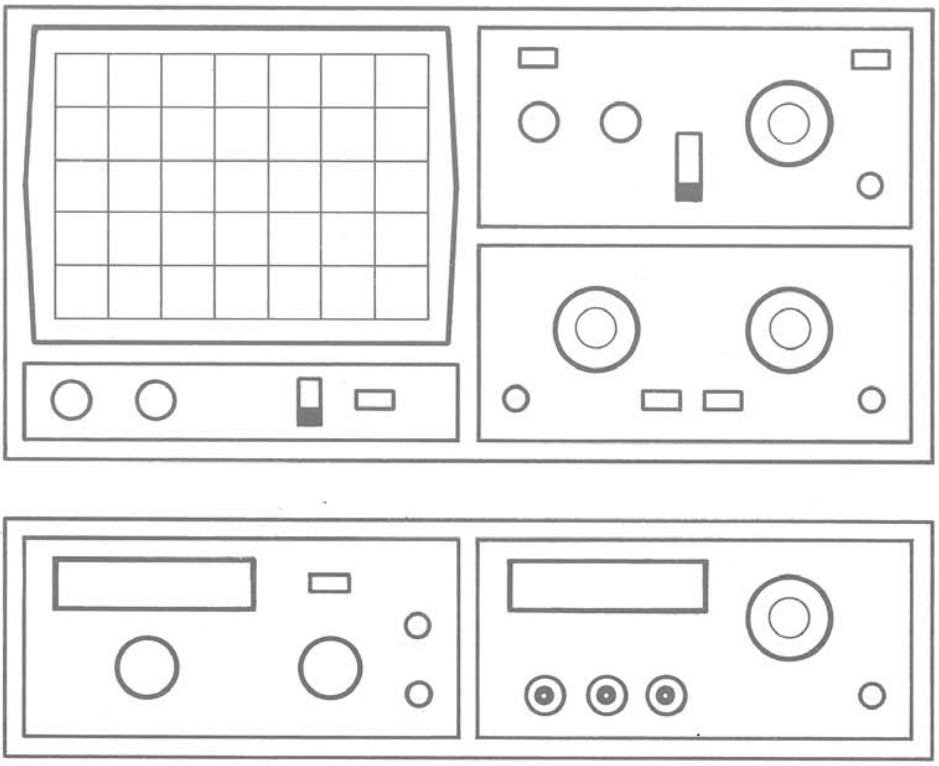
HAMEG
Instruments

MANUAL

SYSTEM MULTIMETER

HM 8112



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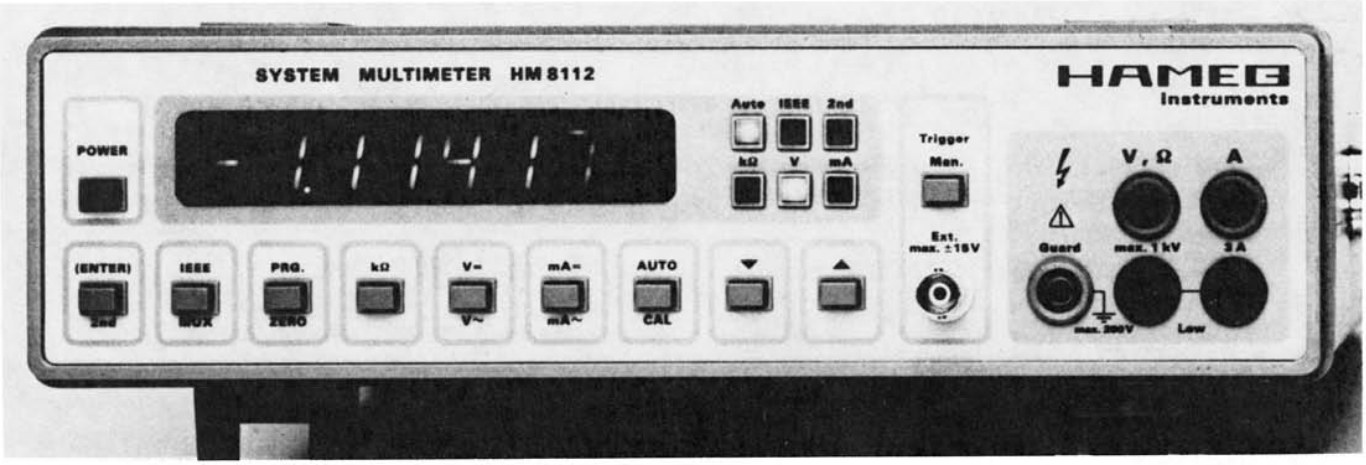


- **6½ Digit Display with 14 mm LED ≙ 1.999.999 digit**
- **True RMS Measurement Capability**
- **Resolution: 100 nV, 1 mΩ, 10 nA – Digital Offset Correction**
- **10 Measurements per Second; Programmable Measuring Time from 0.1 s - 10 s**
- **IEEE-488-Bus standard – Built-in Self Test Function**
- **High Input Resistance: 1 GΩ (0.2 V and 2 V range)**
- **Electronic Calibration via Keyboard or via IEEE-488-Bus for all Ranges**
- **Automatic or Manual Range Setting**
- **Optional built in 4-pole 10-Channel Scanner, Controllable via Keyboard or IEEE-488-Bus**
- **Trigger Input for Manual or Controlled Triggering**

With the HM 8112, HAMEG extends its successful range of professional oscilloscopes and test equipment with an exceptionally low priced 6½ digit high accuracy system multimeter. Fully matching the dimensions of HAMEG's Modular System 8000, very compact, efficient and flexible test facilities can be assembled requiring only a minimum of space.

Incorporating high stability amplifiers and a precision A/D converter, the HM 8112 permits DC-measurements with 100 nV resolution at 1 sec. integration time. True RMS measurements with DC-coupling are provided in all AC ranges, and resistances can be determined with 1 mΩ resolution during two-pole measurements. The digital offset correction feature enables easy offset voltage compensation at the touch of a pushbutton. This facility is particularly useful for counteracting both undesired thermoelectric EMF in measurement set-ups and test lead resistance in two-wire resistance measurement.

Three integration times (0.1, 1, 10 secs.) and two display modes (5½ digits and 6½ digits) can be selected via keyboard , IEEE-Bus, or manual control. An extensive start-up self test routine with concise error messages checks all analog functions of the instruments, including its digital calibration state. Instrument calibration, manually or via the IEEE-Bus, is straight forward, and does not require removal of the case. Calibration constants for all ranges are stored in a non-volatile memory.

The HM 8112 incorporates a talker/listener IEEE-Bus interface as a standard feature, allowing controlled measurements and calibration in all ranges. Full system integration and compatibility with all currently available controllers is ensured by a variety of programming and control commands. This includes a selection of 9 different terminating character combinations.

When set to "talk only" mode, all measurement data and parameters can be transferred directly to the "Listen only" printer for documentation purposes, without necessity for an external controller or any specific software.

The HM 8112's measurement versatility can be enhanced further by an additional 4-pole/10-channel scanner option. This measuring point selector can be activated manually via the front panel, or by remote control via the IEEE-Bus. Special high quality long-life switch contacts, rated for currents up to 3 A, ensure low resistance and unusually small thermoelectric EMF of less than 1 µV.

Wherever there is a requirement for fast and above average measurement accuracy, combined with high reliability and ease of operation, the HM 8112 is an ideal solution for monitoring and registering electronic measuring data.

Optional accessories:
HZ 81: Adapter card for scanner input; HZ 42: 19" rack mount kit; HZ 72: IEEE 488 bus cable

Specifications HM 8112 (Ref. temp.: 23°C ± 2°C)

DIRECT VOLTAGE V_{DC}

Ranges: ±0.2V, ±2V, ±20V, ±200V, ±1000V[2]

Accuracy: [3] [4]

	24h, 23±1°C		1 year, 23±5°C		Temperature Coefficients[5]
Range	% rdg.	% f.s.	% rdg.	% f.s.	±[% rdg. + % f.s.]
±0.2V	0.005	0.0007	0.012	0.0007	0.001 0.00015
±2V	0.003	0.0005	0.010	0.0005	0.0003 0.0001
±20V	0.005	0.0015	0.012	0.0015	0.001 0.0001
±200V	0.005	0.0015	0.013	0.0015	0.001 0.0001
±1000V	0.005	0.0015	0.013	0.0015	0.001 0.0001

	0.1 sec.	1+10 sec.	
Integration Times:			
Fullscale:	199.999	1.999.999	
1000V Range	100.000	1.000.000	
Resolution:	1µV	100nV	
Input Resistance:	±0.2V, ±2V		1GΩ
	±20V, ±200V, ±1000V		10MΩ

Zero Stability: Temperature drift less than 0.3µV/°C
Long term stability better than 5µV in 90 days

Measuring gaps: None. 125ms for range or function changings.

Overload Protection: (between „V/Ω-HI" and „V/Ω-LOW")
±0.2V, ±2V ranges: for 60sec. ±1000V[1]
continuous ± 700V[1]
±20V, ±200V, ±1000V ranges : continuous ±1000V[1]
Between „V/Ω-LOW" and GUARD : 125V DC or AC_{peak} [2]
Between GUARD and case : 125V DC or AC_{peak} [2]

Interference Rejection
(Measured by increasing the peak-peak interference signal level until a display error of 1 digit results with 1 sec. measuring time).
Series mode interference rejection
50Hz/60Hz power line frequency..... : better than 60dB
Common mode interference rejection (connected to one input terminal via low resistance path, 1kΩ inserted in series with one input lead) DC or 50/60Hz..... : 140dB

ALTERNATING VOLTAGE V_{AC}

Ranges: 0.2V, 2V, 20V, 700V[2]

Conversion Method:
True RMS value with DC coupling of the input sockets.

Input Resistance: 10MΩ II <60pF

Transient Response Time: 0.5s to 0.1% rdg.

Overload Limits:
Input V/Ω : ±1000V_{peak} or 700V_{rms} with the restriction of 10^7V·Hz [2]
Between GUARD and case : 125V peak
Between „V/Ω-LOW" and GUARD : 125V peak

Accuracy: ±[% of reading (% rdg.) + % of full scale (% f.s.)][1]
(1 year, 23±5°C)

Range	DC	20Hz	10kHz	20kHz	100kHz
0.2V	.....0.5+0.3.....	0.3+0.1			
2V	.....0.5+0.3.....	0.3+0.1.....	2+0.4.....	3+0.4.....	
20V	.....0.5+0.3.....	0.3+0.1.....	2+0.4.....	3+0.4.....	
200V	.....0.5+0.3.....	0.3+0.1.....	5+0.4.....	8+0.4.....	
700V	.....0.5+0.3.....	(DC–100Hz)			

Temperature Coefficient:
10°C to 18°C and 28°C to 40°C / x2 at 0°C–50°C

kHz	± [% rdg. + % f.s.] /°C
0–20	0.01 0.004
20–100	0.04 0.005

Integration Times (sec.): Selectable 0.1; 1; 10

Full Scale: 199.999 (700.00 in the 700V range)

Crest Factor: 7:1 peak value (max. 1.5xf.s.)

[1] Shield connected to „V/Ω-LOW" input socket, sinusoidal signal greater than 5% of full scale.
[2] Restricted to 125V_{peak} with a max. 10^6V·Hz when the scanner is incorporated.
[3] ±[% of reading (% rdg.) + % of full scale (% f.s.)]
[4] ±1 Digit after offset correction (rdg. = reading / f.s. = full scale)
[5] 10°C to 18°C and 28°C to 40°C / x2 at 0°C–50°C

CURRENT

	mA=	mA~
Ranges:	±2mA, ±2A	2mA, 2A
Integration Times (sec.):	0.1; 1; 10	0.1; 1; 10
Full Scale / Resolution:	199.999/10nA	199.999/10nA
Accuracy: (1 year, 23±5°C)[1]	DC	20Hz–20kHz
Ranges 2mA and 2A	0.05+0.005	0.5+0.07
Temperature Coefficient: [1] [5]	0.002+0.001	0.01+0.004
Maximum Burden: Range	2mA : <10mV;	2A : <600mV

Overload Limits: 250V (3A fuse protected)[2]
Crest Factor: 7:1 (Peak value max. 1.5 f.s.)
Transient Response Time: 0.5sec. to reach final value within 0.1%

RESISTANCE kΩ

	0.1 sec.	1+10 sec.
Integration Times:		
Full Scale / Resolution:	199.999/1mΩ	1.999.999/1mΩ
		1.200.000 (10MΩ range)

Accuracy: [3] [4]

	24h, 23±1°C		1 year, 23±5°C		Temperature Coefficients[5]
Range	% rdg.	% f.s.	% rdg.	% f.s.	±[% rdg. + % f.s.]
200Ω	0.01	0.002	0.015	0.003	0.002 0.0005
2kΩ	0.005	0.001	0.015	0.002	0.0015 0.0005
20kΩ	0.005	0.001	0.015	0.002	0.0015 0.0005
200kΩ	0.005	0.001	0.015	0.002	0.0015 0.0005
2MΩ	0.005	0.001	0.015	0.002	0.002 0.0005
10MΩ	0.05	0.003	0.1	0.006	0.01 0.0005

Current through measured resistor:

Range		
	200Ω, 2kΩ	0.7mA
	20kΩ	70µA
	200kΩ	7µA
	2MΩ, 10MΩ	0.7µA

Open circuit terminal voltage: approx 14V max.
Overload limit: ±300V_{peak} (125V_{peak} with Scanner)

SCANNER / MULTIPLEXER

Channels / Contacts per Channel / Function: 10 / 4 / 1 of 10
Thermoelectric EMF: Less than 1µV after 1.5h warm-up time
Max. Voltage: 125V_{peak} or 10^6V·Hz (whichever is less)
Max. Switch Current: 3A
Time between 2 switching actions: Shorter than 100ms/2Hz
Max. Contact Resistance (initial value): Less than 20mΩ
Contact Life: 2x100.000.000 switching actions (0.1A, 10V_{DC})
Insulation Resistance: 3GΩ at 60% relative humidity
Capacitance between the Contacts: <100pF

IEEE-488-BUS INTERFACE

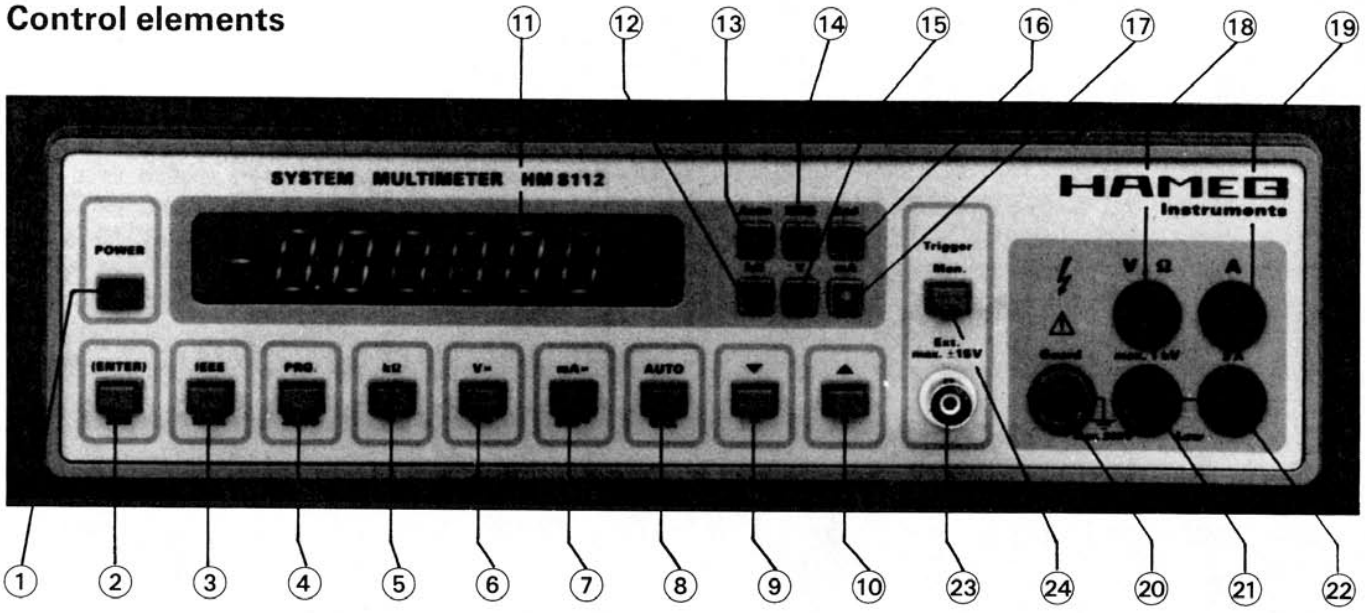
Supported IEEE-488-Bus Functions:
SH1/AH1/T5/L3/RL1/DC1/DT1/SR1

Output Data: Numerical data for measurement result, function, range, and integration time.
Input Data: Function, range, integration time, start command, nominal calibration value.
Address: Selectable from 0 to 30, can be set via keyboard.
Terminator: 9 combinations available for selection.

