Bulletin 64-9-1
Use of dc-to-dc converters (power optimizers) in PV installations
Rules 64-202, 64-206

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Scope

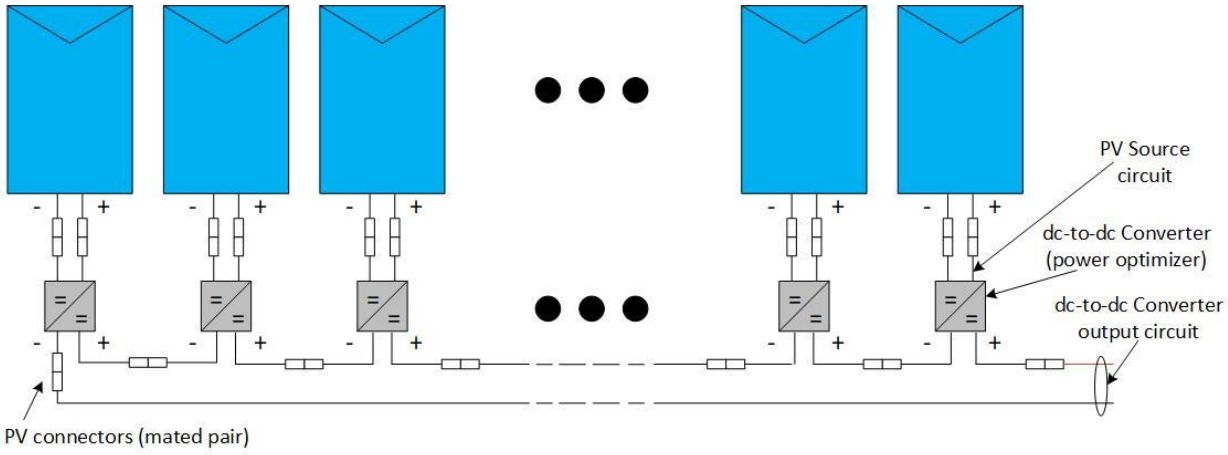
1) Background
2) Calculation of PV string voltage and current
3) Marking requirements for PV output circuit
4) Overcurrent protection requirements for PV string circuits

1) Background

Based on CSA standard C22.2 No. 107.1, power optimizer is defined as “a dc-dc converter used to maximize the output power of a dc power source or a system of dc power sources”.

Diagram B1 shows simplified application of dc-to-dc converters in PV installations.

Diagram B1- Use of dc-to-dc converters (power optimizers)



The use of dc-to-dc converters in solar installations is not specifically addressed by the OESC with respect to voltage and current calculations which are required to be based on the module nameplate data rather than the converter output circuit ratings.

2) Calculation of PV string voltage and current

Rules 64-202 and 64-206 require the PV string voltage and current to be calculated based on the PV module nameplate values (open circuit voltage and short circuit current).

Dc-to-dc converters enable the inverter to automatically maintain a fixed string voltage at the optimal point for dc-ac conversion by the inverter regardless of string length and individual module performance. **The inverter sees the output voltage and current of the converter circuit not the module(s).**

Notwithstanding Rules 64-202 and 64-206, where dc-to-dc converters are used, it is permissible to calculate the PV string voltage and current based on the converter output circuit values under all of the following conditions:

- the converter is approved to the applicable Canadian standard (i.e. CSA C22.2 No. 107.1);
- the converter input ratings are equal to or greater than the PV module
  - rated power;
  - voltage as calculated in accordance with Rule 64-202; and
  - rated short circuit current
- converter connections using pin and sleeve type connectors are mated pair in accordance with Rule 64-220 1) g) - see Bulletin 64-4-* for further details;
- bonding of converters is in accordance with Rule 64-070; and
- the converters are installed in accordance with the manufacturer's installation instructions.

3) Marking requirements for PV output circuit

Rule 64-200 1) requires marking for the photovoltaic output circuit. Notwithstanding all the requirements of Rule 64-200 1), the required marking for photovoltaic output circuit when dc-to dc converters are used, shall include the operating voltage and operating current of the converter output circuit, for example, as per Diagram B2.

Diagram B2 – Example of PV output circuit marking

PV OUTPUT CIRCUIT OPERATING VOLTAGE	360 V dc
PV OUTPUT CIRCUIT OPERATING CURRENT	18 A dc

The additional marking requirements of Rule 64-200 1) b) and c) for maximum PV source circuit voltage calculated in accordance with Rule 64-202 1) and 2) and rated short circuit current are unnecessary for dc-to-dc converter output circuits. The converter output voltage is not temperature dependant as is the case with PV modules and the converter output circuit is protected against short circuit in accordance with the product standard.

4) Overcurrent protection requirements for PV string circuits

Rule 64-206 specifies that the ampere rating of a PV source circuit is the rating of the fuse size marked on the PV module or the ampacity of the conductors, whichever is less. When dc-to-dc converters are used, the fuse size marked on the PV module is not

required to be considered since the output of the dc-to-dc converters is connected to an inverter. The ampacity of the PV circuit shall be determined based on the ampacity of the conductors.

