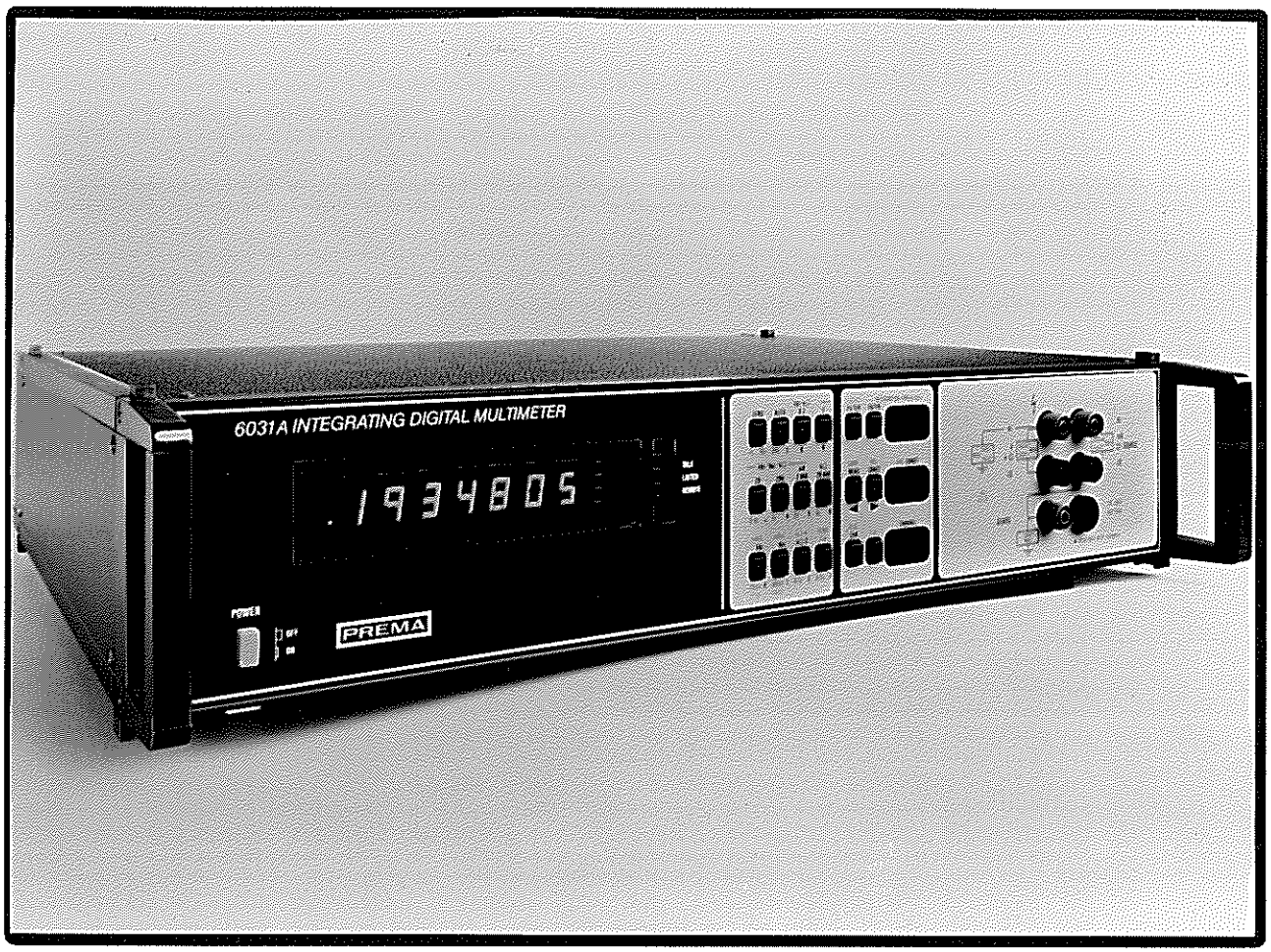
PREMA®



Digital Multimeter
DMM 6031 A

Instruction Manual

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6031Ae - 9333

WARNING!

I/O terminals are sensitive to electrostatic voltage (especially the IEEE connector).
It can damage
your instrument!

OBSERVE PRECAUTIONS FOR HANDLING

Never touch input plugs or terminals without precautionary measures!

Damage caused by electrostatic voltage is not covered by warranty!

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1. Introduction

This manual is valid in common for instruments in the ranges 6030S and 6031. In addition to all the functions of the 6030S, the Digital Multimeter 6031 features the optional 20-channel measuring points selector switch (scanner), the temperature measuring function with a PT 100 platinum resistance thermometer, a 2 A current measuring range and two further integration times of 40 msec and 20 msec respectively.

In other respects, the functions and operating procedure are the same for all these instruments. However, the performance specifications differ in the common functions. In spite of the same readout display resolution of 6 1/2 digits, the Digital Multimeter (DMM) 6031 has the same or a superior accuracy, compared with the DMM 6030.

This manual is not valid for instruments in the 6030 range without the 6030S accessory. Where necessary, attention is drawn to the additional functions of the Digital Multimeter 6031.

1.1. Description of the Instrument

The 6 1/2 digit Digital Multimeters 6030/6031 from PREMA (6031 with optional 20-channel scanner) are top class instruments with outstanding performance and exceptionally good technical specifications. With the patented integrating measuring method, the high input resistance of 10 GOhms in the measuring ranges up to +/- 20 V, the selectable integration times up to 20 sec and the excellent linearity and small long-term drift, both instruments offer ideal conditions for making precision measurements which are reproducible at any time.

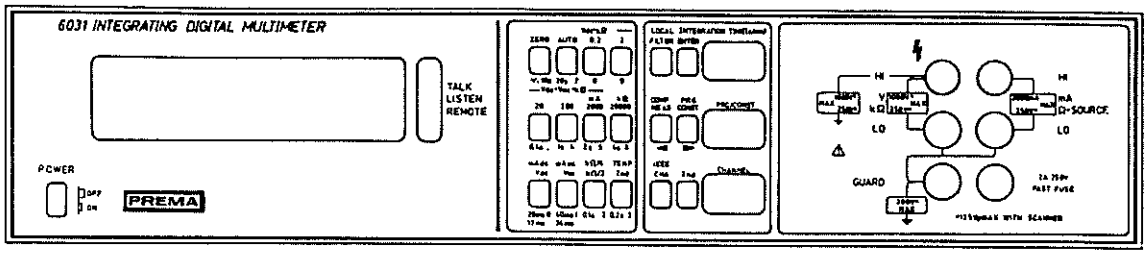


Fig. 1.1. View to the Front Panel of the 6031 DMM

The extremely stable amplifiers and a precision integrator with automatic zero offset correction permit continuous integration without disturbing breaks for offset measurements, even with 100 nV resolution (0.2 V measuring range, 1 second integration time).

The analog to digital conversion is performed by the PREMA multiple ramp integration method which is proven since longer than a decade. By synchronizing the oscillator frequency to the mains frequency using a phase locked loop, this conversion method achieves otherwise unobtainable rejection factors for common mode and series mode disturbance. The input signal is present at the input of the converter all the time, without any breaks, so that even very small changes of the measured value are acquisitioned correctly. An additional offset correcting facility allows compensation of thermoelectric emfs or the resistance of the connecting leads. A switched digital filter attenuates interfering signals by 20 dB.

The PREMA Digital Multimeters 6030S and 6031 provide facilities for measuring direct voltages with 100 nV resolution, alternating voltages, optionally with DC or AC coupling, with100 uV resolution, direct and alternating current (6031) with 10 uA resolution, resistance optionally in two-pole or four-pole circuit, with 100 uOhm resolution and temperature (6031) with PT 100 elements, in two-pole or

four-pole circuit with 0.01°C resolution (optionally also °F or K). The measurements can be made continuously or as single or group measurements using an (6031) external or internal trigger signal to start each measurement. When the resolution is reduced to 4 1/2 display digits, a sampling rate of 50 measurements per second can be achieved with the 6031.

With the comprehensive set of mathematical programs, this digital multimeter can perform many kinds of calculations directly on the measured values. Alarm thresholds can be monitored, measured values can be rescaled or recalculated according to numerous available mathematical functions, to correspond to the desired display format. Curve linearization is possible with polynomial functions up to the 8th degree. The statistical functions, e.g. calculation of averages and standard deviations, permit convenient observation of a signal over long time periods without requiring further equipment and auxiliary facilitiers (such as connection to a computer). Operation with the internal mathematical programs in many case obviates collection and external evaluation of measured values by a connected control computer which is thus relieved of such routine tasks.

The PREMA digital multimeters are equipped with an IEEE bus interface (IEEE 488) for connection to a computer, as a standard feature. Full remote control of the digital multimeter, including digital calibration, is possible via this interface. The computer can also write directly to the display of these digital multimeters and interrogate their keyboard via the IEEE interface. The outstandingly good resolution of these digital multimeters is unimpaired even in system operation, by virtue of the very good electrical isolation between the measured signal and the IEEE interface.

Digital calibration makes alignment of the digital multimeter very simple. The linearity of the A/D converter is so good that entering a single nominal value (on the keyboard or via the IEEE interface) in each measuring range suffices to calibrate it. Each measuring range can be calibrated independently of all others. The entered nominal value may lie between 5% and 100% of the range end value. A concealed switch prevents unintentional changes of the calibration values and the basic settings of the multimeter.

After switch-on, a self-test program checks the functions of the digital multimeter and that the calibration values are correct. Error messages point out any manual control errors or equipment faults in every situation. Errors found during the self-test indicate faults in the hardware, in the EPROMs, in the RAM or in the calibration data. The other error messages report overflow, offset or calibration errors and errors in control of the IEEE interface.

The measuring points selector switch (scanner) which can be fitted as an option in the digital multimeter (6031) permits four-pole switch-over between up to 20 precision measuring channels. Except for the maximum permitted voltages, the performance specifications of the digital multimeter are unchanged by incorporation of the scanner.

The clear and synoptical construction and the use of customer-specific integrated circuits minimize the number of electronic components, enhance servicing convenience and contribute significantly to the high dependability of the PREMA digital multimeters.

1.2. The Measuring Principle

The P R E M A multiple ramp procedure for analog to digital conversion (German Patent Document No. 2114 141, US Patent No. 3765012) is the functional basis for a reliable digital voltmeter with excellent linearity and unusually good long-term stability, using continuous integration of the measured signal without falsifying breaks. This also eliminates disturbance by averaging it out.

An amplifier which is connected as integrator with the capacitor C (Fig. 1.2.1) continuously integrates a current Ii proportional to the voltage which is to be measured.

This procedure gives very good linearity because it is not necessary to switch off the input voltage periodically. This avoids the input voltage dependent switching surge error otherwise caused by the capacitance of the transistors customarily used as signal switches.

The capacitor (Fig. 1.2.2) is discharged periodically by a current Iref from a reference voltage source Uref which has opposite polarity with respect to the input signal (discharge times t1 to tn).

Before the start of a down integration the comparator determines the sign of the input voltage and thus selects the polarity of the reference voltage. The same reference voltage and the same down integration resistor are used for both polarities, so that the value in the display is the same on reversing the input voltage, with a tolerance of only one digit.

The end of each down integration period is defined by coincidence of the comparator response and a pulse flank of the clock oscillator. Since the total change of charge on the capacitor during one measuring period is zero, it follows that

$$\frac{1}{R_e}\int_0^T U_e dt + \frac{1}{R_0} U_{ref} \sum t_i = 0$$

or

$$\frac{1}{T}\int_0^T U_e dt = -\frac{R_e}{R_0 T} U_{ref} \sum t_i$$

so that the sum of the discharge times ti is proportional to the mean value of the input voltage and constitutes the displayed measurement result.

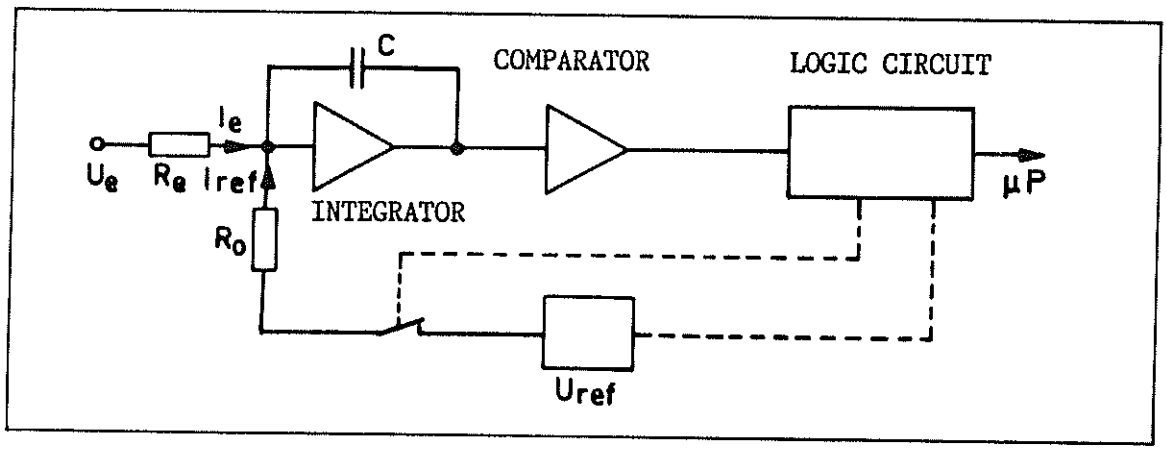


Fig. 1.2.1 Simplified circuit diagram showing the funttional principle

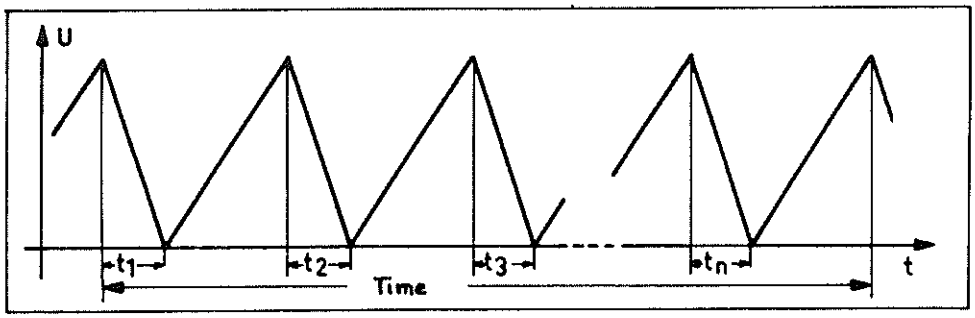


Fig. 1.2.2 The output signal of the integrator

In this method of voltage to time conversion the result is not falsified by the dielectric loss factor of the capacitor or by drift of its capacitance value. The result is also indepent of the frequency of the clock oscillator, because the determination of T and all ti is made with the same frequency. Drift and speed of the comparator are uncritical in the PREMA multiple ramp procedure, so that a reasonably low-cost design of the complete instrument is possible in spite of the top class performance as digital multimeter.

1.3 Functional Overview

The PREMA digital multimeter offers numerous functions and possible connections. The following chapter gives a short overview of the layout and functions of the manual control elements and device connections. Figs. 1.3.1 to 1.3.4 show the locations of the manual control elements.

1.3.1 Manual Control Elements and Connections on the Front Panel

All elements which are required for manual control of the digital multimeter are arranged synoptically on the front panel. Operator access to all device functions is provided via the keyboard which is sectioned into two logically separate blocks. The right part of the keyboard is used to select the operating mode. The left part of the keyboard has three functional levels which are used to select the function and range, the integration time or for data input. The read-out display has four fields which, together with the light emitting diodes in the keyboard, give a continual status and function overview of the instrument. The signal which is to be measured must be connected via the safety sockets on the right side of the front panel. The numbering of the following explanations designates the locations of the elements in the layout diagram (Fig. 1.3.1 and 1.3.2).

(1) The mains switch makes safe double-pole connection and disconnection of the mains input voltage to the instrument.

(2) The main display field is used for readout of measurement results with up to 6 1/2 digits and calculation results with up to 7 1/2 digits. The input values for calibration, constants, IEEE address and terminating characters appear in the main display field for checking, and the device and error messages also appear in the main display field.

(3) The IEEE status display indicates the operating state of the instrument when the latter is being operated via the IEEE bus. The "REMOTE" display segment is lit when the instrument is in remote control status. Two further segments indicate whether the instrument is operating as listener or as talker.

(4) The integration time display shows the currently selected measuring time. For measuring times which are longer than 4 seconds, the still remaining time in the current period is counted down in the display.

(5) This subsidiary display field has several functions. Depending on the selected operating mode, this display shows the number of the program selected from the set of mathematical functions, the chosen constant designation number when entering a constant or the number of preselected measurements in the "single measurements" operating mode.

(6) When the measuring points selector switch (scanner) (6031) is fitted, the channel selection display shows the designation number of the channel which is currently connected to the measuring inputs.

(7) Keyboard for selecting the operating mode of the digital multimeter. The possible operating modes are output of the measurement result, output of the calculation result, program selection, integration time selection, constant display, single, group or continuous measurements, channel selection for the scanner (6031), selection of the IEEE address setting and switch-on or switch-off of the digital filter. When operating the instrument on the IEEE bus, manual control can be enabled via the keys 2nd LOCAL. This keyboard has two function levels. The blue legend second functions are accessed by first pressing the 2nd key. The two center keys are provided for CURSOR control when making numerical entries.

(8) Depending on the selected operating mode, this keyboard is used to select measuring functions and ranges, to select measuring times or to enter numerical values, e.g. for constant and program number entries. The blue legend second functions are accessed by first pressing the 2nd key. The red legend measuring times are accessed by first pressing the ENTER key.

The keys in the upper row are provided to switch-on autoranging, to switch-on the digital filter, to select the offset compensation and to terminate manual control status of the instrument.

(9) The light emitting diodes in the keys indicate the operating status of the instrument.

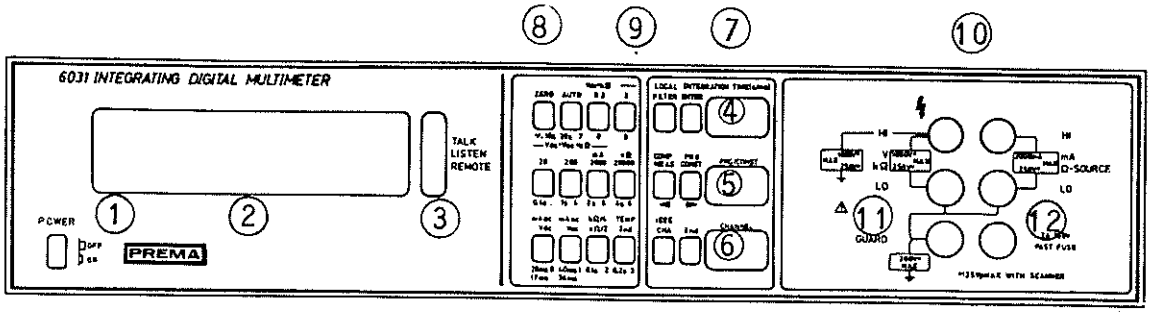


Fig. 1.3.2 Keyboard, subsidiary displays and input sockets

(10) The Teflon-insulated safety measuring sockets have the high insulation resistance required for the specified high input resistance of more than 10 GOhms for the digital multimeter. Voltages and currents are connected to the input of the multimeter via separate input sockets.

(11) The provided guard socket allows shielding of the measured signals by connection to the internal shield line of the instrument.

(12) The current fuse (instrument fuse cartridge, 3.15 A medium delay) is accessible from the front. Replace it by a fuse cartridge of the same type when it has blown after a current overload.

1.3.2 Manual-Control Elements and Connections on the Rear Panel

The chief items on the rear panel are all device connections such as mains input, trigger signal input, IEEE bus connection and the input sockets of the optional scanner (6031). The following numbers refer to the locations on the layout diagram (Fig. 1.3.3 and 1.3.4).

(13) The mains power supply connection of the instrument is made via a 3-pole DIN-connector for cold equipment. The connection is set for 220 V / 50 Hz nominal AC mains input voltage. The instrument must be grounded via the safety ground contact of the mains input connector. The case is electrically isolated from the measuring sockets, from the trigger signal input and from the IEEE interface.

(14) The mains fuse is rated for operation on 220 V / 50 Hz mains input voltage. This is a 200 mA instrument fuse. If it has blown, replace it with a fuse cartridge of the same type. Before replacing the mains fuse, the instrument must be disconnected from the mains voltage.

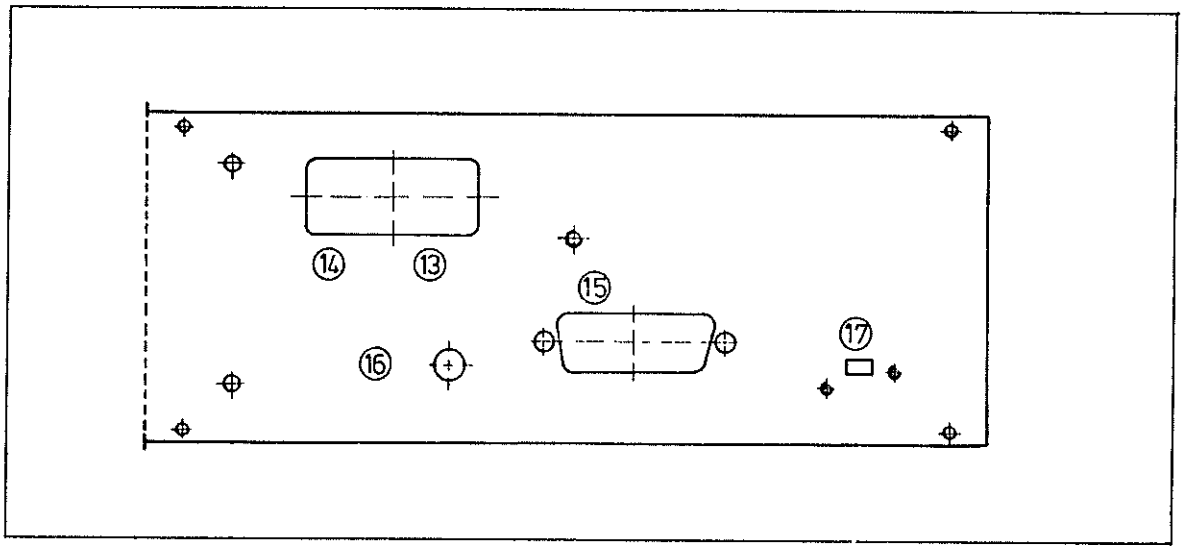


Fig. 1.3.3 Mains connection, IEEE bus, trigger and calibration switch

(15) The connection of the digital multimeter to a computer with IEEE bus is made via this interface. The connector conforms to the IEEE-488 standard. When operating the instrument in this way, conform to the values stipulated in the standard, e.g. not more than 16 devices on the bus and maximum line length 2 m between any two devices. Pin 12 of the IEEE plug connector is connected to safety ground.

(16) Triggering: In single or group measurements operating mode the measurements can be started by an external trigger signal. For this purpose, the trigger input, which rests Low, must be switched briefly to logic level High (TTL signal, 400 microseconds).

(17) This concealed calibration switch enables and disables recalibration of measuring ranges and changes of the basic settings of the instrument. In the "MEAS" setting, all calibration data and basic settings of the instrument are protected against accidental loss or change. Great care is required in the "CAL" setting, because even a brief power supply failure or a manual control error can destroy some or all of the data required for proper functioning of the instrument.

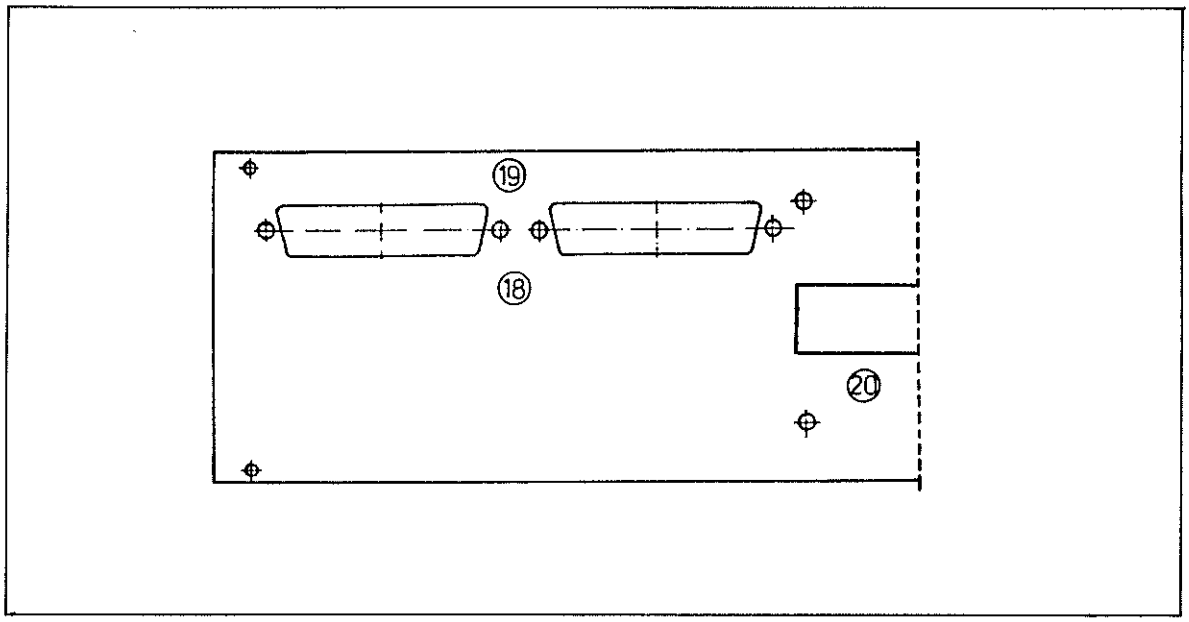


Fig. 1.3.4 Measuring inputs on the rear panel

(18) Inputs for the scanner: Up to 20 channels for selection can be connected to the rear 50-pole subminiature D sockets, for connection via the scanner to the measuring input of the Digital Multimeter 6031. The connection to the measuring input (parallel to the sockets on the front panel) is made on four poles for each channel. All functions of the 6031 can be used via the front or rear panel sockets as well as via the optionally incorporated scanner. When using the scanner, further signals can be connected in parallel via the front or rear panel sockets. When the optional scanner is fitted, the maximum permitted input voltage is 125 V (with respect to the connections of the multiplexer, the guard and safety ground).

(19) The instrument can be provided with measuring inputs on the rear panel as alternative to those on the front panel. The connections of the measuring circuit may then be made only on the rear panel.

(20) The type specification plate states the type (model) and the serial number of the instrument. Please quote the type and serial number of your instrument with all enquiries.

2. TECHNICAL DATA

2.1. DIRECT VOLTAGE Vdc

RANGES	+/-0.2V; +/-2V; +/-20V; +/-200V; +/-1000V		
MEASURING TIMES (sec.)	0.02+0.04	0.1+0.2+0.4	1+2+4+10+20
MAX. DISPLAY SPAN	19 999	199 999	1 999 999 (except 1000V)
RESOLUTION	10/uV	1/uV	100nV

RANGE SELECTION ..... manual, automatic or by remote control

TOLERANCES +/-(% of reading (%R) + % of max. reading (%m.R))*)

24h, 23°C +/- 1°C

	%R	%m.R	
0.2V range	0.001	0.0005	
2 V range	0.0008	0.0001	
20 V range	0.0008	0.0001	
200 V range	0.002	0.0003	
1000 V range	0.003	0.0002	1)

90 days, 23°C +/- 5°C

	%R	%m.R	
0.2V range	0.002	0.0020	
2 V range	0.002	0.0003	
20 V range	0.002	0.0001	
200 V range	0.004	0.0004	
1000 V range	0.004	0.0003	1)

1 year, 23°C +/- 5°C

	%R	%m.R	
0.2V range	0.004	0.0020	
2 V range	0.003	0.0003	
20 V range	0.003	0.0003	
200 V range	0.004	0.0005	
1000 V range	0.004	0.0005	1)

*) These values in each case +/- 1 digit
1) 1000 V range only in instruments without scanner

In specifying these values it is assumed that the measuring time dependent display span is set to be large enough to give a readout with sufficient resolution of the particular tolerance. The natural rounding error of +/- 1 digit must be added to the error expressed as a percentage of the maximum reading (%m.R). It is also assumed that the "guard" socket is connected to the "V/Ohm LO" socket.

