RCL meter
PM 6303

9452 063 03001

Operating manual
Gebrauchsanleitung
Notice d'emploi

9499 520 08201

83 12 01/1/01-02

PHILIPS

NEW

Easy-to-read crystal display
Extremely fast automatic operation
Simultaneous display of:
- **Measured value**
- **Appropriate unit of measurement**
- **Graphic representation of equivalent circuit**

One or two pushbutton selection of nine different parameters
Two-or four-wire connection or via optional test attachment

Automatic RCL meter PM 6303

Fast operation, clear display

The PM 6303 automatic RCL meter will rapidly determine the value, electric dimension and equivalent – circuit of passive components to a very high order of accuracy, and over a wide range. The measured value, together with the appropriate unit of measurement and the equivalent circuit-graphics, are easily read on a large 4-digit liquid-crystal display.

Rapid connection

Connection of a component to be tested is effected easily and rapidly, using either a two- or four-wire connector or an optional test attachment. Less than one second after connection, the dominate component's measured value, its effective dimension and its equivalent circuit, will be clearly displayed. For example: when measuring a coil having a Q-factor of 1, both the series inductance and resistance and the equivalent circuit-graphics will be displayed almost instantly. Apart from using the auto mode of the PM 6303, it is possible to select from a maximum of nine differing parameters (D, Q, Rp, Rs, Z, Ls or Lp, Cs or Cp and Cs 2V bias), using only two pushbuttons.

Universal capability

Features like these make the PM 6303 an ideal instrument for a very wide range of applications; educational-institutes laboratories specialised service centres, and in general-purpose workshops. Its automatic operation, coupled with a direct digital readout, also makes the PM 6303 a most attractive proposition for use in research, development, and in quality-control; setmakers too, will find the PM 6303 a most useful aid in batch-sampling techniques.

Connection facilities

- 2 sockets for measuring voltage (HI) Drive and Sense connection
- 2 sockets for measuring current (LO) Drive and Sence connection
- 1 socket guard connection

Parameter Selection

- 2 pushbuttons for stepping from item to item in the parameter menu.
- 1 pushbutton to reset to RCL AUTO mode in which the dominant component is measured.

Parameters

- Dominating component R, C or L (autoselection)
- Q
- D
- Rp
- Rs
- Z
- Cp, Lp
- Cs, Ls
- Cp Biased (internally generated dc voltage)

TECHNICAL SPECIFICATION

Display
Large 18 mm, 4 digits LCD

Dimension Indications
- Ω, kΩ, MΩ, pF, nF, μF, mF, μH, mH, H, kH

Out of Range Indication
- 4 middle digit segments flashing

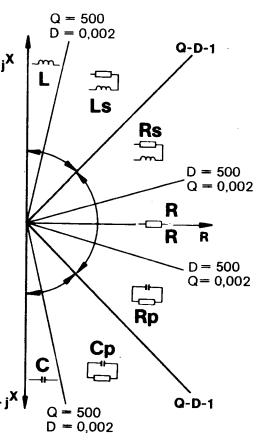
Measuring Ranges
- Resistance Rp, Rs, Z
  0.000Ω...200 MΩ
- Capacitance Cp, Cs
  0.0pF...100mF
- Inductance Lp, Ls
  0.0 μH...32 kH
- Quality Factor Q
  0.002...500
- Dissipation Factor D
  0.002...500

Maximum Resolution per Range
- Resistance
  1mΩ
- Capacitance
  0.1pF
- Inductance
  0.1μH
- Quality/Dissipation Factor
  0.001

Equivalent circuits
– 7 Equivalent circuits

- D > 500
- D < 0,002, Q > 500
- Q > 500, no display of the secondary parameter

D or Q	parameter selection
≤ 500	RCL AUTO, Cp, Rp, D, Z
≤ 500	Cs, Rs
≤ 500	RCL AUTO, Ls, Rs, Q, D, Z
≤ 500	Lp, Rp



Measuring Accuracy
Basic Error ±0.25% ±1 digit

Measuring Frequency
1 kHz ±0.025%

DUT Stress
≤5mA, ≤2V
(linked to a $2V_{RMS}$ Source with an internal resistance of 400Ω)

Type of Connectors
4 mm sockets
– 2 sockets for measuring voltage (HI) Drive and Sense connection
– 2 sockets for measuring current (LO) Drive and Sense connection
– 1 socket guard connection

Measurement update rate
approx. 2 measurements per second

Zero Capacitance Adjustment
Co trim by means of screwdriver adjustment on front panel. Maximum adjustable capacitance: 5pF

POWER REQUIREMENTS
Voltage: 110, 128, 220, 238V ±10%
Frequency: 50...100 Hz ±5%
Power-Consumption: 13W

ENVIRONMENTAL CAPABILITIES

Ambient Temperatures
Reference Value: +23°C ±1°C
Operation: +5°C +40°C
Storage and Transport: −40°C...+70°C

DIMENSIONS AND WEIGHT
(w x h x d) 310 x 140 x 310mm
(12.2 x 5.15 x 12.2-in)
4.8 kg (10,6 lb)

ACCESSORIES SUPPLIED
Two-terminal fixture
Operating manual
Fuse 250mAT

OPTIONAL ACCESSORIES
PM 9541 Four-wire test cable
PM 9542 RCL test adapter
Service manual

PM 6303 is extremely versatile making it a valuable measurent tool in industry, service workshop or education

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Please note

In correspondence concerning this instrument, please quote the type number and serial number as given on the type plate.

Bitte beachten

Bei Schriftwechsel über dieses Gerät wird gebeten, die Typennummer und die Gerätenummer anzugeben. Diese befinden sich auf dem Typenschild an der Rückseite des Gerätes.

Noter s. v. p.

Dans votre correspondance et dans vos réclamations se rapportant à cet appareil, veuillez toujours indiquer le numéro de type et le numéro de série qui sont marqués sur la plaquette de caractéristiques.

Important

As the instrument is an electrical apparatus, it may be operated only by trained personnel. Maintenance and repairs may also be carried out only by qualified personnel.

Wichtig

Da das Gerät ein elektrisches Betriebsmittel ist, darf die Bedienung nur durch eingewiesenes Personal erfolgen. Wartung und Reparatur dürfen nur von geschultem, fach- und sachkundigem Personal durchgeführt werden.

Important

Comme l'instrument est un équipement électrique, le service doit être assuré par du personnel qualifié. De même, l'entretien et les réparations sont à confier aux personnes suffisement qualifiées.

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Printed in Germany

CONTENTS

INHALTSVERZEICHNIS

TABLE DES MATIERES

1. GENERAL

1.1. INTRODUCTION

The **PM 6303 RCL meter** is used for measurements of resistances, capacitances and inductances. Providing auto-function and auto-ranging facility the instrument allows fast and high precision measurements of passive components over a wide range.

The component under test is directly connected to the instrument, either via a two-terminal test fixture, a four-wire test cable or a four-terminal test adapter. The measurement result, namely numerical value, dimension and the equivalent-circuit symbol, is immediately displayed on a large 4-digit liquid-crystal display (LCD), updated at a rate of two measurements per second.

A microprocessor controls the measurement process, computates the measurement value and transfers the result to the display.

In the RCL AUTO mode the dominant component, either R, C or L of the component under test is automatically selected for display. RCL AUTO is also the default mode of the instrument after power-on.
For an inductance e.g. with quality factor $500 > Q > 1$ the instruments indicates the measurement value of the series inductance and as equivalent-circuit symbol the series connection of a resistance and an inductance.

