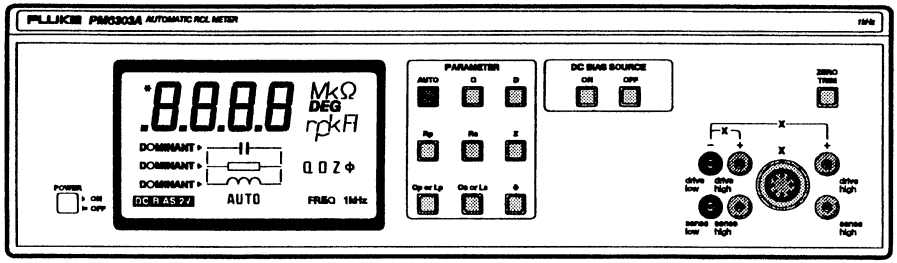
Automatic RCL Meter

PM6303A

Users Manual

4822 872 10158
November 1995, Rev. 2, 02/99



FLUKE®

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 suffisamment qualifiées.

CONTENTS

USERS MANUAL

CONTENTS

SHIPMENT NOTE

The following parts should be included in the shipment:

1 Fluke PM6303A Automatic RCL Meter 1 kHz

1 Users Manual

1 Power Cable

2 Fuses

2 Single Test Posts

INITIAL INSPECTION

Check that the shipment is complete and note whether any damage has occurred during transport. If the contents are incomplete or there is damage, file a claim with the the carrier immediately, and notify the Fluke Sales or Service organization to facilitate the repair or replacement of the instrument. The addresses are listed in the back of the manual.

The performance of this instrument can be tested by using the Performance Test in Chapter 5 of this manual.

Chapter 1

INSTALLATION AND SAFETY INSTRUCTIONS

1 INSTALLATION AND SAFETY INSTRUCTIONS

1.1 SAFETY INSTRUCTIONS

Upon delivery from the factory the instrument complies with the required safety regulations (see Chapter 4). To maintain this condition and to ensure safe operation, the instructions below must be followed carefully.

1.1.1 Maintenance and Repair

Failure and excessive stress:
If the instrument is suspected of being unsafe, remove it from operation immediately and secure it against any unintended operation. The instrument is considered to be unsafe when any of the following conditions exist:

- It shows physical damage.
- It does not function anymore.
- It is stressed beyond the tolerable limits (e.g., during storage and transportation).

Disassembling the Instrument:

WARNING

Calibration, maintenance, and repair of the instrument must be performed only by trained personnel who are aware of the hazards involved. To avoid electric shock, do not remove the cover unless you are qualified to do so.

Before removing the cover, disconnect the instrument from all power sources. The capacitors in the instrument may remain charged for several seconds after all power has been disconnected.

1.1.2 Grounding (Earthing)

Before any other connection is made the instrument must be connected to a protective earth conductor via the three-wire power cable.
The power plug shall be inserted only into a grounded outlet.
Do not defeat the protective action by using an extension cord without a grounded conductor.
Do not connect a protective ground conductor into the measurement contacts on the front panel, the four contacts of the connector to which the circuit ground is applied, or the external contact of the connector plug.

WARNING

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

1.1.3 Connections

The circuit ground potential is applied to four of the eight contacts of the front panel connector and is connected to the instrument case via parallel-connected capacitors and a resistor. The external contact of the connector is connected to the instrument case. This avoids ac ground loops while providing good RF grounding.

If the circuit ground potential in a measurement setup is different from the protective ground potential, make sure that the four contacts of the front panel connector are not live.

1.1.4 Line Voltage Setting and Fuses

Before plugging in the line cable, make sure that the instrument is set to the correct line voltage.

WARNING

To avoid injury or death, changing fuses and modifying line cables to local power must be done by qualified service personnel who are aware of the hazards involved.

On delivery from the factory, the instrument is set to one of the following line voltages:

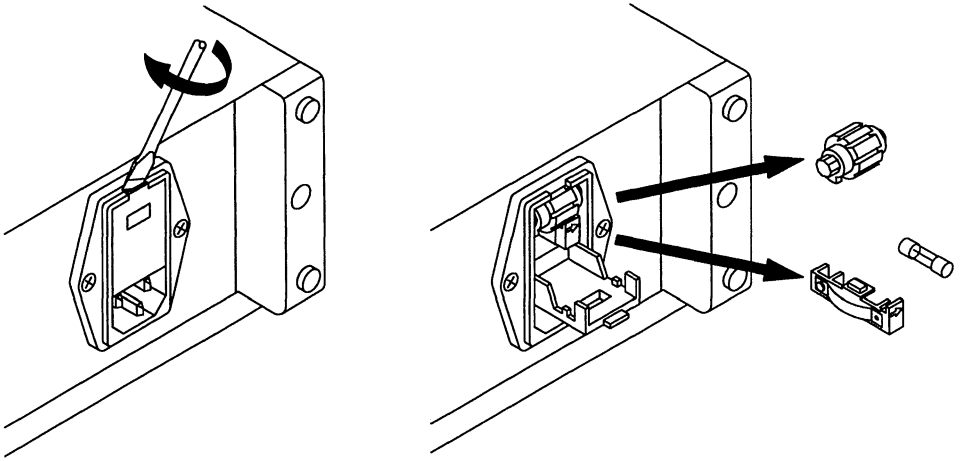
Type	Code No.	Line Voltage	Delivered Power Cable
PM6303A	9452 063 03101	220 V	Universal Europe
PM6303A	9452 063 03103	120 V	North America
PM6303A	9452 063 03104	240 V	England (U.K.)
PM6303A	9452 063 03105	220 V	Switzerland
PM6303A	9452 063 03108	240 V	Australia

The line voltage setting and the corresponding fuse specification are indicated on the rear panel.

Make sure that replacement fuses are of the type and current rating specified. The use of repaired fuses and/or the short-circuiting of fuse holders are prohibited. Do not defeat this important safety feature.

The instrument can be set to the following line voltages: 100 V, 120 V, 220 V and 240 V ac. These nominal voltages can be selected by means of the voltage selector, located on the rear panel, next to the line voltage connector. The fuse is located in a holder at the same place. For line voltage selection or replacement of the fuse, remove the line cable and pry open the compartment with a small screwdriver (see illustration).

Turn the selector to select the appropriate voltage range. If necessary, insert the specified fuse (T0.1A or T0.2A according to IEC127 or T0.125A or T0.25A according to CSA/UL198G) that matches the line voltage setting into the fuse holder.



1.2 OPERATING POSITION OF THE INSTRUMENT

The instrument can be operated on a horizontal surface in a flat position or with the tilt bale extended. Ensure that the ventilation holes are free of obstruction. Do not position the instrument in direct sunlight or on any surface that produces or radiates heat.

1.3 RADIO INTERFERENCE SUPPRESSION

Radio interference of the instrument is suppressed and checked carefully. If radio frequency interferences occurs in connection with deficiant suppressed other instruments, further suppression actions may be required.

Chapter 2

MAIN FEATURES

2 MAIN FEATURES

The **PM6303A Automatic RCL Meter** is used for precise measurements of resistance, capacitance and inductance. The instrument provides auto-function and auto-ranging facility. It allows fast and high precision measurements of passive components over a wide range.

The component to be measured is connected to the instrument via front panel test posts, the PM 9541A four-wire test cable, or the PM 9542A four-terminal test adapter. The Adapter PM 9542SMD or the PM 9540/TWE SMD Tweezers for surface-mounted components are also available.

The measurement result, the numerical value, dimension, and the equivalent circuit symbol, is immediately displayed on the large four-digit liquid-crystal display (LCD), which is updated at a rate of two measurements per second.

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

In the AUTO mode the dominant parameter, either R, C, or L of the component under test is automatically selected for display.
For example, for an inductance with a quality factor Q between 1 and 500, the instrument 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 AUTO mode, eight component parameters can be selected manually by pressing pushbuttons:

- 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
- Phase angle Φ

An internal DC BIAS voltage can be added to the measurement voltage for electrolytic capacitors.

The PM6303A RCL Meter is especially suited for use in laboratories, for quality control, in service workshops, and for educational purposes.

Chapter 3

OPERATING INSTRUCTIONS

3 OPERATING INSTRUCTIONS

3.1 GENERAL INFORMATION

This section outlines the procedure and precautions necessary for operation. It identifies and briefly describes the functions of the front and rear panel controls and the display, and explains the practical aspects of operation.

