

dcbel™ Solar Guide

1 What is the purpose of this guide?

The dcbel™ Solar Guide was created to **assist you in determining if dcbel™ r16** is compatible with your **client's** solar installation plans. In this guide, you will find:

- **dcbel™'s** key functionalities
- FAQ about dcbel™ and PV systems
- Solar sizing methodology with key sizing examples for California
- Rapid shutdown regulations and compatibility

If you are a solar installer or have experience with PV systems, you can go directly to Section 5 for the advanced technical information.

If you want to know more about PV systems and general installation information continue reading.

2 Disclaimer

Information herein is for reference only and subject to change without notice. **dcbel™** does not endorse any of the brands or companies mentioned in this document, they are simply used as a reference. All the brands mentioned belong to their respective companies.

The installer must always validate all references and calculations available in this document, since these data points are for reference only. The installer must also make sure the installation is compliant with all national and local electrical codes and regulations. **dcbel™** will not be held responsible if regulations have evolved since the publication of this document. It is the installer's responsibility to reference the latest version of the electrical codes.

3 What are **dcbel™'s** key functionalities?

dcbel™ r16 replaces the functions normally provided by the following equipment:

- Level 2 electric vehicle charger
- Fast DC bidirectional electric vehicle charger
- Solar inverter
- Stationary battery charger / inverter

For more details on **dcbel™'s specifications**, view the [dcbel datasheet](#).

Here are common questions and answers to help you determine if **dcbel™ r16** is compatible with your solar project.

4 Frequently Asked Questions

4.1 Installing Solar Panel Arrays with **dcbel™**

4.1.1 *What is required for a solar installation?*

dcbel™ will perform the solar inverter functionality for a typical residential solar installation. Your project will require additional hardware, cables and permits. To learn more about this, you can consult:

- Non-profit associations like [SEIA](#)
- Government websites like [GoSolarCalifornia](#)
- Specialized websites like [EnergySage](#)
- Qualified solar installers

4.1.2 *Do I need a permit to install **dcbel™** at my home?*

The **dcbel™** installation will be one part of your solar project which may require permits. In general, article 690 of the National Fire Protection Agency (NFPA) National Electric Code (NEC) 70 provides all the requirements for a safe solar installation.

In addition to the NFPA requirements, each state, utility, county and municipality have their own set of regulations and requirements.

A qualified solar installer is responsible for ensuring that all the permits and licenses are obtained for your installation.

4.1.3 *Can **dcbel™** work with my existing PV system?*

If you already have a solar inverter installed, **dcbel™** can operate in parallel. However, you will not be able to take full advantage of the optimization and energy management benefits of **dcbel™** if the solar panel array is connected to an inverter other than **dcbel™**.

If a solar panel array is already installed on a roof, its compatibility is not guaranteed with **dcbel™**. To determine if an existing solar panel array is compatible with **dcbel™**, refer to section 7 at the end of this document and use your solar panel specifications and location temperature data to perform the sizing calculations.

If the number of panels in your installation is within **dcbel™**'s specifications for power, open circuit voltage and short circuit current, then your installation is compatible with **dcbel™**.

4.1.4 *Is **dcbel™** compatible with micro-inverters?*

dcbel™'s PV inverter inputs are in DC and cannot accept AC from the micro-inverters. The PV must be connected in DC to **dcbel™**.

4.1.5 *Is **dcbel™** compatible with my existing solar inverter?*

See question: Can **dcbel™** work with my current PV system?

4.1.6 *Is **dcbel™** compatible with all types of PV modules (type, number of cells...)?*

dcbel™ is compatible with all types of PV modules. To be installed with **dcbel™**, a solar panel array must be sized adequately to meet **dcbel™** solar inverter specifications.

4.1.7 What is **dcbel™**s compatibility with rapid shutdown?

dcbel™ is compatible with all rapid shutdown devices that are compliant with NFPA 70 2020 article 690.12.

It should be noted that not all rapid shutdown devices are designed to be universally compatible with all inverter brands. **dcbel™ does offer** its own PV Rapid Shutdown (PVRSS) and DC Optimizer devices (sold separately).

4.1.8 Is **dcbel™** compatible with PV DC optimizers?

dcbel™ does not require the use of PV DC optimizers as its two separate MPPT inputs provide the flexibility to optimize your solar output **based on your roof's surface area**. However, depending on the unique characteristics of your home, installing DC optimizers may allow you to harvest additional energy from your solar installation. The additional benefit of optimizers varies from home to home and should only be installed after a qualified installer has performed a site visit.

It should be noted that not all DC optimizers are designed to be universally compatible with all inverter brands.

4.1.9 How many MPPT inputs does **dcbel™** support?

dcbel™ is equipped with two MPPT inputs. You can install two independent solar panel arrays for more flexibility.

Having two separate inputs allows you to **better take advantage of your roof's surface area** which can result in improved power generation and significant utility bill savings.

4.1.10 Is **dcbel™** compatible with a solar installation that is partially shaded or a sloped rooftop installation?

Absolutely! **dcbel™'s two MPPT inputs means that you can have one separate MPPT array** in the section of your roof that is shaded or facing east and a second MPPT array in the non-shaded or west facing section allowing you to leverage both the morning and afternoon sun more efficiently.

Since each of these arrays experience different patterns of solar irradiance throughout the day, they are managed differently by **dcbel™'s MPPT algorithm** in order to leverage the most power out of each array.

See questions 4.1.8 and 4.1.9 for more details.

4.1.11 Is **dcbel™** compatible with net metering?

dcbel™ is capable of net metering if allowed by your local utility. See your utilities rules and regulations for more details.

