HIOKI

INSTRUCTION MANUAL

3161·62

CLAMP ON POWER HiTESTER

HIOKI E.E. CORPORATION

Contents

Introduction

Thank you for purchasing this HIOKI "3161·3162 CLAMP ON POWER HiTESTER." To get the maximum performance from the unit, please read this manual first, and keep this at hand.

Inspection

When the unit is delivered, check and make sure that it has not been damaged in transit. In particular, check the accessories, panel switches, and connectors. If the unit is damaged, or fails to operate according to the specifications, contact your dealer or HIOKI representative.

Accessory

Instruction Manual	1
9082 CARRYING CASE	1
9003 CLAMP SENSOR (for 3161)	2
9002 CLAMP SENSOR (for 3162)	2
9092 LINE CORD	1
Fuse 0.3 A/250 V (20 mm × 5.2 mm dia.)	1

Safety Notes

- **To avoid short circuits and accidents that could result in injury or death, use clamp testers only with power lines carrying 500 Vrms or less.**
- **To avoid short circuits and accidents that could result in injury or death, when the tips of jaws are open, do not use on bare conductors.**

Safety symbols

This Instruction Manual provides information and warnings essential for operating this equipment in a safe manner and for maintaining it in safe operating condition. Before using this equipment, be sure to carefully read the following safety notes.

⚠	In the manual, this mark indicates explanations which it is particularly important that the user read before using the equipment.
⏚	Indicates a grounding terminal.

The following symbols are used in this Instruction Manual to indicate the relative importance of cautions and warnings.

⚠ DANGER	Indicates that incorrect operation presents extreme danger of accident resulting in death or serious injury to the user.
⚠ WARNING	Indicates that incorrect operation presents significant danger of accident resulting in death or serious injury to the user.
⚠ CAUTION	Indicates that incorrect operation presents possibility of injury to the user or damage to the equipment.
NOTE	Denotes items of advice related to performance of the equipment or to its correct operation.

Notes on Use

In order to ensure safe operation and to obtain maximum performance from the unit, observe the cautions listed below.

⚠ DANGER

- **Always connect the voltage cable to the secondary side of a breaker. On the secondary side of a breaker, even if the lines are shorted the breaker can trip and prevent an accident. On the primary side, however, the current capacity may be large, and in the event of a short-circuit there may be a serious accident.**
- **When connecting, if the end of a clip of voltage cable or a clamp on sensor touch the two wires together, a short-circuit accident or a serious accident will result.**
- **This unit cannot be used on voltage lines of 500 Vrms. If the voltage exceeds 500 VAC, a short-circuit accident or an electrocution accident will result.**

⚠WARNING

- **When working with live circuits, take all suitable precautions against accidents, including the use of electrical safety gear such as rubber gloves, rubber boots, and safety helmets.**
- **In order to maintain safety and assure the stable operating performance of this unit, be sure to connect the ground terminal to a proper ground.**

⚠CAUTION

- Before using the unit, make sure that the sheathing on the leads is not damaged and that no bare wire is exposed. If there is damage, using the unit could cause electric shock. Contact your dealer or HIOKI representative.
- When the power is turned off, do not apply voltage or current to the voltage cable connector or clamp sensor. Doing so may damage the unit.
- To avoid damage to the unit, do not short the output terminal and do not input voltage to the output terminal.
- Before measurement, check the position of the range switch. The unit may be damaged if current or voltage at levels in excess of the measurement limit is applied for a long time.
- Do not store or use the unit where it will be exposed to direct sunlight, high temperatures, high humidity, or condensation. If exposed to such conditions, the unit may be damaged, the insulation may deteriorate, and the unit may no longer satisfy its specifications.
- To avoid damage to the unit, do not subject the equipment to vibrations or shocks during transport or handling. Be especially careful to avoid dropping the equipment.
- Dirt on the split face of the clamp-on sensor may affect measurement. Clean it off by wiping lightly with a soft cloth.

NOTE

- Accurate measurement may be impossible in locations subject to strong external magnetic fields, such as transformers and high-current conductors, or in locations subject to strong external electric fields, such as radio transmission equipment.

- After the start switch is depressed to start integration, do not change the function or range settings. If any of the switches are inadvertently pressed, the data will be completely inaccurate, necessitating a restart.
- The basic operating principle of the integrator prohibits operations with negative voltage values. Check the power meter display and make sure it does not have a minus sign in it prior to starting integration of power consumption or taking mean power readings.
- This instrument may not be used to obtain power consumption measurements for commercial purposes.

Chapter 1 Overview

1.1 Introduction

The HIOKI 3161, 3162 CLAMP ON POWER HiTESTER is a small, lightweight instrument designed to measure single or 3-phase active power, or 3-phase reactive power in current-carrying conductors.

The built-in integrator allows the measurement of power consumed over a period of time controlled by the operator. The use of clamp on sensors means that test set-ups may be made with the system circuit fully energized.

An additional feature gained through the use of the integrator is the ability to take an average reading of power consumed over a 36 second interval. This value is output to a static display-completely eliminating the difficult-to-read, rolling display typical of most wattmeters or power meters used where power line fluctuations are severe. Integration time control may also be accomplished through an external control terminal. Thus, integration may be stopped at any time determined to be most effective for system operation. A data output connector and output terminal are provided on the rear panel for system expansion. A printer or recorder may be connected either now or in the future for more complete data collection.

1.2 Features

(1) No need to interrupt equipment operation-set-up may be made and clamp on sensor used on current-carrying conductors.

(2) Power (or current) is accurately measured using a special clamp on sensor developed by HIOKI. The clamp sensor circuit is constructed using high-permeability magnetic materials and a Hall element. This method of construction results in superior circuit linearity and minimizes measurement errors caused by the clamp core to circuit wire positioning relationship.

(3) The two wattmeter method assures that active power can be accurately measured even in unbalanced circuits. Power measurements conform closely to theoretical values, and measurement fidelity is maintained even in circuits containing higher harmonics.

(4) The measurement value is continually transmitted through the OUTPUT terminal (2 V/f.s.), allowing the use of a recorder for obtaining hard-copy data for record keeping purposes.

(5) Integration operations may be controlled externally, allowing the operator to vary the integrating time for power measurements.

(6) The average-reading power measurement feature provides a static display even where power line fluctuations are severe.

(7) Decimal point positioning is controlled by the RANGE switch. Measurements may be read direct-eliminating scale factoring or other calculations normally required.

(8) The power meter section is equipped with a 3-1/2 digits LCD, and the integrator uses a 6 digits LCD.

(9) The instrument may be operated using an AC adapter, or on batteries(four R14P dry batteries).

(10) The 3171 DIGITAL PRINTER (option) may be connected through the data output connector for obtaining printed copy records of integration results.

(11) The built-in battery back-up function assures continuous system operation in the event of power failure.

