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Instruments

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Distortion Meter HM 8027



Distortion Meter HM8027

- **Frequency Range:** 20Hz to 20kHz
- **Resolution:** 0.01%, maximum
- **Display:** 3 Digit LED
- **Automatic Frequency Fine-Tuning**
- **Monitor Output for Distortion Analysis**

The **HM8027** Distortion Meter was developed for the measurement of harmonic distortion in the audio frequency range.

Due to its **low inherent distortion of 0.005%** (1kHz), it is ideally suited for tests and measurements of high-grade audio systems.

The digital display allows distortion readout with a maximum resolution of **0.01%**. In addition, the **HM8027** has the option to visually **check the residual distortion** of the measured signal on an oscilloscope connected to its control output. This feature enables a qualitative evaluation of the

reading for signals with noise or cross-over distortion beyond the indicated distortion value. Test frequency adjustments are performed via a rotary dial and push-button frequency range selectors. The **automatic frequency fine-tuning** with a 15% capture range ensures fast and easy operation of the **HM8027**.

The Distortion Meter **HM8027**, combined with the Sine Wave Generator **HM8037**, provides a complete test system to be used primarily in the audio frequency range. The clearly arranged front panel assures problem-free operation.

Specifications

(Reference Temperature: 23°C ± 1°C)

Frequency Range:

Frequency Range: 20Hz to 20kHz

Range Steps: 3 Decade Steps

Variable Frequency Control: 10:1 (overlapping ranges)

Distortion Measurement Range:

Measurement Range: 0.01% - 50%
divided in 2 ranges

Full Range: 10% and 100%

Resolution:

100% Range: 0.1%

10% Range: 0.01%

Accuracy:

100% Range: ±5% ±1 digit for $k \leq 10\%$

10% Range: ±5% ±1 digit for $k \leq 1\%$

Residual Distortion and Noise: ≤ 0.5 digit

Fundamental Rejection:

30dB greater than measured distortion factor

or ≥70dB in the 100% range

or ≥90dB in the 10% range

Input Voltage:

min. for 100% Calibration: 300mV

max. for 100% Calibration: 50V

Input Impedance: 100kΩ

Monitor Output:

Output Voltage: 1mV/digit
(short circuit proof)

Output Impedance: 10kΩ

Attenuators:

(1 pushbutton switch) -20dB

(1 pushbutton switch) -10dB

(1 continuous variable attenuator) -15dB

General Information:

1 switch selectable high-pass filter 1kHz,

12dB/Octave

Supply Voltages (from HM8001):

+12V/60mA

-12V/60mA

+5V/100mA

($\Sigma = 1.94W$)

Operating conditions:

0°C to +40°C

Max. Relative Humidity: 80%

Dimensions (without 22-pin flat connector):

W135, **H**68, **D**228mm

Weight: approx. 650g

Values without tolerances are meant to be guidelines and represent characteristics of the average instrument.

General information

The operator should not neglect to carefully read the following instructions and those of the mainframe HM8001, to avoid any operating errors and to be fully acquainted with the module when later in use. After unpacking the module, check for any mechanical damage or loose parts inside. Should there be any transportation damage, inform the supplier immediately and do not put the module into operation.

This plug-in module is primarily intended for use in conjunction with the Mainframe HM8001. When incorporating it into other systems, the module should only be operated with the specified supply voltages.

Safety

This instrument has been designed and tested in accordance with **IEC Publication 1010-1, Safety requirements for electrical equipment for measurement, control, and laboratory use**. It corresponds as well to the CENELEC regulations EN 61010-1. All case and chassis parts are connected to the safety earth conductor. Corresponding to Safety Class 1 regulations (three-conductor AC power cable). Without an isolating transformer, the instruments power cable must be plugged into an approved three-contact electrical outlet, which meets International Electrotechnical Commission (IEC) safety standards.

Warning!

Any interruption of the protective conductor inside or outside the instrument or disconnection of the protective earth terminal is likely to make the instrument dangerous. Intentional interruption is prohibited.

The instrument must be disconnected and secured against unintentional operation if there is any suggestion that safe operation is not possible. This may occur:

- if the instrument has visible damage,
- if the instrument has loose parts,
- if the instrument does not function,
- after long storage under unfavourable circumstances (e.g. outdoors or in moist environments),
- after excessive transportation stress (e.g. in poor packaging).

