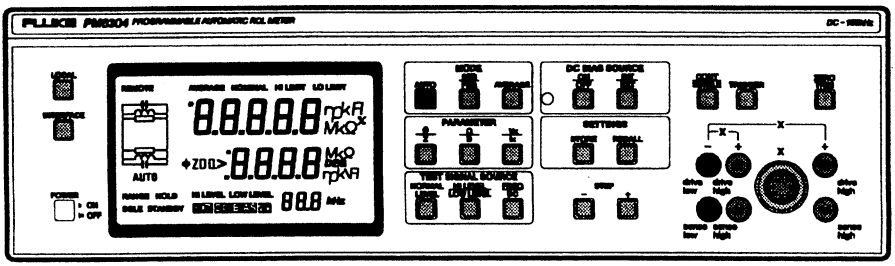
Programmable Automatic RCL Meter

PM6304

Reference Manual

4822 872 10166
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.

GENERAL

The **PM6304 Programmable Automatic RCL Meter** belongs to the 0.1%-basic-accuracy class. The **PM6304C Programmable Automatic RCL Meter** has a higher accuracy of 0.05 % at test signal frequencies up to 2 kHz. Due to automatic ranging and display functions, the instruments feature fast measurement and diagnosis of two-pole electronic devices, e.g. passive two-pole components. The CUT (Component Under Test) is connected to the instrument in 4-wire technique by Kelvin contacts. Measurements are performed at one of 204 selectable test frequencies in the 50 Hz to 100 kHz range, using one of three selectable test voltages.

In the 'AUTO' mode, the large-area backlit LCD simultaneously shows the values of the dominant and the secondary parameter of the CUT, for example, the inductance and the series resistance of a lossy coil. A scheme of the equivalent circuit gives information at a glance about the main parameters of the CUT. Additionally the test frequency and status indications of the instrument, for example, 'SINGLE STANDBY' for the triggered SINGLE MODE, are displayed.

In the 'SECONDARY PARAMETER SELECTED' mode the non-dominant secondary parameter, for example the quality figure Q or the impedance Z, is selected by special parameter keys.

Installed options add extra test capabilities to the basic instrument:

- Equipped with the optional PM 9565 DC Unit, the instrument can perform dc resistance measurements.
- Via the optional PM 9548 IEEE-488 Interface or the PM 9549 RS-232 Interface, the instrument can be completely controlled for all settings and interrogated for these and all measuring data. Additionally, through the RS-232 Interface the measuring results sequentially can be sent directly to a printer for creating a test protocol.
- The PM 9559 Bin Programmer, a hand-held IR controller, and the PM 9566 Handler Interface are provided for the binning mode of the instrument.

- The 4-wire connection of the CUT is achieved by test posts on the front side of the instrument, by the optional PM 9541A 4-wire test cable, or by the PM 9542A RCL Adapter.

- For surface-mounted components the PM 9542SMD, SMD Adapter or the PM9540/TWE, SMD Tweezers can be used.

- The PM 2272 Inspector, a versatile PC software package, provides a comfortable user interface for statistical analysis and additional processing of cumulated instrument measuring data. Inspector also allows all instrument functions to be remote-controlled from the PC. Test results can be stored on disk, printed out in report form, or exported to spreadsheet programs.

CONTENTS

Chapter 1

CHARACTERISTICS

1 CHARACTERISTICS

1.1 SAFETY AND EMC REQUIREMENTS

The PM6304 Programmable Automatic RCL Meter 100 kHz is

in accordance with EN 61010–1 (safety requirements),
an electrical instrument for measurement and test including accessories
- intended for indoor use.
- Overvoltage Category II, Pollution Degree 2

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.

1.2 PERFORMANCE SPECIFICATION

Properties expressed in numerical values with stated tolerance are guaranteed by the manufacturer. Specified non-tolerance 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 and for reference conditions; see Section 1.4.

CUT PARAMETERS (CUT = Component Under Test)	R Resistance C Capacitance L Inductance Q Quality factor D Dissipation factor Z Impedance Φ Phase angle V CUT voltage I CUT current	Total ranges for specified accuracy, see Pages 1 – 6 and 1 – 7; for AUTO mode the dominant and the secondary parameter R, C, or L automatically are displayed; other secondary parameters are selectable by corresponding parameter keys.
CIRCUIT MODES	Series or parallel selectable	
TEST FREQUENCY	DC, 50 Hz, 60 Hz, 100 Hz, 120 Hz, 200 Hz to 20 kHz in 100 Hz steps, 100 kHz; selectable	DC only for instruments equipped with a DC Unit
	200 Hz to 20 kHz in 200 Hz steps; 100 kHz	For FAST MODE
▪ **Error limits**	±0.01 % 0.023 % ±0.01 %	Exclusive for 10.9 kHz For 10.9 kHz

AC TEST VOLTAGE rms	1 V via 100 Ω 2 V via 400 Ω 50 mV via 100 Ω	NORMAL LEVEL HI LEVEL LOW LEVEL, selectable by level keys
DC TEST VOLTAGE	1 V via 100 Ω 2 V via 400 Ω 0.3 V via 100 Ω	NORMAL LEVEL HI LEVEL LOW LEVEL selectable by level keys
▪ **Error limits**		
of source voltage	± 2 % for AC ±10 % for AC ± 4 % for DC	f ≤ 20 kHz f = 100 kHz
of int. resistance	± 1 %	
DC BIAS INTERNAL		For capacitors
▪ Voltage	2 V ±5 %	
▪ Charge time typ.	14 ms x (0.6 + 0.01 x C/mF)	For exceeding 1.6 V, or for falling below 0.4 V.
	≤60 ms 2.3 x 10^{-4} s x C/µF	For C ≤270 µF For C >270 µF For exceeding 95 % of final voltage.
DC BIAS EXTERNAL	0 to 40 V	Via 2 kΩ int. resistor
DISPLAY	Backlit LCD, simultaneous display of ▪ Dominant parameter ▪ Secondary parameter ▪ Equivalent circuit diagram ▪ Test frequency ▪ HI or LOW LEVEL, if selected ▪ Status indications, e.g., SGLE STANDBY	

OPERATIONAL MODES

RCL AUTO	Automatic measurement and display of the dominant and the secondary CUT parameter.
SECONDARY PARAMETER SELECTED	Automatic measurement and display of the dominant and the preselected secondary CUT parameter.
SERIES/PARALLEL	Selectable display of the series or parallel equivalent circuit and the corresponding CUT parameters.
BINNING	Measurement and display of the selected parameter and the programmed corresponding bin number in the presentation bin x with x = 0, 1, 2, ..., or 9.
AVERAGE ON	Exponential averaging of the displayed measuring values in CONT mode with increased time constant.
CONTinuous mode	Repetitive measurements and display updates.
SINGLE mode	One measurement and display update after triggering.
RANGE HOLD	Fixed measuring range and resolution via IEEE-488 or RS-232 Interface in SINGLE mode.
FAST mode	SINGLE mode with short measuring period for high data rates via IEEE-488 or RS-232 interface.
Restrictions	▪ Test frequencies DC, 200 Hz to 20 kHz in 200 Hz steps, 100 kHz. ▪ No measuring result display. ▪ Error limits are 10 times larger than those, specified for the other operational modes.

DISPLAY UPDATE RATE Typical about 2 per second

MEASURING PERIOD

- Typical display update period for CONT mode after 1st display
  for AC [1 + 10/(f/Hz)] x 0.42 s
  for DC 460 ms
- Typical display update period for RANGE HOLD in SINGLE mode Same as above

- Additional time for SINGLE mode (without RANGE HOLD) or 1st CONT mode display: 290 ms for Z ≥ 9.5 kΩ and f ≤ 300 Hz; 70 ms else
- Additional time for 60 Hz mains and for test frequencies 60 Hz and 120 Hz: 70 ms
- Measuring period for FAST mode: 85 ms + 10 ms/(f/kHz)
- Typical additional time for communication via IEEE-488 bus: 25 ms for FAST mode — Including trigger, status interrogation, data transfer, array-element storage.
  120 ms for normal SINGLE mode — Additionally including clear status, parameter query, monitor display.

ZERO TRIM FUNCTION

Automatically performed after ZERO TRIM key actuation for compensation of

- The open-circuit adapter impedance, if it is >100 kΩ.
- The short-circuit adapter impedance, if it is <10 Ω.

COMPONENT CONNECTION

4-wire connection by Kelvin clips via

- Test posts, inserted into the frontpanel 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.