(12) The instrument is compact and lightweight for maximum mobility.

Chapter 2
Specifications

Display	Power meter Integrator	3-1/2 digits LCD 6 digits LCD
Measurement Functions	Power meter Integrator	Single/3-phase active power; 3-phase reactive power Integrated power (Wh); mean power
Active power range	Power meter Integrator	20/200 kW (3161) 200/1000 kW (3162) $10^{2,4}/10^{3,5}$ kWh (3161) $10^{3,5}/10^{4,6}$ kWh (3162)
Reactive power range	Power meter Integrator	20/200 kvar (3161) 200/1000 kvar (3162) $10^{2,4}/10^{3,5}$ kvarh (3161) $10^{3,5}/10^{4,6}$ kvarh (3162)
Accuracy (at 23±5℃)	Power meter Integrator	±1.0% rdg.±0.5%f.s. (cos ϕ or sin ϕ=1) ±1.0% rdg.±1 dgt. (at 2.5 to 120%f.s.)
Frequency response	Power meter	within±3%, 40 to 500 Hz (cos ϕ =1)
Power-factor induced error	Power meter	Less than ±3% rdg. (cos ϕ =0.5)
Temperature induced error	Power meter Integrator	Within±3%, 0 to 40℃ Within±2% (at f.s.), 0 to 40℃
Logic level External control terminal	Integrator	OFF open circuit (or Hi: 6 V) ON short circuit (or Lo: 0 V)
Data output	Integrator	Hi: 6 V, Lo: 0 V, CMOS logic
Mean power sampling interval	Integrator	36±0.1 s
Conductor positioning error	Within ±1% at any conductor position within the sensor core	
Maximum lead dimensions	9003: 30 mm dia. (for 3161) 9002: 46 mm dia. (for 3162)	

Output terminal voltage	2 V at maximum indicated value
Maximum input voltage	500 Vrms
Current rating	500 Arms (3161) 1000 Arms (3162)
Dielectric strength	2 kVAC/min between input terminal and case
Power source	AC adapter (6 V, 300 mA), four R14P dry batteries (life: approx. 48 hours)
Battery voltage induced error	Within specified accuracy until BATT mark displayed (approx. 4 V)
Dimensions/Mass Main unit Clamp on sensors	 218(W) × 85(H) × 240(D) mm, approx. 2 kg 9003: 85(W) × 175(H) × 40(D) mm, 600 g (for 3161) 9002: 90(W) × 190(H) × 40(D) mm, 650 g (for 3162)
Test lead length	3 m
Accessories	9082 CARRYING CASE ×1 9092 LINE CORD ×1 9003 (for 3161) or 9002 (for 3162) CLAMP ON SENSOR ×2 Instruction Manual ×1 Fuse 0.3 A/250 V (arc quenching 20 mm×5.2 mm dia.) ×1
Options	3171 DIGITAL PRINTER (with carrying case) 9290 CLAMP ON ADAPTER (1500 AACmax) 9149 CARRYING CASE

Chapter 3
Operating Principle

3.1 Clamp Sensor

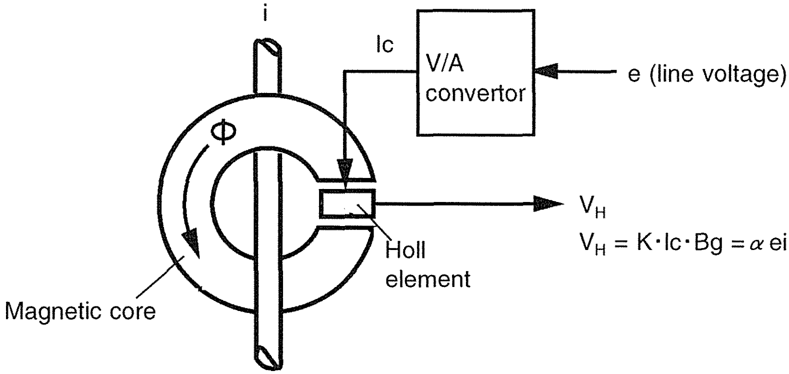


Figure 3.1-1 Clamp on Sensor Core

Figure 3.1-1 shows a diagram used to illustrate the basic operating principle of the clamp on sensors. The clamp portion of the sensor consists of a core constructed of high-permeability magnetic materials and a Hall element. In Figure 3.1-1, where the current flowing through the conductor under test is represented by i, the magnetic flux density at the gap which is Bg is calculated by

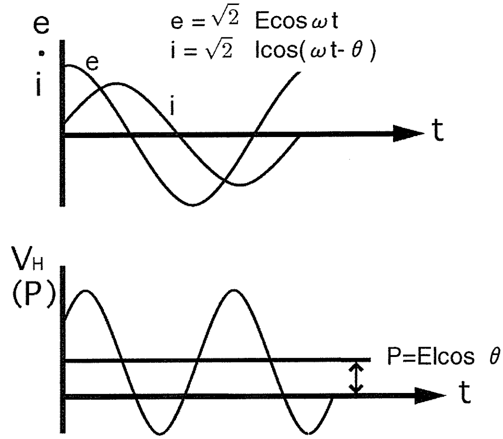
$$Bg = i/\{(Rg + Rc)Sg\} \quad [Wb/m^2] \quad \cdots\cdots ①$$

Rg: gap reluctance
Rc: core reluctance
Sg: cross-sectional area of gap

Now, if a control current I_C is applied to the Hall element, then the output voltage V_H of the Hall element will be expressed by

$$V_H = K\cdot Ic\cdot Bg = K\cdot i\cdot Ic\{(Rg + Rc)Sg\}\ [V] \cdots\cdots ②$$

K: sensitivity of hall element



P=e·i=EIcos θ + EIcos(2ωt- θ)

Figure 3.1-2 Power Calculation Waveform

Thus, in power measurements where voltage between the neutral and current-carrying conductor is expressed by $e = \quad E\cos\omega t$, and line current by $i = \quad I\cos(\omega t - \theta)$ (shown in Figure 3.1-2), and a control current IC is applied to the Hall element output voltage V_H will conform to equation ②, and will be expressed as follows.

$$V_H \propto K\cdot Ic\cdot i = \alpha ei$$
$$= 2\alpha EI \cos\omega t\cos(\omega t - \theta)$$
$$= \alpha\{EI \cos\theta + EI\cos(2\omega t - \theta) \cdots\cdots ③$$

α : constant

Thus, the DC components of the Hall voltage V_H (derived in Equation ③) is equivalent to active power.

