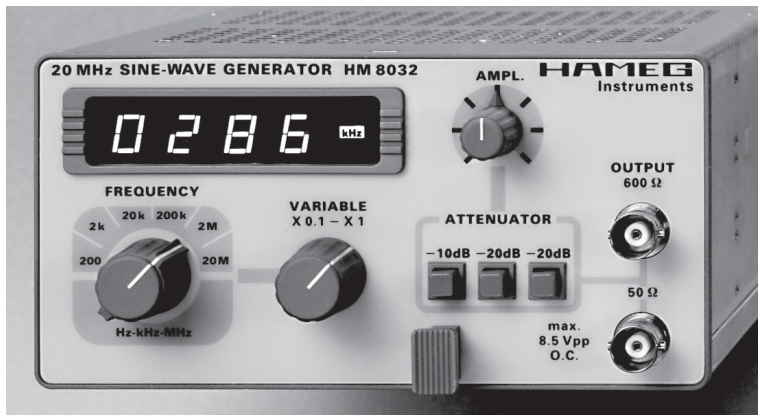


**Generator
HM 8032**



KONFORMITÄTSERKLÄRUNG
DECLARATION OF CONFORMITY
DECLARATION DE CONFORMITE



HAMEG[®]
Instruments

Name und Adresse des Herstellers
Manufacturer's name and address
Nom et adresse du fabricant

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HAMEG S.a.r.l.
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F - 94800 Villejuif

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

Bezeichnung / Product name / Designation: Sinus Generator / Sine Wave Generator / Générateur sinusoïdal

Typ / Type / Type: **HM8032**

mit / with / avec: **HM8001-2**

Optionen / Options / Options: -

mit den folgenden Bestimmungen / with applicable regulations / avec les directives suivantes

EMV Richtlinie 89/336/EWG ergänzt durch 91/263/EWG, 92/31/EWG
EMC Directive 89/336/EEC amended by 91/263/EWG, 92/31/EEC
Directive EMC 89/336/CEE amendée par 91/263/EWG, 92/31/CEE

Niederspannungsrichtlinie 73/23/EWG ergänzt durch 93/68/EWG
Low-Voltage Equipment Directive 73/23/EEC amended by 93/68/EEC
Directive des équipements basse tension 73/23/CEE amendée par 93/68/CEE

Angewendete harmonisierte Normen / Harmonized standards applied / Normes harmonisées utilisées

Sicherheit / Safety / Sécurité

EN 61010-1: 1993 / IEC (CEI) 1010-1: 1990 A 1: 1992 / VDE 0411: 1994
Überspannungskategorie / Overvoltage category / Catégorie de surtension: II
Verschmutzungsgrad / Degree of pollution / Degré de pollution: 2

Elektromagnetische Verträglichkeit / Electromagnetic compatibility / Compatibilité électromagnétique

EN 50082-2: 1995 / VDE 0839 T82-2
ENV 50140: 1993 / IEC (CEI) 1004-4-3: 1995 / VDE 0847 T3
ENV 50141: 1993 / IEC (CEI) 1000-4-6 / VDE 0843 / 6
EN 61000-4-2: 1995 / IEC (CEI) 1000-4-2: 1995 / VDE 0847 T4-2: Prüfschärfe / Level / Niveau = 2

EN 61000-4-4: 1995 / IEC (CEI) 1000-4-4: 1995 / VDE 0847 T4-4: Prüfschärfe / Level / Niveau = 3

EN 50081-1: 1992 / EN 55011: 1991 / CISPR11: 1991 / VDE0875 T11: 1992

Gruppe / group / groupe = 1, Klasse / Class / Classe = B

Datum /Date /Date

14.12.1995

Unterschrift / Signature /Signature

E. Baumgartner
Technical Manager
Directeur Technique

Specification

(Reference Temperature: 23°C ± 1°C)

Operation Mode:

Sine wave, free-running with AGC

Frequency Range:

20 Hz to 20 MHz, in 6 decade steps
Variable control 10:1,
overlapping ranges

Frequency Drift:

(medium position of frequency control)
15 min. 0.5% (20 MHz range)
8 hrs. 0.3% (20 MHz range)
15 min. 0.05% (2 MHz + 200 kHz range)
8 hrs. 0.05% (2 MHz + 200 kHz range)
15 min. 0.1% (other ranges)
8 hrs. 0.1% (other ranges)

Display:

4 digit 7-Segment LED display
LED-Indicators for Hz/kHz/MHz

Accuracy:

1 digit

Distortion:

20 Hz – 500 Hz : max. 0.2 %
500 kHz – 1 MHz : max. 1 %
1 MHz – 20 MHz : max. 2.5 %

Output (short-circuit-proof)

Output Voltage:

min. 1.5V into 50 Ω; 3V open circuit

Output Impedance:

approx. 600 Ω and 50 Ω

Amplitude Flatness: (Ref. 1 kHz)

20 Hz to 2 MHz: max. ± 0.2 dB
2 MHz to 20 MHz: max. ± 0.5 dB

Attenuation: min. 60 dB

2 Attenuators: – 20 dB ± 0.5 dB each

1 Attenuator: – 10 dB ± 0.5 dB

Variable control: 0 dB to – 10 dB min.

