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HIOKI

INSTRUCTION MANUAL

3164

DC CLAMP ON POWER Hi TESTER

WARNING

This Instument is designed to prevent accidental shock to the operator when propely used. However, no engineering desigh 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. Product Outline

The 3164 is a clamp-on power meter designed for measuring both AC and DC voltage, current, and power in current-carrying conductors. Construction of the sensor allows the measurement to be made without cutting the power line, or stopping equipment operation.

Two interchangeable clamp-on sensors having different capacity ratings can be used to increase measurement range significantly.

AC voltage and current are quantified using the true rootmean-square method. Consequently, measurements taken in lines having thyristors or other distortion -producing devices are indicated with high accuracy.

A three-channel analog output terminal produces the values for voltage, current, and power simultaneously, and when used in conjunction with the 3172 GP-IB Interface Adapter, the 3164 can be used in a GP-IB automatic measurement system.

2. Features

1. Easy-to-read LED digital display.
   Digital display reduces chances of a reading error.
2. Wide measurement range.
   Two interchangeable clamp-on sensors having different ratings provide an easy means of extending measurement range.
3. Good frequency response.
   Frequency response covers the range between DC and 1kHz with virtually no increase in error.
4. Position of conductor inside clamp core has virtually no affect on accuracy.
5. Affect of external magnetic fields minimal.
   The meter can be used near high current-carrying lines with virtually no affect on accuracy.
6. AC values indicated as true root-mean-square values.
   Internal operation circuits convert measurements to their TRMS value. Measurements of distorted waveforms are accurate.
7. Multi-function output terminals.
   Voltage, current, and power values are output simultaneously. When the mode switch is set to DC, the output terminals can be used for monitoring purposes; when set to AC, recording can be made of voltage, current, and power waveforms, plus the transient phenomena produced by thyristors, inverters, etc.

8. GP-IB compatible.
Used in conjunction with the 3172 GP-IB Interface Adapter, the 3164 can be used in a computer-controlled GP-IB system.

9. ± display function indicates direction of current flow.
Polarity is automatically indicated for DC measurements, making analysis of unknown or complex circuits much easier.

10. Overload input warning.
Warning lamps are coupled to both the voltage and current circuit. Since these lamps only light when an overload is present, they can be used as a guide in setting power measurement range.

11. Protection against overcurrent.
The sensor and internal circuits are constructed to withstand overcurrent input (within reasonable limits).

12. Good portability.
Compact and lightweight design makes the instrument easy to carry where needed.

3. Specifications

Display: 3 ½-digit LED display, with mode, function, and overrange annunciators.

Measurement Functions: AC and DC voltage, current, and power (AC indicated as a true RMS value.)

Measurement Range:	9001-01 sensor	9002-01 sensor
Voltage	50/500V	50/500V
Current	20/200A	20/2000A
Power	2/20/200kW	20/200/1000kW

(Power ranges determined by multiplying rated voltage by the current ranges.)

Accuracy: AC voltage, ±1% rdg ±1 dgt
AC Current, ±1% rdg ±4 dgt
AC power, ±1% rdg ±6 dgt
(Specified for 23°C ±5°C, DC and 50/60Hz, powerfactor of 1.) (Using 9002-01, AC current accuracy specified for up 1500A.)

Frequency Response: Voltage; ±2.0% or better at DC and 20Hz-4kHz.
Current; ±2.0% or better at DC and 20Hz-1kHz.
Power; ±2.0% or better at DC and 20Hz-1kHz, PF=1

Power-Factor Induced Error; Less than ±1% at PF=1 (50/60Hz)

Temperature Characteristics: ±1.5% or better, 0-40°C

Error Induced by Conductor Positioning: Less than ±1% at any position within the clamp jaws.

Error Induced By External Fields:

Sensor \ Ext. field	AC	DC
9001-01 sensor	0.2A	0.2A
9002-01 sensor	0.8A	0.4A

(Field strength of 400A/m.)

Crest Factor: Less than 4 or the peak values listed below.
Voltage: Lo range, 120V; Hi range, 750V
Current: 9001-01 Lo range, 800A; Hi range, 2000A

Allowable Circuit Voltage: <750V peak value.

Output Terminals (Analog): 2V output for 2000-count display.
(Three channels (A, V, W,) output simultaneously, switchable to MONITOR or RECORD output)
Digital control: CMOS level, Hi=5V, Lo=0V.
(BCD, decimal point, function, range)

Power Source: AC 100, 120, 220, 240V ±15%, 50/60Hz, specified at order.

