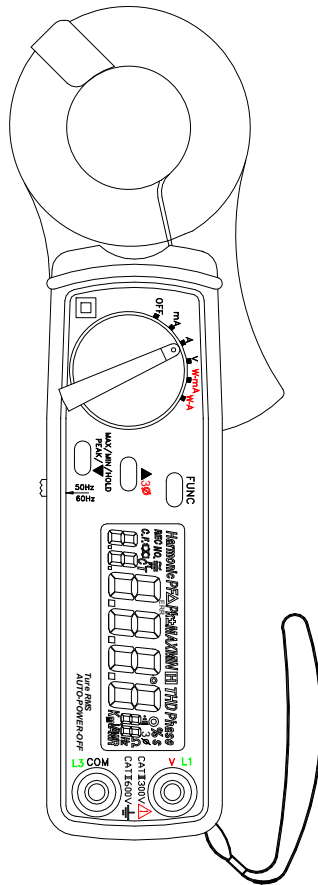


Power Harmonics and Leakage Tester Model 21/23 Leakage and Harmonics Tester Model 19 Users Manual



PROVA INSTRUMENTS INC.



EN 61010-2-032
CAT II 600V
CAT III 300V
Pollution Degree 2

Definition of Symbols:



Caution: Refer to Accompanying Documents



Caution: Risk of Electric Shock



Double Insulation

Over-voltage Category I (CAT I):

Equipment for connection to circuits in which measures are taken to limit the transient over-voltages to an appropriate low level.

Over-voltage Category II (CAT II):

Energy-consuming equipment to be supplied from the fixed installation.

Over-voltage Category III (CAT III):

Equipment in fixed installations.

WARNING: If the clamp meter is used in a manner Not specified by the manufacturer, the protection Provided by the clamp meter may be impaired.

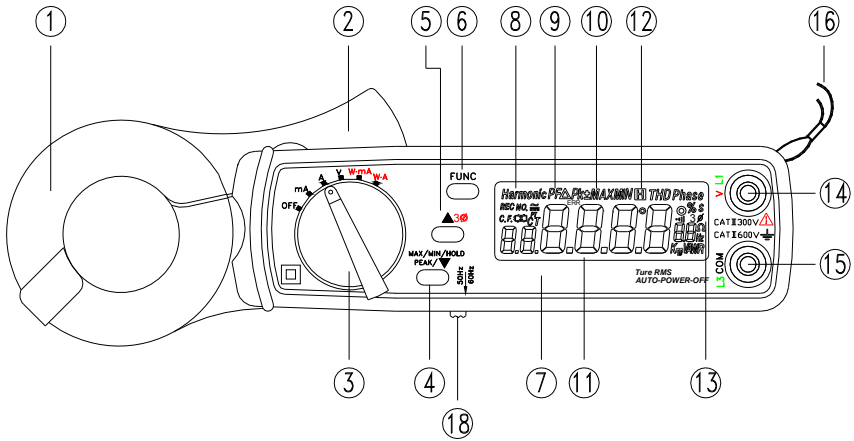
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I. FEATURES

- a. Active (W, KW, HP), reactive (VAR, KVAR) and apparent (VA, KVA) power.
- b. Power factor (PF), phase angle (Φ), and energy (mWH, WH, KWH).
- c. Measurement of standby power consumption for IT products.
- d. Non-interrupted AC current harmonic analysis.
- e. 1 to 99th order of harmonics at 1.0% basic accuracy.
- f. Total harmonic distortion (%THD-F) and crest factor (CF).
- g. True RMS measurement of V and A at 0.5% basic accuracy.
- h. Fast peak function (39 μ s for 50 Hz, 33 μ s for 60Hz).
- i. Measurement of balanced 3 Φ power.
- j. Measurement of balanced 3 Φ sequence.
- k. Programmable CT ratio from 1 to 250.
- l. Max, Min and data hold functions.
- m. Leakage current measurement at 10 μ A resolution.
- n. Active power in H.P.
- o. Auto power off function in 30 minutes.
- p. Shielded Jaw immune to external interference (Model 19, 21)

II. PANEL DESCRIPTION



1. Transformer Jaw Assembly

This is used to pick up current signal. To measure AC current or Power/Watt, the jaw must enclose conductor completely.

2. Transformer Trigger

Press the trigger to open the jaw.

3. Rotary Switch

This is used to turn the power on and select measurement of current, voltage or power.

4. MAX/MIN/HOLD/PEAK and ▼ Button

In the measurement of mA, A, or V, press this button to perform function of MAXIMUM, MINIMUM, HOLD and PEAK. It is also used to decrement the order of harmonics or CT ratio.

If this button is hold when turning on power, the tester can perform measurement of phase sequence instead of phase angle in the balanced 3Φ power system.

5. ▲ 3Φ Button

This button is used to increment order of harmonics or CT ratio. When the rotary switch is set at W-mA or W-A position, press this button to select measurement of balanced 3Φ power instead of single-phase power.

This button is also used to select AUTO Hz. If users hold this button and turn the power on, the unit will automatically detect the frequency of the signal within 40 to 65 Hz. If the frequency is outside 40 to 65 Hz, the unit will select 50 or 60 Hz based upon the position of sliding switch 18.

6. FUNC Button

In the measurement of mA, A, or V, press this button to select function of harmonics, THD-F, or CF. In the measurement of W-mA or W-A, press this button to select function of VA, VAR, PF, phase angle, HP, or energy (KWH).

7. LCD

This is a 4+2+2 digit Liquid Crystal Display. Function symbols, units, sign, decimal points, low battery symbols, max, min symbols, peak and harmonic symbols are included.

8, 9, 10, 12

Those are symbols of selected functions such as, Harmonic, PEAK, MAX, MIN or HOLD.

11. Primary Digits

These digits display the value of measurement, such as current, voltage, or power.

13. Symbols of Units

These are symbols of current, voltage, and power. There are two digits used to display the fundamental frequency 50 or 60 Hz.

14. V Input Terminal

This terminal is used as input for voltage and power measurements.

15. COM Terminal

This terminal is used as common reference input.

16. Hand Strap

Put your hand through the hole of hand strap to avoid accidental drop of the clamp meter.

18. Sliding Switch

Users should select the correct fundamental frequency (50/60 Hz) by moving the sliding switch to a correct position.

