Photovoltaic Power Profile Emulation (PPPE)

Introduction

The Photovoltaic Power Profile Emulation (PPPE) software automatically calculates solar array voltage and current profiles based on user-defined parameters. These profiles can be sequentially sent to a Magna-Power Electronics power supply, which will emulate defined characteristics. The user can define a limitless number of profiles to be emulated and sequenced over a given time period.

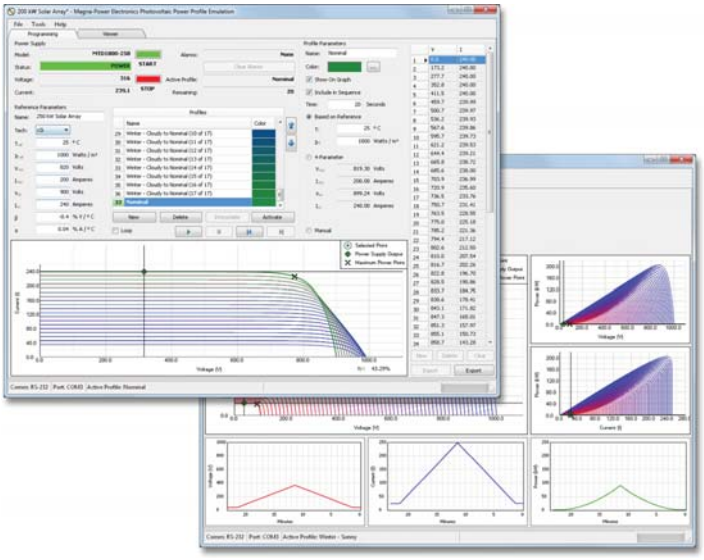
Design and production validation for photovoltaic connected electronics requires a photovoltaic emulating power source with flexible output characteristics. Inverters and specialized DC-DC converters employ maximum power point tracking (MPPT) control algorithms to maximize utilization of nonlinear energy sources, such as solar panels and wind turbines. For development and manufacturing, using photovoltaic arrays for validation is costly with uncontrolled source characteristics. By utilizing a power supply with user-programmable output characteristics, the user can evaluate the full range of power conditions.

After the profile is defined, it can be transferred to the power supply for either static or dynamic emulation. A time dependent parameter defines how long the power supply should emulate that profile before loading the next profile in the sequence.

Modeling and Operation

A profile is a voltage/current curve that the power supply's output should emulate. There are three methods to generate a power profile in the PPPE software:

- **Automatic, based on solar array parameters**
  The user selects the desired solar panel technology, nominal temperture, irradiance, voltage and current values. Each V-I profile is then defined only by new temperature and irradiance values. The rest of the parameters: maximum power point (Vmp, Imp), open circuit voltage (Voc), and short circuit current (Isc); are all calculated automatically in accordance with the EN50530 standard.
- **Automatic, based on 4-parameters**
  The user defines the maximum power point (Vmp, Imp), open circuit voltage (Voc), and short circuit current (Isc). The profile is then generated based on these parameters.
- **Manual**
  The user defines up to 50 current and voltage points for the power supply to emulate. The power supply performs a piecewise linear approximation between points to provide a smooth output curve.



Magna-Power Electronics Photovoltaic Power Profile Emulation (PPPE) software: main programming window (foreground); Viewer window (background)

Key Features:

A profile is a voltage/current curve that the power supply's output should emulate. There are three methods to generate a power profile in the PPPE software:

- Automatic voltage current profile calculation from reference parameters
- Autosequencing through power profiles, at user-defined rate
- Graphical profile view and real-time output with advanced graphical viewer panel
- Compatible with Magna-Power Electronics programmable DC power supplies including the:
  - SL Series (1 kW - 4 kW)
  - XR Series (2 kW - 8 kW)
  - TS Series (5 kW - 45 kW)
  - MS Series (30 kW - 75 kW)
  - MT Series (100 kW - 2000 kW+)
- EN50530 V-I curve generation model
- Curve interpolation for smooth transitions
- SCPI command export for solar emulation functionality in LabVIEW
- Data logging
- Curve import and export