When removing or replacing the metal case, the instrument must be completely disconnected from the mains supply. If any measurement or calibration procedures are unavoidable on the opened-up instrument, these must only be carried out by qualified personnel acquainted with the danger involved.

Symbols as Marked on Equipment



ATTENTION refer to manual.



DANGER High voltage.



Protective ground (earth) terminal.

Operating conditions

The ambient temperature range during operation should be between +10°C and +40°C and should not exceed -40°C or +70°C during transport or storage. The operational position is optional, however, the ventilation holes on the HM8001 and on the plug-in modules must not be obstructed.

Warranty

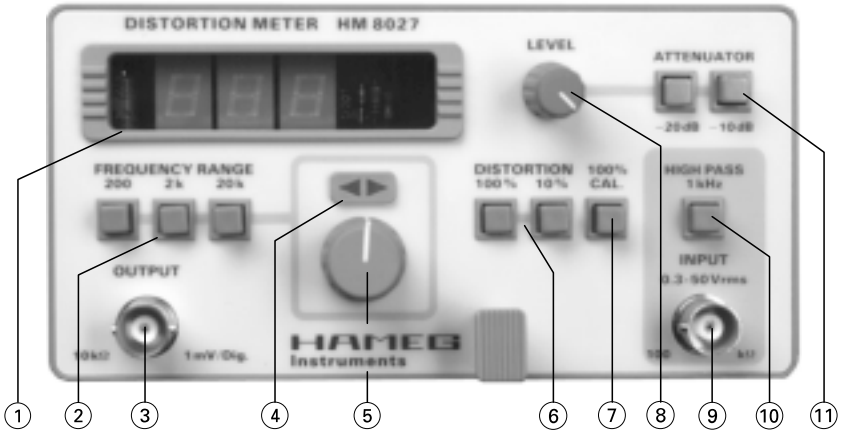
Before being shipped, each plug-in module must pass a 24 hour quality control test.

Provided the instrument has not undergone any modifications Hameg warrants that all products of its own manufacture conform to Hameg specifications and are free from defects in material and workmanship when used under normal operating conditions and with the service conditions for which they were furnished. The obligation of HAMEG hereunder shall expire two (2) years after delivery and is limited to repairing, or at its option, replacing without charge, any such product which in Hamegs sole opinion proves to be defective with the scope of this warranty. This is Hamegs sole warranty with respect to the products delivered hereunder. No statement, representation, agreement or understanding, oral or written, made by an agent, distributor, representative or employee of, which is not contained in this warranty will be binding upon Hameg, unless made in writing and executed by an authorized Hameg employee. Hameg makes no other warranty of any kind whatsoever, expressed or implied, and all implied warranties of merchantability and fitness for a particular use which exceed the aforesaid obligation are hereby disclaimed

by Hameg be liable to buyer, in contract or in tort, for any special, indirect, incidental or consequential damages, expenses, losses or delays however caused.

In case of any complaint, attach a tag to the instrument with a description of the fault

observed. Please supply name and department, address and telephone number to ensure rapid service. The instrument should be returned in its original packaging for maximum protection. We regret that transportation damage due to poor packaging is not covered by this warranty.



