -100 % to +400 %

Time Base 50 s/cm – 5 ns/cm

1 MPts memory per channel allows zoom up to 40,000:1

Acquisition modes: Single Event, Refresh, Average, Envelope, Roll, Peak-Detect

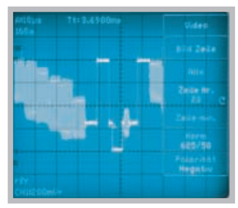
RS-232 Interface, optional: RS-232/USB, IEEE-488, Ethernet

Signal display: Yt and XY;
Interpolation: Sinx/x, Pulse, Dot Join (linear)

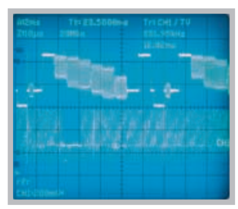
See page 110 for technical specifications.

inclusive | RS-232 | optional IEEE-488 | optional USB | optional TCP/IP

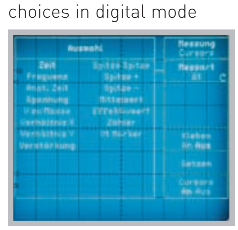
Either PAL or NTSC: Line triggering with line counter



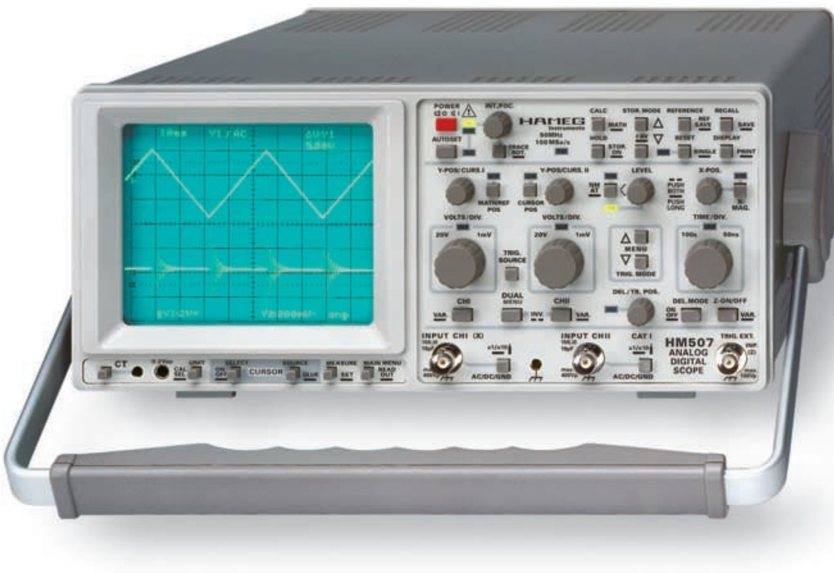
Digital Mode: TV field and zoomed display of one selected line



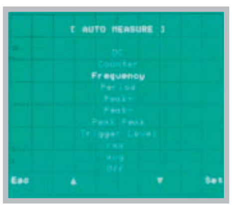
Cursor measurement choices in digital mode



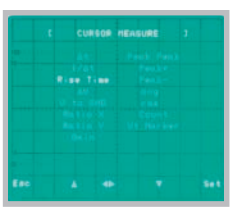
50 MHz Analog-/Digital-Oscilloscope HM507



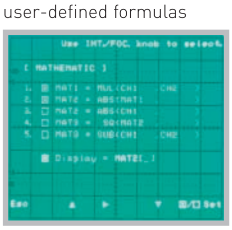
Automatic measurements



Cursor measurement



Signal processing with user-defined formulas



Specifications and functions, see HM504-2 (page 18)

Digital mode:
Single, Refresh, Envelope, Average, Roll and XY modes

Low-Noise 8-bit Flash A/D Converters with max. 100 MSa/s Real Time Sampling, 2 GSa/s Random Sampling and 2 kPts Memory per Channel

Pre-/Post-Trigger -10 cm to +10 cm

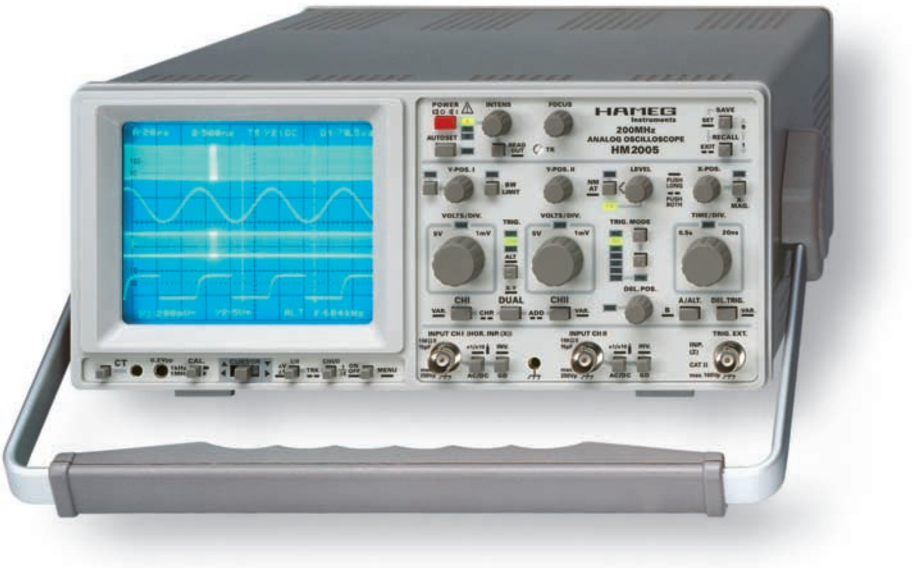
Digital Time Base 100 s – 100 ns/cm, with X Magnification up to 20 ns/cm

Programmable Mathematical Signal Processing

RS-232 interface for control and signal data transfer, incl. Windows® software

See page 107 for technical specifications

200 MHz Analog Oscilloscope HM2005



Two Channels with deflection coefficients of 1 mV – 5 V/cm, Low Noise Amplifiers

Two Time Bases 0.5 s – 20 ns/cm and 20 ms – 20 ns/cm (X x 10 to 2 ns/cm), allow for complete signal and signal portion display with a maximum of 1,000-fold X Magnification

Triggering (time bases A and B) from 0 – 300 MHz from 5 mm signal level

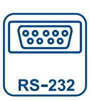
14 kV CRT features high writing speed and allowing the display of slowly repeating fast signals

Autoset, Cursor Measurement Functions, Readout

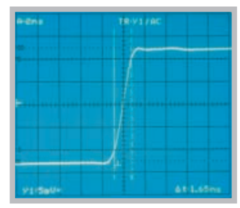
Maximum of 2.5 million Signal Displays per sec.

RS-232 interface (for parameter queries and control only)

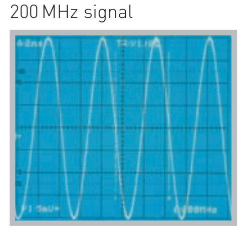
See page 108 for technical specifications.



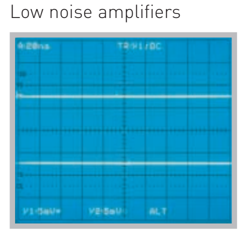
Even fast rising edges do not cause overshoot



Full screen display of 200 MHz signal

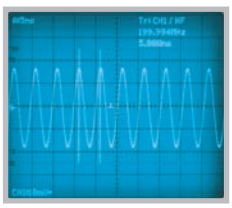


Low noise amplifiers

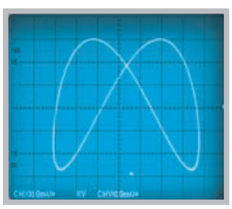


150 MHz Analog Oscilloscope HM1500

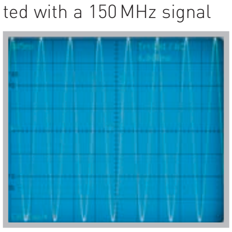
199.994 MHz Sine Wave Signal, measured with internal frequency counter.



Lissajous Figure (XY Mode)



Excellent dynamic range characteristics demonstrated with a 150 MHz signal



Two Channels with deflection coefficients of 1 mV – 20 V/cm

Low Noise Measuring Amplifiers with high pulse fidelity

Two Time Bases: 0.5 s – 5 ns/cm and 20 ms – 5 ns/cm

Videotrigger: Odd and even frames, line selection (525/60 and 625/50 standard)

200 MHz 6-Digit Frequency Counter, Cursor and Automatic Measurement

14 kV high writing speed CRT, Readout, Autoset, Delay Line, no Fan

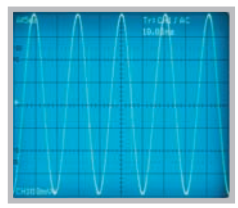
Save/Recall Memories for instrument settings

Help Function, Multilingual Menu

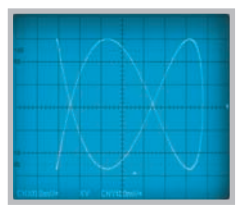
See page 111 for technical specifications.

100 MHz Analog Oscilloscope HM1000

Undistorted display of a 100 MHz sine wave signal



Lissajous Figure (XY Mode)



Two asynchronous signals triggered by alternate triggering

Two Channels with deflection coefficients of 1 mV – 20 V/cm

Low Noise Measuring Amplifiers with high pulse fidelity

Two Time Bases: 0.5 s – 5 ns/cm and 20 ms – 5 ns/cm

Videotrigger: Odd and even frames, line selection (525/60 and 625/50 standard)

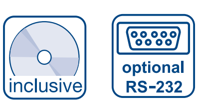
200 MHz 6-Digit Frequency Counter, Cursor and Automatic Measurement

14 kV high writing speed CRT, Readout, Autoset, Delay Line, no Fan

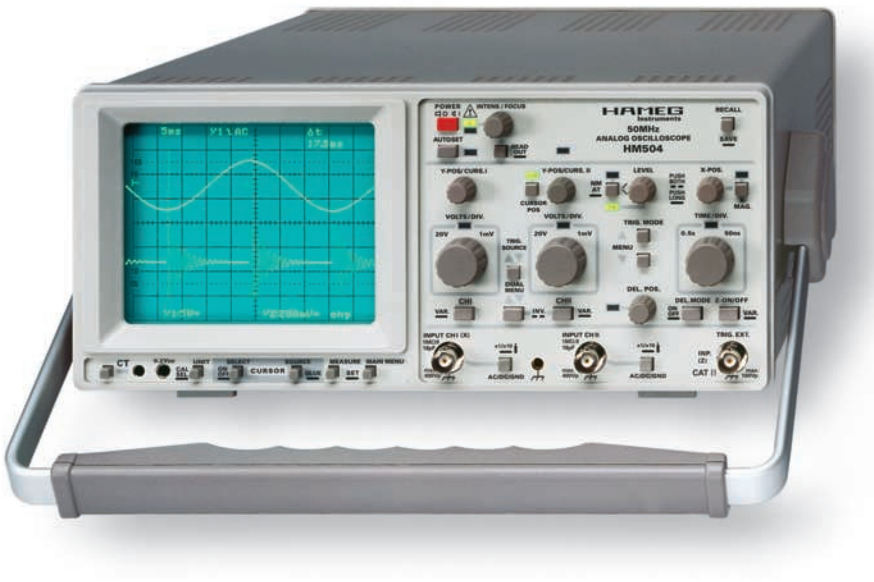
Save/Recall Memories for instrument settings

Help Function, Multilingual Menu

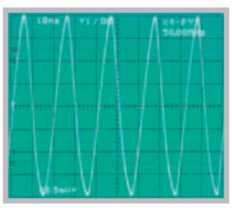
See page 109 for technical specifications.



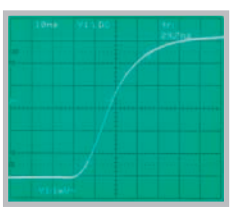
50 MHz Analog Oscilloscope HM504-2



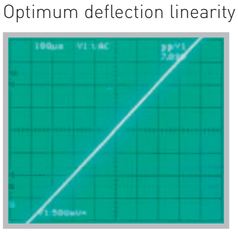
Wide dynamic range of vertical amplifiers allows full screen display of 50 MHz sine wave



Rise-time measurement with cursors



Optimum deflection linearity



2 Channels with deflection coefficients of 1 mV – 20 V/cm, Low Noise, Time Base 0.5 s – 50 ns/cm (with X magnification to 10 ns)

Triggering from 0 to 100 MHz from 5 mm signal level

Time Base delay provides allows high X Magnification of any portion of the signal

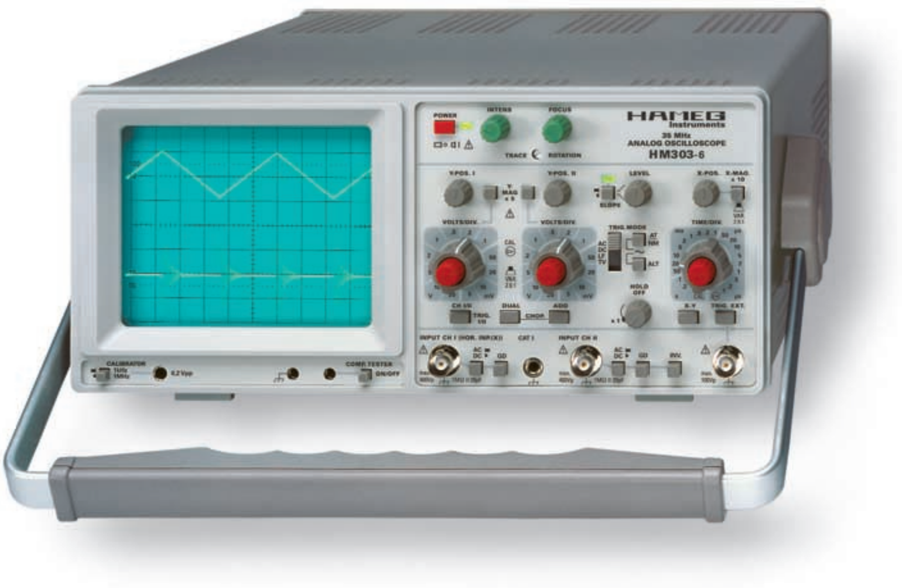
Automatic amplitude, frequency (up to 100 MHz) and period measurement

Maximum of 1 million signal displays per second in optimum analog quality

RS-232 interface (for parameter queries and control only)

See page 107 for technical specifications

35 MHz Analog Oscilloscope HM303-6



Maximum signal fidelity with minimum overshoot

2 Channels with deflection coefficients of 1 mV – 20 V/cm, Low Noise Amplifiers

Time Base 0.2 s – 100 ns/cm, with X Magnification to 10 ns/cm

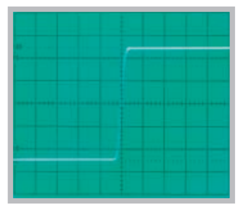
Triggering from 0 to 50 MHz from 5 mm signal level (100 MHz › 8 mm)

Analog mode provides unexcelled signal presentation at high resolution and up to 500,000 signal displays/sec.

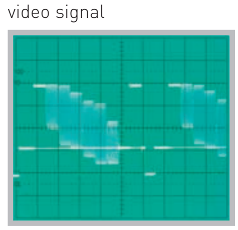
Yt, XY and component-test modes

See page 109 for technical specifications

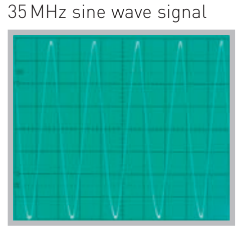
No signal distortion resulting from overshoot



Line triggered composite video signal



Full screen display of 35 MHz sine wave signal



HAMEG
Spectrum Analyzers

To many, spectrum analysis appears to be a type of "secret knowledge" dominated by only few specialists. One might acquire this impression from reading the available literature on this topic. It is full of theories, integrals, differential equations as far as the eye can see. The practical engineer's central interest, though, basically focuses on two questions: "How does it work and what can I do with it?"

In this article HAMEG has taken the "practical" route to address these questions. We would like to demonstrate that measurements with the spectrum analyzer are not any more difficult than working with an oscilloscope. Properly used, the applications of spectrum analyzers in research and development, quality assurance and electromagnetic compatibility (EMC) are very diversified. In the following we try to reduce theory and mathematics to a necessary minimum.

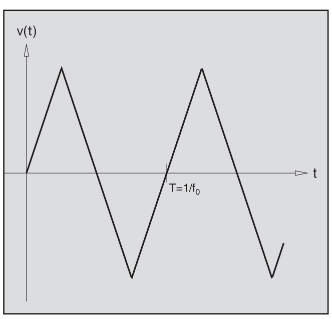
This article will give you a general overview of signal analysis as well as the types of equipments and applications. Examples are taken from practical applications in the field of EMI and frequency response measurement.

Introduction

One reason for the high performance of modern electronics (semiconductor components, microprocessors, oscillators, ...) is the constantly increasing speed of processing. The signal frequencies extend into the classical high frequency range, in this range also spectrum analysis is used. Oscilloscopes and spectrum analyzers both have their specific strengths and weaknesses to be covered in the following paragraphs.

The oscilloscope

The traditional method of analysis of electrical signals is the display of amplitude versus time. Oscilloscopes in their normal Yt operating mode (picture 1) display just this. This type of display versus time is familiar to humans. For this reason, oscilloscopes are also used in digital electronics. The vertical or amplitude scale of oscilloscopes is normally linear, hence oscilloscopes have a fairly low dynamic range (30 dB to 50 dB).



Picture 1: Classical oscilloscope display: amplitude versus time (Yt-operating mode). Signal: triangle.

Oscilloscopes which are used to measure electromagnetic interference must be very fast and feature rise times of a few nano seconds, they are consequently quite expensive.

The spectrum analyzer

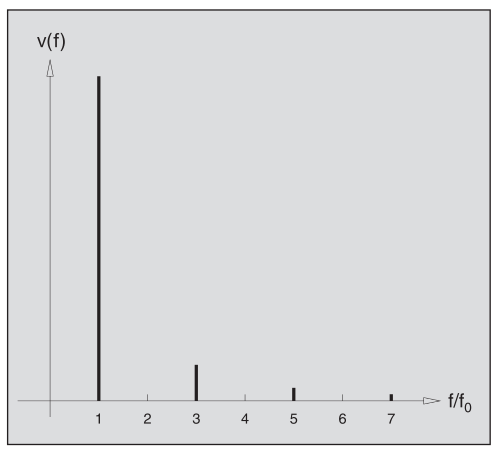
A simple example is the tuning display of any radio receiver. This is in principle a "small" spectrum analyzer. While tuning through a frequency band the field strength meter will display the intensity (power) of the frequency to which the set is tuned. The input signal from the antenna to the radio receiver contains the frequencies of all stations. After manually tuning once through a complete frequency band the result will be a chart of amplitude versus frequency. Spectrum analyzers (picture 2) work on this principle, first employed in World War II in order to obtain a quick broadband overview of enemy activities.

Spectrum analyzers can resolve signal components to very high frequencies (300 GHz). Due to logarithmic signal processing, they feature an extremely high dynamic range (> 80 dB). The input as a rule is 50 Ω, it is very delicate and can be easily destroyed by high signal levels (please observe the maximum input voltage!).

It is therefore advisable, if the signal to be measured is still unknown, to test first whether signal levels might be excessive. It is furthermore recommended to start any measurement with maximum attenuation and the maximum frequency range. It is important to bear in mind that measurements with a standard spectrum analyzer will only display the amplitude of the signals, time and phase information is lost, however in most practical applications this is of no consequence.

Different representations of the same signal

Each periodic signal may be represented versus time or versus frequency. As mentio-



Picture 2: Spectrum analyzer display: display of amplitude versus frequency (Yf-operating mode). Same signal as in pic. 1.

table 1: comparison oscilloscope/-spectrum analyzer

	Oscilloscope	Spectrum Analyzer
display:	Yt-operating mode (amplitude versus time)	Yf-operating mode (amplitude versus frequency)
x-direction/scale	linear (time)	linear (frequency)
y-direction/scale	linear (amplitude)	logarithmic (amplitude)
frequency range	DC to 12 GHz	0 to 300 GHz (no DC component)
dynamic range	30 to 50 dB	larger than 80 dB
phase information	yes	lost
prices	from a few thousand EURO to 100,000.00 EURO	a few thousand EURO up to 100,000.00 EURO

ned, these two representations are not of equal quality, because an ordinary spectrum analyzer will only retain the amplitudes of the individual frequency components, time and phase information is lost. Hence the signal representation versus time cannot be reconstructed from the amplitude versus frequency representation of an ordinary spectrum analyzer. The representations in the time and frequency domains are related by the Fourier transform.

time domain ↔ frequency domain

Time function ↔ amplitude spectrum

$v(t) \leftrightarrow V(f)$

This will be detailed in the following paragraph information theory.

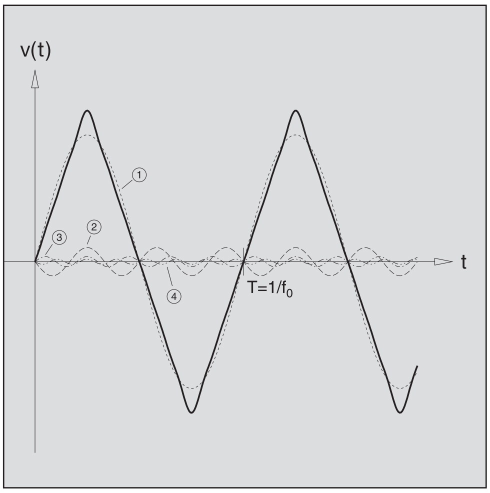
In table 1 the most important features of oscilloscopes and spectrum analyzers are compared. Picture 1 shows a signal versus time and picture 2 shows the same signal versus frequency.

Information theory

Time domain

Jean Joseph Fourier showed in 1808 that each periodic signal may be broken down into a fundamental frequency and its harmonics. In electronics that means: Each periodic signal (square wave, triangle, sawtooth, other waveforms) may be constructed by a sum of sine waves of different amplitude and phase.

In picture 3 the curves 1 to 4 are superimposed in order to obtain a triangle waveform. The fundamental frequency (curve 1) has the same period as the signal. The curves 2 to 4 are called harmonics and are always integer multiples of the fundamental. The more harmonics are taken into consideration, the more the display will come close to a true triangle wave form.



Picture 3: Curve 1 – 4 superimposed form a triangle waveform

Frequency domain

In order to look at the triangle waveform in the frequency domain a real time analyzer may be used. This instrument contains a multitude of band pass filters connected in parallel to its input. If a triangle wave form is applied to the input, only those filters will respond the resonance frequencies of which coincide with the frequencies of the curves 1 to 4. The output voltage of each filter is a measure of the amplitude of the individual frequency.

Table 2 refers to our example:

Curve 1	Frequency	f_0 = 10 kHz	Amplitude = 1
Curve 2	Frequency	$3f_0$ = 30 kHz	Amplitude = 0.111
Curve 3	Frequency	$5f_0$ = 50 kHz	Amplitude = 0.04
Curve 4	Frequency	$7f_0$ = 70 kHz	Amplitude = 0.02

Table 2

Fourier Analysis

As shown the triangle signal may be displayed on an oscilloscope in the time domain (pic. 1) or in the frequency domain (pic. 2) with a spectrum analyzer.

The transformation between the time and frequency domains is done using the Fourier transform. This requires integral calculus. We intentionally renounce on a theoretical mathematical treatment because the spectrum analyzer does the Fourier transform for us.

How to interpret the Y-scale of a spectrum analyzer

The Y-axis in oscilloscopes is linear. Each division corresponds to the same amount.

Example:
1 Div. = 2 V means that a 5 Div. display = 10 V.

In contrast the Y-axis of spectrum analyzers is logarithmic. Hence each division corresponds to the same value in dB.

Example:
1 Div. = 10 dB means that a 5 Div. display = 50 dB.

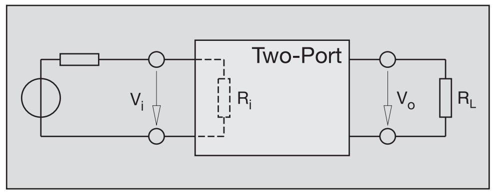
The advantage of a logarithmic scale is the ability to display a very large range on screen.

The designation dB (= decibel) equals 1/10 of the unit Bel. One Bel is the decade logarithm (lg) of the ratio of two powers. It is thus a pure number (see table 3).

Calculation of power in dB

Picture 4 shows a two port: The input voltage is designated V_i, the output voltage is designated V_o. The input resistance R_i is equal to the load resistance R_L. The power amplification of the two-port A_P may be expressed in dB.

$A_P = 10 \lg (P_L/P_i)$ dB   Equation 1



Picture 4: The power amplification Ap of the Two-Port may be expressed in dB.

Voltages expressed in dB

If a voltage (V) is applied to a resistor (R) a power (P) equals V^2/R will be generated.

$P_i = V_i^2/R_i$ and $P_L = V_o^2/R_L$.

If this is inserted in equation 1 we get:
$A = 10 \lg (V_o^2 \times R_i / V_i^2 \times R_L)$

as $R_i = R_L$, it follows:
$A = 10 \lg (V_o^2/V_i^2)$
$A = 10 \lg (V_o/V_i)^2$ or
$A = 2 \times 10 \lg (V_o/V_i)$
$A_V = 20 \lg (V_o/V_i)$ dB   Equation 2

Example of a calculation using dB

Assuming that $V_o = 10$ V, $V_i = 2$ V it follows:

$A_V = V_o/V_i = 10/2 = 5$
Inserted into equation 2:
$A_V = 20 \lg 10/2$ dB $= +13.96$ dB

If for instance an attenuator with -10 dB is followed by an amplifier with +19 dB the amplification of the whole chain is equal to the sum of -10 dB + 19 dB = +9 dB.

Table 3

Decade logarithm (dB-value) and ratio of power		In practice:
0 Bel	$\hat{=} 10^0 = 1$	signal is transmitted 1:1, i. e. there is neither amplification nor attenuation
1 Bel	equals a ratio of powers of $10^1 = 10$	amplification of the signal by a factor of 10
-1 Bel	equals $10^{-1} = 0.1$	attenuation of the signal by a factor of 0.1
1 dB	equals $10^{0.1} = 1.259$	amplification by a factor of 1.259
3 dB	equals $10^{0.3} = 1.995 \approx 2$	amplification by a factor of 2
10 dB	equals $10^1 = 10$	amplification by a factor of 10
Mathematics: 1 Bel $= \lg 10^1 = \lg (10^{0.1})^{10} = 10 \lg 10^{0.1}$ Bel 10 dB		

dB based on a reference level (= absolute level)

The unit dB is non-dimensional and expresses only the ratio of two values; e.g. voltages. For the application of absolute levels, reference levels were introduced in technical applications. The customary magnitude 1 mW is based on power output.

0 dBm	≙ 10^0mW		=	1 mW
30 dBm	≙ 10^3mW	= 1000 mW	=	1 W
-30 dBm	≙ 10^{-3}mW	= 1/1000 mW	=	1 µW

Since the relationship $P = U^2/R$ is valid for any available resistance, one can also express voltages in dBm. For a reference resistance of 50 Ω the results are:

$V_{ref} = \sqrt{50\,\Omega \times 1\,mW} = 224\,mV_{rms}$ Equation 3

as reference voltage.

In order to avoid the uncertainties for the voltage values in dBm (reference resistor 50 Ω, 75 Ω, 600 Ω), it is customary to refer voltage levels to 1 µV. For larger voltages, 1 Volt is employed as reference magnitude.

0 dBµV	≙ 10^0µV		=	1 µV
60 dBµV	≙ 10^3µV	= 1000 µV	=	1 mV
-60 dBµV	≙ 10^{-3}µV	= 1/1000 µV	=	1 nV

Example: Conversion from reference levels:
0 dBµV ≙ 1 µV ≙ -120 dBV

The following applies:
dBµV is a measure of how much greater a certain voltage is than the reference magnitude (here 1 µV). It makes no special sense, but one could for instance also the express mains voltage in dBµV. (230 V_{eff} in equation 2:

$A_V = 20\lg(230\,V/1\,\mu V)\,dB$
$= 167\,dB\mu V$).

For power, there is a similar validity; here the values in Equation 1 are employed. The reference value ($P_i = P_0$) is 1 mW, for a power output of e.g. 4 mW a value of 6 dBm is computed.

Conversion from dBm to mW

The height of the amplitude (A_p) at the spectrum analyzer is directly displayed in dBm. If you for instance read a value of –47 dBm, then you can convert the power output to mW. Equation 1 is:

$P_L/P_i = 10^{Ap/10}$
$\rightarrow P_L = P_i \times 10^{Ap/10}$
$P_L = 1\,mW \times 10^{-47/10} \rightarrow P_L = 2\,nW$

i.e., if you read a level of - 47 dBm on a spectrum analyzer, then this means – for the corresponding frequency – a power output of 20 nW.

Conversion from dBm to voltage (mV)

In order to be able to convert the power output (reference magnitude 1mW) into voltages, one must constantly refer to a firmly defined (termination) resistance. The spectrum analyzer has a 50 Ω input.

According to Equation 3:
$V_{ref} = 224\,mV_{rms}$

Transposition of Equation 2:
$A_V = 20\lg V_0/V_{ref}$ dB the following:
$A_V/20 = \lg V_0/V_{ref}$ or
$10^{AV/20} = 10\lg(V_0/V_{ref}) = V_0/V_{ref}$

$\rightarrow V_A = V_{ref} \times 10^{A_V/20}$

$V_A = 224\,mV \times 10^{-47/20} = 1\,mV$

Conversion dBm – dBµV

From Equation 3 the following:
0 dBm ≙ 1 mW ≙ 224 mV_{eff} (50 Ω)

is employed in Equation 2:
$A_V = 20\lg(224\,mV/1\,\mu V)\,dB = 107\,dB\mu V_{eff}$

This results in the overall relationship:
0 dBm ≙ 1 mW ≙ 224 mV_{eff} ≙ 107 dBµV

Resumed: In order to derive dBµV from dBm add 107 dB to the dBm value. Vice versa in order to derive dBm from dBuV subtract 107 dB. (See table 4.)

How to select a spectrum analyzer

Disregarding price which may reach 100,000 Euro very high performance spectrum analyzers are available. Those are much too expensive for general application. Many measurement tasks can be solved using instruments markedly lower priced. In the following the most important parameters are listed.

Table 4: Level definition with diverse reference magnitudes

Size Reference value	Letter symbols	Level definition	Unit	
Power level Reference value 1 W	$A_{P/W}$	$= 10 \lg (P_L/1\ W)$ dB	dBW	$P_L = 1\ W \cdot 10^{A_{P/W}/10}$
Power level Reference value 1 mW	$A_{P/mW}$	$= 10 \lg (P_L/1\ mW)$ dB	dBm	$P_L = 1\ mW \cdot 10^{A_{P/mW}/10}$
Voltage level Reference value 1 V	$A_{V/V}$	$= 20 \lg (V_O/1\ V)$ dB	dBV	$V_O = 1\ V \cdot 10^{A_{U/V}/20}$
Voltage level Reference value 1 µV	$A_{V/\mu V}$	$= 20 \lg (V_O/1\ \mu V)$ dB	dBµV	$V_O = 1 \mu V \cdot 10^{A_{U/\mu V}/20}$

Frequency range

This parameter has the most decisive influence on the price. Instruments with an upper limit of 1 GHz allow measurements in most of the amateur bands, in the ISM band (433 MHz), in the frequency range of the D cell phone system, the lower GSM band, in the terrestric radio and TV bands as well as of EMI measurements. Above 1 GHz the cost increases sharply, e.g. a frequency-stabilised YIG (yttrium-iron-garnet) oscillator may be needed for the first mixer stage.

Resolution

Resolution defines the ability of a spectrum analyzer to differentiate between two adjacent signals. This ability will depend on the qualities resp. properties of the IF section, i.e. the bandwidths and slopes of the filters therein (see picture 5). If e.g. the smallest filter bandwidth is 9 kHz the minimum frequency difference between two spectral lines will be also 9 kHz, otherwise they can not be recognized as separate. However, bandwidths ‹ 10 kHz mandate that the oscillators used are of adequate quality. FM signals e.g. require such quality.

Frequency stability

Of course, a spectrum analyzer must feature a much better frequency stability than the signal to be measured. This stability of the whole instrument is dependent on the local oscillator's stability. Longterm and shortterm stability specifications are necessary.

Amplitude accuracy

As a rule the vertical (amplitude) scale of spectrum analyzers is calibrated logarithmic. Assuming the standard 8 cm display 80 dB of amplitude can be displayed, this is equivalent to a voltage ratio of 1:10,000. The accuracy of amplitude measurements is influenced by the frequency response and the quality of the logarithmic amplifier. Total errors of ± 1 dB may be regarded as excellent.

Dynamic range/compression

The dynamic range of a spectrum analyzer is an important feature and will determine the range of small and high amplitudes which can be displayed.

The maximum level is limited by linearity constraints of the mixer stages which may generate distortions and false signals.

The lowest signal level usable is given by the noise level of the instrument. The noise may be reduced by reducing the filter bandwidth as exemplified by equations 4 and 5, thus increasing the dynamic range.

Input sensitivity

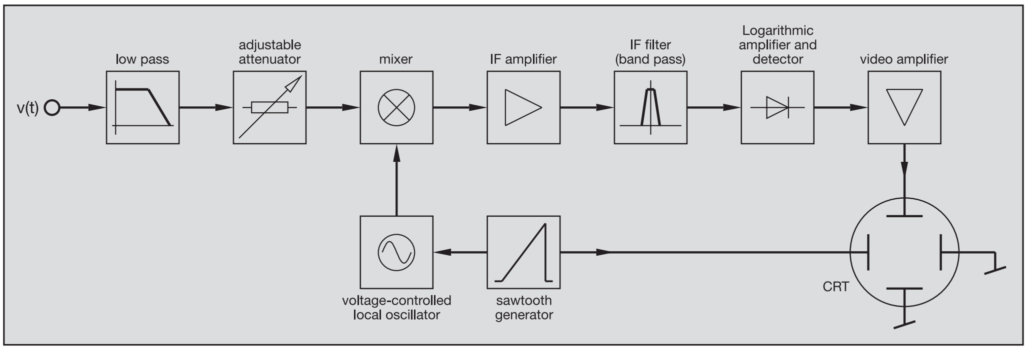
The sensitivity defines the smallest signal measurable and is limited by the noise level. Only signals which stick out from the noise band are measurable. We differentiate between thermal and non-thermal noise.

Thermal noise is given by:

$P_{therm} = K \times T \times B$ Equation 4

P_{therm}: Noise power in watts
K: Boltzmann's constant = 1.38 x 10 exp. – 23 VAs/degr. K
T: absolute temperature
B: Bandwidth in Hz

$B\ (dB) = 10 \lg B_{(IF)}\ (Hz)$ Equation 5



Picture 5: Block diagram of a Spectrum Analyser using the superhet principle.

Equation 4 shows that noise power is directly proportional to bandwidth. Reducing filter bandwidth by a decade step will reduce the noise power by a factor of 10 dB which in turn will mean an increase of sensitivity by 10 dB. All other noise sources are assumed as being non-thermal.

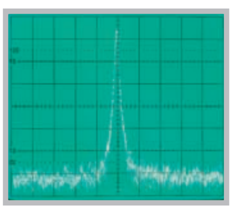
Spectrum analyzers sweep a wide frequency band and are narrow bandwidth measuring instruments as described in the beginning. All signals within the frequency range of a spectrum analyzer are converted to an intermediate frequency and pass an IF filter. The detector following the filter only responds to the noise contained in the filter passband, and only this noise will be displayed. Consequently, maximum sensitivity is achieved by using the smallest filter bandwidth available.

When comparing spectrum analyzers it is important to note that the filter bandwidth is identical.

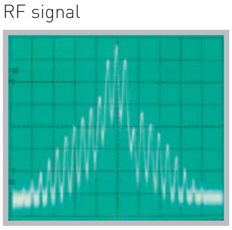
At room temperature the theoretically achievable sensitivity would be - 134 dBm at 10 kHz bandwidth and a perfectly square filter response. Signals from approx. - 131 dBm should then be just visible, equivalent to a signal-to-noise ratio of 3 dB. Of course, such numbers are unattainable. - 100 dB are quite practical and - 115 dBm may be regarded as the ultimate achievable with any reasonable effort.

