# User Manual
## Solar Panel I-V Curve Tracer
**MODEL PV48**

# User Manual
# Solar Panel I-V Curve Tracer

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# 1 Safety

## 1.1 Safety Warnings

**WARNING**

Read, understand, and follow all safety information and operating instructions in this manual before using this device

Do not use this device if it appears damaged or is operating abnormally. If in doubt, contact customer support.

To avoid electrical shock, use caution when working with voltages > 35 V DC.

Do not exceed the maximum rated input limits.

## 1.2 Safety Cautions

**CAUTION**

This device can only be used to measure one (1) photovoltaic solar panel, and the test lines must be directly connected to the terminal connections on the panel. Intermediate connections through other connecting wires, or similar means, should not be attempted, as they would affect the accuracy of the measurements.

Do not measure solar panels with a power output > 800 W, as it may damage the equipment.

Do not measure solar panels with a voltage > 60 V, as it may damage the equipment.

Do not measure solar panels with a current > 30 A, as it may damage the equipment.

When using this device, do not connect the solar panel simultaneously to other controllers or devices.

If the device triggers a high-temperature alarm, wait for the device to cool down before continued use.

In the manual mode, the device prohibits measuring solar panels with a power output > 100 W. The equipment may continuously generate heat under overload conditions, and if the temperature reaches unsafe levels, the device will automatically stop the test.

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

For indoor use only.

## 1.3 International Safety Symbols

| | |
|---|---|
|  | This symbol, adjacent to another symbol or terminal, indicates the user must refer to the manual for further information. |
|  | This symbol, adjacent to a terminal, indicates that, under normal use, hazardous voltages may be present. |
|  | Double insulation. |

# 2 Introduction

Thank you for selecting the FLIR PV48 Solar Panel I-V Curve Tracer.

The PV48 measures the maximum power output of a solar panel. The greater the power output, for any given sunlight intensity, the better the performance of the panel.

The PV48 is a maximum power point tester (MPPT), designed to optimize the match between a solar panel and a battery bank or power utility grid. To accomplishes this, the PV48 measures the optimal power generation voltage for the panel. By measuring the maximum power point, and the corresponding $V_{max}$, the optimal power generation voltage can be determined.

Special features are listed below.

- Batch mode, for quickly analyzing 10 readings.
- Peak Data mode, for logging 30 readings.
- IV/PV curve mode for plotting power, voltage, and current measurements graphically on one screen.
- Manual mode for optimizing measurement accuracy on low power solar panels (< 100 W).

# 3 Rechargeable Battery

## 3.1 Battery Overview

The tracer is powered by an internal rechargeable lithium battery. Short press the power button to switch the tracer ON, long press the power button to switch the tracer OFF. The battery status icon at the upper right corner of the display indicates battery power. When battery power is critically low, the battery status icon will appear empty and will turn red. See Fig. 3.1, below.

**Figure 3.1** Battery status icon stages.

The battery is not user-serviceable. If the battery will not charge, or otherwise behaves abnormally, contact customer support.

## 3.2 Battery Charging with Tracer OFF

Connect the supplied USB cable to the tracer (bottom) and to a 5 V charger. The display will switch ON and show a large vertical battery image at the centre of the screen.

The number of horizontal bars in the image indicates the charge status, five bars indicates a full charge. The image flashes as the tracer charges. When fully charged, the flashing stops and all five bars are shown. See Fig. 3.2, below

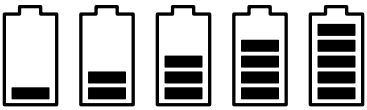

**Figure 3.2** Battery image, when charging with the tracer switched OFF. Battery is fully charged at right.

## 3.3 Battery Charging with Tracer ON

Connect the supplied USB cable to the tracer (bottom) and to a 5 V charger. A charging icon will appear to the right of the battery status icon at the top right corner of the display, see Fig. 3.3, below.

**Figure 3.3** When charging the battery with the tracer ON, the charging icon appears to the right of the battery status icon.

