INSTRUCTION MANUAL

DIGITAL MULTIMETER

MODEL 1504

KIKUSUI ELECTRONICS CORPORATION

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1. GENERAL

Kikusui Model 1504 Digital Voltmeter is a multiple-purpose digital voltmeter which measures DC and AC voltages and currents, and resistances also. The maximum display value of the digital readout is 19999.

For DC voltage or current measurement, the instrument automatically identifies the polarity of the input and displays a minus sign when the input is negative.

The measuring sensitivity is high and the instrument covers wide measuring ranges. Namely, the measuring ranges of DC voltage is 10 μV - 1000 V, AC voltage 10 μV - 750 V, DC and AC currents 10 nA - 1000 mA, and resistance 0.01 - 19.999 MΩ.

The instrument employs a double-intergration system for measurement. As the automatic zero erase circuit is incorporated, the instrument requires no zero adjustment and ensures reliable measurement.

Employing ICs and LEDs, the instrument is compact, light, and consumes less power, while ensuring a high operation reliability.

The input circuit can be floated from the casing, enabling safer measurement of a voltage between two points which are floated from the ground.

2. SPECIFICATIONS

Instrument name: Model 1504 Digital Multimeter

Measuring functions: DC voltage, DC current, AC voltage, AC current, and resistance

Measuring system: Double integration system

Indications

- Display: LED readout
- Maximum effective display value: 19999
- Polarity indication: Automatic (minus sign alone)
- Over-range indication: With LED light

Sampling rate: Approx. 2.5 times/sec

Ambient temperature and himudity: 0°C to 40°C (32°F to 104°F), less than 85% RH

Storage temperature: -20°C to 70°C (-4°F to 158°F)

Withstand voltage to ground: 500 V maximum

Power requirements: 90 - 128.7 V, 50/60Hz AC, approx. 2 VA (with 100 V AC line)

External dimensions: 200 W × 80 H × 250 D mm
(7.88 W × 3.15 H × 9.85 D in.)

(Maximum dimensions): 220 W × 90 H × 295 D mm
(8.66 W × 3.55 H × 11.62 D in.)

Weight (net): Approx. 2.4 kg (5.3 lbs)

Accessory:

- Input cable 1
- Instruction manual 1
- Fuse (0.1 A) 1
- Fuses (1 A) 2

DC voltage section

(23°C ±5°C (73.4°F ± 9°F), RH<85%, 90 days)

Voltage range	Accuracy	Resolution	Input resistance	Input over-voltage
200 mV	±(0.05% of rdg +0.01% of FS +1 digit)	10 µV	$\geq 10^9 \Omega$	1100 V peak
2000 mV		100 µV		
20 V	±(0.07% of rdg +0.01% of FS +1 digit)	1 mV	$10^7 \Omega$	
200 V		10 mV		
1000 V		100 mV		

Range selection: Automatic and manual

Normal-mode rejection ratio: 40 dB (50/60 Hz, ±0.5%)

Effective common-mode rejection ratio: 100 dB (50/60 Hz,±0.5%, 1 kΩ, single-ended)

AC voltage section

(23°C ±5°C (73.4°F ± 9°F), RH<85%, 90 days)

Voltage range	Frequency range	Accuracy	Resolution	Input resistance	Input over-voltage
200 mV	45 Hz to 1 kHz	±(0.3% of rdg +0.2% of FS +1 digit)	10 µV	$10^7 \Omega$ <200 pF	750 V rms
2000 mV			100 µV		
20 V		±(0.5% of rdg +0.2% of FS +1 digit)	1 mV		
200 V			10 mV		
1000 V	45 Hz to 500 Hz	±(1% of rdg +0.2% of FS +1 digit)	100 mV		

Range selection: Automatic and manual

(Note: The 1000 V range is used as 750 V rms range.)

