

TOOL OVERVIEW

The CPS String Sizer tool is an Excel file split into four main tabs:

String Sizing: This tab uses a handful of design parameters to output string sizing suggestions. This is where you will likely spend most of your time in the tool.

Approval Letter: As the name suggests, this tab will be populated with a CPS approval letter once satisfactory design parameters are input into the String Sizing tab. The approval letter may then be distributed to AHJs or other project stakeholders and printed for project record-keeping and future warranty considerations.

P-Custom Module: Use this tab to enter the key PV module(s) parameters, all of which can be found on the module's datasheet. Enter a name for the module(s) and the name will appear in the String Sizing tab.

Scratch Pad: This is a blank, unlocked tab that may be used if needed to perform additional calculations.

Note: If the file opens in Protected View click "enable editing" from the banner menu.

Note: Users may need to enable macros to run the tool. This is done by closing out the Excel file; right-clicking on the file name (which should appear in the Downloads folder); clicking "properties" and checking the "unblock" box. After clicking the "apply" button, reopen the Excel file and it should work normally.

STRING DESIGN PROCESS

Follow these steps to use the CPS String Sizer tool:

STEP 1 – ENTER PV MODULE DATA

Use the **P-Custom Module** tab and the module datasheet to enter basic parameters such as *module type* (monofacial, bifacial, thin-film) and *rated power at STC*, as well as system parameters such as the *maximum system voltage* and *series fuse rating*.

Note: Do not include bifacial effects – only include STC frontside values in the **P-Custom Module** tab.

Note: **Yellow cells** indicate missing or incorrect data.

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Enter one module per row and ensure that all columns are filled out completely. The module name entered in the first column will then appear in the *MPPT Type 1-3 Module* dropdown menus in the **String Sizing** tab. See Figures 1 and 2 below.

Manufacturer and Model	Rated power @ STC (W)	Rated power tolerance (%)	Max. System Voltage Rating	Max. power voltage (Vmp)	Max. power current (Imp)	Open-circuit voltage (Voc)	Short-circuit current (Isc)	Pmp/Vmp temp. coefficient (%/°C)	Voc temp. coefficient (%/°C)	Module Type (Mono/Bi/Facial/Thin Film) (MF/BF/TF)	Series fuse rating (A)
Module Example	250	+3/3	1000	30.34	8.24	37.47	8.76	-0.440	-0.340	MF	20
Module Example 2	300	+3/3	600	31.90	7.83	37.20	8.44	-0.480	-0.340	MF	20

Figure 1: Data entry for an example module in the P-Custom Module tab. Note that if any of the cells in this row were yellow, that would indicate a conflict or missing data.

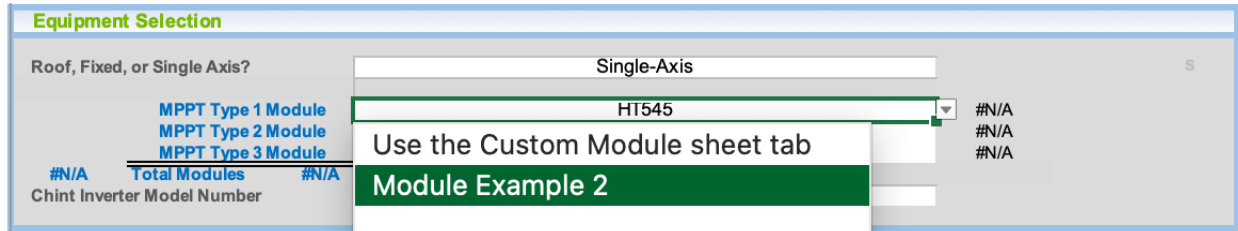


Figure 2: Dropdown menu with custom “Module Example 2” listed as a selectable option.

STEP 2 – ENTER SITE LOCATION DATA

Return to the **String Sizing** tab and fill out the parameters in the “Project Name” box in the upper left corner of the tab. Select the *Temperature Data Source* from the dropdown menu (“ASHRAE 2% High Temp” is the default and most common selection) and enter the *State/Province* as well as the *ASHRAE Weather Station* information.