3.2 TURNING THE INSTRUMENT ON

WARNING

Before turning the instrument on, ensure that it has been installed in accordance with the instructions in Chapter 1.

After the instrument has been connected to the line voltage in accordance with Section 1.1.4, it can be turned on by setting the **POWER** switch on the front panel to **ON**.

The specifications given in chapter 4 are valid when the instrument is installed in accordance with the instructions in chapter 1 and a warm-up period of 5 minutes.

After turning the power off, wait at least 5 seconds before turning it on again. This allows all power to completely discharge and the instrument to reset.

3.3 SELF-TEST ROUTINE

After power on, the instrument performs a self-test of the PROM, processor RAM, and external RAM. After this the software version is indicated in the upper line of the display for approximately 1 second. All segments of the display field are shown for approximately 2 seconds, and the instrument automatically recalls its instrument state before power off.

A possible fault is indicated as follows:

e.g. 

The digits mean:

1 Program memory checksum
2 RAM processor
3 External RAM defective
4 Backup memory

For detailed information see Section 3.5.5.

3.4 BRIEF CHECKING PROCEDURE

3.4.1 General

This procedure checks the instrument functions with a minimum of steps. It is assumed that the operator doing the test is familiar with the instrument and its characteristics. If this test is started within a short period after power on, test steps may be out of specification due to insufficient warm-up time.

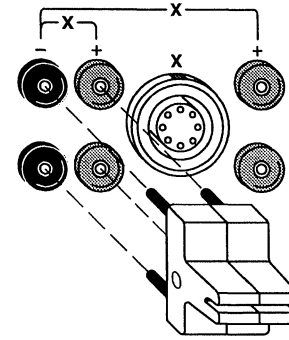
WARNING

Before turning the instrument on, ensure that it has been installed in accordance with the instruction in Chapter 1.

3.4.2 Functional Test

Immediately after power on a self-test routine is performed. Then the instrument automatically recalls measurement settings prior to the last power off (see Section 3.3).

Insert the test posts supplied into the connector on the front panel (Logos face to face).



Press the green **AUTO** key.

The display shows:

AUTO

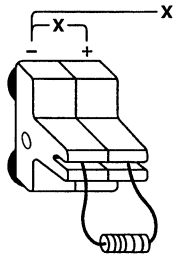
Press the **ZERO TRIM** key.

The display shows
for approximately 3 seconds:

If the ZERO TRIM operation
is unsuccessful, the display shows:
Refer to Section 3.5.3.

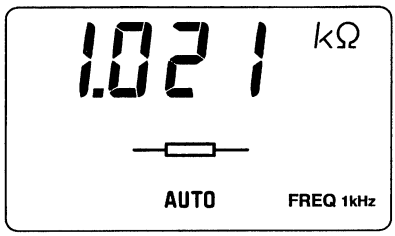
If the ZERO TRIM operation
is successful, the display shows:

Insert a known component into
the test posts, e.g., a 1 kΩ resistor.



The display shows:

When the display is correct
the functional test is finished.

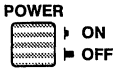
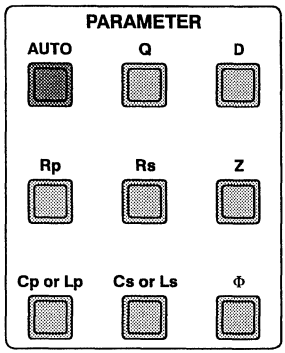
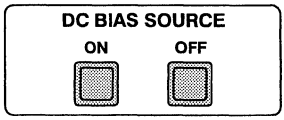


3.5 OPERATION AND APPLICATION

3.5.1 Control Elements, Display and Connections

3.5.1.1 Front Panel

Keyboard

Description	Function
	Power switch
	Keypad used to select required measurement: **AUTO** Automatic measurement mode: the dominant parameter is automatically displayed. **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 Φ Phase angle
	Key used to switch the internal 2 V dc bias on or off (to measure electrolytic capacitors).
	Key used for automatic trimming of ▪ Open-circuit impedance (>100 kΩ) ▪ Short-circuit impedance (<10 Ω)

Description	Function

Display Section

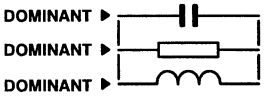
*8.8.8.8

Maximum of four digits for the measurement value. The asterisk indicates that the componen is outside the 0.25 % accuracy range of the instrument.

MkΩ
DEG
nμkH

Display of measuring unit:

M Ω k Ω Ω	For resistances
DEG (degree)	For phase angle
n F p F μ F m F	For capacitances
μ H m H H kH	For inductances



Equivalent circuit symbols with marker for dominant component.

Q D Z Φ

Display of selected parameter

- **Q** : Quality factor
- **D** : Dissipation factor
- **Z** : Impedance
- **Φ** : Phase angle

DC BIAS 2V

Indication that internal bias voltage is turned on.

AUTO

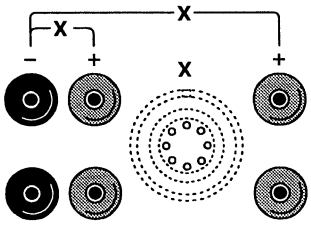
Automatic measurement of dominant parameter.

FREQ 1kHz

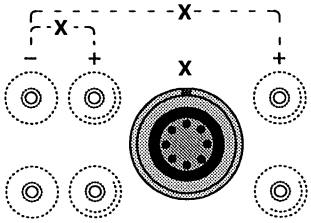
Measurement frequency 1 kHz (fixed).

Description	Function

Connections

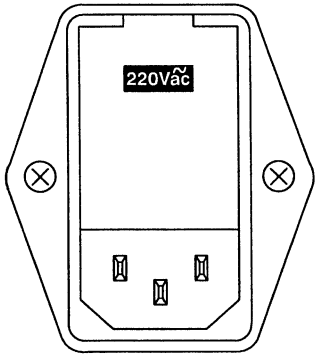


Connectors for
- Test posts for four-wire measurement.
- PM 9542SMD, SMD ADAPTER



Connector for
- PM 9541A 4-wire Kelvin Clip Test Cable
- PM 9542A RCL Adapter
- PM 9540/TWE, SMD TWEEZERS
- PM 9540/BAN, 4-WIRE TEST CABLE with banana plugs

3.5.1.2 Rear Panel



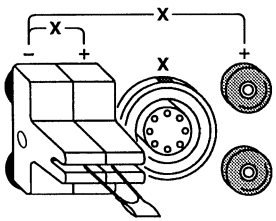
Input power module with fuse and voltage selector.
⌣ ac (alternating current).
For details, see Section 1.1.4:
Line Voltage Setting and Fuses.

3.5.2 Measurement Setup and Accessories

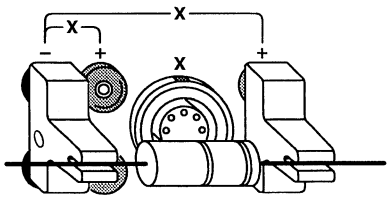
For best accuracy, you should perform ZERO TRIM (see Section 3.5.3) when you change the measurement setup.

Test posts

Most common components can be measured with the supplied test posts plugged into the front panel connectors.



Radial–Lead Component

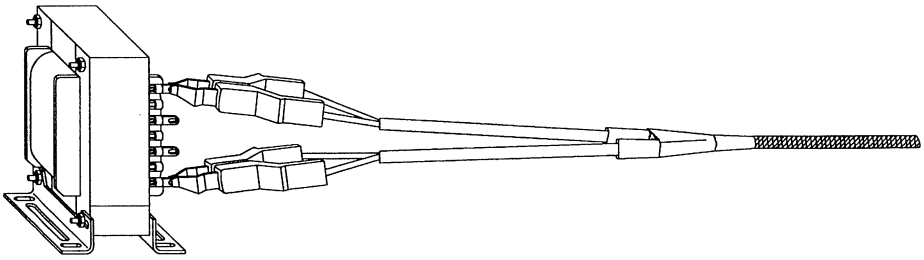


Axial–Lead Component

PM 9541A Test Cable with Kelvin Clips

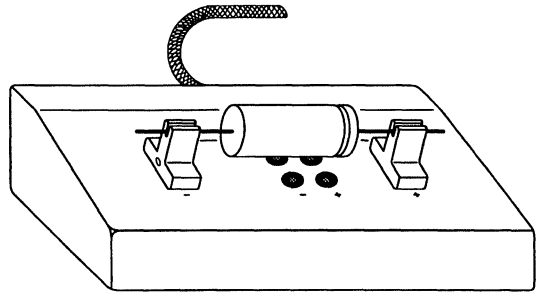
Use the test cable to measure in-circuit components or components of large size.

