HIOKI E.E. CORPORATION

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HIOKI

3108 · 3109

INSTRUCTION MANUAL

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WARNING

This Instrument is designed to prevent accidental shock to the operator when properly used. However, no engineering design can render safe an instrument which is used carelessly. Therefore, this manual must be read carefully and completely before making any measurement. Failure to follow directions can result in a serious or fatal accident.

CONTENTS

1. INTRODUCTION

The Model 3108/3109 is a compact, portable instrument designed to take AC/DC current and voltage measurements from current-carrying power lines. Its clamp-on sensor feature means that the equipment does not require shutting down, nor do conductors require cutting for the measurement set up.

The sensor portion of the clamp consists of a magnetic circuit developed by HIOKI using high-permeability magnetic materials and Hall elements. Sensor circuit linearity is superior, and measurement error induced by the positioning of the conductor within the clamp core is reduced to a minimum.

The portability and convenience of battery operation makes the instrument ideal for various inspection-maintenance applications in electrical systems of facilities engaged in chemical production, automotive production and repair, welding, and railroad-related industries.

Output terminals are provided on the instrument for system expansion, increasing substantially the range of application possibilities through the use of recorders and waveform monitors, etc.

2. FEATURES

1. Extremely wide measurement range capability (10—250A range and 100—2500A range). Additionally, measurements are easily made by simply clamping the sensor over current-carrying conductors-no need to interrupt power to equipment under test.
2. Good frequency response characteristics mean that AC current at frequencies ranging from 20 to 500Hz can be measured with virtually no error.
3. The unique construction of the clamp-on sensor minimizes the effect of conductor positioning within the clamp core. The meter reading is accurate within ±1% at any conductor position within the jaws of the clamp.

4. Thorough shielding allows the instrument to be used in the presence of high-current conductors with minimum affect on the reading due to magnetic fields.

5. Degaussing not required. The high permeability-low coercivity magnetic materials used in the construction of the clamp core means that DC current readings are minimally affected by core magnetization.

6. True RMS readings available via an optional adapter for accurate measurements of current waveforms containing the type of distortion typically produced in thyristor-control circuits.

7. Two versatile output terminals are provided on the instrument for connecting a recorder (AC), or waveform monitor (DC). This convenient function permits transients and other phenomena to be monitored, or recordings made for permanent records.

8. AC/DC impressed components may be measured separately to eliminate errors inherently produced in such cases.

9. DC current flow polarity may be instantly detected, making the instrument a valuable asset in analyzing unknown or complex circuits.

10. A center-zero function permits DC functions in circuits varying between positive (+) and negative (−) values to be measured directly with the flick of a switch.

11. Thorough overcurrent protection extends to both the clamp sensor and the internal meter circuitry for operator peace of mind and instrument safety.

12. AC plus DC voltage measurement capability makes the instrument valuable as an all-around assistant in power line maintenance and inspection programs.

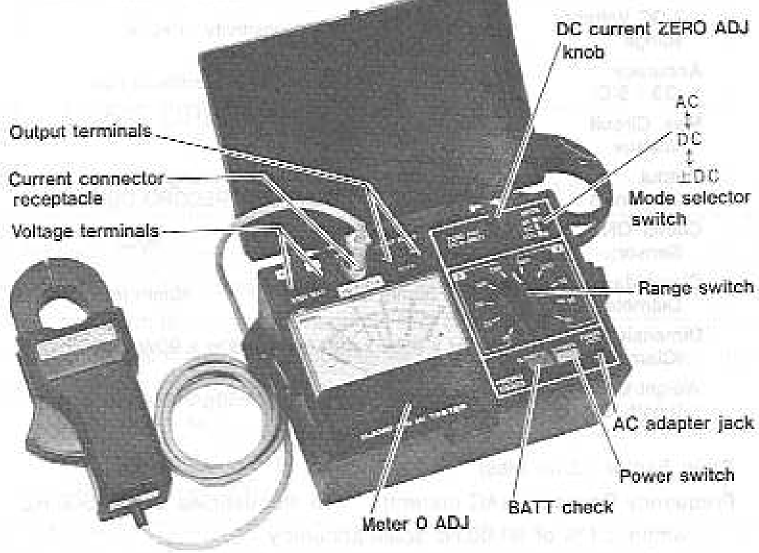
13. Safety-first design. All test lead inputs, voltage and output terminals are designed to minimize the chance of operator contact.