Power Consumption: Approx. 5W.

Affect of Power Source Voltage: Accuracy assured for power source specifications above.

Dimensions/Weight:
3164 unit, 85H × 250W × 220D (mm)/2.2kg (approx)
9001-01, 175H × 85W × 40D, 30mm jaws/600g (approx)
9002-01, 180H × 90W × 40D, 46mm jaws/650g (approx)

Accessories Provided: Voltage cable, 1; Line cord, 1; Midzet fuse (0.3A), 1; carrying case, 1; Instruction manual, 1.

4. Operating Principle

4-1. Power Measurements

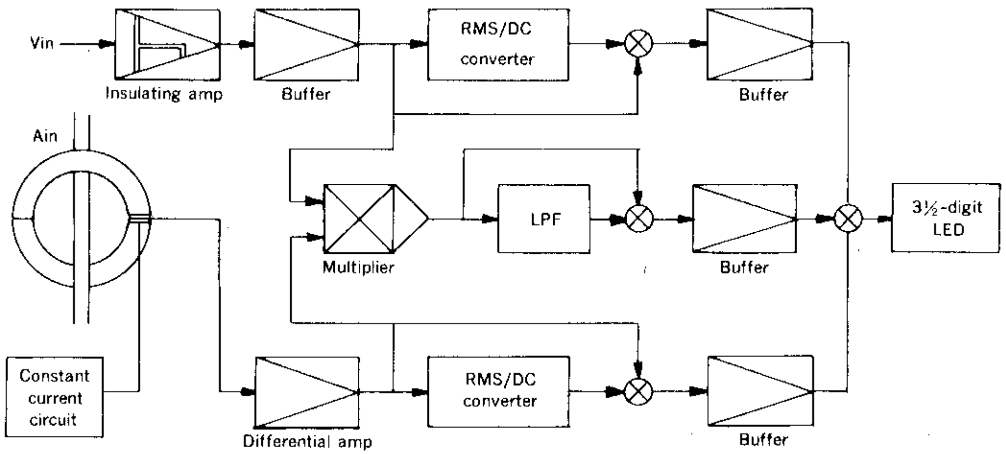
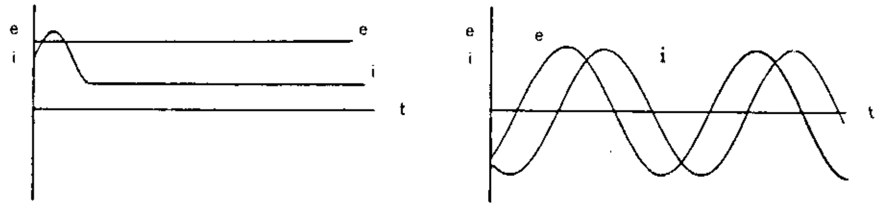


Fig 4-1 Circuit Block Diagram.

Figure 4-1 shows a block diagram of the instrument's major circuits.

- o The voltage input has an isolated primary and secondary due to use of the insolating amp. The frequency response band of the insolating amp extends from DC up to several kilohertz, resulting in good measurement accuracy.
- o For the current input circuit, the special design of the clamp-on sensor insolates the primary from the secondary. Here too, frequency response for the clamp-on sensor extends from DC to several kilohertz for good measurement accuracy. The Hall element drive circuit is built right into the clamp-on sensor, so two interchangeable sensors having different capacity ratings can be used on the same instrument.
- o For power measurements, the use of a wideband multiplier covering frequencies from DC to several kilohertz makes accuracy good in power calculations.

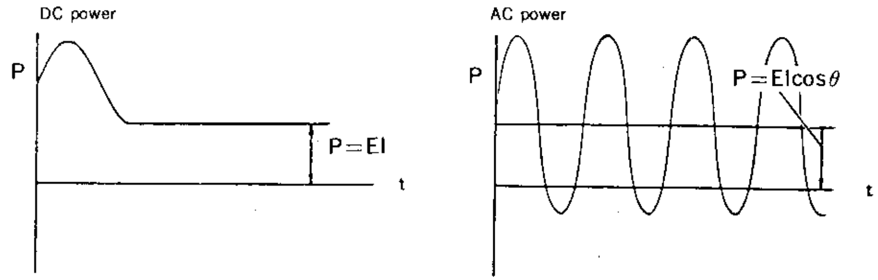
Figure 4-2 shows the calculation for DC and AC power.