MAX. CONSTANT EXT. DC VOLTAGE/CURRENT

between terminals

- HI and LO 100 V/50 mA
- HI and ground 50 V/50 mA
- LOW and ground 0.5 V/500 mA

MAX. CHARGED CAPACITOR DC VOLTAGE

See Appendix, Figure 1

- For C <2 µF 500 V
- For 2 µF ≤C ≤2 mF 117 x $(C/mF)^{-0.234}$ V
- For C >2 mF 100 V

MEASURING ACCURACY

BASIC ERROR LIMITS ±0.1 % ±1 digit generally,
±0.5 % ±1 digit for AC/LOW LEVEL,
10-times larger for FAST mode
i.e., ±1 % ±1 digit generally,
±5 % ±1 digit for AC/LOW LEVEL

PM6304C has an higher accuracy of ±0.05 % ±1 digit in the frequency range 50 Hz to 2 kHz at NORMAL LEVEL; see Figure 2. Component connection not via PM 9541A 4-wire test cable or PM 9540/TWE, SMD Tweezers.
AVERAGE on in CONTinouos mode or mean value from 5 measurements in SINGLE mode.

PM6304 and PM6304C:
Hum interference may degrade measurement accuracy in FAST mode.

CONDITIONS FOR BASIC ERROR LIMITS

- Test frequency 50 Hz to 20 kHz
  For 60 Hz and 120 Hz at 50 Hz AC mains and 50 Hz at 60 Hz AC mains hum interference may degrade measurement accuracy.

- Impedance range See Appendix,
  Figures 2, 3, 4, and 5; e.g.,
  1 Ω to 2 MΩ, 2 Ω to 4 MΩ,
  3 Ω to 700 kΩ in the 300 Hz to 10 kHz range for NORMAL, HIGH, or LOW LEVEL.

- C range — According to impedance range, max. resolution 0.01 pF.
- L range — According to impedance range, max. resolution 0.01 µH.
- R_{DC} range — 4 Ω to 500 kΩ, NORMAL LEVEL
8 Ω to 1 MΩ, HIGH LEVEL
13 Ω to 150 kΩ, LOW LEVEL,
see Appendix, Figure 5,
max. resolution 5 digits, 0.1 mΩ.
- Used test fixture — See COMPONENT CONNECTION, 4-wire technique, page 1–5. PM 9541A 4-wire test cable for AC measurements at the high ohmic and low-ohmic ends only, if trimming is carefully performed with unchanged cable/Kelvin clips configuration.
- ZERO TRIM function — Executed with actually used test fixture at actual test frequency.
- D for R_{AC} measurement, Q for C measurement or L measurement — ≥ 1
- Ambient temperature — 0 to 50 °C
- Calibration — Performed within the calibration period.

GENERAL ACCURACY SPECIFICATION

RELATED TOTAL PARAMETER RANGES

- For R_{AC} and Z — 0.0000 Ω to 200 MΩ
- For R_{DC} — 0.0000 Ω to 50 MΩ
- For C — 0.00 pF to $(2\pi f \times 0.1\ m\Omega)^{-1}$, e.g., 0 pF to 31.8 F at f = 50 Hz
- For L — 0.00 µH to 200 MΩ/(2 πf), e.g., 0 µH to 637 kH at f = 50 Hz
- For Q and D — 0.000 to 1000, or 0.000 to 200 for AC/LOW LEVEL
- For Φ — −90.0 deg to 0 to 90.0 deg
- For V — 0.1 µV to 2.00 V
- For I — 0.005 µA to 10.0 mA

ERROR LIMITS

▪ For dominant R, C, L, or for Z	See Appendix, Figures 2, 3, 4 plus ±1 digit; in the following this error, derived from the figures, is referred as E.	
▪ For R_{DC}	See Appendix, Figure 5 plus ±1 digit	
▪ For secondary R (Q >1)	±E x Q ±1 digit	
▪ For secondary C or L (D > 1)	±E x D ±1 digit	
▪ For Q ≥1	±E x (1 + Q) ±1 digit	E = C or L error limit
▪ For D ≥1	±E x (1 + D) ±1 digit	E = R error limit
▪ For Φ	±1.2 E ±1 digit	E = dominant parameter error
▪ for V_{AC} 300 Hz to 20 kHz	± 3 % ±1 digit ±E	E = Z error, E = 0 for Z >10 kΩ
50 to 200 Hz, and 100 kHz	±15 % ±1 digit ±E	E = Z error, E = 0 for Z >10 kΩ
▪ For V_{DC}	± 5 % ±1 digit ±E	E = Z error, E = 0 for Z >10 kΩ
▪ For I_{AC} 300 Hz to 20 kHz	± 3 % ±1 digit ±E	E = Z error, E = 0 for Z <10 Ω
50 to 200 Hz, and 100 kHz	±15 % ±1 digit ±E	E = Z error, E = 0 for Z <10 Ω
▪ For I_{DC}	± 5 % ±1 digit ±E	E = Z error, E = 0 for Z <10 Ω
▪ For FAST mode	10-times larger than specified under the same conditions for normal speed.	

CONDITIONS FOR GENERAL ACCURACY SPECIFITION	In regard of the test fixture, ZERO TRIM function, ambient temperature, and the calibration the same as for the basic error limits.	
CALIBRATION PERIOD	1 year	
BINNING		
Total number of programmable bins	10, bin 0 to bin 9	Bin 0 used for an additional sorting condition.
Bin limits data entry	Absolute or relative	
Sorting method	Sequential or nested limits	
STORAGE REGISTERS	10 for complete instrument settings exclusive bin sets; register 0 is used for the actual settings and is automatically updated; all storage registers are nonvolatile. 10 for maximum 10 bin sets; in register 0 the actually programmed bin set is saved, when switching over to binning or normal mode; all storage registers are nonvolatile.	

1.3 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 %
▪ Voltage range and operating limits	±10 % of nominal value
▪ Nominal frequency range	50 to 60 Hz

- Frequency operating limit range 47.5 to 63 Hz
- Power consumption 31 VA
- Power cable versions Alternatively supplied for
  - Universal Europe
  - North America
  - England (U.K.)
  - Switzerland
  - Australia

1.4 ENVIRONMENTAL CONDITIONS

Ambient temperature

- Reference range 0 °C to 50 °C (PM6304C: 23 °C ±5 K)
- Nominal operating range 0 °C to 50 °C
- storage and transport range −40 °C to 70 °C

Relative humidity

- Reference range 45 % to 75 %
- Nominal operating range 20 % to 80 %
- Limit range for use 10 % to 90 %
- Storage and transport range 0 % to 90 %

Air pressure	
▪ Reference value	1013 hPa
▪ Nominal operating range	800 to 1060 hPa
Air speed	
▪ Reference range	0 to 0.2 m/s
▪ Nominal operating 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. acceleration 5 g (10 to 150 Hz)
Functional shock	MIL-T-28800D
▪ Acceleration	20 g
Operating position	Normally upright or flat with bow fold down
Warm-up time	5 minutes

1.5 SAFETY & QUALITY DATA, CABINET

Safety	According to Low Voltage Directive 73/23/EEC, EN 61010–1 CAT II Pollution 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	<0.2 units per year
MTBF (calculated)	20,000 hours
Cabinet dimensions	▪ Width 315 mm (12.4") ▪ Height 105 mm (4.13") ▪ Depth 405 mm (15.9") ▪ Weight 4.7 kg (10.4 lb)

1.6 OPTIONS, ACCESSORIES

OPTIONS

PM 9548 IEEE-488 INTERFACE

Interface functions	AH1, SH1, L4, T6, RL1, SR1, C0, DC1, DT1, PP0, E2
Galvanical isolation	Opto-electronically
Instrument command set	See Users Manual or Programmers Manual.

PM 9549 RS-232 INTERFACE

Galvanical isolation	Opto-electronically
Instrument command set	Same as for PM 9548, see Users Manual or Programmers Manual.
Pre-setting parameters	
▪ Operating mode	Communication or printer mode
▪ transmission rate	110, 150, 300, 600, 1200, 2400, 4800, 9600, or 19200 Baud
▪ Data bits	7 or 8
▪ Stop bits	1, 2 for 110 Baud
▪ Parity check	Odd, even or none (none for 8 data bits only)
▪ X_{ON}/X_{OFF} handshake	on or off
Hardware handshake	DSR/DTR and CTS/RTS
Connection	9-pin connector (instrument rear panel): 3 data wires inclusive ground 4 handshake wires

PM 9565 DC UNIT For DC resistance (R_{DC}) measurements; specifications, see Section 1.2.