TEMPERATURE COEFFICIENTS
($10^{\circ}C$-$18^{\circ}C$ and $28^{\circ}C$-$40^{\circ}C$)

	+/- (%R + %m.R)/$^{\circ}C$		
0.2V range	0.0003	0.0001	
2 V range	0.0002	0.00005	
20 V range	0.0002	0.00005	
200 V range	0.0004	0.0001	
1000 V range	0.0004	0.0001	1)

TEMPERATURE COEFFICIENTS
($0^{\circ}C$-$10^{\circ}C$ and $40^{\circ}C$-$50^{\circ}C$) Values for ($10^{\circ}C$-$40^{\circ}C$)x2

ZERO POINT
Offset voltage (after one hour warm-up)

Temperature coefficient ..... less than 0.3 uV/$^{\circ}C$
Long-term drift ..... less than 5 uV in 90 days

INPUT RESISTANCE
+/-0.2V, +/-2V, +/-20V DC
ranges ..... 10 GOhm (up to +/-0.2V or +/-2V or +/-20V input voltage, respectively)
+/-200V, +/-1000V ranges .... 10 MOhm 1)

DISTURBANCE SUPPRESSION (measured by increasing the disturbing signal peak value until an error of 1 digit is indicated with a measuring time of 400 msec without filter)

SERIES MODE REJECTION
50/60 Hz mains frequency .... better than 100 dB
46 to 56 Hz or 56 to 66 Hz .. better than 50 dB

The peak value of the superimposed alternating voltage must be less than the direct voltage component.

1) 1000V range only for instruments without scanner

COMMON MODE REJECTION	(Shield connected by low resistance path to one of the two inputs, with 1 kOhm in series with one of the two connecting leads)
Direct voltage	160 dB
50 Hz mains	160 dB
MEASURING BREAKS	none, except when using a calculation program whose calculation time exceeds the measuring time or when changing polarity; 50 msec after range or function change
MEASURING PROCEDURE	fully integrating PREMA multiple ramp procedure (German Patent No.2114141, US Patent No.3765012)
POLARITY CHANGE	automatic, max. 100 msec
OVERLOAD LIMITS between "V/Ohm-HI" and "V/Ohm-LO" input +/-0.2V, +/-2V, +/-20V range for	
60 seconds	+/- 1000V 1)
continuous	+/- 700V 1)
+/-200V, +/-1000V range, continuous	+/- 1000V 1)
between "Ohm-LO" input and guard	50V direct voltage or peak voltage
between guard and case	200V direct voltage or peak voltage 1)
OVERFLOW INDICATION	ERROR 1 in the main display

1) Max. 125 V peak for instruments with scanner

2.2. RESISTANCE kOhm

MEASURING METHOD ..... 4-pole, optionally 2-pole

RANGES ..... 200 Ohm, 2 kOhm, 20 kOhm, 200 kOhm, 2 MOhm, 20 MOhm

MEASURING TIMES (sec)	0.02+0.04	0.1+0.2+0.4	1+2+4+10+20
MAX. DISPLAY SPAN	19 999	199 999	1 999 999
RESOLUTION	10 mOhm	1 mOhm	100 uOhm

MEASURING BREAKS ..... 100 msec after range or function switching

RANGE SELECTION ..... manual, automatic or remote control

TOLERANCES +/- (% of reading (%R) + % of maximum reading (%m.R))*)

24h, 23°C +/- 1°C

	%R	%m.R
200 Ohm range	0.002	0.0005
2 kOhm range	0.001	0.0003
20 kOhm range	0.001	0.0003
200 kOhm range	0.002	0.0003
2 MOhm range	0.004	0.0009
20 MOhm range	0.03	0.0025

90 days, 23°C +/- 5°C

	%R	%m.R
200 Ohm range	0.003	0.002
2 kOhm range	0.002	0.0007
20 kOhm range	0.002	0.0007
200 kOhm range	0.003	0.0008
2 MOhm range	0.007	0.0009
20 MOhm range	0.04	0.0025

1 year, 23°C +/- 5°C

	%R	%m.R
200 Ohm range	0.004	0.003
2 kOhm range	0.003	0.0007
20 kOhm range	0.003	0.0007
200 kOhm range	0.004	0.001
2 MOhm range	0.009	0.001
20 MOhm range	0.05	0.0025

*) These values plus +/- 1 digit in each case

In specifying these values it is assumed that the measuring time dependent display span is set to be large enough to give a readout with sufficient resolution of the particular tolerance. The natural rounding error of +/- 1 digit must be added to the error expressed as a percentage of the maximum reading (%m.R).

TEMPERATURE COEFFICIENTS
(10°C-18°C, 28°C-40°C)

	+/- (%R + %m.R) °C
200 Ohm range	0.001 0.0001
2 kOhm range	0.0005 0.0001
20 kOhm range	0.0003 0.0001
200 kOhm range	0.0006 0.0001
2 MOhm range	0.0006 0.0001
20 MOhm range	0.004 0.00015

TEMPERATURE COEFFICIENTS
(0°C-10°C, 40°C-50°C) Values for (10°C-40°C) x 2

CURRENT FLOWING THROUGH THE MEASURED RESISTOR

200 Ohm range	1 mA
2 kOhm range	1 mA
20 kOhm range	100 uA
200 kOhm range	10 uA
2 MOhm range	1 uA
20 MOhm range	0.1 uA

VOLTAGE AT OPEN-CIRCUIT TERMINALS about 5V max.

OVERLOAD LIMIT ..... +/- 250V peak 1)

OVERFLOW INDICATION ..... ERROR 1 in the main display

1) max. 125V peak for instruments with scanner

2.3. ALTERNATING VOLTAGE Vac

CONVERSION TYPE ..... true rms value, can be switched over to pure alternating voltage or to sum of direct and alternating voltage

RANGES	2 V	20 V	200 V	700 V
MAX. DISPLAY SPAN	1 99999	19 9999	199 999	700 00
RESOLUTION	10/uV	100/uV	1mV	10mV
MEASURING TIMES	100 msec to 20 sec			

RANGE SELECTION ..... manual, automatic or remote control

TOLERANCES (1 year) +/- (% of reading (%R) + % of maximum reading (%m.R))*)
(23°C +/- 5°C)

Range	DC+30Hz	1kHz	10kHz	100kHz	300kHz
2V	/---0.07+0.05---/	---0.1+0.05---/	---0.4+0.1---/	---7+2---/	
20V	/---0.07+0.05---/	---0.1+0.05---/	---0.4+0.1---/	---5+2---/	
200V	/---0.07+0.05---/	---0.1+0.05---/	---0.4+0.1---/		
700V	/----0.1+0.05---/	---0.7+0.5----/			

*) Shield connected to the black socket of the Vac input; sinusoidal signal greater than 5% of maximum reading. The specified tolerances assume that the "V/Ohm-LO" socket is connected to ground potential in a suitable manner.

TEMPERATURE COEFFICIENT
(10°C-18°C and 28°C-40°C)

0 - 20 kHz	+/- (0.01% of the reading + 0.004% of the maximum reading)/°C
20 - 300 kHz	+/- (0.04% of the reading + 0.005% of the maximum reading)/°C

TEMPERATURE COEFFICIENT
(0°C-10°C and 40°C-50°C ..... Values for (10°C-40°C) x 2

CREST FACTOR ..... 7 : 1

The peak value must not be greater than 3.5 times the nominal value of the measuring range, or 1000V (125V limit for instruments which are fitted with the scanner).

INPUT IMPEDANCE	1 MOhm in parallel with less than 60 pF

OVERLOAD LIMITS

Input voltage	+/- 1000V peak with the limitation of 10 000 000V x Hz 1)
Shield to case	+/- 200V peak 1)
Shield to "V/Ohm-LO" input	+/- 50V peak
MEASURING BREAKS	320 msec after range or function switching
SETTLE TIME	1 s for 0.1% residual error
OVERFLOW INDICATION	ERROR 1 in the main display

1) max. 125V peak for instruments with scanner

2.4. DIRECT CURRENT mAdc

RANGE ..... +/- 2A

MAX. DISPLAY SPAN 1999.99

MEASURING TIMES ..... 20 msec - 20 sec

RESOLUTION 10/uA

TOLERANCE +/- (% of reading (%R) + % of maximum reading (%m.R))*)
1 year, 23°C +/- 5 °C

2A range	(up to 1000 mA)	0.01	0.002
.....	(up to 2000 mA)	0.07	0.005

*) These values +/- 1 digit and after offset correction

TEMPERATURE COEFFICIENT
(10°C-18°C and 28°C-40°C)

2A range ..... +/- (0.002% of reading + 0.001% of maximum reading)/°C

TEMPERATURE COEFFICIENT
(0°C-50°C) ..... Values for (10°C-40°C) x 2

VOLTAGE DROP

2A range ..... less than 0.6V
with option 6031/01
installed ..... less than 2V

MEASURING BREAKS ..... 100 ms after range or function switching

OVERLOAD LIMITS ..... max. 3A/250V peak (fuse protection with rating 3.15A)
In the direct current function the sockets "V/Ohm-LO" and "A-LO" are connected together internally. The maximum permitted current between these two sockets is +/- 100 mA (100 mA fuse).

OVERFLOW INDICATION ..... ERROR 1 in the main display

2.5. ALTERNATING CURRENT mAac

RANGE ..... +/- 2A rms
MAX. DISPLAY SPAN 1999.99
MEASURING TIMES ..... 100 msec - 20 sec
RESOLUTION 10/uA

TOLERANCE +/- (% of reading (%R) + % of maximum reading (%m.R))*)
1 year, 23°C +/- 5 °C

2A range	DC+30Hz	1kHz	5kHz
	/-----0.1+0.1------/	-----1.0+1.0------/	

*) Sinusoidal signal greater than 5% of maximum reading and black input socket at mains ground potential.

TEMPERATURE COEFFICIENT
(10°C-18°C and 28°C-40°C)

0 - 1 kHz ..... +/- (0.01% of reading + 0.004% of maximum reading)/°C
1 - 5 kHz ..... +/- (0.04% of reading + 0.005% of maximum reading)/°C

TEMPERATURE COEFFICIENT
(0°C-50°C) ..... Values for (10°C-40°C) x 2

CREST FACTOR ..... 7 : 1

The peak value must not be greater than 1.5 times the nominal measuring range value or 3 A.

VOLTAGE DROP

2A range ..... less than 0.6 V
with option 6031/01
installed ..... less than 2V

MEASURING BREAKS ..... 320 msec after range or function switching

OVERLOAD LIMITS ..... max. 3A/250V peak-peak (fuse 3A)

In the alternating current measuring function the sockets "V/=hm-LO" and "A-LO" are connected together internally. The maximum permitted current between these two sockets is +/- 100 mA (fuse 100 mA).

SETTLE TIME ..... 1 s for 0.1% error of reading

OVERFLOW INDICATION ..... ERROR 1 in the main display

2.6. TEMPERATURE °C, °F, K

MEASURING METHOD ..... 4-pole, PT 100 measurement with linearization

DISPLAY SPAN	Display span	Resolution
Centigrade (Celsius)	-200°C to + 850°C	0.01°C
Fahrenheit	-328°F to + 1562°F	0.01°F
Kelvin (Absolute)	+ 73 K to + 1123 K	0.01 K

MEASURING CURRENT 100/uA

VOLTAGE AT OPEN-CIRCUIT TERMINALS ..... about 5 V

MEASURING TIMES (sec) ..... 0.2+0.4+1+2+4+10+20

MEASURING BREAKS ..... 100 msec after range or function switching

TOLERANCE ..... +/- 0.05°C over the entire range at 23°C +/- 5°C for one year (without sensor tolerance)

TEMPERATURE COEFFICIENTS

10°C-18°C, 28°C-40°C	0.001°C/°C
0°C-10°C, 40°C-50°C	0.002°C/°C

SENSOR ALIGNMENT ..... at any arbitrary, exactly known temperature anywhere within the entire range, optionally in °C, °F or Kelvin

LINEARIZATION ..... conforming to DIN IEC 751 standard specification

2.7. TRIGGER INPUT

TRIGGERING	positive flank, with maximum time uncertainty of 10 msec until the start of the measurement
min. pulse height	+ 2V
max. pulse height	+ 15V
overload limit	+/- 25V
Plug connector type	3.5 mm jack plug
max. voltage between socket and mains ground	50V

The trigger socket is electrically isolated from the case. The ground connection of the socket (outer visible sleeve) is connected to ground potential of the IEEE bus interface.

2.8. SCANNER 6031/01 (Option)

SWITCHING MODE	4-pole, 1 from 20
CHANNELS	20
CONTACTS PER CHANNEL	4
SWITCHING ELEMENTS	monostable mechanical switches
THERMOELECTRIC EMF	less than 1/uA after 1.5h warm-up
PROTECTION SHIELD	present
MAX. VOLTAGE BETWEEN 2 CONTACTS OF ONE CHANNEL	125V peak with the limitation of 1 000 000 x V x Hz
MAX. MEASURED VOLTAGE	125V peak with the limitation of 1 000 000 x V x Hz
MAX. SWITCHED CURRENT	2Adc or 3A peak
TIME BETWEEN TWO SWITCHING CYCLES	shorter than 100 ms
DELAY OF MEASUREMENT START AFTER CHANNEL SWITCHING	20 msec plus the times for any range or function switching
MAX. CONTINUOUS SEQUENCE CHANNEL SWITCHING FREQUENCY	2 Hz
MAX. SERIES RESISTANCE (PER LINE)	1 Ohm
SERVICE LIFE	2×10^8 switching cycles (0.1A, 10V DC)
INSULATION RESISTANCE BETWEEN 2 CONTACTS	3 GOhm when relative humidity is less than 60%
INSULATION RESISTANCE TO CASE	3 GOhm when relative humidity is less than 60%
CAPACITANCE BETWEEN CONTACTS ...	smaller than 100 pF
INTERVAL TIME	1 to 9999 minutes
TRIGGER DELAY TIME	0.1 to 999.9 sec
SWITCH-ON TIME	0.1 to 999.9 sec

2.9. IEEE 488 INTERFACE

OPERATING MODES	TALKER/LISTENER or TALK ONLY
ISOLATION FROM INPUT	electrically isolated from the input stage
OUTPUT INFORMATION	numerical data from measurement result, calculation result, function, range, measuring time, calculation program number, key code, constants and other device settings
INPUT INFORMATION	function, range, measuring time, start command, nominal value for calibration, display text and other device settings; can be triggered via GET
ADDRESS	selectable from 0 to 30, TALK ONLY can be set via the keyboard
SUPPORTED FUNCTIONS	SH1, AH1, T5, L3, RL1, DC1, DT1, SR1
KEYBOARD	can be switched off with REN can be switched on with GTL can be locked out with LLO
TERMINATING CHARACTERS	9 different combinations can be selected
COMPATIBILITY	IEEE Standard 488 (1978) and IEC 625 Part 1 and 2
BUS PLUG CONNECTOR	24-pole conforming to IEEE-488

2.10. GENERAL

WARM-UP TIME	20 min to reach the 1 year tolerance 1 hour for full accuracy

RELATIVE HUMIDITY

up to 25°C	up to 75% relative humidity
above 25°C	up to 65% relative humidity

POWER SUPPLY	100V, 120V, 220V, 240V; switched; 50 or 60 Hz, 20VA
WEIGHT	about 5.1 kg
CASE	19" flat case, aluminium

DIMENSIONS

Table cabinet

Height without feet	about 88 mm
Height with feet	about 105 mm
Width	about 444 mm
Depth without handles and without manual control elements	about 356 mm
Depth with handles	about 396 mm

2.11. BASIC DEVICE SETTINGS on power-up

MEASURING FUNCTION	Direct voltage Vdc
MEASURING RANGE	1000V range
INTEGRATION TIME	2 sec
AUTORANGING	Switched off
OPERATING MODE	Measuring, continuous
PROGRAM	No program selected
DISPLAY	Measured value, 6 1/2 digits
DIGITAL FILTER	Switched off
CONSTANTS	All constants C0 to C9 cleared
CHANNEL SELECTION (Scanner option)	All channels switched off, front sockets switched on
CHANNEL PRESELECTION (Scanner option)	No channel selected, all times = 0, automatic channel switching switched off

IEEE Bus

STRING FORMAT	Long string, measured value and status information
SERVICE REQUEST FUNCTION	Switched off, no SRQ
DISPLAY MODE	Switched off
REMOTE CONTROL	Switched off; manual control enabled
IEEE ADDRESS AND TERMINATOR	Set to address 07; terminator 8 or last saved setting
TRIGGER INPUT	Switched off

3. Commissioning

3.1. Delivery

Before delivery, every PREMA instrument is carefully checked in detail to ensure that it is in good condition and functioning in accordance with all the electrical specifications. Therefore this instrument should be in perfect mechanical and electrical condition when you receive it. In order to check for any shipping damage, you should test the instrument immediately after arrival. If you find any grounds for complaint, please draw-up a damage report together with the shipping agent. Please also check immediately that the actual contents of the delivery correspond to the scope of delivery specified on the delivery note.

3.2. Connecting the Instrument to the Mains Voltage

This PREMA instrument is equipped for connection to 100V/120V/220V/240V alternating mains voltage with 50Hz or 60Hz frequency. In the condition as delivered, the instrument is set to the mains voltage of 220V/50Hz which is customary in the European area. Before you connect the instrument to the mains voltage, check that the nominal mains voltage setting (type designation plate and mains fuse) corresponds to the actual mains voltage (see the chapter headed "Calibration" for the instructions to change the instrument settings for a different mains frequency).
Voltage fluctuations of +/-10% and frequency changes of +/-4% are tolerated. The power consumption is about 20 VA. A DIN power connector for cold equipment, with ground contact, is provided on the rear of the instrument for the mains input connection. The instrument is protected by a 0.2A slow-blow miniature fuse. This fuse must be replaced by one having 0.4A rating when changeing over to 100V or 120V mains voltage.

The instrument is connected to and disconnected from the mains voltage on both poles by the "POWER" switch on the front panel.

3.2.1. Grounding

To protect the operator, the case of the instrument must be grounded by connecting the mains cable to a suitable grounded power outlet. The case is electrically isolated with respect to the shield (GUARD), the measuring sockets, the trigger input and the IEEE interface (except for Pin 12).

3.3. Preventing Accidents

When operating this instrument, always observe the general regulations for preventing accidents which apply to the use of electrical measuring equipment.

3.4. Special Considerations when the Optional Scanner is fitted

When the scanner (measuring points selector switch), which is offered as an option, is fitted, bear in mind that this scanner restricts the maximum limits for direct and alternating voltage measurements. The maximum permitted input voltage is 125 Vdc/peak when the scanner is fitted. This limit applies for the front panel sockets too. Any damage to the scanner caused by not observing these limits is not covered by warranty.

3.5 Warranty

PREMA guarentees dependable functioning of the instrument and correct calibration data for the duration of one year after delivery.
Any repairs which become necessary within this period will be carried out without charge.

Damage caused by improper operation of the instrument or by exceeding the specified limiting data is not covered by warranty.
We also point out herewith that we are not liable in any way for any consequential damage.

3.6. Switching-On the Instrument

To switch-on the instrument, press in the "POWER" pressbutton switch. After switch-on and automatic execution of the self-test routines which check the electronic components and the relays in the instrument, the unit automatically switches to the 1000V direct voltage measuring range. Autoranging is switched off. If the optional scanner is fitted, all multiplexer inputs are switched off. The integration time is 1 second with continuous measuring mode. The display shows the measurement result. No mathematical program is selected (program numbers display "00"). The trigger input is switched off and the instrument is ready for manual control. Remote control is disabled. The digital filter is switched off.

The following is true when operating the instrument on the IEEE bus:
The basic device address is set to IEEE.07.8 in the factory, i.e. address 7, terminator 8 (EOI). Display mode and SRQ are switched off. Unless declared otherwise, output is in long string format (see chapter describing the IEEE bus).

The basic device address which is set automatically on power-up can be changed by the user to a value differing from the factory setting (see chapter describing the IEEE bus).

4. Construction of the Instrument

The construction of the digital voltmeter is sectioned into several different functional components. The central microprocessor (Fig. 4.1) controls execution of the measurement, interrogation of the keyboard, writing to the display, function switching, range switching and channel selection (when the optional scanner is fitted). The microprocessor also services the IEEE bus interface and organizes the internal serial data traffic.

Independetly of control of the hardware, the microprocessor also provides numerous software functions, such as execution of mathematical programs, simple digital calibration, self-testing and error detection.

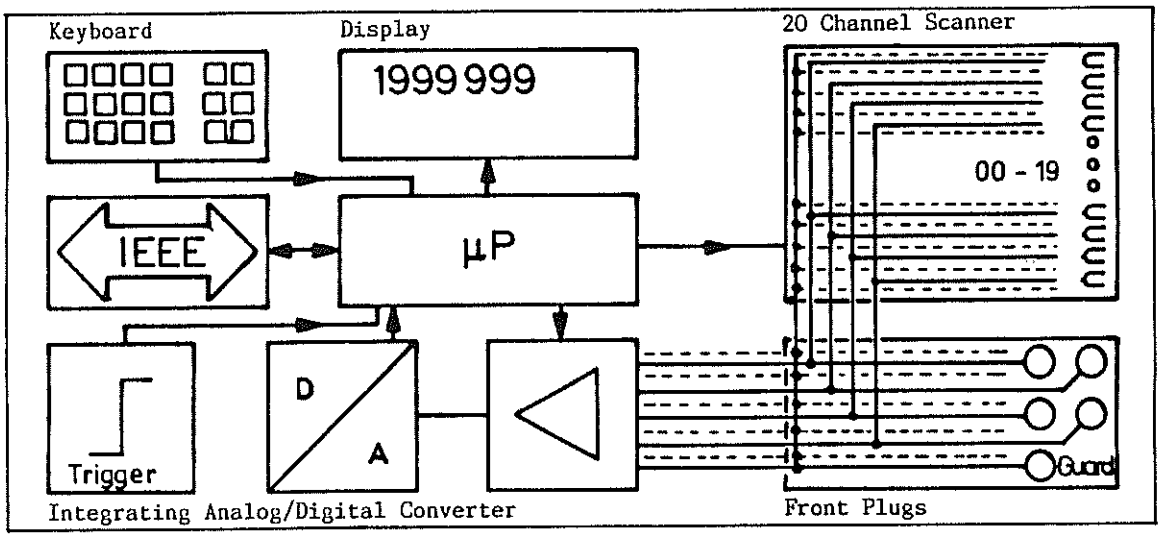


Fig. 4.1 Block diagram of the construction of the instrument

The microprocessor board, the digital section, the analog circuits board and the optional scanner are separately mounted, to avoid mutual disturbance. The data exchange between the analog section and the microprocessor board is performed by serial data transmission via opto-couplers giving electrical isolation. This almost completely prevents any possibility for unwanted interaction between the analog and the digital parts.

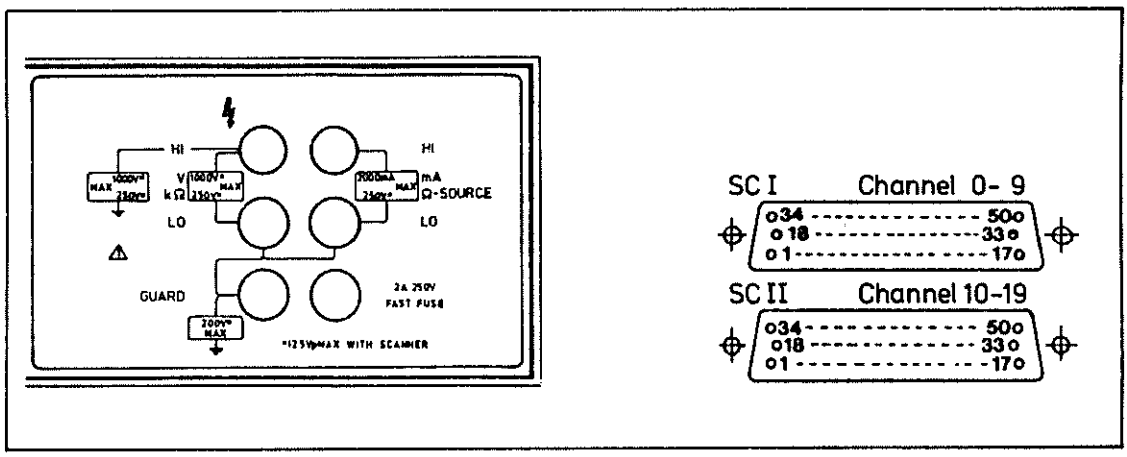
The relays of the optional scanner are driven using a special procedure which avoids undesired heat-up of the relay contacts and ensures that thermoelectric emfs remain smaller than 1 µV.

The well-conceived design of the analog section reduces the number of critical components and the total components count to a minimum. This enhances dependability. A high degree of disturbance rejection is ensured by the well-designed shielding system.

The overall design ensures stable compliance with all performance specifications. The use of a 19" case allows simple incorporation in a measuring system.

4.1. Measuring Inputs

The digital multimeter is equipped with safety sockets on the front panel or on the rear panel for connecting the signal which is to be measured (Fig. 4.1.1.). When the optional scanner is fitted, the front panel sockets can be disconnected or connected as from the 21st channel. The sockets on the rear panel can not be fitted when the scanner is incorporated in the multimeter.



Front panel Scanner Rear panel

Fig. 4.1.1. Circuit diagram of the measuring inputs

4.1.1. Connecting the Measuring Cables

The measured signals should always be connected such that the cable whose potential lies closest to ground potential is connected to the black input socket (LO) and the cable which has the higher potential is connected to the red input socket (HI). The display then gives a reading with positive sign. The display gives a reading with negative sign if the potential at the black socket is greater than that at the red socket.

Voltage measuring connections and connections for two-wire resistance measurements must be made to the two left sockets which are marked with the designations "V, kOhm". Connections for four-wire resistance or temperature measurements must be made to the two left sockets (measuring inputs) and to the two right sockets (current source). Correct polarity must be observed thereby (HI-HI, LO-LO). Current measuring connections must be made via the two sockets on the right which are marked with the designations "mA" and "OHM-Source".

4.1.2. Limiting Data for the Measuring Inputs

Observe the specified limiting data when connecting-up the signals which are to be measured. These limiting data are stated on the front panel adjacent to the measuring inputs (Fig. 4.1.2). The limiting data differ for instruments with and without the optional scanner, as follows:

	without fitted scanner	with
Measuring input		
HI-LO	1000V peak	125V peak
LO-Ground	200V peak	125V peak
GUARD-Ground	200V peak	125V peak
Ohm-Source		
HI-LO	250V peak / 2A peak	125V peak / 2A peak
LO-Ground	200V peak	125V peak

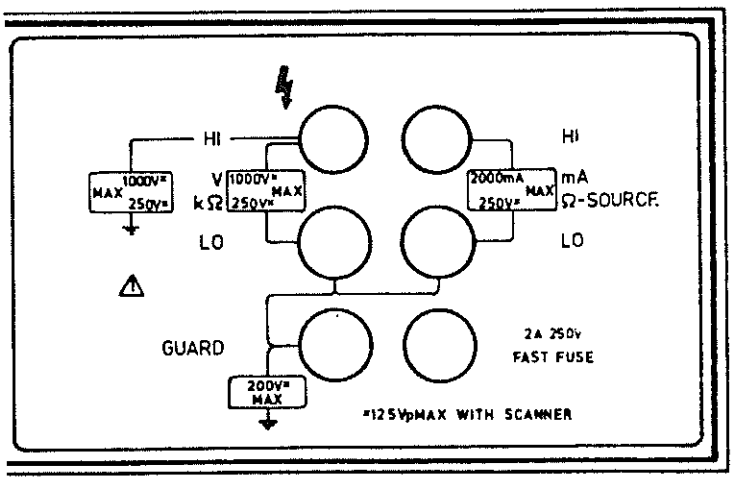


Fig. 4.1.2 Statement of the limiting data on the front panel

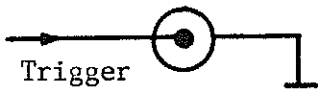
4.2. Shielding (GUARD)

All measuring inputs are surrounded by shielding lines. Some very important rules must be observed for proper functioning of the shielding (see operating instructions for the individual measuring functions). All measuring channels have the same shield when the optional scanner is fitted. Connect the shield of the measuring cable to the shield of the digital multimeter via the blue socket which is marked with the designation "GUARD". Observe the limiting data as specified above.