Resistance section

(23°C±5°C (73.4°F± 9°F), RH<85%, 90 days)

Resistance range	Accuracy	Resolution	Measuring current	Maximum allowable input voltage
200 Ω	±(0.1% of rdg + 0.05% of FS + 1 digit)	10 mΩ	1 mA	200 V AC or 100 V DC
2000 Ω		100 mΩ	1 mA	
20 kΩ		1 Ω	100 μA	
200 kΩ		10 Ω	10 μA	
2000 kΩ	±(0.2% of rdg + 0.1% of FS + 1 digit)	100 Ω	0.1 μA	
20 MΩ		1 kΩ	0.1 μA	

Range selection: Automatic and manual

DC current section

(23°C ± 5°C (73.4°F ± 9°F), RH < 85%, 90 days)

Current range	Accuracy	Resolution	Voltage drop between terminals
200 μA	±(0.5% of rdg + 0.07% of FS + 1 digit)	10 nA	250 mV or less
2000 μA		100 nA	
20 mA	±(0.8% of rdg + 0.07% of FS + 1 digit)	1 μA	
200 mA	±(3.5% of rdg + 0.07% of FS + 1 digit)	10 μA	400 mV or less
1 A		100 μA	650 mV or less

Range selection: Manual

Input protection: Internal 1-ampere fuse

AC current section

(23°C ± 5°C (73.4°F ± 9°F), RH < 85%, 90 days)

Current range	Frequency range	Accuracy	Resolution	Voltage drop between terminals
200 μA	45 Hz to 500 Hz	±(0.7% of rdg + 0.3% of FS + 1 digit)	10 nA	250 mV or less
2000 μA			100 nA	
20 mA		±(1% of rdg + 0.3% of FS + 1 digit)	1 μA	
200 mA		±(3.5% of rdg + 0.3% of FS + 1 digit)	10 μA	400 mV or less
1 A			100 μA	650 mV or less

Range selection: Manual

Input protection: Internal 1-ampere fuse

3. OPERATION METHOD

3.1 Explanation of Front Panel

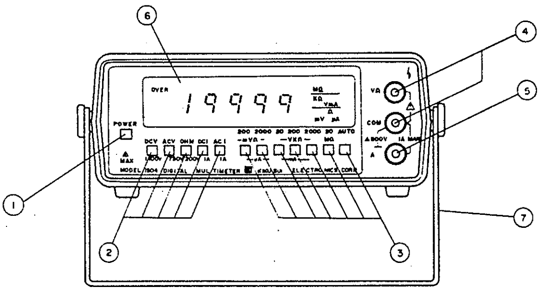

Figure 3-1

① POWER: AC main power ON-OFF switch. The depressed and locked state is for ON; the pushed again and popped-up state is for OFF.

② FUNCTION: Pushbuttons for selecting measuring functions for DCV (DC voltage), ACV (AC voltage), OHM (resistance), DCI (DC current) and ACI (AC current). The figures noted at the buttons are the maximum applicable input values.

③ RANGE: Pushbuttons for selecting measuring ranges. The figures noted at the buttons are full-scale values of voltage, current and resistance ranges. These buttons are used, in conjunction with the FUNCTION button of 2, to select appropriate measuring ranges. When set in the AUTO state, the instrument itself automatically selects an appropriate measuring range for the input signal, except the case of current measurement. For AUTO ranging, range-up occurs at 20000 and range-down at 1799.

④ V·Ω, COM: Input terminals for measurement -- the V·Ω terminal for high impedance and the COM terminal for low impedance. These terminals are isolated from the casing, for floating voltage measurement. The withstand voltage with respect to the ground is 500 V. The mark indicates the high voltage side of the input signal.

The ⚡ mark is an international mark for operation safety, which indicates a note for the voltage applied between V·Ω and COM terminals.

⑤ A: Terminal for current measurement. The current to be measured should be connected between this terminal and COM terminal.

⑥ Readout: 5-digit readout with LEDs for 0 - 19999. When in over-input, the OVER indicator light (LED) lights. The decimal point moves in accordance with range setting. The minus sign "-" is displayed for a negative DC voltage or current input.

⑦ Handle: The carrying handle can be used also as a tilting support. For tilting, turn and lock the handle in the LOCK position.

3.2 Explanation of Rear Panel

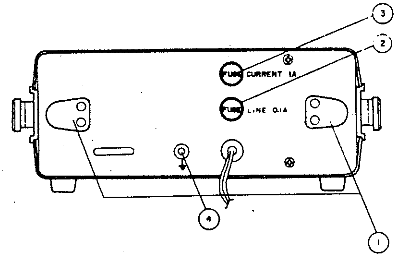

Figure 3-2

(1) Power cord hooks: When carrying the instrument, take up the power cord on these hooks

(2) LINE, 0.1A: AC power line fuse, 0.1 ampere. (for 100 V AC line)

(3) CURRENT, 1A: Fuse of DC and AC current measuring circuit, 1 ampere

(4) Ground terminal: Normally, connected to the earth when the instrument is in use

Note: When the AC line voltage of the instrument is converted to other voltage than 100 V, change the AC line voltage indication and fuse rating indication. (Labels are available from Kikusui Electronics Corporation.)