III. OPERATING INSTRUCTIONS

III.1. Measurement of AC mA and A

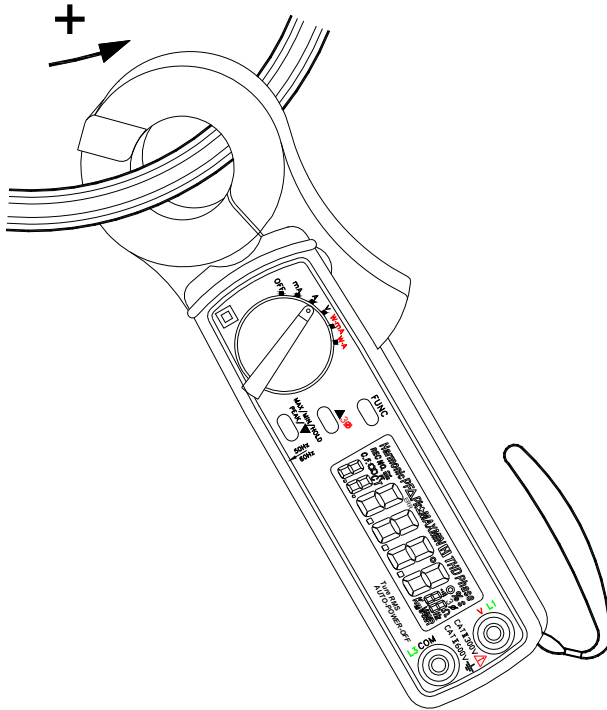
NOTE:

1. Select the correct fundamental frequency (50 or 60 Hz) of current by moving the sliding switch at the side of the tester. Or hold the ▲ button to select AUTO Hz.
2. Select the proper position of the rotary switch for the range of current. If the AC current is less than 0.6A, then set the rotary switch at the position of mA. If the AC current is greater than 0.6A, then set the rotary switch at the position of A.
3. If the peak value of the input AC current is greater than the maximum value of the range, then symbol of OL will be displayed.
4. If users hold the ▲ button and turn the power on, the unit enters the AUTO Hz mode. The unit will automatically detect the frequency between 45 to 65Hz. Additional error occurs if the measured frequency is not 50 or 60 Hz.

NOTE: Whenever the rotary switch is set at a new position, the CT ratio and fundamental frequency will be displayed first.

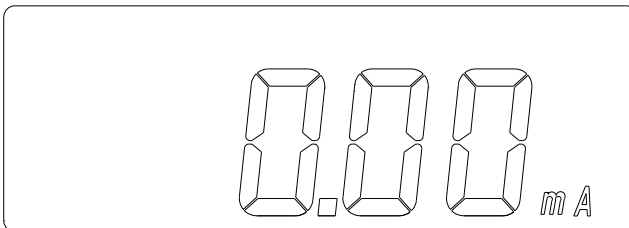
WARNING: If the unit clamps on to a load (current) about twice the range, the unit not only display OL, but also display Low Battery.

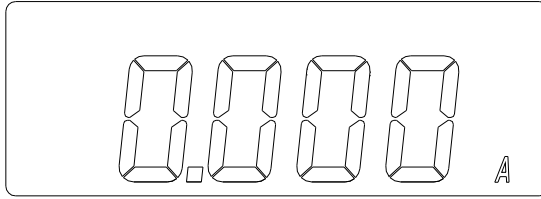
NOTE: If the CT ratio is not 1, a symbol of "CT" will be shown in the LCD display for the measurement of mA or A. The reading of current shown in LCD is equal to the true RMS value measured by the tester multiplied by CT ratio ($A_{LCD} = A_{RMS} \times CT$).



WARNING: Make sure that all the test leads are disconnected from the meter's terminals for current measurement.

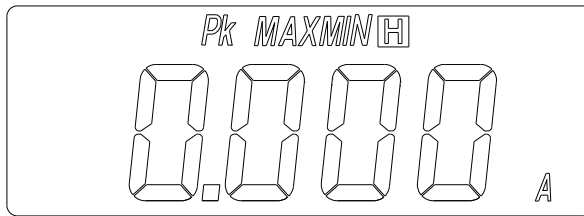
III.1.1. True RMS value of AC Current





- Set the rotary switch at mA or A depending on the range of AC current. Then select the correct frequency by moving the sliding switch at the side of the tester.
- Press the trigger to open the jaw and fully enclose the conductor to be measured.
- Read the measured value from the LCD display.

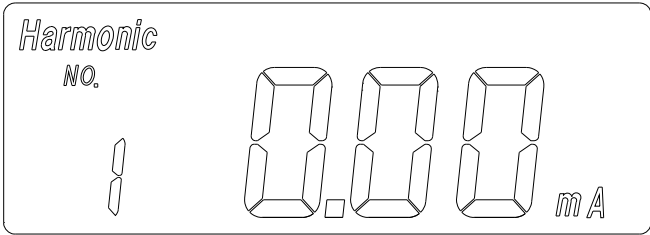
III.1.2. HOLD, MAX, MIN and PEAK of AC Current.



- Set the rotary switch at mA or A depending on the range of AC current. Then select the correct frequency by moving the sliding switch at the side of the tester.
- Press the trigger to open the jaw and fully enclose the conductor to be measured.
- The measured value from the LCD display. If the ▼ button is pressed, the symbol of "HOLD", "MAX", "MIN" or "PEAK" will be shown in LCD alternatively. And the value of the HOLD, MAX, MIN or PEAK function will be displayed in LCD alternatively.
- To return to the display of current measurement, hold the ▼ button for more than 2 seconds.

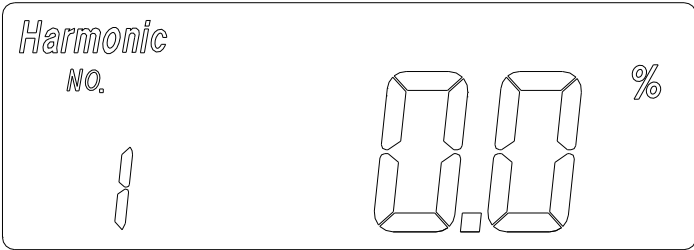
NOTE: The PEAK function displays the maximum value of a AC periodic waveform. The sampling time for the PEAK function is 39 μ s (50Hz) or 33 μ s (60Hz). The HOLD, MAX, or MIN function displays the true RMS value.

III.1.3. Harmonics of AC Current in Magnitude (mA or A)



- a. Set the rotary switch at the position of “mA” or “A” depending on the range of AC current. Then select the correct fundamental frequency by moving the sliding switch at the side of the tester.
- b. Press the trigger to open the jaw and fully enclose the conductor to be measured.
- c. Press the FUNC button once. The symbols of “Harmonic” and “NO” will be shown in LCD. The n-th order (1 to 99) will be shown in front of the reading of the magnitude (mA or A) of the current.
- d. Press the ▲ or ▼ button to increment or decrement the order of harmonics in front of the reading. The number will roll over when the maximum (99) or minimum (1) is reached.

III.1.4. Harmonics of AC Current in Percentage (%)

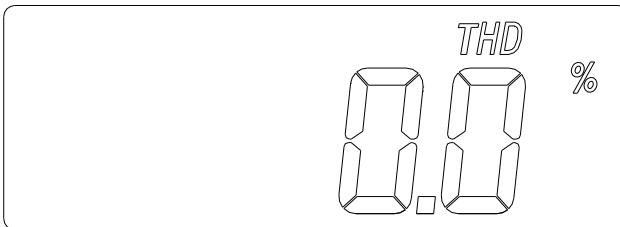


- a. Set the rotary switch at the position of “mA” or “A” depending on the range of AC current. Then select the correct fundamental frequency by moving the sliding switch at the side of the tester.
- b. Press the trigger to open the jaw and fully enclose the conductor to be

measured.