The test cable is connected to the instrument via the round plug (red markings face to face). The plug locks automatically. To unlock the plug, pull on the ridged part.



PM 9542A RCL Adapter

The RCL adapter allows you to make component measurements away from the front panel of the instrument. The RCL adapter can also handle larger components than the front panel connector can.



The RCL adapter is connected to the instrument via the round plug on the front panel (red markings face to face).

The supplied single test posts and the double test post can also be directly inserted into the front panel connector of the instrument.

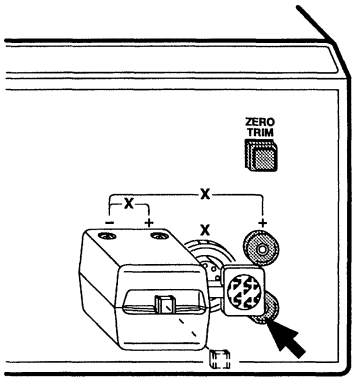
Note: For accurate measurements you should insert only the test posts, cable, or adapter that you need for the actual measurement.

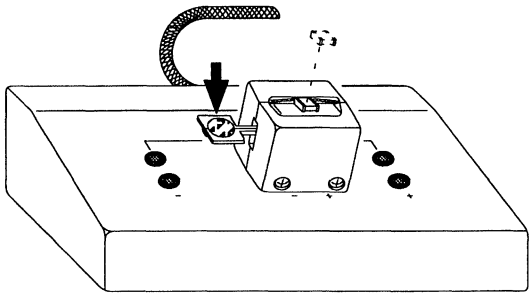
PM 9542SMD, SMD Adapter

The SMD adapter can be used to measure SMD components with a length of 2 to 10 mm, depth >1 mm, height >0.5 mm, or a diameter >1 mm.

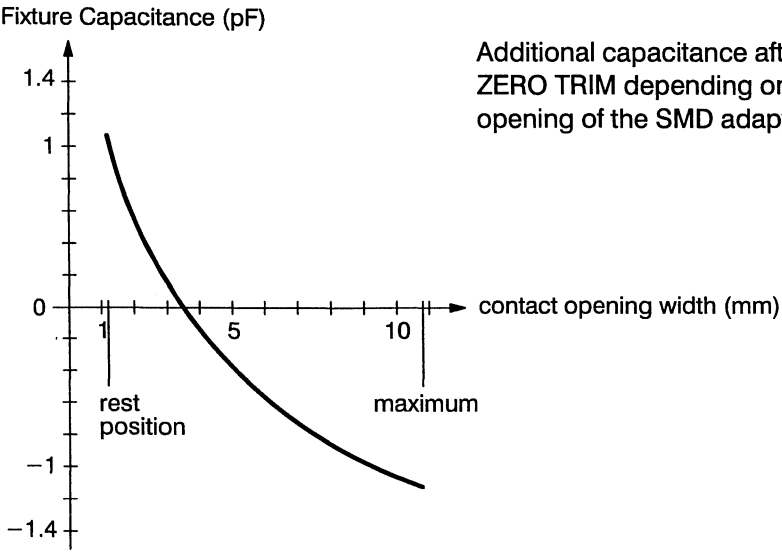
For easy and quick insertion and removal of components, insert the SMD adapter into the PM 9542A RCL Adapter.

You can also insert the SMD adapter directly into the front panel connector of the instrument. To ease insertion of components, set the instrument in a sloping position (handle folded down)



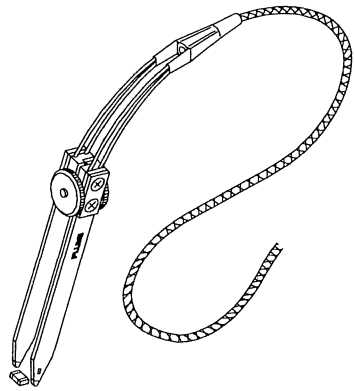


When you use the SMD adapter to measure very small capacitances especially below 100 pF, you must take into account the alteration of the stray fixture capacitances, depending on the separation of the contacts.



PM 9540/TWE SMD Tweezers

Use the SMD Tweezers to measure single SMD components or in-circuit SMD components.

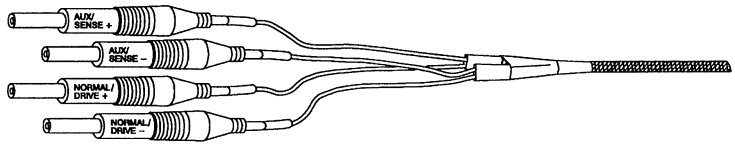


The SMD Tweezers are connected to the instrument via the round plug on the front panel (red marking face to face).

For open-circuit trimming when you are measuring small capacitances, set the opening of the tweezers to the size of the component.
The two-wire measuring technique and the pressure applied by the tips of the tweezers can cause a measuring error in addition to the basic error of the RCL Meter, due to the additional serial resistance (typical 0.02 Ω). The presence of dirt or contaminants on the tips of the tweezers can also affect measurements. The tips may be periodically cleaned with alcohol and a non-abrasive cloth.

PM 9540/BAN Test Cable with Banana Plugs

Use the test cable if you need banana plugs for your own special applications.

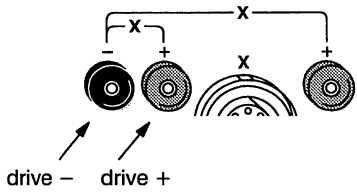


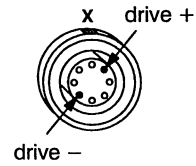
The test cable is connected to the instrument via the round plug on the front panel (red marking face to face).

When you perform ZERO TRIM short-circuit DRIVE+ with SENSE+ and DRIVE– with SENSE– for the open-circuit trimming. Short-circuit all four plugs for the short-circuit trimming.

Two-Wire Measurements

You can measure components with normal test leads in two-wire mode by using the upper two connectors. To reduce stray capacitances and interferences, use short leads. These connections are also available on the eight-pole round connector.





The technical specifications given in chapter 4 are valid for four-wire measurements, which are particularly important for low resistance components and large capacitances.

3.5.3 Automatic Zero Trim

When pressing the **ZERO TRIM** key for approximately 2 seconds the instrument performs an impedance measurement of the measurement setup and stores the value determined. The display shows PASS. For all further measurements this value will be taken into consideration. **To ensure best measuring accuracy you should perform ZERO TRIM when you change the measurement setup.**

If you press the **ZERO TRIM** key with a component connected with an impedance of <10 Ω or >100 kΩ, the value of the component will be taken into consideration. At open or short-circuited contacts of the measurement setup the instrument now indicates a negative resistance value, for instance, or an inductance in case of a connected capacitance (or a capacitor in case of a an inductance.) Please perform ZERO TRIM once again without any component connected in order to obtain correct values.

The TRIM data are stored in a memory and will persist even if the instrument is switched off.

Short-Circuit Trimming

For measuring low impedances, below 100 Ω in particular, please short-circuit the contacts of the measurement setup and press the **ZERO TRIM** key for approximately 2 seconds. The display shows **bUSY**. The instrument now performs a measurement and stores the value determined, which is the short circuit impedance. The display shows **PASS**. For all further measurements this value is taken into consideration, including the line and contact impedances.
If during short circuit trimming the measured impedance is >10 Ω, **FAIL** will be displayed.

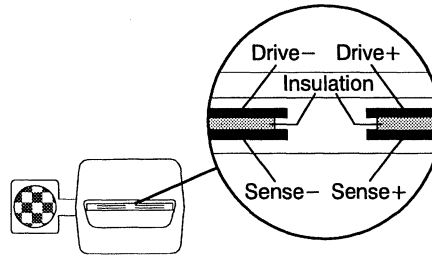
Open-Circuit Trimming

When you measure low capacitances the open-circuit impedance of the measurement setup may affect the result. Remove any connected component and press the **ZERO TRIM** key for approximately 2 seconds. The display shows **bUSY**. The instrument again performs a measurement considering the value determined, which is the open-circuit impedance, for all following measurements. The display shows **PASS**.
If the impedance measured during open-circuit trimming is <100 kΩ, the diplsay shows **FAIL**.

