Potential Induced degradation

By: Waaree Energies Limited

Abstract

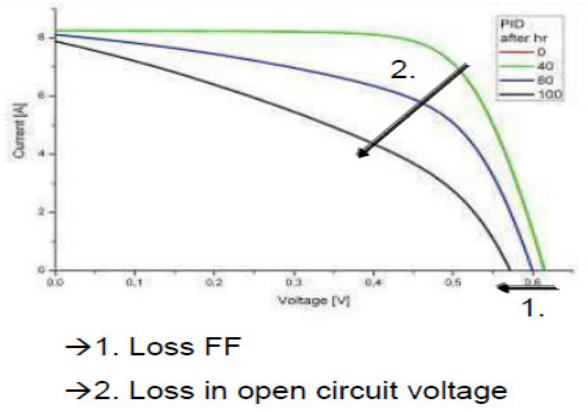
The PID defect is affecting all the manufacturers around the world. This defect is byproducts of the aggressive competition in the solar field among manufacturers, hence the compromise between quality and the cost. Through this paper we discuss the types of PID and the levels in which it is affected. The methods of detecting PID and ways to prevent it are discussed. In the end, methods to recover are also discussed.

Introduction

The photovoltaic industry has grown exponentially from the year 2000; the solar capacity worldwide crossed 139 gigawatts. The solar plants are increasing in size year on year, the standard set by industry are being exceeded by installers, which in turn are putting huge stress on the system. This increasing voltage levels has given rise to a new type of degradation, which was noticed starting 2005. The cell manufactured nowadays are more efficient, however are also more sensitive to this kind of degradation. The existing recommended PV test IEC 61215 (or any other test world over) does not have the provision to test this type of degradation. The test procedure for PID test (IEC 62804) is still in draft stage, and would help the industry as whole in future for more reliable PV modules. The modules can be made PID free by using various combinations of cell, encapsulate, and glass.

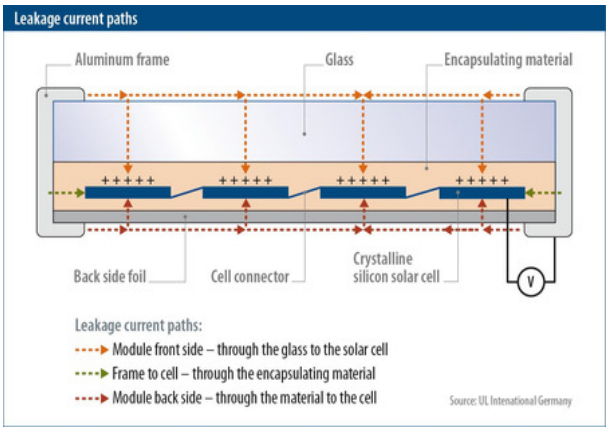
Definition

PID or Potential Induced Degradation is a problem that occurs on many photovoltaic panels when they are exposed to a negative voltage to ground. In the existing models the PID is due to the high voltages forcing the sodium ions to diffuse from glass through encapsulate and accumulating on the surface of cell. This increases surface recombination, leading to increased local shunting, and also results in drops in the fill factor. Mostly the modules on negative side are more affected. In the PID affected module high potential difference between the cells and frame causes a polarization effect leading to increase in leakage current, from cell surface through encapsulation and the glass, which is discharged to the ground.



→1. Loss FF

→2. Loss in open circuit voltage



Types

There are two types PID existing:-

- Non reversible: - Observed mostly on thin films, due to electrochemical reactions leading to the electro-corrosion of Transparent conducting oxide (TCO).
- Reversible: - Surface Polarization.

Surface Polarization is the accumulation of positive charges on the solar cell, leading to increased leakage currents. The amount of leakage current depends on the grounding configuration of the solar array. The accumulated charge hampers the solar cell generation capability. However the accumulated charges can be controlled and reversed and also prevented by taking necessary precautions at – cell, encapsulate and module level.