DC voltage e = E (V) Sinusoidal voltage $e = \sqrt{2}E \cos\omega t$ (V)

DC current i = I (A) Sinusoidal current $i = \sqrt{2}I \cos(\omega t + \theta)$ (A)

The product of voltage and current (e • i) represents instantaneous power.



Instantaneous power = e • i

Instantaneous powber

$= e \cdot i$

$= 2EI \cos\omega t \cos(\omega t + \theta)$

$= EI \cos(2\omega t + \theta) + EI \cos\theta$ (W)

Therefore, effective (real) power is P = EI (W), the product of voltage and current.

Therefore, effective (real) power is $P = EI\cos\theta$ (W), the DC component of the product of voltage and current.

Fig. 4-2

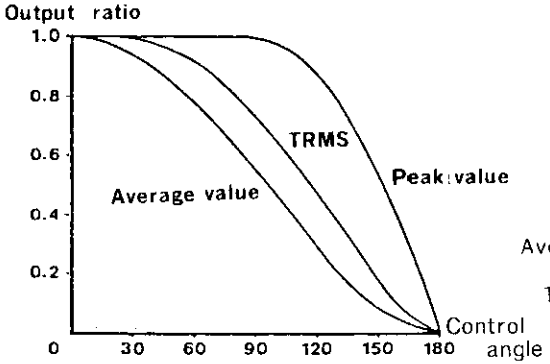
4-2. Voltage and Current Measurements (RMS value)

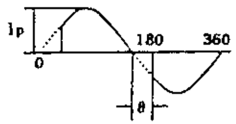
The normal method of specifying amplitude of AC voltage and current is as a RMS (root-mean-square) value. However, until recently, most power meters measured voltage and current by sensing their average values and then converting those values to an equivalent RMS value. This method works for perfect sine waves, but cannot account for irregularities and distortion (typical when SCRs, inverters, etc. are used in the circuit) in the sine wave. In order to obtain good measurement accuracy, the meter must be capable of sensing and calculating true RMS values.

The 3164 uses a special IC that performs the required calculations for measuring the RMS values of AC quantities.

Example: Figure 4-3 shows the difference that would result when using three different method to measure current in a thyristor-Controlled circuit.

Reading error produced by thyristors at different control (firing) angles.





Average value: $\frac{1}{\pi}\int_{\theta}^{\pi} I_p \sin \omega t \, dt$

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

Peak value: I_p

Fig. 4-3

4-3. Crest Factor

The dynamic range of this instrument is expressed as a crest factor.

$$\text{Crest factor} = \frac{\text{Peak value}}{\text{effective value}}$$

When range is set appropriately for effective value of an AC quantity, if there are high peaks (such as those typically occurring in thyristor-controlled circuits) in the waveform, the dynamic range of the circuit will be exceeded. When this occurs, the portion of the waveform that exceeded the dynamic range will be clipped, reducing measurement accuracy.

This instrument can measure a peak value 4 times the RMS value.

Since it is capable of measuring both DC and AC quantities, maximum rating and

circuit dynamic range for each measurement range and for each clamp-on sensor is specified as a peak-value.

Voltage: Lo range, 120V max. Hi range, 750V max.

Current: 9001-01

Lo range, 80A max. Hi range, 500A max.

9002-01

Lo range, 800A max. Hi range, 2000A max.

The overload warning lamps are set to light when the circuit dynamic ranges are exceeded. (For power measurements, range can be lowered to increase resolution as long as the maximum ratings are not exceeded.)