For the ZERO TRIM the contacts DRIVE+ and SENSE+ as well as DRIVE– and SENSE– should be connected. As far as the adapters available from Fluke are concerned, this is normally ensured automatically, except for the PM 9540/BAN cable and for the PM 9542SMD SMD Adapter.

If you use the PM 9540/BAN cable in your own special application short-circuit DRIVE+ with SENSE+ and DRIVE– with SENSE– for the open-circuit trimming. Short-circuit all four plugs for the short-circuit trimming.

As far as the SMD Adapter is concerned the contacts are insulated from each other. The contacts are only closed when a component is inserted.



Contacts of the PM 9542SMD, SMD Adapter

To perform ZERO TRIM at an open adapter with the DRIVE/SENSE contacts connected, the SMD Adapter is equipped with SMD components with an impedance of $Z \rightarrow \infty$. Please use this component for open-circuit trimming. For short-circuit trimming you can use one of the attached components with an impedance of $Z \rightarrow 0\ \Omega$. These components have a real resistance of typical 4 mΩ. You should take into account this value if you measure low impedances.

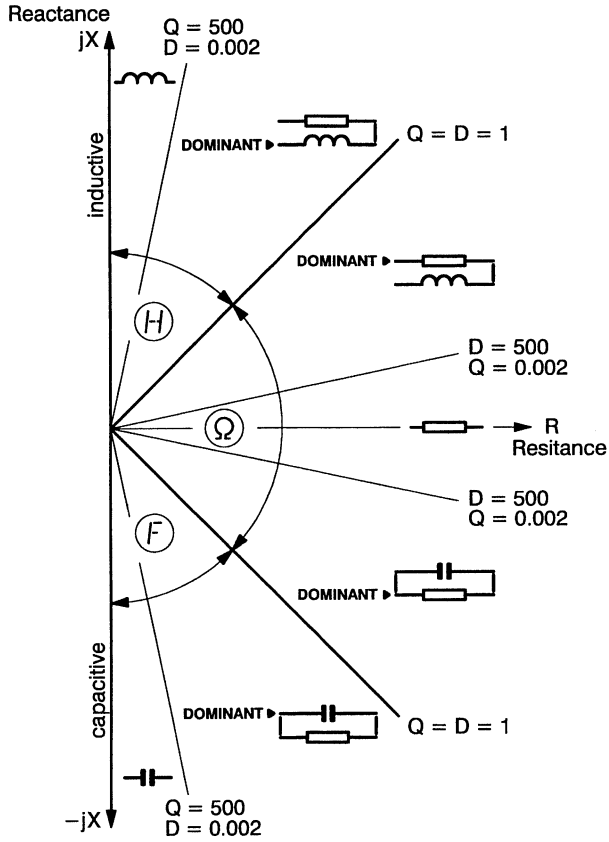
If you need spare sets you can order them via your Service Organization with the following number: 5322 310 32275.

3.5.4 Component Measurement

Choose a convenient measurement setup (see Section 3.5.2) and, if necessary, press the **ZERO TRIM** key. Insert the component.

CAUTION: To avoid demage of the instrument discharge capacitors with high residual charge (>5 V) before connecting them to the instrument.

After power on, the instrument automatically recalls measurement settings prior to the last power off. The measurement frequency is 1 kHz fixed.
In most cases you will be interested in the dominant parameter of the component under test. This is automatically detected and displayed in AUTO mode. Press the green **AUTO** key. The display shows AUTO, the value of the dominant parameter and the appropriate equivalent circuit symbol.
The decision criterion for defining the dominant parameter is Q = D = 1 (see Section 3.6). Values Q and D are related to the internal measurement frequency 1 kHz.



AUTO Mode Dicision Diagram

If you want to display any other parameter, press the appropriate key:

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 resistance)
Cp or Lp	Parallel capacitance/inductance
Cs or Ls	Series capacitance/inductance
Φ	Phase angle

Electrolytic capacitors should be measured with the internal bias voltage on. Press the **DC BIAS ON** key; the display shows DC BIAS 2V.

3.5.5 Out-of-Range and Error Messages

The center segments of the digits flash when the following limits are exceeded:

- Resistances >200 MΩ
- Capacitances >100 mF
- Inductances > 20 kH
- Quality/dissipation factor >500

The segments also flash when **DC BIAS** is switched on during measurement of resistors or inductors, indicating that direct current is being sourced to the component.

The asterisk in front of the digits indicates that the measured component is outside the 0.25 % accuracy range of the instrument.

During operation the instrument checks the trim data, the measurement range setting, the counter, and the communication to the storage register. Errors are indicated as follows:

Err3	External RAM defective
Err5	Trim data error
Err6	Error of measurement range setting
Err7	Counter overflow
Err8	Error of reference measurement

1, 2, and 4 are error messages that occur during power-on; see Section 3.3.

3.5.6 Component Measurement at Range Limits

As described in previous chapters, in AUTO mode the instrument determines and displays the dominant parameter of the component under test. The measurement frequency determines whether the reactance or the resistance is dominant. PM6303A measures at 1 kHz. You must take this into account when you measure low-resistance capacitors and inductors or high value resistors. For example, a 10 MΩ resistor may appear to be more capacitive than resistive to the instrument because the shunt capacitance across the resistor is dominant.

Lossy inductors:

When you measure small lossy inductances, the series loss resistance is often identified as the dominant parameter and is displayed, because at 1 kHz, the series reactance is very low. Therefore, for Ls or Lp display, press **Cs or Ls** or the **Cp or Lp** key.

Lossy capacitors with high capacitance, e.g. electrolytic capacitors:

Because the reactance of large capacitors is very low, the series resistance may be dominant, resulting in Q <1 and display of the parallel resistance Rp. Therefore, for capacitance display, press **Cp or Lp** or the **Cs or Ls** key.

High-resistance resistors:

When you measure resistors in the higher MΩ range, the parasitic parallel capacitance may be displayed as the dominant parameter. Press **Rp** or **Rs** to display the resistance value.

Large inductance paralled by a parasitic capacitance:

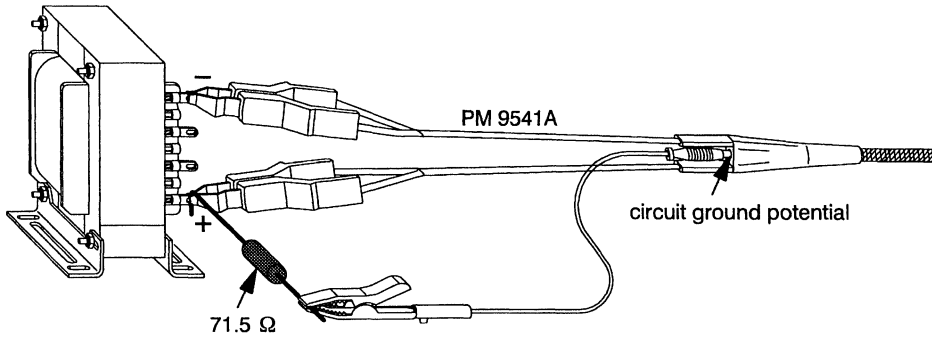
The resonant frequency of the component may be below the measurement frequency of 1 kHz. At 1 kHz the component represents a capacitance, and the display shows a parallel capacitance as the dominant parameter.