In addition to the RCL AUTO mode with display of the dominating component 8 further parameters can be selected by 2 pushbuttons providing a stepping function, whereby the appropriate parameter is marked by a LED:
Quality factor Q, dissipation factor D,
parallel resistance Rp, series resistance Rs,
impedance Z,
parallel capacitance Cp or parallel inductance Lp,
series capacitance Cs or series inductance Ls,
series capacitance, internally biased Cs (2 V BIAS).

The instrument is especially suited for use in laboratories, for quality control, service workshops and for education purposes.

1.2. CHARACTERISTICS

1.2.1. Safety characteristics

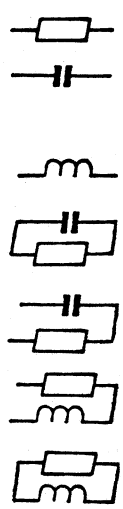
This apparatus has been designed and tested in accordance with Safety Class I requirements of IEC Publication 348, Safety Requirements for Electronic Measuring Apparatus, and has been supplied in a safe condition. This manual contains some information and warnings which must be followed by the user to ensure safe operation and to retain the apparatus in a safe condition.

1.2.2. Performance characteristics, specifications

Properties expressed in numerical values with stated tolerance are guaranteed by the manufacturer. Specified non-tolerance numerical values indicate those that could be nominally expected from the mean of a range of identical instruments.

This specification is valid after the instrument has warmed up for 5 minutes (reference temperature 23°C).
If not stated otherwise, relative or absolute tolerances relate to the set value.

designation	specification	additional information
9 parameters	RCL AUTO Q D Rp Rs Z Cp or Lp Cs or Ls Cs (2 V BIAS)	for RCL AUTO the dominant component R, C or L is automatically determined, see Fig. 1 internal bias voltage for capacitors
3 pushbuttons for parameter selection	1 reset button 2 step buttons	RCL AUTO for selection of required parameter: stepping from parameter to parameter; continuous stepping when button is kept pushed
display		Liquid-crystal display (LCD)
measuring value	4 digits	7-segment, 18 mm high
11 dimension indications	Ω, kΩ, MΩ pF, nF, μF, mF μH, mH, H, kH	
7 equivalent-circuit symbols		



parameter	condition
RCL AUTO, Rp, Rs, Z, Q	D > 500
RCL AUTO, Z, D, Cp, Cs, Cs (2 V BIAS)	Q > 500
RCL AUTO, Ls, Lp, Z, D	Q > 500
RCL AUTO, Cp, Rp, Q, D, Z Cs, Rs, Cs (2 V BIAS) RCL AUTO, Ls, Rs, Q, D, Z Lp, Rp	500>Q>0,002 0,002<D<500

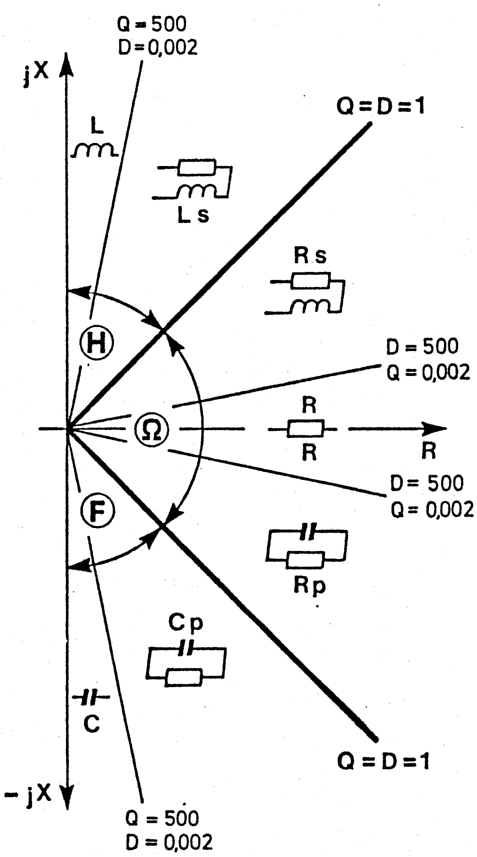


Fig. 1 Equivalent-circuit symbol and dominating parameter in the sectors of the phasor plane (RCL AUTO)

designation	specification	additional information
measuring ranges		
– resistance	0.000 Ω – 200 MΩ	Rp, Rs, Z
– capacitance	0.0 pF – 100 mF	Cp, Cs
– inductance	0.0 μH – 32 kH	Lp, Ls
– quality factor	0.002 – 500	Q
– dissipation factor	0.002 – 500	D
max. resolution		
– resistance	1 mΩ	
– capacitance	0.1 pF	
– inductance	0.1 μH	
– quality factor	0.001	
– dissipation factor	0.001	
measuring accuracy:		
basic error	±0.25 % ±1 digit	} of display reading, see Fig. 2, 3, 4
additional error		
measuring range for basic error		see Fig. 2
– resistance	0.4 Ω ··· 4 MΩ	D > 10
– capacitance	40 pF ... 400 μF	Q > 10
– inductance	60 μH ... 600 H	Q > 10
– quality factor	0.3 ... 3.0	
– dissipation factor	0.3 ... 3.0	