3.3 Preparations for Measurement

(1) Turn off the power switch on the front panel.

(2) Connect the power cord to an AC line outlet (100 V, 50/60 Hz).

(3) Turn on the POWER switch.

(4) The instrument is ready for measurement when its power is turned on. When a higher measuring accuracy is required, however, allow a stabilization period of approximately 30 minutes or over.

3.4 Measuring Procedures

3.4.1 DC Voltage Measurement

(1) Press the DCV button of the FUNCTION selector and set the RANGE selector at a range suitable for the voltage to be measured.

(2) Connect the input cable (supplied as an accessory) to the COM and V·Ω input terminals. The wire ends of the cable are interchangeable between clips and chips. Use convenient ones.

When long lead wires are required, it is most recommendable to use shielded wires of good insulation.

(3) If the level of the voltage to be measured is unpredictable, set the RANGE selector in the AUTO state or set it at the highest range and then gradually lower the ranges until the readout displays a value lower than 19999. At the 1000 V range (the panel indication is 2000), however, the displayed value should be 10000 or less.

3.4.2 DC Current Measurement (manual)

(1) Press the DCI button of the FUNCTION selector and set the RANGE selector at a range suitable for the current to be measured.

(2) Connect the input cable to the COM and A input terminals and measure the current. If the level of the current to be measured is unpredictable, start measuring with the 1000 mA range (the panel indication is 2000).

3.4.3 AC Voltage Measurement

(1) Press the ACV button of the FUNCTION selector and set the RANGE selector at a range suitable for the voltage to be measured.

(2) Connect the input cable to the COM and V·Ω input terminals.

(3) If the level of the voltage to be measured is unpredictable, set the RANGE selector in the AUTO state or set it at the highest range and gradually lower the ranges until the readout displays a value lower than 19999. At the 1000 V range (the panel indication is 2000), however, the displayed value should be 7500 or less.

3.4.4 AC Current Measurement (manual)

(1) Press the ACI button of the FUNCTION selector and set the RANGE selector at a range suitable for the current to be measured.

(2) Connect the input cable to the COM and A input terminals and measure the current. If the level of the current to be measured is unpredictable, start measuring with the 1000 mA range (the panel indication is 2000).

3.4.5 Resistance Measurement

(1) Press the OHM button of the FUNCTION selector and set the RANGE selector at a range suitable for the resistance to be measured.

(2) Connect the input cable to the COM and V·Ω input terminals and measure resistance. If the level of the resistance to be measured is unpredictable, set the RANGE selector at first at 20 MΩ and then gradually reduce the ranges or set it in the AUTO state.

(3) If lead wires longer than the accessory input cable are used, pay attention to the resistance of the leadwires when measuring at low ranges or to their insulation resistance when measuring at high ranges.

4. OPERATING PRINCIPLE

4.1 Outline of Measuring Principle

The 1504 Digital Multimeter basically is a DC voltmeter. (See the block diagram of Figure 4-1.) For AC voltage measurement and resistance measurement, the input signal is converted into a DC signal. For DC current measurement, the current to be measured is fed through a resistor and the voltage drop across the resistor is measured. For AC voltage measurement the voltage is divided with a voltage divider