Large inductors in the kH range:

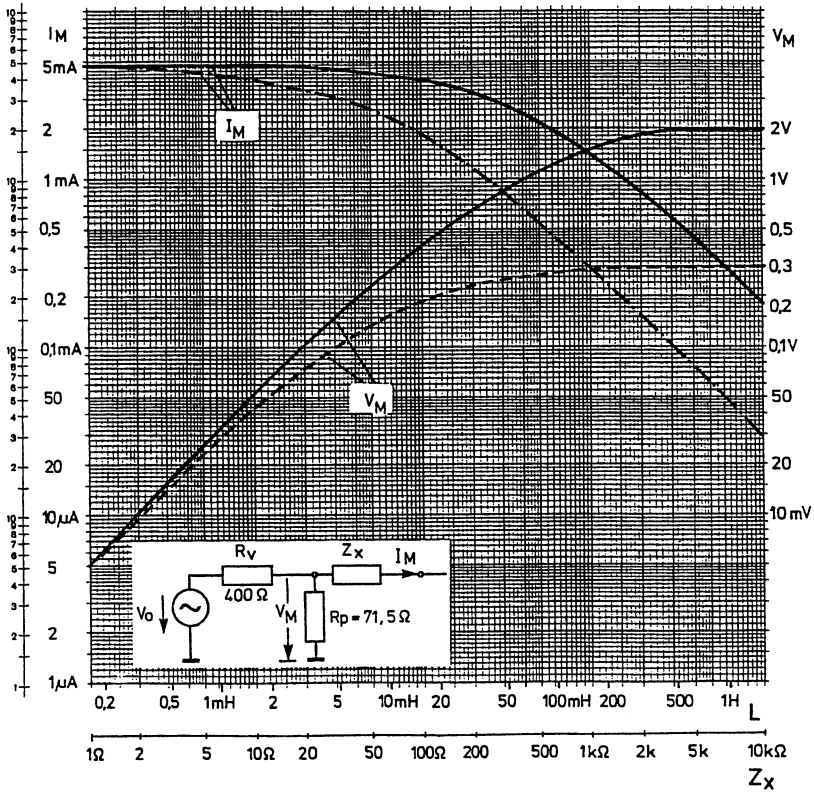
The measurement result may be influenced by relatively small parallel capacitances. Be sure to use the **ZERO TRIM** function to remove stray capacitance effects from the fixture.

Inductors with ferromagnetic cores:

When you measure inductors with ferrite cores the inductance decreases with increasing voltage and current amplitudes due to saturation effects. Smaller test signals may be required.
In the PM6303A, the open-circuit voltage is 2 Vrms with 400 Ω internal resistance. The impedance of the component determines the amplitudes. For lower amplitudes, an additional resistor ≥ 71.5 Ω may be connected between measurement output and circuit ground potential. For this the PM 9541A 4-Wire Kelvin Clip Test Cable is best suited.
Adding this resistor lowers the drive level through the voltage divider relationship as shown in the following illustrations.



For a parallel resistor of 71.5 Ω the following diagram shows the measurement voltage and current as a function of the test component impedance. The error limit in the inductance range shown increases to a maximum of 0.5 % with this load resistor.



Ignoring the impedance of the component under test you can caluculate Rp for different drive levels V_M:

$$V_M = \frac{Rp}{Rp + 400\,\Omega} \times V_O \qquad V_O = 2\,V$$

3.6 MEASUREMENT PRINCIPLE

The component measurement is based on the current and voltage technique. The component voltage and the component current are measured and converted into binary values. The CPU calculates the electrical parameters of the component from these values. Depending on the parameters that were selected on the front panel, either the dominant parameter is automatically displayed (in **AUTO** mode resistance, capacitance, or inductance) or the selected parameter is displayed.

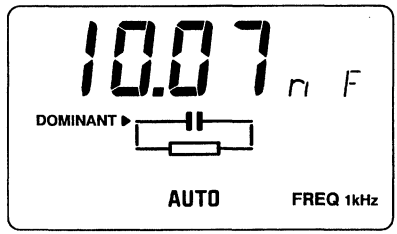
Each measurement cycle lasts approximately 0.5 seconds and consists of five single measurements, the results of which are stored and arithmetically evaluated. Finally the result is transferred to the display. The five single measurements are as follows:

1. **Reference measurement**

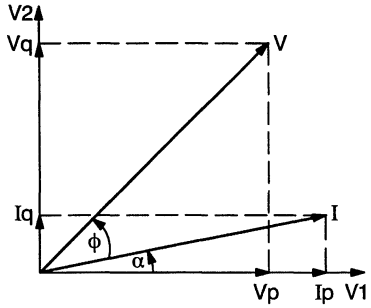
   At the beginning of each measurement cycle, a reference measurement is performed. The measured value serves as reference for the subsequent four measurements.

2. **Voltage measurement: 0°**
3. **Voltage measurement: 90°**
4. **Current measurement: 0°**
5. **Current measurement: 90°**

At the end of the single measurements, the five measured values are stored. Using the measurement values, the microprocessor calculates the equivalent series resistance Rs, the equivalent series reactance Xs, and the quality factor Q = Xs/Rs of the component. In AUTO mode, the microprocessor determines the dominant parameter, Rs, Rp, Cp, or Ls, calculates its value, and displays it together with the equivalent circuit symbol. If one of the other parameters is manually selected, this parameter is calculated and displayed. After that the next measurement cycle starts with the next five single measurements.



The following phase diagrams and formulas show the mathematic basics for internal calculation of the component value.



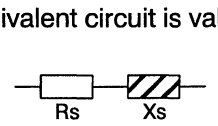
V: voltage
I: current
V1, V2: 0°-voltage, 90°-voltage

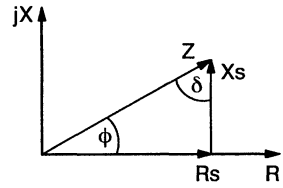
The phase angle between I and V is ϕ.
The phase angle between I and V1 is α.

In the diagram the phase relation between I and V happens to be a lossy inductance.
In each measurement cycle, the following components are determined:
Vp, Vq, Ip, Iq.
The series resistance and reactance are calculated from these components.

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

The following equivalent circuit is valid:





Quality factor: $Q = \tan\phi = 1/D = \frac{|Xs|}{Rs}$ (3)

Dissipation factor: $D = \tan\delta = 1/Q = \frac{|Rs|}{Xs}$ (4)

The magnitude of Q and the sign of Xs determine which parameter of the component is dominant.

Xs positive = inductive
Xs negative = capacitive

The formulas for the various parameters are as follows:

$Q = \frac{|Xs|}{Rs}$ see equation (3)

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

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

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

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

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

Rs see equation (1)

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

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

Impedance $Z = R + jX$
Admittance $Y = 1/Z$

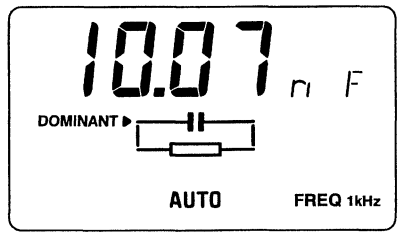
Example:
By using the five measurements, the instrument has calculated Rs and Xs in accordance with formulas 1 and 2, for example,

$Rs = 3.037\ k\Omega$
$Xs = -15.197\ k\Omega$

From this the instrument calculated:

$$Q = \frac{|Xs|}{Rs} = 5.004$$

The instrument displays the corresponding equivalent circuit symbol with the dominant parameter, according to the criteria of the Auto Mode Decision Diagram on page 3 – 16; in this case, as Xs is negative and 1 < Q < 500:



The calculation of the dominant parameter Cp was done according to the following formula:

$$Cp = \frac{1}{\omega(1 + 1/Q^2)|Xs|}$$

$$Cp = \frac{1}{2\pi \text{ x } 1 \text{ kHz } (1 + 1/5.004^2) \text{ x } 15.197 \text{ k}\Omega} = 10.068 \text{ nF}$$

The maximum display is four digits ±1 digit tolerance.

Calculation of the other selectable parameters are performed as follows:

$$D = \frac{1}{Q} = \frac{1}{5.004} = 0.199$$

$$Rp = (1 + Q^2) \text{ x } Rs = (1 + 5.004^2) \text{ x } 3.037 \text{ k}\Omega = 79.08 \text{ k}\Omega$$

Rs = 3.037 kΩ (calculated by the instrument according to formula 1)

$$Z = \sqrt{Rs^2 + Xs^2} = \sqrt{(3.037 \text{ k}\Omega)^2 + (15.197 \text{ k}\Omega)^2} = 15.497 \text{ k}\Omega$$

$$Cs = \frac{1}{\omega|Xs|} = \frac{1}{2\pi \text{ x } 1 \text{ kHz x } 15.197 \text{ k}\Omega} = 10.472 \text{ nF}$$

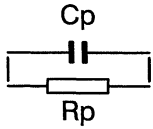
Φ : The instrument calculates

$$\tan \Phi = \frac{|Xs|}{Rs} = \frac{15.197 \text{ k}\Omega}{3.037 \text{ k}\Omega} = 5.004$$

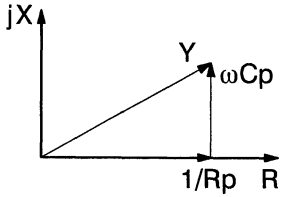
and gets Φ from an internal tangent table similar to a calculator

Φ = – 78.7 DEG

If you are interested in mathematics, the following two pages show the phasor diagrams and formulas for the various components as an appendix.