Note: Filling in a project name is optional.

Note: Filling out site *latitude* and *longitude* is optional but entering a *state/province* is mandatory to determine bifacial gain(s).

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Project Name		Test		# 23145
Site Location (Lat/Lon)?	<input type="checkbox"/> Y	37.0	80.2	18 Miles to Selected Station
Choose your region	North_America			
Temperature Data Source	ASHRAE 2% High Temp			
Country	United_States			
State/Province	Virginia		Lat	Lon
ASHRAE Weather Station	VIRGINIA TECH ARPT		37.2	80.4
				E3
	ASHRAE	SELECTED		
Extreme Low Temp	-15.3 °C	-15.3 °C		
ASHRAE 2% High Temp	32.3 °C	32.3 °C		

Figure 3: Site temperature entry using “ASHRAE 2% High Temp” as the default source.

If “Manual Entry” is selected from the *Temperature Data Source* dropdown menu, a new data entry box will appear. Enter *extreme low temperature* and *ASHRAE 2% high temperature* data into these fields. A warning message will appear if the manually entered values differ from the closest ASHRAE weather station by >4°C.

Site Location (Lat/Lon)?	<input type="checkbox"/> N			
Choose your region	North_America			
Temperature Data Source	Manual Entry			
Country	United_States			
State/Province	Virginia		Lat	Lon
ASHRAE Weather Station	VIRGINIA TECH ARPT		37.2	80.4
				E3
	ASHRAE	SELECTED	MANUAL ENTRY	↓Select
Extreme Low Temp	-15.3 °C	-21.0 °C	-21.0 °C	Temp difference
ASHRAE 2% High Temp	32.3 °C	46.0 °C	46.0 °C	Temp difference

Figure 4: Site temperature entry using “Manual Entry.” Note the manual entry box in the lower right and the temperature difference warning message in red text.

STEP 3 – ENTER EQUIPMENT AND SITE CONFIGURATION DATA

Moving downward to the “Equipment Selection” box in the **String Sizing** tab, select the *array type* from the dropdown menu; select the *MPPT 1-3 modules* from their respective dropdown menus (based on data from the **P-Custom Module** tab in Step 1); and select the *Chint inverter model* from its dropdown menu.

Equipment Selection	
Roof, Fixed, or Single Axis?	Single-Axis
MPPT 1 Module	HT545
MPPT 2 Module	FS FS6420 Test-Thin Film
MPPT 3 Module	Astronergy
Strings= 14	Total Modules 84
Chint Inverter Model Number	SCA60KTL-DO/US-480-UL

Figure 5: Equipment selection for an example system configuration.

STEP 4 – ENTER SYSTEM DESIGN PARAMETERS

Next, fill out the “System Design Parameters” box. Start by selecting the preferred *inverter voltage range* for your project. Two options are available: MPPT Range (power limit mode – generally preferred) and Total Operate Range (current limit mode – most often used in retrofit situations).

Figure 6: MPPT Range selected for *inverter voltage range*. This is preferred in most cases and will lead to longer minimum recommended string lengths.

Finally, indicate whether kVA overhead will be used and if any MPPTs will be paralleled together. If the inverter is not capable of paralleling MPPTs, that selection box will automatically be greyed out.

Note: Using kVA overhead will increase the maximum AC output current. The string sizer will also calculate the maximum overcurrent protection device needed under these conditions.