### 3.4 Automatic Power OFF (APO)

After five (5) minutes of inactivity (no button presses), the tracer will automatically switch OFF.

# 4 Product Descriptions

## 4.1 Tracer Description

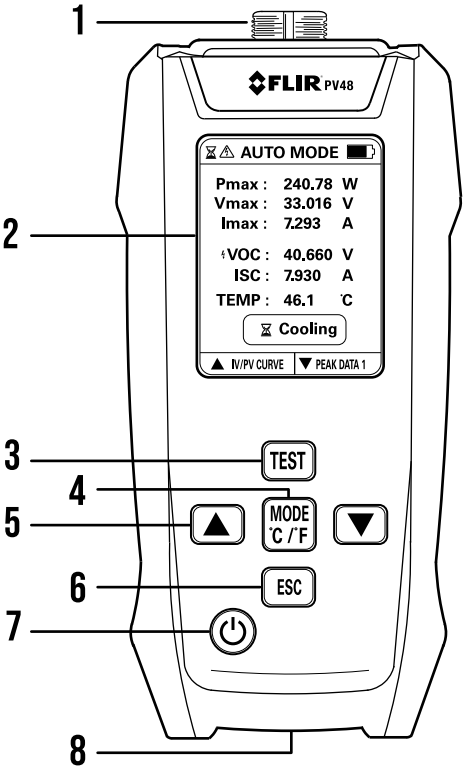


**Figure 4.1** Tracer parts.

1. Probe socket.
2. Color display.
3. Test start button.
4. Mode (short press) and Units (long press) button.
5. Up and down arrow buttons (to select other modes and to make adjustments in manual mode).
6. Escape button (to return to Home screen).
7. Power ON (short press) and OFF (long press) button.
8. USB-C port and tripod mount.

## 4.2 Button Descriptions

| | |
|---|---|
| ⏻ | Short press to switch the tracer ON.<br>Long press to switch the tracer OFF. |
| **MODE**<br>**℃/℉** | Short press to switch between automatic and manual modes.<br>Long press to switch between ℃ and ℉ temperature units. |
| ▲▼ | In automatic mode, use the arrow buttons to switch operational modes (Batch mode, Peak Data, IV/PV Curve).<br>In manual mode, use the arrow buttons to adjust the power scale. |
| **TEST** | Short press to start a test, when the tracer is in the 'READY' state (the check icon ⓥ is shown on the upper left corner and at the centre of the display). |
| **ESC** | Short press to return to the Home screen. |

### 4.3 Home Screen Description

When switched ON, the tracer shows the Home screen. Press the ESC button from any other screen to return to the Home screen. Other screens are shown for specific modes of operation, these are covered in their respective sections of this manual.

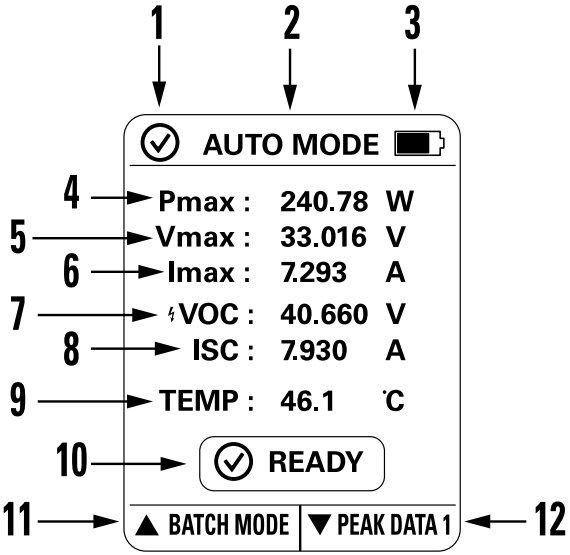


**Figure 4.2** Home page description.

1. Check mark indicates that the tracer is ready for testing.
2. Automatic mode.
3. Battery status.
4. Maximum power measurement.
5. Maximum voltage at maximum power.
6. Maximum current at maximum power.
7. Open circuit voltage.
8. Short circuit current.
9. Temperature measurement.
10. Tracer is ready for testing.
11. Press the up arrow to scroll up through other mode screens.
12. Press the down arrow to scroll down through other mode screens.

