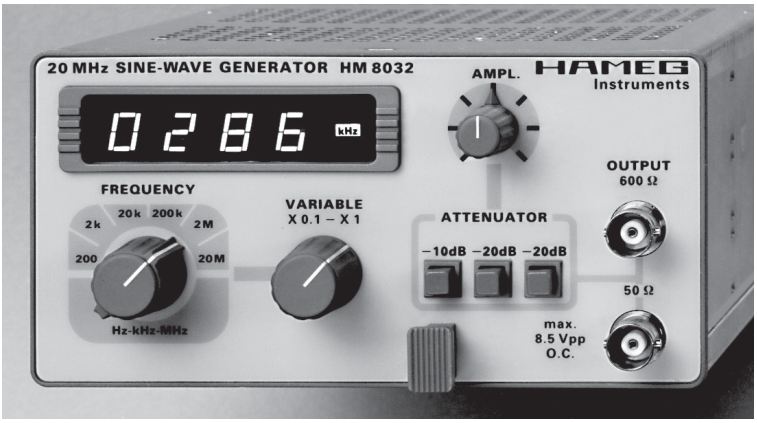
ENGLISH

HAMEG®
Instruments

Generator
HM 8032



MANUAL • HANDBUCH • MANUEL

KONFORMITÄTSERKLÄRUNG
DECLARATION OF CONFORMITY
DECLARATION DE CONFORMITE

CE

HAMEG®
Instruments

Name und Adresse des Herstellers **Manufacturer´s name and address** **Nom et adresse du fabricant**	**HAMEG GmbH** **Kelsterbacherstraße 15-19** **D - 60528 Frankfurt** **HAMEG S.a.r.l.** **5, av de la République** **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 conformite 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 equipements 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 /Signatur

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)

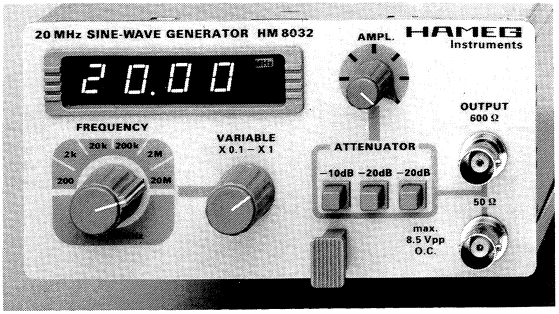
Output Voltage:
min. 1.5 V into 50 Ω; 3 V open circuit
Output Impedance: approx. 600 Ω and 50 Ω
Amplitude Flatness: (Ref. 1 kHz)
20 Hz to 2 MHz: max. ±0.2 dB
2 MHz to 20 MHz: max. ±0.5 dB
Attenuation: min. 60 dB
2 Attenuators: −20 dB ±0.5 dB each
1 Attenuator: −10 dB ±0.5 dB
Variable control: 0 dB to −10 dB min.

Amplitude Stability: 0.12 % (4 hours)

General Information
Supply (from HM8001):
+5 V/120 mA;
+15 V/30 mA;
−12 V/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 1.5 V 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 intented 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 istrument 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.

Symbos 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 wich 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 thiss 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 merchantibility and fitness for a particular use which exceed the aforestated obligation are hereby disclaimed by Hameg be liable to buyer, in contract or in tort, for any special, indirect, incidental or consequential damages, espresses, 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 th the instructions provided in the sections "Operational check" and "Alignment procedcure". 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:

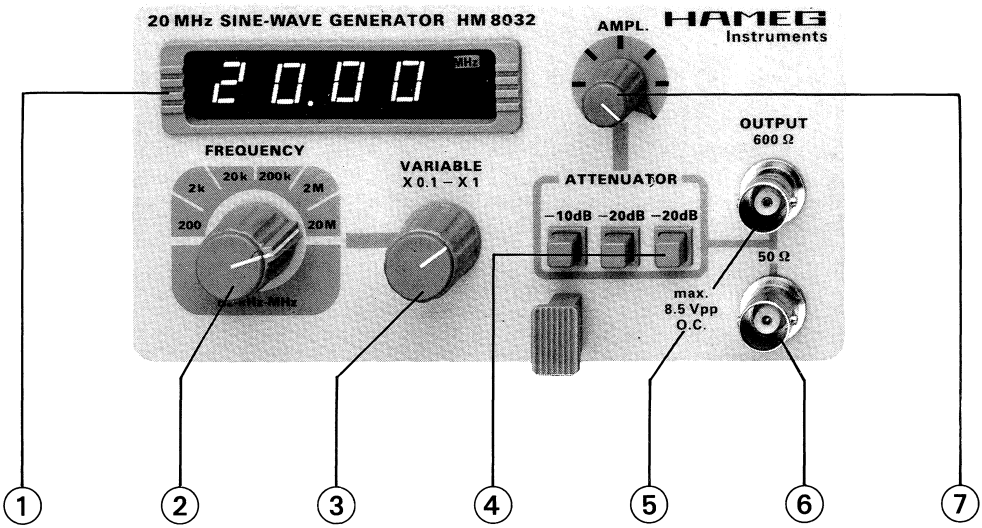
Before exchanging the module, the mainframe must be switched off. A small circle (o) is now revealed on the red power button in the front centre of the mainframe.

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.

HM 8032 control elements



① **DISPLAY** (7-segment LED)
4-digit frequency meter. Accuracy 0.1% ± 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)
Continous frequency adjustment. Overlapping the ranges selected with ②. Setting range is from x0,1 to x1 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)
Continous 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 T 110 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 HM 8001 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 HM 8001 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 HM 8032 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 −60 dB. With the maximum amplitude of 1.5 V, the minimum signal voltage to be supplied is about 1.5 mV. 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 8.5 V_{pp}. For interconnecting with other equipment only high quality coaxial cables should be used, e.g. HZ 34.

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 Ω through termination HZ22
Resistor 600 Ω
Coaxial Cable HZ34
UPM550 Level Meter (Sennheiser) or equivalent

Frequency variation of all ranges

a) HM8032 setting:

② FREQUENCY	200 Hz
③ VARIABLE	x0.1 (ccw)
⑦ AMPLITUDE	min. (ccw)
no buttons pressed	

b) Following the table beow, the limits of all frequency ranges can be checked.

	Limits of display	
Range	**Freq. Variable ③ x0.1**	**Freq. Variable x1**
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 Ω 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	x0.1 (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 Ω. 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:

②FREQUENCY	2 kHz
③VARIABLE	1 kHz
⑦AMPLITUDE	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
	20kHz	cw	ccw	not pressed

Connect Digital Multimeter HM8011-2 to OUTPUT ⑥ of HM8032. Adjust VR101 [1] for an output voltage of 3V.

B – Maximum frequency – lower range

Setting:	②	⑦	③	④
	20kHz	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 VC103 and VC104 to the same value mentioned in step 1). Max. allowable tolerance is ±0.3V. Frequency display should read between 21.8 and 22.2kHz.
3) Repeat steps 1) and 2) until given values are obtained.

C – Maximum frequency – 20MHz range

Setting:	②	⑦	③	④
	20MHz	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 VC102 and VC105 to the same value mentioned in step 1). Max. allowable tolerance is ±0.3V. Frequency display should read between 20.8 and 21.2kHz.
3) Repeat steps 1) and 2) until given values are obtained.