5. Instrument Nomenclature

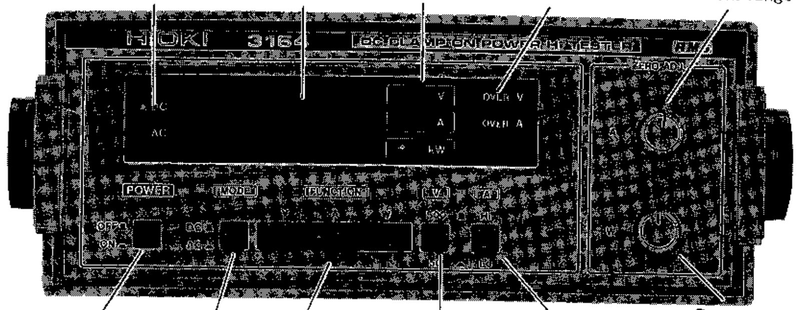


Fig. 5-1 Front Panel

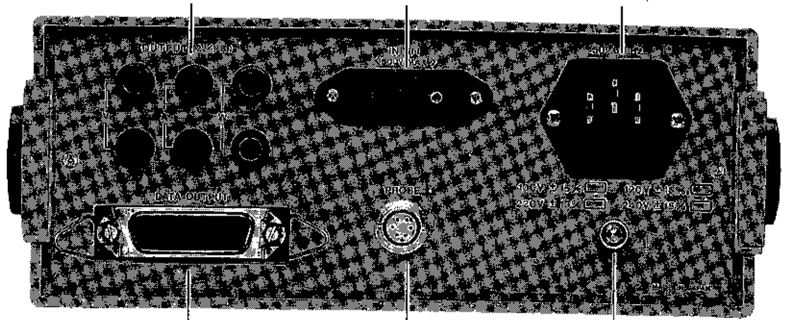


Fig. 5-2 Rear Panel

6. Panel Description

1. Power switch

Always turn the power switch ON before making the measurement setup. Allow approximately 10 minutes warm-up time.

2. Display

3½-digit LED display, maximum reading of "1999" Indicates the measurement value of the function switch pressed. The whole digits go off when the input level exceeds the maximum value.

3. Mode lamp

Indicates AC or DC, depending on mode switch setting.

4. Unit indicator

Lights to indicate function switch setting.

5. Overload input warning lamp

Lights when voltage or current input exceeds circuit dynamic range for the measurement range setting.

6. Mode switch

Selects AC or DC measurements.

7. Function switch

Selects the voltage, current, or power measurement function.

8. Voltage range switch

Sets the voltage measurement range.

9. Current range switch

Sets the current measurement range. (The decimal point is repositioned automatically when the clamp-on sensors are changed.)

10. Current zero adj. knob

Used to zero the meter for DC current measurements.

11. Power zero adj. knob

Used to zero the meter for power measurements.

12. Output terminal

Produces an output of 2V for full-scale (2000-count) display reading. The output terminals are not coupled to the function switch; output is continuous from all three channels.

Do not short-circuit, or apply voltage to these terminals. This can damage the instrument's internal circuits.

13. Voltage input connector

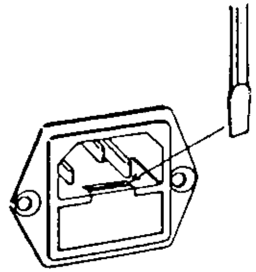
Used to connect the voltage input cable.

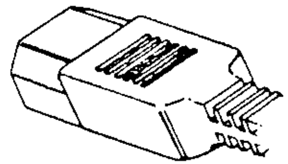
14. Current input connector

Used to connect the 9001-01 or 9002-01 clamp-on sensors.

15. AC inlet

Receptacle used to connect the instrument's power cord. Always use the power cord provided with the instrument. A fuse and line filter are built into the receptacle. The power source voltage that the instrument should be used on is marked underneath the voltage inlet. Do not attempt to use the instrument on other power sources.





1. Disconnect power cord.

2. Remove fuse holder, check and replace blown fuse.

Fuse Repaycement.

16. Ground (earth) terminal

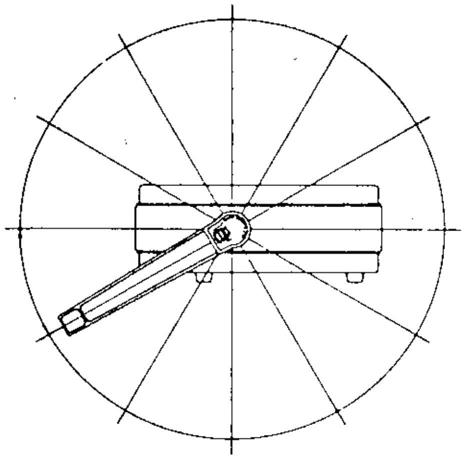
Always connect the ground terminal to a good earth ground to assure operator safety, and proper instrument operation. (This terminal is connected to circuit ground.)

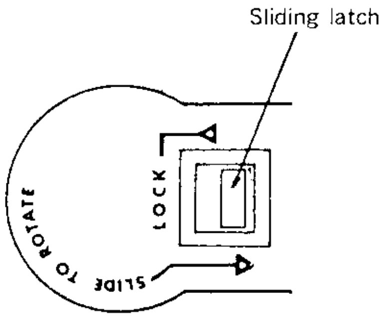
17. Data output connector

Used to connect the HIOKI 3172 GP-IB Interface Adapter cable. Do not connect other instruments to this connector, and do not short-circuit or apply voltage to these connector pins. This can result in internal damage.