- c. Press the FUNC button twice. The symbols of “Harmonic” and “NO” will be shown in LCD. The n-th order (1 to 99) will be shown in front of the reading of the percentage (%) of the current.
- d. Press the ▲ or ▼ button to increment or decrement the order of harmonics in front of the reading. The number will roll over when the maximum (99) or minimum (1) is reached.

III.1.5. Total Harmonic Distortion (% THD-F)



- a. Set the rotary switch at the position of “mA” or “A” depending on the range of AC current. Then select the correct fundamental frequency by moving the sliding switch at the side of the tester.
- b. Press the trigger to open the jaw and fully enclose the conductor to be measured.
- c. Press the FUNC button three times. The symbols of “THD” and “%” will be shown in LCD. The total harmonic distortion in percentage with respect to the fundamental frequency (50 or 60 Hz) will be measured and displayed.

$$\%THD-F = (\sqrt{V_2^2 + V_3^2 + \dots + V_{49}^2 + V_{50}^2}) / V_1 * 100$$

Where,

V1: magnitude at the fundamental frequency

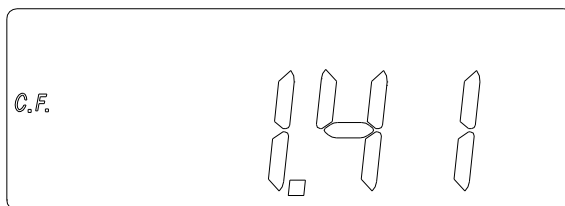
V2: magnitude at the second harmonics

...

V50: magnitude at the 50-th harmonics.

NOTE: In the measurement of THD, the response to the button or switch operation becomes slow due to heavy math calculation.

III.1.6. Crest Factor (C.F.)



- Set the rotary switch at the position of “mA” or “A” depending on the range of AC current. Then select the right frequency by moving the sliding switch at the side of the tester.
- Press the trigger to open the jaw and fully enclose the conductor to be measured.
- Press the FUNC button four times. The symbol of C.F. will be shown in LCD. The crest factor (C.F.) will be measured and displayed. The crest factor (CF) is defined as following:

$$\text{C.F.} = (\text{peak value}) / (\text{RMS value})$$

III.1.7 Frequency of AC Current

- Set the rotary switch at the position of “mA” or “A” depending on the range of AC current.
- Press the trigger to open the jaw and fully enclose the conductor to be measured.
- Press the FUNC button five times. The symbol of Hz will be shown in LCD.
- The frequency of AC current will be measured and shown in LCD. If the frequency is less than 40 Hz, 0 Hz will be shown in LCD. If the frequency is greater than 65 Hz, OL Hz will be shown in LCD.

NOTE: In the mA range, the AC current must be greater than 10mA for frequency measurement. In the A range, the AC current must be greater than 1A for frequency measurement.

III.2 Measurement of AC Voltage

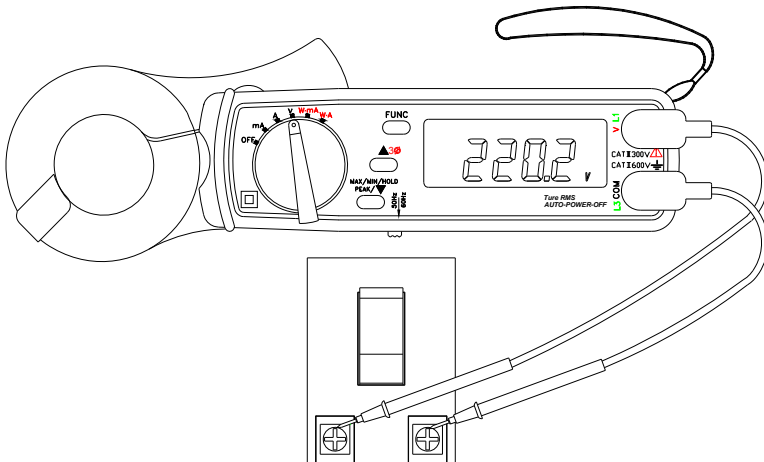
NOTE:

1. Select the correct fundamental frequency of voltage by moving the sliding switch at the side of the tester.
2. If the peak value of the input AC voltage is greater than the maximum value of the range, then symbol of OL will be displayed.
3. If users hold the ▲ button and turn the power on, the unit enters the AUTO Hz mode. The unit will automatically detect the frequency between 45 to 65Hz. Additional error occurs if the measured frequency is not 50 or 60 Hz.

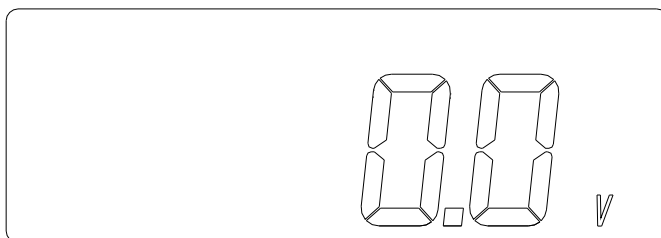
NOTE: Whenever the rotary switch is set at a new position, the CT ratio and fundamental frequency will be displayed first.

NOTE: If the CT ratio is not 1, a symbol of “CT” will be shown in the LCD display.

WARNING: Maximum input for ACV is 600. Do not attempt to take any voltage measurement that exceeds the limits. Exceeding the limits could cause electrical shock and damage to the clamp meter.

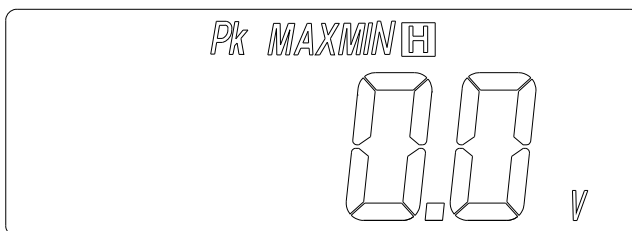


III.2.1. True RMS value of AC Voltage



- Set the rotary switch at position V. Then select the correct fundamental frequency by moving the sliding switch at the side of the tester.
- Insert the test leads into the input jack. Connect the test prods of the test leads in PARALLEL to the circuit to be measured.
- Read the measured RMS value from the LCD display.

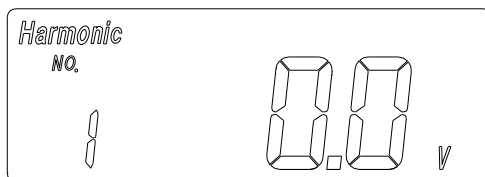
III.2.2. HOLD, MAX, MIN and PEAK value of AC Voltage



- Set the rotary switch at position V. Then select the correct fundamental frequency by moving the sliding switch at the side of the tester.
- Insert the test leads into the input jack. Connect the test prods of the test leads in PARALLEL to the circuit to be measured.
- The measured value is displayed in the LCD display. If the ▼ button is pressed, the symbol of "HOLD", "MAX", "MIN" or "PEAK" will be shown in LCD alternatively. And the value of the HOLD, MAX, MIN or PEAK function will be displayed in LCD alternatively.
- To return to the display of current measurement, hold the ▼ button for more than 2 seconds.