3.2 Active Power (Watt)

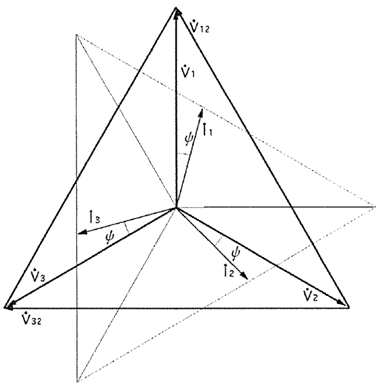
A block diagram of the various circuits making up the 3161 is shown in Figure 3.2-1. A control current is supplied to the Hall element of each sensor relative to the voltage between the neutral and current-carrying conductor(s) of the circuit under test. Hall voltage (V_H) is output in accordance with equation ③.

In single-phase measurements (using only one channel), the DC component of the Hall voltage output is amplified and output to the 3-1/2 digits LCD as single-phase active power.

For 3-phase (3-wire) measurements, the DC components of the Hall voltage output from each sensor are amplified, then combined in an add. The sum is output to the LCD as 3-phase active power. In a symmetrically balanced circuit as shown in the figure below, the following equation applies.

$$P_1 = V_{12} I_1 \cos(\pi/6 + \psi)$$
$$P_2 = V_{32} I_3 \cos(\pi/6 - \psi)$$
$$P_{3\phi} = P_1 + P_2 = 3VI\cos\psi \quad \cdots\cdots ④$$

V: phase voltage
I: phase current



Thus, 3-phase active power measurements are accurate whether the power source is symmetrical or asymmetrical, or whether the load is balanced or unbalanced.

3-phase Effective Power

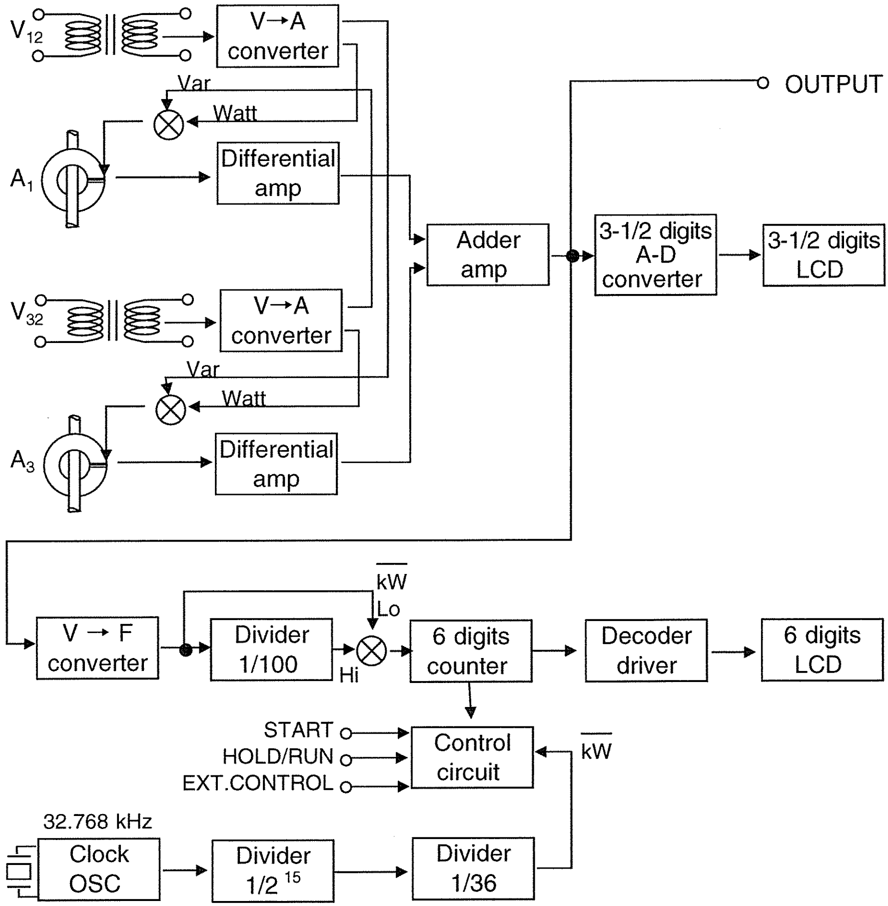


Figure 3.2-1 Block Diagram

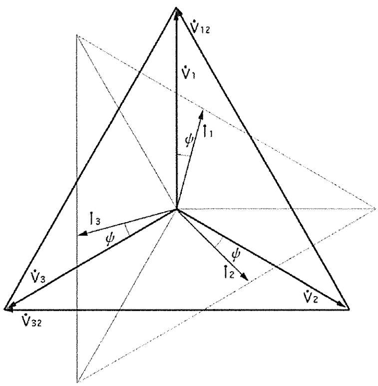
3.3 3-phase Reactive Power (var)

The internal processing circuitry of the meter multiplies the voltage obtained between the neutral and each current-carrying conductor by$\sqrt{3}/2$, then supplies a control current proportional to$\sqrt{3}/2\ V_{12}$ to the Hall element of the A_3 sensor and proportional to $-\sqrt{3}\ /2V_{32}$ to the Hall element of the A_1 sensor.
3-phase reactive power is the sum of output voltage of the two Hall elements.
In a symmetrically balanced circuit as shown in the figure below, equation below applies.

In 3-phase reactive power measurements, if the power source is symmetrical, then measurements will be accurate even though the load is unbalanced.

$$
\begin{aligned}
Q_3\phi &= \sqrt{3}/2V_{12}I_3\cos(\pi/2-\psi) - \sqrt{3}/2V_{32}I_1\cos(\pi/2+\psi) \\
&= \sqrt{3}/2V_{12}I_3\sin\psi + \sqrt{3}/2V_{32}I_1\sin\psi \\
&= 3VI\sin\psi \quad \cdots\cdots \text{⑤}
\end{aligned}
$$

V: phase voltage
I: phase current



$$
\begin{aligned}
P_1 &= V_{12}\ I_1\ \cos(\pi/6+\psi) \\
P_2 &= V_{32}\ I_3\ \cos(\pi/6-\psi) \\
V_{12} &= V_{32} = \sqrt{3}V \\
I_1 &= I_3 = I \\
P_3\phi &= P_1 + P_2 = 3VI\cos\psi \\
Q_3\phi &= \sqrt{3}/2\{V_{12}I_3\ \cos(\pi/2-\psi) - V_{32}I_1\ \cos(\pi/2+\psi)\} \\
&= 3VI\sin\psi
\end{aligned}
$$

3-phase Active Power

3.4 Integrated Power (kWh)

Total integrated power is obtained by applying a voltage proportional to the power measurement output of the power meter section to a V-F converter. A frequency equivalent of the voltage is obtained, and the resulting frequency pulse count represents the total power consumed over a given period of time.