Amplitude Stability: 0.12 % (4 hours)

General Information

Supply (from HM 8001):

+ 5V/120 mA;

+ 15V/30 mA;

– 12V/30 mA

(Σ = 4,6 W)

Operating Conditions: +10°C bis +40°C

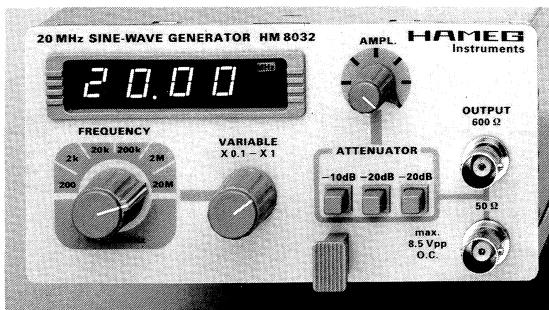
max. relative humidity: 80 %

Dimensions: (without multipoint connector)

W 135, H 68, D 228 mm

Weight: approx. 650 g

Subject to change without notice



Sine Wave Generator HM 8032

- Frequency Range 20 Hz to 20 MHz
- Distortion < 0.2%
- Digital Frequency Readout
- Output Voltage 1.5V into 600 Ω
- Amplitude Flatness < ± 0.2 dB

Outstanding characteristics of this sine wave generator are the **wide frequency range and the exceptionally high amplitude stability**. It is especially useful for wide-band measurements on linear amplifiers and systems up to **approx. 20 MHz**. As a high quality signal source, however, the **HM 8032** is equally suitable for many other applications as test oscillator with **low total harmonic distortion**, e.g. in the audio and video sectors.

The **internal frequency counter** with 4-digit LED display enables exact adjustments of the desired frequency.

The use of quality components in the frequency-determining circuitry provides a **long-term stability of better than 0.3%** in 24 hours. The two signal outputs, 600 ohm and 50 ohm, are short-circuit-proof.

The convenient and clear arrangement of the front panel ensures that even operators with limited experience in the measurement field will soon become familiar with the **HM 8032**.

Optional Accessories

HZ 33, HZ 34: 50 Ω test cable BNC-BNC;

HZ 22: 50 Ω through-termination.

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

Every module is manufactured and tested for use only with the mainframe HM8001 according to IEC 348 Part 1 and 1a (Safety requirements for electronic test and measurement equipment). 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 instrument's 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



DANGER – High voltage



Protective ground (earth) terminal.



ATTENTION – refer to manual.

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 Hameg's sole opinion proves to be defective with the scope of this warranty.

This is Hameg's 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, espesses, 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.

Maintenance

The most important characteristics of the instruments should be periodically checked according to the instructions provided in the sections "Operational check" and "Alignment procedure". To obtain the normal operating temperature, the mainframe with inserted module should be turned on at least 60 minutes before starting the test. The specified alignment procedure should be strictly observed.

When removing the case detach mains/line cord and any other connected cables from case of the mainframe HM8001. Remove both screws on rear panel and, holding case firmly in place, pull chassis forward out of case. When later replacing the case, care should be taken to ensure that it properly fits under the edges of the front and rear frames.

After removal of the two screws at the rear of the module, both chassis covers can be lifted. When reclosing the module, care should be taken that the guides engage correctly with the front chassis.

Operation of the module

Provided that all hints given in the operating instructions of the HM8001 Mainframe were followed – especially for the selection of the correct mains voltage – start of operation consists practically of inserting the module into the right or left opening of the mainframe. The following precautions should be observed:

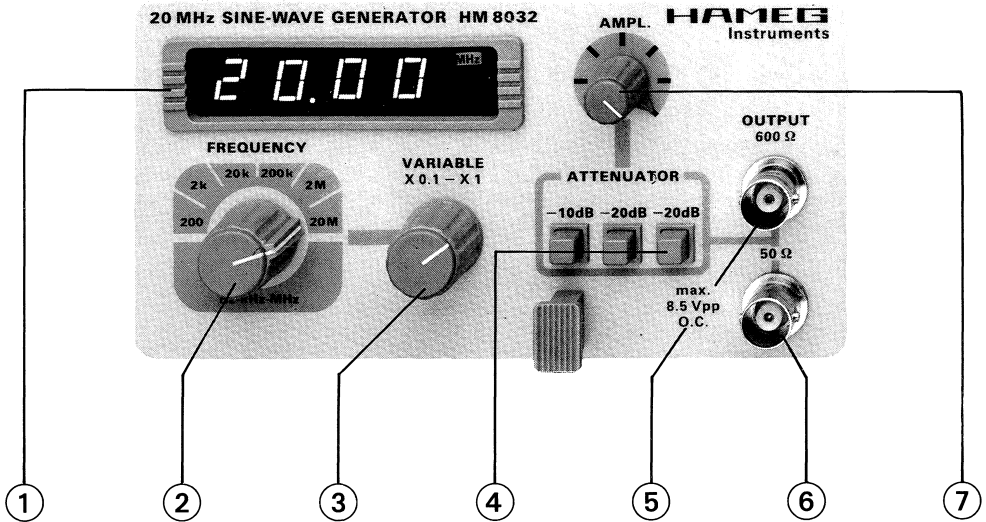
Before exchanging the module, the mainframe must be switched off. A small circle (o) is now revealed on the red power button in the front centre of the mainframe.