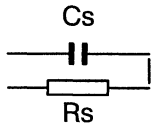


$$Y = \frac{1}{Rp} + j\omega Cp \qquad Z = \frac{Rp\,(1 - j\omega CpRp)}{1 + (\omega CpRp)^2}$$

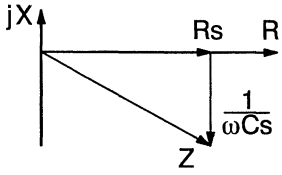


$$D = \frac{1}{\omega CpRp}$$

$$Cs = (1 + D^2) \times Cp \qquad Rs = \frac{D^2}{1 + D^2} \times Rp$$

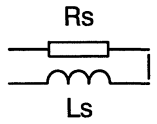


$$Z = Rs - j\frac{1}{\omega Cs}$$

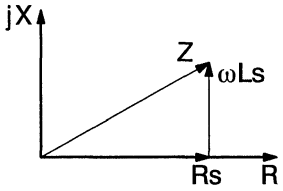


$$D = \omega CsRs$$

$$Cp = \frac{1}{1 + D^2} \times Cs \qquad Rp = \frac{1 + D^2}{D^2} \times Rs$$

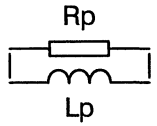


$$Z = Rs + j\omega Ls$$

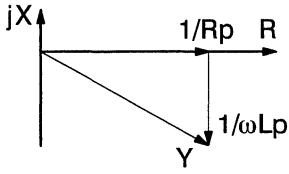


$$D = \frac{Rs}{\omega Ls}$$

$$Lp = (1 + D^2) \times Ls \qquad Rp = \frac{1 + D^2}{D^2} \times Rs$$



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



$$D = \frac{\omega Lp}{Rp}$$

$$Ls = \frac{1}{1 + D^2} \times Lp \qquad Rs = \frac{D^2}{1 + D^2} \times Rp$$

3.7 SELF DIAGNOSTICS

The test program contains the following six subprograms:

Pro 1	Display test
Pro2	Keyboard test
Pro3	Storage register test
Pro4	Test of the single measurement steps
Pro5	Test of a measurement cycle
Pro6	Test of measurement range settings

Tests 4, 5, and 6 serve as an aid to the Service Technician for trouble shooting. In-circuit measurements with an open instrument are necessary; therefore, those tests are described in the Service Manual.

Press the **AUTO** key, while turning the instrument on. After the power-on routine the letters tESt appear in the display, then the menu of subprograms Pro 1 to 6 appears. Press any key briefly to select and carry out the test required. Press a key again for about 1 second to return to the subprogram menu. To leave the test program, turn the instrument off.

Program 1: Display Test

The display test checks the liquid crystal display and the respective decoders/ drivers. When the text Pro 1 appears in the subprogram menu, press a key. All segments of the display are switched on one after the other. You can stop and release the test with any key. The instrument then waits with the total display lit up until you press any key to return to the submenu or until you leave the test program.

Program 2: Keyboard Test

This test checks the function of each key as well as those of the keyboard encoder.
Press any key when the text Pro2 appears in the submenu; the display shows bCod. If you briefly press any key in random, the current number of this key appears in the display alone with a control number, e.g., 2-3 when key **Q** is pressed. This control number is generated by the keyboard encoder and can be changed to 0, 1, 2, or 3 by pressing this key again. The keys are numbered row by row from left to right. For example, the **ZERO TRIM** key has the number 6, and the **Z** key has number 9. To return to the subprogram menu, press any key for one second.

Program 3: Memory Register Test

This test checks the memory for the storage of instrument settings and trim data (**ZERO TRIM**). The contents of this memory are not written over or deleted during the test and can be used as usual when the test has been completed.

The test runs automatically. The display shows rEG and then shows PASS at the end of the test. If the test finds an error, the display shows Err.
Press any key to return to the subprogram menu.

To leave the test program, turn the instrument off.

Chapter 4

CHARACTERISTICS

4 CHARACTERISTICS, SPECIFICATIONS

4.1 SAFETY AND EMC REQUIREMENTS

The PM6303A Automatic RCL Meter is

in accordance with EN 61010–1 (safety requirements),
an instrument for measurement and test including accessories
- intended for professional, industrial process, and educational use.
- Overvoltage Category II, Pollution Degree .

in accordance with EN 55011 (radio interference suppression),
an ISM equipment (industrial, scientific, and medical RF-equipment)
- of Group I,
  which intentionally generates and/or uses conductively coupled radio frequency energy which is necessary for the internal functioning of the equipment itself.
- of Class B,
  suitable for use in domestic establishments and in establishments directly connected to a low voltage power supply network which supplies buildings used for domestic purposes.

in accordance with EN 50082-1 (radio frequency immunity)
an instrument for use in all locations which
- are characterized by being supplied directly at low voltage from the public mains.
- are considered to be residential, commercial or light-industrial, both indoor and outdoor.

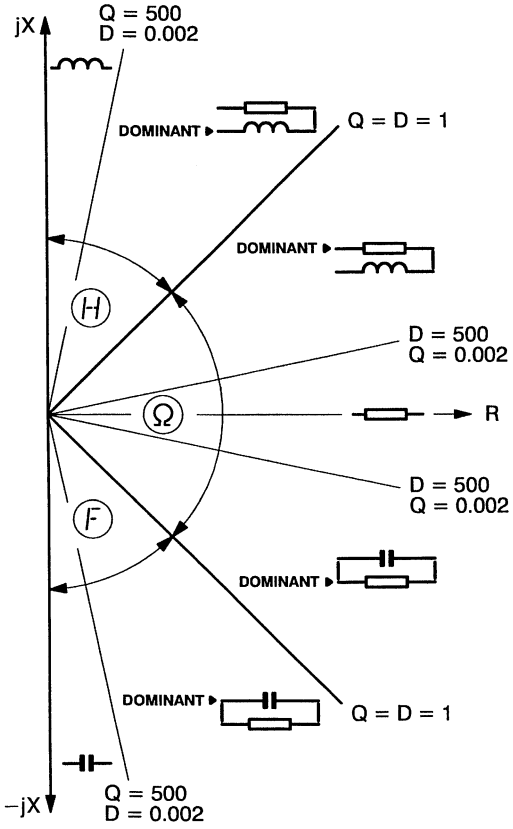
4.2 PERFORMANCE SPECIFICATIONS

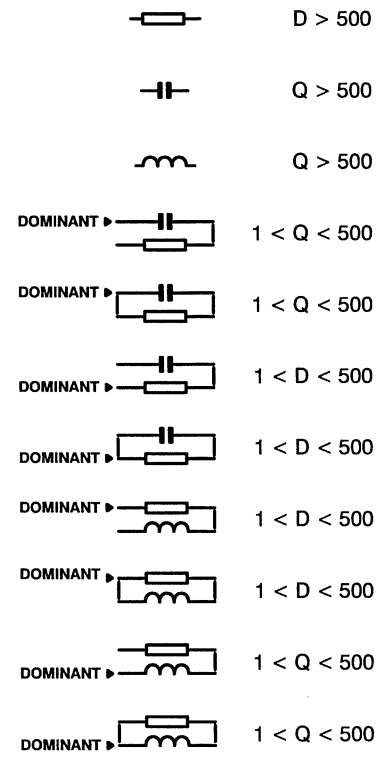
Properties expressed in numerical values with stated tolerance are guaranteed by the manufacturer. Specified non-tolerance numerical values indicate those that could be nominally expected from the mean of a range of identical instruments. This specification is valid after the instrument has warmed up for 5 minutes. For reference conditions, see Sections 4.3 and 4.4.

PARAMETERS 9 pushbuttons for the parameters	AUTO Q Quality factor D Dissipation factor Rp Rs Z Cp or Lp Cs or Ls Φ Phase angle	For AUTO the dominant parameter R, C, or L is automatically determined.
DC BIAS SOURCE 2 pushbuttons	2 V ON and OFF	Internal bias voltage for galvanic non-conducting components, e.g., electrolytic capacitors.
Meas. voltage (rms) Max. measurement current (rms)	2 V ±0.2 V 5 mA ±0.5 mA	Voltage source with 2 V open-circuit voltage and 400 Ω internal resistance.
Meas. frequency	1 kHz ±0.025 %	Fixed
Meas. update rate	2 measurements per second.	