## 4.4 Display Icon Descriptions

| | |
|---|---|
|  | Battery status icon.<br>The lightning bolt icon is shown to the right of the battery symbol when the battery is charging. |
|  | Tracer is ready for testing. |
|  | Tracer is actively testing (typical test time is 1 to 2 seconds). |
|  | Tracer is actively testing, and is detecting voltage. |
|  | When the hourglass is shown on the upper left, the tracer has finished a test and is processing the test data.<br>When shown at the centre of the display, the tracer is cooling (typical cooling time is 1 to 10 seconds). |
|  | A high-temperature condition is detected. Allow tracer to cool to a safe temperature before use. |
|  | A measurement overload is detected. |
|  | Voltage > 1 V DC is detected. |

### 4.5 Probe Descriptions

The PV48 is supplied with MC4 (300 V) photovoltaic connection cables (Figure 4.3, below) and a set of Kelvin clips (Figure 4.4, below). Use the photovoltaic connecting cables when the solar panel under test has matching mating connectors. Use the Kelvin clips when connecting directly to the solar panel circuitry.

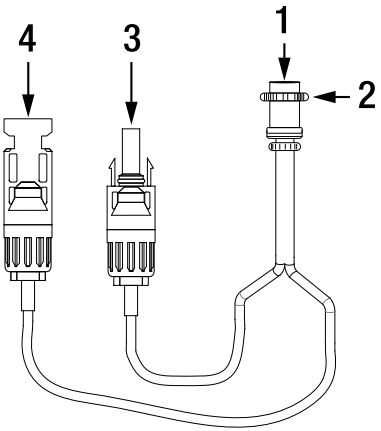


**Figure 4.3** Photovoltaic connecting cables. 1. Connect to the keyed probe socket at the top of the meter; 2. Turn the locking nut to tighten and secure the connection; 3. Connect to the female connector on the solar panel; 4. Connect to the male connector on the solar panel.

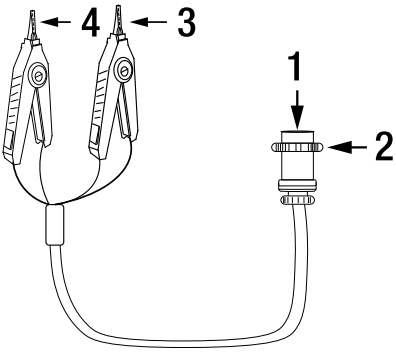


**Figure 4.4** Kelvin clip test leads. 1. Connect to the keyed probe socket at the top of the meter; 2. Turn the locking nut to tighten and secure the connection; 3. Connect the black lead to the negative side of the circuit on the solar panel; 4. Connect the red lead to the positive side of the circuit on the solar panel.

# 5 Operation

**WARNING**

**Reverse Polarity Connection**

When the tracer detects that the polarity of the measurement lines is reversed, a pop-up window (Fig. 5.1) will alert the user.

When the tracer detects that the polarity of the measurement lines is no longer reversed, the alert window will close. A reminder will continue to display for 5 seconds. If correct wiring is detected within this time, another pop-up (Fig. 5.2) will inform the user that the wiring is now correct, and this message will also be displayed for 5 seconds.

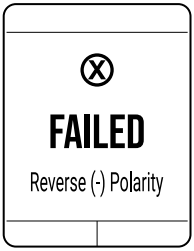


**Figure 5.1** Pop-window appears when test lead polarity is reversed.

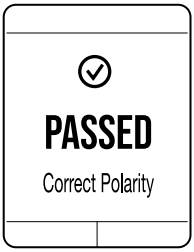


**Figure 5.2** If correct wiring is detected within 5 seconds of a failed polarity test, this pop-up will appear for 5 seconds.

**WARNING**

**High Temperature Condition**

When the temperature alarm icon is displayed, wait for the tracer to naturally cool down to a safe temperature range before continuing to test.