The two conversion proportional constants α [V/kW] and β [Hz/V] are multiplied by the two variables, x [kW] and T [s] to obtain integrator output.

x [kW] $\times$ α [V/kW] $\times$ β [Hz/V] $\times$ T [s] count ······ ⑥

Output voltage of the power meter section of the instrument is determined by the range used. Thus,

α = 0.01 [V/kW] ········ 200 (1000) kW range
= 0.1 [V/kW] ·········· 20 (200) kW range ( ): 3162

and constant β [Hz/V] is determined to be 27.777....

Additionally, since the decimal point is positioned automatically by the power meter range switch, the count can be read directly off the LCD as kWh units of integrated power. For example, if an average of 13 kW of power were integrated for one hour in the 20 kW range, the count would be calculated as,

$13 \times 0.1 \times 27.777... \times 60 \times 60 = 129999.99...$ count

and the decimal point positioning would be determined by the RANGE switch and RANGE (kWh) switch (Lo) combination to be behind the second digit (to the right of the MSD) of the LCD, resulting in a direct read-out of 12.9999 kWh (i.e.; 13.0000 kWh).

If a means by which the count could be divided were not provided on the integrator, inputs to the power meter approaching full scale values would cause the 6 digits counter to overflow in a short period of time (approx. 5 hours). Consequently, the RANGE (kWh) switch divides the output of the V-F converter by 100; count becoming 1/100th of the actual number of pulses. Thus integration of full scale input may continue for up to 500 hours. In this range, the decimal point is automatically shifted two places to the right, and in the example provided on the previous page, if set to Hi, the reading would be 0012.99 kWh.

Total power consumption is balanced with a function of time. Thus, to accurately measure power consumption over a given period of time, some means must be provided to control integration time. The 3161 uses a manually operated HOLD/ON switch and an external terminal for automatic operations.

3.5 Mean Power (kW)

Where power line fluctuations are severe, it is usually very difficult to obtain a reading from the rolling display. Hold switches are sometimes provided, but the instantaneous value held by the switch is often grossly in error when trying to obtain an average reading. The 3161 uses the integration feature described above for accurate mean power readings.

The rapid response of the V-F converter to voltage input proportional to instantaneous power is used to form a pulse train accurately proportional to that instantaneous power value. Those pulses are counted (as in normal integration operation) over a set period of time.

Extracting the desired time-frame from integration operations provides a simple method by which mean power may be measured.

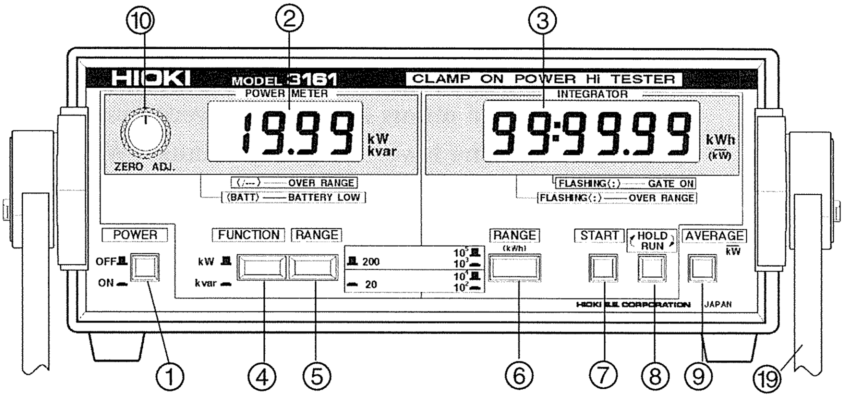
The 3161 uses the kWh reading of the INTEGRATOR display, thereby eliminating any scale factoring or other calculations. One hour contains 3600 seconds, and the mean power count runs for 36 seconds; mean power is displayed directly with the decimal point correctly positioned.

A simple example would be the averaging of power over a 36 s interval in the 20 kW range where for the first 18 seconds the power line was constant at 14.00 kW and the last 18 seconds was constant at 15.00 kW. Here, the count value conforms with Equation. (6) as,

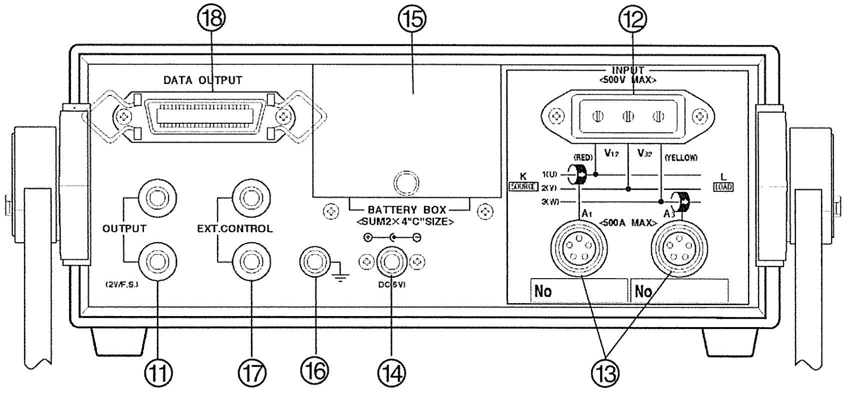
$$14 \times 0.1 \times 27.777 \times 18 + 15 \times 0.1 \times 27.777 \times 18$$
$$= 699.9 + 749.9$$
$$= 1450 \text{ counts}$$

Mean power measurements use the 4 right-hand digits of the 6 digits LCD, and decimal point positioning is determined by the RANGE switch. Thus, in the above example, the mean power reading over a 36 s interval is 14.50 kW.

Chapter 4 Names and Functions of Parts



Front Panel



Rear Panel

① POWER switch

⚠CAUTION	When the power is turned off, do not apply voltage or current to the clamp sensor or voltage connecting cable. Doing so may damage the unit.

Turn the POWER switch ON and allow the unit a 5 minute of warm-up prior to making any measurements.

② POWER METER display
3-1/2 digits LCD display indicates values up to 1999. When input exceeds maximum value, the MSD and decimal point (and minus sign if displayed) remain illuminated and the lower 3 digits go blank. When battery voltage drops below 4 V, the BATT mark will be displayed in the lower left corner.

③ INTEGRATOR display
6 digits LCD display indicates values up to 999999. When count exceeds maximum value, the decimal point positioned behind the MSD will start blinking (at approx. 1 s), and the count will start over immediately from 0. When the display is in a count (run) status, the colon (:) behind the second digit (from left) will blink at approx. 1 s; in hold status it is extinguished.
The decimal point is positioned automatically by the RANGE switch combination for direct reading of the displayed value. (Integration measurements are read in kWh units, and mean power measurements in kW units.)

④ FUNCTION switch
Use this switch to select active or reactive power measurements. Single-phase reactive power cannot be measured.

⑤ RANGE (power range) switch

Use this switch to select the 20 or 200 (200 or 1000: 3162) kW(kvar) range. Use this switch to set measurement range to the input level expected.