General

Warm up time: typ. 90min. to specified accuracy.
Power requirements: 110/220V±15%; 45-60Hz; 17VA
Ambient temperature: –40°C to +70°C (storage)
+10°C to +40°C (operation)
Humidity: 10%–75%, no condensation
Dimensions: 285x75x365mm (WxHxD). **Weight:** approx. 4kg
Safety: Class I, according to IEC 348
The „V/Ω-LOW" socket and the „A-LOW" socket are connected together internally. The maximum permissible current between these sockets is ±0.1A (fuse 0.1A).
Values without tolerances are meant to be guidelines and represent characteristics of the average instrument.

Control elements



① **Power switch**

② **2nd:** Switches to the second function level of the keyboard.

③ **IEEE-Key:** To set the device address, the end character and calling the trigger mode, in conjunction with the up and down keys.
MUX-Key: Channel selection for the 10-channel scanner option by means of the 2nd-Key.

④ **PRG:** To set the integration time (measuring time) between100ms and 10 sec. by means of the up and down keys. The selected time is displayed together with the appropriate display resolution.
ZERO: Offset correction for compensating thermoelectric EMF or measuring lead resistance.

⑤ **kΩ** (measuring function): To select resistance measuring function.

⑥ **V=/V~** (measuring function): To select the voltage measuring function.
VAC is selected in conjunction with the 2nd-key.

⑦ **mA=/mA~** (measuring function): To select the current measuring function.
mA~ is selected in conjunction with the 2nd-key.

⑧ **Auto:** Switches to autoranging for all measuring functions.
CAL: Together with the 2nd-key switchover to the digital calibration mode, after unlocking the protection switch on the rear panel.

⑨ **▼:**Manual range selection (down key)

⑩ **▲:** Manual range selection (up key)

⑪ **Display:** 8-digit LED display for alphanumerical readout of the measured values and device messages.

⑫ **kΩ** (LED state indication): ON when resistance measuring function is selected.

⑬ **Auto** (LED state indication): ON when autorange is selected.

⑭ **IEEE** (LED state indication): ON when IEEE-Bus setting mode is selected.
This mode enables the user to set the IEEE-Bus device number, the end character and to call the trigger mode, in conjunction with the up and down keys.

⑮ **V** (LED state indication): ON when V= or V~ measuring functions are selected.

⑯ **2nd** (LED state indication): ON when the second function level is selected (MUX/Zero/V~/mA~/Cal.).

⑰ **mA** (LED state indication): ON when mA= or mA~ measuring functions are selected.

⑱ Input terminal (high) for voltage and resistance measurements.

⑲ Input terminal (high) for current measurements.

⑳ Guard terminal: Guarding technique gives high rejection factor for series mode interference, even under adverse measuring conditions.

㉑ Input terminal (low) for voltage and resistance measurements.

㉒ Input terminal (low) for current measurements.

㉓ External trigger input.

㉔ Pushbutton for manual triggering of a single measurement.

Rear panel elements: Mains connector with voltage selector (110/125/220/240V) and fuse holder; IEEE-488-Bus connector; Calibration data protection switch; 10-channel scanner input (Option).

A recessed switch gives protection against unintentional changes of the stored calibration factors. Recalibration is only possible after selecting the calibration mode with this switch.

The 24pole IEEE-488-Bus connector and the 50pole submimiature type D socket strip connector of the optional 10-channel scanner are situated on the rear panel. An optional adapter card can be plugged into the scanner input, permitting screw terminal connection of measuring lines, providing two antiparallel 3A clamp diodes for each current channel.

A 19" rack mount kit (HZ80) with 2 HU enables rack mounting of the HM8112.

Printed in West Germany
Subject to change without notice

Warranty

Before being shipped, each instrument must pass a 10 day burn-in and a 48 hour quality test. Most failures can be detected by means of intermittend operation during this test. Nevertheless,a component may fail, but only after a longer period of operation.

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 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 imlplied, and all implied warranties of merchantibility and fitness for a particular use which exceed the aforestated obligation are hereby disclaimed by Hameg and excluded from this agreement. Under no circumstances shall Hameg be liable to buyer, in contract or in tort, for any special, indirect, incidental or consequential damages, espresses, losses or delays however caused.

WARNING

The optional Scanner is equipped with bistable relays, whose contacts are in arbitrary state when the power supply is switched on or off. Thus it is very important to make quite sure that the unit is switched on or off only when no measuring cables are connected if the signal sources can deliver voltages or currents which exceed the limit values specified in the technical data for this unit (Limiting resistors will normally help.).
The arbitrary state of the relay contacts at switch-on or switch-off time may short-circuit measured signals in an uncontrolled manner and without due precautions this might damage your measuring circuit or the scanner.
We expressly point out that we accept no liability for consequential damage. Damage to the relay contacts is also not covered by our warranty obligations.

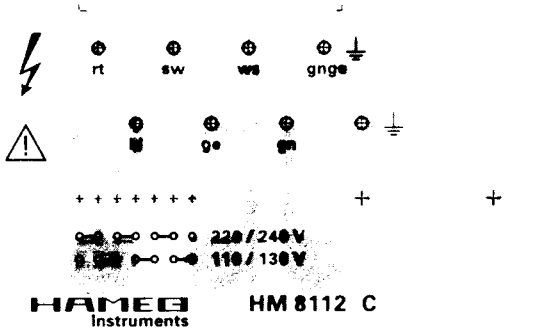
Commencing Operation

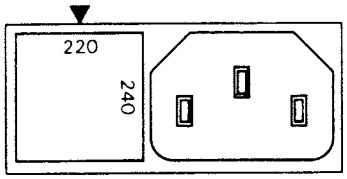
Every HAMEG HM 8112 unit has been carefully tested in detail before leaving the factory, to make sure that its function conforms to all technical specifications. The unit should be in perfect electrical condition on arrival at the customer. To verify this, the unit should be

examined for transportation damage immediately on arrival. In the case of grounds for complaint, a protocol of damage found should be drawn up together with the deliverer.

Mains Connection

This HAMEG measuring unit is intended for connection to one of the voltages 110V, 125V, 220V, 240V, 50/60 Hz AC mains input voltage as power supply. Make sure you have an instrument that corresponds to your power line voltage!
When changing the line voltage please open up the instrument and set the jumpers on the mains pcb to the position corresponding to the line voltage desired. (Fig. 1)





Fuse type: Size **5 x 20 mm**; 250 V~, C;
IEC 127, Sheet III; DIN 41 662 (possibly DIN 41 571 sheet 3).
Cutoff: **time lag (T)**.

Fig. 1 MAINS setting PCB

Voltage fluctuations of +/- 10% and frequency fluctuations of +/- 4% are tolerated. The power consumption is about 17 VA. A cold equipment mains connector with grounding contact, conforming to DIN, is located on the rear of the unit. The unit is protected by a slow blow 0.1 A(220V, 240V line voltage) or 0.2 A(110V/125V line voltage) miniature fuse.

Grounding

To protect the user against possible electric shock, the case of the unit must be grounded by connecting the mains cable to a suitable power outlet with grounding contact. The case is electrically isolated from the shield and from the two input sockets.

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

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.

Keyboard and Integration Setting

The ten element keyboard is double-assigned. All functions marked above the keys are activated by single actuation of the respective key. All functions marked beyond the keys are called by first pressing the "2nd" function key and then the respective function key. The LED marked "2nd"

is always lit too when a "2nd"- function has been selected, i.e. it is lit together with the LED which is designated with the corresponding function.
The functions direct voltage "V=", alternating voltage "Vac", direct current "mA=", alternating current "mAac" and resistance "KOhm" are selected by pressing the respective key.

Range selection is automatic when the "Auto" key has been pressed, or manual with the range keys (up and down keys). When one of these keys is pressed, the autoranging function is switched off and the active range is switched one step up or down for each keypress.

The fast autoranging function makes a preliminary decision within the first third of the set measuring time, wether the active range is the correct one. If the set range is retained after the preliminary decision (fast autoranging), then two further checks are made after elapse of the complete measuring time:
1. The next higher range is selected if the span limit is reached or exceeded.
2. If less than 8% of the set span is reached, then the next lower range is selected. The next measurement then commences in the new range 100 msec after switchover.

When range selection is made via the rear input (see section headed IEEE 488 bus interface, then the range keys on the front panel are disabled. The control unit is electrically isolated from the input.

A brief measurement with reduced accuarcy is inititated in response to each keypress and each range change, when autoranging is switched on. The brief measurement takes 200 ms and produces no service request when SRQ is selected in IEC bus operation.

After pressing the "Prg" key, "P1" appears in the display for about 1s. If the "Prg" key is pressed again within the 1s delay time, then "P2" appears, again for 1s. "P1" and "P2" stand for Program 1 and Program 2.

If no key is pressed during the 1 second delay time, then the programs are executed.

Program 1: Setting the integration time

Program 2: Switch-on, switch-off of the external trigger facility

The up and down keys are used to set the integration time. The following measuring times are available:

0.1 sec. ..... 100 ms integration time, display 5 1/2 digit

1 - 5 sec. ..... 1 s integration time, display 5 1/2 digit

1 - 6 sec. ..... 1 s integration time, display 6 1/2 digit

10 sec. ..... 10 s integration time, display 6 1/2 digit

Pressing any other key exits this program and the integration time standing in the display at this instant is taken over for determining the measured values.
Switch-on and switch-off of the external trigger facility is made with the "up" key. The display shows "trig on" or "trig off", after alternate presses of the "up" key. Pressing any other key exits the program and the last displayed status is taken over. If start mode has been chosen, then the actual measured value appears in the display.

"Cal","Zero","IEEE" and "MUX" are described in corresponding subsections

Digital Display

The measurement results with decimal point, the negative sign and error messages are shown on the digital display of the digital multimeter. Certain operating modes of the multimeter are indicated here too. The active function and the operating mode are indicated by LEDs marked with the corresponding functions.

Offset Correction

Zero point displacement (drift) is one possible source of error. Normally this type of error is immediately evident by a display reading differing from Zero when the input is shorted. A zero point correction can be made with the "Zero" key. For this purpose place a short circuit at the "VOhm" input and then press the "Zero" key. The instrument makes a zero point measurement whose duration is determined by the set integration time. With 6 1/2 digit display, the zero point measurement takes 20 seconds in the functions "Vdc", "mAdc", during which time the display shows "null" and the remaining time in seconds until the end of the measurement. With 5 1/2 digit display, the zero point measurement takes 2 seconds and only the text message "null" appears in the display. The keyboard is disabled during the correction measurement.

The maximum allowable offset is 1% of the measuring range!

Deviations up to 1% of the measuring range span can be corrected. If the deviation exceeds this limit, then the message " Error 4 " appears in the display and on the IEEE 488 bus, and the old correction value is preserved.

The sequence of the correction measurement differs slightly from the description given above, for the functions "KOhm", "Vac" and "mAac". For these functions the zero point is corrected immediately by continual observation of the measured value. If autoranging was switched on before calling the zero point measurement, then all ranges of one function are corrected in succession for zero point. Now the zero point measurement takes 10 seconds for each 6 1/2 digit display span, and 1 second for each 5 1/2 digit display span. When the measurement duration is 10 seconds, the display shows "null" and the remaining time. When the measuring time is 1 s, only the text message "null" appears in the display. For the current measuring ranges, the zero points are corrected with open-circuit sockets.

No short circuit; active current sink circuit!

No short circuit is placed internally in the multimeter for the offset correction, so that the user can place the short circuit at any desired location in the external circuit, to include external error sources in the compensation. This is particulary important for the 2-wire resistance measuring function. The error due to the finite resistance of the measuring leads can be eliminated by the offset correction.

Error Messages and Self-Test

Self-Test

The digital multimeter executes an automatic self-test routine on mains power-up. Progress of the individual test routines is indicated in the main display by the message "Contr.1-3".

If an error occurs during the self-test, this error is reported by a corresponding error message and the multimeter aborts further execution of the self-test routines. To resume execution of the self-test routines press any key. No voltage greater than 300 V may be present at the input sockets of the multimeter during self-test.

Contr. 1 initializes the multimeter and checks for correct functioning of the analog section.

Contr. 2 forms a checksum of the calibration factors stored in the battery backed up RAM and compares this recalculated checksum with the old stored value.

Contr. 3 forms a checksum for the program ROMs and compares this recalculated checksum with a stored control checksum.

Error Messages

The digital multimeter recognizes the following error situations caused by incorrect operation or manual control. They are reported in the main display and via the IEEE 488 bus with the designation "Error" and a code number. The code numbers have the following meanings:

1 - Overflow for measurement: The reading exceeds the allowed range

4 - Error during offset measurement: The offset is too large

5 - Error during calibration:
1. Nominal value smaller than 5% or greater than 100% of range
2. Calibration switch on the rear of the unit is set to "MEAS".

6 - IEEE 488 bus interface error: The multimeter has received a message string containing more than 30 characters.

8 - Error during self-test 2: The redetermined and the old check sum do not agree (lithium battery exhausted).

9 - Error during self-test 3: Error in the program ROMs.

Operation Instructions for Direct Voltage Measurements (V=)

Connect the voltage to be measured to the two input terminals marked "V/Ohm" and ground on the front panel. A voltage which is positive at the red socket relative to the black socket gives a positive readout in the display.
Make sure that the maximum permitted values of the "LOW" input and guard (see section "shielding"), and 500 V DC or peak-peak AC between guard and case, are not exceeded. This condition must be taken into consideration when selecting polarity for high voltage circuits which are not isolated from the power mains.

