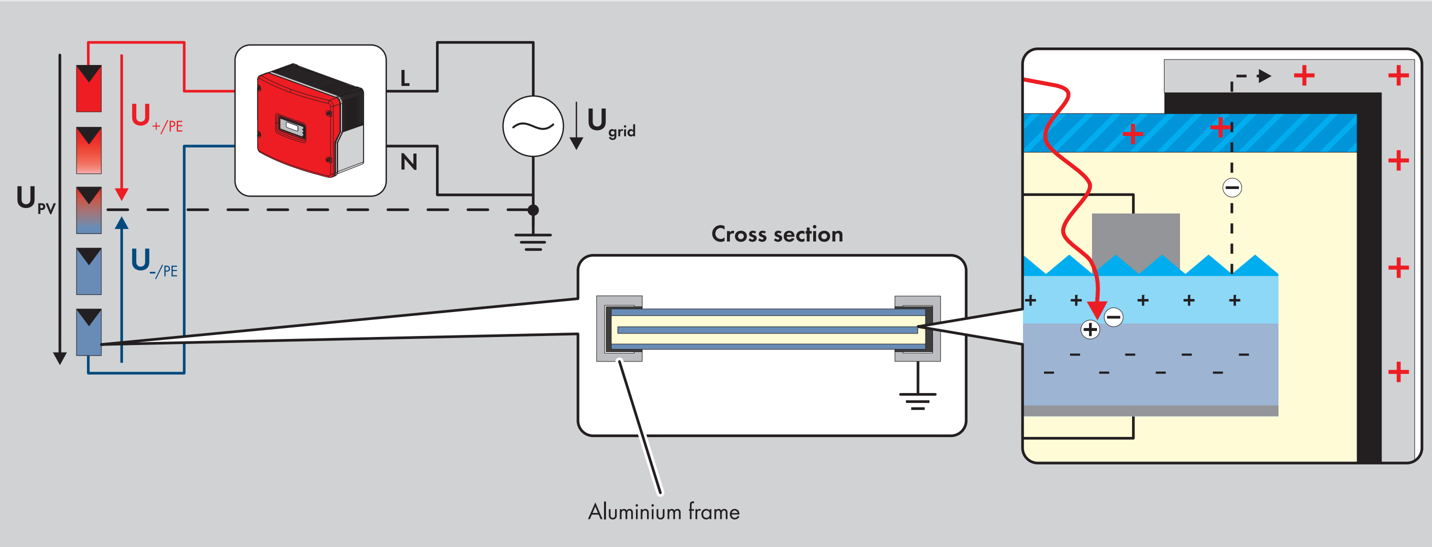
Potential Induced Degradation (PID)



Content

Many electrically qualified persons and plant operators have recently heard or read about an inexplicable power loss. Often, they do not know the exact cause of this effect, known as potential induced degradation (PID), and cannot assess whether it is relevant in their given situation. The question of how to identify an affected PV module and what counter measures are recommended always arises.

The purpose of this technical information is to describe the background of the PID effect and to explain the various influencing factors. The good news for operators is that there are a number of different corrective measures. Along with grounding the negative pole, there is the option of using the PV Offset Box (PVO-Box) developed by SMA Solar Technology AG to neutralize the polarization over night. In addition, most module manufacturers are working on a solution involving the implementation of other materials.

1 Potential to ground

Most PV modules supply a voltage of approximately 30 V. In a PV plant, they are therefore serially connected – in "strings" – to achieve a typical MPP voltage of 300 V ... 500 V. The electrical voltage is described as potential compared to the surrounding conditions (ground). Various factors determine how the array voltage is divided, relative to the zero potential (ground). Examples for a system with 400 V (see Figure 1):

- Ungrounded inverter with galvanic isolation (transformer): The voltage is distributed symmetrically with the positive pole at +200 V and negative pole at – 200 V.
- Inverter with galvanic isolation and negative grounding: negative pole at 0 V; positive pole at +400 V.
- Inverter with galvanic isolation and positive grounding: positive pole at 0 V; negative pole at – 400 V.
- Transformerless inverter: This depends on the design. The voltage is symmetrical for many models, and for some it is offset more to the negative side. For example, the Sunny Tripower's negative pole is at – 350 V in the case in question.

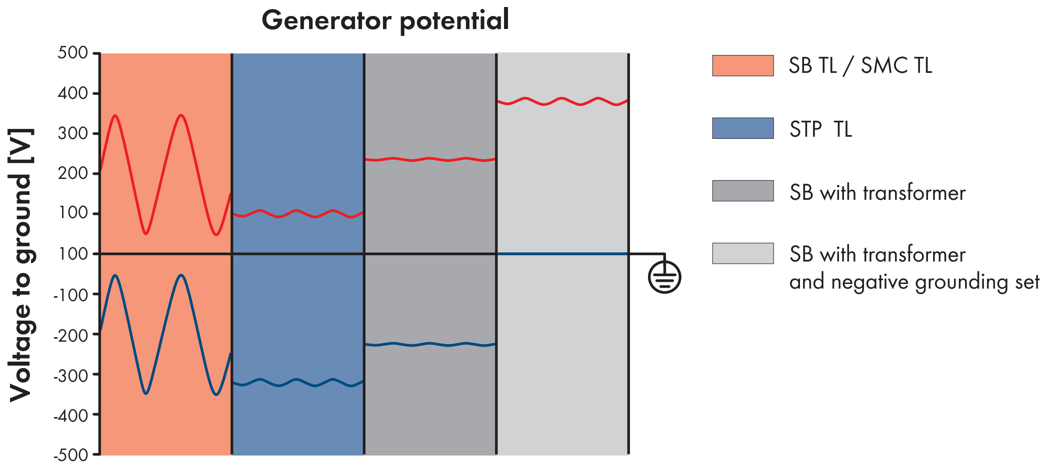


Figure 1: The potential of a string's lowest (blue) or highest (red) PV module depends on the inverter used and whether an array pole is grounded. Example for MPP voltage of 400 V.