18. Handle

To release the handle for turning, slide the latch in the direction of the arrow (marked "SLIDE TO ROTATE"). The handle is free-swinging, with detents located at 30 intervals. When the desired position is located, slide the latch back to the LOCK position. When the handle is being used to prop the instrument up at an angle, do not set heavy objects on, or apply force to the top of the instrument.





7. Operating Proceudre

7-1. Measurement Preparations

Prior to starting the measurement, connect the clamp-on sensor and voltage input cable to the instrument, then turn the power switch ON. Allow approximately 10 minutes (normal temperature) for the instrument to warm-up. (Warm-up time should be adjusted according to ambient temperature.)

7-2. DC Voltage Measurements

(1) Set the mode switch to DC, and the function switch to V.

(2) Set the range switch to 50 or 500V, depending on circuit voltage.
(The red voltage input lead should be connected to the positive, (+) side; the black lead to the negative (−) side.) Zero adj. is not required.

7-3. AC Voltage Measurements

(1) Set the mode switch to AC, and the function switch to V.

(2) Set the range switch to 50 or 500V, depending on circuit voltage.
(Polarity is not involved with AC measurements.) Zero adj. is not required.

7-4. DC Current Measurements

(1) Set the mode switch to DC, and the function switch to A.

(2) Depending on expected circuit current, set the range switch to Hi or Lo, then turn the current zero adj. Knob until the display reads "0000" (Always make sure that the clamp-on sensor jaws are completely closed when adjusting zero.)

(3) Clamp the sensor over the conductor with the current flow direction arrow marked on the clamp panel point ing in the direction of current flow.

Note: Perform zero adjustment periodically if the instrument is used for a long time.

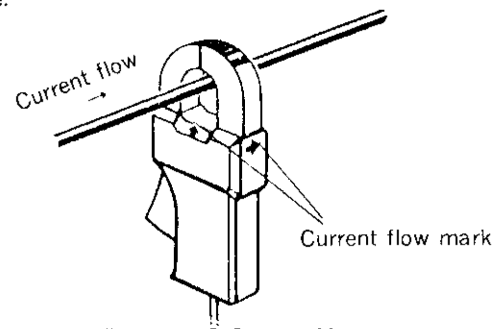


Fig 7-4 DC Current Measurment.

7-5. AC Current Measurements

(1) Set the mode switch to AC, and the function switch to A.

(2) Depending on expected circuit current, set the range switch to Hi or Lo.
(Adjusting zero is not required for AC current measurements.)

(3) Clamp the sensor over the current-carrying conductor. (The direction of the clamp makes no difference in this case.)

7-6. DC Power Measurements

(1) Set the mode switch to DC.

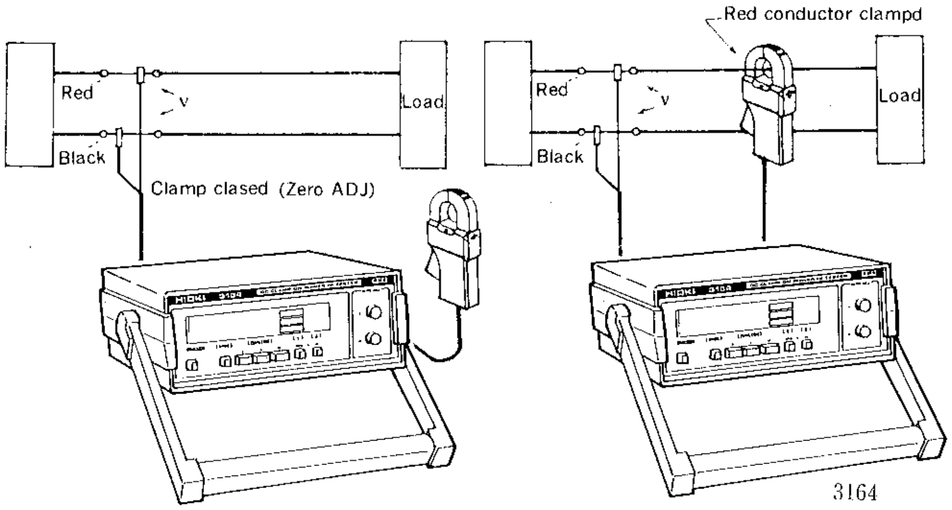
(2) Taking into account circuit voltage and current, set the A and V range switches accordingly. (This automatically establishes proper power range.)

(3) Set the function switch to A, and turn the current zero adj. knob until the display reads "0000".

