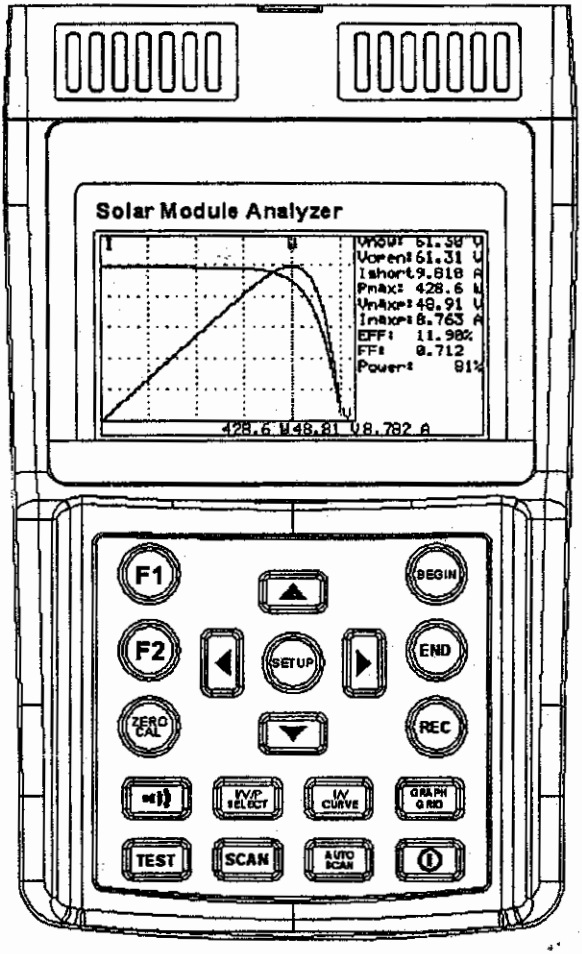
Solar Module Analyzer

Users Manual



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I. Preparation

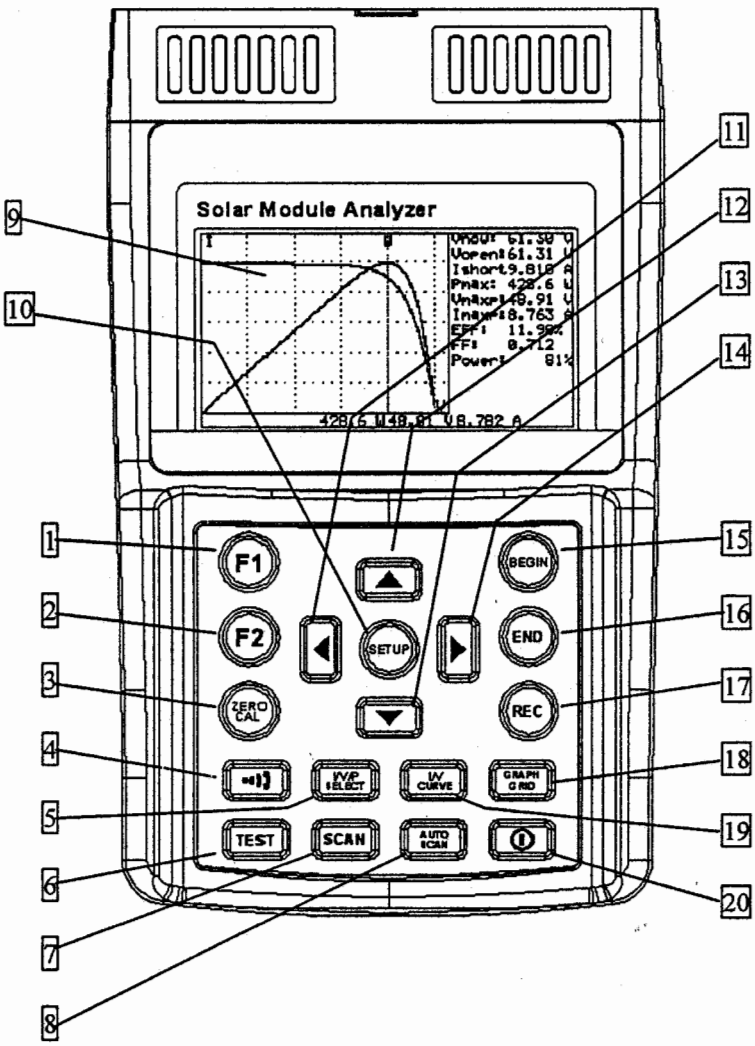
This Solar Module Analyzer uses rechargeable lithium battery. Before using the new rechargeable lithium battery, please charge it for 10~12 hours continuously for better battery life. The lithium battery is pre-installed at the factory. Users can plug in the AC adaptor and the rechargeable lithium battery is charged automatically.

II. Features

- I-V Curve Test for solar module.
- 60V and 12A Capability.
- Maximum Solar Power (Pmax) search by auto-scan.
- Maximum Voltage (Vmaxp) at Pmax.
- Maximum Current (Imaxp) at Pmax.
- Voltage at open circuit (Vopen).
- Current at short circuit (Ishort).
- I-V curve with cursor.
- Data logging function to analyze solar power characteristics over a period of time.
- Efficiency (%) calculation of solar panel.
- Scan delay setting. (0 ~ 3000 mS)
- Solar panel area setting. (0.001 m^2 ~ 9999 m^2)
- Standard light source setting. (10 W/m^2 ~ 1000 W/m^2)
- Min. power setting for alarm function.
- Built-in Calendar Clock.
- Rechargeable lithium battery with built-in charging circuit.
- Optical USB cable for PC.
- Option: portable thermal printer (model: 310XP or 300XP) to print (hardcopy) the LCD displays of Solar Module Analyzer.