If the BNC sockets at the rear panel of the HM8001 unit were in use before, the BNC cables should be disconnected from the basic unit for safety reasons. Slide in the new module until the end position is reached.

Before being locked in place, the cabinet of the instrument is not connected to the protective earth terminal (banana plug above the mainframe multipoint connector). In this case, no test signal must be applied to the input terminals of the module.

Generally, the HM8001 set must be turned on and in full operating condition, before applying any test signal. If a failure of the measuring equipment is detected, no further measurements should be performed. Before switching off the unit or exchanging a module, the instrument must be disconnected from the test circuit.

HM8032 control elements



① **DISPLAY** (7-segment LED)

4-digit frequency meter. Accuracy $0.1\% \pm 1$ digit. LED indicators for Hz, kHz and MHz.

② **FREQUENCY** (6-position rotary switch)

Frequency coarse adjustment from 20 Hz to 20 MHz in 6 decade steps.

③ **VARIABLE** (adjusting knob)

Continuous frequency adjustment. Overlapping the ranges selected with ②. Setting range is from $\times 0,1$ to $\times 1$ of selected range.

④ **-10 dB, -20 dB, -20 dB** Attenuators (pushbuttons)

Three fixed attenuators of -10 dB, -20 dB respectively. They can be used separately. When all buttons are

pressed a total attenuation of -50 dB is obtained. Including the amplitude control ⑦, the max. attenuation amounts to -60 dB (factor: 1000).

⑤ **600 Ω OUTPUT** (BNC connector)

Short-circuit-proof signal output of generator. Output impedance 600 Ω.

⑥ **50 Ω OUTPUT** (BNC connector)

Short-circuit-proof signal output of generator. Output impedance 50 Ω.

⑦ **AMPLITUDE** (adjusting knob)

Continuous adjustment of output amplitude from 0 dB up to -10 dB when outputs are terminated with indicated load resistor.

Principle of operation

The sine wave generator of the HM 8032 unit consists basically of a Wien bridge inserted into the negative feedback circuit of a high-speed linear amplifier. A PLL circuit with a crystal reference oscillator provides good frequency stability and a high accuracy of the 4-digit display. The oscillator signal drives a low-distortion output amplifier, which supplies the amplitude required for the two output sockets at 50 ohms load.

The Wien bridge is inserted into the negative feedback circuit of a linear amplifier (T 101-106) having high input impedance. The frequency is adjusted with a variable two-gang capacitor and resistors switched in decades. Via the T110 transistor, the linear amplifier output feeds a potentiometer to permit output amplitude adjustment. Furthermore the linear amplifier controls a level detector, which is decoupled from the oscillator output via the T 107 transistor and drives the amplitude control circuit and a trigger amplifier. The VR 102 superimposes a DC voltage to the oscillator signal. This provides adjustment of the maximum output voltage level. After this processing, the signal is applied via D 105 and T 109 to the input of a control circuit composed by the operational amplifier (IC 101) and additional components. The output of this operational amplifier contains a dual FET (T 105) connected as controllable resistor. Due to the resistance change depending on the applied voltage, a control circuit continuously changes the loop gain of the linear amplifier, until the voltage at the operational amplifier (IC 101) input becomes zero. This results in the stabilization of the oscillator output voltage to the level adjusted with VR 102.

The amplitude-stabilized oscillator signal is applied to a trigger amplifier (IC 103), where it is prepared for subsequent frequency division (IC 104-105). The division ratio is subdivided into decades between 5 and 5000, which are used according to the selected frequency range. The divided signal serves as a reference frequency for a PLL circuit (IC 107). The output signal of the VCO (voltage-controlled oscillator) of the PLL (phase-locked loop) circuit is applied to the input of a counter (IC 201), after having been prepared for PLL phase comparison by 1/2, 1/4 or 1/10 division (IC 104-106). This results in high accuracy of the digital frequency display in all frequency ranges and in a constant measuring rate of 4 measurements per second.

The output amplifier (T 111-115) has a voltage gain of 2 and a low output impedance. The offset voltage at the output is aligned by a control circuit including the operational amplifier (IC 108). This results in a constant output resistance and low distortion factor of the output amplifier, even when low frequencies are processed. The output amplifier output voltage is applied to the output sockets via three attenuators of constant impedance, which can be activated and deactivated.

Operation

First-time operation of the module

Provided that all hints given in the operating instructions of the HM 8001 Mainframe were followed – especially for the selection of the correct mains voltage – start of operation consists practically of inserting the module into the right or left opening of the mainframe. The following precautions should be observed:

Before exchanging the module, the mainframe must be switched off. A small circle (o) is now revealed on the red power button in the front centre of the mainframe.

If the BNC socket at the rear panel of the HM8001 unit was in use before, the BNC cable should be disconnected from the basic unit for safety reasons. Pull out the previously used module by its handle and slide in the new module until the end position is reached.

The mains plug of the HM8001 should be inserted before connections are made to measuring circuits.

Frequency adjustment

Coarse adjustment is performed with the range switch ② divided into decades. The desired frequency is selected by turning the VARIABLE control ③. The selected frequency appears on the 4-digit display ①. Compared to knob scales, this display has a much higher resolution. The Hz and kHz range indicators are integrated into the display panel.