4.3. Trigger Input

Single measurements can be started by a short trigger pulse via the insulated trigger input provided on the rear panel. For this purpose the instrument must be switched to the "single measurement" operating mode.
The connection is made with a 3.5 mm jackplug. The trigger input is designed to accept TTL levels (0V=LOW, 5V=HIGH).

The outer part of the socket is connected to microprocessor ground (IEEE bus ground). The signal goes via the inner part (Fig. 4.3.1).



Flank 0V-5V=Trigger active
0V=Trigger inactive

Fig. 4.3.1 Connections to the trigger socket

The trigger socket is electrically isolated with respect to the protection ground. The start time for a single measurement is the rising flank of the trigger pulse, with a time uncertainty of 10 msec (Fig. 4.3.2). Each trigger pulse starts a new measurement. If another trigger pulse arrives during a measurement, then the running measurement is aborted and a new measurement is started.

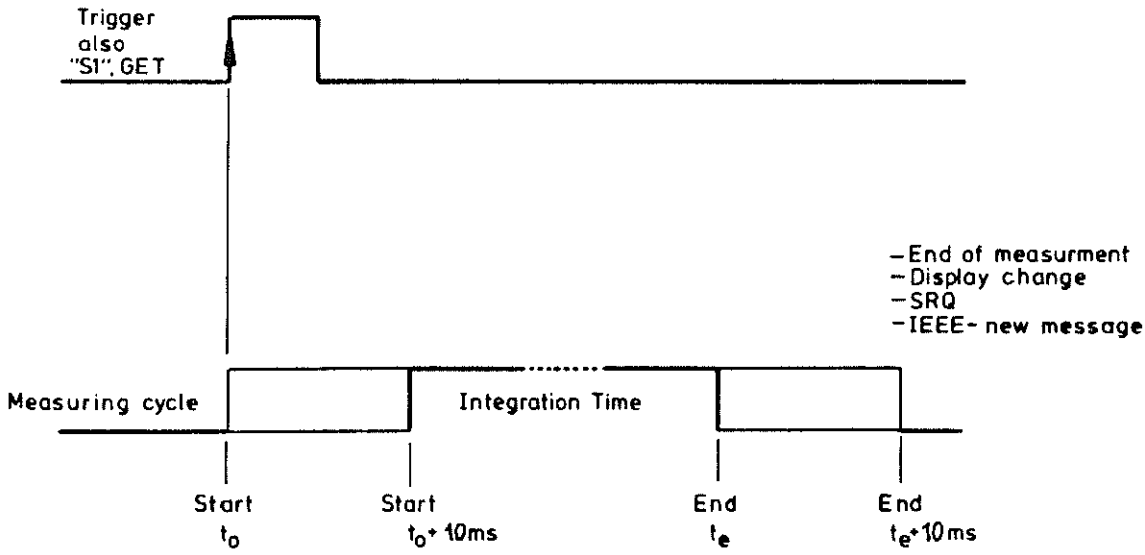


Fig. 4.3.2 Start of the measurement by a trigger signal

The trigger signal must have a pulse amplitude of at least 2V but not more than 15V for correct triggering. To avoid damage, the value must not exceed +/- 25V. The maximum tolerated voltage between the trigger signal and ground is 50 V. The duration of the trigger pulse must be at least 400 microseconds.

4.4. IEEE 488 Bus Interface

The 24-pole IEEE socket is provided for connecting a computer via the IEEE 488 bus interface. According to the standard specification for this bus, not more than 16 devices may be connected on a maximum total bus length of about 20 meters, whereby the maximum permitted distance between successive devices is 2 meters.

The computer which is connected to the bus for controlling the data transfer (CONTROLLER) can address the digital multimeter as LISTENER for receiving data or as TALKER for transmitting data, so that bilateral data communication between the multimeter and the computer is possible. Data exchange takes place via 8 data lines according to a procedure with three transfer control lines DAV, NRFD and NDAC (handshake) which is defined in this bus standard. 5 interface control lines are used for control of the IEEE bus by the CONTROLLER. The outer shield of the IEEE bus cable is connected to Pin 12. Pin 12 is connected to protection ground inside the digital multimeter. The other return lines are connected to signal ground. The pinout (Fig. 4.4.1) of the 24-pole socket conforms to the IEEE 488 standard.

DIO1	1	13	DIO5	Data bus:		INPUT/OUTPUT
DIO2	2	14	DIO6	DIO1-DIO8	Data bits 1-8	I/O
DIO3	3	15	DIO7	Transfer control bus: (Handshake)		
DIO4	4	16	DIO8	DAV	DATA VALID	I/O
EOI	5	17	REN	NRFD	NOT READY FOR DATA	I/O
DAV	6	18	GND(6)	NDAC	NO DATA ACCEPTED	I/O
NRFD	7	19	GND(7)	Interface control bus: (Management)		
NDAC	8	20	GND(8)	IFC	INTERFACE CLEAR	I
IFC	9	21	GND(9)	ATN	ATTENTION	I
SRQ	10	22	GND(10)	SRQ	SERVICE REQUEST	O
ATN	11	23	GND(11)	REN	REMOTE ENABLE	I
SHIELD	12	24	GND	EOI	END OR IDENTIFY	I/O

GND Signal ground
SHIELD Protection ground

Fig. 4.4.1 Pinout and functions of the IEEE bus signals

All IEEE bus signal levels are TTL compatible and active LOW, i.e. true when the signal level is 0. The drivers of the IEEE bus interface can typically sink 48mA current for LOW signals. The IEEE interface is electrically isolated with respect to the measuring circuit inputs.

The device address required for operating the digital multimeter on the IEEE bus is set under software control.

4.5. Scanner (Option)

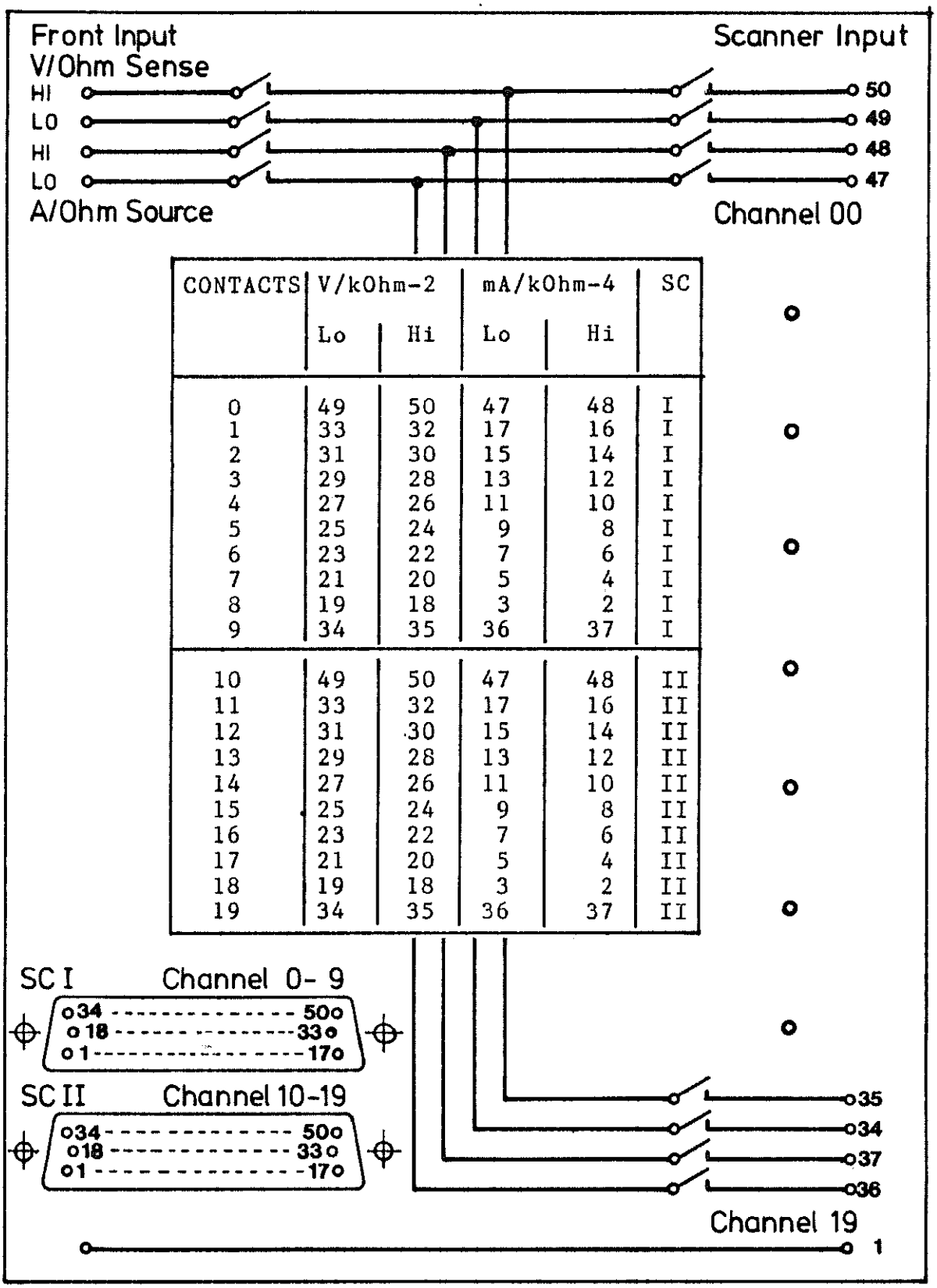
The digital multimeter (6031) can be fitted with an optional 20-channel four-pole scanner (measuring points selector switch, multiplexer)) which has very low thermoelectric emfs.

The connections to the multiplexer are made via two 50-pole subminiature D sockets on the rear panel. The left socket is used for the channels 00-09 and the right socket is used for the channels 10-19. Voltage, current and resistance measuring signals (two-pole or four-pole) can be switched via the multiplexer.

The thermoelectric emfs of the contacts are less than 1 microvolt. The maximum permitted current is 2A. The maximum allowed voltage between any two contacts is 125V peak with the additional restriction of 1V per microsecond maximum slew rate. When the multiplexer (scanner) is fitted, this restriction holds for all inputs of the digital multimeter, including the front panel and rear panel sockets, even when the channels are switched off.

The switching function is of type 1 from 20, i.e. only one channel at a time can be connected through. The connected channel is disconnected before the next channel is connected (break before make switching action). There is a delay of 1-3 msec between switch-off of one channel and switch-on of the next channel.

The four output lines of the multiplexer are connected via relays (which can be switched off) to the sockets "V,kOhm" and "uA, Ohm-Source" on the front panel and rear panel. Pin 1 of the subminiature socket is connected to the shield line and to the blue "GUARD" socket. Each one of the 20 four-pole signal lines is shielded individually. Fig. 4.5.1 shows the pinout of the subminiature D sockets.



CONTACTS	V/kOhm-2		mA/kOhm-4		SC
	Lo	Hi	Lo	Hi	
0	49	50	47	48	I
1	33	32	17	16	I
2	31	30	15	14	I
3	29	28	13	12	I
4	27	26	11	10	I
5	25	24	9	8	I
6	23	22	7	6	I
7	21	20	5	4	I
8	19	18	3	2	I
9	34	35	36	37	I
10	49	50	47	48	II
11	33	32	17	16	II
12	31	30	15	14	II
13	29	28	13	12	II
14	27	26	11	10	II
15	25	24	9	8	II
16	23	22	7	6	II
17	21	20	5	4	II
18	19	18	3	2	II
19	34	35	36	37	II

Fig. 4.5.1 Pinout of the sockets for the 20-channel scanner

4.6. Calibration Switch

The switch (Fig. 4.6.1) in the rear panel of the digital multimeter must be switched to the "CAL" setting in order to change basic settings of the instrument (IEEE bus device address, constants, etc.) and to recalibrate the measuring functions. This protects the programmed data against unintentional overwriting. In normal operation of the instrument the switch is set to "MEAS" and the data stored in the CMOS-RAM with battery backup are then protected.

The overwrite protection for the stored data is disabled when the switch is moved from the "MEAS" to the "CAL" setting. The instrument is then in calibration mode.

Great care is required in this state of the instrument to avoid unintentional change of the stored data. The digital multimeter should never be switched off whilst in calibration mode, because otherwise several manual actions would be required to restore the instrument to a properly functioning condition (see the chapter describing calibration procedure).

After changing basic settings of the instrument or completing the recalibration, return the slide switch immediately to the "MEAS" setting, to protect the data again.

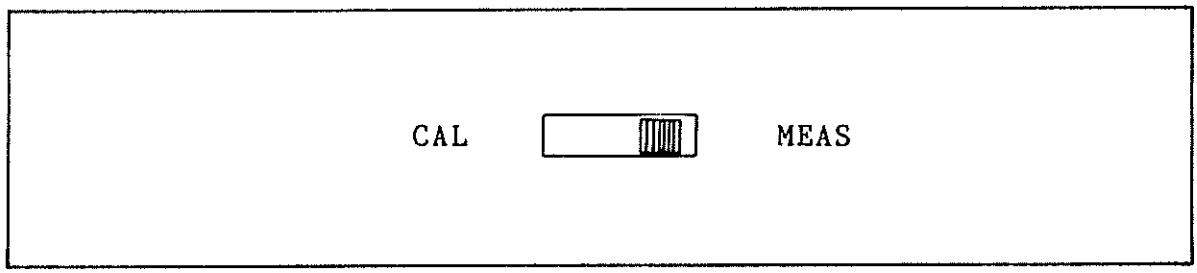


Fig. 4.6.1 Settings of the calibration switch

Use a suitable tool, e.g. a small screwdriver, to actuate the switch.

4.7. Keyboard

The keyboard of the digital multimeter is sectioned into two fields. The right field is used to select the operating mode of the multimeter and the left field is used to set measuring functions and ranges or for data entries. The operating status is indicated by light emitting diodes in the keys.

4.7.1. Keyboard Section for Selecting the Operating Mode

The six keys in the right field are used to select the operating mode or to set special device functions. Two levels are provided for function selection. The black-legend functions are accessed just by pressing the respective keys. The blue-legend second functions are accessed by pressing the "2nd" key and then the respective function key.

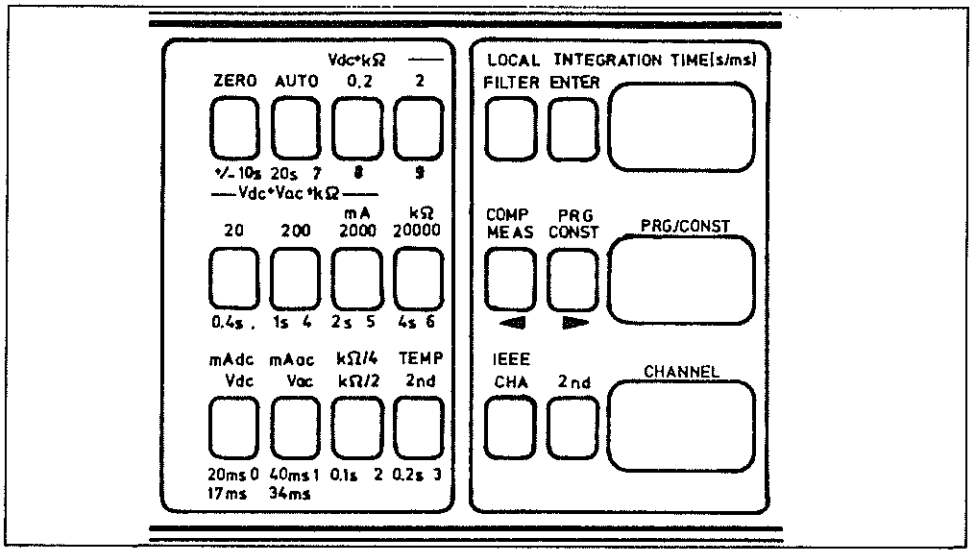


Fig. 4.7 The keyboard of the digital multimeter

Pressing the "2nd" key once switches over to the 2nd function level. Pressing the "2nd" key again switches back to the 1st function level. After the first press of the "2nd" key, the previous display result remains in the display. This can be used for intermediate storage of measurement results. The "MEAS" key switches over to the "measure" operating mode; "2nd COMP" switches over to the "compute" operating mode. The "CONST" key enables input of constants. Program codes for calculation mode can be selected with "2nd PRG". These keys provide cursor control whilst making numerical entries via the data input

field. The "ENTER" key terminates entries made on the data input field or prepares selection of the red-legend integration times (press "ENTER", then the desired integration time). The digital filter can be switched on and off with the "FILTER" key.

The key "2nd LOCAL" is pressed to switch over the instrument from remote control mode (IEEE bus) to manual control mode. The scanner channels can be switched selectively to the measuring input by pressing the "CHA" key and then entering the channel number on the left keyboard field. After pressing the key "2nd IEEE", an IEEE bus device address and a terminator code can be entered on the data input keyboard field.

4.7.2. Keyboard Field for Function Selection and Data Entry

The twelve keys in the left keyboard field have black legend in the first function level for measuring function and range selection, blue legend in the second function level for selecting further measuring functions and red legend in the third function level for selecting the integration time. Apart from selecting the just mentioned functions, these keys are also used to select special functions such as auto-ranging ("AUTO") or offset correction ("ZERO"). The functions of the black-legend first level are executed immediately on pressing the respective key. To access the blue-legend 2nd level function of a key, the "2nd" key must be pressed first (now in the left keyboard field). After pressing the "2nd" key, the previous result remains in the display until a further keypress is made.

For data entry, the keys are marked with the numerals 0 to 9, the decimal point and the sign. The sign changes in response to each press of the "+/-" key. Keys which are not required for data entries are ignored. Autoranging can be switched on by pressing the "AUTO" key and switched off again by pressing this key again or by selecting a fixed range.

4.8. Display

The display of the digital multimeter is sectioned into four fields for synoptical clarity.
The main display field is on the left side. Three subsidiary display fields are located to the right of the keyboard field for operating mode selection. Light emitting diodes for status indication are fitted in all keys.

4.8.1. Main Display Field and IEEE Status Indication

Measured and calculated values are output to the main display field as decimal numbers with decimal point and sign. Measured values are displayed with the resolution corresponding to the accuracy of the measured value. Input and output of constants and output of calculated values are always made with 7 1/2 digits. Device and error messages, the setting of the IEEE bus address and text messages sent via the IEEE bus are shown in the main display. The possible forms of display and their meanings are:

"+1.1276289"	Calculated value, 7 1/2 digits
"+1.298657"	Measured value, 4 1/2 to 6 1/2 digits
"-0.23°C"	Temperature 4 1/2 digits, °C, °F or K
"+.--------"	Constant (free)
"Error 1"	Error message
"Ctrl. 3"	Self-test routine
"IEEE. 07.8"	IEEE address setting
"null"	Zero correction
"donE"	Zero correction / PT 100 completed
"CAL."	Calibration mode

The main display field has a window on the right side which displays the status of the instrument on the IEEE bus. The status can be one of the following:

REMOTE:	The digital multimeter is in remote control mode
LISTENER:	The digital multimeter can receive commands
TALK:	The digital multimeter can send messages to a computer

The respective display segment is lit. "TALK" is lit continuously in TALK ONLY mode.

4.8.2. Integration Time Display (top display)

The integration time display shows the currently set measuring time. For measuring times longer than 2 seconds, the remaining time of the running measurement is counted down in one second intervals in this display field. Measuring times shorter than 100 msec are displayed with leading "0", e.g. "04" for 40 msec. Times shorter than 1 second are displayed with decimal point, e.g. "0.2" for 200 msec. Times of 1 second and greater are displayed without leading "0".

During channel preselection for the automatic measuring points interrogation (6031), a deselected channel is indicated by the display "OP" (opened) and a selected channel is indicated by the display "cl" (closed).

4.8.3. Program and Constant Display (center display)

This display field is used to display program numbers for calculation mode and constant designation numbers when entering or displaying the values of constants. Program numbers are always displayed as two digits, e.g. program No.6 as "06". Constant numbers are displayed with the letter C followed by the constant number 0 to 9, e.g. "C8". The changeable display digit flashes when entering new values. When the number of measurements is being entered for start mode, this is designated in the display by the letters "ct" (for count).

4.8.4. Channel Number Display (bottom display)

When the optional scanner is fitted, the number of the currently selected channel is output on this display field. When a channel is being selected, the bottom segment of the "1" in the front display digit flashes, to draw attention to the limited numerical range of "0" or "1" for the front digit. This display field remains blanked when no channel is selected.

5. Functions of the Instrument

The digital multimeter combines numerous measuring functions and measuring ranges with individual selection of parameters for execution of the measurements. Measurements can be made continuously or triggered individually or in groups (start mode). The resolution of the result and the repetition rate of the measurements can be preselected by choosing a corresponding integration time. An additional filter can be switched into circuit to suppress disturbances.
The result of a measurement can be output directly as measurement result, or as calculation result after processing with programs chosen from the mathematical functions.
Fixed ranges or autoranging can be used for making the measurements. An offset correction (zero correction) can be made independently in every range of every function.
The optional measuring points selector switch (scanner or multiplexer) permits selection from 20 signals connected to the digital multimeter.

5.1 Measuring Functions

The digital multimeter can be switched to the functions for direct voltage measurement, alternating voltage measurement (with or without direct voltage component), direct and alternating current measurement (6031), resistance measurement (two-wire or four-wire circuit) and temperature measurement (6031) with PT 100 resistance thermometers (^{o}C, ^{o}F, K). The various measuring functions have different settle times. This is taken into account by measuring pauses of different lengths. The display span corresponds to the specified resolution of the selected function. The measuring function determines the number of possible measuring ranges.

5.2. Measuring Ranges

Fixed measuring ranges can be selected, or autoranging can be switched-on for automatic matching of the measuring range to the actual magnitude of the measured signal. The number of measuring ranges depends on the selected measuring function.

5.2.1 Manual Preselection of the Measuring Range

If the order of magnitude of the signal which is to be measured is known, then a fixed measuring range can be set so that all measurements are made using this range. If a measuring range which does not exist for the selected function is chosen, then the nearest existing range is switched-on. The digital multimeter outputs an error message (ERROR 1) if the measured signal exceeds the display span of the selected measuring range.

5.2.2. Autoranging

When autoranging is switched on, the digital multimeter automatically chooses a suitable measuring range such that the measured value lies between 8% and 100% of the nominal range end value. The digital multimeter switches to the next lower measuring range when the reading undershoots the lower limit, or to the next higher range when the reading overshoots the upper limit. For correct range selection, the autoranging circuit makes a quick provisional decision by observing the measurement result and then checks the result with respect to the upper and lower limits on completion of the measurement. The measurement starts 100 msec after switchover to the new range. The digital multimeter outputs an error message (ERROR 1) on overshoot of the display span of the highest measuring range.

5.3. Integration Times

In addition to selection of the measuring function and measuring range, the resolution of the result can be determined by selecting a corresponding integration time. The integration time determines the length of time for which the input signal will be observed before output of a result. When the signal is measured with a long integration time, any disturbance is averaged-out more completely so that the result will be more accurate and can be output with higher resolution. A short integration time allows faster tracking of signals which are changing in time. The integration times are phase-locked to the mains frequency for optimum rejection of interference, so that only integer multiples of a mains period can be used as integration times. Thus the shortest possible measuring time with 50 Hz mains frequency is 20 msec (16 2/3 msec with 60 Hz mains frequency). The longest measuring time is 20 seconds. Depending on the chosen integration time, the result is output with 4 1/2 to 6 1/2 digits resolution. A 6 1/2 digit result can be obtained with 1 second or longer integration time.

5.4. Digital Filter

Independently of the integration times, a digital filter can be switched into circuit to give a gliding average of the last 10 measurements. After each measurement, the oldest measurement is discarded and the new result is included in the averaging. The resulting additional disturbance rejection amounts to 20 dB.

5.5. Offset Compensation

A zero point correction can be made individually in each measuring range of each measuring function, e.g. to make compensation for thermoelectric emfs or for the resistance of the connecting leads. A zero point correction is possible when the offset is less than about 0.2% of the range end value for direct voltage measurements or less than about 5% of the range end value for resistance and alternating voltage measurements (also temperature measurements). If the offset is greater than this limit, then the instrument outputs an error message (ERROR 4). The offset correction can be made for fixed range mode or for autoranging mode. The procedure for making the offset correction is described in the chapter containing the "operating instructions" and differs according to the set function. The message "null" appears in the main display and the integration time display shows the remaining measuring time whilst an offset correction is being made. Large offset values can be compensated or introduced using the "offset" program of the mathematical functions.

5.5.1. Offset Compensation with Fixed Measuring Range

If the zero point reading of the selected range differs significantly from zero, e.g. due to the resistance of the connecting leads in a two-wire resistance measuring circuit, a zero correction can be made to give true zero reading. This correction is made only in the selected measuring range. The zero points of other measuring ranges remain unaffected.

5.5.2. Offset Compensation with Autoranging

When autoranging is switched-on, the zero points of all measuring ranges of a function are corrected successively. Making the offset correction in autoranging mode avoids the need for manual switching actuations for correcting the zero offsets of the individual ranges.

5.6. Start Mode

Apart from the continuous measuring mode which is preset in the digital multimeter, another operating mode can be chosen in which single measurements or a pre-declared number of measurements are made. The start of a measurement is synchronized with the continuous measuring sequence and then the pre-declared number of measurements is output. The number of measurements which are to be made must be entered after selecting the measuring function, the integration time and the measuring range (or autoranging).

Each measurement is started either by an IEEE bus command or via the keyboard or by an external trigger signal. The maximum time delay uncertainty between the start command and the actual start of the measurement, due to the synchronization to the continuous measuring sequence, is 10 msec.
Before a measurement is started, the appropriate settle and wait time must be allowed to elapse after function or range switching before starting a measurement.
These times are observed automatically when operating on the IEEE bus with the SERVICE REQUEST function (SRQ). The number of measurements which are to be made after a start is determined by the constant "CT" (Count).

5.7. Measuring Mode

In measuring mode, the result of a measurement is displayed directly. The number of displayed digits in measuring mode depends on the selected function and the selected integration time. Measurements can be made in continuous sequence or in start mode (single measurements or groups of measurements). The readout can be matched to the magnitude of the signal by selecting a fixed range or by switching to autoranging. To output the measurement result, the multimeter must be switched to measuring mode (Meas). This is the default setting.

5.8. Calculation Mode

In calculation mode the result of a measurement is processed by a calculation program and the result of the calculation is shown in the display. Depending on the size of the measured value, the calculation may lead to overflow of the display span. This is reported by the multimeter as "ERROR 2". To make the calculation, a mathematical program must be chosen and the constants required by the algorithm must be entered. To output the calculation result, the multimeter must be switched to the calculation mode (Compute). Autoranging must be switched off in order to ensure that the physical unit of the calculation (V, mA, kOhm) corresponds to the chosen calculation procedure. Combinations of several calculation procedures can be used by setting up a compound program consisting of several cascaded program codes.