Input resistance in DC ranges

In order to make full use of the excellent linearity of the measuring method, the input resistance for voltage measurement is extremely high in some ranges. For example, this still permits relatively accurate measurements up to +/- 2 V even when the internal resistance of the

measured voltage source is 100 kOhm. In the 20 V, 200 V and 1000 V direct voltage measuring ranges, 100 Ohms internal resistance of the measured voltage source already give an error of 1 digit when using 100,000 digits resolution. For input resistance, display span and resolution see the following table:

Range	Display span	Input Resistance	max.Resolution
0,2 V	.2000000 V	1 GOhm	100 nV
2 V	2.000000 V	1 GOhm	1 uV
20 V	20.00000 V	10 MOhm	10 uV
200 V	200.0000 V	10 MOhm	100 uV
1 000 V	1000.000 V	10 MOhm	1 mV

Overload Protection

All ranges are effectively protected against destruction by voltages greater than the full-range value. The max. overloads in this sense are:

+/-0.2V,+/-2V ranges: +/- 1000V for 60 sec or +/- 700V cont.

+/-20V, +/-200V, +/-1000V ranges: +/- 1000V continuous

However, bear in mind that heavy overloads in the lower ranges will inevitably cause heat-up of the safety resistors and diodes, so that subsequently thermoelectric EMFs may cause a zero displacement until internal temperature equilibrium has been reestablished.

Common mode supression

The common mode rejection of a measuring unit is the capability of indicating only the wanted difference signal between the "HI" and "LOW" input, with ideally complete supression of any response to a common voltage which both input terminals may have with respect to ground. Whereas an ideal system would give no response to a common mode signal, so that it would show no error due to this cause, in a practical system stray capacitances, finite insulation resistance and resistive circuit assymmetry will convert a portion of the common mode voltage to a series voltage. The common mode rejection factor of this multimeter is better than 140 dB when the resistive asymmetry of the measuring leads has any value up to 1 kOhm.

Shielding

If problems due to common mode voltage are expected in a given measuring task, then the guard input (blue socket) should be strapped to the "LOW" input (black socket).

A high rejection factor for direct voltage and common mode voltage can be obtained in critical cases by appropriate connection of the guard input. Common mode voltages are voltages which occur between the low point of the voltage to be measured and mains (power) ground, or between power ground of the voltage source and ground potential of the measuring unit. Common mode voltages attempt to send currents in the same direction via both input sockets. For optimum shielding effect, connect the guard input to a direct voltage potential equal to that of the "LOW" input such that currents flowing in the shield do not flow through resistances in the voltage source circuit and voltage measuring leads, which could disturb the voltage being measured.

Operating Instructions for Alternating Voltage Measurements Vac

The digital multimeter measures the true RMS value of the input voltage, i.e. the RMS value of the applied direct and alternating voltage.

A recommenced arrangement for measuring alternating voltages consists of a two-conductor shielded cable with the shield connected to the "guard"-input. For all measurements, the "guard" and the "V/Ohm-LOW"-input should be connected to the measuring point which lies closest to ground potential.

Somewhat poorer shielding is achieved by using a single coaxial cable and establishing a link between the "guard" and the "V/Ohm-LOW"-input. This often used arrangement is nevertheless satisfactory for most measurements except in very high ambient noise levels and/or when measuring very small voltages.

In the 200 V and 1000 V ranges and when measuring alternating voltages with high frequencies (above 100 kHz for the 200 V range or above 10 kHz for the 1000 V range), it must be ensured that the applied alternating voltage does not exceed the RMS value product of 10 million V*Hz.

Measuring Direct Current mAdc and Alternating Current mAac

When connecting the measuring circuit to the DMM, bear in mind that the two black "LOW"-sockets of the inputs "V/Ohm" and "A" are connected together internally. Thus it is not possible to connect simultaneously two measuring leads for current measurement and two leads for voltage measurements, if there is a potential difference between the respective measuring points. The internal connection between the "V/Ohm" socket an the "A"-"LOW" socket is protected against current overload by a 0.1 A fuse (slow blow).

Offset correction by keypress is possible for the current measuring ranges too. But in contrast to all other functions, the offset correction for current measuring ranges must be made with the input sockets open circuit (see also the section headed "offset correction").
A 0.1 Ohm shunt is used in the 200mA range. But in the 2 mA range a current compensation circuit is used which permits load voltages smaller than 1 mV. The current measuring ranges are protected by power diodes and an additional quick blow 3 A fuse.

Before replacing blown fuses, disconnect the mains plug and all measuring cable plugs. The 3A (quick blow) fuse is located near the input sockets of the instrument and the 0.1 A (slow blow) fuse is located close to the large blue 0.1 Ohm shunt at the front right inside the instrument.

Operating Instructions for Resistance Measurements kOhm

Resistance measurements with this multimeter are made according to the following principle: A load-independent current (I) is passed through a resistance (Rx) which is to be measured. This current also flows via a known internal range resistor. The voltage drop across Rx is measured via the input sockets "V=" and the ratio of this voltage drop to the voltage drop across the internal range resistor is determined. Thus any drift or ageing of the reference voltage source has no effect on the accuracy of the resistance measurements.

The digital multimeter makes resistance measurements in 2-wire circuit. For measuring small resistances too with high accuracy, careful compen-

sation of the measuring lead resistances and of thermoelectric EMFs is required, with the aid of the offset correction facility.
For this purpose connect the two measuring leads with their test clips to one side of the resistor to be measured, and then make offset correction by pressing the "Zero" key. This correction compensates for all possible sources of error, such as measuring lead resistance, contact resistance and thermoelectric EMFs. Shielded measuring should be used when measuring large resistances (100 kOhm or greater). Connect the shield to ground potential, to prevent errors due to foreign voltages (mains ripple).

The currents trough the resistance to be measured have the following values in the respective ranges:

2 kOhm-range	700 uA
20 kOhm-range	70 uA
200 kOhm-range	7 uA
2 MOhm-, 10 MOhm-ranges	0,7 uA

The polarity of the current flowing trough Rx is defined such that the end of Rx which is connected to the upper "HI" socket of the "V/Ohm" input has a negative potential with respect to the other end of Rx.

Operating Instruction for 10-channel 4-pole Scanner/Multiplexer (Option)

When the DMM has been equipped with the scanner option, the maximum permitted voltage at the subminiatur type D 50-pole socket on the rear or at the "V/Ohm"-input sockets, is 125 V peak-peak, with the restriction for the RMS product to be lower than 1 Million V*Hz.

The optional Scanner is equipped with bistable relays, whose contacts are in arbitrary state when the power supply is switched on or off. Thus it is very important to make quite sure that the unit is switched on or off only when no measuring cables are connected if the signal sources can deliver voltages or currents which exceed the limit values specified in the technical data for this unit. The arbitrary state of the relay contacts at switch-on or switch-off time may short circuit measuring signals in an uncontrolled manner and without due precautions this might damage your measuring circuit or the scanner.

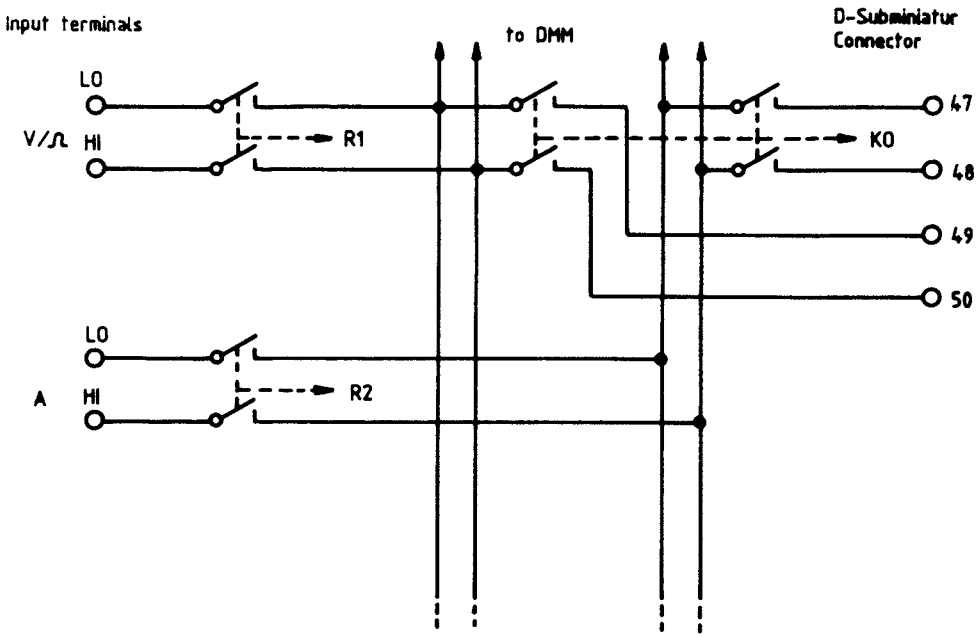
The multiplexer is of type "1 of 10", i.e. one freely selectable channel at a time can be connected through. The inputs are collected on a 50-pole subminiature type D socket connector mounted on the rear of the unit. The 4 output lines of the multiplexer are connected internally to the multimeter input terminals "V/Ohm" and "A". The front terminals too can be switched-in and switched-out via the IEEE 488 bus interface. When the front terminals are switched-in, they too are connected to the "V, KOhm" and "A" inputs of the multimeter. The front terminals are in switched-in state immediately after power-up of the DMM. For operating instructions for this function see section headed "IEEE 488 bus".

A shield is provided separately for each multiplexer channel and is connected to the "guard" terminal on the front of the unit and to pin 1 of the subminiature type D socket connector. An adapter card is also available which plugs onto the subminiature socket connector and provides screw terminal connections for the multiplexer inputs.
Channel selection can be made via the keyboard as well as via the IEEE 488 bus. After pressing the "Mux"-key (first press "2nd" and then press "Mux"), the presently selected channel is shown in the display.

A new channel can now be selected with the range key. The ten channels are numbered consecutively from 0 to 9. Between channels 9 and 0 there

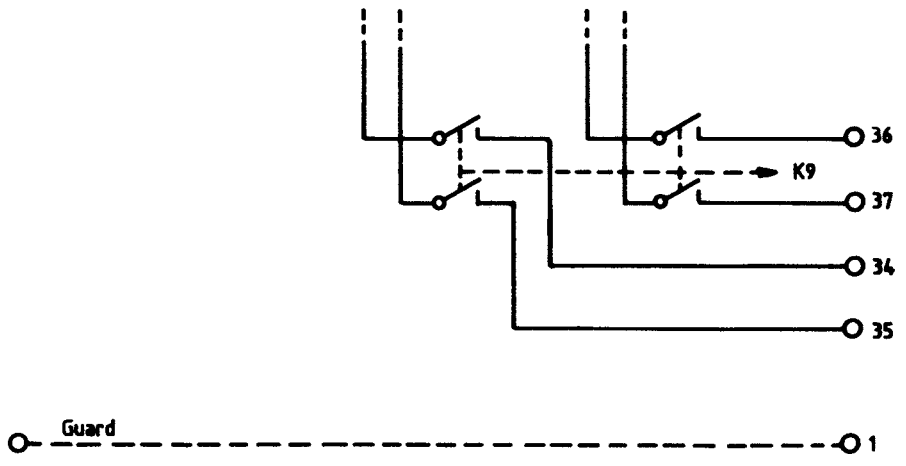
is a state with indication "-" in the display, corresponding to the state "multiplexer switched off". To exit this program and connect through the selected channel, press any other key.

Channel selection is made via the IEEE 488 bus interface using the command "MX" (see section headed "IEEE 488 bus interface").



	Channel:	K0	K1	K2	K3	K4	K5	K6	K7	K8	K9
Input terminals	A LO	47	17	15	13	11	9	7	5	3	36
	A HI	48	16	14	12	10	8	6	4	2	37
	V/ LO	49	33	31	29	27	25	23	21	19	34
	V/ HI	50	32	30	28	26	24	22	20	18	35

Connector contact plan

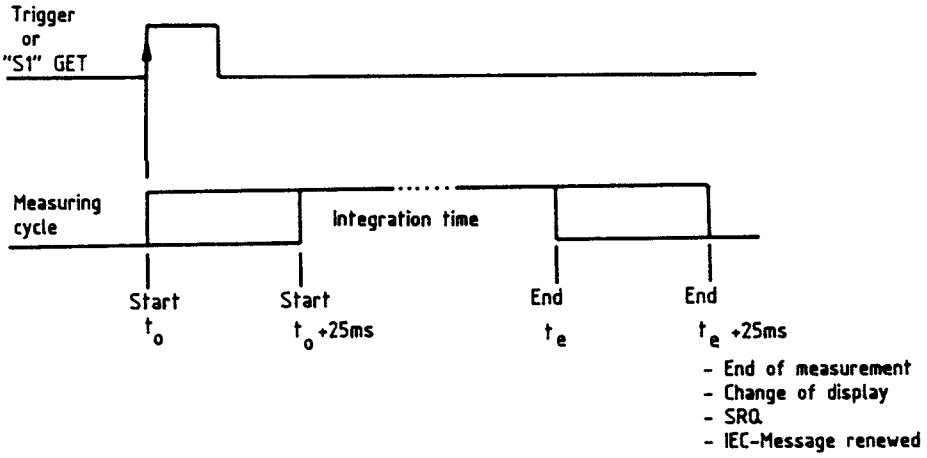


EXTERNAL TRIGGERING

The digital multimeter can be triggered for a single measurement via the BNC-Connector on the front panel or by means of the trigger key. Another start mode under software control is posible too, via the IEEE 488 bus. All start modes have the same time sequence.

If program 2 (see the section describing the keyboard) has placed the digital multimeter in "trig on" status, single measurements can be started via the trigger socket or the trigger key. The start time is the rising flank of a trigger pulse with a time jitter not exceeding 25 ms.

Via the IEEE bus, the digital multimeter is placed in start mode by the command "S1". Each further transmission of "S1" then corresponds to a trigger as described above. The digital multimeter can also be started by the addressed command GET (Goup Execute Trigger). The display and the IEEE message are refreshed at the end of the measuring time. If service request is switched on, then the SRQ line is activated. In "TALK ONLY" mode, the digital multimeter sends a message to a connected device in "LISTEN ONLY" mode. Range and function switching operations carried out shortly before triggering may lead to delay times of up to 225 ms.



IEEE 488 - Bus - Interface

Capabilities of the IEEE 488 bus interface

SH1	Handshake source function
AH1	Handshake sink function
T5	Talker function
L3	Listener function
RL1	Remote control
DC1	Reset function
DT1	Trigger function
SR1	Service request function

Programming the Digital Multimeter via the IEEE 488 bus Interface

Set the device address using the numerical keyset of the digital multimeter. For this purpose, first press the "IEEE"-key . The digital multimeter is then in status "set device address". The display shows the present device address setting, e.g. "IEEE.07.8" which means that the unit is set at present to device address 7 and end character type 8. The digital multimeter is set to this device address and end character as delivered from the factory. The "07" in the display is flashing, to indicate that the device address can now be changed.

Use the "up" key to change the device address. The first actuation of this key starts a cyclic run-through of device addresses from 01 to 30. After address 30 the characters "--" appear in the display for operating status "TALK ONLY". When the desired address or "TALK ONLY" is reached, the process is stopped by pressing the "up" key again. To select the end character by its designation number, press the "down" key. The digit after the decimal point now flashes, indicating that the end character can now be changed. Selection of one of nine possible end characters is made with the "up" key in the same manner as for selecting the device address.

The following terminating characters and combinations are available :

Designation number	Terminating character (Combination)
0	CR + EOI
1	CR
2	LF + EOI
3	LF
4	CR + LF + EOI
5	CR + LF
6	LF + CR + EOI
7	LF + CR
8	EOI

The desired device address including the designation number of the terminating character combination is now present in the display. Press any key except a range key to transfer this address information into working memory and exit the status "set device address".
If it is desired to take over these new settings into protected memory, set the calibration switch on the rear of the unit to position "Cal" before takeover of the address data.