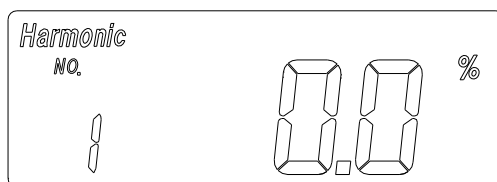
NOTE: NOTE: The PEAK function displays the maximum value of a AC periodic waveform. The sampling time for the PEAK function is 39 μ s (50Hz) or 33 μ s (60Hz). The HOLD, MAX, or MIN function displays the true RMS value.

III.2.3. Harmonics of AC Voltage in Magnitude (V)



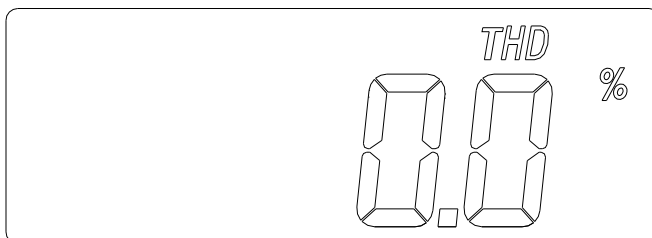
- Set the rotary switch at position V. Then select the correct fundamental frequency by moving the sliding switch at the side of the tester.
- Insert the test leads into the input jack. Connect the test prods of the test leads in PARALLEL to the circuit to be measured.
- Press the FUNC button once. The symbols of "Harmonic" and "NO" will be shown in LCD. The n-th order (1 to 99) will be shown in front of the reading of the magnitude (V) of the voltage.
- Press the ▲ or ▼ button to increment or decrement the order of harmonics in front of the reading. The number will roll over when the maximum (99) or minimum (1) is reached.

III.2.4. Harmonics of AC Voltage in Percentage (%)



- Set the rotary switch at position V. Then select the correct fundamental frequency by moving the sliding switch at the side of the tester.
- Insert the test leads into the input jack. Connect the test prods of the test leads in PARALLEL to the circuit to be measured.
- Press the FUNC button twice. The symbols of "Harmonic" and "NO" will be shown in LCD. The n-th order (1 to 99) will be shown in front of the reading of the percentage (%) of the voltage.
- Press the ▲ or ▼ button to increment or decrement the order of harmonics in front of the reading. The number will roll over when the maximum (99) or minimum (1) is reached.

III.2.5. Total Harmonic Distortion (% THD-F)



- Set the rotary switch at position V. Then select the correct fundamental frequency by moving the sliding switch at the side of the tester.
- Insert the test leads into the input jack. Connect the test prods of the test leads in PARALLEL to the circuit to be measured.
- Press the FUNC button three times. The symbols of "THD" and "%" will be shown in LCD. The total harmonic distortion in percentage with respect to the fundamental frequency (50 or 60 Hz) will be measured and displayed.

$$\%THD-F = (\sqrt{V2^2 + V3^2 + \dots + V49^2 + V50^2}) / V1 * 100$$

Where,

V1: magnitude at the fundamental frequency

V2: magnitude at the second harmonics

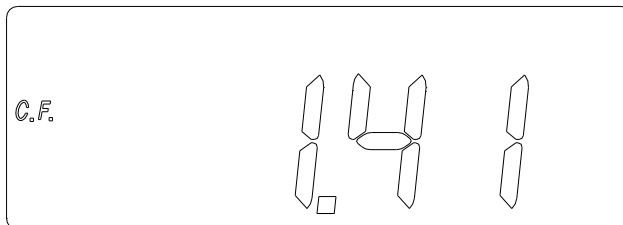
...

V50: magnitude at the 50-th harmonics.

NOTE: In the measurement of THD, the response to the button or switch operation becomes slow due to heavy math calculation.

NOTE: For model 23, users can not disable the auto-power-off function by holding the FUNC button for 2 seconds in the measurement of THD.

III.2.6. Crest Factor (C.F.)



- Set the rotary switch at position V. Then select the correct fundamental frequency by moving the sliding switch at the side of the tester.
- Insert the test leads into the input jack. Connect the test prods of the test leads in PARALLEL with the circuit to be measured.
- Press the FUNC button four times. The symbol of C.F. will be shown in LCD. The crest factor (C.F.) will be measured and displayed. The crest factor (CF) is defined as following:

$$\text{C.F. (Crest Factor)} = (\text{Peak Value}) / (\text{RMS Value})$$

III.2.7 Frequency of AC voltage

- Set the rotary switch at position V.
- Insert the test leads into the input jack. Connect the test prods of the test leads in PARALLEL with the circuit to be measured.
- Press the FUNC button five times. The symbol of Hz will be shown in LCD.
- The frequency of AC voltage will be measured and shown in LCD. If the frequency is less than 40 Hz, 0 Hz will be shown in LCD. If the frequency is greater than 65 Hz, OL Hz will be shown in LCD

NOTE: The AC voltage must be greater than 50V for frequency measurement.

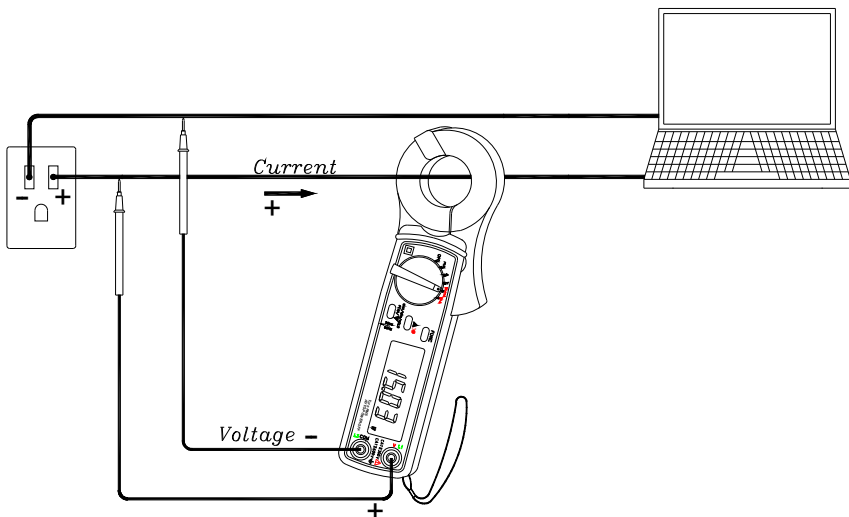
III.3 Measurement of Single Phase AC Power Quality (21, 23)

NOTE:

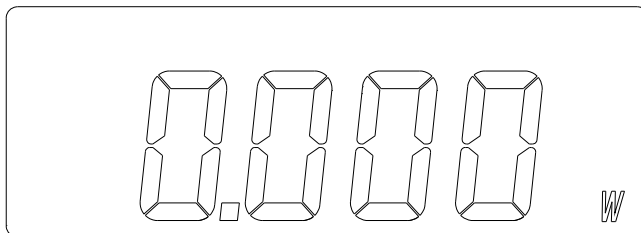
1. Select the correct fundamental frequency of current and voltage by moving the sliding switch at the side of the tester.
2. Select the proper position of the rotary switch for the range of current. If the AC current is less than 0.6A, then set the rotary switch at the position of W-mA. If the AC current is greater than 0.6A, then set the rotary switch at the position of W-A.
3. If the peak value of the input AC current is greater than the maximum value of the range, then symbol of OL will be displayed.
4. If users hold the ▲ button and turn the power on, the unit enters the AUTO Hz mode. The unit will automatically detect the frequency between 45 to 65Hz. Additional error occurs if the measured frequency is not 50 or 60 Hz.