⑥ RANGE (kWh) (integrator range) switch

The RANGE (kWh) switch is coupled to the RANGE switch and is used to select the time duration over which integration may occur. The table below shows a combination of possible settings.

Table 1 Combination Settings

Power range switch	Integrator range switch	Decimal point position	Maximum integration time at full scale input
a) 20 (200)	10^2 (10^3)	□□.□(·)□□□	5 hours
b) 20 (200)	10^4 (10^5)	□□□□.□(·)□	500 hours
c) 200 (1000)	10^3 (10^4)	□□□.□(·)□□	5 (10) hours
d) 200 (1000)	10^5 (10^6)	□□□□□.□(·)	500 (1000) hours

( ): 3162

NOTE

Maximum integration time at full scale input (e.g.; 20 kW in (a) above) means that the 6 digits counter will overflow after the number of hours shown have elapsed.

⑦ START switch

The integrator circuit will be reset and integration will immediately commence when the START switch is depressed (except when the power is displaying a minus sign). The START switch overrides the HOLD and AVERAGE switch. Consequently, if the unit is in the count (run), hold, or average status at the time the START switch is depressed, that status will be cleared and integration will start immediately from 0.

⑧ HOLD/RUN switch

This switch is used to stop the INTEGRATOR display, or to restart it. At any point after integration has started, a static INTEGRATOR display may be obtained by depressing this switch and the total power integration up to that point will be shown on the display. The counter continues to increment however, and when the switch is pressed again, the display will return to the integration (run) status and show the total power integration from the initial start. This switch maybe depressed as often as is necessary to take integration readings from the start point without affecting the end results of the integration operation.

⑨ AVERAGE switch

Depress this switch to obtain a mean power reading output to a static display. This feature is particularly convenient to use where power line fluctuations are severe. Mean power measurement starts from the point this switch is depressed, and 36 seconds later the results are output to the display. .Until the averaging operation status is cleared, a new display will appear every 36 seconds showing the mean power reading of the previous 36 second interval.

Mean power is shown by the lower 4 digits of the 6 digits INTEGRATOR display; the 2 upper digits and the colon (behind the second digit) is extinguished.

NOTE

- The first static display shown at the time this switch is depressed shows counter contents from previous integration operations and has no relationship to mean power being currently averaged. The mean power display will first appear 36 seconds after the AVERAGE switch has been depressed.

· Averaging operation becomes effective from the time the switch is first depressed; pressing the switch later will not affect the results of the operation. A new mean power display will appear every 36 seconds from the time the switch was first depressed.

⑩ ZERO ADJ (zero adjustment) knob

This knob is used to adjust the power display to a 000 reading. Zero adjust should be performed each time the function or power range switch is changed with the voltage input leads connected and clipped to the circuit, but without input to the clamp on sensors. (Turn the knob to the left side to decrease the value. Turn the knob to the right side to increase the value.)

⑪ OUTPUT terminal

The output terminal is connected to the power meter section. 2 V output is obtained for the maximum value displayed (2000 count) in each range. (Response time 3161: approx. 140 ms, 3162: approx. 70 ms)

⑫ Voltage input connector

The accessory voltage test lead is plugged into this connector.

⑬ Clamp on sensor input connector (A_1, A_3)

The accessory clamp on sensors are connected to the instrument through these input connectors. The clamp with the male fitting is connected to A_1, and the clamp with the female fitting is connected to A_3.

NOTE

Clamp on sensors are not interchangeable; even with instruments of the same model. (A label is provided on the back panel with the serial numbers of the clamps recorded on it.)

⑭ AC Adapter jack

> ⚠WARNING **Use an AC adapter that conforms to IEC 950 standards in respect to safety is rated for 6 V - 300 mA, has 5 mm-dia.-terminals and has a center pin with negative polarity.**

AC adapter (6 V, 300mA) is plugged into this jack.

⑮ Battery box

This houses four R14P batteries used for battery operation. When battery voltage drops below approximately 4 V, "BATT" will appear in the lower left corner of the POWER METER display.

Battery life is approximately 48 hours and battery voltage drops rapidly after the "BATT" display appears, resulting in inaccurate readings. It is thus recommended that the batteries be replaced immediately with the appearance of the "BATT" mark.

Battery voltage is continually monitored as long as the POWER switch is ON. Thus, if battery voltage is low, or there are no batteries installed in the unit, the "BATT" mark will appear in the display even though the unit is being operated through the AC adapter.

Additionally, when the "BATT" mark first appears and the instrument is switched to AC adapter operation, the batteries will no longer be loaded and may recover enough the cause the "BATT" to disappear from the display, yet still have insufficient voltage for continued operation.

An AC adapter/Battery relay circuit is set for AC adapter priority, but in the event voltage of the AC adapter drops (power failure), operation automatically shifts to battery.

⑯ Ground terminal

Connect the ground terminal to the ground to prevent electric shock and malfunction by noise.

⑰ External control terminal

⚠CAUTION	To avoid damage to the unit, do not input a voltage exceeding +6 VDC to the external control terminals.

For normal operations, these terminals are open (or Hi logic: 6 V). However, when remote control operation is desired, the terminals may be shorted (or Lo logic: 0 V) for integration operations. Integration continues for as long as the terminals are shorted together (or Lo logic is held).

At the time the terminals are shorted together, as with START switch operation, all integrated values accumulated by other modes of operation are immediately cleared and a new count is started.

At the time the terminals are opened, as with HOLD/RUN switch operation, all integrated values obtained since the terminals were shorted are output to the display.
The external control terminal includes a built-in waveform shaping circuit, and normal operation of the system depends on the basic criteria shown in Figure 4.3 being met.

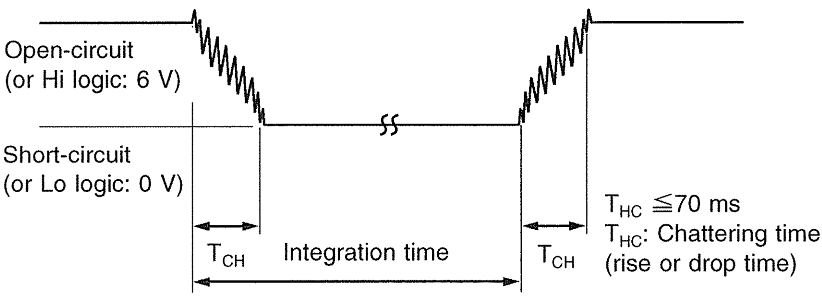


Figure 4.3 External Control Terminal

⑱ Data output connector (Rear Panel)

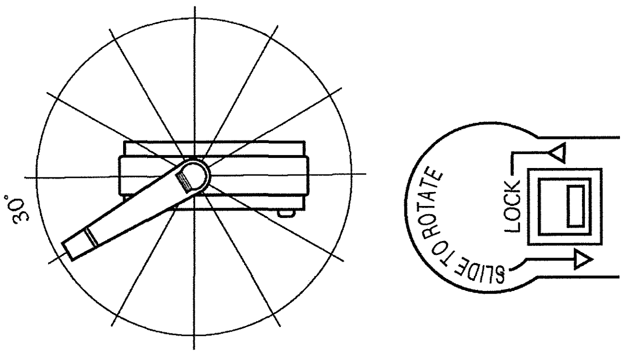
⚠CAUTION	To avoid damage to the unit, do not short the data output terminal and do not input voltage to the data output terminal.