5.8.1. Selecting Calculation Programs

Various calculation programs (Fig. 5.8.1) can be chosen with the program selection function, for processing the measurement result. The calculation programs are selected with a program code number. The constants required for the selected program must first be set to the desired values. The calculations always use the display-related physi-

cal units of the functions, i.e. V, mA, kOhm and, for temperature measurements, ^{o}C, ^{o}F or K. The constants must be entered as the values which are valid for these physical units. Calculation mode can be combined with continuous measurements, single measurements or groups of measurements.

5.8.2. Selecting the Constants

Various constants are required for the calculations, depending on the selected program number. Up to 10 constants C0 to C9 can be loaded with the values required for the calculations. C9 is also used to enter program combinations, whereby the first character must always be a decimal point. If the selected constants have physical dimensions, for example in program 01 (offset), then the entered value must be based on the physical unit of the display. For example, to insert an offset of 1.8 kOhm, C0 must be given the value C0 = "1.8000000". For a current offset of 1.2A, C0 must be entered as C0 = "1200.0000" and for a current offset of 17 mA as C0 = "17.000000". The values for the constants can be chosen without restriction in the range from +/- .00000000 to +/- 19999999.

5.8.3. Description of the Calculation Programs

The calculation which is selected by program number is performed according to the formulae shown in Fig. 5.8.1. The respective calculation times have the specified values. If the specified calculation time (for program combinations, the sum of the calculation times) exceeds the selected integration time, then the results of new measurements are taken into account only after expiry of the calculation time. The individual program numbers correspond to the following mathematical functions:

Programs 01 to 10

The effects of these programs are described by the mathematical formulae in Table 1. In particular the program 06 (polynomial) has a very wide range of applications. With nine freely definable constants, this program is very suitable for linearization and curve-fitting operations, e.g. for sensors which have non-linear characteristics. Program 06 can not be used in program combinations.

Programs 11 to 13 : Limiting Value

In these programs an upper limit value can be specified in the constant 7, a lower limit value can be specified in the constant C6, or both limits can be specified together.
The measured value is displayed, as long as it lies within the allowed range. If it lies outside the allowed range, the display shows alternately the message "LO" (or "HI") and the difference with respect to the overshot limit, with correct sign.

Programs 14 to 16 : Max - Min

The maximum value, the minimum value and the difference between the maximum and minimum value of a sequence of measurements can be determined with this program. When start mode has been selected, the number of measuring cycles which shall be observed can be specified.

Programs 17 to 20 : Statistics

These programs have been devised for statistical evaluation of measurements made with the digital multimeter. The provided statistical functions are the algebraic mean, the scatter, the standard deviation and the root mean square value (quadratic mean). The various statistical functions are calculated parallel in time and are then available for call-up. The corresponding statistics program numbers must be entered for this purpose. For these programs the number of measuring cycles which shall be observed can be defined with the constant "CT" (see the chapter describing start mode).

Program 30 : Program Combinations

Up to four different programs (see set of mathematical programs) can be combined in any desired order to give a new compound program. Each program thereby uses the calculation result of the previous program in the sequence.

Only one program from the following program groups may be used in a compound program:
1st group: Program numbers 11 to 13
2nd group: Program numbers 14 to 16
3rd group: Program numbers 17 to 20
If an invalid program combination is entered, the message "ERROR 2" appears in the display.

Program 50 to 54 : Channel selection for automatic mode for instruments in which the optional scanner is fitted

The required parameters for automatic channel scanning can be entered on the keyboard using the programs 50 to 54. The following parameters can be chosen:

1. Interval time (Program 50)

The interval time defines the time separation between successive scan cycles. The interval time (TI) must be entered in minutes.

2. Delay time (Program 51)

The delay time is the time which elapses between through-connection of a channel and start of a measurement. After elapse of the delay time (TD) and start of the first measurement, further measurements are carried out continuously according to the set integration time.

3. Switch-on duration (Program 52)

The switch-on duration (TO) determines how long a channel remains connected before switchover to the next channel takes place.

The switch-on duration and the delay time must be entered in multiples of 100msec. The delay time must be shorter than the switch-on time. The sum of the switch-on times of all participating channels must be shorter than the chosen interval time.

4. Channel preselection (Program 53)

All channels which are to participate in the cyclic interrogation are selected with this program. Each channel can be declared as "OP" (opened, i.e. not participating in the cyclic interrogation) or as "cl" (closed, i.e. participating in the cyclic interrogation). Channels which are declared as "OP" are skipped in the scan cycles.

5. Automatic channel interrogation (Program 54)

After setting the required parameters TI, TD, TO and selecting the channels which are to be interrogated in each scan cycle, the automatic channel scanning is started by selecting program 54 and switching to the "Compute" mode. The cyclic scanning is stopped by switching over from "Compute" mode to "Meas" mode.

Program 98 : Self-Test

The initialization and self-test routine which is automatically executed by the digital multimeter on power up can also be started at any other desired time by selecting program 98 and switching to "Compute" mode. On return from this routine, the instrument is in the same state as after power up (basic settings).

Program 99 : Calibration

For manual calibration of measuring ranges use program 99. It will function only when the "CAL, MEAS" switch at the rear is set to position "CAL" (otherwise "ERROR 5" appears in the display). To calibrate a measuring range, first correct the zero point as described under "offset correction". Then start program 99 with "2nd PRG 99 2nd COMP". The program waits for entry of a nominal value, corresponding to the input signal connected with the instrument. Start calibration procedure by pressing "ENTER". Whilst the calibration procedure "CAL" remains in the display and the integration time display counts down from "10 s" to "00". After successful calibration the new measured value appears in the display. If any faults occured then "ERROR 5" appears.

MATHEMATICAL PROGRAMS SET

Program No.	Mathematical Function	Expression	Calculation time
	Linear functions		
01	Offset	$R = X - C_0$	4.5 ms
02	Multiplication	$R = X \cdot C_5$	7.5 ms
03	Ratio	$R = \frac{X}{C_4}$	10 ms
04	Power	$R = \frac{X^2}{C_4}$	18 ms
05	Percentage deviation	$R = 100 \frac{X \cdot C_4}{C_4}$	20 ms
	Polynomial		
06	Polynomial	$R = C_0 + C_1 \cdot x + \ldots + C_8 \cdot x^8$ with $x = \frac{X}{C_9}$	120 ms
	Non-linear functions		
07	Logarithm	$R = C_5 \cdot \log \frac{X}{C_4}$	180 ms
08	Square root	$R = C_5 \cdot \sqrt{\frac{X}{C_4}}$	200 ms
09	Tangent	$R = C_5 \cdot \tan \frac{X}{C_4}$	180 ms
10	Arc tangent	$R = C_5 \cdot \arctan \frac{X}{C_4}$	200 ms
	Limit values		
11	Limit	$C_7 > X > C_6$	6 ms
12	Limit greater than	$X < C_7$	4 ms
13	Limit less than	$X > C_6$	4 ms
14	Maximum measured value	$R = X_{max}$	5.5 ms
15	Minimum measured value	$R = X_{min}$	5.5 ms
16	Range of measured values	$R = X_{max} - X_{min}$	7 ms
	Statistical functions		
17	Average value	$R = \frac{1}{I} \cdot \sum_{k=1}^{I} x_k = \bar{X}$	60 ms
18	Variance	$R = \frac{1}{I-1} \cdot \sum_{k=1}^{I} (X_k - \bar{X})^2$	60 ms
19	Standard deviation	$R = \sqrt{\frac{1}{I-1} \cdot \sum_{k=1}^{I} (X_k - \bar{X})^2}$	270 ms
20	Root mean square (rms)	$R = \sqrt{\frac{1}{I} \cdot \sum_{k=1}^{I} x_k^2}$	300 ms
30	Program combination	$C_9 = .xxyy..zz$	
	Scanner programming		
50	Interval time	TI	
51	Delay time	TD	
52	Duration of switch-on	TO	
53	Channel preselection	Channel 00 to 19	
54	Automatic scan	Start/Stop	
	Special programms		
98	Selftest		
99	Calibration		

Fig. 5.8.1 The set of mathematical programs of the digital multimeter

5.8.4. Program Combinations

Up to four programs can be combined in any desired order. The only restriction is that the program codes must not be mutually excluding. To distinguish the mutually excluding programs, the table of program number codes (Fig. 5.8.1) has been divided into four groups. Only one program from each of the groups 2, 3 and 4 can be used in program combinations. When using programs from group 1 in combinations, bear in mind that some programs use the same constants so that combination may not be possible in mutually independent form. The program 06 (polynomial), see 5.8.3., can not be used at all in combinations. The polynomial calculation must always be used as stand-alone program. The execution order of the programs is defined in the constant C9. The program numbers must always be specified with two digits in this constant, e.g. program 1 would be specified as "01". The first character in C9 must be a decimal point. The program numbers follow thereafter. The message "ERROR 2" appears if an incorrect program combination is entered. The programs corresponding to the selected numbers (constant C9) are executed in the specified order. The result of each program is made available to the next program in the sequence, which further processes this result. For example, the combination C9=".010817" means that first of all the offset (01) is combined with the measurement result, then the square root is taken (08) and the mean value (17) of this operation is displayed.
To carry out this compound calculations, values must have been entered for the constants C0, C4 and C5.

5.9 Scanner

The signals which are to be measured by the digital multimeter are chosen by selecting the corresponding measuring channels. Switchover from one channel to the next channel always takes place such that the old channel is switched off and then the new channel is switched on after a delay of about 1 to 3 msec. When switching signals via the scanner, make sure that the signals which are to be measured and the measuring function to which the instrument is set are mutually compatible and that the signal lines are connected correctly to the measuring inputs. No other measuring signals may be connected via the front panel or rear panel input sockets when operating the scanner.

5.9.1. Direct Channel Selection

Each channel (00 to 19) can be selected and switched-on directly. When a measuring channel is switched-on, the front panel input sockets are automatically disconnected from the measuring inputs of the multimeter. A channel remains switched-on until another channel is selected or until the channel selection is switched off. When the channel selection is switched off, the front panel sockets or the rear panel sockets are reconnected to the measuring inputs of the multimeter.

5.9.2. Automatic Channel Selection

In automatic channel selection mode, the selected channels (Program 50 to 53 or IEEE command) are connected in cyclic sequence to the measuring inputs of the multimeter. The duration of a cycle, the number of measurements to be made on each channel and the delay time before the first measurement after channel switching, are defined by the values entered for the parameters TI, TD and TO (see 5.8.3.). In automatic channel switching mode, the input sockets on the front or rear panel are always disconnected. The scan cycle is started by program 55 or by IEEE bus command. After stopping the channel interrogation, all channels are disconnected and the front panel sockets are reconnected to the measuring inputs of the multimeter. In "TALK ONLY" operating mode, each obtained measurement result is output via the IEEE bus, e.g. to a connected printer ("LISTEN ONLY").

5.10. Self-Test

The digital multimeter executes an automatic self-test after switching-on the mains voltage. Execution of the individual test routines is reported on the main display as "Contr. 1" to "Contr. 4" and output via the IEEE bus. If an error takes place during this self-test, it is reported with an error message. No voltage greater than 300V is allowed at the input sockets of the multimeter whilst the self-test is running.

Contr. 1 initializes the multimeter and checks that the analog section is functioning correctly.

Contr. 2 calculates a checksum from the calibration factors stored in the battery backed-up RAM and compares this checksum with a control value.

Contr. 3 calculates a checksum of the program ROMs and compares this checksum with a control value.

The self-test can also be started at any other desired time by calling the program number 98. For this purpose, select program 98 and then start the test by pressing the "Compute" key.

5.11. Error Messages

The digital multimeter recognizes the following operator errors. They are indicated on the main display and via the IEEE bus with the designation "Error" and a code number.
The code numbers have the following meanings:

Error 1 Overflow of measurement result
Overshoot of the allowed numerical span.

Error 2 Overflow of calculation result
Overshoot of the allowed numerical span.

Error 3 Ohm or Vac wrong
An external offset has been compensated but is now no longer present; the multimeter sees "negative" resistance values or rms values.

Error 4 Error during offset measurement
The offset which is present at the input sockets is too large.

Error 5 Error during calibration
1. The nominal value is smaller than 5% or greater than 100% of the display span.

2. The calibration switch on the rear of the instrument is set to "MEAS".

Error 6 Error in IEEE bus interface
The multimeter has received more than 31 characters in a device message.

Error 7 Error during self-test 1
A voltage greater than 300 V is present at the input sockets of the multimeter, or a hardware fault is present in the analog section of the multimeter.

Error 8 Error during self-test 2
The calculated checksum does not agree with the control checksum in the non-volatile RAM. This appears if important data for calibration or offset values are lost. This may happen in the appearance of strong electrically disturbances or high energy high frequency signals or transients, exceeding the maximum allowed values. Also lithium backup battery may be exhausted.

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

5.12. Additional Functions when operating on the IEEE-Bus

Some of the functions of the digital multimeter can be used only when operating the instrument on the IEEE bus. Setting of the IEEE bus address is required only for operating the digital multimeter on the IEEE bus. Writing of any desired text to the main display and interrogation of key codes can be carried out only by a computer. Various events can cause the unit to send a service request (SRQ) when operating on the IEEE bus, to call for action by the computer.

5.12.1. IEEE Bus Address Setting

To connect the digital multimeter to a computer via the IEEE bus interface, an IEEE bus address must be set and a message terminator (e.g. EOI) must be agreed between the digital multimeter and the computer. The setting procedure is described in Section 8.1.4.

5.12.2. Display Mode

In display mode the connected control computer can send messages via the IEEE bus to the display of the digital multimeter. The seven segment display devices permit only a limited set of characters which are listed in the following table (Fig. 5.12.2). Clearly readable messages can be constructed by judicious text selection.

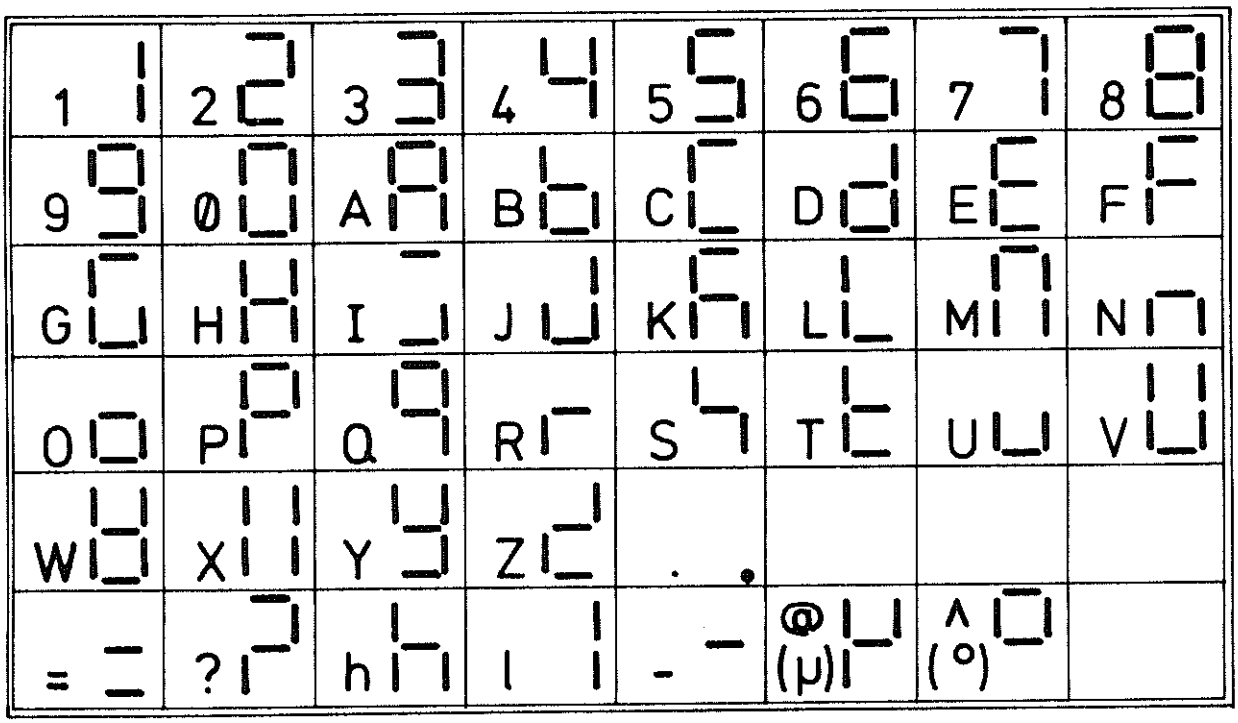


Fig. 5.12.2 Symbols which can be displayed with 7 segments

5.12.3. Keyboard Interrogation

The keys on the keyboard of the instrument are numbered in running sequence starting with "01" at the top left. Each keypress inserts the code number of the pressed key into the device message transmitted by the digital multimeter. The code number is held there until the message is read by the computer. After it has been read, the code number is set to "00" until another key is pressed. In SRQ mode, every keypress produces a SRQ with which the multimeter requests the attention of the computer. Fig. 5.12.3 shows the possible key codes.

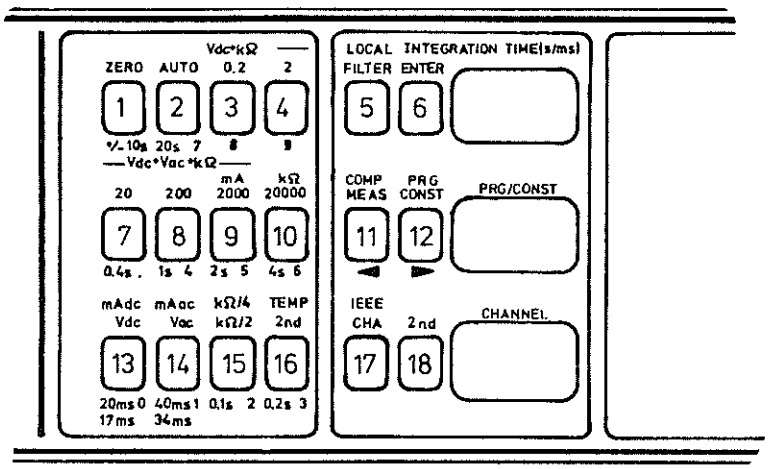


Fig. 5.12.3 The key codes of the multimeter keyboard

5.12.4. Service Request (SRQ)

When the service request function is switched on, the instrument requests service by the computer when an error message has appeared, when the set integration time has expired, when a keypress has been made or after the digital multimeter has carried out a reset.
This gives the computer the opportunity to recognize the reason for the service request and to execute appropriate programs in response.

The recognition is according to the status bits in SERIAL POLL, as defined in the following table.

The bits have the following meanings:

Bit 1: End of measurement
Bit 2: not used
Bit 3: not used
Bit 4: Error message
Bit 5: Out of limits
Bit 6: RESET
Bit 7: SRQ
Bit 8: Keypress

The service request function can be switched on or off by command. In connection with start mode SRQ can be chosen such that a service request is sent out either after every measurement or only after completion of the specified number of measurements.
A detailed description is given in Section 8.2.4.

6.1. Operating Instructions for Direct Voltage Measurement Vdc

Input connections

The input connections for the voltage which is to be measured must be made on the front panel via the two sockets which are marked "V/kOhm". A positive voltage at the red socket relative to the black socket gives a positive value in the display as measurement result. Take care not to exceed the maximum allowed voltage of 50 Vdc or peak between the "LO" input and GUARD, and 200 Vdc or peak between GUARD and case. Furthermore, the sum of these two voltages must not exceed 200V peak. These limits must be taken into consideration when operating with high voltage units which are not isolated from the mains voltage.

Input resistance for Vdc

In order to be able to exploit the high linearity of the measuring procedure, the input resistance for voltage measurements has been made very high in the measuring ranges up to +/- 20V. Thus this instrument still gives very accurate readings even when the measured source has 100 kOhm internal resistance. However, in the 200V and 1000V range, 100 Ohms source resistance already produces an error corresponding to one digit with 100 000 numerical resolution. The following table specifies the input resistance, display span and resolution:

Range	maximum display span	input resistance	Resolution
0.2V	.1999999V	10 GOhm	100 nV
2 V	1.999999V	10 GOhm	1 uV
20 V	19.99999V	10 GOhm	10 uV
200 V	199.9999V	10 MOhm	100 uV
1 000 V	1000.000V	10 MOhm	1 mV

Overload protection

All ranges are well protected against destruction by large voltages. The tolerated voltage overloads are:

+/-0.2V, +/-2V, +/-20V ranges, for 60 seconds: +/-1000V
or continuously: +/- 700V
+/-200V, +/-1000V ranges, continuously: +/-1000V

But bear in mind that large overloads of the lower ranges will produce inevitable heating of the protection resistors and diodes. The resulting thermoelectric emfs can cause a zero offset until internal temperature equilibrium is reached again.

Series mode disturbance voltage rejection

One of the main advantages of the integrating measuring procedure is its high rejection of series alternating voltage disturbance superimposed on the measuring voltage.

For 50 Hz mains frequency disturbance the rejection factor is better than 100 dB with 400 ms measuring time. Frequencies greater than 47 Hz are always averaged-out better than 50 dB (determined by increasing the input alternating voltage until an error of one digit is produced). These excellent values are achieved by synchronizing the internal clock oscillator to the mains frequency.

Common mode disturbance rejection

Common mode rejection is the ability of a measuring instrument to respond only to the difference signal between the "HI" and "LO" input terminals, rejecting any common voltage of both terminals with respect to ground as completely as possible. In an ideal system common mode voltages produce no error. However, in a real system stray capacitances, finite insulation resistances and ohmic asymmetries convert a portion of the common mode voltage into a difference mode voltage. The common mode rejection factor is better than 160 dB without filter when the asymmetry in the connecting leads is 1 kOhm.

Shielding

If no problems with common mode voltages are expected for the intended measurements, then the guard input (blue socket) should be connected to the LO input (black socket).

In critical cases a high rejection factor for direct and alternating common mode voltages can be achieved with the aid of the guard input. Common mode voltages are voltages which lie between the low terminal of the voltage which is to be measured and mains ground as well as between mains ground of the voltage source and the measuring instrument. Common mode voltages attempt to send current in the same direction into both input sockets. In order to achieve optimum shielding, the guard input should be connected to a direct voltage potential which is the same as that of the LO input, such that currents flowing in the shield line will not flow through resistances of the voltage source and measured voltage connecting leads which would affect the measured voltage.

6.2. Operating Instructions for Resistance Measurement kOhm

Resistance measurements are made as follows: A current (I) is passed through the resistance (Rx) which is to be measured and at the same time through a known internal range resistor. The resulting voltage drop across Rx is measured via the input sockets for Vdc and the ratio of this voltage drop to the voltage drop across the internal range resistor is determined. Thus ageing or drift of the reference voltage source does not affect the resistance measurement.

Two-wire measurements

The connections for a simple two-wire resistance measurement are established inside the instrument after selecting the two-wire resistance measuring mode. Only one shielded cable is used for making such measurements. The inner conductor of this cable is connected to the "V-kOhm" input "HI" and the outer conductor is connected to the "LO" socket.

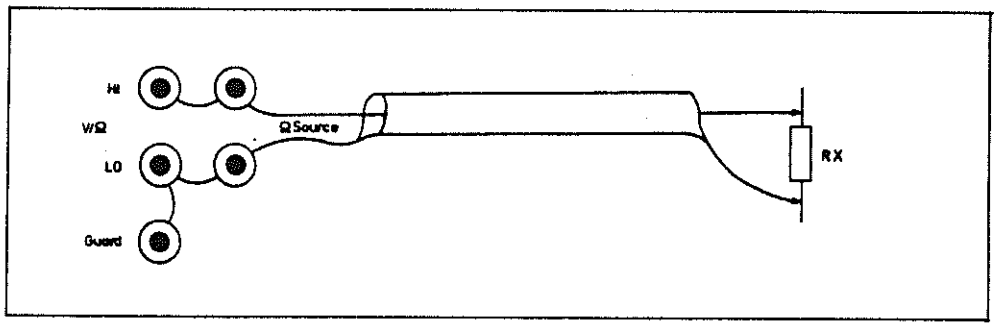


Fig. 6.2.1 Two-wire resistance measurement

The measuring configuration of Fig. 6.2.1 gives acceptable readings only within a resistance range which is restricted by an upper and lower limit. Leakage current problems arise with large resistance values, due to the parallel connection of Rx and the cable insulation resistance. With low resistances, particularly in the 100 Ohm range, the series resistance of the connecting leads causes an appreciable error. A four-wire measuring configuration is recommended for these ranges.

Four-wire measurements

Fig. 6.2.2 shows the arrangement for making four-wire resistance measurements. Each respective inner conductor is connected to the "HI" socket of the "V-kOhm" input or the "OHM-Source" output. The shielding is connected to the respective "LO" socket.

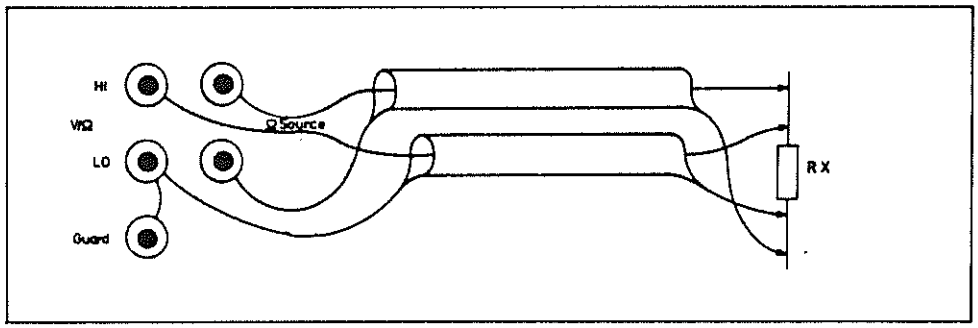


Fig. 6.2.2 Ordinary four-wire resistance measuring configuration

The effect of the resistance of the connecting leads is eliminated in the measuring configuration according to Fig. 6.2.2. However, cables with Teflon insulation must be used when measuring high resistances. In a four-wire resistance measuring circuit, a voltage drop of up to about 0.5 V in each line is tolerated between the "OHM-Source" outputs and the measured resistor. Overflow due to too large Rx is indicated with "ERROR 1" in the main display.

Three-wire measurements

The configuration shown in Fig. 6.2.3 can be used for making resistance measurements in the 10 MOhm range when strong external disturbance is present. This configuration minimizes injection of unwanted alternating voltages and is intended only for the 10 MOhm range.

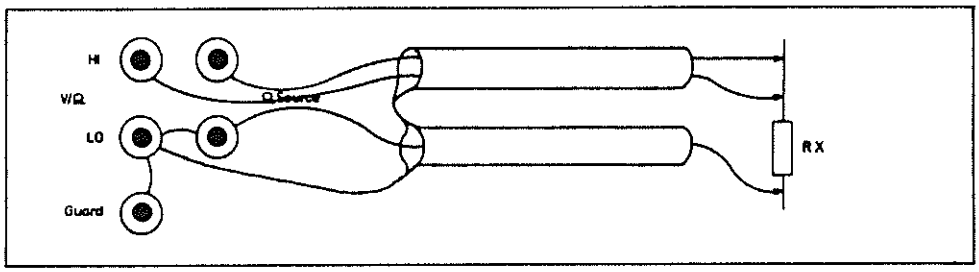


Fig. 6.2.3 Three-wire resistance measuring configuration

General remarks: The currents which flow through the measured resistance in the respective ranges are:

200 Ohm range	1 mA
2 kOhm range	1 mA
20 kOhm range	100 /uA
200 kOhm range	10 /uA
2 MOhm range	1 /uA
20 MOhm range	0.1 /uA

The polarity of the current flowing through Rx has been chosen such that the end of Rx which is connected to the upper socket of the "Ohm-Source" output has a negative potential with respect to the other end of Rx. Always make sure that the end of the resistance Rx which is connected to the upper (HI) socket of the "Ohm-Source" output is also connected to the upper (HI) socket of the "V/kOhm" input (see Fig. 6.2.1 to 6.2.3). The analogous rule holds for the lower sockets.

