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Stand-Alone System Integration Using Mobile Training Toolkit (MTT)
A Five-Step MTT Quick Start Guide

STEP 1 - ASSEMBLY OF PV ARRAY

Required Components

- PV modules (x2)
- Module Rack
- Sundial
- Module extension cable (optional)
- Insulated Tool Set
- Rack screws (x6)
- Rack wing nuts (x6)
- Sundial mounting screw (x1)

Set-up of PV Array

① Align both PV modules face down on table and place module rack on inner frame between the modules, aligning the six screw holes

② Insert rack screws (x6) from the top and hand-tighten rack wing nuts (x6) to the screws from the bottom
STEP 2: ASSEMBLY OF DIRECT CURRENT (DC) WIRING BOARD

Required Components

- Charge Controller
- DC/AC light sockets
- Insulated Tool Set
- MTT Wiring Board
- DC Switches (x4)
- Long Screws (x4)
- Short Screws (x4)

Set-up of DC Wiring Board

1. Unscrew top part and attach light sockets to DC Light 1 and 2 and AC Light with long screws
2. Attach charge controller with long screws to screw inserts on upper left corner of wiring board
STEP 3: WIRING DC COMPONENTS

Required Components

Wiring of PV Wiring Board

1. Connect positive terminal of DC Light sockets 1 and 2 with long red wires #1 and #2 to upper terminal inputs of DC switches. (Flat terminal ends go into upper terminal input of DC switches)

2. Connect both DC switches to the left side of distribution bar with short red wires #1 and #2 (Flat terminal end goes into lower terminal input of DC switches)

3. Snap on four DC switches to DIN rails by pushing in yellow tabs at the bottom of the switch

4. Light sockets, charge controller and DC disconnect switches attached to Wiring Board
Stand-alone Solar PV Technician Training Curriculum
(with corresponding MTT exercises)

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<tr>
<th>Training Module</th>
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<th>Description</th>
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<td>L1 – 1</td>
<td>Voltage and Current Measurement</td>
<td>Measurement of key electrical parameters (voltage and current) of battery and PV module</td>
<td>Demonstrate electrical parameters of battery and PV module with basic testing equipment</td>
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<td>L1 – 2</td>
<td>Resistance Measurement</td>
<td>Measurement of resistance of small and large gauge wires and fuses with ohmmeter</td>
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<td>Electricity Basics</td>
<td>L1 – 3</td>
<td>Electrical Measurement in a Series Circuit</td>
<td>Measurement of key electrical parameters (voltage and current) and calculation of resistance, power and energy in a series circuit with two loads</td>
<td>Demonstrate basic electrical parameters in a series circuit with basic testing equipment</td>
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<tr>
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<td>L1 – 4</td>
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<td>Measurement of key electrical parameters (voltage and current) and calculation of resistance, power and energy in a parallel circuit with two loads</td>
<td>Demonstrate basic electrical parameters in a parallel circuit with basic testing equipment</td>
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## COMPONENTS – PV MODULE

<table>
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<th>Description:</th>
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<tr>
<td>Understand how temperature affects the current output of a PV module</td>
<td>Measurement of short circuit current and temperature of a PV model and calculation of temperature coefficient of current (perform this measurement during clear sky condition only)</td>
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## TEMPERATURE EFFECT ON CURRENT

### Test Set-up

1. PV Modules (2x)
2. PV Array Mounting Rack
3. Sundial
4. Digital Multi Meter
5. Mini IR Thermometer
6. Banana Cables (1 red, 1 black)

### Instructions

1. Assemble MTT PV array **indoors** as described in MTT Quick Start Guide
2. Take PV array **outdoors** and orient towards sun (Keep surface of test PV module covered with a cardboard and the other module is not used in this experiment)
Test Procedure: Measurement of Temperature and Current

① Connect multimeter to PV module and aim IR thermometer towards test module surface (center of module)

② Remove cover off PV module and simultaneously measure current of test module ($V_{OC}$) and temperature on PV module surface ($T_{front}$) until 10°-15°C raise above ambient temperature

Calculation: Calculations of Temperature Coefficient for Current (Sample Calculations in red)

① Record and plot data points in a spreadsheet program (e.g. Excel)

<table>
<thead>
<tr>
<th>Temp (°C)</th>
<th>Current (A)</th>
</tr>
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<tbody>
<tr>
<td>11.00</td>
<td>1.77</td>
</tr>
<tr>
<td>12.20</td>
<td>1.78</td>
</tr>
<tr>
<td>13.60</td>
<td>1.79</td>
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<tr>
<td>15.40</td>
<td>1.79</td>
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<tr>
<td>16.00</td>
<td>1.79</td>
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<td>17.00</td>
<td>1.79</td>
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<tr>
<td>18.30</td>
<td>1.79</td>
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<td>19.00</td>
<td>1.79</td>
</tr>
<tr>
<td>20.30</td>
<td>1.80</td>
</tr>
<tr>
<td>21.00</td>
<td>1.80</td>
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</tbody>
</table>

Record your observation: **Current slightly increases as the temperature increases (negligible influence of temperature on current for small stand-alone systems)**

Calculate the temperature coefficient = Slope = ($1.80 - 1.78$)/(20 - 12) = 0.02/8 = 0.0025 A/°C (nearly no change)

**Note:** Since current is directly proportional to irradiance and the temperature coefficient for current is very small, any thin and invisible passing cloud can make a large scattering of data points in the above plot. For small stand-alone PV systems, the temperature coefficient for current can be ignored (that is: it can be considered “zero percent per degree Celsius”). As compared to the front glass temperature, the backsheet temperature is more representative of solar cell temperature and hence, performing this experiment with backsheet temperature would be more accurate and recommended

Practice:

**Practice 1:** Repeat the experiment with backsheet infra-red temperature

**Practice 2:** Repeat the experiment with backsheet thermocouple (supplied with MTT) temperature

(Note: thermocouple tip/junction covered with a thermal tape would be less susceptible to the wind effect and hence should be more accurate, as compared to infrared temperature, in windy locations)
### OBJECTIVE:
Understand how temperature affects the current output of a PV module.

### DESCRIPTION:
Measurement of short circuit current and temperature of a PV model and calculation of temperature coefficient of current (perform this measurement during clear sky condition only).

### TEST PROCEDURE: MEASUREMENT OF TEMPERATURE AND CURRENT

1. Simultaneously measure current ($I_{sc}$) and temperature ($T_{module}$) of PV module front surface until 10°-15°C raise above ambient module temperature.

<table>
<thead>
<tr>
<th>Temp (°C)</th>
<th>Current ($I_{sc}$)</th>
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<tr>
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**Observations:**

**Calculation:** Temperature Coefficient for Current

1. Record and plot data points in a spreadsheet program (e.g., Excel).

2. Record your observation:

3. Calculate the temperature coefficient $= \text{Slope} =$

**Calculation:**

**Practice 1:**
Repeat the experiment with backsheet infra-red temperature.

**Practice 2:**
Repeat the experiment with backsheet thermocouple (supplied with MTT) temperature. **(Note: thermocouple tip/junction covered with a thermal tape would be less susceptible to the wind effect and hence should be more accurate, as compared to infrared temperature, in windy locations)**.