PM 9566 HANDLER INTERFACE

Connection 15-pin connector at instrument rear panel

Galvanical isolation Opto-electronically

Input

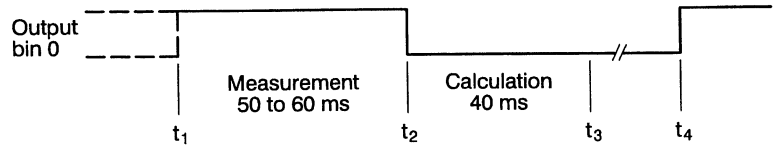
- Function: Trigger input for single measurements, especially for binning and FAST mode.
- Signal: Active-low TTL or short circuit to ground;
  pulse width >0.5 ms,
  for FAST mode >0.11 ms

Outputs 11, for bin 0 to bin 9 and fail bin.

- Configuration: Open collector
- Switchable current: ≤200 mA
- Switchable voltage: ≤40 V (positive voltage)

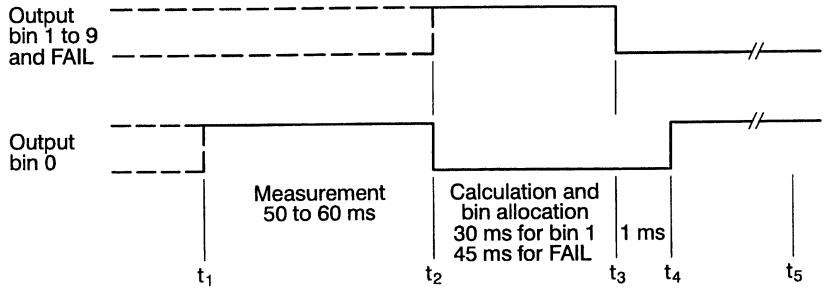
The output bin 0 provides a timing signal in FAST measurement mode

Timing Signal Bin 0 in FAST Mode



t_1 : Trigger starts measurement. Measurement time depends on test signal frequency and CUT; 50 to 60 ms at 1 kHz.
t_2 : End of measurement; CUT can be removed.
t_3 : Measurement result available.
t_4 : Trigger starts next measurement.

Timing Signal Bin 0 in FAST Mode during Binning



t_1 : Trigger starts measurement. Measurement time depends on test signal frequency and CUT; 50 to 60 ms at 1 kHz.
t_2 : End of measurement; CUT can be removed.
t_3 : Outputs bin 1 to 9 or FAIL are set.
t_4 : Outputs are valid; CUT can be handled according to the set bin.
t_5 : Trigger starts next measurement.

ACCESSORIES

STANDARD ACCESSORIES

- Power cable
- Fuses
- Test post red 5322 264 30351
- Test post black 5322 264 30352
- Users Manual 4822 872 10162
- Reference Manual 4822 872 10166

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 9536/041, 3 m RS-232 cable
- PM 2295/10, 1 m IEEE-488 BUS CABLE
- PM 2295/20, 2 m IEEE-488 BUS CABLE
- PM 9563, RACK MOUNT KIT (3E high)
- PM 9564, RACK MOUNT KIT (2E high)
- PM 2272, TEST SOFTWARE 'INSPECTOR'
- PM 9559, BIN PROGRAMMER
- Programmers Manual 4822 872 15169
- Service Manual 4822 872 15089
- Test Set 5322 310 32273

PM 9559 CHARACTERISTICS

- General description: Hand-held, battery operated IR controller for bin programming and binning mode switching on.
- Viewing angles onto the instrument (vs. front panel perpendicular);
  vertical operating range: −20 deg to 15 deg
  horizontal operating range: −18 deg to 18 deg
- Distance to PM6304 / PM6304C: <1.5 m (<6 feet)
- Battery: 9 V, DIN 40871, type 6F22G
- Supply current: Quiescent: 10 µA
  Operating: ≤35 mA
- Ambient temperature
  – operating range: 0 to 50 °C
  – storage and transport range: −20 to 70 °C

Chapter 2

PRINCIPLE OF OPERATION

2 PRINCIPLE OF OPERATION

2.1 INTRODUCTION

The two-pole CUT (Component Under Test) Zx is connected to the SELECTOR section of the instrument by four wires:

- Via the HD (High Drive) wire. The sinusoidal ac or the dc test voltage from the SOURCE or the DC source is routed to one CUT terminal by means of this wire.

- Via the LD (Low Drive) wire, which is forced electronically to near ground voltage level. The current through the CUT is routed by means of this wire either to the AC/V CONVERTER or, in the dc measuring mode, to the DC/V CONVERTER.

- By the HS (High Sense) and LS (Low Sense) wires, the voltages at the CUT terminals are picked up for processing.

In the dc-measuring mode, the sense voltages from the CUT and the DC/CONVERTER output voltages are converted to a 2 kHz ac voltage by the DC/AC CONVERTER in the DC UNIT. Within one measuring cycle, these voltages or, for the ac-measuring mode, the sense voltages from the CUT and the AC/V CONVERTER output voltage, are processed alternately in the AMPLIFIER-FILTER-MULTIPLYING DAC channel. In the DAC, the individual sinusoidal measuring voltage at A5 is multiplied successively by two quadrature-phase reference sine waves from the SIGNAL SYNTHESIZER, thus creating at A6 dc voltages proportional to the in-phase components of the measuring voltage. These dc terms are converted to binary numbers by a dual-slope ADC, consisting of the DUALSLOPE INTEGRATOR and the COUNTER, which are then read by the CPU. At the end of one measuring cycle in the ac measuring mode, seven numbers are normally in the CPU RAM:

- Two 'voltage numbers' for the two quadrature-phase components of the CUT voltage.

- Two 'current numbers' for the two quadrature-phase components of the CUT current.

- One 'voltage reference' number for the main ac component of the CUT voltage measuring channel, short-circuited at the ac selector input.
- A 'current reference' number for the main ac component of the CUT current measuring channel, short-circuited at the ac selector input.
- A quadrature-phase 'voltage reference' or 'current reference' number, depending on the used larger amplifier gain.

These seven numbers, the appropriate amplifier gains and reference sine wave phases, the instrument trim and calibration data, all combine to form the basis for the calculation of the CUT parameters. This calculation is performed by the CPU according to pre-defined algorithms. The results are transferred to the display.

2.2 DESCRIPTION OF THE BLOCK DIAGRAM

SIGNAL SYNTHESIZER

The TWS (Triangle Wave Synthesizer) reads out sine wave tables loaded in the sine wave PROMs, and so creates 8-bit-word sequences of the test signal, the reference sine wave for the MULTIPLYING DAC and the DC/AC CONVERTER in the DC UNIT. The test signal is converted to an analog sine wave by the DAC. The CPU controls frequency and phase settings.

SOURCE

The test signal is filtered within the SOURCE section and set to the programmed high, normal or low level amplitude by the ac source. A bias regulator creates the dc current for fast biasing of tested capacitors. Overload protection circuits protect the test signal source and the bias source from being damaged by external load.

SELECTOR

The source resistor belonging to the selected test signal level is switched on by relays. The ac selector multiplexes the CUT voltage behind the sense buffer stages, the voltage from the AC/V CONVERTER and, for the reference measurements, the ground level. A differential amplifier pre-amplifies and buffers the multiplexed voltages in ac measuring mode. The AC/V CONVERTER converts the CUT current to a proportional ac voltage. The dc selector multiplexes the CUT terminal voltages and the voltage from the DC/V CONVERTER to the DC/AC CONVERTER in the DC UNIT. A bias selector inhibits the bias currents or routes either the EXTERNAL BIAS or the internal bias current from the SOURCE to the CUT.

DC UNIT

The DC voltage source, the DC/V CONVERTER for the CUT current and the DC/AC CONVERTER form the DC UNIT. The DC/AC CONVERTER converts the measuring voltages from the CUT terminals and the DC/V CONVERTER output voltage to a 2 kHz sine wave voltage. This is achieved by multiplication with the 2 kHz digital wave from the SIGNAL SYNTHESIZER.

AMPLIFIER

The preamplifier equalizes the amplitude differences, depending on the test signal level. The main amplifier-voltage divider channel is controlled by the CPU and set to such an overall gain. That at the output of the FILTER section, the window detector senses the in-range condition. For very low CUT voltages or currents, i.e., very low or very high CUT impedances, the corresponding gains are set to maximum.

FILTER

Depending on the selected test frequency, the AMPLIFIER output signal is filtered by a 300 Hz LPF, a 300 Hz to 20 kHz BPF, or a 100 kHz BPF. The output is buffered and sensed by the window detector (see Section AMPLIFIER).