III. Panel Description

A. Front Panel



1.  **F1 button:** (Reserved)

2.  **F2 button:** (Reserved)

3.  **ZERO CAL:**

   Zero calibration of voltage and current. Connect (short) the two Kelvin clips together and press this button. Regular calibration of zero would maintain the accuracy of the instruments.

4.  **(buzzer) button:**

   Press this button to turn on/off the beeper (low Power) alarm function.

5.  **I/V/P SELECT button:**

   Select display of I-V/ V-I curve, P-V/P-I curve, or both curves.

6.  **TEST button:**

   Single point I-V test based upon specified value.

7.  **SCAN button:**

   Manual scan I-V curve test based upon specified value.

8.  **Auto Scan button:**

   Auto scan I-V curve test.

9. **LCD:**

   LCD displays measurement data and curves.

10.  **SETUP button:**

    Enter/Exit SETUP menu.

11.  **button:**

    (1) In a curve, press it to move the cursor left.

    (2) In SETUP menu, press it to decrement value by 1.

12.  **button:**

In the SETUP menu, press ▲ button to select previous item.

13.  **button:**

In the SETUP menu, press ▼button to select next item.

14.  **button:**

(1) In a curve, press it to move the cursor right.

(2) In the SETUP menu, press it to increment value by 1.

15.  **BEGIN button:**

"Start scanning point (current)" setting.

16.  **END button:**

"Stop scanning point (current)" setting.

17.  **REC button:**

(1) Press this button to start data logging. Press it again to stop data logging.

(2) How to clear recorded data: keep pressing REC button and turn on the analyzer, then all the data recorded in the analyzer will be deleted.

18.  **GRAPH GRID button:**

Display/Cancel graph grid.

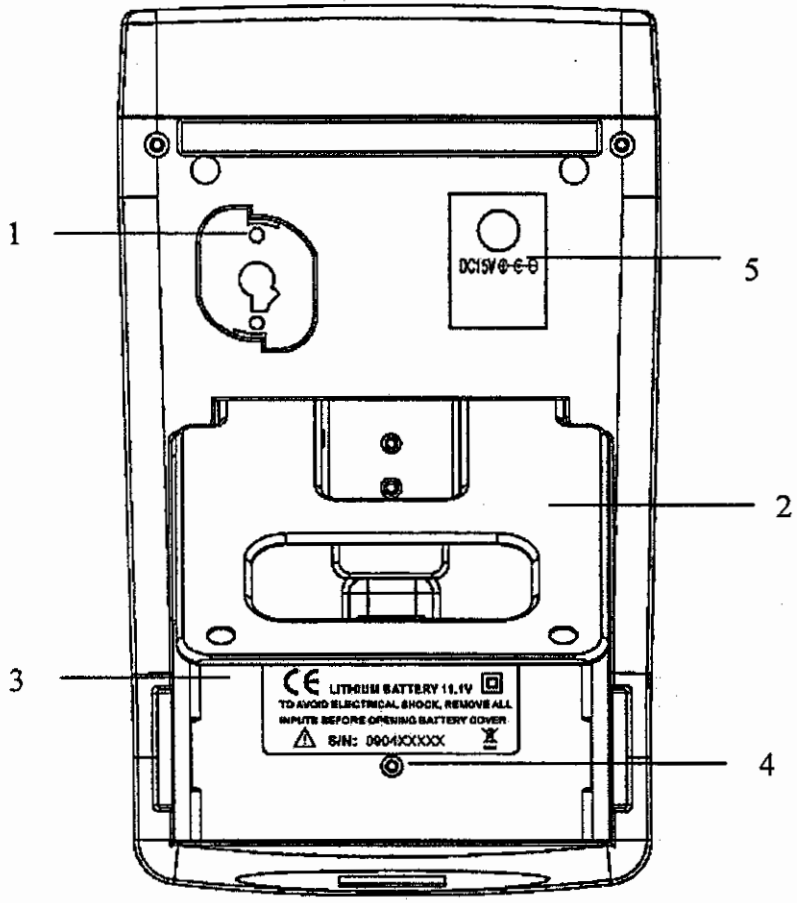
19.  **I/V CURVE button:**

Select I or V as horizontal coordinate.

20.  **Power button:**

Turn on/off the power of Solar Module Analyzer.

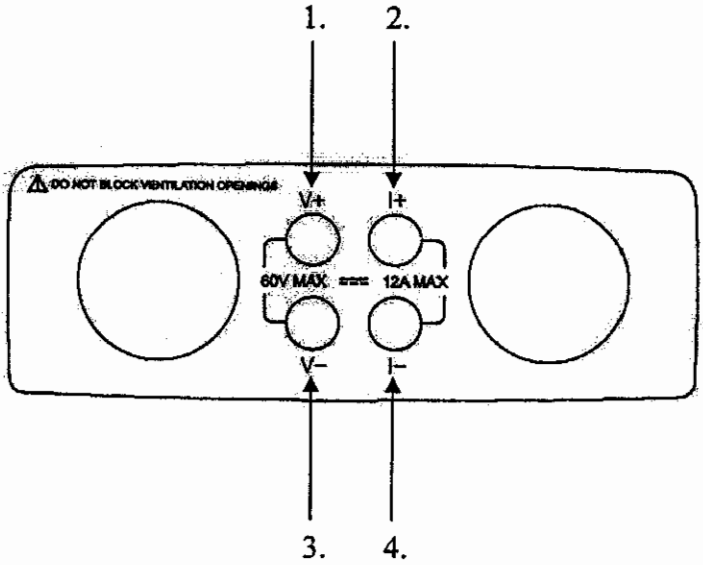
B. Rear Panel



1. **Communication Window:**

   To connect Solar Module Analyzer with PC via USB cable.
2. **Stand.**
3. **Battery cover.**
4. **Screw of battery cover.**
5. **AC to DC adaptor input.**