NOTE: Whenever the rotary switch is set at a new position, the CT ratio and fundamental frequency will be displayed first.

NOTE: If the CT ratio is not 1, a symbol of “CT” will be shown in the LCD display for the measurement of W-mA or W-A.

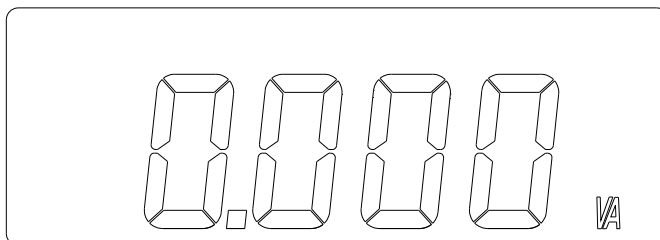


III.3.1 Single Phase AC Watt



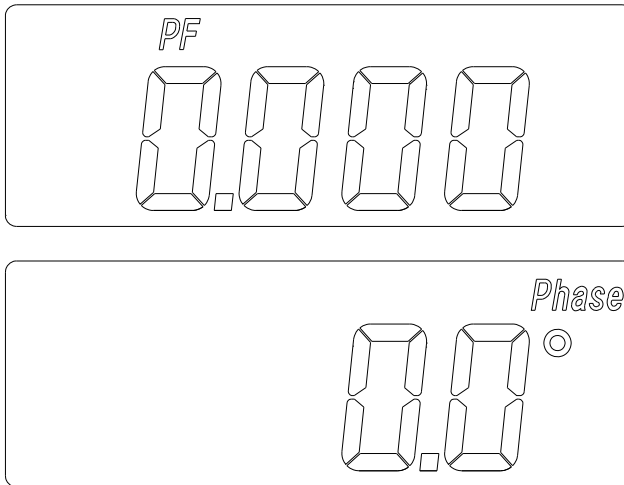
- Connect the test leads to the voltage source in parallel with the load.
- Clamp on one of the wire to the load. The current should flow from the front of the tester to the side of the battery cover.
- Select proper Watt range (W-mA or W-A).
- Read the value shown on LCD in mW, W, or KW. The unit of watt is automatically scaled.

III.3.2. Apparent Power (VA, KVA) and Reactive Power (VAR, KVAR)



- Connect the test leads to the voltage source in parallel with the load.
- Clamp on one of the wire to the load. The current should flow from the front of the tester to the side of the battery cover.
- Select proper Watt range (W-mA or W-A).
- The value of mW, W, or KW will be displayed in LCD. The unit of watt is automatically scaled.
- Press the FUNC button once to display VA or KVA. The unit is automatically scaled.
- Press the FUNC button twice to display VAR or KVAR. The unit is automatically scaled.

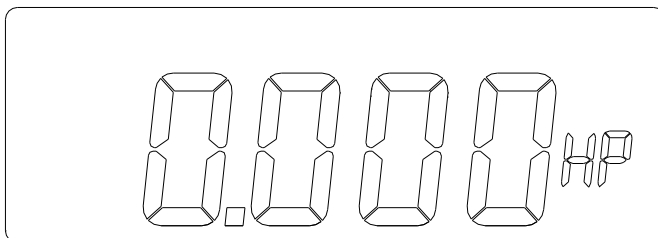
III.3.3. Power Factor (PF), and Phase Angle (Φ)



- Connect the test leads to the voltage source in parallel with the load.
- Clamp on one of the wire to the load. The current should flow from the front of the tester to the side of the battery cover.
- Select proper Watt range (W-mA or W-A).
- The value of mW, W, or KW will be displayed in LCD. The unit of watt is automatically scaled.
- Press the FUNC button three times to display PF from 0.000 to 1.000.
- Press the FUNC button four times to display phase angle (Φ) from -180° to $+180^\circ$.

NOTE: To display phase angle (Φ) from 0 to 360, hold the \blacktriangle button, then turn the power on. Once the tester is turned on in this way, the tester will display phase angle from 0 to 360° (when phase angle function is selected).

III.3.4. Horse Power (H.P.)

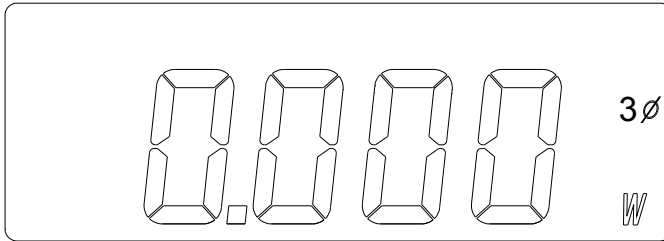


- Connect the test leads to the voltage source in parallel with the load.
- Clamp on one of the wire to the load. The current should flow from the front of the tester to the side of the battery cover.
- Select proper Watt range (W-mA or W-A).
- The value of mW, W, or KW will be displayed in LCD. The unit of watt is automatically scaled.
- Press the FUNC button five times to display power in the unit of HP.

III.3.5. Energy (mWH, WH, or KWH)

- Connect the test leads to the voltage source in parallel with the load.
- Clamp on one of the wire to the load. The current should flow from the front of the tester to the side of the battery cover.
- Select proper Watt range (W-mA or W-A).
- The value of mW, W, or KW will be displayed in LCD. The unit of watt is automatically scaled.
- Press the FUNC button six times. A character of H is displayed in front of reading to indicate energy (mWH, WH, or KWH). The energy is displayed in 6 digits (Four large digits and two small digits). The energy will be reset to zero at the beginning when this function is selected.

