Smart Bypass Diode for Smart Power

[1]Prof. Prachi D. Mohite, [2]Prof. S. S. Kamble, [3]Prof. Shweta Abhay Khalatkar

[1]Assistant Professor, [2,3]Associate Professor
Electrical Engineering Department,
P.E.S. College of Engineering, Aurangabad, Maharashtra, India,

Abstract- **Increasing efficiency of photovoltaic (PV) panels is the most effective effort to achieve cost reduction when designing solar panels. Bypass diodes protect each of the three substrings in a 72 cells PV panel to prevent hot-spots in the event of partial shading. Traditionally, diodes have been used for this purpose. They operate at a voltage drop of typically 0.5 – 0.7 V, with low dissipation. The new generation models of PV panels is increasing conversion efficiency and operates at even higher currents, pushing the limits of the thermal balance in the panel. Smart diodes respond to the industry requirements to reduce losses in the panel and lower operating temperatures. This paper describes the functionality of a smart bypass diode and quantifies the potential for increasing energy yield in PV systems.**

Index terms **–array, bypass, cells, diodes, panels.**

I. INTRODUCTION

When one(or many) of the module in a solar panel comes under the effect of shading(which can be due to trees, neighboring buildings, clouds and many more circumstances can be here), its voltage drops, so, it works as a load instead of working as a generator. A bypass diode is connected to ensure that particular shaded module doesn't get damaged and does not have voltage mismatch. Under Partial shading (when one cell is under shading), bypass diode starts conducting. So, in characteristics curve we do not get a unique maximum power point (MPP) but receive several local peak values and one MPP. If bypass diode is removed from the system to simplify the complications of so many peak values, but as a result power is reduced which significantly increase the cost of solar power generation. So, a bypass diode is not removed.

II. BYPASS DIODES IN SOLAR PANELS

A typical crystalline Silicon (c-Si) photovoltaic (PV) module consists of 60 to 72 individual PV cells connected in series. A bypass diode is required for every 20-24 cells to avoid hot-spot conditions and damage to the cell. When a panel in a string is completely or partially shaded, the shaded solar cells operate in reverse mode, effectively becoming resistors. At the same time the string current is being pushed through the reverse cells, which eventually will damage the cell and possibly cause fire.The system is analysed by graphic tool of pvsyst. Following is the electrical behaviour of electrical PV arrays shown with the help of reverse characteristics, mismatch and array with shaded cells.

Reverse characteristics

It is shown for basic PV module for generic model for Pnom 110 wp 29volt, Si poly and model poly 110Wp 72 cells.The output is for external conditions of irradiation 1000Watts per meter square as shown in fig 1.

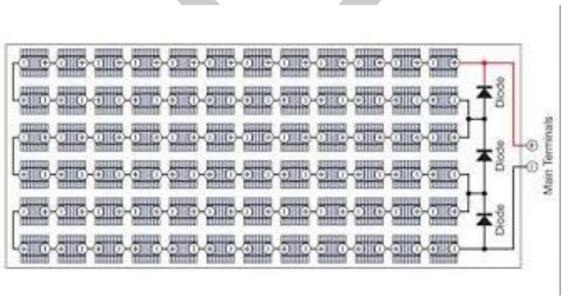

Figure 1: PV module with 72cells.

One single PV cell

The following shows characteristics for PV module for single cell. For a irradiance oF 1000Watts per meter square. It will behave as a normal PV cell with characteristics shown in Fig 2.

