PREMA

Instruction Manual

MODEL 6030

INTEGRATING DIGITAL MULTIMETER

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1.1. General Description

The PREMA 6030 is a Digital Multimeter with 6 1/2 digits resolution with uncompromising top class performance. For direct voltage measurements with input voltages up to +/- 20 V, source loading is only 10 GOhm, an important condition for making high precision measurements. Extremely stable amplifiers and an integrator with the same degree of precision, permit uninterrupted averaging without disturbing gaps for offset measurements, even with 100 nV resolution, which is reached after 1 second integration time.

This digital multimeter is capable of measuring direct and alternating voltages as well as resistance values, with integration times of up to 5555 hours.
The utilized, fully integrating multiple ramp technique without pauses and oscillator frequency synchronization to the power mains frequency using a Phase Locked Loop (PLL) circuit, achieve a degree of common mode and series mode rejection which would be unattainable by other means.

The RMS value is determined in alternating voltage measurements, optionally with DC or AC coupling of the test sockets.

Resistance measurements can be made with a resolution of 100µOhm, optionally in two-pole circuit.

An additional facility for offset correction permits compensation of thermoelectric EMFs with the test leads shorted, and line resistance compensation in the case of resistance measurements in two-pole circuit.

The extensive resident mathematics program package in the Digital Mutlimeter 6030 offers a wide range of data processing functions, for example response curve linearization, threshold monitoring and statistics. Emphasis has hereby been placed not so much on simple measurements data collection (which is more appropriately performed with the memory facilities of an additional minicomputer), but rather on relieving the user of tiresome calculations in standalone operation of this digital multimeter.

An IEEE 488 bus interface is incorporated as standard feature. This permits remote control and remote monitoring of all functions of the multimeter, including digital calibration. Excellent electrical isolation between the test sockets and the interface connector permits perfect 100 nV resolution for direct voltage measurements even in system operation.

Simple digital calibration reduces conventional-type alignment complexity of the multimeter. The A/D Converter is so extremely linear, that entry of a single nominal value via the keyboard or via the IEEE 488 bus suffices to calibrate a measuring range. The nominal value may lie in a wide range. Each measuring range and each function can be recalibrated independently. A concealed mechanical switch on the rear panel of the multimeter prevents unintentional destruction of the correction factors.

A self test with error messages checks all functions of the multimeter on power-up or by call when required at other times.

Clear synoptical construction without extensive cable harness facilitates servicing and considerably improves reliability.

1.2. Measuring Principle

The P R E M A multiple ramp method for analog to digital conversion (German patent No. 2114 141) is used in the Model 6030. It is the basis for a reliable digital multimeter with outstanding linearity and long-term accuracy, with continuous integration of the measured signal to cancel any interference, without falsifying breaks.

An amplifier which operates as integrator with the capacitor C (fig.1) continuously integrates a current Ie which is proportional to the current being measured. This procedure has inherent high linearity, because it does not require periodic switch off of the input voltage. The capacitances of switch-transistors used today in other circuits requiring input voltage switching lead to errors caused by switching surges which change with the input voltage.
The capacitor is periodically discharged (fig.2) by a current Iref from a reference voltage source Uref (discharge times t1 to tn), which has opposite polarity with respect to the signal voltage being measured. Prior to the down integration, the comparator determines the sign of the input voltage to define the polarity of the reference voltage. The same reference voltage and the same down integration resistor are used for both polarities, so that the same reading is obtained with a tolerance of only one digit when the input voltage is reversed. The end of a down integration is defined by coincidence of comparator response and a pulse flank of the clock oscillator. Since the total change of charge on the capacitor during one measuring cycle is zero, it follows that

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

or

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

This means that the sum of the discharge times ti is proportional to the mean value of the input voltage and is displayed as result of the measurement.

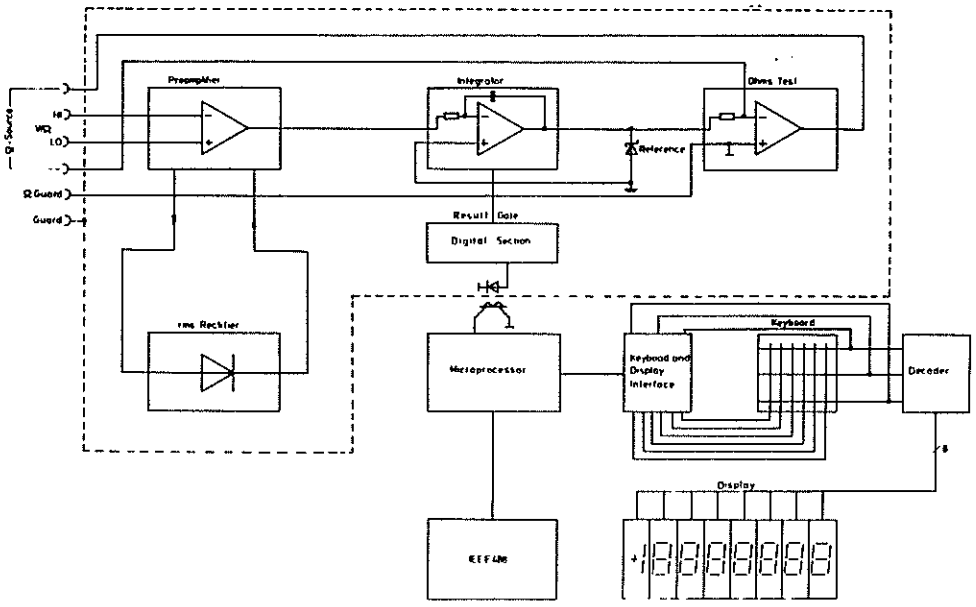


fig.1 Simplified block diagramm

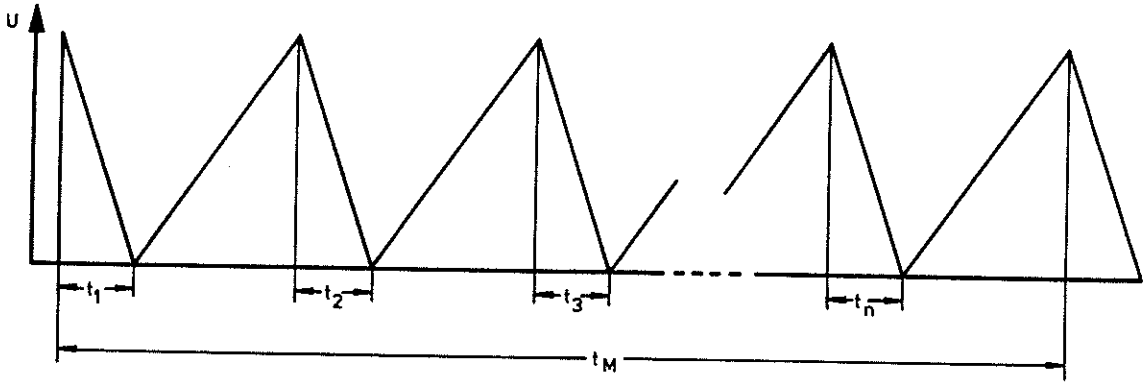


fig.2 Integrator output voltage

6030 SPECIFICATIONS

DC VOLTS

RANGES ..... +/-0.1V; +/-1V; +/-10V; +/-100V; +/-1000V

INTEGRATION TIMES (sec.)	0.1;0.2;0.4	1;2;4;10;20
FULL SCALE	199 999	1 999 999 (except
RESOLUTION	1µV	100nV 1000V)

RANGING ..... manual, automatic or by IEEE 488 bus

ACCURACY +/-(% of reading (%rdg.) + % of full scale (%f.s.))*)

24hrs +/- 1°C

Range	%rdg.	% f.s.
0.1V	0.001	0.0005
1V	0.0012	0.0003
10V	0.001	0.0002
100V	0.002	0.0003
1000V	0.003	0.0002

90 days

Range	%rdg.	% f.s.
0.1V	0.0035	0.0025
1V	0.0035	0.0004
10V	0.0035	0.0003
100V	0.004	0.0004
1000V	0.004	0.0003

1 year

Range	%rdg.	% f.s.
0.1V	0.007	0.0025
1V	0.005	0.0004
10V	0.005	0.0004
100V	0.011	0.0007
1000V	0.011	0.0006

*) Add +/- 1 digit

It is furthermore assumed that the "Guard" socket is connected to the "V/Ohm-LO" socket.

TEMPERATURE COEFFICIENTS
(10°C to 40°C) +/- (%rdg.+ % f.s.)/°C

Range	%rdg.	% f.s.
0.1V	0.0009	0.00015
1V	0.0003	0.0001
10V	0.0003	0.0001
100V	0.001	0.0001
1000V	0.001	0.0001

TEMPERATURE COEFFICIENTS (0°C to 50°C): 2 x Values of temperature range 10°C to 40°C

ZERO POINT
Offset Voltage (after one hour warm-up time)

TEMPERATURE COEFFICIENTS..... better than 0.3 µV/°C
LONG TERM STABILITY..... better than 5 µV about 90 days

INPUT RESISTANCE

+/-0.1V;+/-1V;+/-10V-range .. 10 GOhm

+/-100V; +/-1000V-range ..... 10 MOhm +/- 0.25%

NOISE REJECTION (Ratio of peak to peak interference to 1 digit reading error with an integration time of 400 ms, filter out).

SERIES MODE REJECTION (Filter out, 400 ms integration time)
60 Hz Power frequency .. better then 100 dB
56 Hz to 65 Hz ..... better then 50 dB

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

COMMON MODE REJECTION (Up to 1 kOhm in either lead; guard connected to one of the inputs).
DC Voltage ..... 160 dB
60 Hz power frequency .. 160 dB

INTERNAL TIME OUT	None, except when a computer programm is selected whose processing time exceeds the measuring limit and in the case of polarity change.
MEASUREMENT TECHNIQUE	Fully integrating PREMA multi-ramp process (DBP.No. 2114141; US-Pat. No. 3765012)
POLARITY CHANGE	Automatic; 100 ms max.

OVERLOAD PROTECTION

Between "V/Ohm-HI" and "V/Ohm-LO" input +/-0.1V; +/-1V; +/-10V-range for	
60 sec.	+/- 1000V
continous	+/- 700V
+/-100V; +/-1000V-range continous.....	+/- 1000V
Between "V/Ohm-LO" input and guard	300V DC or peak to peak AC
Between guard and enclosure .	500V DC or peak to peak AC
OVERLOAD INDICATION	"ERROR 1" in the main display

RESISTANCE Ohm/kOhm

MEASUREMENT SCHEME ..... True 4 wire with active guard; can be switched to 2 wire on front panel or by IEEE 488 bus

RANGES ..... 100 Ohm; 1 kOhm; 10 kOhm; 100 kOhm; 1 MOhm; 10 MOhm

INTEGRATION TIMES (sec.)	0.1;0.2;0.4	1;2;4;10;20
FULL SCALE	199,999	1,999,999
RESOLUTION	1 mOhm	100 µOhm.

RANGING ..... manual, automatic, or by IEEE 488 bus

ACCURACY +/- (% of reading (%rdg.) + % of full scale (% f.s.))*)

24hrs +/- 1°C

Range	% rdg.	% f.s.
100 Ohm	0.003	0.0005
1 kOhm	0.002	0.0003
10 kOhm	0.002	0.0002
100 kOhm	0.003	0.0003
1 MOhm	0.004	0.0003
10 MOhm	0.02	0.002

90 days

Range	% rdg.	% f.s.
100 Ohm	0.005	0.002
1 kOhm	0.004	0.0008
10 kOhm	0.004	0.0007
100 kOhm	0.005	0.0008
1 MOhm	0.007	0.0008
10 MOhm	0.03	0.002

1 year

Range	% rdg.	% f.s.
100 Ohm	0.006	0.003
1 kOhm	0.005	0.001
10 kOhm	0.005	0.001
100 kOhm	0.006	0.001
1 MOhm	0.009	0.001
10 MOhm	0.03	0.002

*) Add +/- 1 digit

It is furthermore assumed that the "Guard" socket is connected to the "V/Ohm-LO" socket.

TEMPERATURE COEFFICIENTS
(10°C to 40°C)

Range	+/- (% rdg.	+ % f.s./°C)
100 Ohm	0.001	0.00015
1 kOhm; 10 kOhm	0.0005	0.0001
100 kOhm; 1 MOhm	0.0008	0.0001
10 MOhm	0.004	0.00015

TEMPERATURE COEFFICIENTS
(0°C to 50°C) 2 x Values of temperature range 10°C to 40°C

CURRENT THROUGH UNKNOWN range

100 Ohm	1 mA
1 kOhm; 10 kOhm	1 mA
100 kOhm; 1MOhm	10 µA
10 MOhm	1 µA

OPEN CIRCUIT VOLTAGE ..... 22 V max.

OVERLOAD PROTECTION ..... +/- 400 V peak

OVERLOAD INDICATION ..... "ERROR 1" in the main display

TRUE RMS AC VOLTS

CONVERSION TYPE ..... True RMS, AC coupled. Can be switched to DC coupled, manual or by IEEE 488 bus.

RANGES	1 V	10 V	100 V	1000 V
FULL SCALE	1.99999	19.9999	199.999	1000.00

INTEGRATION TIMES ..... 0.4 to 20s

RANGING ..... manual; automatic or by IEEE 488 bus

ACCURACY (1 year) +/- (% of reading (%rdg.) + % of full scale (% f.s.)) *)

Range	DC+20Hz	1kHz	10kHz	40kHz	100 kHz	300 kHz
1 V	/----0.25+0.07-------/--0.4+0.4-/---5+2---/					
10 V	/----0.25+0.07-------/--0.4+0.4-/---5+2---/					
100 V	/----0.25+0.07-------/--0.7+0.4-/					
1000 V	/-0.25+0.1-/-7+0.5/					

*) Guard connected to "V/Ohm-LO" input; apply for sine curve input voltages above 5% f.s.. These values are specified assuming that the "V/Ohm LO" socket is connected to ground potential in a suitable manner

TEMPERATURE COEFFICIENTS
(10°C to 40°C)

0	to	20 Hz	+/- (0.01% rdg. + 0.004% f.s.)/°C
20	to	300 Hz	+/- (0.04% rdg. + 0.005% f.s.)/°C

TEMPERATURE COEFFICIENTS
(0°C to 50°C) ..... 2 x Values of temperature range 10°C to 40°C

CREST-FACTOR ..... 7 : 1 at nominal range input voltage, 1,414 kV peak max.

The peak value must not exceed 7 x the nominal range end value or 1,414 kV.

INPUT RESISTANCE ..... 1 MOhm//smaller 60pF

OVERLOAD PROTECTION
- Voltage input ..... +/- 1414 V peak, with the limitation 20,000,000xVxHz
- Guard to enclosure ..... +/- 500 V peak
- Guard to "V/Ohm-LO" input ..... +/- 200 V peak

SETTLING TIME ..... 1 s to 0.1% of step size

OVERLOAD INDICATION ..... "ERROR 1" in the main display

IEEE 488 BUS INTERFACE

DECOUPLING	Galvanically insulated from the input stage
OUTPUT INFORMATION	Numerical read out of measurement result, computed result, constants, function, range, measuring time, and computer program number.
INPUT INFORMATION	Function, range, measuring time, start command, computer program number, and values of constants.
ADDRESS	Selectable from 0 to 30, can be set up via switch on the rear of the enclosure.
FUNCTIONS	SH1, AH1, T5, L3, RL1, DC1, DT1, SR1
KEYBOARD	Can be switched off via REN, can be switched in via GTL.
END-CHARACTER	EOI
COMPATIBILITY	IEEE-Standard-488 (1978) and IEC 625 part 1 and 2
BUS CONNECTOR	24 pin Amphenol compatible to IEEE 488

GENERAL

WARMUP TIME ..... 20 min. for 1 year accuracy
1 hr for full accuracy

HUMIDITY OPERATING
up to 25°C ..... less then 75% rel.
above 25°C ..... less then 65% rel.