This connector accepts the 3171 DIGITAL PRINTER (option) and cable connector for printed copy results of total power consumption (integrated power) or for mean power measurements.
Open this terminal when not using the printer.

⑲ Handle

⚠CAUTION	The handle can be used as a stand to inclinde the instrument, but force should not be applied to the instrument from above when using it in this manner.

Both sides have a sliding latch that when pressed in the direction of the SLIDE TO ROTATE arrow release the ratchet for 360° rotation. A stop is provided every 30°, and returning the latch to the LOCK position at these points secures the handle in that position.



Handle

Chapter 5 Operating Instructions

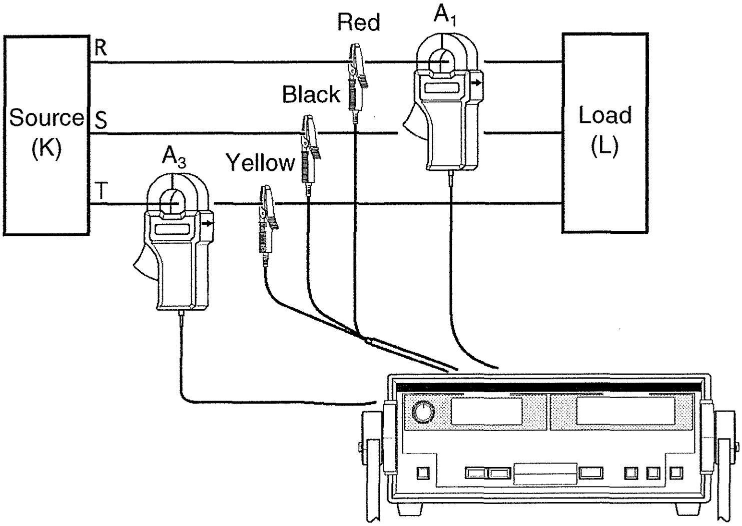
Turn the POWER switch ON and allow the unit a 5 minute of warm-up prior to making any measurements.

⚠DANGER **This unit cannot be used on voltage lines of 500 Vrms. If the voltage exceeds 500 VAC, there will be a short-circuit accident or electrocution accident will result.**

⚠CAUTION Before measurement, check the position of the RANGE switch. The unit may be damaged if current or voltage exceeds the measurement limit is applied for a long time.

NOTE
- If the meter is used for continuous measurements, periodically perform zero adjustment.
- Clamps are not interchangeable with any other instrument, including instruments of the same model. When using two or more similar instruments, always make certain the serial number of the clamp matches the number recorded on the rear panel label.

5.1 3-phase Active Power Measurements (3-phase, 3-wire)



Note: Always clip the voltage test leads to bare wires.

3-phase Active/reactive Power Measurement Connection Diagram (3-phase, 3-wire)

(1) Place the FUNCTION switch to the kW position and connect the accessory voltage test lead and the A_1 and A_3 clamp on sensors to their respective panel connectors. Clip the three voltage test leads to the three circuit conductors.

(2) At this point (voltage input, clamp on sensors connected but not clamped over conductors), perform zero adjustment.

(3) Clamp the A_1 clamp on sensors (red labeled clamp) over the conductor the red voltage test lead is clipped to, and the A_3 clamp on sensor (yellow labeled clamp) over the conductor the yellow test lead is clipped to and take the reading.

NOTE

Make sure the directional indicator (arrow) on each of the clamps is facing toward the load. If clamped on backwards, the display will indicate a minus reading.

5.2 3-phase Reactive Power Measurements (3-phase, 3-wire)

(1) Place the FUNCTION switch in the kvar position and connect the leads and clamps as noted for 3-phase active power measurements in 5.1 on previous page.

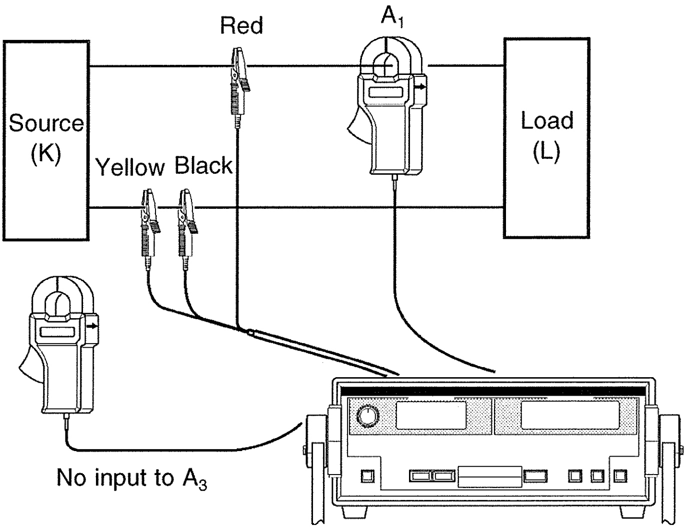
(2) At this point (voltage input, clamp on sensors connected but not clamped over conductors), perform zero adjustment.

(3) Clamp the sensors over the conductors matching the lead/clamp colors.

(4) When the test leads and clamps are connected in the R-S-T order shown on the rear panel diagram (for reactive power measurements), if the reading is positive (+), the lagging (LAG) power-factor phase reading will be indicated. If the reading is negative (−), then the leading (LEAD) power-factor phase is indicated. (A reversed set-up will also reverse the power-factor phase indications.)

5.3 Single-phase Power Measurements

Single-phase power measurements are made through one voltage-current input channel consisting of a V_{12} /A_1 or V_{32}/A_3 combination.



Note: Always clip the voltage test leads to bare wires.

Single-phase Power Measurement
Connection Diagram

> ⚠CAUTION
>
> For safety, connect the unused yellow wire to the line to which the black wire is connected. In addition, measurement is possible even if an unused clamp sensor A_3 is connected to the main unit. Do not input current, however.

(1) Place the FUNCTION switch to the kW position and connect the accessory voltage test lead and A_1 clamp on sensor to their respective panel connectors. Clip the red and black voltage test leads to the two circuit conductors.

(2) At this point(voltage input, clamp on sensor connected but not clamped over conductor), perform zero adjustment.

(3) Clamp the A_1 clamp on sensor (red labeled clamp) over the conductor the red voltage test lead is clipped to and take the measurement.