(4) Next, set the function switch to W, and connect the voltage input cable to the circuit under test. (Connect the red lead to the positive (+) side; and the black lead to the negative (−) side of the circuit.)
In this condition (with voltage input to the meter), turn the power zero adj. knob until the display reads "0000"

(5) After this adjustment is complete, clamp the clamp-on sensor over the conductor that the red voltage input lead is connected to. (Make sure that the current flow direction mark on the sensor points toward the load.)

Note: Perform zero adjustment periodically if the instrument is used for a long time.



(1)ZERO ADJ procedure (2)Power measurment

Fig 7-6 DC Power Measurment.

7-7. AC Current Measurements

(1) Set the mode switch to AC.

(2) Taking into account circuit voltage and current, set the A and V range switches accordingly. (This automatically establishes proper power range.)

(3) Next, set the function switch to W, and connect the voltage input cable to the circuit under test. In this condition (with voltage input to the meter), turn the power zero adj. knob until the display reads "0000". (For AC power measurements, adjusting zero for current is not required.)

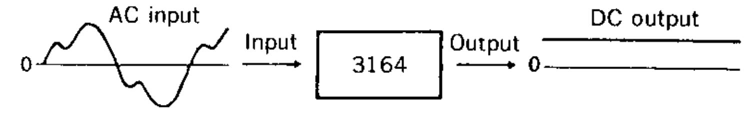
(4) After this adjustment is complete, clamp the clamp-on sensor over the conductor that the red voltage input lead is connected to. (Make sure that the current flow direction mark on the sensor points toward the load.)

Note: Perform zero adjustment periodically if the instrument is used for a long time.

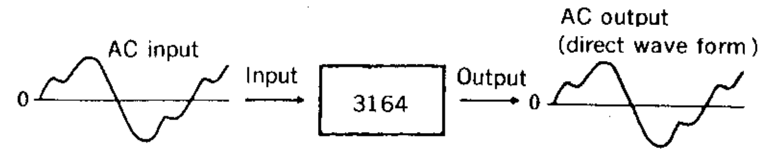
7-8. Using the Output Terminals

The output terminals on this instrument have two settings depending on the purpose for which output is going to be used. The AC setting is for RECORDER OUTPUT, and the DC setting is for MONITOR OUTPUT.

Mode	Output Configuration	Input Signal	Output Voltage	Applicable Frepuency
AC	*Note 1 RECORD OUT	AC	DC 2V	20Hz~
		DC	*Note 3	
DC	*Note 2 MONITOR OUT	AC	AC 2V	DC~
		DC	DC 2V	



Recora out mode.



Monitor out mode

Note 1: In RECORD OUT, the AC input is converted to DC for output.

Note 2: In MONITOR OUT, the AC or DC input is output without modification.

Note 3: When an AC component is riding on the DC signal, only the AC portion is converted to DC for output.

* When using the DC mode and MONITOR OUT combination for an AC input, the measurement value cannot be taken from the instrument display.

- ○ Response speed (time-constant): Approx. 170ms for power in RECORD OUT setting. Approx. 110ms for voltage or current in RECORD OUT setting.
- ○ Load impedance: >200Ω
- ○ Output current: 10mA max.

(1) Recording DC quantities.

- ○ When recording DC voltage, current, or power quantities, set the mode switch to DC and connect the recorder to the output terminals. Full-scale output level will be DC 2V. (Recording and waveform monitoring is possible.)

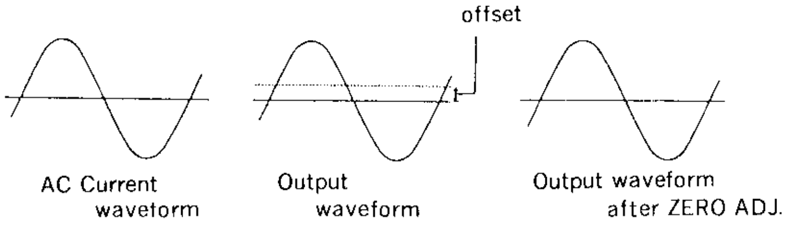
(2) Recording AC quantities.

- ○ When recording AC voltage, current, or power quantities, set the mode switch to AC and connect the recorder to the output terminals. Full-scale output level will be DC 2V.

  (Only recording is possible.)

○ To monitor an AC voltage, current, or power waveform, set the mode switch to DC, and the waveform can be monitored directly. Output level will be AC 2V. (Recording possible using a high-speed recorder, etc.)