Inverter Specifications		SCA60KTL-DO/US-480-UL	
Inverter Model Number			
Output (AC)			
Max Rated Output Power	(W) (VA)	60,000 W	60,000 VA
Rated Output Voltage		480 VAC	
Neutral Required		NO	
Max. Rated Output Current (I _{MAX})		72.3 Aac	90.3 Aac (I _{MAX} x 1.25)
Manufacturer Specified Maximum OCPD		125 Aac	
Input (DC)			
MPPTs Strings per MPPT		3	5
Maximum Input Voltage		1000 Vdc	
Max W _{dc} _{STC} Input	(TOTAL MPPT)	90000 Wdc	33000 Wdc
Max I _{sc} _{STC} Input	(TOTAL MPPT)	163.2 Adc	54.4 Adc
MPPT Voltage Range		540 Vdc-Min	850 Vdc-Max
DC Operation Range		200 Vdc-Min	950 Vdc-Max
DC/AC Ratio	(LIMIT Actual)	1.50 DC/AC	0.49 DC/AC

Figure 7: “Inverter Specifications” box for a project with kVA overhead. Note the max rated output current and OCPD sizing parameters. Yellow cells indicate a conflict or missing data.

STEP 5 – ENTER STRING CONFIGURATION

Almost done. Move down to the “Array Design Options” box and enter the desired *string length* per MPPT Type based on the recommended minimum and maximum values provided.

Note: MPPT Type refers to a design configuration, which could be replicated for more than one MPPT in the inverter. For example, the CPS 250/275kW inverter has 12 MPPTs. In that case, a designer would specify up to three different stringing configurations (“MPPT Types”) that could be assigned to any number of the 12 MPPTs.

Next, enter the number of strings (i.e., the number of homeruns from the array to MPPT input within the inverter). The value in parenthesis is a suggested maximum number of strings based on the CPS inverter model selected in step 3.

If using thin-film modules for one or more MPPT Type configurations, select the number of *thin-film parallel substrings*. We define these substrings as the number of fused thin-film strings paralleled to a single homerun which connects to the inverter’s MPPT. Since thin-film modules operate at relatively low currents and high voltages, paralleling fused substrings together in the field may reduce total component costs and more closely match the inverter’s MPPT input ratings. See Figure 8 below for an example.

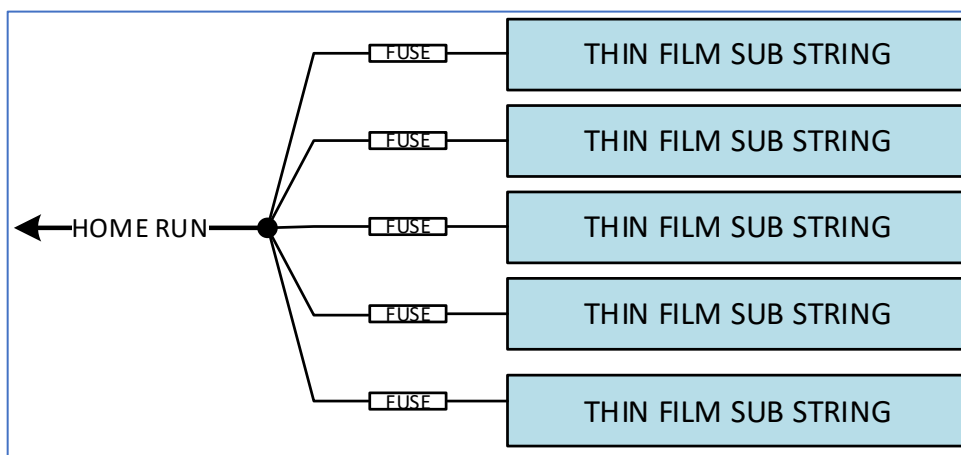


Figure 8: An example of 5 thin-film substrings paralleled to a single homerun. This would be entered as 5 *thin-film parallel substrings* in the string sizer tool. Each homerun can be considered a normal string in the *number of strings* field.

Finally, assign a number of MPPTs for each MPPT Type configuration. See Figure 9 below for an example.

Array Design Options			
	MPPT Type 1	MPPT-Type 2	MPPT-Type 3
String Length	4	4	18
String Length (Max Min)	27 14	6 3	29 15
Number of Strings (3)	2	2	2
Thin Film Parallel SubStrings		5	
Configured MPPTs (12 MAX)	4	7	1

<- 12 Total MPPTs

Figure 9: “Array Design Options” box. Note the suggested string length range in the second row and the maximum number of strings (3) recommended in parenthesis. For this design, MPPT Type 2 included 5 thin-film substrings and this MPPT Type design configuration was assigned to 7 of the 12 total MPPTs in the inverter.