****
* DO NOT FORGET TO RETURN THE CALIBRATION SWITCH TO POSITION " MEAS " *
****
The new device address will now not be lost when the digital multimeter is switched off. The keyboard of the digital multimeter is disabled after the digital multimeter has been accessed once via the IEEE 488 bus interface. The keyboard is enabled again when the "REN" becomes inactive or when the controller transmits the addressed command GTL(go to local).

The "TALK ONLY" capability in conjunction with a printer with "Listen Only" attribute, permits set-up of a self-complete measuring station. After each end of measurement (e.g. after a trigger), the DMM outputs a measured value with the selected terminating characters to the IEEE bus.

The DMM does not interrupt its continuous measuring sequence within the talker function. It understands the commands DCL(Device Clear), SPD(Serial Poll Disable), and SPE(Serial Poll Enable). The command DCL sets the DMM into status "DC-Volts measurement with 1000 V range".

To program the DMM, proceed as follows: Data input is possible as a character string of length 2 to 30 characters, e.g. "VDR3A0M3Q1L1" or "VDR3" or "R3". Every DMM command consists of two characters. The sequence of several commands within one string is arbitrary, with the exeption of the command "NV" (see description of this command).

The ISO-7-bit code is used for command transfer. Any spaces in the transferred string are ignored. If the DMM receives more than 30 characters (excluding any spaces), then it evaluates the first 30 characters and also reports a transmission error (see section "error messages").

Device Messages understood by the digital multimeter

VD	Direct Voltage					
VA	Alternating Voltage					
02	Resistance measurement, 2-wire circuit					
ID	Direct current					
IA	Alternating current					
R1	Range	0,2	Vdc, Vac,	kOhm,	....	....
R2	Range	2	Vdc, Vac,	kOhm	2mAdc	2mAac
R3	Range	20	Vdc, Vac,	kOhm	....	....
R4	Range	200	Vdc, Vac,	kOhm	....	....
R5	Range	1000	Vdc, Vac,	2000kOhm,	2000mAdc,	2000mAac
R6	Range	10000	... ...	12000kOhm	....	....
A0	(A/Zero) Autoranging off					
A1	Autoranging on					
T1	Integration time 100ms; display 5 1/2 digits					
T2	Integration time 1 s; display 5 1/2 digits					
T3	Integration time 1 s; display 6 1/2 digits					
T4	Integration time 10 s; display 6 1/2 digits					
ZO	Zero					
S1	Start mode, Start					
S0	(S/Zero) continuous measuring					
L0	(L/Zero) DMM transmits only measurement result					
L1	DMM transmits measurement and programmed status data					
Q0	(Q/Zero) without Service Request SRQ					
Q1	with Service Request SRQ					
NVXXXXXX	Nominal value (for calibration)					
MO	Multiplexer switched off					
M0	Multiplexer channel 0 selected (M/Zero)					
M1	" " 1 "					
M2	" " 2 "					
M3	" " 3 "					
M4	" " 4 "					
M5	" " 5 "					
M6	" " 6 "					
M7	" " 7 "					
M8	" " 8 "					
M9	" " 9 "					
C0	(C/Zero) Front terminals switched-out					
C1	Front terminals switched-in					

Description of the device messages

"VD" Selects the measuring function "direct voltage"

"VA" Selects the measuring function "alternating voltage".

"O2" Selects the "resistance" measuring function.

"ID" Selects the "direct current" measuring function.

"IA" Selects the "alternating current" measuring function.

"RX" The measuring range within each function is selected with "RX". "X" stands for the designation number of the desired measuring range. Note that some measuring ranges can be selected only in conjunction with a corresponding measuring function, e.g. R6 only for function "kOhm".

"A0" (A/Zero) switches off autoranging.

"A1" switches on autoranging.

"TX" Sets the integration time and the number of digits shown in the display for the measurement result.
6 1/2 digits are always transmitted via the IEEE 488 bus.

"ZO" Starts an offset correction.

"S0" (S/Zero) Starts the continuous measuring sequence.

"S1" Stops the continuous measuring sequence. The delay until execution of the commands "S0" and "S1" may amount up to 25 msec.

"MX" Selects a multiplexer channel. "MO" switches off the multiplexer "M0"(M/Zero) to "M9" select the respective multiplexer channels

"C0" (C/Zero) disconnects the front terminals when scanner is fitted

"C1" Connects the front terminals when scanner is built in

"L0" (L/Zero) Short format: The multimeter transmits only the first data block (measurement data and text messages)

"L1" Long format: The DMM transmits both data blocks (measurement data and text messages in first block and programming data in second block).

"Q0" (Q/Zero): The multimeter transmits no Service Request SRQ.

"Q1" The multimeter transmits a Service Request SRQ with:
- each new measurement result, each error message, reset

"NVXXXXXX" After NV the DMM expects a 6-digit unsigned decimal integer number as nominal value for calibration via the IEEE 488 bus. A nominal value for calibration must be transmitted alone, i.e. no further command from the table above may be contained in the same string. The DMM commences the calibration measurement after receiving the nominal value.

Description of the transmitted data set

The contents of the display are transmitted in the 12 characters of the first data block. These are measurement results and text messages. The measurement results are always transmitted right justified, i.e. termination with the 12th character.

The first character is always the sign, "+" or "-", for direct voltage measurements. All not required leading digits before the measurement result are filled with zero. No sign is output for resistance, alternating voltage and current measurements and all not required leading digits in front of the measurement result are filled with zero.

Measurement results are output in exponential form without spaces,

e.g. +01.9876E+2

The text messages have the format "ERR. X", "NULL", "CAL."

These messages are always left justified, i.e. they commence with the first character of the data block. All not required characters are filled with spaces (blanks).

The second data block always commences with the 13th character. This data block outputs the programmed status of the multimeter. Output of the second data block can be enabled or disabled with the digital multimeter command "L1" or "L0" (L/Zero) respectively (see section headed "Programming the digital multimeter via the IEEE bus interface").

Device Messages Transmitted from the Multimeter (IEC 625 Part2)

The device messages transmitted from the DMM consist of a data set which is generated and transmitted as a block, with end specification. The data set consists of two data blocks. The first data block contains programming status data. Each data block consists of a character string with a fixed number of characters, so that no end character is required or sent between the two data blocks. The first character string contains 12 characters and the second character string contains 16 characters + terminating character(s).

If character transmission from the DMM is discontinued before the DMM has gone to TIDS status, transmission commences with the first character of the data set after a new call.

The terminating character(s) of the data set are as chosen according to the section "Programming the DMM via the IEEE 488 bus interface".

The ISO-7-bit code is used for transmitting the device messages.

```
1st. character                28.th character
!                             !
+X.XXXXXXE+XVDRXA0TXS0Q0C0MXEND
            VA  A1  S1Q1C1
            O2
            ID
            IA
(----------)(---------------)
1st. data      2nd. data
   block          block
```

\+ Sign of mantissa for VD and ID,
Zero for VA,O2 and IA

X.XXXXXX	7 digit mantissa
E+X	1-digit exponent with sign
VD,VA,02,ID,IA	Measuring function: VD - Direct voltage VA - Alternating voltage O2 - Resistance, 2-wire-circuit ID - Direct current IA - Alternating current
R1-R6	Measuring range: R1 = 0,2 Vdc, Vac, kOhm, ... R2 = 2 Vdc, Vac, kOhm, 2 mAdc, 2 mAac R3 = 20 Vdc, Vac, kOhm, ... R4 = 200 Vdc, Vac, kOhm, ... R5 = 1000 Vdc, Vac, 2000 kOhm, 2 Adc, 2 Aac R6 = 10000 ..., ..., 12000 kOhm, ...
A0, A1	Autoranging (0(Zero) = off, 1 = on)
T1-4	Integration time, number of display digits
T1	100ms , 5 1/2
T2	1s , 5 1/2
T3	1s , 6 1/2
T4	10s , 6 1/2
S0, S1	Start, Stop
Q0, Q1	SRQ-status (0(Zero)=without, 1=with SRQ)
MO, M0-9	MO = multiplexer is switched off M0(M/Zero)-M9 = multiplexer channel 0...9 selected
C0, C1	Front sockets switched-out (C/Zero) or Front sockets switched-in
END	Terminating character(s) as selected when setting the device address. For terminating character No.8, EOI is transmitted together with the final (26th.) string character.

Service request function (SR interface function)

The IEEE 488 bus interface of the digital multimeter is equipped with a service request function (SR function, SRQ). The individual status bits transmitted with a service request have the following meanings:

Bit 1: End of measurement
Bit 3: Overflow during measurement
Bit 4: Error messages
Bit 6: Reset
Bit 7: SRQ

Bit 1, end of measurement, can appear together with the other status bits, in order not to falsify the SRQ in the case of fast measurement sequences.
Bit 6 appears with a reset, i.e after power-up or in the case of a strong external source interference event. A reset always takes the multimeter to basic status (DC, 1000V, etc.), so that the control computer must reprogram the multimeter according to section 11.1 after detecting a reset.

Programming examples for the IEEE 488 bus interface

Before the digital multimeter can be operated via the IEEE 488 bus interface, the device address and the end character(s) must be set as described at the beginning of this section. Address 7 and the end character number 8 (only EOI) are recommended in the following examples for Commodore and Tektronix computers.

Signs and Symbols: @ = Number sign (double cross) < = greater than
& = "at"-character ^(^) = square bracket

COMMODORE CBM 3032

Control of the DMM by CBM 3032. The DMM is listener.

```
100 print " your entry please "
110 input a$
120 open 1,7        "7" is the device address of the DMM
130 print@1,a$
140 close 1
```

Reading the character string with the CBM. The DMM is talker.

```
200 open 2,7              "7" is the device address of the DMM
210 input@2,b$
220 close 2
230 print b$
240 goto 100=
```

TEKTRONIX 4051:

Control of DMM by Tektronix 4051. The DMM is listener.

```
100 PRI " YOUR ENTRY PLEASE "
110 INP A$
120 PRI & 7:A$      "7" is the device address of theDMM
130 GO TO 100
```

Reading the character with the Tektronix 4051. The DMM is talker.

```
140 INP & 7:B$      "7" is the device address of the DMM
150 PRI B$
160 GO TO 100
```

HEWLETT PACKARD HP 85

The device address of the multimeter is 7, the end character No.5

Control of the DMM by HP 85. The DMM is listener.

```
130 PRINT " YOUR ENTRY PLEASE "
140 INPUT B$
160 OUTPUT 707;B$
190 END
```

Reading the character string with the HP 85. The DMM is talker.

```
530 DIM A$^(50^)  choose string size at least 29 characters
550 ENTER 707;A$
580 DISP A$
590 END
```

HEWLETT PACKARD HP 87

The device address of the multimeter is 7, the end character is No.5

```
10 DIM A$ ^(40^), B$ ^(30^)  string size at least 29 characters
```

Control of the DMM by HP 87. The DMM is listener.

```
20 INPUT B$   via HP 87 keyboard (voltmetercode), up to 30 char.
30 OUTPUT 707;B$       string transfer from the HP 87 to the DMM
```

Reading the character string with the HP 87. The DMM is talker.

```
40 ENTER 707;A$    string transfer from DMM to HP87 (26-28 char.)
50 PRINT A$
60 GOTO 20
```

HEWLETT PACKARD HP 87 (but now with SRQ)

The device address of the multimeter is 7, the end character is No.5

```
10 ON INTR 7 GOSUB 500              checks IRQ from IEEE 488 bus
20 DIM A$ ^(30^), B$ ^(40^)        string size at least 29 char.
30 Input B$                             entry via HP 87 keyboard
40 OUTPUT 707;B$          string transfer from the HP 87 to DMM
50 ENABLE INTR 7;8                   enable IRQ initiated by SRQ
60 GOTO .....                        line number of user program
500 STATUS 7,1; W
510 P=SPOLL (707)            transfer of the SRQ status register
520 IF P<63 THEN GOSUB 1000   (evaluation of register contents)
530 ENABLE INTR 7,8                  enable IRQ initiated by SRQ
540 RETURN
1000 ENTER 707;A$              read in the message from the DMM
1010 PRINT A$, P, "DEVICE NO.7"
1020 RETURN
```

HP 9816 (200 Series)

```
1000   !******** Data transmission HP 9816 *****
1020   !Declaration of variables
1040   COM / DMM 5000/ & Dmmnr, Setup$ ^(30^), DISPLAY$ ^(30^)
1060   ! Adress assignment -- 7 = & Dmmnr
1080   ASSIGN  & Dmmnr TO 707
1085   ON INTR 7,1 CALL Serialpoll
1100   READING THE DESIRED SETUP VIA THE KEYBOARD
1120   INPUT Setup$
1130   OUTPUT  & Dmmnr ; Setup$
1150   ! ENABLE INTERRUPT
1170   ENABLE INTR 7;2       !IRQ by appearence of an SRQ signal
1180   Haupt:   !
1190          GOTO Haupt
1200          END
1230   SUB Serialpoll
1240   ! CHECKS DEVICE FOR SERVICE REQUEST, READS IF REQUIRED AND
1250   ! RETURNS TO THE WAITING LOOP OF THE MAIN PROGRAM
1280   COM /Dmm5000/  & Dmmnr, Setup$ ^(30^), DISPLAY$ ^(30^), P
1300   P=SPOLL ( & Dmmnr)
1320   IF P<63 THEN CALL Measval
1330   ENABLE INTR 7
1340   SUBEND
1370   SUB Measval
1390   !READS IN THE PRESENT MEASURED VALUE FROM THE VOLTMETER
1410   COM/Dmm5000/ & Dmmnr, Setup$ ^(30^), DISPLAY$ ^(30^),P
```

```
1420    ENTER  & Dmmnr; DISPLAY$
1430    PRINT DISPLAY$,P
1440    SUBEND
```

APPLE II with CCS Interface Module 7490

```
 2 PRINT
 3 PRINT "SET DMM 5000 TO ADDRESS 07.0 ."
 5 PRINT
 6 PRINT "WHEN YOU HAVE DONE SO,"
 7 PRINT "PRESS THE RETURN KEY."
 8 INPUT C$
 10 DIM A$(30), B$(30)   dimension the string arrays sufficiently large
 12 PRINT:PRINT
 15 PRINT "YOUR ENTRY PLEASE:"
 20 INPUT B$
 30 PR @3                                    initialize slot 3 for output
 40 PRINT "&':"       &  switches to address mode; REN and ATN active;
                     '  transmits listener address 7;
                     :  switches back to Command mode;
 50 PRINT "'";B$;"'      the message is transmitted;
                     '  switches text mode on and off;
 60 PRINT "&G:"       &  switches to address mode;
                     G  transmits talker address 7;
                     :  switches back to Command mode;
 70 PR @0            data from IEEE bus are printed directly on screen
 80 INPUT "";A$                  read-in the message from the IEEE bus
 90 IN @0
100 GOTO 20
```

CALIBRATION

Allow a period of 2-3 hours to elapse after switching on, before commencing calibration, so that the digital multimeter has reached thermal equilibrium.

The DMM has a digital calibration facility which permits individual range or complete recalibration. It is not necessary to open the unit for recalibration. Recalibration is possible under front panel keyboard control or via the IEEE 488 bus. The correction values from the first calibration carried out in the HAMEG factory are stored in the programm EPROM and in a CMOS RAM with a lithium battery as backup power supply. The multimeter normally uses the correction values which are stored in the CMOS RAM. The battery service life is about 10 years.