- (1) DIGITAL DISPLAY** (7-segment LEDs)
3-digit display for indication of the measured distortion factor in %.
- (2) FREQUENCY RANGE** (Pushbutton switches)
Selection of frequency range for signal under test. (20Hz-200Hz, 200Hz-2kHz, 2kHz-20kHz).
- (3) OUTPUT** (BNC connector)
Monitor output for distortion factor. (Residual distortion). Output Voltage is 1mV/digit.
- (4) TUNING INDICATOR** (LEDs)
If the built-in filter is incorrectly tuned, one of the two LEDs will indicate in which direction the filter frequency deviates from the input frequency. Turn the tuning knob in the opposite direction until the LED goes out.
- (5) TUNING** (Adjusting knob)
Permits tuning of the built-in filter for maximum rejection of the fundamental wave. Fine tuning is automatic with a capture range of approx. 15%. If both LEDs (4) are off, the filter is properly synchronised.
- (6) DISTORTION** (Pushbutton switches)
Range selection for 10% or 100% full scale.
- (7) 100%-CALIBRATION** (Pushbutton switch)
Selection of calibration mode. Adjustment for 100% reading with LEVEL (8).
- (8) LEVEL** (Adjusting knob)
Continuous attenuation of input signal up to max. 15dB to achieve 100% reading when in the calibration mode.
- (9) INPUT** (BNC connector)
Input for measurement signal. The permissible input voltage range is 0.3V - 50V for a valid measurement.
- (10) 1kHz HIGH-PASS** (Pushbutton switch)
1kHz high-pass filter with a roll off of 12dB/octave for rejection of low frequency hum and noise.
- (11) ATTENUATOR** (Pushbutton switch)
Input signal attenuation with two pushbutton switches of 20dB or 10dB attenuation, respectively. They can be used separately. Both pushbutton switches activated, together with the variable attenuator (9) must enable a 100% reading when in the calibration mode, otherwise the input voltage should be adjusted.

General

A distortion factor meter is used to measure the distortion content of an otherwise pure sine wave signal. The proportion of distortion is displayed as a percentage of the measured signal.

Distortions, in general, represent undesired components of a signal being produced by or passing through a non-linear system. There are different kinds of distortion, which are more or less pronounced depending on the type of system used for measurement set-up. Harmonic distortions occurring e.g. in signal generators consist of undesired frequencies which are integer multiples of the generated frequency. These harmonics of different order vary in phase and amplitude. They are detected as effective values during distortion measurement.

The most frequently measure used for describing nonlinear distortions is the distortion factor. It specifies the share of harmonics in the total signal. There are two different sorts of distortion factors: The overall distortion factor designated „d“, and the n-th order factor „dn“ which is also called partial distortion factor or distortion coefficient. A distortion meter, such as the HM8027 model, determines the overall distortion factor (d) defined by the following formula:

$$d = \frac{\sqrt{U_{2f1}^2 + U_{3f1}^2 + U_{4f1}^2 + \dots}}{U_{\text{tot}}}$$

d = distortion factor (without dimension)

$U_{2f1}, U_{3f1}, U_{4f1}, \dots$ = Voltage of harmonics

f1 = frequency of measuring signal (Hz)

U_{tot} = voltage of distorted measuring signal

(all voltages are rms values)

100% calibration

The signal to be investigated is to be applied to the INPUT socket (9). Via this socket, the HM8027 module accepts input voltages ranging from 0.3V to 50V. Within this voltage range, the instrument can be adjusted to

100% full deflection. Smaller voltages permit no 100% adjustment, thereby leading to inaccurate distortion factor readings; higher voltages are also situated beyond the adjustment range and can result in destruction of the HM8027 input stages. Within the admissible voltage range, the signal is adapted by use of two attenuators (11) and the calibration knob (8).

The alignment mode is selected by pressing the CALIBRATION pushbutton (7). When the 100% calibration is completed, the frequency alignment is then carried out. A new 100% calibration is only required when the input signal amplitude has been changed.

Frequency alignment

During frequency alignment, the frequency of the integrated filter is tuned to the input signal frequency. First the FREQUENCY RANGE pushbuttons (2) are pressed to select the range of the input signal frequency. The available frequency ranges are subdivided as follows:

20Hz to 200Hz,
200Hz to 2kHz,
2kHz to 20kHz.

The continuous adjustment within the selected range is performed by means of knob (5). During this coarse adjustment, one of the two LEDs indicates the direction of the frequency deviation of the integrated filter with respect to the input signal; i.e. when the LED on the right lights up, the adjustment knob must be turned counter clockwise, until the LED goes off, and vice versa. When both LEDs are off, the alignment procedure is completed. Fine adjustment is carried out by the integrated automatic alignment circuitry with a capture range of about 15%.