1 GHz Spectrum Analyzer HM5510 / HM5511

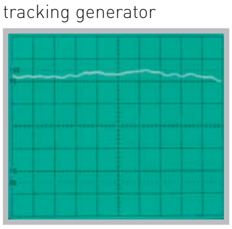
Unmodulated RF signal



Amplitude-modulated RF signal



Amplifier frequency response measured using a tracking generator



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): 20 kHz and 500 kHz

Keypad for frequency and amplitude setting

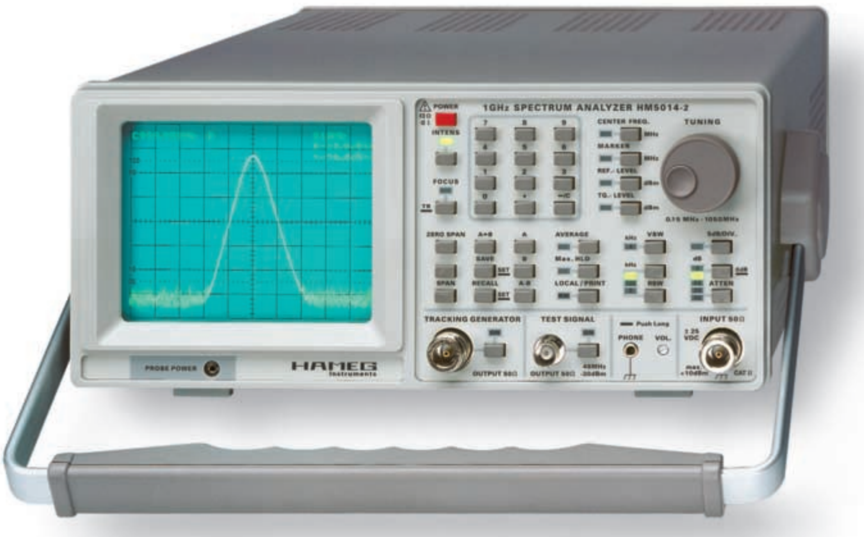
Analog signal processing and display

HM5510 only:
Test signal output

HM5511 only:
Tracking Generator with output amplitude of – 50 dBm to + 0 dBm

See page 116 for technical specifications

1 GHz Spectrum Analyzer
HM5012-2 / HM5014-2



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

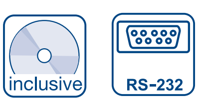
Pre-compliance EMI measurement

Serial interface for documentation and control software for documentation included

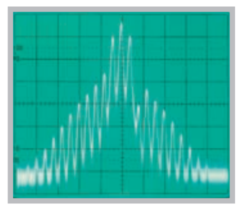
Additional measurement functions for EMI measurements with optional software

HM5014-2 only:
Tracking Generator with output amplitude from – 50 dBm to + 1 dBm

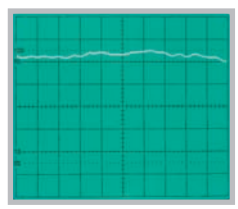
See page 115 for technical specifications



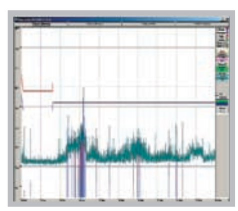
Amplitude-modulated RF Signal



Amplifier frequency response measured using a tracking generator



Measurement of line-conducted interference with HM5012-2

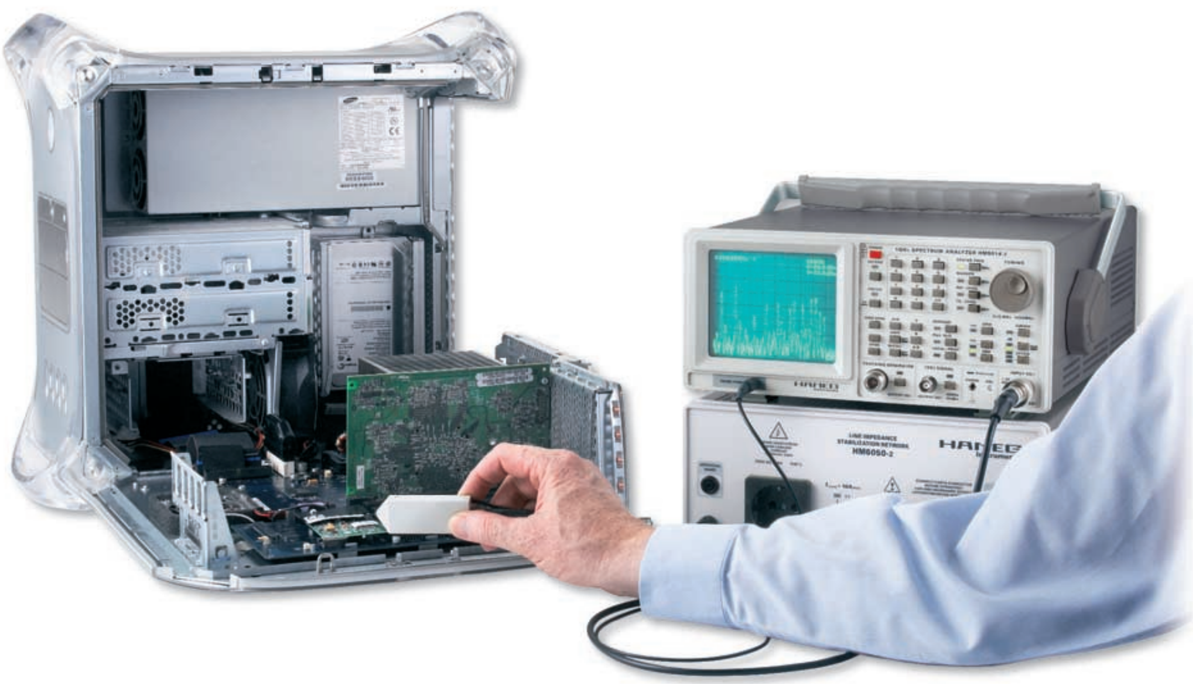


HAMEG Instruments

HAMEG
EMI measurement tools

Whoever sells an electric or electronic instrument or apparatus within the EWR must conform to the European Union Directives on Electromagnetic Compatibility, EMC. This applies as well to manufacturers as to importers in the European Union plus Island, Liechtenstein, and Norway.

HAMEG offers very cost-effective solutions to active (emission) measurement problems which allow to perform so called pre-compliance measurements.



Active and passive electromagnetic interference

Due to increasing operating frequencies and integration the measuring instruments must meet ever increasing demands for higher performance in order to guarantee that electric and electronic apparatus will conform to the standards. The frequency range to be covered extends from 150 kHz to 1 GHz.

The equipment necessary and thus cost can become partly immense, however, if good judgment is used and proper instruments and suitable methods applied cost will remain under control.

How much does it cost to comply with EMI standards?

Compliance with EMI standards needs not be expensive. Provided EMI considerations were taken into account from the beginning of a design and provided that EMI tests were performed all along the design cycle it was shown that the material cost of EMI components amount to 3 to 5 % of the total material bill.

Negligence towards EMI compliance may become very costly, especially if the first EMI test was performed at the completion of the design. In such a case easily 30 to 50 % of the total design cost will be consumed by EMI prevention measures. It may become necessary to start all over again, high costs will be incurred by extensive tests and having to resort to external expertise.

Compliance measurements are mainly reserved to specialized, well equipped laboratories. The equipment required is very expensive, and the procedures are extensive. This being the case it becomes necessary to perform one's own tests during the design cycle, good enough to come close to compliance and with moderate effort and affordable measuring instruments. In order to achieve this it is not necessary to own the expensive equipment nor to set up a test installation which conforms strictly to the standards. It is more important to quickly identify the critical zones within an electronics circuit and the wiring where interference emanates in order to determine the optimum and cost-effective counter EMI measures.

Oscilloscope or...

Inspite of its versatility the oscilloscope is not the best choice for EMI measurements. It will display the waveform of the interference signal vs. time but not the spectral lines involved.

The EMI standards require "average" and "quasi-peak" measurements. The bandwidths of the frequency selective measurements are dependent on the frequency.

The frequency range to be covered when measuring active interference, i.e. emissions, reaches from 150 kHz to 1 GHz. In addition to featuring this range a measuring instrument must sport a very high sensitivity; it must be able to measure down to a few µV.

The display of a large frequency range and the logarithmic display of amplitude with a range of 80 dB allow to see at a glance where the problems arise as well as which effects countermeasures have.

Spectrum analyzer, and ...

It is still disappointing how seldomly spectrum analyzers can be found in design labs. Quite often their high cost is mentioned. The spectrum analysis equipment required during the course of a design need not be of Rolls Royce standard, however. Regarding the fact that spectrum analyzers are rarely used daily it is advantageous to have instruments which can be used easily, i.e. those which can be used by any design engineer immediately without awe and without time-consuming training. It is most important to be able to perform comparative measurements quickly and inexpensively. The following example demonstrates how quickly a spectrum analyzer will be amortised: It costs 1,000 Euro or more to hire a specialized lab for one day. A simple and inexpensive spectrum analyzer will be already amortised if it can save 2 to 3 days in such a lab. It should be the goal of efficient design management to have to hire such a lab only once.

Thus the spectrum analyzer belongs to the standard equipment of any designer right next to his oscilloscope. As soon as you once worked with a spectrum analyzer you will be well able to judge its usefulness.

Line-impedance stabilization network (LISN)

This instrument is required in additon to a spectrum analyzer in any design and compliance test lab. It serves to isolate, identify, and quantify conducted interference in the frequency range 150 kHz to 30 MHz. Compliance test labs use the LISN in conjunction with a special test receiver. For pre-compliance tests the use of the LISN together with a spectrum analyzer is a much faster and thus more practical solution. HAMEG series 5000 spectrum analyzers and the HM6050 LISN offer results which are comparable to those obtained in external labs.

... and sniffer probes

What to do upon return from an unsuccessful visit to an external test lab? All you know is there is something which generates interference, but where?

E.g.: free-field emissions

Interference may be radiated or conducted. EMI rules specify the range to be tested from 30 MHz to 1 GHz. It is to be expected that the upper limit will be extended.

The measurements of radiated interference are conducted using antennae and receivers in a set-up free from reflections and third-party interference. Mostly such measurements are performed in anechoic chambers (rooms).

Such measurements are inefficient, time consuming and expensive if performed during the design phase. In practice it is necessary to have a means which allows to quickly identify sources of interference inside of circuits and especially from conductors and the harness. Although we speak of free-field emissions mostly it is the conductors and the wiring harness which act like antennae and thus ease radiation.

Measurement of conducted interferences via Spectrum Analyzer and LISN.

In the design lab most of the EMI work will have to do with the interference caused by conductors. With suitable means it is possible to perform such measurements directly close or even on conductors carrying signals, power, ground or their shield.

He who performs such measurements for the first time using a spectrum analyzer will be much astonished to see even strong high frequency signals on "slow" signal or static conductors which stem from other sources and which ride on those slow conductors.

Using an oscilloscope will not reveal this interference as it will be buried in the noise. The electromagnetic interference field uses the metallic conductor as a guide to propagate efficiently alongside.

In the design lab a spectrum analyzer and a suitable probe will be all that is necessary to identify such interference. Different types of probes are required, however.

How to test sources of interference in detail

Sniffer probes are especially useful to test the effect of EMI countermeasures. There are E field and H field probes available which, together with high impedance and low capacitance probes, help the engineer to select the appropriate EMI countermeasures.

Active E field probe

The active E field probe is a high bandwidth high sensitivity device. It allows judging the total radiation emitted from a complete set or modules thereof. The normal measuring distance is 0.5 to 1.5 m. The efficiency of shields can be tested as well as the effects of filters on all conductors and cables connected to the unit under test.

Due to its high sensitivity the active E field probe may receive interference emanating from other instruments in the lab. In order to exclude such disturbances from the measurements intended it is customary to make a first measurement with the unit under test switched off thus receiving only disturbing interference, then to perform a second measurement after turning on the unit under test and watching for signals which now appear.

All measurements with an active E field probe are similar to far-field antenna measurements and thus dependent on the measurement set-up. Placement of cables will play an important role. If reproducible measurement results are desired it is necessary to define the set-up precisely, preferably by mounting everything onto a board.

The active E field probe may also be used to analyze interference from the surroundings. In case such interference may exist an active E field probe together with a spectrum analyzer will allow detecting any such interference. As the analysis is performed in the frequency domain the source of interference will mostly be quickly identified. This allows to improve the set's EMI properties such it will pass a second compliance test.

Probe set HAMEG HZ530 consisting of 3 active probes (E field, H field, high impedance probe)

Active H field probe

Watching for interference currents is the route to success when searching for its sources. The use of oscilloscopes creates a tendency to look for voltages only. Successful EMI engineers have learnt to look for currents. In order to test for interference currents without disrupting circuits or dissecting conductors on EC boards active H field probes are the optimum choice.

Active H field probes are near-field probes which measure the H field. In the near-field this is directly related to the currents flowing. H field probes are fairly insensitive to external interference (third party interference). They show an intense increase in output when closing in on an interference source. They allow thus to locate such sources very precisely.

Leaks alongside the seam of a shield or housing are easily detectable with an H field probe, e.g. slots.

However, the ever increasing integration on EC boards makes it difficult to localize interference sources with ordinary H field probes. Here the HAMEG μH field probe HZ545 is applicable which allows locating sources down to the mm region and thus is ideal for EC board tests.

As mentioned all metallic cables are antennae for interference radiation as well as reception.

Testing cables with an H field probe in contact and a spectrum analyzer, one will be astonished to find sizeable levels of RF interference even on mains cables, telephone cables or slow data transmission lines like harmonics of clock frequencies. Making use of the H field probe and the logarithmic amplitude display of a spectrum analyzer it is easy to ascertain whether all cables carry the same level of interference or whether some conduct more. This will allow to determine proper countermeasures. The usefulness of which can be tested and verified fast and efficiently in the lab, without the need for shielded cabins and also without extensive measuring set-ups.

High impedance probe

The high impedance probe allows to connect e.g. to an IC pin or any single conductor without loading the pin with the usual 50 Ω of a spectrum analyzer. The bandwidth is > 1 GHz. The impedance of HAMEG high impedance probes contained in the sets is predominantly capacitive and < 2 pF. The high impedance probe may also be connected to an oscilloscope with 50 Ω input impedance or 50 Ω feedthrough termination, thus acting as a probe featuring the above mentioned bandwidth and impedance.

The load on the point of measurement may be further reduced by the low capacity probe HZ543 with ‹ 0.3 pF and 3 GHz bandwidth. This lower load will allow very true measurements even in critical RF circuits.

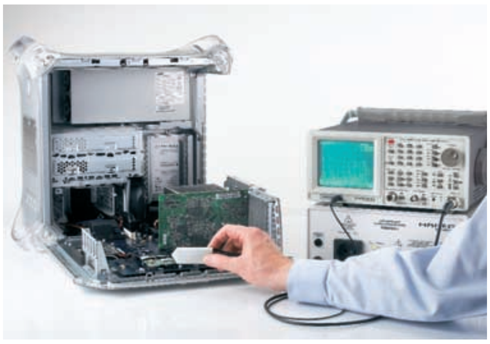
The essential advantage is that the point of measurement will see practically no load. Otherwise a low impedance probe may suppress or reduce just that oscillation which was to be measured. This problem is aggravated as the frequency of interest moves upward. Each pF is of enormous importance. Using the HZ543 this problem may be disregarded up to the bandwidth limit. The low capacitance probe features just a tiny tip and is used without a ground connection. The circuit is closed through the capacitance of the probe to the body of the test person. Thus it is indeed possible to test the individual interference of an IC pin or a conductor. The capacitive and high impedance coupling of the probe also allows to test for common mode interference and identify its source.

Practical EMI problems

The electronics circuit designer meanwhile became knowledgeable as regards EMI prevention e.g. on EC boards. The worth of EMI countermeasures often is seen only when radiation is measured. As the amount of time and cost for such measurements is high, the effect of individual circuit changes is seldomly tested. After several circuit changes were made a test will not reveal anymore which effect an individual measure had.

It is hence advantageous to test prior to going to a test lab using the near-field probes resp. sniffer probes mentioned. The E field probe reacts to electric AC fields, the H field probe is sensitive to changes of magnetic flux.

Before using these probes one is well advised to realize which fields play the decisive role in modern EC boards. In the case of high voltages but low currents the E field will be predominant. In the case of low voltages and high currents the H field will



Determination of radiated distortion using a magnetic field probe (H-Field) and a Spectrum Analyser

dominate. The former case was the rule with electron tube circuits.

Modern IC's operate with low voltages and high currents. Of course, it is not the amplitude of a current which counts but in addition its rate of change (or frequency). If an electromagnetic wave is generated it is also the rate of change of the magnetic field vs. unit of time which is the determining factor.

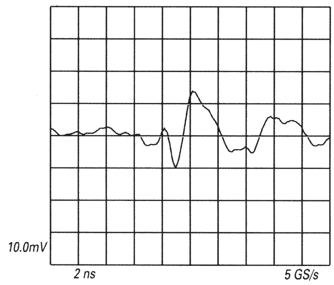
It is exactly this component which is sensed by the H field probe. The amplitude of the probe signal is directly proportional to the flux change and thus to the change of the current creating the field. Hence these probes are eminently suited to a first and rough test of the efficiency of EMI countermeasures.

The majority of such probes suffer from a disadvantage: their spatial resolution is very limited. It is hence difficult to locate the source of the measured signal. Therefore, when shopping for a probe, it is advisable to look especially for a probe with high resolution of the magnetic field. This becomes ever more important as the degree of integration on EC boards increases so that localizing individual sources of interference requires resolution down to millimeters.

Measurements on 4 layer EC boards

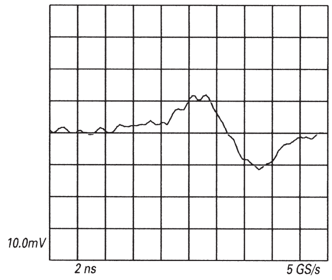
The following describes how to extract interesting details from the probe signals. Principally the signals may be displayed in the time or frequency domains. The display vs. time may be more transparent. The following measurements were taken from a 4 layer EC board of "Europe" format 100 x 160 mm square. The power distribution on this board is on individual layers. The distance between the V_{CC}- and ground layers is 100 µm. In the middle of this board a set of capacitors is located which connect both layers for AC.

Picture 1 shows the current signal in the vicinity of the V_{CC} pin of a 74AC163. The signal amplitude is proportional to the rate of change of the magnetic field and thus of the current at this location of the layer. The rise and fall times are in the subnanosecond range.



Picture 1: Current signal in the V_{CC} layer and close to the V_{CC} pin of a 74AC163.

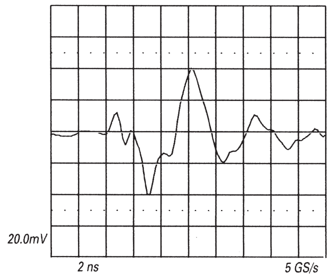
The reason is that the high frequency currents will flow mostly close to the V_{CC} pin as they can only be fed from the charge of the layers there. Such high frequency components can not be fetched far as the impedance would become too high. There is no bypassing capacitor at the V_{CC} pin as it would not be able to deliver high frequency current. Of course, the two layers V_{CC} and ground have a set of capacitors in the middle of the board. But this set can only deliver the low frequency components.



Picture 2: Current changes in the power distribution layers close to the set of capacitors.

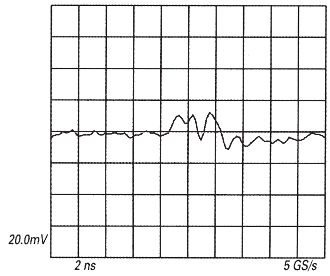
Picture 2 shows the current changes in the vicinity of this set of capacitors. It is obvious that this signal is much slower than that of picture 1. Here the rise and fall times are approx. 3 ns. The set of capacitors can only deliver current slowly to the layers. Such details are only visible with high resolution probes such as the µH field probe.

The following example demonstrates the effect of absorption measures. In picture 3 the signal was taken directly at the V_{CC} pin of a 74AC00 using the µH field probe. This IC is powered by a V_{CC}-ground system which is undamped. The changes of the magnetic field are strong.



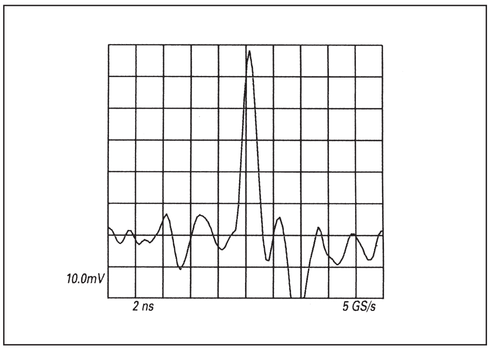
Picture 3: Signal directly close to the V_{CC} pin of a 74AC00.

In contrast to this picture 4 shows the same signal pick-off point, but now the IC is powered by a two-stage damped distribution system. The V_{CC} pin is connected to the V_{CC} layer via a large bandwidth filter choke, also this layer is damped by a layer of carbon. The reduction of amplitude is obvious. Just using this probe allows to determine the effect of the measure without the use of any further equipment.



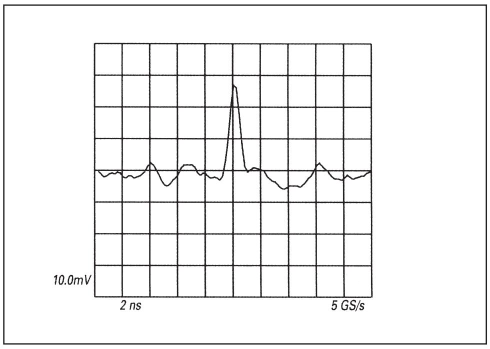
Picture 4: Comparable signal taken in a power distribution system with 2 stage damping.

The last example shows the signal taken from a clock distribution point on a "Europe" size EC board. The signal is taken directly from the output of the clock generator. Picture 5 shows the signal without any EMI damping measures, a very large amplitude signal of 60 mV is measured.



Picture 5: µH field probe signal taken from a circuit with no EMI prevention measures taken.

A popular means of improving the situation is the insertion of a series resistance directly at the output of the clock generator. In this case 82 Ω were used. Picture 6 shows the result: the signal amplitude is cut by half. The effect of the measure is visible immediately.



Picture 6: A series resistor at the output of the clock generator cuts the amplitude in half.

HZ530 Near-Field Probe Set

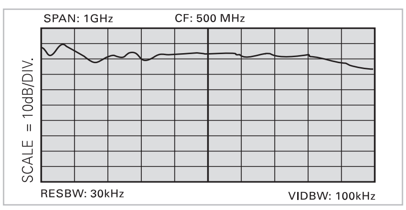
The HZ530 Probe Set consists of three active broadband probes for EMI diagnosis. The probes are designed for connection to a HAMEG spectrum analyzer with input impedance of 50 Ω. The probes can be powered by the spectrum analyzer or batteries. The slim format ensures easy access to the test object even in cramped test environments.

The H-field probe provides a signal that is proportional to the magnetic field strength to the spectrum analyzer. This makes it possible to localize sources of interference with relatively high precision.

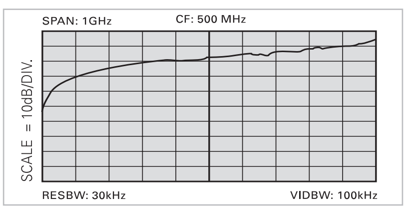
The high-impedance probe can be used to determine interference levels on contacts, lines and printed circuit boards.

The E-field probe is the most sensitive of the three probes. It can be used to assess the total effect of shielding and filtering in a tested unit.

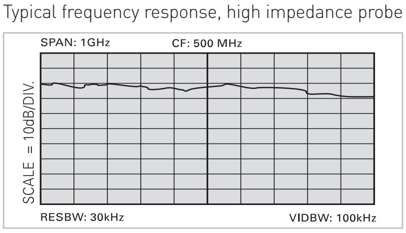
Typical frequency response, E-field probe



Typical frequency response, H-field probe



Typical frequency response, high impedance probe



Technical specifications at 23 °C ± 2 °C

Frequency Range:	100 kHz to 1 GHz
Supply Voltage:	6 V DC from Spectrum Analyzer or batteries (4x Mignon/AA, not included)
Supply Current:	approx. 10 – 24 mA DC
Probe Dimensions:	40 x 90 x 195 mm
Cabinets:	plastic, internal electrical shielding
Set includes:	1 E-field probe 1 H-field probe 1 high-impedance probe 1 BNC cable 1.5 m 1 power cable Operator's Manual Robust carrying case

Line Impedance Stabilization Network HM6050-2

Measurement of line-conducted interference within the range from 9 kHz to 30 MHz (CISPR 16)

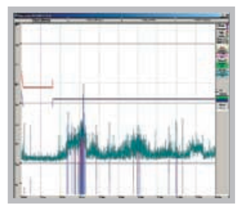
Switchable transient limiter

Artificial hand connector

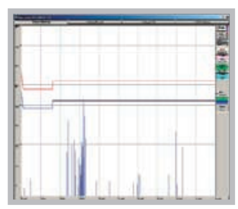
Technical Specifications at 23 °C ± 2 °C

Frequency Range:	9 kHz to 30 MHz
Impedance Characteristics:	Z = 50 Ω || (50 µH + 5 Ω), Error < 20 % under terms of VDE 876T1
Max. Current:	16 A
Line Voltage/Frequency:	230 V/50-60 Hz, CAT II
Artificial Hand:	220 pF+511 Ω
PE (switchable):	50 µH || 50 Ω
Transient Limiter	
Frequency Range:	150 kHz to 30 MHz
Transmission Loss:	10 dB (+1.5 / – 0.5 dB)
Connectors	
Measurement Output:	50 Ω BNC
Power Supply Socket for DUT:	Standard German electrical socket
Artificial Hand:	4 mm banana socket
Power cable:	fixed
Miscellaneous	
Operating Temperature:	10 °C to 40 °C
Power Supply:	115 / 230 V ± 10 %, 50-60 Hz
Safety Class:	Safety class I (IEC1010-1 / VDE 0411)
Dimensions and Weight:	W 285, H 125, D 380 mm, approx. 6 kg

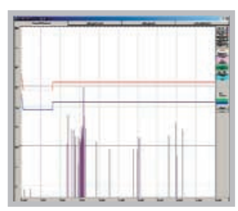
Measurement of line-conducted interference with HM5014-2



Measurement of line-conducted interference with HM5014-2



Measurement of line-conducted interference with HM5014-2



HAMEG
Power Supplies

Whether in labs or in production sites, the reliable HAMEG power supplies are ubiquitous. These power supplies are easy to operate by their simple and intuitive front panel layouts. HM7044 and HM8142 feature RS-232 or IEEE-488 interfaces and can be incorporated in automated test systems. Together with other programmable HAMEG instruments professional test systems can be set up at moderate cost.

Standard properties

HAMEG power supplies feature floating outputs which are overload and short-circuit proof. They contain linear regulators which deliver well regulated low ripple output voltages. Separate displays for voltages and currents indicate the levels set. Using the ability to series connect or parallel outputs it is your choice to obtain higher voltages or higher currents. All instruments sport a finely adjustable current limit which protects the loads connected.

Pushing a button is all that is needed to turn an output or all outputs on or off without turning the instrument itself off. Further all supplies are thermally protected. The HM7044 and HM7042-5 have fans which are temperature-controlled.

Turning outputs on/off

The outputs of all HAMEG supplies can be activated/deactivated by pressing a button. The supply remains turned on. This allows to preset all output voltages prior to connecting them to the loads by pressing the associated OUTPUT button.

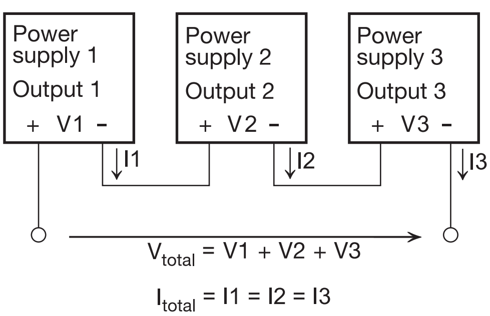
Parallel and series operation

The outputs to be connected in series or parallel must be independent. The outputs of one supply may also be connected with the outputs of another supply. For series operation the connections are as follows:

Series operation

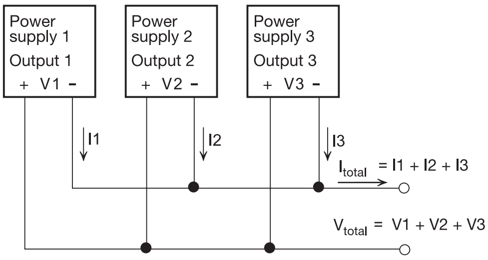
Attention! High Voltage!

In series mode the voltages add (or subtract), thus the total voltage may exceed the safe voltage of 42 V. In this case touching live parts may be fatal! The maximum current in series mode is given by the smallest current set in any of the supplies involved as the current is the same in all.



Series operation

Parallel operation



Parallel operation

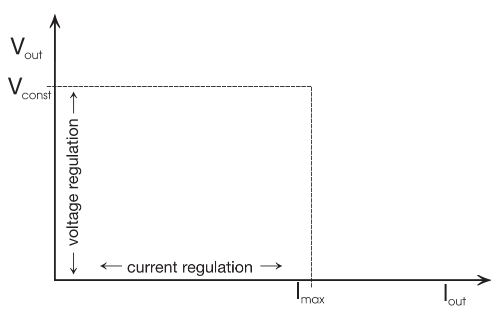
In order to increase the total current the outputs of the supplies are connected in parallel. The output voltages are identical and are limited by the output with the lowest maximum voltage specification. The total current is the sum of the individual currents of the paralleled sources.

Stop! Danger for some supplies

In case of parallel connection please check whether the total current is evenly distributed among the supplies, assuming supplies of equal specification. Parallel connection may lead to equalizing currents flowing between supplies. If supplies of other make should be used which may not be overload proof, such supplies can be destroyed by equalizing currents!

Current limiting and electronic fuse

Current limiting means that only a maximum current set is allowed to flow. This is adjusted prior to operating a test circuit and prevents too large damages to this circuit in case of malfunction like a short-circuit.

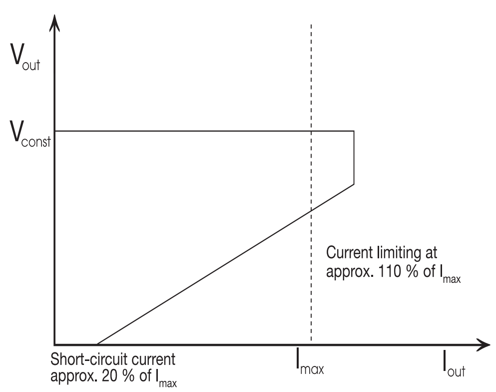


V-I-characteristic

The picture shows that in the range of voltage regulation the voltage remains constant while the current may increase to its maximum value. If this value is reached voltage regulation will yield to current regulation, i.e. the maximum current remains constant even if the load increases. Instead the output voltage will decrease to almost zero with a short circuit. The current flowing remains constant and limited to Imax. HAMEG supplies are hence also current supplies and hold the current adjusted constant. We recommend to set the maximum current prior to connecting the supply to a test circuit, thus protecting this from major damage.

In order to still better protect sensitive loads HAMEG supplies HM8040-3, HM7042-5, HM7044 feature a so called electronic fuse in addition to current limiting. This circuit disconnects the outputs extremely fast as soon as I_{max} is reached, that is no current will flow.

Some supplies on the market have a voltage dependent current limiting characteristic called fold-back. In case of overload or short circuit current limiting will set in at approx. 110 % of maximum current, the current will then be reduced depending on the load approx. 20 % with a short to applied. After removal of the overload the supply will return to normal operation. However, this is only true if the characteristic of the load is such that there is no stable operating point at the intersection of the supply characteristic and the load characteristic. A case in point are lamp loads: it may happen hat the supply will not reach the voltage level set but remain in a low voltage low current "hang-up" situation!



Fold-back V-I-characteristic

Tracking operation

Tracking means that several outputs will be controlled such that all outputs involved will follow the "leader" by keeping the relationship of the voltages constant which were set in the beginning. Example: If voltage 1 is changed from 10 to 12 V, voltages 2 and 3 will follow from 5 to 6 V. Voltage 4 will follow from 20 to 24 V.

However, if the maximum current of one output is limited and if this limit should be reached all currents of the outputs slaved to the leader will also enter current limiting. In case the electronic fuse was selected the output reaching its limit will be disconnected, and the slaved outputs will hence also be disconnected.

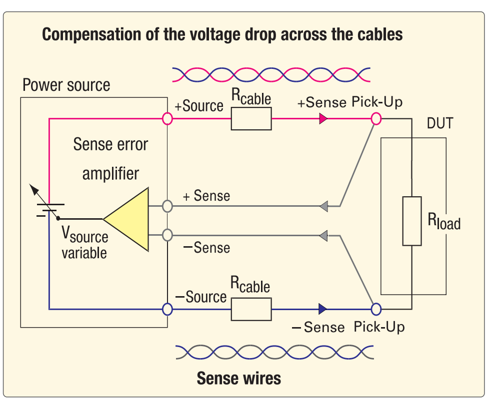
SENSE operation Compensation of conductor resistances

In the SENSE mode the voltage regulation circuit will take its input from the sense terminals which are connected directly to the load thus keeping the voltage there constant. The load current will cause a voltage drop in the connecting wires which would normally subtract from the supply's output voltage.

$V_{load} = V_{out} - V_{cable}$

$V_{cable} = I_{load} \times R_{cable}$

This voltage loss by the cables has to be compensated. In order to achieve this, the voltage is measured directly at the load by using the SENSE terminals. Because the current in the SENSE wires is minute there is no appreciable voltage drop, i.e. the



voltage sensed by the supply is in fact the true load voltage. The supply now increases its output to the sum of the cable voltage drop and the load voltage desired. The voltage drop across the cable is thus compensated, and the load will see the voltage set.

HM8040-3
Triple Power Supply

This especially compact and robust supply in the modular 8000 series was designed mainly for applications in training, service and lab. The HM8040-3 features linear

regulators, 3 independent outputs with a total power of 25 W. In additon to low ripple and good regulation the HM8040-3 offers very good quality and an optimum price/-performance ratio. This module requires the use of the mainframe HM8001-2.

HM7042-5
Triple Power Supply

This supply offers a cost-effective alternative to many standard supplies on the market. In addition to low ripple and high efficiency the HM7042-5 sports all features to be expected of a lab supply. There are 3 independent output voltages. These may be

series or parallel connected. The instrument has current limiting as well as over-current disconnect.

HM7044
High Performance
Power Supply

The HM7044 is a universal precision instrument with 4 outputs of exceptional voltage and current stability, programmable current limiting and electronic fuse

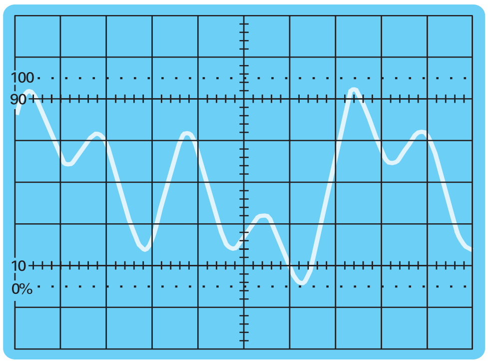
especially suited for lab and test facility use. The tracking mode allows simultaneous changes of output voltages as well as the disconnection of individual or all outputs in case a limit set was exceeded. SENSE terminals measure the voltage at the load compensating for cable losses.

HM8142
Arbitrary Power Supply

The HM8142 is a multifunctional work-horse, you get 3 instruments in one.

A Power Supply with 3 independent floating outputs which may be series or parallel connected. All outputs may be turned on or off by pushing a button. The 30 V/1 A outputs may be externally modulated or may be operated in the tracking mode allowing to change their voltages resp. currents simultaneously. Sense terminals measure the voltages directly at the respective loads thus keeping the load voltages constant. For digital circuits a 5V/2A output is provided.