Output amplitude and signal connection

The HM8032 provides two outputs of different impedance. The values of 50 Ω or 600 Ω respectively allow an easy adaptation to the different measuring applications. Both output signals are of same phase and amplitude.

Adaptation in decade steps to the desired amplitude range is performed by the use of three attenuators ④, which are activated by pushbuttons.

Including the continuously adjustable AMPLITUDE control ⑦, the maximum attenuation amounts to –60dB. With the maximum amplitude of 1.5V, the minimum signal voltage to be supplied is about 1.5mV. These values are obtained when the generator outputs are terminated with 50 Ω or 600 Ω respectively. In the open-circuit condition, the available signal amplitude is about twice as high. Therefore the maximum output voltage of the output socket is specified with 8.5V_{op}. For interconnecting with other equipment only high quality coaxial cables should be used, e.g. HZ34.

It should be noted that the used terminating resistor must dissipate the corresponding effective power.

Both outputs of the HM 8032 are short-circuit-proof. However, applying an external voltage to the outputs may destroy the internal power stage.

Operational check

General

This test will allow you to check the functions of the HM8032 unit at certain time intervals without using any special test equipment. To obtain the normal operating temperature, the mainframe with inserted module should be turned on at least 30 minutes before starting the test.

Measuring equipment required

Oscilloscope, bandwidth ≥ 100 MHz
 HM8021-2 Frequency Counter
 $50\ \Omega$ through termination HZ22
 Resistor $600\ \Omega$
 Coaxial Cable HZ34
 UPM550 Level Meter (Sennheiser) or equivalent

Frequency variation of all ranges

- a) HM8032 setting:
- ② FREQUENCY 200 Hz
 - ③ VARIABLE $\times 0.1$ (ccw)
 - ⑦ AMPLITUDE min. (ccw)
 - no buttons pressed
- b) Following the table below, the limits of all frequency ranges can be checked.

| Range | Limits of display | |
|---------|-------------------------------|---------------------------|
| | Freq. Variable ③ $\times 0.1$ | Freq. Variable $\times 1$ |
| 200 Hz | 19 Hz – 20 Hz | 200 Hz – 230 Hz |
| 2 kHz | 190 Hz – 200 Hz | 2 kHz – 2.3 kHz |
| 20 kHz | 1.9 kHz – 2 kHz | 20 kHz – 23 kHz |
| 200 kHz | 19 kHz – 20 kHz | 200 kHz – 230 kHz |
| 2 MHz | 190 kHz – 200 kHz | 2 MHz – 2.3 MHz |
| 20 MHz | 1.9 MHz – 2 MHz | 20 MHz – 23 MHz |

Output amplitude stability

- a) HM8032 setting:
- ② FREQUENCY 2 kHz
 - ③ VARIABLE 1 kHz
 - ⑧ AMPLITUDE max. (cw)
 - no button pressed
- b) Connect OUTPUT ⑥ of HM8032 to Y-input of the oscilloscope via coaxial cable. Use $50\ \Omega$ termination.
- c) Adjust oscilloscope to 0.5 V/div. and 1 ms/Div. Adjust HM8032 AMPLITUDE ⑦ to 6 div. on oscilloscope.

- d) Check output voltage within the entire frequency range, using FREQUENCY ② and VARIABLE ③.
- e) The output amplitude should not vary by more than ± 0.2 dB (approx. 0.05 div.) from 20 Hz to 2 MHz, and more than ± 0.5 dB (approx. 0.2 div.) from 2 MHz to 20 MHz.

Accuracy of Digital Frequency Readout

- a) HM8032 setting:
- ② FREQUENCY 200 Hz
 - ③ VARIABLE $\times 0.1$ (ccw)
 - ⑦ AMPLITUDE min. (ccw)
 - no button pressed
- b) Connect OUTPUT ⑥ to input of HM8021-2 frequency counter.
- c) Using FREQUENCY ② all measuring ranges should be checked. In every range the maximum frequency is displayed.
- d) The readings of the HM8032 should be identical with the HM8021 readings within the tolerances given in the table below.

| Range | Maximum deviation |
|---------|----------------------------|
| 200 Hz | ± 0.2 Hz ± 1 Digit |
| 2 kHz | ± 2 Hz ± 1 Digit |
| 20 kHz | ± 20 Hz ± 1 Digit |
| 200 kHz | ± 200 Hz ± 1 Digit |
| 2 MHz | ± 2 kHz ± 1 Digit |
| 20 MHz | ± 20 kHz ± 1 Digit |

Output attenuator function

- a) HM8032 setting:
- ② FREQUENCY 2 kHz
 - ③ VARIABLE 1 kHz
 - ⑦ AMPLITUDE max. (cw)
 - no button pressed
- b) Connect Level Meter to OUTPUT ⑥. Terminate with $50\ \Omega$. Adjust for 1 V amplitude.
- c) Firstly press one button ④ then two, then all buttons ④ simultaneously. The reading should be 0.1 V or, 10 mV and 3, 15 mV (± 0.5 dB) respectively.

Maximum output amplitude

a) HM8032 setting:

| | |
|-------------|-------------------|
| ② FREQUENCY | 2 kHz |
| ③ VARIABLE | 1 kHz |
| ⑦ AMPLITUDE | max. (cw) |
| | no button pressed |

b) Connect Level Meter to OUTPUT ⑥. Terminate with 50Ω.