14. Dual-power source method permits the meter to be operated from internal batteries, or by optional AC adapter.

15. The compact, lightweight design of the instrument means that it can be used for field service applications, or wherever measurements are required.

3. INSTRUMENT NOMENCLATURE

(Model 3108 is shown for illustration purposes. The range scale and clamp-on sensor for the Model 3109 is slightly different.)



4. INSTRUMENT SPECIFICATIONS

Model No.	3108	3109
AC/DC Current Range	10, 25, 50, 100, 250A	100, 250, 500, 1000, (2500) A *2000A max.
AC/DC Voltage Range	10, 25, 50, 250, 500V (Sensitivity : 6kΩ/V)	
Accuracy (23±5°C)	±2.5% of FS (1500 ~ 2000A : ±5% of FS)	
Max. Circuit Voltage	500V RMS	
Output Terminals	1V output at full-scale in each range. (DC : MONITOR OUT ; AC : RECORD OUT)	
Clamp-ON Sensor	9001	9002
Clamp Jaw Diameter	30mm max.	46mm max.
Dimensions (Clamp)	175H x 85W x 40D (mm)	180H x 90W x 40D(mm)
Weight/Cable length (Clamp)	600g/2m (approx.)	650g/2m (approx.)

Crest Factor : 3 (or less)

Frequency Responce (AC current) : At frequencies 20 to 500 Hz, within ±1 % of 50/60 Hz scale accuracy.

External Magnetic Field Induced Error (400 A/m)

3108 : Less than 0.1 A equivalent.

3109 : Less than 0.2 A equivalent.

Conductor Positioning : Less than ±1 % at any position.

Induced Error : within the clamp core.

Temperature Characteristics : Less than ±1.5 %, 0~40°C.

Environmental Requirements : −10~50°C, <85 % RH

RMS Readings : Possible using 9143 RMS Adapter Module.

Power Source : Four size C (SUM-2) batteries (continuous life : 36 hours), or AC adapter. (DC6V-300mA)

Power Consumption : 360 mW (approx.)

Dimensions/Weight : 115 H x 200 W x 135 D mm/1.25 kg (approx.)

Accessories Furnished : Clamp-on sensor, 1 ea.; 9083 carrying Case, 1 ea.; 9060 Test Lead-Probe Set, 1 ea.; Instruction manual, 1 ea.; SUM-2 batteries, 4 ea.

Optional Accessories : CT101A Line Splitter; 9143 RMS Adapter Module

5. BASIC OPERATING PRINCIPLE

The basic principle of the clamp-on current sensor is illustrated in Fig. 1-A and B. The clamp-jaw portion consists of a core constructed from high-permeability magnetic materials and a Hall element sensor. Now, if i is considered as the current flowing through the conductor under test, and the opposition presented to magnetic flux flow in the gap cut through the core and sensor element is represented as Rc and Rg respectively, then magnetic flux flow (Φ) across the gap can be calculated as :

$$\Phi = i/(Rg + Rc)$$

Rg : Gap reluctance

Rc : Core reluctance

Magnetic flux density (Bg) can also be derived using the above relationship when the surface area of the gap (Sg) is known. This becomes :

$$Bg = \Phi/Sg = i/(Rc + Rg)\,Sg$$

Now, when a control current Ic is applied to the Hall element, voltage output V_H from the element will become :

$$V_H = K \cdot Ic \cdot Bg = K \cdot Ic \cdot i/(Rg + Rc)\,Sg$$

K : Hall element sensitivity constant

Thus, it is evident that if the reluctance components within the magnetic circuit are linear quantities, then the output voltage produced by the Hall element will be in proportion to the current flow in the conductor. Consequently, DC current measurements may be accurately made simply by amplifying Hall voltage, and do not require further processing. On the other hand, the sinusoidal wave of AC current is passed through a linear detector for modulation prior to activating the meter pointer.