An Arbitrary Waveform Generator with 512 points allowing to generate user-defined waveforms in the low frequency range. The arbitrary signals are generated digitally and can be defined fairly simply. In general, an arbitrary signal consists of a multitude of amplitude levels which are addressed one after the other thus creating a waveform

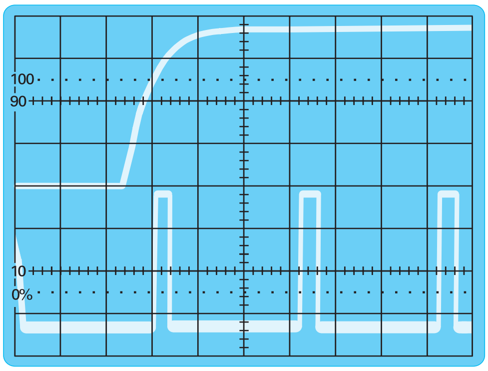


Arbitrarysignal AF

which may be periodically repeated. The signal may be freely defined within the instrument specifications and will be stored by the instrument. Such signals may be defined using the instrument controls or by using the RS-232 or the IEEE-488 interfaces.

Modulation

The two 30V outputs may be modulated using the rear terminals. The high slew rate



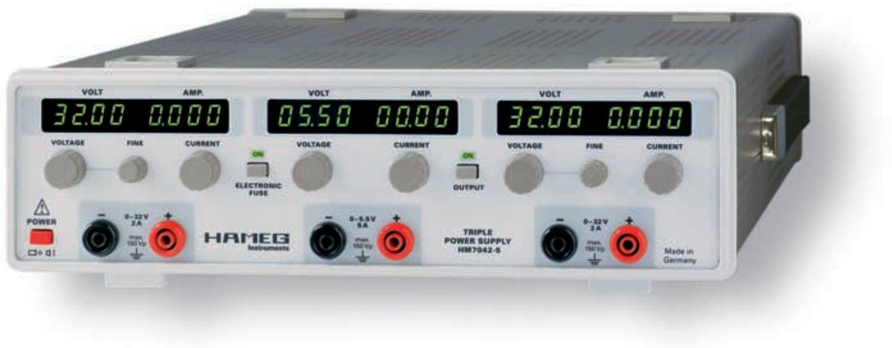
Slew Rate 0.7V/µs

of 0.7V/µs for modulation and the minimum pulse width of 100µs in the arbitrary mode allow to generate complex load profiles. For external modulation the low distortion of the linear output stage is available over the full power range.

An Electronic Load with a 30W specification. Currents of up to 1A per channel are permissible. The change of operating modes is automatic and will be indicated by a minus sign preceding the current display.

LabVIEW drivers are available for HM7044 and HM8142 and may be downloaded from www.hameg.com.

Triple Power Supply
HM7042-5



2x 0-32 V/0-2 A   0-5.5 V/0-5 A

Separate voltage and current displays for each output:
4 digits at channel I+III; 3 digits at channel II

Display resolution: 10 mV/1 mA at outputs I+III; 10 mV/10 mA at output II

Adjustable current limiting and electronic fuse for each output

Pushbutton for activating/deactivating all outputs

Low residual ripple, high output power, very good regulation

Temperature-controlled fan

See page 118 for technical specifications

Silicone test cable HZ10

Quadruple High-Performance Power Supply HM7044

4x 0-32 V/0-3 A

Up to 384 W output power; pre-regulation with DC/DC converter ensures low dissipated power

4-digit displays for current and voltage

Display resolution 10 mV/1 mA

Linear inline regulator with low residual ripple

Tracking mode for all outputs

Adjustable current limiting and electronic fuse for each output

SENSE lines for each output

Temperature-controlled fan

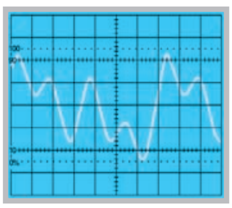
See page 118 for technical specifications

RS-232

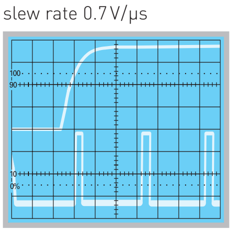
Silicone test cable HZ10

Arbitrary Power Supply HM8142

AF arbitrary signal



Fast output stage
slew rate 0.7 V/µs



HO88-2 IEEE-488 Interface

2x 0-30 V/0-1 A   5 V/0-2 A

Display resolution 10 mV / 1 mA

Arbitrary waveform power supply (512 points)

Tracking mode for 30 V outputs

External modulation of output voltages

Electronic load up to 30 W per channel (max. 1 A)

SENSE lines

Multimeter mode for all adjustable outputs

See page 119 for technical specifications

optional RS-232   optional IEEE-488

Triple Power Supply HM8040-3

2x 0-20 V/0.5 A 5 V/1 A

3-digit switchable displays for current and voltage

Display resolution 0.1 V/1 mA

Adjustable current limiting

Linear in line regulator

Low residual ripple and low noise

Pushbutton for activating/deactivating all outputs

Electronic fuse

Mainframe HM8001-2 or HM8003 required for operation

See page 119 for technical specifications

Mainframe HM8001-2

Mainframe HM8003

Silicone test lead HZ10

Programmable Measuring Instruments Series 8100

HAMEG Programmable Measuring Instruments

HAMEG Programmable Measuring Instruments Series 8100 are ideally suited for test installations in production and automated tests in laboratories. They support either a RS-232 or an IEEE-488 interface and thus may be easily integrated in any test system.

In combination with other HAMEG measuring instruments which have an interface high performance test systems may be easily and cost effectively set up. Of course, any of these instruments can be operated manually and used in laboratories.

Function Generators

The HM8130 function generator is a good and cost effective signal generator which should belong to the standard equipment of every laboratory. The frequency range is 10 mHz to 10 MHz. The signal frequency selected may be read from the digital display of the instrument with the accuracy of a frequency counter. The HM8130 generator features arbitrary waveform generation, frequency sweep, external triggering, and external gating. In spite of its many features the instrument may be easily and intuitively operated.

The output delivers a voltage of up to 20 V_{pp} and is short circuit proof. It is also protected against external sources up to ±15 V. The rise time of square wave signals is below 10 ns with little overshoot .

Function Generator HM8130

The HM8131-2 offers the same basic functions as the HM8130 (except duty-cycle modulation). Additionally it offers white and pink noise, FSK and PSK modulation. The signals are generated by DDS (direct digital synthesis) and thus have the high accuracy and stability of a synthesizer.

Arbitrary signals are available up to 10 MHz, the vertical resolution is 12 bits. The waveforms are read out at 40 MS/s. The memory depth is either 4 K words or 16 K words. Waveform data and instrument control settings may be stored on an S-RAM card. The HM8131-2 features an integrated arbitrary editor which allows to manipulate each individual point of an arbitrary function.

Arbitrary-Function Generator HM8131-2

The HM8131-2 may be externally triggered or gated. It is also possible to connect an external reference signal in order to increase the accuracy of the internal precision oscillator. The master slave function provided allows to synchronise up to three generators.

Similar to the HM8130 the HM8131-2 has a very fast output stage with high bandwidth, low noise and little overshoot.

The HM8142 power supply should be mentioned here as it also is a function generator. User defined waveforms may be generated with currents up to 1 A. The frequency range is 8 kHz. The arbitrary waveform can be defined by 512 points.

Arbitrary Function Power Supply HM8142

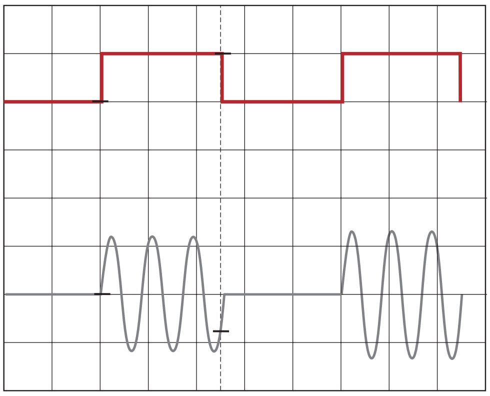
The RF signal generators HM8134-3 and HM8135 are high precision synthesisers with a frequency range of 1 Hz to 1.2 GHz respectively 3 GHz.

RF-Synthesizer HM8135

Operating Modes and Functions

Trigger

In the operating mode "triggered" the trigger signal is connected to the trigger signal input of the function generator. In this operating mode the external trigger signal will be synchronised. That means that the trigger signal prepares the generator for the next waveform period which always



positive slope triggering

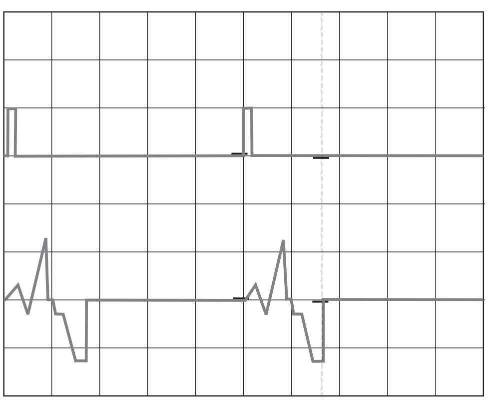
starts at zero. Depending on the length of the trigger signal one or several complete periods of the signal will be generated. Once a signal period was started it will be completed even if the trigger signal disappeared in the meantime.

The sine wave starts at zero with the positive slope of the trigger signal. Generation of the sine wave signal will stop after completion of the last full period following the negative slope of the trigger signal.

Burst Mode

Burst signals may be generated by an external trigger signal. This trigger signal may either come via the serial interface or from an external generator.

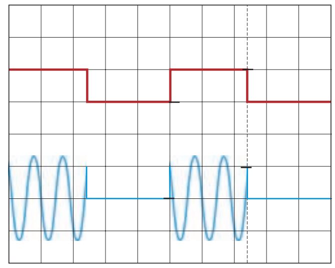
A burst signal in the arbitrary mode will be generated by a short trigger pulse. As the trigger signal is shorter than the period of the burst, only one full period of the burst signal will be generated.



Positive trigger slope generates burst signal

Gate Mode

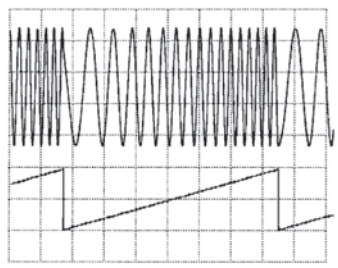
Also in gated mode the output signal of the generator will be controlled by a signal fed into the external trigger input. The gated mode is asynchronous, that means, that the gate signal just gates the internal signal to the output. In contrast to this in the trigger mode the output signal will always start at zero. In the gated mode there is no correlation between the gate signal and the signal generated. The signal will start anywhere in its period upon the positive slope of the gate signal and will end anywhere in its period with the negative slope of the gate signal.
The output signal is hence always present as long as the gate signal is high. The signal will disappear as soon as the gate input is pulled low. This is visible in the picture beside.



Gated output signal

Sweep Mode

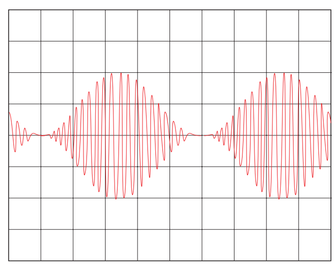
If the sweep mode is activated an LED will light up. The parameters sweep time, start frequency, and stop frequency are independently selectable and may be changed during operation. If a parameter is changed during operation the sweep will be stopped immediately and a new sweep will be started. The display will show the actual parameter setting. This ability of parameter change online allows to judge the influence of different parameters directly at the signal output. If the start frequency is set to a lower value than the stop frequency the sweep will run from the lower to the higher frequency. If the start frequency is selected to be higher than the stop frequency the sweep will go from the higher to the lower frequency. With the HM8131-2 the sweep may be either linear or logarithmic, the sweep time is selectable. The frequency of the output signal will be changed in steps. Depending on the sweep time selected the number of steps will be different.



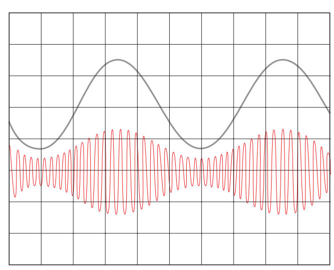
Swept Output Signal

AM Amplitude Modulation

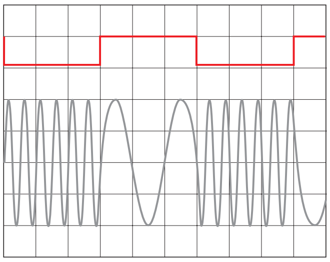
With AM a high frequency carrier signal will be modulated by a low frequency signal. The modulation degree or depth indicates the percentage of modulation of the carrier signal. The picture to the right shows a carrier signal 100 % modulated. The second picture shows a modulation depth of 50 %.



Internal signal source HM8131-2: V_o=10 V_{pp}, 20 kHz, 5 V/cm ; generator set to 100% modulation depth.



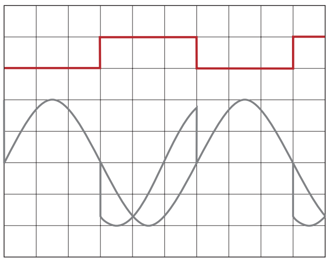
Generator1: V_e= 1,40 V_p, 1 kHz, 1 V/div; HM8131-2: U_a= 10 V_{pp}, 20 kHz, 5 V/div; generator set to 50% modulation depth.



FSK signal 500 Hz / 2 kHz

FSK Frequency Shift Keying

In FSK mode the signal alternates between two frequencies individually selectable. The first frequency "f_0" is also called the carrier frequency, the second frequency "f_1" is called the hop frequency. The frequency change depends on the signal fed to the external trigger input. The frequencies of the carrier and the hop signal may be selected independently of each other.



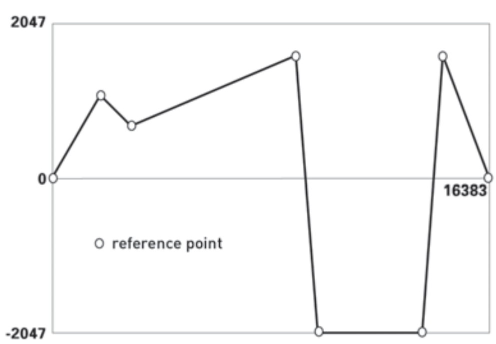
PSK signal
Ph0=70°; Ph1=0° phase shift

PSK Phase Shift Keying

In the modulation mode PSK the signal changes its phase upon a trigger signal. The picture shows a square wave signal with 5 V TTL-level. Also a sine wave signal is shown the zero crossings of which coincide with the slopes of the square wave signal. This is the sine wave signal not yet shifted in phase. The second sine wave signal shown which is cut off is the PSK signal. This signal was shifted by Ph0=70° during the high level of the trigger signal and returns to Ph1=0° during the low level.

Arbitrary Mode

The arbitrary signals are generated digitally and may be simply defined. In general, an arbitrary signal is defined by a certain number of amplitudes which define the shape of the signal during one period. Within the instrument's specifications the user is free to define the signals which will be stored in the instrument. As soon as an arbitrary signal was defined, it may be called from the memory like any other waveform. There are several ways to define arbitrary signals. One method is to use the front panel key board and the arbitrary editor contained in the firmware of the HM8131-2. Definition is also possible via one of the optional interfaces. It also



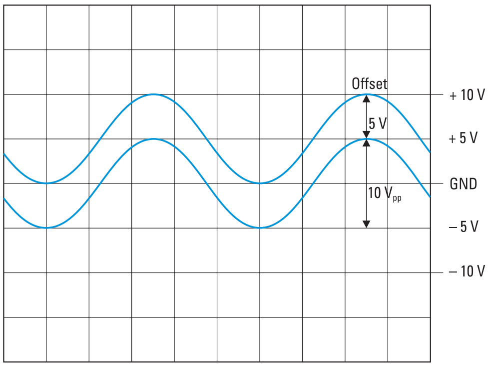
possible to take the waveform over from an oscilloscope, the software necessary for the data transmission via the serial interface is available on the HAMEG website. Please note that freely defined and digitally generated waveforms will contain harmonics far above the frequency of the waveform itself. Watch out for possible effects of those harmonics on the circuits to be tested.

Noise

The HM8131-2 also offers white and pink noise. White noise contains all frequencies from zero to infinity. As infinity has not been realised yet (we work on it), the HM8131-2 offers a bandwidth for white noise of 10 MHz. Pink noise means that the frequency spectrum will be reduced to 100 kHz.

Offset Voltage

It is possible to add a negative or positive offset to the output signal. The selection of the offset voltage is quite simple. It is either possible by using the keyboard or the knob. If the output signal contains an offset this will be indicated by a LED. The picture below shows two signals. The lower curve has no offset and is referred to ground. Its amplitude is 10 V_{pp}. The upper curve was offset by +5 V. This means that the signal was shifted by +5 V in positive direction.



Maximum offset: chart with two sine waves

Universal Counter

The universal counter HM8123 features three high sensitivity inputs and allows the measurement of signals in the frequency range between DC and 2.6 GHz.

Due to the high frequency of the internal

Universal counter HM8123

oscillator of 100 MHz the time resolution is 10 ns. Additional control and trigger functions are available via inputs on the rear of the instrument. There are inputs for arming, gate and trigger and outputs for gate and trigger signals.

Frequency measurements

A high input sensitivity is not always desirable for frequency measurements. The counter becomes sensitive to noise. Therefore frequency measurements should be made with as much attenuation as possible. If signals have a DC content this should be blocked by a capacitor. Such AC-coupling may be disadvantageous when measuring low frequencies. A low pass filter may be switched in if a low frequency signal is superimposed by high frequency interference.

Time Interval Measurements

In the operating mode time interval A/B the time between the start pulse at input A and a stop pulse at input B is measured. If the pulsewidth is to be measured the signal will be only connected to input A.

Pulse Width Measurement

Pulsewidth measurement is a special case of time interval measurement. The signal will be connected to input A, internally it is connected to input B. By suitable selection of the trigger slope for inputs A and B the pulsewidth may be measured. The measurement will be started at input A and stopped at input B.

Arming

Arming prevents that a counting sequence can be started by interference. The arming input is nothing else but an additional trigger. As long as there is a low level at this input the counter cannot start a new measurement. However, the counter will be prepared for a new measurement. The measurement will start after the arming signal went high, and the trigger condition was fulfilled and the synchronisation time expired.

Gated Mode

The gate input allows full control of start and stop of the counter. When this function is selected and there is a low level at the gate input the counter will prepare for a measurement.

The measurement will start when the gate input goes high and the triggering of the input signal after the expiration of the synchronising time. The measurement will be terminated as soon as the gate input goes low. The external gate signal has a higher priority than the gate time selected.

6½ -Digit Precision Multimeter HM8112-3

6½-digit display (1,200,000 counts)

Resolution 100 nV, 100 pA, 100 µΩ, 0.01 °C/F

DC basic accuracy 0.003 %

2-wire / 4-wire measurements

Measurement intervals adjustable from 0.1 to 60 sec.

Up to 100 measurements transmitted to PC per second

True RMS measurement, AC+DC and AC

Offset correction

RS-232 interface

See page 120 for technical specifications

RS-232
optional IEEE-488
optional USB

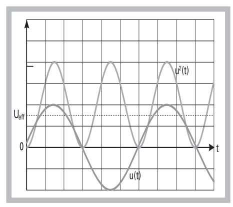
HZ42 19" Rackmount kit

Precise temperature measurement with sensor

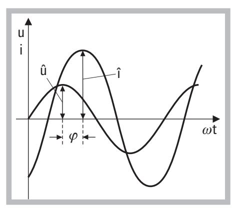
8 kW Power Meter
HM8115-2

HZ815 Power adapter

RMS value



Active power



Power measurement up to 8 kW

Simultaneous voltage, current and power display

Display of apparent, effective and reactive power

Power factor display

Autoranging, simple operation

Suitable for measurements on frequency converters

Frequency range DC to 1 kHz

RS-232 interface (including software)

See page 121 for technical specifications

RS-232 inclusive

2.6 GHz Programmable Counter HM8123

Fig. similar

Frequency range from 0 Hz to 2.6 GHz

200 MHz time base with 0.2 ppm stability

Two identical inputs, up to 200 MHz each

9-digit resolution at 1 sec. gate time

9 measurement functions, external gate and arming

Input for external time base (reference signal 10 MHz)

See page 122 for technical specifications

RS-232 | optional IEEE-488 | optional USB

HZ33, HZ34
Test cable BNC/BNC

HZ42 19" Rackmount kit

HZ20 Connector
BNC to 4mm socket

10 MHz Function Generator HM8130

Frequency range from 10 mHz to 10 MHz

High signal purity and amplitude stability

Output voltage 20 V_{pp}, 10 V_{pp} into 50 Ω

Surge- and short-circuit-proof output

Rise and fall time < 10 ns

Pulse width adjustment

High-precision digital frequency display

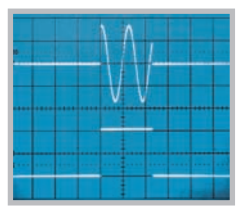
Arbitrary waveform generator 10 MSa/s (1024 x 1024 x 10 bits)

Burst, gating, external triggering, sweep

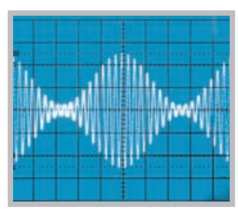
See page 123 for technical specifications

RS-232 inclusive

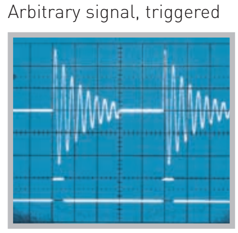
Sine wave, gated



Sine wave with amplitude modulation

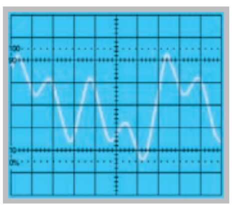


Arbitrary signal, triggered



15 MHz Arbitrary Function Generator HM8131-2

AF arbitrary signal



Option HO86
High stability TCXO

Option HO831
SRAM Memory Card 1MB

Frequency range from 100 µHz to 15 MHz

DDS signal generator (frequency stability 10 ppm)

6 standard signal forms and arbitrary

Master-slave mode for up to 3 generators

SRAM memory card for signal storage (Option HO831)

Increased frequency stability with TCXO
(Option HO86): ± 5 x 10^{-7} at 23° C (24 hrs.)

See page 124 for technical specifications

1.2 GHz RF-Synthesizer HM8134-3

Frequency range from 1 Hz to 1.2 GHz

Frequency resolution 1 Hz (accuracy 0.5 ppm)

Output power from – 127 dBm to + 13 dBm

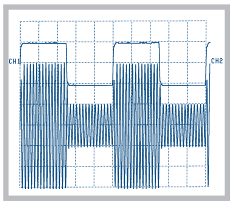
High spectral purity

AM / FM / PM and gate modulation

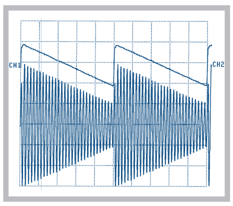
See page 125 for technical specifications

Option HO85, high- stability oscillator with a stability of ± 5x10^{-9} per day

Internal modulation source



Internal modulation source



RS-232

optional IEEE-488

optional USB

3 GHz HF Synthesizer
HM8135

3rd Quarter

Frequency range from 1 Hz to 3 GHz

Output power from -144 dBm to +13 dBm

High frequency accuracy: ±1 x 10^{-8}

Modulation modes: AM, FM, φM, pulse modulation, FSK, PSK

Rapid pulse modulation: 200 ns

Internal modulator 10 Hz to 300 kHz

High spectral purity: harmonics ‹ -40 dBc

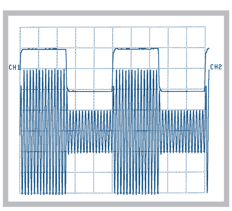
Electronic attenuator 30 dB for broad output voltage range without switch peaks

RS-232/USB interface included as standard (IEEE-488 optional)

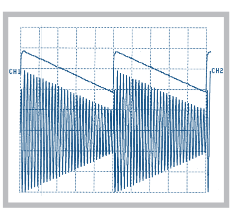
See page 126 for technical specifications

RS-232 | optional IEEE-488 | USB

Internal modulation source



Internal modulation source



Arbitrary Power Supply HM8142

2x 0-30 V/0-1 A   5 V/0-2 A

Display resolution 10 mV/1 mA

Arbitrary waveform power supply (512 points)

Tracking mode for 30 V outputs

External modulation of output voltages

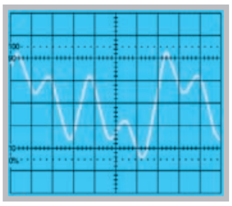
Electronic load up to 30 W per channel (max. 1 A)

SENSE lines

Multimeter mode for all adjustable outputs

See page 119 for technical specifications

AF arbitrary signal



HO88-2 IEEE-488 Interface

HO89-2 RS-232 Interface

optional RS-232   optional IEEE-488

HAMEG
Modular System Series 8000

In many years of practical application the HAMEG Modular System Series 8000 has proven its value to the customer.
The advantages of this modular system have been demonstrated by several 100,000 modules sold. The unexcelled price-performance ratio and the enormous flexibility of the plug-in system allow you to adapt your measurement set-ups quickly and cost effectively to changing requirements. You save space by stacking up to 5 instruments. This will offer you 10 instruments on a minimum of space.

The blank module HM800 is available for your own designs to be integrated with the other measuring instruments. The power supply voltages necessary are available from the mainframe.

Especially for schools and training centers the Modular System Series 8000 offers a cost effective flexible alternative to conventional measuring equipments. As the mainframe HM8001-2 allows the simultaneous operation of two modules in any combination most often a single such basic unit will be all that is needed for a student in a laboratory. The modules necessary will be issued to the students depending on the requirements of the specific exercise.

Mainframe HM8001-2

The HM8001-2 is the mains-operated mainframe for the HAMEG Modular System Series 8000. Any two modules may be operated simultaneously in one such basic unit. The mainframe provides for eight independent and galvanically isolated power supply voltages for the modules. The total power available for both modules is 36 W. The standard power supply requirement of one module is below 12 W. The power supply module HM8040-3 with a power output of 25 W should not be operated simultaneously at full load together with a second HM8040-3. The mainframe has thermal protection and electronic overload protection.

Mainframes equipped with option HO801 feature four BNC-connectors on the rear panel. These can be used with some modules like HM8018, HM8021-4, HM8030-6 to feed signals to the modules or take signals from them.

The mechanical stability of the basic units is such that five instruments may be stacked. The top covers of the instruments feature receptacles for the feet of the instrument above. The mainframes thus cannot move and may also be stacked together with other HAMEG instruments like oscilloscopes.

Measuring Instruments

The **programmable digital multimeter HM8012** should be standard on any laboratory bench. It allows voltage measurements up to 1,000 V_{DC} / 750 V_{AC}, current measurements from 500 µA to 10 A, resistance measurements up to 50 MΩ, continuity tests, temperature measurements with PT100 or only the measurement of levels. With certainty you will always have an application for the HM8012. The instrument displays the true RMS value, and this will be correct up to a crest factor of 7. When analysing low frequency signals those may also be read directly in dB. The offset function allows to compensate for cable resistances or to perform relative measurements.

The PC software supplied with the instrument may be used to control the instrument or to automatically record measurement results. The measurement results will be shown in numeric and graphical form. Further, the HM8012 may be integrated anytime as a system instrument into automated test set-ups.

Measurement basics

Abbreviations and units used:

W	active power	P
VA	apparent power	S
VAR	reactive power	Q
$v_{(t)}$	voltage, actual value	
$v^2_{(t)}$	voltage squared	
$\lvert\bar{v}\rvert$	voltage rectified value	
V_{rms}	voltage rms value	
$\hat{v}$	voltage peak value	
I_{rms}	current rms value	
$\hat{i}$	current peak value	
φ	phase angle between V and I	
cos φ	power factor, valid only for sine waves	
PF	power factor, general, for non-sinusoidal wave forms	

Arithmetic mean value

$$\overline{x}_{(t)} = \frac{1}{T}\int_0^T x_{(t)}\,dt$$

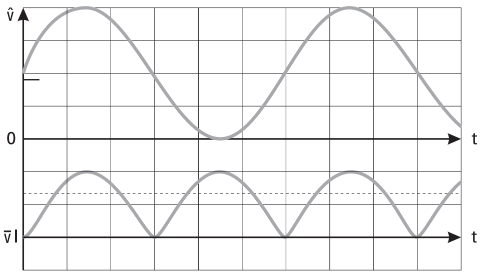
The arithmetic mean of a periodic signal is the average taken over one period T. This is equivalent to the DC content of the signal.

- If the average is equal to 0 this is a pure AC signal.
- For DC signals the average is identical to the momentary value.
- For signals with AC and DC content the average is the DC content.

Rectified value

$$\overline{|x|} = \frac{1}{T}\int_0^T |x_{(t)}|\,dt$$

The rectified value is the arithmetic mean of the absolute values for one period. The absolute values are derived by rectifying the signal.



For an AC sine wave voltage $v(t) = \hat{v}\ \sin\ \omega t$ the rectified value is $2/\pi$ (0.637) of the peak value.

This is the formula for the rectified value of a sine wave signal:

$$\overline{|v|} = \frac{1}{T}\int_0^T |\hat{v}\ \sin\ \omega t|\,dt = \frac{2}{\pi}\ \hat{v} = 0{,}637\ \hat{v}$$

RMS Value

The mean squared value $x^2(t)$ of a signal is equal to the average of the signal squared.

$$\overline{x_{(t)}}^2 = \frac{1}{T}\int_0^T x_{(t)}^2\,dt$$

The root mean squared value is equal to:

$$x_{(rms)} = \sqrt{\frac{1}{T}\int_0^T x_{(t)}^2\,dt}$$

In order to use the same formulas with AC signals as they are used for DC signals, e. g., for the calculation of resistances, powers, etc., the root mean square value of a signal has been defined. The root mean square value of an AC signal generates the same effect as a DC signal of the same magnitude.

Example:

If an incandescent bulb is supplied from an AC-line with 230 V_{rms}, it will take the same power from the line as if it were powered from a DC line of 230 V_{DC}.

For sine wave signals the root mean square value is $1/\sqrt{2}$ (0.707) of the peak value.

$$V = \sqrt{\frac{1}{T}\int_0^T (\hat{v}\ \sin\ \omega t)^2\,dt} = \frac{\hat{v}}{\sqrt{2}} = 0.707\,\hat{v}$$

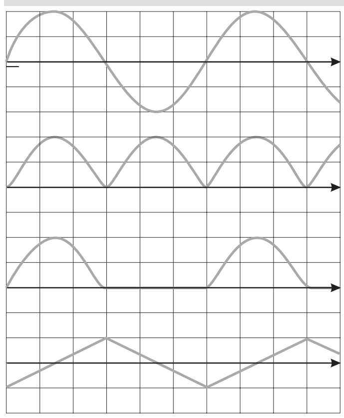
Form Factor

If the rectified value is multiplied by the form factor of a signal the result will be the RMS value of the signal as follows:

$$F = \frac{V_{rms}}{\overline{|v|}} = \frac{\text{RMS value}}{\text{Rectified value}}$$

For pure sine wave signals the form factor is:

$$\frac{\pi}{2\sqrt{2}} = 1.11$$



Form Factors	Crest Factor C	Form Factor F
(sine wave)	$\sqrt{2}$	$\frac{\pi}{2\sqrt{2}} = 1.11$
(full-wave rectified sine)	$\sqrt{2}$	$\frac{\pi}{2\sqrt{2}} = 1.11$
(half-wave rectified sine)	2	$\frac{\pi}{2} = 1.57$
(triangle)	$\sqrt{3}$	$\frac{2}{\sqrt{3}} = 1.15$

Crest factor

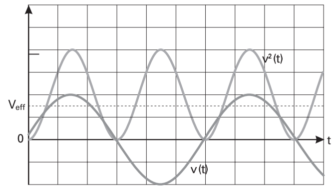
The crest factor is defined as the ratio of the peak value to the RMS value.

It is important when measuring distorted signals.

$$C = \frac{\hat{v}}{V_{rms}} = \frac{\text{Peak value}}{\text{RMS value}}$$

For pure sine wave signals the crest factor is $\sqrt{2}$ = 1.414.

If the crest factor specified for a measuring



RMS Value

instrument is exceeded the measurement results may be erroneous.

The accuracy of the RMS value calculated is dependent on the crest factor and will be decreased the higher the crest factor of a signal is. Usually, the maximum permissible crest factor specified is relative to the full scale value. If a measuring range is used only partly (e. g. 230 V in the 500 V range), the crest factor may be increased by the ratio of the full scale value to the portion of the range used.

Relative Measurements

A relative measurement is the measurement relative to a reference value. First this reference value will be measured. When using the HM8012 the reference value will be stored by pressing the hold/offset pushbutton. From now on the reference value stored will be automatically subtracted from every measurement result. The display will thus indicate the difference from the reference value stored. This function may also be used to compensate for the cable resistance in the two-wire resistance measurement. First the test cables will be short-circuited at their end. The resistance value measured is that of the cable resistances R_L and will now be stored as the reference value. In this offset mode from now on this reference value will be subtracted automatically from each resistance measurement R_m. Hence the true value of the unknown resistor will be displayed.

$R_m = R + R_L + R_L$

Testing of Diodes and other Semiconductors

In this mode the instrument will furnish a constant current, the HM8012 will deliver 1 mA.

If now the semiconductor or the diode will be connected to the test leads and the diode polarity is correct the instrument will display the diode voltage valid at 1 mA.

The HM8014 allows the selection of three different currents (0.2 mA, 2 mA, 20 mA). If the diode polarity was wrong the instrument will display overflow.

The **milliohm meter HM8014** is an excellent choice to measure small resistances precisely. Typical applications are measurements of the resistances of coils, transformers, motor windings or to look for short circuits on printed circuit boards.

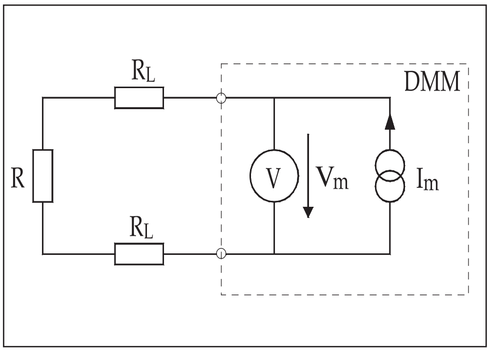
As the measuring voltages are quite low, 4 mV – 200 mV, and also the measuring currents are 10 µA – 20 mA even measurements on printed circuit boards with components are possible without the danger of turning semiconductors on which might effect the measurement accuracy. Also, the measuring current is low enough to allow the test of sensitive components. With measurements the pitch of the tone audible from the loudspeaker built in or from a headphone will indicate the resistance value. The volume may be adjusted. Additionally, the HM8014 allows selection of three different measuring currents for testing semiconductors.

Two-Wire Resistance Measurements

The instrument sends a constant current through the test cables to the unknown resistor R. The voltage drop across R will be measured. Also a small voltage drop will be caused by the test leads R_L. When measuring small resistances (< 1 kΩ) it is advantageous to compensate for the cable resistances by use of the offset mode.

In order to compensate for the resistances of the test cables the test cables are shorted at their end and the off-set push button pressed. All errors caused by test cables and contact resistances are thus eliminated.

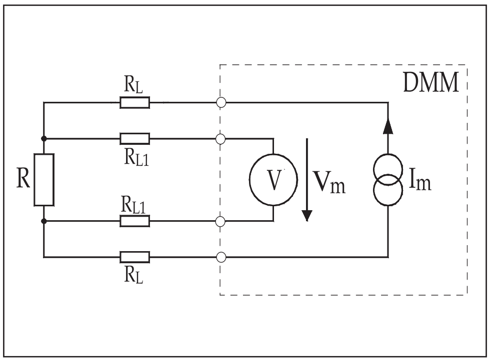
If this correction is not used the resistance values obtained will always be on the high



Principle of two-wire resistance measurement side as the sum of all parasitic resistances in the measuring circuit will be included in the result.