To prevent unintentional destruction of the correction values, they are protected in memory by setting a recessed sliding switch S2 which is above the IEEE- Bus connector at the rear of the unit. The settings of this switch are marked "MEAS" and "CAL". To recalibrate the digital multimeter, move the switch S2 with the aid of a small screwdriver or similar tool from "MEAS" to "CAL".

The "CAL" operating mode is indicated by periodic appearance of the legend "CAL" in the main display. In this status the correction values stored in the CMOS RAM are unprotected and can be overwritten. If correction values have been lost accidently by improper calibration attempts and recalibration is not possible because no calibration standards are available, then the correction values which have been stored by HAMEG in the program EPROM at the time of initial calibration of the instrument, can be copied into the CMOS RAM. For this purpose, set the mains switch of the multimeter once to "OFF" and then to "ON" again, whereby the calibration switch on the rear side of the instrument must be left in setting "CAL". Hereby the calibration correction factors are automatically copied from the EPROM to the battery backed-up CMOS RAM and all correction values for the input offset are cleared. **Thus it is necessary thereafter to make new compensation of the input offset for all functions and ranges.**

For this purpose, place a short circuit at the input sockets "V/Ohm" of the digital multimeter, select measuring function "Vdc" and "Auto" for autoranging and then press the "Zero" key. The multimeter now corrects all Vdc measuring ranges in automatic succession and places the found correction values in the RAM which can subsequently be protected. To correct a single measuring range, select just this range, leaving autoranging ("Auto") switched off.

Calibrating the Direct Voltage Measuring ranges

First select the measuring range which is to be calibrated and then connect an exactly known positive or negative reference voltage to the input terminals. This reference voltage should not be less than 5% or more than 100% (preferably 50% to 100%) of the range span. The multimeter now displays a measurement result which has been calculated using the old calibration factor. If this actual value differs unacceptably from the nominal value (known value of the reference voltage), then call the calibration program by first pressing the "2nd" function key and then the "Cal" key. The nominal value can now be set using the "up" and "down" keys.
The "down" advances the digit opened for correction. When the digit to be corrected in the display has been reached, it starts counting cyclically 0-9 by pressing the "up" key . This counting can be stopped and started again with the "up" key. When all digits have been corrected to the nominal value, start the actual calibration measurement by pressing the "enter" key .
"CAL." thereupon appears in the display and the remaining time of the calibration measurement is counted down to Zero in the display, similar to the sequence of events for a Zero point measurement.

Thereafter the unit exits the calibration program and new functions and ranges can be selected. The calibration program is also aborted when any other key except "up", "down" or "enter" is pressed, in which case the old calibration factor is retained and no change has been made. To recalibrate several measuring ranges individually, start the entire procedure as described above for each range. After completing all intendend recalibrations, make quite sure that the recessed switch S2 on the rear panel of the unit is returned from "Cal" to "Meas", so that the calibration data are protected again.

Calibration procedure via the IEEE 488 bus is basically analogous to the described procedure via the front panel keyboard. The nominal value is set as integer number with the command "NVXXXXXX" (see calibration program in the section headed "IEEE 488 bus interface"). The calibration program and the calibration measurement are started automatically on transmission of the nominal value. When no further ranges and functions are to be calibrated, terminate the calibration procedure by returning the switch S2 on the rear panel of the unit from setting "Cal" to setting "Meas".

Calibrating the Resistance Measuring Ranges

The resistance measuring ranges are calibrated in 2-pole circuit. First connect the zero point by the procedure described in before. Also observe the instructions given in the section headed "operating instructions for resistance measurements Ohm/kOhm", in particular regarding compensation of the measuring leads resistance. Calibration procedure for the resistance measuring ranges is otherwise analogous to calibration of the direct voltage measuring ranges.

Calibrating the Alternating Voltage Measuring Ranges

The alternating voltage measuring ranges should be calibrated with a sinusoidal alternating voltage with a frequency of 1 KHz. For the function Vac too, the zero point must be compensated with function setting "zero". The calibration procedure is analogous to calibration of the direct voltage measuring ranges.

Calibration of the Direct and Alternating Current Measuring Ranges

For the current measuring ranges too, make the same calibration preparations as specified before. The zero point measurement must be made with open circuit input sockets (no short circuit).

Do not leave any measuring cables connected to the input sockets for the zero point measurement (see also operating instructions for mAdc and mAac). 1kHz sinusoidal reference currents are required for calibrating alternating current measuring ranges. The calibration current (reference current) must not be greater than 1 A in the 2 A range.

****
* DO NOT FORGET TO RETURN THE CALIBRATION SWITCH TO THE POSITION "MEAS"
****

ACCESSORIES

Mating Plug for Sub-D (HZ 82)

For connecting the measuring leads to the scanner, a 50-pole subminiature type D plug can be used for each group of 10 channels. This plug connector has soldered connections.

Adapter Card (HZ 81)

One adapter card can be plugged externally onto the 50-pole subminiature type D socket of the HM 8112, for connecting the measuring leads at screw terminals. The adapter card is also fitted with two antiparallel 3A clamp diodes for each current path, (see circuit diagram of adapter card). These clamp diodes may be removed for other applications, especially when switching currents greater 0.5A-peak shall be switched (diode forward voltage drop!). One adapter card is required for connecting all 10 channels.

Maximum current (without clamp diodes)	2 A
Maximum current (with clamp diodes)	0,5 A peak
Maximum voltage	40 V
Dimensions	about 115 x 123 mm/4.5 x 4.8 in

****
* WARNING *
****

Safety consideration
require that no voltages gereater than 40 V with respect to ground may be connected, because the screw terminals are not protected against accidental human contact entailing danger of electric shock.

HZ 72 IEEE-488-Bus-Cable, 60 inch

HZ 42 19" rack mount kit 2HU

HZ 15 Silicon test leads with test probes and sheathed banana plug

HZ 14 Test probe kit with two sprung hooks to stackup HZ 10 - HZ 13

HZ 13 Silicon test leads with fixed sheathed banana plug

HZ 12 Silicon test leads with stackup banana plug each end (retractable sheath)

HZ 10 Silicon test leads with stackup banana plug each end. Set of 5 peaces (one color). Colors: red, black, blue, yellow, green

INTRODUCTION

These service instructions for the HAMEG Digital Multimeter 8112 are intended as a supplement to the user manual, to give the experienced electronics engineer the information required for maintenance, fault tracing and repair of the instrument.

WARNING

The service tasks described here may be carried out only by qualified technicians. When the cover of the instrument is removed, human contact with points carrying potentially lethal voltages is possible. Thus the following safety precautions must be observed.

a) Before opening the case, disconnect the mains plug and all connections at the measuring sockets.
b) Always use an isolating transformer when making measurements and adjustments in the opened instrument.
c) When the instrument is in the opened state, connect only non-dangerous voltages to the measuring inputs.

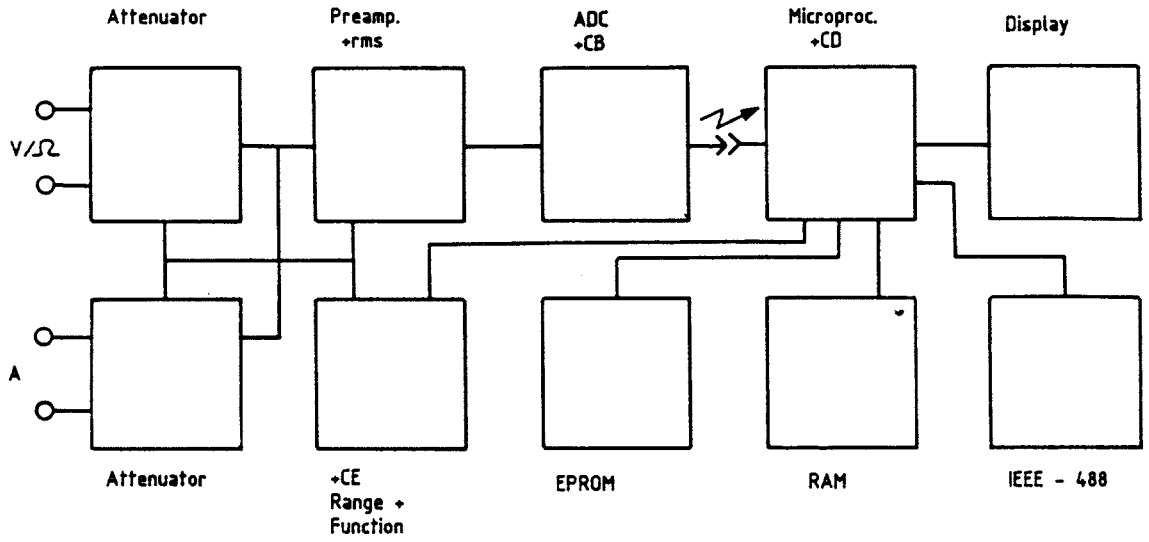
This instrument is guaranteed to be in perfect condition when leaving the factory. HAMEG accepts no liability for any damage caused by incorrect operation or improper handling of this instrument.

WARNING

The analog section of the Digital Multimeter HM 8112 is aligned with respect to alternating voltages. Replacement of components and especially replacement of the printed circuit board to repair the instrument may make realignment and recalibration necessary. The data stored in the battery backed-up RAM may be lost during repair work, due to a short circuit on the printed circuit board, disconnection of the RAM from the battery or even by electrostatic discharge. As a general rule, any repairs of the HM 8112 should be carried out only at a workplace which is suitably protected against static electricity. Bear in mind that the lithium battery may explode if it is short-circuited.

Functional principles of the HAMEG Digital Multimeter 8112

The measured signal is taken via the attenuator and via the preamplifier to the converter. The converter transforms the analog signal into a proportional pulse group which is sent via the "MEASUREMENT RESULT" line (CB=U9, Pin 8) to the microprocessor circuit board. The pulses are transmitted in basic state HIGH or LOW, depending on the polarity of the measured signal. A sub-measurement is complete after every 25 ms. This is reported to the SERIAL TO PARALLEL CONVERTER (U12) via the line "END OF SUB-MEASUREMENT" (U9,Pin 11) by means of a pulse. The converter and preamplifier offset of the measured data is subtracted in the microprocessor section. The data are then multiplied by a calibration factor. The subtrahend and the calibration factor are determined at the time of zero measurement and calibration respectively (see user manual) and stored in battery backed-up RAM. The results are then filtered by software according to the set integration time and finally output to the seven segment display and to the IEEE 488 bus. The data from the keyboard evaluator (U 4) are sent via (U 12) and Q 5 to the relay control circuit (U 10), for function and range selection of the DMM.



ASSEMBLY / DISASSEMBLY

Microprocessor printed circuit board

Unsolder the transformer connecting wires from the mains PCB, the mains ground connection from the floor of the case and the two connecting wires of the trigger socket. Disconnect the plug connectors to the display and analog circuit board. Remove the screws: 2 x IEEE 488 bolts, 4 x transformer mounting screws , 1 x screw on printed circuit board, 1 x screw on the 5 V regulator.
The heat dissipated by the 5V regulator (on the underside of the microprocessor circuit board) must be removed by an adequately dimensioned heat sink even when the circuit board is operated briefly in the removed state (e.g. by a 40x100x20 mm ribbed heat sink). When remounting the microprocessor circuit board, the case of the 5V regulator must be attached to the case of the instrument in electrically isolated manner (using the insulating nipple and the mica disc).
The washer, the insulating nipple and mica insulating disc below this nipple on the 5V regulator must be remounted in this order.

Analog circuit board

Release the three mounting screws of the circuit board and the plugged ribbon cable connection to the microprocessor circuit board (observe the correct DIP-PLUG ORIENTATION). The analog circuit board can now be folded out to the front for repair. To take out this circuit board completely, it is also necessary to disconnect the five leads which go to the display board (or to the scanner board).

Scanner circuit board (option)

Release the mounting screw of the printed circuit board and the plugged ribbon cable connection to the analog circuit board (observe the correct DIP-PLUG ORIENTATION). Unscrew the two bolts of the 50-pole subminiature D plug) out of the rear panel of the instrument. The scanner circuit board can now be pulled slightly towards the front panel and can then be folded out upwards. To take it out completely, also disconnect the leads which go to the analog and display circuit board.

Functional tests

Aids: 20 MHz single-channel oscilloscope (HM 203/204 or similar)
Auxiliary digital multimeter (6 1/2 digits)

Power supply voltages

Microprocessor circuit board:

+ 5V: Power supply for the microprocessor board and for display board.

+/- 15V: Power supply for the analog board and for the scanner board. A 5V regulator on each of these circuit board produces another internal power supply voltage from the +15V supply (U8 and U4).

The "DIGITAL" ground (5V supply ground) on the microprocessor board and display board is electrically isolated from the case of the Digital Multimeter and from the "ANALOG" ground (+/- 15V supply ground) of the analog board and scanner board. Thus voltage measurements must be referenced to the corresponding ground potential. The fourth line which is totally electrically isolated is the GUARD connection.

The 5V regulator (U 1) on the underside of the microprocessor board is screwed directly but electrically isolated (mica disc) to the case of the instrument for efficient heat removal. R 1 and R 2 (each 10 Ohms on microprocessor board) are safety resistors for the +/- 15V supply. R 1 and R 2 must be replaced after current overload (repair).

Analog circuit board

The +/- 15V supplies transferred by the plug connector between the microprocessor board and the analog board, must be present at the reference element (U 4) on the analog circuit board: +15 V at pin 3, -15 V at pin 2, analog ground at pin 4, the reference voltage of about 7V at pin 1. +5V with respect to +/-15V "ANALOG" ground must be present at the cathode of CR 4 and at pin 10 of U 9. An auxiliary voltage of 1.2 V is also present at pin 6 of U 9.

Scanner circuit board

+15 V transferred by the plug connector between the analog board and the scanner board, are present at pin 1 of U 1 and the generated +5 V supply should be measured at pin 16 of U 3, in each case with respect to +/-15V "ANALOG" ground.

DIGITAL SIGNALS

Microprocessor circuit board

CLOCK: The microprocessor clock signal (about 800 kHz) is generated in U 9 on the analog circuit board and lies at U 9, pin 7. The opto-coupler U 13, pin 6 transfers the "CLOCK" signal to the microprocessor board.

ERG: The RESULT signal lies at U 9, pin 8 on the analog board. The opto-coupler U 14, Pin 6 transfers the "ERS" (RESULT) signal to the microprocessor board.

UME: The sub-measurement end signal lies at U 9, pin 11 on the analog board. The opto-coupler U 15, pin 5 transfers the "UME" signal to the microprocessor board.

U 16, U 17 and U 18 service the IEEE 488 ROUTINES. U 4 evaluates the keyboard and handles the display elements.

Analog circuit board

The ranges and functions of the HM 8112 are set with BISTABLE relays which are driven by HIGH (greater than or equal to 13 V) and LOW (smaller than or equal to 0.6 V) signals at the outputs of U 10 (Pin 4, 5, 6, 7, 8, 9, 10, 12). U 10 obtains its data from the microprocessor via the interface U 12 (Pin 18) and the opto-coupler Q 5 on the analog board. When repair is necessary (Q5 defective), it may be necessary to adjust the base resistor R38 (100K), to improve the transfer performance of Q5.