**WARNING**

**Overload Condition**

When an overload condition is detected by the tracer, the overload icon ⊗ will appear and testing must be stopped. Do not use the tracer to measure signals that exceed the specific range limits.

## 5.1 Connecting Test Probes to the Tracer

The tracer is shipped with a set of Kelvin clip leads and a set of standard photovoltaic cables. Connect either of these to the socket at the top of the tracer. See Figure 5.3, below.

Carefully align the connector pins (1) and the connector key (2), insert the probe, and tighten the locking nut. Do not overtighten.

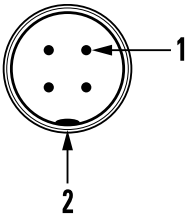


**Figure 5.3** Probe socket at top of tracer. 1. Connector pins; 2. Connector key.

## 5.2 Testing in Automatic Mode

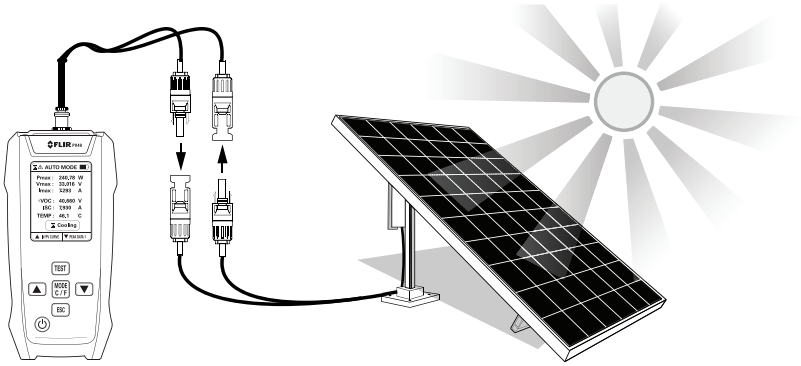


**Figure 5.4** Connecting to solar panels and testing in automatic mode.

1. Connect the test probes to the tracer and then to the positive and negative terminals on the solar panel as described in Section 4.5 and shown in Figure 5.4. Do not connect the solar panel to other controllers or testers while testing.
2. When the tracer is in the ready state (indicated by the check mark ⊘), short press the TEST button.
3. While testing, the testing icon ⊙ will appear on the upper left. The voltage warning icon ⚠ will appear next to the testing icon if voltage is detected.
4. When the test is done, the hourglass icon ⧗ will appear as the test data is being processed. The check mark icon ⊘ will appear again when processing is complete.
5. View the test results on the display. Refer to Figure 4.2 for test result basics.
6. Use the arrow buttons to select a different mode of operation: Batch mode, Peak Data, and IV/PV Curve. These functions are explained in the next sections.

### 5.3 Batch Mode

Batch mode is used for a quick ten reading test session. Note that these readings are not saved when the tracer is switched OFF.

1. Connect the test probes to the tracer and then to the positive and negative terminals on the solar panel as described in Section 4.5. Do not connect the solar panel to other controllers or tracers while testing
2. From the Home screen, press the up arrow button to access the Batch mode screen. A table with ten rows will appear, as shown in Figure 5.5, below.
3. Press the TEST button to take the first test. The test results will appear on row 1. The voltage icon ⚠ is shown at the top of the screen, wait until this icon switches OFF before continuing.
4. Press the TEST button again to take the second test, the results will appear on row 2.
5. Continue taking tests until all ten rows are populated. The row with blue represents the highest power reading of the ten tests.
6. Press the up arrow to go to the IV/PV Curve mode or press the down arrow button to return to the automatic mode.
7. Press the ESC button to return to the Home screen.