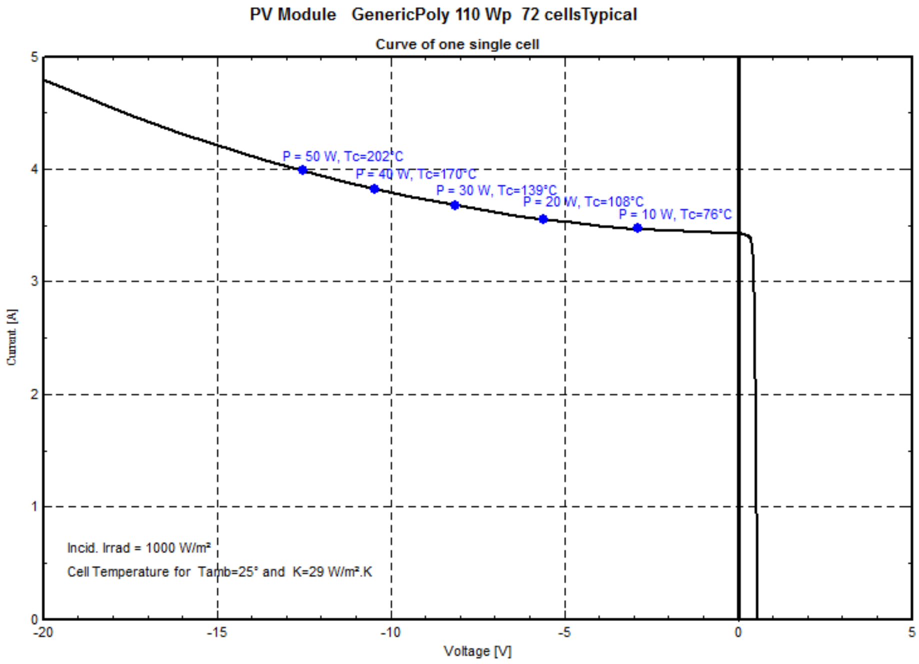

Figure 2: Curve of one single cell

PV module without by pass diode

It will also behave in usual way as a single PV cell.It will excibit low power output and more thermal imbalance as shown in fig 3.

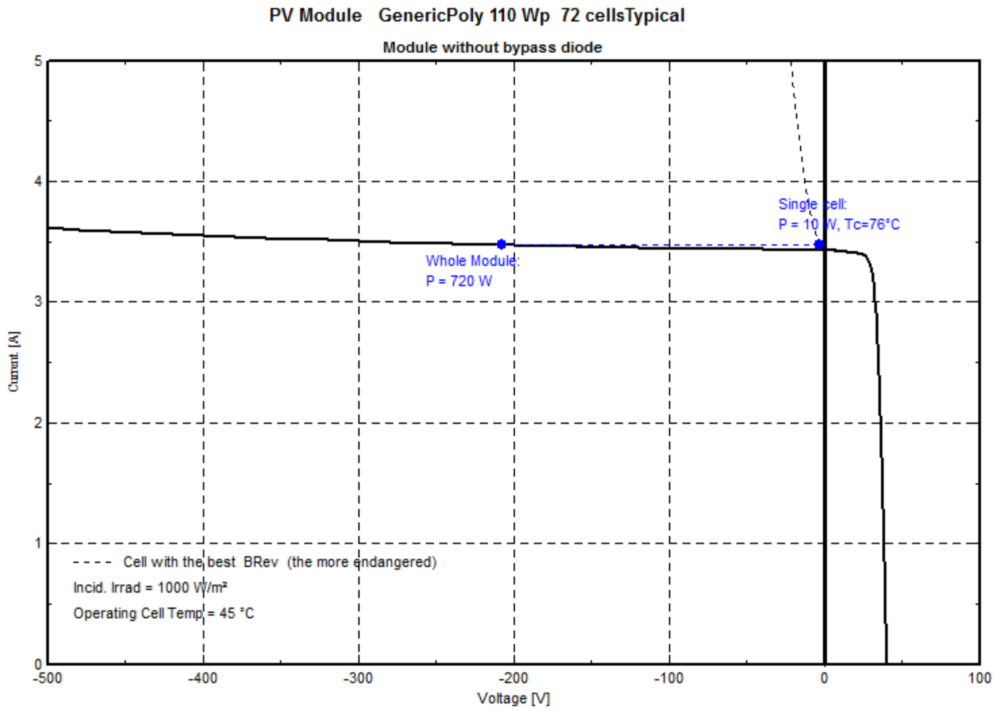

Figure 3 : V/I Curve of module without bypass diode.

PV module with by pass diode Bypass Diodes which in electronics we know as free-wheeling diodes, are wired in parallel with individual solar cells or panels, to provide a current path around them in the event that a cell or panel becomes faulty or open-circuited. This allows a series (called a string) of connected cells or panels to continue supplying power at a reduced voltage rather than no power at all. It is shown in Fig 4.