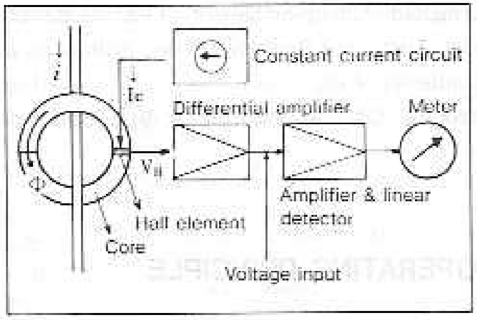


Fig. 1-A 3108 Basic Operating Principle

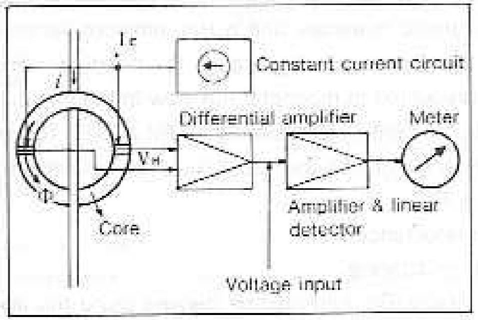
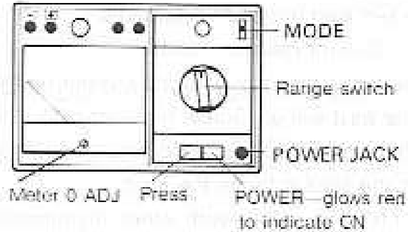


Fig. 1-B 3109 Basic Operating Principle

6. MEASUREMENT PROCEDURE

(Note that the power switch must always be ON prior to attempting a measurement.)

6-1. Preparations



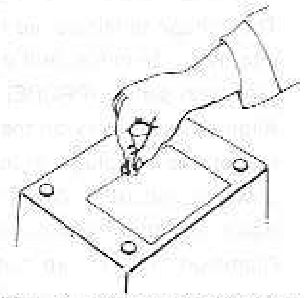


Fig. 2 Battery Replacement

(1) **Zero the meter**

If the instrument is not permanently leveled (e.g., bench-mounted etc.), the pointer will usually not be on "0". Set it to "0" using a screwdriver to turn the METER 0 ADJ screw located at the pointer pivot point.

(2) Press the POWER switch ON (ON will be indicated by the switch glowing red.) Always turn POWER back OFF when the measurement is complete.

Pressing the power switch OFF will sometimes result in the pointer momentarily deflecting to the stop. Note that this is not a malfunction.

(3) Check the condition of the batteries by pressing the BATT check switch. If the pointer rises to or above the BATT OK zone, the batteries are in good condition.

○ If the pointer fails to reach the BATT OK zone, the batteries require replacement. This may be accomplished by using coin to loosen the battery cover screw and replacing the batteries inside, observing the correct pole polarity. The instrument uses four size C (SUM-2) cells. (Refer to Fig. 2)

* Battery check may also be performed while the measurement is in progress by pressing the BATT check switch.

(4) **Connect the cables.**

○ Test lead probes……Voltage measurements

The voltage terminals are marked with + and −. Plug the black lead into the − terminal, and the red lead into the + terminal.

○ Clamp-on sensor (PROBE)……Current measurements

Align the guide key on the sensor connector with the cut-out on the receptacle and plug it in as far as it will go. Screw the connector ring down to secure it. When clamping the sensor over the conductor, make sure that the arrow on the sensor faces the load.

○ Clamp-on sensors are not interchangeable with other instruments (even of the same model). Thus, always make sure you are using the sensor with the same serial number as the instrument.

○ Output terminals (OUTPUT)

Output cables are not provided with the instrument. A standard cable terminated with banana plugs may be used for this purpose. Connect the + terminal to the + input on the recorder or other device, and the − terminal to the − input.

6-2. DC Current Measurement

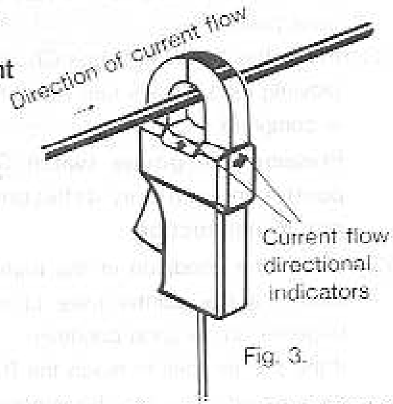


Fig. 3.

(1) Position the mode selector switch to DC or ±DC.

(2) Set the range switch to the range nearest expected circuit current, then zero the pointer by turning the ZERO ADJ knob. (Make certain the clamp jaws are closed when adjusting zero.)

(3) Clamp the sensor over the conductor noting the current direction marks (arrows) embossed on the front and side panels of the clamp. These should be facing with the flow of current, or toward the load. (See Fig. 3.)

6-3. AC Current Measurement

(1) Place the mode selector switch in the AC position.

(2) Set the range switch to the range nearest expected circuit current. (ZERO ADJ is not required here.)