Four-Wire Resistance Measurements

The classical method of measuring small resistances correctly is the so called Four-Wire-Measurement or Kelvin-Principle. Also here the instrument delivers a precise constant current. Two additional test cables which are connected directly to the unknown resistor R_x will measure the voltage drop thus directly at this resistor irrespective of any voltage drops in the test leads which conduct the measuring current. The instrument terminals which deliver the constant current are called the source terminals.

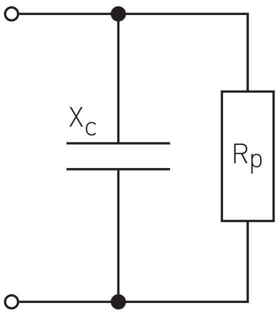


Principle of four-wire resistance measurement

The instrument terminals which are used for measuring the voltage drop directly at the unknown resistor are called the sense input. The input resistance of the sense input is very high so that the current caused by this input resistance is extremely small and thus negligible.

The **LC-Meter HM8018** is a full feature measuring instrument. Depending on the range used three different frequencies are automatically selected. The HM8018 measures inductances and capacities as well as the series resistances of inductances and the parallel conductances of capacitances. From these measurements the Q and loss factors of the components measured may be calculated. A special measuring principle allows the simple determination of the real and imaginary components even for a phase angle of 45° with an accuracy of better than 1 %.

Losses of a capacitor



$$\tan\delta = \frac{G_p}{B_c}$$

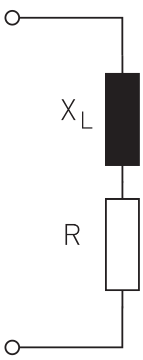
$$\tan\delta = \frac{X_c}{R_p}$$

$$Q = \frac{1}{\tan\delta}$$

$$\delta = 90° - \varphi$$

$\tan\delta$	loss tangent
G_p	conductance
B_c	conductance of capacitor
X_c	impedance of capacitor
R_p	resistance representing loss
Q	Q-factor
δ	angle of loss
φ	phase angle between V and I

Losses of an inductor



$$\tan\delta = \frac{R}{X_L}$$

$$Q = \frac{1}{\tan\delta}$$

$$\delta = 90° - \varphi$$

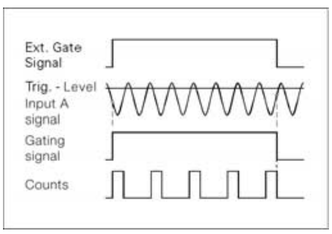
$\tan\delta$	loss tangent
X_L	impedance of inductor
R	resistance representing loss
Q	Q-factor
δ	angle of loss
φ	phase angle between V and I

Universal Counters

The **universal counter HM8021-4** has two high sensitivity inputs and allows the measurement of signals between DC and 1.6 GHz. A temperature-compensated crystal time base (TXCO) ensures the exceptionally high stability of 0.5 ppm per degree over the operating temperature range. As a universal counter the HM8021-4 allows frequency, period, pulse duration, time interval measurements and event counting. Hold, offset, and auto-trigger functions are also provided. The measurement of complex signals is easy by using the auto-trigger function, the manual adjustment of the trigger level and the selectable input coupling. Basic units equipped with option HO801 have BNC connectors on the rear panel, here an external gate signal may be applied in order to control the gate time.

External Gate Signal

The external gate input of basic units equipped with option HO801 allows the control of start and stop of the counter. If this function was selected and there is a TTL low level signal at the external gate input the counter will be prepared for a measurement. The measurement will be started after the application of a high level signal to the gate input and triggering by the input signal after the start synchronisation time expired. The measurement will be stopped when the signal at the external gate input changes from high to low.



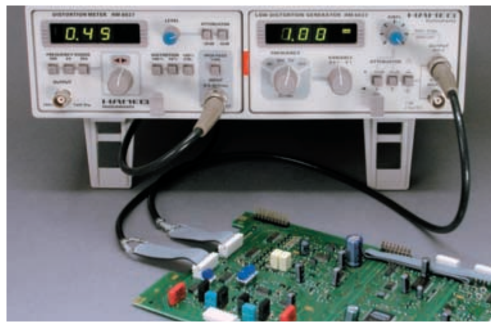
EXT Gate-Signal

Distortion Measurement Instrument

The **distortion measurement instrument HM8027** measures the content of distortions in a sine wave signal. The distortions will be indicated in percent of the input signal. As the intrinsic distortion of the instrument is only 0.005 % at 1 kHz it is specially suited for measurements on high quality audio systems. The harmonics of the measuring signal are available at the monitor output of the HM8027. The output signal may be displayed on an oscilloscope. This allows analysing the signal for noise and distortions. The frequency adjustment is semi-automatic with a capture range of 15 % which allows convenient use of this distortion-measuring instrument.

Distortion Factor

A signal generated by a non-linear system or signal which was sent through a non-linear system will contain distortions. Harmonic distortions as they are generated within signal generators consist of undesired frequency components which are multiples of the frequency generated. These harmonics of different order vary in amplitude and phase and the distortion



Distortion measurement with HM8037 and HM8027

measuring instrument measures their root mean square value. The distortion factor is the ratio of the RMS value of all harmonics and the RMS value of the total signal. There are various distortion factors by definition. The total distortion factor k, the distortion factor of order k_n , which is the ratio of RMS value of the end harmonic divided by the root mean square value of the total signal. The distortion measurement instrument HM8027 measures the total distortion factor k.

$$k = \frac{\sqrt{V_{2f1}^2 + V_{3f1}^2 + V_{4f1}^2 + \dots}}{V_{total}}$$

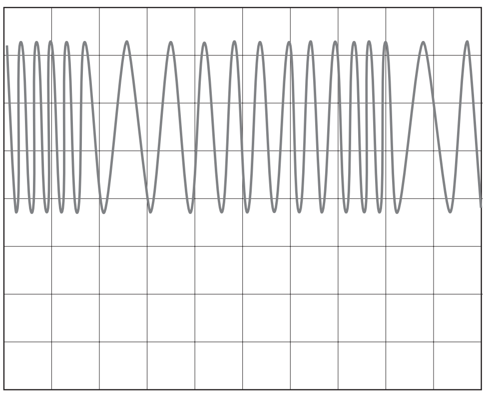
k = distortion factor (dimensionless)
V_{2f1}, V_{3f1}, V_{4f1}, ...= voltage of the end harmonic
f1 = frequency of the fundamental signal (Hz)
V_{total} = voltage of the distorted total signal

(all voltages are rms values)

Signal Generators

The signal generators within the modular system 8000 are very cost effective alternatives to stand-alone instruments. Depending on the application you may choose between the function generator HM8030-6, the pulse generator HM8035, the low distortion sine wave generator HM8037.

The **function generator HM8030-6** has four basic functions: sine wave, square wave, triangle and pulse and features a high signal quality and a good amplitude stability. Also its short rise time of below 15 ns and the internal or external frequency sweep feature make it an ideal choice on any laboratory bench. The outputs are shortcircuit proof and protected against the application of voltages up to 45 V. Those are preconditions for survival in schools and training centres.



swept signal

The **low distortion sine wave generator HM8037** is a high quality instrument for the generation of sine wave signals of low harmonic content. The six decade frequency range from 5 Hz to 50 kHz and the high amplitude stability present the HM8037 as an ideal instrument for measurements on amplifiers and filters. In the low frequency ranges the resolution is 0.1 Hz. The output has an impedance of 600 Ω and is short-circuit proof. The output signal may be attenuated up to 60 dB with two attenuators. The synchronisation output has an internal impedance of appr. 1 kΩ and an open circuit voltage of 2 V_{pp}, it is also short circuit proof. A switch allows disconnecting the output from the case. That means that the output can be floated. This will eliminate any problem which may be caused by ground loops This instrument together with the distortion measuring instrument HM8027 constitude a compact and low cost measuring system for all frequency measurements.

The **pulse generator HM8035** features a very short rise time of typically 2 ns, and a duty cycle may be adjusted over a wide range. Periodic pulse signals or single pulses may be generated. The HM8035 has a TTL-compatible trigger output and an input for external or manual triggering. Both outputs have an impedance of 50 Ω and deliver complementary positive and negative output signals from 2 V_p to 5 V_p. Both, trigger output and signal output are short circuit proof.

Power Supply HM8040-3

This compact and robust power supply module within the Modular System Series 8000 was especially developed for powering test circuits in schools, in training, in service departments and laboratories. The HM8040-3 uses linear regulators and delivers three independent voltages with a total power output of approx. 25 W.

HM8040-3 offers low ripple, good regulation, a very good quality and an optimum price-performance ratio.

Mainframe
HM8001-2

The mainframe is supplied without the modules shown in the illustration

Modular system

HM8001-2 mainframes can be stacked up to 5 units high

Option HO801 – BNC connectors on rear panel

Basic unit for modules from the Modular System Series 8000

Power supply for two modules

DC voltages electronically regulated, floating and short-circuit proof

Power transformer with thermal fuse

Up to 5 mainframes can be stacked

Module HM800 for customized instrument construction available

4 BNC connectors on the rear panel of the HM8001-2 (Option HO801) provide for signal transmission to or from HM8018, HM8021 and HM8030-6 modules

See page 127 for technical specifications

Mainframe
HM8003

The mainframe is supplied without the modules shown in the illustration. Figure similar

Basic unit for modules from the Modular System Series 8000

Power supply for one module

Space saving

DC voltages electronically regulated, ungrounded and short-circuit proof

Module HM800 for customized instrument construction available

See page 127 for technical specifications

Mainframe HM8003 without module

HM800

4¾ -Digit Multimeter
HM8010

Temperature Sensor HZ812

HZ15 (included)

Mainframe HM8001-2

4¾-digit display with 50,000 counts, basic accuracy 0.05 %

Automatic and manual range selection

Max. resolution 10 µV, 0.01 dBm, 10 nA, 10 mΩ, 0.1 °C/°F

Offset function / relative value measurement in basic measurement functions

Input impedance >1 GΩ (0.5 V and 5 V DC range)

Mainframe HM8001-2 or HM8003 required for operation

See page 127 for technical specifications

4¾ -Digit Programmable Multimeter HM8012

4¾-digit display with 50,000 counts, basic accuracy 0.05 %

Automatic and manual range selection

Max. resolution 10 µV, 0.01 dBm, 10 nA, 10 mΩ, 0.1 °C/°F

Offset function / relative value measurement in basic measurement functions

Input impedance ›1 GΩ (0.5 V and 5 V DC range)

RS-232 interface

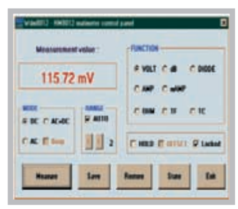
PC software for control and data logging

Mainframe HM8001-2 or HM8003 required for operation

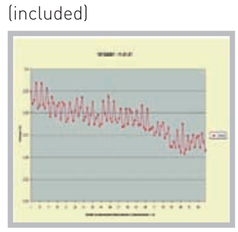
See page 127 for technical specifications

HZ15 (included)

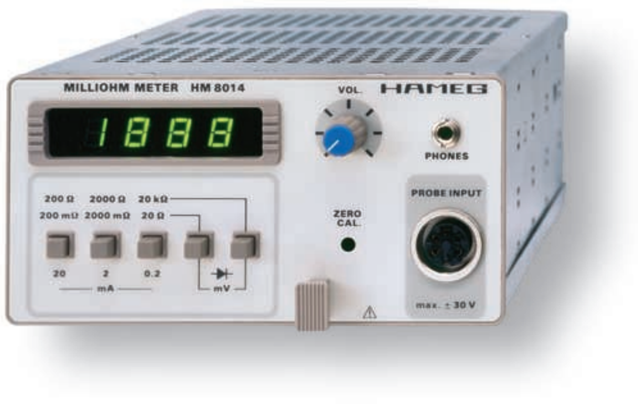
WDM8012 Software (included)



WDM8012 Software (included)



3½-Digit Milliohm Meter HM8014



HZ19 Test tweezers

HZ17 Test lead (included)

HZ18 Kelvin test lead

Measurement ranges from 200 mΩ to 20 kΩ

Resolution 100 µΩ, basic accuracy 0.25 %

4-wire Kelvin measurement

Low measurement voltages from 4 mV to 200 mV

Low measurement current from 10 µA to 20 mA

Mainframe HM8001-2 or HM8003 required for operation

See page 128 for technical specifications

3 kW Power Meter
HM8015

Power measurement (AC/DC) up to 3 kW

Automatic range selection, easy operation

6 measurement functions

Display of power factor

Frequency range up to 1 kHz

AC and DC power measurement

Mainframe HM8001-2 or HM8003 required for operation

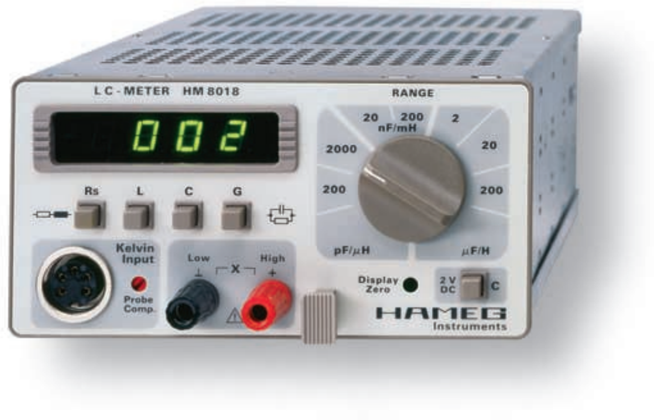
See page 129 for technical specifications

Mainframe HM8001-2

Mainframe HM8003

HZ815 Power adapter

3½-Digit LC Meter
HM8018



Option HO801, page 72

HZ17 Test lead (included)

Option HZ18 Kelvin test lead

Measurement functions: L, C, R

3½-digit display with 2,000 counts, basic accuracy 0.5 %

4-wire measurement

Max. resolution: 0.1 pF, 0.1 µH, 10 mΩ, 0.01 µS

Internal bias for electrolytic capacitors selectable

Offset adjustment of cable capacity for the "Kelvin test lead"

AC voltage signal at rear-panel BNC connector proportional to value shown in the display (with Option HM801 only)

Mainframe HM8001-2 or HM8003 required for operation

See page 129 for technical specifications

1.6 GHz Universal Counter HM8021-4

Frequency range 0 Hz to 1.6 GHz

10 MHz time base with 0.5 ppm stability (TCXO)

Input A:
Input impedance 1 MΩ, maximum sensitivity 20 mV_{rms}

Input C:
Input impedance 50 Ω, maximum sensitivity 30 mV_{rms}

Time interval resolution up to 10 ps

Offset mode over the entire measurement range

Gate input (in combination with HO801)

Mainframe HM8001-2 or HM8003 required for operation

See page 129 for technical specifications

Mainframe HM8001-2

Option HO85, a high-stability oscillator with a stability of ± $5x10^{-9}$ per day

Option HO801, page 72

Distortion Meter
HM8027

Mainframe HM8001-2

HZ32 Test cable

HM8037 Low-distortion
sine wave generator

Frequency range 20 Hz to 20 kHz

Resolution up to 0.01 %

Low inherent distortion of 0.005 %

Automatic frequency fine tuning (capture range 15 %)

Control output for residual distortion measurement

A complete measurement system for AF measurement equipment in combination with the HM8027

Mainframe HM8001-2 or HM8003 required for operation

See page 130 for technical specifications

10 MHz Function Generator HM8030-6

Frequency range 50 mHz to 10 MHz

High signal purity and amplitude stability

Distortion factor ‹ 0.5 % up to 1 MHz

Output voltage 20 V_{pp} (10 V_{pp} into 50 Ω)

Surge- and short-circuit-proof output

Rise and fall time typ. 15 ns

Internal and external sweep

Pulse width adjustment

Highly accurate digital frequency display

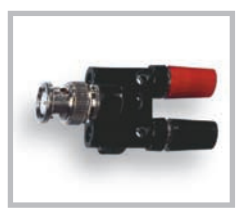
Mainframe HM8001-2 or HM8003 required for operation

See page 131 for technical specifications

Option HO801, page 72

HZ33, HZ34
Test cable BNC/BNC

HZ20 Connector
BNC to 4mm socket



20 MHz Pulse Generator HM8035

Frequency range 2 Hz to 20 MHz

Pulse duration 20 ns to 200 ms with a duty factor of up to 99.9999 %

2 separate outputs (positive/negative)

Single pulse triggering

Rise time ‹3 ns

Output voltage 0.8 - 5 V_{pp} into 50 Ω

Mainframe HM8001-2 or HM8003 required for operation

See page 131 for technical specifications

Mainframe HM8001-2

HZ33, HZ34
Test cable BNC/BNC

HZ24 Attenuators

50 kHz Low-Distortion Sine Wave Generator
HM8037

Frequency range 5 Hz to 50 kHz

A complete measurement system for AF measurement equipment in combination with the HM8027

3-digit digital frequency display

High amplitude stability

Distortion factor < 0.01 % (20 Hz-10 kHz)

Output voltage 1.5 V_{pp} into 600 Ω

Mainframe HM8001-2 or HM8003 required for operation

See page 132 for technical specifications

Mainframe HM8001-2

HZ33, HZ34
Test cable BNC/BNC

Distortion Meter HM8027

Triple Power Supply HM8040-3

2x 0-20 V/0.5 A   5 V/1 A

3-digit switchable displays for current and voltage

Display resolution 0.1 V/1 mA

Adjustable current limiting

Linear in line regulator

Low residual ripple and low noise

Pushbutton for activating/deactivating all outputs

Electronic fuse

Mainframe HM8001-2 or HM8003 required for operation

See page 119 for technical specifications

Mainframe HM8001-2

Mainframe HM8003

Silicone test lead HZ10

Blank Module HM800

Module for customized instrument construction

Guide rails for mounting circuit boards at 4 different levels

Plastic front panel for easy processing

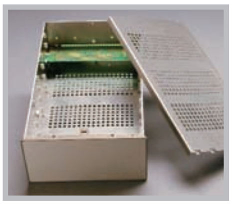
Power is supplied by the mainframe

Available supply voltages (max. 18 W):
2 x 8 V_{AC}/ 0.5 A
2 x 5 V_{DC}/ 1 A
4 x 20 V_{DC}/ 0.5 A

Mainframe HM8001-2 or HM8003 required for operation

Mainframe HM8001-2

Open blank module



Test adapter HZ809

Oscilloscopes

Spectrum Analyzer

EMI measurement tools

Power Supplies

Programmable Measuring Instruments Series 8100

Modular System Series 8000

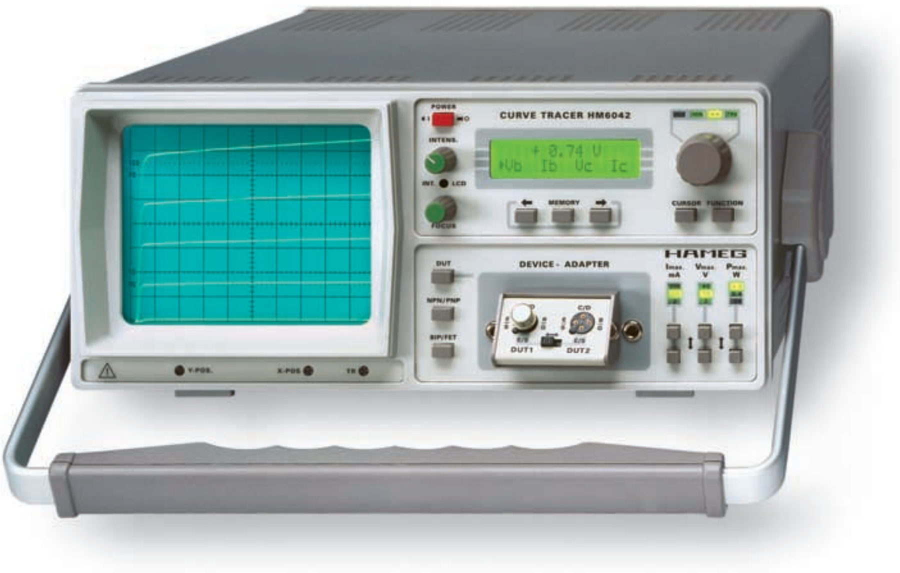
Component Tester

Options

Accessories

Specifications

Curve Tracer HM6042



For testing and selection of:
transistors, MOS-FETs, diodes, Z-diodes, LEDs, thyristors

On-screen display of 5 dynamically generated curves

The LCD display shows the active parameters and dynamic numeric data corresponding to the cursor position on the screen

Automatic calculation of h and y parameters

Easy comparison of components based on reference values stored in memory

Intuitive, logical key-based operation

HZ820: Switching feature (DUT 1 and DUT 2) for rapid transistor selection (U_{test} max. 40 V)

See page 132 for technical specifications

HZ820 (included)

Oscilloscopes

Spectrum Analyzer

EMI measurement tools

Power Supplies

Programmable Measuring Instruments Series 8100

Modular System Series 8000

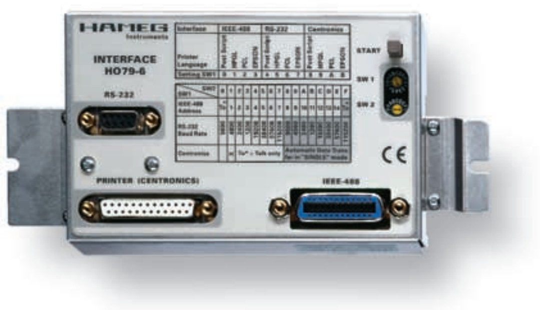
Component Tester

Options

Accessories

Specifications

Multifunction Interface HO79-6



Bidirectional connection to the instrument via SCPI (control and signal data)
Direct printing of the signal data (without PC)

IEEE-488 Interface
IEEE-488 compliant socket (24-pin)
Talk-only mode
Device mode (address selectable from 1 to F)

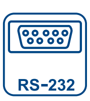
RS-232 Interface Full duplex (V.24)
9-pin connection to D-Sub socket
automatic Baud rate recognition
Baud rate from 1.2 to 115.2 kBaud

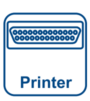
Parallel Interface (Centronics)
25-pin connection to D-Sub socket
PostScript, HPGL, PCL and EPSON

The HO79-6 multifunction interface allows print-out of data recorded by oscilloscopes in digital operating mode on a standard printer. When the start key is pressed, data is transferred directly to the printer via one of the three ports. No PC is required.

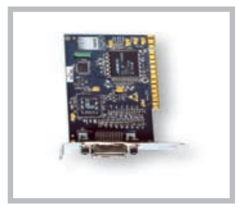
The oscilloscope can be controlled by a PC via the bidirectional IEEE-488 or RS-232 ports. For programming ease SCPI commands are used. Signal and parameter data can be read out and processed further. The interface is very easy to install. Once it has been attached to the rear panel of the oscilloscope, it is ready to use.

The HO79-6 interface is suitable for use with the following oscilloscopes: HM407, HM507 and HM1507

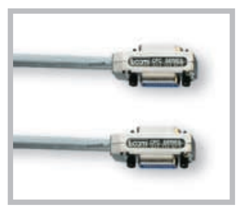




IEEE-488 PC Interface Card, 32-bit PCI (HO82)



IEEE-488 Interface Cable HZ72S



IEEE-488 Interface Cable HZ73

IEEE-488 Interface Card PCI / PCMCIA H082 / H083

H082: PC interface for PCI bus 32bit (IEEE-488, IEEE-488.2)
H083: PC interface PCMCIA format (IEEE-488, IEEE-488.2)

24-pin connection in accordance with IEEE-488 (socket)

Up to 15 components to one IEEE-488 bus

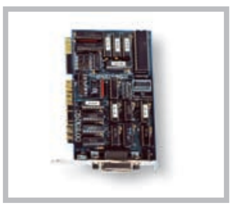
Drivers and communication software for GPIB, HP-IB, SCPI, SICL/TULIP NI-VISA

C-Library for user-defined programming applications

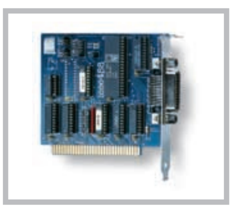
Operating system: Windows® 95, 98, ME, NT, 2000, XP

IEEE-488 PC Interface Card, PCMCIA format (H083)

IEEE-488 PC Interface Card 16-bit ISA (H080-3)



IEEE-488 PC Interface Card 8-bit ISA (H080-2)



H082/H083: The GPIB driver is installed automatically. The card is tested for proper function and initialized. A command interpreter is used for plain-text programming. The interpreter serves as the interface between the programming language and the card's BIOS. 26 programming languages are supported. The syntax of a GPIB command is checked and errors are identified and displayed. The real-time bus monitor checks the IEEE-488 participants and reports bus status and malfunctions.

Compatible with: HP-VEE, HP Bench Link, HAT-Basic, DT-VEE, TestPoint, Viewdac, Asyst®, Asystant, DASYLab®, DIA/DAGO-PC®, DigiS, disylab, DaDisp488, DISAN, FRAME/FAMOS®, LabWindows®, LabView® and agilent®VEE.

H080-2 (8-Bit ISA Bus): Drivers and software support Quickbasic, MS-Basic, Turbo Pascal and MS-Quick C. Operating system MS-DOS, version 5.0 and above
H080-3 (16-Bit ISA Bus): Drivers and software for GPIB-PCW, GIPB-HS-NT+. Operating system Windows® 3x, 9x, NT, 2000 and ME.

IEEE-488

IEEE-488 Bus Interface
HO88-2

IEEE-488 interface
24-pin connection in accordance with IEEE-488 (socket)
Galvanic separation of test device and interface
Up to 15 components to one IEEE-488 bus

The interface is available for the following Series 8100 system instruments:

HM8122	Universal Counter
HM8130	Function Generator 10 MHz
HM8131-2	Function Generator 15 MHz
HM8134-3	RF Signal Generator
HM8135	RF Signal Generator
HM8142	Arbitrary Power Supply Unit

IEEE-488

RS-232 Interface
HO89-2

RS-232 interface, full duplex in accordance with V.24
24-pin connection to D-sub socket
Galvanic separation of test device and interface
Automatic Baud rate recognition
Baud rates up to 19,200 Baud

The interface is available for the following Series 8100 system instruments:

HM8122	Universal Counter
HM8130	Function Generator 10 MHz
HM8131-2	Function Generator 15 MHz
HM8134-3	RF Signal Generator
HM8142	Arbitrary Power Supply Unit

RS-232

HZ10 Silicone Test Lead

Silicone test lead with stackable banana plugs

Length:	1.0 m
Packaging unit:	set of 5
HZ10S	color: black
HZ10R	color: red

HZ15 PVC Test Lead

PVC test lead with test probes and sheathed banana plugs

Color:	black and red
Length:	1.0 m
Packaging unit:	1 piece per color

HZ17 4-Wire Test Lead

4-wire test lead with test probe and 5-pin DIN connector for HM8014 and HM8018

Packaging unit:	1 piece

HZ18 Kelvin Test Lead

Kelvin test lead with gold-plated Kelvin contacts, 5-pin DIN connector and shielding mass on alligator clip, for HM8014 and HM8018

Packaging unit:	1 piece

HZ19 SMD Test Tweezers

Kelvin test lead with SMD test tweezers, 5-pin DIN connector for HM8018

Packaging unit:	1 piece

HZ16 Test Cable with micro-clamps

Silicone-test lead with BNC plug to miniature clamp probe

Packaging unit:	1 piece

HZ31 Test Cable 50 Ω

Test cable 50 Ω, BNC to BNC angle connector

Length:	1.0 m
Packaging unit:	1 piece

HZ32 Test Cable

Test cable, BNC to 4 mm banana plug

Length:	1.0 m
Packaging unit:	1 piece

HZ33/HZ34 Test Cable 50 Ω

Test cable 50 Ω, BNC to BNC, BNC straight plug

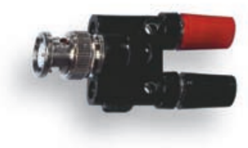
Length:	0.5 m - HZ33
Packaging unit:	1 piece
Length:	1.0 m - HZ34
Packaging unit:	1 piece

HZ33S/HZ34S Test Cable 50 Ω

Test cable 50 Ω, BNC to BNC socket, insulated

Length:	0.5 m - HZ33S
Packaging unit:	1 piece
Length:	1.0 m - HZ34S
Packaging unit:	1 piece

HZ20 Adapter Plug



Adapter BNC plug / 4 mm banana socket

Description:	BNC plug with 2x 4 mm sockets
Packaging unit:	1 piece

HZ21 Adapter Plug

Adapter N-plug / BNC socket

Description:	N-plug with BNC socket
Packaging unit:	1 piece

HZ22 Feed-Through Termination 50 Ω

50 Ω feed-through termination, 1 GHz, 1 Watt

Description:	BNC plug BNC socket
Packaging unit:	1 piece

HZ24 Attenuators 50 Ω

One set of 50 Ω attenuators with 3/6/10/20 dB attenuation (1 GHz, 1 Watt) and 1 HZ22

Packaging unit:	1 set

HZ26 BNC-T-Adapter

BNC-T-Adapter UG274, 50 Ω

Description:	1 BNC plug to 2 BNC sockets
Packaging unit:	1 piece

HZ200 Probe 1:1/10:1 designed for HM1000, HM1008, HM1500 and HM1508

Attenuation ratio:	10:1
Bandwidth:	250 MHz
Rise time:	<2.4 ns
Input impedance:	10MΩ II 12 pF
Max. Voltage:	400 V (DC + peak AC)
LF compensation:	1
RF compensation:	2
Cable length:	1.2 m
Probe factor identification	

HZ51 Probe 10:1

Attenuation ratio:	10:1
Bandwidth:	150 MHz
Rise time:	<2.4 ns
Input impedance:	10 MΩ II 12 pF
Max. Voltage:	600 V (DC + peak AC)
LF compensation:	1
RF compensation:	1
Cable length:	1.2 m

HZ52 Probe 10:1

Attenuation ratio:	10:1
Bandwidth:	250 MHz
Rise time:	<1.4 ns
Input impedance:	10 MΩ II 10 pF
Max. Voltage:	600 V (DC + peak AC)
LF compensation:	1
RF compensation:	2
Cable length:	1.2 m

HZ53 Probe 100:1

Attenuation ratio:	100:1
Bandwidth:	100 MHz
Rise time:	<3.5 ns
Input impedance:	100 MΩ II 4.5 pF
Max. Voltage:	1200 V (DC + peak AC)
LF compensation:	1
Cable length:	1.2 m

HZ154 Probe 1:1 / 10:1

Attenuation ratio:	1:1
Switchable:	10:1
Bandwidth:	10/150 MHz
Rise time :	<35/3.5 ns
Input impedance:	1/10 MΩ II 82/12 pF
Max. voltage:	(10:1) 600 V (DC + peak AC)
LF compensation:	1 at 10:1
RF compensation:	2 at 10:1
Cable length:	1.2 m

HZ40 Spare Parts Kit for Probes

2 spring hooks
2 probe tips
Ground cable

HZ100 Differential Probe 20:1/200:1

Technical specifications at 23 °C ± 2 °C

Differential input voltage (DC + peak AC) max.:	±700 V
Max. input voltage per input:	±700 V
Attenuation ratio:	20:1
Switchable:	200:1
Bandwidth:	30/40 MHz
Rise time:	12/9 ns
Input impedance:	8 MΩ II 1.2 pF
Output impedance:	50 Ω
Max. output voltage:	±3.5 V at 1 MΩ
Max. noise:	2 mV
Accuracy after 1min:	±3 % (18 °C – 30 °C)
Common mode rejection DC/AC 1MHz:	70 dB/>50 dB
Inputs:	2 safety connectors
Input leads:	2 test leads 50 cm with spring hooks

HZ109 Differential Probe 1:1 / 10:1

Technical specifications at 23 °C ± 2 °C

Differential input voltage (DC + peak AC) max.:	±35 V
Max. input voltage per input:	±35 V
Attenuation ratio	1:1
Switchable:	10:1
Bandwidth:	20/30 MHz
Rise time:	17/12 ns
Input impedance:	20 MΩ II 5 pF
Output impedance:	50 Ω
Max. output voltage:	±3.5 V at 1 MΩ
Max. background noise:	2 mV
Accuracy after 1min:	±3 % (18 °C – 30 °C)
Common mode rejection DC/AC 1MHz:	70 dB/>50 dB
Inputs:	2 safety connectors
Input leads:	2 test leads 50 cm with spring hooks

HZ115 Differential Probe 100:1/1000:1

Technical specifications at 23 °C ± 2 °C

Differential input voltage (DC + peak AC) max.:	± 1500 V
Max. input voltage per input:	± 1500 V
Attenuation ratio:	100:1
Switchable:	1000:1
Bandwidth:	20/30 MHz
Rise time:	17/12 ns
Input impedance:	60 MΩ ॥ 1.5 pF
Output impedance:	50 Ω
Max. output voltage:	± 1.5 V an 1 MΩ
Max. background noise:	2 mV
Accuracy after 1 min:	± 3 % (18 °C - 30 °C)
Common mode rejection DC/AC 1 MHz:	70 dB / › 50 dB
Input leads:	2 test leads 75 cm with safety test clips

HZ70 Opto-Interface

The Opto-Interface HZ70 is an optical fiber transmission line, for easy data transfer (RS-232) without flow control. It is used in cases where the test configuration requires galvanic separation or transmission must be free of interference. The use of an optical fiber transmission line also prevents problems caused by multiple grounding. The standard cable length is 4 m.

HZ72S/HZ72L IEEE-488 Interface Cable

IEEE-488 bus interface cable
double-shielded
90 ° angle, stackable

Length: 1.0m - HZ72S

Length: 1.5 m - HZ72L

HZ73 IEEE-488 Interface Cable

IEEE-488 bus interface cable
double-shielded
90 ° angle on one side, stackable

Length: 2.0 m

HZ56 AC/DC Current Probe

This AC/DC Current Probe is used to measure currents from 1 mA to 30 A over a broad frequency range. The measurement principle is based on the Hall Effect that registers the magnetic field generated by the current flow. Even for complex waveforms a high degree of measurement accuracy is achieved. The output voltage is proportional to the measured current and well suited to be displayed on an oscilloscope. The current probe complies with the safety standards defined in IEC/EN 61010.

Measurement range:	± 30 A_{DC}/20A_{AC}
Accuracy:	± 1% ± 2 mA
Bandwidth:	DC to 100 kHz
Resolution:	1 mA
Output voltage:	100 mV/A
Load impedance:	› 100 MΩ II 100 pF
Dielectric strength:	3.7 kV/50 Hz/1 min.
Output cable/Connector:	2 m (50 Ohm)/BNC

Current measurement

HZ65 Component Tester

Reasonably priced component tester for semiconductors, resistors, capacitors and inductors

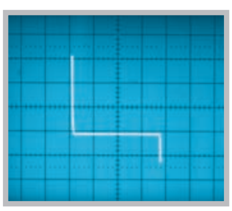
Components can be tested individually or in circuit

Comparative measurements of intact and defective circuits for error localization

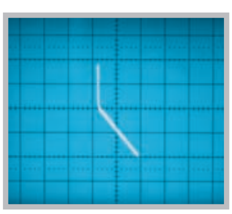
Can be used with any oscilloscope with XY-mode capability

Test voltage (rms):	approx. 8.2 V/50 Hz
Test currents (rms):	5 mA/50 mA/200 mA (selectable)
Connections:	2 test leads for components with thicker connections or soldered to the circuit; two 3-pin transistor sockets; three selectable connection options
Power supply:	115 V AC or 230 V AC/max. 6.5 W
Safety Class:	Safety Class 1
Dimensions:	125 x 80 x 42 mm
Accessories supplied:	Operator's Manual, 2 test leads with probe tips
Optional accessories:	HZ33/HZ34 Test Cable 50 Ω

Base/Emitter junction

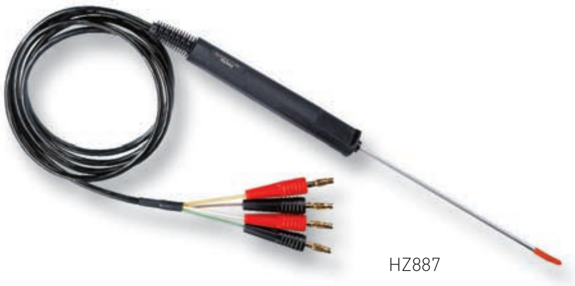


Parallel connection of diode and resistor



HZ812/HZ887 PT100 Temperature Probe

HZ812



HZ887

Temperature measurement HZ812 in combination with HM8012

The HZ812 and HZ887 Temperature Probes are immersion sensors with a platinum test resistance of PT100. They ensure excellent precision over a broad temperature range. The probes are of robust construction, waterproof and also suitable for use in air or dusty environments. The technical specifications apply for immersion depths of at least 60 mm.