6.3. Operating Instructions for Alternating Voltage Measurement Vac

The digital multimeter can measure optionally the rms value of the mixed direct and alternating input voltage, or the rms value of the alternating voltage component alone.

A recommended meassuring circuit configuration for alternating voltage measurements consists of a shielded two-conductor cable, whereby the shield is connected to the "Guard" input. For all measurements, the "Guard" and the "V/kOhm-LO" input should be connected to the measuring point whose potential lies closest to ground.

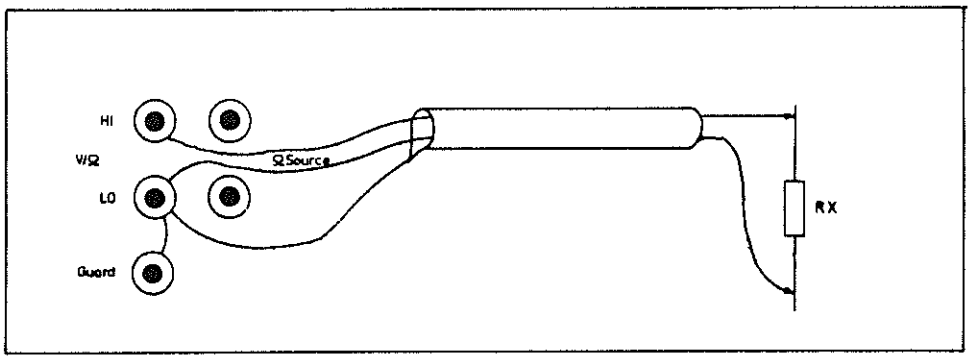


Fig. 6.3.1 Alternating voltage measurement with shielded two-conductor cable

In most cases a simple coaxial cable suffices to give good measurement results, except when the ambient electrical noise level is high or when very small voltages are being measured. Connect the outer conductor of the coaxial cable to the "GUARD" and "V/kOhm-LO" sockets.

In the 200V range and in the 700V at high frequencies (above 100 kHz in the 200V range, above 10 kHz in the 700V range) and when connecting signals to the measuring inputs, make sure that the flank slope does not exceed 10V per microsecond.

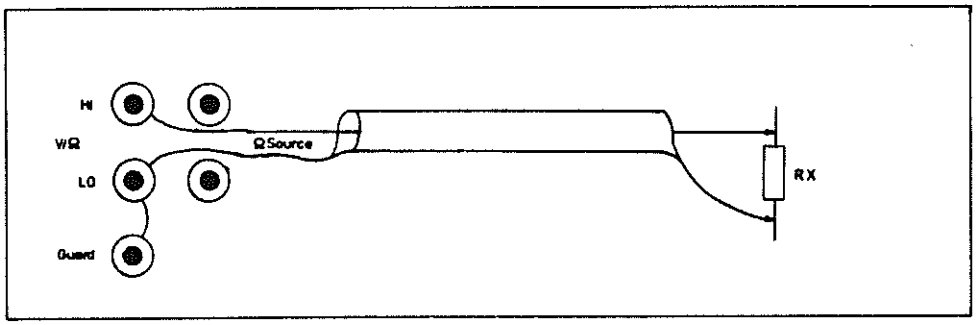


Fig. 6.3.2 Alternating voltage measurement using coaxial cable

6.4. Operating Instructions for Current Measurement mAdc and mAac

Direct currents and alternating currents can be measured with this digital multimeter. The "mA-HI-LO" input of the multimeter is used for this purpose. When connecting the measuring cables, bear in mind that the two black "LO" sockets of the two inputs "V/kOhm" and "A" are connected together internally inside the instrument. Thus it is not possible to connect two cables for current measurement and two cables for voltage measurement simultaneously if there is a potential difference between them. The internal connection between the "V/kOhm-LO" socket and the "mA-LO" socket is protected against current overload with a 0.1A (slow blow) fuse.

A 0.1 Ohm shunt is used in the 2A measuring range. The voltage drop across this shunt is less than 600 mV.

The current measuring range is protected with a 3A (quick blow) fuse which is located on the front panel adjacent to the guard socket.

****
* CAUTION *
****

Disconnect the plugs of all measuring cables before replacing a blown fuse.

Offset correction: Offset correction is done by short circuit the input plugs for voltage measurements HI-LO.

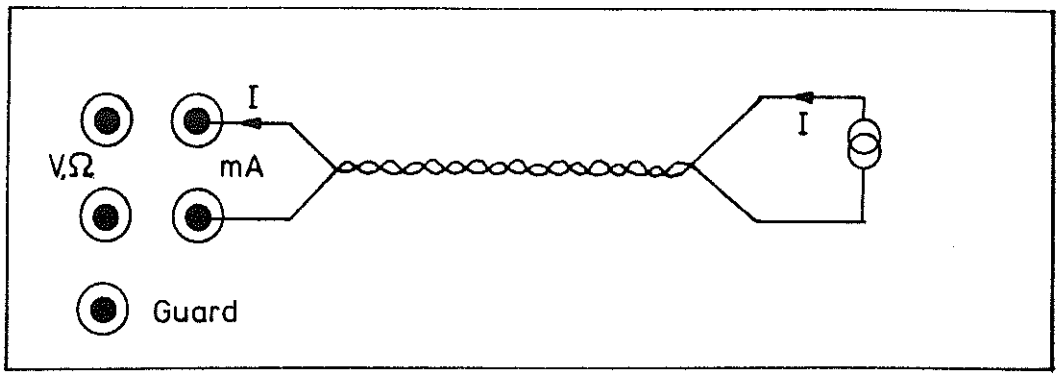


Fig. 6.4.1. Current measurement with twisted two-wire leads

6.5. Operating Instructions for Temperature Measurement °C, °F or K

Temperature measurements are made with a Pt-100 resistance thermometer which is connected in four-pole circuit to the inputs "V/kOhm-HI-LO" and "Ohm-Source-HI-LO". When connecting-up, make sure that the polarity of the measuring lines and current source is "HI-HI" and "LO-LO".

The temperature measurement is based on a four-wire resistance measurement with an excitation current of about 100 µA. The resistance reading is linearized (conforming to DIN IEC 751) and then converted by calculation to the corresponding readout value in degrees Centigrade (Celsius), degrees Fahrenheit or Kelvin. The instructions for four-wire resistance measurements given in Section 6.2. and Fig. 6.2.2 apply here too for connecting the measuring leads and the shield.

Offset Correction and Sensor Compensation

Just as for the other measuring functions, an offset correction can be made for the temperature measurement too. Because of the subsequent conversion by calculation and linearization, the procedure for temperature offset correction differs slightly from the procedures for the other functions: A short circuit is placed on the "V/kOhm" inputs. The multimeter thereupon reports an overflow condition as "ERROR 1". The offset correction is started ("ZERO"). When the offset correction is finished, the message "donE" appears in the display.

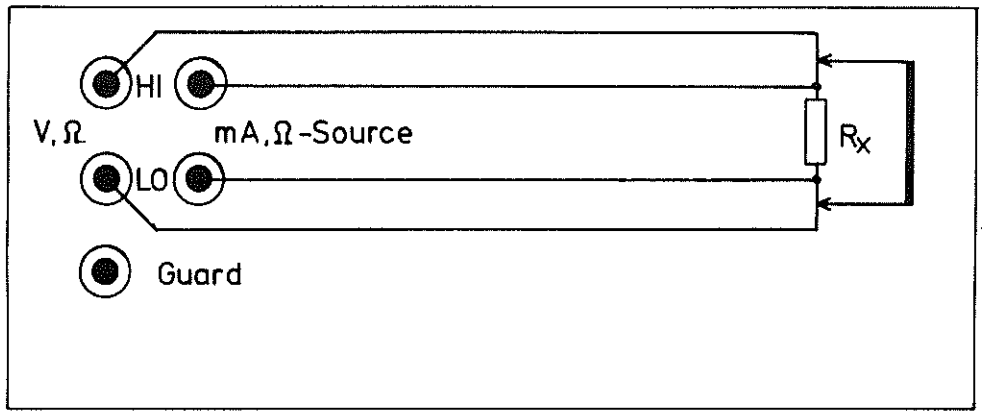


Fig. 6.5.1 Offset correction circuitry

After having carried out the offset correction, the sensor compensation can be made at an exactly known temperature with the aid of a precisely known reference resistor. The compensation is made by calibrating onto this exactly known value (see "calibration").

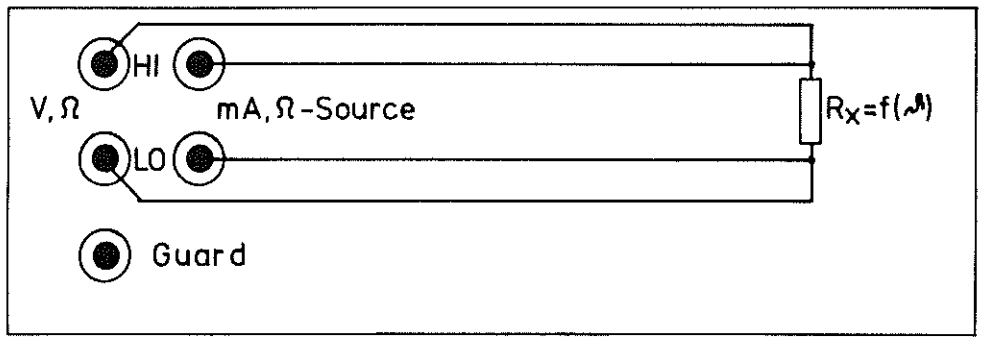
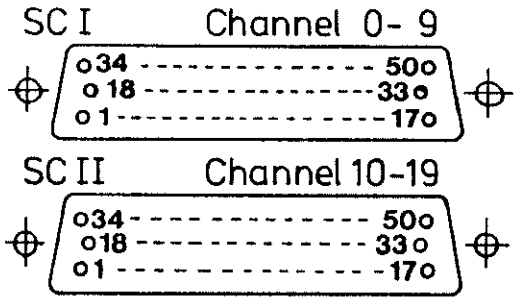


Fig. 6.5.2. Sensor alignment for RTD (PT 100 resistor)

6.6 Operating Instructions for Scanner/Multiplexer (Option 6031/01)

The digital multimeter can be equipped optionally with a low thermoelectric emf 20-channel 4-pole scanner (measuring points selector switch or multiplexer). The maximum allowed voltage at the "V/kOhm" input and at the 50-pole subminiature D sockets is then 125 Vdc or peak, with the further restriction that the slew rate must not exceed 1V per microsecond. These restrictions still hold when all channels are switched off.

The scanner is of type 1 from 20, i.e. only any one channel at a time can be connected through to the digital multimeter. The inputs are grouped on two 50-pole subminiature type D sockets which are mounted on the rear side of the instrument. The four output lines of the multiplexer are connected inside the instrument to the multimeter inputs "V/kOhm" and "A". The front panel sockets are switched off when one of the measuring channels 1-20 is switched on. When the front panel sockets are connected, none of the measuring channels 1-20 is connected to the "V/kOhm" and "A" inputs of the multimeter. On power-up of the digital multimeter, the front panel sockets are connected and the measuring channels are switched off. Each multiplexer signal line is individually shielded. All the shields are connected to the "Guard" socket on the front panel and to pin 1 of each subminiature type D socket. The pinout of these sockets is shown in Fig. 6.6.1. Adapter cards with sets of screw terminals for the multiplexer input connections are vailable for plugging onto the subminiature sockets.



CONTACTS	V/kOhm-2		mA/kOhm-4		SC
	Lo	Hi	Lo	Hi	
0	49	50	47	48	I
1	33	32	17	16	I
2	31	30	15	14	I
3	29	28	13	12	I
4	27	26	11	10	I
5	25	24	9	8	I
6	23	22	7	6	I
7	21	20	5	4	I
8	19	18	3	2	I
9	34	35	36	37	I
10	49	50	47	48	II
11	33	32	17	16	II
12	31	30	15	14	II
13	29	28	13	12	II
14	27	26	11	10	II
15	25	24	9	8	II
16	23	22	7	6	II
17	21	20	5	4	II
18	19	18	3	2	II
19	34	35	36	37	II

Fig. 6.6.1. Pin configuration of the 20 channel input connector

7. Manual Control Procedure

Manual control of all functions of the instrument is carried out via the two-field keyboard, in conjunction with the four display sections. Some of the functions of the instrument can be selected directly with a single keypress (measuring function, range, autoranging, offset correction). Second level functions are selected by first pressing the "2nd" key and then pressing the key corresponding to the desired blue-legend second level function. Instrument presettings and data entries are made by selecting the corresponding operating mode and then making the numerical entry on the data input field of the keyboard. All data entries must be terminated by pressing the "ENTER" key.

7.1. Selecting a Function of the Instrument

The functions of the measuring instrument are selected by pressing the following keys:

Direct voltage measurement	Vdc
Alternating voltage measurement without direct voltage component	Vac
Alternating voltage measurement with direct voltage component	Vac Vdc
Vdc must be pressed within 1 second after pressing Vac	
Resistance measurement (two-wire circuit)	kOhm/2
Resistance measurement (four-wire circuit)	2nd kOhm/4
Direct current measurement	2nd mAdc
Alternating current measurement, always with direct current component	2nd mAac
Temperature measurement with selected scale (^{o}C, ^{o}F, K)	2nd TEMP
Temperature measurement, change scale	2nd TEMP
The keystroke sequence 2nd TEMP must be repeated as many times as necessary to bring the desired temperature scale into the display.	

Example: Four-wire resistance measurement

Press the "2nd" key, then the key "kOhm/4". The light emitting diodes in the keys are lit to indicate the selected function. A new measured value appears in the display after elapse of the measuring time, or an error message if an error has ocurred.

7.2. Selecting a Measuring Range

A measuring range can be selected in fixed manner or the instrument can select the measuring range automatically. Range selection is made by pressing the following keys:

RANGE/FUNCTION		KEY
Autoranging switch-on/switch-off		AUTO
Range	0.2 Vdc, 0.2 kOhm	0.2
Range	2 Vdc, Vac, 2 kOhm	2
Range	20 Vdc, Vac, 20 kOhm	20
Range	200 Vdc, Vac, 200 kOhm	200
Range	1000 Vdc, 700 Vac, 2 MOhm	2000
Range	20 MOhm	20000

The light emitting diode in the key corresponding to the selected range is lit. The light emitting diode in the "AUTO" key is lit too when autoranging is switched-on.
On attempting to select a measuring range which does not exist for the selected measuring function, the instrument switches to the nearest existing measuring range. Autoranging is switched off whenever a fixed range is selected.

Example: Range switchover for alternating voltage measurement

You desire to switch over from the 200 Vac range to the 0.2 Vac range. Autoranging is switched off. Press the "0.2" key. The instrument switches over to the 2 Vac measuring range, because a 0.2 Vac range does not exist.

7.3. Selecting an Integration Time

An integration time is selected by pressing a red-legend key after first pressing the "ENTER" key. The chosen integration time appears in the integration time display field. For times longer than 2 seconds, this display counts down in seconds.

Integration Time	Display	Keys
20msec (16.7msec/60Hz)	.02	ENTER 20ms
40msec (33.3msec/60Hz)	.04	ENTER 40ms
100msec	01	ENTER 0.1s
200msec	02	ENTER 0.2s
400msec	04	ENTER 0.4s
1 sec	1	ENTER 1s
2 sec	2	ENTER 2s
4 sec	4	ENTER 4s
10 sec	10	ENTER 10s
20 sec	20	ENTER 20s

The measurement result is displayed with 4 1/2 to 6 1/2 digits resolution, depending on the chosen integration time. If you attempt to select an integration time which does not exist for the selected measuring function, then the nearest existing integration time for this function is switched-on.

Example: Integration time 10sec for direct voltage measurement Vdc

Press the "ENTER" key, then 10sec. "10" appears in the integration time display. After elapse of one second the display starts to count down 9, 8, 7,... until a measurement result appears. The next measurement then starts.

7.Digital Filter

A further 20dB of disturbance rejection can be obtained with the digital filter which carries out a gliding determination of the average of the 10 most recent measured values.

The filter is switched on and off by pressing the "FILTER" key.

The built-in light emitting diode is lit when the filter is switched on.

7.5. Offset Correction

An offset compensation can be made as described under "Operating Instructions" after establishing the measuring circuit input connections.

For offset correction of a single measuring range: ZERO

For offset correction of all ranges of a function: AUTO ZERO

Between pressing the ZERO key and pressing the AUTO key, you should wait for completion of at least one measurement. After automatic offset correction, autoranging remains switched on until a fixed measuring range is selected or until autoranging is switched off. The offset correction procedure takes different lengths of time, depending on the function, range and integration time. Whilst offset correction is being made, the remaining time is counted down in the integration time display. The message "null" appears in the main display during this time. When offset correction is made in autoranging mode, all ranges of the selected measuring function are corrected in this manner successively.

7.6. Continuous Measurements and Start Mode

Measurements can be made with the digital multimeter in the "measure" or in the "compute" operating mode. These operating modes are selected respectively by pressing the "MEAS" key or the keys "2nd COMP". In both operating modes, measurements can be made continuously or in start mode.

7.6.1. Display of the Measurement Result

The measurement result is displayed directly when the "measure" mode has been selected by pressing the "MEAS" key. When making continuous measurements, each new measurement is automatically written into the display after expiry of its integration time. If the value for the constant "CT" differs from "0" then a single measurement is made in response to each start and the result is written to the display. This result remains in the display until a new measurement is started by pressing the "MEAS" key.

7.6.2. Display of the Calculation Result

The calculation result is displayed when compute mode has been selected by pressing the keys "2nd COMP". In continuous measuring mode, the new calculation result is automatically written to the display after elapse of the set integration time and completion of the selected calculation program. If a value differing from "0" has been set for the constant "CT", then the corresponding number of measurements is made and the calculation result is written to the display after each measurement. The last result then remains in the display until a new measuring sequence is started by pressing the keys "2nd COMP" again.

7.6.3. The Number of Measurements in Start Mode

The number of measurements which are to be made successively in start mode is specified by the value to which the constant "CT" is set. Any desired integer value within the numerical range which is valid for constants can be entered for CT. No sign is taken into consideration. If non-integer values are entered, only the integer digits before the decimal point are accepted. To enter a value for CT, press the keys "2nd ENTER" and then enter the value on the data input keyboard in just the same way as for any other constant. "ct" appears in the constant number display after pressing "2nd ENTER". Terminate the entry by pressing the "ENTER" key. The constant CT must be cleared (clear constant command) or the value "0" must be entered for the constant CT, in order to make measurements in continuous mode.

7.7. Making Data Entries via the Keyboard

All data entries are made on the left keyboard field after selecting the corresponding data entry program. Data entries are necessary to select a program number, to select a constant number, to specifiy the number of measurements to be made in response to each start in start mode, to enter a value for a constant, to set the IEEE bus device address, to select a measuring channel, to set the parameters for measuring channel switching and for calibrating measuring ranges.

The data entry programs are selected with the following keystroke sequences:

Constant number entry, where x is the single digit number designating the desired constant (x = 0, ... , 9)	CONST x ENTER
Entry of the value for the constant	..... ENTER
Program number entry, where xx is the two-digit number of the desired program (xx = 00, ... , 99)	2nd PRG xx ENTER
To specify the number of measurements in start mode	2nd ENTER ... ENTER
To set the IEEE bus device address	2nd IEEE ... ENTER
To select a measuring channel, where xx is the two-digit number of the desired measuring channel (xx = 00, ... , 19)	CHA xx
To set parameters for the measuring points switching	2nd PRG xx ENTER

xx = 50	Interval time	TI
xx = 51	Delay time	TD
xx = 52	Switch-on duration	TO

To enter a calibration value (possible only when the calibration switch is open)	2nd PRG 99 ENTER
	..... ENTER

The keystroke sequence which is designated by ..... means that the manual operating procedure is identical to that specified in the section headed "constant value entry" (Section 7.8.2.). The keystrokes which are shown as ..... may be data value digits, cursor functions or other functions of the particular data entry program.

7.8. Using Calculation Programs

To display the result of a calculation instead of the measurement result, enter the program number "xx" for the desired calculation, taken from the table of available calculation functions. Before selecting the program, or after selecting the program but before starting it, the values for any of the constants C0 to C9 which are required by the calculation must be entered. If the program is to operate in start mode, then a value must be entered for the constant CT too.

7.8.1. Entering the Program Number

Enter the program number with the keystroke sequence "2nd PRG xx ENTER". The calculation result is displayed after pressing the keys "2nd COMP". If calculation programs are used for which the calculation time exceeds the set integration time, then new measurement results are taken into account only after elapse of the calculation time. Some measurements are lost in such cases, e.g. for continuous averaging.

7.8.2. Entering Constants

The value for a constant can be entered after selecting the constant number with the keystroke sequence "CONST x". Each press of a numerical key 0-9 then brings the corresponding constant number "Cx" into the constant number display. The present value of the corresponding constant appears in the main display. The constant entry procedure can be terminated by pressing the right arrow key. To take over the last measured value into the just selected constant, press the left arrow key ("MEAS"). This also terminates the constant entry procedure.

When the "ENTER" key is pressed after having selected a constant, e.g. after the keystroke sequence "CONST", "8", "ENTER" for the constant C8, a flashing cursor position appears in the main display. This cursor position can be moved right or left over the display by pressing the arrow keys. On attempting to move the cursor beyond the left end of the display, the constant is cleared and the display then reads "+--------". The cursor can not be moved to the right beyond an empty digit position "-". Numerical entries are always made from the flashing cursor position moving to the right. The sign can be changed at any stage. When a decimal point is entered, it always appears in the display position in front of the cursor position. Any formerly entered decimal point is cancelled. To delete a decimal point from a number without entering a new decimal point, press the right arrow key when the cursor is standing on the extreme right of the display. Terminate the entry of a numerical value for a constant by pressing the "ENTER" key.

7.9. Setting the Scanner

The keyboard can be used to switch individual channels as well as for manual control of the automatic channel scanning sequence. The currently switched-on channel is always shown in the channel number display at the bottom right.

7.9.1. Selecting a Measuring Channel

After pressing the "CHA" key, the bottom segment of the front digit of the channel number display flashes. The numerical range of this front digit is limited to "0" or "1". After entering 0 or 1, the cursor moves to the rear digit. Any value in the range 0 to 9 can be entered here. Terminate the channel number entry by pressing the "ENTER" key. This connects the selected channel. To disconnect a channel setting, enter a decimal point instead of a digit. Immediately after entering the decimal point, the last selected channel is disconnected and the channel setting program is terminated.

7.9.2. Setting the Automatic Channel Scanning

To carry out automatic channel scanning, the following values must be set on the digital multimeter: Enter the desired preset values for TI, TD and TO using the programs 50, 51 and 52. For this purpose, select the respective program with "2nd PRG 5 x ENTER" and prepare for making the entry by pressing "2nd COMP". The present value for the respective time then stands in the display and can be modified with the arrow keys and numerical entry keys. When the desired time is standing in the display, store it by pressing "ENTER". Use program 53 to select the channels which are to participate in the scan cycles. Channel selection is ready after pressing "2nd PRG 53 ENTER" and "2nd COMP". The channel number display flashes with the digit "0" and the integration time display shows the present status of channel "0" as "CL" for selected (closed) or "OP" for not selected (open). The main display is switched off. A cyclic run through the channel numbers in the channel number display can be started by pressing the cursor keys. The right arrow key starts a count-upwards run, the left arrow key starts a count-downwards run. Pressing either key again stops the run. Any channel can be selected or deselected during such runs. Each press of the "CHA" key changes the preset status from "OP" to "CL" or from "CL" to "OP". When the desired status has been selected for all channels, terminate the setting program by pressing "ENTER".

7.9.3. Operating Automatic Scanner

Use program 54 to start and stop the automatic scanner. After selecting program 54 with the keystroke sequence "2nd PRG 54 ENTER", the channel switching sequence (scan cycle) can be switched on and off with "2nd COMP". When the channel scan function is switched on, the program number display reads "r" (run). When the scan function is switched off, the program number display reads 54 again. The currently switched-on channel is shown in the channel number display. At the end of each measurement, the obtained result is written to the main display. All channels are switched off on completion of a scan cycle. The channel switching always takes place such that the channels marked with "CL" during channel preselection (program 53) are switched-on in ascending numerical sequence 00,...,19. Deselected channels, i.e. those which are marked "OP", are skipped. Elapse of the trigger delay time (program 51) is awaited after channel switch-on. The measurement then starts with the set integration time. The sum of the integration time and the trigger delay time must be less than the switch-on duration (program 52) of the channel. At the end of the switch-on time, the channel is switched off and a new channel is switched on. After elapse of the interval time (program 50) a new cycle starts again.

7.10. Self-Test

The self-test is carried out automatically every time that the multimeter is switched on, and at any other desired time by call. To call the self-test, select program 98 with the keystroke sequence "2nd PRG 98 ENTER". The self-test routine then starts on pressing "2nd COMP". At the end of this routine, the settings of the instrument are the same as after switch-on and automatic self-test.

7.11. Calibration

Use the program 99 to calibrate a measuring range via the keyboard. Program 99 will function only when the "CAL, MEAS" switch is set to "CAL" (otherwise ERROR 5 appears in the display on attempting to run program 99). To calibrate a measuring range, first correct the zero point as described under "offset correction". Then start program 99 with "2nd COMP". The program waits for entry of a nominal value. The corresponding signal must be connected to the measuring inputs. After entering the nominal value, start the calibration procedure by pressing "ENTER". Whilst calibration is being carried out, "CAL" remains in the display and the integration time display counts down from "10" seconds to "0". After successful calibration, the new measured value appears in the display. In the case of operating or measuring error, ERROR 5 appears in the display.

7.12. IEEE Bus Address Setting

After pressing the keys "2nd IEEE", the IEEE bus address and the terminating character sequence can be enetered on the data input keyboard field (see IEEE bus interface, Section 8.1.4). To set the "TALK ONLY" operating mode, clear the device address (the front pair of digits). For this purpose, press the decimal point key "." . Hyphens then appear in the display in place of these digits.

7.13. Switchover to Manual Mode

When the digital multimeter is operated on the IEEE bus, manual control via the keyboard is disabled until the computer sends "GTL" (go to local) or the REN-line (remote enable) goes inactive. However, the operator can cancel the remote control status by pressing the keys "2nd LOCAL" to switch the instrument to manual control mode. "2nd LOCAL" functions only as long as the computer does not prevent manual control mode with "LLO" (local lock out).

8. IEEE Bus Interface

All functions are accessible via the keyboard and via the IEEE bus interface. The only exception hereto is setting of the device address and terminating character sequence, which can be set only via the keyboard.

8.1. Operation on the IEEE Bus

The keyboard is disabled for manual control of the functions of the instrument as soon as the first command has been received via the IEEE bus interface. Thereafter, manual control via the keyboard is possible again only when the computer enables the keyboard (command "GTL") or when the "REN" line goes to the inactive state and thus cancels the remote control status of the instrument. The "REMOTE" segment is lit in the right window of the main display in remote control status.

The instrument understands up to 30 characters within a command message. All characters are ASCII characters (ISO 7 bit code). Several commands may be combined in a command message character string (e.g. "VDR5A1"), but some commands must be sent alone.

Blanks (SPACE, ASCII Code 20 H) contained in the character string sent by the computer are ignored. If the character string contains more than 30 characters, then the message "ERROR 6" is output. This will be the case, for example, if the terminator is set incorrectly.
The instrument can receive commands (operation as LISTENER) and it can output device messages reporting its status (operation as TALKER).

The time instant at which the instrument outputs messages can be defined by the computer. One possibility is to let the computer address the instrument as TALKER to read the device message. The second possibility is to operate the instrument in SRQ mode. The instrument then requests attention from the computer when a status change has taken place. Switchover to SRQ mode is possible by command. The basic setting after switch-on is operation without SRQ.