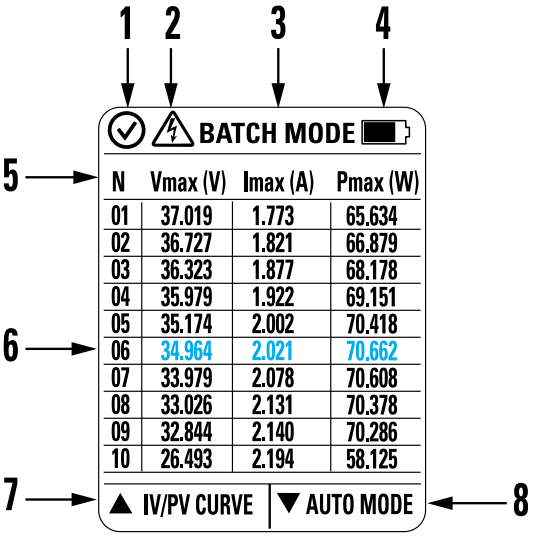


**Figure 5.5** Batch mode screen. Each numbered item in the figure is defined below.

1. Tracer is ready to test.
2. Tracer is testing and voltage is present.
3. Batch mode indicator.
4. Battery status.
5. Test data row headers for maximum voltage, current, and power measurements.
6. Test data for the ten tests. Test 6 was the highest power reading so it is shown in blue.
7. Press up arrow to go to the IV/PV Curve mode.
8. Press down arrow to return to AUTO mode.

### 5.4 IV/PV Curve

The IV/PV Curve shows test measurements graphically, plotting current and voltage (IV) and power and voltage (PV) on the same color-coded graph. See Figure 5.6, below.

1. Connect the test probes to the tracer and then to the positive and negative terminals on the solar panel as described in Section 4.5. Do not connect the solar panel to other controllers or tracers while testing.
2. From the Home screen, press the up arrow button twice to step to the IV/PV Curve mode.
3. Press the TEST button to start the test.
4. The status icon in the upper left corner of the display will switch from check mark icon ⓥ (ready), to the testing icon ⓟ, then to the hourglass icon ⧗ (processing), and then back to the check mark.
5. View the data plotted on the graph. Power is plotted in blue, and current/voltage are plotted in black. Refer to Figure 5.6, below.

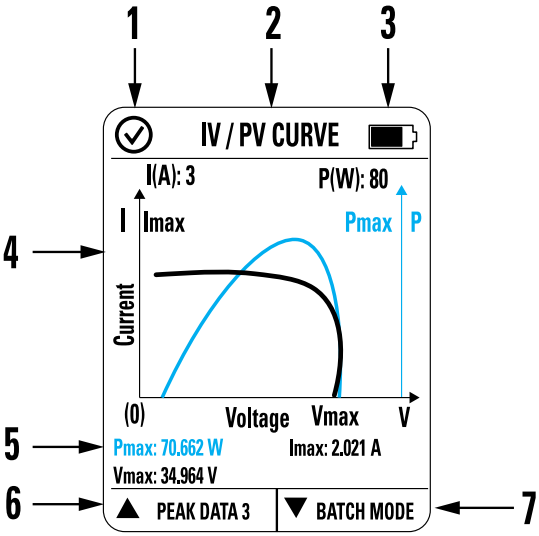


**Figure 5.6** IV/PV Curve screen. Each numbered item in the figure is defined below. $P_{max}$ is the maximum power. $V_{max}$ is the voltage at maximum power. $I_{max}$ is the current at maximum power.

1. Test status icon area. Check mark indicates that the tracer is ready to test.
2. Mode name.
3. Battery status icon.
4. Graph.
5. Maximum measurements during test.
6. Press up arrow to switch to the Peak Data mode.
7. Press the down arrow to switch to the Batch mode.

## 5.5 Peak Data Mode

In the Peak Data mode, one test will take thirty (30) readings. The readings are spread across three pages (Peak Data 1, 2, and 3) with ten readings on each page. Use the arrow buttons to step through the pages. See Figure 5.7, below.

The measurement row showing blue text indicates the maximum power detected.

1. Connect the test probes to the tracer and then to the positive and negative terminals on the solar panel as described in Section 4.5. Do not connect the solar panel to other controllers or tracers while testing.
2. From the Home screen, press the down arrow button to access Peak Data page 1.
3. Press the TEST button to start the test.
4. The status icon in the upper left corner of the display will switch from check mark icon ⊘ (ready), to the testing icon ⊙, then to the hourglass icon ⧗ (processing), and then back to the check mark.
5. View the data on the table. The row with blue represents the highest power reading in the table.
6. Use the arrow buttons to step through pages Peak Data 1, 2, and 3.