WORKING TEMPERATURE RANGE ... 0 to + 50°C
STORAGE TEMPERATURE RANGE ... -10 to + 70°C

POWER SUPPLY ..... 100V, 120V, 220V, 240V AC,
50 or 60 Hz, 20VA

WEIGHT ..... ca. 5,1 kg (11.2 lbs)

ENCLOSURE Aluminium-19-inch

DIMENSIONS

Height without feet	89 mm (3.5 ins)
Height with feet	105 mm (4.14 ins)
Width	443 mm (17.4 ins)
Depth without handles	356 mm (14.1 ins)
Depth with handles	396 mm (15.6 ins)

3. Commissioning

Every PREMA measuring unit has been thoroughly and carefully tested for conformity to all performance specifications before leaving the factory. These units should therefore arrive in perfect electrical condition. To verify this, please examine the unit immediately after receipt, for any signs of shipping damage. In the case of complaints, a record of damage should be made together with the shipping agent.

Mains Connection

This PREMA measuring unit is intended for connection to 100V, 120V, 220V or 240V 50/60 Hz AC mains voltage (see the chapter headed "Calibration" for conversion to a different mains frequency).
Voltage fluctuations of +/- 10% and frequency fluctuations of +/- 4% are tolerated. The power consumption is about 20 VA. A cold equipment mains connector with ground contact, conforming to DIN specification, is located on the rear of the unit. The unit is protected by a 0.2 A miniature fuse which must be replaced by a 0.4 A fuse (slow blow) on conversion to 100V or 120V mains input voltage. The unit is switched on and off in the mains input circuit with the double-pole pressbutton switch marked "POWER" on the front panel.

Grounding

To protect the user, the cabinet of the unit is grounded via the mains cable, provided that the latter is connected to a properly grounded power outlet. The cabinet is electrically insulated from the shielding and from the two inputs.

4. Keyboard

The front panel keyboard consists of two keysets. The left keyset comprises the range, function, integration time and decimal keys. The right keyset comprises the mode and control keys.

Up to three functions are assigned to some of the keys. Function level selection is made with the right mode and control keyset. Function levels are emphasized by color designation of the legend.

BLACK LEGEND:
The first function level is designated in black and assigned to the operating modes Measure ("Meas") and Compute ("Comp").
The main display shows the measurement result or the computed result, according to the selected operating mode. The keys "Vdc", "Vac", "kOhm/2", "kOhm/4" respectively select the functions direct voltage measurement, alternating voltage measurement, two-wire resistance measurement and four-wire resistance measurement.

The "Zero" key permits separate input offset correction for all functions and ranges. The individual ranges of the functions can be selected with the keys 0.1 to 10000".

The "Auto" key activates fast autoranging for simplified measurements with the type 6030 multimeter. The digital multimeter makes advance decision within the first third of the selected measuring time, whether or not the correct range is set. If the advance decision (fast automatic mode) retains the set measuring range, then two further tests are made after expiry of the total measuring time:

1. If the set span is reached or exceeded, then the next higher range is selected.
2. If less than 8% of the set span is reached, then the next lower range is selected. The next measurement in the new range commences 100 msec after switchover.

The front panel range keys are disabled when range selection is made via the rear panel input (see chapter headed "IEEE 488 Bus Interface"). The control circuit is electrically insulated from the measuring circuit input.

"Filter":
A walking average over 10 measurements is maintained when this key has been pressed. Continual updating is made by including the most recent result in and discarding the oldest one from the averaged set of 10 measurements, i.e. the result is always maintained as the average of the last ten measurements.

BLUE LEGEND:
The second function level is designated in blue. It comprises the operating modes select program number ("Prg"), select constant ("Const") and enter. The blue decimal keyset is provided for entering program numbers for constants in decimal form, including decimal point and sign.
The "Enter" key is used to enter measured and computed results into constants.

WHITE LEGEND:
The third function level is designated in white and is assigned to the operating mode select integration time ("Integration Time"). After pressing the "Integration Time" key, integration times from "0.1s" to "20s" can be selected with the white legend keys in the left keyset.

5. Display

The display of the Type 6030 multimeter is organized in three sections for synoptical and comprehensive visual presentation of information:

The main display section is provided for readout of measured and computed values, together with sign and decimal point. This section also displays error messages and certain operating modes of the multimeter.

The top right supplementary section bears the legend "Integration time" in white, corresponding to the associated keyset, and reads the set measuring time, when the latter is less than 4 seconds.
If the measuring time is set to be 4 seconds or longer, then this display section reads the remaining integration time in the current cycle, with a count down in seconds to Zero. This count down commences always with the actually set measuring time, e.g. 20, 19, 18,..., and then repeats for the next measuring cycle. This presents the user with clear information in the case of long measuring times, at which instant the display has been updated with a new result, and when the next such instant will be.

The bottom right supplementary section of the display bears the blue legend "Program" and "Constant", corresponding to the associated keyset function level. It reads the designation number of the selected computation program, e.g. 12, or the designation number of one of the predefinable constants C0 to C9 used in the computation programs. The current value of the called constant is shown at the same time in the main display section.

LEDs are fitted in the respective keys to indicate range, function and operating mode.

6. Offset Correction

Range zero displacement or drift is a common source of error requiring correction in a multimeter. Normally such errors can be tested by checking whether the display reading differs from zero when the input is shorted.
The model 6030 incorporates automatic zero correction for internally caused offsets. This of cause does not take external thermoelectric EMFs at the input terminals into account, and these may lead to a visible zero offset in the most sensitive ranges. Such errors can be corrected by pressing the "Zero Key" to initiate an automatic offset correction run which takes 4s to 40s for completion, depending on the actual measuring range which is being corrected.
During this time the "Integration time" display section flashes, the main display reads " null " and the keyboard is disabled. If autoranging is in status "Off", then only the offset in the selected measuring range is corrected. But if autoranging is in status "On", then all measuring ranges for the selected function are corrected in sequence before normal operation of the multimeter is reenabled.

The offset correction run can be used too for compensating other than thermoelectric zero displacements. Any external circuit configuration in a state which the user wishes to give zero reading, can be corrected to fulfill this condition, within the limits specified below. To permit this, an internal short is never placed on the measuring input during an offset correction run. This is very important, for example, when making resistance measurements in two-wire circuit. The offset correction will here eliminate all errors otherwise produced by the finite resistance of the measuring leads.
Errors of up to 0.2% of the nominal span can be corrected for direct voltage measurements. The corresponding limit is 5% of the nominal span for resistance and alternating voltage measurements. If the actual error exceeds these limits, then the message "Error 4" appears in the main display section and the old correction value is retained without change.

For direct readout of the deviation from a predefined nominal value, use the two mathematical programs No.1 "Offset" for absolute deviation and No.5 "Percentage deviation" for relative deviation. For further details, refer to chapter headed "Operating Instructions for the Mathematics Program Package".

7. Error Messages and Self-Test

7.1 Error Messages

The Type 6030 Digital Multimeter will recognize the following error conditions resulting from the manner of operation. Corresponding messages with the designation "Error" and a code number are shown in the main display and output via the IEEE 488 bus. The Error code numbers have the following meanings:

1 - Measurement overflow:
The available numerical span is exceeded.

2 - Computation overflow:
The available numerical span is exceeded.

3 - Ohm or Vac plausibility error:
An external offset was corrected and is no longer present; the multimeter reads "negative" resistance or RMS alternating voltage values which therefore have no interpretable meaning.

4 - Offset measurement error:
The offset which is present at the input sockets is too large for correction.

5 - Calibration call error:
1. The specified nominal value is less than 5% or more than 100% of the readout span.
2. The calibration switch on the rear of the unit is set to "MEAS".
3. Calibration is attempted in function Ohm/2
4. Calibration is attempted in function Vac with direct instead of the required alternating voltage.

6 - IEEE 488 bus error:
The multimeter has received a data telegram which is longer than 30 characters.

7 - Self-test error type 1:
A voltage exceeding 300 V is present at the multimeter input sockets, or a hardware fault exists in the analog section of the multimeter.

8 - Self-test error type 2:
Checksum verify error (Lithium battery exhausted).

9 - Self-test error type 3:
Program ROM error

10 - Self-test error type 4:
Working RAM error

7.2 Self-Test

The self-test runs on power-up of the multimeter. Pass through the successive test routines is shown with the messages "Contr. 1" to "Contr. 4" in the display. If an error is encountered, the corresponding error message is displayed. Any voltage which is present at the input sockets of the multimeter during the self-test must not exceed 300V.

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

Contr. 2 recalculates the checksum for the calibration factors held in non-volatile RAM (backup battery) and verifies agreement with the stored checksum.

Contr. 3 performs the corresponding checksum verification for program ROM contents

Contr. 4 checks working RAM for defective memory locations

In addition to automatic run on power-up, the self-test can be called at any time by program number 98. For this purpose, select program 98 and start the test by pressing the "Comp" key.

8.1. Operating Instructions for Vdc (Direct Voltage)

Measuring Voltage Connection

Use the two front panel sockets marked "V/Ohm". Polarity giving a positive potential at the red socket relative to the black one leads to a display reading with positive sign. Make quite sure that the maximum allowed common mode voltages, determined as direct or as peak-peak alternating voltage do not exceed 300V between "LO" input and guard (see section headed "Shielding") and 500V between guard and case. Bear in mind that this may dictate polarity selection in the case of high voltage equipment which is not mains isolated.

Input Resistance Vdc (Direct Voltage Ranges)

In order to be able to exploit the high linearity of the measuring principle used by this multimeter, the input resistance is extremely large in some of the voltage ranges. For example, this still permits relatively accurate measurements with 100kOhm source resistance of the measured voltage up to +/- 20V. But in the 100 V and 1000 V ranges with 100 thousand digits readout resolution, 100 Ohms source resistance already lead to an error of 1 digit. The following table of measuring ranges lists the values for input resistance, span and resolution:

Range	maximum physical span	input resistance	maximum resolution
0.1 V	.2000000 V	10 GOhm	100 nV
1 V	2.000000 V	10 GOhm	1 µV
10 V	20.00000 V	10 GOhm	10 µV
100 V	200.0000 V	10 MOhm	100 µV
1000 V	1000.000 V	10 MOhm	1 mV

Overload Protection

All ranges are protected to a high degree against destruction by overvoltage. The limits are:

+/-0.1V, +/-1V, +/-10V	ranges	+/-1000V for 60 seconds
	or	+/- 700V continuous
+/-100V, +/-1000V	ranges	+/-1000V continuous

But bear in mind that heavy overload in the sensitive ranges will heat the series resistors and diodes, leading to temporary zero offset due to thermoelectric EMFs until internal temperature equilibrium has been reestablished after removing such overload.

Series Mode Disturbance Voltage Rejection

A major advantage of integrating conversion methods for digital voltage measurement lies in the excellent rejection of series mode alternating voltage superimposed on the wanted direct voltage.

With 60 Hz mains frequency, the rejection factor for 60 Hz components achieved by averaging is greater than 100 dB with 100 ms measuring time. All frequencies greater than 56 Hz are rejected by a factor of better than 50 dB (can be checked by deliberately superimposing known alternating voltage and increasing the magnitude thereof until an error of 1 digit results, but do not thereby exceed the maximum safe alternating voltage). This high class performance is obtained by mains synchronisation of the internal clock oszillator (see alignment instructions).

Common Mode Rejection

Common mode voltages at the input of a measuring unit are equal voltages with respect to ground which are present simultaneously at both input terminals. In the ideal case of perfect common mode rejection, these voltages should produce no response in the display. The measuring unit should respond only to voltages which are present as a difference signal between the "HI" and "LO" input terminal. In any practical system, stray capacitances, finite insulation resistance and resistive asymmetries will convert a part of common mode voltages to series mode voltages, so that the common mode rejection becomes finite. The common mode rejection for the Model 6030 is better than 160 dB without filter when 1kOhm asymmetry is present in the connecting leads.

Shielding

If no common mode voltage problems are expected in a measuring circuit, then the guard input (blue socket) should be connected to the "LO" input (black socket).

In critical configurations the guard input can be used to achieve high rejection for DC/AC common mode voltages. These are voltage differences existing between the low potential point of the voltage to be measured and mains ground, or between mains ground of the voltage source and mains ground of the measuring unit. All common mode voltages inject equal direction currents through both input sockets. In order to obtain optimum shielding effect, the guard input must be connected to a DC potential equal to that of the "LO" input, such that shield currents do not flow through any voltage source and feedline resistances large enough to significantly disturb the measured voltage.

8.2. Operating Instructions for Ohm/KOhm

The Type 6030 Digital Multimeter makes resistance measurements in the following manner: A current (I) is sent through the resistance (Rx) which is to be measured, and this same current flows trough a known value internal range resistor. The voltage drop produced across Rx is measured via the input sockets for Vdc and the ratio of this voltage drop to that across the internal range resistor is determined. Drift or ageing of the reference voltage source has no effect on the resistance reading in this method.

Two-Wire Measurements

The connections for a simple two-wire Ohm measurement are established internally in the unit on pressing the "kOhm/2" key. Only a single shielded cable is required for such measurements, with the inner conductor connected to the "V/Ohm HI"-input and the cable shield used as the return line, connected to the "V/Ohm LO"-input. This configuration gives acceptably accurate readings only over a certain resistance range which is limited at the top and bottom end. Leakage current problems reduce the accuracy of high resistance readings (parallel connection of Rx and the cable insulation resistance), whereas the resistance of the measuring leads reduces the accuracy of low resistance readings, particulary in the 100 Ohm range. A four-wire measurement is recommended for these ranges.

Four-Wire Measurements

One possible configuration for four-wire measurements is shown in Fig. 8.2b on page 8/2/3. The respective cable inner conductors are connected to the "HI"-socket of the "V Ohm"-input and so the "Ohm source"-output, whilst the shields are connected to the respective "LO"-terminal.

The effect of the feedline resistance is eliminated in this as well as in the next configuration Fig. 8.2.c. But cables with Teflon insulation are required when making high resistance measurements in the arrangement Fig. 8.2.b. Ordinary insulation materials suffice even in the MOhm range for the configuration of Fig. 8.2.c. The shields of the twin shielded cables used here must be connected to the Ohm ground socket ("Ohm Guard").

Three-Wire Measurements

The configuration shown in Fig. 8.2.d on page 8/2/3 can be used in the 10 MOhm range in the case of severe external interference. This arrangement will minimize stray alternating voltage injection and is intended only for the 10 MOhm range.

Four-wire measurements will tolerate up to about 0.5V drop on each line connected to the "Ohm Source" outputs. Overflow due to a too large value for Rx will bring the message "Error 1" in the main display.

