Specification
(Reference Temperature: 23°C ± 1°C)

Frequency Range:
20 Hz to 20 kHz
in 3 decade steps
Variable control 10:1, overlapping ranges

Distortion Measurement Range:
0.01% to 50% 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 ≤ 10%
10% range: ±5% ± 1 digit for k ≤ 1%

Residual Distortion and Noise:
≤ 0.5 digit

Fundamental Rejection:
30 dB greater than measured distortion factor
or ≥ 70 dB in the 100% range
≥ 90 dB in the 10% range
(whichever is better)

Input Voltage:
min. for 100% Calibration: 300 mV
max. for 100% Calibration: 50V

Input Impedance: 50 Ω

Monitor Output: (short circuit proof)

Output Voltage: 1 mV/digit

Output Impedance: 10 kΩ

Attenuator: (for input signal)
1 pushbutton switch – 20 dB
1 pushbutton switch – 10 dB
1 continous attenuator – 15 dB

General Information:
Switch-selectable high-pass filter
F = 1 kHz, Slope = 12 dB/Oktave
Supply voltages: (from HM 8001):
+12V/80 mA
–12V/80 mA; +5V/100 mA
Total power consumption = 1.94 W

Operating conditions: +10°C to +40°C
max. relative humidity: 80%

Dimensions (mm): (without multipoint connector)
W 136, H 68, D 228
Weight: approx. 0.6 kg

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

Subject to change without notice

Distortion Meter
HM 8027

- Frequency Range 20 Hz to 20 kHz
- Distortion Measurement to within to 0.01%
- Digital Display
- Automatic Frequency Nulling
- Monitor Output for Distortion Analysis

The HM 8027 distortion analyzer was developed for the measurement of non-linear distortion in the audio frequency range. Due to its low residual distortion and noise of only 0.005%, it is ideally suited for tests and measurements of high quality audio systems. The HM 8027 features a 3-digit display readout with a resolution of 0.01% to simplify and enhance distortion measurements. A calibrated distortion output is provided for visual inspection or spectral analysis of the input signal after the fundamental has been filtered out.

Together with pushbutton frequency range selectors and single control frequency tuning, the automatic frequency nulling with 15% capture range ensures quick and easy measurements with the HM 8027.

When combined with a low distortion oscillator, such as the HM 8037, it can solve many of your measurement problems, and provide fast and easy results even for the unskilled operator. It is the ideal system for any lab and satisfies many applications including telephony, production testing and general lab use.
Control Elements of HM8027

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 ⑤ 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 ⑥ 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 measured value for describing non-linear distortions is the distortion factor. It specifies the share of harmonics in the total signal. There are two different sorts of distortion factors: The general 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:

\[ d = \sqrt{\frac{U_{2f1}^2 + U_{3f1}^2 + U_{4f1}^2 + \ldots}{U_{mf}}} \]

- \( d \) = distortion factor (without dimension)
- \( U_{2f1}, U_{3f1}, \ldots \) = voltages of harmonics
- \( f1 \) = frequency of measuring signal (Hz)
- \( U_{mf} \) = 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 \( \text{⑤} \). 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 \( \text{①} \) and the calibration knob \( \text{⑥} \).

The alignment mode is selected by pressing the CALIBRATION pushbutton \( \text{②} \). 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 \( \text{②} \) 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 \( \text{⑤} \). 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 counterclockwise, 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 \( \text{⑥} \). 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%. 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 12 dB/Oct. can be inserted into the signal path. This will efficiently suppress any mains-frequency interference for distortion measurement of frequencies above 1 kHz.

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 (−3 dB). This means that the harmonics contained in a test signal having a fundamental frequency of 20 kHz are only evaluated up to the third order. Likewise, the noise bandwidth is limited to 80 kHz. A further evaluation of the residual distortion can be carried out via the OUTPUT socket \( \text{③} \). 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 dis-
played 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 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 0.75 mV corresponds to a distortion factor of 0.0075%. The evaluation capability is limited by the inherent distortion and noise of the HM8027 module.