Selection of the distortion range

When the frequency alignment has been accomplished, the desired measurement range is selected by pressing the DISTORTION pushbuttons (6). In case of unknown magnitude of the distortion factor,

the 100% range should be selected first, otherwise the display will start flashing as soon as the full-deflection value of the measurement range is exceeded. In case of insufficient resolution of the display, the next smaller measurement range should be selected. The two measurement ranges only differ with respect to the obtainable resolution, i.e. resolution of 0.1% in the 100% range and of 0.01% in the 10% measurement range. The difference in suppression of the fundamental wave in the two measurement ranges is not visible on the display, because the inherent distortion and noise of the HM8027 unit are less than 0.5 digit. These values are only significant during evaluation of the signals via the monitor output (see the "OUTPUT" section). The distortion factor is directly read out on the display in percent, requiring no further conversion. The read-out range extends from 99.9% to 0.1% or from 9.99% to 0.01%, respectively.

Analysis of the measurement result

When measuring mains-operated equipment, the test signal is often deteriorated by low-frequency interferences. To eliminate a part of these interferences, a high-pass filter with a cut-off frequency of 1 kHz and a roll-off characteristic of 12dB/Oct. can be inserted into the signal path. This will efficiently suppress any mains-frequency interference for distortion measurement of frequencies above 1kHz. When measuring any signals near the upper frequency range limit of the HM8027 module, the frequency response of the internal measurement amplifier should be taken into consideration. Its high-end cut-off frequency is around 80kHz (-3dB). This means that the harmonics contained in a test signal having a fundamental frequency of 20kHz are only evaluated up to the third order. Likewise, the noise bandwidth is limited to 80kHz. A further evaluation of the residual distortion can be carried out via the OUTPUT socket (3). This socket is used for qualitative evaluation of distortions excluding the fundamental wave of the test signal, e.g. by means of an oscilloscope. It can be determined whether the displayed distortion

factor is caused by linear distortions or by noise. Due to the specified sensitivity of 1 mV per indicated digit, a further evaluation of the distortion measurement is possible beyond the specified resolution of the HM8027 unit. For this purpose, a 4½ digit multimeter, e.g. the HM8011-3 module, is connected to socket (3). Now the distortion can be read out directly from the multimeter display in the 200 mV AC range. A read-out of 00.75 (mV) corresponds to a distortion factor of 0.0075%. The evaluation capability is limited by the inherent distortion and noise of the HM8027 module.

Operational check

Measuring equipment required

- 1 Low Distortion Generator HM8037
- 2 Generators HM8030-3 or 8037
- 1 Digital Multimeter HM8011-3 or any other with 200mV AC range.

Check of input sensitivity

Setting: (2) (7) (8) (11) (10)
2k Cal. max. 0dB released

- 1) Adjust output voltage of HM8037 to 300mV at 1kHz.
- 2) Connect the output of HM8037 to the input (9) of HM8027.
- 3) With the above setting the display (1) of the HM8027 should indicate a value ≥ 100 .

Check of input signal attenuation

Setting: (2) (7) (8) (11) (10)
2k Cal. max. 0dB released

- 1) Connect the output of HM8037 to the input (9) of the HM8027.
- 2) Adjust readout (1) to 100 by means of the amplitude control of the Sine Wave Generator HM8037.
- 3) Check the following values:

- (8)Min. Stellung, (11)=0dB, Display ≤ 19
- (8)Max. Stellung, (11)=-10dB, Display ≤ 30
- (8)Max. Stellung, (11)=-20dB, Display ≤ 10

Check of monitor output

Setting: (2) (7) (8) (11) (10)
2k Cal. max. 0dB released

- 1) Connect the output of HM8037 to the input **(9)** of HM8027.
- 2) Adjust output voltage of Sine Wave Generator HM8037 at 1 kHz to get a readout **(1)** of 100 on HM8027.
- 3) Measure the output voltage at the monitor output **(3)** of HM8027 using DMM HM8011-3. The obtained value should be $100\text{mV} \pm 5\%$.

Check of high pass filter

Setting: (2) (7) (8) (11) (10)
2k Cal. 100% Cal. released

- 1) Set frequency of Sine Wave Generator HM8037 to 100 Hz.
- 2) Calibrate display **(1)** of HM8027 to 100.
- 3) Select 100%-distortion range with one of the pushbuttons **(6)**.
- 4) Switch high-pass filter on by pushing pushbutton **(10)**.
- 5) Check display **(1)** for ≤ 5 .