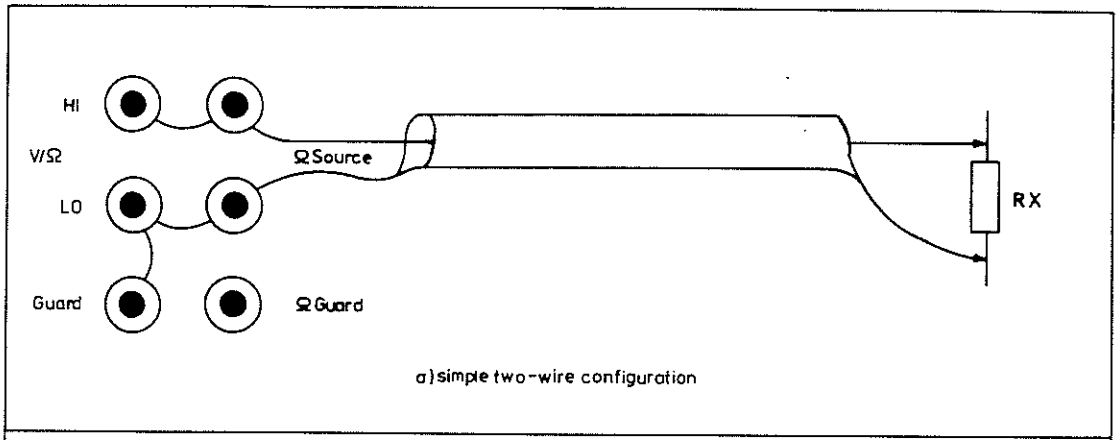
General Comments:
The currents passed through the measured resistance in the respective ranges are:

100 Ohm, 1 kOhm, 10 kOhm	ranges	1mA
100 kOhm, 1 MOhm	ranges	10µA
10 MOhm	range	1µA

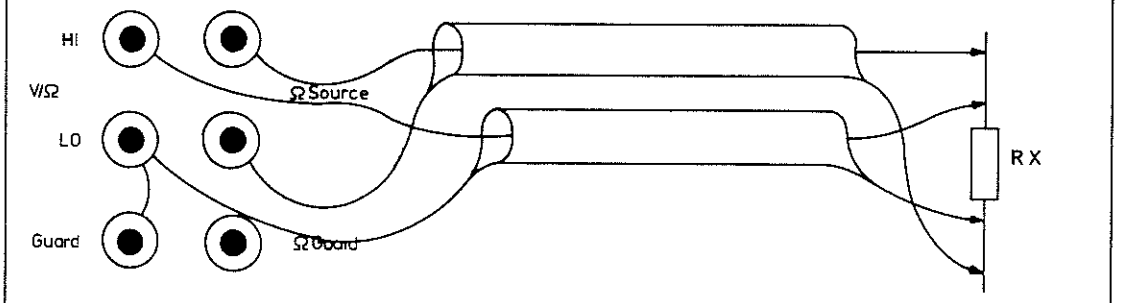
The polarity of the current through Rx is defined such that the end of Rx which is connected to the upper socket of the "Ohm Source" output will have a negative potential with respect to the other end of Rx. Always connect the end of the resistance Rx which is connected to the top socket of the "Ohm Source" output, to the top "HI" socket of the "V/Ohm" input too, and analogously for the bottom sockets.

Semiconductor Test

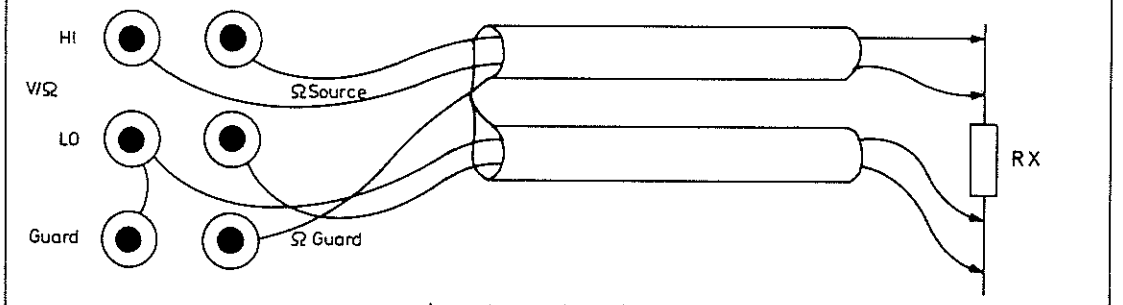
The resistance measuring ranges 10 kOhm, 1MOhm and 10 MOhm are suitable too for testing semiconductors. Connect the pn-junction of a semiconductor which is to be tested in place of a resistor. The Ohm section of the multimeter delivers a load-independent current of 1, 10 or 1000 µA according to the selected measuring range (see above). The reading obtained will be the forward bias voltage of the pn-junction for this current. The numerical display must be interpreted as 19.999999 V for full span, irrespective of the actually displayed position of the decimal point. For correct polarity, bear in mind that the black "V/Ohm" socket "LO" carries positive potential with respect to the red "V/Ohm" socket "HI". The avalanche breakdown voltages of Zener diodes up to 20 V can be measured too. The current and voltage limiting (about 22 V) precludes any damage to the tested components.



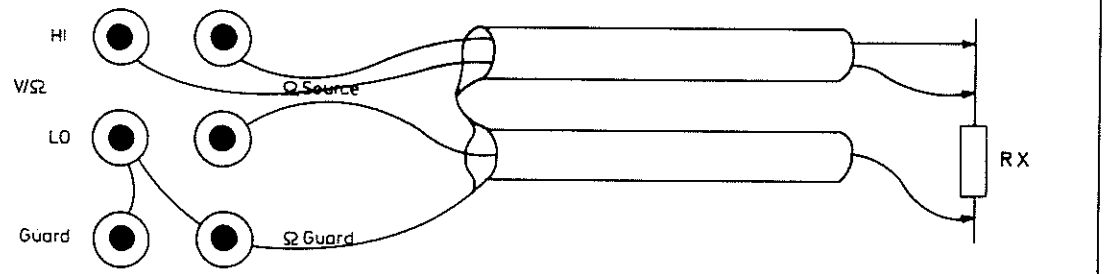
a) simple two-wire configuration



b) normal four-wire configuration



c) special configuration for high resistance ranges, to minimize cable insulation leakage current errors



d) special shielded three-pole configuration for measurements in the 10MOhm range, to minimize errors due to cable insulation leakage current and severe AC interference

9. Operating Instructions for the Mathematics Program Package

The ROM-resident mathematics program package in the type 6030 Digital Multimeter provides numerous programs which relieve the user of tiresome calculations. Each program can be called by its program number.
The utilized constants C0 to C9 can be assigned any desired values in the range +/- 0.000000 to +/- 999999.

Caution: The constant C8 defines the number of measurements to be made and the "Start mode" function. For certain values the digital multimeter may make only single measurements. For further details, refer to the chapter headed "Start Mode".

The last computation result is held in memory on switchover from a mathematical program back to measuring mode "MEAS". This computation result is called into the display on returning to computation mode by pressing the "Comp" key, until it is placed by a new computation result.

PROGRAM 00

This program displays the last computation result irrespective of the next measurement results or start. This feature can be used to protect a computation result against manual control error.

PROGRAMS 01 to 10

The functions of these programs are described by the mathematical expressions in table 1. The polynomial program 06 is particulary versatile. The four freely selectable constants make this program well suited for linearization and response curve matching, e.g. for transducers which have nonlinear characteristics.

PROGRAMS 11 to 13 LIMIT VALUE

For using this program, an upper limit value can be assigned to the constant C7 and a lower limit value can be assigned to the constant C6. Either value alone or both simultaneously may be used.
Readings within the allowed range are displayed in normal manner. Beyond limit values are displayed by alternation of "LO" or "HI" and the limit overshoot value with correct sign in the display.

PROGRAMS 14 to 16 MAX - MIN

The maximum and the minimum value out of a set of measurement readings, and their difference, can be displayed. The constant C8 (see chapter headed "Start Mode") specifies the number of measuring cycles to be evaluated.

PROGRAMS 17 to 20 STATISTICS / EXTENDEDED INTEGRATION TIME

These programs have been devised for statistical evaluation of measurements made with the digital multimeter. The algebraic average, the variance, the standard deviation and the root mean square (RMS) value are determined. These statistical functions are determined concurrently and are available for call by entering the corresponding statistics program numbers. For these programs too, the number of measurement cycles to be taken into account can be specified by the constant C8 (see chapter headed "Start Mode").

Program 17 performs a continuous average determination (extended integration time) over a number of measurements in the range 1 to 999999 which must be assigned to the constant C8. A fixed range must be selected (Autoranging can not be used).
CAUTION in the case of polarity changes:
A pause of 100 ms results when zero is undershot or overshot by more than 1°/oo of the readout span for the measuring range which is being used.

PROGRAM 30 PROGRAM COMBINATION

Up to three different programs (see mathematics programs set) can be combined in any order to constitute a new program. Each successive program thereby operates on the last computation result of the preceding program.
The sequence of the programs must be entered as a contiguous string of decimal digit pairs preceded by a decimal point in the constant C9. The sign is ignored. For example, if the value +/- .040703 is assigned to C9, i.e. the sequence of decimal digit pairs 04,07,03 in this order, then program 04 runs first, then program 07 using the result of program 04, and finally program 03 runs using the result from program 07.

CAUTION: When combining programs, a combination may contain only one (or no) program for each of the following groups:

1st Group	Programs	11 to 13
2nd Group	Programs	14 to 16
3rd Group	Programs	17 to 20

If a non-valid combination is entered, then the last computation result stays in the display.

PROGRAM 40 START MODE

Outputs the unchanged measurement result after a start (see also the chapter headed "Start Mode").

MATHEMATICS PROGRAMS SET

Prog.No.	Mathematical function	Expression
01	Offset	R = X-C0
02	Multiplication	R = X*C5
03	Ratio	R = X/C4
04	Power	R = X*X/C4
05	Percentage deviation	R = 100*(X-C4)/C4
06	Polynomial	R = C0+C1*X+C2*X*X+C3*X*X*X
07	Logarithm	R = C5* LOG(X/C4)
08	Square root	R = C5* SQR(X/C4)
09	Tangent	R = C5* TAN(X/C4)
10	Arctangent	R = C5* ARCTAN(X/C4)
11	Limit	C7 greater X greater C6
12	Limit greater	X smaller C7
13	Limit smaller	X greater C6
14	Maximum measured value	R = Xmax
15	Minimum measured value	R = Xmin
16	Difference between extreme values	R = Xmax - Xmin
	In the following expressions, summation is over all values for k from 1 to i	
17	Average	R = SUM(Xk)/i = X'
18	Variance	R = SUM((Xk-X')(Xk-X'))/(i-1)
19	Standard deviation	R = SQR(Variance)
20	Root mean square (RMS) value	R = SQR(SUM(Xk*Xk/i))
30	Program combination	

40	Start Mode	The measurement result is output after a start *)
97	IEEE-Setting	Setting the IEEE-bus address and terminating character
98	Self-test	Call by pressing the "Comp" key after selecting program 98
99	Calibration	

Do not choose an integration time shorter than 1s for programs 07-10 and 17-30 because otherwise some measurements may be ignored as a result of too long computation time.

*)Provided for Start mode without using any special mathematical function

Selecting Program Numbers for the Computation Programs

The programs can be changed in the course of a measurement and also in the course of a computation, but not during an automatic calibration run.

Pressing the "Program" key cancels the status measurement result or computation result, measuring time and constant. The program numbers appear in the bottom display on the key-board and change by digit shift-in from the right.

1.) Press the "Program" key
2.) Enter program number digits between 0 and 9 with the left keyset, in any desired sequence and string length. The last two entered digits, as finally displayed, represent the selected program number.
3.) To terminate program number entry: Select Measurement, Compute, Integration-Time or Const.

Entering Constants for the Computation Programs

10 constants whose values are freely programmable, are available for the computation programs. The constant designation numbers associated with the individual computation programs are listed in the description for the "Mathematics Programs Set".

The designation number of the selected constant appears as "Cx" in the bottom display on the keyboard and the currently assigned value of this constant is shown in the main display. The last measurement result or the last computation result can be assigned as value for a constant.

To select and display a desired constant:

1.) Press the "Const." key.
2.) Enter the designation number for the desired constant on the decimal keyset (blue legend, 0-9). The designation number and the currently assigned value of the constant are displayed.
3.) To terminate selection of the constant designation number: Press "Meas", "Comp", "Integration-time" or "Prog".

To inspect several constants in sequence, the steps 1-3 defined above must be executed for each constant. It is not possible to inspect a sequence of constants just by entering their designation numbers after pressing the "Const" key only once.

To assign the last measurement or computation result as a value for a constant:

1.) Press the "Const" key
2.) Select the constant designation number.
3.) Press the "Enter" key. This transfers the measurement or computation result which was standing in the main display to the constant.
4.) Terminate the entry procedure by pressing one of the keys "Meas", "Comp", "Integration-Time", "Prog" or "Const"

To assign an arbitrary value to a constant:

1.) Press the "Const" key
2.) Select the constant designation number
3.) Use the decimal keyset (blue legend) to enter the desired value for the constant, with the decimal point in the right position. Up to seven digits can be entered.
The sign may be entered and modified, at any point during the numerical value entry, by pressing the sign key. Each successive keypress changes the sign.
4.) Terminate the entry by pressing one of the keys "Meas", "Comp", "Integration Time", "Prog" or "Const"

10. START MODE (Meaning of the Constant C8)

A specified number of measurements can be triggered in start mode. The desired number of measurements must be assigned as value (in the range 1 to 999999) for the constant C8. Start mode is possible only in computation ("Comp") operating mode.

Start mode can be activated or deactivated by programming the constant C8 accordingly. Start is triggered via the IEEE bus interface (see section describing the IEEE bus interface), or by pressing the "Comp" key repeatedly. The meanings of the individual digits in the constant C8 are:

C8 =	+/-	X1	X2 X3 X4 X5 X6 X7	.	X8
	ignored		number of measurements to be evaluated		status

Digit X8 (first digit to the right of the decimal point) switches start mode on and off.

The following status levels are possible:

X8 = 0 The multimeter makes a continuous stream of measurements without waiting for a start command.

X8 = 1 The multimeter makes a single measurement in response to a start command, and issues a service request (SRQ) on the IEEE bus

X8 = 2 After a start command, the multimeter makes the number of measurements specified by X2,..,X7 of C8, shows the result of each successive measurement in the display and also issues a SRQ each time on the IEEE bus.

X8 = 3 After a start command, the multimeter makes the number of measurements preselected in C8. The result is displayed only after completion of all measurements and only one SRQ is transmitted on the IEEE bus

If a new start command arrives before complete execution of the previous one, then the first start sequence is aborted and execution of the new start command commences from the beginning.

In order that the measurement result can be selected again, also after switching over to "Comp", restart does not take place at once after switching over to "Comp", but only after pressing the "Comp" key again.