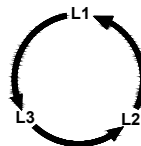
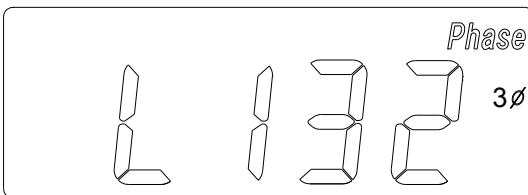
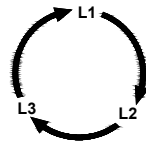
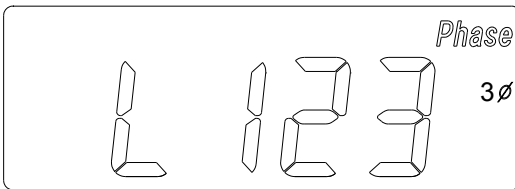
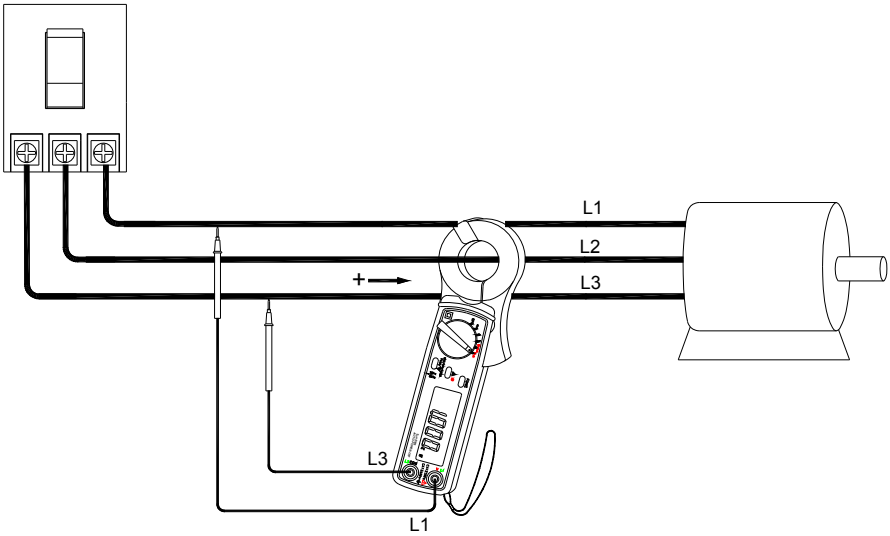
III.4 Measurement of the Balanced 3 Phase AC Power Quality (21, 23)



- Connect the black test lead to the voltage L3, and connect the red test lead to L1.
- Clamp on one of the wire to L2. The current should flow from the front of the tester to the side of the battery cover.
- Select proper Watt range (W-mA or W-A).
- Press the ▲ button to select balanced 3ϕ . A symbol of " 3ϕ " will be shown in LCD.
- The value of mW, W, or KW will be displayed in LCD. The unit of watt is automatically scaled.

NOTE: Users can also obtain the measurements of VA, VAR, PF, Phase Angle, HP, and energy (WH) for balanced 3ϕ power system. The operations are the same as the measurements for the single-phase power system.

III.5 Measurement of the Balanced 3 Phase Sequence (21, 23)



- Hold the ▼ button, and then turn the power on. Set the rotary switch at the W-mA or W-A position.
- Connect the black test lead to the voltage L3, and connect the red test lead to

L1.

- c. Clamp on to the wire of L2. The current should flow from the front of the tester to the side of the battery cover.
- d. Press the ▲ button to select 3 phase power system. A symbol of 3Φ will be shown in LCD.
- e. Press the FUNC button to select phase angle function. The LCD will show L123 to indicate the clockwise sequence. Or the LCD will show L132 to indicate counter clockwise sequence.

IV. SET THE CT RATIO

To set the CT ratio, hold the FUNC button, and then turn the power on. A symbol of “CT” will be shown in LCD. The default value of CT is 1. To change the CT ratio, users can press the ▲ or ▼ button to increment or decrement the value by 1. Holding the ▲ or ▼ button will speed up the process of incrementing or decrementing.

To exit the setting of CT ratio, press the FUNC button.

V. DISABLE AUTO-POWER-OFF

The tester has an auto-power-off function. The tester will turn the power off after power is turned on for 30 minutes. To disable the auto power off function, hold the FUNC button for more than 2 seconds. A beep sound will be heard to indicate that the auto power off function is disabled.

For Model 23, users can not disable the auto-power-off function in the measurement of THD.

VI. SPECIFICATIONS (23°C±5°C)

AC Watt (50 or 60 Hz, PF 0.6 to 1. CT = 1, Voltage is greater than AC 4V, Current is greater than AC 1mA for mA range, and Current is greater than AC 0.04A for A range. Specification applies to continuous waveforms)

Model 21

| Range (0 to 30A) | Resolution | Accuracy of Readings ^{1,2} |
|------------------|------------|-------------------------------------|
| 0.050 – 9.999 W | 0.001W | ±2% ± 0.025W |
| 10.00 – 99.99 W | 0.01W | ±2% ± 0.25W |
| 100.0 – 999.9 W | 0.1W | ±2% ± 2.5W |
| 1.000 – 9.999 KW | 0.001 KW | ±2% ± 0.025KW |
| 10.00 – 99.99 KW | 0.01 KW | ±2% ± 0.25KW |
| 100.0 – 999.9 KW | 0.1 KW | ±2% ± 2.5KW |
| 1000 – 9999 KW | 1 KW | ±2% ± 25KW |

Model 23

| Range (0 to 60A) | Resolution | Accuracy of Readings ^{1,2} |
|------------------|------------|-------------------------------------|
| 0.050 – 9.999 W | 0.001W | ±2% ± 0.025W |
| 10.00 – 99.99 W | 0.01W | ±2% ± 0.25W |
| 100.0 – 999.9 W | 0.1W | ±2% ± 2.5W |
| 1.000 – 9.999 KW | 0.001 KW | ±2% ± 0.025KW |
| 10.00 – 99.99 KW | 0.01 KW | ±2% ± 0.25KW |
| 100.0 – 999.9 KW | 0.1 KW | ±2% ± 2.5KW |
| 1000 – 9999 KW | 1 KW | ±2% ± 25KW |

¹For CT ≠1, the accuracy in percentage is the same (±2%). But the additional wattage should be multiplied by the CT ratio.

For example, ±0.025W becomes ±0.025W * CT ratio

²**If Auto Hz is selected, the AC voltage must be greater than 50V, and add 2° phase angle error to the accuracy.**

| Model 21 Range (30 – 50A) Model 23 Range (60 – 100A) | Resolution | Accuracy ^{3,4} |
|---|------------|-------------------------|
| 0.050 – 9.999 W | 0.001W | ±2% of VA ± 5dgts |
| 10.00 – 99.99 W | 0.01W | ±2% of VA ± 5dgts |
| 100.0 – 999.9 W | 0.1W | ±2% of VA ± 5dgts |
| 1.000 – 9.999 KW | 0.001 KW | ±2% of VA ± 5dgts |
| 10.00 – 99.99 KW | 0.01 KW | ±2% of VA ± 5dgts |
| 100.0 – 999.9 KW | 0.1 KW | ±2% of VA ± 5dgts |
| 1000 – 9999 KW | 1 KW | ±2% of VA ± 5dgts |

³For CT ≠1, the accuracy in percentage is the same (±2%). But the additional digits should be multiplied by the CT ratio.

For example, ±5 digits becomes ±5 digits * CT ratio

⁴If Auto Hz is selected, the AC voltage must be greater than 50V.