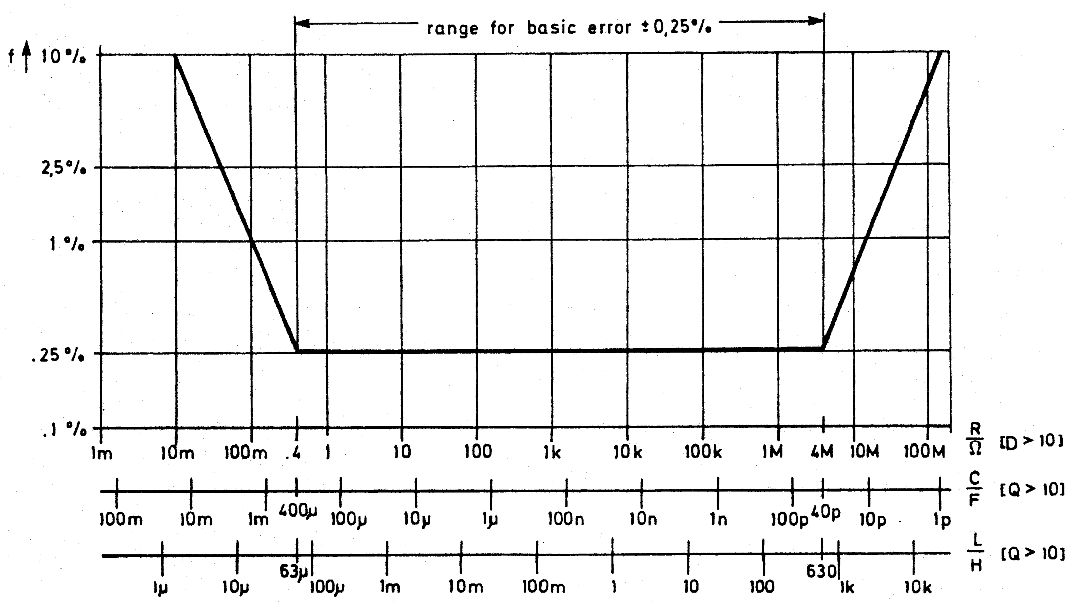


Fig. 2 measurement error

designation	specification	additional information

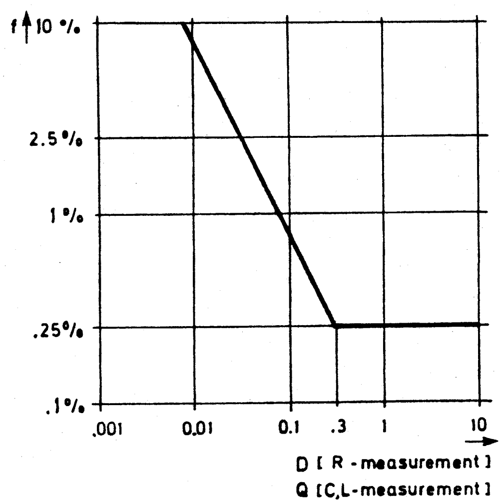


Fig. 3 error limits versus Q and D

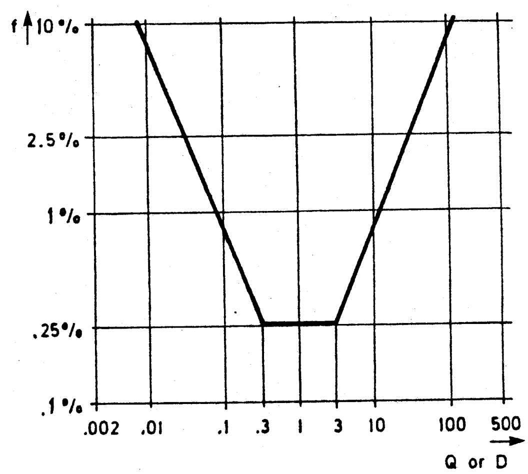


Fig. 4 error limits for Q and D

designation	specification	additional information
overrange indication	flashing of the four digits center segments	• R > 200 MΩ C > 100 mF L > 32 kH Q > 500 D > 500 • for Q, D > 500 flashing for parameter selection deviating from displayed equivalent-circuit symbol • for Cs (2 V Bias), if Q < 0.1 or if inductance is identified
connection of component		
– for meas. voltage (HI)	two 4 mm sockets	SENSE and DRIVE (-BIAS) connection
– for meas. current (LO)	two 4 mm sockets	SENSE and DRIVE (+BIAS) connection
– for measuring earth	one 4 mm socket	GUARD
max. ext. voltage	±5 Vdc	between GUARD and all other socket, between HI and LO
max. component load	2 V, 5 mA	voltage source with 2 V open-circuit voltage and 400 Ω int. resistance
measuring frequency	1 kHz	
– tolerance	±0.025 %	
measurement update rate	approx. 2 meas./s	
compensation of zero-capacitance	Co TRIM	by screwdriver, on front panel
– max. comp. capacitance	5 pF	

1.2.3. Power supply

Power supply	ac mains
reference value	220 V
nominal values	110 V/128 V/220 V/238 V, selectable by solder links
nominal operating range	±10 % of selected nominal value
operating limits	±10 % of selected nominal value
nominal frequency range	50 - 100 Hz
limit range of operation	47.5 - 105 Hz
power consumption	13 W

1.2.4. Environmental capabilities

The following environmental data are valid only if the instrument is checked in accordance with the official checking procedure. Details on these procedures and failure criteria are supplied on request by the PHILIPS organization in your country or by PHILIPS INTERNATIONAL B.V., SCIENTIFIC & INDUSTRIAL EQUIPMENT DIVISION, EINDHOVEN, THE NETHERLANDS.

Ambient temperature:	
reference value	+23 °C ±1 K
nominal working range	+ 5 °C ... +40 °C
limit range of operation	+ 5 °C ... +40 °C
limits for storage and transport	-40 °C ... +70 °C
Relative humidity:	
reference range	45 ... 75 %
nominal working range	20 ... 80 %
limit range of operation	10 ... 85 %
limits for storage and transport	0 ... 85 %
Air pressure:	
reference value	1013 mbar (≙ 760 mm Hg)
nominal working range	800 ... 1066 mbar (≙ 600 ... 800 mm Hg, up to 2200 m height)
Air speed:	
reference value	0 ... 0.2 m/s
nominal working range	0 ... 0.5 m/s
Heat radiation:	direct sunlight radiation not allowed
Vibration:	
limits for storage and transport	max. 0.35 mm amplitude (10 to 60 Hz)
	max. 5 g (60 to 150 Hz)
radio interference voltage	level of interference $<$ K
operating position	normally upright on feet or with handle fold down
warm-up time	5 min

1.2.5. Cabinet

protection type (see DIN 40 050)	IP 20
protection class (see IEC 348)	class I, protective conductor
line connection	mains cable, fixed to the instrument
overall dimensions:	
height	140 mm
width	310 mm
depth	310 mm
weight	4.8 kg (11 lbs)

1.3. ACCESSORIES

1.3.1. Standard

operating manual, 9499 520 08201
2-terminal test fixture, 5322 265 24026
fuse 250 mAT

1.3.2. Optional

	service manual, order no. 9499 525 00911
PM 9541	4-wire test cable
PM 9542	RCL adapter

1.4. OPERATING PRINCIPLE

1.4.1. Description of the block diagram, Fig. 30

The 16 MHz crystal clock generates the basic frequency for all signals, so the count pulses for the analog to digital converter ADC.

The frequency divider generates the 8 MHz clock pulse for the microprocessor and the 1 kHz test frequency in 3 reference phases, namely 0^{o}, 90^{o} and 180^{o}.

In the phase selector the CPU selects the appropriate reference phase 0^{o}, 90^{o} or 180^{o} for the phase sensitive rectifier and the ADC.

The band-pass filter 1 converts the TTL signal into a 1 kHz sine wave signal.

The test voltage amplifier amplifies the 1 kHz sine wave signal to a 2 Veff open circuit voltage at the component under test (CUT) connection. In the 'Cs biased' mode 2 Vdc are added to the 1 kHz signal.

The isolating buffer senses the voltage at the CUT.

The inverting amplifier feeds a compensating current via capacitor C (90^{o} phase shift) into the current to voltage converter input for equalizing the stray capacitances. The amplitude of the compensating current is set by Co TRIM.

The current to voltage converter converts the current through the CUT into a proportional voltage. The conversion factor can be switched by a factor of 10.

For current or voltage measurement the input of the subsequent differential amplifier is switched over by the voltage/current (V/I) selector controlled by the CPU.
In the programmable amplifier gain factors x0.1, x1 or x10 are selected by the CPU depending on the impedance of the CUT. For the reference measurement the input is short-circuited.

The 1 kHz band-pass filter 2 suppresses hum interference and reduces the harmonic components of the 1 kHz measurement signal.

The level detector compares the output voltage of band filter 2 with a preset reference value. If this value is exceeded, the CPU switches the programmable amplifier to a lower gain factor.

The phase sensitive rectifier generates dc voltages which are proportional to that component of the measuring voltage being in-phase with the reference voltage.

The analog to digital converter ADC converts the output signal of the rectifier into a binary number which can be processed by the CPU.

The central processing unit CPU with the inherent microprocessor controls and monitores the measurement process, computates and stores the measurement values and transfers the result to the display.

The LCD control transforms the serial data transmitted by the CPU into parallel data and controls the liquid-crystal display which operates in duplex mode.