(3) Clamp the sensor over the conductor. (The direction of current flow is inconsequential for AC.)

6-4. DC Voltage Measurement

(1) Position the mode selector switch to DC or ±DC.

(2) Set the range switch to the range nearest expected circuit voltage. (ZERO ADJ is not required here.)

6-5. AC Voltage Measurement

With the exception of setting the range selector switch to AC, measurement procedures follow those listed for DC voltage.

6-6. Output Terminal Connection and Application procedure

The output voltage produced through these terminals is 1V relative to a full-scale meter reading. When the instrument is in the ±DC mode, the output through the + terminal will be +1V/FS, and that through the − terminal −1V/FS. The output terminals function in the RECORD OUT mode for AC mode settings, and in the MONITOR OUT mode for both DC and ±DC mode settings.

Mode (Instrument)	Output Mode	Input Signal	Output Voltage	Frequency Range
AC	Note 1 RECORD OUT	AC	DC 1(V)	20~500Hz
		DC	Note 3	
DC	Note 2 MONITOR OUT	AC	AC 1(V)	DC~500Hz
		DC	DC 1(V)	
±DC	Same	AC	AC 1(V)	DC~500Hz
		DC	DC 1(V)	

Note 1: In RECORD OUT, an AC input is converted to DC output. (See Fig. 4.)

Note 2 :In MONITOR OUT, both AC and DC input are output as a direct waveform. (See Fig. 5.)

Note 3 :When AC and DC signals are impressed, output includes only the DC voltage portion of the AC signal components.

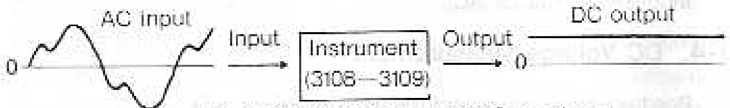


Fig. 4 RECORD OUT Mode Operations

Fig. 5 MONITOR OUT Mode Operations

* When the instrument is in the DC or ±DC mode and an AC input is applied to the output terminals (MONITOR OUT), the measurement value cannot be read from the meter.

- Response rate (time constant) : Approx. 160ms (RECORD OUT)
- Load impedance : Greater than 100-ohms
- Output current : Approx. 10mA (max.)

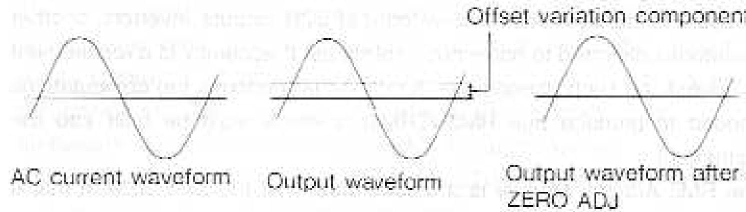
(1) **Recording DC current**

- With the instrument setup for DC current measurements (6-2), 1VDC will be produced through the output terminals for use in driving a recorder or waveform monitor.

(2) **Recording AC current**

- With the instrument setup for AC current measurements (6-3), 1VDC will be produced through the output terminals for use in driving a recorder.
- When monitoring AC current waveforms is desired, place the mode selector switch to DC and monitor the waveform directly. Output level for AC is 1V. (Use an electromagnetic **oscillograph** or high-speed recorder.)

  * Any existing offset variations within the circuit will occur as impressed DC components. This necessitates performing ZERO ADJ prior to the measurement as was done for DC current measurements.



(3) **Recording AC/DC voltage** (Recording voltage is hazardous and should be avoided if not absolutely required.)

- The instrument setup for recording voltage is the same as for measuring voltage. (Refer to 6-4 for DC and 6-5 for AC procedures, and position the mode selector switch to DC for activating MONITOR OUT.) ZERO ADJ is not required for recording AC/DC voltage phenomena.

  * Note that when recording voltage complete circuit isolation between the input side (voltage terminals) and output side (output terminals) does not exist. Consequently, if the circuit under test is floating, or when measuring AC, the hot side is inadvertently connected to the— voltage terminal, it is possible for voltage at the output terminals to reach values approaching the measurement voltage. At higher ranges (i.e., 250, 500V) this presents a serious shock hazard and could destroy the equipment in the setup.
  * Do not apply an external voltage to the output terminals under any circumstances.

6-7. Using the AC adapter

When an AC 100V power supply is available, use of the AC adapter (DC 6V-300mA) is recommended. Plug the AC adapter into the wall socket, then plug the output cable into POWER JACK on the instrument.