4.2 Sizing Solar Panel Arrays with **dcbel™**

4.2.1 How many solar panels will my home need?

This depends on your **home's** electric consumption (load) and what percentage of this load you wish to be powered by solar.

A qualified solar panel installer will help you determine the best solar panel sizing for your needs.

In addition, the solar panel array size may also be limited by the size of your roof, your location, the characteristics of the solar inverter and the brand and model of the solar panel.

For more details, please consult Section 5 (Solar sizing data for selected location in California).

4.2.2 *Is there a maximum limit of solar power that dcbel™ can handle?*

dcbel™ can manage up to 20 kW of installed PV or 10 kW per MPPT.

The actual number of panels that can be installed depends on the characteristics of the panels such as open circuit voltage, short circuit current and temperature derating factors which depend on the panel brand and model.

The extreme minimum temperature of the location will also affect the maximum number of panels that can be installed.

See Section 7 at the end of this document for more details about determining the maximum number of panels that can be installed on a dcbel™ unit.

4.2.3 *How are solar panel systems sized?*

Each Solar panel array (solar panel system) is sized in accordance with the solar inverter specifications, solar panel specifications and location of the installation.

For more details, please consult Section 5 (Solar sizing data for selected location in California).

4.2.4 *Why does my PV sizing not match the dcbel™ maximum input capacity?*

As explained in section 4.2.1, the number of solar panels and the maximum solar power depend on your energy needs, your location, the inverter and solar panel's specifications.

Your solar power needs **may be less than the inverter's** max capacity .

On the other hand, your needs may be higher than the inverter's maximum input capacity, thus limiting the size of the solar array that can be installed.

4.3 Working off-grid with dcbel™

4.3.1 *Can dcbel™ operate completely off-grid?*

dcbel™ is designed to operate on-grid with blackout power capabilities. It is not recommended to use dcbel™ in a completely off-grid system.

4.3.2 *What do I need to install to be able to operate in blackout power mode?*

A dcbel™ unit and Blackout Power kit includes all the major hardware components that enables blackout power mode.

4.4 General Questions about dcbel™

4.4.1 *What is dcbel™'s warranty?*

Please refer to the dcbel™ warranty document.

4.4.2 *I'm a solar installer – Can I offer dcbel™ to my clients?*

dcbel™ is always interested in partnering with qualified solar installer

For further information on becoming a dcbel™ partner, please complete the [Partner Form](#) on the dcbel™ website.

5 Solar sizing data for selected locations in California

5.1 Introduction

This section presents typical configurations of solar panel array with **dcbel™** for three locations in California. Two different models of solar panels are used for the examples.

Results and selected configurations are presented for each location followed by a brief qualitative analysis and high-level schematics.

5.2 Methodology and Data

This section presents a high-level view of the methodology and data for calculating the solar panel array sizing presented in Section 5.3 below.

Two **dcbel™** configurations were selected for the sizing examples:

- **dcbel™** with one MPPT (10 000 Watts peak DC input);
- **dcbel™** with two MPPTs (20 000 Watts peak DC input).

Three locations were selected for the sizing examples:

- San Diego area;
- Los Angeles area;
- San Francisco area.

Two solar panel models were selected for the sizing examples:

- Sun Power SPR-X22-360 (360 Watts);
- Canadian Solar CS6X-300P (300 Watts).

Five typical solar panel power configurations were selected for the sizing examples:

- 2,500 Watts;
- 5,000 Watts;
- 7,500 Watts;
- 10,000 Watts;
- 15,000 Watts.

Derating for temperature was performed using the voltage correction factors table 690.7(A) from the NFPA 70 2020, article 690.7.

For a detailed description of the methodology with formulas and examples, please refer to section 7.

5.3 Results and Discussion

Results are presented for the San Diego, Los Angeles, and San Francisco areas.

5.3.1 San Diego Area Results

The table below presents the solar panel sizing results for various desired solar panel output configurations using **dcbel™** with the Sun Power SPR-X22-360 panel.

PV Desired Output (W)	PV Max DC Input (Wp)	Number of MPPT	Total Number of panels	Number of Strings	Number of panels per string
2 500	2 520	1	7	1	7
5 000	5 040	1	14	2	7
7 500	7 560	1	21	3	7
10 000	12 600	2	35	5	7
15 000	15 120	2	42	6	7

The table below presents the solar panel sizing results for various desired solar panel output configurations using **dcbel™** with the Canadian Solar CS6X-300P panel:

PV Desired Output (W)	PV Max DC Input (Wp)	Number of MPPT	Total Number of panels	Number of Strings	Number of panels per string
2 500	3 600	1	12	1	12
5 000	6 600	1	22	2	11
7 500	7200	1	24	2	12
10 000	13 200	2	44	4	11
15 000	14 400	2	48	4	12

5.3.2 Los Angeles Area

The table below presents the solar panel sizing results for various desired solar panel output configurations using **dcbel™** with the Sun Power SPR-X22-360 panel:

PV Desired Output (W)	PV Max DC Input (Wp)	Number of MPPT	Total Number of panels	Number of Strings	Number of panels per string
2 500	2 520	1	7	1	7
5 000	5 040	1	14	2	7
7 500	7 560	1	21	3	7
10 000	12 600	2	35	5	7
15 000	15 120	2	42	6	7

The table below presents the solar panel sizing results for various desired solar panel output configurations using **dcbel™** with the Canadian Solar CS6X-300P panel:

PV Desired Output (W)	PV Max DC Input (Wp)	Number of MPPT	Total Number of panels	Number of Strings	Number of panels per string
2 500	3 600	1	12	1	12
5 000	6 600	1	22	2	11
7 500	7200	1	24	2	12
10 000	13 200	2	44	4	11
15 000	14 400	2	48	4	12

5.3.3 San Francisco Area

The table below presents the solar panel sizing results for various desired solar panel output configurations using **dcbel™** with the Sun Power SPR-X22-360 panel:

PV Desired Output (W)	PV Max DC Input (Wp)	Number of MPPT	Total Number of panels	Number of Strings	Number of panels per string
2 500	2 520	1	7	1	7
5 000	5 040	1	14	2	7
7 500	7 560	1	21	3	7
10 000	12 600	2	35	5	7
15 000	15 120	2	42	6	7

The table below presents the solar panel sizing results for various desired solar panel output configurations using **dcbel™** with the Canadian Solar CS6X-300P panel:

PV Desired Output (W)	PV Max DC Input (Wp)	Number of MPPT	Total Number of panels	Number of Strings	Number of panels per string
2 500	3 600	1	12	1	12
5 000	6 600	1	22	2	11
7 500	7200	1	24	2	12
10 000	13 200	2	44	4	11
15 000	14 400	2	48	4	12

5.3.4 Discussion of Results

As can be seen in the tables above, when considering the maximum number of panels, the configurations are the same for a specific brand and model of solar panel regardless of the location in California.

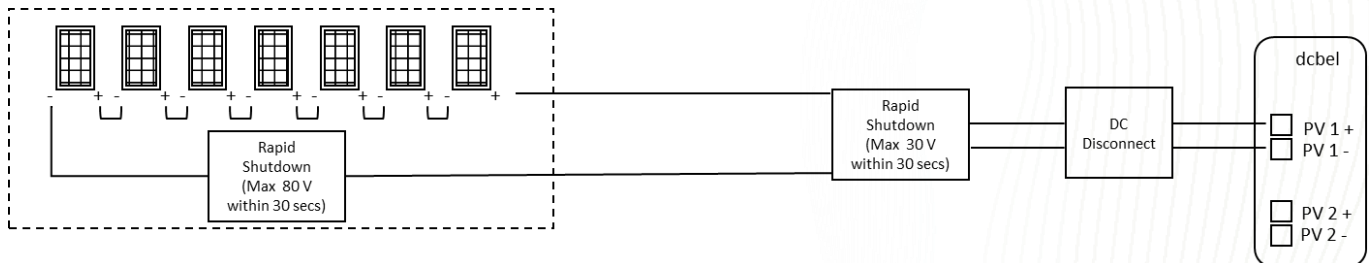
This was to be expected considering that the maximum number of panels in a string is determined by the open circuit voltage corrected for the extreme minimum temperature, which is very similar from one location to another.

5.4 Schematics for Typical Solar Panel Configurations

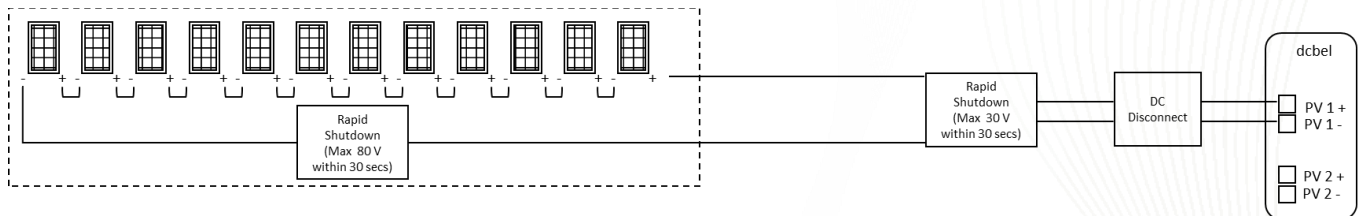
This section presents high level schematics of the 2,500 W, 5,000 W, 7,500 W, 10,000 W and 15,000 W configurations for the Sun Power SPR-X22-360 and the Canadian Solar CS6X-300P solar panels.

5.4.1 2,500 Watts configurations schematics

Sun Power SPR-X22-360: 2,500 W with 7 panels (1 string of 7 panels in series)

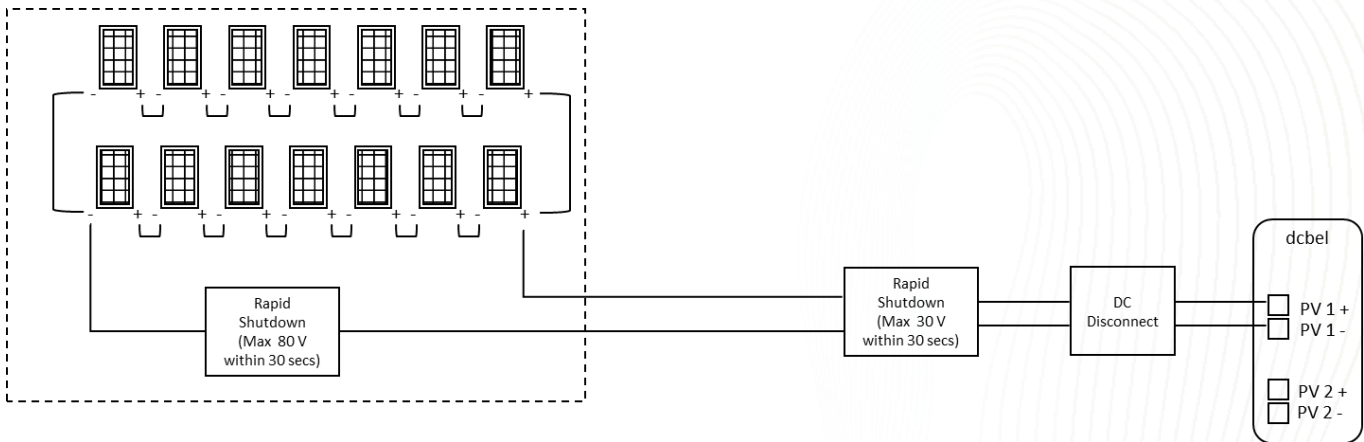


Canadian Solar CS6X-300P: 2,500 W with 12 panels (1 string of 12 panels in series)