Range of CT Ratio: 1 to 250

H.P. (Horse Power)

$$1 \text{ H.P.} = 746 \text{ W}$$

AC Apparent Power (VA, from 0.000VA to 9999 KVA)

$$VA = V \text{ r.m.s.} \times A \text{ r.m.s}$$

AC Reactive Power (VAR, from 0.000 VAR to 9999 KVAR)

$$VAR = \sqrt{(VA^2 - W^2)}$$

AC Active Energy (mWH, WH, or KWH, from 0 mWH to 999,999 KWH)

$$WH = W * \text{Time (in hours)}$$

AC Current (Accuracy is of Reading, Auto Range, True RMS, Crest Factor < 4, CT=1, Max. peak values 880mADC for mA range, 73.5ADC for A range, and Overload Protection AC 600A)

Model 19,21

| Range | Resolution | Accuracy (50/60Hz) ^{5,6} |
|--------------|------------|-----------------------------------|
| 0.5 – 60mA | 0.01mA | ±0.5% ± 5dgts |
| 60 – 100mA | 0.01mA | ±0.5% ± 50dgts |
| 100 – 600 mA | 0.1 mA | ±0.5% ± 5dgts |
| 0.05 – 3 A | 0.001 A | ±0.5% ± 5dgts |
| 3 – 30 A | 0.01 A | ±0.5% ± 5dgts |
| 30 – 50 A | 0.01 A | ±1.0% ± 5dgts |

| Range | Resolution | Accuracy (45-1KHz) ^{5,6} |
|--------------|------------|-----------------------------------|
| 0.5 – 60mA | 0.01mA | ±1.5% ± 5dgts |
| 60 – 100mA | 0.01mA | ±1.5% ± 50dgts |
| 100 – 600 mA | 0.1 mA | ±1.5% ± 5dgts |
| 0.05 – 3 A | 0.001 A | ±1.5% ± 5dgts |
| 3 – 30 A | 0.01 A | ±1.5% ± 5dgts |
| 30 – 50 A | 0.01 A | ±1.5% ± 5dgts |

Model 23

| Range | Resolution | Accuracy (50/60Hz) ^{5,6} |
|--------------|------------|-----------------------------------|
| 0.5 – 60mA | 0.01mA | ±0.5% ± 5dgts |
| 60 – 100mA | 0.01mA | ±0.5% ± 50dgts |
| 100 – 600 mA | 0.1 mA | ±0.5% ± 5dgts |
| 0.05 – 3 A | 0.001 A | ±0.5% ± 5dgts |
| 3 – 30 A | 0.01 A | ±0.5% ± 5dgts |
| 30 – 90 A | 0.01 A | ±1.0% ± 5dgts |

| Range | Resolution | Accuracy (45-1KHz) ^{5,6} |
|--------------|------------|-----------------------------------|
| 0.5 – 60mA | 0.01mA | ±1.5% ± 5dgts |
| 60 – 100mA | 0.01mA | ±1.5% ± 50dgts |
| 100 – 600 mA | 0.1 mA | ±1.5% ± 5dgts |
| 0.05 – 3 A | 0.001 A | ±1.5% ± 5dgts |
| 3 – 30 A | 0.01 A | ±1.5% ± 5dgts |
| 30 – 90 A | 0.01 A | ±1.5% ± 5dgts |

⁵For CT ≠ 1, the accuracy in percentage is the same (±0.5%). But the additional digits should be multiplied by the CT ratio.

For example, ± 5 digits becomes ± 5 digits * CT ratio

⁶If Auto Hz is selected, the AC current must be greater than 10mA for mA range, and greater than 1A for A range.

AC Voltage (Accuracy is of reading, Auto Range, True RMS, Crest Factor < 4, Input Impedance 10 MΩ, Max peak value 860VDC, and Overload Protection AC 800V)

Model 19, 21, 23

| Range | Resolution | Accuracy (50/60Hz) ⁷ |
|---------------|------------|---------------------------------|
| 5V – 250 V | 0.1 V | $\pm 0.5\% \pm 5$ dgts |
| 250 V – 600 V | 0.1 V | $\pm 0.5\% \pm 5$ dgts |

| Range | Resolution | Accuracy (45-1KHz) ⁷ |
|---------------|------------|---------------------------------|
| 5V – 250 V | 0.1 V | $\pm 1.5\% \pm 5$ dgts |
| 250 V – 600 V | 0.1 V | $\pm 1.5\% \pm 5$ dgts |

⁷If Auto Hz is selected, the AC voltage must be greater than 50V.

Harmonics of AC Voltage in Percentage (1 to 99th order, minimum voltage at 50 or 60 Hz is greater than AC 80V. If the voltage is 0 at 50 or 60 Hz, all the percentage (%) display is 0).

| Range (Model 19, 21) | Resolution | Accuracy |
|-----------------------|------------|---------------------------------|
| 1 – 10 th | 0.1 % | $\pm 1\%$ of reading $\pm 1\%$ |
| 11 – 20 th | 0.1 % | $\pm 5\%$ of reading $\pm 1\%$ |
| 21 – 50 th | 0.1 % | $\pm 15\%$ of reading $\pm 1\%$ |
| 51 - 99 th | 0.1 % | $\pm 35\%$ of reading $\pm 1\%$ |

| Range (Model 23) | Resolution | Accuracy |
|----------------------------------|------------|----------------------------------|
| 1 – 10 th | 0.1 % | $\pm 0.7\%$ of reading $\pm 1\%$ |
| 11 – 20 th | 0.1 % | $\pm 2\%$ of reading $\pm 1\%$ |
| 21 – 50 th (A range) | 0.1 % | $\pm 5\%$ of reading $\pm 1\%$ |
| 21 – 50 th (mA range) | 0.1 % | $\pm 10\%$ of reading $\pm 1\%$ |
| 51 - 99 th | 0.1 % | $\pm 35\%$ of reading $\pm 1\%$ |

Harmonics of AC Voltage in Magnitude (1 to 99th order, minimum voltage at 50 or 60 Hz is greater than AC 80V)

| Range (Model 19, 21) | Resolution | Accuracy |
|-------------------------------|------------|------------------------|
| 1 – 10 th | 0.1 V | ±1% of reading ±7dgts |
| 11 – 20 th | 0.1 V | ±5% of reading ±7dgts |
| 21 – 50 th | 0.1 V | ±15% of reading ±7dgts |
| 51 – 99 th | 0.1 V | ±35% of reading ±7dgts |

| Range (Model 23) | Resolution | Accuracy |
|----------------------------------|------------|-------------------------|
| 1 – 10 th | 0.1 V | ±0.7% of reading ±7dgts |
| 11 – 20 th | 0.1 V | ±2% of reading ±7dgts |
| 21 – 50 th (A range) | 0.1 V | ±5% of reading ±7dgts |
| 21 – 50 th (mA range) | 0.1 V | ±10% of reading ±7dgts |
| 51 – 99 th | 0.1 V | ±35% of reading ±7dgts |

Harmonics of AC Current in Percentage (1 to 99th order, minimum current at 50 or 60 Hz is greater than 100mA for mA range, and greater than 1A for A range. If the current is 0 at 50 or 60 Hz, all the percentage (%) display is 0)

Model 19, 21

| Range | Resolution | Accuracy |
|-----------------------|------------|---------------------|
| 1 – 10 th | 0.1 % | ±1% of reading ±1% |
| 11 – 20 th | 0.1 % | ±5% of reading ±1% |
| 21 – 50 th | 0.1 % | ±15% of reading ±1% |
| 51 – 99 th | 0.1 % | ±35% of reading ±1% |

Model 23

| Range | Resolution | Accuracy |
|----------------------------------|------------|----------------------|
| 1 – 10 th | 0.1 % | ±0.7% of reading ±1% |
| 11 – 20 th | 0.1 % | ±2% of reading ±1% |
| 21 – 50 th (A range) | 0.1 % | ±5% of reading ±1% |
| 21 – 50 th (mA range) | 0.1 % | ±10% of reading ±1% |
| 51 – 99 th | 0.1 % | ±35% of reading ±1% |