6-8. 9143 RMS Adapter Module

The most common method of specifying AC voltage and current is by its root-mean-square (RMS) value. However, most measuring instruments (including clamp-on current meters) are restricted to indicating RMS of average-value rectified current, and this results in serious errors when measurements are made on waveforms of SCR outputs, inverters, or other waveforms distorted to non-sinusoidal shape. If accuracy is a requirement in quantifying such phenomena, a circuit that performs the computations needed to produce true RMS (TRMS) readings must be built into the instrument.

The RMS Adapter Module is a unique feature of the 3108/3109 in that it may be installed as required. This module contains a monolithic IC capable of performing log/antilog computations in converting the measurement to TRMS. It additionally features ideal PN junction rise characteristics, and the temperature stability needed for accurate conversion operations.

Example : Figure 6 shows the magnitude of error resulting when current is measured in a thyristor (SCR) circuit at different phase control (firing) angles.

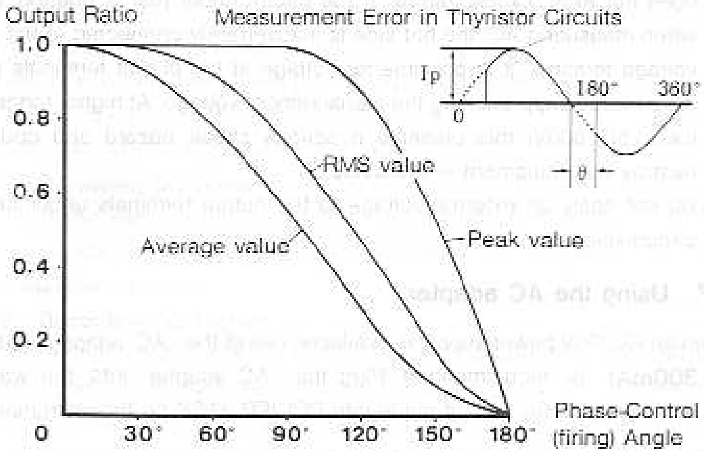


Fig. 6.

Average value : $\frac{1}{\pi}\int_{\theta}^{\pi} Ip \cdot \sin \omega t \; dt$

RMS value : $\sqrt{\frac{1}{\pi}\int_{\theta}^{\pi} (Ip \cdot \sin \omega t)^2 \, dt}$

Peak value : Ip

The above figure clearly illustrates that the difference between RMS value and average value is a function of firing angle Φ. (Note that when firing angle is delayed 90°, the difference (hence, error) between the average-responding and TRMS-responding meter is approximately 30%.)

Instrument specifications using the RMS Adapter Module

◎Response rate (time constant) : Approx. 270ms (RECORD OUT)

◎Load impedance : Greater than 100-ohms

◎Output current : Approx. 10mA (Max)

◎**Crest factor**

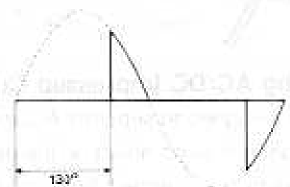
The dynamic range of the meter circuitry is expressed as its crest factor derived from the following equation.

$$\text{Crest factor} = \frac{\text{Peak value}}{\text{Effective value (RMS)}}$$

Thus when measuring phenomena with a high peak value and relatively small effective value (RMS) (e.g., thyristor outputs), selecting the proper range for RMS will likely result the the peak value of the waveform exceeding the dynamic range of the meter circuit. Measurement accuracy will thus be affected, because the portion of the waveform that exceeded the dynamic range will be lost as a computation factor.

Crest factor for the 3108/3109 is 3 (or less), meaning that any waveform whose peak value exceeds its RMS by a factor of 3 will be properly computed.

Example : The measurement of thyristor-control current is an area where crest factors are of concern. Here, crest factors are controlled by the firing angle ; and delays of up to approximately 130° can be handled without exceeding circuit dynamics. If the firing angle delay exceeds this value, switch to the next higher range.



7. NOTES AND PRECAUTIONS

7-1. Measurements in the Presence of Magnetic Fields

When using the instrument in low ranges for DC current measurement, excessively high inputs applied to the sensor core, or approaching a strong magnetic force field will cause the core to become weakly magnetized, resulting in a slight shift of meter zero. This can normally be compensated for by performing ZERO ADJ prior to the measurement, and error should be insignificant.

Note also that ZERO ADJ should always be performed with the clamp jaws closed. If magnetization is present, pointer position will be different for the open and closed position.

