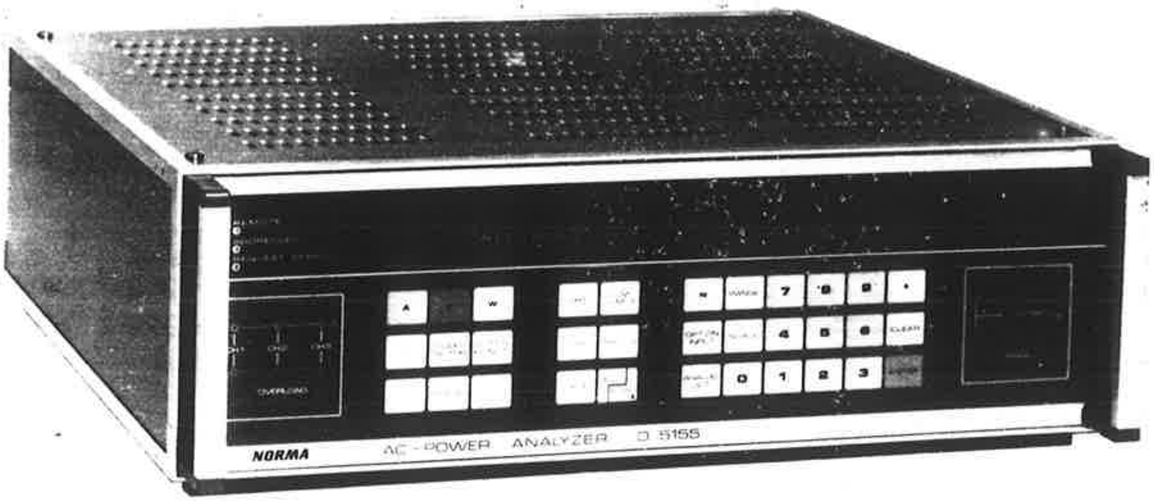
AC-POWER ANALYZER D5155

(Precision Wattmeter D5155)

TEIL 1: GEBRAUCHSANLEITUNG

PART 2: OPERATING INSTRUCTIONS



Listen-Nr.: A4607 03013
A4607 03014
A4607 03020
A4607 03021

NORMA Messtechnik, Optik, Elektronik Gesellschaft m.b.H.

IMPORTANT NOTICE

A. In order to avoid discharging the buffer battery for the C-MOS memory with consequent loss of calibrating data, it is recommended to operate the instrument with mains power switched on for at least five hours every 6 months, thus recharging the buffer battery.

B. For the attention of users

This measuring device should be used by qualified or trained personnel only and solely in correspondence with its technical data and in compliance with the safety regulations and precautions listed below.

For any given application, the legal and safety regulations pertaining thereto should be strictly complied with. This also applies when accessories made by other manufacturers are used.

If there is reason to believe that safe operation is no longer possible, switch off the instrument and secure it against unintentional reclosure.

Impossibility of further safe operation must be assumed

- if the instrument is visibly damaged,
- if the instrument fails to operate,
- after extended storage under unfavorable conditions (e.g. storage outside the climatic declaration without adaptation to ambient climate etc.),
- after major transport stresses (e.g. drop from considerable height without visible external damage etc.)

C. Maintenance

Service work (e.g. readjustment) must only be performed by trained, competent personnel. Any repair or readjustment work must in no case impair safety by modifying any design parameters of the device; replacement parts must be the equivalent of the original parts replaced and reassembled in workmanlike manner to the original factory standard.

D. Short instructions to locate faults

This device was tested accurately by the manufacturer after solicitous production and pre-tests and was submitted to a BURN-IN-TEST before delivery. If notwithstanding all precautions malfunctions occur, please consult the following schedule to recognize possible operating and/or device defects or to locate malfunctions. If this procedure is negative, please contact the supplier, the next service office or the manufacturer.

Defect	Possible causes	Elimination of defect
instrument without function, all LED dark	mains failure fuse defective voltage selector wrong power board defective instrument defective	check change adjust correctly contact next service office
error message during power-on test	high electrical or magnetic fields, transient voltages, battery discharged	see manual item 5.2.1
display of "NO OPTION" at A,V,W ... (except Wh)	measurement with missing channel board RAM disturbed instrument defective	switch instrument to RUN and perform measuring contact next service office
no new values	instrument is in HOLD high "N"	see manual change or wait till "N" is reached
values incorrect	wrong ranges/overload wrong scale factors measurement set-up faulty signal unsuitable	select correctly input new correct set-up
input is not stored after "ENTER"	address > 30 scale factor 0 N = 0	rectify
instrument changes to HOLD position	HOLD after N selected	change to RUN
remote operation is not possible	wrong address, terminator wrong or absent, remote control orders wrong, wrong or uncomplete order	rectify
LED ADDRESSED alight permanently	"TALK ONLY" is active	switch off de-address instrument

Defect	Possible causes	Elimination of defect
no data-output at bus	instrument in HOLD lack of request-command no trigger	
	high N	wait till N is reached or requested new data-output
	high timing	check timer
asynchrounus data-output	time-out of controller too short	change or use time loops
string too long error in controller	too many values in one variable	request data in parts, use better computer
no print-out in TALK ONLY	printer is not addressed no LISTEN ONLY switch	use plug-adaptor "LISTEN ONLY" Cat.No. A 6416 02004
faulty calibration (CAL TEST FAIL)	disturbances during calibration	disconnect leads switch off high fields repeat calibration
	instrument out of calibrating tolerance	contact service office
no or partial instrument function	loose connectors or print boards in instrument defective boards	rectify contact service office
asymmetrical voltages with artifical star-point	star point floating against ground	exchange HI and LO symmetrize with low ohm resistors
voltage measurement wrong (too high values up to 1.4 times)	high harmonics above 10 kHz	use potential transformers to reduce harmonics
power-on test is repeated	mains voltage breakdown	use better line stabilizer, uninterruptible power supply
disturbances during measuring	high transient voltages in measuring circuit	use potential transformer, ground secondary winding

CONTENTS

1. GENERAL

The Precision Wattmeter is a highly accurate digital measuring instrument that handles AC quantities in single-phase and polyphase systems under any type of load.

1. 3 x current } are measured as true RMS values by RMS
2. 3 x voltage } converters and subsequent A/D conversion
3. 3 x active power } are determined by the
4. 3 x electrical energy (optional) } time-division method

All 9 (12) quantities are measured simultaneously.

The following quantities are computed from the above basic quantities:

5. 3 x apparent power
6. 3 x power factor (cap (lead), ind (lag), +, -)
7. 3 x absolute value of impedance $|Z|$
8. 3 x active resistance, Real (Z)
9. Total values of active power, apparent power, power factor, impedance, active resistance, electrical energy and mean of current and voltage

With current and voltage inputs mutually floating, the following applications appear relevant:

- measurements in up to three single-phase systems with summation (e.g., for tests of electrical plant)
- measurements in three-wire three phase systems under symmetric or asymmetric load
- measurements in four-wire three phase systems under symmetric or asymmetric load
- measurements of reactive power in three-phase systems by suitable connection of voltage inputs resulting in a 90° phase turn of voltage

The large total range permits utilization of the instrument for measurements ranging all the way from small quantities to super-high energy applications.

All input circuits may float mutually and with respect to earth/ground up to U_{rms} = 660 V. The built-in test and calibrating functions ensure the accuracy of measurement results and make for maximum long-term accuracy. Typing in the transmission factors for current and voltage results in correct digits and decimal shown on a 20-digit alphanumeric display. Data output is effected via an IEEE Standard 488 (IEC 625) Interface. Up to 32 simultaneously acquired measured values may be serially polled from the Bus. Any one of the measured quantities can be freely selected for transmission to the analog output (optionally up to 6 outputs). The instrument is controlled either from the clearly arranged foil-type keyboard with prompting on the display or from the built-in Interface. When the instrument is switched off, the set values remain available (C-MOS RAM), thus greatly facilitating operation.

Functional description

Each channel uses a current transformer and a voltage transformer for range matching and galvanic separation. Compensation of the transformers is electronic, and range selection is effected on the secondary side. The secondary winding is terminated by a precision resistor and produces a voltage drop of 2 volts at full level. These six voltages are converted into equivalent DC voltages of 2 V by six RMS converters on the one hand and into DC voltages of 2 V equivalent to active power by means of three time-division converters on the other. These nine voltages are digitalized over the same period of 360 ms by 9 16-bit analog-digital converters and passed to the microprocessor by the internal bus. If the optional energy-measurement facilities are included, the three output voltages of the time-division multipliers are digitalized by voltage-frequency converters, summed in a counter module and transmitted to the microprocessor every 500 ms. This method ensures uninterrupted measurement of energy. The microprocessor controls the entire measuring process, it performs the desired computations of measured values and passes the measured values to the Interface processor for data output, to the digital-analog converters for output of the desired analog values, and to the display processor for showing the measured values in the display area. The display processor also transmits the data typed in on the foil-type keyboard to the main processor.

During "Talk-Only" operation, data output is controlled by the internal timer. Underrange and overrange recognition is effected at the output of the current and voltage transformers by eight comparators per channel. During hold operation, the underrange or overrange message can be polled by the Interface 3 ms after applying a measuring value. On calling the internal calibration program, accurate triangular signals (constant currents at approx. 70 Hz) are applied to the transformer outputs, correcting values for each channel are determined and stored in the buffered C-MOS RAM.
Trigger facilities afforded by the Interface or the external trigger socket permit synchronization with the measuring or testing process or with other devices used in the measuring set-up. When measuring energy, triggering permits starting and stopping of the counter. By means of the Interface all instrument functions may be remote-controlled and measured data transferred.

2. TECHNICAL DATA

(for special version Transformertest see item 5.6)
(for special version Motortest see item 5.7)

Ranges:	
Current:	0.1 0.2 0.5 A 1 2 5 A 10 20 50 A
Overload:	60 A permanently; 100 A max. 5 s (in each current range). No fuse in circuit
Voltage:	65 V 130 V 260 V 520 V 650 V
Overload:	800 V permanently; 1.4 kV max. 5 s (in each voltage range)
Accuracy range:	3 - 120 % for both channels with overrange indication
Input impedance:	
Current channel:	approx. 1 mOhm transformer with compensation
Voltage channel:	660 kOhm ± 0.1 % in all ranges
Crest factor:	max. 2, for full-scale value (for both channels)
Transmission factor:	10^{-6} ... 10^{6}
Display range:	10^{-6} ... 10^{12} (automatic switching-over when measuring energy)
Resolution:	for transmission factor 1 in the lowest range: for current measurement 10 µA for voltage measurement 10 mV for power measurement 1 mW for energy measurement 1 mWh
Accuracy:	based on 1 year at 23 °C, relative humidity ≤ 65 %
Current and voltage:	± (0.1 % of m.v. + 0.1 % of set range) *) **)
Voltage x $\sqrt{3}$:	corresponds to phase voltage in a symmetrical voltage triangle
Active power:	for cos phi = 1 ± 0.1 % of range) *) **) for cos phi = 0.1 ± 0.5 % of range) *) range = U . I . cos phi power display is automatically switched to resolution x10 below 10 % of nominal value reset to normal resolution above 11 % of nominal value
Apparent power:	sum of errors of current and voltage
Electrical energy:	error of active power ± 0.1 %
Power factor:	sum of errors of apparent and active power

*) Specifications are based on 45 Hz ... 65 Hz.

**) The error doubles for 15 Hz ... 45 Hz and 65 Hz ... 500 Hz.
Error multiplied by five for 500 Hz ... 1000 Hz.

Absolute value of impedance: sum of errors of voltage and current

Active resistance: sum of errors of 2 x current and active power

Efficiency: sum of errors of the individual powers

Temperature coefficient: less than 0.01 % of range per kelvin for current, voltage and active power

Long-term stability: ±0.02 % of range for current, voltage and active power per year

Analog output: -10...0...+10 V max. 2 mA, max. 6 outputs
Assignment of the measured quantity to the analog output can be typed in from the keyboard. For adjusting the connected device, zero and ±10 V can be applied to the output.

Additional error: ±(0.25 % of full-scale value + 0.03 %/K)

External voltage: max. U_{rms} = 125 V but not exceeding U_p = 180 V

General

Digital display: 20-digit fluorescent display (green) 5 x 7 dot matrix, character size 9 x 6.3 mm

Single-value display: 4 to 5 digits, max. 0 ... 30000 with sign, unit and channel assignment

Two-value display: 4 digits, max. 0 ... 9999 with sign, unit and channel assignment, measured values freely selectable for display

Three-value display: 4 digits, max. 0 ... 9999, display of I_{rms}, U_{rms} and P (with sign) and channel assignment are fixed. Display of three identical freely selectable functions features sign and unit.

Measuring principle: Current and voltage: RMS value by analog computation method
Active power: time-division multiplication timed at approx. 70 kHz
Electrical energy: voltage to frequency conversion after time-division multiplication

Measuring period: 480 ms at 50 Hz mains frequency
400 ms at 60 Hz mains frequency

Relaxation period: max. 5 sec on change of range

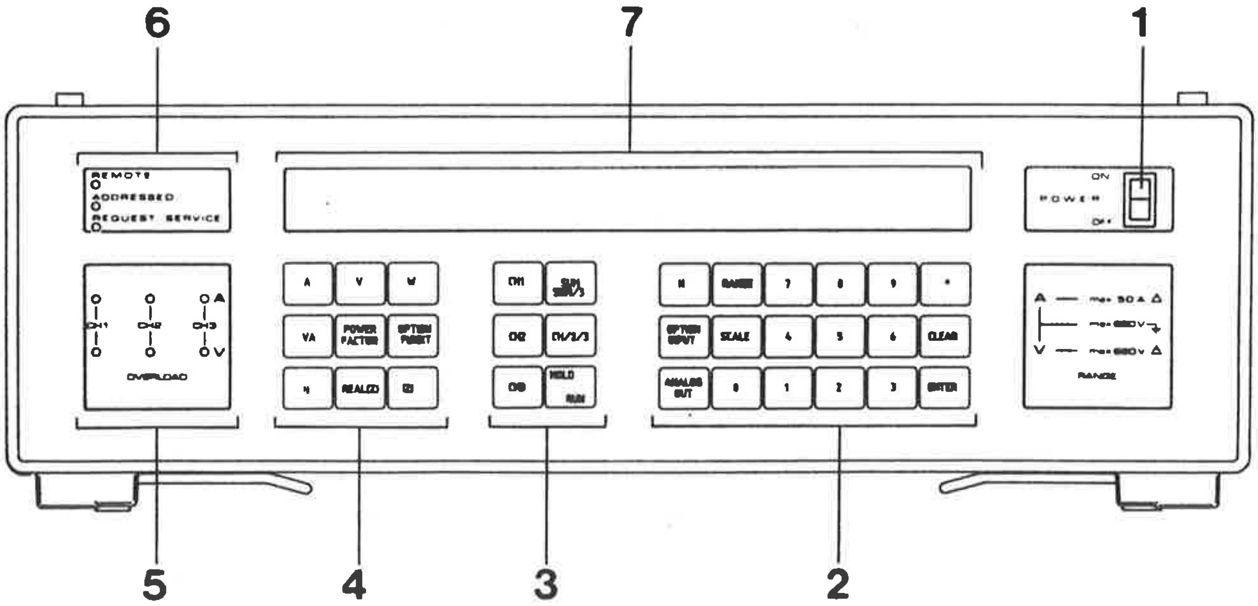
Response time: 3 sec when applying a measured value 10 - 90 % and a deviation of less than the specified accuracy

Averaging of measured values: linear averaging over 1 ... 99999 measurements

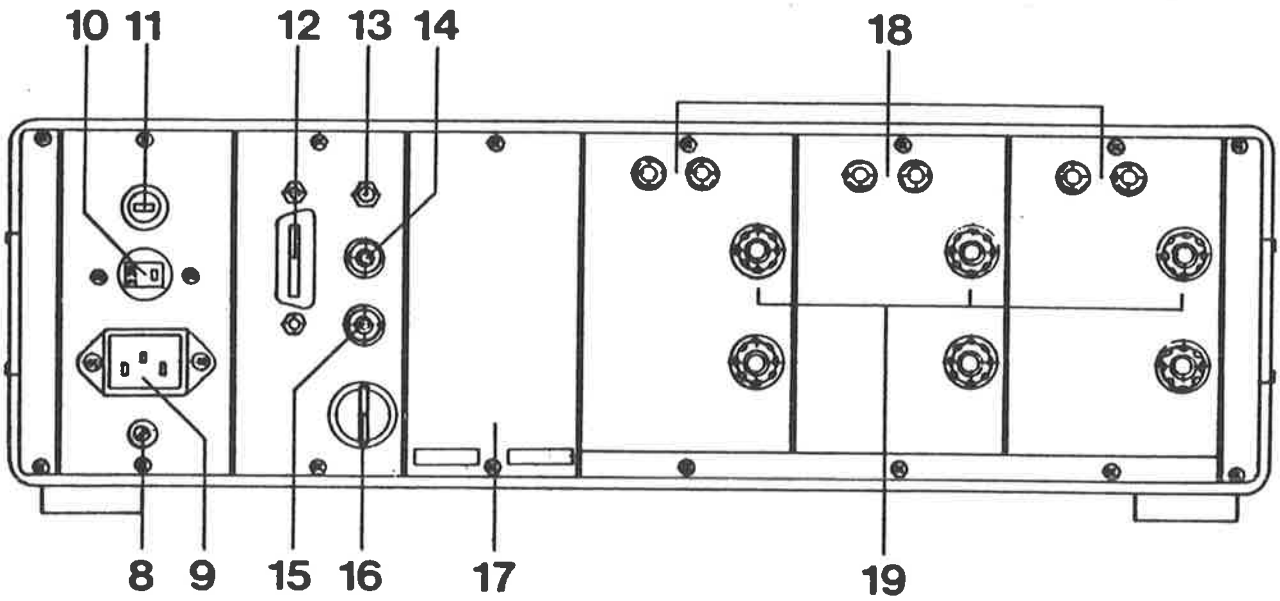
Range and function selection:	manual, from the front (foil-type keyboard), or remote-controlled from Interface
System Interface:	IEC 625 or IEEE Standard 488/1978
Interface functions:	SH1, AH1, T5, L4, SR1, RL1, PP0, DC0, DT1, C0, E2
Test function:	Display test and internal memory test every time the instrument is switched on
Calibrating function:	Automatically tests all channels from the input transformers by internal reference signals. Deviations are stored for computation of measurements. This makes it possible to calibrate the instrument for other temperatures.
Function test:	By comparing the display of the three channels during the measurements of the same signal in combination with the calibrating function ensures proper instrument function.
Buffering:	The internal C-MOS RAM is supplied by a rechargeable NiCd battery (max. 1/2 year with the instrument switched off). This maintains the calibration data and the latest settings even after the instrument has been switched off.
Climatic class:	KYG as by DIN 40040 standard
Working temperature range:	0 ... 40 °C, mean relative humidity ≤ 65 %
Nominal temperature:	23 °C
Storage temperature range:	-20 ... +50 °C
Floating:	All input circuits may float mutually and with respect to earth/ground up to U_{rms} = 600 V, U_p = 930 V.
Test voltage:	Input voltages mutually, with respect to case and mains circuit 2 kV Mains circuit with respect to input circuits and case 1.5 kV
Safety regulations:	VDE 0411 part 1/10.73 and DIN 57411 page 1
Protective class:	1
Mains connection:	selectable 115/220 V ± 10 %, 45 ... 65 Hz, approx. 66 VA
Warm-up period:	30 min
Dimensions:	142 mm high by 431.5 mm wide by 454 mm deep 19" 3 height units
Mass:	approx. 9 kg included all plug-in units

3. DESCRIPTION OF CONTROLS

Front



Rear



Front:

1 Mains switch

Disconnects both poles of the instrument from the mains.

2 Range selection, scale factor and averaging

Pressing the "RANGE" key establishes the range-selection state for the previously selected channel.
The flashing CURSOR indicates the spot to be selected. Pressing the "RANGE" key again makes the CURSOR jump to the right. After pressing the desired digit the CURSOR will continue automatically to jump to the right. Once the range has been selected, it is stored and the original measuring program switched on automatically by pressing the "ENTER" key. Pressing the "SCALE" key sets up the scale-factor input state. The flashing CURSOR indicates the spot to be selected. The factor is adjusted as described above with the digit, "SCALE", "CLEAR" and "ENTER" keys.
The "." (decimal) and "ENTER" keys have multiple functions. (See DISPLAY, ANALOG OUT AND INTERFACE.)
The key "N" is used for averaging. The key "Option Input" is not used for the standard instrument

3 Channel selection keys

Pressing the "CH1", "CH2" or "CH3" key puts the data selected by keys (4) into the display area (7).
Pressing the "SUM" or "SUM/3" key displays the current sum or mean respectively (see item 4).
Pressing the "CH1/2/3" key displays the measured value selected by keys (4) simultaneously for all three channels.
On pressing the "HOLD/RUN" key the current measured values are stored and can be polled and displayed in any order.

4 Keys for selection of function

Pressing the desired function key displays the corresponding value with correct digits and decimal and together with sign, unit and function.
Pushing the "V" key twice activates or disactivates the display of voltage x $\sqrt{3}$ (V_Δ).
For the computed quantities "POWER FACTOR", "REAL (Z)", "$|Z|$" or "η" flashing 8888 is displayed if one of the measured quantities required for computation is less than 1 % of full-scale value.