C. Connecting Wires (Connectors)

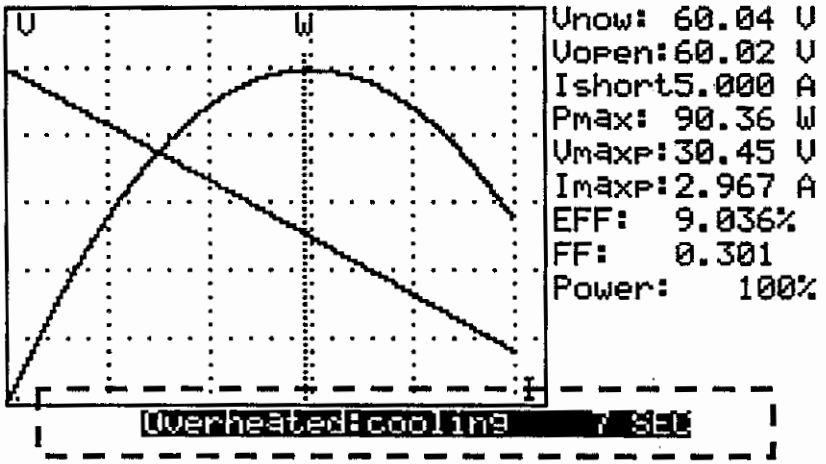


1. V+ Terminal.
2. I+ Terminal.
3. V- Terminal.
4. I- Terminal.

IV. Operation

Warning: when users see "Overheated" warning shown in LCD:

1. Users must wait during this "Overheated: cooling" period before they start next simulation.
2. And if users would like to turn the unit off, they must wait for another 3 min. (at least) for the cooling fan to cool off the internal components.



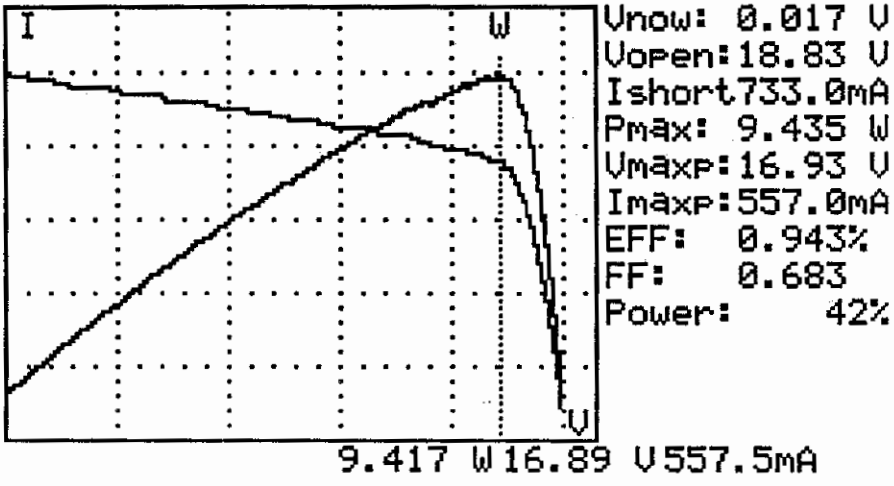
Warning: When using a lithium battery as the power source, please do not plug in an AC adaptor. Or the power source will be stopped and the data will disappear.

Note: When pressing any button, users will hear a sound of buzzer. When keeping pressing it for more than 2 seconds, users will hear another sound of buzzer.

A. Selected Condition of Auto Scan, Manual Scan, or Test

A-1 Users should first select **AUTO SCAN** (AUTO SCAN) to obtain a general idea of characteristics of a solar panel.

1. Press ⏻ button to turn on the Analyzer. Properly connect the pair of Kelvin clips to the solar panel and the Analyzer. The red Kelvin clip is for positive pole and the black Kelvin clip for negative pole.
2. Press AUTO SCAN button to start **AUTO SCAN**. After the scanning is finished, the result will come out like below.



A-2 Afterward, if users are interested in a specific operating range, they can enter the beginning and ending values of scan in the setup menu. Press **SCAN** (SCAN) button to test the specific range.

1. Press  button to turn on the Analyzer. Properly connect the pair of Kelvin clips to the solar panel and the Analyzer. The red Kelvin clip is for positive pole and the black Kelvin clip for negative pole.

2. Press  button to enter the SETUP menu: (Type in the current range for scanning)

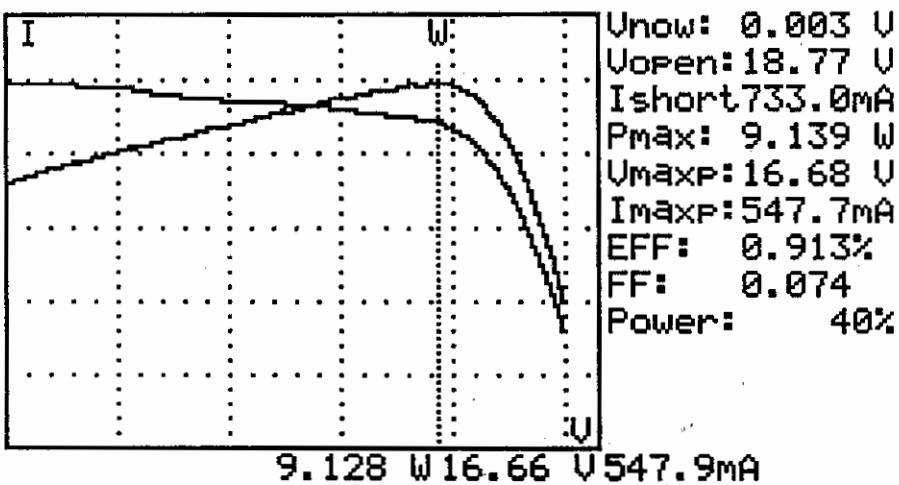
   Current Range of Scan begin:200mA

   Current Range of Scan end:548mA

   After setting up the current range, press  button again to exit the SETUP menu.