Measurements other than for DC current are unaffected by core magnetization. (Refer to Fig. 7.)

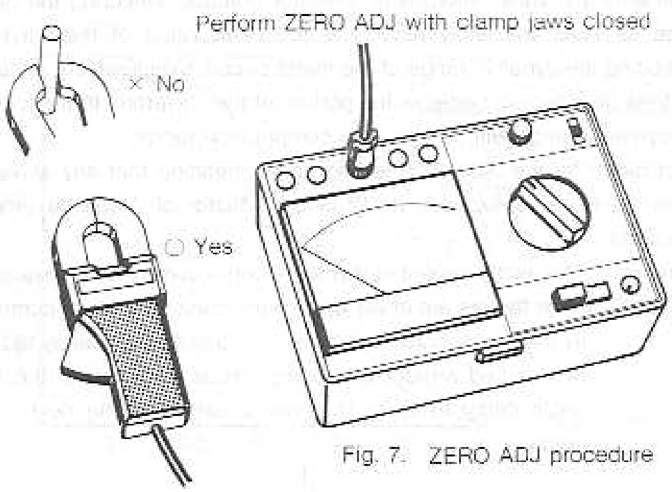
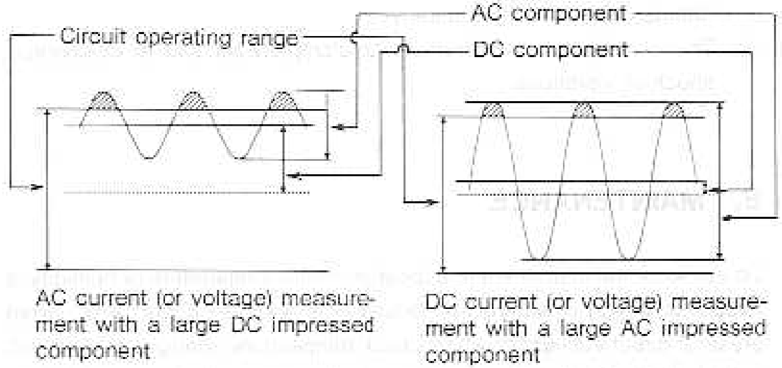


Fig. 7. ZERO ADJ procedure

7-2. Measuring AC/DC Impressed Components

The 3108/3109 is designed to separate AC and DC components so that the unwanted component has no affect on the desired mode of measurement, and in most cases this is effective. Note however, that when the unwanted components are several times greater in magnitude than the measurement mode components (e. g., when attempting to measure DC current and the impressed AC component is several times greater, or vice versa), the operating level of the meter circuitry is likely to be exceeded, resulting in an erroneous reading. When this is the case, the affect of the unwanted component can be eliminated by switching the range selector to the next higher range. (For example, if you are now in the 100A range, switch to the 250A range.)



7-3. Care of the Clamp-on Sensor

The clamp-on sensor consists of a core enclosed in a protective housing made of high-strength, heat-resistant plastic with core ends ground to a precision finish. Do not scratch or otherwise damage the ends of the core. Also, wipe off any dust or dirt accumulation on the ends of the cores with a soft cloth. Rust should not be a problem under normal usage conditions, however, any rust that does accumulate here can be removed by gently sanding with an extremely fine grade of sandpaper.

7-4. Miscellanous (Notes and Precautions)

(1) Always make certain the range setting of the instrument is compatible with the circuit under test. DO NOT OVERLOAD THE METER CIRCUIT.

(2) Ascertain that the maximum circuit voltage or current does not exceed the rating of the instrument prior to setting the meter up.

(3) Observe standard safety precautions while working with electrical equipment to avoid electrical shock to yourself and short-circuiting the instrument. (Note that this precaution is particularly applicable when working with the output terminals.)
(4) Do not use this instrument for high-voltage work, and where possible, avoid working around bare wires even in low-voltage circuits.
(5) Avoid working around transformers or any other large current-carrying power lines. The magnetic field radiated by these sources adversely affects measurement accuracy.
(6) Do not subject the instrument or clamp-on sensors to mechanical shock or vibrations.

8. MAINTENANCE

Do not store the instrument in a location where temperature or humidity is excessively high or where condensation is likely to occur. Also, avoid areas of direct sunlight or where quick temperature changes could result in thermal shock. When the instrument is not going to be used over a long period of time, store it with the batteries removed, and with a light coating of oil applied to the sensor core ends to prevent rust.