5 Overrange indication

If there is an overrange condition (more than 120 % of full-scale value), the corresponding LED "OVERLOAD" is lit.

6 Indication of BUS functions

LED "REMOTE" is lit after the Controller has put the instrument into the remote-control state.

LED "ADDRESSED" is lit if the instrument is addressed by the Controller or is transmitting data.

LED "REQUEST SERVICE" is lit if the instrument is transmitting "SERVICE REQUEST".

7 Display area

20-digit green fluorescent display in 5 x 7 dot matrix, digit size 9 x 6.3 mm.

The display area shows the desired measured value (4 to 5 digits, max. 30000) with sign, unit and channel assignment as selected.

Two-value display features 4 digits with sign, unit and channel assignment.

For displaying three identical functions (e.g., P_1, P_2, P_3) all functions can be freely selected but only the same function for all three channels.

Mixed three-value display features 4 digits without units with channel assignment (in the order of current, voltage and active power). Besides the measured values, scale factors and ranges, the device address for BUS functions, individual program steps in TALK ONLY operation and the test functions are also displayed.

Rear:

8 Terminal for connection of protective wire
For connecting a protective wire (protective class I) if no protective ground is available from the main supply.

9 Mains socket for connecting to the supply voltage

10 Mains-voltage selector 115/220 V

11 Mains fuse DIN 41662 - T 0.63 for 220 V
DIN 41662 - T 1 A for 115 V

12 BUS connection

"D" Standard socket:	IEEE Standard 488 - 24-pole (e.g., amphenol)
"D" Standard plug:	IEC 625 - 25-pole (e.g., amphenol)

13 "Return to local"
Operation of this key removes the instrument from the remote-control state, e.g. for performing manual adjustments or measurements. Transmission of the next set of remote-control data resets the instrument in remote operation. The key can be disabled by transmitting "LLO" (local lock-out) at the start of a program.

14 External trigger input
Input: BNC socket, TTL level negative logic
By applying LOW potential to the BNC socket or short-circuiting, a measuring cycle can be started in the "HOLD" state. The triggering can be repeated after the measuring and output period has elapsed.

If the trigger input is maintained LOW for longer than a measuring period, the next measuring cycle is started automatically and concluded without regard to the trigger.
When energy is being measured, measurement starts with dropping the trigger to LOW (short circuit) and ends with raising the trigger to HIGH (open).

15 Analog Out
See section 5.5.6. Do not apply voltage to the socket!

16 Turn key switch for internal calibration. See section 6.4.

17 Space for optional plug-in unit for 5 additional analog outputs

18 Voltage inputs
max. 650 V, R_i = 660 kOhm, max. U_{rms} = 660 V with respect to earth/ground
↓ corresponds to terminal k (voltage input)

19 Current inputs
max. 50 A, R_i = approx. 1 mOhm, max. U_{rms} = 660 V with respect to earth/ground
↓ corresponds to terminal k (current input) and marks the terminal closer to the source.

4. COMPUTATION OF MEASURED VALUES

Measured quantities

Currents:	I_1, I_2, I_3;	I_1, I_3 *)
Voltages:	U_{10}, U_{20}, U_{30};	U_{12}, U_{23} *)
Powers:	P_1, P_2, P_3;	P_{12}, P_{23} *)
Electrical energy:	$P_1 \cdot t, P_2 \cdot t, P_3 \cdot t$; $P_{12} \cdot t, P_{23} \cdot t$ *)	

Computed quantities:

Mean of currents Σ/3: $\bar{I} = \frac{I_1 + I_2 + I_3}{3}$

Mean of voltages Σ/3: $\bar{U} = \frac{U_{10} + U_{20} + U_{30}}{3}$

Power, three-phase $\Sigma P = P_1 + P_2 + P_3; \Sigma P = P_{12} + P_{23}$*) W

Apparent power (single-phase) $S_1 = U_{10} \cdot I_1, S_2 = U_{20} \cdot I_2, S_3 = U_{30} \cdot I_3$ VA

Apparent power (three-phase) $\Sigma S = S_1 + S_2 + S_3$

Power factor (single-phase) $\lambda_1 = \frac{P_1}{S_1}, \lambda_2 = \frac{P_2}{S_2}, \lambda_3 = \frac{P_3}{S_3}$

cos φ_1

Power factor (three-phase) $\Sigma\!: \lambda = \frac{P_1 + P_2 + P_3}{S_1 + S_2 + S_3}$

Impedance (single-phase) $|Z_1| = \frac{U_{10}}{I_1}, |Z_2| = \frac{U_{20}}{I_2}, |Z_3| = \frac{U_{30}}{I_3}$

Impedance (three-phase) $\Sigma\!: |Z| = \frac{1}{\frac{1}{|Z_1|} + \frac{1}{|Z_2|} + \frac{1}{|Z_3|}}$

Active resistance (single-phase) $R_e(Z_1) = \frac{P_1}{I_1^2}, R_e(Z_2) = \frac{P_2}{I_2^2}, R_e(Z_3) = \frac{P_3}{I_3^2}$

Active resistance (three-phase) $\Sigma\!: R_e(Z) = \frac{1}{\frac{1}{R_e(Z_1)} + \frac{1}{R_e(Z_2)} + \frac{1}{R_e(Z_3)}}$

Electrical energy (three-phase) $\Sigma W = (P_1 + P_2 + P_3) \cdot t$

$\Sigma W = (P_{12} + P_{23}) \cdot t$*)

$U \times \sqrt{3}$ $(U_{10}, U_{20}, U_{30}, \Sigma\, U/3) \times 1.73205$

Efficiency

$$\eta = \frac{P_2}{P_1 + P_3}$$

Averaged measured values:

$MW = \frac{\sum_{i=1..N} MWi}{N}$ in "RUN" mode $MW = \frac{\sum_{i=1..n} MWi}{n}$ in "HOLD" mode for $n \leq N$

MWi ... measured value for I from 1 to N
N ... number of averaging processes
n ... current state of averaging process

corresponds to cos phi for sinusoidal quantities

*) applies to two-wattmeter method

5. START-UP

5.1 Items supplied, accessories

Precision Wattmeter, with 1 analog output -10...0...+10 V incl. Interface

Accessories supplied with instrument:

1 mains connecting cable, 1.5 m long
2 spare fuses
6 pairs of measuring leads, 1 m long, with banana plugs and test prods
1 book of operating instructions

Available accessories:

Option energy measurement (Wh) can be built in later
Additional analog output (maximum 5)
  Voltage output: -10...0...+10 V can be built in later

Precision current transformer
  Primary 0.1...150 A on terminals, up to 4000 A in plunger operation,
  secondary 5 A / 1 A respectively, cl. 0.1 /0.2 respectively,
  nominal frequency 50 Hz.
  Detailed description see List PM 1704 + 6100 PM 1E

Zero resistance 110...660 V, 660 kOhm, cl. 0.1, 45...65 Hz

19-inch plug-in set

5.2. Start-up preparations

After unpacking perform visual check for transport damage.

Caution: Before connecting up, check correct position of the mains voltage switch (10) and corresponding mains fuse (11) and correct if required:

For 220 V ... DIN 41162 T 0.63 A

For 115 V ... DIN 41162 T 1 A

The instrument can then be connected to a three-pin socket with the mains connecting cable supplied (9) and switched on with the mains switch (1). If no three-pin plug is available, suitable earth/ground connection must be made at the protective-wire terminal (8).

Caution: The instrument, being of protective class 1, must always be operated with the case earthed/grounded.

Please note that in supply networks with high surges the built-in protective circuit of the switched power supply is triggered, switching of the mains. This will occur when main voltage upwards exceed the following level:

220 V position ... U_p = 353 V

115 V position ... U_p = 183 V

In this case place a line conditioner or a stabilizer in series. If major voltage reductions occur in the supply network, a buffered supply must be placed in front of the instrument in order to prevent it from switching itself off.

5.2.2 Initial state

After power-up an internal test cycle occurs. During this test all 20 matrix displays in the display area are lit serially. Subsequently all LEDs are tested. The internal test program tests the checksum of the program memories and of the memory holding the calibrating data.
If errors occur in program storage, the possibility of trapping depends on the type of error. If a faulty EPROM is ascertained, the message "ROM TEST K FAIL" (K = 1...4) appears. If the error cannot be located, the display or instrument function will show faulty behavior (e.g., periodic lamp test).
If "RAM TEST FAILED" occurs on the display, two cases are possible:
a) set data are faulty (e.g. scale factor)
b) calibrating date are faulty
Remedy: First assume case a):

Caution: The measuring leads must be disconnected before the calibration process is started.

a) Switch off instrument. Press "rtl" key on rear panel, switch on instrument, keeping "rtl" key pressed until normal display appears (approx. 6 s). If a measured value occurs on the display, all required setting data are now rewritten into the RAM. All previously entered data are, however, lost, with automatic assumption of default values (e.g. scale factor 1 : 1; range 130 V, 1 A).

If "RAM TEST FAILED" re-occurs on the display, proceed as under b):

b) Switch off instrument. Turn calibrating switch to "CAL", press "rtl" key, switch on instrument, keeping "rtl" key pressed until "CALIBRATING" appears on the display. The instrument is then recalibrating.

If the calibration process can be performed, the instrument should remain on for approx. 5 hours in order to charge the NiCd battery. If the calibrating process is not completed, "CAL TEST FAIL" occurs on the display. Treat this message as provided for in section 6.4.
After positive completion of the internal testing program, the last state valid before switching-off is automatically re-established. Similarly all previously programmed values (SCALE, RANGE, ADDR) remain valid.
If the instrument is in an input state, that state can be left again by pressing the "ENTER" key; if this is not possible, there has been faulty input (e.g., scale factor 000000/100,000 V/V; Addr. 38; Talk only; etc.). Measurement can only be continued after completion of input or correction of the error according to the appropriate section of the Operating Instructions.

Caution: If the display is not changing with the measured value then the instrument is in "Hold" condition or a high "N" is selected.

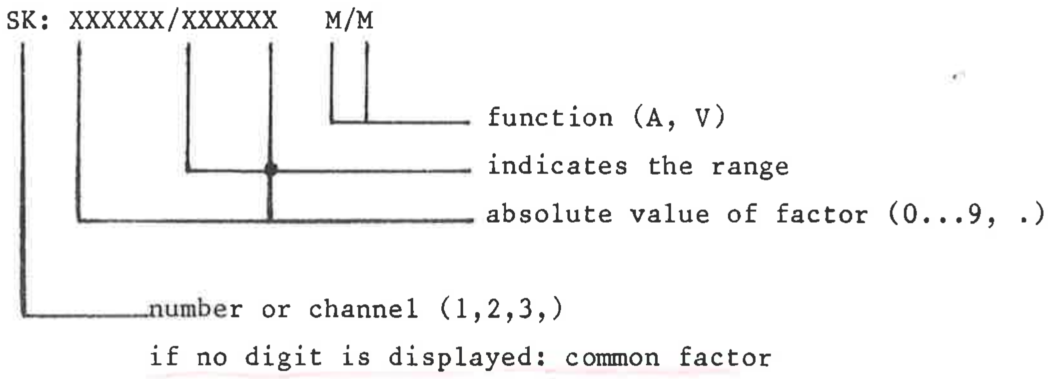
5.3 Scale factor

The scale factor takes into account the ratios of external current and voltage transformers. The (primary) measured value is shown in the display area with correct digits and decimal.
In order to set the factor, observe section 3.2. If a common factor is to be entered for all channels, press the "SUM, SUM/3" key after pressing the "SCALE" key and the appropriate function key. The value shown in the display (7) is valid for all channels after programming. If only one channel is to be changed, press the desired channel key instead of the "SUM, SUM/3" key. After changing and pressing the "ENTER" key the scale factor is changed only for the channel in question.

Caution:
The internal procedure program is designed for the "SCALE" function always to jump to the channel and function selected most recently. Therefore it may be necessary to press the desired channel key and the function key ("CH1", "A" or "V", etc.)

After completion of input, pressing the "ENTER" key performs storage and simultaneously shows the range of the selected channel and mode in the display area (7). If the scale factor remains on display, an input error has occurred, and storage can only be performed after correction.

Quantities to be selected:



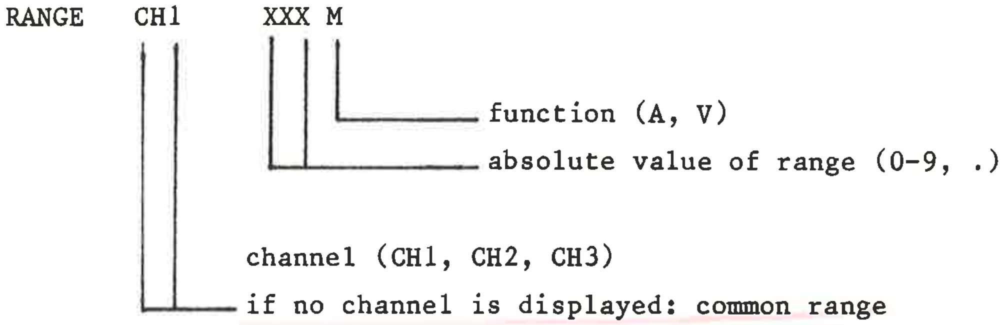
e.g., S1: 220000/110.00 V/V
S : 1250.0/5.0000 A/A
input range: 999999 to .00001

The input state may be left by pressing the "ANALOG OUT" key without changing the programmed value.

5.4 Range

After entering the scale factor, the valid range (second part of scale factor) is automatically selected and shown in the display area (7). Another range can then be selected nonetheless. Selection by keys follows the procedure of section 3 (2).

Quantities to be selected



e.g., RANGE CH1 130 V
RANGE 005 A
input range: 65 ... 650 V
0.1 ... 50 A

If the range is to be changed without changing the scale factor, this input mode can be selected directly by pressing the RANGE key. If no standard range is programmed, the lower standard range is always selected up to an excess < 20 %, or else the next higher standard range. For common or individual pre-selection of channels proceed as outlined in section 5.3. The selected range is stored on pressing the "ENTER" key. The input state may be left by pressing the "ANALOG OUT" key without changing the programmed value.

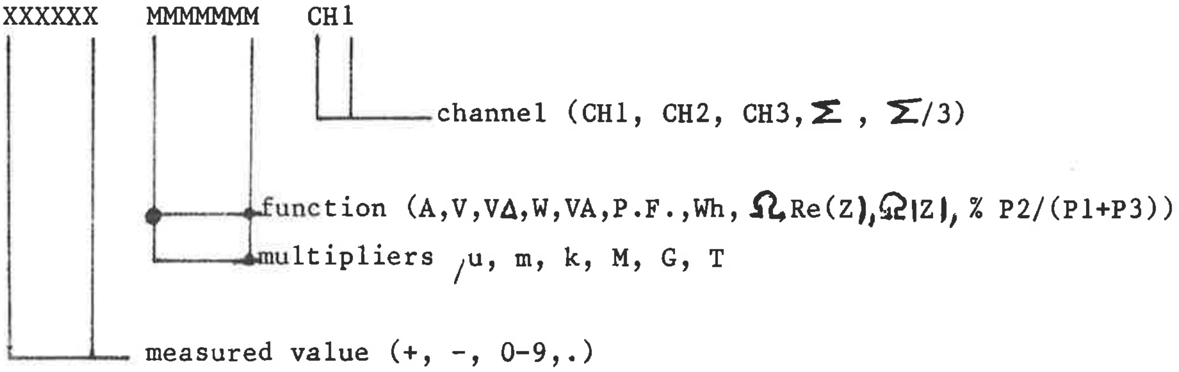
5.5 Display of measured values

5.5.1 Single-value display

Display of a single measured value features 4 to 5 digits, max. 30000 with sign, unit and channel assignment.

Selection of the quantity to be measured is made by key (4) and channel selection with key (3) (CH1, CH2, CH3).

Pressing the "SUM, SUM/3" key displays the mean value of the three individual quantities when current or voltage is measured. For measurements of power, power factor and energy the summation value is displayed, for resistance measurement the parallel replacement resistance (see section 4). Pressing the "CH1/2/3" key displays the three measured values of the selected function (see section 5.5.4).



channel (CH1, CH2, CH3, Σ , Σ/3)

function (A,V,VΔ,W,VA,P.F.,Wh, ΩRe(Z),Ω|Z|, % P2/(P1+P3))

multipliers µ, m, k, M, G, T

measured value (+, -, 0-9,.)

Flashing 8888 is displayed if no measured value can be computed.

NO OPTION is displayed if the display selected is not incorporated.

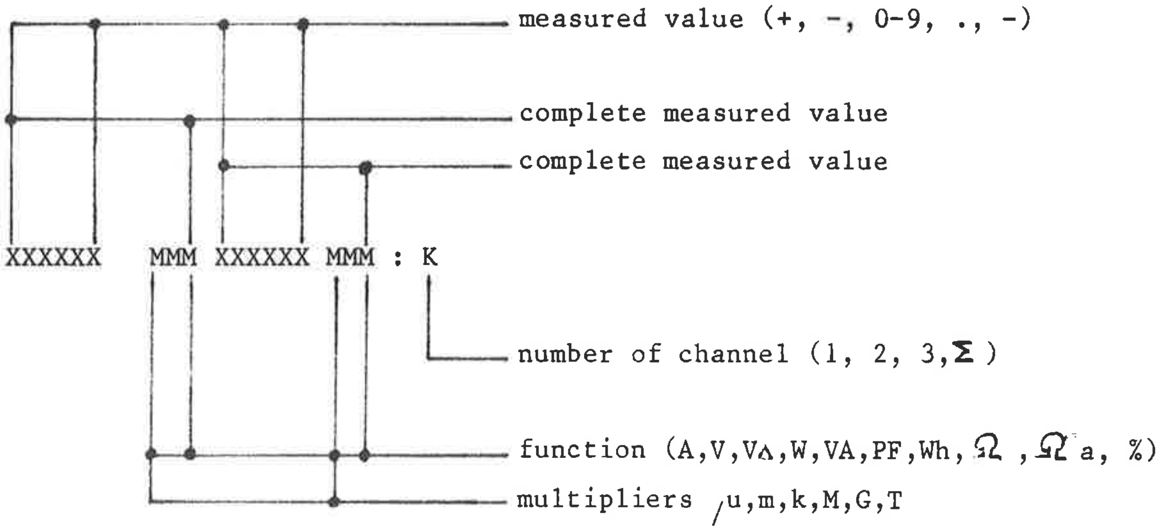
5.5.2 Two-value display

The display features 4 digits max. 9999 with sign, unit and channel number.

Pressing the "." key moves from single-value to two-value display.

The latest valid value of the single-value display is automatically written into the left-hand half. The right-hand half shows the function from the latest two-value representation. If another function is to be shown in the right-hand half, press key "2" before selecting the function. Press key "1" for a change in the left-hand half. Within a channel all 8 measured values can be displayed on the right-hand or left-hand side as desired. The digit to the right of the colon shows the channel number.

If summation values are to be displayed, the " Σ " symbol is shown to the right of the colon. Depending on the measured quantity, the values displayed correspond to the mean value (current, voltage) or to the sum of all three channels (power).



Flashing 8888 is displayed if no measured value can be computed.

The symbol "-" occurs if that option is not incorporated.

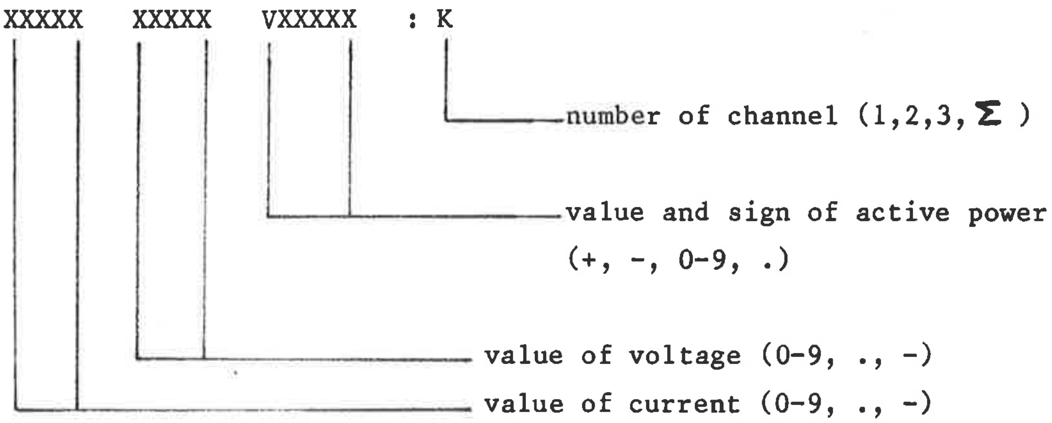
5.5.3 Three-value display (current, voltage and power of a given channel)

The display features 4 digits max. 9999, sign of the active power and channel number. Multiplication factor and unit are not displayed.

Pressing "." again in the two-value display mode selects three-value display. The three measured values of a given channel are displayed in the order of current, voltage and active power.

The digit to the right of the colon indicates the channel number.

If summation values are to be displayed, the symbol " Σ " is displayed to the right of the colon. The values displayed correspond to the mean value for current and voltage and to the sum of all three channels for power.