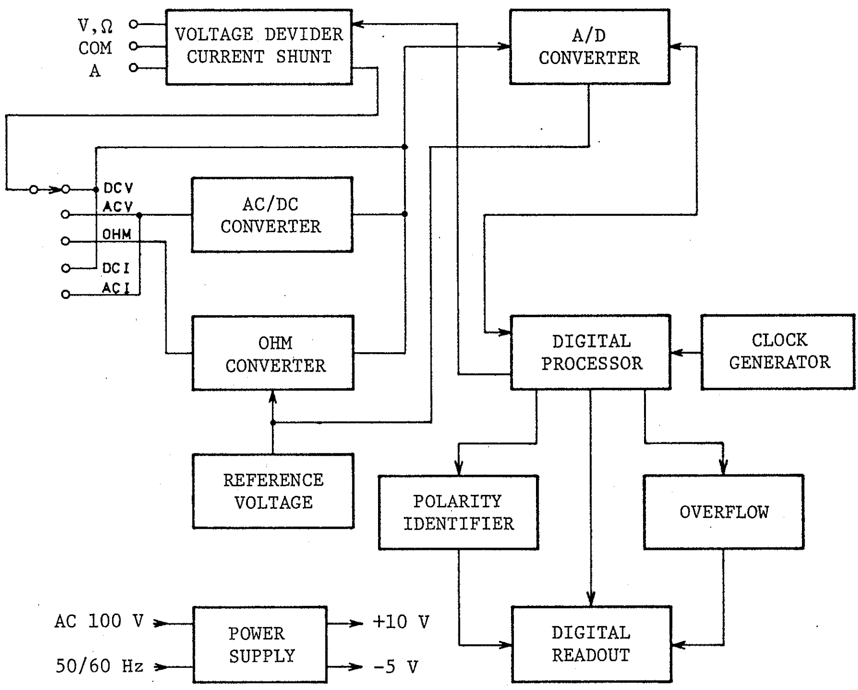

Figure 4-1. Block diagram

and for AC current measurement the current is fed through a resistor, and the resultant AC voltage is converted into a DC voltage by the AC/DC converter. For resistance measurement, the signal is converted into a DC voltage signal by the OHM converter.

4.2 Voltage Divider and Current Shunt

The voltage divider and current shunt are used in common for DC and AC voltage measurements and DC and current measurements, respectively. The voltage divider divides the voltage AC-wise also, with compensation capacitors. For resistance measurement, the voltage-dividing resistors are used as standard resistors for developing voltage drops.

4.3 AC/DC Converter

This device converts the AC voltage input signal into a DC voltage output signal with a good conversion linearity. It consists of a buffer amplifier and a linear detector.

4.4 OHM Converter

This device accurately sets the current to be fed to the resistor to be measured, by feeding the current to the voltage divider resistors used as standard resistors and comparing the developed voltage with the reference voltage using a high-gain amplifier. The voltage developed across the resistor to be measured is determined with the A/D converter as is the case for DC voltage measurement.

4.5 A/D Converter

The A/D converter consists of an integrator, an analog comparator which senses the state of the integrator, a reference voltage control logic circuit which controls the pulse width of the reference voltage in response to the state of the comparator, and an automatic zero erase circuit.

When in the automatic compensation period, the internal offset voltage and drift voltage are converted into an automatic zero compensation storage voltage. Referring to this voltage, the circuit is maintained in a balanced state for automatic zero compensation and, at the next measuring cycle, the offset and drift voltages are balanced out.

When in the measuring period, the input voltage signal is applied to the buffer amplifier and its output is applied to the integrator.

The comparator detects the change in the balanced state of the circuit during the automatic zero compensation period due to application of the input signal, and sends the detected signal to the digital processor.

The digital processor generates a reference voltage control logic signal to adjust the integrator output voltage to the storage voltage. It controls the pulse width of the signal applied to the integrator so that its output restores the balanced state. In synchronization with the reference voltage control logic signal, the BCD counter operates and the analog input voltage is converted into a digital output signal.

4.6 Digital Processor

The digital processor consists of a control circuit, a time base counter, a BCD counter, a latch memory, and a multiplexer circuit.

The control circuit generates a timing signal and controls the reference voltage control logic signal with respect to the state of the comparator output. The time base counter generates a clock signal (time base signal) for switching between measuring period and automatic zero compensation period.

The digital data is loaded in the latch memory, converted into a BCD signal by the multiplexer, and sent to the readout.

4.7 Reference Voltage Generator

The reference voltage generator produces a highly stable DC voltage which is used as a reference voltage by the A/D comparator and OHM converter.

4.8 Clock Generator

This device is a crystal-controlled oscillator which generates a stable frequency signal used as a clock signal for digital signal processing.

4.9 Power Supply

The power supply provides regulated DC supply voltages of +10 V and -5 V for the various circuits of the Multimeter.

5. MAINTENANCE

5.1 Removing the Casing Covers

Before removing the casing covers, be sure to disconnect the power cord from the AC line receptacle. Undo the clamping-screws and then remove the top and bottom casing covers.

5.2 Layout of Adjustments

When the top and bottom casing covers are removed, the adjustments are accessible as shown in Figure 5-1. The adjusting holes are at the right-hand side. For adjustment, use a screwdriver which has an insulated shaft, especially when adjusting C2.