The probe is connected to the measuring instrument either with a 2-pin connection using a grounded plug (HZ812) or with a 4-pin connection via a 4 mm banana plug (HZ887). The length of the connector cable is 1.2 m for both probes.

HZ812 is suitable for use in combination with HM8012.
HZ887 is suitable for use in combination with HM8112.

Technical specifications in accordance with EN60751 (formerly IEC751)

Probe diameter:	4 mm
Measurement range:	- 50 °C to + 400 °C
Accuracy, Class A:	± (0.2 % of the reading + 0.15 °C)
t_{99} (s):	12 s (time required to display 99 % of the temperature change)
Connection HZ812:	Grounded plug, 4 mm, 1.2 m PVC cable
Connection HZ887:	4 mm banana plug, 1.2 m PVC cable

Accuracy, HZ812 in combination with HM8012:	
- 50 °C ‹ T ° ‹ 200 °C	± (0.2 % of reading + 0.25 °C)
200 °C ‹ T ° ‹ 400 °C	± (0.2 % of reading + 0.45 °C)

HZ560 Transient Limiter

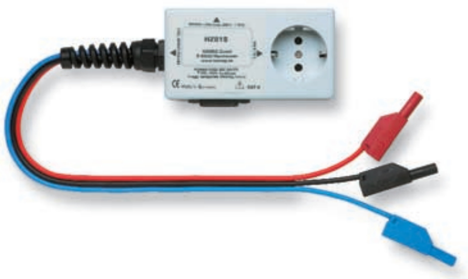
The HZ560 Transient Limiter protects the input circuits of spectrum analyzers and test receivers.

The input of the Transient Limiter is connected via BNC cable to the signal source. The output can be connected directly to the spectrum analyzer.

Technical specifications at 23 °C ± 2 °C

Frequency range:	150 kHz to 30 MHz
Insertion loss:	10 dB (+1.5/-0.5 dB)
Max. input level:	+33 dBm (2 W, average)
Max. input voltage:	± 50 V_{DC}
VSWR:	1.5:1 or better
Connections:	BNC (input and output)
Dimensions:	67 x 32 x 32 mm

HZ815 Power Adapter for HM8015/HM8115-2



Adapter for simplified measurement of power consumption, line voltage and current consumption of mains operated consumers (3-wire grounding-type plug or European standard plug) using the HM8015 and HM8115-2 Power Meters.

HZ809 Test Adapter for Modular System 8000

Test adapter for the testing and repair of insert modules for Modular System 8000 outside the mainframe HM8001-2. The module connection terminals in the basic unit HM8001-2 are led through 1 to 1. The modules can then be operated outside the mainframe while the housing is open.

HZ575 Converter

HZ575 is a 75 Ω to 50 Ω converter enabling measurement in 75 Ω systems in connection with 50 Ω input impedance spectrum analyzers.

The 75 Ω input is a 75 Ω BNC socket which is AC coupled internally. The output is a 50 Ω N male connector which is DC coupled. HZ575 can also be used for reverse operation converting 50 Ω to 75 Ω.

Specifications

Frequency Range:	5 MHz – 1.2 GHz
Insertion loss:	less than 1 dB
Max. Level/Voltage	
at 75 Ω connector:	+ 10 dBm / ± 20 Vdc
at 50 Ω connector:	+ 10 dBm / 0 Vdc
Dimensions:	25 x 25 x 58 mm (W x H x D)
Weight:	100 g

HZ97 Carrying Case

We recommend the HZ97 Carrying Case for protection and transport of oscilloscopes and spectrum analyzers. The instruments can be transported conveniently and safely in the case. An extra pocket provides space for test gear and accessories.

HZ520 Plug-in Antenna

Telescopic Antenna for RF reception

BNC connector

HZ541 VSWR Test Unit

This unit is used to measure the voltage standing wave ratio (VSWR) and the reflection coefficient of a device under test with an impedance of 50 Ω.

Typical test objects include attenuators, terminations, frequency switches, amplifiers, cables and mixers. The measurement range is specified from 150 kHz to 1 GHz.

Technical specifications (temperature range from + 10° C to + 45° C)

Frequency range:	150 kHz - 1,050 MHz
Impedance:	50 Ω
Directivity:	› 28 dB (150 kHz – 300 kHz) › 35 dB (300 kHz – 1 GHz)
Reflection loss at DUT port:	› 20 dB
Insertion loss	
IN → OUT:	20 dB (150 kHz - 300 kHz)
IN → OUT:	17 dB (300 KHz - 1 GHz)
IN → DUT:	1.7 dB
DUT → OUT:	16 dB
Max. Power Dissipation:	+ 26 dBm (400 mW)
Connectors:	N (female)
Dimensions:	151.5 x 38 x 29.5 mm (W x H x D), without connectors)
Weight:	450 g
Temperature range:	+ 10° C to + 45° C
Accessories supplied:	Termination 50 Ω (male) Adapter, N male to N male (2 ea.) Carrying case (265 x 225 x 50 mm)

HZ541 connected with HM5014-2

HZ42 2RU 19” Rackmount Kit

For mounting HAMEG instruments with a case height of 75 mm (e.g. Series 8100 System Instruments)

Dimensions:	W440, D365
2 RU:	88.1 mm

HZ43 3RU 19” Rackmount Kit

For mounting HAMEG instruments with a case height of 125 mm (e.g. oscilloscopes)

Dimensions:	W440, D365
3 RU:	132.5 mm

Specifications

Features	Analog Oscilloscopes HM1000	Analog Oscilloscopes HM1500	Analog/Digital CombiScope HM1008	Analog/Digital Mixed Signal CombiScope HM1508
Autoset	•	•	•	•
Save/Recall Memories	9	9	9	9
Readout	•	•	•	•
Autom. Measurement Functions	6	6	10	10
Cursor Measurement Functions	7	7	13	13
Frequency Counter (50 ppm)	0.5 Hz – 200 MHz	0.5 Hz – 250 MHz	0.5 Hz – 200 MHz	0.5 Hz – 250 MHz
RS-232 Interface	optional	optional	•	•
Interface Options	—	—	RS232/USB, Ethernet, IEEE-488	
Vertical Channels	2	2	2	2 Analog + 2 Logic
Bandwidth (-3 dB)	0-100 MHz	0-150 MHz	0-100 MHz	0-150 MHz
BW Limiter (20 MHz)	•	•	•	•
Deflection Coefficients	1 mV/cm to 20 V/cm			
Y Delay line	•	•	•	•
Trigger Bandwidth	0-200 MHz	0-250 MHz	0-200 MHz	0-250 MHz
Min. level	≥ 5 mm	≥ 5 mm	≥ 5 mm	≥ 5 mm
Coupling	AC, DC, HF, LF, NR, TV			
Source	CH 1, CH 2, Line, External			CH 1, 2, 3 and 4, Line, External
Peak-to-Peak	•	•	•	•
Alternate	•	•	•	•
After Delay	•	•	•	•
TV (PAL, NTSC)	625 Line / 50 Hertz and 525 Line / 60 Hertz Standard			
Field selection	all, odd, even			
Line selection	all, line counter			
Logic Trigger Source	—	—	—	CH 1 or 2, CH 3, CH 4
Threshold	—	—	—	TTL, CMOS, ECL, User defined
Logic	—	—	—	AND/OR, TRUE/FALSE
Time Base, analog from with magnification x 10 to	0.5 s/div. 5 ns/div.	0.5 s/div. 5 ns/div.	0.5 s/div. 5 ns/div.	0.5 s/div. 5 ns/div.
Delayed Time Deflection with 2nd Time Base from and magnification x 10 to	• 20 ms/div. 5 ns/div.	• 20 ms/div. 5 ns/div.	• 20 ms/div. 5 ns/div.	• 20 ms/div. 5 ns/div.
Variable Hold-Off	•	•	•	•
XY Mode	•	•	•	•
Horizontal Bandwidth	0-3 MHz	0-3 MHz	0-3 MHz (analog), 0-100 MHz (digital)	0-3 MHz (analog), 0-150 MHz (digital)
Digital Signal Capture and Display Modes	—	—	Refresh, Envelope, Average, Roll, Single, Peak Detect, XY	
Max. Sampling Rate (Random)	—	—	10 GSa/s	
Max. Sample Rate (Real-Time)	—	—	1GSa/s	
Reference Signal Memory	—	—	9	
Math. Signal Functions	—	—	ADD, SUB, MUL, DIV, ABS, INV, SQ, POS, NEG, 1/x	
Math. Signal Memory	—	—	5 with 5 formulas each	
Memory Depth / Channel	—	—	1 M-Samples per Channel	
Pre-/Post-Trigger	—	—	-100 % to +400 %	
Time Base (digital)	—	—	50 s/div. to 5 ns/div.	
Memory ZOOM (digital)	—	—	max. 40,000:1	
Signal Display	—	—	Dots, Vectors (Interpolation and Dot Join), Optimal (all Samples weighted)	
Component Tester	•	•	•	•
Calibrator 1 kHz / 1 MHz	•	•	•	•
CRT (acceln voltage)	14 kV	14 kV	14 kV	14 kV
Power Consumption	37 Watt	41 Watt	42 Watt	47 Watt

Features		Analog Oscilloscopes HM303-6	HM504-2	HM2005	Analog/Digital Oscilloscope HM507
Autoset		—	•	•	•
Save/Recall Memories		—	9	9	9
Readout		—	•	•	•
Auto Measurement Functions		—	7	1	10
Cursor Meas. Functions		—	8	3	15
RS-232 Interface		—	•	•	•
Multifunction Interface		—	—	—	optional
Vertical Channels		2	2	2	2
Bandwidth (-3 dB)		0-35 MHz	0-50 MHz	0-200 MHz	0-50 MHz
BW Limiter		—	—	•	—
Deflection	from	1 mV/div.	1 mV/div.	1 mV/div.	1 mV/div.
	to	20 V/div.	20 V/div.	5 V/div.	20 V/div.
Delay line		—	—	•	—
Trigger Bandwidth		0-100 MHz	0-100 MHz	0-300 MHz	0-100 MHz
Min. level		≥5 mm	≥5 mm	≥5 mm	≥5 mm
Coupling		AC/DC	AC/DC/HF	AC/DC/HF	AC/DC/HF
		LF/TV	LF/TV	NR/LF/TV	LF/TV
Source		Int./Ext./~	Int./Ext./~	Int./Ext./~	Int./Ext./~
Peak-to-Peak		•	•	•	•
Level Display		—	•	•	•
Alternate		•	•	•	•
After Delay		—	•	•	•
TV-Sync. Separator		•	•	•	•
Time Base, analog	from	0.2 s/div.	0.5 s/div.	0.5 s/div.	0.5 s/div.
with magnification x 10	to	10 ns/div.	10 ns/div.	2 ns/div.	10 ns/div.
Delayed Time Deflection		—	•	•	•
with 2nd Time Base	from	—	—	20 ms/div.	—
	to			2 ns/div.	
Horizontal Bandwidth		0-2.5 MHz	0-3 MHz	0-5 MHz	0-3 MHz
Variable Hold-Off		•	•	•	•
XY Mode		•	•	•	•
Digital Signal Capture Modes		—	—	—	Refr. / Roll
					Single/XY
					Envelope
					Average
Max. Sampling Rate (Random)		—	—	—	2 GSa/s
Max. Sampl. Rate (Real-Time)		—	—	—	100 MSa/s
Signal Memories		—	—	—	2
Reference Signal Memory		—	—	—	3
Math. Signal Memory		—	—	—	3
Memory Depth / Channel		—	—	—	2048x8 bit
Pre-Trigger		—	—	—	•
Post-Trigger		—	—	—	•
1st Time Base (digital)	from	—	—	—	100 s/div.
	to				20 ns/div.
Dot-Join Function (linear)		—	—	—	•
Component Tester		•	•	•	•
Calibrator 1 kHz / 1 MHz		•	—	•	—
Calibrator DC, 1 Hz bis 1 MHz		—	•	—	•
CRT (accel. voltage)		2 kV	2 kV	14 kV	2 kV
Power Consumption		36 Watt	34 Watt	43 Watt	42 Watt

50 MHz Analog/ Digital Oscilloscope HM507

Product description, page 14

Vertical Deflection

Operating Modes:	Channel I or II only Channels I and II (alternate or chopped) Sum or Difference of CH I and CH II
Invert:	CH II
XY Mode:	via CH I (X) and CH II (Y)
Bandwidth:	2 x 0 – 50 MHz (-3 dB)
Rise Time:	‹ 7 ns
Overshoot:	max. 1 %
Deflection Coefficients:	1-2-5 Sequence
1 mV/div. – 2 mV/div.:	± 5 % (0 to 10 MHz (-3 dB))
5 mV/div. – 20 V/div.:	± 3 % (0 to 50 MHz (-3 dB))
Variable (uncalibrated):	› 2.5: 1 to › 50 V/div.
Input Impedance:	1 MΩ II 18 pF
Coupling:	DC – AC - GND (ground)
Max. Input Voltage:	400 V (DC + peak AC)

Triggering

Automatic (Peak to Peak):	20 Hz – 100 MHz (≥ 5 mm)
Normal with Level Control:	0 – 100 MHz (≥ 5 mm)
Slope:	positive or negative
Sources:	Channel I or II, CH I/CH II alternate (≥ 8 mm) Line and External
Coupling:	AC (10 Hz – 100 MHz), DC (0 – 100 MHz), HF (50 kHz – 100 MHz), LF (0 – 1.5 kHz)
Trigger Indicator:	with LED
Triggering after Delay:	with Level Control and Slope selection
External Trigger Signal:	≥ 0.3 V_{PP} (0 – 50 MHz)
Active TV sync. separator:	Field and Line, +/-

Horizontalablenkung (analog u. digital)

Analog	
Time Base:	0.5 s/div. – 50 ns/div. (1-2-5 Sequence)
Accuracy:	± 3 %
Variable (uncalibrated):	› 2.5 :1 to › 1.25 s/div.
Magnification x 10:	up to 10 ns/div. (± 5 %)
Accuracy:	± 5 %
Delay (selectable):	140 ms – 200 ns (variable)
Hold-Off Time:	variable to approx. 10 : 1
XY Mode	
Bandwidth X amplifier:	0 – 3 MHz (-3 dB)
XY Phase shift ‹ 3°:	‹ 120 kHz
Digital	
Time Base:	100 s/div. – 100 ns/div. (1-2-5 Sequence)
Accuracy:	± 2 %
X Magnification x 10:	up to 20 ns/div.
Accuracy:	± 2 %
XY Mode	
Bandwidth X Amplifier :	0 - 50 MHz (-3 dB)
XY Phase shift ‹ 3°:	‹ 10 MHz

Digital Storage

Operating Modes:	Refresh, Roll, Single, XY, Envelope, Average, Random Sampling
Interpolation:	Linear Dot Join Function
Sampling Rate (Real Time):	max 100 MSa/s, 8 bit Flash A/D Converter
Sampling Rate (Random):	2 GSa/s relative
Post/Pre-Trigger:	-10 div. to + 10 div. (continuous)
Display Refresh Rate:	max. 180/s
Bandwidth:	2 x 0 – 50 MHz (-3 dB)
Rise Time, Overshoot:	‹ 7 ns, ≤1 %
Signal Memory:	3x 2 k x 8 bit
Reference Signal Memory:	3x 2 k x 8 bit
Mathematical Signal Memory:	3x 2 k x 8 bit
Resolution (dots/div.) Yt Mode:	X: 200/div., Y: 25/div.
Resolution (dots/div.) XY Mode:	X: 25/div., Y: 25/div.

Operation / Readout / Control

Manual:	via controls
Autoset:	automatic signal related parameter settings
Save and Recall:	9 user defined parameter settings
Readout:	display of menu, parameters, cursors and results
Autom. Measurement (analog):	Freq./Period, Udc, Upp, Up+, Up-, Trigger Level
Cursor Measurement (analog):	Δt, 1/Δt, tr, ΔV, V to GND, Gain, Ratio X and Y
Autom. Measurement (digital):	as analog, plus: rms, average
Cursor Measurement (digital):	as analog, plus: V_{pp}, V_p+, V_p-, rms, average, count, V_t marker
Frequency counter:	4 digit (0.01 % ± 1 digit) 0.5 Hz – 100 MHz
Interface (standard fitting):	RS-232 (Control, Signal Data)
Interface Option:	HO79-6 (IEEE-488, RS-232, Centronics)

Component Tester

Test Voltage:	approx. 7 V_{rms} (open circuit)
Test Current:	max. 7 mA_{rms} (short-circuit)
Test Frequency:	approx. 50 Hz
Test Connection:	2 banana jacks 4 mm Ø

One test circuit lead is grounded via protective earth (PE)

Miscellaneous

CRT:	D14-363GY, 8 x 10 cm with internal graticule
Acceleration Voltage:	approx. 2 kV
Trace Rotation:	adjustable on front panel
Z-Input (Intens. modulation, analog):	max. + 5 V (TTL)
Calibrator Signal (Square Wave):	0.2 V ± 1 %, 1 Hz - 1 MHz (tr ‹ 4 ns), DC
Power Supply (Mains):	105-253 V, 50/60 Hz
Power Consumption:	approx. 42 Watt at 230 V/50 Hz
Min./max. ambient temperature:	0° C...+40° C
Safety class:	Safety class I (EN61010-1)
Weight:	approx. 6.0 kg
Dimensions (W x H x D):	285 x 125 x 380 mm

Subject to change without notice

Accessories supplied: Line Cord, Operators Manual and Software for Windows on CD-ROM, 2 Probes 1:1 / 10:1
Optional accessories: Multifunction Interface HO79-6, Opto Interface (with optical fiber cable) HZ70

50 MHz Analog Oscilloscope HM504-2

Product description, page 18

Vertical Deflection

Operating Modes:	Channel I or II only Channels I and II (alternate or chopped) Sum or Difference of CH I and CH II
Invert:	CH II
XY Mode:	via CH I (X) and CH II (Y)
Bandwidth:	2 x 0 - 50 MHz (-3 dB)
Rise Time:	‹ 7 ns
Overshoot:	max. 1 %
Deflection Coefficient:	1-2-5 Sequence
1 mV/div. – 2 mV/div.:	± 5 % (0 – 10 MHz (-3 dB))
5 mV/div. – 20 V/div.:	± 3 % (0 – 50 MHz (-3 dB))
Variable (uncalibrated):	› 2.5:1 to › 50 V/div.
Input Impedance:	1 MΩ II 18 pF
Input Coupling:	DC -AC-GND (ground)
Max. Input Voltage:	400 V (DC + peak AC)

Triggering

Automatic (Peak to Peak):	20 Hz – 100 MHz (≥ 5 mm)
Normal with Level Control:	0 – 100 MHz (≥ 5 mm)
Slope:	positive or negative
Sources:	Channel I or II, CH I/CH II alternate (≥ 8 mm), Line and External
Coupling:	AC (10 Hz - 100 MHz), DC (0 –100 MHz), HF (50 kHz –100 MHz), LF (0 –1.5 kHz)
Trigger Indicator:	LED
Triggering after Delay:	with Level Control and Slope selection
External Trigger Signal:	≥ 0.3 V_{pp} (0 - 50 MHz)
Active TV sync. separator:	Field and Line, +/-

Horizontal Deflection

Time Base:	0.5 s/div. – 50 ns/div. (1-2-5 Sequence)
Accuracy:	± 3 %
Variable (uncalibrated):	› 2.5 :1 to › 1.25 s/div.
X Magnification x 10:	up to 10 ns/div. (± 5 %)
Accuracy:	± 5 %
Delay (selectable):	140 ms – 200 ns (variable)
Hold-Off Time:	variable to approx. 10 : 1
<u>XY</u>	
Bandwidth X amplifier:	0 – 3 MHz (-3 dB)
XY Phase shift ‹ 3°:	‹ 120 kHz

Operation / Readout / Control

Manual:	via controls
Autoset:	automatic signal related parameter settings
Save and Recall:	9 user defined parameter settings
Readout:	display of menu, parameters, cursors and results
Autom. Measurement:	Freq./Period, Vdc, Vpp, Vp+, Vp-, Trigger Level
Cursor Measurement:	Δt, 1/Δt, tr, ΔV, V to GND, Gain, Ratio X and Y
Frequency counter:	4 digit (0.01 % ± 1 digit) 0.5 Hz – 100 MHz
Interface (standard fitting):	RS-232 (for control)

Component Tester

Test Voltage:	approx. 7 V_{rms} (open circuit)
Test Current:	max. 7 mA_{rms} (short-circuit)
Test Frequency:	approx. 50 Hz
Test Connection:	2 banana jacks 4 mm Ø

One test circuit lead is grounded via protective earth (PE)

Miscellaneous

CRT:	D14-363GY, 8 x 10 cm with internal graticule
Acceleration Voltage:	approx. 2 kV
Trace Rotation:	adjustable on front panel
Z-input (Intens. modulation):	max. + 5 V (TTL)
Calibrator Signal (Square Wave):	0.2 V ± 1 %, 1 Hz – 1 MHz (tr ‹ 4 ns), DC
Power Supply (Mains):	105 – 253 V, 50/60 Hz
Power Consumption:	approx. 34 Watt at 230 V/50 Hz
Min./max. ambient temperature:	0° C...+ 40° C
Safety class:	Safety class I (EN61010-1)
Weight:	approx. 5.4 kg
Dimensions (W x H x D):	285 x 125 x 380 mm

Subject to change without notice

Accessories supplied: Line Cord, Operators Manual and Software for Windows on CD-ROM, 2 Probes 1:1 / 10:1
Optional accessories: Opto Interface (with optical fiber cable) HZ70

200 MHz Analog Oscilloscope HM2005

Product description, page 15

Vertical Deflection

Operating Modes:	Channel I or II only Channels I and II (alternate or chopped) Sum or Difference of CH I and CH II
Invert:	CH I and CH II
XY Mode:	via CH I (X) and CH II (Y)
Bandwidth:	2 x 0–200 MHz (-3 dB)
with Bandwidth Limiter:	2 x 0– approx. 50 MHz (- 3dB)
Rise Time:	‹ 1.75 ns
Overshoot:	max. 1 %
Deflection Coefficients:	1-2-5 Sequence
1 mV/div. – 2 mV/div.:	±5 % (0 - 10 MHz (-3 dB))
5 mV/div. – 5 V/div.:	±3 % (0 – 200 MHz (-3 dB))
Variable (uncalibrated):	›2.5 :1 to ›12.5 V/div.
Input Impedance:	1 MΩ II 15 pF
Coupling:	DC-AC-GND
Max. Input Voltage:	250 V (DC + peak AC)
Delay Line:	approx. 70 ns

Triggering

Time Base A	
Automatic (Peak to Peak):	20 Hz-300 MHz (≥ 5 mm)
Normal with Level Control:	0 - 300 MHz (≥ 5 mm)
Slope:	positive or negative
Triggering Indicator:	LED
Sources:	Channel I or II, CH I / CH II alternate (≥ 8 mm) Line and External
Coupling:	AC (10 Hz- 300 MHz), DC (0 -300 MHz), HF (50 kHz - 300 MHz), LF (0 -1.5 kHz), NR (noise reject) 0– 50 MHz (≥ 8 mm)
Time Base B:	with Level Control and Slope selection
Coupling:	DC (0 - 300 MHz)
Active TV sync. separator:	Field and Line, +/-
External Trigger Signal:	≥ 0,3 V_{pp} (0 - 200 MHz)

Horizontal Deflection

Time Base Modes:	A, B, A and B alternate
Time Base A:	0.5 s/div.- 20 ns/div. (1-2-5 Sequence)
Accuracy:	± 3 %
Variable (uncalibrated):	› 2.5 : 1 to › 1.25 s/div.
Time Base B:	20 ms/div. – 20 ns/div. (1-2-5 Sequence)
Accuracy:	± 3 %
Variable (uncalibrated):	› 2.5 : 1 to › 50 ms/div.
X Magnification x 10:	up to 2 ns/div.
Accuracy:	± 5 %
Hold-Off Time:	variable to approx. 10 : 1
<u>XY Mode</u>	
Bandwidth X Amplifier:	0 - 5MHz (-3dB)
XY Phase shift ‹ 3°:	‹ 220 kHz

Operation / Readout / Control

Manual:	via controls
Autoset:	automatic signal related parameter settings
Save and Recall:	9 user defined parameter settings
Readout:	display of parameters and cursors
Cursor Measurement Functions:	of ΔV, Δt or 1/Δt (freq.)
Interface (standard fitting):	RS-232 (for control)

Component Tester

Test Voltage:	approx. 7 V_{rms} (open circuit)
Test Current:	max. 7 mA_{rms} (short-circuit)
Test Frequency:	approx. 50 Hz
Test Connection:	2 banana jacks 4 mm Ø

One test circuit lead is grounded via protective earth (PE)

Miscellaneous

CRT:	D14-375GH, 8x10 cm with internal graticule
Acceleration Voltage:	approx. 14 kV
Trace Rotation:	adjustable on front panel
Calibrator Signal (Square Wave):	0.2 V ± 1 %, ≈ 1 kHz/1 MHz (tr ‹ 4 ns)
Z-input (Intens. modulation):	max. + 5 V TTL
Power Supply (Mains):	105-253 V, 50/60 Hz
Power Consumption:	approx. 43 Watt at 230 V/50 Hz
Min./max. ambient temperature:	0° C...+ 40° C
Safety class:	Safety class I (EN61010-1)
Weight:	approx. 5.9 kg
Dimensions (W x H x D):	285 x 125 x 380 mm

Subject to change without notice

Accessories supplied with HM1004-3: Line Cord, Operators Manual and Software for Windows on CD-ROM, 2 Probes 10:1

35 MHz Analog Oscilloscope HM303-6

Product description, page 19

Vertical Deflection

Operating Modes:	Channel I or II only
	Channels I and II (alternate or chopped)
	Sum or Difference of CH I and CH II
Invert:	CH II
XY Mode:	via CH I (X) and CH II (Y)
Bandwidth:	2 x 0 to 35 MHz (-3 dB)
Rise Time:	‹ 10 ns
Overshoot:	max. 1%
Deflection Coefficients:	1-2-5 Sequence
1 mV/div. – 2 mV/div.:	± 5 % (Bandwidth 0 – 10 MHz (-3 dB))
5 mV/div. – 20 V/div.:	± 3 % (Bandwidth 0 – 35 MHz (-3 dB))
Variable (uncalibrated):	› 2.5 : 1 to › 50 V/div.
Input Impedance:	1 MΩ II 20 pF
Input Coupling:	DC – AC – GND (ground)
Max. Input Voltage:	400 V (DC + peak AC)

Triggering

Automatic (Peak to Peak):	20 Hz – 50 MHz (≥ 5 mm)	
	50 MHz - 100 MHz (≥ 8 mm)	
Normal with Level Control:	0 - 50 MHz (≥ 5 mm)	
	50 MHz – 100 MHz (≥ 8 mm)	
Trigger Indicator:	LED	
Slope:	positive or negative	
Sources:	Channel I or II, CH I / CH II alternate (≥ 8 mm), Line and External	
Coupling:	AC	(10 Hz – 100 MHz)
	DC	(0 – 100 MHz)
	LF	(0 – 1.5 kHz)
Trigger Indicator:	LED	
External Trigger Signal:	≥ 0.3 V_{pp} (30 Hz – 50 MHz)	
Active TV sync. separator:	pos. and neg.	

Horizontal Deflection

Time Base:	0.2 s/div. – 0.1 µs/div. (1-2-5 Sequence)
Accuracy:	± 3 %
Variabel (uncalibrated):	› 2.5:1 to › 0.5 s/div.
X Magnification x 10:	up to 10 ns/div.
Accuracy:	± 5 %
Hold-Off Time:	variable to approx. 10 : 1
XY	
Bandwidth X Amplifier:	0 – 2.5 MHz (-3 dB)
XY Phase shift ‹ 3°:	‹ 120 kHz

Component Tester

Test Voltage:	approx. 7 V_{rms} (open circuit)
Test Current:	max. 7 mA_{rms} (short-circuit)
Test Frequency:	approx. 50 Hz
Test Connection:	2 banana jacks 4 mm Ø

One test circuit lead is grounded via protective earth (PE)

Miscellaneous

CRT:	D14-363GY, 8 x 10 cm with internal graticule
Acceleration Voltage:	approx. 2 kV
Trace Rotation:	adjustable on front panel
Calibrator Signal (Square Wave):	0.2 V ± 1 %, ≈ 1 kHz/1 MHz (tr ‹ 4 ns)
Power Supply (Mains):	105 – 253 V, 50/60 Hz
Power Consumption:	approx. 36 Watt at 230 V/50 Hz
Min./max. ambient temperature:	0° C...+ 40° C
Safety class:	Safety class I (EN61010-1)
Weight:	approx. 5.4 kg
Dimensions (W x H x D):	285 x 125 x 380 mm

Subject to change without notice

Accessories supplied: Line Cord, operator's manual, 2 Probes 1:1 / 10:1

100 MHz Analog Oszilloscope HM1000

Product description on page 17

Vertical Deflection

Channels:	2
Operating Modes:	CH 1 or CH 2 separate, DUAL (CH 1 and CH 2 alternate or chopped), Addition
Y in XY-Mode:	CH 1
Invert:	CH 1, CH 2
Bandwidth (-3dB):	2 x 0 - 100 MHz
Rise time:	‹ 3.5 ns
Overshoot:	max. 1 %
Deflection Coefficient(CH 1, 2):	14 calibrated steps
1 mV – 2 mV/cm:	± 5 % (0 - 10 MHz (-3 dB))
5 mV – 20 V/cm:	±3 % (1-2-5 sequence)
variable (uncalibrated):	› 2.5 :1 to › 50 V/cm
Inputs CH 1, 2:	
Impedance:	1 MΩ // 15 pF
Coupling:	DC, AC, GND (ground)
Max. Input Voltage:	400 V (DC + peak AC)
Y Delay Line:	70 ns
Measuring Circuits:	Measuring Category I
Auxiliary input:	
Function (selectable):	Extern Trigger, Z (unblank)
Coupling:	AC, DC
Max. input voltage:	100 V DC + peak AC

Triggering

Automatic (Peak to Peak):		
Min. signal height:	5 mm	
Frequency range:	10 Hz - 200 MHz	
Level control range:	from Peak- to Peak+	
Normal (without peak):		
Min. signal height:	5 mm	
Frequency range:	0 - 200 MHz	
Level control range:	–10 cm to +10 cm	
Operating modes:	Slope/Video	
Slope:	positive, negative, both	
Sources:	CH 1, CH 2, alt.1/2, Line, Ext.	
Coupling:	**AC:**	(10 Hz-200 MHz)
	DC:	(0-200 MHz)
	HF:	(30 kHz–200 MHz)
	LF:	(0 -5 kHz)
		Noise Rej. switchable
Video:	pos./neg. Sync. Impulse	
Standards:	525 Line/60 Hz Systems	
	625 Line/50 Hz Systems	
Field:	even/odd/both	
Line:	all/line number selectable	
Source:	CH 1, CH 2, Ext.	
Indicator for trigger action:	LED	
External Trigger via:	Auxiliary Input	
Coupling:	AC, DC	
Max. input voltage:	100 V DC +peak AC	
2nd Trigger		
Min. signal height:	5 mm	
Frequency range:	0 - 200 MHz	
Coupling:	DC	
Level control range:	–10 cm to +10 cm	

Horizontal Deflection

Operating modes:	A, ALT (alternating A/B), B
Time base A (Sequence):	0.5 s/cm - 50 ns/cm (1-2-5)
Time base B (Sequence):	20 ms/cm - 50 ns/cm (1-2-5)
Accuracy A and B:	+/- 3 %
X Magnification x10:	+/- 5 % (to 5 ns/cm)
Variable time base A/B:	cont. 1:2.5
Hold Off time:	var. 1:10 LED-Indication
Bandwidth X-Amplifier:	0 - 3 MHz (-3 dB)
X-Y phase shift ‹ 3°:	‹ 220 kHz

Operation/Measuring/Interfaces

Operation:	Autoset, Menu and help functions (multilingual)

Save/Recall (instrument parameter settings):	9
Signal display:	max. 4 traces CH 1, 2 (Time Base A) in combination with CH 1, 2 (Time Base B)
Frequency counter:	max. 180/s
6 digit resolution:	>1 MHz – 200 MHz
5 digit resolution:	0.5 Hz – 1 MHz
Accuracy:	50 ppm
Auto Measurements:	Freq./Period/Vdc/Vpp/p+/-
Cursor Measurements:	ΔV/Δt, 1/Δt (f), V to Gnd, ratio X, ratio Y
Resolution Readout/Cursor:	1000 x 2000 Pts
Interfaces (plug-in):	RS-232 (HO710), Ethernet,
Optional:	Dual-Interface RS232/USB

Display

CRT:	D14-375GH
Display area (with graticule):	8 cm x 10 cm
Acceleration voltage:	ca. 14 kV

General Information

Component tester:	
Test voltage:	approx. 7 V_{rms} (open circuit), approx. 50 Hz
Test current:	max. 7 mA_{rms} (short circuit)
Reference Potential:	Ground (safety earth)
Probe ADJ Output:	1 kHz/1 MHz square wave signal 0,2 V_{pp} (tr < 4 ns)
Trace rotation:	electronic
Line voltage:	105 – 253 V, 50/60 Hz, CAT II
Power consumption:	37 Watt at 230 V, 50 Hz
Protective system:	Safety class I (EN61010-1)
Weight:	5.6 kg
Cabinet (W x H x D):	285 x 125 x 380 mm
Ambient temperature:	0° C ...+40° C

Subject to change without notice

Accessories supplied: Line cord, Operating manual, 2 Probes 10:1 with attenuation ID
Optional accessories: Dual-Interface RS-232/USB HO720, Ethernet HO730, IEEE-488 (GPIB) HO740, Opto-Interface (with optical fiber cable) HZ70

100 MHz Analog/Digital CombiScope HM1008

Product description on page 13

Vertical Deflection

Channels:	
Analog:	2
Digital:	2
Operating Modes:	
Analog:	CH 1 or CH 2 separate, DUAL (CH 1 and CH 2 alternate or chopped), Addition
Digital:	CH 1 or CH 2 separate, DUAL (CH 1 and CH 2), Addition
Y in XY-Mode:	CH 1
Invert:	CH 1, CH 2
Bandwidth (-3 dB):	2 x 0 - 100 MHz
Rise time:	< 3.5 ns
Overshoot:	max. 1 %
Deflection Coefficient(CH 1, 2):	14 calibrated steps
1 mV – 2 mV/cm (10 MHz)	± 5 % (0 - 10 MHz (-3 dB))
5 mV – 20 V/cm	±3 % (1-2-5 sequence)
variable (uncalibrated):	> 2.5 :1 to > 50 V/cm
Inputs CH 1, 2:	
Impedance:	1 MΩ // 15 pF
Coupling:	DC, AC, GND (ground)
Max. Input Voltage:	400 V (DC + peak AC)
Y Delay Line (analog):	70 ns
Measuring Circuits:	Measuring Category I
Analog mode only:	
Auxiliary input:	
Function (selectable):	Extern Trigger, Z (unblank)
Coupling:	AC, DC
Max. input voltage:	100 V DC +peak AC