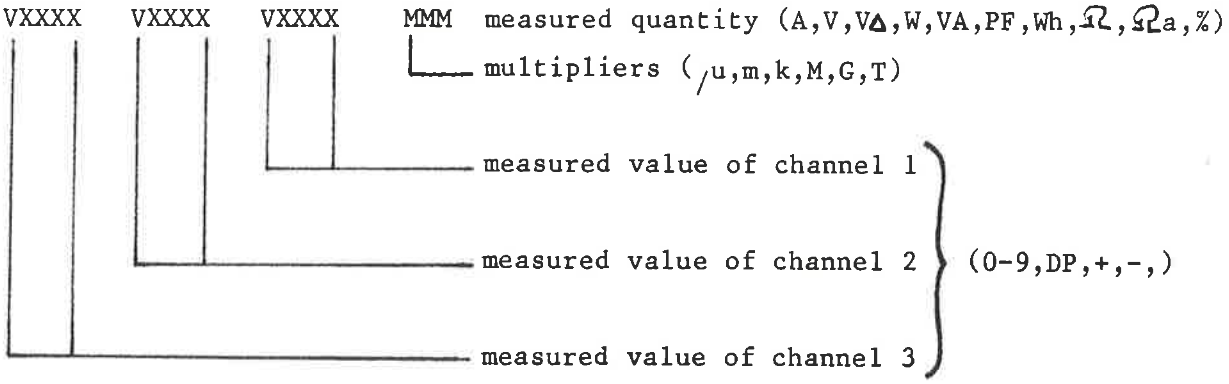


The symbol "-" occurs if that option is not incorporated.

5.5.4 Displaying three identical quantities from different channels

Pressing the "CH1/2/3" key and the desired quantity key puts all three channels in the display simultaneously.

The display features 4 digits max. 9999 with sign and unit.



Flashing 8888 is displayed if no measured value can be computed.

The symbol "-" occurs if that option is not incorporated.

In the power mode, signs are displayed.

5.5.5 Display selection process

The display mode for the measured values is selected with the "." key. Each time the key is pressed, the next mode is selected (scrolling): The process depends on the current state of the display, e.g.:

1. Single-value display	press CH1, CH2 or CH3
2. Two-value display	press "." once
3. Three-value display of mixed quantities	press "." once (or twice from state 1)
4.=1. Single-value display	press "." once (or twice from state 2)
5. Three-value display of identical quantities	press key "CH1/2/3" from any state (1, 2 or 3)

5.5.6 Averaging measured values

After pressing "N", the display status is attained for the current number of averaging processes.

n = XXXXX, run at 00000 —— Number of averaging processes (N)

Type of averaging (hold [hld], run)

Current number of averaging processes

This display state may be left again by pressing the "ENTER" key.

Pressing the "N" key twice attains the input state for the number of measurements over which averaging is to take place.

N = XXXXX, RUN after N

selectable (HOLD, RUN) by "."

number of averaging process (0 ... 9)

Input range N = 00001 to 99999

In the input state of "N" it is further possible to select whether the instrument is to pass into the "HOLD" or "RUN" state on completion of averaging. Selection is made by pressing the "." key. If "HOLD" is selected, the instrument passes automatically in "HOLD" condition. On completion of input, pressing the "ENTER" key causes storage and start of the averaging process. If "HOLD" was selected, the current average value is displayed during the averaging process - in case of "RUN" the last value measured before averaging is displayed during the averaging process. Current measuring values are not displayed during averaging for N > 1. After the number of averaging processes has been completed, the final result is displayed; in the RUN mode a new averaging process is started.

5.5.7 Analog recorder output

recorder

Standard accessories include a recorder output -10 ... 0 ... +10 V with a maximum permissible load of 2 mA; as an option up to 6 outputs are available.

The signal permanently applied to socket (15) "ANALOG OUT" is assigned and scaled by programming from the keyboard (2). The full-scale value selected from the keyboard (2) as visible in the display area (7) corresponds to 10 V. Pressing key (4) "ANALOG OUT" prepares the instrument for selection of the full-scale value. This presupposes that the device is in any of the states of measured-value display.

Quantities to be selected:

AK: XXXEMM f.s. CH1

number of channel (1,2,3,Σ)
function (A,V,W,VA,PF,Wh, Ω , Ωa, %)
multiplier (μ,m,k,M,G,T)
full-scale value (0-9, .)
number of analog output (1-6)

The flashing CURSOR indicates the possibilities of modification. The measured quantity and the number of the desired channel are entered directly by keys (4) and (3) respectively. The multiplier is selected by pressing the "." key when the cursor is located in front of the unit. The "ANALOG OUT" and "CLEAR" keys move the CURSOR to the right of left respectively each time they are pressed. The cursor scrolls, i.e. on leaving the display area after a key is pressed it reappears at the other end. After the desired value has been set (by the CURSOR and pressing the desired key), it is stored in memory by the "ENTER" key. The new measured value is automatically applied to the output socket in question, and the display value valid before the "ANALOG OUTPUT" call reappears in the display area.

An adjustment aid is provided for adjusting the recorder to the full-scale value of ±10 V and to zero. The desired channel is selected in the "ANALOG OUT" state. When the cursor is placed on the channel number, the channel output selected can be switched to zero by pressing the "." key. The display area shows "AK:TEST ZERO". Pressing "." again switches over to positive full-scale value, and "AK-TEST + f.s." is displayed. Pressing "." a third time switches to negative full-scale value, the display shows "AK-TEST - f.s." (K = 1...6). Pressing the "ENTER" key again displays the previously selected measured value. Proceed in the same way for programming channels 2 to 6. If an analog output is selected but not incorporated, "AK:NO OPTION" is shown in the display area. This state is left by pressing the "CLEAR" key.

5.5.8 "TALK ONLY" Operation (IEC BUS)

Printer.

Data may be printed at pre-selectable intervals by a printer with bus capabilities using the data line.

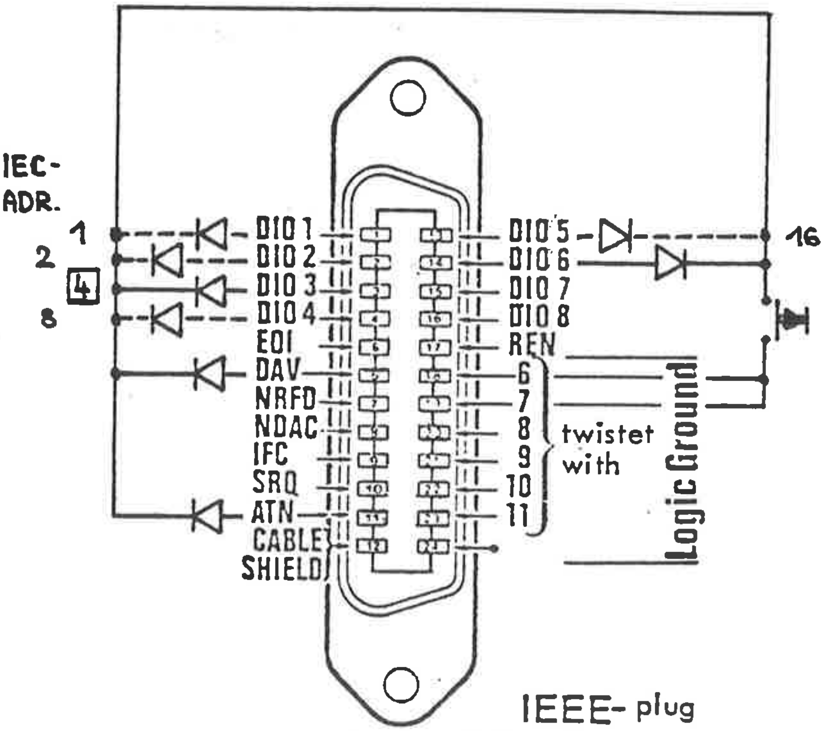
Each measured value is output as 15 bytes and terminated with

CR (carriage return) and
LF (line feed).

```
Printer output format              function
M M M     X . X X X X E ± X X——— three characters (PRO)
K M M O ± X . X X X X E ± X X——— two characters (VA, PF, Wh)
K M   O ± X . X X X X E ± X X——— one character (U, I, P, Z, X, V)
| | | | | |                 |
| | | | | |_________________|___ measured value
| | | | |_______________________ sign of active power
| | | |_________________________ overrange message
| |_|___________________________ measured quantity
|_______________________________ channel (A, B, C, D)
```

Printer settings differ from model to model. If there is a timer, switch it off (e.g., P4995 minimum time). If auto line-feed is provided, switch it off. Connect printer with interface cable and address as listener ("Listen only" switch on).

If the printer used does not support auto-addressing as listener, it can be addressed with the help of an adapter plug by pressing the key. This adapter plug is available among accessories (pre-set for printer address 4).



IEEE- plug
Type 57 Microribben connector

Pressing the "ENTER" and "." keys passes from the state of measured-value display into the "Talk only" input state.

Quantities to be selected:

T.ONLY ZZ: MM KK ↲ CR/LF selectable with "CLEAR" key
KK — channels (CH1, CH2, CH3, Σ , Σ /3)
MM — function (A,V,V ,W,VA,PF,Wh, Ω , Ω a, %)
ZZ — line number on printer (01-38)

Pressing the appropriate function key (A, V, W, ...) selects the quantity desired for printout. Pushing the "V" key twice activates or disactivates the output of voltage x V3 (V▲). Instead of the output of a measured value it is possible to select a BLANK by means of the "." key, or, by pressing this key again, the end of input (end of printing) "END". With the "CLEAR" key it is possible to set or suppress an end-of-line (CR/LF) for each input after output of the measured value. BLANK together with CR/LF signifies a blank line - SPACE without CR/LF results in spaces for the width of one measured value. This permits output of measured values in tabular form on a page printer. Pressing the "ENTER" key stores the program step and attains the next input position.

T.ONLY ZZ:	BLANK	BLANK ENTER ↲	END
	blank space	blank line	end of printing

T.ONLY TIMER XXXXX s
XXXXX — Time interval (digits 0-9)

input range: 1 ... 99999

The flashing CURSOR indicates the input position. After each input the CURSOR jumps to the next position to the right. The CLEAR key sets the CURSOR to the next position to the left.

Caution:

The time interval entered must be adapted to the printer speed and to the number of measured values and blank lines to be printed. An interval that has been chosen too short cannot be complied with.

Pressing the "ENTER" key stores the value as entered and simultaneously starts the interval.

In order to change the interval press the following keys:

"ENTER" - enter line number of the last line (END) or line 38 and terminate with "ENTER", or keep pressing "ENTER" until the last line with "END" appears in the display; "ENTER" (TIMER) - "ENTER" (display state, simultaneously starting the time interval).

After the programmed time interval has elapsed, all current preselected measured values are output to the printer. If the instrument is in the "HOLD" state, nor measured value is output, or output of the last block is concluded. If the state is shifted from "RUN" to "HOLD" during the pause interval, an additional printout of the last current values is caused. The time raster selected is not influenced by the change from "RUN" to "HOLD". This permits commanding an individual printout after a long time interval (say 99999 s) has been selected.

Caution:

Press the "CLEAR" key in the address display mode to prepare the deletion of the "TALK ONLY" operation. By switching off the mains or transmission of "IFC" through BUS the "TALK-ONLY" operation is actually cancelled.

In "TALK ONLY" mode the error message for energy measurement appears in byte 4 of the print-out (overrange-message) according to the following table:

main failure	P	-	X								X	X	X	X	X	X	X
arithmetic	F	-		X				X	X	X				X	X	X	X
change range scalef.	C	-			X		X		X	X		X	X			X	X
overrange	O	-				X	X	X		X	X		X		X		X
byte 4		blank	P	F	C	O	G	H	K	L	M	Q	R	S	T	U	V

X ... actual valid error message

Outputindication:

I ... current
U ... voltage
V ... voltage x $\sqrt{3}$
P ... active power
VA ... apparent power
FC ... power factor lead
FI ... power factor lag
WH ... energy
Z ... active resistance
X ... impedance
PRO... efficiency

Special version for transformertest:

UM ... rectified mean x 1.11
VM ... rectified mean x 1.11 x $\sqrt{3}$.
FF ... formfactor
PC ... corrected power

5.5.9 Option Function - electrical energy measurement

Before beginning to measure, make sure (in the display mode) that the counter has been erased, since the counter state preserves even if the instrument has been switched off. The memory may be cleared in the HOLD state by pressing the "CLEAR" key.

This action erases whatever values happen to be in the display. This means that in case of single-value display (CH1, CH2 or CH3) only the channel that happens to be selected is cleared. In case of two-value display the value in the left-hand half is cleared, and in case of three-value display all three. The display of the summation value is corrected after the next run. In display of the summation value all three channels and the sum value are cleared. After clearing the flashing sign " < " is displayed, which is deleted in "RUN" mode and value exceeding 0,1 nW.

Pressing the "RUN" key starts energy measurement, which can be stopped again by pressing "HOLD". If "RUN" is started again without erasing the old values, the new measured values are added.

The external trigger input corresponds to pressing the "RUN/HOLD" key and effects starting and stopping of the energy measurement within 100 µs ... 20 ms depending on state of the processor.

In the single value display the following error message is displayed between value and unit:

\- 600.24 mWh P F C O CH1

O overrange for U, I at any channel
C change of range or scale factor
F out of arithmetic range
P main failure

These messages are stored during the measuring time. They are used for examination of the measured value and cleared with the value.

Reserved for personal remarks

5.6 Special version for transformertest

This compact measuring system is particularly suitable for testing large transformers. Besides the RMS values the rectified mean value of the three voltages are measured and their average value as well as the form factors are computed. In relation to the standard version the accuracy of active power measurements at low power factors has been improved. Measurements of the rectified mean value permits correction of unload power loss, while the improved accuracy is required for measurement of short-circuit losses. Simultaneous acquiring of all values ensures maximum accuracy of the measured and computed values.

For improved accuracy, current ranges have been limited to 1-2-5 A. Energy measurement is not possible.

5.6.1 Technical Data as for standard version, but in addition:

Rectified mean value of voltages: $|\overline{U_{10}}|$ $|\overline{U_{20}}|$ $|\overline{U_{30}}|$ $\Sigma/3: |\overline{U}| = \dfrac{|\overline{U_{10}}| + |\overline{U_{20}}| + |\overline{U_{30}}|}{3}$

shown on Display and output:
$|\overline{U}| \times 1.11$ 1.11 ... formfactor for sinusoidal signals
that means U_{RMS} for sinusoidal voltages

Limits of error: ±(0.1% of m.v. + 0.1% of range)

Formfactor: $F = \dfrac{U_{rms}}{|\overline{U}|}$

F_{10} F_{20} F_{30} $\Sigma: F = \dfrac{U_{10} + U_{20} + U_{30}}{|\overline{U_{10}}| + |\overline{U_{20}}| + |\overline{U_{30}}|}$

Limits of error: Sum of errors of U_{rms} and $|\overline{U}|$

Active power: Switchover of power display to x 10 if display $<$ 10 % of range

Limits of error: ±(0.08% of m.v. + 0.015% of range)
applies to all power factors within the frequency range of 45...65 Hz
range = $U_N \cdot I_N$

Corrected active power:

$PC = P/(0.5 + 0.5 \cdot (1.1107/F)^2)$
$\Sigma PC = PC_1 + PC_2 + PC_3$

This formula for the correction of the unload-losses for transformer with oriented steel corresponds to the most national and international regulations for transformer test.

IEC Publ. 76-1 1976

VDE 0532 part 1/11.71

ANSI/IEEE C57.12

ÖVE M20 part 1

5.6.2 Functional description

The instrument has three average rectifiers (rectified mean) and three A/D-converter instead of the energy option. On display or output value is multiplied with 1.11 (FF for sinus). The three additional values are calibrated with the same triangular signal as the other nine values (3x U, 3x I, 3x P). Range- and scalefactor for the average rectifier are the same as for the "RMS" converters and may be selected only together.

From the 12 measured values all other values are calculated.

5.6.3 Operation over keyboard (front panel)

Selection of display modes, enter modes and measuring functions is operated as in the standard model.

Some keys have two functions:

V key:	Selects the functions U or U delta and switches the display between V and V delta (= U x $\sqrt{3}$) if one of these functions is active. The multiplication is only made for the display and "TALK ONLY" mode. At V delta the rectified mean voltage is also multiplied with $\sqrt{3}$.
OPTION FUNCTION key:	Selects the function rectified mean x 1.11 or rectified mean delta x 1.11 and switches the display between V and V delta (= V x $\sqrt{3}$) if one of these functions is active. The multiplication is only made for the display and "TALK ONLY" mode. At V delta the RMS voltage is also multiplied with $\sqrt{3}$.
P key:	Selects the function P or P corr. and switches the display between P and PC if one of these functions is active.
POWER FACTOR key:	Selects the function PF and FF and switches the display between PF and FF if one of these functions is active.
TALK ONLY:	The functions U, U delta, V, V delta may be selected independent. U delta and V delta are not interlocked.
ANALOG OUT:	The functions U delta and V delta are not selectable.

5.6.4 Remote control commands

Remote programming of RANGE, SCALE, ANALOG OUT, RUN/HOLD, N and SRQ are same as in the standard model. Range- and scalefactors are same for RMS and Rectified mean. The new functions are programmed and indicated over BUS as following:

Function (control command)		Outputindication	
		BUS	DISPLAY
U ...	RMS	... U	V
V ...	rectified mean x 1.11	... UM	$\overline{V}$, Vrmean
W ...	form factor	... FF	FF
Q ...	corrected power	... PC	Wc, wcorr
	U△ (TALK ONLY)	... V	V△
	V△ (TALK ONLY)	... VM	$\overline{V}$△ , V△ rmean

Special version for motortest

Reserved for personal remarks

6. FUNCTIONAL DESCRIPTION

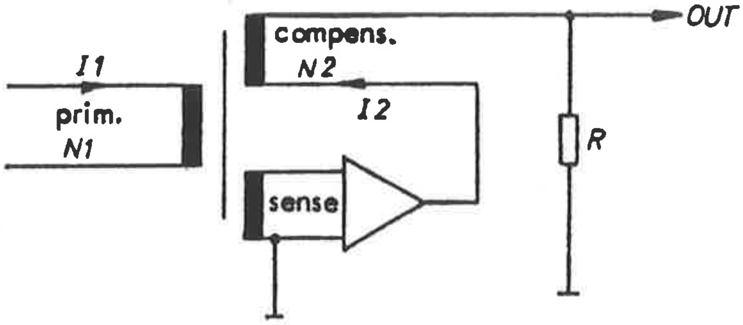
6.1 Signal pre-processing

(acquisition and processing of measured quantities up to conversion into digital quantities)
Each input quantity is standardized by a transformer (1 x current, 1 x voltage per channel) at the secondary and subsequently converted into proportional DC voltages in an RMS converter (current, voltage) an in a multiplier (power). These 9 DC quantities are converted into digital signals in 9 separate analog-digital converters. The voltages proportional to active power are each passed to a voltage-frequency converter, which converts them into a proportional frequency.

6.1.1 Input transformer

Current transformer

Principle:



The flux produced by I_1 x N_1 is compensated for by I_2 x N_2, so that the voltage across the sense winding becomes zero.

$I_1.N_1 = I_2.N_2$; therefore $I_2 = \frac{N_1}{N_2} \cdot I_1$ proportional to the input current.
The current I_2 produces the standardized voltage drop across R for further processing.
The primary winding consists of a single turn (copper tape of approx. 16 mm^2 cross-section). Range selection is effected on the secondary side, by means of 1-2-5 steps at the secondary winding (N2) and 0.1-1-10 steps in the following amplification. This yields 9 ranges from 0.1 to 50 A. At the output a standardized voltage of $U_{I\ ACrms}$ = 2 V is available.

Voltage transformer

The voltage transformer uses the same principle as the current transformer. In this case, however, the input voltage is converted by a series resistor (660 kOhm) into a current passing through the primary winding (many turns). Ranges are again selected at the secondary by means of secondary taps (5 ranges from 65 V to 650 V). At the output a standardized voltage of $U_{U\ ACrms}$ = 2 V is available.

6.1.2 Overload and underload recognition

The voltages $U_{I\ AC}$ and $U_{U\ AC}$ are passed to 4 comparators each, comparing these voltages with 2 thresholds each (one for overload, one for underload), in each case once for the positive and once for the negative half-wave. The outputs of these comparators are read by the CPU at certain intervals. The overload threshold is at 120 %, the underload threshold at 40 % of nominal load.

6.1.3 RMS conversion

The voltage $U_{I\ AC}$ and $U_{U\ AC}$ are converted into a DC voltage equivalent to the RMS value by an RMS converter each, using the formula

$$U_{rms} = \sqrt{\frac{1}{T}\int_0^T U_{(t)}^2\,dt}$$

At the output a DC voltage of 2 V proportional to the measured quantity is available ($U_{I\ DC}$; $U_{U\ DC}$).

6.1.4 Multiplier

The quantities $U_{I\ AC}$ and $U_{U\ AC}$ are multiplied by the time-division method and converted into a DC voltage proportional to active power. At the output of the multiplier a DC voltage of approx. 2 V is available ($U_{P\ DC}$).