The output voltage should be min. 1.5V.

c) Disconnect 50Ω termination. The output voltage should be approx. 3V.

If no Level Meter is available, these tests can also be performed by using an oscilloscope. However, the results are less accurate.

Adjustment procedure

The following instructions will allow you to correct any deviation of the measured data from the specification. The specified adjustment sequence should be strictly observed.

Before opening the set, you should carefully read the **Safety** and **Warranty** information on page M2 of these operating instructions.

Removal of Case

Detach mains/line cord and any other connected cables from case of the mainframe HM8001. Remove both screws on rear panel and, holding case firmly in place, pull chassis forward out of case.

When later replacing the case, care should be taken to ensure that it properly fits under the edges of the front and rear panels.

After removal of the two screws at the rear of the module, both chassis covers can be lifted. When reclosing the module, care should be taken that the guides engage correctly with the front chassis.

Adjustment location

All adjustment elements are accessible from the component side of the PC board of the module.

The numbers surrounded by a square ① indicate the adjustment locations. They are identical with the numbers indicated on the PCB soldering side.

Adjustments steps

A – Output amplitude

| | | | | |
|-----------------|--------|----|-----|-------------|
| Setting: | ② | ⑦ | ③ | ④ |
| | 20 kHz | cw | ccw | not pressed |

Connect Digital Multimeter HM8011-2 to OUTPUT ⑥ of HM8032. Adjust VR 101 ① for an output voltage of 3V.

B – Maximum frequency – lower range

| | | | | |
|-----------------|--------|----|-----|-------------|
| Setting: | ② | ⑦ | ③ | ④ |
| | 20 kHz | cw | ccw | not pressed |

- 1) Measure DC-voltage at point ② of test connector CN101 by using DVM HM8011-2 or oscilloscope. Keep measured value in mind.
- 2) Set VARIABLE ③ to cw position. Adjust VC 103 and VC 104 to the same value mentioned in step 1). Max. allowable tolerance is $\pm 0.3V$. Frequency display should read between 21.8 and 22.2 kHz.
- 3) Repeat steps 1) and 2) until given values are obtained.

C – Maximum frequency – 20MHz range

| | | | | |
|-----------------|--------|----|-----|-------------|
| Setting: | ② | ⑦ | ③ | ④ |
| | 20 MHz | cw | ccw | not pressed |

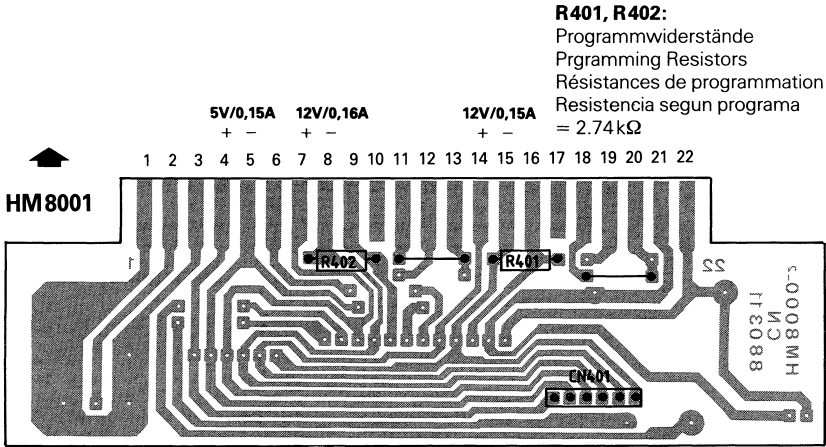
- 1) Measure DC-voltage at point ② of test connector CN101 by using DVM HM8011-2 or oscilloscope. Keep measured value in mind.
- 2) Set VARIABLE ③ to cw position. Adjust VC 102 and VC 105 to the same value mentioned in step 1). Max. allowable tolerance is $\pm 0.3V$. Frequency display should read between 20.8 and 21.2 kHz.
- 3) Repeat steps 1) and 2) until given values are obtained.

D – Compensation of output amplifier

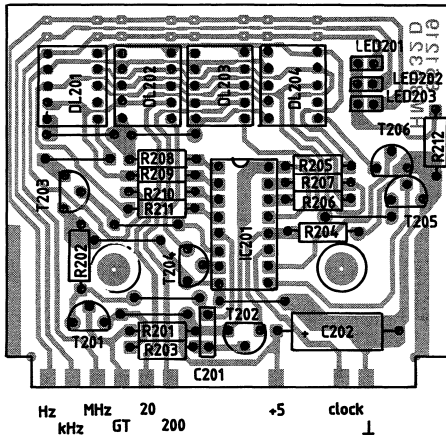
| | | | | |
|-----------------|--------|----|----|-------------|
| Setting: | ② | ⑦ | ③ | ④ |
| | 20 MHz | cw | cw | not pressed |

- 1) Connect oscilloscope to OUTPUT ⑥ of HM8032 by using coaxial cable and 50Ω through termination. Adjust for 6 div. deflection.
- 2) Set FREQUENCY ② to 2MHz. Adjust VC 103 again for 6 div.
- 3) Set FREQUENCY ② to 20MHz. Adjust VC 104 for 6 div.
- 4) Repeat steps 2) and 3) until desired amplitude stability is reached.