MULTIPLYING DAC

The FILTER output signal is multiplied by the digital reference sine wave from the SIGNAL SYNTHESIZER. For the CUT voltage signal and the CUT current signal, two quadrature-phase reference signals are successively used (see introduction). The polarity detector provides the CPU with information about the right phase settings.

DUAL-SLOPE INTEGRATOR

The DUAL-SLOPE INTEGRATOR executes for each analog/digital conversion first, for a fixed period, the dc integration and then the de-integration to zero with a fixed dc input. This is always monitored by the timer within the COUNTER section and of the CPU. The reset & hold circuit sets the initial zero output voltage condition of the integrator.

COUNTER

During the de-integration period of the DUAL-SLOPE INTEGRATOR the COUNTER accumulates the number of the count-clock pulses. The final number, which is proportional to the integrated dc input, is read out by the CPU (see introduction). The timer controls the integration period of the DUAL-SLOPE INTEGRATOR. DUAL-SLOPE INTEGRATOR and COUNTER represent the dual-slope ADC.

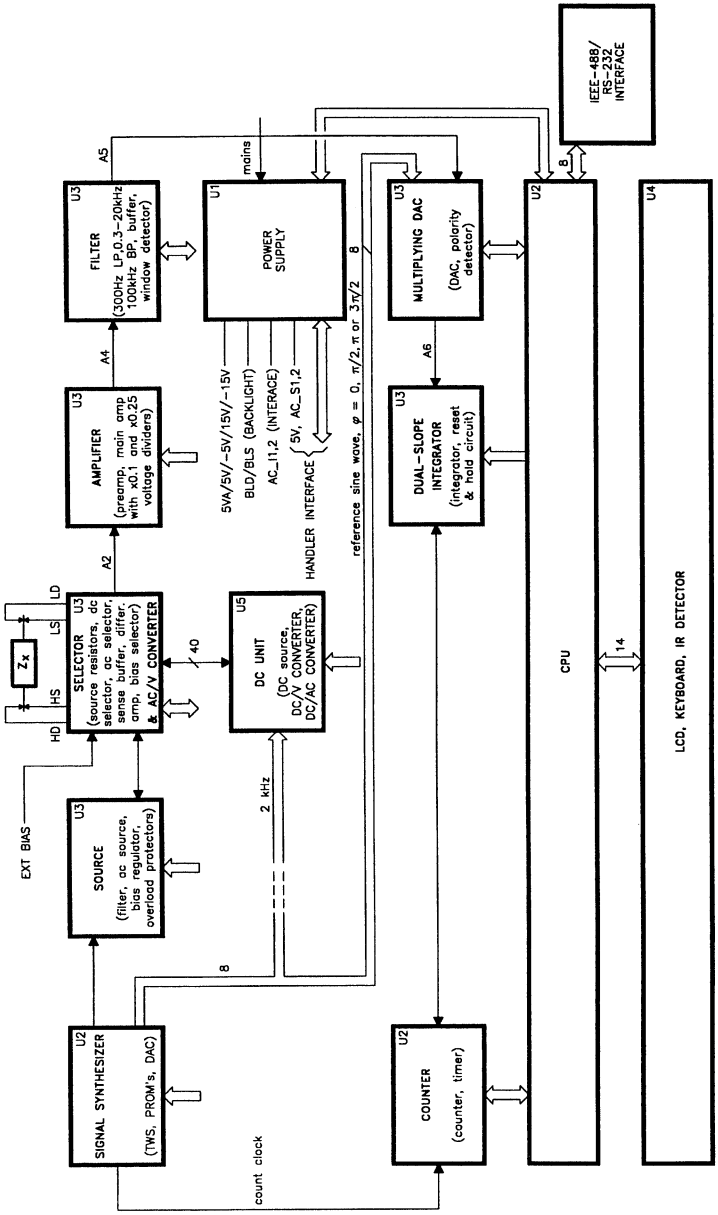
CPU, LCD & KEYBOARD, IR DETECTOR

The instrument is operated from the KEYBOARD, or remoted by the IEEE-488 Interface or the RS-232 Interface, or via IR DETECTOR from the binning programmer. The CPU processes these instructions as well as the information from the window and the polarity detector for controlling the various functional units in the instrument. The computation results, derived from the measurement data, are transferred to the LCD, the HANDLER INTERFACE and the IEEE-488 Interface or the RS-232 Interface.

SUPPLY

The SUPPLY provides dc supply voltages for the various functional units in the instrument, a dc current for the LCD backlight and ac supply voltages for the IEEE-488 Interface or the RS-232 Interface, and the HANDLER INTERFACE. The data lines for the HANDLER INTERFACE are routed through the SUPPLY section.

2.3 BLOCK DIAGRAM



Chapter 3

BRIEF CHECKING PROCEDURE

3 BRIEF CHECKING PROCEDURE

3.1 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. Allow 5 minutes minimum warm-up time before starting the procedure.

WARNING

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

3.2 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,

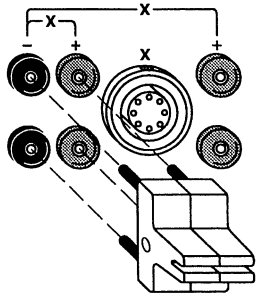
for example: 

For detailed information, see Pages 4–2 to 4–3.

3.3 FUNCTIONAL TEST

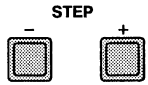
Immediately after power on a self-test routine is performed. Then the instrument automatically recalls measurement settings prior to the last power off.

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



If the display shows **dc**, press the **FREQ DC** key.

Select an appropriate measurement frequency, for example, 1 kHz.



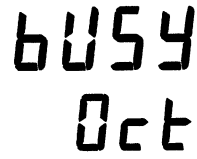
Press the green **AUTO** key.

The display shows:

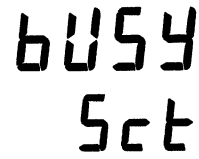
AUTO

Press the **ZERO TRIM** key for 2 seconds.

For open-circuit trimming
the display shows:



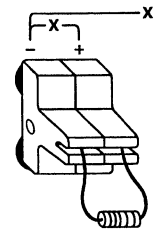
For short-circuit trimming short circuit
the test posts with a short wire or
similar object and press the ZERO TRIM key;
the display shows:



If the ZERO TRIM operation is
unsuccessful, the diplay shows:
Refer to Users Manual, Section 4.7.

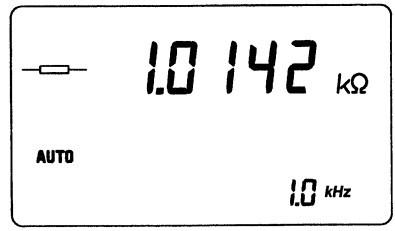
If the ZERO TRIM operation was
successful, the diplay shows:

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.



Chapter 4

PERFORMANCE TEST

4 PERFORMANCE TEST

4.1 INTRODUCTION

A performance test may be used as an acceptance test upon receipt of the instrument. If the test fails, an indication is given, that repair and/or adjustment is required.

The test procedure for the key parameters of the instrument refers to the Performance Specification in Chapter 1.

The PM6304 / PM6304C must be warmed up with all covers in place for at least 5 minutes before starting the tests.

4.2 RECOMMENDED TEST EQUIPMENT

AC rms Voltmeter	Fluke 8920A
DC Voltmeter	Philips PM 2535
Counter	Philips PM 6665

For performance verification in Section 4.4.1, the errors of these instruments must be taken into account.

2 Single Test Posts	Standard accessory
Test Set for PM6304, PM6304C, PM6306	5322 310 32273
If you only test PM6304 you can also use the **Test Set**	5322 310 32225

Test Set 5322 310 32273

Component	Used for		Instrument Accuracy		Max. CUT Tolerance for Test	Component Value Value
	PM6304	PM6304C	PM6304/06	PM6304C		
R 1 Ω	•	•	±0.1 %	±0.1 %	±0.02 %	**CV1**
R 4 Ω	•	•	±0.1 %	±0.1 %	±0.02 %	**CV2**
R 100 Ω [1)]	•	•	±0.1 %	±0.05 %	±0.005 %	**CV3**
R 1 kΩ		•	±0.1 %	±0.05 %	±0.01 %	**CV4**
R 10 kΩ [1)]	•	•	±0.1 %	±0.05 %	±0.005 %	**CV5**
R 20 kΩ		•	±0.1 %	±0.05 %	±0.01 %	**CV6**
R 500 kΩ	•	•	±0.1 %	±0.1 %	±0.02 %	**CV7**
R 2 MΩ	•	•	±0.1 %	±0.1 %	±0.02 %	**CV8**
R 100 MΩ	•	•	±5 %	±5 %	±1 %	**CV9**
C 10 nF	•	•	±0.1 %	±0.05 %	±0.02 %	**CV10**

1) For these resistors tighter tolerances are necessary because they are also used for recalibration of the PM6304 and PM6304C.