Principle:

By this method the rectangular signal of a multivibrator (frequency for this purpose approx. 70 kHz) is subjected to a change in keying ratio by either of the quantities to be multiplied (in this case $U_{I\ AC}$). The second input signal (in this case $U_{U\ AC}$) changes the amplitude of the rectangular signal. If the integral (mean) of the resulting signal is taken, the product of the two signals results, weighted by their phase shift. The output signal (DC voltage) is therefore proportional to the active power of the input signals.

6.1.5 Analog-digital conversion

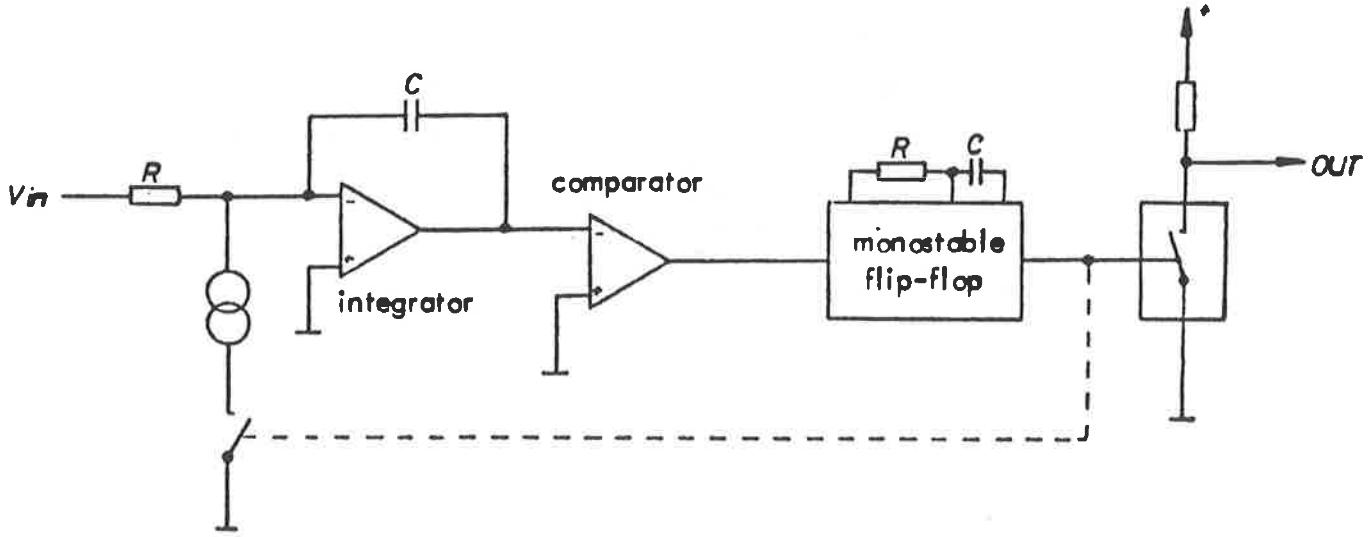
The 9 DC voltages (proportional to input current, voltage and active power in each channel) are digitalized in 9 separate ADCs. The ADCs work by the integrating charge-compensation method. The integration period is 360 ms, followed by an auto-zero phase of 120 ms, so that total conversion time is 480 ms.

The oscillator for controlling the conversion is synchronized with the mains frequency in the range from 47 Hz to 63 Hz by means of a synchronizing circuit (PLL ... phase-locked loop), thus affording optimum suppression of any superimposed disturbances from the mains on the ADC input. The periods quoted above refer to a mains frequency of 50 Hz.

6.1.6 Wh converter

The three voltages proportional to active power $U_{P\ DC}$ in channels 1, 2, 3 are converted into a frequency (up to 100 kHz) by a voltage-frequency converter). These pulses are summed on the CPU panel by one counter each.

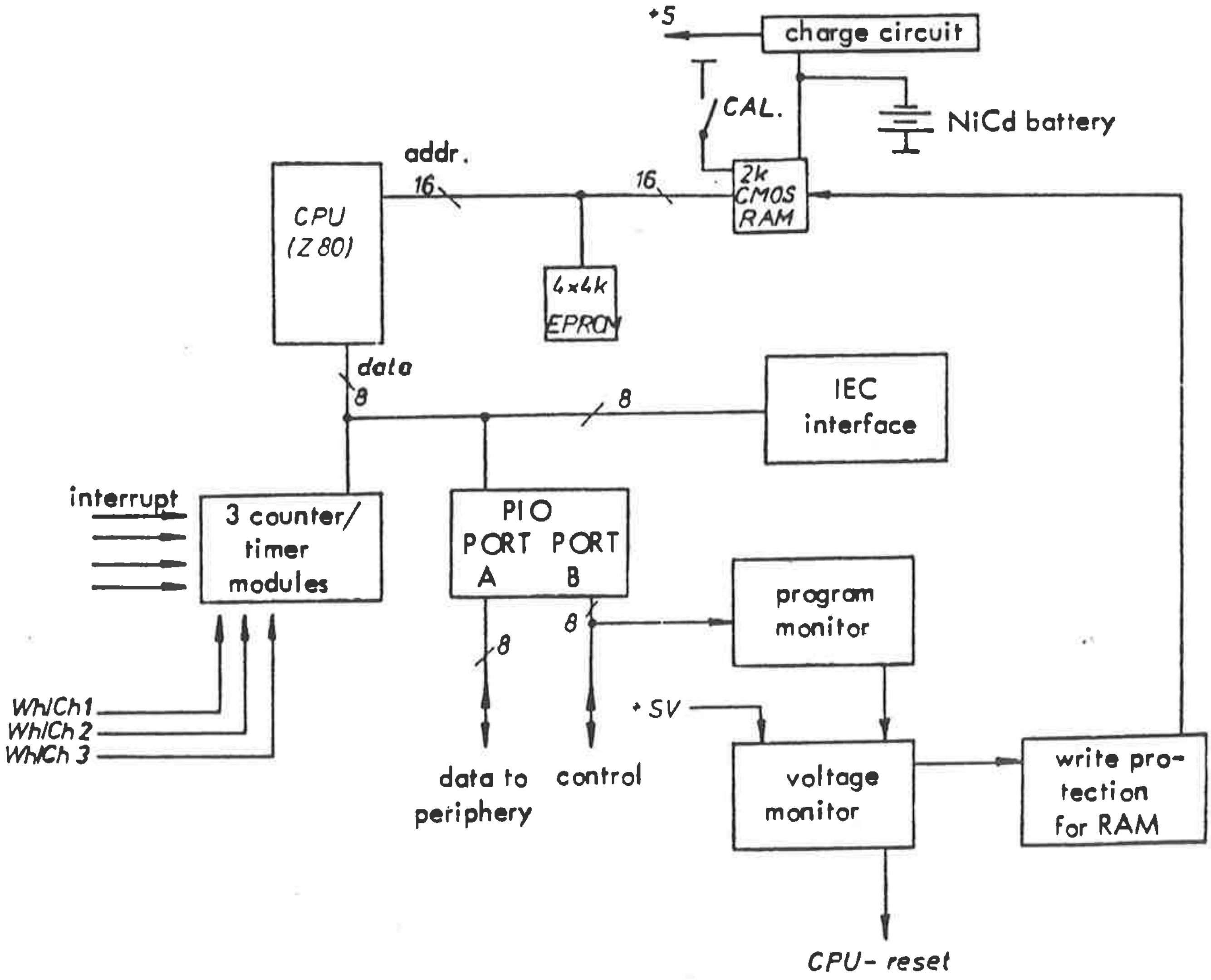
Principle:



The input voltage is integrated down by the integrator until its output attains a value of zero. At that time the comparator starts a monostable multivibrator, whose output switches on a constant-current source at the integrator input for a precisely defined period. Then down-integration by the input voltage is resumed. The frequency of switching on the constant-current source corresponds to the input voltage, i.e., the output frequency of the monostable flip-flop is proportional to the input voltage.

6.2 CPU

The task of the CPU is controlling the whole measuring process, to read the measured data into the ADC and to multiply them by the appropriate factors (range, scale, calibrating factor), to determine the quantities to be computed therefrom and to format them for the various output modes. It must also perform control of the IEC bus and the handshake with the display processor.



All data are stored in a CMOS RAM which maintains its data even though the instrument may be switched off, using a NiCd storage battery.
Two circuits monitoring the program and the supply voltage make for maximum system reliability.

6.3 Data output and input

6.3.1 Keyboard

The keyboard is of the completely welded foil type. When a key is pressed, the two contact strips of the spaced foils touch and close a contact.

The display processor (8039) inquires the position of the depressed key and supplies an appropriate code to the main processor (Z80).

6.3.2 Display

The display unit consists of the display tube and its control (processor 8039 and control components.)

The display tube is a fluorescent vacuum tube with 20 digits comprising a 5 x 7 dot matrix each. The filament of the tube is simultaneously the cathode, the grid behind it is used for selecting the controlled spot (multiplex method). The 5 x 7 points of the matrix are formed by 35 anodes coated with a fluorescent substance, which makes them glow green when a current flows. The plate voltage is approx. 40 V; it is produced by a separate DC/DC converter.

The data for the display and for the 11 LEDs in the front panel are transmitted by the main processor (Z80) to the display processor via the data bus and additional handshake lines.

6.3.3 Interface

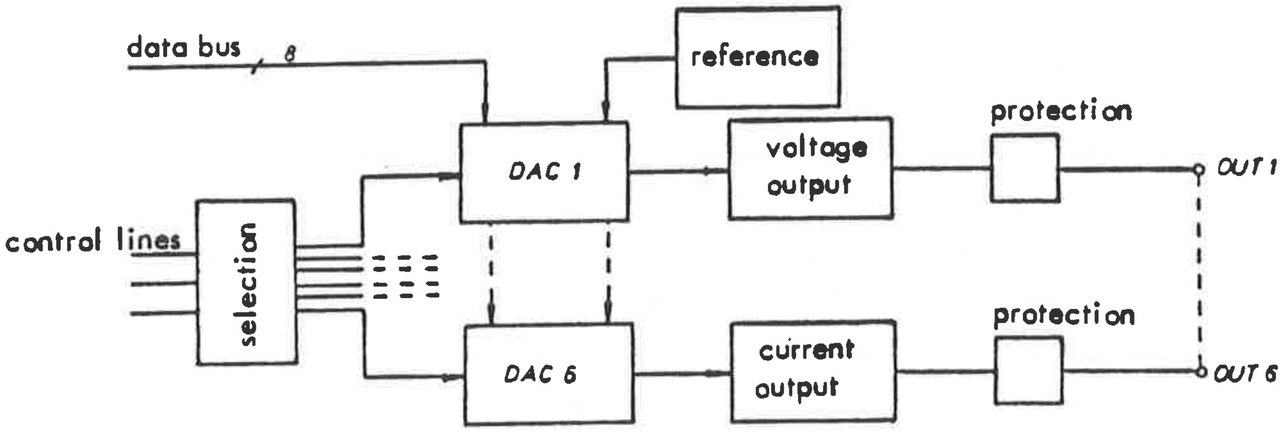
Transfer of data to the IEC bus and from the IEC bus to the main processor is effected by a separate integrated component specially designed for this purpose with two following bus drivers.

This integrated component also reads the state of switches at the rear of the Interface (rtl switch, CAL/RUN switch, trigger socket).

If the Talk Only mode is switched on, the instrument is addressed and transmits the requested data to a connected printer via the Interface. Special hardware for this purpose is not required.

6.3.4 Analog outputs

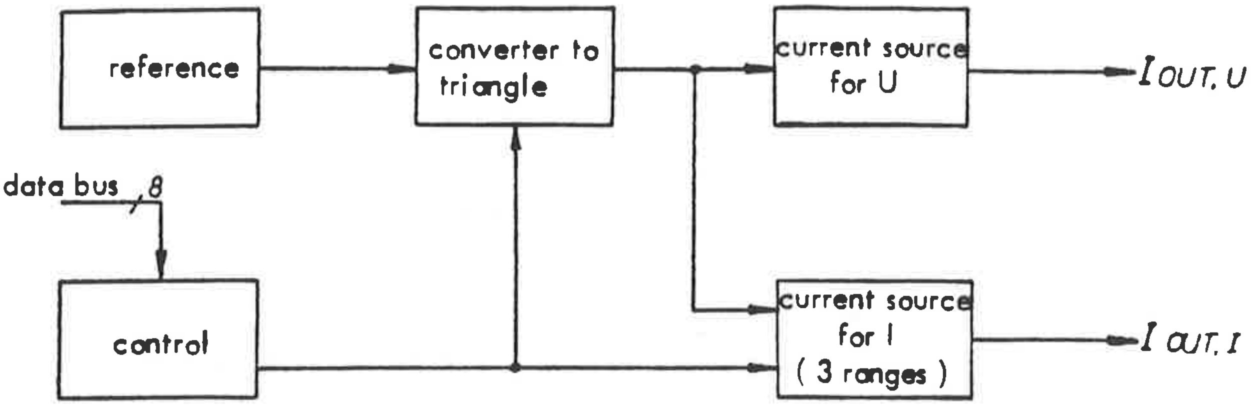
Up to 6 digital-analog converters are connected to the internal data bus via intermediate memory.



Data are inscribed, already correctly formatted, into the appropriate DAC by the CPU after each ADC conversion (480 ms). The output circuit of the DAC supplies ± 10 V for maximum possible signal.

Each output is protected against the application of an external voltage up to U_{rms} = 125 V by means of a PTC and protective power diodes.

6.4 Calibration



The accurate voltage of a heated and thermostat-controlled reference diode is converted into a calibrated triangular signal (approx. 70 Hz). This signal is further converted into a current for calibration of the voltage circuit and another current for calibration of the current branch and subsequently fed into the reference resistors R at the output of the compensated transformers.

These reference values are measured by the ADC, time-division converters and Wh converters, compared with expected values and deviations stored in C-MOS RAM.

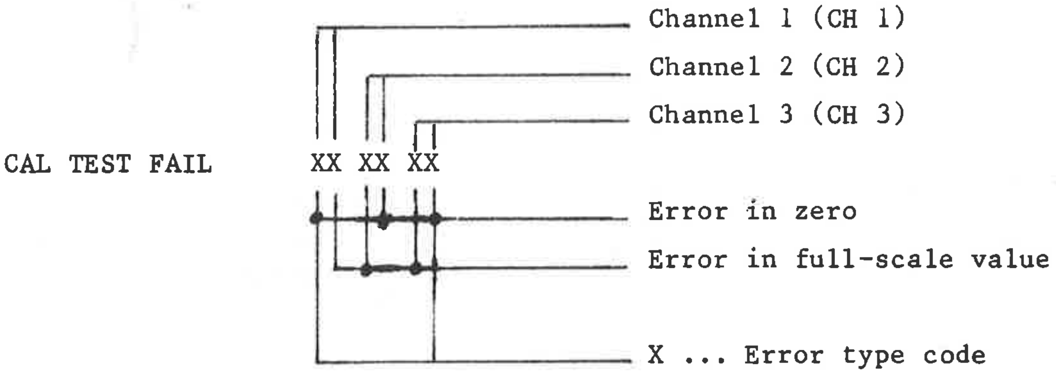
Before performing a calibration the warm-up period of the instrument should have expired.

For internal calibration all signals should be disconnected at the rear and the turnkey switch moved to the "CAL" position. The calibration process takes approx. 3 min. On completion of the internal calibration process

TURN KEY TO RUN

is displayed in the display area (7). After turning the turnkey switch, the instrument is ready to measure with the new reference values.

At the end of a calibration process the new calibration data are checked for acceptability. If a hardware error were to render one value or several values invalid, the corresponding old values are not overwritten, and an appropriate message appears in the display:



Error type code:
0 ... no error
1 ... error current
2 ... error voltage (also in combination,
4 ... error power e.g. 6 ... error voltage + power)
8 ... error energy

Above "9" hexadecimal digits are displayed:
10 ... A
11 ... B
12 ... C
13 ... D
14 ... E
15 ... F

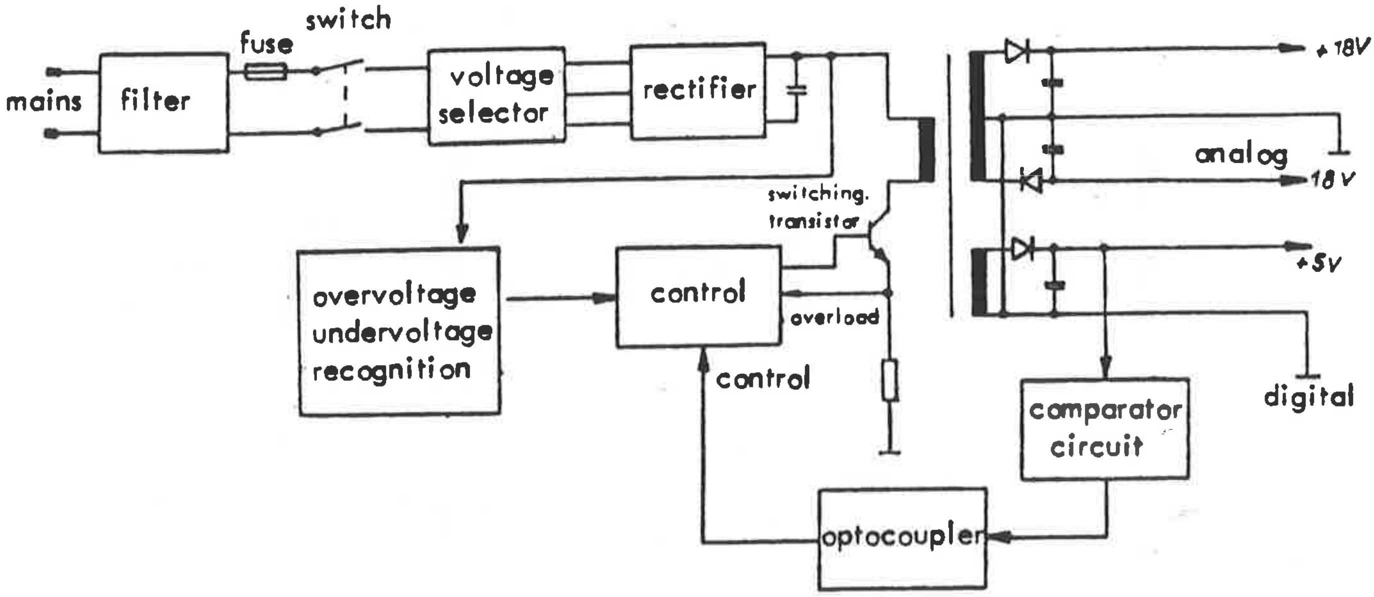
The error message appears if a calibration value deviates by more than 1 % from the old value.

In this form of calibration, deviations from the expected value after the compensated input transformers are ascertained by feeding-in exact reference values and subsequently stored. These deviations are taken into account when measured values are computed.

Matching of the compensated transformers is done in the plant and may be considered sufficiently stable for physical reasons, unless the instrument becomes defective.

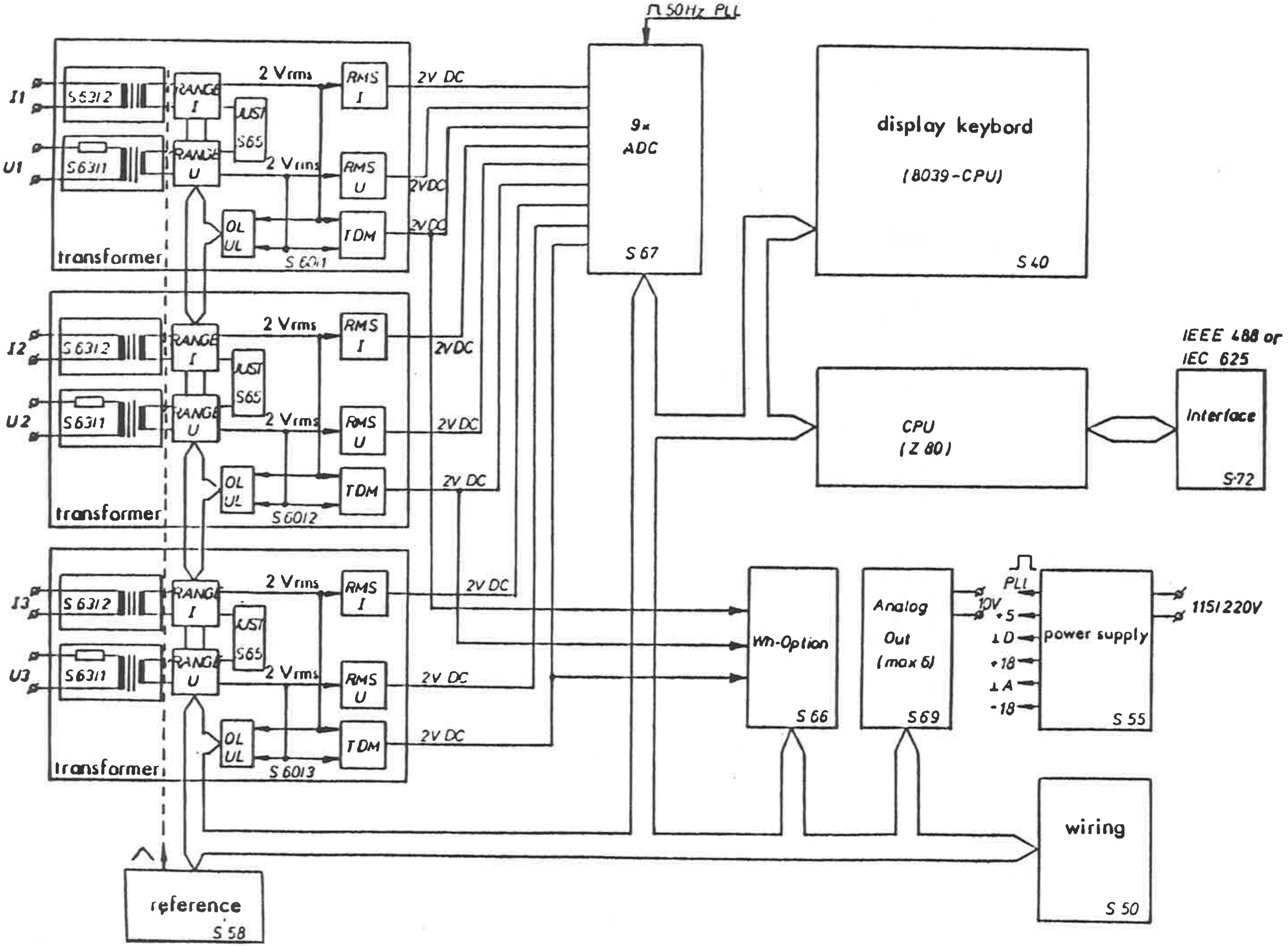
The deviation of individual channels can be ascertained by connecting the three currents paths in series and the voltage paths in parallel, applying measured quantities at the approximate level of the nominal ranges and comparison of displayed values for each channel. Since a defect or change with identical error effects in all three channels is extremely improbable, this test in conjunction with the calibrating function will ensure instrument accuracy.