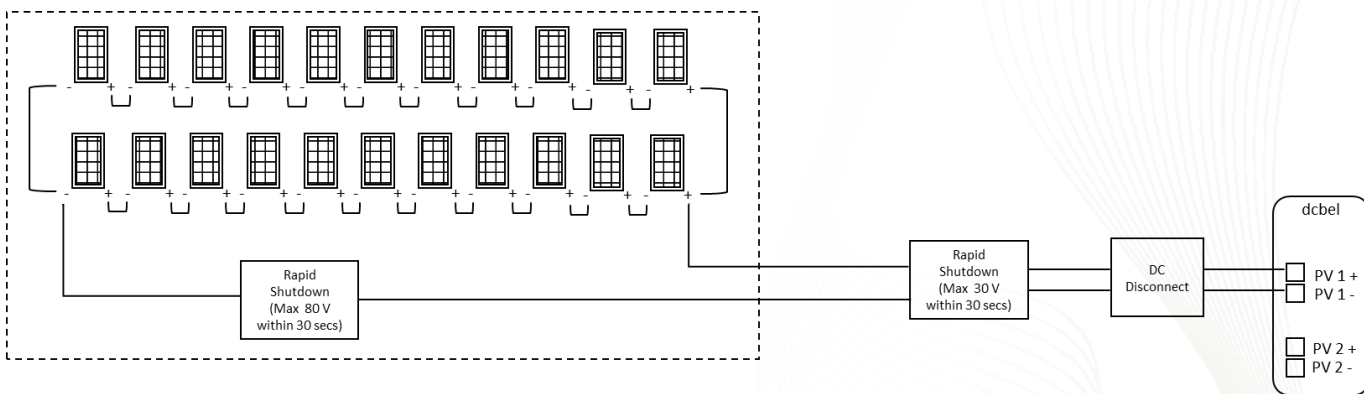


5.4.2 5,000 Watts configurations schematics

Sun Power SPR-X22-360: 5,000 W with 14 panels (2 string of 7 panels in series)

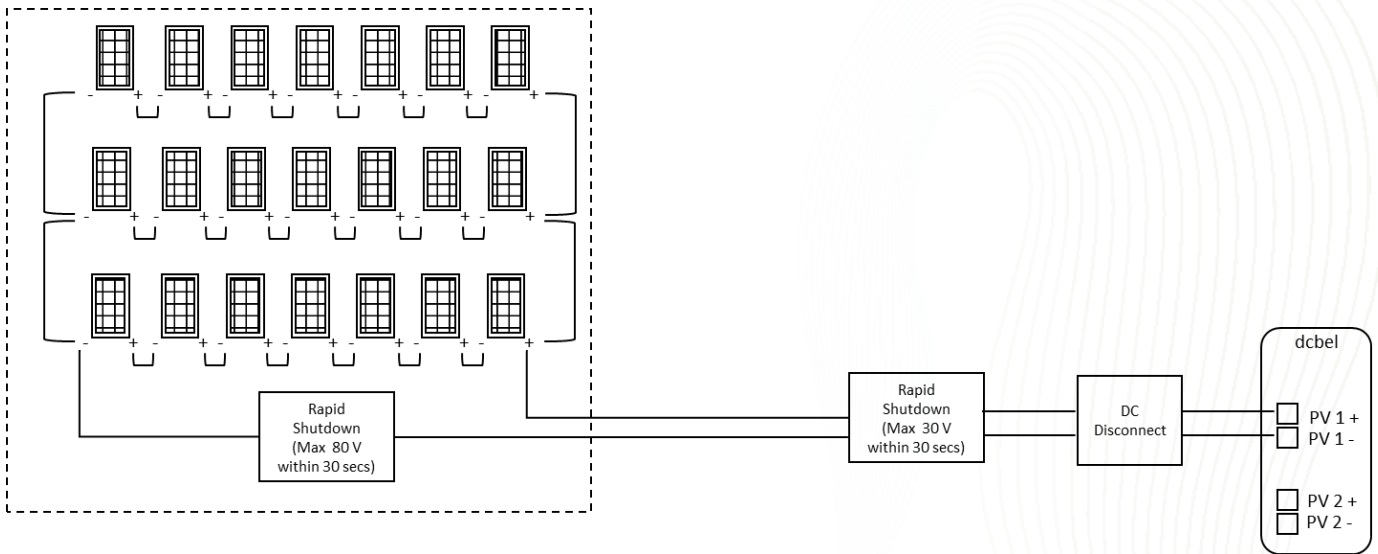


Canadian Solar CS6X-300P: 5,000 W with 22 panels (2 string of 11 panels in series)