Triggering

Analog and Digital Mode		
Automatic (Peak to Peak):		
Min. signal height:	5 mm	
Frequency range:	10 Hz - 200 MHz	
Level control range:	from Peak- to Peak+	
Normal (without peak):	Slope/Video	
Min. signal height:	5 mm	
Frequency range:	0 - 200 MHz	
Level control range:	–10 cm to +10 cm	
Operating modes:	Slope/Video	
Slope:	positive, negative, both	
Sources:	CH 1, CH 2, alt.1/2, Line, Ext.	
Coupling:	**AC:**	(10 Hz-200 MHz)
	DC:	(0-200 MHz)
	HF:	(30 kHz–200 MHz)
	LF:	(0 -5 kHz)
		Noise Rej. switchable
Video:	pos./neg. Sync. Impulse	
Standards:	525 Line/60 Hz Systems 625 Line/50 Hz Systems	
Field:	even/odd/both	
Line:	all/line number selectable	
Source:	CH 1, CH 2, Ext.	
Indicator for trigger action:	LED	
External Trigger via:	Auxiliary Input	
Coupling:	AC, DC	
Max. input voltage:	100 V DC +peak AC	
Digital mode		
Pre/Post Trigger:	-100 % to +400 % related to complete memory	
Analog mode		
2nd Trigger		
Min. signal height:	5 mm	
Frequency range:	0 - 200 MHz	
Coupling:	DC	
Level control range:	–10 cm to +10 cm	

Horizontal Deflection

Analog mode	
Operating modes:	A, ALT (alternating A/B), B
Time base A (Sequence):	0.5 s/cm - 50 ns/cm (1-2-5)

Time base B (Sequence):	20 ms/cm – 50 ns/cm (1-2-5)
Accuracy A and B:	+/- 3 %
X-Mag. x10:	+/- 5 % (to 5 ns/cm)
Variable time base A/B:	cont. 1:2.5
Hold Off time:	var. 1:10 LED-Indication
Bandwidth X-Amplifier:	0 - 3 MHz (-3 dB)
X-Y phase shift ‹ 3°:	‹ 220 kHz
Digital mode	
Time base range (sequence)	
Refresh Mode:	20 ms/cm - 5 ns/cm (1-2-5)
with Peak Detect:	20 ms/cm – 50 ns/cm (1-2-5)
Roll Mode:	50 s/cm – 50 ms/cm (1-2-5)
Accuracy time base	
Time base:	50 ppm
Display:	+/- 1 %
MEMORY ZOOM:	max. 40,000:1
Bandwidth X-Amplifier:	0 - 100 MHz (-3 dB)
X-Y phase shift ‹ 3°:	‹ 100 MHz

Digital Storage

Acquisition (real time):	2x 500 MSa/s, 1 GSa/s interleaved
Acquisition (random sampling):	10 GSa/s
Bandwidth:	2 x 0 - 100 MHz (random)
Memory:	1 M-Samples per channel
Operating modes:	Refresh, Average, Envelope/ Roll: Free Run/Triggered, Peak-Detect
Resolution (vertical):	8 Bit (25 Pts/cm)
Resolution (horizontal):	
Yt:	11 Bit (200 Pts/cm)
XY:	8 Bit (25 Pts /cm)
Interpolation:	Sinx/x, Dot Join (linear)
Delay:	1 Million * 1/Sampling Rate to 4 Million * 1/Sampling Rate
Display refresh rate:	max.170/s at 1 MPts
Display:	Yt, XY (acquired points only), Interpolation, Dot Join
Reference Memories:	9 with 2 kPts each (for recorded signals)
Display:	2 signals of 9 (free selectable)

Operation/Measuring/Interfaces

Operation:	Menu (multilingual), Autoset, help functions (multilingual)
Save/Recall (instrument parameter settings):	9
Signal display:	max. 4 traces
analog:	CH 1, 2 (Time Base A) in combination with CH 1, 2 (Time Base B)
digital:	CH1,2 and ZOOM or Reference or Mathematics)
Frequency counter:	
6 digit resolution:	›1 MHz – 200 MHz
5 digit resolution:	0.5 Hz – 1 MHz
Accuracy:	50 ppm
Auto Measurements:	
Analog mode:	Freq./Period/Vdc/Vpp/p+/-
add. in digital mode:	V_{rms}/V_{avg}
Cursor Measurements:	
Analog mode:	ΔV/Δt, 1/Δt (f), V to Gnd, ratio X, ratio Y
add. in digital mode:	Pulse count, Vt to Trigger, Peak to Peak, Peak+, Peak-
Resolution Readout/Cursor:	1000 x 2000 Pts, Signals: 250 x 2000
Interfaces (plug-in):	RS-232 (HO710)
Optional:	IEEE-488, Ethernet, Dual-Interface RS-232/USB

Mathematic functions

Number of Formula Sets:	5 with 5 formulas each
Sources:	CH 1, CH 2, Math 1-Math 5
Targets:	5 math. memories, Math 1-5
Functions:	ADD, SUB, 1/X, ABS, MUL, DIV, SQ, POS, NEG, INV
Display:	max. 2 math. memories (Math 1-5)

Display

CRT:	D14-375GH
Display area (with graticule):	8 cm x 10 cm
Acceleration voltage:	approx. 14 kV

General Information

Component tester	
Test voltage:	approx. $7 V_{rms}$ (open circuit), approx. 50 Hz
Test current:	max. $7 mA_{rms}$ (short circuit)
Reference Potential :	Ground (safety earth)
Probe ADJ Output:	1 kHz/1 MHz square wave signal $0.2 V_{pp}$ (tr ‹ 4 ns)
Trace rotation:	electronic
Line voltage:	105 – 253 V, 50/60 Hz, CAT II
Power consumption:	42 Watt at 230 V, 50 Hz
Protective system:	Safety class I (EN61010-1)
Weight:	5.6 kg
Cabinet (W x H x D):	285 x 125 x 380 mm
Ambient temperature:	0° C ...+40° C

Subject to change without notice

Accessories supplied: Line cord, Operating manual, 2 Probes 10:1 with attenuation ID, Windows Software for control and data transfer
Optional accessories: Dual-Interface RS-232/USB HO720,Ethernet HO730 IEEE-488 (GPIB) HO740, Opto-Interface (with optical fiber cable) HZ70

150 MHz Analog Oszilloscope HM1500

Product description on page 16

Vertical Deflection

Channels:	2
Operating Modes:	Analog CH 1 or CH 2 separate, DUAL (CH 1 and CH 2 alternate or chopped), Addition
Y in XY-Mode:	CH 1
Invert:	CH 1, CH 2
Bandwidth (-3dB):	2 x 0 - 150 MHz
Rise time:	‹ 2.3 ns
Overshoot:	max. 1 %
Deflection Coefficient(CH 1, 2):	14 calibrated steps
1 mV – 2 mV/cm:	± 5 % (0 - 10 MHz (-3 dB))
5 mV – 20 V/cm:	±3 % (1-2-5 sequence)
variable (uncalibrated)	› 2.5 :1 to › 50 V/cm
Inputs CH 1, 2:	
Impedance:	1 MΩ // 15 pF
Coupling:	DC, AC, GND (ground)
Max. Input Voltage:	400 V (DC + peak AC)
Y Delay Line:	70 ns
Measuring Circuits:	Measuring Category I
Auxiliary input:	
Function (selectable):	Extern Trigger, Z (unblank)
Coupling:	AC, DC
Max. input voltage:	100 V DC + peak AC

Triggering

Automatic (Peak to Peak):		
Min. signal height:	5 mm	
Frequency range:	10 Hz - 250 MHz	
Level control range:	from Peak- to Peak+	
Normal (without peak)		
Min. signal height:	5 mm	
Frequency range:	0 - 250 MHz	
Level control range:	–10 cm to +10 cm	
Operating modes:	Slope/Video	
Slope:	positive, negative, both	
Sources:	CH 1, CH 2, alt.1/2, Line, Ext.	
Coupling:	AC:	(10 Hz-250 MHz)
	DC:	(0-250 MHz)
	HF:	(30 kHz–250 MHz)
	LF:	(0 -5 kHz)
		Noise Rej. switchable
Video:	pos./neg. Sync. Impulse	
Standards:	525 Line/60 Hz Systems 625 Line/50 Hz Systems	
Field:	even/odd/both	
Line:	all/line number selectable	
Source:	CHI, CHII, Ext.	

Indicator for trigger action:	LED
External Trigger via:	Auxiliary Input
Coupling:	AC, DC
Max. input voltage:	100 V DC +peak AC
2nd Trigger	
Min. signal height:	5 mm
Frequency range:	0 - 250 MHz
Coupling:	DC
Level control range:	–10 cm to +10 cm

Horizontal Deflection

Operating modes:	A, ALT (alternating A/B), B
Time base A (Sequence):	0.5 s/cm - 50 ns/cm (1-2-5)
Time base B (Sequence):	20 ms/cm - 50 ns/cm (1-2-5)
Accuracy A and B:	+/- 3 %
X Magnification x10:	+/- 5 % (to 5 ns/cm)
Variable time base A/B:	cont. 1:2.5
Hold Off time:	var. 1:10 LED-Indication
Bandwidth X-Amplifier:	0 - 3 MHz (-3 dB)
X-Y phase shift <3°:	<220 kHz

Operation/Measuring/Interfaces

Operation:	Menu (multilingual), Autoset, help functions (multilingual)
Save/Recall (instrument parameter settings):	9
Signal display:	max. 4 traces CH 1, 2 (Time Base A) in combination with CH 1, 2 (Time Base B)
Frequency counter:	max. 180/s
6 digit resolution:	>1 MHz – 250 MHz
5 digit resolution:	0.5 Hz – 1 MHz
Accuracy	50 ppm
Auto Measurements:	Freq./Period/Vdc/Vpp/p+/-
Cursor Measurements:	ΔV/Δt, 1/Δt (f), V to Gnd, ratio X, ratio Y
Resolution Readout/Cursor:	1000 x 2000 Pts
Interfaces (plug-in):	RS-232 (HO710), Ethernet,
Optional:	Dual-Interface RS232/USB

Display

CRT:	D14-375GH
Display area (with graticule):	8 cm x 10 cm
Acceleration voltage:	ca. 14 kV

General Information

Component tester:	
Test voltage:	approx. 7 V_{rms} (open circuit), approx. 50 Hz
Test current:	max. 7 mA_{rms} (short circuit)
Reference Potential:	Ground (safety earth)
Probe ADJ Output:	1 kHz/1 MHz square wave signal 0.2 V_{pp} (tr < 4 ns)
Trace rotation:	electronic
Line voltage:	105 – 253 V, 50/60 Hz, CAT II
Power consumption:	41 Watt at 230 V, 50 Hz
Protective system:	Safety class I (EN61010-1)
Weight:	5.6 kg
Cabinet (W x H x D):	285 x 125 x 380 mm
Ambient temperature:	0° C ...+40° C

Subject to change without notice

Accessories supplied: Line cord, Operating manual, 2 Probes 10:1 with attenuation ID
Optional accessories: Dual-Interface RS-232/USB HO720, Ethernet HO730, IEEE-488 (GPIB) HO740, Opto-Interface (with optical fiber cable) HZ70

150 MHz Analog/Digital CombiScope HM1508

Product description on page 12

Vertical Deflection

Channels:	
Analog:	2
Digital:	2 + 2 Logic Channels
Operating Modes:	
Analog:	CH 1 or CH 2 separate, DUAL (CH 1 and CH 2 alternate or chopped), Addition
Digital:	Analog Channels: CH 1 or CH 2 separate, DUAL (CH 1 and CH 2), Addition Logic Channels: CH 3 and CH 4
Y in XY-Mode:	CH 1
Invert:	CH 1, CH 2
Bandwidth (-3 dB):	2 x 0 - 150 MHz
Rise time:	< 2.3 ns
Overshoot:	max. 1 %
Deflection Coefficient(CH 1, 2):	14 calibrated steps
1 mV – 2 mV/cm (10 MHz)	±5 % (0 - 10 MHz (-3 dB))
5 mV – 20 V/cm	±3 % (1-2-5 sequence)
variable (uncalibrated):	> 2.5 : 1 to > 50 V/cm
Inputs CH 1, 2:	
Impedance:	1 MΩ // 15 pF
Coupling:	DC, AC, GND (ground)
Max. Input Voltage:	400 V (DC + peak AC)
Y Delay Line (analog):	70 ns
Measuring Circuits:	Measuring Category
<u>Digital mode only:</u>	
Logic Channels:	CH 3, CH 4
Select. switching thresholds:	TTL, CMOS, ECL
User definable thresholds:	3
within the range	-2 V to +3 V
<u>Analog mode only:</u>	
Auxiliary input:	CH 4: 100 V DC + peak AC
Function (selectable):	Extern Trigger, Z (unblank)
Coupling:	AC, DC
Max. input voltage:	100 V DC + peak AC

Triggering

<u>Analog and Digital Mode</u>		
Automatic (Peak to Peak):		
Min. signal height:	5 mm	
Frequency range:	10 Hz - 250 MHz	
Level control range:	from Peak- to Peak+	
Normal (without peak):		
Min. signal height:	5 mm	
Frequency range:	0 - 250 MHz	
Level control range:	–10 cm to +10 cm	
Operating modes:	Slope/Video/Logic	
Slope:	positive, negative, both	
Sources:	CH 1, CH 2, alt.1/2, Line, Ext.	
Coupling:	**AC:**	(10 Hz-250 MHz)
	DC:	(0-250 MHz)
	HF:	(30 kHz–250 MHz)
	LF:	(0-5 kHz)
		Noise Rej. switchable
Video:	pos./neg. Sync. Impulse	
Standards:	525 Line/60 Hz Systems 625 Line/50 Hz Systems	
Field:	even/odd/both	
Line:	all/line number selectable	
Source:	CH 1, CH 2, Ext.	
Indicator for trigger action:	LED	
External Trigger via:	CH 4	
Coupling:	AC, DC	
Max. input voltage:	100 V DC +peak AC	
<u>Digital mode:</u>		
Logic:	AND/OR, TRUE/FALSE	
Source:	CH1 or 2, CH3 and CH4	
State:	X, H, L	
Pre/Post Trigger:	-100 % to +400 % related to complete memory	
<u>Analog mode</u>		
2nd Trigger		

Min. signal height:	5 mm
Frequency range:	0 - 250 MHz
Coupling:	DC
Level control range:	–10 cm to +10 cm

Horizontal Deflection

Analog mode	
Operating modes:	A, ALT (alternating A/B), B
Time base A (Sequence):	0.5 s/cm - 50 ns/cm (1-2-5)
Time base B (Sequence):	20 ms/cm – 50 ns/cm (1-2-5)
Accuracy A and B:	+/- 3 %
X-Mag. x10:	+/- 5 % (to 5 ns/cm)
Variable time base A/B:	cont. 1:2.5
Hold Off time:	var. 1:10 LED-Indication
Bandwidth X-Amplifier:	0 - 3 MHz (-3 dB)
X-Y phase shift < 3°:	< 220 kHz
Digital mode	
Time base range (sequence)	
Refresh Mode:	20 ms/cm - 5 ns/cm (1-2-5)
with Peak Detect:	20 ms/cm – 50 ns/cm (1-2-5)
Roll Mode:	50 s/cm – 50 ms/cm (1-2-5)
Accuracy time base	
Time base:	50 ppm
Display:	+/- 1 %
MEMORY ZOOM:	max. 40,000:1
Bandwidth X-Amplifier:	0 - 150 MHz (-3 dB)
X-Y phase shift < 3°:	< 100 MHz

Digital Storage

Acquisition (real time):	Analog channels: 2 x 500 MSa/s, 1 GSa/s interleaved Logic Channels: 2 x 500 MSa/s
Acquisition (random sampling):	Analog channels:10 GSa/s
Bandwidth:	2 x 0 - 150 MHz (random)
Memory:	1 M-Samples per channel
Operating modes:	Refresh, Average, Envelope/ Roll: Free Run/Triggered, Peak-Detect
Resolution (vertical):	8 Bit (25 Pts/cm)
Resolution (horizontal):	
Yt:	11 Bit (200 Pts/cm)
XY:	8 Bit (25 Pts /cm)
Interpolation:	Sinx/x, Dot Join (linear), Pulse
Delay:	1 Million * 1/Sampling Rate to 4 Million * 1/Sampling Rate
Display refresh rate:	max.170/s at 1 MPts
Display:	Yt, XY (acquired points only), Interpolation, Dot Join
Reference Memories:	9 with 2 kPts each (for recorded signals)
Display:	2 signals of 9 (free selectable)

Operation/Measuring/Interfaces

Operation:	Menu (multilingual), Autoset, help functions (multilingual)
Save/Recall (instrument parameter settings):	9
Signal display:	max. 4 signals or 4 traces
analog:	CH 1, 2 (Time Base A) in combination with CH 1, 2 (Time Base B)
digital:	CH 1, 2 and CH 3, 4 or ZOOM or Reference or Mathematics)
Frequency counter:	
6 digit resolution:	>1 MHz – 250 MHz
5 digit resolution:	0.5 Hz – 1 MHz
Accuracy:	50 ppm
Auto Measurements:	
Analog mode:	Freq./Period/Vdc/Vpp/p+/-
add. in digital mode:	V_{rms}/V_{avg}
Cursor Measurements:	
Analog mode:	ΔV/Δt, 1/Δt (f), V to Gnd, ratio X, ratio Y
add. in digital mode:	Pulse count, Vt to Trigger Peak to Peak, Peak+, Peak-
Resolution Readout/Cursor:	1000 x 2000 Pts, Signals: 250 x 2000
Interfaces (plug-in):	RS-232 (HO710)
Optional:	IEEE-488, Ethernet, Dual-Interface RS-232/USB

Mathematic functions

Number of Formula Sets:	5 with 5 formulas each
Sources:	CH 1, CH 2, Math 1-Math 5
Targets:	5 math. memories, Math 1-5
Functions:	ADD, SUB, 1/X, ABS, MUL, DIV, SQ, POS, NEG, INV
Display:	max. 2 math. memories (Math 1-5)

Display

CRT:	D14-375GH
Display area (with graticule):	8 cm x 10 cm
Acceleration voltage:	approx. 14 kV

General Information

Component tester	
Test voltage:	approx. 7 V_{rms} (open circuit), approx. 50 Hz
Test current:	max. 7 mA_{rms} (short circuit)
Reference Potential :	Ground (safety earth)
Probe ADJ Output:	1 kHz/1 MHz square wave signal 0.2 V_{pp} (tr < 4 ns)
Trace rotation:	electronic
Line voltage:	105 – 253 V, 50/60 Hz, CAT II
Power consumption:	47 Watt at 230 V, 50 Hz
Protective system:	Safety class I (EN61010-1)
Weight:	5.6 kg
Cabinet (W x H x D):	285 x 125 x 380 mm
Ambient temperature:	0° C ...+40° C

Subject to change without notice

Accessories supplied: Line cord, Operating manual, 4 Probes 10:1 with attenuation ID, Windows Software for control and data transfer
Optional accessories: Dual-Interface RS-232/USB HO720,Ethernet HO730 IEEE-488 (GPIB) HO740, Opto-Interface (with optical fiber cable) HZ70

Functions	Spectrum Analyzers with Direct Digital Frequency Synthesizer (DDS)			
	HM5510	HM5511	HM5012-2	HM5014-2
Frequency				
Measurement Range	150 kHz to 1 GHz	150 kHz to 1 GHz	150 kHz to 1 GHz	150 kHz to 1 GHz
Center Frequency Range	0 kHz to 1.05 GHz	0 kHz to 1.05 GHz	0 kHz to 1.05 GHz	0 kHz to 1.05 GHz
Setting Resolution	1 kHz	1 kHz	1 kHz	1 kHz
Span (1 - 2 - 5 Sequence)	1 MHz to 1 GHz	1 MHz to 1 GHz	1 MHz to 1 GHz	1 MHz to 1 GHz
Zero Span	•	•	•	•
Full Span	•	•	•	•
Resolution Bandwidths (RBW)	20 kHz/ 500 kHz	20 kHz/ 500 kHz	9 kHz/ 120 kHz/1 MHz	9 kHz/ 120 kHz/1 MHz
Video Bandwidth (VBW)	4 kHz/OFF	4 kHz/OFF	4 kHz/OFF	4 kHz/OFF
Sweep Time (autom.)	20 ms	20 ms	40 ms, 320 ms	40 ms, 320 ms
Amplitude				
Measurement Range	-100 to +10 dBm	-100 to +10 dBm	-100 to +10 dBm	-100 to +10 dBm
Input Impedance	50 Ohm	50 Ohm	50 Ohm	50 Ohm
Input Attenuator Range (10 dB increments)	0 - 40 dB	0 - 40 dB	0 - 40 dB	0 - 40 dB
Max. Reference Level	+10 dBm	+10 dBm	+10 dBm	+10 dBm
Reference Level Resolution	0.5 dBm	0.5 dBm	0.4 dBm	0.4 dBm
Scaling (log)	10 dB/div.	10 dB/div.	10 dB/div., 5 dB/div.	10 dB/div., 5 dB/div.
Marker Functions	Signal Frequency, Level	Signal Frequency, Level	Signal Frequency, Level	Signal Frequency, Level
Signal detection				
Digital			Sample, Average, MAX. HOLD	Sample, Average, MAX. HOLD
Analog	•	•		
Signal processing	—	—	A - B	A - B
Signal Display				
CRT	•	•	•	•
Y Resolution, Display (8 div.)	160 dots	160 dots	200 dots	200 dots
X Resolution, Display (10 div.)	2000 dots	2000 dots	2000 dots	2000 dots
Memory				
Memory Depth per Signal	—	—	2 kByte	2 kByte
Number of Signal Memories	—	—	2	2
Save/Recall Memories	—	—	10	10
Tracking Generator	—	•	—	•
Output Level at 50 Ohm		- 50 dBm to 0 dBm		- 50 dBm to +1 dBm
Resolution		0.5 dB		0.2 dB
Interface	—	—	RS-232	RS-232
Power Supply	105 - 253 V~	105 - 253 V~	105 - 253 V~	105 - 253 V~

1 GHz Spectrum Analyzer HM5012-2 / HM5014-2

Product description, page 29

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 (HM5014-2 only)
Rotary Encoder Input:	Center Frequency, Reference Level, Marker, Tracking Generator Level (HM5014-2 only)
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 (HM5014-2 only)

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
Operating Temperature:	10° C to 40° C
Power Supply:	105-253 V, 50 / 60 Hz
Power Consumption HM5012-2:	approx. 30 W at 230 V/50 Hz
Power Consumption HM5014-2:	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 (HM5012-2):	approx. 6 kg
Weight (HM5014-2):	approx. 6.5 kg

Subject to change without notice
*) in combination with software AS100E only

Accessories supplied:
Line Cord, Operators Manual and Software for Windows on CD-ROM
Optional accessories:
Opto Interface HZ70, Antenna HZ520, Near Field Probe Set for EMI Diagnosis HZ530

1 GHz Spectrum Analyzer HM5510 / HM5511

Product description, page 28

Frequency Characteristics

Frequency Range:	0.15 MHz to 1.050 GHz
Stability:	±5 ppm
Ageing:	±1 ppm/year
Frequency Resolution:	1 kHz (6 ½ -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:	0.5 dB, 3 ½ digit
Resolution Bandwidths (RBW) @ 3dB:	500 kHz and 20 kHz
Video filter (VBW):	4 kHz
Sweep Time:	20 ms

Amplitude Characteristics (Marker Related) 150 kHz – 1 GHz

Measurement Range:	–100 dBm to +10 dBm
Scaling:	10 dB/div.
Display Range:	80 dB (10dB/div.)
Amplitude Frequency Response (at 10 dB Attn., Zero Span and RBW 500 kHz, Signal – 20 dBm):	±3 dB
Display (CRT):	8 x 10 division
Amplitude Scale:	logarithmic
Display Units:	dBm
Parameter Display (LCD):	20 Characters per Line, Center Frequency, Span, Marker Frequency, Reference Level, Marker Level
Input Attenuator Range:	0 - 40 dB, (10 dB increments)
Input Attenuator Accuracy rel. to 10 dB:	±2 dB
Max. Input Level (continuous)	
10 - 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 500 kHz:	±1 dB
Min. Average Noise Level:	approx. –100 dBm (RBW 20 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 500 kHz and Zero Span:	±1 dB

Inputs / Outputs

Measurement Input:	N-socket
Input Impedance:	50 Ω
VSWR: (Attn. ≥ 10 dB)	typ. 1.5 : 1
Supply Voltage for Probes (HZ530):	6 V DC
Audio output (phone):	3.5 mm Ø jack
HM 5511 only:	
Tracking Generator Output:	N-socket, output Impedance 50 Ω
HM 5510 only:	
Test Signal output:	N-socket, output Impedance 50 Ω
Frequency:	10 MHz
Level	0 dBm (±2 dB)

Functions

Keyboard Input:	Center Frequency, Reference and Tracking Generator Level
Rotary Encoder Input:	Center Frequency, Reference and Tracking Generator Level, Marker, Intensity (CRT), Contrast (LCD),
HM5511 only:	
Tracking Generator	
Frequency Range:	0.15 MHz – 1.050 GHz
Output Level:	–50 dBm to 0 dBm

Frequency response	
0 dBm to -9.5 dBm	± 4 dB
-10 dBm to -50 dBm	± 3 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
Operating Temp. Range:	+10° C to +40° C
Power Supply:	105 - 253 V, 50/60 Hz
Power Consumption HM5510:	approx. 30 W at 230 V/50 Hz
Power Consumption HM5511:	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, with adjustable, lockable tilt handle
Color:	techno-brown
Weight:	
HM 5510:	approx. 5.6 kg
HM 5511:	approx. 6.0 kg

Information subject to change.

Accessories supplied:
Line Cord, Operators Manual
Optional accessories:
Antenna HZ520, Near Field Probe Set for EMI Diagnosis HZ530

Features	Power Supplies HM8040-3	HM7042-5	HM8142	HM7044
Outputs	3	3	3	4
Output Ch1	0 to 20 V 0.5 A	0 to 32 V 2 A	0 to 30 V 1 A	0 to 32 V 3 A
Output Ch2	0 to 20 V 0.5 A	0 to 5.5 V 5 A	0 to 30 V 1 A	0 to 32 V 3 A
Output Ch3	5 V 1 A	0 to 32 V 2 A	5 V 2 A	0 to 32 V 3 A
Output Ch4				0 to 32 V 3 A
Interference, hum, effective	≤ 1 mV	≤ 1 mV/2mV	≤ 2 mV	≤ 1 mV
Display	3-digit	4-digit	4-digit	4-digit
V resolution	100 mV	10 mV	10 mV	10 mV
I resolution	1 mA	1/10 mA	1 mA	1 mA
Load change min. 10% to 90%	**Ch1, Ch2**	**Ch1, Ch3**	**Ch1, Ch2**	**Ch1 to Ch4**
Settling time	200 µs	115 µs	200 µs	
Dyn. control difference	1.5 mV	15 mV	0.03 %	
Load change min. 10% to 90%		**Ch2**		
Settling time		330 µs		
Dyn. control difference		35 mV		
Operating mode	serial / parallel	serial / parallel	serial / parallel	serial / parallel
Constant voltage	•	•	•	•
Constant current	•	•	•	•
Tracking mode			•	•
Selectable outputs	•	•	•	•
Current limitation	0 - 0.5 A	0 - 0.5 A/0 - 2 A	0 - 1 A	5 mA - 3 A
Electronic fuse	•	•	•	•
SENSE			•	•
External modulation			•	•
Arbitrary function			•	
Electronic load			1 A	
Type	linear	time controlled / linear	linear	time controlled / linear
Output power	25 W	155 W	70 W	384 W
Interface			RS-232 opt. IEEE488 opt.	RS-232
Function			remote control	remote control
Weight	1.07 kg	7.40 kg	10.00 kg	8.50 kg
Remarks	Basic unit HM8001-2 or HM8003 required for operation			tracking mode

Triple Power Supply HM7042-5

Product description, page 46

Outputs	
2 x 0 – 32 V and 0..5.5 V	ON/OFF pushbutton control, SMPS followed by a linear regulator, floating outputs for parallel/serial operation, current limit and electronic fuse.

Channel I + III (32 V)	
Range:	2 x 0 – 32 V, continuously adjustable 2 knobs (coarse/fine)
Ripple:	≤ 100 µV_{rms} (3 Hz – 300 kHz)
Current:	max. 2 A
Current limit/electronic fuse:	0 – 2 A, continuously adjustable (knob)
Recovery time (10 % - 90 % load variation)	
	80 µs within ±1 mV of nominal value
	30 µs within ±10 mV of nominal value
	00 µs within ±100 mV of nominal value
	Max. transient deviation:typ. 75 mV
Recovery time (50 % basic load, 10 % load variation)	
	30 µs within ±1 mV of nominal value
	05 µs within ±10 mV of nominal value
	00 µs within ±100 mV of nominal value
	Max. transient deviation:typ. 17 mV
Display	
7-segment LED:	32.00 V (4 digit) / 2.000 A (4 digit)
Resolution:	0.01 V / 1 mA
Display accuracy:	±3 digit voltage / ±4 digit current
LED:	indicates current limit

Channel II (5.5 V)	
Channel II (5.5 V):	0 – 5.5 V, continuously adjustable (knobs)
Ripple:	≤ 100 µV_{rms} (3 Hz – 300 kHz)
Current:	max. 5 A
Current limit / electronic fuse:	0 – 5 A, continuously adjustable (knob)
Recovery time (10 % - 90 % load variation):	
	80 µs within ±1 mV of nominal value
	10 µs within ±100 mV of nominal value
Max. transient deviation:	typ. 170 mV
Recovery time (50 % basic load, 10 % load variation):	
	30 µs within ±1 mV of nominal value
	15 µs within ±10 mV of nominal value
	00 µs within ±100 mV of nominal value
	Max. transient deviation: typ. 60 mV
Display	
7-segment LED:	5.50 V (3 digit) / 5.00 A (3 digit)
Resolution:	0.01 V/10 mA
Display accuracy:	±3 digit voltage / ±1 digit current
LED:	indicates current limit

Maximum ratings	
Max. voltage applicable to output terminals (ON/OFF):	
Reverse voltage:	max. 0.4 V
Reverse current:	max. 5 A
Voltage to earth:	max. 150 V

Miscellaneous	
Safety class:	Safety class I (EN61010-1)
Mains supply:	115 V/230 V ± 10 %; 50/60 Hz
Mains Fuse:	115 V: 2 x 5 A slow blow 5 x 20 mm 230 V: 2 x 2.5 A slow blow 5 x 20 mm
Power consumption:	max. 330 VA/250 W
Operating temperature:	0° to +40 °C
Storage temperature:	–20 °C to +70 °C
Max. relative humidity:	‹ 80% (without condensation)
Dimensions (W x H x D):	285 x 90 x 389 mm
Weight:	approx. 7.4 kg

Values indicated without tolerances are intended as aids to orientation and reflect the characteristics of an average device.
Reference temperature 23°C ± 2°C. Subject to change without notice.

Accessories supplied: Operator's Manual and power cable
Optional accessories: HZ10 Silicon test leads, HZ42 19'' Rackmount kit

Quadruple High-Performance Power Supply HM7044

Product description, page 47

Identical specifications for outputs I, II, III and IV

Constant voltage source	
Voltage setting:	0 - 32 V DC
Resolution:	10 mV, 4-digit display
Setting accuracy:	± 5 Digit
Ripple and noise:	‹ 1 mV_{rms} voltage regulation
Current setting:	5 mA - 3 A
Resolution:	1 mA, 4-digit display
Setting accuracy:	± 8 digit
Ripple and noise:	‹ 1 mV_{rms}/ 100 µA current regulation

Parallel operating mode	
Output voltage:	32 V max.
Output current:	12 A max. with four outputs
Output power:	384 W max.

Serial operating mode	
Output voltage:	128 V max. with four outputs
Output current:	3 A max.
Output power:	384 W max.

Tracking mode

Voltage tracking with up to 4 outputs

Electronic fuse	
Current setting:	5 mA - 3 A; fuse selectable for each output
Number of fuses:	4

Programmable output deactivation

On overcurrent at one output, up to four outputs can be disconnected from load.

Output deactivation

All outputs can be activated/deactivated separately or together by pressing a key.

7-segment displays

Eight displays, 4-digit voltage and current display

LED indicators

Output activated, current limit activated, fuse activated (3 LEDs per output)

Interface

Serial RS-232 interface for connection to PC

Command - processing time:	100 ms until output voltage reaches the digitally transmitted level

General information	
Interior resistance	
static:	typ. 2.5 mΩ
dynamic:	typ. 150 mΩ
10 / 90 % load settling time (constant voltage ± 100 mV):	≤ 2.5 ms
Stability:	0.1 mV at line voltage variation of up to ± 10 % at ‹ 80 W per output
Temperature coefficient:	100 ppm / C°
Overcurrent cut-off time (› 3 A to 0 A):	‹ 50 µs
DC floating outputs:	max. ±150 V outputs to chassis ground
Power consumption:	max. 530 W at 384 W power output
Operating temperature:	+ 10 °C to + 40 °C
Max. relative humidity:	10 - 90 % (without condensation)
Power supply:	115/230 V~ ± 10 %, 50 - 60 Hz
Safety class:	Safety class I (EN61010-1)
Weight:	approx. 8.5 kg
Dimensions (W x H x D):	285 x 125 x 380 mm

Values indicated without tolerances are intended as aids to orientation and reflect the characteristics of an average device.
Reference temperature 23 °C ±2 °C. Subject to change without notice.

Accessories supplied: Operator's Manual and power cable
Optional accessories: HZ10 Silicon test leads

Triple Power Supply (module) HM8040-3

Product description, page 49

Outputs	
2 x 0-20 V and 5 V	Single pushbutton control of all outputs, linear regulators with overheating protection. Floating outputs for parallel/serial operation, current limit and electronic fuse

20 V Output	
Setting range:	2 x 0 - 20 V, continuously variable
Residual ripple:	≤1 mV_{rms}
Output current:	max. 0.5 A
Current limit / electronic fuse:	0 - 0.5 A continuously variable
Dynamic behaviour:	
Load change 10 % - 90 % of full load	
Recovery time:	200 µs
Max. transient deviation:	1.5 mV
Dyn. output impedance:	3.75 mΩ
Load change at 50 % basic load and ±10 % of full load	
Recovery time:	150 µs
Max. transient deviation:	400 µV
Dyn. output impedance:	4 mΩ

5 V Output	
Range:	5 V ±0.5 V screw-driver adjustment
Ripple and noise:	≤1 mV_{rms}
Output current:	max. 1 A continuous, short-circuit-proof

Combined displays of 20 V outputs	
7-segment LED:	2 x 3-digit displays, each switchable for voltage and current (V, mA)
Resolution:	0.1 V/1 mA
Display accuracy:	±1 digit voltage/±4 digit current
LED:	current limit indication

Maximum limits	
Reverse voltage:	25 V, each output
Reverse current:	500 mA, each output
Voltage to ground:	100 V, each terminal
Temperature control:	If the inside temperature exceeds 75...80° C, the HM8040-3 will be turned off.

Miscellaneous	
Power supply (from HM8001-2):	1 x 8 V 2 x 24 V 1 x 5 V 1 x 18 V_{AC}
Power consumption, with HM8001-2:	max. 90 VA/75 W (max. 110 VA/95 W, 5 V output shorted)
Operating temperature:	0 °C to +40 °C
Storage temperature:	–20 °C to +70 °C
Max. relative humidity:	<80 % (without condensation)
Safety class:	Safety class I, (EN61010-1)
Dimensions (W x H x D):	135 x 68 x 245 mm
Weight:	approx. 1.07 kg

Values indicated without tolerances are intended as aids to orientation and reflect the characteristics of an average device.
Reference temperature 23° C ± 2° C.
Subject to change without notice.