6.5 Voltage supply



The switching-networks section delivers 5 V for the instrument, stabilized for supplying the digital assemblies (permissible load approx. 3.5 A) and ± 18 V unstabilized for the supply of analog assemblies (permissible load approx. 600 mA).

The voltage required in each case is produced on the appropriate module from ± 18 V by following fixed-voltage regulators.



⊓ 50Hz PLL
I1
U1
S6312
S6311
RANGE I
RANGE U
JUST S65
2 Vrms
RMS I
RMS U
2V DC
2VDC
OL UL
TDM
S 6011
transformer
I2
U2
S 6012
I3
U3
S 6013
9x ADC
S 67
display keybord
(8039-CPU)
S 40
CPU
(Z 80)
IEEE 488 or
IEC 625
Interface
S72
Wh-Option
S 66
Analog Out (max 6)
S69
PLL
10V
+5
⊥D
+18
⊥A
-18
power supply
115/220V
S 55
wiring
S 50
reference
S 58

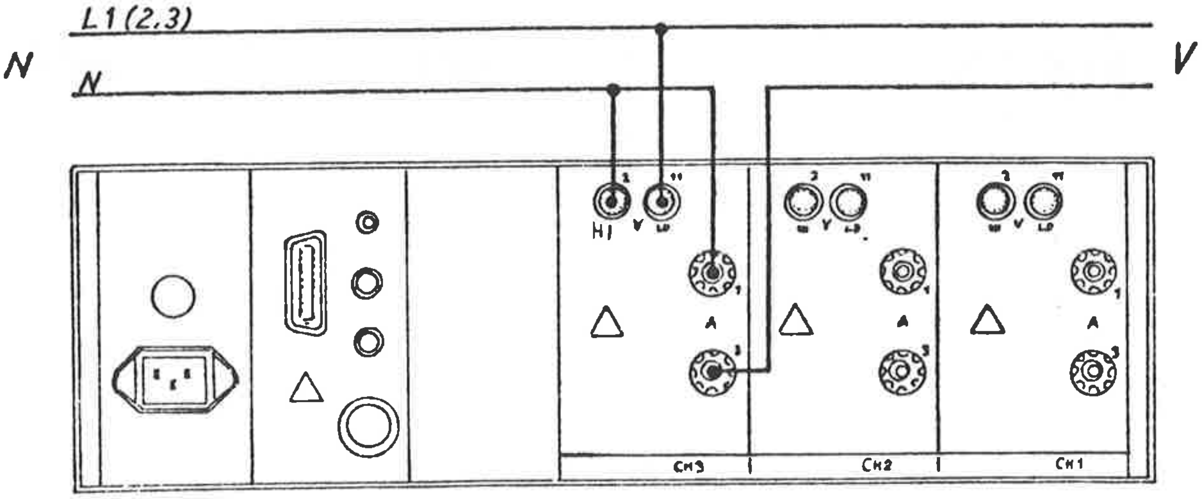
Reserved for personal remarks

Reserved for personal remarks

7. CONNECTING DIAGRAMS

The reference arrow indicates the terminal closer to the source.

7.1 Single phase AC system



Single-channel display Keys: CH3 (or CH2 or CH1)

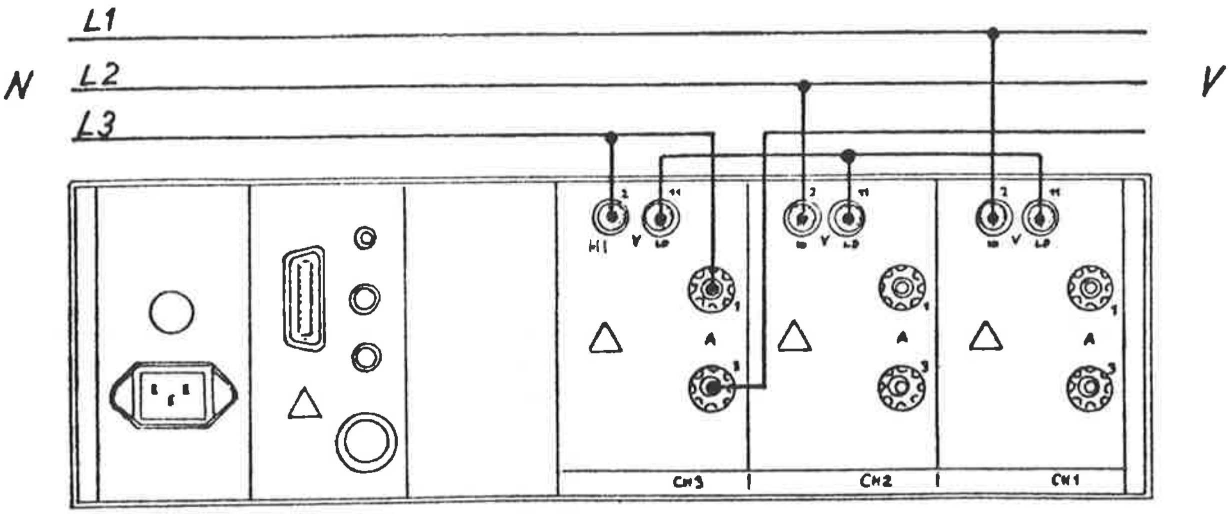
Display corresponds to: U, I, P, S, λ, $|Z|$, Re(Z), W

Connection to all three channels permits measurement of three consumers and measurement of mean or total value.

Measurement of reactive power is only possible with an additional 90 ° phase-turning component.

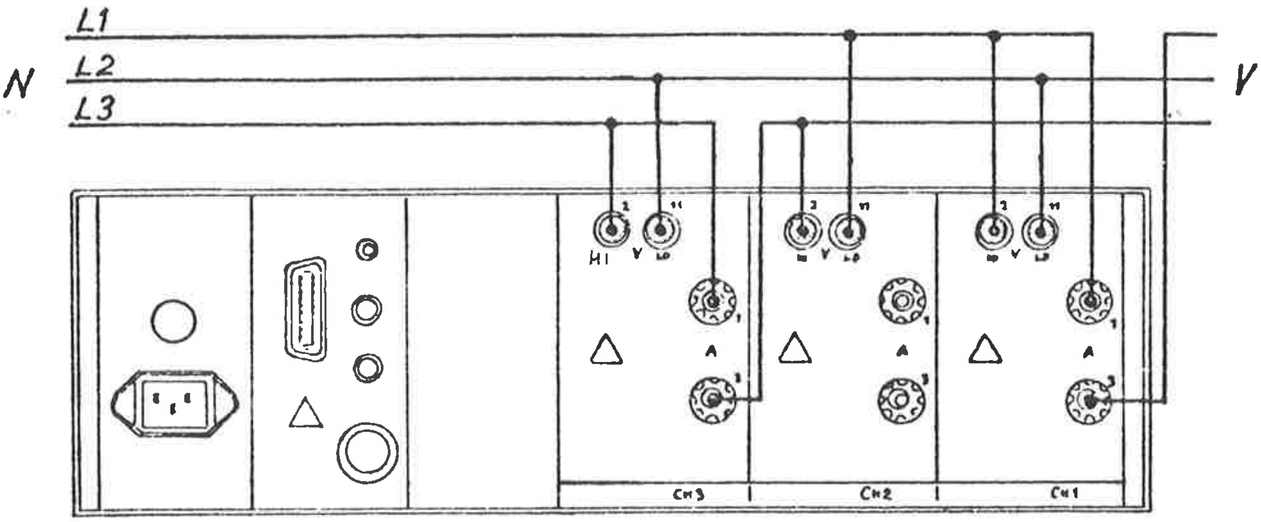
7.2 Three-wire three-phase system

Active power single phase, symmetric load



Display: single channel	Keys CH3 (or CH2 or CH1)
Display corresponds to	U_{10}, U_{20}, U_{30}, I_3, λ_3
Display x 3 for	P, S, W
Display / 3 for	$|Z|$, Re (Z)

Active power two-phase, asymmetric load (two-wattmeter method)



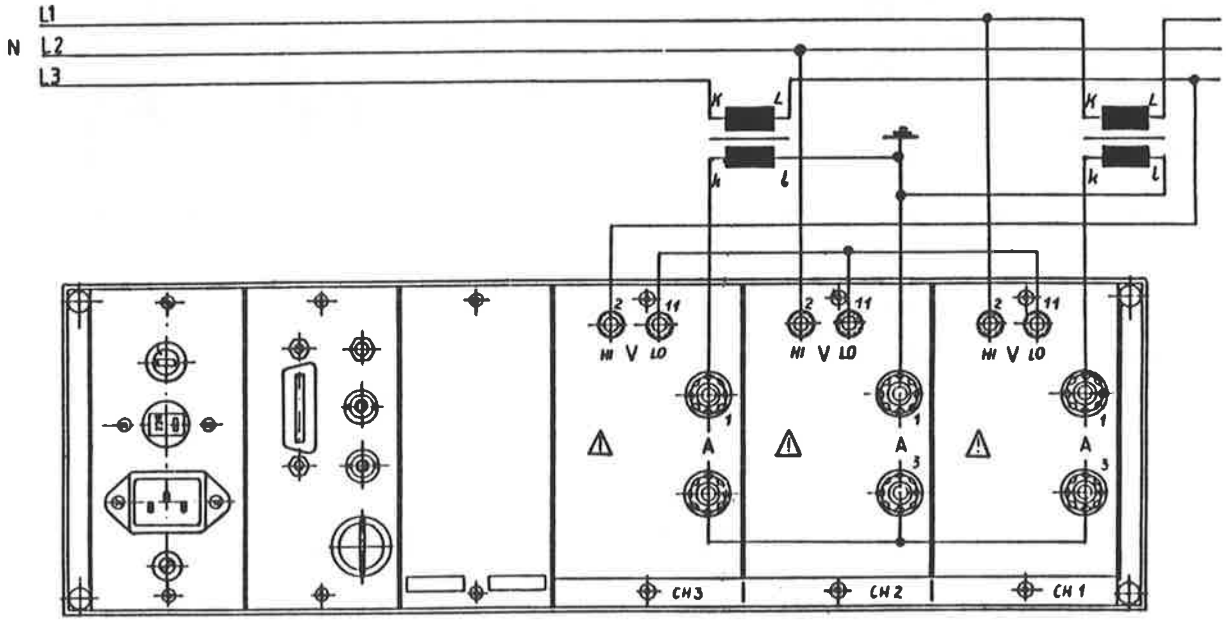
Display: two channels	Keys CH1/2/3
three channels for U	
Display corresponds to:	U_{13}, U_{12}, U_{23}, I_1, I_3, $\Sigma P = P_{12} + P_{23}$ $\Sigma W = W_{12} + W_{23}$

Display erroneous for λ , $|Z|$, Re (Z)

SUM, SUM/3 for (U,P,W) only, because only 2/3 will be displayed for mean value of I (SUM/3)

Active power two-phase, asymmetric load

In order to avoid the drawback of the two-wattmeter method (values partially incorrect owing to the 30° phase rotation of the voltage), the following circuitry will work in three-phase systems:



The current $I_2 = -(I_1 + I_3)$ is summed by summing over the two current transformers and pole-changing. With this circuitry all values are displayed correctly as for the three-wattmeter method.

Display three channels Keys CH1/2/3

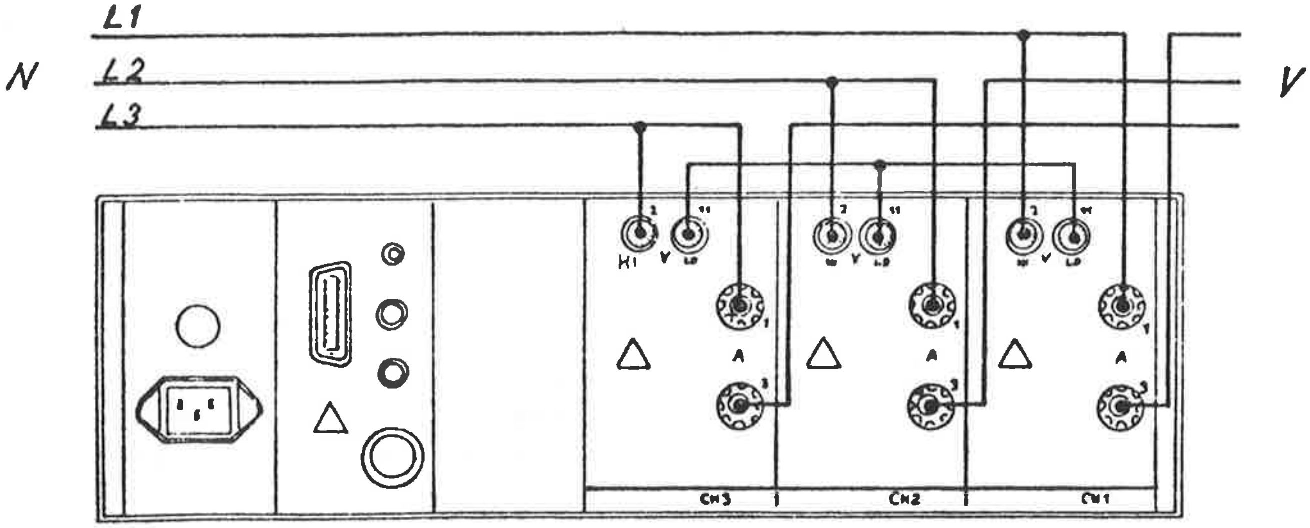
Display corresponds to U_{10}, U_{20}, U_{30}, I_1, I_2, I_3, P_1, P_2, P_3, S_1, S_2, S_3

$\lambda 1$, $\lambda 2$, $\lambda 3$, $|Z_1|$, $|Z_2|$, $|Z_3|$, $Re(Z_1)$, $Re(Z_2)$, $Re(Z_3)$, W_1, W_2, W_3

Key SUM, SUM/3

Display corresponds to $\overline{U}$, $\overline{I}$, ΣP, ΣS, $\Sigma \lambda$, $\Sigma |Z|$, $\Sigma Re(Z)$, ΣW

Active power three phases, asymmetric load



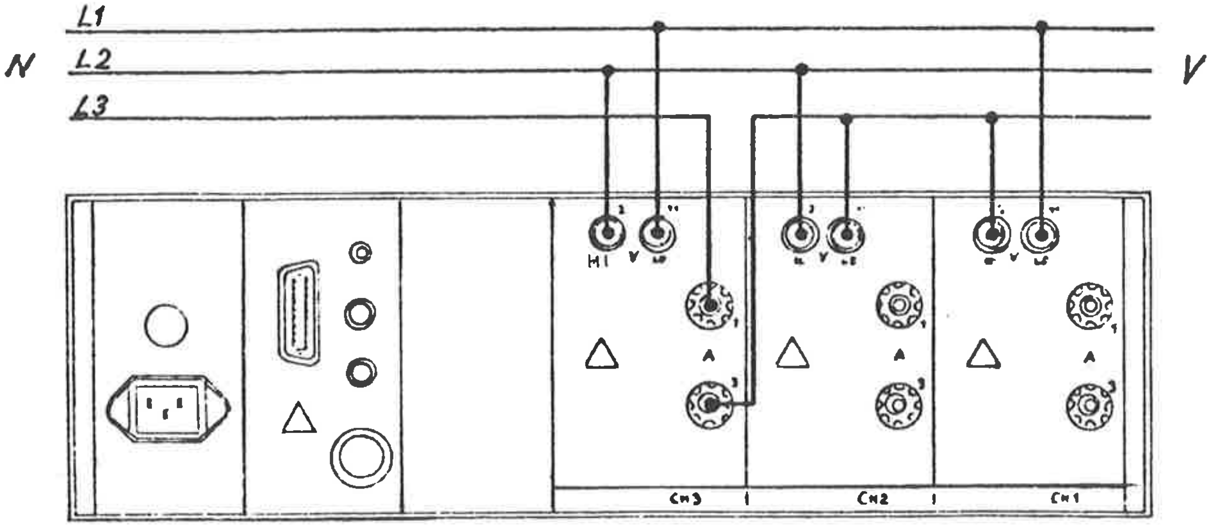
Display three channels   Keys: CH1/2/3

Display corresponds to U_{10}, U_{20}, U_{30}, I_1, I_2, I_3, P_1, P_2, P_3,
S_1, S_2, S_3, λ_1, λ_2, λ_3, $|Z_1|$, $|Z_2|$, $|Z_3|$,
Re(Z_1), Re(Z_2), Re(Z_3), W_1, W_2, W_3

Key SUM, SUM/3

Display corresponds to $\bar{U}$, $\bar{I}$, ΣP, ΣS, $\Sigma \lambda$, $\Sigma |Z|$, Σ Re(Z), ΣW

Reactive power single-phase, symmetric load



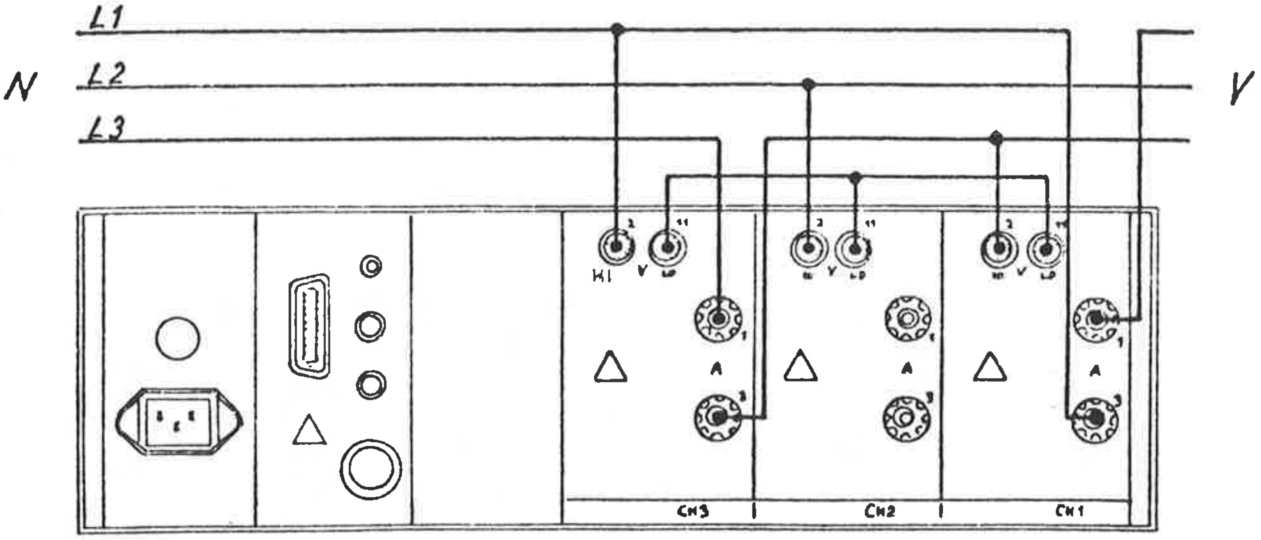
Caution: Because of artificial phase turning, power factor and active resistance are not computed correctly when measuring reactive power

Display single channel   Keys: CH3 (or CH2 or CH1)