11. IEEE 488 Bus Interface

Functions supported by the IEEE 488 Bus interface

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

11.1 Programming the Digital Multimeter 6030 via the IEEE 488 Bus Interface

The device addresses and the end characters can be set using the keyboard of the digital multimeter. For this purpose, press the "program" key and then enter program number 97 on the left keypad with the blue legend decimal number keys 0 to 9. The main display now shows, for example, "IEEE 07.8", i.e. the digital multimeter is set to the device address 7 and the end character 8 in this example. The digital multimeter is set to this device address and end character as delivered from the factory.
The device address and the end character can now be changed with the keys in the decimal keypad. Hereby the digits are shifted into the display from right to left, so that three digits must always be entered for a new setting. Just enter the three digits in correct order, without the period between the device address and the end character. Device addresses smaller than 10 must be entered with a leading zero.
Legal values for the device address range from 01 to 30, and 9 different end characters can be selected from the following list:

Designation	End characters
0	CR + EOI
1	CR
2	LF + EOI
3	LF
4	CR + LF + EOI
5	CR + LF
6	LF + CR + EOI
7	LF + CR
8	EOI

You can change the setting shown in the display any number of times, just by entering three new digits. When the display shows the desired setting, press any one of the keys "integration time", "Prg", "Const", "Meas" or "Comp". This writes the setting shown in the display into memory and the digital multimeter exits "set device address"-mode.

If it is desired to take over these new settings into protected memory, set the calibration switch on the rear of the unit to the position "Cal" before takeover of the address data.

```
**********************************************************
*  Do not forget to return the calibration switch to the  *
*             Position     " M E A S "                    *
**********************************************************
```

The new device address will now not be lost when the digital multimeter is switched off. The keyboard of the digital multimeter is disabled after the digital multimeter has been accessed once via the IEEE bus interface. The keyboard is enabled again when the "REN" becomes inactive or when the controller transmits the addressed command "GTL"(Go To Local).

The digital multimeter does not interrupt its continuous measuring sequence within the talker function. The digital multimeter understands the universal commands "DCL"(Device CLear), "SPD"(Serial Poll Disable), and "SPE"(Serial Poll Enable). The command "DCL" sets the digital multimeter in status "Direct Voltage measurement with 1000V range".

Of the addressed commands, the digital multimeter understands the following: "GTL"(Go To Local), "GET"(Group Execute Trigger) and "SDC"(Selected Device Clear). The "GET" command starts the continuous measuring sequence if the digital multimeter has been stopped previously. The command "SDC" switches the multimeter to the function status "Direct Voltage Measurement with 1000Vdc range"
To program the digital multimeter, follow the instructions of the corresponding description or proceed according to the table at the end of this chapter. Data entry can be in the form of a single string of up to 30 characters, e.g. "MRT3R4F1P20", or in the form of shorter strings for individual logic blocks, e.G. "MR", "P01", "C5", "C5123.5" or "T4".

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

Device Messages Recognized by the Digital Multimeter 6030

"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 computation result of the selected program appears in the display of the digital multimeter and in the character string of the talker function.

"P" The digital multimeter expects a program number after receiving "P". The program numbers are shifted through from right to left. For example, if program "01" was set and the next received program number is "P2", then the new program number is "12". "P21" sets program number "21", irrespective of the previous program number. To terminate the entry, one of the messages measurement results "MR", computation result "CR", constant number "CX" or measuring time "TX" must always be sent (even when transmission of the device message was disjunct). For example, "P21T5" will terminate an entry.

"C" The digital multimeter expects a constant designation number after receiving "C". For example, if "C5" is entered, the currently assigned value of the constant No.5 will appear in the main display of the multimeter and the bottom right supplementary display reads "C5". The next characters expected by the digital multimeter are the new numerical value of the constant. If no new value is to be entered or to terminate the entry, one of the terminating messages measurement result "MR", computation result "CR", program number "Pxx" or measuring time "Tx" must be sent, even if transmission of the complete device message was disjunct.
If a constant number is entered and the digital multimeter then read out, the first message unit of the talker function contains the currently assigned value of the constant in the 1st to 13th characters and the second message unit contains the characters "CX" in positions 14 an 15, as long as no terminating combination "MR", "CR", "Pxx" or "Tx" has been sent.

The constants can be entered in two numerical forms:

1. The normal form: The most significant decimal digit is entered first, then proceeding in order to the least significant digit. The decimal point is the delimiter between positive and negative exponent digits. The sign can be changed at any stage.

2. With mantissa and exponent:
The mantissa can have up to 8 digits and thee decimal point may lie anywhere in the mantissa. The sign can be changed at any stage of entering the mantissa digits. The exponent is prefixed with the letter "E" and consists of a single digit not greater than 7. The sign must be changed to negative, if desired, before entering the exponent digit. No sign for the exponent defaults to positive sign.

Example: The entry +300.1-2E+3 is interpreted as -300.12E+3.

The same as for keyboard entry, the last computation or measurement result can be assigned to a constant via the IEEE 488 bus too. For this purpose, send "CxCMR" (or CR, Tx, Pxx instead of MR). Here too, the measurement or computation result which previously stood in the main display, is assigned to the constant x.

"R" After receiving "R", the digital multimeter expects a digit specifying a measuring range. Note that various ranges are valid entries only in conjunction with the corresponding measuring function:

R1 = 0.1 V/kOhm only with Vdc and Ohm
R6 = 10000 kOhm only for Ohm
R7 selects autoranging and can be used for all measuring functions. It is cancelled again the next time a specific range is selected.

"D" Selects the measuring function "Direct Voltage" in the digital multimeter.

"AD" Selects the measuring function "RMS value of alternating voltage with superimposed direct voltage component".

"A" Selects the measuring function "Pure Alternating Voltage" Any superimposed direct voltage component is rejected.

"O2" Selects the Ohm measuring function in two-wire configuration.

"O4" Selects the Ohm measuring function in four-wire configuration.

"F0" 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 has just been called. For example, the message "CF1" is interpreted as "C1", i.e. a call to constant No.1.

"S" When the constant C8 has first been loaded with the appropriate value and a mathematical program has been selected, a measurement can be started with the command "S" (see description of "Start Mode"). All status levels are possible, the same as for manual programming. The interval between successive trigger commands must be longer than the set measuring and computation time.

"Q" The multimeter expects a 0 or a 1 after receiving "Q". 0 sets operation with and 1 sets operation without service request.

"Z" Initiates an offset correction run. The instructions given in the corresponding chapter are valid.

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

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

Device Messages Recognized by the Multimeter 6030

MR	Measurement result				
CR	Computation result				
Pxx	Program number				
Cx	Constant number				
R1	Range	0.1	Vdc,		kOhm
R2	Range	1	Vdc,	Vac,	kOhm
R3	Range	10	Vdc,	Vac,	kOhm
R4	Range	100	Vdc,	Vac,	kOhm
R5	Range	1000	Vdc,	Vac,	kOhm.
R6	Range	10000			kOhm
R7	Autoranging				
D	Direct voltage				
A	Alternating voltage				
AD	Alternating voltage with direct voltage component				
02	Ohm/2 - wire				
04	Ohm/4 - wire				
F0	(F/Zero) Filter off				
F1	Filter on				
T0	Measuring time	100	ms		
T1	Measuring time	200	ms		
T2	Measuring time	400	ms		
T3	Measuring time	1	s		
T4	Measuring time	2	s		
T5	Measuring time	4	s		
T6	Measuring time	10	s		
T7	Measuring time	20	s		
S	Start				
Q0	(Q/Zero) Without SRQ				
Q1	With SRQ				
Z	Zero				
L0	(L/Zero) Digital multimeter transmits only measurement result				
L1	Digital multimeter transmits measurement result and programmed status data				

11.2 Device Messages Transmitted by the Multimeter

The device messages transmitted by the multimeter as talker consists of a data telegram which is generated as a coherent unit with terminator. The data telegram comprises two subunits, the first one of which contains measurement or text data and the second one of which contains programming status data. Each subunit is a string with a fixed number of characters. Thus no delimiter is required or transmitted between the two subunits. The first unit has 13 characters, the second one 16 characters.

If character transmission by the digital multimeter is aborted before transition to TIDS status, transmission recommences with the first character of the data telegram after renewed call-up. The terminating character(s) of the data set are as chosen according to the section headed "Programming the digital multimeter via the IEEE 488 bus interface".

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

Description of the Transmitted Data Telegram

The contents of the main display are output in the 13 characters constituting the first subunit string. These are chiefly measurement and computation results, values assigned to constants and text messages. The measurement and computation results as well as the values assigned to constants are always output in right justified format, i.e. they terminate in the 13th character position.

The first character is always the sign "+;-" for direct voltage measurement results, computed results and values of constants. A sign is not required for resistance and alternating voltage measurements. All unrequired leading digits in front of the measurement and computation results or values of constants are filled with Zero characters.

Values of constants and the results of measurements and computations are output in format with mantissa and exponent without embedded blanks, e.g.

"+01.987654E+2" .

Text messages comprise

"ERROR x", "NULL ", "CONTR x",
"CAL ", "HI ", "LO "

These messages are always output left justified, i.e. they start in the first character position. All unrequired character positions are filled with blanks.

The second substring starts with the 14th character. It outputs the programming status of the multimeter.

The characters have the following meanings:

14th and 15th character
"DC", "AC", "AD", "02", "04"

Specify the measuring function:

DC = Direct voltage measurement
AC = Alternating voltage measurement without direct voltage component
AD = Alternating voltage measurement with direct voltage component
02 = Ohm measurement in 2-wire circuit
04 = Ohm measurement in 4-wire circuit

16th and 17th character
"MR", "CR", "Cx"

MR = Measurement result
CR = Computation result
Cx = Designation number of the last selected constant

18th to 20th character
"Pxx"

The number of the selected program

21st to 23rd character
"Rxx"

The set measuring range is output in autoranging mode too.

R01 = Range	0.1	Vdc, ...,	kOhm
R02 = Range	1	Vdc, Vac,	kOhm
R03 = Range	10	Vdc, Vac,	kOhm
R04 = Range	100	Vdc, Vac,	kOhm
R05 = Range	1000	Vdc, Vac,	kOhm
R06 = Range	10000	..., ...,	kOhm

22nd character

The 22nd character states whether or not autoranging is switched on, e.g.

R11 = Range 0.1 Vdc, ..., kOhm with autoranging on
R01 = Range 0.1 Vdc, ..., kOhm with autoranging off

24th and 25th character
"Fx"

Specifies whether or not the filter is in circuit
F0 = Filter off
F1 = Filter on

26th and 27th character
"Tx"

Specifies the set integration time
T0 = 100 ms
T1 = 200 ms
T2 = 400 ms
T3 = 1 s
T4 = 2 s
T5 = 4 s
T6 = 10 s
T7 = 20 s

The measuring time display for T5-T7 is counted down to 0 in 1sec rhythm. But the intermediate times, e.g. 19,18,17,...are not transmitted via the IEEE 488 bus. For example, just T7 is transmitted for 20s.

28th and 29th character
"QX"

Specifies whether or not SRQ is sent
Q0 = without SRQ
Q1 = with SRQ

Summary of the Device Messages Transmitted by the Multimeter 6030

(IEC 625 Part 2)

```
1st. character                29.th character
!                             !
+X.XXXXXXXE+XDCMRPxxRxxFxTxQxEND
-           - ACCR
              ADCx
              02
              04
(-----------)(--------------)
 1st. data      2nd. data
    block          block
```

+,-	Sign of mantissa for DC, Zero for AC,AD,02 and 04
X.XXXXXXX	8 digit mantissa
E+X	1-digit exponent with sign
DC,AC,AD,02,04	Measuring function: DC - Direct voltage AC - Alternating voltage without direct voltage component AD - Alternating voltage with direct voltage component 02 - Resistance, 2-wire-circuit 04 - Resistance, 4-wire-circuit
MR,CR,Cx	Type of display MR - Measurement result CR - Computation result Cx - Value of a constant
Pxx	Program number
R01-R06 R11-R16	Measuring range 0.1 to 10000, autoranging off Measuring range 0.1 to 10000, autoranging on
F0,F1	Filter status (0 = without, 1 = with Filter)
T0 - T7	Measuring time 100 ms to 20 s
Q0,Q1	SRQ status (0 = without, 1 = with SRQ)
END	Terminating character(s) as selected when setting the device address. For terminating character No.8, EOI is transmitted together with the final (29.th) string character.

Service Request Function (SR Interface Function)

The IEEE 488 bus interface of the Type 6030 Digital Multimeter is equipped with a service request function (SR function, SRQ). The transmitted status bits have the following meanings:

Bit 1: Measurement end
Bit 2: Overflow during computation
Bit 3: Overflow during measurement
Bit 4: Ohm plausibility error (Error 3)
Bit 5: Outside limit
Bit 6: Reset
Bit 7: SRQ

Bit 1 (measurement end) can appear together with the other status bits, in order not to falsify the SRQ in the case of a fast measurement sequences.

Bit 6 appears with a reset, i.e after power-up or severe external interference. A reset reestablishes basic program status of the digital multimeter 6030 (DC, 1000V, etc.), so that the controlling computer must reprogram the Digital Multimeter 6030 according to section 11.1 after every reset

Programming Examples for the IEEE 488 Bus Interface

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

COMMODORE CBM 3032

Control of the digital multimeter by the CBM 3032. The CBM 3032 is the controller and the digital multimeter is the listener.

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

Reading the character string from 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
                                "7" is the device address of the
                                digital multimeter
          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 4051 is the controller, the digital multimeter is the listener

```
4051:  100 PRI " YOUR ENTRY PLEASE "
       110 INP A$
       120 WRI @  7:A$
                                "7" is the device address of the
                                digital multimeter
```

Reading the character string from the digital multimeter by the Tektronix 4051. The Tektronix 4051 is the controller, the digital multimeter is the talker.

```
4051:  140 INP @  7:B$
                                "7" is the device address of the
                                digital multimeter
       150 PRI B$
       160 GO TO 100
```

HEWLETT PACKARD HP 85

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

Control of the digital multimeter by the HP 85. The HP 85 is the controller and 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$(50)
                          string size agreement ;choose large
                          enough, at least 29 characters
        550 ENTER 707;A$
        580 DISP A$
        590 END
```

HEWLETT PACKARD HP 87

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

```
HP 87 :  10 DIM A$ [40], B$ [30]
```

string size agreement, choose large enough, at least 29 characters

Control of the digital multimeter by the HP 87. The HP 87 is the controller and the digital multimeter is the listener.

```
20 INPUT B$
```

entry via HP 87 keyboard (voltmeter-code), up to 30 characters

```
30 OUTPUT 707;B$
```

string transfer from the 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.