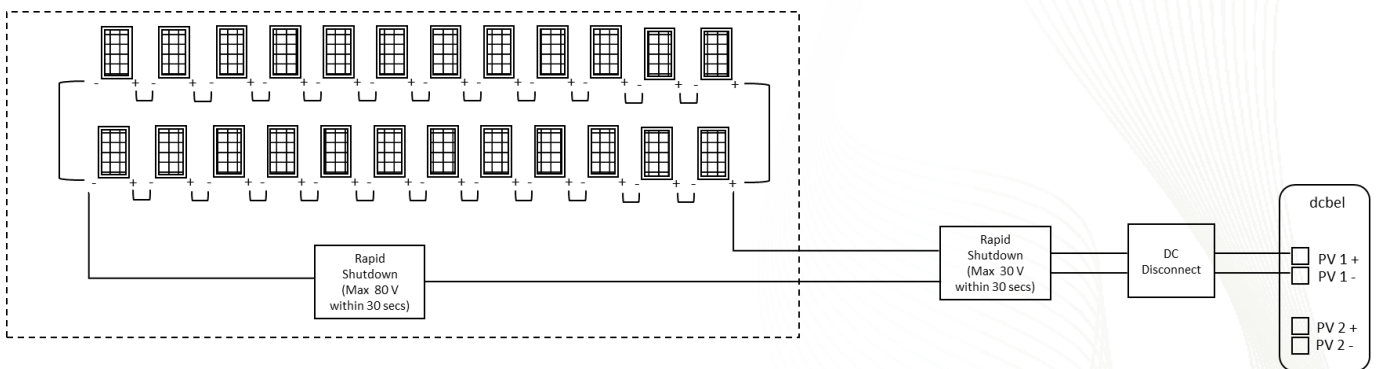


5.4.3 7,500 Watts configurations schematics

Sun Power SPR-X22-360: 7 500 W with 21 panels (3 string of 7 panels in series)

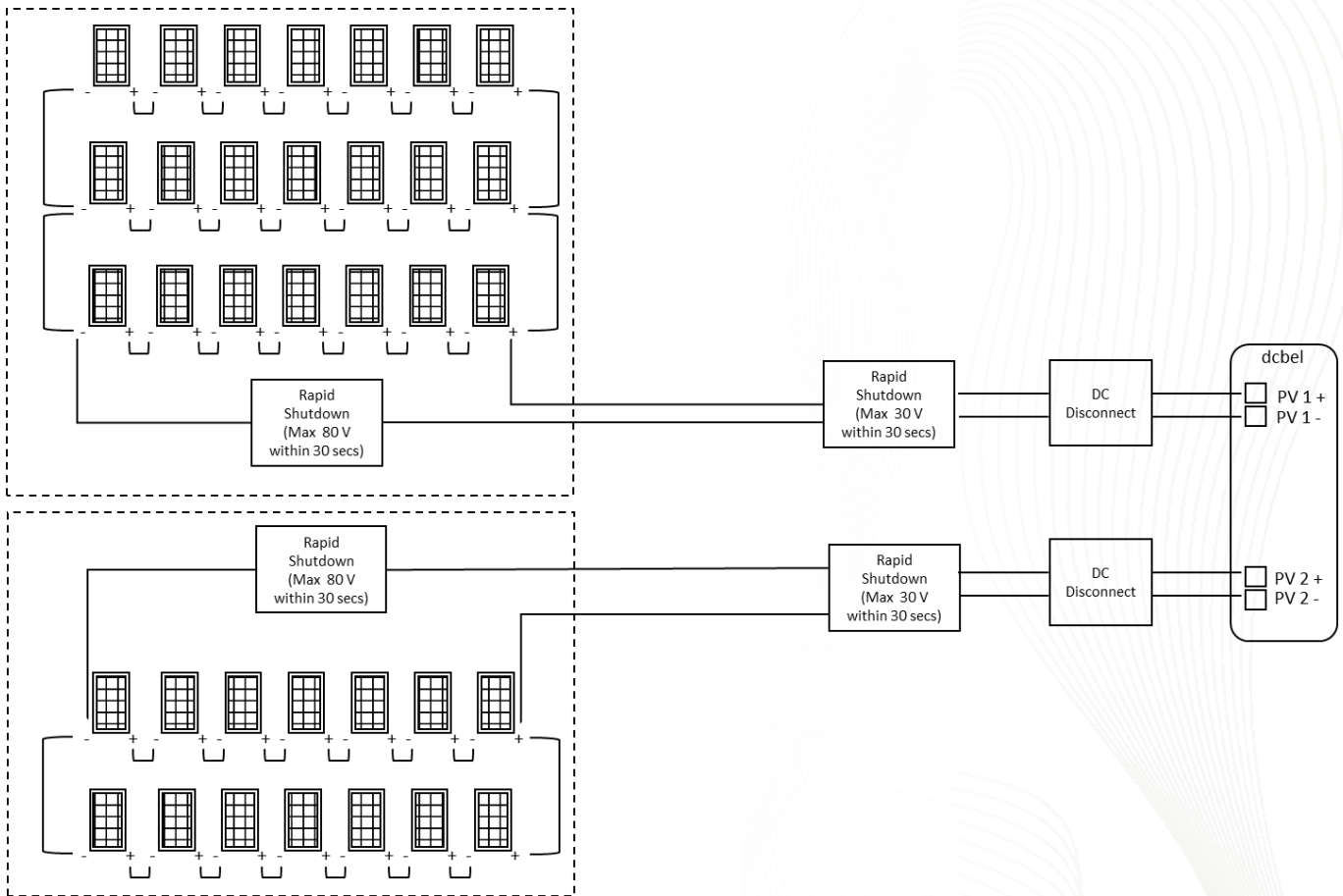


Canadian Solar CS6X-300P: 7 500 W with 24 panels (2 string of 12 panels in series)