In the LED control the parameter key actuations are verified and processed. The selected parameter is indicated by a LED. Simultaneously the information is BCD-coded and sent to the CPU, whereby the most significant bit directly switches on the 2 Vdc voltage, when the parameter Cs (2 V Bias) is set.

The power supply generates the required stabilized dc voltages +15 V, -15 V and +5 V for the circuitries.

1.4.2. Measuring principle

The **measurement principle** is based on the so-called **current and voltage measurement technique:** the component voltage and after that the component current are measured. The measurement values are converted to binary numbers. From these numbers the CPU is computing the CUT parameter of interest. According to the front panel parameter selection, either the dominating component —resistance, capacitance or inductance— or one of the various parameters which is selected is displayed.

Each measurement cycle lasts approx. 0.5 s. It comprises **5 single measurements,** the results of which are stored in the microprocessor data memory, a subsequent arithmetic evaluation and a final transfer of the result to the display. The 5 single measurements are as follows:

1. Reference measurement:
At the beginning of each measurement cycle a reference measurement is performed, whereby the input of the programmable amplifier is short-circuited. The counter contents of the A/D conversion at the end of this measurement serves as reference for the subsequent 4 measurements.

2. 0^{o} voltage measurement:
The voltage at the CUT is measured.

The switching phase of the phase sensitive rectifier is 0^{o}.

3. 90^{o} voltage measurement:
The voltage at the CUT is measured.

The switching phase of the phase sensitive rectifier is 90^{o}.

4. 0^{o} current measurement:
The inputs of the differential amplifier are switched over to the output of the current to voltage converter.

The current through the CUT is measured.

The switching phase of the phase sensitive rectifier is 0^{o}.

5. 90^{o} current measurement:
The current through the CUT is measured.

The switching phase of the phase sensitive rectifier is 90^{o}.

At the end of the 5 single measurements the 5 corresponding binary numbers of the A/D conversions and the assigned gain factors are stored in the microprocessor data memory. From this the microprocessor first calculates the equivalent series resistance Rs, the equivalent series reactance Xs and the quality factor Q = Xs/Rs of the CUT. In the RCL AUTO mode the microprocessor determines the dominant component, either Rs resp. Rp, Cp or Ls, calculates its value, dimension and equivalent-circuit symbol by arithmetic routines and transfers the result to the display. If one of the 8 other parameters is selected by the step keys this parameter is calculated and displayed. After that the microprocessor starts the next measurement cycle with the single measurement routines.

2. INSTALLATION INSTRUCTIONS

2.1. INITIAL INSPECTION

Check the contents of the shipment for completeness and note whether any damage has occurred during transport. If the contents are incomplete, or there is damage, a claim should be filed with the carrier immediately, and the Philips Sales or Service organisation should be notified in order to facilitate the repair or replacement of the instrument.

2.2. SAFETY INSTRUCTIONS

Upon delivery from the factory the instrument complies with the required safety regulations, see para. 1.2.1. To maintain this condition and to ensure safe operation, the instructions below must carefully be followed.

2.2.1. Maintenance and repair

Failure and excessive stress:
If the instrument is suspected of being unsafe, take it out of operation permanently.
This is the case when the instrument
- shows physical damage
- does not function anymore
- is stressed beyond the tolerable limits (e.g. during storage and transportation)

Dismantling the instrument: When removing covers or other parts by means of tools, live parts or terminals could be exposed. Before opening the instrument, disconnect it from all power sources.

If the **open live instrument needs calibration, maintenance or repair,** it must be performed only by trained personnel being aware of the risks. After disconnection from all power sources, the capacitors in the instrument may remain charged for some seconds.

2.2.2. Earthing (grounding)

Before any other connection is made the instrument shall be connected to a protective earth conductor via the three-core mains cable. The mains plug shall be inserted only into a socket outlet provided with a protective earth contact. The protective action shall not be negated by the use of an extension cord without protective conductor.
The GUARD connection must not be used to connect a protective conductor.

WARNING:	Any interruption of the protective conductor inside or outside the instrument, or disconnection of the protective earth terminal, is likely to make the instrument dangerous. Intentional interruption is prohibited.

2.2.3. GUARD connection

The circuit earth potential is applied to the GUARD connection and is connected to the cabinet by means of a parallel-connected capacitor and resistor. By this means hum loops are avoided and a clear HF earthing is obtained.
If the circuit earth potential in a measurement set-up is different from the protective earth potential, it must be noticed, that the GUARD connection can be touched and that it must not be live, see the safety regulations on the subject (VDE 0411).

2.2.4. Mains voltage setting and fuses

Before inserting the mains plug into the mains socket, make sure that the instrument is set to the local mains voltage.
The instrument shall be set to the local mains voltage only by a qualified person who is aware of the hazard involved.

WARNING:	If the mains plug has to be adapted to the local situation, such adaption should be done by a qualified person only.

Make sure that only fuses of the required current rating, and of the specified type, are used for renewal. The use of repaired fuses, and/or the short-circuiting of fuse holders, are prohibited.
The fuse shall be renewed only by a qualified person who is aware of the hazard involved.

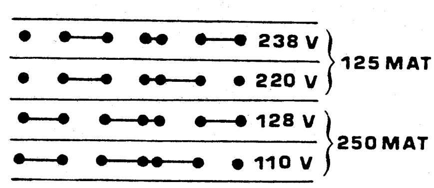
WARNING:	The instrument shall be disconnected from all voltage sources when a fuse is to be renewed, or when the instrument is to be adapted to a different mains voltage.

2.3. MAINS VOLTAGE SETTING AND FUSES

The safety instructions in chapter 2.2.4. must be followed.

On delivery from the factory the instrument is set to 220 V.
If the instrument is to be used on a different supply voltage proceed as follows:

- Unplug the mains connector
- Fold up the handle to the top.
  For this push the buttons of the handle.
- Loosen the central screw at the rear
- Dismantle the cabinet
- Change the solder links
  according to the connection diagram on the bottom side of the instrument



- If necessary, insert the supplied fuse 250 mA delayed into the fuse holder instead of the fuse built-in
- Change the mains voltage plate at the rear of the instrument in accordance with the mains voltage selected. The plates for the other supply voltages are inserted into a plastic cover, as the fuse just mentioned.
- Close the instrument

2.4. OPERATING POSITION OF THE INSTRUMENT

The instrument may be used in the positions indicated in clause 1.2.4. With the handle folded down, the instrument may be used in a sloping position; for this push the buttons of the handle. The characteristics mentioned in Section 1.2. are guaranteed for the specified positions.
Ensure that the ventilation holes in the cover are free of obstruction.
Do not position the instrument on any surface which produces or radiates heat, or in direct sunlight.

2.5. DISMANTLING THE INSTRUMENT

- Unplug the mains connector
- Fold up the handle to the top. For this push the buttons of the handle
- Loosen the central screw at the rear
- Dismantle the cabinet

3. OPERATION AND APPLICATION

3.1. GENERAL INFORMATION

This section outlines the procedures and precautions necessary for operation. It identifies and briefly describes the functions of the front panel controls and indicators, and explains the practical aspects of operation to enable an operator to evaluate quickly the instrument's main functions.

3.2. SWITCHING ON THE INSTRUMENT

After the instrument has been connected to the mains voltage in accordance with clauses 2.2.4 and 2.3, it can be switched on by depressing the mains switch POWER. The white spot inside the POWER switch mechanically indicates that the instrument is switched on.

Having switched on the instrument, it is immediately ready for use. With normal installation in accordance with Section 2.4 and after a warming-up time of 5 minutes, the characteristics specified in Section 1.2 are valid.