```
40 ENTER 707;A$
```

string transfer from digital multimeter to the HP 87 (26-28 characters)

```
50 PRINT A$

60 GOTO 20
```

HEWLETT PACKARD HP 87

Operation of the digital multimeter as before, but now with SRQ.

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

```
HP 87 :  10 ON INTR 7 GOSUB 500
                        checks IRQ from IEEE 488 bus
         20 DIM A$ [30], B$ [40]
                        string size agreement, choose
                        large enough, at least
                        29 characters
         30 INPUT B$
                        entry via HP 87 keyboard , e.g.:
                        "Q1" for SRQ enabled
         40 OUTPUT 707;B$
                        string transfer from the HP 87 to the
                        digital multimeter
         50 ENABLE INTR 7;8
                        enable IRQ initiated by SRQ
         60 GOTO .....
                        line number of user program


        500 STATUS 7,1; W

        510 P=SPOLL (707)
                        transfer of the SRQ status register
        520 IF P>=63 THEN GOSUB 1000
                        evaluation of the register contents
        530 ENABLE INTR 7,8
                        enable IRQ initiated by SRQ
        540 RETURN



       1000 ENTER 707;A$
                        read in the message from the
                        digital multimeter
       1010 PRINT A$, P, "DEVICE NO.7"
                        and print it on the screen together
                        with status information
       1020 RETURN
```

APPLE II with CCS Interface Module 7490

```
  2 PRINT
  3 PRINT "SET DMM6030  TO ADDRESS 07.0 ."
  5 PRINT
  6 PRINT "WHEN YOU HAVE DONE SO,"
  7 PRINT "PRESS THE RETURN KEY."
  8 INPUT C$
 10 DIM A$(30), B$(30)
                    dimension the string arrays sufficiently
                    large
 12 PRINT:PRINT
 15 PRINT "YOUR ENTRY PLEASE:"
 20 INPUT B$
 30 PR #3
                    initialize slot 3 for output
 40 PRINT " @ ':"
                     @  switches to address mode;
                        REN and ATN active;
                     '  transmits listener address 7;
                     :  switches back to Command mode;
 50 PRINT "'";B$;"'"
                    the message is transmitted;