STEP 6 – DATA INTERPRETATION

By this point, you’ve entered all the data needed – well done! But how do you interpret the information shown in the “Module Specifications” and “Inverter Specifications” boxes on the right side of the **String Sizing** tab? Let’s take a look and provide some analysis.

Note: “Isc(t) Method” may be selected as Y/N on the right side of this section. If “Y” is selected, Isc will be calculated using NEC 690.8(A)(1) methodology:
The calculated maximum current value shall be based on the highest 3-hour current average resulting from the simulated local irradiance on the PV array accounting for elevation and orientation.
 If the 3-hour method is selected, the Isc value listed in the spreadsheet must be multiplied by 1.25 for fuse sizing.

Module Specifications			
	HT545	FS FS6420 Test-Thin Film	Astronergy
MODULE NAME			
Rated Power (STC)	545 Wstc	420 Wstc	320 Wstc
Rated Power (t) [Regional Simulation Estimate]	513 W(t)	379 W(t)	288 W(t)
Max System Voltage (Vdc)	1500 Vdc	1500 Vdc	1500 Vdc
Module Voc (STC)	50 Vdc	219 Vdc	45 Vdc
Module Vmp (STC)	42 Vdc	180 Vdc	37 Vdc
Module Imp (STC)	13.1 Adc	2.3 Adc	8.7 Adc
Module Isc (STC) - No Bifacial Gain	14.0 Adc	2.5 Adc	9.3 Adc
Module Isc(t) (3hr Avg)	14.9 Adc	2.6 Adc	9.5 Adc
Manufacturer’s Fuse Rating (Max)	25.0 Adc	5.0 Adc	15.0 Adc
Voc Correction (%/°C)	-0.290%	-0.280%	-0.311%
Vmp Correction (%/°C)	-0.390%	-0.320%	-0.408%
Type- MonoFacial (MF) / BiFacial (BF) / ThinFilm (TF)	BF	TF	MF
Adjusted Module Voc @ Low Temp	54.9 Vdc	240.6 Vdc	50.6 Vdc
Adjusted Module Vmp @ High Temp	38.4 Vdc	168.3 Vdc	33.8 Vdc
Adjusted Module Vmp @ Low Temp	47.7 Vdc	201.3 Vdc	42.5 Vdc

Isc(t) Method	Y	3-Hr
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Figure 10: “Module Specifications” box. Note the two sections highlighted in green, with module rated power and Isc at STC (static conditions) and over time (dynamic, location-based conditions).

STEP 7 – DESIGN OPTIMIZATION (AS NEEDED)

The String Sizer tool will automatically offer guidance on how to optimize your design using color codes as shown below. All sections in the “Inverter Design Compatibility Status” box should be marked “Approved” before finalizing the design.

INVERTER DESIGN COMPATIBILITY STATUS			
High Voc	Status Prompt	Isc	Status Prompt
Vmin<Vmppt(min) - Reduced Production?		3hr-AVG	Approved

Figure 11: “Inverter Design Compatibility” box. Each of the three sections shown here must be tagged as “Approved” prior to finalizing the design. If not approved, follow the color-coded text and cells to address any issues.

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The following color codes are used across the entire tool:

Green FILL or FONT – Approved.

Light yellow FILL or yellow FONT – Approved but not optimal. Look for yellow text to define the error.

Red FILL or FONT – Not approved. Look for red text to define the error.

The following color codes are used for the “Inverter Design Compatibility Status” box:

Magenta FILL – High Voc. Look for a magenta cell(s) throughout the document that will highlight the error.

Gold FILL – High Isc. Look for a gold cell(s) throughout the document that will highlight the error.

Blue FILL – DC/AC ratio error. Usually caused by entering too many modules per string or too many strings in the “Array Design Options” box. Look for a blue cell(s) throughout the document that will highlight the error.

Red FILL or FONT – Not approved. Look for red text to define the error. Typical errors are for excessively high Isc or Voc.