Display corresponds to: U_{12}, U_{23}, U_{31}, I_3

Display/$\sqrt{3}$ for: Q, reactive energy

Reactive power two phases, asymmetric load

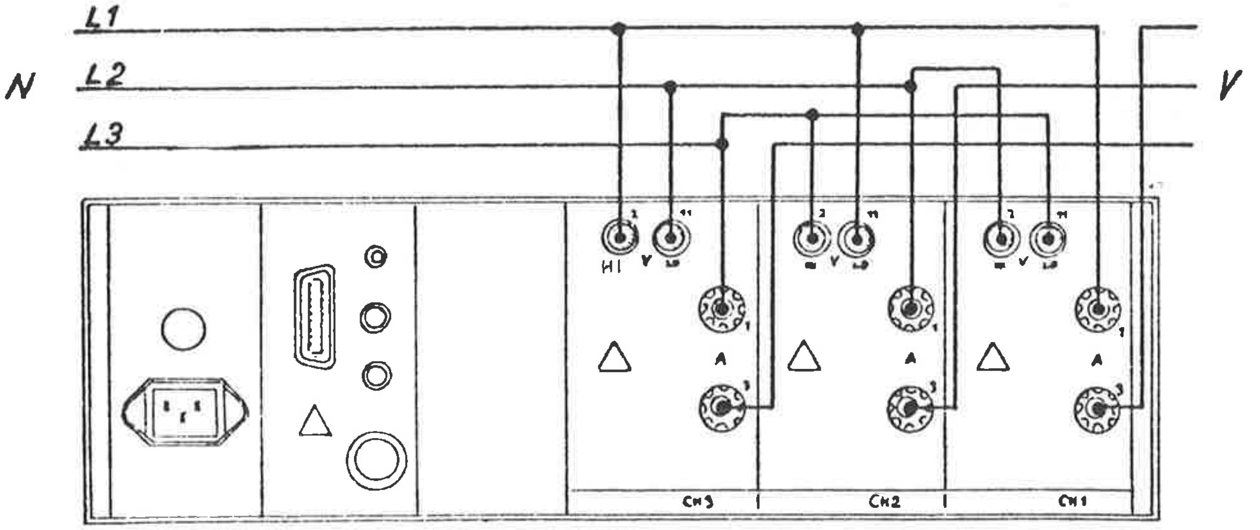


Display two channels — Keys CH1/CH2/CH3

Display corresponds to: — U_{10}, U_{20}, U_{30}, I_1, I_2

Display x$\sqrt{3}$ for : — Σ $Q = Q_1 + Q_2$, sum of reactive energy

Reactive power three phases, asymmetric load



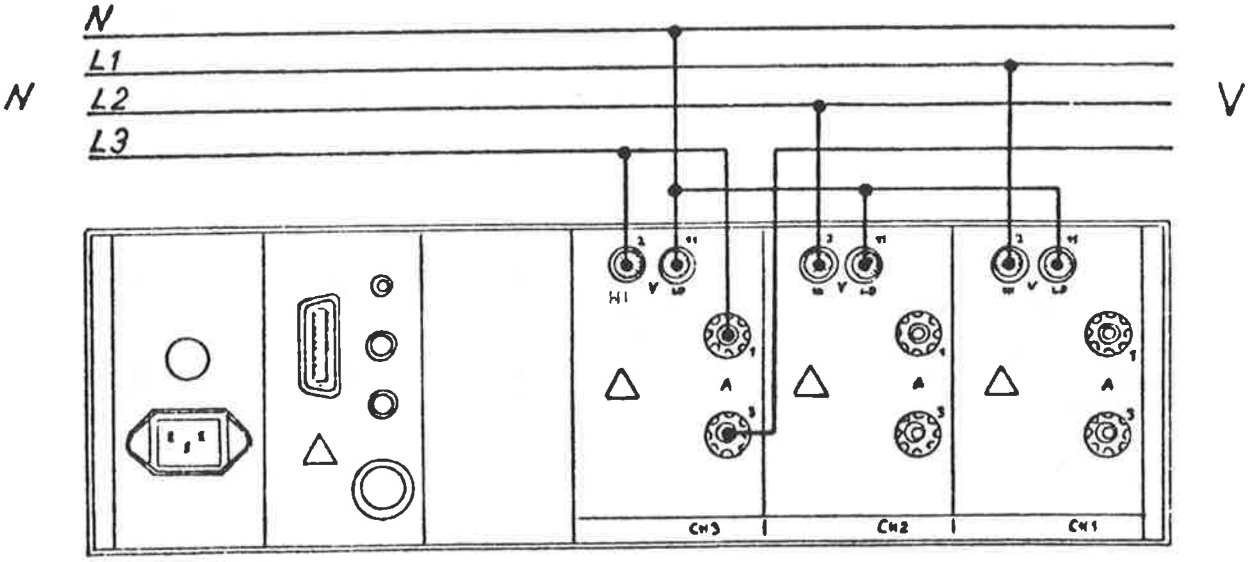
Display: three channels — Key CH1/2/3, SUM, SUM/3

Display corresponds to: — U_{12}, U_{23}, U_{31}, I_1, I_2, I_3, U, I

Display /$\sqrt{3}$ for — Σ Q, sum of reactive energy

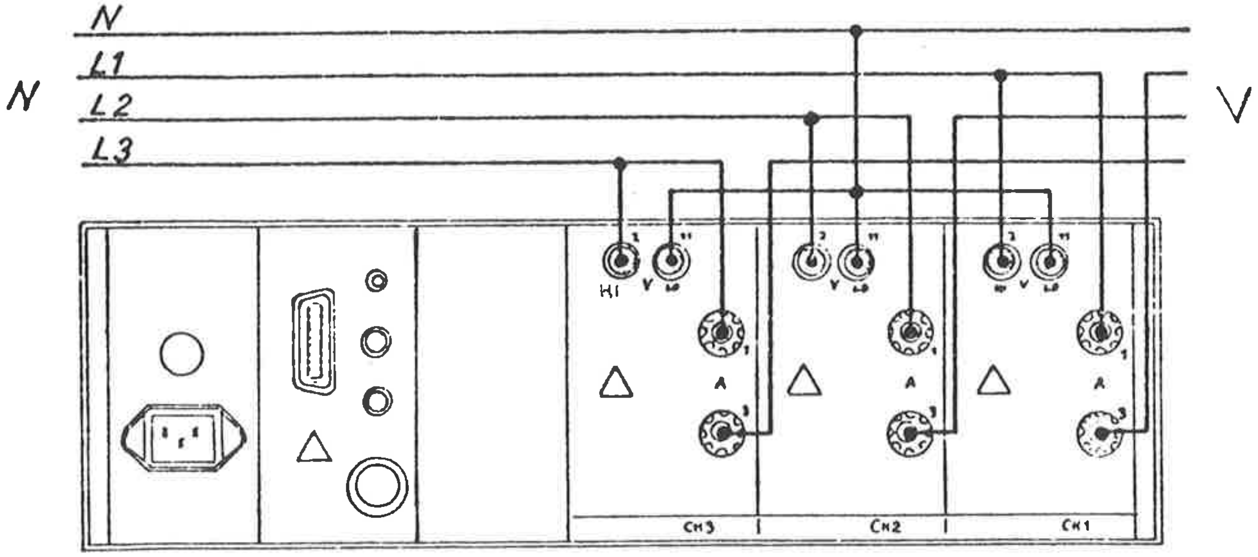
7.3 Four-wire three phase system

Active power single phase, symmetric load



Display single channel	Keys CH3 (or CH2 or CH1)
Display correct for	U_{10}, U_{20}, U_{30}, I_3, λ_3
Display x3 for	P, S, W
Display /3 for	$\lvert Z \rvert$, Re(Z)

Active power three phases, asymmetric load



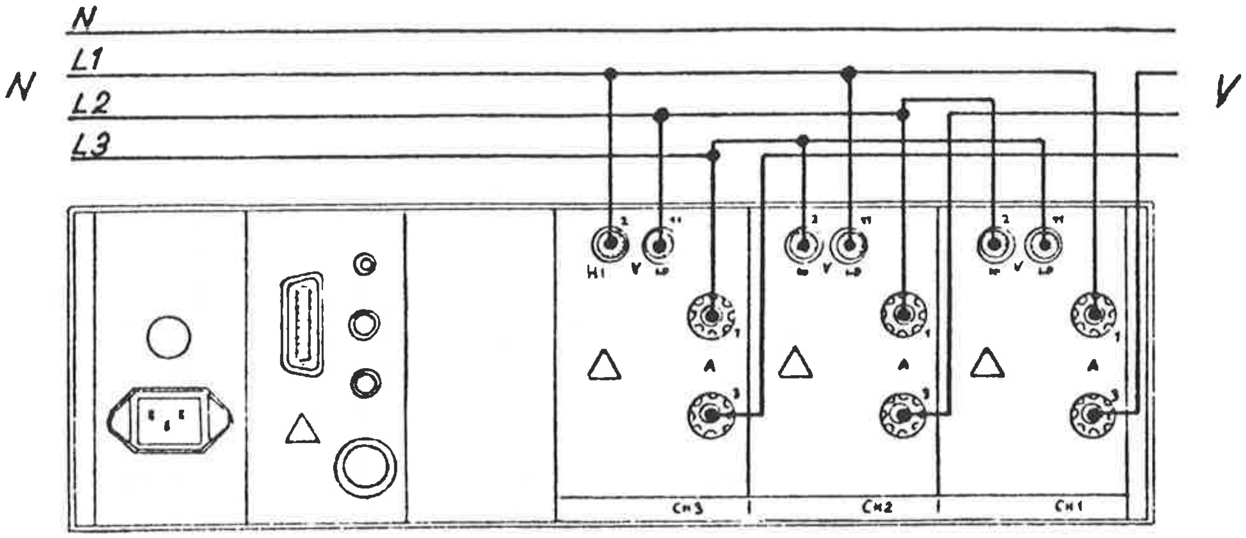
Display three channels	Keys CH1/2/3

Display corresponds to U_{10}, U_{20}, U_{30}, I_1, I_2, I_3, P_1, P_2, P_3, S_1, S_2, S_3, λ_1, λ_2, λ_3, $\lvert Z_1 \rvert$, $\lvert Z_2 \rvert$, $\lvert Z_3 \rvert$, Re(Z_1), Re(Z_2), Re(Z_3), W_1, W_2, W_3

Key SUM, SUM/3

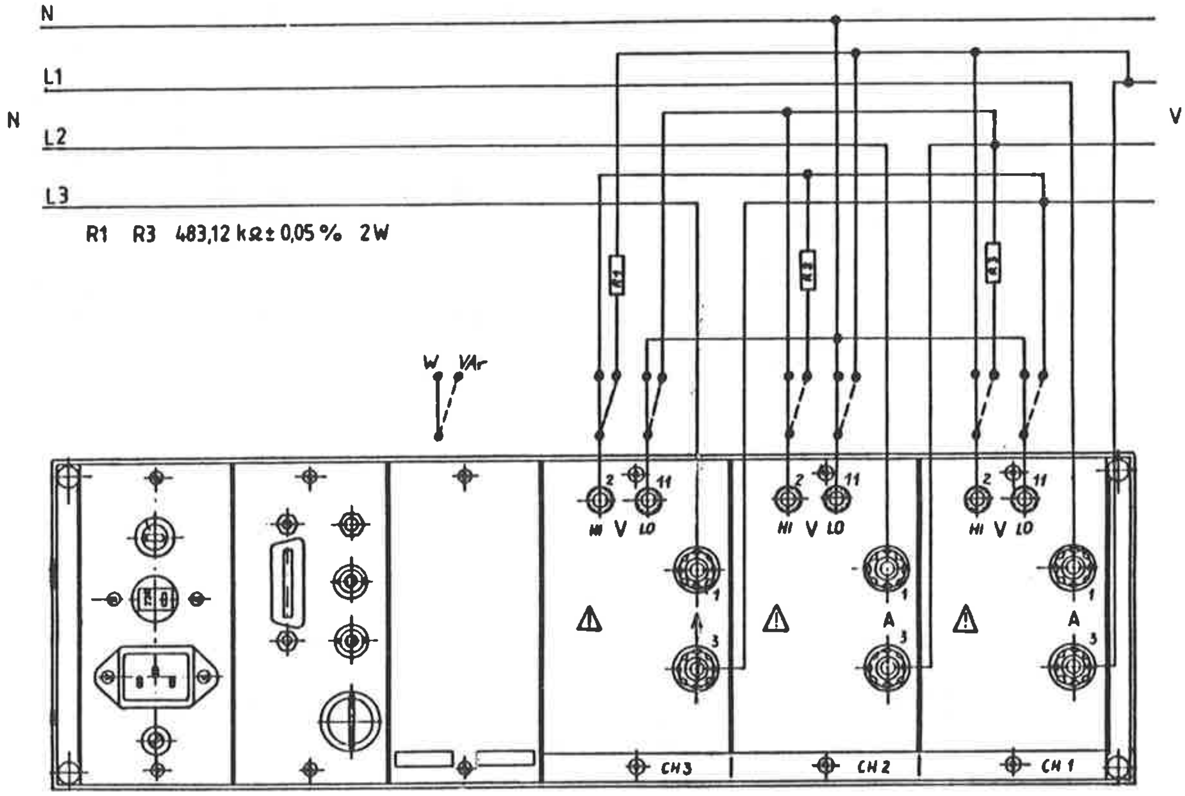
Display corresponds to $\bar{U}$, $\bar{I}$, Σ P, Σ S, $\Sigma\lambda$, $\Sigma\lvert Z \rvert$, Σ Re(Z), Σ W

Reactive power three phases, asymmetric load



Display three channels	Keys CH1/2/3, SUM/SUM/3
Display corresponds to:	U_{12}, U_{23}, U_{31}, I_1, I_2, I_3, U, I
Display /$\sqrt{3}$ for	ΣQ_1, sum of reactive energy

Active power three phases, asymmetric load
Reactive power three phases, asymmetric load
with switch over for three phase system



Display three channels   Keys CH1/2/3   Switch in W

Display corresponds to U_{10}, U_{20}, U_{30}, I_1, I_2, I_3, P_1, P_2, P_3, S_1, S_2, S_3
λ_1, λ_2, λ_3, $|Z_1|$, $|Z_2|$, $|Z_3|$, $Re(Z_1)$, $Re(Z_2)$, $Re(Z_3)$, W_1, W_2, W_3

Key SUM, SUM/3

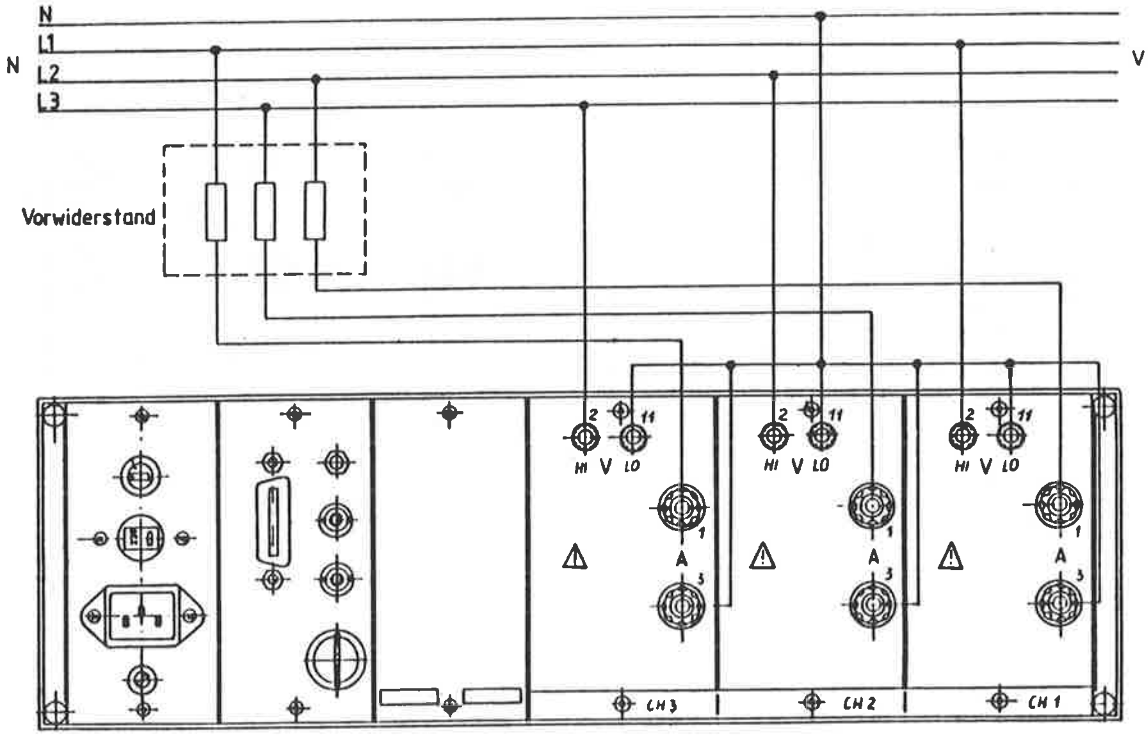
Display corresponds to $\overline{U}$, $\overline{I}$, ΣP, ΣS, $\Sigma \lambda$, $\Sigma |Z|$, $\Sigma Re(Z)$, ΣW

Switch in VAr

Display three channels   Keys CH1/2/3, SUM/SUM/3

Display corresponds to   Q, ΣQ, sum of reactive energy + Σ

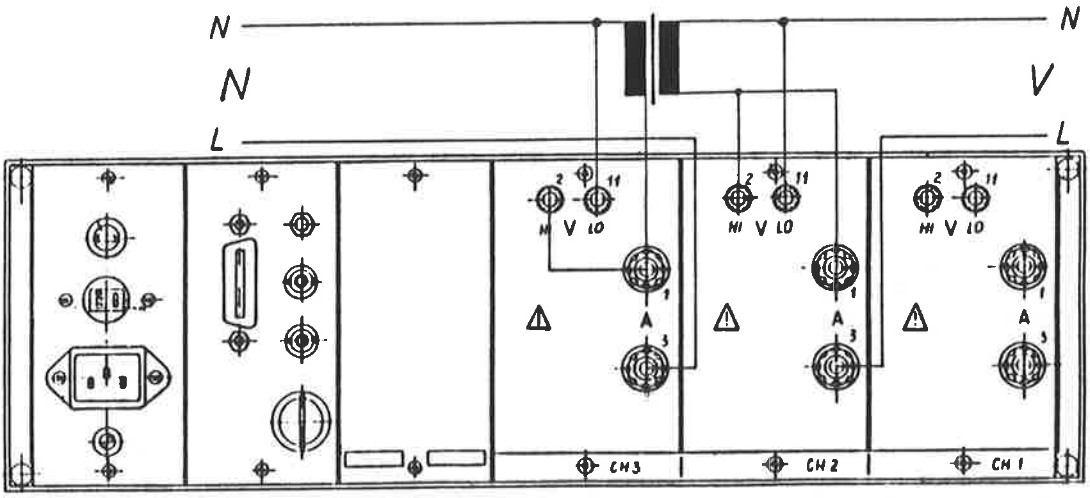
Measuring phase angle



Range:	U depends on voltage applied I 0.1 A; series resistance depends on voltage applied
Function:	P F
Display three-channel	keys CH1/2/3
Display corresponds to	cos φ_{12}, cos φ_{23}, cos φ_{31} At φ... $\underline{120}$ ° this yields -0.500 Pf φ = 180 - arc cos

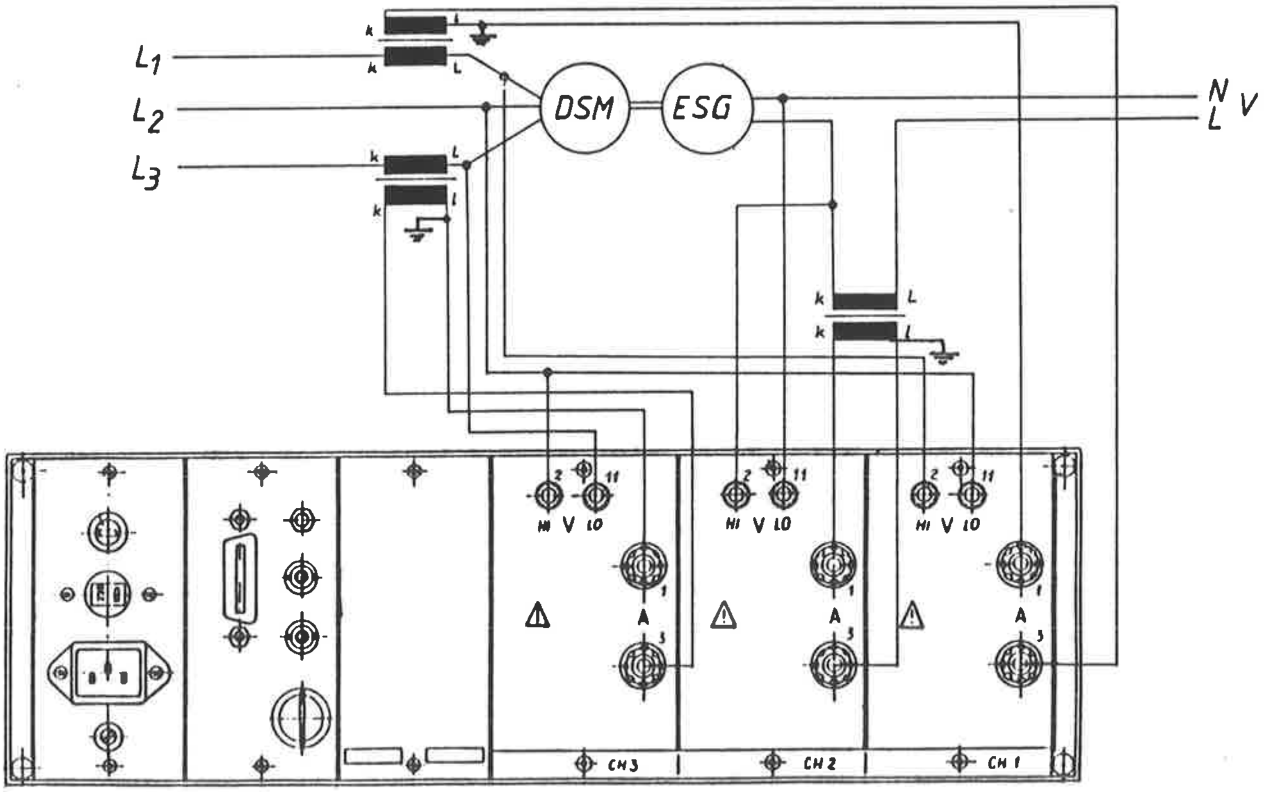
For measuring the phase angles between the phase voltages, connect them in delta.