                     '  switches text mode on and off;
 60 PRINT " @ G:"
                     @  switches to address mode;
                     G  transmits talker address 7;
                     :  switches back to Command mode;
 70 PR #0
                    data from IEEE bus are printed directly
                    on the screen
 80 INPUT " ";A$
                    read-in the message from the IEEE bus
 90 IN #0
100 GOTO 20
```

Lines 20 to 100 are essential.

Lines 2 to 15 are optional for user guidance.

12. CALIBRATION

12.1 Aligning the PLL Circuit to Different Mains Frequencies

The digital multimeter is delivered with the PLL circuit factory aligned to the customary mains frequency in the country of destination. A correction is necessary if the unit is to be operated on a different mains frequency. For this purpose, unscrew the cover of the unit. Connect an oscilloscope to the test pin in the front top corner of the vertical PC board. Connect oscilloscope ground to the hexagonal bolt on the top side of the PC board. Adjust the trimmer on the PC board for 4V +/-0.5V. The superimposed control signal voltage should have a peak-peak amplitude of less than 0.5 V.

When converting to a different mains frequency (e.g. from 50Hz to 60Hz), the EPROMs on the microprozessor board must be replaced by the correct ones for the new mains frequency. If it is omitted, then the actual measuring times will differ from the legend on the front panel of the digital multimeter, in opposite ratio to the frequency change (e.g. from 1 second to 833 msec).

12.2 Calibration

Allow the unit to reach final operating temperature over a period of 2 to 3 hours before commencing calibration. The digital calibration facility incorporated in the Digital Multimeter 6030 allows single range or total recalibration of the unit. It is not necessary to open the unit for this purpose. Calibration is possible via the IEEE bus as well as via the front panel keyboard. The correction values with checksum are stored in CMOS-RAM with Lithium backup battery giving about 10 years service life. To prevent unintentional destruction of the correction values, they are protected by a recessed slideswitch located at the left on the rear panel of the unit. The settings of this switch are designated "MEAS" and "CAL". The normal setting is "MEAS". To recalibrate the digital multimeter, move the switch from "MEAS" to "CAL", using a small screwdriver or other suitable tool. The correction values are now unprotected and therefore the unit must not be disconnected from the mains voltage in this state.

"CAL" status is indicated by the legend "CAL" periodically appearing in the main display. An input offset compensation run must now be made before recalibrating a measuring range. For offset compensation short the input sockets "V/Ohm" of the digital multimeter, select autoranging in function "Vdc" and then press the "Zero" key. The multimeter thereupon determines zero-correction values for all Vdc measuring ranges in succession and stores them in the protected RAM. To correct only a single measuring range, select this range instead of autoranging.

12.2.1 Calibrating the Direct Voltage Measuring Range

First select the measuring range and the calibration program 99. For this purpose, press the keys "Prg","9","9" in this order. The blue legend is valid. Then connect an exactly known positive or negative reference voltage between 5% and 100% (preferably between 50% and 100%) of the display span in the respective measuring range, to the input sockets. Enter the nominal value into the constant number 9. For this purpose, press the "Const" key and then key "9", followed by entry of the decimal value of the reference voltage with decimal point, via the blue legend numerical keyset.
Then start the calibration run by pressing the "Comp" key. The multimeter now starts a calibration procedure. This is indicated by the text "CAL." in the main display. Calibration takes 20 seconds. The keyboard is disabled during this time. The calibration time is counted down in seconds from 20 to zero in the upper right supplementary display. Calibration of the selected measuring range is finished when the countdown has been completed. To recalibrate further ranges, select these successively by keystrike and repeat the procedure as described above, except for calling program 99.