8.1.1. Capabilities of the IEEE Bus Interface

The IEEE bus computer interface has the following capabilities conforming to the IEEE 488 standard:

SH 1	Handshake source function
AH 1	Handshake sink function
T6	TALKER function
L3	Listener function
RL1	Remote control
DC1	Reset function
DT1	Originate function
SR1	Service request function

8.1.2. Interface Functions

The instrument understands the global commands DCL, SPE and SPD. The command DCL sets the instrument to its basic state (Vdc, 1000V). The addressed commands GET, GTL, LLO and SDC are understood.

The commands have the following effects:

DCL	Device Clear	Vdc, 1000V, scanner off, long string
SDC	Selected Device Clear	Vdc, 1000V, scanner off, long string
GTL	Go To Local	Remote control is cancelled
LLO	Local Lock Out	The instrument can not be switched to manual control at the keyboard
SPE	Serial Poll Enable	Prepare for serial polling
SPD	Serial Poll Disable	Terminate serial polling
GET	Group Execute Trigger	Start the addressed instruments

8.1.3 Setting the DMM for Operation on the IEEE Bus

In order to be able to operate the instrument on a computer with IEEE bus interface, some more conditions must be fulfilled apart from the existence of the interface and the correct link-up cable.
The following settings must be made so that the computer and the instrument can understand each other:

A device address must be assigned to the instrument, so that the computer can access the instrument via this address. The IEEE 488 standard allows the address numbers 00-30 for accessing devices selectively. For proper data exchange between the computer and the instrument, the character sequence for terminating a data transmission between the two units must be agreed.
This character sequence generally differs from one computer to another. Thus a terminating character sequence agreement is required. Please consult the manual for your computer or for the IEEE bus interface of the computer to determine the particular terminator sequence used by your computer.

The instrument provides a choice of 9 terminator character sequences according to the following table. Make your selection according to the specification by the computer manufacturer. Select the corresponding designation number.

Designation Number	Terminator Sequence	Typical Computer
0	CR + EOI line	Apple
1	CR	
2	LF + EOI line	
3	LF	
4	CR + LF + EOI line	
5	CR + LF	HP
6	LF + CR + EOI line	
7	LF + CR	
8	EOI line	Commodore

8.1.4. Setting the Device Address and the Terminator Sequence

The device address and the terminator sequence for operation on the IEEE bus must be set via the keyboard.

For example, suppose you wish to operate the instrument on an Apple computer with CCS interface, then the terminator sequence CR + EOI line must be chosen. 17 is to be assigned as device address, for example. The terminator sequence CR + EOI line has the designation number 0 in the table given above.

Press the "2nd" key, then "IEEE" (blue legend). "IEEE.07.8", for example, appears in the display, indicating that the instrument is at present set to address 7 and terminator sequence 8 (EOI line only).
The front digit of "07" is flashing in the display, indicating that the device address may now be changed. For the example stated above, the setting must be changed to "IEEE.17.0".

Press the "1" key on the data input keyboard field. The display then reads "IEEE.17.8". The digit "7" is now flashing. Press the CURSOR key to move on the flashing digit to the right, to the value for the terminator sequence. Enter the digit value "0".
The display now reads the wanted complete setting "IEEE.17.0". Store this setting by pressing the ENTER key. To make the address non-volatile after switch-off, set the calibration switch to "CAL" before pressing the ENTER key. Do not forget to return the calibration switch to the "MEAS" setting (see Section 4.6.) immediately after pressing the ENTER key.

8.2. Operating the Digital Multimeter

To prepare the instrument for receiving commands, it must be addressed as LISTENER. The instructions for doing this are contained in the computer manual. The "LISTEN" segment in the right window of the main display is lit when the multimeter has been addressed as LISTENER.

The instrument understands the following commands:

"MR" The measurement result is selected. It appears in the display of the digital multimeter and in the character string of the TALKER function.

"CR" The calculation result of the selected program appears in the display of the digital multimeter and in the character string of the TALKER function.

"Cx" The digital multimeter expects a constant number after "C". For example, when "C5" is entered, the value of the constant No.5 appears in the main display of the digital multimeter and "C5" appears in the right bottom auxiliary display. The digital multimeter expects the new numerical value for the constant in the next characters of the command string. If no new value is to be entered or if the entry is to be terminated, then measurement result "MR", calculation result "CR", program number "PXX" or measuring time "TX" must always be sent last (even if transmission of the device message was interrupted).
Constants can be input as floating point number with mantissa and exponent.
The mantissa may consist of up to 8 digits. The decimal point may stand anywhere in the mantissa. The sign can be changed at any stage. The exponent is designated with "E". Its value must not be longer than one digit or greater than 7. Its sign must be changed, if desired, before the exponent. If no sign is input for the exponent, then positive sign is assumed.
Example: The value +300.581 for constant 5 can be input as C5300.581 or as C5+300.581E0 or as C53.00581E2.

"CT" "CT" sets the number of measurements which will be made after a start command in start mode (valid for computional mode "CR" only)

"VD" Sets the digital multimeter to the "direct voltage" measuring function.

"VA" Selects the "alternating voltage" measuring function. The true rms value of the alternating voltage is measured without (ignoring) any superimposed direct voltage component.

"VC" This sets the digital multimeter to measure the true rms value of the alternating voltage "with" superimposed direct voltage component.

"O2" Selects the resistance measuring function in 2-wire circuit.

"O4" Selects the resistance measuring function in 4-wire circuit.

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

"IA" Selects the "alternating current" measuring function. The true rms value of the alternating current with superimposed direct current component is measured.

"TC" Selects temperature measurement (PT100-4-wire), display in °C

"TF" Selects temperature measurement (PT100-4-wire), display in °F

"TK" Selects temperature measurement (PT100-4-wire), display in K

"Pxx" The digital multimeter expects a program number after "P". All program numbers must be input with two digits, e.g. "P06" for program No.6. To terminate the input, always send one of the following (even if transmission of the device message was interrupted): Measurement result "MR", calculation result "CR", constant number "CX" or measuring time "TX", e.g. "P06T5".

"AO" (A/zero) switches autoranging off.

"A1" Switches autoranging on.

"Rx" Selects the measuring range; x stands for the designation number of the desired range. Bear in mind that some ranges can be selected only in conjunction with the corresponding measuring function, e.g. R6 only for kOhm.

"Tx" Sets the integration time and the number of digits shown in the display.

"DO" (D/zero) switches off display mode.

"D1" Switches on display mode. A text sent after "D1", e.g. "D1RUN", is written to the display of the multimeter. The internal display is switched off.

"FO" (F/zero) switches off the auxiliary filter.

"F1" Switches on the auxiliary filter. The filter can not be switched on or off when a program or constant number is currently called-up. The message "CF1" is interpreted as call-up of the constant 1.

"Q0" (Q/zero) switches the multimeter such that no SRQ is sent.

"Q1" Switches the multimeter such that a SRQ is sent when:
- a new measurement result has come
- an error message has appeared
- a reset has taken place
- an off-limit status has appeared

"Q2" The multimeter is switched such that it sends a SRQ after making the preset number of measurements in start mode (valid for computional mode "CR" only).

"S0" (S/zero) starts the continuous measuring sequence.

"S1" Switches over to start mode; each S1 command starts a measurement. For both commands, the delay until start of the measurement may be up to 10 ms.

"L0" (L/zero) short format. The multimeter outputs only the first message section (measurement data and text message).

"L1" Long format. The multimeter outputs both message sections (measurement data/text messages and programming data).

"Z0" Starts an offset correction in the desired range. If auto-ranging "A1" is selected the offset is adjusted in all ranges of the function.

"Mxx" Selects a scanner channel. "MOF" switches off the scanner; "M00-M19" selects the respective scanner channel.
Selecting a scanner channel automatically disconnects the front panel input sockets from the multimeter input (effective only when the multimeter is fitted with the scanner).

"MOF" Reconnects the front panel sockets to the multimeter input (effective only when the digital multimeter is equipped with the scanner). The previously connected scanner channel is disconnected.

"CAxx...zzON" determines channels, which are selected for the automatic scan cycle (channel preselection)
"CAxx...zzOF" determines channels, which are skipped from automatic scan cycle

"TIxxxx" contains the value of the interval time of one scan cycle. The time is xxxx times 1 min.

"TOxxxx" contains the value of the channel switch on time. The time is xxxx times 100 msec.

"TDxxxx" contains the value of the trigger delay time. The time is xxxx times 100 msec.

"P54CR" starts automatic scan operation
"P54CR" stops automatic scan operation

"NVxxxxxxxx" After NV the multimeter expects an 8-digit unsigned integer decimal number as nominal value for calibration via the IEEE 488 bus (Exception Temperature: "NV+xxxxxxx" or "NV-xxxxxxx"). Transmission of a nominal value must be made alone, i.e. no other command listed above may be contained in the same string. The digital multimeter starts the calibration measurement after transmission of the nominal value.

END Terminator sequence, as selected when setting the device address. With the terminator No.8, the EOI signal is output coincident with the last character.

8.2.1. Description of the Commands accepted by the Instrument

VD	Direct voltage
VA	Alternating voltage
VC	Alternating voltage with DC coupling
O2	Resistance measurement, 2-wire circuit (Ohm 2-wire)
O4	Resistance measurement, 4-wire circuit (Ohm 4-wire)
ID	Direct current
IA	Alternating current
TC	Temperature measurement with PT 100, in ^{o}C
TK	Temperature measurement with PT 100, in Kelvin
TF	Temperature measurement with PT 100, in ^{o}F
Pxx	Selects a mathematics program, xx=00,...,99
PxxCR	Operation of the selected program

R1	Range	0.2	Vdc, Vac,	0.2	kOhm, ...	....	^{o}C, ^{o}F, K
R2	Range	2	Vdc, Vac	2	kOhm, ...	....	
R3	Range	20	Vdc, Vac	20	kOhm, ...	....	
R4	Range	200	Vdc, Vac	200	kOhm, ...	....	
R5	Range	1000	Vdc, Vac,	2000	kOhm, mAdc, mAac		
R6	Range	.....	..., ...,	20000	kOhm, ...	....	

Ax	x=0	Autoranging off
	x=1	Autoranging on

Tx	x=0	Integration time	20msec	Display	4 1/2 digits
	x=1	"	40msec	"	4 1/2 digits
	x=2	"	100msec	"	5 1/2 digits
	x=3	"	200msec	"	5 1/2 digits
	x=4	"	400msec	"	5 1/2 digits
	x=5	"	1sec	"	6 1/2 digits
	x=6	"	2sec	"	6 1/2 digits
	x=7	"	4sec	"	6 1/2 digits
	x=8	"	10sec	"	6 1/2 digits
	x=9	"	20sec	"	6 1/2 digits

Sx	x=0	Continuous measurements	
	x=1	Start mode, start by S1, Trigger or GET	2)
Fx	x=0	Digital filter switched off	
	x=1	Digital filter switched on	
Lx	x=0	Short string output (only measured value)	3)
	x=1	Long string output (measured value and status)	3)
Qx	x=0	switch-off SRQ mode	3)
	x=1	switch-on SRQ mode, SRQ after every measurement	3)
	x=2	switch-on SRQ mode, SRQ after making "ct" measurements	3)
Dx	x=0	switch-off display mode	3)
	x=1	switch-on display mode	3)

D1text The text entered as string is shown on the main display 2),3)

CTxxxxxxxx Preset of xxxxxxxx measurements for start mode 2)

CY Select constant number Y 2)

CYxxxxxxxx Select constant number Y and assign value xxxxxxxx to it 2)

Mxx Switch-on scanner channel xx, switch-off front panel sockets

MOF Switch-off scanner channels, switch-on front panel sockets

ZO Zero, offset correction 2)

NVxxxxxxxx Nominal value xxxxxxxx for calibration 2)

NV±xxxxxxx alignment for platinum resistance sensor

Automatic scan operation

CAxx...yy...zzON Channel preselection for channels xx to zz (switch-on) 1)

CAxx...yy...zzOF Channel preselection for channels xx to zz (switch-off) 1)

TDxxxx Set trigger delay time xxxx * 100msec 2)

TOxxxx Set channel switch-on duration xxxx * 100msec 2)

TIxxxx Set interval time xxxx * 1min 2)

P54 CR Start automatic scan of channels 2)

CR Stop automatic scan of channels 2)

1) Only switch-on or only switch-off allowed within each command string
2) These commands must be sent alone or at the end of a command string
3) See notes on next page

When operating the instrument on the IEEE bus, there are three functions which can be set only via the IEEE interface.
This is done using the commands Q0, Q1, D0, D1, L0 and L1.

Description of the functions:		
	Display mode	D0, D1
	Select string length	L0, L1
	SRQ mode	Q0, Q1, Q2

8.2.2. Display Mode

In display mode the computer can output text to the display of the instrument, independently of the other functions of the instrument. The command "D1" switches display mode on. The ASCII characters which follow directly thereafter are written to the display as text. All ASCII characters for which a segment code is defined according to the ASCII segment table (Fig. 8.1) can be displayed. All other characters produce a blank character position. All surplus characters after "D1" and the displayable number of characters are ignored. If "D1text" is sent together with other commands in a single character string, then "D1text" must be the last command in the character string. "D0" switches display mode off again. The display associated with the present operating mode then appears again.

The characters and character combinations must be interpreted according to the following table.

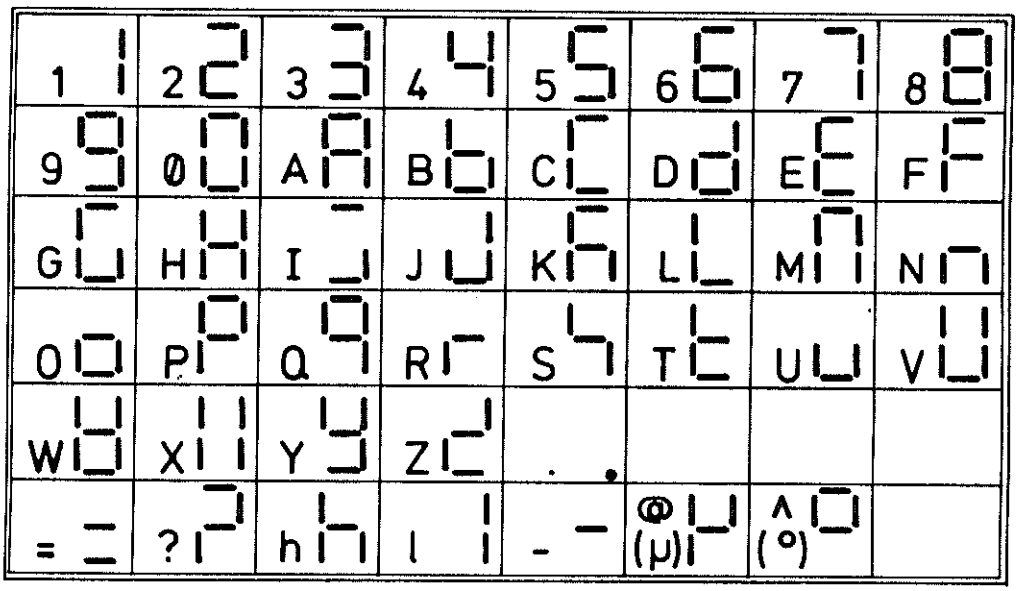


Fig.8.1 Display code table ASCII SEGMENT CODE

8.2.3. String Length Selection

The digital multimeter can send different length messages to the computer. The computer selects the length of the desired string with "L0" or "L1". When the computer sends the command "L0", then the most recent measurement result is output. The status information is not output with "L0". After "L1", the instrument sends the most recent measurement result and the status information to the computer.

8.2.4. SRQ Mode

If it is desired that the digital multimeter shall request service from the computer when a status change has taken place, instead of being continually interrogated by the computer, then SRQ (service request) mode can be switched-on for this purpose with the command "Q1" or "Q2". A SRQ is then sent to the computer, for example, when a key has been pressed on the keyboard, when an error message has appeared or when a reset has been initiated. Use of SRQ mode requires that the connected computer is able to recognize a SRQ and reply thereto with "Serial Poll" (see computer manual). When SRQ mode is switched-on with "Q1" a SRQ is output after each measuring or calculation result, whereas with "Q2" a SRQ is sent out only after completion of the last one of the number of single measurements which have been preset for start mode.

8.3. Operating the Digital Multimeter as TALKER

After request by the computer, the instrument sends a message containing the present status data and the most recent measured value. For this purpose, the instrument must be addressed as TALKER by the computer. For how to do this, please consult the computer manual. When the instrument has been addressed as TALKER, the message "TALK" is lit in the right window of the main display.

The transmitted message consists of a character string. Each character string ends with the agreed terminator sequence with which the computer recognizes the end of the string (end of the message). The message consists of two parts. The first part contains the most recent measurement or calculation result. The second part contains the programmed status information. Both parts are tranmsmitted together as one string. If transmission of the message string is discontinued before the terminator has been transmitted (before the TIDS (talker idle state) is reached), then the transmission restarts with the first character of the message string in response to the next call-up. The terminator is the sequence selected with the IEEE setting program. ASCII code (ISO 7-bit) is used to transmit the message string.

The length of the two parts of the message string is fixed at 27 characters plus the terminator. The length of the first part of the message is 13 characters for output of measurement and calculation results.

If the short string is requested as output (command "LO"), only the first message part is sent. The status information (second message part) is not sent.

Differences in Continuous and Triggered Measuring modes

Continuous Measuring mode: The DMM allowes the reading of measurement results at any time but only once. After reading of the result the selected integration time must complete to get the next result. This means, if i.e. 4sec integration time are selected, only in 4sec intervals new readings are accessible.
If you use a computer or interface timeout function you should bear this in mind to choose the time long enough.

Triggered Measuring mode: After a "S1" command the multimeter starts a measurement and returns the result after completion of the integration time. Only one single measurement is executed. If you try to read a measurement result but you didn't start it by trigger command "S1" then a "NO VALUE " message appears to point to the missing trigger command.

8.3.1. Description of the Transmitted Message String

The following table gives an overview of the possible lengths of the message string depending on the selected operating mode.
A message string consists of one (short string format) or of two (long string format) message parts, followed by a terminator. The second message part is called the status information. The length of a message string is determined by the operating mode. It is:

a) for measuring and calculation mode

40 (13) characters + terminator

Example: "+01.298764E+0MRVDP00AOR2F0T1D0S0Q0M0FB00" + Terminator
"+01.298764E+0" + terminator

b) Automatic scan cycle

40 (18) characters + terminator

Example: "+01.298764E+0MRVDP54AOR2F0T2D0S0Q0M02B00" + terminator
"+01.298764E+0R2M02" + terminator

In "TALK ONLY" mode the DMM always use the second string type, containing 18 characters.

c) for error and text messages

40 (13) characters + terminator

Example: "ERROR.01.....MR04P00A1R6F0T2D0S0Q0M0FB00" + Terminator
"ERROR.01 " + terminator

The numbers in brackets (..) are the number of characters in short string format.

8.3.2. Description of the Transmitted Message Blocks

The transmitted characters have the following meaning, depending on the selected operating mode:

Operating mode measure or compute

The read-out string has the following form, for example:

"+1.3201987E-1MRVDP00AOR1F0T1D0S0Q0M0FB00" + Terminator

The string contains the most recent measured value or the most recent calculation result together with the status information. Numerical values or test messages may stand in the 1st message block. This block consists of 13 characters. These may be measurement and calculation

results or values of constants (all right justified) or text messages from the main display field (all left justified). For calculation results, values of constants or signed measured values, the first character is always the sign "+,-". For unsigned measured values (kOhm, Vac, Iac), all numbers are output without sign and with the leading digits filled with "0". Numbers are output in exponent form, e.g. :

"+01.98265E-1".

Text messages are "ERROR x", "null ", "DONE ", "Contr. x", "CAL ", "HI ", "LO ", "NO VALUE"

Unused character positions are filled with blanks.

The second message block (status information) begins with the 14th character.

8.3.3. Interrogation of the Keyboard via the IEEE Bus

In remote control status (Remote), the instrument does not perform the corresponding function when a key is pressed but, instead, places the numerical code for the last pressed key into the device message string.

This information can be used by the computer to make the instrument operate as command unit in remotely controlled test systems. The keypresses can be used to send requests for specific programs to the computer.

B01	B02	B03	B04	B05	B06
B07	B08	B09	B10	B11	B12
B13	B14	B15	B16	B17	B18

Fig. 8.3.1 The key codes for keyboard interrogation

After each keypress, the IEEE output buffer is updated with the new key code.The key code is set to "B00" when the message has been read by the computer. If the SERVICE REQUEST function is enabled, each key-press produces a SRQ.

8.3.4. Table of Device Messages sent by the Multimeter

The device message contains the following characters to designate the status or settings of the instrument:

```
(----------)(------------------------)
1st message        2nd message
   block              block

1st char.   14th char.                  40th char. + terminator
!            !                           !
+.xxxxxxxxE+xMRVDPxxAxRxFxTxDxSxQxMOFBxx

- 00000000 -OCRVA 00 0 0 0 0 0 0 0 00 00
0 ........  :CxVC :: 1 : 1 : 1 1 1 :   :
  ........  :CTID ::   :   :     2 :   :
  ........  :  IA ::   :   :       :   :
  99999999  7  02 99   6   9       19 18
               04                      :
               TC                      :
               TK                      +EOI, EOS1, EOS2
               TF
```

Text messages and their meanings

NO VALUE	No measurement result, device not triggered
ERROR 01	Issue of eror conditions (Error 1 = Overload)
CONTR. 1	Self test procedures (Contr.1, ..., 4)
NULL	Offset correction in progress
DONE	Offset correction for sensor alignment finished
CAL	Calibration procedure in progress
HI	HI limit exceeded
LO	LO limit exceeded

Meaning of the transmitted characters

Position		(first, last character) of the device message
(1, 1)	"+"	positive sign of the mantissa
	"-"	negative sign of the mantissa
(2, 10)	"x"	8-digit mantissa or text message, numerical range 0.0000000 - 99999999
(11, 11)	"E"	Exponent designator
(12, 12)	"+"	Positive sign of exponent
	"-"	Negative sign of exponent
(13, 13)	"x"	Value of the exponent

(14, 15)	"MR"	Measurement result is being given out
	"CR"	Calculation result is being given out
	"Cx"	Value of constant No.x is being given out
	"CT"	Number of measurements selected for start mode
(16, 17)	"VD"	Direct voltage measurement is selected
	"VA"	Alternating voltage measurement is selected
	"VC"	Alternating voltage measurement with DC coupling
	"ID"	Direct current measurement is selected
	"IA"	Alternating current measurement is selected
	"O2"	Resistance measurement, two-wire configuration
	"O4"	Resistance measurement, four-wire configuration
	"TC"	PT 100 temperature measurement, readout in ^{o}C
	"TF"	PT 100 temperature measurement, readout in ^{o}F
	"TK"	PT 100 temperature measurement, readout in Kelvin
(18, 20)	"Pxx"	Mathematical program No.xx selected
(21, 22)	"Ax"	x=0 Autoranging switched off x=1 Autoranging switched on
(23, 24)	"Rx"	Measuring range "x" set

R1	0.2 Vdc, ...	0.2 kOhm, ..., ...	
R2	2 Vdc, Vac	2 kOhm, ..., ...	
R3	20 Vdc, Vac	20 kOhm, ..., ...	
R4	200 Vdc, Vac	200 kOhm, ..., ...	
R5	1000 Vdc, Vac	2000 kOhm, mAdc, mAac,	$^{o}C, ^{o}F, K$
R6	..., ...	20000 kOhm	

(25, 26)	"Fx"	x=0 Digital filter switched off x=1 Digital filter switched on
(27, 28)	"Tx"	Integration time "x" set

T0	20 msec	4 1/2 digits display
T1	40 msec	4 1/2 digits display
T2	100 msec	5 1/2 digits display
T3	200 msec	5 1/2 digits display
T4	400 msec	5 1/2 digits display
T5	1 sec	6 1/2 digits display
T6	2 sec	6 1/2 digits display
T7	4 sec	6 1/2 digits display
T8	10 sec	6 1/2 digits display
T9	20 sec	6 1/2 digits display

(29, 30)	"Dx"	x=0 Display mode switched off x=1 Display mode switched on

(31, 32)	"Sx"	x=0 Start mode switched off x=1 Start mode switched on
(33, 34)	"Qx"	x=0 SERVICE REQUEST function switched off x=1 SRQ at end of every measurement x=2 SRQ at end of last measurement of the set of measurements specified with "CT"
(35, 37)	"MOF"	Multiplexer inputs disconnected, input signal connected via front panel sockets
	"Mxx"	Multiplexer channel "xx" connected (xx=00,...,19); the front panel sockets are disconnected
(38, 40)	"Bxx"	xx=00 No key has been pressed xx=01,.....,18 Key xx has been pressed
(40, 40)	EOI	EOI signal active with last character sent when a terminator containing EOI has been selected (terminator No.8 is EOI only)
(41, 42)	EOS1 EOS2	Terminator agreement EOS1, EOS2 (end of string) at end of the device message, optionally with or without EOI signal with output of the last character. Whether only one terminating character (EOS1) or two terminating characters (EOS1+EOS2) are sent out, depends on the selected terminator code (0,...,8).

Programming examples for the IEEE bus interface

Before the digital multimeter can be operated via the IEEE bus interface, the device address and the terminator must be set (selected) as described at the beginning of this chapter. The two following examples of programming for Commodore and Tektronix computers assume that the address "7" has been assigned and that number 8 (only EOI) is used as terminator (recommended).

COMMODORE CBM 3032

Control of the digital multimeter by the CBM 3032. The CBM 3032 is the CONTROLLER, the digital multimeter is the LISTENER.

```
CBM 3032:   100 print "your entry please"
            110 input a$
            120 open 1,7 : REM "7" is the device address of the DMM
            130 print #1,a$
            140 close 1
            150 goto 100
```

Reading the character string of the digital multimeter with the CBM 3032. The CBM 3032 is the CONTROLLER, the digital multimeter is the TALKER.

```
CBM 3032:   200 open 2,7 : REM "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 the digital multimeter with the Tektronix 4051:
The Tektronix is the CONTROLLER, the digital multimeter is the LISTENER.

```
4051:  100 PRI "YOUR ENTRY PLEASE"
       110 INP A$
       120 PRI @7:A$  ("7" is the device address of the DMM)
       130 GO TO 100
```

Reading the character string of the digital multimeter with the Tektronix 4051: The Tektronix is the CONTROLLER, the digital multimeter is the TALKER.

```
4051:  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 digital multimeter is 7, the terminator is No.5 (CR + LF without EOI).

Controlling the digital multimeter with the computer HP 85. The HP 85 is the CONTROLLER, the digital multimeter is the LISTENER.

```
HP 85:  130  PRINT "YOUR ENTRY PLEASE"
        140  INPUT B$
        160  OUTPUT 707;B$
        190  END
```

Reading the character string from the digital multimeter with the HP 85. The HP 85 is the CONTROLLER, the digital multimeter is the TALKER.

```
HP 85:  530  DIM A$[50]     Field size declaration, chosen generously
                            (reserve at least 42 character positions)
        540  ENTER  707;A$
        580  DISP A$
        590  END
```

HEWLETT PACKARD HP 87

The device address of the digital multimeter is 7, the terminator is No.5 (CR + LF without EOI).

```
HP 87:  10  DIM A$[50], B$[30]
                    Field size declaration, at least 42 character
                    positions required, DIM A$ at least 42
```

Controlling the digital multimeter with the computer HP 87. The HP 87 is the CONTROLLER, the digital multimeter is the LISTENER.

```
HP 87:  20  INPUT B$    Entry on the keyboard of the HP 87
        30  OUTPUT 707;B$
                    String transfer from HP 87 to the digital
                    multimeter
```

Reading the character string from the digital multimeter with the HP 87. The HP 87 is the CONTROLLER, the digital multimeter is the TALKER.

```
HP 87:  40  ENTER 707;A$
                    String transfer from the digital multimeter
                    to the HP 87 computer
        50  PRINT A$
        60  GOTO 20
```

HEWLETT PACKARD HP 87

Operating the digital multimeter same as above, but now with SRQ.