   Note: If the "Current Range of Scan begin" is over "Ishort", then the scanning will not be performed and no result will come out.

3. Press  button to start **MANUAL SCAN**. After the scanning is finished, the result will come out like below.



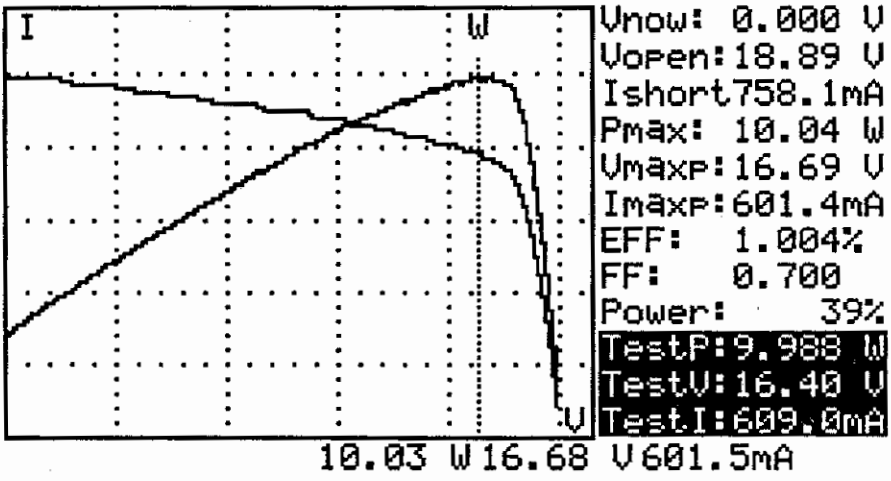
A-3 If users are interested in a specific point of test current, users can enter the current value for a **Single Test Point.** Press **TEST** (TEST) to test the characteristics at the current.

1. Press ⏻ button to turn on the Analyzer. Properly connect the pair of Kelvin clips to the solar panel and the Analyzer. The red Kelvin clip is for positive pole and the black Kelvin clip for negative pole.

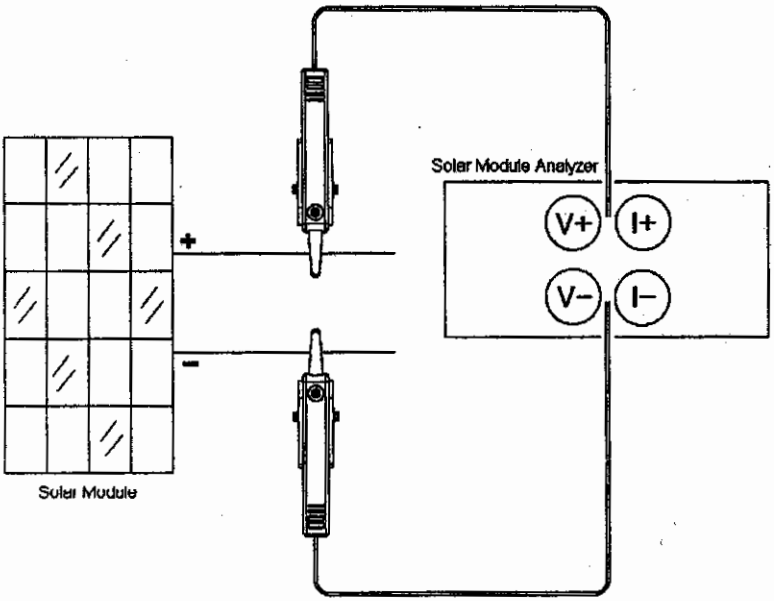
2. Press SETUP button to enter the SETUP menu: (Type in the testing current) Single Test Point:609mA

   After setting up the current value, press SETUP button again to exit the SETUP menu.

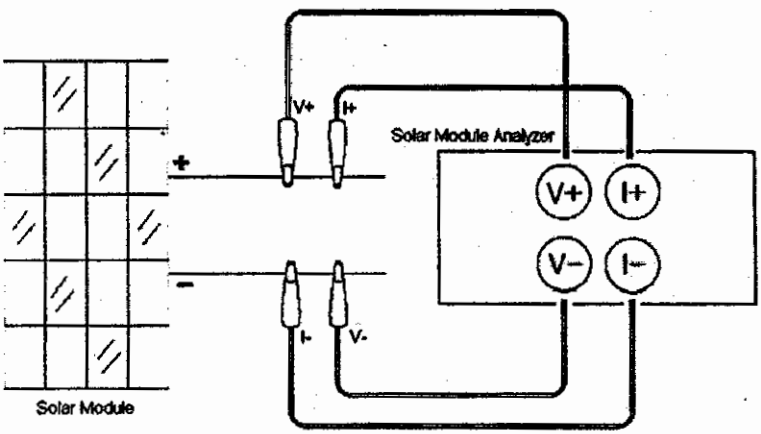
3. Press TEST button to start **Testing a Single Test**. After the testing is finished, the result will come out like below. The result (P, V, I) is shown in reverse video as below.



B. Connecting Diagram



Kelvin Clip Connecting Diagram



Alligator Clip Connecting Diagram

C. Auto Scan

1. Press  button to turn on the Analyzer.

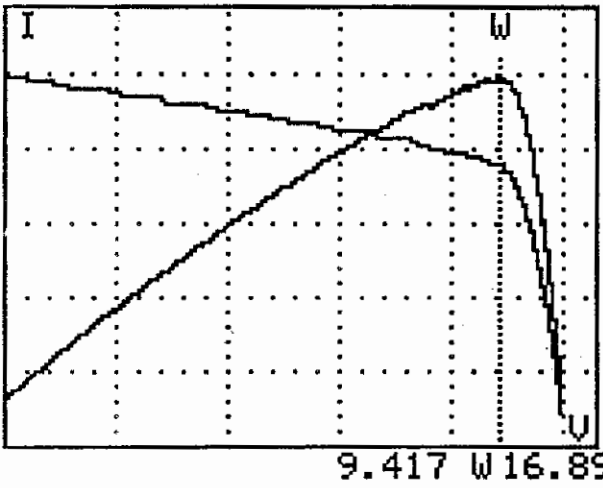
2. Properly connect the pair of Kelvin clips to the solar panel and the Analyzer. The red Kelvin clip is for positive pole and the black Kelvin clip for negative pole. (refer to above Connecting Diagram).