Steckerleiste, Versorgungsspannungen
Multipoint connector, supply voltages
Carte connecteur, tensions d'alimentation
Placa conector de los voltajes de alimentación

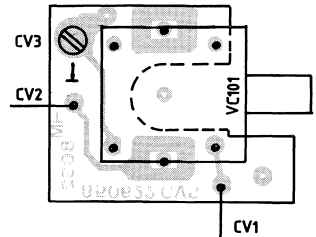


Bestückungsplan
Repérage des composants



Display-Board
Carte affichage
Placa indicator

Component Locations
Localizacion de componentes

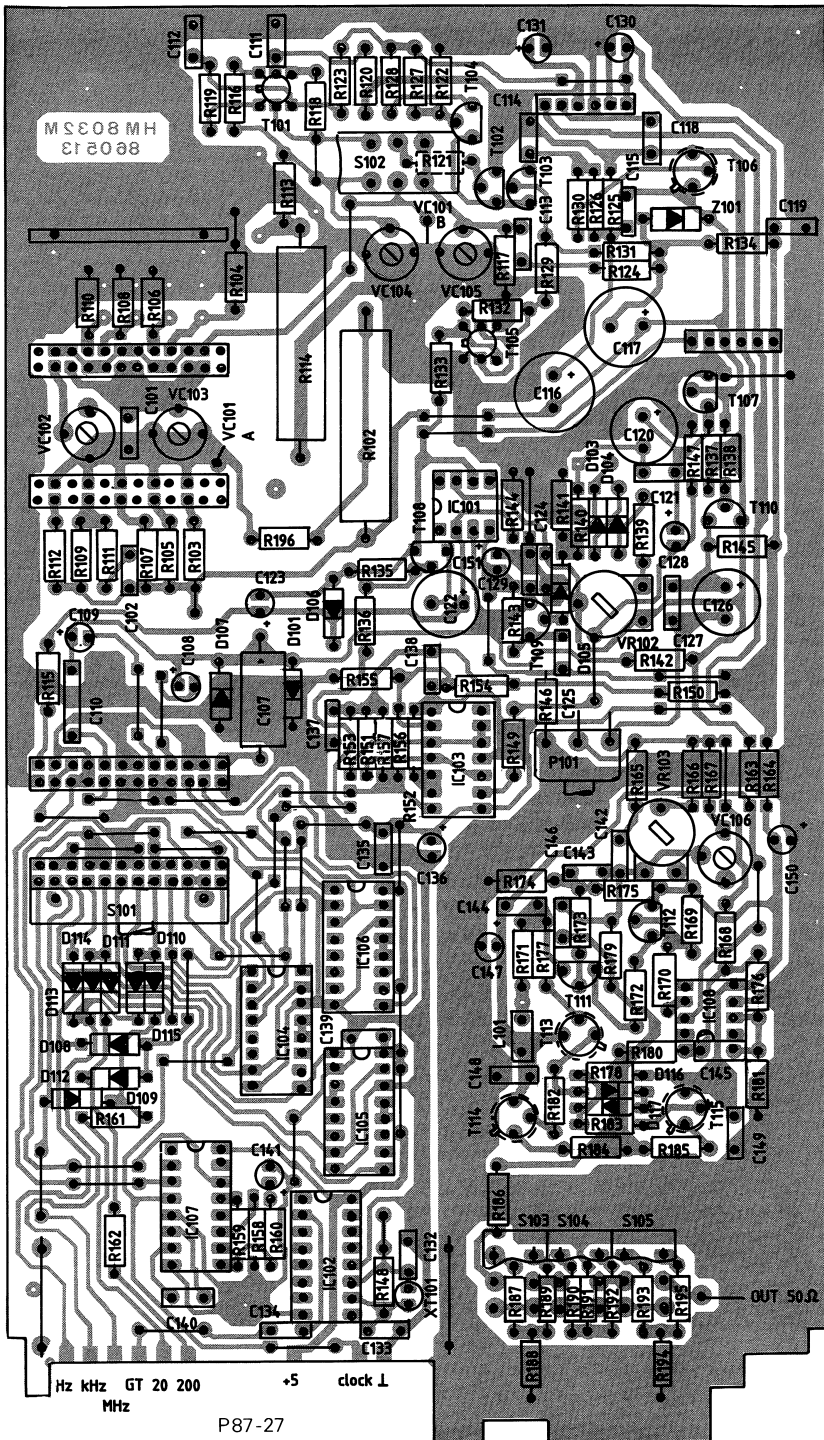


CV Board
Carte C.V.
Circuito CV

**Bestückungsplan, Hauptplatte
Implantation des composants**

**Mainboard
Circuit principal**

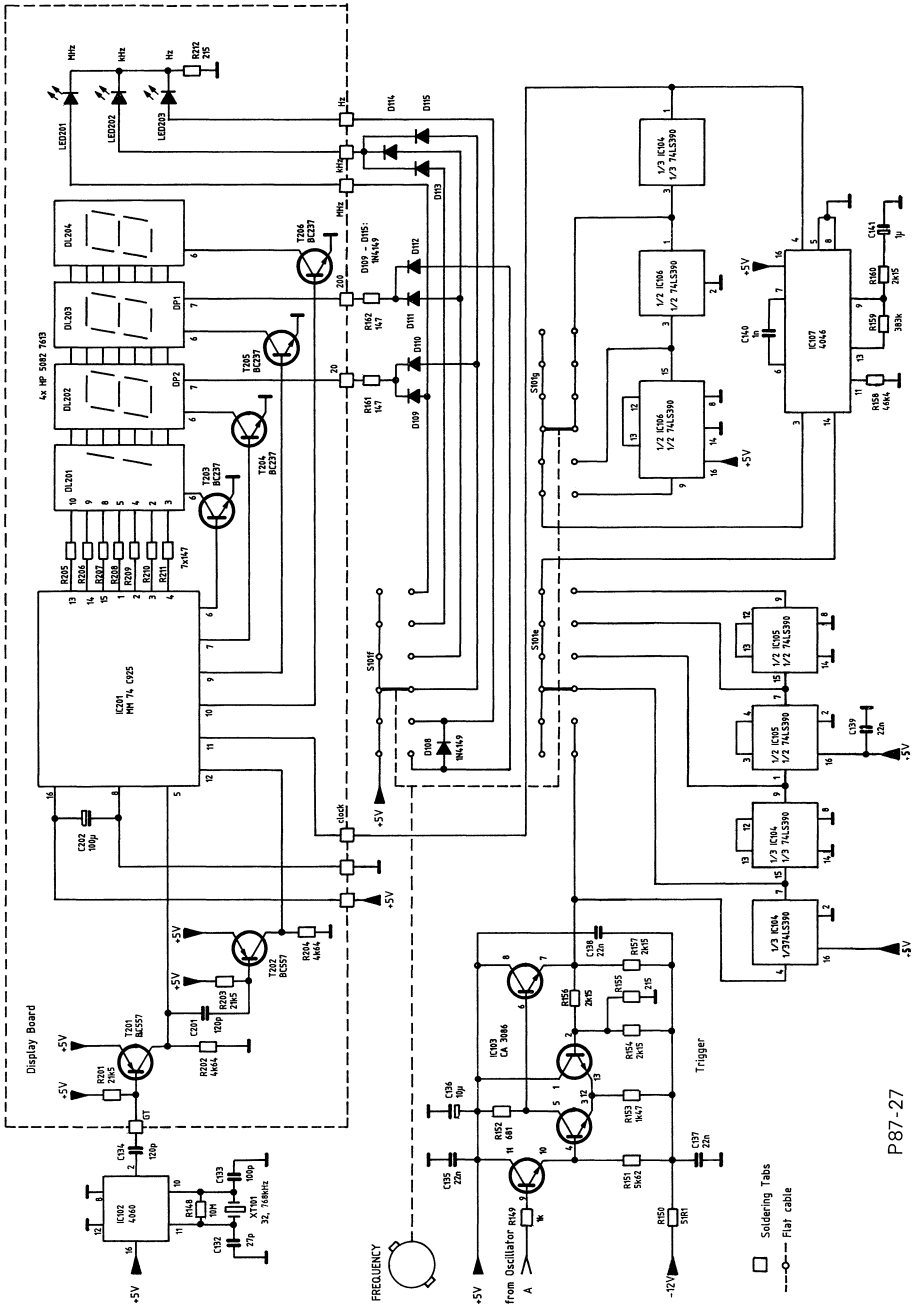
**Component Locations
Localizacion de componentes**