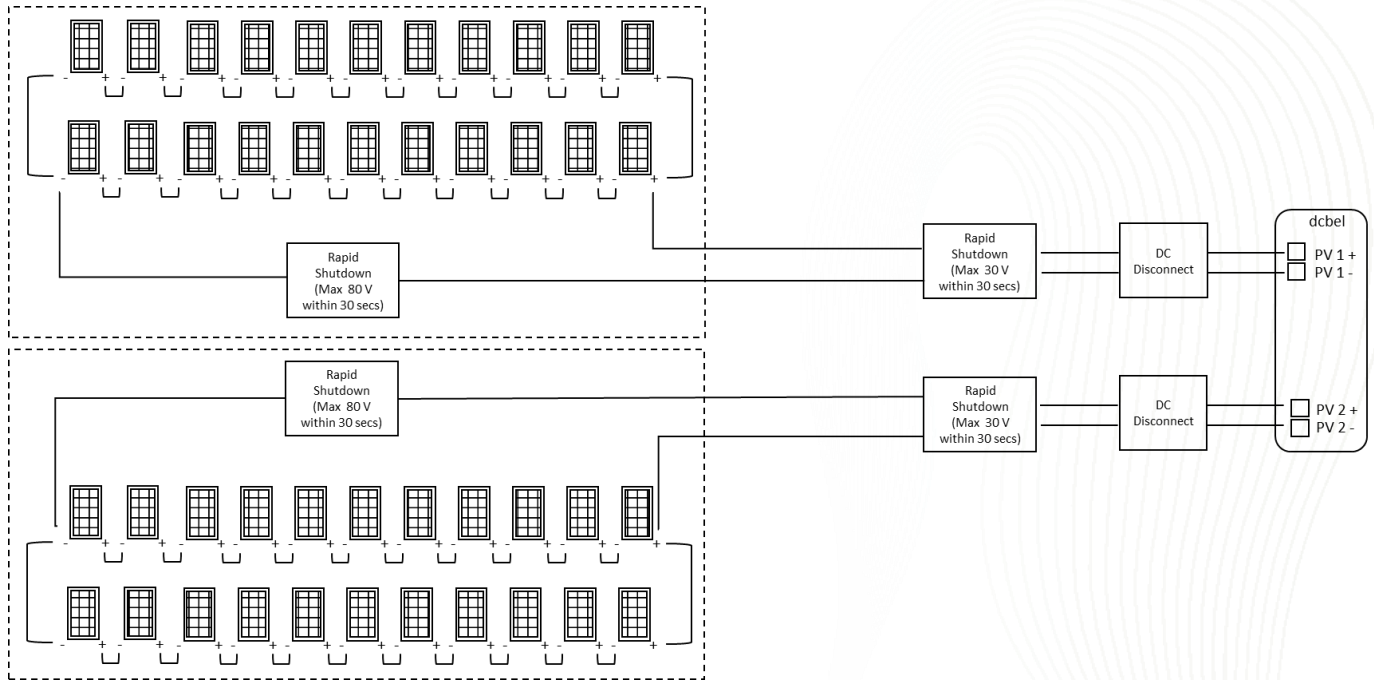


5.4.4 10,000 Watts configurations schematics

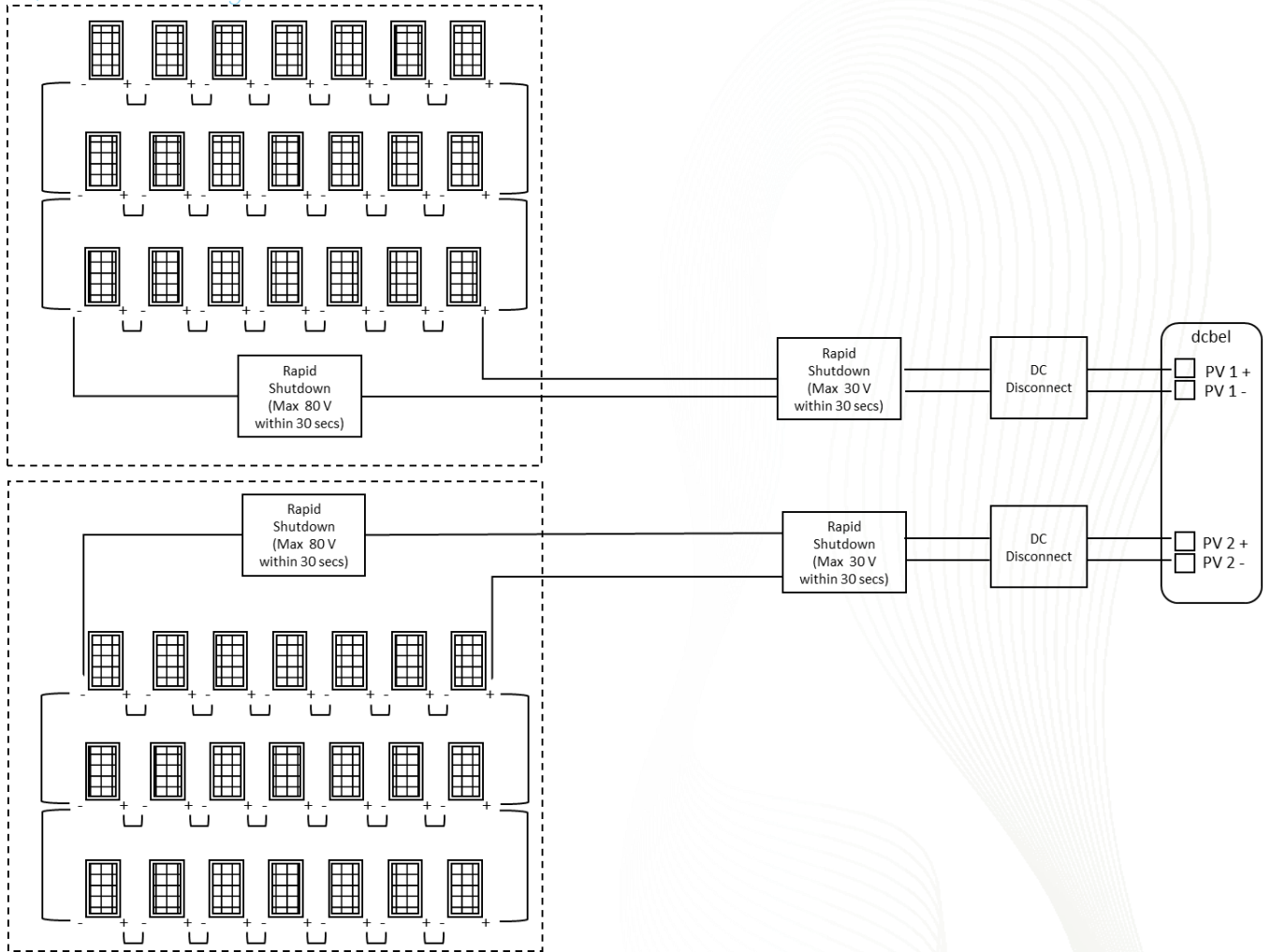
Sun Power SPR-X22-360: 10,000 W with 35 panels (5 string of 7 panels in series)