After switching power off, a time intervall of at least 5 s should pass by –allowing the capacitors of the power supply to discharge– before the device is switched on again. This procedure is necessary to set the internal logic circuitry to its correct initial condition.

WARNING:	Before switching on, ensure that the instrument has been installed in accordance with the instructions mentioned in Section 2.

3.3. SELFTEST ROUTINE

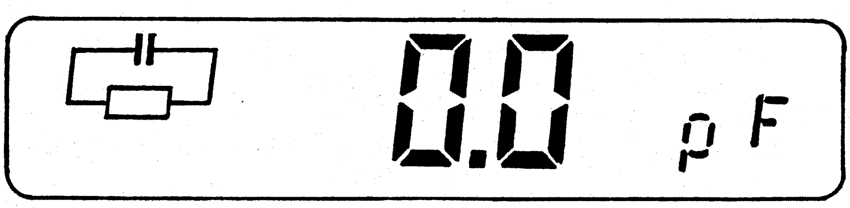
Immediately after power being switched on a selftest routine is performed, whereby several functions are tested. For check of the display all segments of the decimal and dimension indications, decimal points and equivalent-circuit symbols are shown for 3 seconds.

After this a possible error will be indicated by the display readings E0 ... E3. The equivalent-circuit symbols are not shown. The error codes are pointing towards the following failures.

E0: RAM test, microprocessor
E1: measuring ranges
E2: analog/digital converter
E3: reference measurement

Further error indications are explained in chapter 3.4.6.

When the selftest routine is terminated the instrument is set to the initial state performing the default mode RCL AUTO. With the zero-capacitance being properly compensated and no component connected the initial state is indicated by the following display reading:



⊗ RCL AUTO

3.4. OPERATION AND APPLICATION

3.4.1. Controls and Sockets (Fig. 31)

Legend	Function
POWER	mains switch:
○ ON	white dot for ON position
● OFF	

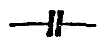
⊗ RCL AUTO ◁ ▭ — **RCL AUTO mode:** default mode of the instrument after POWER ON

Reset button for RCL AUTO mode, if a different parameter was selected. Numerical value and dimension of the **dominating component** of the componet under test is displayed. The appropriate equivalent-circuit symbol is indicated (for details see chapter 3.4.4.)

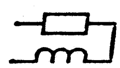
Display range:
- resistance 0.000 Ω – 200 MΩ
- capacitance 0.0 pF – 100 mF
- inductance 0.0 μH – 32 kH

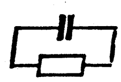
equivalent-circuit symbol:

 D > 500

 Q > 500

 Q > 500

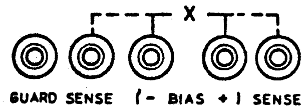
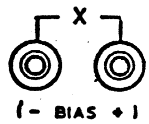
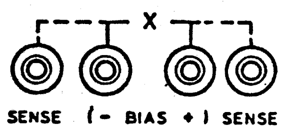
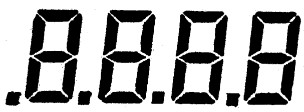
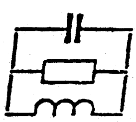
 Q resp. D ⩽ 500

 Q resp. D ⩽ 500

△ ▭
▽ ▭

Step buttons for parameter selection.
Continuous stepping in the marked direction, when pushbutton is kept pushed.
Selected parameter is indicated by a LED.
Parameters:

⊗ RCL AUTO	diminating component (see above)
⊗ Q	quality factor (tan φ; Q = 1/D)
⊗ D	dissipation factor (tan δ; D = 1/Q)
⊗ Rp	parallel resistance
⊗ Rs	series resistance
⊗ Z	impedance (image impedance)
⊗ Cp or Lp	parallel capacitance/inductance
⊗ Cs or Ls	series capacitance/inductance
⊗ Cs (2 V BIAS)	series capacitance with 2 V internal bias voltage, e.g. for electrolytic capacitors

Legend	Function
	**Connections at the frontplate** (1 row of 5 sockets)
	Connection for component measurement applying 2-wire system
	Connection for component measurement applying 4-wire system (recommended for low impedance, < 100 Ω)
 GUARD	measuring earth, screen (do not shorten to other connectors at the frontplate)
Co TRIM	screw driver adjustment for compensation of the zero-capacitance (max. 5 pF). For adjustment see chapter 3.4.3.
	Display of the measurement result
	max. 4 digits for the numerical value
	dimension display: Ω, kΩ, MΩ pF, nF, μF, mF; μH, mH, H, kH no display of dimension for Q and D
	equivalent-circuit symbols: 7 different display combinations
	**Overrange indication:** flashing of the four digits centre segments, when the following limit values are passed: – resistance > 200 MΩ – capacitance > 100 mF – inductance > 32 kH – quality factor > 500 – dissipation factor > 500

- for Q, D > 500 flashing for parameter selection deviating from displayed equivalent-circuit symbol
- for Cs (2 V Bias), if Q < 0.1 or if inductance is identified

3.4.2. Component Connection

By means of the supplied 2-terminal test fixture common components are connected.
For precise results low-ohmic impedances should be measured applying 4-wire system. For this a 4-wire test cable with Kelvin clamps (PM 9541) and the RCL adapter (PM 9542) are optional available.

Furthermore it is possible to connect components to the 4 mm input sockets of the RCL meter via single line cables. When measuring high-ohmic CUTs the zero-capacitance must be considered.
If screened cables (single screened wires) are used to reduce additional zero-capacitance the screens must be connected to the GUARD.

ATTENTION: Capacitors with high residual charge (> 5 V) must be discharged before connecting to the measuring input.

3.4.3. Compensation of the Zero-Capacitance

When measuring high-ohmic components the indicated zero-capacitance must be taken into account or compensated by Co TRIM:

- Apply appropriate test fixture or test adapter without CUT to the instrument.
- Select "Cp or Lp" by the step buttons ▽ or △ .
- Adjust trimmer Co TRIM by screw driver for 0.0 pF display.

On adjustments < 0.0 pF overrange is indicated. If Co TRIM is turned more clockwise an inductance (kH) may be displayed.

3.4.4. RCL AUTO, parameter menu

RCL AUTO is the default mode of the instrument after POWER ON. If necessary, perform compensation of the zero-capacitance by Co TRIM according to chapter 3.4.3.

In this RCL AUTO mode the numerical value and dimension of the dominating component of the CUT are displayed. In addition the appropriate equivalent-circuit symbol is indicated. Q = D = 1 is the decision threshold of the RCL meter for defining the dominating component, see Fig. 5. It must be noticed that Q and D are related to the instruments' internal 1 kHz test frequency.

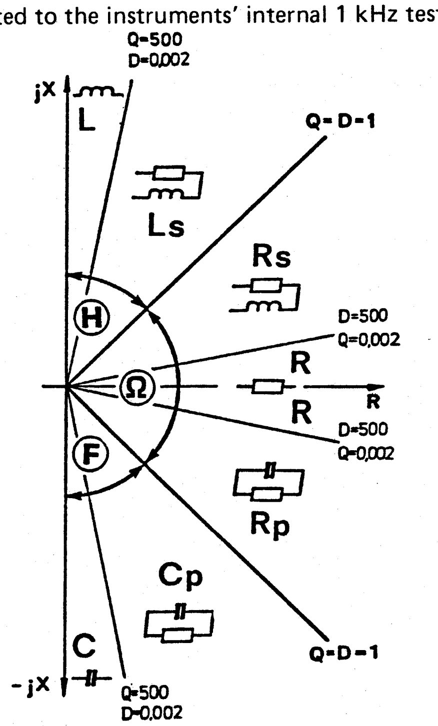


Fig. 5 Displayed equivalent-circuit symbol and dominating component in the various sectors of the CUT impedance phasor plane (RCL AUTO)

In most cases the user will be interested in the dominating component of the CUT, displayed in the RCL AUTO mode. If any other parameter shall be displayed the user may select it from the front panel menu by activating the stepping key ∇ or △ .