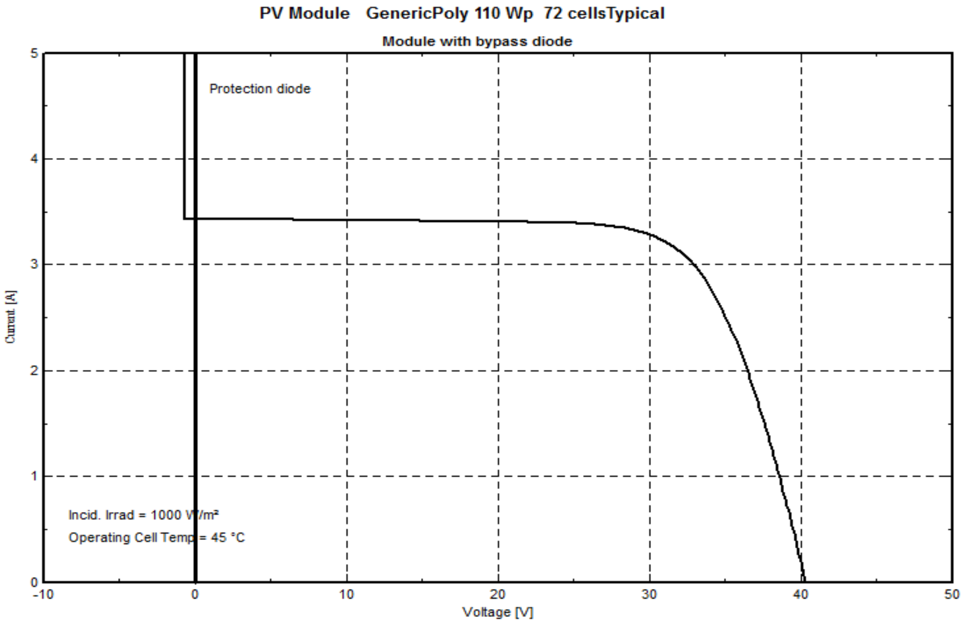

Figure 4 : V/I Curve of module without bypass diode.

Mismatch

Mismatch losses are caused by the interconnection of solar cells or modules which do not have identical properties or which experience different conditions from one another. Mismatch losses are a serious problem in PV modules and arrays under some conditions because the output of the entire PV module under worst case conditions is determined by the solar cell with the lowest output. For example, when one solar cell is shaded while the remainder in the module are not, the power being generated by the "good" solar cells can be dissipated by the lower performance cell rather than powering the load. This in turn can lead to highly localised power dissipation and the resultant local heating may cause irreversible damage to the module.Shading of one region of a module compared to another is a major cause of mismatch in PV modules.Mismatch in PV modules occurs when the electrical parameters of one solar cell are significantly altered from those of the remaining devices as shown in fig 5. The impact and power loss due to mismatch depend on:

1. The operating point of the PV module;
2. The circuit configuration; and
3. The parameter (or parameters) which are different from the remainder of the solar cells.

Differences in any part of the IV curve between one solar cell and another may lead to mismatch losses at some operating point. A non-ideal IV curve and the operating regime of the solar cell is shown below. Although mismatch may occur in any of the cell parameters shown below, large mismatches are most commonly caused by differences in either the short-circuit current or open-circuit voltage.