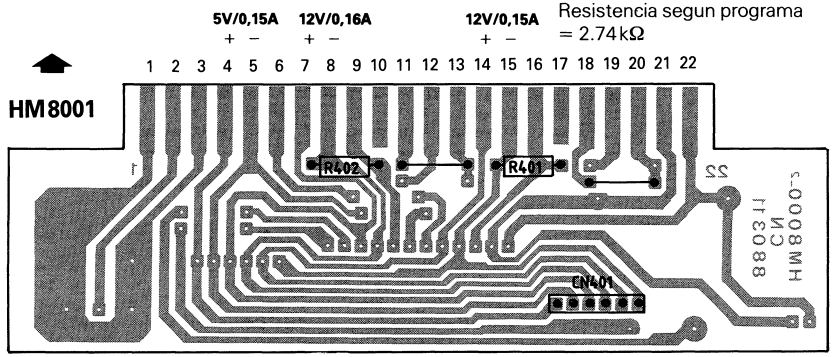
D – Compensation of output amplifier

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

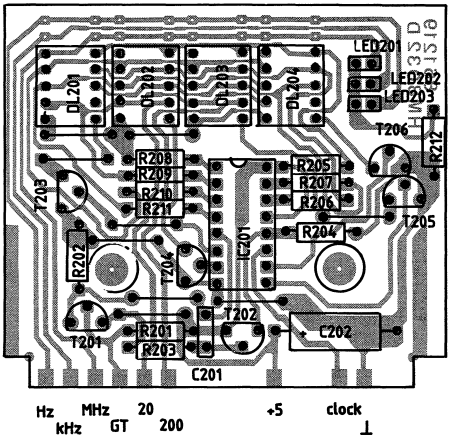
1) Connect oscilloscope to OUTPUT ⑥ of HM8032 by using coaxial cable and 50Ω through termination. Adjust for 6div. deflection.
2) Set FREQUENCY ② to 2MHz. Adjust VC103 again for 6div.
3) Set FREQUENCY ② to 20MHz. Adjust VC104 for 6div.
4) Repeat steps 2) and 3) until desired amplitude stability is reached.

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

R401, R402:
Programmwiderstände
Prgramming Resistors
Résistances de programmation
Resistencia segun programa
= 2.74kΩ