Measuring efficiency e.g. in a single-phase transformer



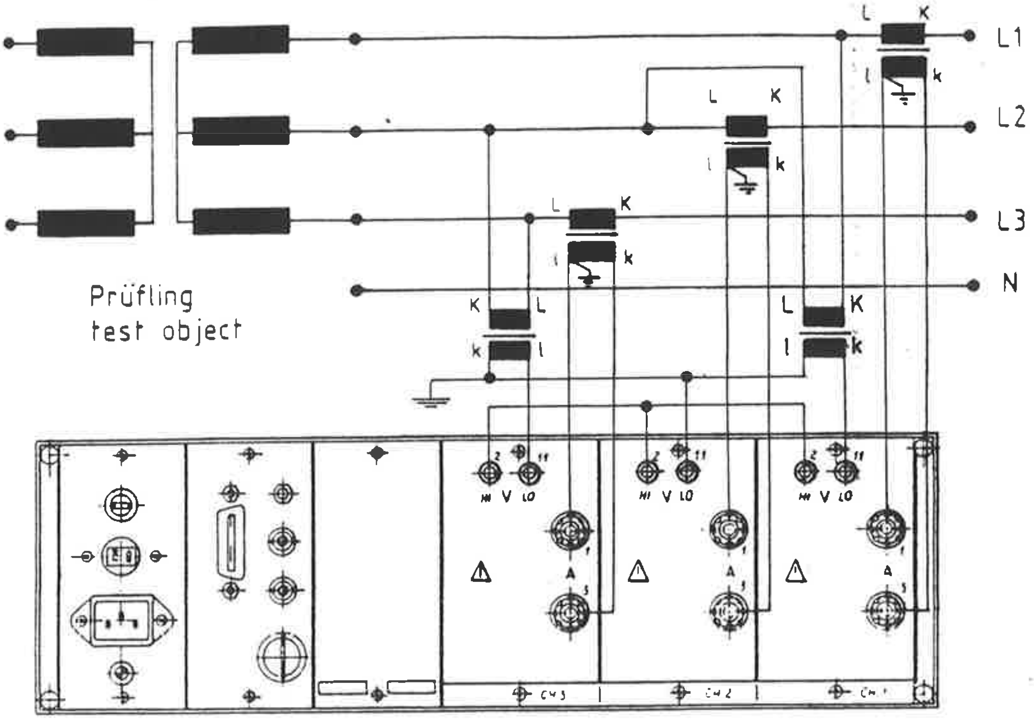
$\eta = \frac{P_2}{P_1 + P_3}$ $P_1 = 0$ $\Sigma P = P_3 - P_2 \triangleq$ power loss

e.g. for a converter 50 Hz three-phase / 16 2/3 Hz single-phase current

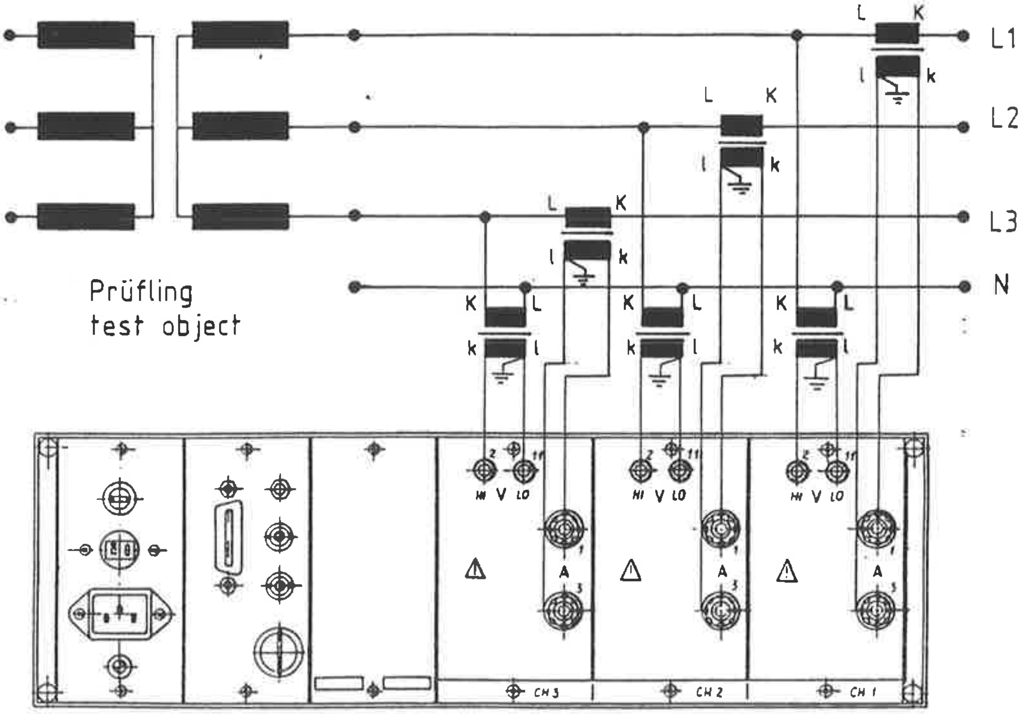


$\eta = \frac{P_2}{P_1 + P_3}$ $\Sigma P = (P_1 + P_3) - P_2 \triangleq$ power loss

Transformertest:



with 2 potential transformers
(with floating star-point HI and LO should be exchanged to achieve symmetrical voltages)



Reserved for personal remarks

8. REMOTE-CONTROL OPERATION - INTERFACE

8.1 Interface functions:

Function	Abbreviation
Source Handshake	SH 0 ... SH 1
Acceptor Handshake	AH 0 ... AH 1
Talker	T 0 ... T 8
Talker Extension	TE 0 ... TE 8
Listener	L 0 ... L 4
Listener Extension	LE 0 ... LE 4
Service Request	SR 0 ... SR 1
Remote-Local	RL 0 ... RL 2
Parallel Poll	PP 0 ... PP 2
Device Clear	DC 0 ... DC 2
Device Trigger	DT 0 ... DT 1
Controller Function	C 0 ... C 28
Interface Type	E 1 ... E 2

Built-in functions see Technical data

Detailed description see IEC 625/IEEE 488-1975 Standard.

8.2 Explanation of abbreviations used

Message	Mnemonic abbreviation
Data In-Out 1	DIO 1
Data In-Out 8	DIO 8
Data valid	DAV
Not ready for data	NRFD
Not data accepted	NDAC
Attention	ATN
Interface clear	IFC
Service request	SRQ
Remote enable	REN
Device clear	DCL
Selection device clear	SDC

Group execute trigger	GET
Data byte	DAB
Data byte accepted	DAC
Go to local	GTL
My listen address	MLA
My talk address	MTA
Other talk address	OTA
Ready for data	RFD
Serial poll enable	SPE
Unlisten	UNL
Untalk	UNT
Status byte	STB

The Bus structure is divided into three groups of signal lines:

Data Bus:	8 signal lines
Transmission Control Bus:	3 signal lines
Interface Control Bus:	5 signal lines

Level assignment:

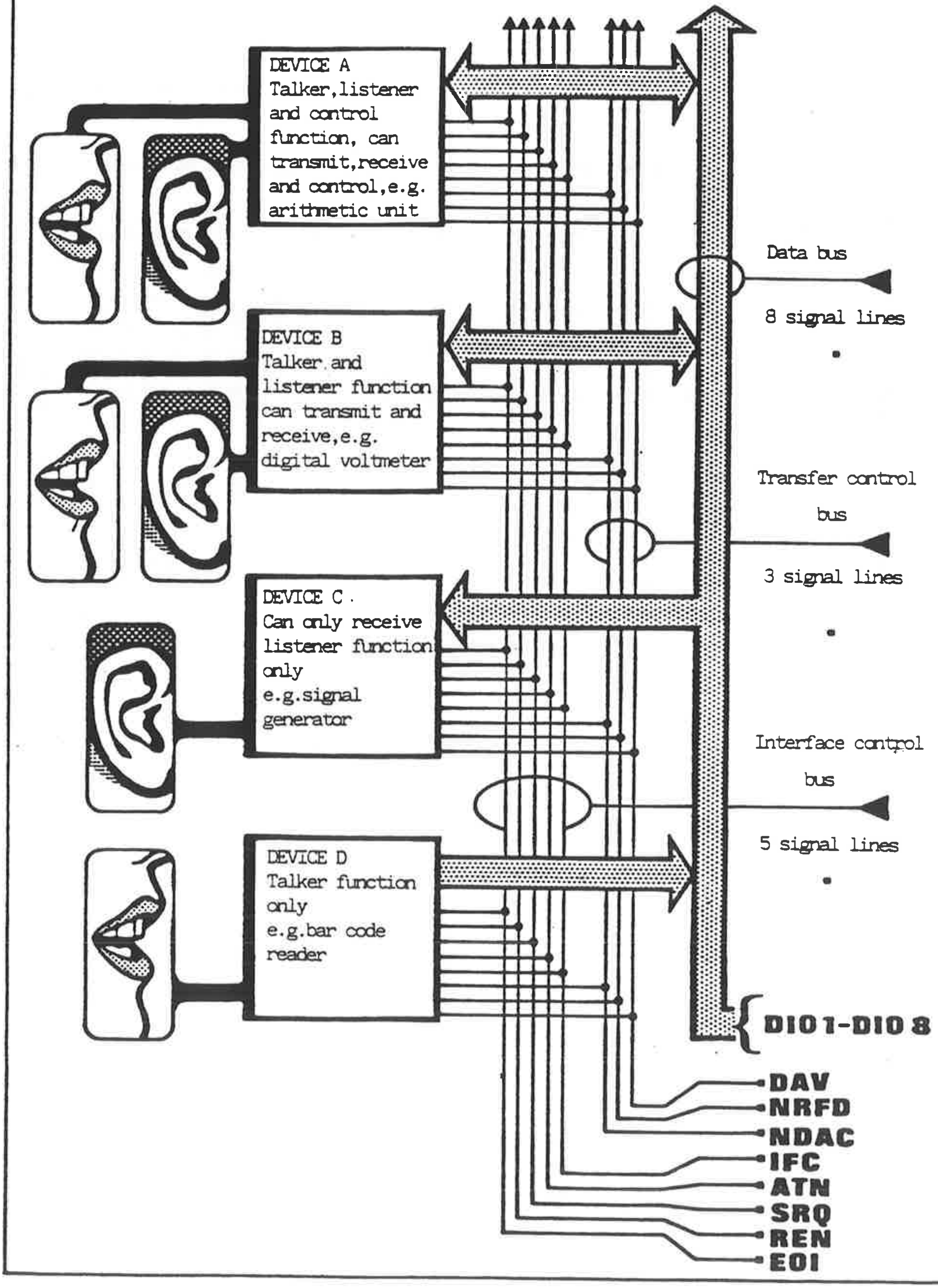
Log. 0	False	High state of signal level H
Log. 1	True	Low state of signal level L

Type of coding: E single-wire message   M multi-wire message

Message class

AB	addressed command
AD	address (for talking and listening)
GA	device-dependent
HA	handshake
UB	universal command
SE	secondary message
ZS	status message

DATA TRANSMISSION PATHS AND ARRANGEMENT OF BUS



Remote messages to which Interface responds

Message	Abbr.	Notes	Coding type	class	Bus signal line(s) and coding of true value of message								
					DIO lines 87 654 321	DAV	NRFD	NDAC	ATN	EOI	SRQ	IFC	REN
ATTENTION	ATN		E	UB	XX XXX XXX	X	X	X	1	X	X	X	X
DATA BYTE	DAB	1,9	M	GA	DD DDD DDD 87 654 321	X	X	X	0	X	X	X	X
DATA ACCEPTED	DAC		E	HS	XX XXX XXX	X	X	0	X	X	X	X	X
DATA VALID	DAV		E	HS	XX XXX XXX	1	X	X	X	X	X	X	X
GO TO LOCAL	GTL		M	AB	X0 000 001	X	X	X	1	X	X	X	X
INTERFACE CLEAR	IFC		E	UB	XX XXX XXX	X	X	X	X	X	X	1	X
MY LISTEN ADDRESS	MLA +	3	M	AD	X0 1LL LLL 54 321	X	X	X	1	X	X	X	X
MY TALK ADDRESS	MTA ++	4	M	AD	X1 0TT TTT	X	X	X	1	X	X	X	X
OTHER TALK ADDRESS	OTA		M	AD	(OTA = TAG $\overline{\text{MTA}}$)								
REMOTE ENABLE	REN		E	UB	XX XXX XXX	X	X	X	X	X	X	X	1
READY FOR DATA	RFD		E	HS	XX XXX XXX	X	0	X	X	X	X	X	X
SERIAL POLL DISABLE	SPD		M	UB	X0 01 1001	X	X	X	1	X	X	X	X
SERIAL POLL ENABLE	SPE		M	UB	X0 01 1000	X	X	X	1	X	X	X	X
UNTALK	UNT		M	AB	X1 01 1111	X	X	X	X	X	X	X	X
UNLISTEN	UNL		M	AB	X0 11 1111	X	X	X	1	X	X	X	X
LOCAL LOCK OUT	LLO x)		M	UB	X0 01 0001	X	X	X	1	X	X	X	X
GROUP EXECUTE TRIGGER	GET x)		M	AB	X0 00 1000	X	X	X	1	X	X	X	X

\+ Bits L5 L4 L3 L2 L1 of Listener address correspond to bits as selected by slide switches

++ Bits T5 T4 T3 T2 T1 of the Talker address can be selected by slide switches. Any combination is permitted except

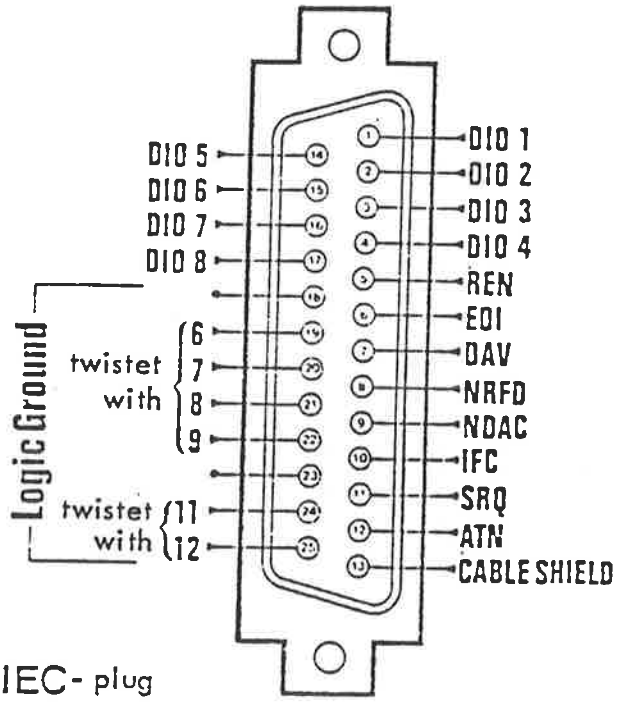
T5	T4	T3	T2	T1
1	1	1	1	1

Remote messages that can be transmitted by the Interface

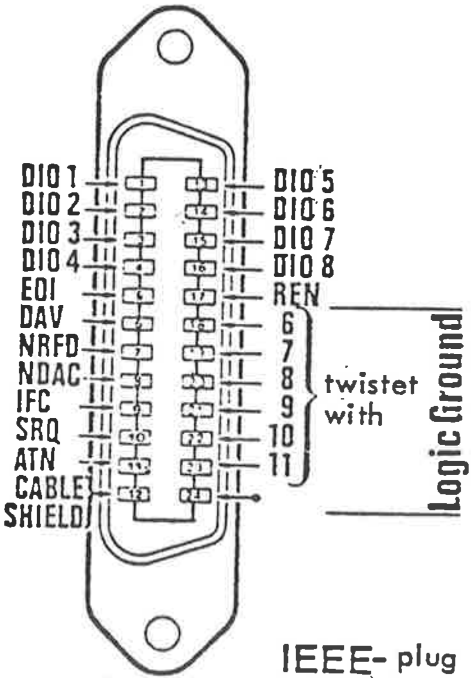
Message	Abbr.	Notes	Coding type	class	Bus signal line(s) and coding of true value of message								
					DIO lines 87 654 321	DAV	NRFD	NDAC	ATN	EOI	SRQ	IFC	REN
DATA ACCEPTED	DAC		E	HS	XX XXX XXX	X	X	0	X	X	X	X	X
DATA VALID	DAV		E	HS	XX XXX XXX	1	X	X	X	X	X	X	X
DATA BYTE	DAB	1,9	M	GA	DD DDD DDD	X	X	X	0	X	X	X	X
READY FOR DATA	RFD		E	HS	XX XXX XXX	X	0	X	X	X	X	X	X
REQUEST SERVICE	RQS	9	E	ZS	X1 XXX XXX	X	X	X	0	X	X	X	X
SERVICE REQUEST	SRQ		E	ZS	XX XXX XXX	X	X	X	X	X	1	X	X
STATUS BYTE	STB		M	ZS	SX SSSSSS	X	X	X	0	X	X	X	X

Notes:
1 D1 ... D8 are the device-dependent data bits
3 L1 ... L5 are the device-dependent listener adress bits
4 T1 ... T5 are the device-dependent talker address bits
9 Messages on ATN lines emanate from Controller, while messages on the DIO lines are enabled by T function
X Disregard when decoding received messages
X Must not be set for decoding when transmitting a message

THE TWO BUS PLUGS



IEC- plug



IEEE- plug
Type 57 Microribbon connector

8.3 Device address setting

Pressing the "ENTER" key passes from measured-value display into the address-input state. If the instrument is in the "TALK ONLY" state - as shown by the appropriate display beside the address - this state must be prepared for clearing by pressing the "CLEAR" key, because otherwise no remote control is possible.

ADDR. AA TALK ONLY

in the TALK ONLY state

Input range: 00 ... 30

The flashing CURSOR indicates the input position. The old address can be changed by input from the digital keyboard. Pressing the "ENTER" key stores the selected address and simultanoulsy returns to the previously valid measured-value display.

8.4 Remote-control commands

S ... scale factor
R ... range
J ... calibration analog output
Y ... range status report
G ... see SRQ section 8.5

NR ... averaging with RUN
NH ... averaging with HOLD
A ... channel 1
B ... channel 2
C ... channel 3
D ... applies to all 3 channels

(outputindication)

I ... current (A) ... I
U ... voltage (V) ... U
P ... active power (W) ... P
L ... apparent power (VA) ... VA
F ... power factor lead ... FC
power factor lag ... FI
W ... energy (Wh) ... WH
Z ... active resistance (real (Z)). Z
X ... impedance (Z) ... X
T ... efficiency ...PRO
O ... analog output

H0 ... run total H2 ... run U,I,P... H4 ... run Wh
H1 ... hold total H3 ... hold U,I,P... H5 ... hold Wh
K1 ... K4 clear of energy counter only in mode H1 or H5 possible
(1, 2, 3, 4 ... CH1, CH2, CH3, CHΣ)

The message "GET" starts the energy measurement. To stop the energy measurement the commands H1 or H5 must be used.

Special version for transformertest:

(indication)

V ... rectified mean x 1.11 ... UM
W ... formfactor ... FF
Q ... corrected power ... PC

8.5 Status byte

In order to avoid erroneous measurement and for easier indification of errors it is possible to inquire the status byte and ascertain the current error. The status byte can be interpreted as the decade sum of the weights of the following 8 bits.

	DIO 8	RQS						DIO 1
Status byte	S8	S7	S6	S5	S4	S3	S2	S1
	128	64	32	16	8	4	2	1

S1 ...	1	in case of trigger error
S2 ...	2	in case of faulty input message
S3 ...	4	in case of underrange for U, I
S4 ...	8	in case of overrange for U, I
S5 ...	16	while the instrument is in the measuring phase
S6 ...	32	if any of the messages S1 ... S4 is current
S7 ...	64	RQS (request service)
S8 ...	128	not used (always zero)

For automatic processing of the error message during a program run, the Controller is programmed for Interrupt by SRQ or the latter is inquired as needed. In order to obtain an SRQ for the desired error message, the instrument must be activated before inquiry with the following commands:

G 0	erases G1 - G6
G 1	trigger error occurs when "GET" is transmitted in mode H0, H3+H5 or when the measuring time has not expired before sending "GET"
G 2	faulty input
G 3	underrange $<$ 40 % of nominal range for U, I
G 4	overrange $>$ 120 % of nominal range for U, I
G 5	conversion completed (after Group Execute Trigger)
G 6	after every conversion

8.6 Additional error messages

Overrange and underrange messages

On being requested with "Y" the instrument transmits a number (4 figures) which may be interpreted as the decade sum of the weights of the following 4 bits.