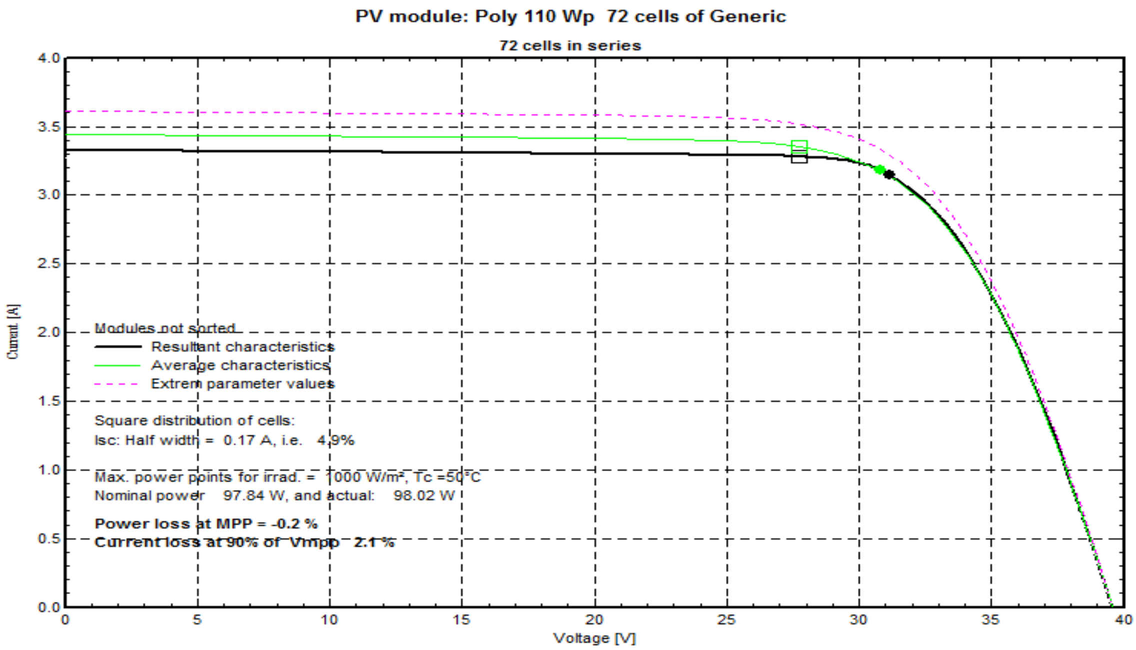

Figure 5: V/I Curve of module with shading effect.

III SMART DIODES

A new generation of active or "smart" diodes is needed to enable further efficiency increases in PV panels. An example of a "smart bypass diode" is the SM74611, which offers a drop-in replacement for surface-mounted Schottky diodes with one order of magnitude improved power dissipation. The SM74611 uses a MOSFET plus control logic to substitute the electrical switching behavior of a standard diode.

For junction boxes using Schottky diodes, the main benefits are:

- Lower power dissipation of 80% or more in forward mode (25 Milli Volt vs. 0.5Volt)
- Less leakage current in reverse mode (<0.001 Milli Ampere vs. 0.5 – 50 Milli Ampere)
- Plug-in replacement for existing Schottky diodes.

IV MAIN APPLICATIONS

Reduced power dissipation gives junction box manufacturers the opportunity to design smaller sized junction boxes that are cheaper and easier to seal against the backside of the panel. Manufacturers with highly automated production lines can replace Schottky diodes and increase the usable current ratings without any changes in the production process with a smart bypass diode, such as the SM74611, in the same package.

Distributed electronic devices in the junction box are experiencing fast growth, adding functionality and new services to the PV system. Typical examples include DC/AC microinverters, DC/DC power optimizer, monitoring and safety shutdown solutions. Due to the high temperatures created by Schottky diodes, integrating the electronics inside a junction box is not practical. Smart bypass diodes with improved thermal conditions allow for advanced compact and integrated electronics solutions to be designed inside the junction box.

VI ENERGY ADVANTAGES

Nevertheless, even the best PV array is exposed to some degree of shading, causing some of the bypass diodes to operate in forwardmode. It is this case where smart bypass diodes achieve some noticeable energy gains due to their 80% power advantage. In residential and commercial systems average shading conditions of up to 10% are quite common and acceptable. Examples include shade caused by neighboring buildings, trees, chimneys, and a variety of other things. A PV array with 10% shading will experience up to 0.5% increased energy yield when active bypass devices are used.

VII CONCLUSIONS

Smart bypass diodes approach "ideal diode" behavior with an order of magnitude performance increase. High-performance panels and integrated electronics will be the first adopters of this new technology, before it will be used in the mass market. The smart bypass diode is the first type of electronic circuitry used in PV panels, opening the path for additional electronic solutions to improve energy yield, new features and services. The energy advantages of the smart bypass diode are noticeable and offer potential for a growing array of opportunities in other markets.

REFERENCES

[1] Influence of the shadows in photovoltaic systems with different configurations of bypass diodes, E. Díaz-Dorado, Department of Electrical Engineering, University of Vigo, ETSEI, Spain, SPEEDAM 2010, International Symposium on Power Electronics
[2] Partially shaded operation of a grid-tied PV system, C. Deline, National Renewable Energy Laboratory, presented at the 34th IEEE Photovoltaic Specialists Conference, Philadelphia, Pennsylvania, June 7–12, 2009
[3] Download a datasheet for the SM74611: www.ti.com/sm74611-ca.
[4] For more information on solar solutions, visit: www.ti.com/solar-ca.