Display	LCD: liquid-crystal backlit display
Measurement value	Maximum 4 digits
Units	Ω, kΩ, MΩ, pF, nF, µF, mF µH, mH, H, kH DEG

11 equivalent circuit symbols.





Equivalent circuit symbol and dominant parameter in the sectors of the phasor plane (AUTO mode).

Measurement ranges

0.000 Ω	to 200 MΩ	R, Z	}	Overrange indicated by flashing of the center segments of the four digits
0.0 pF	to 100 mF	C		
0.0 µH	to 32 kH	L		
0.002	to 500	Q, D		
−90.0	to +90.0 DEG	Φ		

ZERO TRIM key

- For open adapter compensation of the open-circuit impedance if this is >100 kΩ.
- For short-circuit adapter compensation of short-circuit impedance if this is <10 Ω.

Component connection

4-wire connection by Kelvin clips via:

- Test posts, inserted into the front panel banana sockets.
- PM 9541A, 4-WIRE TEST CABLE
- PM 9542A, RCL ADAPTER
- PM 9542SMD, SMD ADAPTER

PM 9540/BAN, 4-WIRE TEST CABLE with banana plugs.

2-wire connection by PM 9540/TWE, SMD TWEEZERS.

Front panel connector

Six 2 mm connector
8-pole round connector

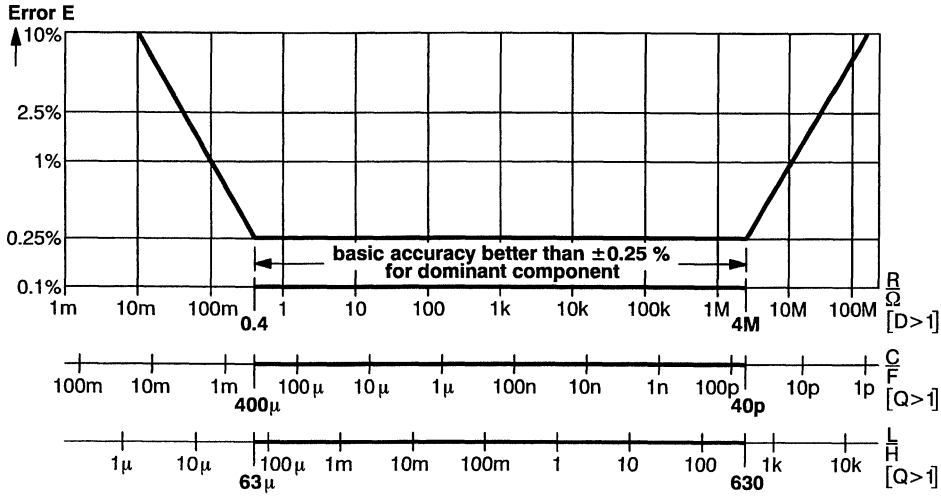
Max. ext. DC voltage ±5 V Between each connector.

Meas. accuracy Data are valid for 4-wire component connection and after ZERO TRIM as described.

Limit for basic accuracy for dominant R, C, L, and for Z.	±0.25 % ±1 digit	R: 0.4 Ω to 4 MΩ C: 40 pF to 400 µF L: 63 µH to 630 H Z: 0.4 Ω to 4 MΩ	D ≥ 1 Q ≥ 1 Q ≥ 1

The asterisk ⋆ on display lights if component exceeds measurement range for basic accuracy. For example, a 10 pF capacitor can be measured with <1.5 % accuracy.

Accuracy limits for domin. R, C, L and for Z in total meas. range: error E ±1 digit



Accuracy limits for secondary R, C, L, and for Z	E x Q ±1 digit E x D ±1 digit E ±1 digit	For R, Q ≥ 1 For C and L, D > 1 For Z
Accuracy limits For Q ≥ 1 D > 1 Φ	E x (1 + Q) ±1 digit E x (1 + D) ±1 digit 1.2 x E ±1 digit	
	E = Error	See figure above.

4.3 POWER SUPPLY

AC power

▪ Nominal voltage rms	100 V, 120 V, 220 V, or 240 V selectable at power input connector.
▪ Reference voltage	220 V ±2 %
▪ Operating limits	nominal voltage ±10 %
▪ Nominal frequency range – Operating limit	50 Hz to 100 Hz 47.5 to 105 Hz
▪ Power consumption	16 VA
▪ Power cable versions	Alternatively supplied for – Universal Europe – North America – England (U.K.) – Switzerland – Australia

4.4 ENVIRONMENTAL CONDITIONS

Ambient temperature:

▪ Reference value	+23 °C ±1 K
▪ Nominal working range	+ 0 °C to +50 °C
▪ Storage and transport range	−40 °C to +70 °C

Relative humidity:

▪ Reference range	45 % to 75 %
▪ Nominal working range	20 % to 80 %
▪ Limit range of use	10 % to 90 %
▪ Range for storage and transport	0 % to 90 %

Air pressure	
▪ Reference value	1013 hPa
▪ Nominal working range	800 to 1060 hPa
Air speed	
▪ Reference range	0 to 0.2 m/s
▪ Nominal working range	0 to 0.5 m/s
Heat radiation	Direct sunlight radiation not allowed.
Vibration	
▪ Limits for storage and transport	Max. amplitude 0.35 mm, max. accelaration 5 g (10 to 150 Hz)
Functional shock	MIL-T-28800D
▪ Acceleration	20 g
Operating position	Normally upright on feet or with tilt bale extended
Warm-up time	5 minutes

4.5 SAFETY & QUALITY DATA; CABINET

Safety	According to Low Voltage Directive 73/23/EEC, EN 61010–1 CAT II Poll. Degree 2 CSA 22.2 no. 231.
Protection type	IP 20 (IEC 529)
EMC	According to Electromagnetic Compatibility Directive 89/336/EEC. Emission according to EN 55 011, Group 1, Class B. Immunity according to EN 50 082-1, inclusive EN 61000–4–2, –3 and –4.
Call rate	< 0.05 units per year
MTBF (calculated)	35,000 hours
Cabinet dimensions	▪ Width 315 mm (12.4") ▪ Height 105 mm (4.13") ▪ Depth 405 mm (15.9") ▪ Weight 3.8 kg (8.4 lb)

4.6 ACCESSORIES

STANDARD ACCESSORIES

- Power cable
- Fuses
- Test post red 5322 264 30351
- Test post black 5322 264 30352
- Users Manual 4822 872 10158

OPTIONAL ACCESSORIES

- PM 9540/BAN, 4-WIRE TEST CABLE with banana plugs
- PM 9540/TWE, SMD TWEEZERS
- PM 9541A, 4-WIRE TEST CABLE
- PM 9542A, RCL ADAPTER with 2 single test posts and 1 double test post
- PM 9542SMD, SMD ADAPTER
- PM 9563, RACK MOUNT KIT (3E high)
- PM 9564, RACK MOUNT KIT (2E high)
- Service Manual 4822 872 15161
- Test Set 5322 310 10634

Chapter 5

PERFORMANCE TEST

5 PERFORMANCE TEST

5.1 INTRODUCTION

This chapter describes the performance test for the key parameters of the PM6303A RCL Meter using the instrument specifications in Chapter 4 as the performance standard.
These performance tests may be used as an acceptance test upon receipt of the instrument, as an indication that repair and/or adjustment is required, or as a performance verification after repair or adjustment of the instrument.
The PM6303A must be warmed up with all covers in place for at least 5 minutes before starting the tests. The reference conditions, described in Sections 4.3 and 4.4, must be met.

5.2 RECOMMENDED TEST EQUIPMENT

AC rms Voltmeter FLUKE 8920A
DC Voltmeter Philips PM 2535
Counter PHILIPS PM 6665
For the voltmeter and counter, no critical specification is required.

2 Single Test Posts PM6303A standard accessory

Test Set of **precision metal film resistors and capacitor**, code no. 5322 264 30353.