Canadian Solar CS6X-300P: 10,000 W with 44 panels (4 string of 11 panels in series)

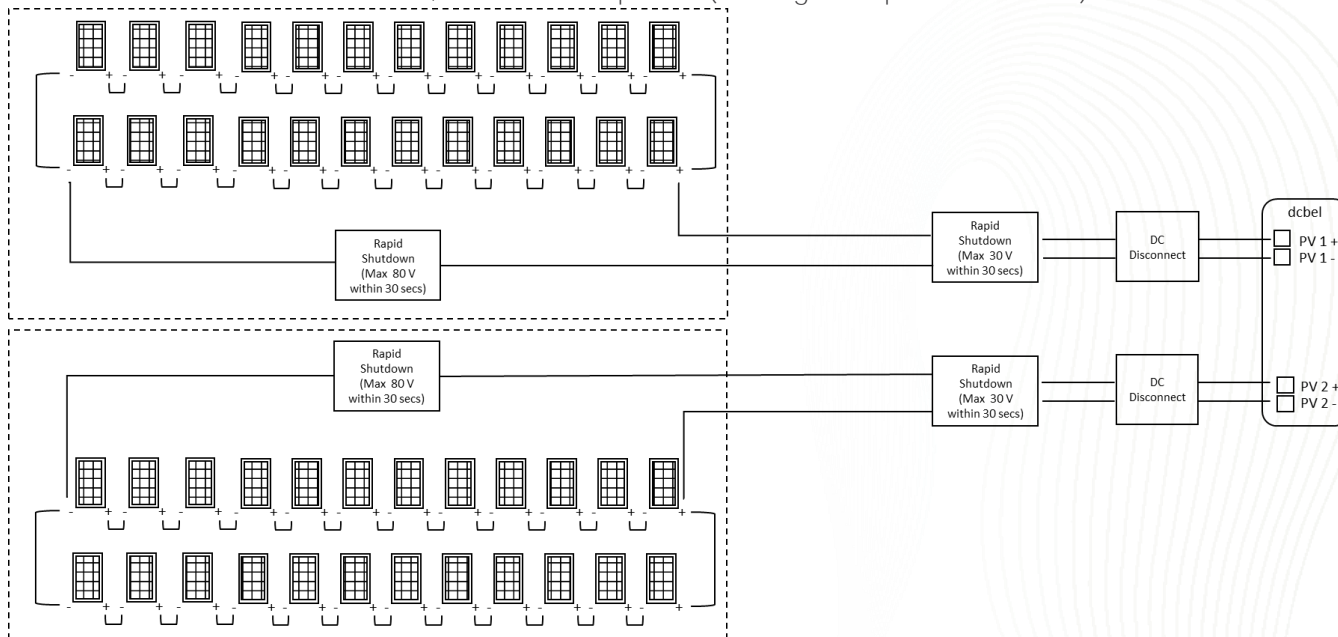


5.4.5 15,000 Watts configurations schematics



Sun Power SPR-X22-360: 15,000 W with 42 panels (6 string of 7 panels in series)

Canadian Solar CS6X-300P: 15,000 W with 48 panels (4 string of 12 panels in series)



6 Rapid Shutdown Regulation

Below is an extract of the USA National Electrical Code (NEC) regarding rapid shutdown systems. Installer must also follow local regulation regarding the PV Rapid Shutdown requirements.

dcbel™ is compatible with all rapid shutdown devices that are compliant with NFPA 70 2020 article 690.12. However, not all rapid shutdown devices are designed to be universally compatible with all inverter brands.

6.1 NEC 2017 690.12 Rapid Shutdown Standard

The information below is an extract of article 690.12.

- All controlled conductor within 305 mm (1 ft) of the Solar panel array boundaries shall be limited to no more than 80 V within 30 seconds after the rapid shutdown initiation;
- All controlled conductor outside 305 mm (1 ft) of the Solar panel array boundaries shall be limited to no more than 30 V within 30 seconds after the rapid shutdown initiation;
- These requirements apply only to Solar panel arrays and inverters installed on or in a building;
- Rapid shutdown can be initiated with at least one of the following means:
 - Building main service disconnecting means (Service panel main breaker);
 - PV system disconnecting means (String Inverter Disconnect);
 - Dedicated Solar panel array disconnect means.