3. Turn on any available light source (e.g. halogen lamp, xenon lamp, tungsten lamp, ...) and let it illuminates solar panel uniformly. Or place the solar panel under the sun.

4. Press  (**AUTO SCAN**) button to perform Auto-scan. After the scanning is finished, the result will come out like below.

5. The unit automatically measures the followings parameters: Vopen, Ishort, Pmax, Vmaxp, and Imaxp. Based upon those parameters, the unit run simulation and draw I-V / V-I curve and P-V / P-I curves in LCD.

6. Users can move the cursor to review each individual values along the curve.



Vnow: 0.017 V
Vopen:18.83 V
Ishort733.0mA
Pmax: 9.435 W
Vmaxp:16.93 V
Imaxp:557.0mA
EFF: 0.943%
FF: 0.683
Power: 42%

9.417 W16.89 V557.5mA

There is a time delay before the unit performs the "Auto Scan". This time delay allows the light source to be turned on before "Auto Scan" starts. Time delay can be set in the SETUP menu.

Note: If the short circuit current (Ishort) exceeds 12A, Auto Scan will not be performed. Please select Manual Scan and limit the ending value of Scan to be less than 12A.

D. Manual Scan

1. Press  button to turn on the Analyzer.

2. Properly connect the pair of Kelvin clips to the solar panel and the Analyzer. The red Kelvin clip is for positive pole and the black Kelvin clip for negative pole.

3. Press  button to enter the SETUP menu: (Type in the current range for scanning)

   Current Range of Scan begin:200mA

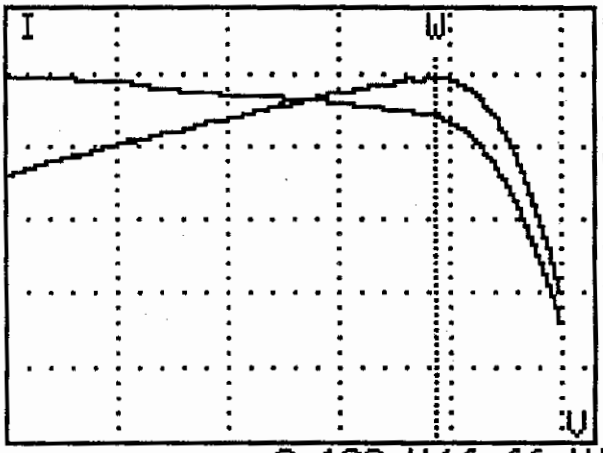
   Current Range of Scan end:[illegible]

   After setting up the current range, press  button again to exit the SETUP menu.

   Note: If the "Current Range of Scan begin" is over "Ishort", then the scanning will not be performed and no result will come out.

4. Press  (**SCAN**) button to start **MANUAL SCAN**. The analyzer run simulation from the BEGIN value to END value, and draw I-V / V-I curve and P-V / P-I curve in LCD. Users can move the cursor to review each individual values along the curve.

   After the scanning is finished, the result will come out like below.



Vnow: 0.003 V
Voпen:18.77 V
Ishort733.0mA
Pmax: 9.139 W
Vmaxp:16.68 V
Imaxp:547.7mA
EFF: 0.913%
FF: 0.074
Power: 40%

9.128 W16.66 V547.9mA

There is a time delay before the unit performs the "Manual Scan". This time delay allows the light source to be turned on before "Manual Scan" starts. Time delay can be set in the SETUP menu.

E. Single Point Test

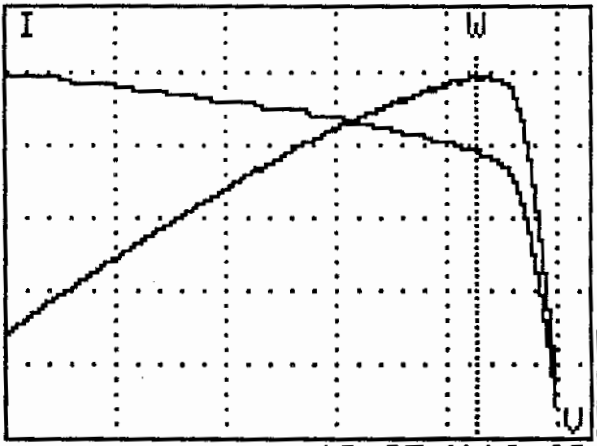
1. Press  button to turn on the Analyzer.

2. Properly connect the pair of Kelvin clips to the solar panel and the Analyzer. The red Kelvin clip is for positive pole and the black Kelvin clip for negative pole.

3. Press  button to enter the SETUP menu: (Type in the testing current) Single Test Point:609mA

   After setting up the current value, press  button again to exit the SETUP menu.

4. Press  button to start **Testing a Single Test.** After the testing is finished, the result will come out like below. The result (P, V, I) is shown in reverse video as below.



Vnow: 0.000 V
Vopen:18.89 V
Ishort758.1mA
Pmax: 10.04 W
Vmaxp:16.69 V
Imaxp:601.4mA
EFF: 1.004%
FF: 0.700
Power: 39%
TestP:9.988 W
TestV:16.40 V
TestI:609.0mA

10.03 W16.68 V601.5mA

> Time delay in the "Single Point Test" allows the current simulation to last longer. Though the max. value is 9.999 sec., the time delay is changed to 10 msec. if power is over 100 W. The time delay is extended to 3 seconds if power is less than 100 mW.