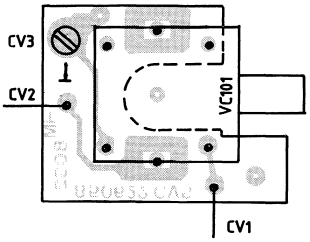


Bestückungsplan
Repèrage des composants



Display-Board
Carte affichage
Placa indicator

Component Locations
Localizacion de componentes

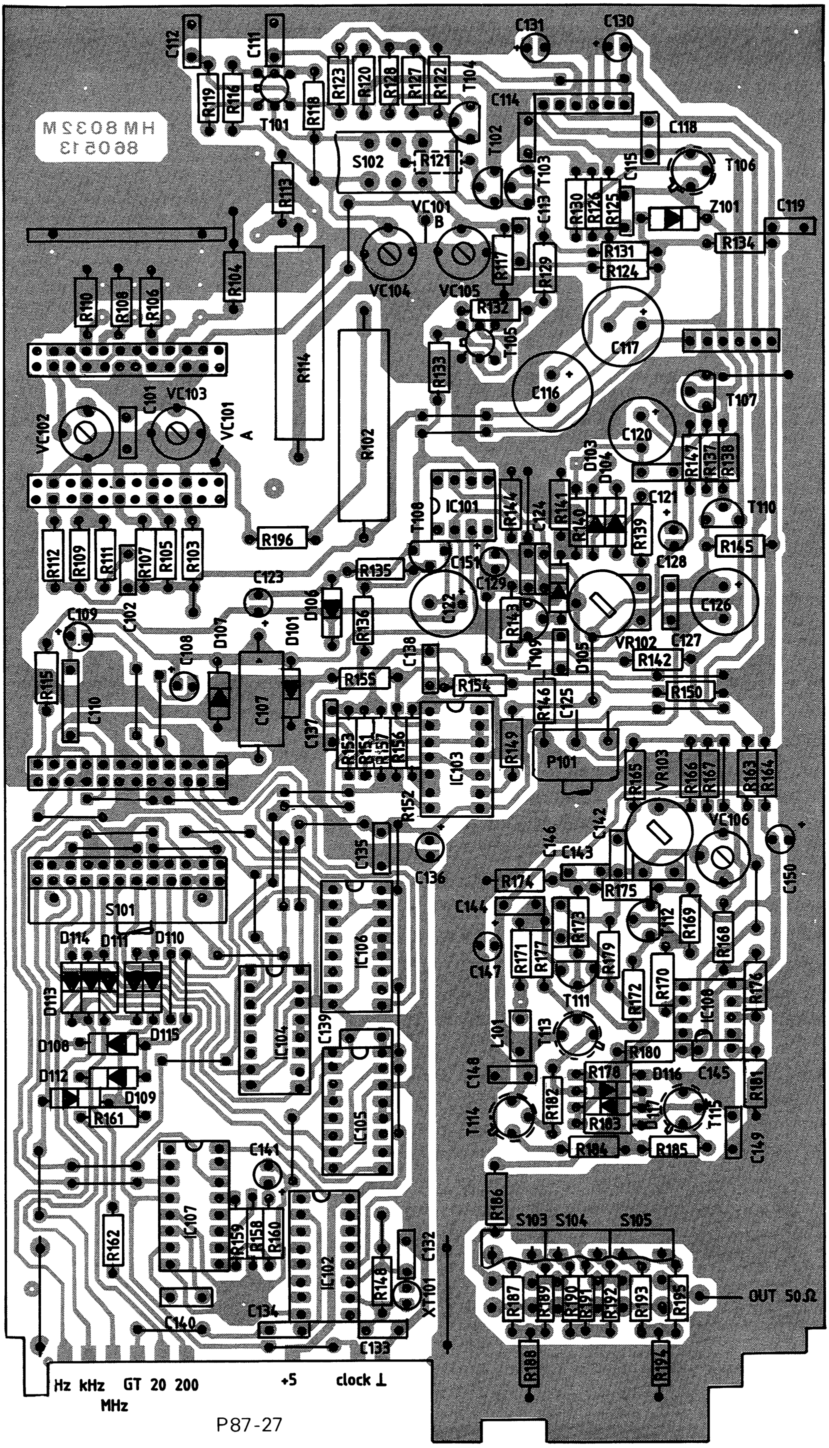


CV Board
Carte C.V.
Circuito CV

Bestückungsplan, Hauptplatte
Implantation des composants

Mainboard
Circuit prinzipal

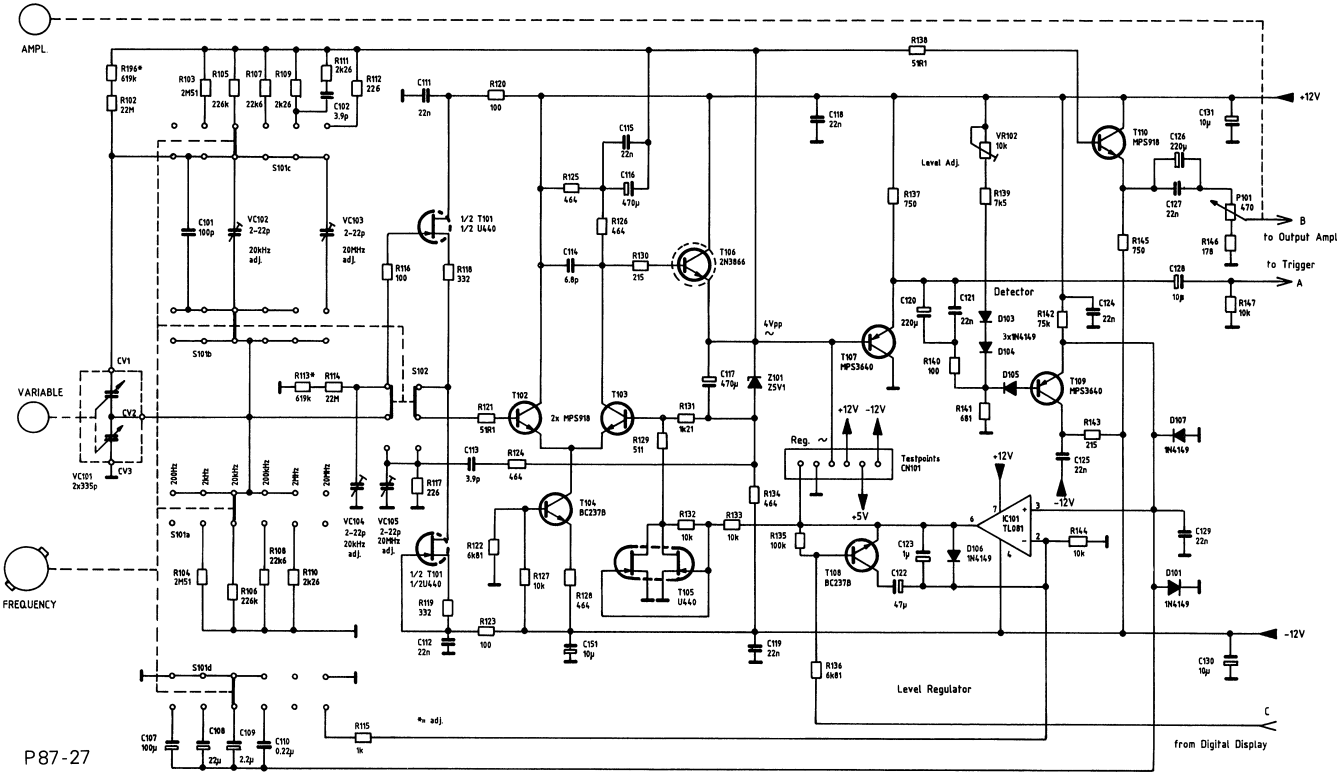
Component Locations
Localizacion de componentes