Scanner circuit board

U 1 on the scanner board is, amalogously to U 10 on the analog board, responsible for the relay drive and thus for channel selection in the scanner: HIGH (greater than or equal to 13 V) at pin 1 to pin 10 of U 1 connects through the respective channels 0 (K0) to 9 (K9). The relays R1 and R2 are driven from U 1 pin 11 and pin 12. In instruments with the scanner option fitted, R1 and R2 connect and disconnect the front panel sockets.

ANALOG SIGNALS

Functional test for attenuator + preamplifier

Direct voltage measurement:

Switch the DMM to the Vdc function. Connect a reference voltage (e.g. Uref = 1 V DC) to the V/Ohm input of the instrument. Using the auxiliary DMM (6 1/2 digits), measure the voltage Uvv at the output of the pre-amplifier (U3, pin 6) with respect to +/-15V analog ground. Switch through the respective Vdc measuring ranges and in each case measure the voltage Uvv. Table 1 lists the nominal values for Uvv in the respective measuring ranges, for input reference voltages of 0.1 VDC and 1 VDC.

V DC Range	Uref Volt	Uvv Volt
0.2	0.1	1.000
2	1	1.000
20	1	0.100
200	1	0.010
1000	1	0.001

Table 1

Resistance measurement

Switch the Digital Multimeter HM 8112 to the kOhm measuring function. Connect a reference resistor (e.g. Rref = 1 kOhm) to the V/Ohm input of the instrument. Using the auxiliary digital multimeter (6 1/2 digits), measure the voltage drop Ua across Rref (see sketch). The current source (U 1) produces the voltage drops Ua across the reference resistor as listed in Table 2 in the respective measuring ranges:

KOhm-Range	Rref/kOhm	Ua/Volt
0.2	1	- 0.7
2	1	- 0.7
20	1	- 0.07
200	1	- 0.007
2000	1	- 0.0007
10000	1	- 0.0007

Table 2

Current measurement

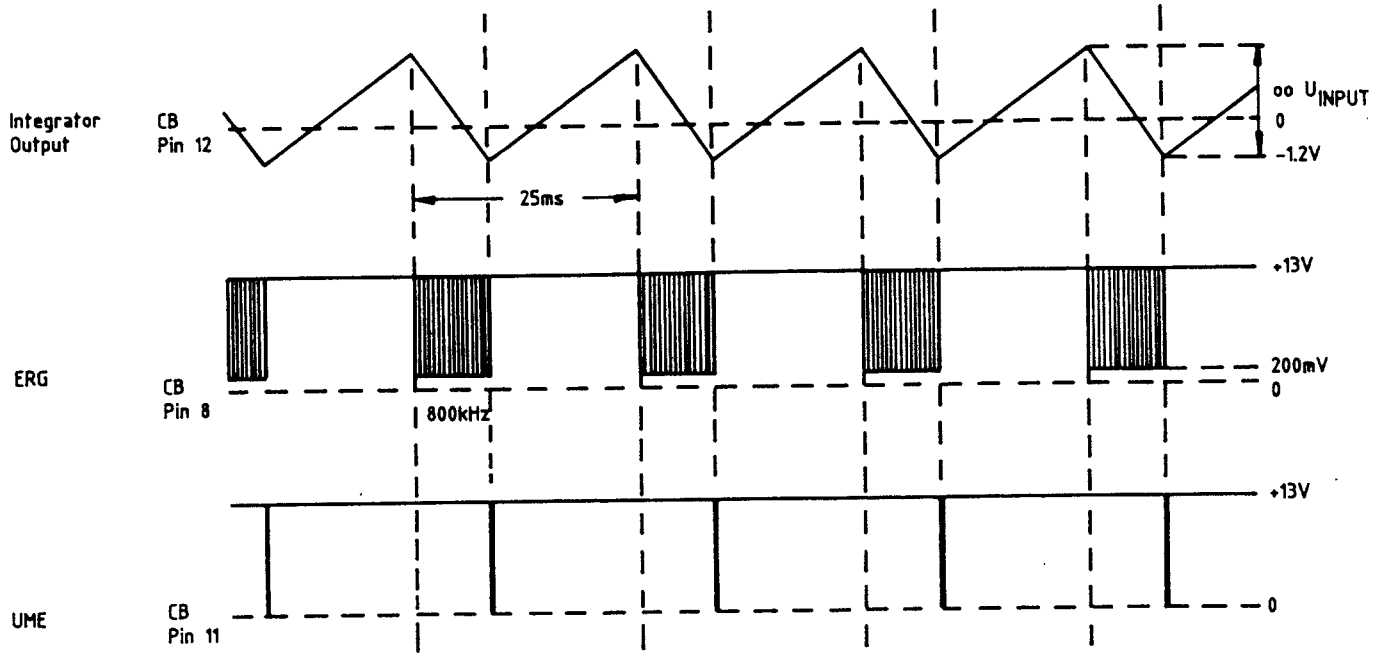
Switch the DMM HM 8112 to the mA DC measuring function. Feed a reference current (e.g. Iref = 1mA) through the A input of the instrument. Using the auxiliary digital multimeter (6 1/2 digits), measure the voltage Uvv at the output of the preamplifier (U3, pin 6) with respect to +/-15V analog ground. The readings listed in Table 3 should be obtained for the two direct current measuring ranges (Iref = 1mA).

mA-Range	Iref/mA	Uvv/Volt
2	+ 1	- 1.000
2000	+ 1	+ 0.001

Table 3

Integrator output signal

The integrator output signal can be measured at U 9, pin 12 with an oscilloscope (with respect to +/-15V analog ground). With negative direct voltage applied to the V/Ohm input of the Digital Multimeter HM 8112 , the oscillogram shown belowin should be obtained.



CIRCUIT BOARD REPLACEMENT

Aids

1. Replacement circuit boards
2. "Extension": 16-pole ribbon cable, 50 cm long, fitted with DIP plug on each end.

Execution

In the instrument which is to be repaired, disconnect the circuit board which is suspected to be defective and connect a replacement circuit board via the "extension". When it has been verified in this manner, which circuit board(s) is/are defective, replace it/them in the HM 8112. The instrument must be recalibrated and a new Vac alignment made after every replacement of a circuit board.

WARNING

Data may be lost in the course of repairs on the microprocessor circuit board. Thereafter the HM 8112 may not start at all, or may start incorrectly, after switch-on. In this case switch to "CAL" (CAL-MEAS switch on the rear panel) and then switch the instrument off and on again. Thereby bear in mind the following:

Offset correction values are erased permanently.

Calibration factors: The values for all ranges and functions which have been determined in the HAMEG factory and stored in the EPROM, as well as the initialization values for the IEEE address (07.8), for the integration time (1 sec, 5 1/2 digits) and for channel preselection (no channel selected) are loaded into the battery backed-up RAM.

The analog circuit board must always be replaced together with the EPROM which contains the specific calibration data for this circuit board. When only the microprocessor board has been replaced and the "old" analog board remains in the instrument, the corresponding "old" EPROM with the calibration data for this "old" analog board must be inserted again into the now "new" microprocessor board. The procedure for loading the calibration data from the EPROM into the battery backed-up RAM is described in user manual for this instrument.

FREQUENCY ALIGNMENT

Aids: AC calibrator (voltage and current)
Auxiliary digital multimeter (6 1/2 digits)

Preparations

The offset of the rms value rectifier (TRUE RMS CONVERTER, U 5) must be compensated before carrying out the frequency alignment of a Digital Multimeter HM 8112. For this purpose, switch the instrument to the 2V AC measuring range. Plug a shorting jumper into the V/Ohm input sockets. Using the auxiliary digital multimeter (6 1/2 digits), measure the voltage Ua rms with respect to +/-15V analog ground at the output of the true rms converter (pin 10, U 5). Adjust the trimmer R 23 (to make Ua rms zero (tolerance +/-50 microvolts). The frequency alignment of the HM 8112 can then be carried out.

IMPORTANT

For checking the frequency response, it is essential to close and efficiently ground the cover of the case. A special cover with holes for access to the trimmers is ideal.

Execution

Frequency alignment

1. 0.2 Vac: No alignment required

2. 2 Vac: No alignment required

3. 20 Vac:
   1. INPUT: 10V/90Hz; note the display reading
   2. INPUT: 10V/10kHz; adjust the trimmer capacitor C 5 (20Vac) to make the display reading the same as for 10V/90Hz.

   NOTE: The 10V/90Hz display reading changes. Thus repeat the steps 1. and 2. alternately until both are correct.

4. 200 Vac:
   1. INPUT: 100V/90Hz; note the display reading
   2. INPUT: 100V/10kHz; adjust the trimmer capacitor C 3 (200Vac) to make the display reading the same as for 100V/90Hz.
      The 100V/90Hz reading should not change.

5. 1000 Vac:
   1. INPUT: 100V/90Hz; note the display reading
   2. INPUT: 100V/1kHz; adjust the trimmer capacitor C7 (1000Vac) to make the display reading as closely as possible equal to the display reading for 90 Hz (deviations up to 2000 digits are tolerated).

   NOTE: The alignment of the 200 Vac range may change, thus repeat alternately until both are correct.

FAULT TRACING

Some faults and their possible causes are described below. First an explanation of the terms "INITIALIZATION" and "RESET":

1. INITIALIZATION in setting "MEAS"

Set the MEAS-CAL switch to "MEAS"; switch the HM 8112 off, then SWITCH IT ON again. The instrument thereupon runs through a sequence of internal check routines: CONTROL 1, 2, 3. Thereafter, the instrument is set to the 1000 Vdc range and the display reads **0000.00**.

2. INITIALIZATION in setting "CAL"

WARNING: All calibration data are erased.
Switch the HM 8112 off, set the MEAS-CAL switch to "CAL" and then switch the instrument on again. The instrument thereupon runs through a sequence of internal check routines: CONTROL 1, 2, 3. The display flashes alternatingly: "CAL" and (1000 Vdc) **0019.XX or 0025.XX.**
These digits (=CONVERTER OFFSET) appear in all functions and measuring ranges.

RESET: The HM 8112 carries out an INITIALIZATION.

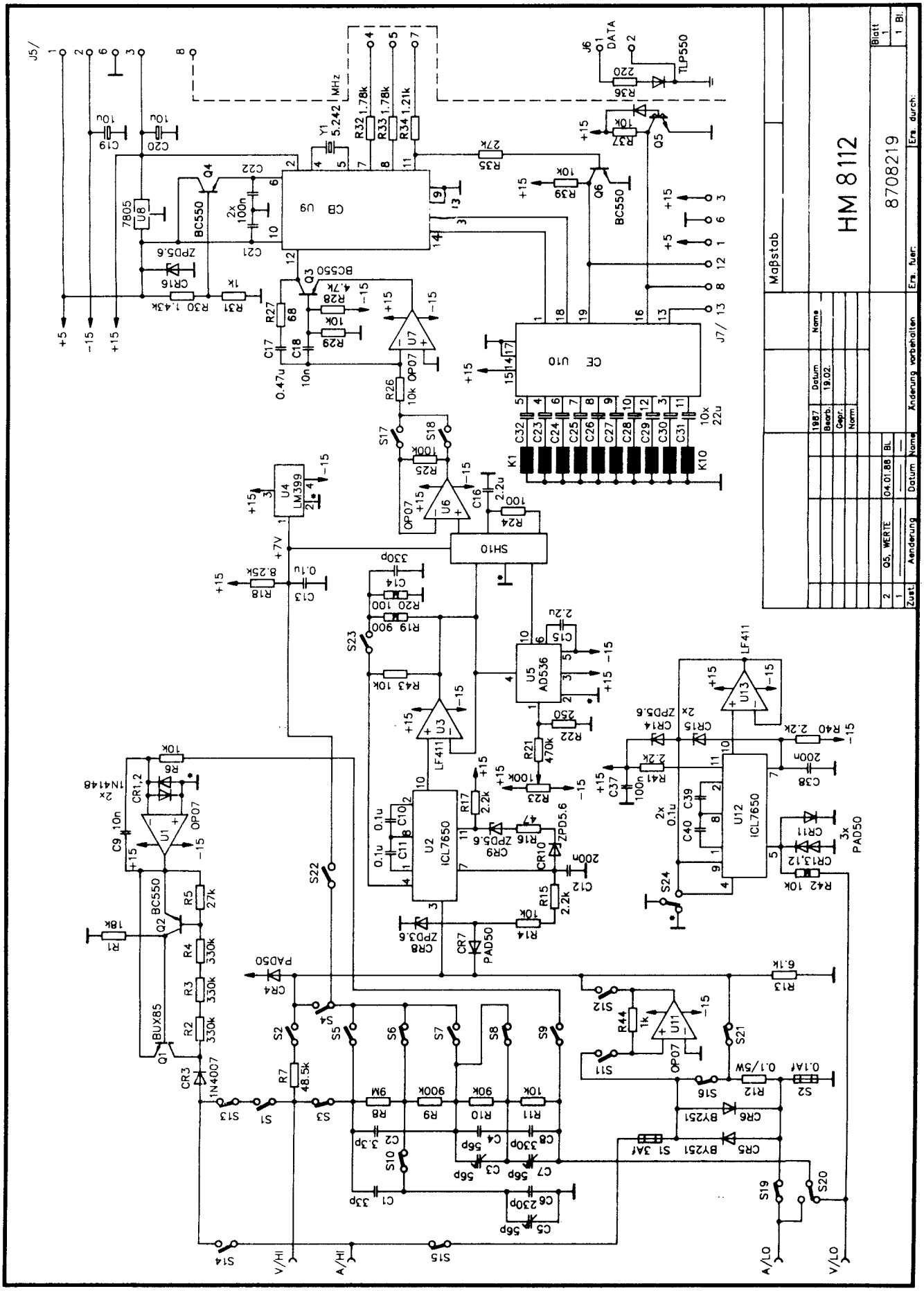
FAULT-SYMPTOMS	POSSIBLE CAUSES
1. No INITIALIZATION, not even in in "CAL" setting	1. RAM (U 7) 2. Socket J5 3. U 9
2. No clock signal	1. Opto-coupler U 13 2. Plug connector 3. U 9 4. Crystal Y1
3. No ERG signal (Result)	1. Opto-coupler U 14 2. Same as for Fault 2.
4. No UME signal (end of sub-measurement)	1. Opto-coupler U 15 2. Same as for Fault 2.
5. Incorrect INITIALIZATION in setting "CAL"	1. U 12 2. U 10 3. SH 10
6. RESET on HV INPUT	The microprocessor board is not screwed down firmly (C 18 with respect to case GROUND)
7. IEEE 488 function	1. Plug connector 2. Control IC U 16 3. Driver IC U 17, 18
8. Fault in RANGE SELECTION	1. U 12 2. U 10 3. U 9 4. Relays

9. "NULL" impossible	U 9
10. No current measurement	1. 3.15A fuse 2. 100mA fuse
11. Vac offset can not be corrected	U 5
12. SCANNER FUNCTION	1. U 1 2. U 3 3. Plug connector 4. RC-combinations around U 3 5. U 9 6. U 10 7. U 12 8. Q5
13. Display reading runs up until "ERR 1" appears	U 9
"ERR 1" in "kOhm"	1. Q1 2. Q2 3. U1 4. U4 7V reference
"ERR 1"	Uvv lies above the RANGE LIMIT (greater than 2V); there are many possible causes for this. Uvv o.k.; then check U 6, U 7, C 18, Q 3
"ERR 1" ("ERR 4")	o.k. in "kOhm" with <u>open</u> V/Ohm input; o.k. in "Vdc", "Vac" 0.1V, 1V with <u>open</u> V/Ohm input
"ERR 8"	1. Data loss 2. Lithium battery low; nominal terminal voltage at least 3.2 V 3. See explanations below.