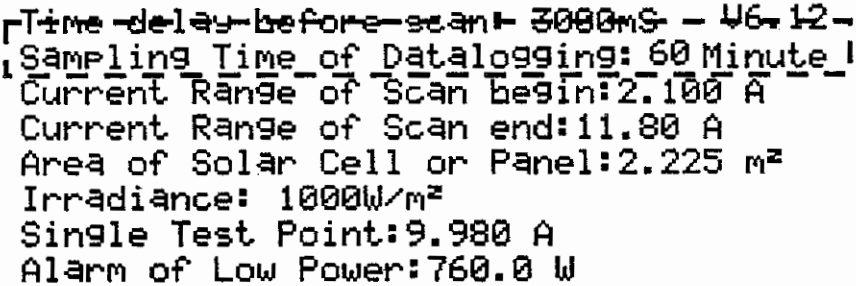
Result of Single Point Test

Vnow: 50.09 V
Vopen:
Ishort
Pmax:
Vmaxp:
Imaxp:
EFF:
FF:
Power: 91%
TestP:12.87 W
TestV:1.324 V
TestI:9.726 A

Perss AUTO or START button

F. Data Logging

Users can perform data logging to record the characteristics of solar power over a period of time (e.g. record data every 60 minutes).



1. Set the sampling time in the SETUP menu.
2. Press the REC button, then AUTO SCAN will be performed and data will be recorded. In the above example, data is collected every 60 minutes.

If the sampling time is set to 0 minutes, only 1 set of I-V curve and characteristics data is recorded.

Please use the application software provided with the Analyzer to read the saved testing results.
(refer to the Software Manual)

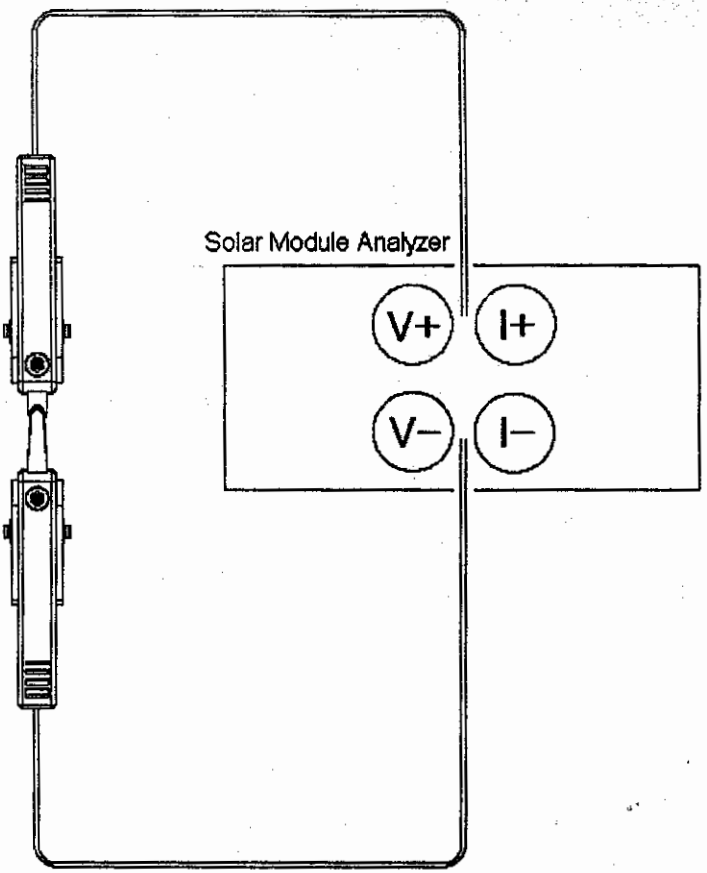
G. Zero Calibration

Calibration of voltage and current zero would improve the accuracy of the instrument before usage.

Connect (short) the two Kelvin clips together and press and hold the

button. A message of "ZERO CAL..." is shown in LCD. Release the button when the message disappears.

Regular calibration of zero would maintain the accuracy of the instruments.



H. Clear recorded testing data

Users can clear the recorded testing data in the Analyzer.

The procedures of deleting saved data:

1. Keep pressing 

(REC) button and turn on the Analyzer (i.e. press  **button)** at the same time.

2. After turning on the Analyzer, all the data recorded in the Analyzer (memory) will be deleted. When the buzzer beeps twice, it means the record data is already cleared.

After performing this CLEAR function, all the recorded data in Analyzer (memory) will be deleted completely and can not be restored. If it is necessary to keep the testing data, please use the Application Software to download and save them before deleting them from the Analyzer.
(refer to the Software Manual)

I. Setup Menu

1. Press  (**SETUP**) button to enter the Parameter Setting screen.
2. Press  or  buttons to select the setting items.

```
Time delay before scan: 3000mS    V6.12
Sampling Time of Datalogging: 1 Minute
Current Range of Scan begin:2.100 A
Current Range of Scan end:11.80 A
Area of Solar Cell or Panel:2.225 m²
Irradiance: 1000W/m²
Single Test Point:9.980 A
Alarm of Low Power:760.0 W
```

Year	Month	Date	Hour	Minute	Second
2009	7	27	11	54	3

(1) **Time delay before scan.**

This delay allows light source to illuminate the solar panel before scan stars.

(2) **Sampling time of data logging** (0 to 99 minutes)

(3) **Current Range of Scan begin.**

The beginning value of current for scan to start.

(4) **Current Range of Scan end.**

The ending value of current for scan to stop.

(5) **Area of Solar Cell or Panel.**

Based upon the input area and irradiance, this unit can calculate the solar power converting efficiency

(6) **Irradiance.**

Light intensity in W/m^2.

(7) **Single Test Point.**

Users can enter a specific value of current here. When users press the TEST button, this specific value of current will be simulated and result will be shown.

(8) **Alarm of Low Power.**

If the maximum power is lower than this value, then a beep sound will be heard.