Quantity	Component Value	Max. Tolerance for Test
1	R 1 Ω (see label)	±0.05 % (of labeled value)
1	R 34.8 Ω	±0.05 %
1	R 3.48 kΩ	±0.05 %
1	R 34.8 kΩ	±0.05 %
1	R 348 kΩ	±0.05 %
1	R 3 MΩ	±0.05 %
1	R 100 MΩ	±1 %
1	C 10 nF (see label)	±0.05 % (of labeled value)

If you use your own test components, the values of which are exactly known, the test result must be calculated accordingly (instrument tolerance is ±0.25 %, or ±5 % for 100 MΩ, each ±1 digit).

5.3 SELF-TEST ROUTINE, ERROR MESSAGES

After power on, the instrument checks the PROM, the processor RAM, and the external RAM. After that, it displays the current software version (Vx.x) and automatically recalls its settings before power off. The instrument also generates error messages if there are faults during measurements or trimming.

A possible fault is indicated as follows:

Err2 The digits mean: 1 = PROM checksum error
2 = Error in processor RAM
3 = External RAM defective
4 = Error in backup memory

During normal operation the instrument checks the trim data, the measurement range setting, the counter, and the communication to the storage register. **Error Messages** indicate the following:

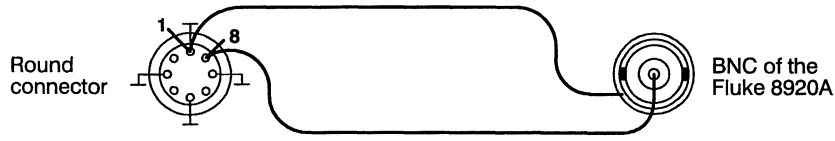
5 = Trim data error
6 = Error of measurement range setting
7 = Counter overflow
8 = Error of reference measurement

5.4 PERFORMANCE VERIFICATION

5.4.1 Measurement Voltage

No component connected to PM6303A.
Test equipment: AC rms Voltmeter, DC Voltmeter

- Set PM6303A to AUTO and to DC BIAS OFF.
- Connect the AC rms voltmeter with tips to pin 8 (HIGH terminal) and pin 1 (circuit ground) of the round connector.
  Pin 1 must be connected to the outer part (ground) of the BNC connector of the voltmeter.



Test result: 1.8 to 2.2 V rms

- Connect the DC voltmeter to pin 8 and pin 1.
- Set PM6303A to DC BIAS ON.

Test result: 1.8 to 2.2 V dc

5.4.2 Measurement Frequency

Test equipment: Counter

- Press the **DC BIAS OFF** key.
- Set counter to 1 s gate time.
- Connect counter with tips between pin 8 and 1 of the round connector.

Test result: 999.75 to 1000.25 Hz

5.4.3 Open-Circuit Trimming

- Insert the two single test posts into the **two left** positions (logos face to face).
- Press the **Cp or Lp** key.
- Press the **ZERO TRIM** key.

Test result:

The display shows ***BUSY*** ***PASS*** and finally ***0.0 pF***

- Press the **Rp** key.

Test result:

The display shows overrange – – – – (flashing)

5.4.4 Short-Circuit Trimming

- Short circuit the test posts by a clean wire, with a minimum diameter of 1 mm.
- Press the **Rs** key.
- Press the **ZERO TRIM** key.

Test result:

The display shows ***BUSY*** ***PASS*** and finally ***0.000 Ω***

5.4.5 Resistor Measurement

- Set the PM6303A to AUTO.

For test 1, the 1 Ω resistor must completely be inserted into the test posts.

The **test result** is calculated in accordance with the instrument tolerance (±0.25 % or ±5 % for 100 MΩ) and the resolution of the display, **±1 digit** in general.

Test	Component Value	Instrument Accuracy	Test Result
1	R 1 Ω (see label)	±0.25 %	Value on label ±0.25 % ±1 digit
2	R 34.8 Ω	±0.25 %	34.70 to 34.90 Ω
3	R 3.48 kΩ	±0.25 %	3.470 to 3.490 kΩ
4	R 34.8 kΩ	±0.25 %	34.70 to 34.90 kΩ
5	R 348 kΩ	±0.25 %	347.0 to 349.0 kΩ
6	R 3 MΩ	±0.25 %	2.992 to 3.009 MΩ
7	R 100 MΩ	±5%	94.9 to 105.1 MΩ

5.4.6 Capacitance/Inductance Measurement

After the measurement accuracy is checked by precision resistors, it is necessary to test the capacitance/inductance measurement function by only one capacitor measurement or by one dissipation factor measurement with one of the resistors:

Test	Component Value	Instrument Accuracy	Test Result
8	10 nF; exact value see label	±0.25 %	Value on label ±0.25 % ±1 digit
or			
9	3.48 kΩ	not applicable	– – – – flashing display indicates overrange, i.e., dissipation factor >500

If you cannot meet the test result for test 8 it might be that the test capacitor has drifted from its labeled original value. Please check whether the capacitor should be measured again.
The measurement uncertainty must be <0.02 %.
You can also order a new capacitor; code number 5322 126 13738.
The original measurement date is indicated on the bag for the capacitor.
The capacitance drift is specified to <0.2 % in 3 years.
According to our experience the drift is much lower: <0.04 % in 3 years.
There are no capacitors with lower drift at the low price of this capacitor on the market.
If you have access to a low-drift standard capacitor in your calibration laboratory or elsewhere, please make use of.

Chapter 6

LIMITED WARRANTY & LIMITATION OF LIABILITY

DECLARATION OF CONFORMITY

6 LIMITED WARRANTY & LIMITATION OF LIABILITY

Each Fluke product is warranted to be free from defects in material and workmanship under normal use and service. The warranty period is one year and begins on the date of shipment. Parts, product repairs and services are warranted for 90 days. This warranty extends only to the original buyer or end-user customer of a Fluke authorized reseller, and does not apply to fuses, disposable batteries or to any product which, in Fluke's opinion, has been misused, altered, neglected or damaged by accident or abnormal conditions of operation or handling. Fluke warrants that software will operate substantially in accordance with its functional specifications for 90 days and that it has been properly recorded on non-defective media. Fluke does not warrant that software will be error free or operate without interruption.

Fluke authorized resellers shall extend this warranty on new and unused products to end-user customers only but have no authority to extend a greater or different warranty on behalf of Fluke. Warranty support is available if product is purchased through a Fluke authorized sales outlet or Buyer has paid the applicable international price. Fluke reserves the right to invoice Buyer for importation costs of repair/replacement parts when product purchased in one country is submitted for repair in another country.

Fluke's warranty obligation is limited, at Fluke's opinion, to refund of the purchase price, free of charge repair, or replacement of a defective product which is returned to an Fluke authorized service center within the warranty period.

To obtain warranty service, contact your nearest Fluke authorized service center or send the product, with a description of the difficulty, postage and insurance prepaid (FOB Destination), to the nearest Fluke authorized service center. Fluke assumes no risk for damage in transit. Following warranty repair, the product will be returned to Buyer, transportation prepaid (FOB Destination). If Fluke determines that the failure was caused by misuse, alteration, accident or abnormal condition of operation or handling, Fluke will provide an estimate of repair costs and obtain authorization before commencing the work. Following repair, the product will be returned to the Buyer transportation prepaid and the Buyer will be billed for the repair and return transportation charges (FOB Shipping Point).

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Fluke Corporation
P.O. Box 9090
Everett, WA
98206-9090
USA

Fluke Industrial B.V.
P.O. Box 680
7600 AR
Almelo
The Netherlands

FLUKE.

DECLARATION OF CONFORMITY
for

FLUKE
Automatic RCL Meter
PM 6303A

Manufacturer
Fluke Industrial B.V.
Lelyweg 1
7602 EA Almelo
The Netherlands

Statement of Conformity
Based on test results using appropriate standards, the product is in conformity with
Electromagnetic Compatibility Directive 89/336/EEC
Low Voltage Directive 73/23/EEC

Sample tests
Standards used:

EN 50081-1 (1992)
Electromagnetic Compatibility Generic Emission Standard:
EN 55011 Group I Class B

EN 50082-1 (1992)
Electromagnetic Compatibility Generic Immunity Standard:
EN 61000-4-2, -3 and -4

EN 61010-1 CAT II Pollution Degree 2
Safety Requirements for Electrical Equipment for Measurement
Control, and Laboratory Use.

The tests have been performed in a typical configuration.

This Conformity is indicated by the symbol CE, i.e. “Conformité européenne”.