Explanations for "ERR 8":

Unusually severe electrical disturbance in the immediate environment of the HM 8112 (electric fields, induction currents, etc.) may affect the data held in the battery backed-up RAM (U 7), so that some or even all the data (calibration factors, offset correction values, IEEE address, integration time and channel preselection) may be changed or lost. The error display "ERR 8" then indicates this state of the instrument. The HM 8112 must now be recalibrated and/or the lost data must be reloaded.

The lost data can be reloaded into the RAM as follows:
Switch-off the HM 8112. Move the CAL-MEAS switch to "CAL". Then switch on the HM 8112 again. Thereby the data which have been stored into the EPROM in the factory are reloaded into the RAM. The offset correction values for the zero points in all ranges and for all functions must be redetermined. Thereafter return the CAL-MEAS switch to the MEAS-setting.


HM 8112
8708219
Maßstab
Änderung vorbehalten
Ers. für:
Ers. durch:
Blatt 1
1 Bl.
Name
Datum
Bearb.
Gepr.
Norm
1987
19.02
04.01.88
Datum
Name
BL.
Änderung
05. WERTE
Zust.
+5
-15
+15
+7V
U1 OP07
U2 ICL7650
U3 LF411
U4 LM399
U5 AD536
U6 OP07
U7 OP07
U8 7805
U9 CB
U10 CE
U11 OP07
U12 ICL7650
U13 LF411
Q1 BUX85
Q2 BC550
Q3 BC550
Q4 BC550
Q5
Q6 BC550
Y1 5.242 MHz
TLP550
DATA
SH10
K1
K10
J5/
J6
J7/
V/HI
A/HI
A/LO
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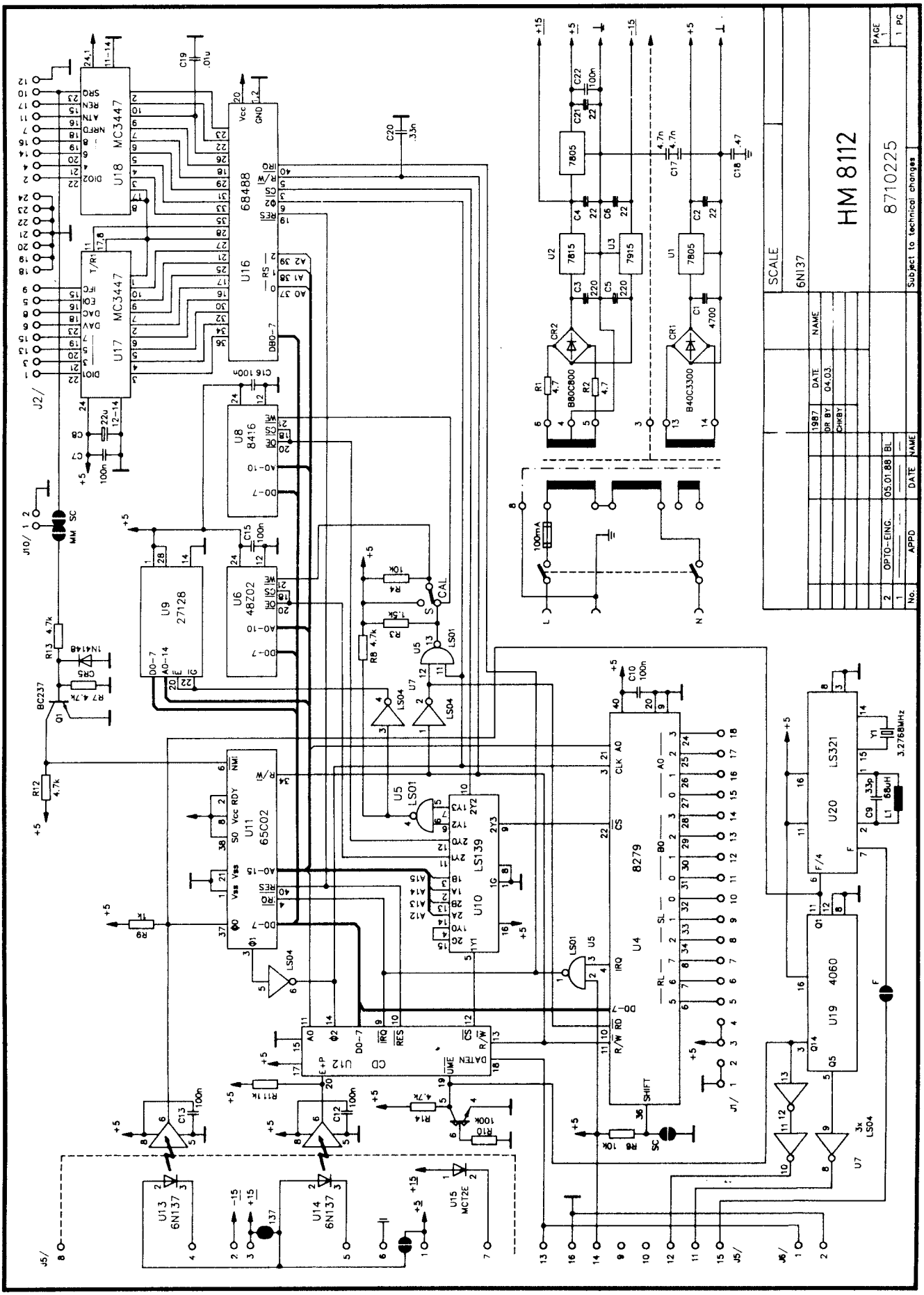
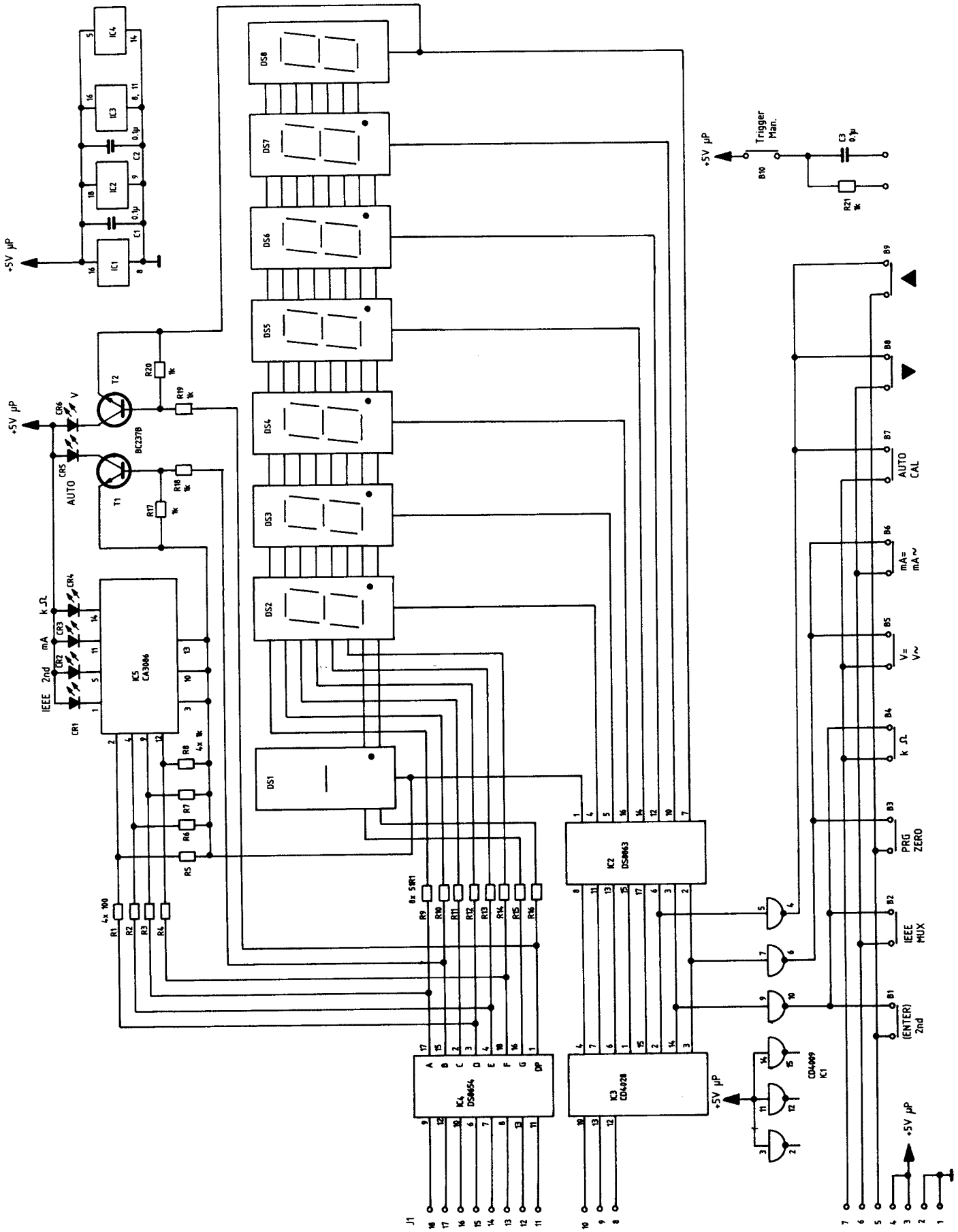
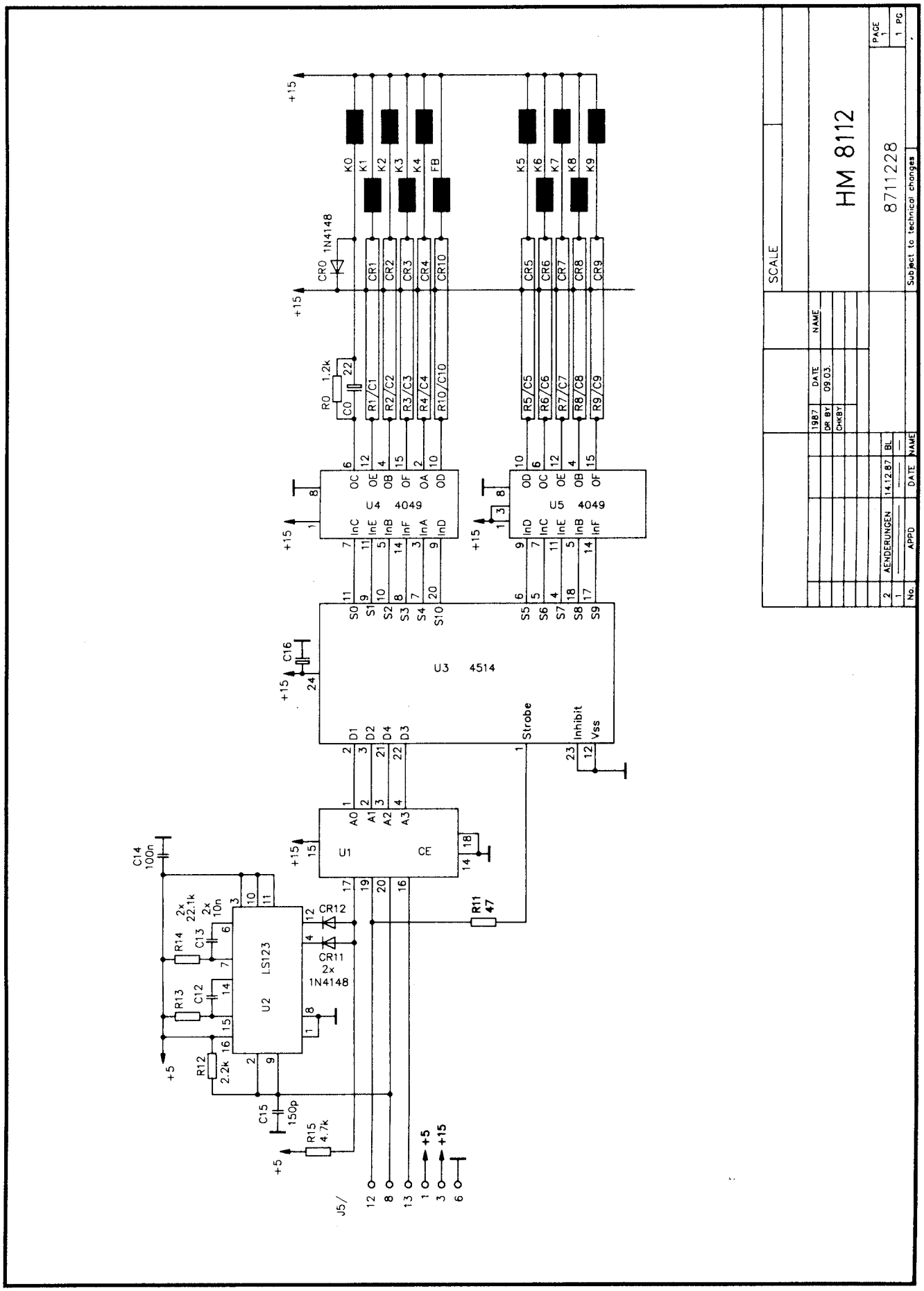
ZPD5.6
ZPD3.6
1N4148



Änderungen vorbehalten / Subject to change without notice


+5V µP
IC4
IC3
IC2
IC1
C1 0,1µ
C2 0,1µ
DS8
DS7
DS6
DS5
DS4
DS3
DS2
DS1
T2
T1
BC237B
R20 1k
R19 1k
R18 1k
R17 1k
CR6 V
CR5 AUTO
CR4 kΩ
CR3 mA
CR2 2nd
CR1 IEEE
IC5 CA3046
R8 4x 1k
R7
R6
R5
R1 4x 100
R2
R3
R4
8x SIP1
R9
R10
R11
R12
R13
R14
R15
R16
IC2 DS8863
IC4 DS8654
IC3 CD4028
CD4009 IC1
J1
Trigger Man.
C3 0,1µ
R21 1k
B10
B9
B8
B7 AUTO CAL
B6 mA= mA~
B5 V= V~
B4 kΩ
B3 PRG ZERO
B2 IEEE MUX
B1 (ENTER) 2nd