Accessories supplied: Operator's Manual
Optional accessories: HZ10 Silicone test leads

Arbitrary Power Supply HM8142

Product description, page 48

Output voltages:	2 x 0 - 30 V_{DC}; 1 x 5 V_{DC}
Output currents:	2 x 0 - 1 A_{DC}; 1 x 2 A_{DC}
Resolution:	10 mV/1 mA
Operating modes:	constant voltage (CV); constant current (CC)
Output impedance:	<5 mΩ II 0.1 µF+1.5 mH (V-source)
Residual ripple (V):	<2 mV_{rms} (at full load; 10 Hz – 100 kHz) <3 mV_{rms} (at full load; 10 Hz – 1 MHz)
(A):	<60 $µA_{rms}$ (at full load)
Bandwidth (-3 dB):	>8 kHz
Slew rate (dV/dt):	typ. >0.7 V/µs
Rise time:	typ. 50 µs
Recovery time:	typ. 40 µs
Current limit response time:	200 µs (2 ms f. I_{out} >3 A)
Stability (dV/dϑ):	<300 ppm/°C+250 µV/°C
(dI/dϑ):	<300 ppm/°C+ 25 µA/°C
Modulation inputs:	0 - 3 V (± 1 V); Ri = 10 kΩ
Setting accuracy:	0,2 % of reading ± 3 digits
Measurement accuracy:	0,2 % of reading ± 3 digits
Load regulation:	0.03 % (at V_A = 15 V; ΔI = 1 A)
Line regulation:	<1 mV/V
Compensation for line resistances:	to max. 1 Ω
Setting time:	<5 ms (manual), <10 ms (IEEE)

Arbitrary function	(for one output voltage only)
Number of points:	512
Point parameters:	voltage and dwell time
Min. dwell time:	100 µs
Max. dwell time:	50 sec.
Step widths:	100 µs, 200 µs, 500 µs; 1, 2, 5 ms; 10, 20, 50 ms...50 s (16 values)
Repeat rate in arbitrary mode:	1-255 fach and ∞
Vertical resolution:	10 mV

Sink mode	
Operating mode:	constant current (CC)
Output power:	30 Watt (max. 1 A) per output
Output impedance:	>100 kΩ + 1 µF (I-source)
Programming accuracy:	0,2 % of reading ± 3 digits
Resolution:	1 mA
Measurement accuracy:	0.2 % of reading ± 3 digits

Miscellaneous	
Power supply:	115/230 V ±15 %; 50/60 Hz
Power consumption:	approx. 160 W
Operating temperature:	0°C to +40°C
Max. relative humidity:	10 %-90 % (without condensation) 5 %-95 % RH
Safety class:	Safety class I, (EN61010-1)
Dimensions (W x H x D):	285 x 75 x 365 mm
Weight:	approx. 10 kg

Values indicated without tolerances are intended as aids to orientation and reflect the characteristics of an average device.
Reference temperature 23° C ± 2° C.
Information subject to change.

Accessories supplied: Operator's Manual and power cable
Optional accessories:

HZ10:	Silicone test leads,
HZ42:	19" Rack mount kit,
HZ72-S/L:	Cable for IEEE bus, 1 m/1.5 m,
HO88-2:	IEEE-488 interface,
HO89-2:	RS-232 interface

6½ -Digit Precision Multimeter HM8112-3

Product description, page 56

DC specifications

Ranges:	0,1 V; 1 V; 10 V; 100 V; 600 V	
Input impedance		
0.1 V, 1.0 V:	› 1 GΩ	
10 V, 100 V, 600 V:	10 MΩ	
Accuracy:	Values given are in ±[(% of reading + % of full scale)	

Range	1 year; 23 ± 2° C %rdg.	%f.s.	Temp. coefficient 10...21° C + 25...40° C
0.1 V	0.005	0.0006	0.0008
1.0 V	0.003	0.0006	0.0008
10.0 V	0.003	0.0006	0.0008
100.0 V	0.003	0.0006	0.0008
600.0 V	0.004	0.0006	0.0008

Integration time:	0.1 sec	1 to 60 sec
Display range:	120,000 digit	1,200,000 digit
600 V range:	60,000 digit	600,000 digit
Resolution:	1 µV	100 nV
Zero point		
Temperature drift:	better than 0.3 V/° C	
Long-term stability:	better than 3 µV for 90 days	

AC specifications

Measurement ranges:	0.1 V; 1 V; 10 V; 100 V; 600 V
Measurement method:	true rms DC or AC coupled (not in 0.1 V range)
Input impedance:	
0.1 V, 1 V:	1 GΩ II ‹ 60 pF
10 V, 100 V, 600 V:	10 MΩ II ‹ 60 pF
Response time:	1.5 sec to within 0.1 % of reading

Accuracy: For sine wave signals › 5 % of full scale.
Values given are in ± (% of reading + % of full scale); 23 ± 2° C for 1 year

Range	20 Hz-1 kHz	1-10 kHz	10-50 kHz	50-100 kHz	100-300 kHz
0.1 V	0.1+0.08	5+0.5(5kHz)			
1.0 V	0.08+0.08	0.15+0.08	0.3+0.1	0.8+0.15	7+0.15
10.0 V	0.08+0.08	0.1+0.08	0.3+0.1	0.8+0.15	4+0.15
100.0 V	0.08+0.08	0.1+0.08	0.3+0.1	0.8+0.15	
600.0 V	0.08+0.08	0.1+0.08			

Temperature coefficient 10...21° C and 25...40° C; (% rdg. + % f.s.)		
at 20 Hz – 10 kHz:	0.01 + 0.008	
at 10 kHz – 100 kHz:	0.08 + 0.010	
Crest factor:	7:1 (max. 5 x range)	
Integration time:	0.1 sec	1 to 60 sec
Display range:	120,000 digit	1,200,000 digit
600 V range:	600,00 digit	600,000 digit
Resolution:	1 µV	100 nV
Overload protection:		
(V/Ω-HI to V/Ω-LO) and to chassis:		
Measurement ranges:	all	
all the time	850 V_{peak} or 600 V_{DC}	
Maximum input voltage LOW against chassis/safety earth:	250 V_{rms} at max. 60 Hz or 250 V_{DC}	

Currentspecifications

Ranges:	100 µA; 1 mA; 10 mA; 100 mA; 1 A		
Integration time:	0.1 sec		1 to 60 sec
Display ranges:	120,000 digit		1,200,000 digit
1 A range:	100,000 digit		1,000,000 digit
Resolution:	1 nA		100 pA
Accuracy:	DC	45 Hz – 1 kHz	1 kHz – 5 kHz
(1 year; 23 ± 2 °C)	0.02 + 0.002	0.1 + 0.08	0.2 + 0.08
Temperature coefficient /°C:	10...21° C		25...40° C
(%rdg. + %f.s.)	0.002+ 0.001		0.01+ 0.01
Voltage:	‹ 600 mV to 1.5 V		
Response time:	1.5 sec to within 0.1 % of reading		
Crest factor:	7:1 (max 5 x range)		
Input protection:	fuse, FF 1 A 250 V		

Resistance

Ranges:	100 Ω, 1 kΩ, 10 kΩ, 100 kΩ, 1 MΩ, 10 MΩ	
Integration time:	0.1 sec	1 to 60 sec
Display ranges:	120,000 digit	1,200,000 digit
Resolution:	1 mΩ	100 µΩ
Accuracy:	Values given are in ± (% of reading + % of full scale)	

Range	1 year; 23 ± 2° C %rdg.	%f.s.	Temp. coefficient /° C 10...21° C	25...40° C
100 Ω	0.005	0.0015	0.0008	0.0008
1 kΩ	0.005	0.001	0.0008	0.0008
10 kΩ	0.005	0.001	0.0008	0.0008
100 kΩ	0.005	0.001	0.0008	0.0008
1 MΩ	0.05	0.002	0.002	0.002
10 MΩ	0.5	0.02	0.01	0.01

Measurement current:	Range	Current
	100 Ω, 1 kΩ	1 mA
	10 kΩ	100 µA
	100 kΩ	10 µA
	1 MΩ	1 µA
	10 MΩ	100 nA
max. measurement voltage:	approx. 3 V	
Overload protection:	250 V_P	

Temperature measurement

PT100 / PT1000 (IEC751):	2- and 4-wire measurement
Range:	–200° C to + 800° C
Resolution:	0.01° C; measurement current 1 mA
Accuracy:	± (0.05° C + sensor tolerance + 0.08 K)
Temperature coefficient	
10...21° C and 25...40° C:	‹ 0.0018° C/° C
NiCr-Ni (K-type)	
Range:	–270 °C to +1372 °C
Resolution:	0.1 °C
Accuracy:	± (0.7 % rdg. + 0.3 K)
NiCr-Ni (J-type)	
Range:	–210° C to +1200° C
Resolution:	0.1 °C
Accuracy:	± (0.7 % rdg. + 0.3 K)

Frequency and period specifications

Range:	1 Hz to 100 kHz
Resolution:	0.00001 Hz to 1 Hz
Accuracy:	0.05 % of reading
Measurement time:	1 to 2 sec.

Interface

RS-232 standard:	9600 or 19200 Baud
Functions:	control / Data fetch
Inputs:	Function, range, integration time, start command
Outputs:	Measurement results, function, range, integration time (10 ms to 60 sec.)

Miscellaneous

Time to change range or function
approx. 125 ms with DC voltage, DC current, resistance
approx. 1 sec with AC voltage, AC current

Memory:	30,000 readings/128 kB
Power supply:	105-254 V~; 50/60 Hz
Power consumption:	approx. 8 W
Operating temperature:	+10° to +40° C
Storage temperature:	-40° to +70° C
Humidity:	‹ 75% (without condensation)
Safety class:	Safety class I, EN 61010
Dimensions (W x H x D):	285 x 75 x 365 mm
Weight:	approx. 3 kg

Values indicated without tolerances are intended as aids to orientation and reflect the characteristics of an average device.
Reference temperature 23° C ± 2° C. Subject to change without notice.

Accessories supplied: Operator's Manual, power cable, HZ15 PVC test Lead
Optional accessories: HZ887 Temperature sensor (PT100; -50° C to + 400° C), HZ42 19" Rackmount kit 2RU for frame height 75 mm, HZ10 Silicone test leads

8 kW Power Meter HM8115-2

Product description, page 57

Voltage	True RMS voltage measurement (AC+DC)		
Ranges:	50 V	150 V	500 V
Resolution:	0.1 V	1 V	1 V
Accuracy:	± (0.4 % + 5 digits) at 20 Hz – 1 kHz		
	± (0.6 % + 5 digits) for DC		
Input impedance:	1 MΩ II 100 pF		
Crest factor:	max. 3.5 at full scale		
Input protection:	max. 500 Vp		

Current	True RMS current measurement (AC+DC)		
Ranges:	160 mA	1.6 A	16 A
Resolution:	1 mA	1 mA	10 mA
Accuracy:	± (0.4 % + 5 digits) at 20 Hz – 1 kHz		
	± (0.6 % + 5 digits) for DC		
Crest factor:	max. 4 at full scale		
Input protection:	fuse, FF 6 A 6.3 x 32 mm (superfast)		

Active power measurement							
Ranges:	8 W	24 W	80 W	240 W	800 W	2400 W	8000 W
Resolution:	1 mW	10 mW	10 mW	100 mW	100 mW	1 W	1 W
Accuracy:	± (0.5 % + 10 digits) at 20 Hz – 1 kHz						
	± (0.5 % + 10 digits) for DC						
Display:	4-digit, 7-segment LED						

Reactive power measurement					
Ranges:	8 var	24 var	80 var	240/800 var	2400/8000 var
Resolution:	1 mvar	10 mvar	10 mvar	100 mvar	1 var
Accuracy:	± (2.5 % + 10 digits + 0.02 x P)				
	at 20 Hz – 400 Hz; P = active power				
Display:	4-digit, 7-segment LED				

Apparent power measurement					
Ranges:	8 VA	24 VA	80 VA	240/800 VA	2400/8000 VA
Resolution:	1 mVA	10 mVA	10 mVA	100 mVA	1 VA
Accuracy:	± (0.8 % + 5 digits) at 20 Hz – 1 kHz				
Display:	4-digit, 7-segment LED				

Power factor measurement	
Display:	0.00 to +1.00
Accuracy:	± (2% + 3 digits) for 50-60 Hz (sine wave)
	voltage and current › 1/10 of full scale

Monitor output (analog)	
Connection:	BNC connector (galvanic isolation to test circuit and RS-232 interface)
Reference potential:	protective earth
Level:	1 V_{AC} at full scale (2400/8000 digits)
Accuracy:	typ. 5 %
Output impedance:	approx. 10 kΩ
Bandwidth:	DC to 1 kHz
Protected up to:	± 30 V

Functions and displays	
Measurement functions:	voltage, current, power, power factor
Range selection:	automatic/manual
Overrange alarm:	visual and acoustic
Display resolution	
Voltage:	3-digit, 7-segment LED
Current:	4-digit, 7-segment LED
Power:	4-digit, 7-segment LED
Power factor:	3-digit, 7-segment LED

Serial interface	
Connection:	D-sub connector (galvanic isolation to test circuit and monitor output)
Type:	RS-232 (3-wire)
Protocol:	Xon / Xoff
Data rate:	9600 Baud
Functions:	control/data fetch

Miscellaneous	
Power supply:	115/230 V ± 10 %, 50/60 Hz
Power consumption:	approx. 15 W at 50 Hz
Operating temperature:	0° to +40° C
Max. relative humidity:	‹ 80 % (without condensation)
Safety Class:	Safety Class I, EN 61010 (IEC 1010)
Dimensions (W x H x D):	285 x 75 x 365 mm
Weight:	approx. 4 kg

Values indicated without tolerances are intended as aids to orientation and reflect the characteristics of an average device.
Reference temperature 23° C ± 2° C.
Subject to change without notice.

Accessories supplied:
Operator's Manual, power cable, interface cable
Optional accessories:
HZ10: Silicone test leads
HZ815: Power Adapter

2.6 GHz Universal Counter HM8123

Product description, page 58

Input characteristics (Input A and B)

Frequency range:		
0 – 200 MHz	(DC-coupled)	
100 Hz – 200 MHz	(1 MΩ, AC-coupled)	
500 kHz – 200 MHz	(50 Ω, AC-coupled)	
Input impedance:	1 MΩ II 30 pF or 50 Ω (switchable)	
Attenuation:	1:1, 1:10, 1:100 (selectable)	
Sensitivity: (normal triggering)		
0 to 80 MHz.	20 mV_{rms} (sine wave), 80 mV_{pp} (pulse)	
80 MHz to 200 MHz	60 mV_{rms} (sine wave)	
20 Hz to 80 MHz	50 mV_{rms} (sine wave, auto trigger)	
Trigger (programmable via encoder or software)		
Attenuation:	**Trigger level:**	**Resolution:**
1:1	0 to ± 2 V	1 mV
1:10	0 to ± 20 V	10 mV
1:100	0 to ± 200 V	100 mV
Max. input voltage:		
Input 1 MΩ:	250 V (DC + AC_{peak}) from 0 to 440 Hz decreasing to 8 V_{rms} at 1 MHz	
Input 50 Ω:	5 V_{rms}	
Minimum pulse duration:	‹5 ns for single pulse	
Input noise:	(typ.) 100 µV	
Auto trigger (AC coupling):	trigger point: 50 % of peak-to-peak value	
Trigger slope:	positive or negative	
Filter:	100 kHz low-pass filter (switchable)	

Input characteristics (Input C)

Frequency range:	100 MHz - 2.6 GHz
Input sensitivity:	up to 1 GHz: 320 mV_{rms} (typ. 20 mV_{rms})
	1 GHz-2.6 GHz: 100 mV_{rms} (typ. 80 mV_{rms})
Input impedance:	50 Ω nominal
Max. input voltage:	5 V (DC + AC_{peak})

Input characteristics

	External Reset	Reference	Gate/Arming
Input impedance:	5 kΩ	500 Ω	5 kΩ
Max. input voltage:	± 30 V	± 20 V	± 30 V
Input sensitivity:	-	typ. 2 V_{rms}	-
High level:	› 2 V	-	› 2 V
Low level:	‹ 0.5 V	-	‹ 0.5 V
Min. pulse duration:	200 ns	-	50 ns
Input frequency:	-	10 MHz	-
Min. eff. gate time:	-	-	20 µs

Measurement functions

Frequency A/B/C; period duration A; width A; duty cycle A; totalize A; RPM A; frequency ratio A:B; time interval A:B;; totalize A during B; time interval A:B (average); phase A to B; burst measurements

Frequency measurement (Inputs A, B, C)

Frequency range:	0 to 200 MHz (2.6 GHz)
LSD:	(1.25 x 10^{-8}s x frequency) / measurement time
Resolution:	± 1 or 2 LSD
Accuracy:	± (resolution / periods ± time inaccuracy ± trigger error / measurement time)

Period duration measurement

Range:	10000 sec. to 5 ns
LSD:	(1.25 x 10^{-8}s x period) / measurement time[1]
Resolution:	1 or 2 LSD
Accuracy:	± resolution / frequency ratio ± (trigger error B / measurement time)

Totalization A

	(manual control)	(external control)
Range:	0 – 200 MHz	0 – 200 MHz
Min. pulse duration:	10 ns	10 ns
LSD:	1 count	± 1 count
Resolution:	LSD	LSD
Accuracy:	(resolution ± ext. gate time error x frequency A)/total	
Pulse resolution:	10 ns	10 ns
Ext. gate error:	-	100 ns

1) NPR=number of pulses per revolution

Time interval / Average time interval

(Input A = start; input B = stop)

LSD:	10 ns (10 ns to 1 ps in "average" mode)	
Resolution:	1 LSD (1 or 2 in "average" mode)	
Accuracy:	± (resolution + trigger error + system error)/time interval ± time basis uncertainty (system error: ‹ 4 ns)	
Number of average:	N = 1-25	LSD = 10 ns
	N = 26-2500	LSD = 1 ns
	N = 2501-250000	LSD = 100 ps
	N = 250001 – 25000000	LSD = 10 ps
	N = › 25000000	LSD = 1 ps

RPM measurement

NPR[1] presetting:	1 – 65535 pulses per revolution
Gate time:	330 ms fixed
LSD:	7.5 x 10^{-8} rpm
Resolution:	resolution/rpm ± (trigger error/0.33) ± time basis error

Offset

Range: Covers the entire measurement range

Resolution: Same resolution as in normal measurement. If the programmed gate time is changed in the offset mode, the offset resolution is the reference value resolution or the current reading resolution, whichever is more precise).

Gate time

Range:	1 ms – 65 sec.
Resolution:	1 ms
External gate time:	min. 20 µs

Time base

Frequency:	200 MHz clock rate; 10 MHz crystal
Stability:	± 2 x 10^{-7} between +10° C and +40° C
Ageing:	‹ 0.27 ppm per month, 0.05 ppm per day
External Reference:	10 MHz± 2 ppm

Miscellaneous

Display:	LCD display (83 x 21 mm)
Power supply:	115/230 V ± 10 %, 45-60 Hz, 40 VA
Opersting temperature:	+10° C to +40° C
Humidity:	10 %-90 %, with no condensation, 5 %-95 % RH
Safety class:	Safety Class I (EN61010-1)
Dimensions (W x H x D):	285 x 75 x 365 mm
Weight:	approx. 4 kg

Values indicated without tolerances are intended as aids to orientation and reflect the characteristics of an average device.
Reference temperature 23° C ± 2° C.
Information subject to change.

Accessories supplied: Operator's Manual and power cable

Optional accessories:

HZ10:	Silicone test leads
HZ42:	19" Rackmount kit for
HZ33/34:	Test cable
HZ24:	Attenuator 50 Ohm
HZ20:	Adapter plug

10 MHz Function Generator HM8130

Product description, page 59

Frequency	
Range:	10 mHz to 10 MHz
Resolution:	5-digit, max. 10 mHz
Display:	5-digit LED
Accuracy:	± (1 digit + 5 mHz)
Temperature coefficient:	0.5 ppm/° C
Aging:	2 ppm/year

Waveforms	
Sine wave	
Frequency range:	10 mHz to 10 MHz
Amplitude:	0 - 20 V_{pp} (open circuit)
Distortion:	‹ 0.5 % (to 500 kHz) ‹ 1 % (500 kHz-3 MHz) ‹ 3 % (3 MHz-10 MHz)
Square wave	
Frequency range:	10 mHz to 10 MHz
Amplitude:	0 - 20 V_{pp} (open circuit)
Rise/fall time:	‹ 10 ns
Overshoot:	‹ 5 % (V_{out} ≥ 200 mV)
Symmetry:	50 % ± (5 % + 10 ns)
Pulse	
Frequency range:	10 mHz to 5 MHz;
Amplitude:	0...+10 V and 0...-10 V
Rise/fall time:	‹ 10 ns
Pulse width:	100 ns to 80 s
Duty cycle:	max. 80 %
Saw thooth	
Frequency range:	10 mHz to 500 kHz
Amplitude:	0 - 20 V_{pp} (open circuit)
Linearity:	better than 1 %
Triangle	
Frequency range:	10 mHz to 2 MHz
Amplitude:	0 - 20 V_{pp} (open circuit)
Linearity:	better than 1 %

Arbitrary generator	
Frequency range:	10 mHz to 100 kHz;
Amplitude:	max. 20 V_{pp} (open circuit)
Sampling rate:	10 MHz
Resolution:	X: 1024; Y: 1024 (each 10 bit)

Inputs	
Gate/trigger:	BNC connector
Impedance:	5 kΩ II 100 pF; protected up to ± 30 V
AMPL. CONTROL:	amplitude modulation, BNC connector
Impedance:	10 kΩ; protected up to ± 30 V

Outputs	
Signal output:	(BNC connector) short-circuit proof; ext. voltage max. ± 15 V
Impedance:	50 Ω
Output voltage: (Range 1)	2.1 - 20 V_{pp} (open circuit)
(Range 2)	0.21 - 2.0 V_{pp} (open circuit)
(Range 3)	20 - 200 mV_{pp} (open circuit)
Resolution: (Range 1)	100 mV
(Range 2)	10 mV
(Range 3)	1 mV
Setting accuracy: (1kHz)	± 2 % (2.1-20 V) ± 3 % (0.21-2 V) ± 4 % (20-200 mV) 3 % additional for pulse and square wave
Frequency response:	± 0.2 dB (‹ 100 kHz) ± 0.5 dB (100 kHz - 2 MHz) + 0.5 dB / - 3 dB (2 MHz - 10 MHz)
Offset error:	± 50 mV (Range 3)
Display:	2½ digit (LED)

DC offset	
Output voltage:	-7.5...+7.5 V (open circuit) -0.75...+0.75 V (open circuit) -75...+75 mV (open circuit)

Trigger output (BNC connector)	
Level:	5 V/TTL

Internal sweep	
Internal sweep:	all waveforms
2 ranges:	10 mHz - 550 kHz / 450 kHz - 10 MHz selectable start and stop frequency
Sweep time:	linear from 20 ms to 100 s, continuous or triggered (ext. signal, interface)
Saw thooth:	0 to 5 V (sweep output)
Output impedance:	1 kΩ

Amplitude modulation:	
Modulation via external signal	
Modulation depth:	0 to 100 %
Bandwidth:	DC - 20 kHz (-3 dB)

Gate (asynchronous)	
Modulation on/off via external TTL signal	
Delay time:	‹ 150 ns
Input signal:	TTL

Trigger function (synchronous)	
Frequency range:	‹ 500 kHz
Burst mode via ext. trigger input or interface	

Miscellaneous	
Memory: For the last device settings and for 9 arbitrary signals	
Interfaces:	RS-232 (optional), IEEE (optional)
IEEE-Systembetrieb	(Option HO88-2)
Power consumption:	approx. 45 Watt
Operating temperature:	+10° C to +40° C
Supply voltage:	115/230 V ± 10 %; 50/60 Hz
Max. relative humidity:	10 % -90 % (without condensation)
Safety class:	Safety Class I (EN61010-1)
Dimensions (W x H x D):	285 x 75 x 365 mm
Weight:	approx. 5 kg

Values indicated without tolerances are intended as aids to orientation and reflect the characteristics of an average device.
Reference temperature 23° C ± 2° C.
Subject to change without notice.

Accessories supplied: Operator's Manual and power cable
Optional accessories:

HZ10:	Silicone test leads
HZ33, HZ34:	50 Ω Test Cable, BNC-BNC
HZ24:	Set of attenuators, 3/6/10 and 20 dB
HZ42:	19" Rackmount kit
HZ72-S/L:	IEEE-488 Interface Cable, 1 m / 1.5 m
HO88-2:	IEEE-488 Interface
HO89-2:	RS-232 Interface

15 MHz Arbitrary Function Generator HM8131-2

Product description, page 60

Frequency specifications

Range:	100 µHz to 15 MHz
Resolution:	100 µHz; 100 mHz (sweep mode)
Display:	‹10 ms (without band change) ‹60 ms (with band change)
Accuracy:	Standard oscillator ±(10 ppm x freq.+ 30 µHz) TCXO (Option HO86) ±(0.5 ppm x freq.+ 30 µHz) HM8125 (ext. reference frequency) ± 30 µHz
Temperature coefficient:	Standard oscillator 2 ppm/° C TCXO (Option HO86) 0.5 ppm/year
Ageing:	Standard oscillator: 10 ppm/year TCXO (Option HO86) 2 ppm/year

Waveforms

Sine wave

Frequency range:	100 µHz to 15 MHz
Amplitude:	0 - 20 V_{pp} (open circuit)
Distortion:	‹0.1 % (10 Hz to 20 kHz) ‹1 % (20 kHz-3 MHz) ‹3 % (3 MHz-15 MHz)
Nonharmonic distortions:	100 µHz-1 MHz: ‹ -65 dBc 1MHz-15MHz: ‹ -(65 dBc + 6 dBc/Octave)
Phase noise:	‹ -90 dBc/√Hz (0 dBm, 1 kHz from carrier)

Rectangle

Frequency range:	10 µHz to 15 MHz
Amplitude:	0 - 20 V_{pp} (open circuit)
Rise/fall time:	‹ 10 ns
Overshoot:	‹5 % (U_{out} ≤ 200 mV)
Symmetry:	50 % ±(5 %+10 ns)

Ramp

Frequency range:	100 µHz to 100 kHz
Amplitude:	0 - 20 V_{pp} (open circuit)
Linearity:	better than 1 %
Polarity:	positive/negative
Rise/fall time:	45 ns

Triangle

Frequency range:	100 µHz to 1 MHz
Amplitude:	0-20 V_{pp} (open circuit)
Linearity:	better than 1 % (‹ 100 kHz)

Noise

White noise:	Bandwidth 10 MHz

Arbitrary

Frequency range:	100 µHz to 10 MHz
Amplitude:	max. 20 V_{pp} (open circuit)
Output rate:	40 MS/s
Resolution:	12 bit (amplitude)
Filter:	Bessel, 7.th order, b=10 MHz
Memories:	1x 4 K-words not volatile 1x 16 K-words volatile
Jitter:	‹ 25 ps

Inputs

Gate/trigger	
Impedance:	5 kΩ II 100 pF (protected to 30 V)
Amplitude modulation	
Impedance:	1 kΩ (protected to ±30 V)
External reference	
Frequency:	10 MHz ± 2 ppm
Input voltage:	1 V_{pp}
Impedance:	500 Ω (protected to ±30 V)

Outputs

Signal output	BNC socket, short-circuit-proof ext. voltage max. ±15 V f. 30 s.	
Impedance:	50 Ω	
Output voltage:	2.1 - 20 V_{pp} (open circuit)	Range 1
	0.21 - 2.0 V_{pp} (open circuit)	Range 2
	20 - 200 mV_{pp} (open circuit)	Range 3
Resolution:	3½ digit (100/10/1 mV) Display of V_{pp} or RMS (except in arbitrary mode)	

Setting accuracy:	Sine wave 1 kHz ±(1% x amplitude + 5 digits) Rectangle 1 kHz ±(3 % x amplitude + 5 digits)
Frequency response:	±0.2 dB (‹100 kHz) ±0.3 dB (100 kHz - 1 MHz) +0.5 dB (1 MHz - 15 MHz)
Temperature stability:	±0.1 %/° C
Trigger output	BNC socket, short-circuit proof
Level:	5V/TTL level
Ramp output	
Voltage progression:	0-5 V; synchronous with sweep
Impedance:	1 kΩ

DC offset

Output voltage:	-5 V... +5 V (open circuit)	Range 1
	-0.5 V... + 0.5 V (open circuit)	Range 2
	-50 mV + 50 mV (open circuit)	Range 3
Resolution:	3 digit	
Accuracy:	±(1 % x offset voltage + 5 digits)	
Temperature stability:	±0.1%/° C	

Phase

Range:	0 - 359.9°
Resolution:	0.1°
Reference:	declining slope of the synch. signal
Jitter:	‹ 25 ps
Accuracy:	except for rectangle ± (0.1+ freq./Hz x 10^{-6}) degrees for rectangle ±(5 + freq./Hz x 30 x 10^{-6}) degrees

Sweep (internal)

Internal sweep:	all waveforms, linear or log.
Ranges:	100 mHz to max. signal frequency selectable beginning and end frequencies
Sweep time:	from 10 ms to 40 s, continuous or triggered (ext. signal, front panel keypad, interface)

Modulation

FSK/PSK:	all signals
Frequency range:	100 µHz to max. frequency
Triggering:	by external signal
Minimum duration:	25 µs
Delay:	typ.10 µs PSK; typ. 15 µs FSK

Amplitude modulation

Modulation source:	internal or external
Modulation depth:	0 to 100 %
Bandwidth:	DC - 20 kHz (-3 dB)
Carrier frequency:	100 µHz to max. signal frequency
Accuracy:	± (5 % of reading + 2 %)
Internal modulation:	1 kHz sine wave
External modulation:	20 Hz – 20 kHz, 1 V_{pp} sine wave f. 100 %
Gate:	(asynchronous)
Delay time:	‹150 ns
Input signal:	TTL
Trigger function:	(synchronous)
Frequency range:	‹500 kHz

Burst mode via ext. trigger or interface

Miscellaneous

Optional memory card:	PCMCIA II format up to 1 MB for storage of up to 16 ARB signals
Memories:	10 for device settings; 1 for ARB signal storage
RS-232:	interface preinstalled
Power consumption:	approx. 30 VA
Ambient temperature range:	+10° C to + 40° C
Supply voltage:	115/230 V ± 10 %, 50/60 Hz
Humidity:	10 %-90 % with no condensation
Safety class:	Safety Class I (IEC1010-1 (VDE411)
Dimensions (W x H x D):	285 x 75 x 365 mm
Weight:	approx. 5 kg

Values indicated without tolerances are intended as aids to orientation and reflect the characteristics of an average device. Reference temperature 23° C ± 2° C. Information subject to change.

Accessories supplied: Operator's Manual and power cable
Optional accessories: HZ33/HZ34 50 Ω Test Cable, BNC-BNC; HO831 Memory Card 1 MB, HO88-2 IEEE-488 Bus interface, HZ10 Silicone test leads

1.2 GHz HF Synthesizer HM8134-3

Product description, page 61

Frequency

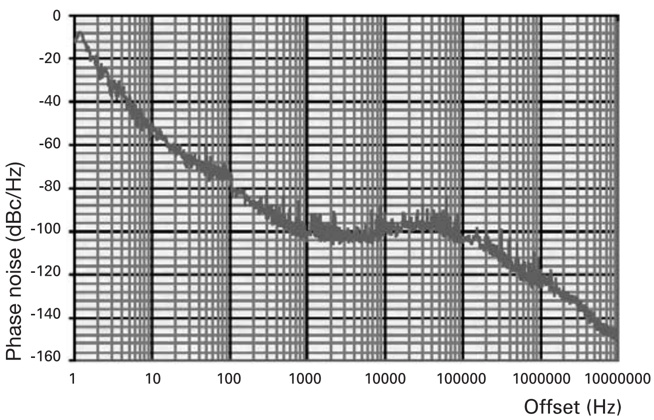
Range:	1 Hz to 1200 MHz
Resolution:	1 Hz
Settling time:	< 10 ms

10 MHz reference (internal)

Stability:	< 0.5 ppm
Aging:	< ±1 ppm/year
Output (rear panel):	TTL
Input (front panel):	Level: > 0 dBm; Frequency 10 MHz

Spectral purity (without modulation)

Harmonic:	≤ - 35 dBc
Non-harmonic:	≤ - 60 dBc (> 15 kHz from carrier)
Phase noise:	(at 20 kHz from carrier)
< 16 MHz:	≤ - 120 dBc/Hz
16 to 250 MHz:	≤ - 95 dBc/Hz
250 to 500 MHz:	≤ - 105 dBc/Hz
500 to 1200 MHz:	≤ - 100 dBc/Hz



(Typical phase noise at 1 GHz)

Output level

Range:	- 127 to + 13 dBm
Resolution:	0.1 dB
Precision:	≤ ± 0.5 dB (for level > - 57 dBm)
Impedance:	50 Ω
V.S.W.R.:	≤ 1 : 1.5

Modulation sources

Internal:	10 Hz - 300 kHz sine wave, 10 Hz - 100 kHz square wave, triangle, saw thooth
Resolution:	10 Hz
External:	(input on front panel)
Impedance:	10 kΩ
Input level:	2 V_{pp} for full scale
Coupling:	AC or DC
Output (on front panel):	Impedance: 1 kΩ; Level: 2 V_{pp}

Amplitude modulation (Level ≤ + 7 dBm)

Source:	internal or external
Modulation depth:	0 to 100 %
Resolution:	0.1 %
Accuracy:	± 4 % of reading ± 0.5 % (AM-depth ≤ 80 % and f_{mod} ≤ 1 kHz)
Ext. frequency resp. (to - 1 dB):	10 Hz to 300 kHz for AC
Distortion:	< 2 % (AM-depth ≤ 60 %, f_{mod} ≤ 1 kHz) < 6 % (AM-depth ≤ 80 %, f_{mod}: 10 Hz to 100 kHz)

Frequency modulation

Source:	internal or external
Deviation:	± 200 Hz to 400 kHz (depending on frequency band)
Resolution:	100 Hz
Accuracy:	± 5 % + residual FM
Ext. frequency response: (to - 1 dB)	
DC coupling:	0 to 100 kHz
AC coupling:	10 Hz to 100 kHz
Distortion:	< 3 % for deviation ≥ 10 kHz

Phase modulation

Source:	internal or external
Deviation:	0 to 3.14 rad (< 16 MHz) 0 to 10 rad (> 16 MHz)
Resolution:	0.01 rad
Accuracy:	± 5 % to 1 kHz + residual PM
Ext. frequency response : (to - 1 dB)	
DC coupling:	0 to 100 kHz
AC coupling:	10 Hz to 100 kHz
Analog PM:	DC up to 100 kHz
Distortion:	< 3 % for f_{mod} = 1 kHz and deviation = 10 rad

FSK modulation

Range:	16 to 1200 MHz
Mode:	2 FSK levels
Data source:	external
Max. rate:	10 kbit/s
Shift (F1 – F0):	0 to 10 MHz
Resolution:	100 Hz
Accuracy:	see under FM

PSK modulation

Range:	16 to 1200 MHz
Mode:	2 PSK levels
Data source:	external
Max. rate:	10 Kbit/s
Shift (Ph1 – Ph0):	0 to ± 3.14 rad (< 16 MHz) 0 to ± 10 rad (> 16 MHz)
Resolution:	0.01 rad
Accuracy:	see under PM

Pulse modulation

Source:	external
Dynamic range:	> 60 dB
Rise/fall times:	< 200 ns
Delay:	< 100 ns
Max. frequency:	2.5 MHz
Input level:	TTL

Sweep mode

Range:	1 Hz to 1200 MHz
Depth:	500 Hz to 1200 MHz
Number of points:	10 to 500
Time/step:	1 ms to 1 s
Resolution:	1 ms
Operating mode:	free, single, manual
Trigger:	internal or external

Protective functions

The synthesiser is protected against reverse power applied on RF output up to 1 W for a 50 Ω source and against any DC source up to ± 7 V. The protection disconnects the output until manually rearmed by operator.

Miscellaneous

Interfaces:	RS-232, 9-pole D-sub
Configuration memories:	10
Power supply:	115/230 V ± 10 %, 50/60 Hz
Power consumption:	approx. 40 VA
Operating temperature:	+ 10 to + 40° C
Max. relative humidity:	10 to 90 % (without condensation)
Safety class:	Safety Class I (EN61010-1)
Dimensions (W x H x D):	285 x 75 x 365 mm
Weight:	approx. 7 kg

Values indicated without tolerances are intended as aids to orientation and reflect the characteristics of an average device.
Reference temperature 23° C ± 2° C. Subject to change without notice.