P87-27

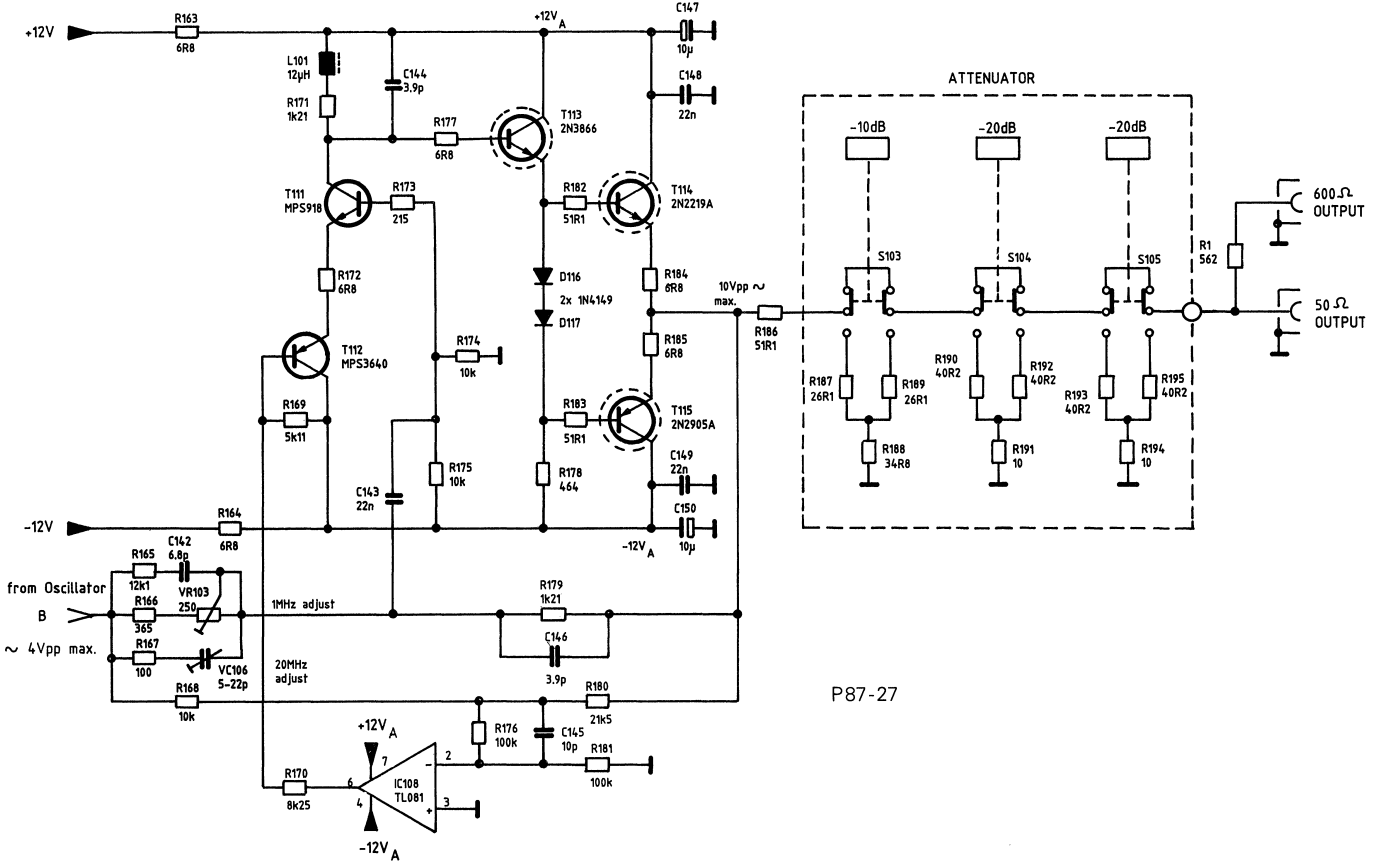
Generator, Frequenzumschaltung
Générateur, commutation de gammes