Calibration via the IEEE bus is analogous to calibration by manual control on the front panel. Consult chapter 11 for the operating instructions for the IEEE bus. When no further ranges and functions are to be recalibrated, terminate the calibration procedure by returning the switch on the rear panel of the multimeter from "CAL" to "MEAS".

12.2.2 Calibrating the Resistance Measuring Ranges

The resistance measuring ranges are calibrated in 4-wire circuit. First of all make Zero offset correction in function setting kOhm/4 as described in section 12.2. Also observe the instructions given in the section "Operating Instructions Ohm/kOhm". The calibration procedure for the resistance measuring ranges is analogous to that for the direct voltage measuring ranges.

12.2.3 Calibrating the Alternating Voltage Measuring Range

The alternating voltage measuring ranges can be calibrated only with alternating voltage coupling. For Vac calibration too, first make zero offset correction as described in section 12.2, using function setting Vac. 1 kHz sinusoidal voltages are required as reference. The calibration procedure is analogous to that for direct voltage measuring range calibration.

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

13. Compensating the Negative Feedback Vac

13.1 Offset Alignment of the Alternating Voltage Attenuator

Before initial calibration of the alternating voltage section of the 6030, align the two offset trimmers R60 and R56 (this is normally carried out in the factory). First allow half an hour warm-up time to elapse. Set the digital multimeter to Vac without direct voltage component, 10 V measuring range and 1s Integration time. Connect a digital voltmeter with 10 µV resolution to the test points M1 (R57, see layout diagramm for preamplifier 6030-V) and M3. Then adjust trimmer R60 for reading 0.00000 V +/-100µV. Thereafter, adjust the trimmer R56 to make the voltage reading between the test points M3 and M2 (R55) equal to 0.00000 V +/-20µV.

13.2 Coarse Precompensation of the Negative Feedback Vac

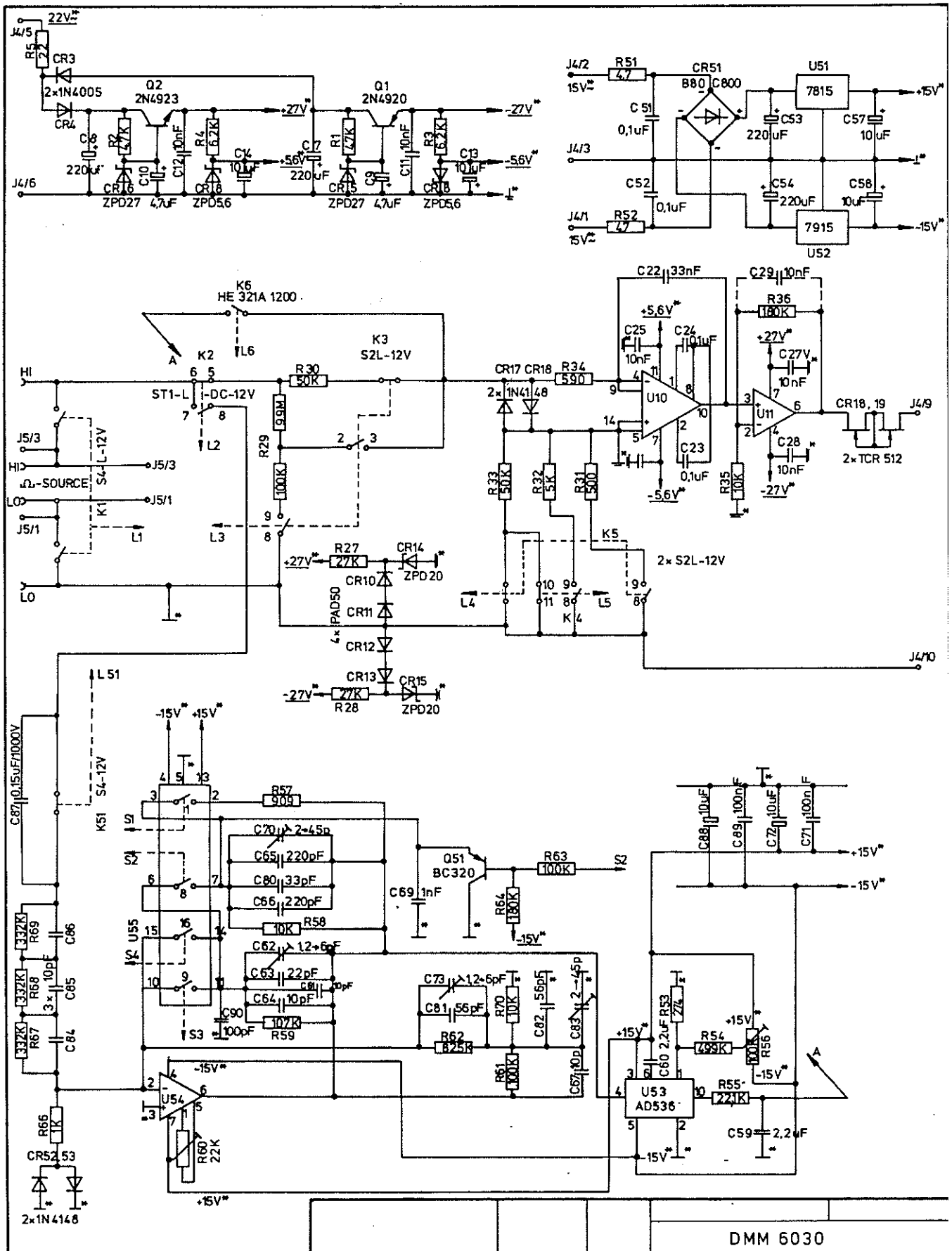
The negative feedback network of the alternating voltage attenuator is coarsely aligned using a rectangular waveform signal. Use a good rectangular waveform signal with 10 kHz frequency and 4V peak-peak amplitude (e.g. from a Philips PM 5715 signal generator) and an oscilloscope with at least 20 MHz bandwidth and accurately aligned signal probes. Apply the rectangular signal voltage to the "V/Ohm"-input sockets and connect the signal probe of the oscilloscope to M1 (R57, see layout diagramm for preamplifier 6030-V) with oscilloscope ground to M3. Now successively align the 1V-range with C73 and C83, the 10V-range with C62 and the 100V-range with C70, in each case for optimum rectangular waveform (compare with the input voltage via a second channel of the oscilloscope if available).

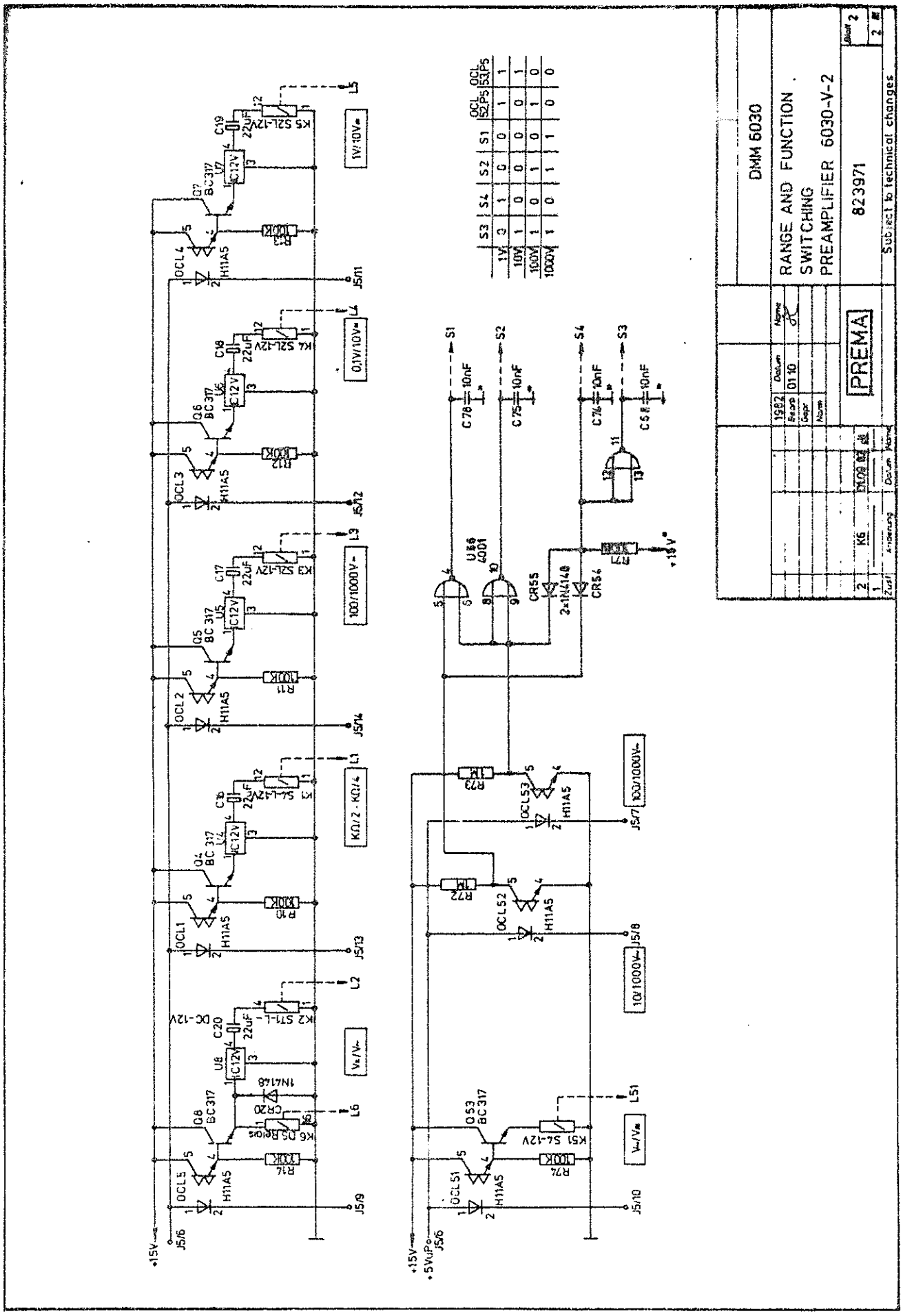
13.3 Digital Calibration of the Alternating Voltage Section

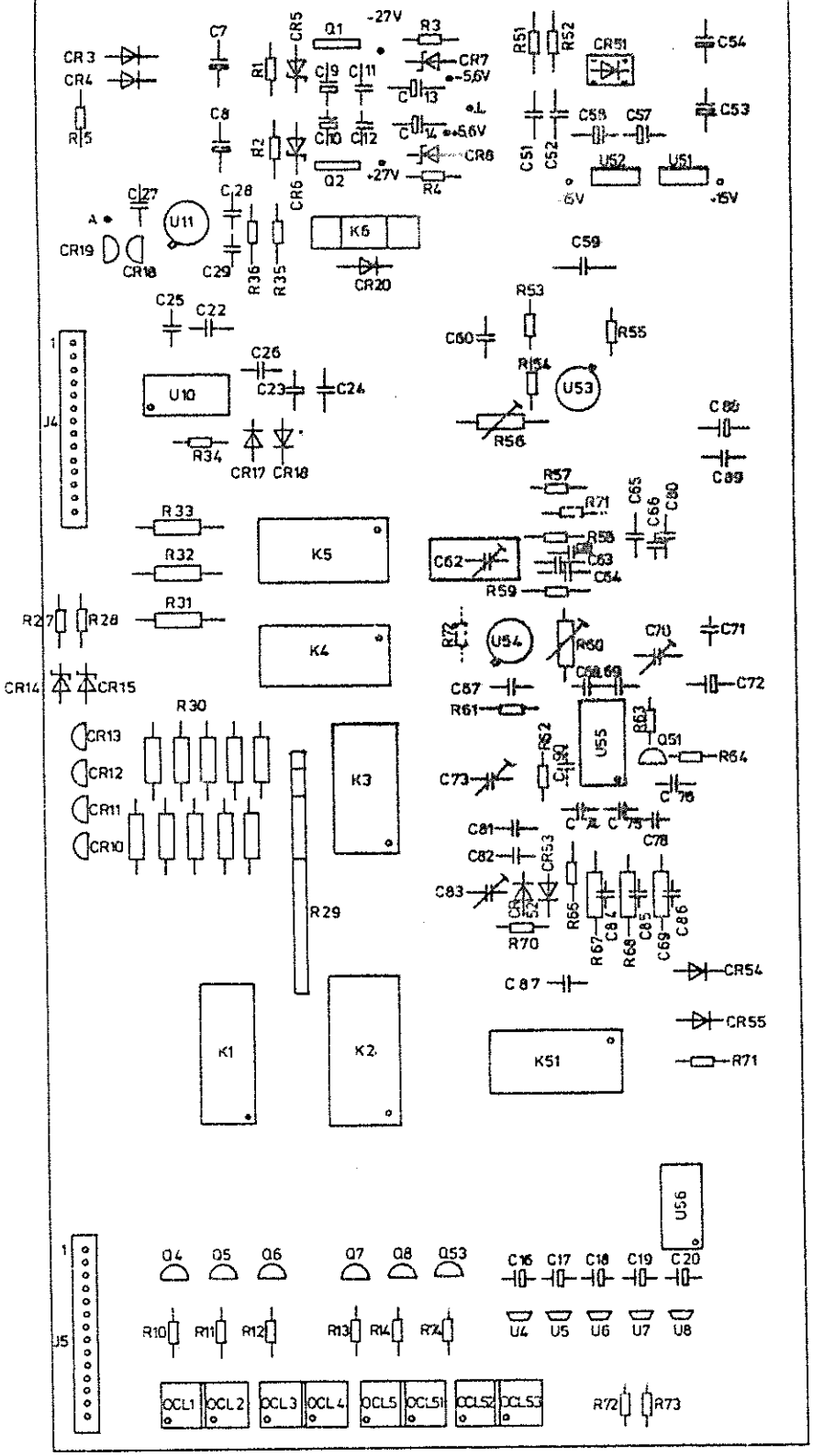
(see chapter calibration)

13.4 Vernier Compensation of the Negative Feedback Vac

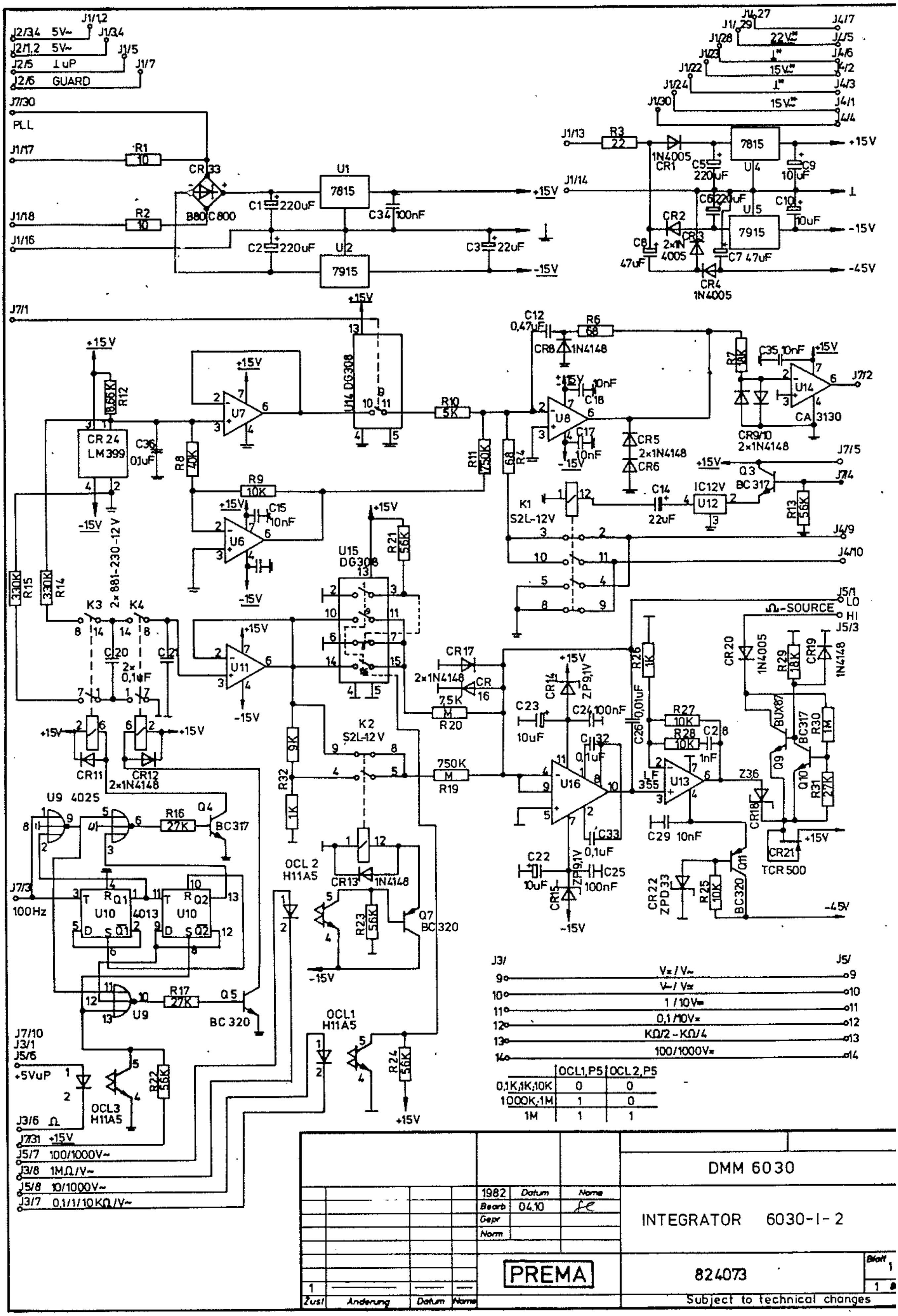
Use a precision sinewave signal generator, e.g. Fluke 5200A, connected to the "V/Ohm" input sockets of the digital multimeter. Connect the low potential pole (with respect to ground) of the signal generator to the "V/OHM LO" input socket of the digital multimeter. Set the signal generator clock frequency to 80 kHz. Successively align the 1 V range with C73, the 10 V range with C62 and the 100 V range with C70, in each case for reading 100000 +/- 20 digits in the main display of the digital multimeter.

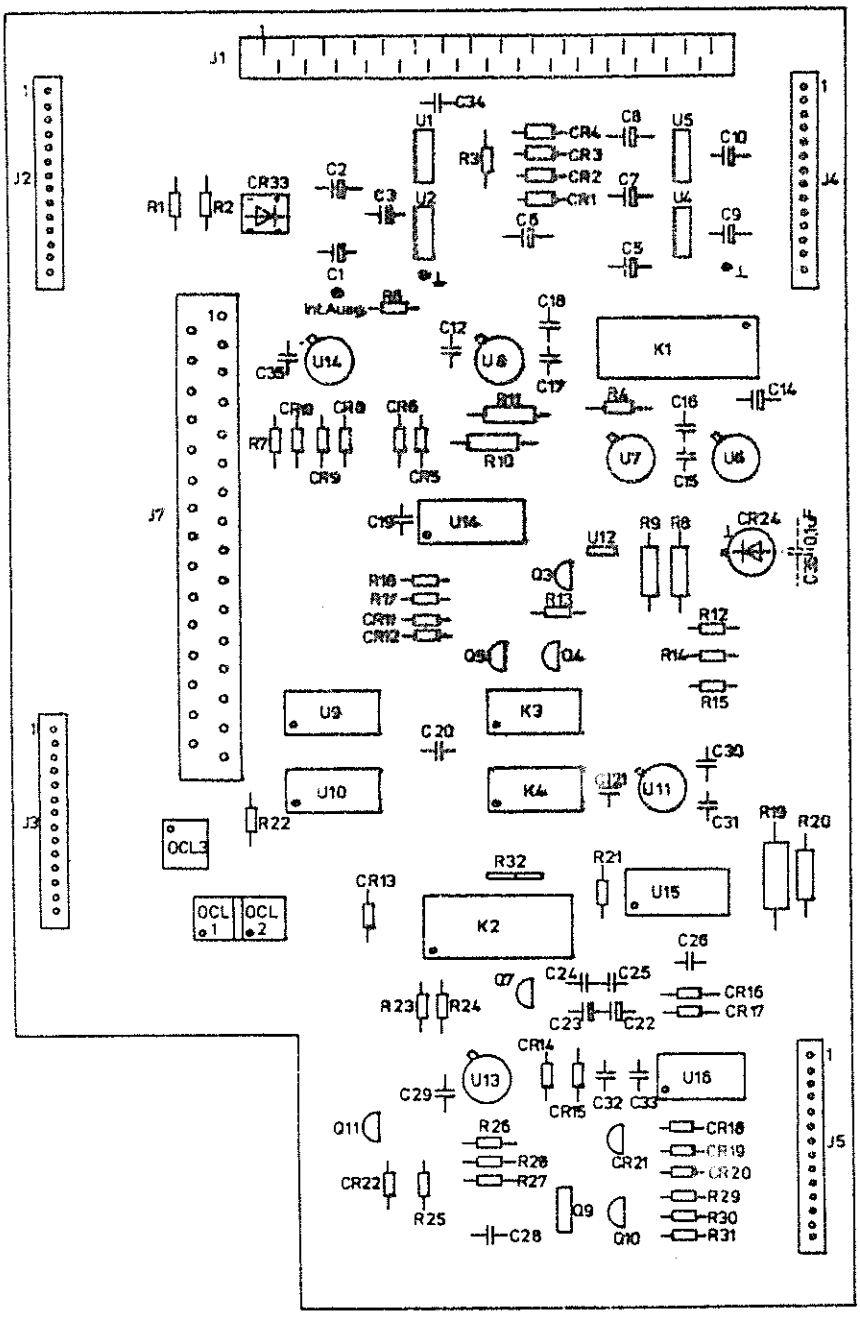

22V~
J4/5
R5 22
CR3
2×1N4005
CR4
Q2 2N4923
Q1 2N4920
+27V*
-27V*
+5,6V*
-5,6V*
C8 220uF*
R2 4,7K
C12 10nF
R4 6,2K
C14 10uF
C7 220uF
R1 4,7K
C11 10nF
R3 6,2K
C13 10uF
C9 220uF*
C10 4,7uF
CR6 ZPD27
CR8 ZPD5,6
CR15 ZPD27
CR16 ZPD5,6
J4/6
J4/2
15V~
R51 4,7
CR51 B80 C800
U51 7815
+15V*
C51 0,1uF
C53 220uF
C57 10uF
J4/3
C52 0,1uF
C54 220uF
C58 10uF
J4/1
R52 4,7
7915
U52
-15V*
K6
HE 321A 1200
A
K2
L6
K3
S2L-12V
HI
ST1-L
DC-12V
R30 50K
R29 99M
100K
L2
J5/3
S4 L-12V
Ω-SOURCE
LO
K1
J5/1
L1
L3
CR17 CR18
2×1N4148
R34 590
C22 33nF
C29 10nF
R36 180K
C25 10nF
C24 0,1uF
+5,6V*
+27V*
C27V* 10nF
U10
U11
C23 0,1uF
-5,6V*
C28* 10nF
-27V*
R33 50K
R32 5K
R31 500
R35 10K*
CR18, 19
J4/9
2×TCR 512
R27 27K
CR14
ZPD20
CR10
CR11
CR12
CR13
4× PAD50
R28 27K