The Test Set is supplied with the component values of the single components. The specified component uncertainties are valid for f <10 kHz.
Because of component aging, it is necessary to measure the components after two years again.

4.3 SELF-TEST ROUTINE

After power on, the instrument checks the PROM, the processor RAM, and the external RAM. Additionally the instrument generates error messages if there are faults during measurements, trimming, recalibration or if there is a fault during data transfer to a printer.

Errors are indicated as follows:

Err 1 Program memory checksum error
Err 2 Processor RAM defective
Err 3 External RAM defective
Err 4 External RAM, backup (current instrument settings) destroyed
Err 5 External RAM, stored instrument settings 1 to 9 destroyed
Err 6 Error during analog to digital conversion of the test signal
Err 7 EEPROM defective

Err 8 Error in trim data (EEPROM)
Err 9 Error in calibration data (EEPROM)
Err 10 Error in binning data (EEPROM)
Err 11 Error during line frequency detection
Err 14 Test signal out of limits during trimming
Err 48 Communication error to the printer (time-out)

Errors 19 to 41 are errors during recalibration.
A detailed description is given in the Service Manual, Chapter 9.

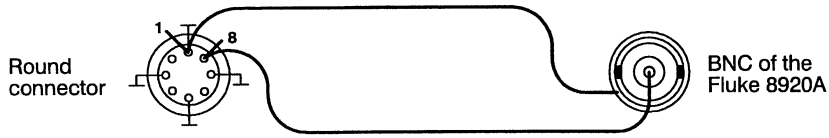
4.4 PERFORMANCE VERIFICATION

4.4.1 Test Signal Voltage

No component connected to PM6304.

Test equipment: AC rms Voltmeter, DC Voltmeter

- Set the PM6304 / PM6304C 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.



- Set frequency to 1 kHz.

Test result:
1 V ±20 mV (NORMAL LEVEL)
50 mV ± 1 mV (LOW LEVEL)
2 V ±40 mV (HIGH LEVEL)

- Connect DC Voltmeter to pin 8 and pin 1.
- Set test voltage to DC.

Test result: 1 V ±40 mV (NORMAL LEVEL)
0.3 V ±12 mV (LOW LEVEL)
2 V ±80 mV (HIGH LEVEL)

4.4.2 Test Signal Frequency

Test equipment: Counter

- Set counter to 1s gate time.
- Set PM6304 / PM6304C to 100 kHz test signal frequency.
- Connect counter with tips to pin 8 and pin 1.

Test result: 99.990 to 100.010 kHz

4.4.3 Open-Circuit Trimming

Insert the two single test posts into the two left positions and press the ZERO TRIM key.

Test result: The display shows BUSY and OCT, PASS, and about 0.0 pF finally.

4.4.4 Short-Circuit Trimming

Short the test posts by a clean wire, diameter approximately 1 mm, and press the ZERO TRIM key.

Test result: The display shows BUSY and SCT, PASS, and about 0.000 Ω finally.

If these tests are not performed accurately, the display shows FAIL instead of PASS. Please check the test conditions, and in doubt, repeat the procedure.

4.4.5 AC Mesurements

For each test frequency perform open-circuit and short-circuit trimming.
At 100 kHz repeat trimming for each level.

Test Signal Frequency	Test Signal Level	Test Component	Test Result Requirement	
100 Hz	LOW	4 Ω	CV2 ±1.13 %	
	NORMAL		CV2 ±0.10 %	
	HIGH		CV2 ±0.15 %	
	LOW	500 kΩ	CV7 ±1.08 %	
	NORMAL		CV7 ±0.10 %	
	HIGH		CV7 ±0.10 %	
1 kHz	LOW	1 Ω	CV1 ±1.5 %	
	NORMAL		CV1 ±0.1 %	
	HIGH		CV1 ±0.2 %	
	LOW	4 Ω	CV2 ±0.5 %	
	NORMAL		CV2 ±0.1 %	
	HIGH		CV2 ±0.1 %	
	LOW	100 Ω	CV3 ±0.5 %	
	NORMAL		CV3 ±0.1 %	(PM6304)
	NORMAL		CV3 ±0.05 %	(PM6304C)
	HIGH		CV3 ±0.1 %	
	LOW	10 kΩ	CV5 ±0.5 %	
	NORMAL		CV5 ±0.1 %	(PM6304)
	NORMAL		CV5 ±0.05 %	(PM6304C)
	HIGH		CV5 ±0.1 %	
	LOW	500 kΩ	CV7 ±0.5 %	
	NORMAL		CV7 ±0.1 %	
	HIGH		CV7 ±0.1 %	
	LOW	2 MΩ 1)	CV8 ±1.43 %	
	NORMAL		CV8 ±0.1 %	
	HIGH		CV8 ±0.1 %	
	NORMAL	100 MΩ	CV9 ±5.0 %	
	HIGH		CV9 ±2.5 %	
	LOW	10 nF 2)	CV10 ±0.5 %	
	NORMAL		CV10 ±0.1 %	(PM6304)
	NORMAL		CV10 ±0.03 %	(PM6304C)
	HIGH		CV10 ±0.1 %	

Test Signal Frequency	Test Signal Level	Test Component	Test Result Requirement
10 kHz	LOW	4 Ω	CV2 ±0.5 %
	NORMAL		CV2 ±0.1 %
	HIGH		CV2 ±0.1 %
	LOW	500 kΩ	CV7 ±0.5 %
	NORMAL		CV7 ±0.1 %
	HIGH		CV7 ±0.1 %
	LOW	10 nF 2)	CV10 ±0.5 %
	NORMAL		CV10 ±0.1 %
	HIGH		CV10 ±0.1 %
100 kHz	LOW	4 Ω	CV2 ±2.0 %
	NORMAL		CV2 ±0.4 %
	HIGH		CV2 ±0.4 %
	LOW	500 kΩ	CV7 ±2.0 %
	NORMAL		CV7 ±0.4 %
	HIGH		CV7 ±0.4 %

In addition for the instrument version **PM6304C:**

Test Signal Frequency	Test Signal Level	Test Component	Test Result Requirement
100 Hz	NORMAL	1 kΩ	CV4 ±0.05 %
300 Hz	NORMAL	20 kΩ	CV6 ±0.05 %
2 kHz	NORMAL	1 kΩ	CV4 ±0.05 %
2 kHz	NORMAL	20 kΩ	CV6 ±0.05 %

1) If you cannot meet the test results for the 2 MΩ resistor it might be that the test resistor has drifted from its labeled original value, because the resistor has a drift of max. <0.04 % in 3 years. Please check whether the resistor should be measured again.

2) If you cannot meet the test results for the 10 nF capacitor 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.

4.4.6 DC Measurements

(for instruments with DC Unit 5 only).

Test Signal Frequency	Test Signal Level	Test Component	Test Result Requirement
DC	LOW	1 Ω	CV1 ±1.30 %
	NORMAL		CV1 ±0.40 %
	HIGH		CV1 ±0.80 %
	LOW	4 Ω	CV2 ±0.33 %
	NORMAL		CV2 ±0.10 %
	HIGH		CV2 ±0.20 %
	LOW	10 kΩ	CV5 ±0.10 %
	NORMAL		CV5 ±0.10 %
	HIGH		CV5 ±0.10 %
	LOW	500 kΩ	CV7 ±0.33 %
	NORMAL		CV7 ±0.10 %
	HIGH		CV7 ±0.10 %
	LOW	2 MΩ	CV8 ±1.33 %
	NORMAL		CV8 ±0.40 %
	HIGH		CV8 ±0.20 %

Chapter 5

PREVENTIVE MAINTENANCE

5 PREVENTIVE MAINTENANCE

5.1 GENERAL INFORMATION

This instrument normally requires no maintenance, since none of its components is subject to wear.
However, to ensure reliable and trouble-free operation, the instrument should not be exposed to moisture, heat, corrosive elements or exessive dust.

5.2 SELF DIAGNOSTIC

In addition to the test during power on a test program is installed which checks the communication from the keyboard, the remote control interface, and the PM 9559 bin programmer as well as the data transfer to the internal memories.