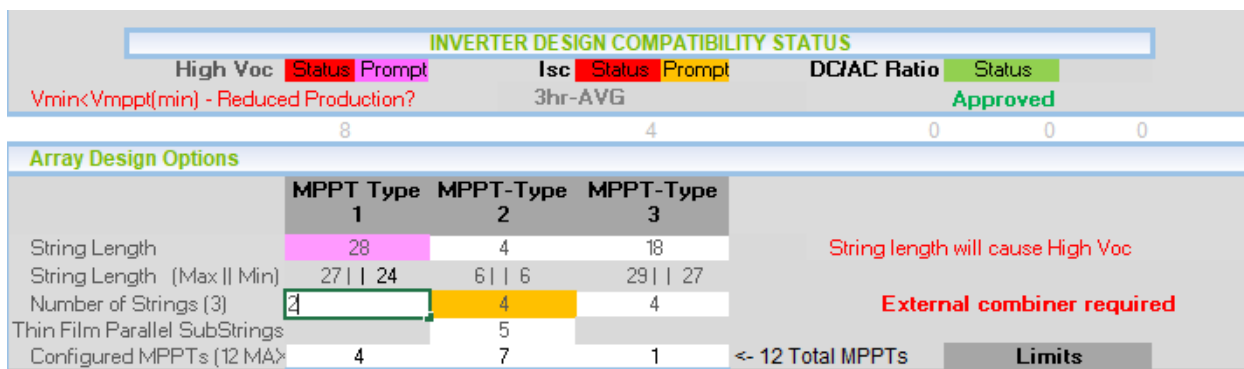



Figure 12: Error color codes and tracing. Note the red “status” cells for Voc and Isc and green “status” for DC/AC ratio. The Voc error can be traced back to the magenta cell in the “Array Design Options” box. The Isc error can be traced back to the gold cell in the same box. Red text suggests a resolution as well.

STEP 8 – APPROVAL LETTER

Once all design parameters have been entered and approved, click “PRINT” in the upper right corner of the **String Sizing** tab to generate an approval letter. This will export a PDF letter that can be used as needed for recordkeeping or finance and warranty applications.

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	Chint Power Systems	V5.0.0
	1380 Presidential Dr. Ste 100 Richardson, TX, 75081 www.chintpowersystems.com	

To Whom it may concern: 1/9/2023

Project: Test - # 72072

Project: # 72072 is Not Warranty Compliant

Inverter: SCH275KTL(250kW)/36In

	MPPT Limit	MPPT- Type 1	MPPT- Type 2	MPPT- Type 3	TOTAL	
Configured MPPTs	12	4	7	1	12	Approved
PV Module Model	--	HT545	FS6420	gy		
String Length	--	27	4	18		
Strings	--	3	20	4	27	
Modules	--	81	80	72	233	
<hr/>						
Max Voltage	1500	1481	963	910		Approved
<hr/>						
Max Wdc(t)	per MPPT	36667	41564	30291	20771	Noted and Approved - See note
Max Wdc(t)	Total	4E+05	92626			
<hr/>						
Isc(t)	per MPPT	50	44.7	52.2	38.0	Approved
Isc(t)	Total	600	134.8			Approved
<hr/>						

NOTES:
Limits on the data sheet reflect the maximum possible Wdc and Isc from the particular site and array configuration over the entire year. The string sizer tool takes these variables into consideration by applying data from regional simulations using TMY data and does not rely on the Static Calculations based on the PV Module at STC.

In addition, Wdc and Isc are related variables with Isc being the most critical and stressful for Inverter operation. Thus, when Isc is within limits and Wdc is out of limits, higher limits on Wdc are considered and approved as noted.

Compliance with the applicable warranty is documented by a printed copy of the String Sizing **and** Approval Letter tabs containing the same project number.

CPS is not responsible for the accuracy of configuration data entry.

Application Engineering Director 1/9/2023
CHINT POWER SYSTEMS USA

Figure 13: Approval letter example. Note the Project # will match what is shown at the top of the String Sizing tab.