CalPower

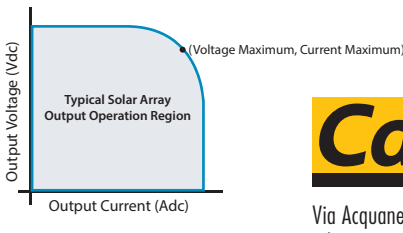
Via Acquanera, 29 22100 COMO
tel. 031.526.566 (r.a.) fax 031.507.984
info@calpower.it www.calpower.it

Advanced Solar Array Emulation

Advanced Features

Magna-Power Electronics worked closely with solar inverter manufacturers to refine the PPPE feature-set. Some of the key advanced PPPE features are as follows:

- **EN50530 Modeling**
  The European EN50530 standard provides a new algorithm for proper solar array modeling. PPPE 2.0 incorporates this model, furthermore allowing the selection of thin film or polycrystalline silicon parameters. Defining a curve is as simple as specifying desired open-circuit voltage, short-circuit current, and maximum power point. Alternatively, manual parameters can be entered for more customized modeling or profile importing from an external file.
- **Live Output Viewer**
  A new live output viewer provides six graphs of instantaneous output parameters versus time. This data allows the user to visualize fluctuations in voltage, current, and power over time.
- **Curve Interpolation**
  An interpolation function was added to automatically generate transitional curves. This functionality enables smooth transitions from one curve to another over a user-defined period of time.
- **Data Logging**
  Customizable data logging functionality was added, allowing for report generation and data analysis using external tools. Data is exported to a comma-delimited (.csv) file.
- **Command Export**
  Leverage the ease of profile generation in PPPE and export the generated SCPI commands for integration into a separate programming environment, such as LabVIEW/LabWindows.

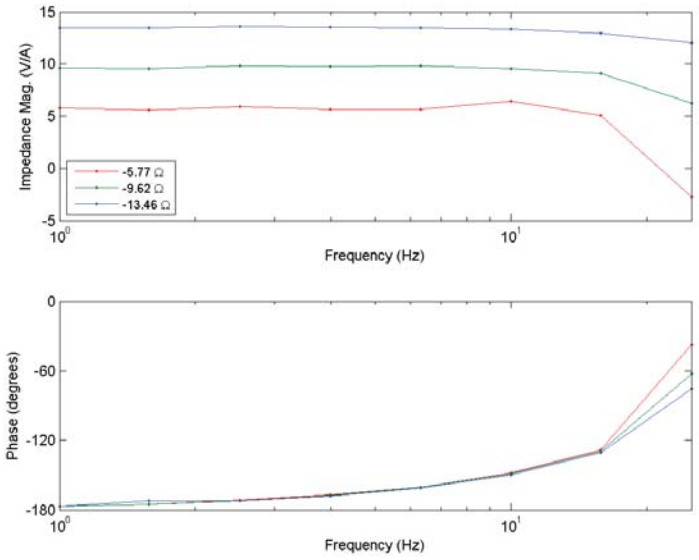


Specifications

Specifications below are related to the PPPE software only. For data on the power supplies, reference the specifications for the individual series: SL Series, XR Series, TS Series, MS Series, and MT Series.

PPPE Specifications	
Bandwidth	With High Slew Rate Output (+HS) Option: 15 Hz Standard Models: 2 Hz
Communication Protocols Supported	RS232, LXI TCP/IP Ethernet, IEEE 488 GPIB, USB
Minimum Time Between Sequential Profiles	2 sec
Number of Profile Sequences	Unlimited
Minimum Voc and Isc	10% of the power supply's rated voltage and current
Maximum Profile Slope	$(\Delta I/\Delta V)\times(Imax/Vmax) \leq -0.05$
Instantaneous Load Change to Short-circuit	Supported with High Slew Rate Output (+HS) option

Note: Specifications are subject to change without notice



Voltage error as a function of operating bandwidth during solar array emulation

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