The test program contains the following nine subprograms:

Pro 1	Display Test
Pro 2	Keyboard Test
Pro 3	Bin Programmer Test
Pro 4	Storage Register Test
Pro 5	EEPROM Test
Pro 6	Internal C-bus Test
Pro 7	Measurement Data Test
Pro 8	Calibration Data Test
Pro 9	Interface Test

Tests 6, 7, and 8 serve as an aid to the Service Technician for trouble shooting. Incircuit measurements with an open instrument are necessary; therefore, those tests are described in the Service Manual.

Press the **LOCAL** 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 9 appears. Press the **LOCAL** key briefly to select and carry out the test required. Press the **LOCAL** key again for about 1 second to return to the subprogram menu. To leave the test program, turn off the instrument.

Program 1: Display Test

The display test checks the liquid crystal display and the respective decoders/ drivers. When the text ***Pro I*** appears in the subprogram menu, press the **LOCAL** key. The text **REMOTE** appears. Press any 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 the **LOCAL** 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 the **LOCAL** key when the text ***Pro 2*** appears in the submenu; the display shows ***bCod***. If you press any key in random, the current number of this key appears in the display alone with a control number, for example, ***3–00*** when **AVERAGE** key is pressed. This control number is generated by the keyboard encoder and can be changed to ***00***, ***0I***, ***I0***, ***II*** 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 8, and the **STORE** key has number 13.
To return to the subprogram menu, press the **LOCAL** key.

To leave the test program, turn off the instrument.

Program 3: Bin Programmer Test

This test checks the function of the infrared transmitter and receiver, the function of the keys, and the encoder.

Press the **LOCAL** key when the text ***Pro 3*** appears in the submenu; the display shows ***ICodE***. If you press any key of the bin programmer in random, the current number of this key appears in the display with a control number, for example, ***4–0*** when the key **BINNING** is pressed. This control number is generated by the encoder and can be toggled from ***I*** to ***0***. The keys are numbered row by row from left to right. For example, the **NOMINAL** key has the number 10, and the **RECALL** key has the number 37.
To return to the subprogram menu, press the **LOCAL** key.

To leave the test program, turn off the instrument.

Program 4: 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 0*** and shows ***PASS*** at the end of the test. If the test finds an error, the display shows ***Error.***
Press the **LOCAL** key to return to the subprogram menu.

To leave the test program, turn off the instrument.

Program 5: EEPROM Test

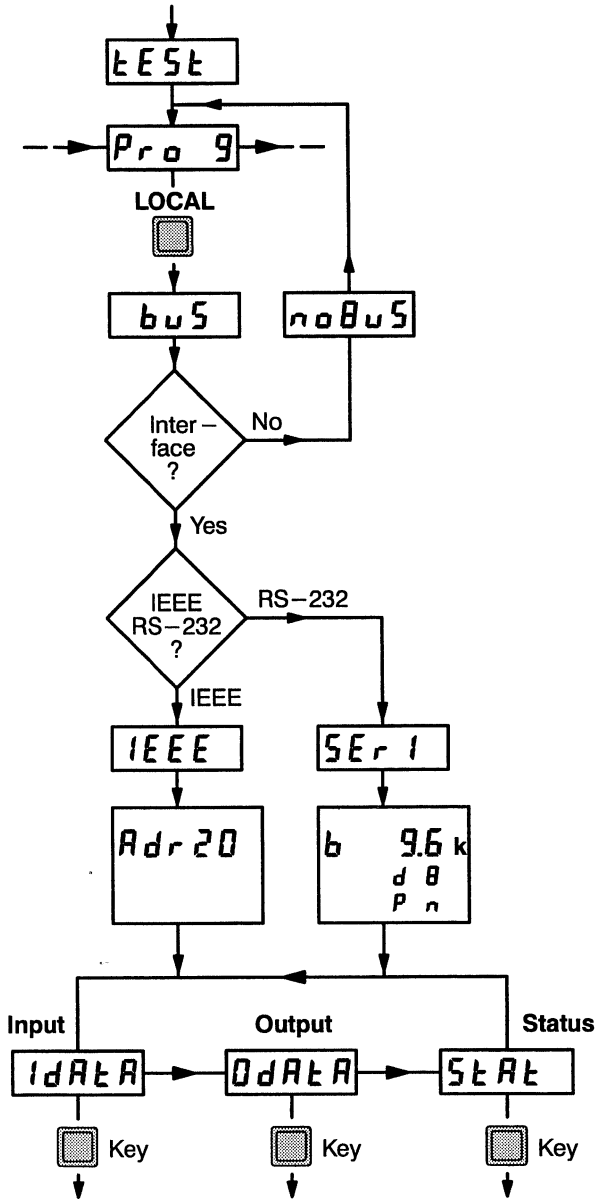
This test checks the function of the EEPROM. Press the **LOCAL** key when the text ***Pro 5*** appears. The test runs automatically. The contents of the memory is not overwritten or deleted during the test. The display shows ***EEPro*** and ***PASS*** at the end of the test. If the test finds an error the display shows ***Error.***
Press the **LOCAL** key to return to the subprogramm menu.

To leave the test program, turn off the instrument.

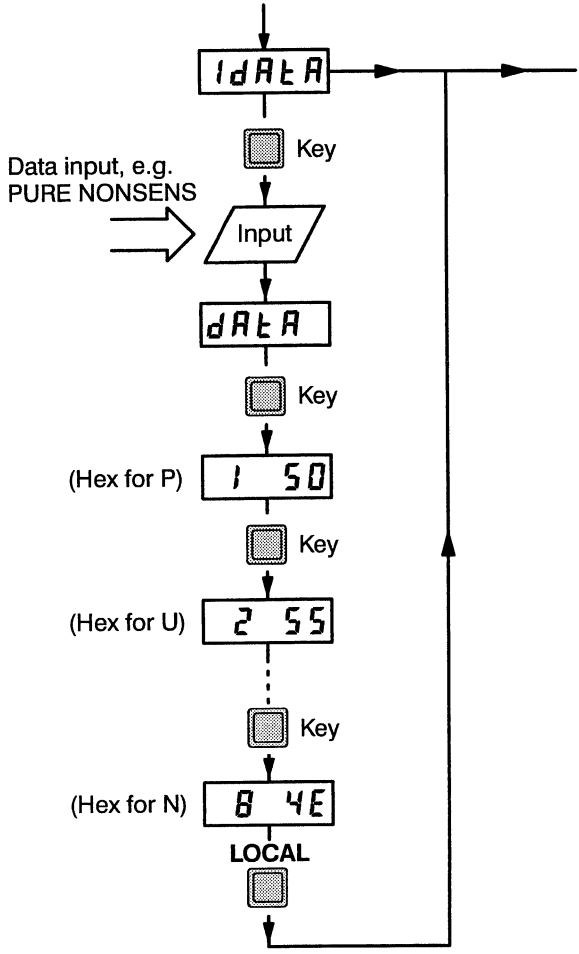
Program 9: Interface Test (RS-232 or IEEE-488)

This test checks the built-in interface, its inputs and output buffers, and the correct coding and decoding of the data transferred.

Press the **LOCAL** key when the text ***Pro 9*** appears. The test automatically checks which interface is actually available; if none, ***noBuS*** appears in the display and the instrument automatically returns to the menu of the test program. In instruments with interface, there is a choice between an input test (***IdAtA***), an output test (***OdAtA***), and a read-out of the device status (***StAt***). Selection is done by pressing any key (except **LOCAL**). For the IEEE-488 Interface, the device address is set to 20. The configuration for the RS-232 interface is: Baud rate 9600, data bits 8, parity no. Using the RS-232 Interface the instrument must be set to remote with ESC 2.


tESt
Pro 9
LOCAL
buS
noBuS
Inter–face ?
No
Yes
IEEE RS–232 ?
RS–232
IEEE
IEEE
SEr 1
Adr 20
b 9.6 k
d 8
P n
Input
Output
Status
IdAtA
OdAtA
StAt
Key
Key
Key

Input Test:
When the instrument received data via interface the display shows ***dAtA***. The first eight figures of the string can be displayed individually in hexadecimal form by pressing any key (except **LOCAL**). The data input can be repeated as often as desired.



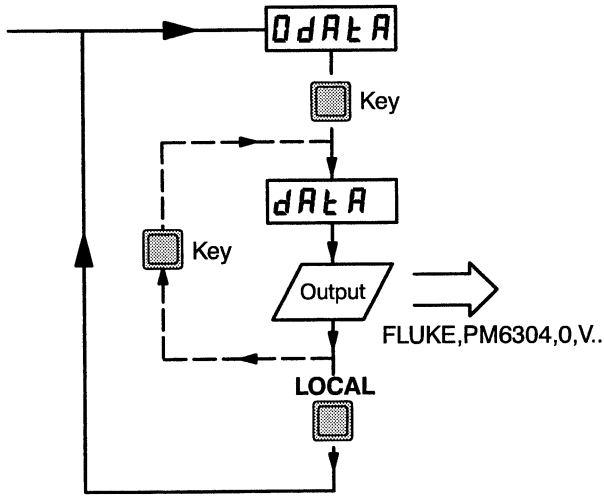
Press the **LOCAL** key to return to the selection between input, output, and status. Press the key again to return to the menu of the test program.