Levels

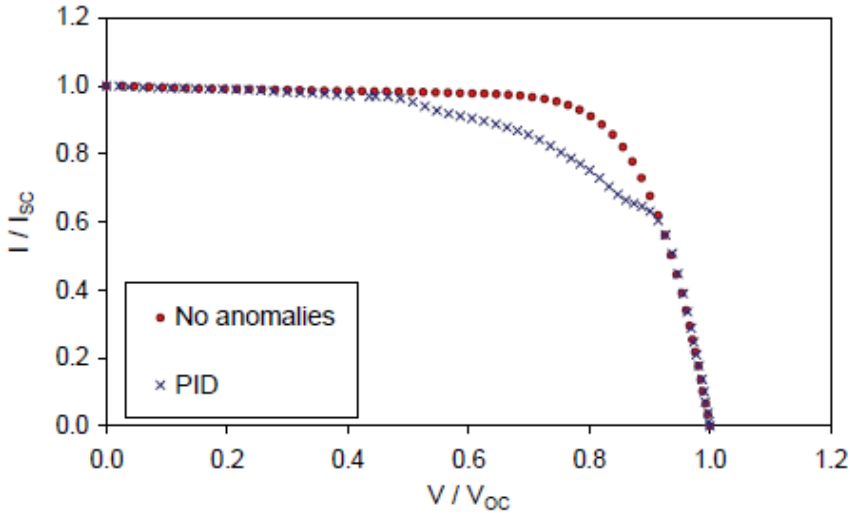
The conditions for the occurrence PID is summed up in these levels:-

- Environmental factors: - These are dependent on the temperature and humidity, they are accelerating agents, they increase the amount of leakage current.
- System factors: - They depend on the system voltage, type of biasing, type of grounding used.
- Module factors: - They can control the leakage current to large extent by increasing electrical resistivity of insulation, by choosing proper materials such as encapsulate, glass type or introducing barrier layer to sodium ions.
- Cell level: - Major factor influencing the PID resistivity at cell level is the refractive index of the ARC on the cell, homogeneity of ARC and also on the Si to N ratio of ARC (SiNx).

Detection

- **Open circuit voltage: -** When a module is affected by PID its open circuit voltage can be lower than the expected one. This is because the reduction of shunt resistance can reduce the open circuit voltage. But this reduction is only noticed when the effect of PID is high.

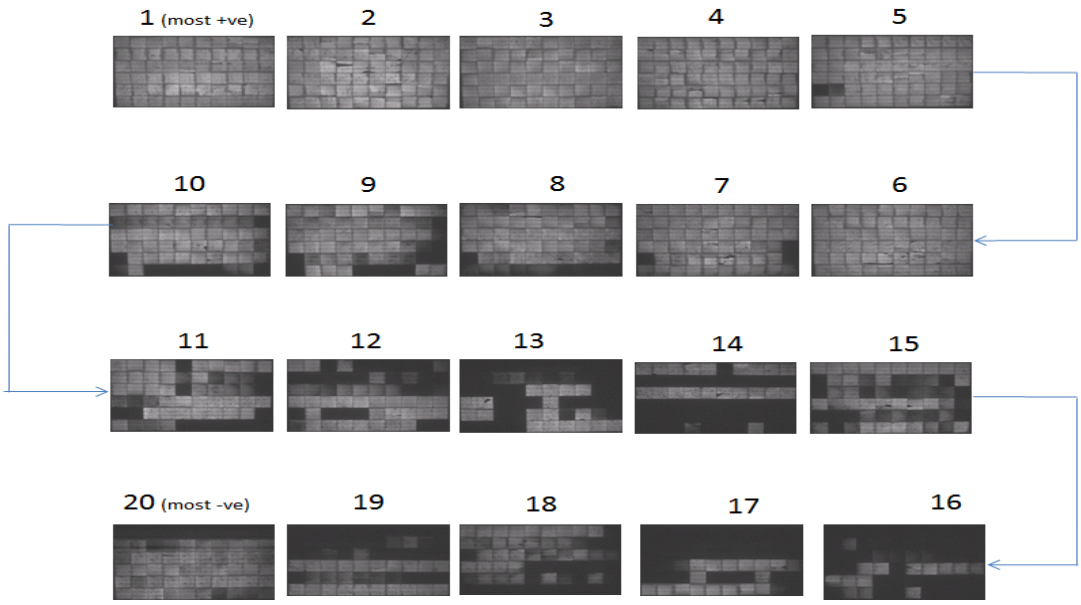
- **IV curve: -** The typical test to know if a module is free of PID is to measure its IV characteristic with an electronic tracer. By the shape of an IV curve, one can easily detect the presence of PID. The Pmax is more flat rather than square shape.



- **Electroluminescence imaging**: - The Electroluminescence imaging can be used to easily detect the PID in the module. This is done with a CCD camera, while the module is biased with a current source and without sunlight.