Generator, Range Selection (Main Board)
Generador y selector de frecuencia (Placa base)



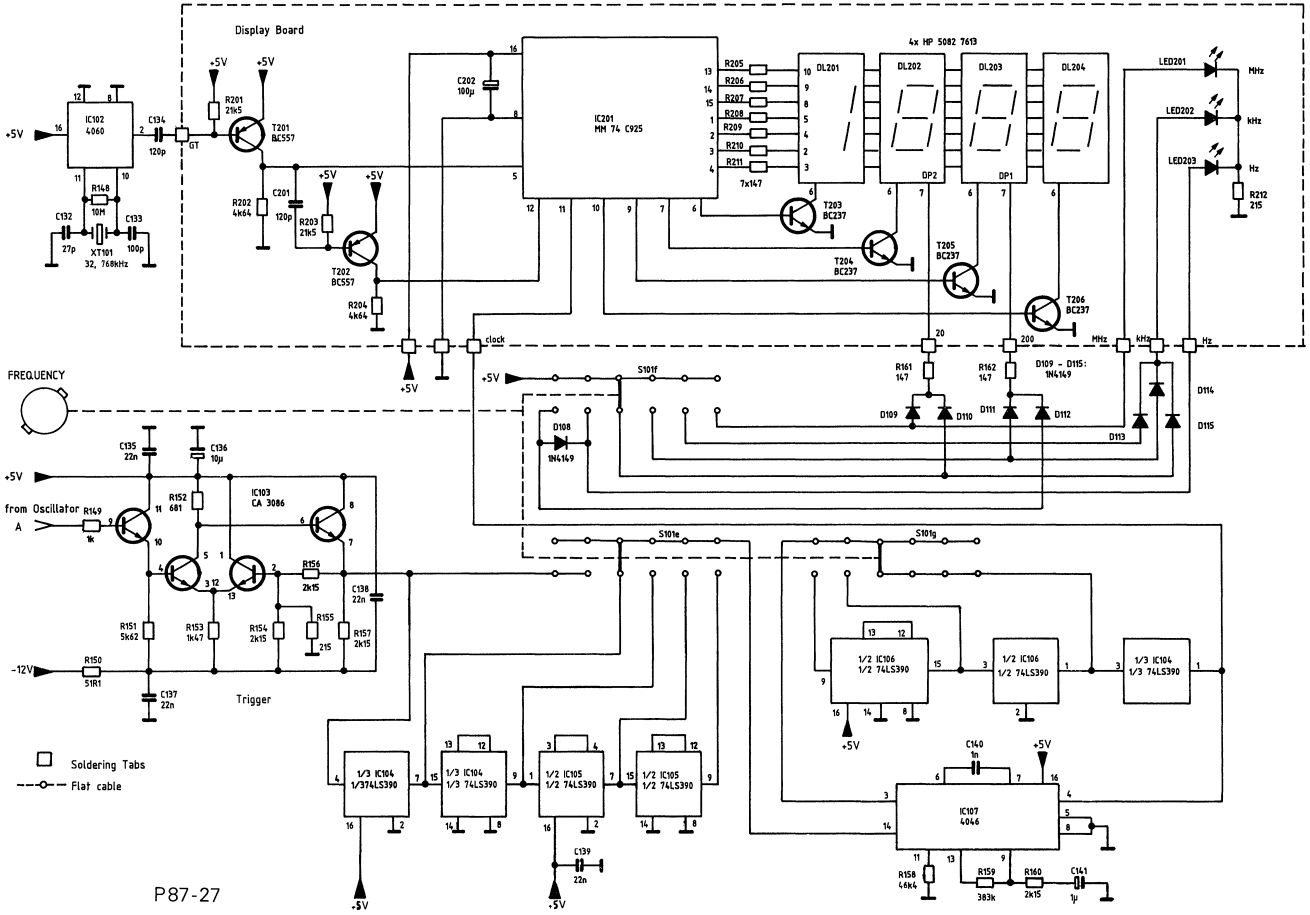
Endverstärker, Abschwächer
Amplificateur de sortie, atténuateur