3. Press  or  buttons to select the setting items.

Press  or  buttons to change the setting values, or press them for few seconds to promptly change setting values.

4. After setting Parameters, press  button to exit SETUP menu.

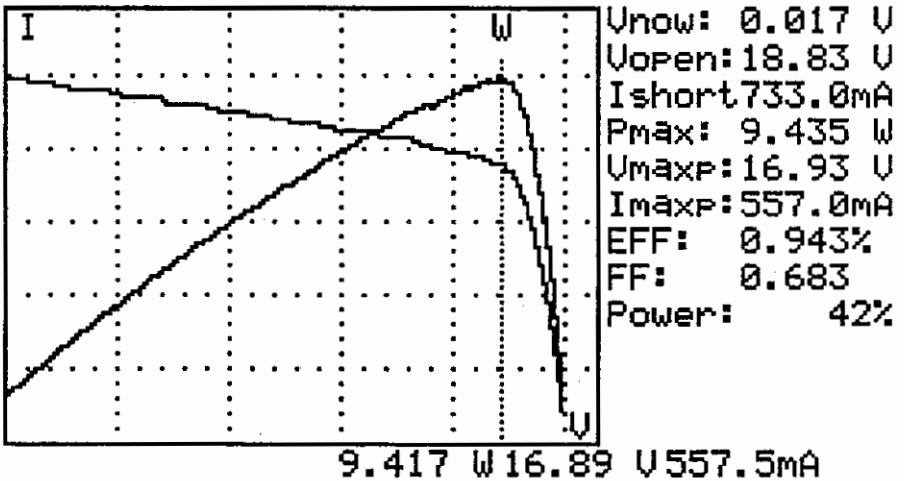
V. Application Notes

A. Quality Control in the Production Line, Warehouse, or Site of Installation.

Manufacturers of solar panels can test the characteristics for quality control purpose in the production line. Due to the advantage of portability of the unit, quality inspectors can randomly pick samples of solar panels and test them in the warehouse to assure quality before shipment.

Installation engineer can randomly test samples of solar panels at site to verify the quality of solar panels used at site of installation.

B. Identify the Solar Power System Requirement.



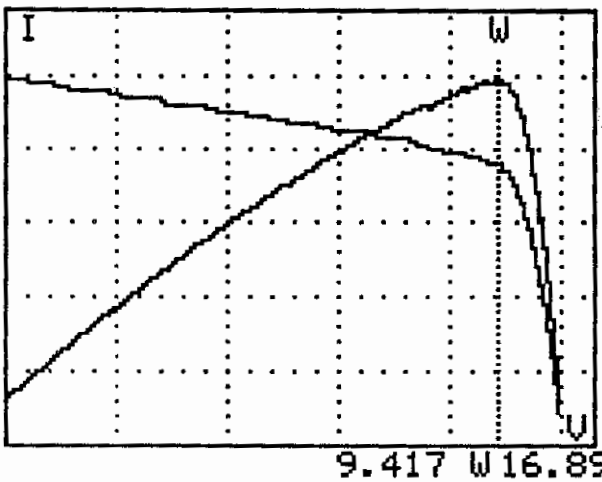
Measure the actual maximum power (Pmax), voltage (Vmaxp), and current (Imaxp) at maximum power. Instead of using the rated maximum power, the system designer needs to be aware of the actual solar power from the solar panel under actual operating condition. So designer can actual know how many pieces of solar panels are required to generate specific power.

The voltage and current under actual operating condition (in the morning, at noon, and in the afternoon) are required for system designer to design the optimal charging system, so most of the solar power can be absorbed and stored in the battery.

Users can test the characteristics of solar panel at different time of day and store the data. Then the designer can know if the solar system can generate appropriate power at any time.

C. Maintenance of Solar Panels.

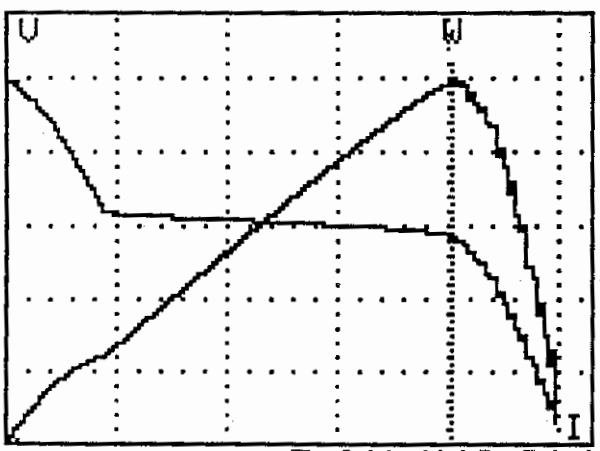
Normal I-V Curve



Vnow: 0.017 V
Vopen:18.83 V
Ishort733.0mA
Pmax: 9.435 W
Vmaxp:16.93 V
Imaxp:557.0mA
EFF: 0.943%
FF: 0.683
Power: 42%

9.417 W 16.89 V 557.5mA

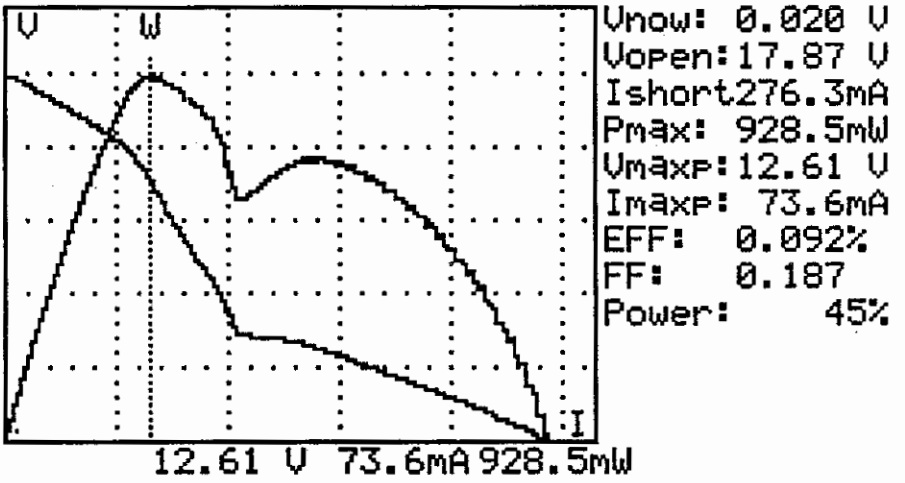
Abnormal I-V Curve (Cells at the corner of solar panel are defected)