Harmonics of AC Current in Magnitude (1 to 99th order, minimum current at 50 or 60 Hz is greater than 100mA for mA range, and greater than 1A for A range)

Model 19, 21, 23

| Range | Resolution | Accuracy |
|-----------------------|--|--|
| 1 – 10 th | 0.01mA / 0.1mA / 0.001A / 0.01A | reading in mA: $\pm 1\%$ of reading $\pm 2\text{mA}$ reading in A: $\pm 1\%$ of reading $\pm 0.3\text{A}$ |
| 11 – 20 th | | reading in mA: $\pm 7\%$ of reading $\pm 2\text{mA}$ reading in A: $\pm 7\%$ of reading $\pm 0.3\text{A}$ |
| 21 – 50 th | | reading in mA: $\pm 15\%$ of reading $\pm 3\text{mA}$ reading in A: $\pm 15\%$ of reading $\pm 0.3\text{A}$ |
| 51 - 99 th | | reading in mA: $\pm 35\%$ of reading $\pm 3\text{mA}$ reading in A: $\pm 35\%$ of reading $\pm 0.3\text{A}$ |

Power Factor (PF, ACV > 4V, AC mA > 1mA, AC A > 0.04A, Watt > 50 digits)

Model 21, 23

| Range | Resolution | Accuracy |
|---------------|------------|------------|
| 0.000 – 1.000 | 0.001 | ± 0.04 |

Phase Angle (Φ , 50 or 60Hz)

Model 21, 23

| Range | Resolution | Accuracy |
|---------------|------------|---------------|
| -180° to 180° | 0.1° | $\pm 2^\circ$ |
| 0° to 360° | 0.1° | $\pm 2^\circ$ |

If function of AUTO Hz is selected, add 2° error to the accuracy.

Frequency (Hz)

Model 19, 21, 23

| Range | Resolution | Accuracy of Readings | Allowed Input |
|---------------|------------|----------------------|---------------|
| mA(45 – 65Hz) | 0.1Hz | $\pm 0.5\text{Hz}$ | 20mA to 1.2A |
| A(45 - 65Hz) | 0.1Hz | $\pm 0.5\text{Hz}$ | 1A to 100A |

Sensitivity (PROVA 19, 21): > 20mA for mA range, > 1A for A range, and > 50V

Sensitivity (PROVA 23): > 20mA for mA range, > 3A for A range, and > 50V

Total Harmonic Distortion (THD-F with respect to the first (fundamental) harmonics, min. value in the range from 45 to 65Hz is greater than AC 80V, greater than 1A for A range, and greater than 100mA for mA range. Calculation is done over 1 to 50th Harmonics. If the voltage or current is 0 in the range from 45 to 65Hz, all the percentage (%) display is 0)

Model 19, 21

| Range (45~65Hz) | Resolution | Accuracy |
|-----------------|------------|-----------------------|
| 0.0 – 10.0 % | 0.1% | ± 2% |
| 10.0 – 40% | 0.1% | ±5% of reading ± 5% |
| 40 – 100% | 0.1% | ±10% of reading ± 10% |
| 100 – 999.9% | 0.1% | ±20% of reading |

Model 23

| Range (45~65Hz) | Resolution | Accuracy |
|-----------------|------------|----------------------|
| 0.0 – 20.0 % | 0.1% | ± 2% |
| 20.0 – 100% | 0.1% | ±3% of reading ± 5% |
| 100 – 999.9% | 0.1% | ±10% of reading ±10% |

Peak Value of AC Periodic Voltage (peak value > 10V) **or AC Periodic Current** (peak value > 10mA for mA range and peak value > 0.5A for A range) **for continuous waveform except for square wave:**

Model 19, 21, 23


| Range | Sampling Time | Accuracy of Reading |
|-------|---------------|---------------------|
| 50 Hz | 39 μs | ± 5% ± 30 digits |
| 60 Hz | 33 μs | ± 5% ± 30 digits |

Crest Factor (C.F.) of AC Voltage (peak value > 10V) **or AC Current** (peak value > 10mA for mA range and peak value > 0.5A for A range) **for continuous waveform except for square wave:**

Model 19, 21, 23

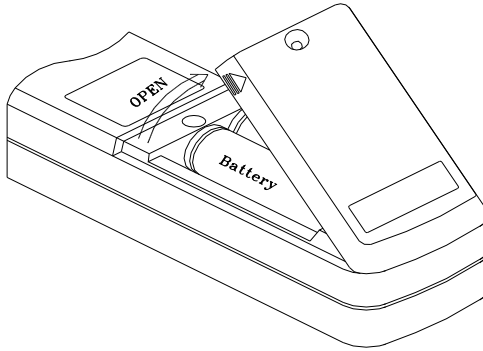
| Range (45~65Hz) | Resolution | Accuracy of Readings |
|-----------------|------------|----------------------|
| 1.00 – 99.99 | 0.01 | ± 5% ± 30 digits |

Indoor Use

| | |
|--|---|
| Conductor Size: | 30mm (approx.) |
| Battery Type: | two 1.5V SUM-3 |
| Display: | 4+2+2 digits LCD |
| Range Selection: | Auto |
| Overload Indication: | OL |
| Power Consumption: | 10mA (approx.) |
| Low battery Indication: |  |
| Auto-Power-Off: | 30 minutes after power-on |
| Update Time: | 2 times/sec. (display) |
| No. Of Samples per Period | 512 (voltage or current) 256 (power) |
| Temperature Coefficient ($<18^{\circ}\text{C}$ or $>28^{\circ}\text{C}$): | $0.15 \times (\text{Specified Accuracy}) / ^{\circ}\text{C}$ |
| Operating Temperature: | -10°C to 50°C |
| Operating Humidity: | less than 85% relative |
| Altitude: | up to 2000M |
| Storage Temperature: | -20°C to 60°C |
| Storage Humidity: | less than 75% relative |
| Dimension: | 210mm (L) x 62mm (W) x 35.6mm (H) 8.3" (L) x 2.5" (W) x 1.4" (H) |
| Weight: | 200g (battery included) |
| Accessories: | test leads Carrying bag x 1 Users manual x 1 Batteries 1.5V x 2 |
| Option: | Alligator clips |

VII. BATTERY REPLACEMENT

When the low battery symbol is displayed on the LCD, replace the old batteries with two new batteries.



- A. **MUST** Turn the power off and remove the test leads from the clamp meter.
- B. Remove the screw of the battery compartment.
- C. Lift and remove the battery compartment.
- D. Remove the old batteries.
- E. Insert two new 1.5V SUM-3 batteries.
- F. Replace the battery compartment and secure the screw.

VIII. MAINTENANCE & CLEANING

Servicing not covered in this manual should only be performed by qualified personnel. Repairs should only be performed by qualified personnel.

Periodically wipe the case with a damp cloth and detergent; do not use abrasives or solvents.

Address of Agent, Distributor, Importer, or Manufacturer

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