(4) When the V_{32}/A_3 channel is used, substitute the red lead and clamp set-up with the yellow lead and clamp set-up. (Clamp on sensors are labeled red or yellow.)

NOTE

Reactive power measurements cannot be taken on single-phase circuits.
Make sure the directional indicator (arrow) on the clamp is facing toward the load. If clamped on backwards, the display will indicate a minus reading.

5.4 Power Consumption (Integration) Measurements

⚠CAUTION

During integration, do not change the function or range settings, and do not change AVERAGE switch. If any of the switches are inadvertently pressed after starting integration, the data will be completely inaccurate, necessitating a restart.

NOTE

The basic operating principle of the integrator prohibits operations with negative voltage values. Check the POWER METER display and make sure it does not have a minus sign in it prior to starting integration of power consumption or taking mean power readings.
This instrument may not be used for obtaining power consumption measurements for commercial purposes.
At the point the external control terminals are shorted together, all integrated values accumulated previously by other modes of operation are cleared.

(1) Set the power meter function and RANGE switch to the appropriate positions, and the RANGE (kWh) switch according to the desired integration time. (Refer to Table 1 in Section 4.)
(2) Make certain zero adjustment has been performed.
(3) Depress the START switch to start integration.
(4) The HOLD/RUN switch may be depressed at any time to read the total amount of integration up to that point. The INTEGRATOR display will go static for this reading.
(5) To restart the display, press the HOLD/RUN switch again. The display will then increment to the amount of power consumption occurring since the initial START switch operation.
(6) The HOLD/RUN switch may be depressed as many times as is required to keep track of integration progress without affecting the end results of the integration operation.

5.5 Mean Power Measurement

(1) Set the power meter function and RANGE switch to the appropriate positions.

(2) Make certain zero adjustment has been performed.

(3) Depress the average switch. The display will go static at this point, but the display will be indicating results from previous counter operations for the initial 36 seconds.

(4) The first mean power display will appear 36 seconds from the time the AVERAGE switch was depressed, and will be held for the next 36 seconds.

(5) From this point, the display will change every 36 seconds, showing the mean power consumption over the previous 36 second interval.

(6) Depressing the AVERAGE switch after the mean power mode has been set by the initial switch operation will not affect averaging operations.

(7) The mean power measurement mode can be cleared by depressing the START switch.

NOTE

Since this mode uses the integrator circuitry, negative power measurements (indicated by a minus sign in the POWER METER display) cannot be integrated.
When measuring the mean power during integration, all power integration data accumulated are cleared.

Chapter 6 Application Examples

6.1 3-phase Circuit Power-factor Calculations (3-phase, 3-wire)

Power-factors may be calculated for 3-phase circuits when using the 3161 in either 3-phase active or reactive power measurements by the equation shown below.

Example:

Active power P = 52.0 kW
Reactive power Q = +44.0 kvar

When we have these values, apparent power (VA) may be determined by

$$\mathrm{VA} = \sqrt{P^2 + Q^2} = 68.1\,\mathrm{kVA}$$

Now this value is written into the power-factor cos ϕ equation.

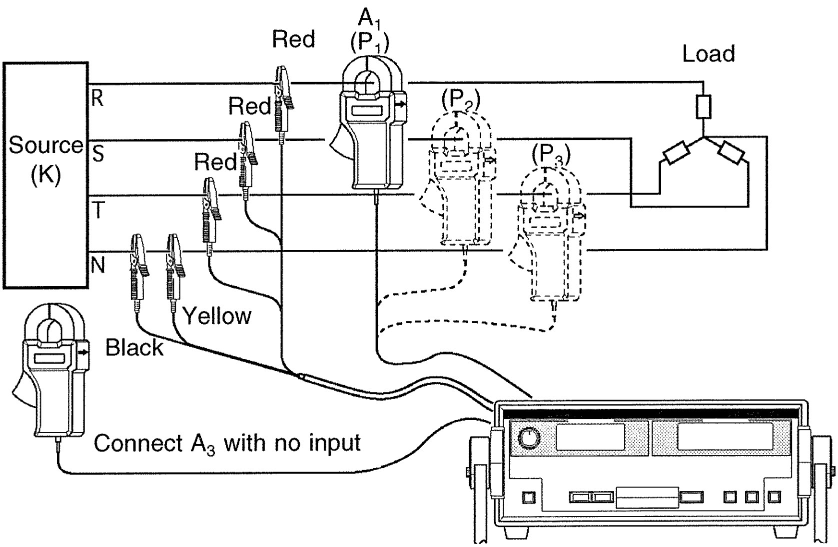
$$\begin{aligned} \cos\phi &= \mathrm{P/VA} \\ &= 52.0\ (\mathrm{kW})/68.1(\mathrm{kVA}) \\ &= 0.76\ (\text{power-factor}) \end{aligned}$$

When the test leads and clamps are connected to the circuit conductors in the order shown in the diagram on the rear panel of the instrument, reactive power Q is a positive value, and is thus the lagging (LAG) power-factor phase.

6.2 Single-phase, 3-wire Measurements

Active power may be measured in single-phase, 3-wire circuits using the same test set-up as for 3-phase, 3-wire circuits, however, reactive power cannot be measured in this case.

6.3 3-phase, 4-wire Measurements



3-phase, 4-wire Active Power Measurements

⚠CAUTION	For safety, connect the unused yellow wire to the line to which the black wire is connected. In addition, measurement is possible even if an unused clamp sensor A_3 is connected to the main unit. Do not input current, however.

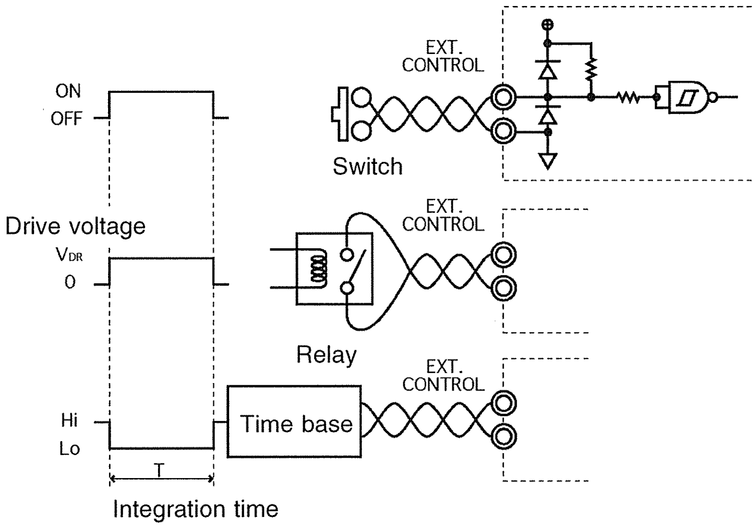
3-phase, 4-wire circuit measurements may be made by making three measurements using the single-phase active power measurement method to obtain the algebraic sum for each measurement. The black and yellow voltage test leads should be connected to the neutral conductor and the red test lead and red labeled A_1 clamp on sensor connected in turn to each current-carrying conductor. Measurement value P_1, P_2, and P_3 are added to obtain active power P.

$$P = P_1 + P_2 + P_3$$

6.4 Using the External Control Terminal

⚠CAUTION	To avoid damage to the unit, do not input a voltage to the external input terminals.