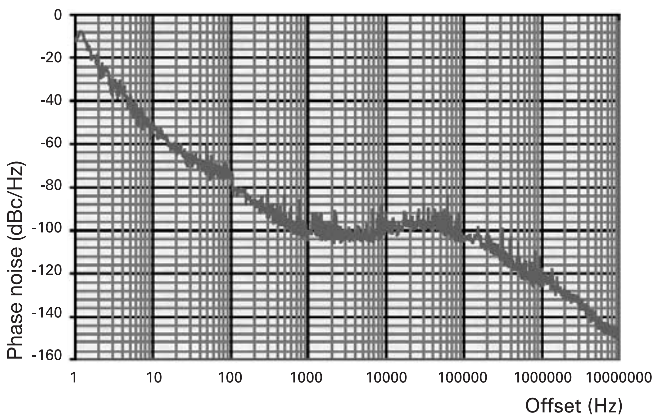
3 GHz HF Synthesizer HM8135

Product description, page 62

Frequency	
Range:	1 Hz to 3 GHz
Resolution:	1 Hz
Settling time:	‹ 10 ms

10 MHz reference (internal)	
Stability:	≤ ± 1 x 10^{-8} (0 to + 50 °C)
Aging:	≤ ± 5 x 10^{-8}/year
Output (rear panel):	TTL
Input (front panel):	Level: › 0 dBm; Frequency: 10 MHz

Spectral purity (without modulation)	
Harmonic:	≤ - 40 dBc (typ.)
Non-harmonic:	≤ - 60 dBc (› 15 kHz from carrier)
Phase noise:	(at 20 kHz from carrier)
‹ 16 MHz:	≤ - 130 dBc/Hz
16 to 250 MHz:	≤ - 95 dBc/Hz
250 to 500 MHz:	≤ - 105 dBc/Hz
500 to 1000 MHz:	≤ - 100 dBc/Hz
1000 to 2000 MHz:	≤ - 95 dBc/Hz
2000 to 3000 MHz:	≤ - 90 dBc/Hz



(Typical phase noise at 1 GHz)

Output level	
Range:	-144 to +13 dBm
Resolution:	0.1 dB
Precision:	≤ ± 0.5 dB (for level › - 57 dBm)
Impedance:	50 Ω
V.S.W.R.:	≤ 1 : 1.5

Modulation sources	
Internal:	10 Hz - 300 kHz sine wave 10 Hz - 100 kHz square wave, triangle, saw thooth
Resolution:	10 Hz
External:	(input on front panel)
Impedance:	10 kΩ
Input level:	2 V_{pp} for full scale
Coupling:	AC or DC
Output (on front panel):	Impedance; 1 kΩ; Level: 2 V_{pp}

Amplitude modulation	(level ≤ + 7 dBm)
Source:	internal or external
AM-depth:	0 to 100 %
Resolution:	0.1 %
Accuracy:	± 4 % of reading ± 0.5 % (AM depth ≤ 90 %, f_{mod} ≤ 1 kHz)
Ext. frequency resp. (to - 1 dB):	10 Hz to 300 kHz for AC
Distortion:	‹ 2 % (AM-depth ≤ 60 %, f_{mod} ≤ 1 kHz) ‹ 6 % (AM-depth ≤ 80 %, f_{mod} 10 Hz to 100 kHz)

Frequency modulation	
Source:	internal or external
Deviation:	± 200 Hz to 400 kHz (depending on frequency band)
Resolution:	100 Hz
Accuracy:	± 5 % + residual FM
Ext. frequency response: (to – 1 dB):	
DC coupling:	0 to 100 kHz
AC coupling:	10 Hz to 100 kHz
Distortion:	‹ 3 % for deviation ≥ 10 kHz

Phase modulation	
Source:	internal or external
Deviation:	0 to 3.14 rad (‹ 16 MHz) 0 to 10 rad (› 16 MHz)
Resolution:	0.01 rad
Accuracy:	± 5 % to 1 kHz + residual PM
Ext. frequency response (to – 1 dB):	
DC coupling:	0 to 100 kHz
AC coupling:	10 Hz to 100 kHz
Analog PM:	DC to 100 kHz
Distortion:	‹ 3 % for f_{mod} = 1 kHz and deviation = 10 rad

FSK modulation	
Range:	16 to 3000 MHz
Mode:	2 FSK levels
Data source:	external
Max. rate:	10 kbit/s
Shift (F1 – F0):	0 to 10 MHz
Resolution:	100 Hz
Accuracy:	see under FM

PSK modulation	
Range:	16 to 3000 MHz
Mode:	2 PSK levels
Data source:	external
Max. rate:	10 kbit/s
Shift (Ph1 – Ph0):	0 to ± 3.14 rad (‹ 16 MHz) 0 to ± 10 rad (› 16 MHz)
Resolution:	0.01 rad
Accuracy:	see under PM

Pulse modulation	
Source:	external
Dynamic range:	› 60 dB
Rise/fall times:	‹ 200 ns (typ. › 50 ns)
Delay:	‹ 100 ns
Max. frequency:	2.5 MHz
Input level:	TTL

Sweep mode	
Range:	1 Hz tos 3000 MHz
Depth:	500 Hz to 3000 MHz
Number of points:	10 to 500
Time/step:	1 ms to 1 s
Resolution:	1 ms
Mode:	free, single, manual
Trigger:	internal or external

Protective functions

The synthesiser is protected against reverse power applied on RF output up to 1 W for a 50 Ω source and against any DC source up to ± 7 V. The protection disconnects the output until manually rearmed by operator.

Miscellaneous	
Interfaces:	RS-232, 9-pole D-sub; USB (standard)
Configuration memories:	10
Operating temperature:	+ 10 to + 40 °C
Dimensions (W x H x D):	285 x 75 x 365 mm
Weight:	approx. 7 kg
Max. relative humidity:	10 to 90 % (without condensation)
Power supply:	115/230 V ± 10 %, 50/60 Hz
Power consumption:	approx. 40 VA
Safety class:	Safety Class I (EN61010-1)

Values indicated without tolerances are intended as aids to orientation and reflect the characteristics of an average device. Reference temperature 23° C ± 2° C. Subject to change without notice.

Basic Mainframe HM8001-2

Product description, page 72

General information

Mainframe with power supply accommodates 2 modules

Power supply module

2 x 8 V~ max. 0.5 A each
2 x 5 V = max. 1 A each
4 x 20 V = max. 0.5 A each
Voltages between 5 V and 20 V are programmable from each module (Polarity selectable)

Available output power:	Max. 36 Watt available for two modules. All DC voltages are electronically stabilized, floating and short-circuit proof.

Miscellaneous

Power switch (ON/OFF) located between the two modules on the front panel.

Power supply:	115/230 V~ (50/60 Hz)
Max. permissible line fluctuation: ± 10 %	
Power consumption:	max. 110 W (with overload protection)
Operating temperature:	0° C to + 40° C
Safety class:	Safety Class I (EN61010-1)
Dimensions (W x H x D):	285 x 75 x 365 mm
Weight:	approx. 4 kg
Color:	techno-brown

Subject to change without notice.

Mainframe HM8003

Product description, page 73

General information

Mainframe with power supply accommodates 1 module

Power supply module

1 x 8 V~ max. 0.5 A (5 V output without load)
1 x 5 V = max. 0.45 A (8 V output without load)
2 x 20 V = max. 0.275 A
Voltages between 5 V and 20 V are programmable from each module (Polarity selectable)

Available output power:	max. 12 Watt

Miscellaneous

Safety class:	Safety Class I (EN61010-1)
Power supply:	230 V ± 10 %, 50/60 Hz
Power consumption:	max. 40 W (with overload protection)
Operating temperature:	0 °C to + 40 °C
Dimensions (W x H x D):	200 x 75 x 280 mm
Weight:	approx. 1.9 kg
Color:	techno-brown

Subject to change without notice.

4¾-Digit Multimeter HM8010 / HM8012

Product description, page 74 / 75

DC voltage

Measurement ranges:	500 mV, 5 V, 50 V, 500 V, 600 V
Resolution:	10 µV, 100 µV, 1 mV, 10 mV, 100 mV
Accuracy:	
5 V, 500 V, 600 V:	±(0,05 % of reading +0.002 % of full scale)
500 mV, 50 V:	± (0,05 % of reading + 0.004 % of full scale)
Overload protection:	
V/Ω-HI to V/Ω-LO and to chassis:	850 V_p at max. 60 Hz or 600 V_{DC}
Low against chassis:	250 V_{rms} at max. 60 Hz or 250 V_{DC}
Input resistance:	
50 V, 500 V, 600 V:	10 MΩ II 90 pF
500 mV, 5 V:	› 1 GΩ II 90 pF
Input current:	10 A
CMRR[1)]:	≥ 100 dB (50/60Hz ± 0.5 %)
SMRR[2)]:	≥ 60 dB (50/60 Hz ± 0.5 %)

dB Mode

Accuracy:	±(0.02 dB+2 digits) (display › -38.7 dBm)
Resolution:	0.01 dB above 18 % of rating

DC current

Measurement ranges:	500 µA, 5 mA, 50 mA, 500 mA, 10 A
Resolution:	10 nA, 100 nA, 1 µA, 10 µA, 1 mA
Accuracy:	
0.5-500 mA:	± (0.2 % of reading + 0.004 % of full scale)
10 A:	±(0.3 % of reading + 0.004 % of full scale)
Voltage drop:	
10A range:	0.2 V max.
500mA range:	2.5 V max.
other ranges:	0.7 V max.

AC voltage

Measurement ranges:	500 mV, 5 V, 50 V, 500 V, 600 V
Resolution:	10 µV, 100 mV, 1 mV, 10 mV, 100 mV
Accuracy 0.5-50 V:	
40 Hz-5 kHz:	± (0.4 % of reading + 0.07 % of full scale)
20 Hz-20 kHz:	± (1 % of reading + 0.07 % of full scale)
500 V and 600 V:	
40 Hz-1 kHz:	± (0.4 % of reading + 0.07 % of full scale)
20 Hz-1 kHz:	± (1 % of reading + 0.07 % of full scale)
Overload protection:	
V/Ω-HI to V/Ω-LO and to chassis:	850 V_s at max. 60 Hz or 600 V_{DC}
Low against chassis:	250 V_{eff} at max. 60 Hz or 250 V_{DC}
Input impedance	
AC mode:	1 MΩ II 90 pF
AC + DC mode:	10 MΩ II 90 pF
Bandwidth at –3 dB:	80 kHz typical
dB mode:	20 Hz - 20 kHz
Accuracy	
–23.8 dBm to 59.8 dBm:	±0.2 dBm
Resolution:	0.01 dB above 9 mV
CMRR[1)]:	≥ 60 dB (50/60 Hz ± 0.5 %)
Crest factor:	7 max.

AC current

Measurement ranges:	500 µA, 5 mA, 50 mA, 500 mA, 10 A
Resolution:	10 nA, 100 nA, 1 µA, 10 µA, 1 mA
Accuracy:	
0.5 - 500 mA:	±(0.7 % of reading + 0.07 % v.E.)40 Hz - 5 kHz
10 A:	±(1 % of reading + 0.07 % of full scale)

AC + DC measurements

As shown for AC + 25 digits

Resistance

Measurement ranges:	500 Ω, 5 kΩ, 50 kΩ, 500 kΩ, 5 MΩ, 50 MΩ
Resolution:	10 mΩ, 100 mΩ, 1 Ω, 10 Ω, 100 Ω, 1 kΩ
Accuracy:	
500 Ω to 500 kΩ:	±(0.05 % of reading + 0.004 % of fs.+50 mΩ)
5 MΩ to 50 MΩ:	±(0.3 % of reading + 0.004 % of full scale)

Input protection max. 300 V_{rms}

Measurement current:	500 Ω-5 kΩ-range:	1 mA
	50 kΩ-range:	100 µA
	500 kΩ-range:	10 µA
	5-50 MΩ-range:	100 na

Measurement voltage: 10 V typical for open inputs, depending on the value of resistance to be measured. Negative polarity of measurement voltage is across common terminal.

Temperature

2-wire resistance measurement with linearization for PT 100 sensors as per standard EN60751

Range:	–200° C to +500° C
Resolution:	0.1° C
Measurement current:	approx. 1 mA
Display:	in ° C, ° F
Accuracy:	± 0.1° C from – 200° C to + 200° C ± 0.2° C from 200° C to 500° C (exception: sensor tolerance)

Temperature coefficient: (reference 23°C)

V =	500 mV, 50 V	30 ppm/° C
	600 V range	80 ppm/° C
	other ranges	20 ppm/° C
V ~	600 V range	80 ppm/° C
	other ranges	50 ppm/° C
mA	all ranges	200 ppm/° C
mA~	all ranges	300 ppm/° C
Ω	5 MΩ, 50 MΩ ranges	200 ppm/° C
	other ranges	50 ppm/° C

Miscellaneous

Power supply (from mainframe):

+ 5 V	300 mA
~26 V	140 mA
Operating conditions:	+ 10° C to + 40° C
Humidity:	80 % (without condensation)

Dimensions (W x H x D) (without 22-pole flat plug): 135 x 68 x 228 mm

Weight: approx. 0.5 kg

[1] Common mode rejection ratio [2] Serial mode rejection ratio

Accessories supplied: Operator's Manual, HZ15 PVC test leads, HM8012: + Software CD
Optional accessories: HZ10 Silicone test leads, HZ812 PT100 Temperature Sensor, HM8012: + Software CD

3½ -Digit Milliohm Meter HM8014

Product description, page 76

Operating mode

Milliohm measurement
Diode testing

Milliohm measurement

Measurement ranges:	200 mΩ-20 kΩ (6 ranges)
Type of measurement:	4-wire measurement (Kelvin test lead)
Resolution:	max. 0.1 mΩ
Accuracy:	200 mΩ-20 Ω: 0.25 % of reading ± 2 digits 200 Ω - 20 kΩ: 0.25 % of reading ± 1 digit

Measurement voltage and current:

Range	max. voltage[1]	Current	Test voltage
200 mΩ	6 mV	20 mA	4 mV
2 Ω	6 mV	2 mA	4 mV
20 Ω	6 mV	0.2 mA	4 mV
200 Ω	300 mV	1 mA	200 mV
2000 Ω	300 mV	100 µA	200 mV
20 kΩ	300 mV	10 µA	200 mV

Max. permissible input voltage: ± 30 V

Diode testing

Voltage measurement range:	1999 mV
Accuracy:	0.25 % of reading ± 1 digit

Measurement voltage and current:

Range	max. voltage[1]	Current	Test voltage
1999 mV	3 V	20 mA	2 V
1999 mV	3 V	2 mA	2 V
1999 mV	3 V	200 µA	2 V

Currents can be selected using pushbuttons

Max. permissible input voltage: ± 30 V

Display

3½-digit 7-segment LED display

Sampling rate: 3 measurements per second

Miscellaneous

A built-in loudspeaker emits acoustic signals at different pitches depending on the size of the measured resistance.
Volume adjustable.
Output power: 250 mW.
When headphones are used, the loudspeaker is automatically deactivated.
Zero calibration on the front panel.

Power supply (from mainframe):	+ 5 V/250 mA +7.5 V/60 mA - 5 V/60 mA (∑= 2.45 W)
Operating temperature:	+10° C to +40° C
Max. relative humidity:	80 % (without condensation)

Dimensions (W x H x D) (without 22-pole flat plug): 135 x 68 x 228 mm

Weight: approx. 0.65 kg

[1] without load

Values indicated without tolerances are intended as aids to orientation and reflect the characteristics of an average device.
Reference temperature 23° C ± 2° C.
Subject to change without notice.

Accessories supplied:
Operator's Manual, HZ17 4-wire test lead

3 kW Power Meter HM8015

Product description, page 77

Measurement functions

Voltage, current, active, reactive and apparent power and power factor

Range selection: automatic

Voltage (TRMS AC + DC)

Ranges:	50 V	150 V	300 V
Resolution:	0.1 V	1 V	1 V
Accuracy:	± (0.6 % + 5 digits) DC to 1 kHz		
Input impedance:	1 MΩ || 100 pF		
Crest factor:	max. 3.5 at full scale		

Current (TRMS AC + DC)

Ranges:	0.16 A	1.6 A	10 A
Resolution:	1 mA	1 mA	10 mA
Accuracy:	± (0.6 % + 5 digits) DC to 1 kHz		
Input impedance:	1 MΩ || 100 pF		
Crest factor:	max. 4 at full scale		
Input protection:	2x Fuse FF 15 A, 6.3 x 32 mm		

Active power measurement

Ranges:	8 W	24 W	48 W	80 W	240 W	480 W	500 W	1500 W	3000 W
Resolution:	1 mW	10 mW	10 mW	10 mW	0.1 W	0.1 W	0.1 W	1 W	1 W
Accuracy:	± (0.7 % + 5 digits) DC to 1 kHz								

Reactive power measurement

Ranges:	8 var	24 var	48 var	80 var	240 var
Resolution:	10 mvar	100 mvar	100 mvar	100 mvar	1 var
Ranges:	480 var	500 var	1500 var	3000 var	
Resolution:	1 var	1 var	10 var	10 var	
Accuracy:	± (2.5 % + 10 digits + 0.02 x Q) 20 Hz to 400 Hz Q = reactive power				

Apparent power measurement

Ranges:	8 VA	24 VA	48 VA	80 VA	240 VA
Resolution:	1 mVA	10 mVA	10 mVA	10 mVA	100 mVA
Ranges:	480 VA	500 VA	1500 VA	3000 VA	
Resolution:	100 mVA	100 mVA	1 VA	1 VA	
Accuracy:	± (0.9 % + 5 digits) 20 Hz – 1 kHz				

Power factor measurement

Display: 0.00 to 1.00

Accuracy: ± (2 % + 3 digits) 50 to 60 Hz (current and voltage at least 1/10 of full scale)

Miscellaneous

Power consumption: approx. 10 W

Operating temperature: + 10° C ... + 40° C

Max. relative humidity: 80 %

Dimensions (WxHxD) (without 22-pole flat plug) : 135 x 68 x 228 mm

Weight: approx. 0.5 kg

Values indicated without tolerances are intended as aids to orientation and reflect the characteristics of an average device.
Reference temperature 23° C ± 2° C. Subject to change without notice.

Accessories supplied: Operator's Manual
Optional accessories: HZ815 Power Adapter

3½ -Digit LC Meter HM8018

Product description, page 78

Operating modes

C measurement
L measurement
Series inductance L, Shunt capacitance C
Series resistance R, Parallel conductance G

Measurement ranges

L: 200 µH-200 H (7 ranges)
Rs: 20 Ω-200 kΩ (5 ranges)
C: 200 pF-200 µF (7 ranges)
G: 20 µS-200 mS (5 ranges)

Max. resolution: 0.1 pF, 0.1 µH, 0.01 Ω, 0.01 µS

Measurement frequencies: (sine wave signal) ~160 Hz, 1.6 kHz, 16 kHz ($\omega = 10^3, 10^4, 10^5\ s^{-1}$)

Measurement voltage: max. 1 V_{pp}

Measurement current: max. 36 mA (eff.)

Power output to device under test: max. 3.2 mW

Measurement accuracy: ± 0.5 % of reading +(3 digit s + 0.5 pF / 0.5 µH / 10 mΩ/0.01 µS)

Measurement error resulting from separation of the real and imaginary part ≤1 % at tanφ ≥ 1

Display

3½-digit 7-segment LED display

Sampling rate: 2 measurements per second

Type of measurement: 2- or 4-wire measurement

Miscellaneous

Inputs are short-circuit-proof and overvoltage protected up to 100 V with a maximum energy consumption of 10 mJ (≙ capacitor 2 µF, charged to 100 V).

Polarization voltage for C measurement: 2 V

Zero point correction for display
Compensation of probe capacitance (HZ18)
AC voltage proportional to display at the rear BNC connector (HM8001 with HM801 Option)

Power supply (from mainframe): +5 V/200 mA, -13 V/130 mA, +13 V/130 mA (∑ = 4.5 W)

Operating temperature: + 10° C to + 40° C

Max. relative humidity: 80 % (without condensation)

Dimensions (W x H x D) (without 22-pole flat plug): 135 x 68 x 228 mm

Weight: approx. 0.65 kg

Values indicated without tolerances are intended as aids to orientation and reflect the characteristics of an average device.
Reference temperature 23° C ± 2° C.
Subject to change without notice.

Accessories supplied:
Operator's Manual
Optional accessories:
Kelvin test lead HZ18

1.6 GHz Universal Counter HM8021-4

Product description, page 79

Measurement functions

Frequency A/C, Period A;
Totalize A;
Pulse width ⎍ / ⊔ (averaged);
Totalize A during ext. gate

Input characteristics (Input A)

Frequency range:
0 – 150 MHz: DC-coupled
10 Hz – 150 MHz: AC-coupled

Sensitivity: (normal triggering)
DC – 80 MHz: 20 mV_{rms} (sine wave), 80 mV (pulse)
80 MHz – 150 MHz: 60 mV_{rms} (sine wave)
20 Hz – 80 MHz, (auto trig.): 50 mV_{rms} (sine wave)

Minimum pulse width: 5 ns

Input noise: 100 µV (typ.)

Coupling: AC or DC (switchable)

Input impedance:	1 MΩ II 40 pF
Attenuator:	x 1, x 20 (switchable)
Max. input voltage:	
0 to 440 Hz:	400 V (DC + AC_{peak})
1 MHz:	decreasing to 8 V_{rms}

Input characteristics (Input C)

Frequency range:	100 MHz – 1.6 GHz
Sensitivity:	
to 1.3 GHz:	30 mV (typ. 20 mV)
to 1.6 GHz:	100 mV (typ. 80 mV)
Input impedance:	50 Ω nominal
Coupling:	AC
Max. input voltage:	5 V (DC + AC_{peak})

Input characteristics (external gate)

Input impedance:	4.7 kΩ
Max. input voltage:	±30 V
High/low level:	› 2 V/‹ 0.5 V
Min. pulse duration:	50 ns
Min. effective gate time:	150 µs

Frequency measurement (Input A)

LSD:	(2.5x10^{-7}s x freq.)/measurement time
Resolution:	±1 or 2 LSD

Period duration measurement

Range:	10000 sec to 66.6 ns
LSD:	(2.5 x 10^{-7}s x period)/measurement time
Resolution:	±1 or 2 LSD

Totalize (manual / external gated)

Range:	DC to 20 MHz
Min. pulse duration:	25 ns
LSD:	±1 count
Resolution:	LSD
Ext. gate error:	
in manual mode only	100 ns

Time interval (averaged)

LSD:	100 ns to 10ps
Resolution:	1 or 2 LSD

Offset

Range:	covers the entire measurement range

Gate time

(Gate time cannot be less than 1 period.)

Range:	100 ms – 10 s in 3 steps
External gate time:	min. 150 µs

Timebase

Frequency:	10 MHz clock
	10 MHz crystal
Accuracy (between 10° C and 40° C):	
	±5 x 10^{-7}
Aging:	±3 ppm/15 years

General information

Display:	8-digit 7-segment LED display with 7.65 mm digit height, sign and exponent
Power consumption:	approx. 7 Watt
Ambient temperature:	+10° C to +40° C
Max. relative humidity:	10 % – 90 % (without condensation), 5 % – 95 % RH
Dimensions (W x H x D):	135 x 68 x 228 mm
Weight:	approx. 0.6 kg

Values indicated without tolerances are intended as aids to orientation and reflect the characteristics of an average device.
Reference temperature 23° C ± 2° C. Subject to change without notice.

Accessories supplied:
Operator's Manual
Optional accessories:
HZ33 BNC Test Cable; **HZ34**; **HZ36** Probe; **HZ24** Attenuators; **HZ20** BNC banana adapter; HO85OCXO; **HZ10** Silicone test leads

Distortion Meter HM8027

Product description, page 80

Frequency range

20 Hz - 20 kHz
subdivided into 3 ranges
variable frequency control 10:1, overlapping ranges

Distortion measurement range

	0.01 % - 50 %, subdivided into 2 ranges
Full range:	10 % and 100 %
Display resolution:	100 % range: 0.1 %
	10 % range: 0.01 %

Display accuracy

100 % range:	±5 % ±1 digit for k ≤ 10 %
10 % range:	±5 % ±1 digit for k ≤ 1 %

Inherent distortion + noise

≤ 0.5 digit

Fundamental rejection

30 dB greater than the measured distortion factor
or ≥ 70 dB in the 100 % range
or ≥ 90 dB in the 10 % range

Input voltage

min. for 100 % calibration: 300 mV
max. for 100 % calibration: 50 V

Input impedance

100 kΩ

Monitor output

Output voltage:	1 mV/digit (short-circuit proof)
Output impedance:	10 kΩ

Input attenuation

1 constant attenuator – 20 dB
1 constant attenuator – 10 dB
1 variable attenuator – 15 dB

Miscellaneous

1 selectable high-pass filter: 1 kHz, 12 dB/octave

Power supply (from mainframe):	+12 V/60 mA
	- 12 V/60 mA
	+5 V/100 mA
	(∑ = 1.94 W)
Operating temperature:	+10° C tos +40° C
Max. relative humidity:	80 % (without condensation)
Dimensions (W x H x D) (without 22-pole flat plug):	135 x 68 x 228 mm
Weight:	approx. 0.65 kg

Values indicated without tolerances are intended as aids to orientation and reflect the characteristics of an average device.
Reference temperature 23° C ± 2° C.
Subject to change without notice.

Accessories supplied:
Operator's Manual
Optional accessories:
BNC Test Cabl HZ33, HZ34, BNC banana adapter HZ20, Silicone test leads HZ10

10 MHz Function Generator HM8030-6

Product description, page 81

Operating modes

Sine, square, triangle, pulse; free running, internal sweep or external frequency modulation, with or without DC offset

Frequency ranges

0.05 Hz to 10 MHz in 8 ranges, variable: x 0.09 to x 1.1 (12:1)

Frequency drift:	‹0.5 %/hr or 0.8 %/24 hrs. at constant ambient temperature

Waveform characteristics

Sine wave distortion	
0.05 Hz to 1 MHz:	max. 0.5 %
1 MHz to 10 MHz:	max. 5 %
Square wave rise time:	typ. 15 ns
Overshoot:	‹5 % (for termination into 50 Ω)
Triangle non-linearity:	‹1 % (to 100 kHz)

Displays

Frequency:	5-digit, 7-segment LED, each 8 x 5 mm
Accuracy:	up to 5 Hz: ± (1 % + 3 digits) 5 Hz to 10 MHz: ± (5 x 10^{-5} + 1 digit)

LED indicators for mHz, Hz, kHz and sec

Outputs

Signal output:	short-circuit proof,
protected against ext. voltage	up to ± 45 V_{DC} max. (30 sec.)
Impedance:	50 Ω
Output voltage:	10 V_{pp} into 50 Ω load; 20 V_{pp} (open circuit)
Attenuation:	max. 60 dB
2 attenuators:	each 20 dB ± 0.2 dB
Variable:	0 to 20 dB
Amplitude error:	(sine wave/triangle)
0.05 Hz to 0.5 MHz:	max. 0.2 dB
0.05 MHz to 10 MHz:	max. 0.5 dB
DC offset:	variable (on/off, except pulse function)
into 50 Ω load:	max. ±2.5 V
in open circuit:	max. ±5 V
Trigger output:	square wave synchronous to signal output, approx. +5 V/TTL

FM input

(VCF, BNC connector on rear panel of HM8001-2 and option HO801)

Frequency deviation:	approx. 1 : 100
Input impedance:	6 kΩ II 25 pF
Input voltage:	max. ± 30 V

Internal sweep

Sweep speed:	20 ms to 15 s
Sweep range:	approx. 1:100

Miscellaneous

Power supply (from mainframe):	+5 V/200 mA +16 V/300 mA; -16 V/250 mA (∑=9.8 W).
Operating temperature:	+10° C to +40° C
Max. relative humidity:	80 % (without condensation)
Case dimensions (W x H x D) (without 22-pole flat plug):	135 x 68 x 228 mm
Weight:	approx. 0.80 kg

Values indicated without tolerances are intended as aids to orientation and reflect the characteristics of an average device.
Reference temperature 23° C ± 2° C.
Subject to change without notice.

Accessories supplied:
Operator's Manual
Optional accessories:
BNC Test Cable HZ33, HZ34, 50 W feed-through terminal HZ22, Silicone test leads HZ10

20 MHz Pulse Generator HM8035

Product description, page 82

Operating modes

Internal, external and manual triggering

Frequency range

2 Hz to 20 MHz, 7 ranges, variable control (› 10 : 1)

Duty cycle:	up to 2 MHz: 50 % ± 10 ns 2 MHz to 20 MHz: 50 % (± 5 % + 10 ns)
Jitter:	≤ ± 0.1 %
Pulse duration:	20 ns to 200 ms 7 ranges variable control (› 10 : 1)
Jitter:	≤ ± 0.1 %
Single pulses:	triggered by key
Pulse duration:	≤ 20 ns to ≥ 200 ms

Pulse characteristics

Rise/fall time:	≤ 3 ns + (0.04 ns/°C); V_a ≤ 4 V, 10-90 %
Overshoot:	≤ 5 % of pulse amplitude
Ringing:	≤ ± 5 % of pulse amplitude (10 ns after pulse edge; 2 Hz – 2 MHz)
Preshoot:	≤ ± 5 % of pulse amplitude

Dual outputs (short-circuit proof)

+ Amplitude:	max. + 5 V into 50 Ω load against ground variable from +2 V_p to +5 V_p
- Amplitude:	max. - 5 V into 50 Ω load against ground variable from -2 V_p to –5 V_p
Attenuation:	1:2.5 (- 8 dB) (variable from ±0.8 V_p to ±5 V_p)
Source impedance:	50 Ω (both outputs)

External trigger input

Pulse sequence frequency:	0 to 20 MHz
Pulse duration:	20 ns min.
Trigger delay:	approx. 20 ns
Trigger level:	square wave + 1 V_p, TTL-compatible sine wave 1 V_p
Max. input voltage:	± 30 V

Trigger output (short-circuit proof)

Amplitude:	0 / +1.9 V_p into 50 Ω load, 0 /‹ + 4 V_p open circuit TTL-compatible
Rise/fall time:	approx. 10 ns
Aberration:	approx. ± 10 % of pulse amplitude
Duty cycle:	identical to non-inverted signal
Delay:	approx. 10 ns fixed, leading

Miscellaneous

Power supply (from HM8001-2):	+ 5 V/250 mA + 20 V/260 mA -20 V/270 mA (∑=11.9 W)
Operating temperature:	+ 10° C to + 40° C
Max. relative humidity:	80 % (without condensation)
Dimensions (W x H x D) (without 22-pole flat plug):	135 x 68 x 228 mm
Weight:	approx. 0.80 kg

Values indicated without tolerances are intended as aids to orientation and reflect the characteristics of an average device.
Reference temperature 23° C ± 2° C.
Subject to change without notice.

Accessories supplied:
Operator's Manual
Optional accessories:
HZ33/34 BNC Test Cable; HZ22 50 Ω feed-through termination; HZ10 Silicone test leads

50 kHz Low-Distortion Sine Wave Generator HM8037

Product description, page 83

Operating modes

Sine wave, continuous, amplitude-regulated

Frequency range:

5 Hz bis 50 kHz, unterteilt in 4 dekad. Stufen
variable control 10:1, overlapping ranges

Frequency drift

(Frequency control in center position)

15 min.	0.08 %	(50 kHz range)
8 hrs.	0.6 %	(50 kHz range)
15 min.	0.08 %	(in all other ranges)
8 hrs.	0.5 %	(in all other ranges)

Frequency display

3-digit, 7-segment LED display

Display accuracy: ±1 digit

Distortion factor

5 Hz - 20 Hz:	max. 0.03 %
20 Hz -10 kHz:	max. 0.01 %
1 kHz:	typ. 0.005 %
10 kHz - 20 kHz:	max. 0.03 %
20 kHz - 50 kHz:	max. 0.05 %

Signal output (short-circuit proof)

Output voltage:	1.5 V into 600 Ω
Internal resistance:	approx. 600 Ω
Amplitude flatness: (5 Hz to 50 kHz)	max. ±0.2dB
Attenuation:	min. 60 dB 2 fixed attenuators: each 20 dB ± 0.2 dB
variable control:	0 dB to 20 dB
Amplitude stability:	0.12 % (4 hrs.)

Synchronous output (short-circuit proof)

Output voltage:	2 V_{pp}, sine wave
Internal resistance:	ca. 1 kΩ

Miscellaneous

The outputs can be isolated from the case ground by pressing a key.

Power supply (from HM8001-2):	+5 V/120 mA +15 V/30 mA –15 V/30 mA (∑ = 6.3 W)
Operating temperature:	+10° C to +40° C
Max. relative humidity:	80 % (without condensation)
Dimensions (W x H x D) (without 22-pole flat plug):	135 x 68 x 228 mm
Weight:	approx. 0.65 kg

Values indicated without tolerances are intended as aids to orientation and reflect the characteristics of an average device.
Reference temperature 23° C ± 2° C.
Subject to change without notice.

Accessories supplied:
Operator's Manual
Optional accessories:
HZ33/34 BNC Test Cable; HZ22 50 Ω feed-through termination; HZ10 Silicone test leads

Triple Power Supply HM8040-3

For technical specifications see page 119

Curve Tracer HM6042

Product description, page 87

Measurement ranges

3 voltage ranges:	collector/drain voltages ≤ 2 V, 10 V, 40 V ±5 %
3 current ranges:	collector/drain currents ≤ 2 mA, 20 mA, 200 mA ±5 %
3 power ranges:	output power ≤ 0.04 W, 0.4 W, 4W ±10 %
Basis/gate voltages and currents:	
I_B	1 µA to 10 mA
V_B	to 2 V ±5 %
V_G	to 10 V ±5 %

Measurement accuracy

Measurement accuracy of static values:	
$V_{C/D}$	± (2 % of rdg. + 3 digits)
$I_{C/D}$	± (2 % of rdg. + 3 digits)
I_B	± (2 % of rdg. + 3 digits)
V_B	± (2 % of rdg. + 3 digits)
V_G	± (3 % of rdg. + 3 digits)
β	to 1000: ± (5 % of rdg. + 3 digits) to 100000: ± [(6 + 0,001 x β)%of rdg. +3 digits]
Measurement accuracy of dynamic values:	
h11	≤ 1000 Ω ± (12 % of rdg. + 3 digits) ≥ 1000 Ω ± [(12 + 0.001 Mw.)% of rdg. +3 digits]
h21	≤ 100 ± (12 % of rdg. + 3 digits) ≥ 1000 ± [(12 + 0.001 Mw.)% of rdg. +3 digits]
y21	≤ 1 S ± (12 % of rdg. + 3 digits)
h/y22	≤ 1 S ± (12 % of rdg. + 3 digits)

Other Functions

Storing of a reference measurement value, e.g. for support in component selection

Cursor measurement functions:	
single mode:	One cursor marks the position on the measurement reading display.
tracking mode:	Two cursors mark the positions at which the readings for the dynamic values were taken.
Analysis of curves for:	diodes, zener diodes NPN/PNP transistors FET/MOS-FET (N/P channel) thyristors (to a limited extent only)
Display:	LCD Display of values in the curve set Screen display of 5 curves, max.

Miscellaneous

CRT:	D14-364GY/123 oder ER151-GH/-, rectangular (8 x 10 cm), internal graticule
Acceleration voltage:	approx. 2 kV
Trace rotation:	adjustable on front panel
Power supply:	100-240 V ~ ±10 %, 50/60 Hz
Power consumption:	approx. 36 Watt at 50 Hz
Operating temperature:	0° C to +40° C
Safety class:	Safety Class I (EN61010-1)
Color:	techno-brown
Dimensions (W x H x D):	285 x 125 x 380 mm Lockable tilt handle
Weight:	approx. 5.6 kg

Values indicated without tolerances are intended as aids to orientation and reflect the characteristics of an average device.
Reference temperature 23° C ± 2° C.
Subject to change without notice.

Accessories supplied:
Operator's Manual, power cable, plug-in test adapter

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