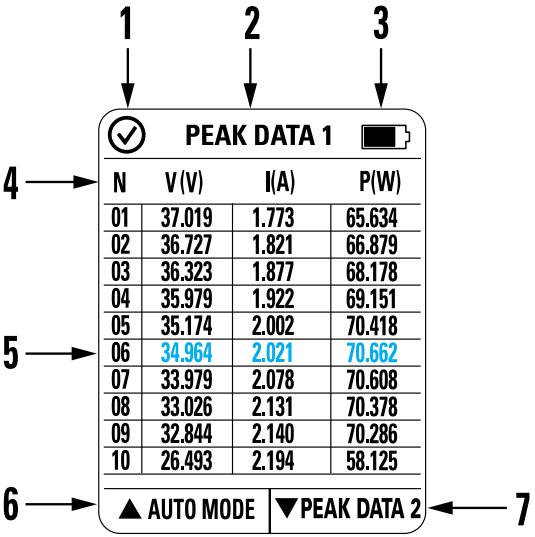


**Figure 5.7** Peak Data 1 screen example. To view Peak Data screens 1 and 2, press the down arrow button. Each numbered item in the figure is defined below.

1. Test status icon. Check mark indicates that the tracer is ready for testing.
2. Mode of operation.
3. Battery status.
4. Table row header (data number [N], voltage, current, power).
5. Test data table. Test 6 was the highest power reading so it is shown in blue.
6. Press the up arrow to return to Auto mode.
7. Press the down arrow to view Peak Data page 2 and then page 3.

## 5.6 Manual Mode

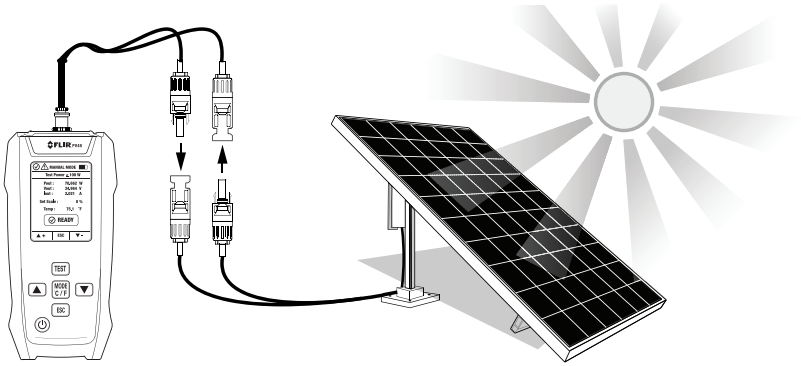


**Figure 5.8** Connecting to solar panels and testing in manual mode.

Manual mode allows you to take high accuracy measurements on low power solar panels (100 W, maximum). Do not use the Manual mode to measure solar panels with higher power.

The adjustable scale setting (item 7 in Figure 5.9, below), allows you to amplify the measurement from 17.80 to 25.00 % so that the tracer can display an otherwise under-range power signal.

1. Connect the test probes to the tracer and then to the positive and negative terminals on the solar panel as described in Section 4.5 and shown in Figure 5.8. Do not connect the solar panel to other controllers or tracers while testing.
2. Short press the Mode button to enter the manual mode, see Figure 5.9.
3. With the adjustable scale set to 0%, check if the tracer will display a power measurement ($P_{out}$). If it does not, Use the up arrow button to amplify the signal. Long press the button to scroll quickly. Allow three seconds between adjustments for the tracer to process the measurement and to avoid overheating.
4. When the scale setting is increased to the point where the reading reaches maximum power, release the arrow button (if the power starts decreasing, lower the setting to find the maximum power again).

5. The ‘READY’ icon (item 9 in Figure 5.9) changes to an alternating pattern of ‘RUNNING’ and ‘STOP’ when the scale setting is increased from zero. This means that the tracer is taking readings (RUNNING) in between periods of rest (STOP).