Vnow: 0.041 V
Vopen:19.07 V
Ishort858.2mA
Pmax: 7.641 W
Vmaxp:10.94 V
Imaxp:698.0mA
EFF: 0.764%
FF: 0.466
Power: 47%

7.641 W 10.94 V 698.0mA

Abnormal I-V Curve (defected cells scattered over the solar panel)



The technicians or maintenance engineers can store the characteristics data of solar panels in the beginning. And compare the characteristics data in the weekly, monthly or yearly maintenance. If the characteristics of any solar panels are different from the previous data, technicians or maintenance engineers can further identify the problems of solar panels.

For example, if any cells of solar panels are damaged, the I-V curve would be very different from a typical curve. If the solar panels are covers by a lot of dust, the I-V curve or the maximum power would be much lower than previously stored data. Once defected panels are found, technicians or maintenance engineers can replace them with new panels.

D. Verify the Best Installation Angle of Solar Panels.

Engineers can collect data of installation angle at different date and time by using the unit at site of installation. The data can be used as reference to design automated angle adjustment system. Or the data can be used to select an optimal angle for a fixed angle installation

VI. Specifications

A. Electrical Specifications

(23℃±5℃, Four-wire Measurement)

DC Voltage Measurement

Range	Resolution	Accuracy
0 ~ 10 V	0.001 V	± 1 % ± (1 % of Vopen ± 0.1 V)
10 ~ 60 V	0.01 V	± 1 % ± (1 % of Vopen ± 0.1 V)

Vopen: open circuit voltage of solar cell or module.

If users use alligator clips to measure voltage only, they must make V+ clip connect with I+ clip; V- clip connect with I- clip. Thus, 4-wire measurement is converted to 2-wire measurement.

DC Current Measurement

Range	Resolution	Accuracy
0.01 ~ 10 A	1 mA	± 1 % ± (1 % of Ishort ± 9 mA)
10 ~ 12 A	10 mA	± 1 % ± (1 % of Ishort ± 0.09A)

Ishort: short circuit current of solar cell or module.

Circuit resistance is compensated in the AUTO SCAN. Ishort is measured at zero circuit resistance. Circuit resistance is not compensated in the Manual Scan or Single Point Test.

DC Current Simulation*

Range	Resolution	Accuracy
0.01 ~ 10 A	1 mA	± 1 % ± 9 mA
10 ~ 12 A	10 mA	± 1 % ± 0.09A

* If current is greater than 12A, test (Auto-Scan, Scan, or Test) can not be performed.

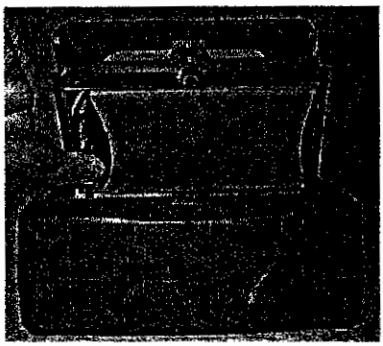
B. General Specifications

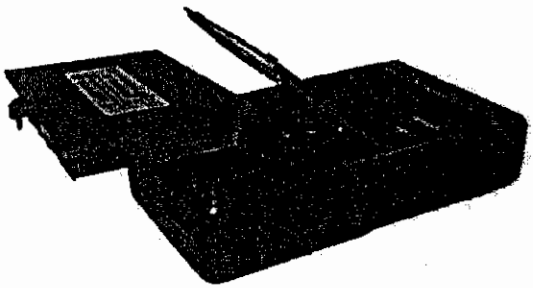
Battery Type	Rechargeable Lithium Battery, 3400mAh
Battery Life	400 times of linear scan from 60V to 0V and 0A to 12A.
Data Logging Memory Size	99 records
AC Adapter	AC 110V or 220V input DC 15V / 1~3A output
Dimension	257(L) x 155(W) x 57(H) mm
Weight	1160g / 40.0oz (Batteries included)
Operation Environment	0℃ ~ 50℃, 85% RH
Temperature Coefficient	0.1% of full scale / ℃ (<18℃ or >28℃)
Storage Environment	-20℃ ~ 60℃, 75% RH
Accessories	User Manual x 1, AC adaptor x 1 Optical USB Cable x 1 Rechargeable lithium battery x 1 Software CD x 1, Software Manual x 1 Kelvin Clips (12A max) x 1 set

VII. Battery Replacement / Recharging

If the lithium battery can not be charged, users should always purchase a new lithium battery from the distributor or importer. The charging circuit built-in is designed only for the lithium battery included.

The lithium battery is always sold with the plastic battery cover. Do not purchase a lithium battery from a source which is not approved by the manufacturer. **Non-approved lithium battery could cause damage to the instrument or hazard to the users.**





Steps of Battery Replacement:

1. Unscrew and remove the battery with cover.
2. Put in a new recharging battery with cover.
3. Screw the battery cover.

Please follow the below steps to charge the lithium battery:

1. Connect the AC Adaptor with the Solar Module Analyzer.
2. Turn on the Solar Module Analyzer.
3. During recharging (takes 10 hours), the % of power is shown 100%.
4. After recharging, remove the AC Adaptor and LCD displays "Power:100%".