If a current or voltage channel is within its regular range, its two bits show a "0" signal. In case of overrange the "OR" bit shows a "1" signal, in case of underrange the "UR" bit shows a "1" signal. These combinations result in the sum of the four-digit number concerned. From this number it is possible to obtain information for range correction in the Controller.

CH 3				CH 2				CH 1			
U		I		U		I		U		I	
UR 2048	OR 1024	UR 512	OR 256	UR 128	OR 64	UR 32	OR 16	UR 8	OR 4	UR 2	OR 1

UR ... underrange

OR ... overrange

e.g., CH 3 U underrange 2048
I underrange 512
CH 2 I overrange 16

$$\left.\begin{array}{l} 2048 \\ 512 \\ 16 \end{array}\right\} Y = 2576$$

Error message for energy measurement

In remote control operation the error message for energy measurement appears in byte 4 of the print-out (overrange-message) according to the following table:

main failure P	-	X								X	X	X	X	X	X	X
arithmetic F	-		X				X	X	X				X	X	X	X
change range, scalef. C	-			X		X		X	X		X	X			X	X
overrange O	-				X	X	X		X	X		X		X		X
byte 4	blank	P	F	C	O	G	H	K	L	M	Q	R	S	T	U	V

X ... actual valid error message

8.7 Programming hints

For programming the wattmeter the required commands must be combined into a remote-control string. Separation of individual commands within the string is effected by the semicolon ";". The entire string must be suitably marked (e.g. between quotation marks) and separated from the IEC command by a prefixed separator (e.g. \ ). The IEC command code, addressing character, separator and string marking are device-dependent and may therefore vary. Refer to the appropriate programming manual and combine them with device commands. In the section on sample programs this combination will be given for several types of computer.

The remote-control commands "R, S, O" must always be in first place within the string. The commands for channel and function can be exchanged in between the semicolons, but for greater clarity the channel code should be transmitted first.

Scale factor:
If the scale factor is not programmed, the scale factor last used is also valid in remote-control operation. The scale factor can be entered as a number of up to 6 digits or in exponential format. Transmission of the scale factor is marked by a prefixed "S".

e.g. Channel 2 voltage, R = 100 (10000/100 V)

Input	"SBU100"	or	"SBU10000 E-2"
Display	S1:000100/1.000 V/V	or	S1:010000/100.00 V/V

e.g. Channel 1 - 3 current 1000/10 A

Input	"SDI 100"	or	"SDI1000E-1"
Display	S:000100/1.000 A/A	or	S:001000/10.000 A/A

Input range: .000001 E-6 - 999999 E+6

No 0 in the mantissa

Range selection:
The correct range is selected by transmitting the maximum expected measured value, characterized by a prefixed "R".

e.g.:	Channel 2 voltage 220 V	all channels current 4 A
Input	"RBU 220"	"RID 4"
Display	RANGE CH2 260 V	RANGE 5.0 A

Input range: 000...999

Averaging of measured values:

e.g.	100 averaging processes running	50 averaging processes with "HOLD"
Input	"NR 100"	"NH 50"
Display	N = 00100 RUN after N	N = 00050 HOLD after N

Request for measured value:

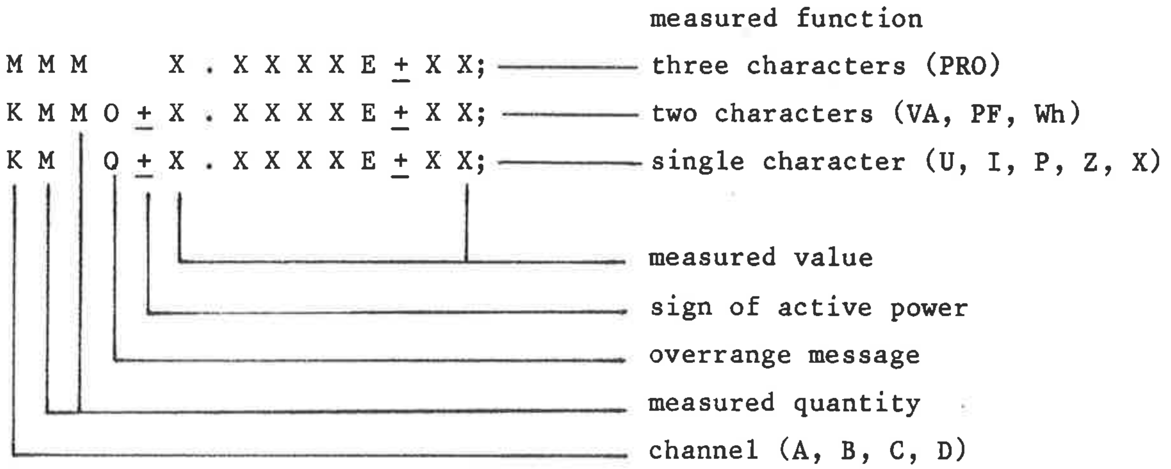
e.g.	Channel 1	current, voltage, active power, power factor
	Channel 2	current, voltage, active power, power factor
	Channel 3	current, voltage, active power, power factor
	Channel sum	current, voltage, active power, power factor

Input "AI;AU;AP;AF;BI;BU;BP;BF;CI;CU;CP;CF;DI;DU;DP;DF"

Identical commands need only be written once, so that the string is considerably simplified:

Input "AI;U;P;F;BI;U;P;F;CI;U;P;F;DI;U;P;F"

Output format:



Each measured value is output at 15 bytes terminated with the end character that the Controller used for the request. All final characters complying with DIN standard 66.22 are accepted. All final characters can be combined with EOI or the data byte transmitted with EOI.

e.g. ETB; ETX; CR; LF; CR/LF; Power On state: CR/LF

For reading the measured values, after a request for measured values read the string with the appropriate read command of the Controller, then format or evaluate as required.

Caution! String length must not exceed the maximum string length of the Controller (e.g. max. 255 bytes).

Input of assignment measured quantity - analog output value

e.g.:

"0 1 U C 100.00 E + 03"

exponent: 1 or 2 digits may be chosen, with or without sign, can also be omitted

max. 6 digits (range 1 µ ... 999 T) except 0

channel (A, B, C, D)

quantity (U, I, P, L, F, W, X, Z)

} can be exchanged

number of output (1...6)

0 for OUT

e.g. 100.000 V corresponds to + 10 V on analog output 1

This input permits any assignment of a measured value to the full-scale value of the analog output. This assignment permits attainment of full-scale deflection even at partial channel levels. In order to avoid overrange conditions, the largest measured value must not exceed the maximum value as entered. If the full-scale value is chosen too large, resolution and accuracy are needlessly reduced.

Input of calibration of analog output

"0 1 J 0"

0 ... zero of analog output
1 ... +f.s. (+10 V) of analog output
2 ... -f.s. (-10 V) of analog output
3 ... calibration analog output
Output (1...6)
0 ... analog output (OUT)

Caution:

If during remote-control operation the instrument was not put permanently in remote state, the programming data (e.g. scale factor, range etc.) can be changed from the keyboard during remote operation. If this is to be prevented, the RTL key should be disabled by transmitting "LLO" and the instrument to be placed in permanent remote state by transmitting "REN". The display remains fully operative even in remote operation. Thus all information can be placed in the display from the keyboard.

"TALK ONLY" operation see section 5.5.8.

8.8 Overview of symbols, representation of measured values, input on the display panel and data output

input / messages:

name:	display:	display:
range/channel/value	RANGE CH1 5.0 A	Range CH1 260 V
scalefactor/cannel/value	S1:10000./10.000 A/A	S1:100.00/100.00 V/V
number of averaging/mode	n=00056,run at 00100	N=00100,RUN after N
address	ADDR. 01	ADDR. 01 T.ONLY
talk only	T.ONLY nn: mm ccc z T.ONLY nn: END	T.ONLY nn: BLANK z T.ONLY TIMER ttttt s
analog out	An: fffpmm fs ccc A1: TEST +fs	A1: TEST ZERO A1: TEST -fs
calibration	CALIBRATING CH1 TURN KEY TO RUN RAM TEST FAILED	CAL TEST FAIL xxxxxx ROM TEST x FAILED

display:	single value	two value	three value
current	16.427 kA CH1	16.43kA 168.2 V:1	16.43 25.16 12.45kA
voltage	168.22 V CH1	168.2 V 16.43kA:1	168.2 215.4 133.6 V
voltage . √3	168.22 VΔ CH1	168.2VΔ 16.43kA:1	168.2 215.4 133.6VΔ
power	+1.5633MW CH1	+1.563MW 168.2 V:1	+1.563+0.625-0.755MW
apparent power	2.7633MVA CH1	2.763MVA 16.43kA:1	2.763 5.419 1.663MVA
power factor	+0.5656Pf capCH1	+0.566Pf 168.2V:1	0.566+0.115-0.453Pf
energy measurement	+17.223MWh CH1	+17.22MWh 16.43ka:1	17.22. 53.17 00.89MWh
efficiency	79.92%P2/(P1+P3)	79.92% 168.2 V:1	79.92 79.92 79.92 %
active resistance	5.792mΩ RE(Z)CH1	5.792mΩ 168.2 V:1	5.792 0.987 4.864mΩ
abs.value of Z	10.241mΩ|Z|CH1	10.24mΩa 168.2 V:1	10.24 08.56 10.73mΩa
current, voltage, power		three value display	A - V - W 16.43 215.4+1.563:1

data output "Talk-Only" - (15 Byte)

channel A/Wh/overrange	AWh0 + 1.2345 E+02
efficiency	PRO 0.9876 E+02
channel D/voltage Σ/3 x √3	DU 0.3800 E+02

Abbreviations:

nn ... position 01 ... 38   fff ... scale factor ... 0 ... 9,

mm ... measured value ... A, V, V , W, VA, Pf, Wh, %, Ω , Ω a

ccc ... channel ... CH1, CH2, CH3, Σ , Σ/3, blank (for %)

p ... power ... µ, m, empty, k, M, G, T

z ... CR/LF

9. SAMPLE PROGRAMS FOR DIFFERENT CONTROLLERS

```
10 REM *****************************************************
20 REM *      PROGRAMMINGEXAMPLE OF D 5155 BY               *
30 REM *                 CBM 8032                           *
40 REM *****************************************************
50 :                         REM ADDRESS OF D5155 = 5
60 OPEN1,5:                  REM OPEN IEEE-CHANNEL
70 PRINT#1,"SAU100E-2":      REM SCALE:S1:000100/100.00 V/V
80 PRINT#1,"SAI1":           REM SCALE:S2:000001/1.0000 A/A
90 PRINT#1,"RAU260":         REM RANGE CH1 260 V
100 PRINT#1,"RAI1":          REM RANGE CH1 1.0 A
110 PRINT#1,"H0":            REM RUN MODE
120 PRINT#1,"AU;I;P;F;X":    REM CALL FOR  CH1:U,I,P,F,X
130 INPUT#1,A$:IFST=2THEN130:REM READ OUT OF TEST RESULTS
140 PRINT#1,"Z":             REM CALL FOR  CH1:Z
150 INPUT#1,B$:IFST=2THEN150:REM READ OUT OF TEST RESULT
160 A$=A$+";"+B$:            REM ADDITION OF TEST RESULTS
170 FOR I =1 TO 6:           REM SEPARATE OF SINGLE TEST RESULTS
180 A$(I)=MID$(A$,15*(I-1)+I,15)
190 :                        REM OF A$ IN A$(I)
200 PRINTA$(I)
210 NEXT:PRINT
220 GOTO120
```

```
10 REM *****************************************************
20 REM *       PROGRAMMINGEXAMPLE OF  D 5155  BY            *
30 REM *                 CBM 8032                           *
40 REM *****************************************************
50 :                         REM ADDRESS OF D5155 = 5
60 OPEN1,5:                  REM OPEN IEEE-CHANNEL
70 PRINT#1,"SDU100E-2;RDU260;RDI1;H1"
80 :                         REM TRANSMITTING OF SETDATA
90 PRINT#1,"01UA250.00":     REM COMMAND FOR ANALOGOUTPUT
100 POKE165,32+5:            REM LISTEN #5 (X0100 01010)
110 SYS 61695:               REM OUTPUT TO IEEE-BUS  +ATN=1
120 POKE165,8:               REM GROUP EXECUTE TRIGGER (X000 1000)
130 SYS 61695:               REM OUTPUT TO IEEE-BUS  +ATN=1
140 POKE165,63:              REM UNLISTEN (X011 1111)
150 SYS 61765:               REM OUTPUT TO IEEE-BUS  +ATN=0
160 :                        REM 100 - 150 START OF MEASUREMENT (TRG#5)
170 PRINT#1,"DU;I;P;F;X":    REM CALL FOR CH1:U,I,P,F,X
180 INPUT#1,A$:IFST=2THEN180:REM READ OUT OF TEST RESULTS
190 PRINT#1,"Z":             REM CALL FOR CH1:Z
200 INPUT#1,B$:IFST=2THEN200:REM READ OUT OF TEST RESULT
210 A$=A$+";"+B$:            REM ADDITION OF TEST RESULTS
220 FOR I =1 TO 6:           REM SEPARATE OF SINGLE TEST RESULTS
230 A$(I)=MID$(A$,15*(I-1)+I,15)
240 :                        REM OF A$ IN A$(I)
250 PRINTA$(I)
260 NEXT:PRINT
270 GOTO100
```

```
 10 REM *************************************************
 20 REM *     PROGRAMMINGEXAMPLE OF D5155 BY SIEMENS    *
 30 REM *           CONTROLLER B 8011                   *
 40 REM *************************************************
 50                           REM ADDRESS OF D5155 = 3
 60 CLEAR # DIM A$(100),M$(16,7)
 70 ICL                     # REM INITIALIZE OF BUS
 80 REN1                    # REM SET REMOTE ENABLE
 90 LLO                     # REM SET LOCAL LOCK OUT
100 SET(V)3="SAU100E-2"     # REM SCALE:S1:000100/100.00 V/V
110 SET(V)3="SAI1"          # REM SCALE:S2:000001/1.0000 A/A
120 SET(V)3="RAU260"        # REM RANGE CH1   260 V
130 SET(V)3="RAI1"          # REM RANGE CH1   1.0 A
140 SET(V)3="H0"            # REM RUN MODE
150 SET(V)3="AU;I;P"        # REM CALL FOR U,I,P  AT CH1
160 MES(V)3=A$              # REM READ OUT OF TEST RESULT
170 FOR I =1 TO 3           # REM SEPARATE OF SINGLE
180 M$(I)=MID$(A$,15*(I-1)+I,15)
190 PRM$(I)                 # REM TEST RESULTS OF A$
200 NEXTI # PR
210 GOTO160
```

```
 10 REM ***************************************************
 20 REM *     PROGRAMMINGEXAMPLE OF D 5155 BY SIEMENS     *
 30 REM *            CONTROLLER B 8011                    *
 40 REM ***************************************************
 50                             REM ADDRESS OF D5155 = 3
 60 CLEAR # DIM A$(100),M$(16,7)
 70 ICL#REN1#LLO               #REM INITIALIZE OF BUS
 80 SET(V)3="SDU100E-2;SDI1;RDU260;RDI1;H1"
 90                             REM TRANSMITTING OF SETDATA
100 SET(V)3="O1UA250.00"       #REM COMMAND FOR ANALOGOUTPUT
110 SET(V)3="DU;I;P"           #REM CALL FOR TEST RESULTS
120 TRG3                       #REM EXECUTE TRIGGER
130 FORT=0TO300#NEXTT
140 MES(V)3=A$                 #REM READ OUT OF TEST RESULTS
150 FORI=1 TO 3                #REM SEPARATE OF SINGLE
160 M$(I)=MID$(A$,15*(I-1)+I,15)#REM TEST RESULTS OF A$
170 PRM$(I)
130 NEXTI#PR
190 GOTO110
```

```
10 REM ****************************************************
20 REM *          PROGRAMMINGEXAMPLE OF D 5155 BY         *
30 REM *              NORMA CONTROLLER C 9895             *
40 REM ****************************************************
50 :                       REM ADDRESS OF D5155 = 5
60 CLI#::FORT=1TO2000:NEXT:REM INITIALIZE OF BUS
70 REN#5:                  REM SET REMOTE ENABLE
80 LLO#:                   REM SET LOCAL LOCK OUT
90 WRT#5\"SAU100E-2":      REM SCALE:S1:000100/100.00 V/V
100 WRT#5\"SAI1" :         REM SCALE:S2:000001/1.0000 A/A
110 WRT#5\"RAU260":        REM RANGE CH1 260 V
120 WRT#5\"RAI1":          REM RANGE CH1 1.0 A
130 WRT#5\"H0":            REM RUN MODE
140 WRT#5\"AU;I;P;F;X;Z":  REM CALL FOR CH1:U,I,P;F,X,Z
150 RED#5\A$:              REM READ OUT OF TEST RESULTS
160 FOR I =1 TO 6:         REM SEPARATE OF SINGLE TEST RESULTS
170 A$(I)=MID$(A$,15*(I-1)+I,15)
180 :                      REM OF A$ IN A$(I)
190 PRINTA$(I)
200 NEXT:PRINT
210 GOTO150
```

```
10 REM ****************************************************
20 REM *          PROGRAMMINGEXAMPLE OF D 5155 BY         *
30 REM *              NORMA CONTROLLER C 9895             *
40 REM ****************************************************
50 :                             REM ADDRESS OF D5155 = 5
60 CLI#:FORT=1TO2000:NEXT:REN#5:LLO#
70 :                             REM INITIALIZE OF BUS
80 WRT#5\"SDU100E-2;SDI1;RDU260;RDI;H1"
90 :                             REM TRANSMITTING OF SETDATA
100 WRT#5\"01UA250.00":          REM COMMAND FOR ANALOGOUTPUT
110 TRG#5:                       REM EXECUTE TRIGGER
120 WRT#5\"DU;I;P;F;X;Z":        REM CALL FOR TEST RESULTS
130 RED#5\A$:                    REM READ OUT OF TEST RESULTS
140 FOR I =1 TO 6:               REM SEPARATE OF SINGLE
150 A$(I)=MID$(A$,15*(I-1)+I,15):REM TEST RESULTS OF A$
160 PRINTA$(I)
170 NEXT:PRINT
180 GOTO110
```

```
10 ! ***************************************************************
20 ! *          PROGRAMMINGEXAMPLE OF D 5155 BY                    *
30 ! *              CONTROLLER HP-85                               *
40 ! ***************************************************************
50 !                             ADDRESS OF D5155=3
60 RESET 7 @ DIM A$[100] !     INITIALIZE OF BUS
70 REMOTE 703 !                SET REMOTE ENABLE
80 LOCAL LOCKOUT 7 !           SET LOCAL LOCK OUT
90 OUTPUT 703 ;"SAU100E-2" !   SCALE:S1:00100/100.00 V/V
100 OUTPUT 703 ;"SAI1" !       SCALE:S2:00001/1.0000 A/A
110 OUTPUT 703 ;"RAU260" !     RANGE CH1 260 V
120 OUTPUT 703 ;"RAI1" !       RANGE CH1 1.0 A
130 OUTPUT 703 ;"H0" !         RUN MODE
140 OUTPUT 703 ;"AU;I;P;F;X;Z" ! CALL FOR CH1:U,I,P,F,X,Z
150 ENTER 703 ; A$ !           READ OUT OF TEST RESULTS
160 FOR I=1 TO 6 !             SEPERATE OF SINGLE TEST RESULTS
170 DISP A$[16*I-15,16*I-1] !  OF A$
200 NEXT I @ DISP
210 GOTO 150
1000 END
```

```
10 ! ***************************************************************
20 ! *          PROGRAMMINGEXAMPLE OF D 5155 BY                    *
30 ! *              CONTROLLER HP-85                               *
40 ! ***************************************************************
50 !                             ADDRESS OF D5155=3
60 RESET 7 @ DIM A$[100] !     INITIALIZE OF BUS
70 REMOTE 703 @ LOCAL LOCKOUT 7
80 OUTPUT 703 ;"SDU100E-2;SDI1;RDU260;RDI1;H1"
90 !                             TRANSMITTING OF SETDATA
100 OUTPUT 703 ;"01UA250.00" !   COMMAND FOR ANALOGOUTPUT
110 OUTPUT 703 ;"DU;I;P;F;X;Z" ! CALL FOR TEST RESULTS
120 TRIGGER 703 !                EXECUTE TRIGGER
130 FOR I=0 TO 200 @ NEXT I
140 ENTER 703 ; A$ !             READ OUT OF TEST RESULTS
150 FOR I=1 TO 6 !               SEPERATE OF SINGLE
160 DISP A$[16*I-15,16*I-1] !    TEST RESULTS OF A$
170 NEXT I @ DISP
180 GOTO 120
1000 END
```

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