The device address of the digital multimeter is 7, the terminator is No.5 (CR + LF without EOI).

```
HP 87:  10  ON INTR 7 GOSUB 500
                waits for IRQ on IEEE 488 bus
        20  DIM A$[50], B$[50]
                field size declaration; at least 42 character
                positions required
        30  INPUT B$
                entry on the HP 87 keyboard, e.g. "Q1" for
                switching-on the SRQ
        40  OUTPUT 707;B$
                string transfer from HP 87 to digital multimeter
        50  ENABLE INTR 7;8
                enables IRQ by SRQ
        60  GOTO ...
                line number of the 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 the register contents
        530 ENABLE INTR 7,8
                enables IRQ by SRQ
        540 RETURN


        1000 ENTER 707;A$
                reading-in the message from the digital multimeter
        1010 PRINT A$, P, "DEVICE NO.7"
                output to screen together with the status information
        1020 RETURN
```

HP 9816 (200 Models) and Digital Multimeter

```
1000   !******** Data transmission HP 9816 - - Digital multimeter
1010   !
1020   ! Declaration of the variables
1030   !
1040   COM / DMM 6031 / @ Dmmnr, Setup$[30], Display$[50]
1050   !
1060   ! Address assignment -> 7 =  @ Dmmnr
1070   !
1080   ASSIGN   @ Dmmnr TO 707
1085   ON INTR 7,1 CALL Serialpoll
1090   !
1100   ! READ-IN OF THE DESIRED SETUP FROM THE KEYBOARD
1110   !
1120   INPUT Setup$
1130   OUTPUT   @ Dmmnr;Setup$
1140   !
1150   ! INTERRUPT ENABLE
1160   !
1170   ENABLE INTR 7;2          ! IRQ WHEN A SRQ APPEARS
1180 Main:    !
1190          GOTO Main         ! User program
1200          END
1210   !.....................................................
1220   !.....................................................
1230   ! SUB Serialpoll
1240   ! CHECKS DEVICE FOR SERVICE REQUEST, READS OUT WHEN REQUIRED
1250   ! AND RETURNS TO THE WAITING LOOP OF THE MAIN PROGRAM
1260   !
1270   !
1280   COM /DMM 6031 / @ Dmmnr,Setup$[30], Display$[50], P
1290   !
1300   P=SPOLL ( @ Dmmnr)
1310   !
1320   IF P>63 THEN CALL Reading
1330   ENABLE INTR 7
1340   SUBEND
1350   !.....................................................
1360   !.....................................................
1370   SUB Reading
1380   !
1390   ! READS-IN THE LATEST MEASURED VALUE FROM THE VOLTMETER.
1400   !
1410   COM/DMM 6031/ @ 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 TO ADDRESS IEEE.07.0"
  5   PRINT
  6   PRINT "WHEN YOU HAVE DONE THIS, "
  7   PRINT "PRESS THE  RETURN  KEY"
  8   INPUT C$


 12   PRINT:PRINT
 15   PRINT "YOUR ENTRY PLEASE"
 20   INPUT B$
 30   PR #3
              Initializes slot #3 for output
 40   PRINT "@':"
              Listener address 7 is sent in address mode, REN and ATN
              active.
              @  switches to address mode,
              '  transmits listener address 7,
              :  switches back to command mode
 50   PRINT "'";B$;"'"
              The message is transmitted
              ' switches text mode on and off
 60   PRINT "@G:"
              Talker address 7 is sent in address mode
              @  switches to address mode,
              G  transmits talker address 7,
              :  switches back to command mode
 70   PR #0
              The data from the IEEE bus are sent directly to the
              screen
 80   INPUT " ";A$
              Read-in of the message from the IEEE bus
 90   IN #0
              Input/output is switched over to the keyboard
100   GOTO 20
```

All line numbers which are not multiples of 10 (10, 20, 30, ... etc.) are only for operator guidance and may be omitted.
If you have booted DOS 3.3, then lines 30, 70, 90 must be written in the form:

```
30   PRINT : PRINT CHR$(4);"PR #3"
70   PRINT : PRINT CHR$(4);"PR #0"
90   PRINT : PRINT CHR$(4);"IN #0"
```

otherwise you will disconnect DOS and have to reboot.

Also you may use CALL 1002 at the end of your program to recover DOS.

IBM Computer or compatibles with National Instruments interface PC2A

```
1000 CLEAR   ,50000!          ' BASIC Declarations
1010 IBINIT1 = 50000!
1020 IBINIT2 = IBINIT1 + 3
1030 BLOAD "bib.m",IBINIT1
1040 CALL IBINIT1(IBFIND,IBTRG,IBCLR,IBPCT,IBSIC,IBLOC,IBPPC,IBBNA,
IBONL,IBRSC,IB SRE,IBRSV,IBPAD,IBSAD,IBIST,IBDMA,IBEOS,IBTMO,IBEOT,
IBRDF,IBWRTF)
1050 CALL IBINIT2(IBGTS,IBCAC,IBWAIT,IBPOKE,IBWRT,IBWRTA,IBCMD,
IBCMDA,IBRD,IBRDA, IBSTOP,IBRPP,IBRSP,IBDIAG,IBXTRC,IBRDI,IBWRTI,
IBRDIA,IBWRTIA,IBSTA%,IBERR%,IBCNT%)
1060 REM
1070 PRINT " --- MULTIMETER CONTROL SOFTWARE ---"
1080 PRINT
1090       CMD$ = SPACE$(30)
1100      WRT$ = SPACE$(30)
1110       RD$ = SPACE$(40)
1120      EOS$ = CHR$(13)
1130 REM --- LOOKING FOR THE DEVICE ---
1140 PRINT" DEVICE NAME IS DEV1, DEVICE ADDRESS SEE AT IBCONF.EXE "
1150 PRINT" SET THE DEVICES ADDRESS TO CORRECT   VALUE (IEEE 01.0)"
1160 PRINT" VALUE MUST ALWAYS HAVE BEEN INSTALLED IN IBCONF.EXE   "
1170 PRINT:PRINT:PRINT:PRINT
1180 PRINT " *** Check correct address/terminator combination ***"
1190 PRINT " *** in IBCONF.EXE is selected ***"
1200 PRINT
1210 REM
1220 REM --- DETERMINATION OF ADDRESS ---
1230 REM ------------------------------------------------------------
1240   BDNAME$ = "DEV1":CALL IBFIND (BDNAME$,DEV1%)
1242 REM ------------------------------------------------------------
1250 PRINT "INPUT OF A COMMAND, SENDING TO THE MULTIMETER "
1254 PRINT "REFER TO CHAPTER 11, IEEE COMMANDS i.e. VD,VA,T1, ..."
1256 PRINT "A  RETURN  FORCES READING OF DEVICE MESSAGE"
1260 LINE INPUT CMD$
1261 PRINT CHR$(12);CMD$
1262 IF CMD$="" THEN 1268
1264 GOSUB 1280:REM SEND COMMAND
1265 FOR I=1 TO 1000:NEXT I: REM WAIT APPROX. 1 SEC
1268 GOSUB 1340:REM READ MESSAGE
1269 GOTO 1250
1270 REM ------------------------------------------------------------
```

(continued)

Subroutines for output of commands and reading of messages

```
1270 REM ------------------------------------------------------------------
1280 REM --- OUTPUT OF COMMANDS TO THE MULTIMETER ---
1290 WRT$=CMD$+EOS$:REM COMMAND + TERMINATOR (EOS)
1300 CALL IBWRT (DEV1%,WRT$)
1310 RETURN
1320 REM --- OUTPUT OF COMMANDS TO THE MULTIMETER ---
1330 REM ------------------------------------------------------------------
1340 REM --- READING OF DEVICE MESSAGES FROM THE MULTIMETER ---
1350 CALL IBRD (DEV1%,RD$)
1360 MW=VAL(RD$)
1370 PRINT RD$;MW
1380 RD$=SPACE$(40)
1390 RETURN
1400 REM --- READING OF DEVICE MESSAGES FROM THE MULTIMETER ---
1410 REM ------------------------------------------------------------------
```

Lines 1000 to 1060 and lines 1270 to 1410 are individual for use of the NI-PC2A interface. For different interfaces use their special syntax.

9. CALIBRATION

Allow the instrument to warm-up for 2-3 hours after switching-on before starting calibration. The digital multimeter has a digital calibration feature with which individual measuring ranges or all measuring ranges can be recalibrated. It is not necessary to open the instrument for this purpose. Calibration can be carried out via the IEEE 488 bus or via the front panel keyboard. The correction values for the initial calibration carried out by PREMA in the factory are stored in the program EPROM and in a CMOS-RAM which is backed-up with a lithium battery. Normally the multimeter uses the correction values which are stored in the CMOS-RAM. The service life of the battery is about 10 years.

To prevent unintentional destruction of the correction values in the CMOS-RAM, they are protected by a recessed sliding switch S2 which is located on the right on the rear panel of the instrument and marked "MEAS" and "CAL". To recalibrate the digital multimeter, move the switch S2 from the "MEAS" to the "CAL" setting with the aid of a small screwdriver or similar tool. In the "CAL" operating mode the legend "CAL" appears intermittently in the main display. In this operating mode the correction values in the CMOS-RAM are unprotected and can be overwritten. If some correction values have been destroyed accidentally by uncautious calibration attempts and it is not possible to recalibrate because no suitable calibration signal sources are available, then you still have the possibility of copying the initial calibration values which PREMA has stored in the program EPROM to the CMOS-RAM. To do this, switch the mains switch of the multimeter "OFF" and then "ON" again, leaving the calibration switch on the rear of the instrument set to "CAL". In this state, after switching the instrument on again, the correction values from the EPROM are copied to the buffered CMOS-RAM and all input offset correction values are cleared. Therefore input offset compensation is necessary thereafter for all functions and ranges. For this purpose, place a short circuit at the "V/Ohm" input sockets of the digital multimeter, switch to "Auto" (autoranging) in the "Vdc" measuring function setting and then press the "Zero" key. The multimeter then automatically corrects the zero points of all Vdc measuring ranges in succession and stores the found compensation values in the protected CMOS-RAM. Correction in a single range is possible by making fixed selection of that range, i.e. by switching autoranging off. Proceed in the same manner for all other measuring functions.

9.1. Calibrating the Direct Voltage Measuring Ranges

First select the measuring range and connect an exactly known positive or negative reference source, which must lie between 5% and 100% (preferably between 50% and 100%) of the display span of the selected measuring range, to the input sockets. The multimeter now outputs a measured value to the display on the basis of the old calibration factor. If the difference between the nominal and the actual reading is out of tolerance, select the calibration program by entering program number 99 and selecting computation mode. Then enter the nominal value on the keyboard (data entry field) and thereafter start the calibration by pressing the ENTER key.

The instrument returns from the calibration program after making the calibration for the selected range. New functions or ranges can then be selected. To recalibrate further ranges, recommence the procedure described above from the beginning. When all desired calibrations have been made, return the protection switch on the rear panel from "CAL" to "MEAS" immediately, so that the calibration data are now protected.

The calibration procedure via the IEEE 488 bus is basically analogous to the described procedure for calibration via the keyboard. To set the nominal value, specify it as an integer number with the command "NVxxxxxxxx", or "NV+xxxxxxx" or "NV-xxxxxxx" for temperature range calibration (see command description in the chapter explaining the IEEE 488 bus interface). The calibration program and the calibration measurement are started automatically on transmission of the nominal value. When you do not want to calibrate any more ranges and functions, terminate the calibrating procedure by switching back from "CAL" to "MEAS" on the rear panel of the multimeter.

9.2. Calibrating the Resistance Measuring Ranges

Calibrate the resistance measuring ranges using the four-wire circuit configuration. First compensate the zero point as described above. Also observe the instructions given in the chapter "operating instructions Ohm/kOhm", in particular for compensating the resistance of the measuring cables. The calibrating procedure for the resistance measuring ranges is analogous to that for the direct voltage measuring ranges. In two-wire circuit configuration it is only necessary to correct the zero points. The calibration data are identical to and common with those for the four-wire circuit configuration.

9.3. Calibrating the Alternating Voltage Measuring Ranges

Switch to alternating voltage measurement without direct voltage component for calibrating the alternating voltage measuring ranges. Use a sinusoidal alternating voltage to calibrate the alternating voltage measuring ranges. Here too, first correct the zero point as described above. 1 kHz sinusoidal voltages are required as reference signal. The calibration procedure is analogous to that for the direct voltage measuring ranges.

9.4. Calibrating the Direct and Alternating Current Measuring Ranges

Make the same preparations for calibration of the current measuring ranges as described above. Direct current signals and 1 kHz sinusoidal currents are required as reference signals. The calibrating current must not exceed 1 A in the 2 A ranges. The calibration procedure is analogous to that described for the direct voltage measuring ranges.

9.5 Calibrating the Temperature Measuring Function

Before calibrating the temperature measurement function the zero point correction must have been executed. Zero point correction is done by simply short circuit the input leads as shown in chapter 6.5, figure 6.5.1. After zeroing "donE" appears in the display or via the IEEE bus. Zero point means the internal offset correction of amplifiers. For sensor alignment put a platinum resistance thermometer (RTD) into a subject of well known temperature and enter this value by keyboard or via IEEE bus. All temperatures in the range from -200°C to +850°C are allowed for calibration. Calibration can be made also by use of an exactly known resistance reference. Only the temperature value according to the resistance must be entered as found in the DIN IEC 751 reference table. For calibration via IEEE bus send "NV+xxxxxxx" or "NV-xxxxxxx" as command. For example use "NV+0017486" for a temperature of +174.86°C.

```
**********************************************************************
* DO NOT FORGET TO RETURN THE CALIBRATION SWITCH TO THE *
*                                                       *
*              POSITION      " M E A S "                *
**********************************************************************
```

10. ACCESSORIES

10.1. Mating Plug / Sub-D (Option 6000/03)

A 50-pole subminiature type D plug can be used for each set of 10 channels to connect the measuring lines to the scanner (option 6031/01). This plug connector has soldered connections and a cable outlet for round cables up to 12 mm maximum diameter. Two such plugs are required for connecting all channels.

10.2. Adapter Card (Option 6031/02)

An adapter card is plugged externally onto the 50-pole subminiature type D sockets strip of the DMM 6031 to make possible screw terminal connections of the measuring leads. Two adapter cards are required for connecting all 20 channels of the option 6031/01.

Maximum permitted current: 3 A peak

Maximum permitted voltage: 40 V

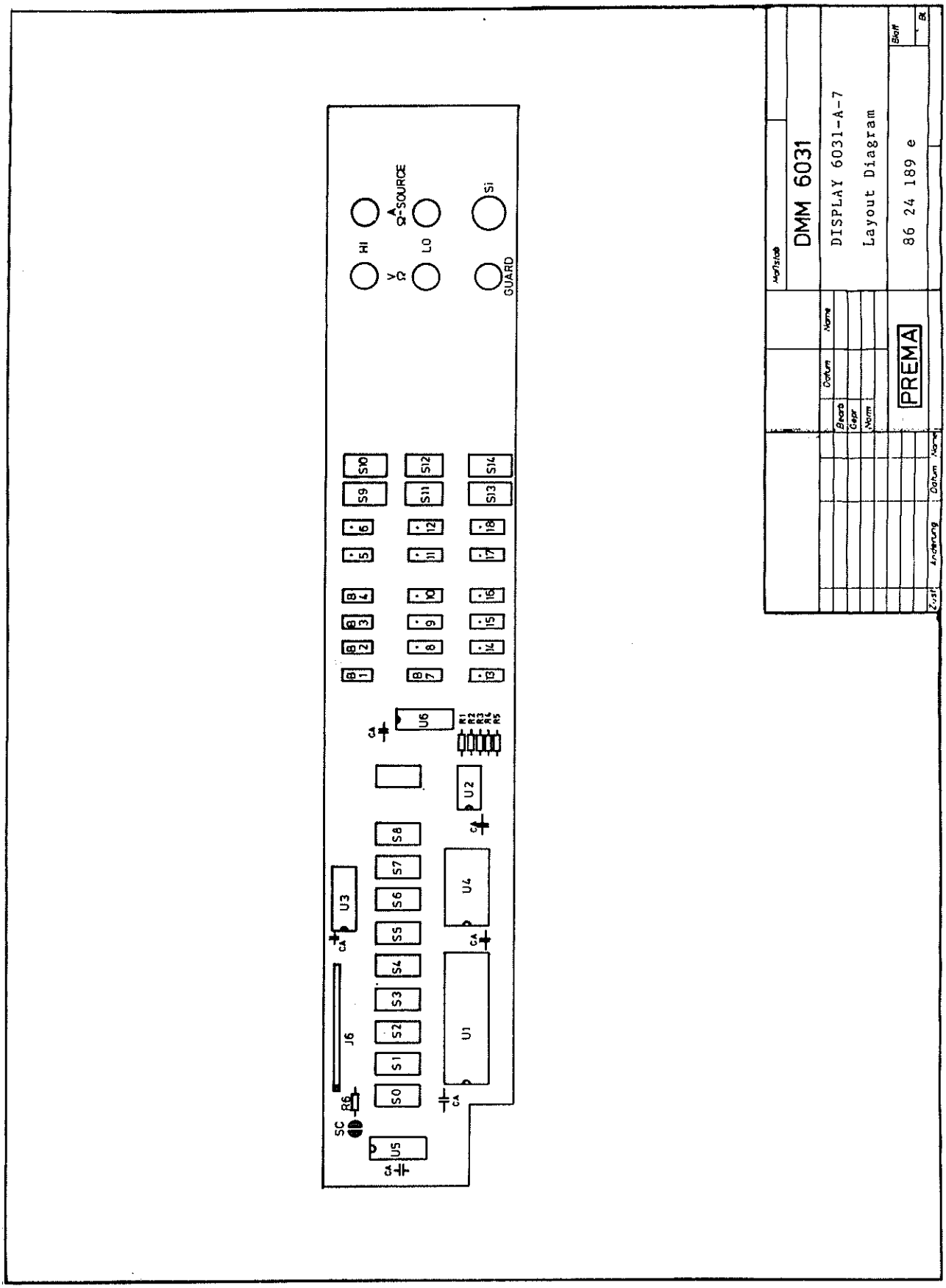
****
* WARNING *
****

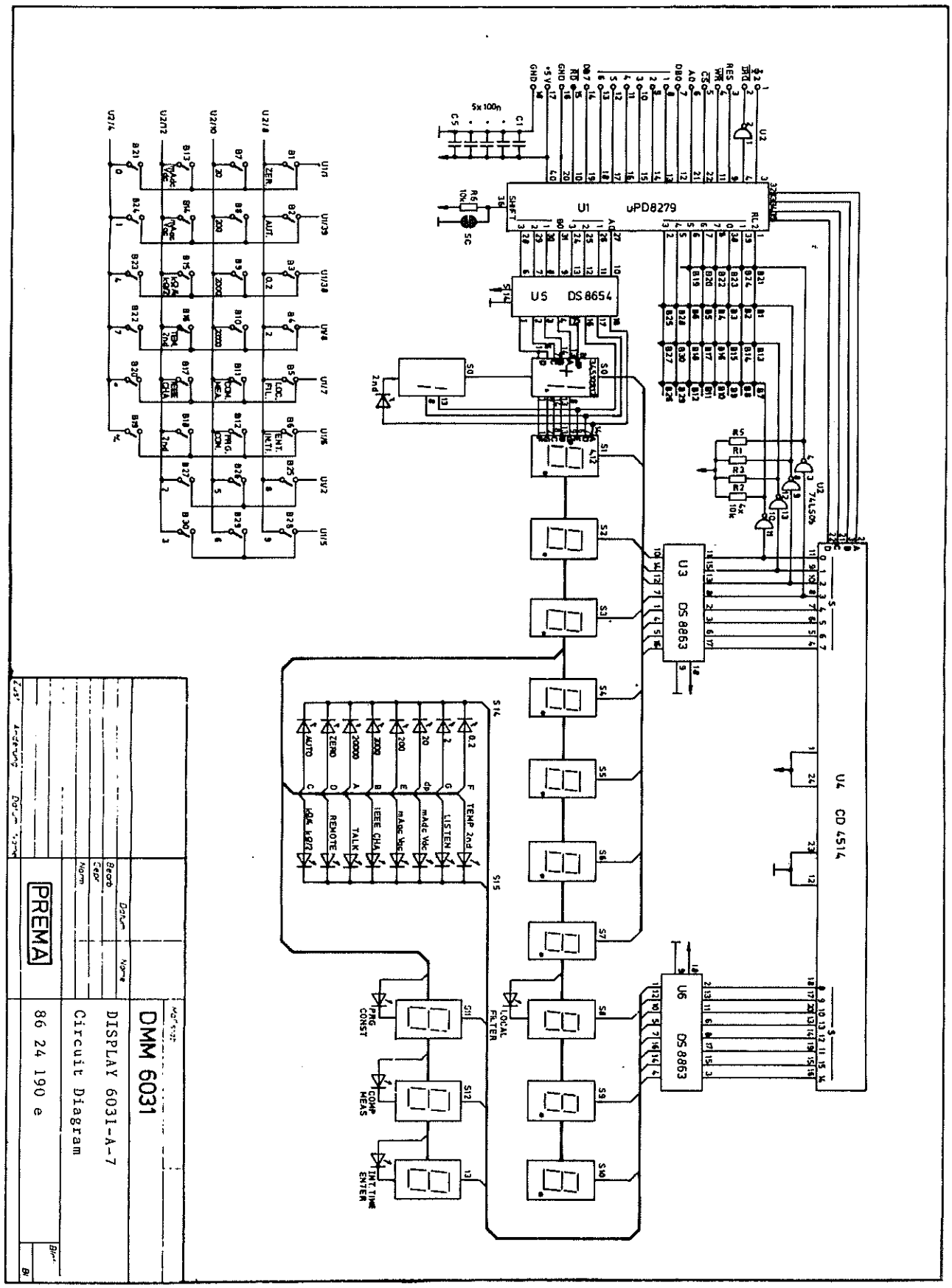
Do not connect any voltages greater than 40V with respect to ground, because the screw terminals are not protected against accidental human contact.

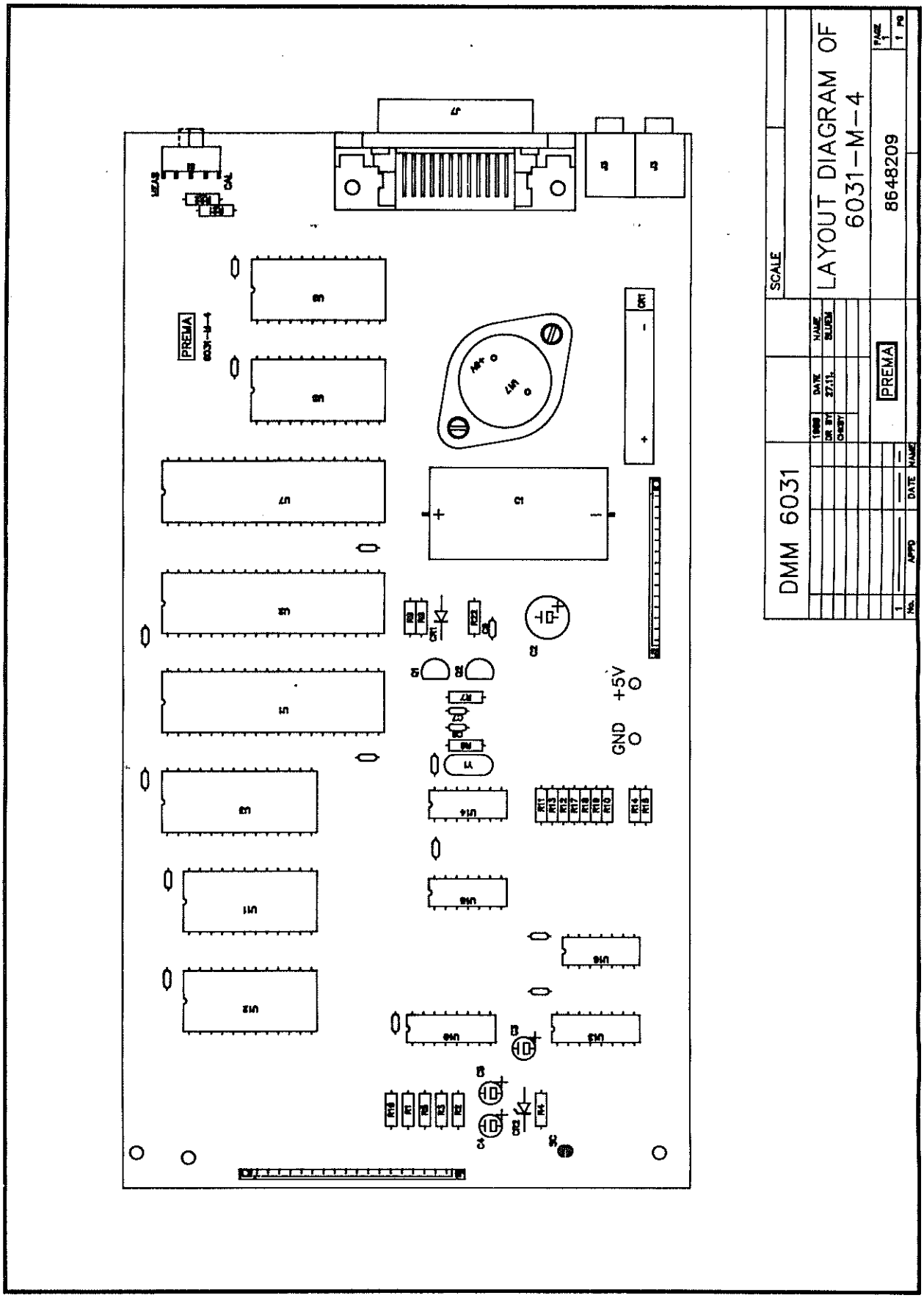
Dimensions: about 70 mm x 110 mm

10.3. Rack Mounting Kit (Option 5020G)

A rack mounting kit is available for mounting the digital multimeter in a 19" equipment rack.