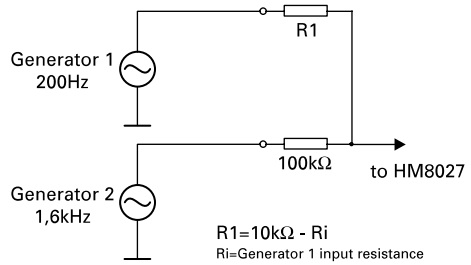
Check of residual distortion

- 1) Connect the output of HM8037 to the input **(9)** of HM8027.
- 2) Calibrate readout **(1)** of HM8027 to 100.
- 3) Check readout **(1)** of HM8027 for ≤ 0.01 on 10% range according to the frequencies listed below.

Range	Frequencies to be checked	
200	20 Hz	200 Hz
2kHz	200Hz	2kHz
20kHz	2kHz	10kHz

Check of distortion measurement ranges

- 1) Adjust both Sine Wave Generators HM8037 for an output of 1 V. (Verify with HM8011-3). Frequency setting 200Hz and 1600Hz is recommended.
- 2) Connect both generators to the input **(9)** of HM8027 according to the circuit below.



- 3) Setting: (2) (5) (6) (8) (11) (10)
2k tuned 100% 100% Cal. released
- 4) Reading **(1)** on HM8027 should be $10.0 \pm 5\%$.
- 5) Change output voltage of Generator 2 to 100mV (-20dB). Verify with HM80113.
- 6) Change setting of distortion measurement range to 10% by pushing **(6)**.
- 7) Check readout **(1)** of HM8027 for $1.00 \pm 5\%$.
- 8) In this case it must be possible to measure a signal of 1.6kHz with an amplitude of 100mV at output (5) of HM8027.

Control range of automatic frequency tuning

Setting: (2) (7) (8) (11) (10)
2k Cal. 100% Cal. released

- 1) Connect output of HM8037 to input **(9)** of HM8027.
Set frequency to 1kHz.
- 2) Calibrate HM8027 to 100% and align frequency by means of control knob **(5)**.
- 3) Adjust frequency control of HM8027 by means of control knob **(5)** so, that the right LED **(4)** just lights.
- 4) Adjust frequency of HM8037 until the left LED just lights.
- 5) The frequency setting of HM8037 should now be approx. 1.15kHz. This corresponds to the specified 15% automatic tuning range.

Alignment procedure Display zero adjustment

Setting: (2) (7) (8) (11)
2k Cal. midposit. 0dB

Gain adjustment

Setting: (2) (7) (11)
2k Cal. -10dB

- 1) Adjust both sine wave generators HM8037 for an output of 1V. (Verify with HM8011-3) Frequency setting 200Hz and 1600Hz is recommended.
- 2) Connect both generators to the input (9) of HM8027 according to the circuit in the section operational check.
- 3) Connect HM8011-3 (setting 2V, AC) to test point E on test connector CN101.
- 4) Adjust measured value to 300mV by means of amplitude control (A).
- 5) Tune frequency control (5) until LEDs (4) go off.
- 6) Select 100% measurement range with (6).
- 7) Adjust readout (1) for 10.0 by means of VR103.

Calibration adjustment

- 1) Same settings and connections as „Gain adjustment“.
- 2) Select calibration mode by means of pushbutton (7).
- 3) Adjust VR301 for 100% readout (1).

Adjustment of frequency control circuit

Setting: (2) (7) (11) (8)
2k Cal. -10dB 100%Cal.

- 1) Connect the output of HM8037 to input (9) of HM8027 (output voltage 1V, 1kHz).
- 2) Adjust display (1) for 100 by means of Level control knob (8).
- 3) Tune frequency control (5) until LEDs (4) go off.
- 4) Adjust frequency control (5) of HM8027 so that the right LED (4) just lights.
- 5) Set frequency of HM8037 to 1150Hz.
- 6) Adjust VR101 so that the left LED (4) just lights.

Frequency compensation

- 1) Connect the output of HM8037 to input (9) of HM8027.
- 2) Tune HM8027 for correct distortion reading.
- 3) Measure and take note of DC-voltage at point A of test connector CN101 (-5V DC typ.).
- 4) Adjust frequency of HM8037 to 20kHz.
- 5) Recalibrate and readjust the HM8027.
- 6) Adjust VC101 to obtain a DC-Voltage same as 3) $\pm 100\text{mV}$.