The RCL meter primarily determines the series reactance and resistance of the CUT. From these two quantities the selected CUT parameter is calculated. The algorithm used by the instrument including series/parallel and parallel/series transformation formulas and phasor diagrams of the various CUT types are presented in Fig. 32.

3.4.5. Special user instructions

As pointed out in the preceding chapter in RCL AUTO mode the instrument identifies the dominant component of the CUT and display it. It must be considered that the decision, if the reactive or the ohmic component is dominating, generally depends on the frequency. In PM 6303 an 1 kHz test frequency is applied. This must be taken into account especially if low-ohmic inductors and capacitors or high-ohmic resistors and measured:

Lossy inductors: When testing small lossy inductances often the series loss resistance is identified as dominant component and displayed, because at 1 kHz the series reactance will be very low. Hence, for Ls or Lp display this parameter must be selected from the front-panel menu.

Lossy capacitors with high capacitance, e.g. electrolytic capacitors:
When testing capacitors the user normally will be interested in the value of the capacitance. As the reactance of large capacitors is very low, the series resistance can be dominant resulting in $Q < 1$ and indication of Rp. Hence, for Cs or Cp display these parameters must be selected.

High-ohmic resistors: When testing resistors in the higher MΩ range the reactance of the parasitic parallel capacitance may be lower than the resistance, resulting in a Cp display. For indication of Rs or Rp these parameters must be selected.

Additional user instructions:
In the **Cs (2 V BIAS)** mode capacitors can be tested with 2 Vdc bias voltage.
For large capacitors some time is needed for stable display due to the charging process (approx. 0.55/mF).
For the parameter Cs (2 V BIAS) overrange is indicated for $Q < 0.1$ or if an inductance is identified.

The resonant frequency of a larger inductance paralleled by a parasitic capacitance can be below the test frequency. Then, of course, the CUT represents a capacitance at 1 kHz which is displayed.

When testing **large inductors** especially in the kH range relative small parasitic parallel capacitances will effect the measurement result. Thus special attention shall be paid on careful Co compensation.

When testing **inductors with ferromagnetic cores** normally due to saturation effects the inductance will decrease with higher current or voltage amplitudes. At PM 6303 these amplitudes are resulting from the 2 Vrms open-circuit voltage and the internal 400 Ω resistance of the instrument and the CUT impedance. For lower amplitudes an additional resistor ⩾ 71.5 Ω may be connected between GUARD and the centre 4 mm socket (marked with a −sign). For Rp = 71.5 Ω fig. 6 shows the CUT voltage and current versus impedance relationship. In the shown impedance range the measurement error is increased to about 0.5 % maximum by the load resistor.

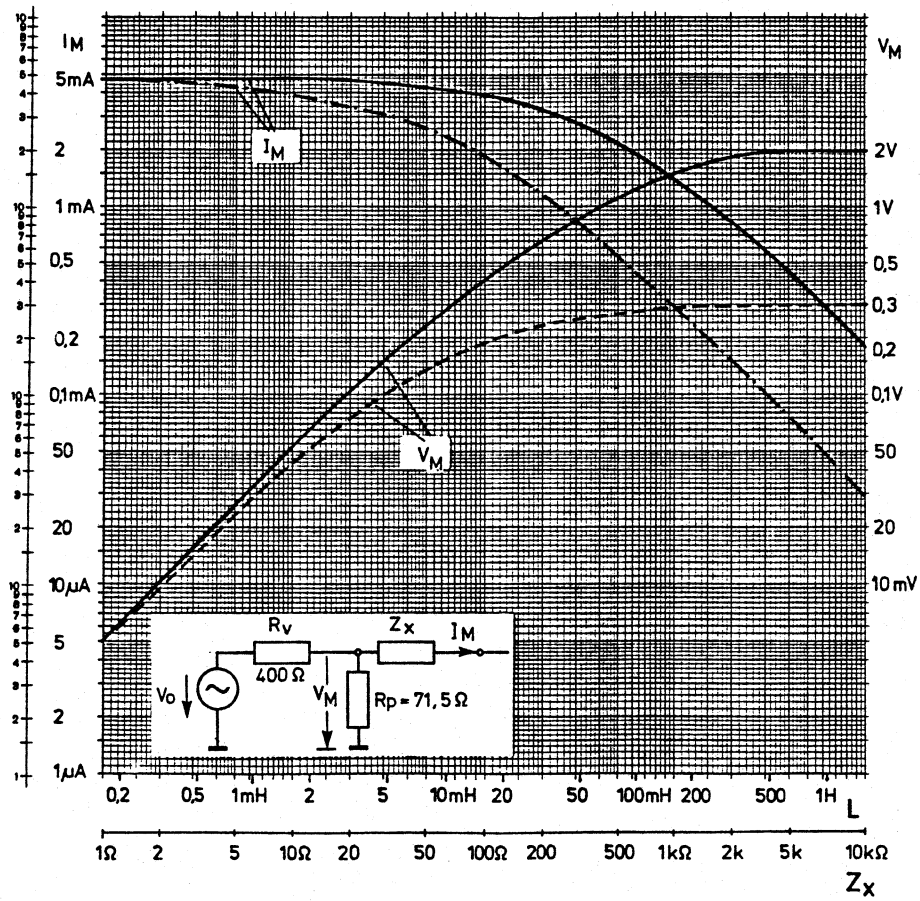


Fig. 6 Measurement voltage and current at an inductive CUT (Q > 10, —— without Rp, - - - with Rp)

3.4.6. Error indication

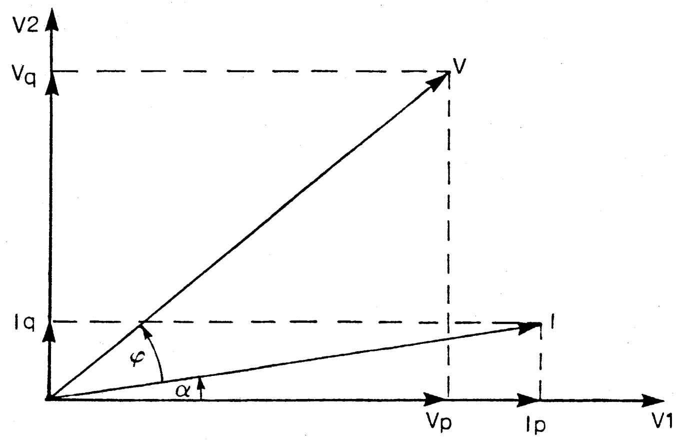
Several functions and logical states of the instrument are continuously internally checked during normal operation. Possible errors are indicated by E0 ... E3 on the display. The meaning of the error codes are given in the following table

Error code	location of malfunction
E0	RAM, microprocessor
E1	progr. amplifier, level detector
E2	counter of ADC, integrator control section
E3	reference measurement circuitry

If an error code is displayed the instrument should be switched off. If after switching on the error code is indicated again please contact the Philips service organisation.