The external control terminal located on the rear panel of the unit may be used to control integration time.

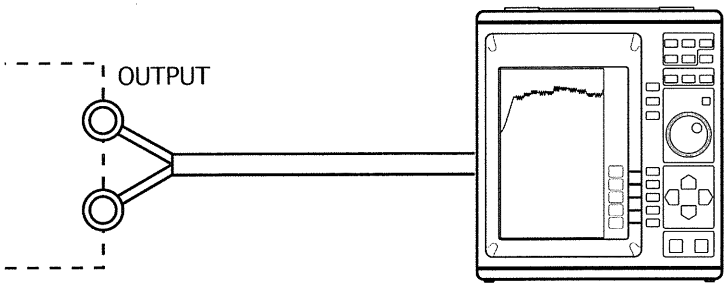


External Control Terminal Interface

6.5 Recorder Connection

⚠CAUTION	To avoid damage to the unit, do not short the output terminal and do not input voltage to the output terminal.

The output terminal located on the rear panel of the unit may be used to drive a recorder. The use of a recorder allows circuit load curves to be plotted.



Recorder Connection

6.6 Printer Connection

⚠CAUTION	To avoid damage to the unit, do not short the data output connector terminal and do not input voltage to the output terminal.

NOTE

· The I/O CMOS logic level for the data output connector is Lo: 0 V, and Hi: 6 V. Do not use a CMOS (or TTL) device with different current/voltage characteristics as an interface.

· The data output connector (rear panel) is a dedicated terminal for the 3171 DIGITAL PRINTER. The printer produces hard-copy print-out of integrated power or mean power for use in system monitoring or for record keeping purposes.

Example Printout

```
00:45-142.722
AV. 190.312  kW
INTVL    047.578

00:30-095.144
AV. 190.292  kW
INTVL    047.573

00:15-047.571
AV. 190.284  kW
INTVL    047.571

START          kWh

00:08-   190.3
00:07-   190.2
00:06-   190.3
00:05-   190.2
00:04-   190.3
00:03-   190.2
00:02-   190.3
00:01-   190.3

AVERAGE         kW

00:02-007.955
EXT.STOP   30sec

00:02-006.342
AV. 190.260  kW
INTVL    003.171

00:01-003.171
AV. 190.260  kW
INTVL    003.171

START          kWh
```

Integrated power measurement

- 00:30-095.144 ← Cumulative integrated power (kWh) occurring between 0:00 and 00:30 min.
- AV. 190.292 kW ← Average power (kW) consumed in the interval between 00:15 and 00:30 min
- INTVL 047.573 ← Integrated power (amount of demand) in kWh between 00:15 and 00:30 min
- START kWh ← The 3161 (3162) START switch ON

Average power measurement

- 00:06- 190.3 ← Average power (36 seconds) in elapsed time 6 min.
- AVERAGE kW ← The 3161 (3162) AVERAGE switch ON.

Using the external control terminal

- EXT.STOP 30sec ← The 3161 (3162) external control terminal opened.
- START kWh ← The 3161 (3162) external control terminal closed.

Chapter 7 Maintenance and Service

7.1 Battery Replacement

⚠WARNING

- To avoid electric shock when replacing the batteries, first disconnect the object to be measured. Also, after replacing the batteries, always replace the cover before using the unit.
- When replacing the batteries, do not install old batteries with new ones, and do not mix different types of batteries. Check the battery polarity carefully when inserting the batteries.
- Do not short-circuit used batteries, disassemble them, or throw them in a fire. Doing so may cause the batteries to explode.
- Be sure to dispose of used batteries according to their type in the prescribed manner and in the proper location.

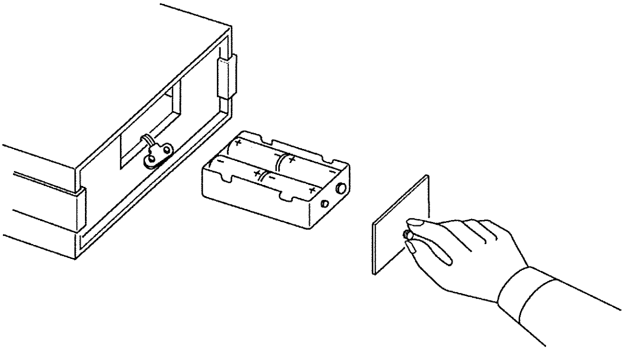
Battery replacement is as follows

(1) Loosen the attachment screw, and remove it with the battery box cover.

(2) Remove the battery snap and slide out the battery box.

(3) Replace the batteries and slide the battery box back in.

(4) Replace the battery snap and the battery box cover.

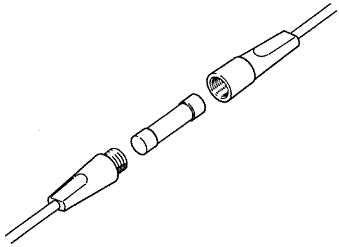


7.2 Fuse Replacement

⚠WARNING

- **To avoid electric shock when replacing the fuse, turn the POWER switch off, disconnect the power code, and disconnect the connection from the object to be measured.**
- **Only use fuses of the specified type that is rated for the specified current and voltage. Using a fuse that does not meet the specifications or shorting the fuse holder may cause an accident that might result in injury or death.**
  F0.3 A/250 V arc-quencing 20 mm × 5.2 mm dia.

Fuses are located in each fuse holders of the voltage connecting cord.



7.3 Cleaning

⚠CAUTION	Gently wipe dirt from the surface of the unit with a soft cloth moistened with a small amount of water or mild detergent. Do not try to clean the unit using cleaners containing organic solvents such as benzine, alcohol, acetone, ether, ketones, thinners, or gasoline. They may cause discoloration or damage.

7.4 Service

⚠CAUTION	If the unit is not functioning properly, check the batteries and fuse blowing. If a problem is found, contact your dealer or HIOKI representative. Pack the unit carefully so that it will not be damaged during transport, and write a detailed description of the problem. HIOKI cannot bear any responsibility for damage that occurs during shipment.

HIOKI 3161·62 CLAMP ON POWER HiTESTER

Instruction Manual

Publication date: October 1996 Revised edition 5

Edited and published by HIOKI E.E. CORPORATION
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Printed in Japan 3161A981-05

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3161A981-05 96-10-0001H