Solar Design Algorithm

The document below defines the calculations used to design and evaluate a PV system in preparation for creating electrical drawings. Most of the computer code is detailed below, and the full system calculation code is found here (https://github.com/kshowalter/SPD_server/blob/master/lib/calculate_system.js). This algorithm is currently implemented in Javascript.

Note: For each section the symbols are perpended by a section name when stored as a variable in the computer code, in the form of "section.symbol".

User input

Description	Symbol	Unit
Inverter manufacturer name	inverter.manufacturer_name	-
Inverter model	inverter.device_model_number	-
Module manufacturer name	array.manufacturer_name	-
Module model	array.device_model_number	-
Grid voltage	inverter.grid_voltage	V
Number of PV Source Circuits	array.num_of_strings	ea.
Total Number of Modules	array.num_of_modules	ea.
Maximum Number of Series-Connected Modules per Source Circuit	array.largest_string	ea.
Minimum Number of Series-Connected Modules per Source Circuit	array.smallest_string	ea.
Minimum Distance Above Roof (in)	module.array_offset_from_roof	in.
Grid type	interconnection.grid_type	
Grid options	interconnection.grid_options	
Connection type	interconnection.connection_type	
Inveter subpanel used (Yes/No)?	interconnection.subpanel	
Inverter Subpanel Feeder Size	subpanel.size	A
Inverter Subpanel Feeder Insulation Type	subpanel.insulation_type	A
Inverter Subpanel Feeder Ampacity @ 75C	subpanel.ampacity	A
Inverter Subpanel Feeder Supply OCPD Rating (A)	subpanel.supply_OCPD_rating	A
Inverter Subpanel Busbar Rating (A)	subpanel.busbar_rating	A
Sum of Inverter Output Overcurrent Protection Devices (A)	subpanel.OCPD_sum	A
Sum of Inverter(s) Output Circuit Current (A)	subpanel.inverter_output_current	A
Total of Load Breakers	subpanel.load_breakers_sum	A
Main panel supply OCPD rating (A)	interconnection.supply_ocpd_rating	A
Main panel busbar rating (A)	interconnection.bussbar_rating	A
Sum of inverter output overcurrent protection devices (A)	interconnection.inverter_ocpd_dev_sum	A
Sum of inverter(s) output circuit current (A)	interconnection.inverter_output_cur_sum	A
Total of load breakers (A)	interconnection.load_breaker_total	A

Constants

Description	Symbol	Limits	Value used	Unit
2% Maximum Temperature	array.max_temp	In Florida: 30 to 36	36	°C
Extreme Annual Mean Minimum Design Dry Bulb Temperature	array.min_temp	In Florida: -9 to 11	-9	°C
Maximum Voltage Rating?	array.code_limit_max_voltage	600	600	V

Javascript:

```
array.max_temp = 36;
array.min_temp = -9;
array.code_limit_max_voltage = 600;
```

Manufacturer data

The following information is taken from the manufacturer specification sheets. In our online express design application, this information is stored in FSEC's database.

Inverter:

Description	Symbol	Unit
UL1741 listed/FSEC approved?	inverter.ul_1741	-
Maximum dc voltage, Vmax,inv (V)	inverter.vmax	V
MPPT minimum dc operating voltage (V)	inverter.mppt_min	V
MPPT maximum operating voltage (V)	inverter.mppt_max	V
Min. dc operating voltage (V)	inverter.voltage_range_min	V
Min. dc start voltage (V)	inverter.vstart	V
Maximum dc operating current per inverter input or MPP tracker (A)	inverter.imax_channel	A
Number of inverter inputs or MPP trackers	inverter.mppt_channels	A
Maximum OCPD Rating (A)	inverter.max_ac_ocpd	A
Imax total	inverter.imax_total	A
Imax per MPPT channel	inverter.imax_channel	A
Max DC input power 120	inverter.max_dc_inputpower_120	W
Max DC input power 208	inverter.max_dc_inputpower_208	W
Max DC input power 240	inverter.max_dc_inputpower_240	W
Max DC input power 277	inverter.max_dc_inputpower_277	W
Max DC input power 480	inverter.max_dc_inputpower_480	W
Nominal AC output power 120	inverter.nominal_ac_output_power_120	W
Nominal AC output power 208	inverter.nominal_ac_output_power_208	W
Nominal AC output power 240	inverter.nominal_ac_output_power_240	W
Nominal AC output power 277	inverter.nominal_ac_output_power_277	W
Nominal AC output power 480	inverter.nominal_ac_output_power_480	W
Max AC output current 120	inverter.max_ac_output_current_120	V
Max AC output current 208	inverter.max_ac_output_current_208	V
Max AC output current 240	inverter.max_ac_output_current_240	V
Max AC output current 277	inverter.max_ac_output_current_277	V
Max AC output current 480	inverter.max_ac_output_current_480	V

Module:

Description	Symbol	Unit
Description	Symbol	Unit
FSEC certified	module.FSEC_approved	-
Maximum power @ STC (W)	module.pmp	W
Open-circuit voltage @ STC (V)	module.voc	V
Short-circuit current @ STC (A)	module.isc	A
Maximum power voltage @ STC (V)	module.vmp	V
Maximum power current @ STC (A)	module.imp	A
Maximum overcurrent device rating (A)	module.max_series_fuse	A
Maximum system voltage rating (V)	module.max_system_v	V
Temp Coeff Voc (%/°C)	module.tc_voc_percent	%/°C
Temp Coeff Vmp (%/°C)	module.tc_vpmax_percent	%/°C
Nameplate rating	module.nameplaterating	W

Calculations

Modules, source circuits, and array

Description	Symbol	Calculation (or validation)
Maximum Power (W)	source.max_power	module.pmp * array.largest_string
Open-Circuit Voltage (V)	source.voc	module.voc * array.largest_string
Short-Circuit Current (A)	source.isc	module.isc
Maximum Power Voltage (V)	source.vmp	module.vmp * array.largest_string
Maximum Power Current (A)	source.imp	module.imp
Source Circuit Maximum Current (A), Isc x 1.25	source.Isc_adjusted	module.isc * 1.25
Voltage Correction Factor	array.voltage_correction_factor	sf.if(array.min_temp < -5, 1.12, 1.14)
Maximum system voltage Option 1 (module temp. correction factor)	array.max_sys_voltage_2	source.voc * (1 + module.tc_voc_percent / 100 * (array.min_temp - 25))
Maximum system voltage Option 1 (general temp. correction factor)	array.max_sys_voltage_1	source.voc * array.voltage_correction_factor
Maximum system voltage	array.max_sys_voltage	sf.max(array.max_sys_voltage_1, array.max_sys_voltage_2)
Minimum array voltage (module temp. correction factor)	array.min_voltage	array.smallest_string * module.vmp * (1 + module.tc_vpmax_percent / 100

Inverter

If max_ac_ocpd is not provided by the manufacturer, it is calculated as follows:

AC_OCPD_max = max_ac_output_current * 1.25

The nominal_ac_output_power is selected from fields based on the user selected grid voltage. As an example, if the user selects 240 VAC, then:

nominal_ac_output_power = nominal_ac_output_power_240
max_ac_output_current = max_ac_ouput_current_240

```
inverter.AC_OCPD_max = sf.if( sf.not( inverter.max_ac_ocpd ), inverter.max_ac_output_current * 1.25, inverter.max_ac_ocpd );
inverter.nominal_ac_output_power = inverter['nominal_ac_output_power_'+inverter.grid_voltage];
inverter.max_ac_output_current = inverter['max_ac_ouput_current_'+inverter.grid_voltage];
```