P87-27

Zähler; Digitalanzeige Compteur; affichage numerique

Counter; Digital Display Contador y indicador digital



Liste elektronischer Teile

Electronic Parts List

| Ref. No. | Description | Ref. No. | Description | Ref. No. | Description |
|----------|-------------|----------|------------------|------------|-------------------|
| R 1 | 562 Ω | R 168 | 10kΩ | C 129 | 22nF 63V 20% |
| R 102 | 22MΩ | R 169 | 5,11kΩ | C 130 | 10μF 35V |
| R 103 | 2,51MΩ | R 170 | 8,25kΩ | C 131 | 10μF 35V |
| R 104 | 2,51MΩ | R 171 | 1,21kΩ | C 132 | 27pF 63VNPO 10% |
| R 105 | 226kΩ | R 172 | 6,8 Ω | C 133 | 100pF 63V 10% |
| R 106 | 226kΩ | R 173 | 215 Ω | C 134 | 120pF 63V 10% |
| R 107 | 22,6kΩ | R 174 | 10kΩ | C 135 | 22nF 63V 20% |
| R 108 | 22,6kΩ | R 175 | 10kΩ | C 136 | 10μF 35V |
| R 109 | 2,26kΩ | R 176 | 100kΩ | C 137 | 22nF 63V 20% |
| R 110 | 2,26kΩ | R 177 | 6,8 Ω | C 138 | 22nF 63V 20% |
| R 111 | 2,26kΩ | R 178 | 464 Ω | C 139 | 22nF 63V 20% |
| R 112 | 226 Ω | R 179 | 1,21kΩ | C 140 | 1nF 160V 5% |
| R 113 | 619kΩ | R 180 | 21,5kΩ | C 141 | 1μF 35V |
| R 114 | 22MΩ | R 181 | 100kΩ | C 142 | 6,8pF400VNPO 5% |
| R 115 | 1kΩ | R 182 | 51,1 Ω | C 143 | 22nF 63V 20% |
| R 116 | 100 Ω | R 183 | 51,1 Ω | C 144 | 3,9pF 63V 10% |
| R 117 | 226 Ω | R 184 | 6,8 Ω | C 145 | 10pF 63V 10% |
| R 118 | 332 Ω | R 185 | 6,8 Ω | C 146 | 3,9pF 63V 10% |
| R 119 | 332 Ω | R 186 | 51,1 Ω | C 147 | 10μF 63V 10% |
| R 120 | 100 Ω | R 187 | 26,1 Ω | C 148 | 22nF 63V 20% |
| R 121 | 51,1 Ω | R 188 | 34,8 Ω | C 149 | 22nF 63V 20% |
| R 122 | 6,81kΩ | R 189 | 26,1 Ω | C 150 | 10μF 35V |
| R 123 | 100 Ω | R 190 | 40,2 Ω | C 151 | 10μF 35V |
| R 124 | 464 Ω | R 191 | 10 Ω | C 201 | 120pF 63V 10% |
| R 125 | 464 Ω | R 192 | 40,2 Ω | C 202 | 100μF 35V |
| R 126 | 464 Ω | R 193 | 40,2 Ω | C 401 | 220μF 16V |
| R 127 | 10kΩ | R 194 | 10 Ω | D 101 | 1N4149 |
| R 128 | 464 Ω | R 195 | 40,2 Ω | D 103-117 | 1N4149 |
| R 129 | 511 Ω | R 196 | 619kΩ | IC 101 | TL081 |
| R 130 | 215 Ω | R 201 | 21,5kΩ | IC 102 | CD4060 |
| R 131 | 1,21kΩ | R 202 | 4,64kΩ | IC 103 | CA3086 |
| R 132 | 10kΩ | R 203 | 21,5kΩ | IC 104 | SN74LS390 |
| R 133 | 10kΩ | R 204 | 4,64kΩ | IC 105 | SN74LS390 |
| R 134 | 464 Ω | R 205 | 147 Ω | IC 106 | SN74LS390 |
| R 135 | 100kΩ | R 206 | 147 Ω | IC 107 | CD4046 |
| R 136 | 6,81kΩ | R 207 | 147 Ω | IC 108 | TL081 |
| R 137 | 750 Ω | R 208 | 147 Ω | IC 201 | MC74C925 |
| R 138 | 51,1 Ω | R 209 | 147 Ω | LED 201 | TL505101 |
| R 139 | 7,5kΩ | R 210 | 147 Ω | LED 202 | TL505101 |
| R 140 | 100 Ω | R 211 | 147 Ω | DL 201- | |
| R 141 | 681 Ω | R 212 | 212 Ω | DL 204 | HP5082-7613 |
| R 142 | 75kΩ | C 101 | 100pF 63VNPO 10% | T 101 | U440 |
| R 143 | 215 Ω | C 102 | 3,9pF 63V 10% | T 102-103 | MPS918 |
| R 144 | 10kΩ | C 107 | 100μF 35V | T 104 | BC237B |
| R 145 | 750 Ω | C 108 | 22μF 40V | T 105 | U440 |
| R 146 | 178 Ω | C 109 | 2,2μF 63V | T 106 | 2N3866 |
| R 147 | 10kΩ | C 110 | 0,22μF 100V 20% | T 107 | MPS3640 |
| R 148 | 10MΩ | C 111 | 22nF 63V 20% | T 108 | BC237B |
| R 149 | 1kΩ | C 112 | 22nF 63V 20% | T 109 | MPS3640 |
| R 150 | 51,1 Ω | C 113 | 3,9μF 63V 10% | T 110-111 | MPS918 |
| R 151 | 5,62kΩ | C 114 | 6,8pF400VNPO 5% | T 112 | MPS3640 |
| R 152 | 681 Ω | C 115 | 22nF 63V 20% | T 113 | 2N3866 |
| R 153 | 1,47kΩ | C 116 | 470μF 25V | T 114 | 2N2219A |
| R 154 | 2,15kΩ | C 117 | 470μF 25V | T 201-202 | BC557 |
| R 155 | 215 Ω | C 118 | 22nF 63V 20% | T 203-206 | BC237 |
| R 156 | 2,15kΩ | C 119 | 22nF 63V 20% | L 101 | 12μH |
| R 157 | 2,15kΩ | C 120 | 220μF 16V | VR 102 | 10kΩ 20% lin. |
| R 158 | 46,4kΩ | C 121 | 22nF 63V 20% | VR 103 | 250 Ω 20% lin. |
| R 159 | 383kΩ | C 122 | 47μF 25V | VC 101 | 2x 335pF |
| R 160 | 2,15kΩ | C 123 | 1μF 35V | VC 102-106 | 2-22pF |
| R 161 | 147 Ω | C 124 | 22nF 63V 20% | POT 101 | 470 Ω 10% lin. |
| R 162 | 147 Ω | C 125 | 22nF 63V 20% | ZD 101 | Z5V1 |
| R 163 | 6,8 Ω | C 126 | 220μF 16V | XT 101 | Crystal 32,768kHz |
| R 164 | 6,8 Ω | C 127 | 22nF 63V 20% | | |
| R 165 | 12,1kΩ | C 128 | 10μF 35V | | |
| R 166 | 365 Ω | | | | |
| R 167 | 100 Ω | | | | |

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