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 setups quickly and cost effectively to changing requirements. You save space by stacking up to 5 instruments. This will offer you 10 instruments in a minimum of space. 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 power supplies, spectrum analyzers and oscilloscopes.

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 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 600 V_{DC}/600 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	
$\overline{v^2_{(t)}}$	voltage squared	
$\lvert\overline{v}\rvert$	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	
$\cos\varphi$	power factor, valid only for sine waves	
PF	power factor, general, for non-sinusoidal wave forms	

Arithmetic mean value

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

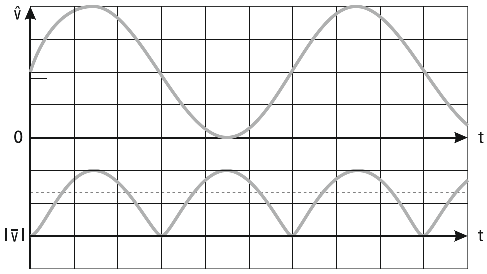
The arithmetic mean of a periodic signal is the average taken over one period T. This is equivalent to the DC content of the signal.

- 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 $\overline{x^2(t)}$ 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:

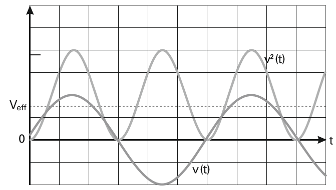
$$x_{(rms)} = \sqrt{\frac{1}{T}\int_0^T x_{(t)}^2\,dt}$$

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.

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



RMS Value

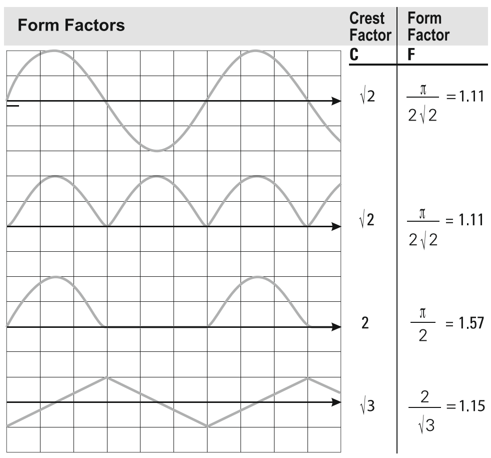
Form Factor

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:

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



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 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 **HM8018 LCR Meter** is a full-featured application-oriented measuring instrument. In addition to the standard measurement functions L, C, and R the HM8018 also allows to measure phase angles, impedances, losses; its basic accuracy is 0.2 %. Either the series or the parallel component parameters may be measured. Further, the display of ratios and offsets is possible, the instrument calculates these values from the measurement results and reference values stored. Parasitic impedances of the measurement leads may be compensated

HM8018 LCR Meter

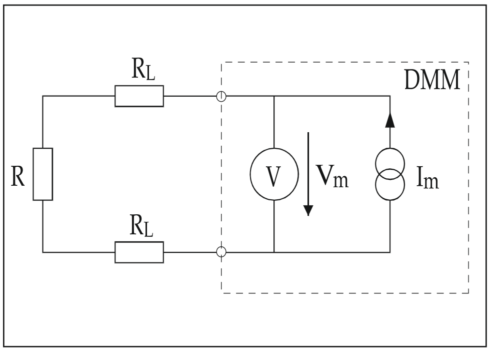
by an open and short calibration procedure. Optimum adaptation of the instrument to the unit under test is assured by 5 frequencies (100 Hz, 120 Hz, 1 kHz, 10 kHz, 25 kHz) and 6 measuring ranges which may be selected automatically or manually. For measurements on aluminum and tantalum electrolytic capacitors a bias voltage of 1 V is provided.

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.

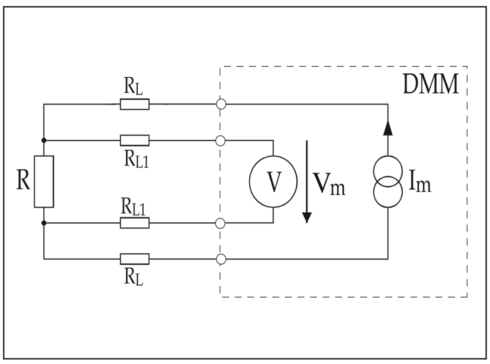
If this correction is not used the resistance values obtained will always be on the high side as the sum of all parasitic resistances in the measuring circuit will be included in the result.



Principle of two-wire resistance measurement

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

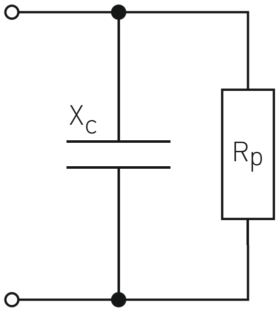


Principle of four-wire resistance measurement

resistor R 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.

The instrument terminals which are used for measuring the voltage drop directly at the unknown resistor are called the SENSE input. The input resistance R_{L1} of the SENSE input is very high so that the current caused by this input resistance is extremely small and thus negligible.

Losses of a capacitor



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

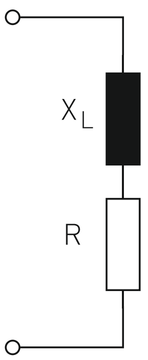
$$\tan\delta = \frac{X_c}{R_p}$$

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

$$\delta = 90° - \varphi$$

$\tan\delta$	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



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

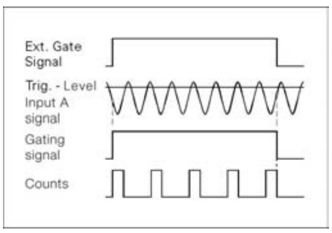
$$Q = \frac{1}{\tan\delta}$$

$$\delta = 90° - \varphi$$

$\tan\delta$	loss tangent
X_L	capacity reactance
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.



EXT Gate-Signal

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.

Signal Generators

The HAMEG HM8030-6 Signal Generator is a very cost-effective alternative to standalone instruments.

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.

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.