After switching power off a time interval of at least 5 s should pass by -allowing the capacitors of the power supply to discharge- before the device is switched on again. This procedure is necessary to set the internal logic circuitry to its correct initial condition.

APPENDIX 1:
Algorithms used in PM 6303;
Phasor Diagrams of Various CUT Types



Definitions:

V:	CUT voltage
I:	CUT current
V1, V2:	switching voltages of the phase-sensitive rectifier

The phase angle between I and V is φ.
The phase angle between I and V1 is α.

In the diagram the phase relation between I and V is related to a lossy inductance.

In each measuring cycle the following components are determined: Vp, Vq, Ip, Iq.

From these components the **series resistance and reactance** of the CUT are calculated by the processor:

$$Rs = \frac{VpIp + VqIq}{Ip^2 + Iq^2} \quad (1) \qquad Xs = \frac{VqIp - VpIq}{Ip^2 + Iq^2} \quad (2)$$

These formulas can be derived from:

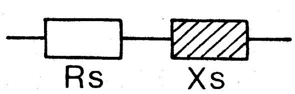
$$I^2 = Ip^2 + Iq^2$$

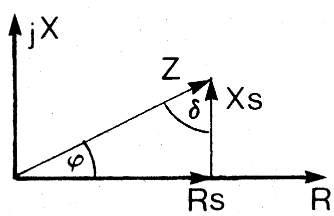
$$Rs = \frac{V}{I}\cos\varphi = \frac{V}{I}\left[\cos(\alpha+\varphi)\cos\alpha + \sin(\alpha+\varphi)\sin\varphi\right] = \frac{V}{I}\cdot\frac{VpIp + VqIq}{VI} = \frac{VpIp + VqIq}{I^2}$$

$$Xs = \frac{V}{I}\sin\varphi = \frac{V}{I}\left[\sin(\alpha+\varphi)\cos\alpha - \cos(\alpha+\varphi)\sin\alpha\right] = \frac{V}{I}\cdot\frac{VqIp - VpIq}{VI} = \frac{VqIp - VpIq}{I^2}$$

Note that α has no influence in the formulas for Rs, Xs. α is assumed to be constant during one measurement cycle.

The following is valid:





$$\varphi = 90^{\circ} - \delta$$

quality factor $\qquad Q = \tan\varphi = 1/D = \frac{|Xs|}{Rs} \quad (3)$

dissipation (loss) factor $\qquad D = \tan\delta = 1/Q = \frac{Rs}{|Xs|} \quad (4)$

The magnitude of Q and the signum of Xs determine which parameter of the CUT is calculated and displayed in the "RCL AUTO" mode. The calculation formulas for the various parameters of the front-panel menu are:

Q as given by equation (3)

$D = \frac{1}{Q}$

$Rp = (1 + Q^2)\ Rs$

Rs as given by equation (1)

$Z = \sqrt{Rs^2 + Xs^2}$

$Cp = \frac{1}{\omega\,(1 + 1/Q^2)\,Xs}$ if $Xs < 0$

$Lp = \frac{(1 + 1/Q^2)\ Xs}{\omega}$ if $Xs > 0$

$Cs = \frac{1}{\omega\ |Xs|}$ if $Xs < 0$

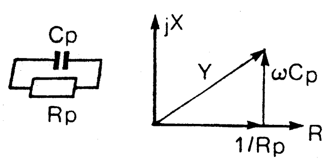
$Ls = \frac{|Xs|}{\omega}$ if $Xs > 0$

Impedance $Z = R + jX$

Admittance $Y = 1/Z = G + jB$

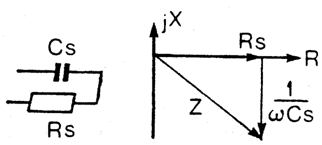
$G = R/(R^2 + X^2)$

$B = -X/(R^2 + X^2)$

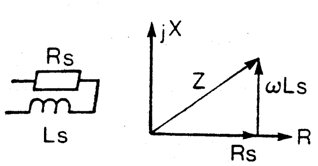


$Y = \frac{1}{Rp} + j\omega Cp$ $D = \frac{1}{\omega CpRp}$ $Cs = (1 + D^2) \cdot Cp$ $Rs = \frac{D^2}{1 + D^2} \cdot Rp$

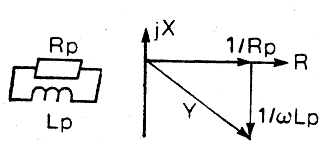
$Z = \frac{Rp\,(1 - j\omega CpRp)}{1 + (\omega CpRp)^2}$



$Z = Rs - j\,\frac{1}{\omega Cs}$ $D = \omega CsRs$ $Cp = \frac{1}{1 + D^2} \cdot Cs$ $Rp = \frac{1 + D^2}{D^2} \cdot Rs$



$Z = Rs + j\omega Ls$ $D = \frac{Rs}{\omega Ls}$ $Lp = (1 + D^2) \cdot Ls$ $Rp = \frac{1 + D^2}{D^2} \cdot Rs$



$Y = \frac{1}{Rp} - j\,\frac{1}{\omega Lp}$ $D = \frac{\omega Lp}{Rp}$ $Ls = \frac{1}{1 + D^2} \cdot Lp$ $Rs = \frac{D^2}{1 + D^2} \cdot Rp$