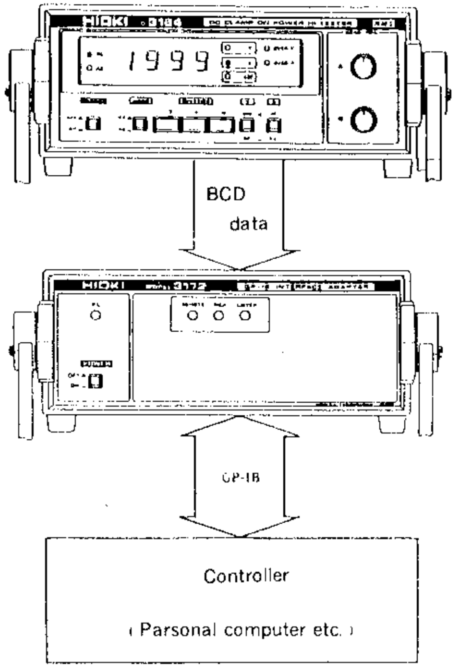
* Circuit offset or other factors may appear impressed on the AC signal as a DC component. In such cases, adjust zero as described for DC measurements.



Note: Perform zero adjustment periodically when recording in the DC mode.

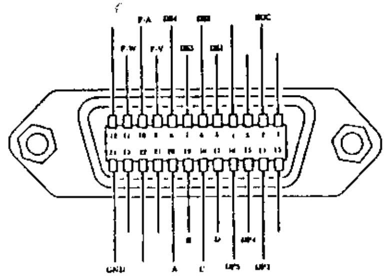
7-9. GP-IB Interface Adapter

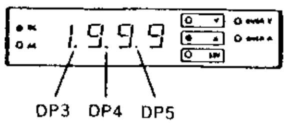
This instrument can be connected to the HIOKI 3172 interface Adapter for use in a GP-IB automated measurement system. (Mode, function, and range settings cannot be made from the controller however.)



7-10. Data Output Connector

The DATA OUTPUT connector pin allocation is illustrated below. The table gives further information on the output signals.



Pin No.	Signal	Function
1.		Unit symbol signal. Set Hi level (+5V).
2.	EOC	End Of Conversion. Output as a 7μs pulse at the end of each conversion cycle.
3.		
4.		
5. 6. 7. 8.	DS1 DS2 DS3 DS4	Digit Select 1～4. Output as a 270μs pulse when the corresponding digit is selected. The timing for EOC and DS1～4 is shown in Fig. 1.
9. 10. 11.	F-V F-A F-W	Function V, A and W. Output as a Hi level (+5V) when the corresponding function is selected on the front panel. Unselected functions remain Lo level (0V).
12.		
13.		
14. 15. 16.	DP3 DP4 DP5	Decimal Point 3～5. Output as a Hi level (+5V) When the display decimal point in the corresponding position is lighted. Remains Lo level (0V) when the decimal point is extinguished. 

Pin No.	Signal	Function
17. 18. 19. 20.	D C B A	BCD data. Output synchronized with DS1～4.
21.		
22.		
23.		
24.	GND	Connected to circuit common.

* Polarity, underrange, and overrange are output to the MSD position when DS1 is active. Coding is as follows.

MSD	D	C	B	A	BCD → 7-segment conversion
+0	1	1	1	0	Blank
−0	1	0	1	0	Blank
+0 UR	1	1	1	1	Blank
−0 UR	1	0	1	1	Blank
+1	0	1	0	0	4-1
−1	0	0	0	0	0-1
−1 OR	0	0	0	0	7-1
−1 OR	0	0	1	1	3-1

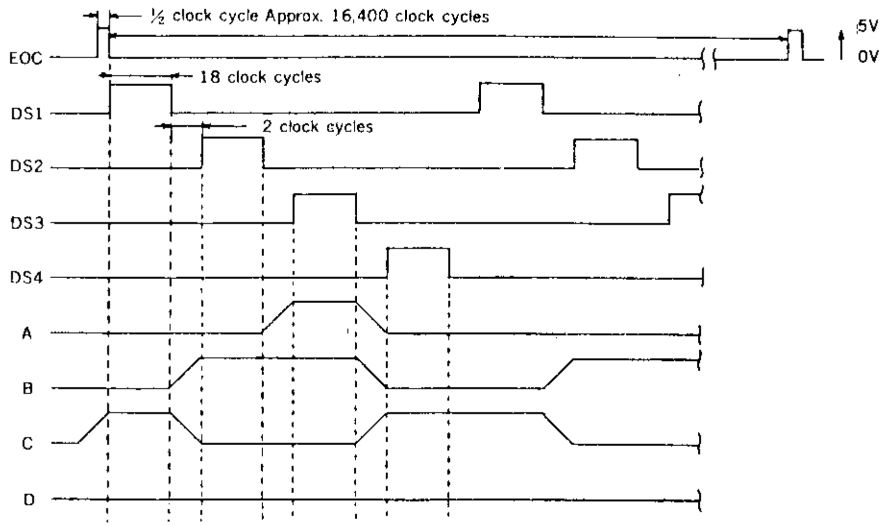
Notes:

D: Hi level when MSD is "0"; Lo level when "1".