To leave the test program, turn off the instrument.

Output Test:
When the output test is selected the display shows ***dAtA*** and the identification string

```
'FLUKE,PM6304,0,Vx.x'
```

can be read out by a controller. This test can be repeated so often as desired by pressing any key (except **LOCAL**).



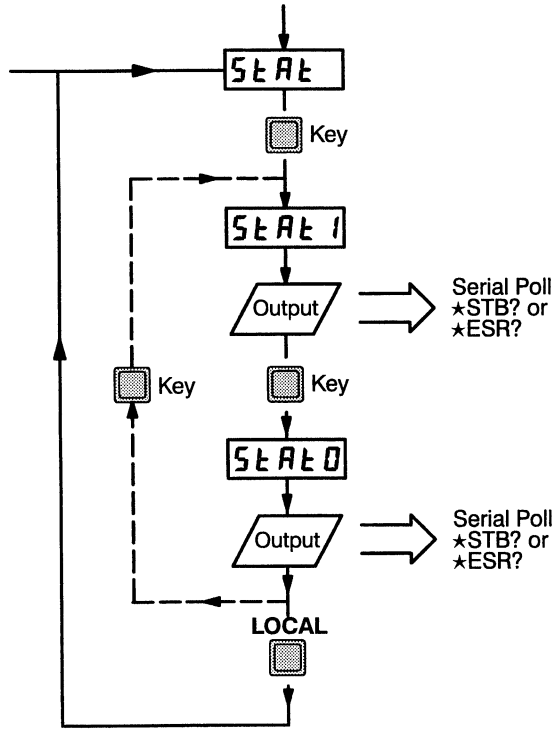
Press the **LOCAL** key to return to the selection between input, output, and status. Press the key again to return to the menu of the test program.

To leave the test program, turn off the instrument.

Device-Status Test:
This test checks the data transfer from the instrument to the Standard Event Status Register and to the Status Byte Register.

Pressing any key (except **LOCAL**) when the display shows ***StAt*** sets the bits of the Standard Event Status Register (ESR) to 1 or 0. The display shows ***StAt 0*** or ***StAt I***.

If the bits of the Standard Event Status Enable Register (ESE) was set to 1 with the command ★ESE 255 the controller can read out the Status Byte Register with serial poll or with the query ★STB? (IEEE-488) respectively with ESC 7 for the RS-232 Interface. The result is 0 or 32 decimal, see Programming Manual, Section 3.3.
The Standard Event Status Register also can be read out by a controller with the query ★ESR?.



Press the **LOCAL** key to return to the selection between input, output, and status. Press the key again to return to the menu of the test program.

To leave the test program, turn off the instrument.

5.3 RECALIBRATION

The instrument was calibrated in the factory prior to shipment. The calibrating data are stored in an EEPROM and are taken into account during every measurement.
It is necessary to calibrate again after loss of data (replacing the EEPROM), after changing components during repair which might influence the measuring result or when the instrument does not meet the Technical Specifications. In normal operation, recalibration once a year is sufficient. More details on this can be found in the SERVICE MANUAL.