Output Amplifier, Attenuator (Main Board)
Amplificador y atenuador de salida (Placa base)



Zähler; Digitalanzeige
Compteur; affichage numerique

Counter; Digital Display
Contactor y indicador digital



P87-27

Liste elektronischer Teile

Electronic Parts List

Ref. No.	Description		
R 1	562 Ω	1%	TK 50
R 102	22 MΩ		
R 103	2,51 MΩ		
R 104	2,51 MΩ		
R 105	226 kΩ		
R 106	226 kΩ		
R 107	22,6 kΩ		
R 108	22,6 kΩ		
R 109	2,26 kΩ		
R 110	2,26 kΩ		
R 111	2,26 kΩ		
R 112	226 Ω		
R 113	619 kΩ		
R 114	22 MΩ		
R 115	1 kΩ		
R 116	100 Ω		
R 117	226 Ω		
R 118	332 Ω		
R 119	332 Ω		
R 120	100 Ω		
R 121	51,1 Ω		
R 122	6,81 kΩ		
R 123	100 Ω		
R 124	464 Ω		
R 125	464 Ω		
R 126	464 Ω		
R 127	10 kΩ		
R 128	464 Ω		
R 129	511 Ω		
R 130	215 Ω		
R 131	1,21 kΩ		
R 132	10 kΩ		
R 133	10 kΩ		
R 134	464 Ω		
R 135	100 kΩ		
R 136	6,81 kΩ		
R 137	750 Ω		
R 138	51,1 Ω		
R 139	7,5 kΩ		
R 140	100 Ω		
R 141	681 Ω		
R 142	75 kΩ		
R 143	215 Ω		
R 144	10 kΩ		
R 145	750 Ω		
R 146	178 Ω		
R 147	10 kΩ		
R 148	10 MΩ		
R 149	1 kΩ		
R 150	51,1 Ω		
R 151	5,62 kΩ		
R 152	681 Ω		
R 153	1,47 kΩ		
R 154	2,15 kΩ		
R 155	215 Ω		
R 156	2,15 kΩ		
R 157	2,15 kΩ		
R 158	46,4 kΩ		
R 159	383 kΩ		
R 160	2,15 kΩ		
R 161	147 Ω		
R 162	147 Ω		
R 163	6,8 Ω	5%	TK 100
R 164	6,8 Ω	5%	TK 100
R 165	12,1 kΩ	1%	TK 50
R 166	365 Ω		
R 167	100 Ω		