$Z = \frac{Rp\,(1 + jRp/\omega Lp)}{1 + (Rp/\omega Lp)^2}$

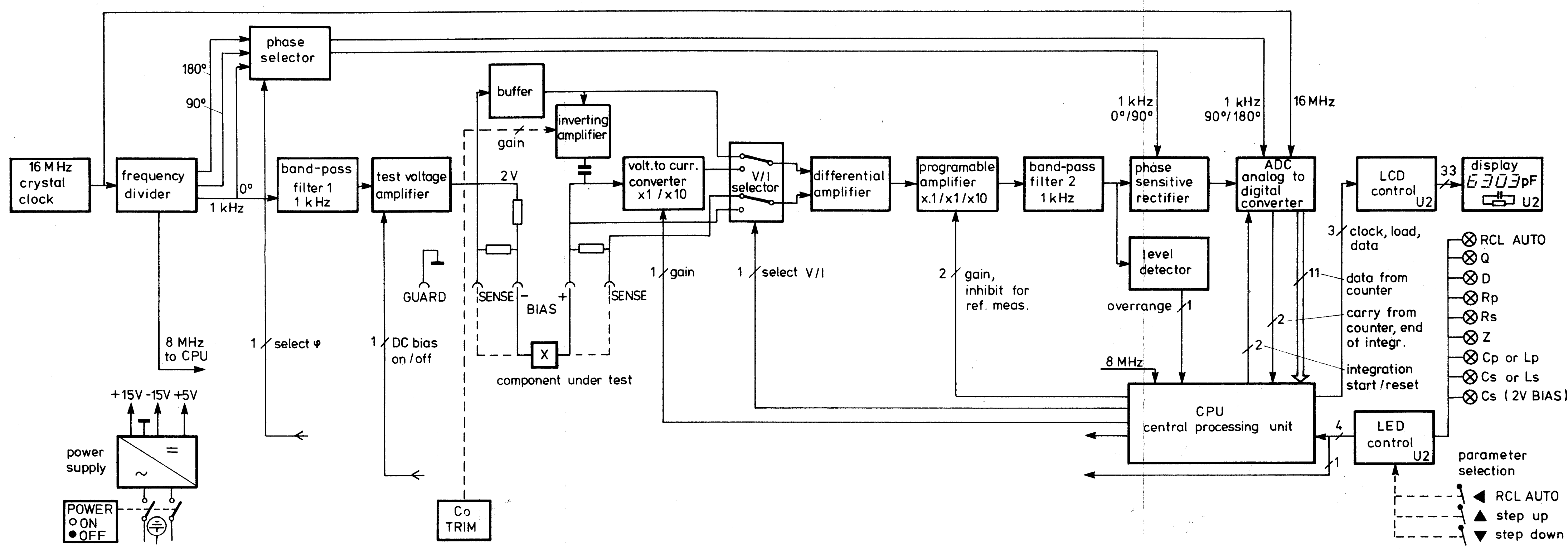


Fig. 30 Block diagram
Blockschaltbild
Schéma synoptique

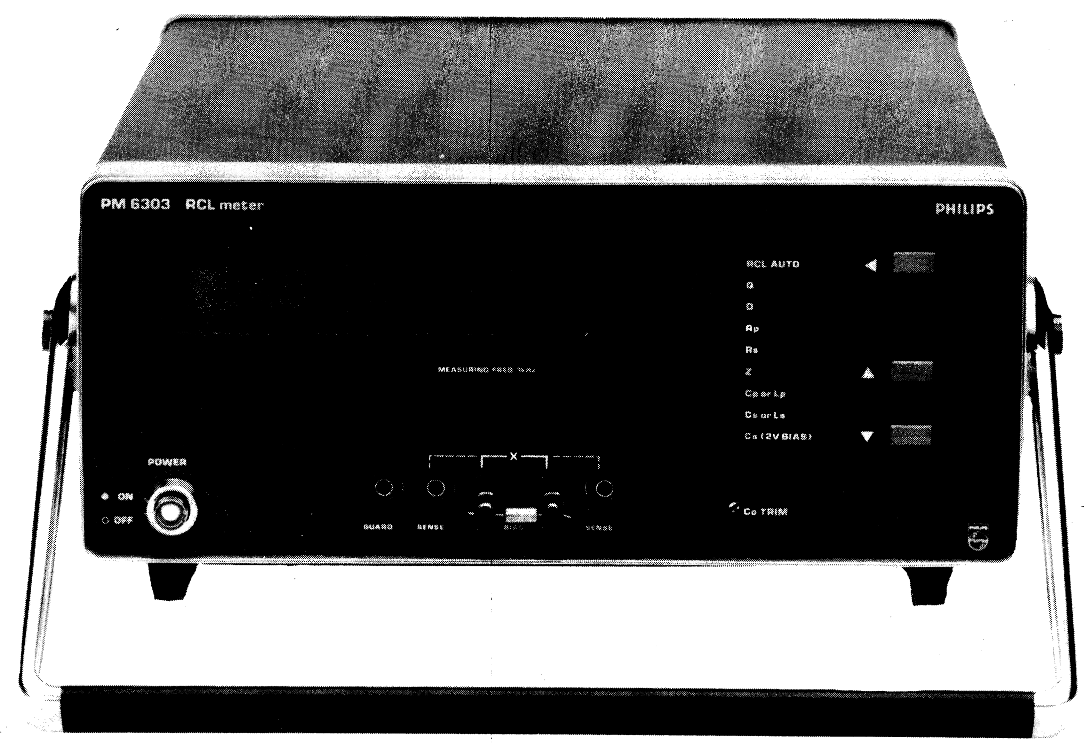


Fig. 31 Front view
Frontansicht
Vue avant

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831215 TEST AND MEASURING EQUIPMENT

PM 9541, PM 9542

English:

The 4-wire test cable PM 9541 and the RCL adapter PM 9542 are optional accessories for the RCL meter PM 6303.
2 single test posts and 1 double test post are delivered with PM 9542.

In the operating manual 9499 520 08201 of the RCL meter, chapter 3.4.2, component connection, the application of the two accessories is described. About compensation of the zero capacitance chapter 3.4.3 gives some information.

Wrong insertion of the plugs into the RCL meter is prevented by unsymmetrical arrangement of the pins.
The cable lengths are approx. 0.6 m.

When measuring low-ohmic components with PM 9541 the short-circuit self-inductance of max. 0.3 µH of the cables must be taken into account.

For understanding the measurement circuit when applying the accessories, the figures on page 2 are depicted.

Deutsch:

Das 4-Leiter-Testkabel PM 9541 und der RCL Adapter PM 9542 sind Sonderzubehör zum RCL-Meter PM 6303.
2 Einzel-Testsäulen und 1 Doppel-Testsäule werden mit PM 9542 geliefert.

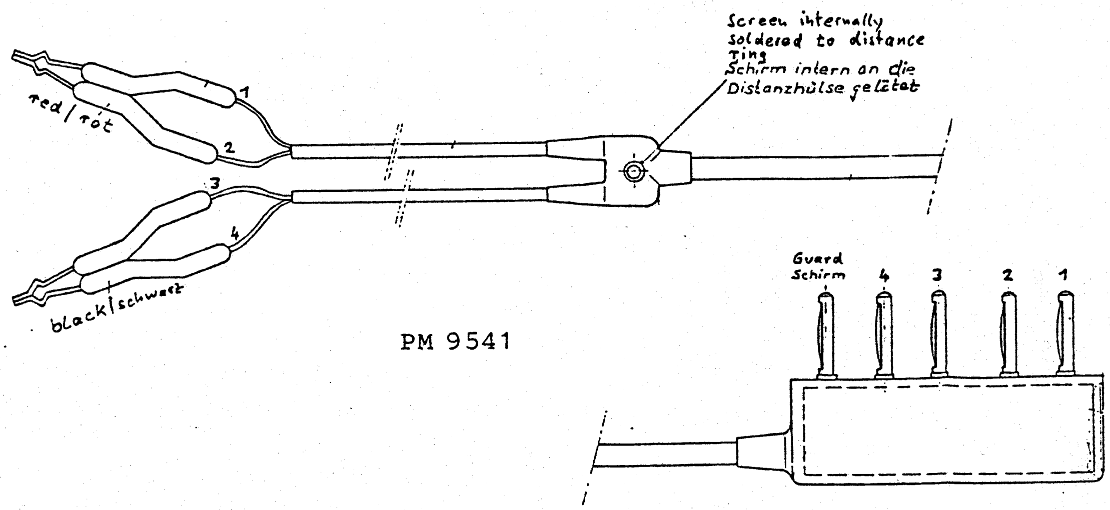
In der Gebrauchsanleitung 9499 520 08201 des RCL Meter wird die Anwendung des Zubehörs im Kapitel 3.4.2, Anschluß eines Prüflings, beschrieben. Kapitel 3.4.3 beschreibt den Ausgleich der Null-Kapazität.

-2-

Die unsymmetrische Anordnung der Steckerstifte gewährleistet richtiges Anschließen an das RCL-Meter.
Die Kabellängen betragen ca. 0,6 m.

Bei der Messung niederohmiger Komponenten mit PM 9541 muß die Eigeninduktivität bei Kurzschluß von max. 0,3 µH berücksichtigt werden.

Zum Verständnis des Meßaufbaus beim Anschluß des Zubehörs dienen die Abbildungen auf Seite 2.



PM 9541