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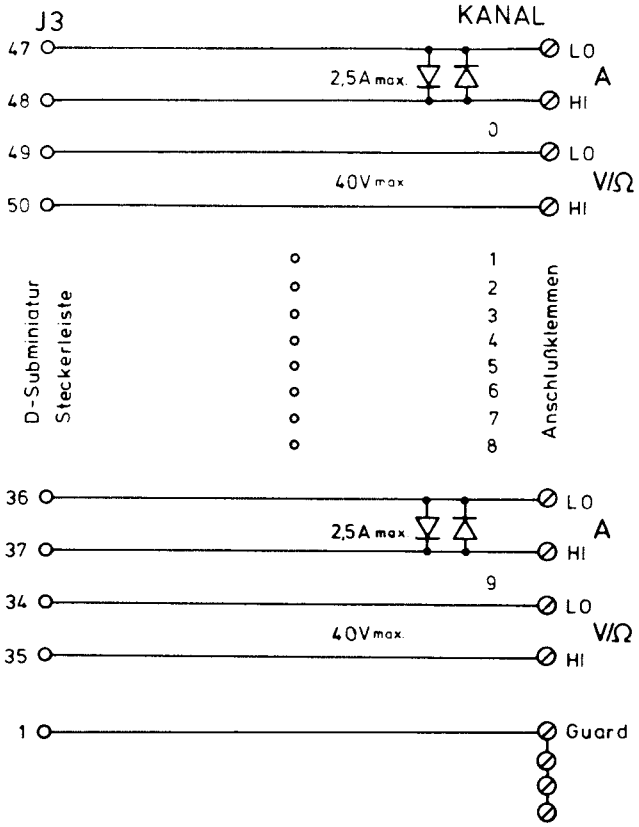
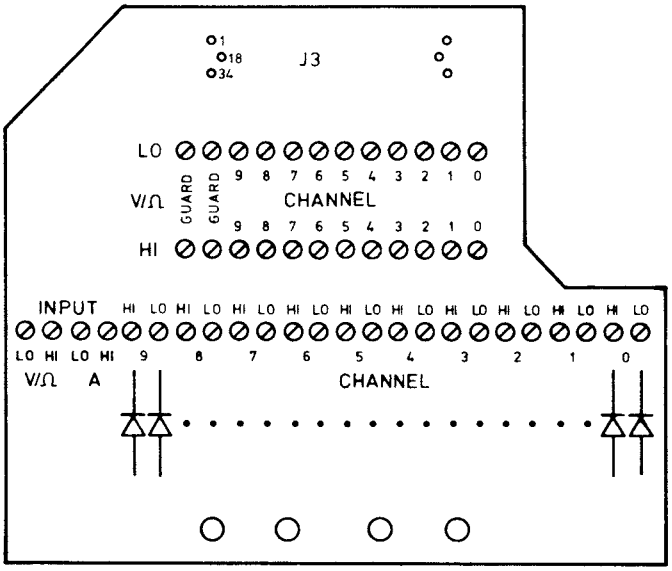
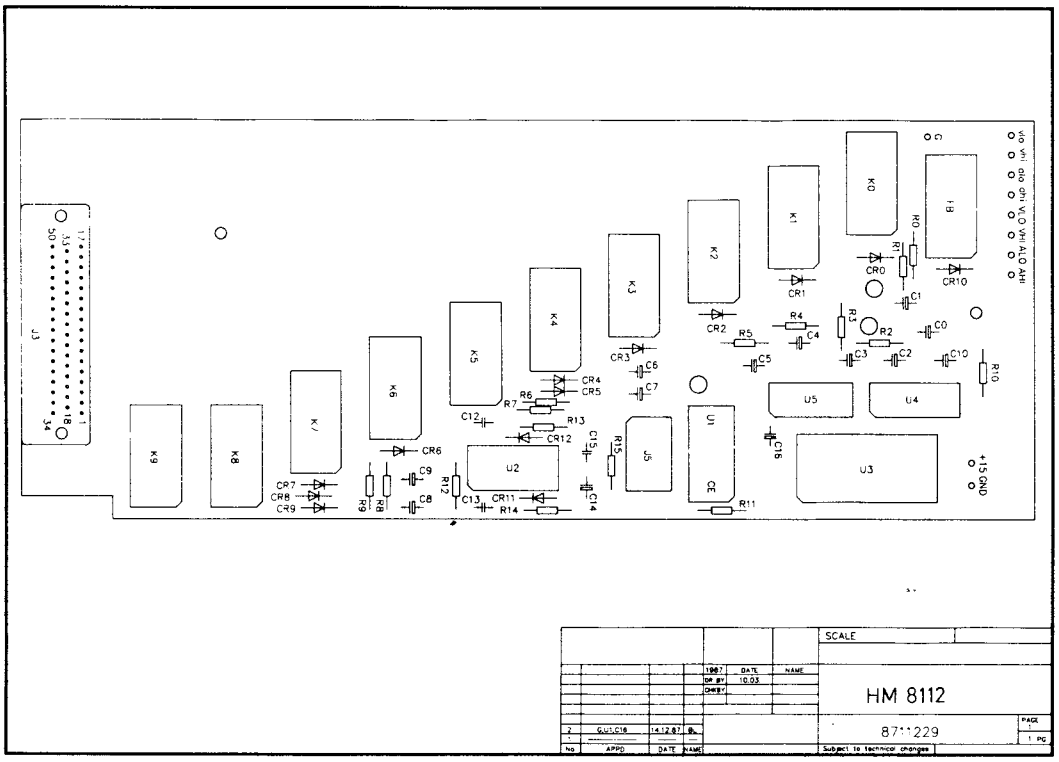
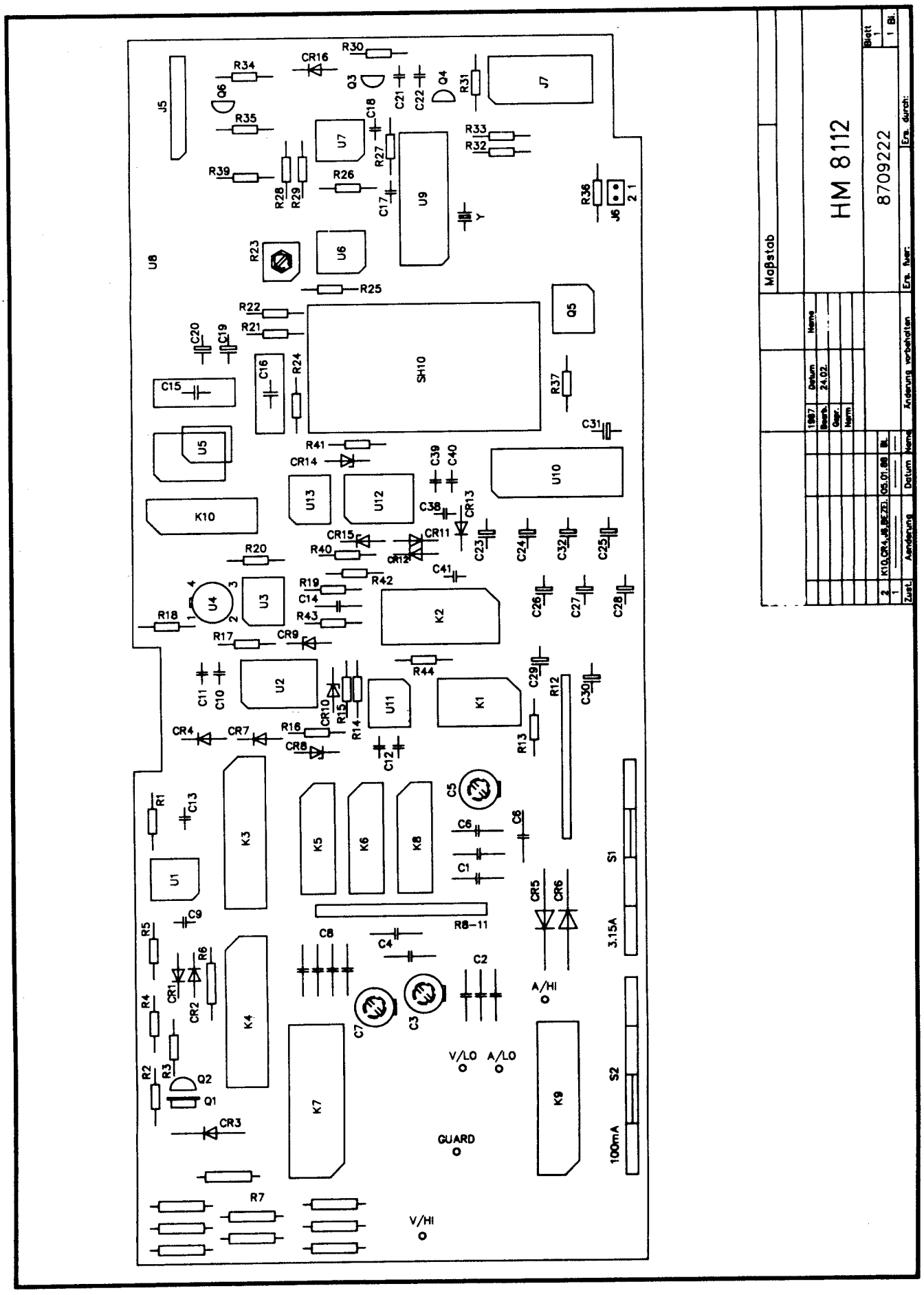




Bestückungsplan Scanner
Component Locations Scanner



Bestückungsplan Vorverstärker
Component Locations Preamplifier



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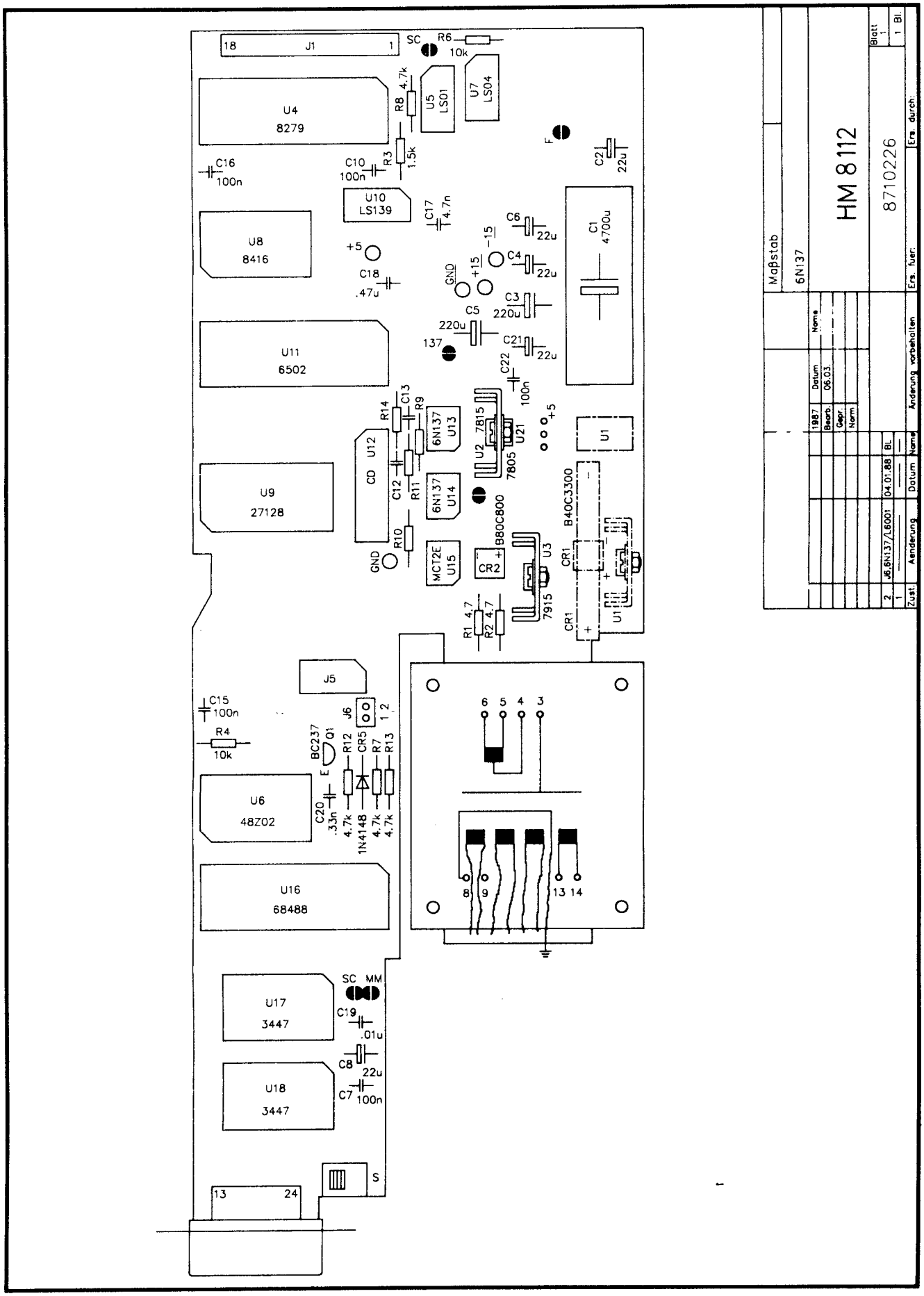
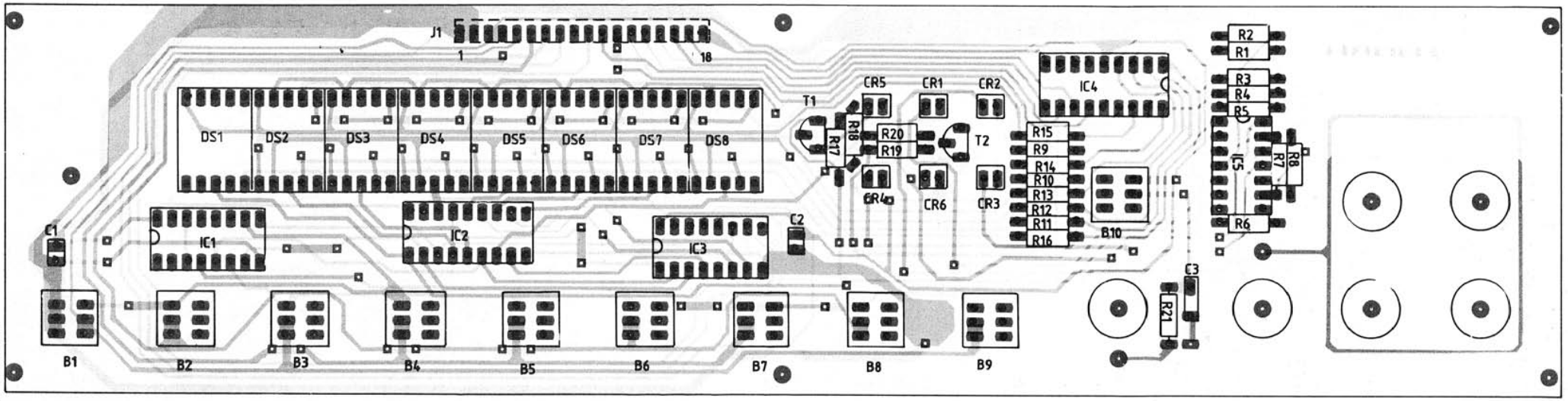

J1
18
1
SC
R6
10k
U4
8279
R8 4.7k
U5
LS01
U7
LS04
C16
100n
C10
100n
R3
1.5k
U10
LS139
C17
4.7n
C2
22u
F
C6
22u
C1
4700u
U8
8416
+5
C18
.47u
GND
+15
-15
C4
22u
C3
220u
C5
220u
137
C21
22u
C22
100n
U11
6502
R14
C13
R9
6N137
U13
7815
U2
U21
7805
+5
U1
CD
U12
C12
R11
6N137
U14
U9
27128
R10
GND
MCT2E
U15
CR2
B80C800
U3
7915
B40C3300
CR1
U11
R1 4.7
R2 4.7
J5
C15
100n
R4
10k
J6
1.2
BC237
Q1
E
R12
CR5
R7
R13
C20
.33n
4.7k
1N4148
4.7k
4.7k
U6
48Z02
6 5 4 3
8 9
13 14
U16
68488
SC MM
U17
3447
C19
.01u
C8
22u
C7
100n
U18
3447
S
13
24
HM 8112
8710226
Maßstab
6N137
Blatt 1
1 Bl.
Name
Datum
1987
Bearb.
06.03
Gepr.
Norm
Änderung vorbehalten
Ers. für:
Ers. durch:
2 J6,6N137/L6001 04.01.88 Bl.
1
Zust. Änderung Datum Name

Bestückungsplan Digitalanzeige
Component Locations Digital Display

HM8112



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