Ref. No.	Description		
R 168	10 kΩ	1%	TK 50
R 169	5,11 kΩ		
R 170	8,25 kΩ		
R 171	1,21 kΩ		
R 172	6,8 Ω	5%	TK 100
R 173	215 Ω	1%	TK 50
R 174	10 kΩ		
R 175	10 kΩ		
R 176	100 kΩ		
R 177	6,8 Ω	5%	TK 100
R 178	464 Ω	1%	TK 50
R 179	1,21 kΩ		
R 180	21,5 kΩ		
R 181	100 kΩ		
R 182	51,1 Ω		
R 183	51,1 Ω		
R 184	6,8 Ω	5%	TK 100
R 185	6,8 Ω	5%	TK 100
R 186	51,1 Ω	1%	TK 50
R 187	26,1 Ω		
R 188	34,8 Ω		
R 189	26,1 Ω		
R 190	40,2 Ω		
R 191	10 Ω		
R 192	40,2 Ω		
R 193	40,2 Ω		
R 194	10 Ω		
R 195	40,2 Ω		
R 196	619 kΩ		
R 201	21,5 kΩ		
R 202	4,64 kΩ		
R 203	21,5 kΩ		
R 204	4,64 kΩ		
R 205	147 Ω		
R 206	147 Ω		
R 207	147 Ω		
R 208	147 Ω		
R 209	147 Ω		
R 210	147 Ω		
R 211	147 Ω		
R 212	212 Ω		

Ref. No.	Description		
C 101	100 pF	63 V NPO	10%
C 102	3,9 pF	63 V	10%
C 107	100 µF	35 V	
C 108	22 µF	40 V	
C 109	2,2 µF	63 V	
C 110	0,22 µF	100 V	20%
C 111	22 nF	63 V	20%
C 112	22 nF	63 V	20%
C 113	3,9 µF	63 V	10%
C 114	6,8 pF	400 V NPO	5%
C 115	22 nF	63 V	20%
C 116	470 µF	25 V	
C 117	470 µF	25 V	
C 118	22 nF	63 V	20%
C 119	22 nF	63 V	20%
C 120	220 µF	16 V	
C 121	22 nF	63 V	20%
C 122	47 µF	25 V	
C 123	1 µF	35 V	
C 124	22 nF	63 V	20%
C 125	22 nF	63 V	20%
C 126	220 µF	16 V	
C 127	22 nF	63 V	20%
C 128	10 µF	35 V	

Ref. No.	Description		
C 129	22 nF	63 V	20%
C 130	10 µF	35 V	
C 131	10 µF	35 V	
C 132	27 pF	63 V NPO	10%
C 133	100 pF	63 V	10%
C 134	120 pF	63 V	10%
C 135	22 nF	63 V	20%
C 136	10 µF	35 V	
C 137	22 nF	63 V	20%
C 138	22 nF	63 V	20%
C 139	22 nF	63 V	20%
C 140	1 nF	160 V	5%
C 141	1 µF	35 V	
C 142	6,8 pF	400 V NPO	5%
C 143	22 nF	63 V	20%
C 144	3,9 pF	63 V	10%
C 145	10 pF	63 V	10%
C 146	3,9 pF	63 V	10%
C 147	10 µF	63 V	10%
C 148	22 nF	63 V	20%
C 149	22 nF	63 V	20%
C 150	10 µF	35 V	
C 151	10 µF	35 V	
C 201	120 pF	63 V	10%
C 202	100 µF	35 V	
C 401	220 µF	16 V	

D 101	1N4149		
D 103-117	1N4149		
IC 101	TL081		
IC 102	CD4060		
IC 103	CA3086		
IC 104	SN74LS390		
IC 105	SN74LS390		
IC 106	SN74LS390		
IC 107	CD4046		
IC 108	TL081		
IC 201	MC74C925		
LED 201	TLSO5101		
LED 202	TLSO5101		
DL 201-DL 204	HP5082-7613		
T 101	U440		
T 102-103	MPS918		
T 104	BC237B		
T 105	U440		
T 106	2N3866		
T 107	MPS3640		
T 108	BC237B		
T 109	MPS3640		
T 110-111	MPS918		
T 112	MPS3640		
T 113	2N3866		
T 114	2N2219A		
T 201-202	BC557		
T 203-206	BC237		
L 101	12 µH		
VR 102	10 kΩ	20%	lin.
VR 103	250 Ω	20%	lin.
VC 101	2x 335 pF		
VC 102-106	2-22 pF		
POT 101	470 Ω	10%	lin.
ZD 101	Z5V1		
XT 101	Crystal 32,768 kHz		

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