APPENDIX

SERVICE CENTERS

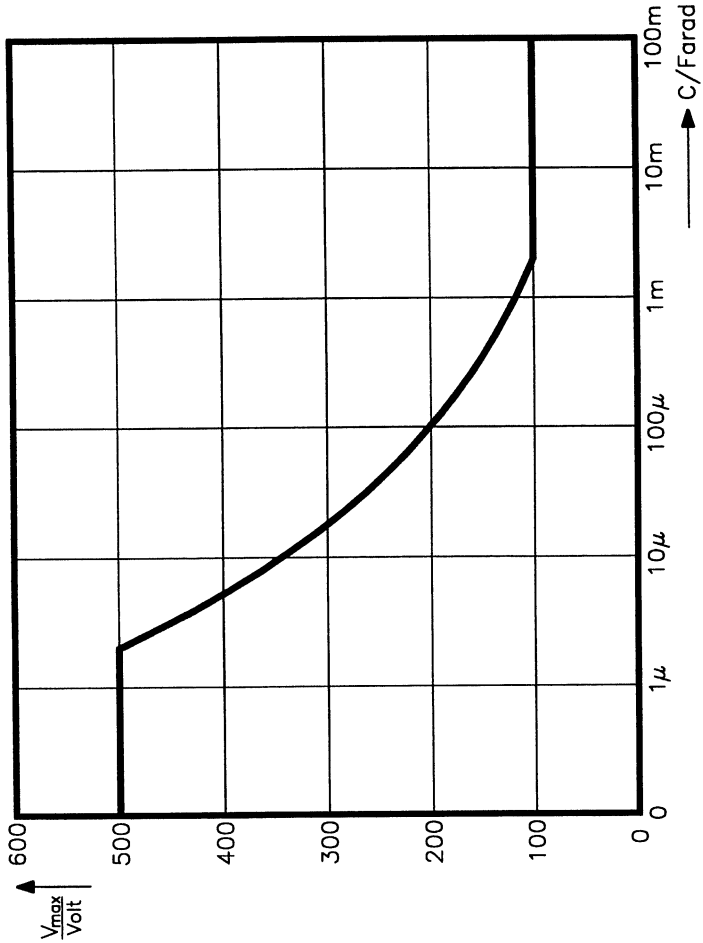


Figure 1 Maximum Charged–Capacitor Voltage

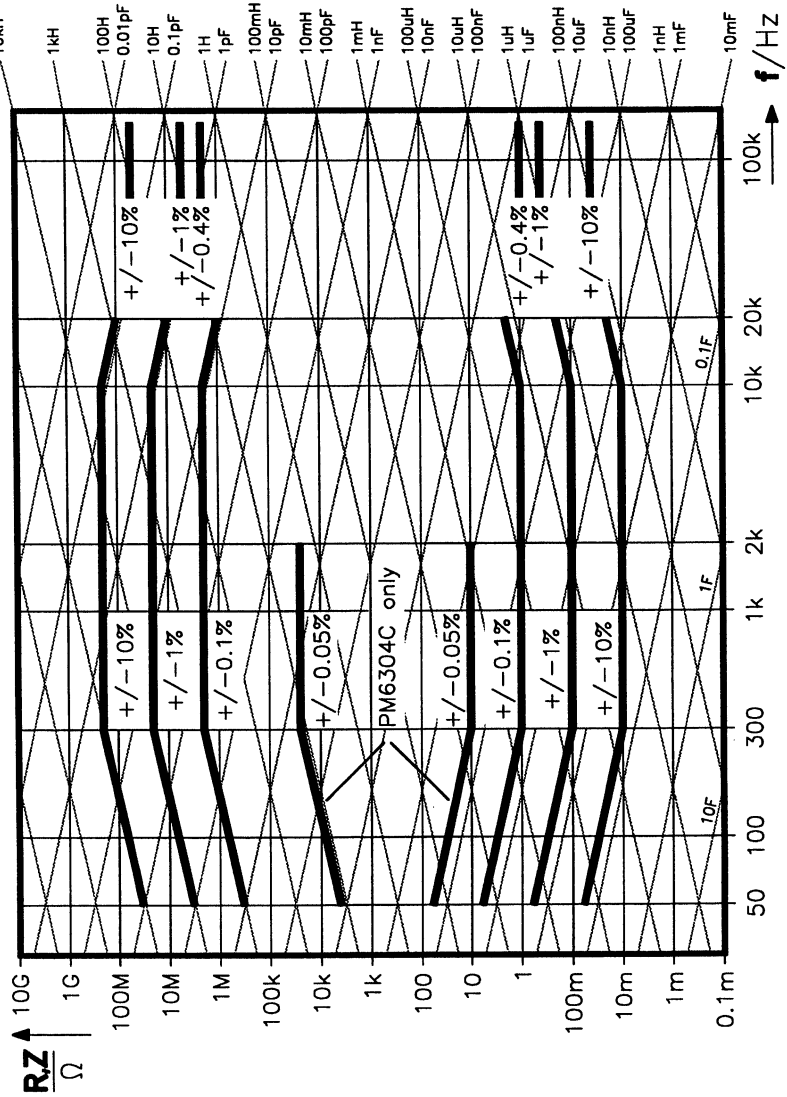


Figure 2 Error Limits for AC, NORMAL LEVEL

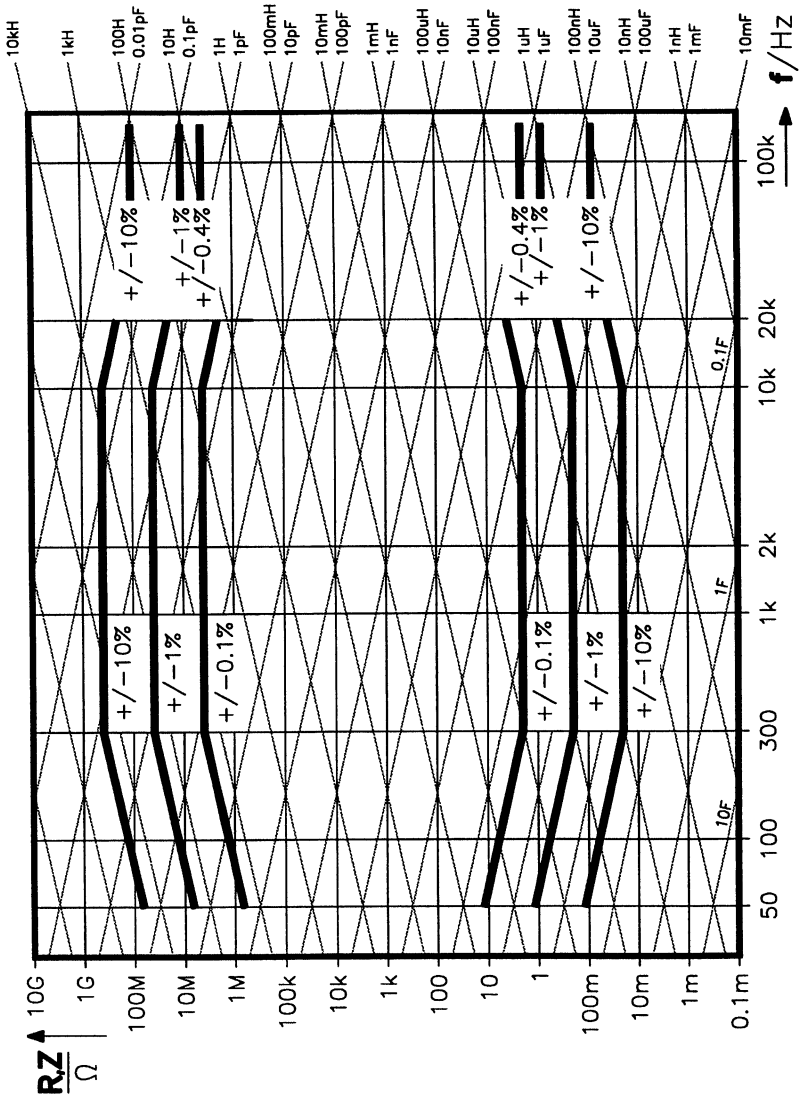


Figure 3 Error Limits for AC, HIGH LEVEL

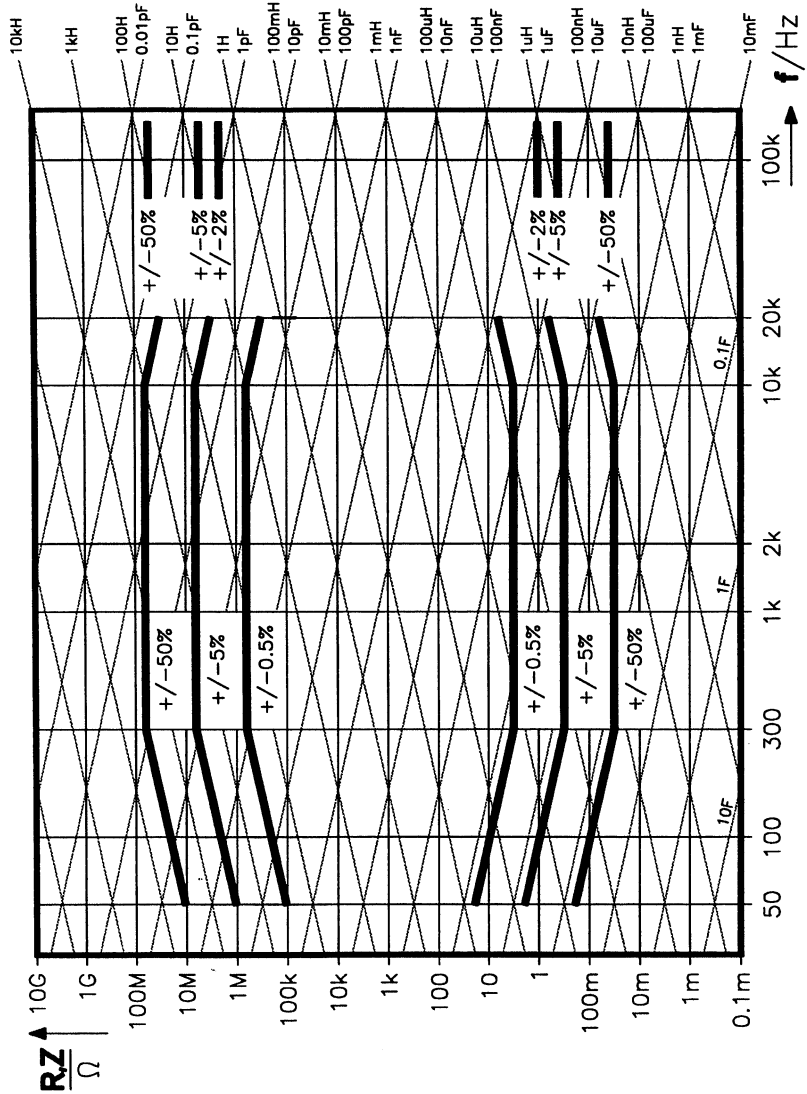


Figure 4 Error Limits for AC, LOW LEVEL

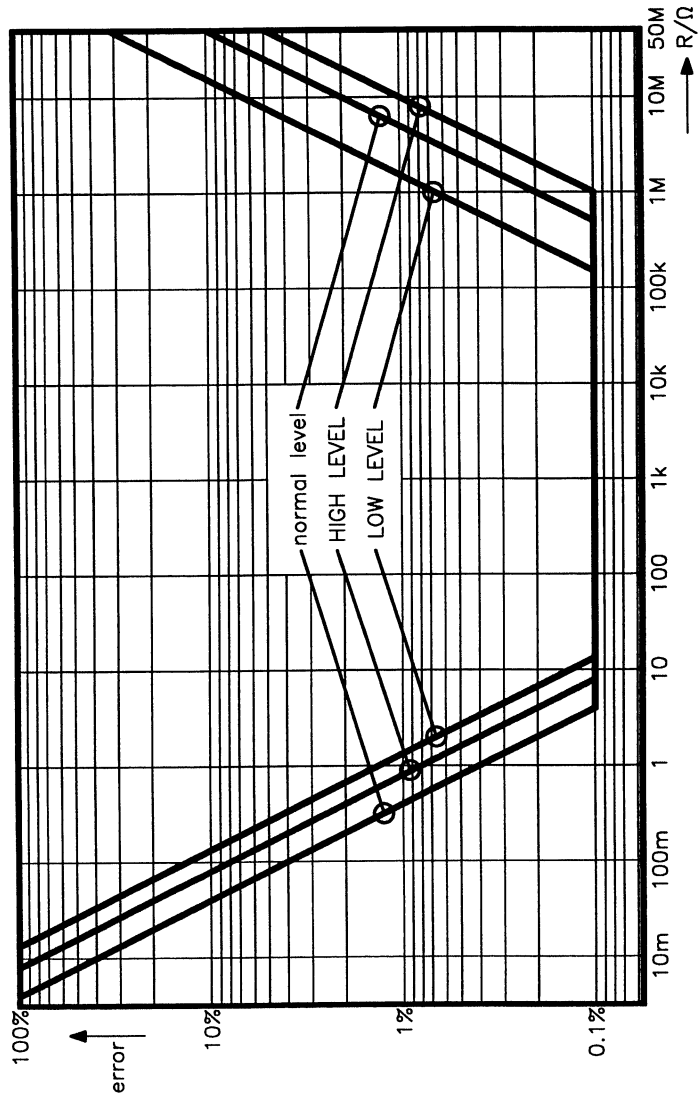


Figure 3 Error Limits for DC, DC Measurements

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