CR15
ZPD20
K5
2× S2L-12V
L4
L5
K4
J4/10
L51
K51 S4-12V
C87 0,15uF/1000V
-15V* +15V*
S1
S2
S3
U55
R57 909
C70 2-45p
C65 220pF
C80 33pF
C66 220pF
10K R58
C62 1,2-6pF
C63 22pF
C64 10pF
C90 100pF
107K R59
Q51 BC320
R63 100K
C69 1nF
R64 180K
C88 10uF
C89 100nF
C72 10uF
C71 100nF
C73 1,2-6pF
C81 56pF
R70 10K
C82 56pF
C83 2-45p
R62 825K
R61 100K
C67 10p
R53 274
C60 2,2uF
R54 499K
R56 100K
R55 221K
U53 AD536
C59 2,2uF
332K R69
C86
332K R68
10pF
3× C85
332K R67
C84
R66 1K
CR52,53
2×1N4148
R60 22K
U54
DMM 6030
RREAMPLIFIER 6030-V-2
PREMA
823971
Subject to technical changes
1982 Datum Name
Bearb 01.10
Gepr
Norm
Zust Änderung Datum Name
Blatt 1
2 Bl


DMM 6030
RANGE AND FUNCTION SWITCHING
PREAMPLIFIER 6030-V-2
823971
PREMA
Subject to technical changes
S1 S2 S3 S4
OCL S2P5 S1
1V 0 1 0 0
10V 1 0 0 0
100V 1 0 1 0
1000V 1 0 1 1
OCL S2P5 S3
1 1
0 1
0 0
1 0

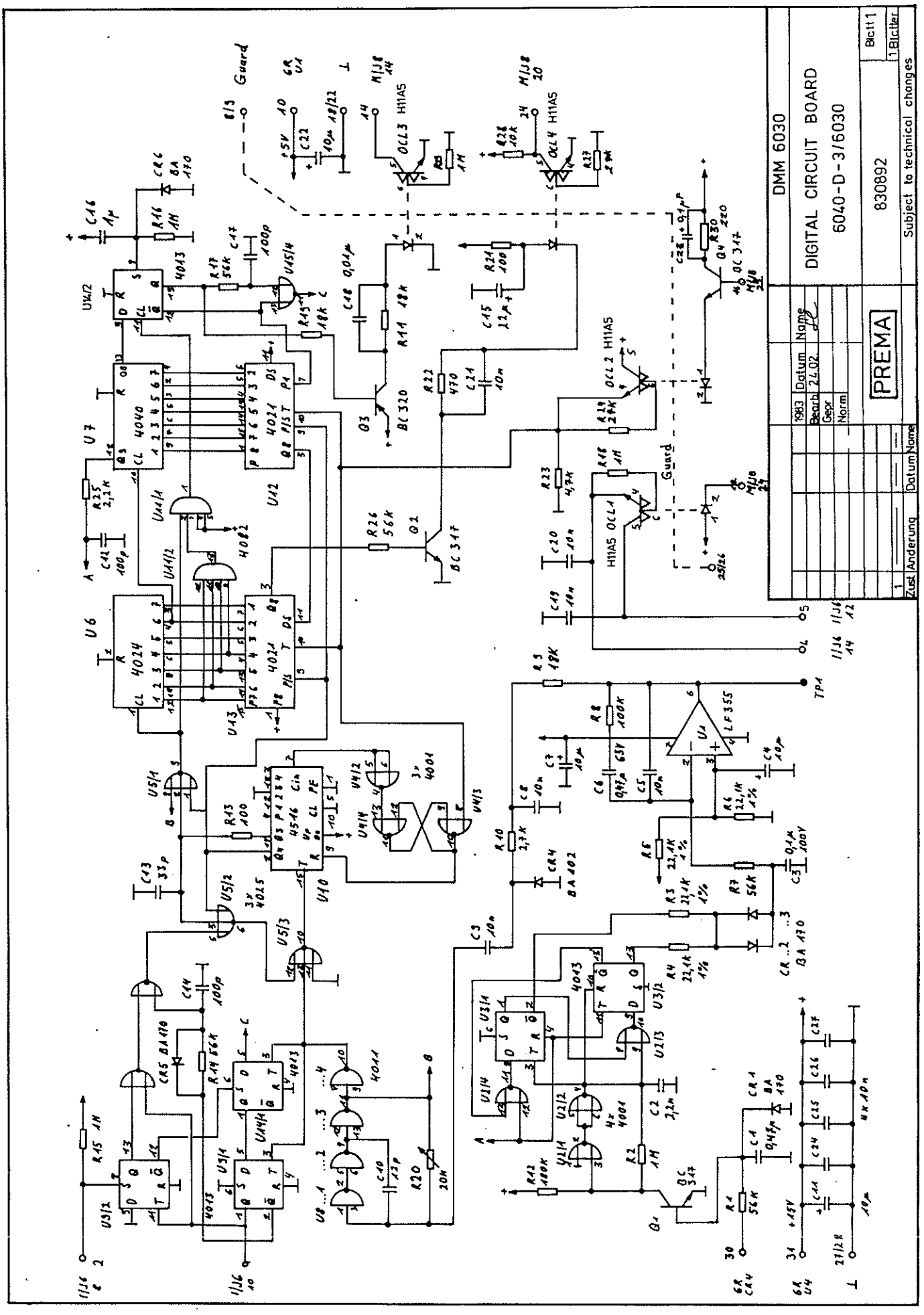


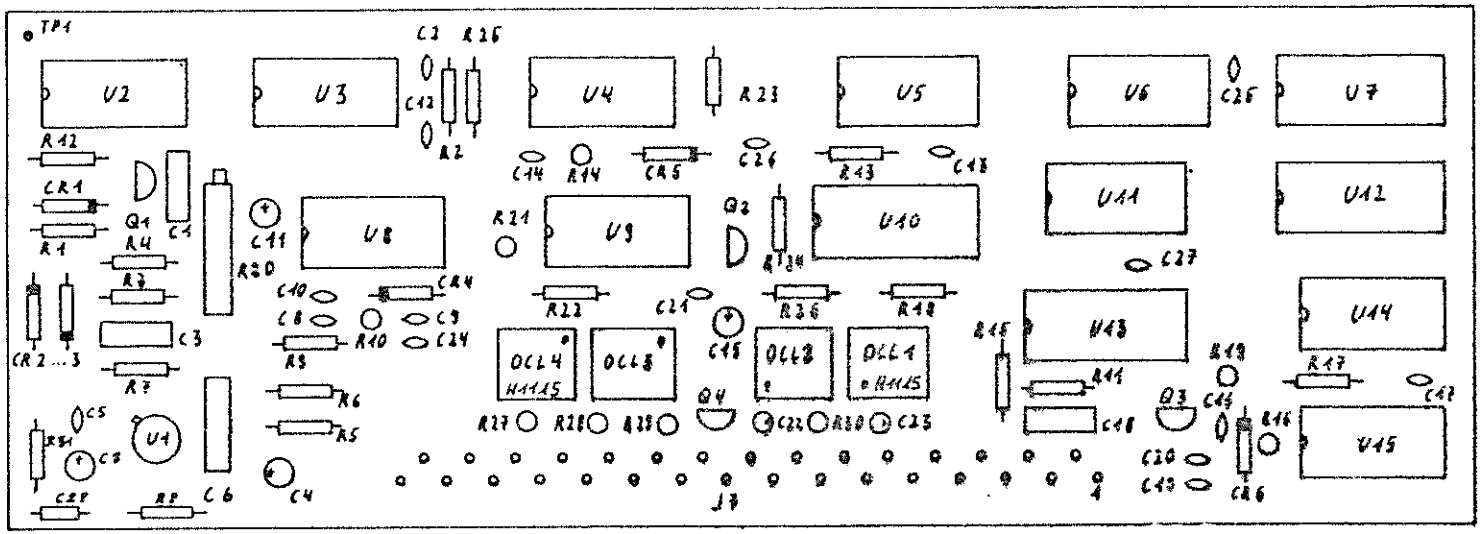
			DMM 6030
	1982 Datum	Name	LAYOUT DIAGRAM OF
	Bearb 0110		PREAMPLIFIER 6030-V-2
	Gepr		
	Norm		
	PREMA		823972
1			Blatt 1 1 Bl
Zust Änderung	Datum	Name	Subject to technical changes


J2/3,4 5V~
J2/1,2 5V~
J2/5 ⊥uP
J2/6 GUARD
J7/30 PLL
J1/17
J1/18
J1/16
CR33 B80C800
U1 7815
U2 7915
C1 220uF
C2 220uF
C3 22uF
C34 100nF
+15V
-15V
J1/13
R3 22
1N4005 CR1
C5 220uF
7815 U4
C9 10uF
J1/14
C6 220uF
C10 10uF
7915 U5
CR2 2×1N 4005 CR3
C8 47uF
C7 47uF
CR4 1N4005
-45V
22V~
15V~
J7/1
U14 DG308
U15 DG308
CR 24 LM399
R12 6.65K
C36 0,1uF
R8 40K
R9 10K
U7
U6
C15 10nF
R10 5K
R11 750K
R4 68
C12 0,47uF
R6 68
CR8 1N4148
U8
C18 10nF
C17 10nF
CR5 2×1N4148 CR6
R7 10K
C35 10nF
U14 CA 3130
CR9/10 2×1N4148
J7/2
J7/5
J7/4
Q3 BC 317
IC12V U12
C14 22uF
R13 5,6K
K1 S2L-12V
J4/9
J4/10
J5/1 LO
Ω-SOURCE HI
J5/3
R15 330K
R14 330K
2× 881-230-12 V
K3
K4
C20 2× 0,1uF C21
CR11
CR12 2×1N4148
U11
R21 5,6K
CR17 2×1N4148 CR16
R20 7,5K
K2 S2L-12V
R32 9K 1K
R19 750K
C23 10uF
CR14 ZP9,1V
C24 100nF
C26 0,01uF
R26 1K
R27 10K
R28 10K
C28 1nF
C32 0,1uF
U16
LF 355 U13
C33 0,1uF
C29 10nF
C22 10uF
CR15 ZP9,1V
C25 100nF
CR20 1N4005
R29 18K
CR19 1N4148
BUX87 Q9
BC317 Q10
R30 1M
R31 27K
Z36
CR18
CR21 TCR500
CR22 ZPD33
R25 10K
Q11 BC320
U9 4025
R16 27K
Q4 BC317
J7/3 100Hz
U10 4013
R17 27K
Q5 BC 320
OCL 2 H11A5
CR13 1N4148
R23 5,6K
Q7 BC320
OCL1 H11A5
R24 5,6K
J7/10
J3/1
J5/6
+5VuP
OCL3 H11A5
R22 5,6K
J3/6 Ω
J7/31 +15V
J5/7 100/1000V~
J3/8 1MΩ/V~
J5/8 10/1000V~
J3/7 0,1/1/10KΩ/V~
J3/ J5/
9 V=/V~ 9
10 V~/V= 10
11 1/10V= 11
12 0,1/10V= 12
13 KΩ/2-KΩ/4 13
14 100/1000V= 14
OCL1,P5 OCL2,P5
0,1K,1K,10K 0 0
1000K,1M 1 0
1M 1 1
DMM 6030
1982 Datum Name
Bearb 04.10
Gepr
Norm
INTEGRATOR 6030-I-2
PREMA
824073
Zust Änderung Datum Name
Subject to technical changes



		DMM 6030
	1982 Datum Name Bearb 0410 Gepr Norm	LAYOUT DIAGRAM OF INTEGRATOR 6030-I-2
1 Zust Änderung Datum Name	PREMA	824074 Blatt 1 1 Bl
		Subject to technical changes


DMM 6030
DIGITAL CIRCUIT BOARD
6040-D-3/6030
PREMA
830892
Subject to technical changes
Guard
Datum
Name
Norm
Änderung



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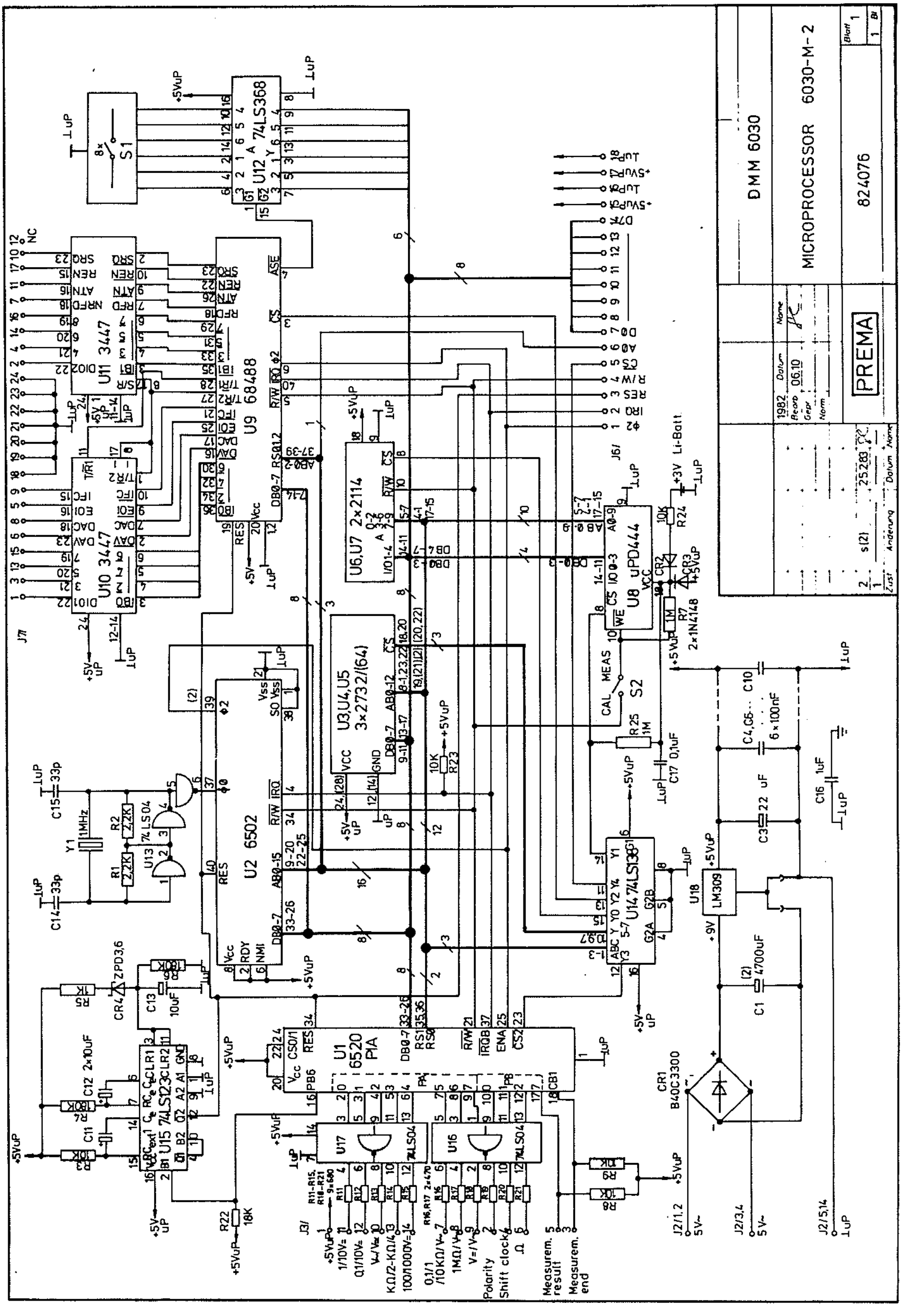
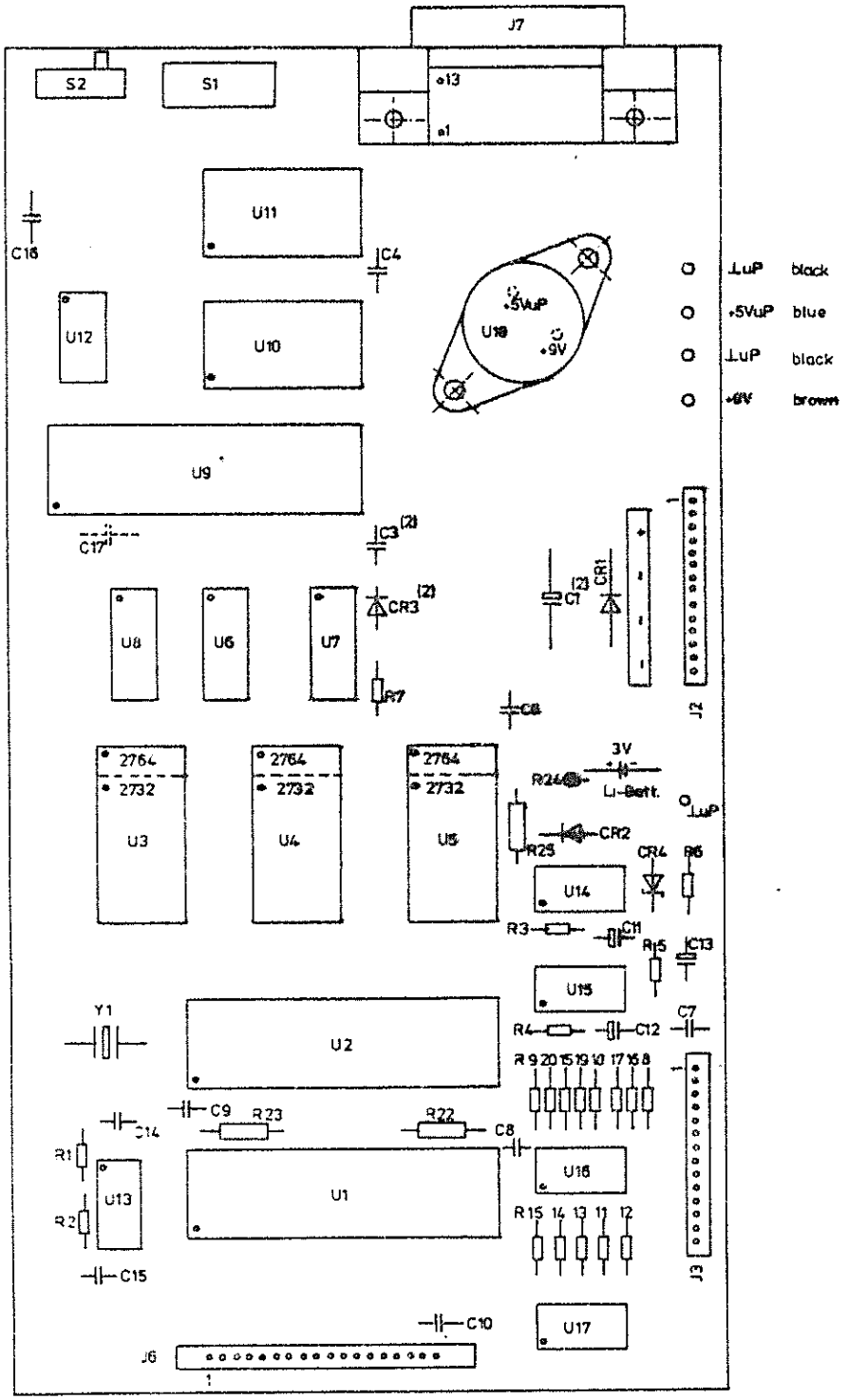
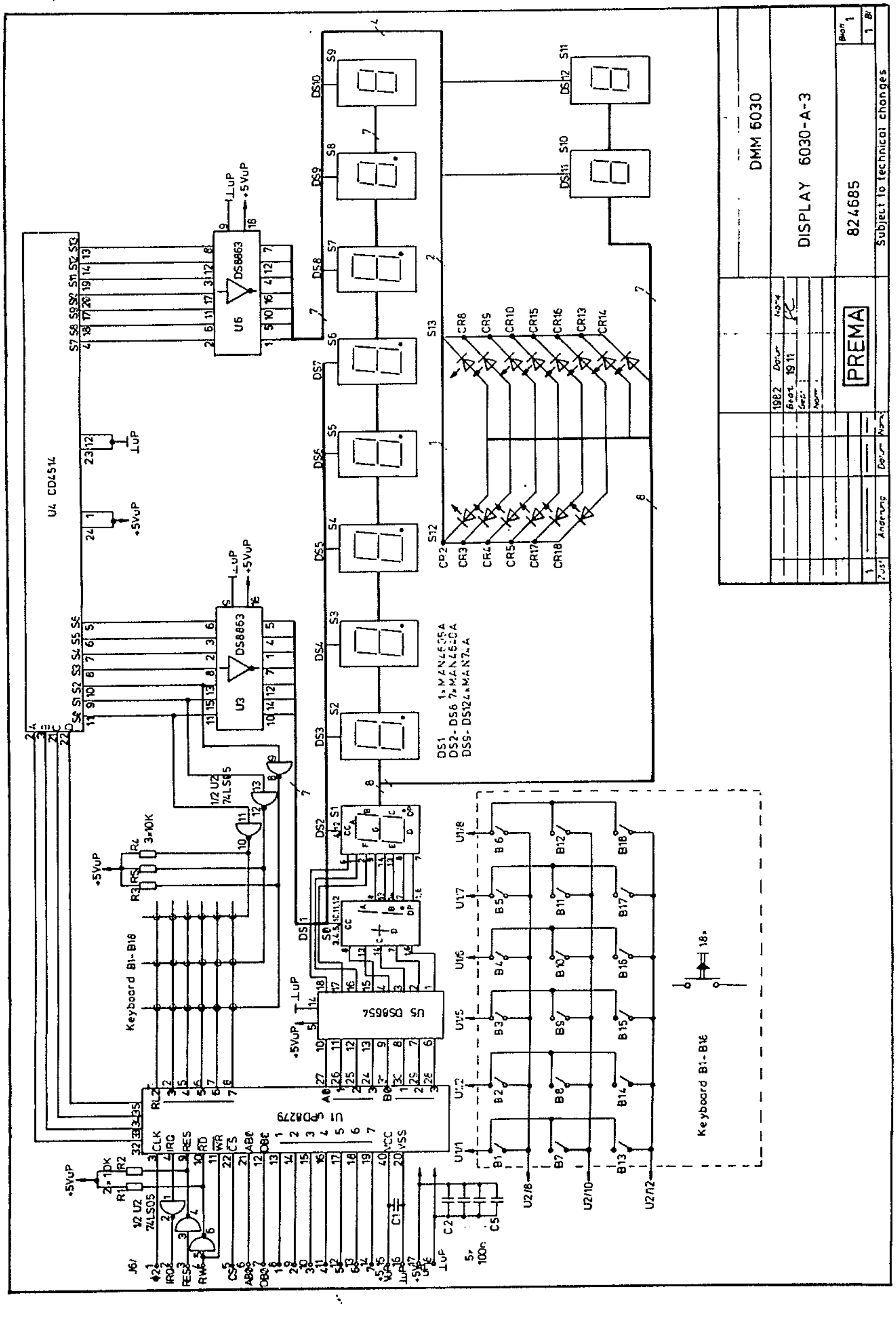
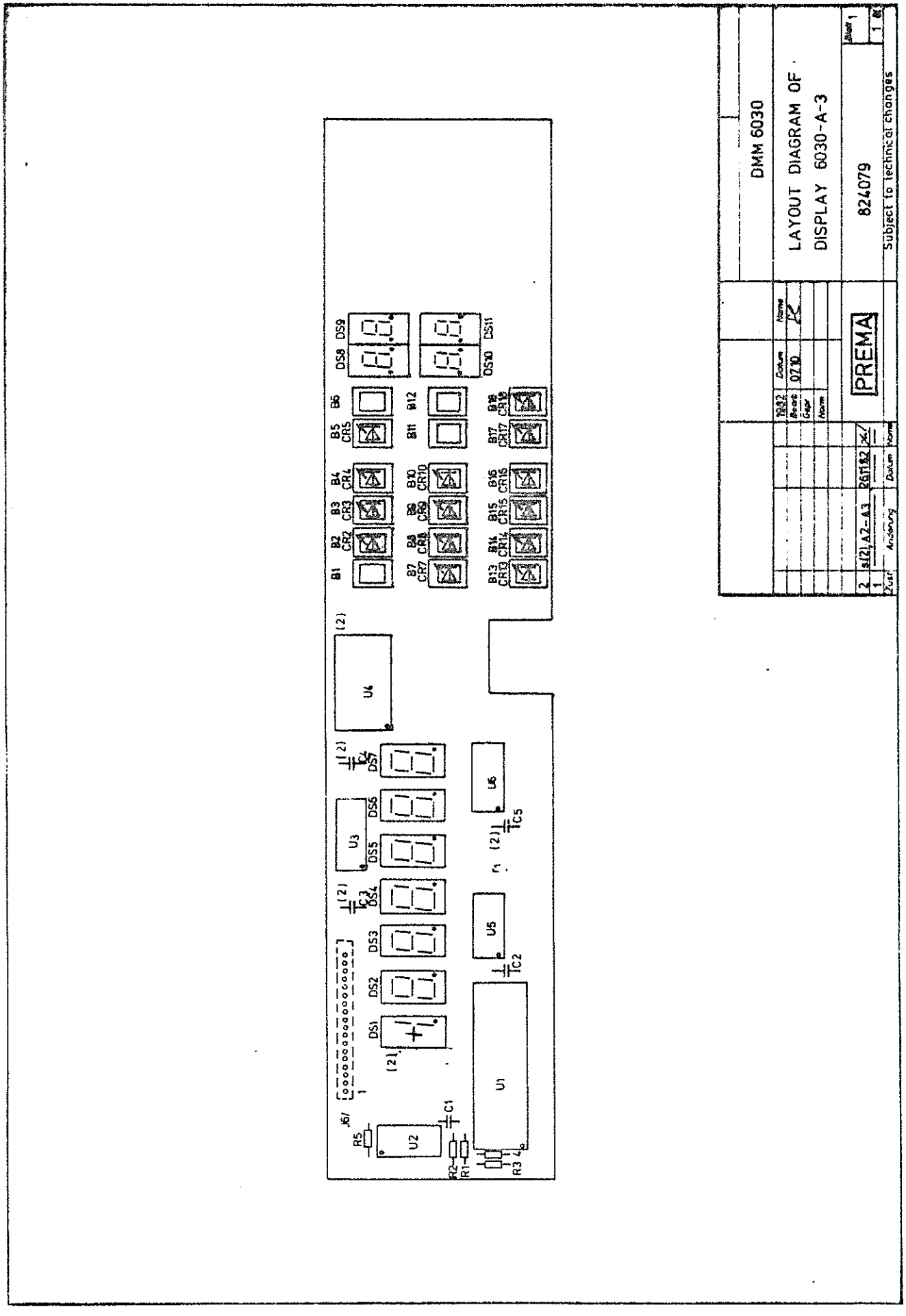
			1993	Datum	Name
			Bearb.	24.02	
			Gepr.		LAYOUT DIAGRAM OF DIGITAL CIRCUIT BOARD 6040-D-3/6030
			Norm		
			PREMA		830893
					Blatt 1
1					1 Blätter
Zust.	Änderung	Datum	Kontr.	Urs.	Subject to technical changes

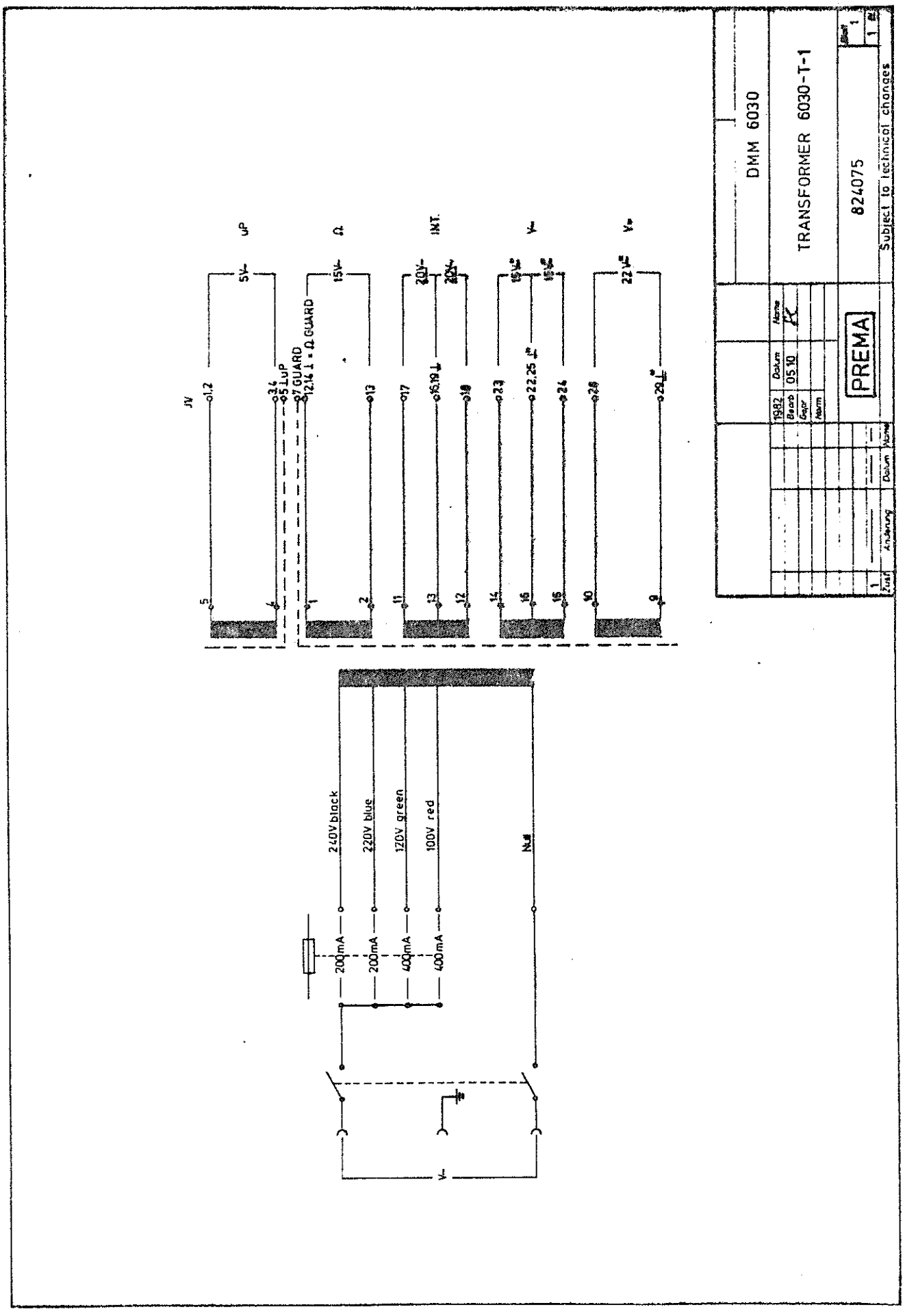

DMM 6030
MICROPROCESSOR 6030-M-2
824076
PREMA
U2 6502
U1 6520 PIA
U9 68488
U10 3447
U11 3447
U12 74LS368
U3,U4,U5 3×2732/(64)
U6,U7 2×2114
U8 uPD444
U14 74LS138
U15 74LS123
U16 74LS04
U17 74LS04
U13 74LS04
U18 LM309
CR1 B40C3300
S1
S2
CAL MEAS
Measurem. result
Measurem. end
Polarity
Shift clock



		DMM 6030
	1982 Datum Name gezeichnet 06.10 Gepr. Norm	LAYOUT DIAGRAM OF MICROPROCESSOR 6030-M-2
2 s (2) 250283 1 Index Änderung Datum Name	PREMA	824077 Subject to technical changes
		Blatt 1 1 Bl


DMM 6030
DISPLAY 6030-A-3
824685
Subject to technical changes
PREMA
U4 CD4514
U6 DS8863
U3 DS8863
U5 DS8654
U1 uPD8279
Keyboard B1-B18
1x MAN4605A
DS2-DS8 7x MAN4610A
DS9-DS12 4x MAN74A


DMM 6030
LAYOUT DIAGRAM OF
DISPLAY 6030-A-3
824079
PREMA
Subject to technical changes
U1
U2
U3
U4
U5
U6
DS1
DS2
DS3
DS4
DS5
DS6
DS7
DS8
DS9
DS10
DS11


DMM 6030
TRANSFORMER 6030-T-1
824075
PREMA
Subject to technical changes
240V black
220V blue
120V green
100V red
Null
200mA
200mA
400mA
400mA