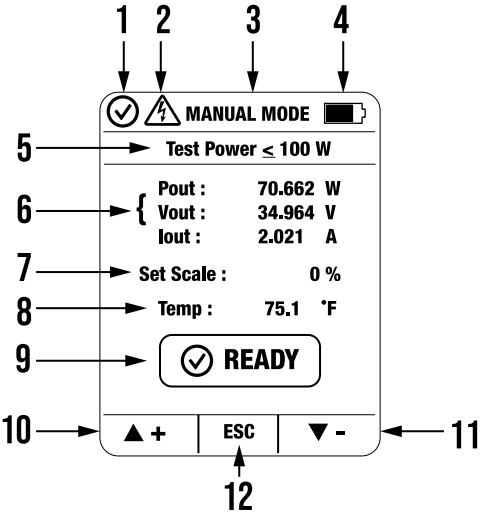


**Figure 5.9** Manual mode screen. Each numbered item in the figure is defined below.

1. Test status icon. Check mark indicates that the tracer is ready for testing.
2. When testing, this icon indicates that voltage is detected.
3. Mode of operation.
4. Battery status.
5. Reminder that tests should not be made on solar panels with a power > 100 W in Manual mode.
6. Test results for power, voltage, and current output.
7. Adjustable scale setting.
8. Temperature measurement.
9. Test status.
10. Use the up arrow to increase the scale setting %. Long press to scroll quickly.
11. Use the down arrow to decrease the scale setting %. Long press to scroll quickly.
12. Press ESC to return to the Home page.

# 6 Specifications

## 6.1 General Specifications

| | |
|---|---|
| Display | TFT type with backlight |
| Measurement update rate | Three (3) samples per second |
| Temperature protection | 140°F (60°C) maximum, in operation |
| Power supply | Rechargeable lithium-ion battery, 3.7 V, 1000 mAh |
| Battery life | 5 hours |
| Automatic Power OFF | After 5 minutes of inactivity |
| Battery charging | 5 V DC (500 mA) |
| Operating temperature | 14 to 122°F (-10 to 50°C) |
| Storage temperature | –4 to 140°F (-20 to 60°C) |
| Operating and storage humidity | < 80 % RH |
| Operating altitude | 6560 ft. (2000 m) |
| Pollution degree | 2 |
| Drop test | 4.9 ft. (1.5 m) |
| Certifications | CE, FCC, RCM |
| Safety compliance | IEC 61010–1/-2 |
| EMC compliance | EN61326–1, FCC Part 15 B |
| Dimensions | 6.0 x 2.8 x 1.5 in. (151.6 x 72.5 x 38 mm) |
| Weight | 7.3 oz. (206 g) |
| Supplied equipment | PV48, USB cable, MC4 test leads (300 V), Kelvin clip test leads, carry pouch, printed Quick Start Guide. |

## 6.2 Electrical Specifications

| Function | Range | Accuracy (of reading) |
|---|---|---|
| Open Circuit Voltage ($V_{OC}$) | 0 to 60 V | ±1% |
| Short circuit current ($I_{sc}$) | 0 to 30 A | ±1% |
| MPPT* point power ($P_{max}$) | 0 to 800 W | ±5% |
| MPPT point voltage ($V_{max}$) | 0 to 60 V | ±5% |
| MPPT point current ($I_{max}$) | 0 to 30 A | ±5% |

*An MPPT, or maximum power point tester, optimizes the match between solar panels and a battery bank or utility grid.

# 7 Customer Support

Customer Support Telephone List

https://support.flir.com/contact

Repair, Calibration, and Technical Support:

https://support.flir.com

# 8 Limited 3–Year Warranty

This product is protected by FLIR's Limited 3-Year Warranty. Visit www.flir.com/testwarranty to read the warranty document.

Teledyne FLIR Commercial Systems, Inc. Taiwan Branch.

10F, No. 57, Zhouzi Street, NeiHu District, Taipei city, 114676, Taiwan

**Website**
http://www.flir.com

**Customer support**
http://support.flir.com



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