Based on Rule 64-214 1), overcurrent protection from all PV source circuits connected must not exceed the rated ampacity of the apparatus or conductors. Where dc-to-dc converters are used, instead of the available short circuit value, the converter output current shall be considered.

Question 1
When is overcurrent protection required for the string conductors?

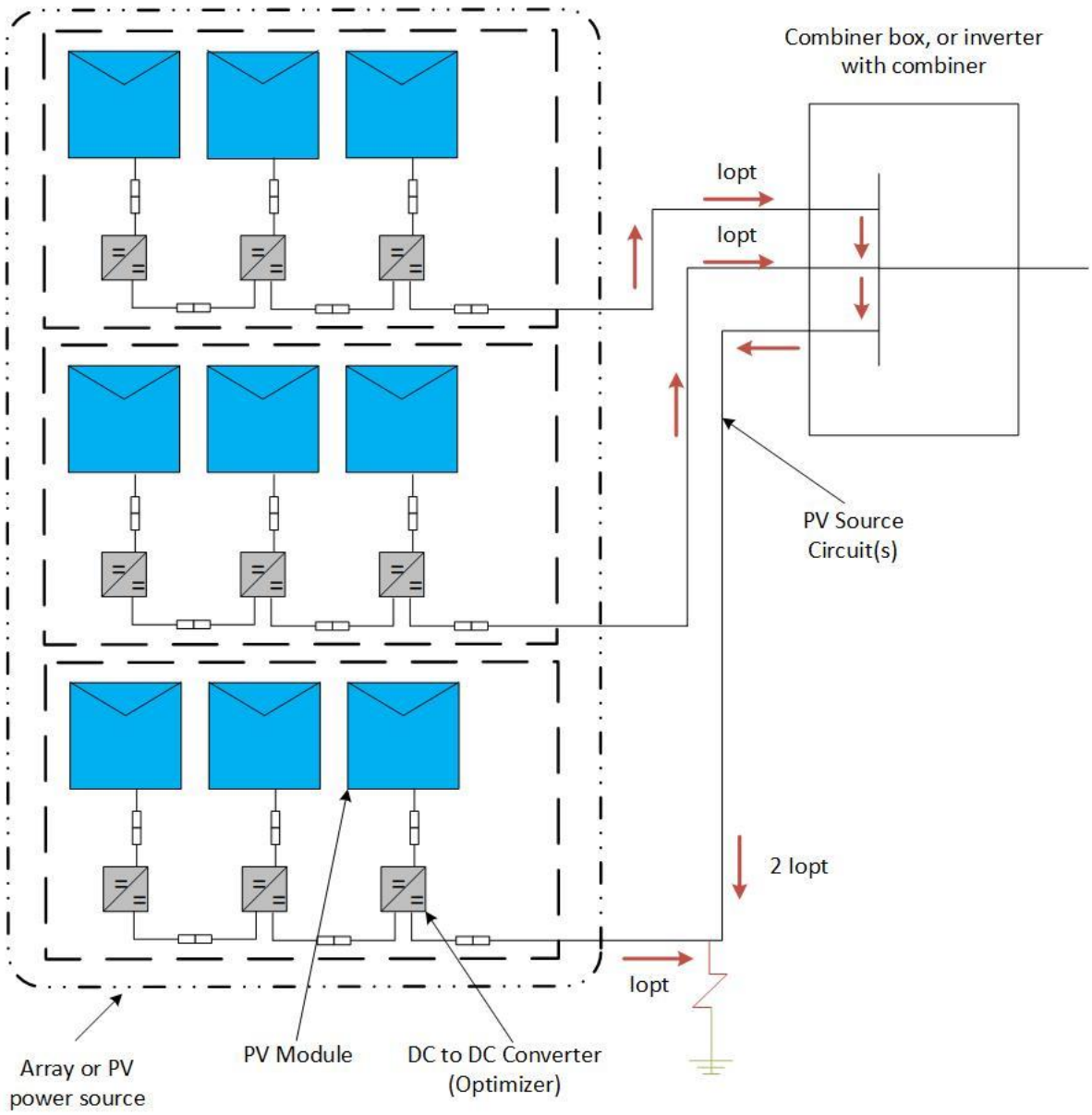
Answer 1
Overcurrent protection shall be provided in each conductor that is not grounded or functionally grounded where the sum of the available dc-to-dc converter output currents exceeds the rated ampacity of the conductors.

To determine overcurrent requirements, the following formula applies (see Diagram B3):

(No. of PV source circuits - 1) x (dc-to-dc converter output current) ≤ ampacity of the conductors

Diagram B3 represents singe line diagram of grounded or functionally grounded PV systems where a conductor that is not grounded, or functionally grounded, is required to be protected by overcurrent device as per Rule 64-214.

Diagram B3 – Overcurrent device requirements



Rationale 1
A worst-case scenario, dc-to-dc converter output current, should be used as conservative criteria for the maximum fault current calculation.

The direction provided applies regardless of the fuse location whether in a combiner box or at the inverter with integral combiner.