HI
V Ω
LO
A Ω-SOURCE
Si
GUARD
S0
S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
S13
S14
U1
U2
U3
U4
U5
U6
J6
SC
B6
C4
R1
R2
R3
R4
R5
Maßstab
DMM 6031
DISPLAY 6031-A-7
Layout Diagram
PREMA
86 24 189 e
Name
Datum
Bearb
Gepr
Norm
Zust
Änderung
Datum
Name
Blatt


U1 uPD8279
U5 DS8654
U3 DS8863
U4 CD4514
U6 DS8863
U2 74LS04
5x100n
S0
S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
S13
S14
S15
TEMP 2nd
LISTEN
made Wdc
IEEE CMA
TALK
REMOTE
LOCAL
COMP MEAS
ENT TIME
PRG CONST
DMM 6031
DISPLAY 6031-A-7
Circuit Diagram
86 24 190 e
PREMA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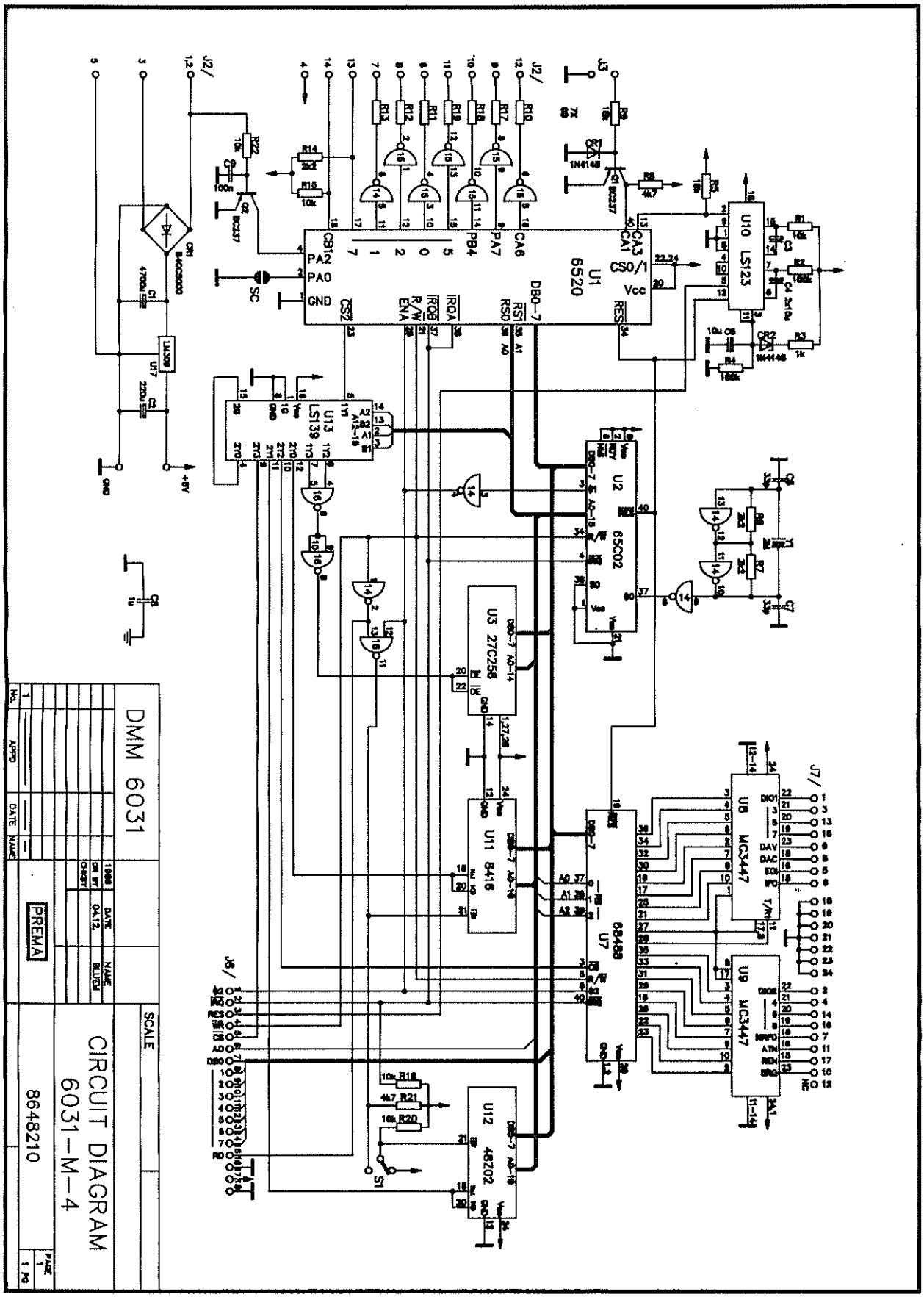
6031-M-4
8648209
PREMA
SCALE
DMM 6031
DATE
NAME
+5V
GND
PREMA
6031-M-4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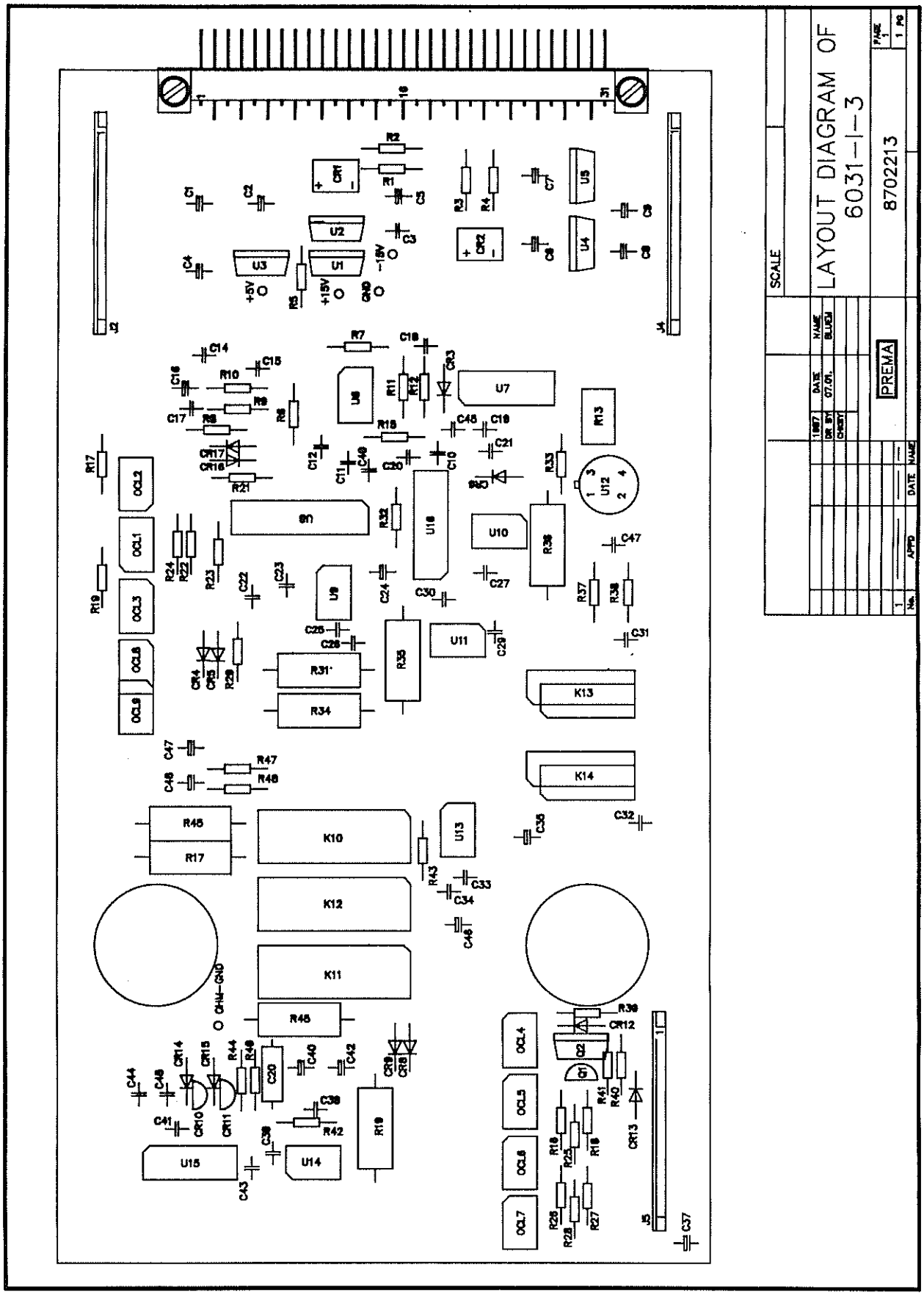
CIRCUIT DIAGRAM
6031-M-4
8648210
PREMA
U1 6520
U2 85C02
U3 27C258
U7 68488
U8 MC3447
U9 MC3447
U10 LS123
U11 8416
U12 48Z02
U13 LS139
U17 LM309
J2/
J3
J6/
J7/
S1
SC
GND
+5V


LAYOUT DIAGRAM OF
6031-1-3
8702213
SCALE
PREMA
DRAWN
CHECKED
DATE
NAME
APPD
J1
J2
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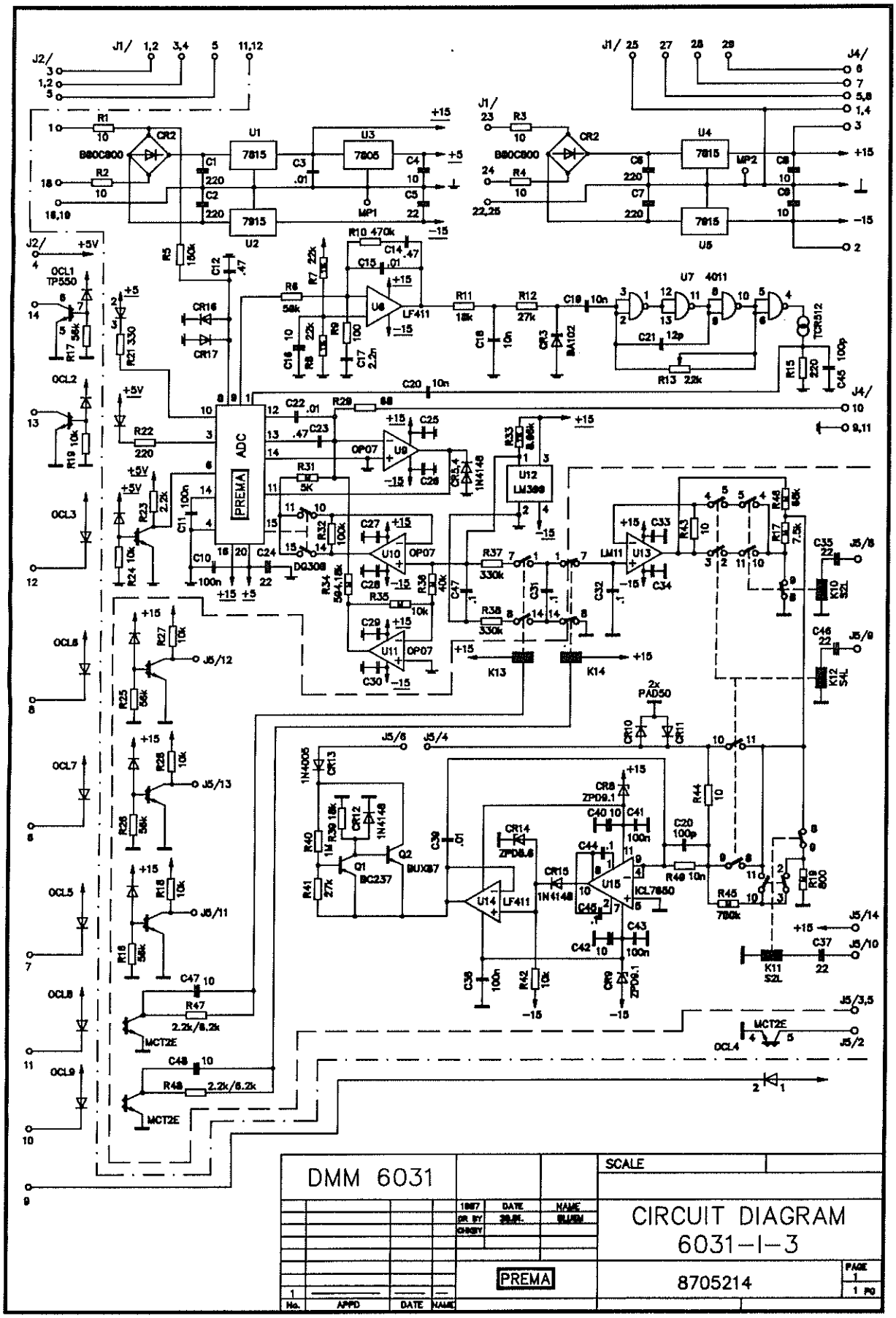
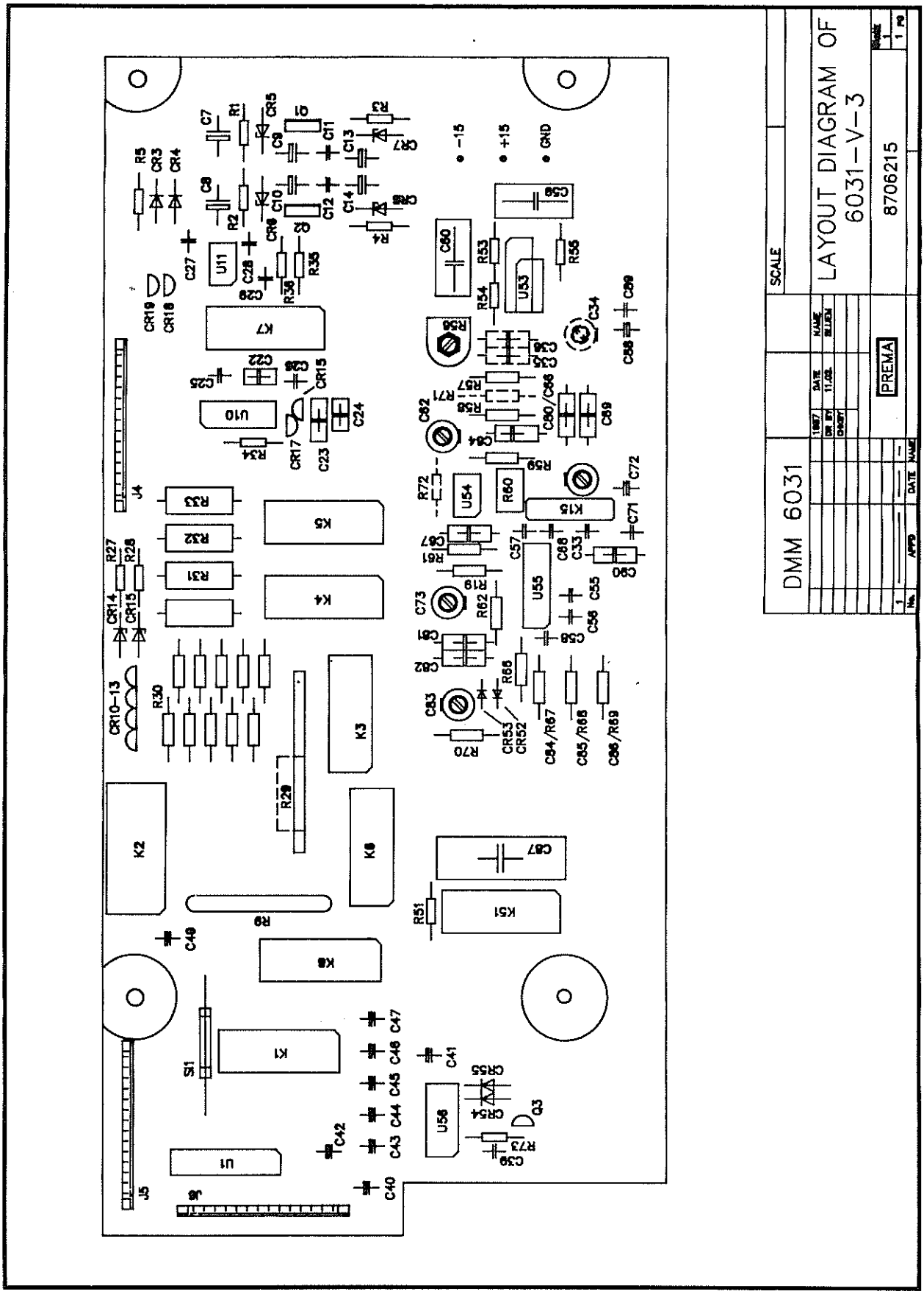
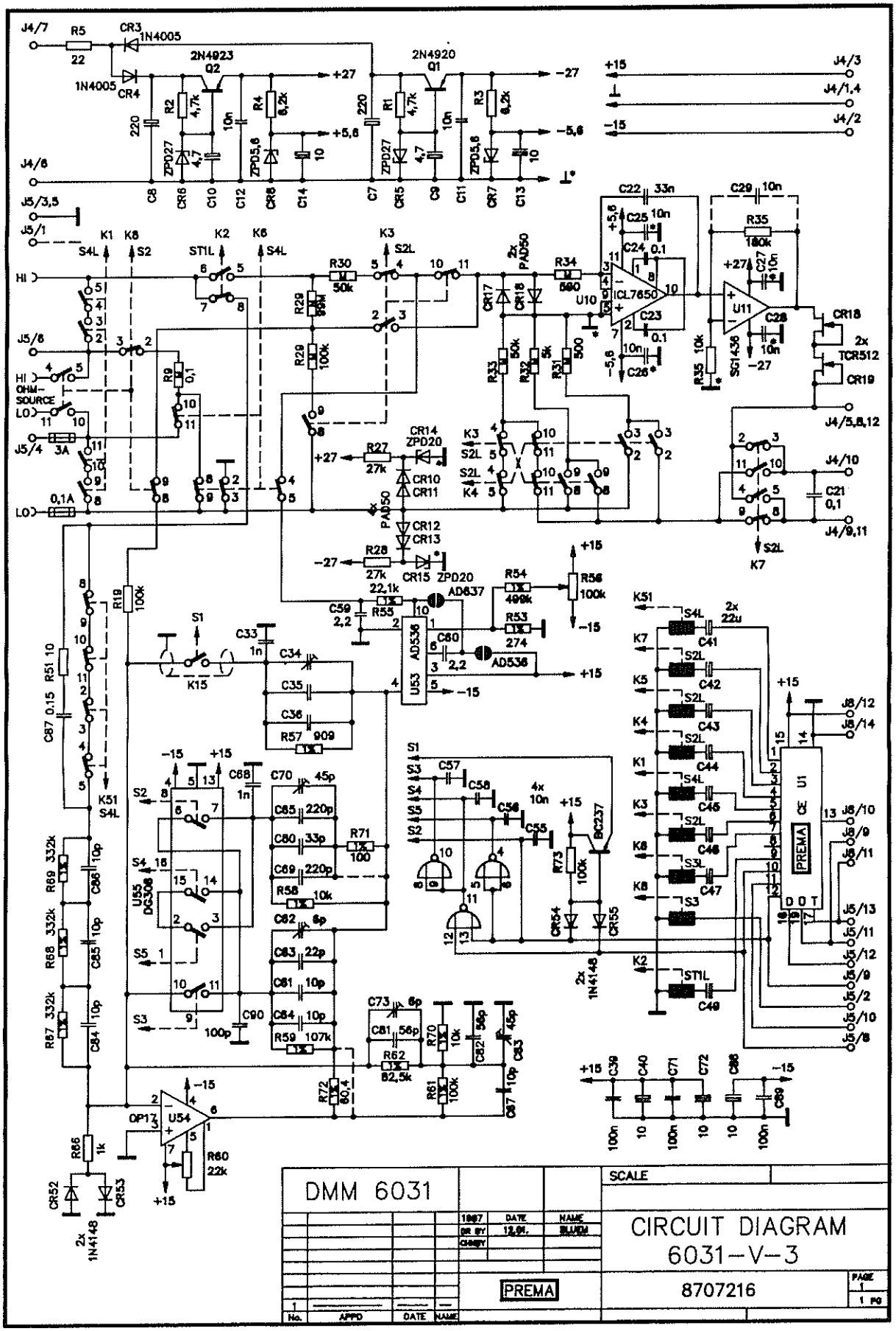
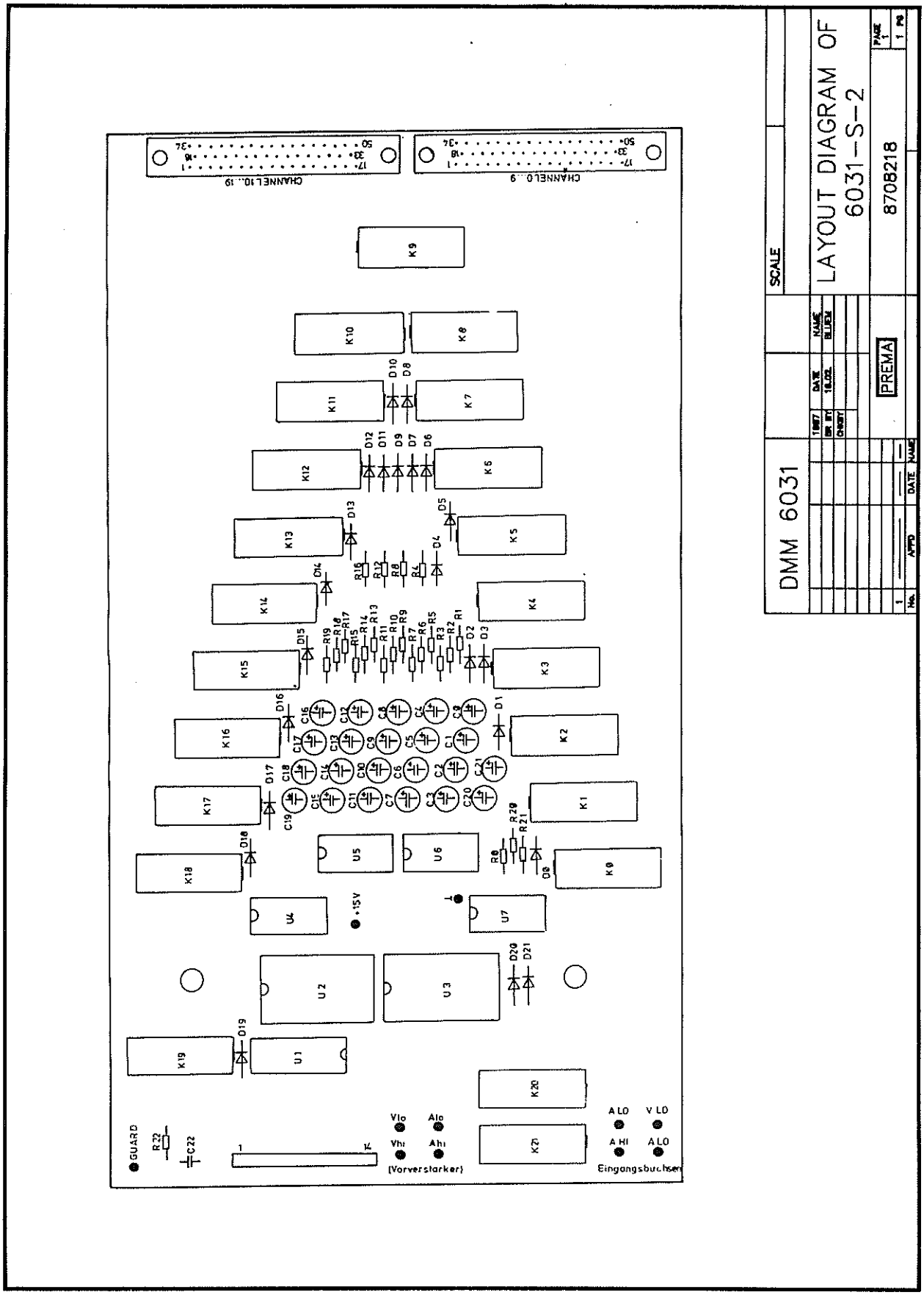
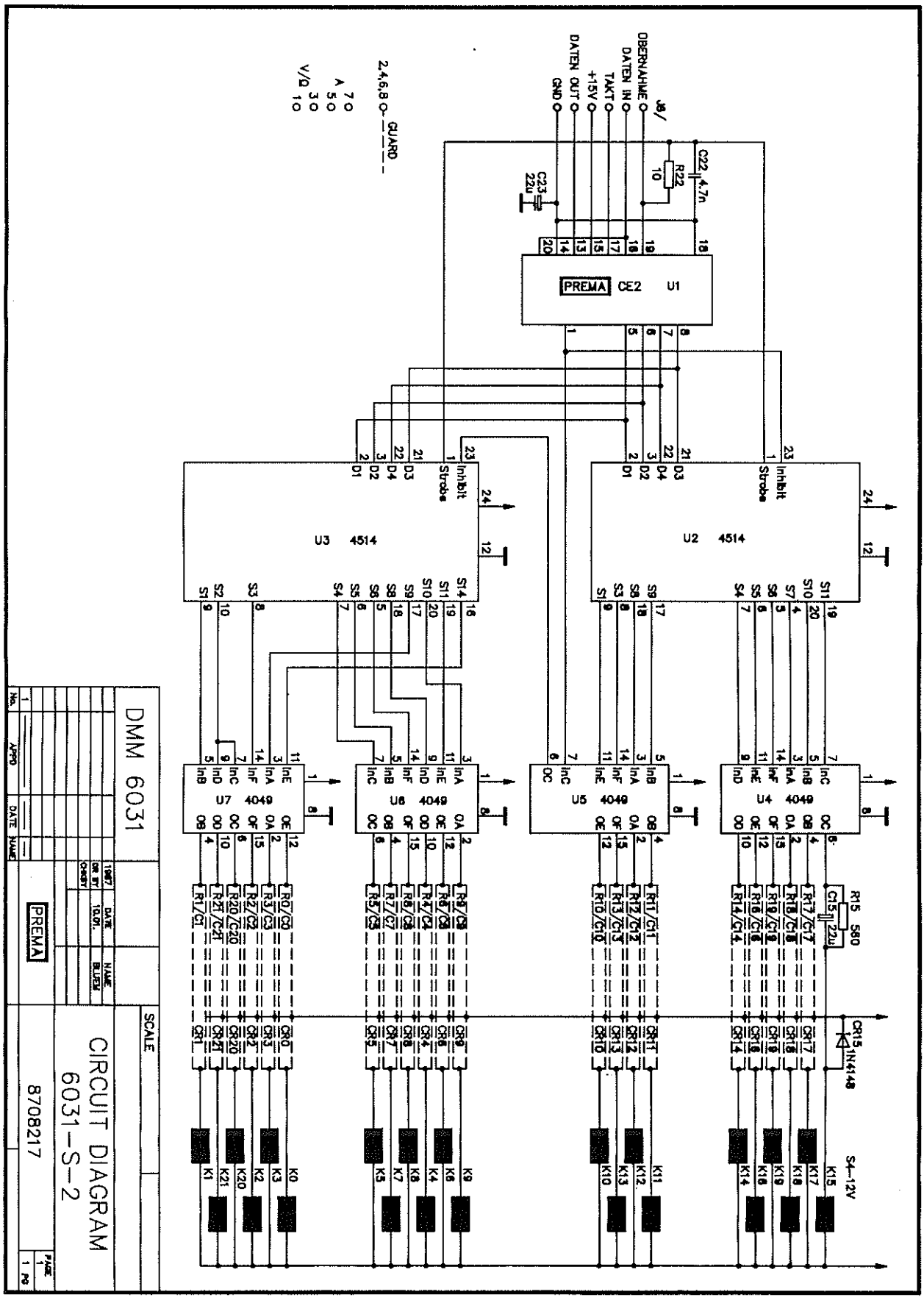
J4
J5
U1
U2
U3
U4
U5
U6
U7
U8
U9
U10
U11
U12
U13
U14
U15
U16
K10
K11
K12
K13
K14
S1
+5V
+15V
-15V
GND
CHASSIS GND


DMM 6031
CIRCUIT DIAGRAM
6031-I-3
PREMA
8705214
SCALE
ADC
PREMA


DMM 6031
SCALE
LAYOUT DIAGRAM OF
6031-V-3
PREMA
8706215
-15
+15
GND


DMM 6031
CIRCUIT DIAGRAM
6031-V-3
SCALE
PREMA
8707216
PAGE
1 PG
DATE
NAME
DRAWN
CHECKED
APPD
No.


DMM 6031
LAYOUT DIAGRAM OF
6031-S-2
8708218
PREMA
SCALE
DATE
NAME
CHANNEL 0 ... 9
CHANNEL 10 ... 19
K1
K2
K3
K4
K5
K6
K7
K8
K9
K10
K11
K12
K13
K14
K15
K16
K17
K18
K19
K20
K21
U1
U2
U3
U4
U5
U6
U7
+15V
GUARD
R22
C22
Vlo
Alo
Vhi
Ahi
(Vorverstärker)
A LO
V LO
A HI
A LO
Eingangsbuchsen


DMM 6031
CIRCUIT DIAGRAM
6031-S-2
8708217
PREMA
SCALE
U1 PREMA CE2
U2 4514
U3 4514
U4 4049
U5 4049
U6 4049
U7 4049
J6/
OBERNAHME
DATEN IN
TAKT
+15V
DATEN OUT
GND
GUARD
2,4,6,8
A
V/Ω
7 0
5 0
3 0
1 0
R22 10
C22 4.7n
C23 22µ
R15 560
C15 22µ
CR15 1N4148
S4-12V
K0
K1
K2
K3
K4
K5
K6
K7
K8
K9
K10
K11
K12
K13
K14
K15
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