2 What does PID mean?

The phenomenon described here occurs most commonly in the PV module that is closest to the negative pole – the "lowest" PV module. In operation, the cells' voltage is – 200 V or – 350 V (the negative pole voltage mentioned above). In contrast, the frame of the PV module has 0 V, because it is grounded for safety reasons.

This electrical voltage between the cells and the frame can cause the electrons to come loose from the materials used in the PV module, migrate into the electrical field, and then discharge through the grounded frame. The result is an electrical charge (polarization). If it goes undetected, it can negatively affect the solar cells' curve (see Figure 2).

Why these charges are so critical can be explained by the way solar cells function. The photovoltaic effect is based on two materials coming together in a solar cell and producing an internal electrical field through a charge exchange. This field causes electrons freed by light energy to be pulled from their place, generating a current flow via the contacts. Additional charges disturb this delicate effect, resulting in power loss.

It has become apparent that such polarizations are generally reversible. They can therefore be distinguished from irreversible effects such as corrosion and normal deterioration. In an article published by module manufacturer Solon, this phenomenon was termed potential induced degradation (PID)* .

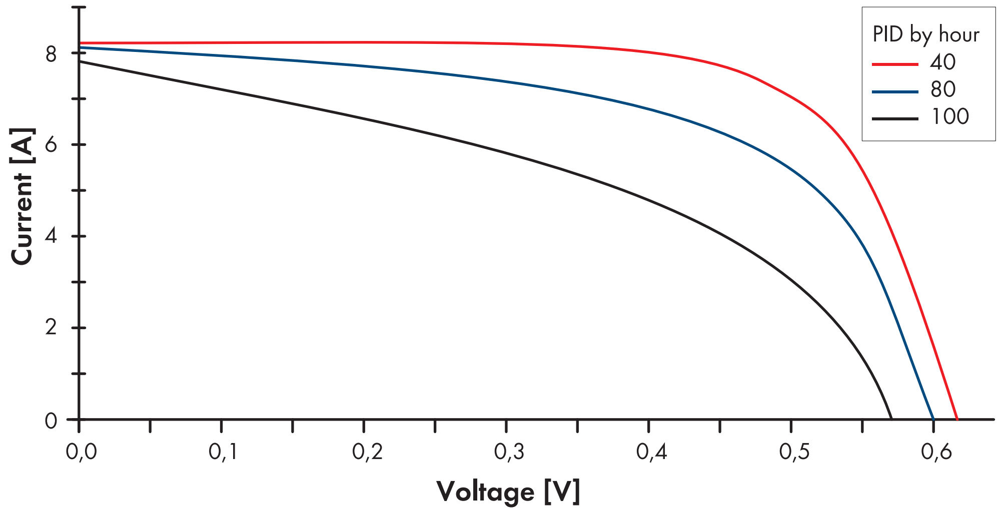


Figure 2: A PV module's curve before and during the degradation process. A flattening of the curve is characteristic, with the open-circuit voltage and the short-circuit current remaining nearly unchanged, and the maximum power point (MPP) being reduced by up to 70%.

3 Further information on PID

In the past, polarization was known to occur in only a few cell types, which the manufacturers attributed to a certain treatment of the PV module. Recently, however, there are increased indications that more and more cell types display this failure pattern, without the manufacturer being aware of it. The article by Solon mentioned above identifies the major influencing factors:

- Solar cells: The solar cells' configuration has an influence on the charge carrier density of the silicon used and the chemical composition of the anti-glare coating.

* J. Berghold et.al, Potential Induced Degradation of solar cells and panels, proceedings of the 25th EU PVSEC, 2010

- PV module: The materials used in the PV module also play a role, for example, the laminating film that comes directly into contact with solar cells (usually EVA).
- System: As described above, the maximum negative potential plays a significant role. This depends on the string length, the inverter and the grounding of the PV array.
- Time: The phenomenon is not immediately noticeable; rather, it develops over time. Periods of several months or a few years are typical.

4 Corrective Actions

To prevent PID, the solar cells must not have a negative voltage relative to their surroundings. Grounding the negative pole of the PV array resolves this problem. A PV Offset Box can be used for transformerless inverters that cannot be grounded. This device, developed by SMA Solar Technology AG, places inverse voltage on the PV array over night, thereby discharging the charged modules.

We have found that the feed-in loss can be largely corrected by taking the actions described. In addition, we expect that in the medium term, all module manufacturers affected by this problem will also take constructive action.

In summary, the occurrence of PID does not present a serious problem for investors or for the advancement of photovoltaics in the long term.

5 What to do in case of power loss

The phenomenon described above applies only to some module types with solar cells made of crystalline silicon (c-Si). It is not to be confused with TCO corrosion, a non-reversible process that can occur with certain thin-film PV modules (particularly CdTe and a-Si). For further information on this subject, see the Technical Information entitled "Module Technology".

Note that a number of errors can lead to yield losses. In such cases, we highly recommend a professional inspection of the PV plant.

Plant operators who suspect that their plants are affected by PID are encouraged to contact their module manufacturer through their electrically qualified persons. SMA Solar Technology AG supports and advises module manufacturers in selecting the appropriate corrective measures.

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