- Rapid shutdown devices and systems DO NOT REPLACE the required physical PV system disconnect switch.

6.2 Rapid Shutdown Devices Compatible with dcbel™:

Below is a list of some rapid shutdown that are compatible with dcbel™ (for reference only and subject to change without notice):

- Tigo Energy TS4-F or TS4-S
- IMO Fire Raptor
- MidNite Solar SOB
- ZJBeny BFS Series

7 Detailed Methodology for Determining the Size of a Solar Panel Array

This section presents all data, specifications and formulas for calculating the configurations presented in Section 5.3. Calculation examples are also provided.

7.1 dcbel™ Solar Inverter Input Specifications

dcbel™ solar inverter specifications used for these sizing examples are presented below:

Maximum Input Peak DC Power:	20,000 Watts Peak
Open Circuit Voltage:	600 V
MPPT Operating Voltage Range:	240 – 500 V
Short Circuit Current:	28 A per MPPT
Max Operating Current:	19 A per MPPT
Number of MPPT:	2

For complete dcbel™ specifications: www.dcbel.ossiac.com/wp-content/uploads/dcbel-specifications.pdf

7.2 Locations

Three locations in California were selected for these sizing examples: San Diego Area, Los Angeles Area and San Francisco Area.

More specifically, the design temperature of these three locations for solar panel sizing are presented below:

Location #1:	San Diego Area
Temperature daily average (2% DB avg):	26 °C
Temperature Extreme Minimum:	5 °C

Location #2:	Los Angeles Area
Temperature daily average (2% DB avg):	26 °C
Temperature Extreme Minimum:	4 °C

Location #3:	San Francisco Area
--------------	--------------------

Temperature daily average (2% DB avg): 25 °C
 Temperature Extreme Minimum: 2 °C

Design temperatures for these locations were obtained from the Solar America Board for Codes and Standards Website which provides data for most major cities in the U.S.A:

www.solarabcs.org/about/publications/reports/expedited-permit/map/index.html

7.3 Solar panels models and specifications

Two typical models of solar panels were used for these sizing examples: a 360 Watts from Sun Power and a 300 Watts from Canadian Solar.

More specifically, the specifications of these panels are presented below:

Sun Power:	SPR-X22-360	Rated Maximum Power:	360 W
Open Circuit Voltage:	69.5 V	Max Power Point Voltage:	59.1 V
Short Circuit Current:	6.48 A	Max Power Point Current:	6.09 A
Current Temp Factor:	0.0348 %/°C	Voltage Temp Factor:	-0.2852 %/°C
Power Temp Factor:	-0.3509 %/°C		

Canadian Solar:	CS6X-300P	Rated Maximum Power:	300 W
Open Circuit Voltage:	44.6 V	Max Power Point Voltage:	36.1 V
Short Circuit Current:	8.87 A	Max Power Point Current:	8.30 A
Current Temp Factor:	0.0474 %/°C	Voltage Temp Factor:	-0.3071 %/°C
Power Temp Factor:	-0.4002 %/°C		

7.4 Calculation Formulas and Examples

This section presents the formulas used to compute the results presented in the tables of the previous section.

Maximum number of panels in series in a string:

$$Max\ Nb\ Panels\ in\ series = Floor \left(\frac{Inverter\ Voc}{Panel\ Voc\ derated} \right)$$

Where,

Inverter *Voc* is the inverter's open circuit voltage;

Panel *Voc* derated is the solar panel open circuit voltage derated for the maximum extreme temperature of the location;

Voc derating is obtained using the voltage correction factors table 690.7(A) from the NFPA 70 2020, article 690.7, as shown below:

Min. Temp. (°C)	NEC Cold Factor	Min. Temp. (°F)
24 to 20	1.02	76 to 68
19 to 15	1.04	67 to 59
14 to 10	1.06	58 to 50
9.5	1.08	49 to 41

4 to 0	1.10	40 to 32
-1 to -5	1.12	31 to 23
-6 to -10	1.14	22 to 14
-11 to -15	1.16	13 to 5
-16 to -20	1.18	4 to -4
-21 to -25	1.20	-5 to -13
-26 to -30	1.21	-14 to -22
-31 to -35	1.23	-23 to -31
-36 and below	1.25	-32 and below

For example, **dcbel™** Voc = 600 V, the CS6X-300P Voc = 44.6, and the extreme minimum temperature in Los Angeles = 4 °C. Thus, Voc derated = 44.6 * 1.10 = 49.06 V

$$\text{Max Nb Panels in series} = \text{Floor} \left(\frac{600}{49.06} \right) = \text{Floor}(12.22) = 12$$

Maximum number of strings in parallel on one MPPT:

$$\text{Max Nb string in parallel per MPPT} = \text{Floor} \left(\frac{\text{Inverter Isc}}{1.25 * \text{Panel Isc}} \right)$$

Where,

Inverter Isc is the inverter's short circuit current;

Panel Isc the solar panel short circuit current;

Isc derating is obtained using the 1.25 factors as required by NFPA 70 2020, article 690.8 (A)(1).

For example, **dcbel™** Isc = 28 A per MPPT, the SPR-X22-360 Isc = 6.48 A. Thus, Isc derated = 8.1 A

$$\text{Max Nb string in parallel per MPPT} = \text{Floor} \left(\frac{28}{8.1} \right) = \text{Floor}(3.46) = 3$$