Standard test conditions

In this document we will review:

- Standard Test Conditions (STCs) for PV cells/modules
- Why such STCs are required
- The temperature coefficients and how they can be used to determine PV cell voltage, current and power at different temperatures

Due to the variability of power output of the PV cells depending on parameters such as irradiation and temperature, the performance of different cells operating under different conditions cannot be compared easily. To enable meaningful comparisons between PV cells (or PV modules), the rated output of a cell or module is always measured under specific conditions. These conditions are standardized across all testing facilities worldwide and are called Standard Test Conditions (STC).

STC parameters are:

- Light spectrum: AM 1.5
- Irradiance: 1,000 W/m²
- Cell temperature: 25 °C

Each finished PV cell (or PV module) leaving the production line undergoes a flash test: it is exposed to a flash of light under careful control of the STC parameters, lasting only milliseconds, and the output performance is recorded. Subsequently, the cells or modules are sorted and sold according to their rated power. The rated power is measured in units of Watt-peak [Wp] or kilowatt-peak [kWp] and refers to the rated power under STC.

Temperature coefficient

The temperature coefficient shows how voltage, current or power output of a PV cell or module change with changing temperature. Module datasheets give temperature coefficients (TC) for open circuit voltage VOC under STC, short circuit current ISC under STC, and power at the maximum power point PMPP under STC. The voltage temperature coefficient is the most common one used. Inverters (and other devices, such as charge controllers) can be damaged by module/string voltages that exceed the specified input voltages of these inverters (and other devices). Conversely, if the voltage is too low, this can cause system underperformance.

Voltage temperature coefficients, normally are given in the form of: % /^{0}C (e.g. ^{0} / %0.36-C) or in V/°C as: 0.156- V / °C or 156- mV / °C.

Current temperature coefficients, normally are given in the form of: % / ^{0}C (e.g. ^{0} / %0.045+C) or in A/°C as: 0.0029 A / ^{0}C or 2.9 mA / ^{0}C.

could Power temperature coefficients, usually are given in the form of: - %/ ^{0}C (e.g / %0.42-^{0}C), but it also be specified by a manufacturer as 0.957-W / °C
Formula to calculate the Voc according to the temperature of the cell:
$Voc(@temp)=Voc+[(T@temp - T_{STC})*(Tc(Voc))$

Calculation Exercise

Assume the following data: The yearly daytime temperature at a location ranges from 10^0-C to 45^0+C. A PV module is being installed which has:

• a VOC of 43.24 V at STC,

• a VMPP of 35.35 V at STC, and

• a temperature coefficient TC (VOC) of 0.168636- V / ^{0}C.

Note: temperature coefficient Tc (VMPP) is slightly different than TC (VOC). In this case, for the calculations, the difference will be neglected. This means that for every C temperature drop below 25^{0}C, the module voltage will rise by 0.168636 V. Similarly for every C temperature rise above 25^{0}C, the module voltage will drop by 0.168636 V.

• **What will be the maximum VOC produced by the module?**

The maximum VOC will be produced at the lowest ambient temperature, 10^0-C. So, the lowest cell temperature will be - 10^{0}C.

Voc(@43.24=(10-v +[(°10-C - °25C)*(0.1686-v/°C)] = 49.14v

• **What will be the maximum V_{MPP} ?**

VMP(@35.35=(10-v +[(°10-C - °25C)*(0.1686-v/°C)] = 41.25v

• **What will be the minimum VOC produced by the module?**

The minimum VOC will happen at the highest ambient temperature, 45^{0}C. But the cell temperature of rooftop or open field PV systems can be 25^{0}C higher than the ambient temperature, so this will be 70^{0}C.

Voc(@43.24=(70+v +[(°70C - °25C)*(0.1686-v/°C)] = 35.65v

- **What will be the minimum V_{MPP} ?**

The minimum VMPP will be produced at the highest ambient temperature, 45^{0}C. But the cell temperature of roof-top or open field PV systems can as a rule of thumb be 25^{0}C higher than the ambient temperature, so this will be 70^{0}C.

VMP(@35.35=(70+v +[(°70C - °25C)*(0.1686-v/°C)] = 27.76v

To summarize: The highest voltage VOC will be at 10^0-C, i.e. 49.14 V. And the voltage range at the MPP will be between 27.76 V and 41.25 V. Similar calculations can be performed to estimate voltages at different temperatures for series strings of PV modules.

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