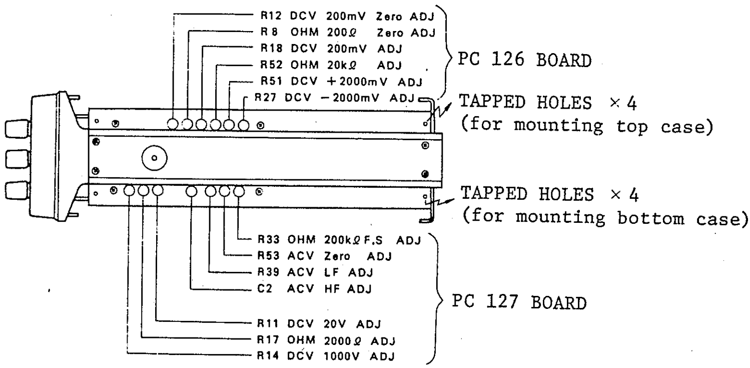

Figure 5-1

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5.3 Calibration

To maintain the high accuracy of the instrument for a long period, the instrument should be periodically inspected and calibrated. Calibration should be done in a stable atmospheric temperature of approximately 23°C (73.4°F). Allow more than 30 minutes of stabilization period after turning-on the instrument power.

5.3.1 Checking the Supply Voltages

Check the supply voltages as shown in Table 5-1.

Table 5-1

Check point	Voltage (with respect to ground)
+10 V power: V_{DD} check point	+9.4 V to +10.6 V
-5 V power: V_{SS} check point	-4.7 V to -5.25 V

5.3.2 Checking the Clock Generator

Connect a frequency counter between IC U_{13-13} and GND terminal and measure the frequency. The frequency should be 100 kHz ±100 Hz. Also check the waveform with an oscilloscope.

5.3.3 Calibration of DC Voltage Ranges

(1) Press the DC button of FUNCTION selector and the 200 mV button of RANGE selector. Short the input terminals (input cable ends), and so adjust R12 (PC126 board) that the readout indicates zero.

(2) Set a DC standard voltage generator (accuracy 0.05% or better) at +1999.0 mV. Apply this voltage to the 1504 Multimeter and so adjust R51 (PC126 board) that the readout indicates +1999.0 mV.

(3) Apply an input voltage of -1999.0 mV and so adjust R27 (PC126 board) that the readout indicates -1999.0 mV.

(4) Set the range at 200 mV. Apply an input voltage of +199.90 mV and so adjust R18 (PC126 board) that the readout indicates +199.90 mV.

(5) Set the range at 200 V. Apply an input voltage of +199.90 V and so adjust R11 (PC127 board) that the readout indicates +199.90 V.

(6) Set the range at 1000 V. Apply a standard input voltage of +1000 V and so adjust R14 (PC127 board) that the readout indicates +1000 V.

5.3.4 Calibration of AC Voltage Ranges

(1) Press the AC button of FUNCTION selector. Short the V·Ω and COM input terminals. So adjust R53 (PC127 board) that the readout indicates zero.

(2) Set a standard AC voltage generator (accuracy 0.1% or better) at 100 Hz, 1999.0 mV. Apply this voltage to the Multimeter and so adjust R39 (PC127 board) that the readout indicates 1999.0 mV.

(3) Set the range at 20 V. Apply an input signal of 1 kHz, 19.990 V and so adjust C2 (PC127 board) that the readout indicates 19.990 V.

5.3.5 Calibration of Resistance Ranges

(1) Press the OHM button of the FUNCTION selector and set the range at 200 Ω. Short the input terminals (connect together the cable wire ends). So adjust R8 (PC126 board) that the readout indicates zero.

(2) Set the range at 200 kΩ. Using a standard resistance box of an accuracy of 0.05% or better, apply a resistance input signal of 199.90 kΩ. So adjust R33 (PC127 board) that the readout indicates 199.90 kΩ.

(3) Set the range at 20 kΩ. Apply an input resistance of 19.990 kΩ and so adjust R52 (PC126 board) that the readout indicates 19.990 kΩ.

(4) Set the range at 2000 Ω. Apply an input resistance signal of 1999.0 Ω and so adjust R17 (PC126 board) that the readout indicates 1999.0 Ω.