

PHOTOVOLTAIC EQUIPMENT PROTECTION BY gPV FUSES

1 - Necessary data required for calculations of photovoltaic protection:

M = number of modules in series in a string (a chain)

N = number of strings (chains) in parallel

For the used module:

IRM = maximum reverse current of a module

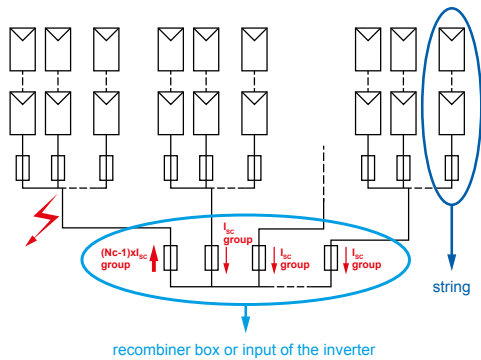
Nota: the module is tested according to the standard **61730-2** at a value equal to:

135% x IRM during **2 hours:**
the module has to withstand this condition

Voc STC = open circuit voltage

Isc STC = short circuit current

STC = Standard Test Conditions = irradiance 1 000 W/m², Air Mass 1.5, Cell temperature 25°C



2 - Presence of fuses at the string level:

- a) **One or two strings in parallel: fuses are not necessary**
- b) **Three or more strings in parallel:** the maximum number of strings in parallel **without electrical protection** is given according to the following formula:

$$N \leq (1 + IRM / ISC STC)$$

3 - Location of fuses in the strings:

Usually, the usage is to put a fuse on each polarity (positive and negative) of each string in floating circuit configuration, and one otherwise.

4 - Rated voltage required for gPV fuses:

The annex BB of the IEC 60269-6 standard gives information to determine the rated voltage of the gPV fuse-link to be selected.

This voltage has to take into account the **Voc STC of the string** at the lowest application temperature.

Voc STC of the string = $M \times \text{Voc STC of one module}$

At -25 °C the open circuit voltage rises to 1.2 times **Voc STC**

Consequently the **fuse-link rated voltage has to be**

$\geq 1.2 \times \text{Voc STC of the string}$

$\geq 1.2 \times M \times \text{Voc STC of one module}$

Nota: the table 104 of the IEC 60269-6 requires breaking tests carried out at a mean value of recovery voltage fixed at 100 (0->+5) % of the fuse rated voltage. These conditions are the same as those of UL standards **UL 248-19** or **UL 2579**.

So, the coefficient **1.2** is applicable with both IEC and UL fuses.

5 - Rated current required for gPV fuses:

The annex BB of the IEC 60269-6 standard gives information to determine the rated current of the gPV fuse-link to be selected. The same calculation has to be applied to the gPV fuses at the string level and to the gPV fuses at the recombination level or at the input of the inverter.

With **an ambient temperature inside the box lower or equal to 45°C**, the fuse rating has to be higher than or equal to **1.4 x I_{sc} STC** according to IEC 60269-6.

As in practice ambient temperature in the boxes can rise up to 65°C or more, a further derating is needed.

Nota: NEC recommends **1.56 x I_{sc} STC** for ambient temperature lower than **50°C** inside the boxes.

6 - Modules protection against reverse currents:

6a) The corrigendum 1 of the IEC 60269-6 specifies that the tests for the verification of the conventional fusing currents "are deemed to give satisfactory results for operation at **1.35 I_n** within **two hours**".

The time-current characteristics of Mersen gPV fuses are in concordance with the following gates:

"non melting current = 1.13 x I_n fuse" and

"melting current = 1.35 x I_n fuse" and so, Mersen gPV fuses meet the gates requirements of the UL and IEC standards.

6b) On another side, we have seen in paragraph 1 that the modules are tested according to the standard **61730-2** at a value equal to **135% x IRM** during two hours

6c) Conclusion for the modules protection:

Conclusion: to protect modules against reverse current, we have to check **1.35 x I_n fuse** lower or equal to **1.35 x IRM**

Certain withstanding of the module

Certain melting of the fuse

END USER HAS ONLY TO CHECK:

I_n (fuse rating) has to be lower or equal to **IRM** (maximum reverse current of the modules)

7 - Fuses gPV at the recombination level:

We apply the rules seen in paragraphs 4 & 5 for the determination of the rated voltage of the gPV fuses and for the determination of their ratings: the end user has to check that the calculated ratings are such that the overload protection of the cables is ensured.