C: Hi level when polarity is "+"; Lo level when "-".

UR: Underrange when display is 180 counts or less.

OR: Overrange when display count exceeds 1999.



F-W and DP5 are Hi level (+5V)

F-V, F-A, DP3 and DP4 are Lo level (0V).

1 clock cycle=15μs (approx)

1 conversion=0.4 sec. (approx)

* The data output signals are CMOS level (Hi=5V, Lo=0V). Interfaces using other levels (CMOS, TTL, etc.) should not bf used.

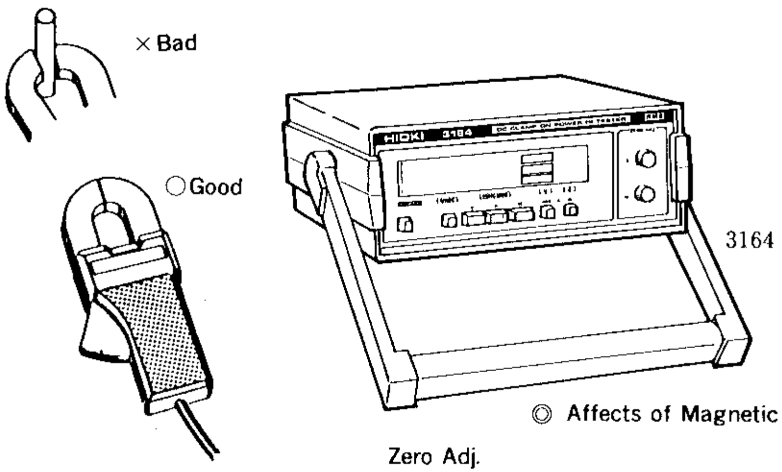
Timing Chart (Illustrated in power range, for 123.4kW output.)

8. Precautions

8-1. The affects of Magnetic Fields

When measuring DC current in the Lo range, applying an overload input to the clamp-on sensor core, or using the sensor in the vicinity of strong magnetic fields can slightly magnetize the core causing the zero point to move off by a few counts in the display. This can normally be corrected by adjusting zero prior to a measurement. Core magnetization will also cause an error if zero is adjusted with the clamp jaws open. Always make sure that the clamp jaws are completely closed when adjusting zero.

(Magnetic fields do not affect measurements other than DC current.)



◎ Affects of Magnetic Fields

Zero Adj.

8-2. Handling the Clamp-on Sensors

The clamp-on sensor is enclosed in a shock resistant, heat resistant plastic housing to protect the core. However, the bare metal surfaces at the jaw opening are precision-ground, and should be handled careful in order to maintain measuring accuracy. Keep these surfaces free of dust and dirt by occasionally wiping them with a soft cloth. Rust should not normally be a problem, but if these surfaces do corrode, sand them carefully with fine-grit sandpaper.

8-3. Zero Adjustment

This instrument uses a Hall device in the current detector. Zero point, however, will shift due to change in environment conditions such as temperature and time elapse. Perform zero adjustment periodically. Further, whenever changing the range, do zero adjustment.

8-4. Other Precautions

(1) Always double-check the range setting prior to taking a measurement. Be careful not to overload the meter.
(2) Do not exceed voltage or current input ratings.
(3) Always work carefully to avoid electrical shock, or short-circuits.
(4) Do not use the instrument in high-voltage circuits. Also, because of the danger involved, do not clamp the sensor over bare conductors if it can be avoided.

(5) The external magnetic fields produced by transformers and high current -carrying circuits will adversely affect measurement accuracy. Such conditions should be avoided where possible.
(6) Do not subject the instrument or the clamp-on sensors to severe shocks and vibration.

9. Maintenance

Avoidstoring the instrument in higt temperature or high humidity locations, and avoid areas where quick temperature changes might cause condensation. Do not store the unit in direct sunlight, or other areas where it may be subjected to thermal shock.

Apply a light film of oil on the bare metal surfaces of the clamp-on sensor before storage.