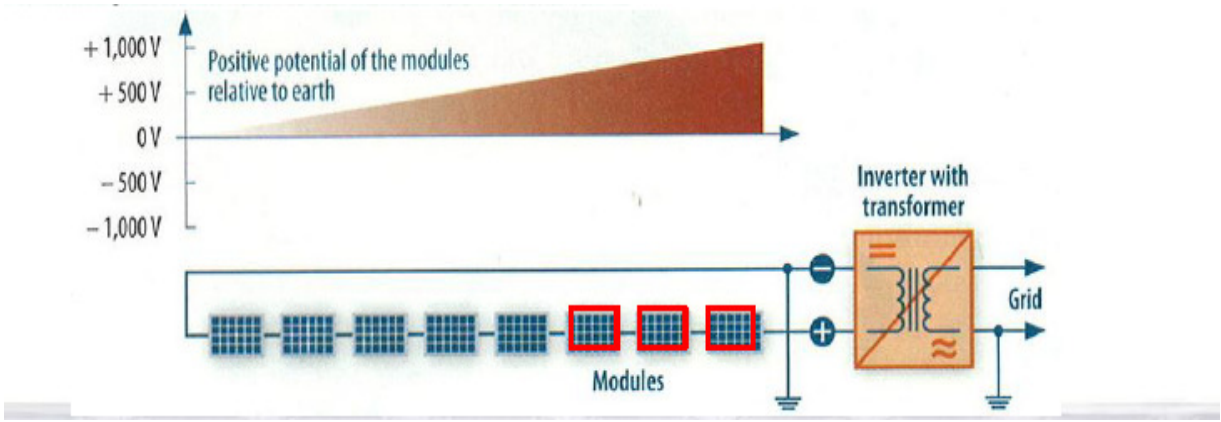
  A module free of PID has an electroluminescence image with all their cells of the same brightness, while a module affected by PID has some dark cells (due to shunting of cells caused by Na ions).

  The degradation of modules in the string shows the pattern, with negative side most affected, and positive side affected the least.

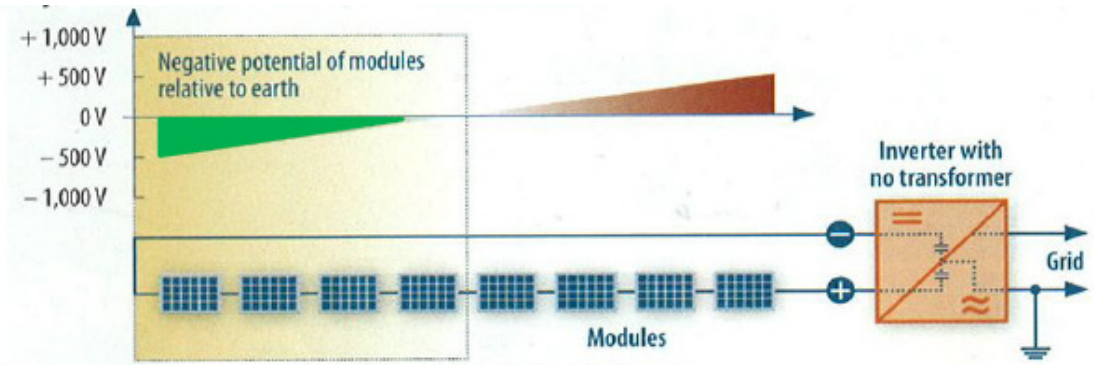


Prevention

- System Level:-
    - Operating plant at less than 500Vdc system voltage.
    - For transformer based inverter: - PID effect can be prevented by grounding the negative string, in consultation with the inverter manufacturer.



- Transformer less Inverter: - Transformer less inverter are lighter, cheaper and most efficient. However in absence of galvanic isolation between AC and DC side we cannot do negative DC grounding.
  However even for such inverters there are technologies available by leading inverter manufacturer, like we can provide recovery solution like PV offset box by SMA, or PID- preventive transformer less inverter inverter by Omron



➢ Module Level:-

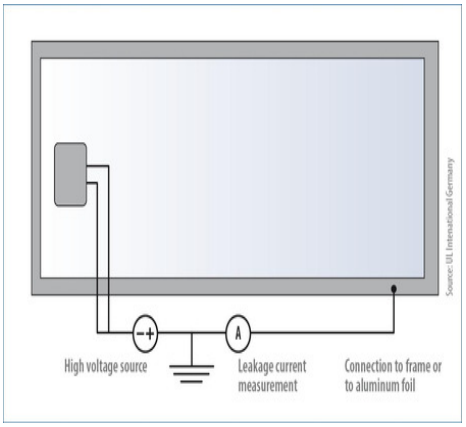
- Reduced accumulation on water on module to avoid leakage charges.
- New technologies in glass can be explored, like Quartz glass, Potassium based glass by AIS.
- More the resistivity of encapsulate, better the performance against PID. Nowadays alternative to encapsulate, like Poly-olefin, Inomers etc. are introduced by various leading solar research laboratories across the world.

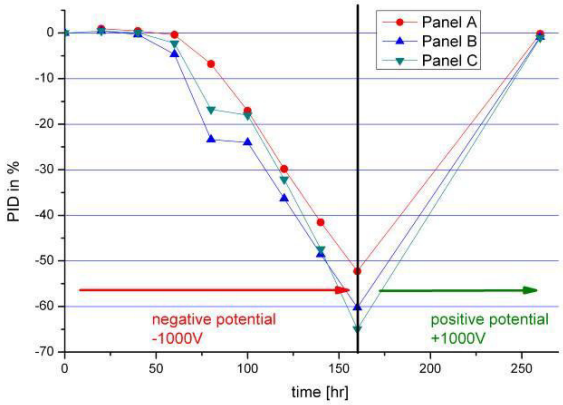
➢ Cell Level:-

- The anti-reflective (AR) coating of the cell is supposed to be in the particular range. There has to be compromise in the ARC layer width, as too much can increase the PID resistivity however reduce the light transitivity and vice-versa.

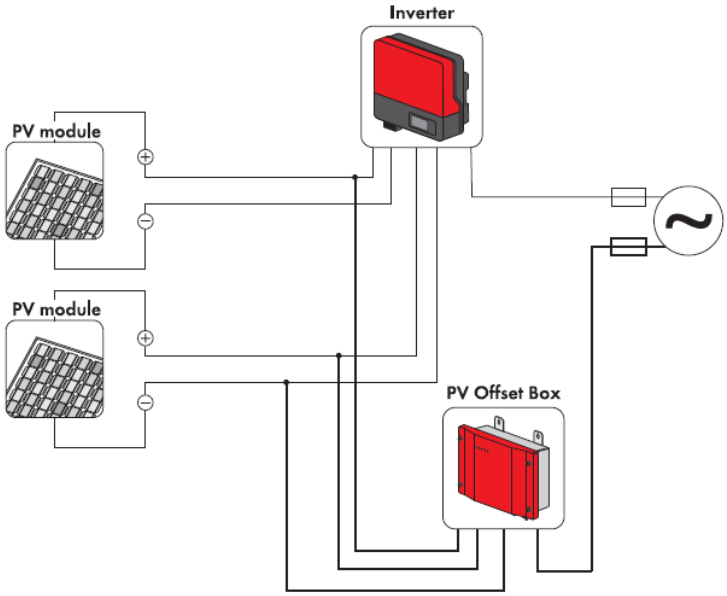
Recovery

- **Heat Recovery:-** The recovery of PID panels by temperature, storing PID panels at around 100°C for 10 hours leads to a recovery close to 100% (depending on module condition). Even though this is a faster process, but recovery procedure at high temperature is stressing the panel and its materials and hence may affects the long term stability.
- **Voltage Bias: -** The modules are stressed under positive (+) bias also helps to recover their lost power.





- **<u>PV offset box by SMA: -</u>** After sunset, the PV Offset Box raises the entire PV array to a high positive potential (between +400 V and +1,000 V to earth). This helps in reversing the polarization effect which occurred during operation. This can assist in the faster recovery of the PV array affected by PID.



Conclusion

PID on module is a reversible process and can be targeted on following level:-

- Cell level: - The sheet resistivity, Ratio of Si:N in ARC, thickness of each layers in cell, homogeneity of layers needs to be strictly monitored. We must only procure PID free cells
- Encapsulation level: - The water absorptivity, resistivity are the major factors affecting the Encapsulation. Also alternatives to EVA like Inomers and Polyolefins can be tried based on the experience of the industry.
- Glass Level: - The glass needs to be monitored for Na content. For the PID resistant modules we need to slowly move towards Quartz glass and phase out the soda lime glass in use at present.
- System Level: - The PID can be reversed or rather prevented on the customer end by adopting the simple procedures and technology available in market and as explained earlier for both transformer and transformer less inverter.
- PID effect is dependent on the combination of all factors from the individual component to the customer end to the system.