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Power Equalizer Application For Partially Shaded Solar Cell

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ABSTRACT

This project gives a photovoltaic (PV)-module embedded power-electronics topology derived from a battery equalizer. The proposed system eliminates the multiple maximum power point peaks common to partial shading in PV modules. The system does so by equalizing the overall energy of the PV module through the use of only one inductive storage element. A PV module is partially shaded when the light cast upon some of its cells is obstructed by some object, creating a shadow .To protect the shaded cells from being destroyed and to minimize losses in power production, PV modules are equipped with bypass diodes .They prevent the shaded cells from working under reverse voltage by short-circuiting them, thus allowing the other cells to work at their normal current

Keywords: electrical energy, photovoltaic systems, effect of shading, modeling and simulation, module layout, power equalization.

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I. INTRODUCTION

The world pays growing attention to the renewable, clean, and practically inexhaustible energy sources . Photovoltaic (PV) installations are a familiar reference in this landscape, ranging from small (less than 5 kW) residential plants to larger (thousands of kilowatts) grid-connected PV fields. They can also compose hybrid power systems, along with other renewable energy sources. PV systems are roughly composed of two parts: the PV modules and their power electronics (PE) applications. While dispersed between these two parts, all PV research themes seek to improve productivity, power, efficiency ,safety ,and reliability. One of the biggest reliability issues of PV systems is the difference between its expected and actual power outputs. This problem can be called PV mismatch, even though there is no consensus in the literature. It can have many sources, and the one addressed in this paper is the partial shading of PV modules. This system proposes a topology based on a battery equalizer as a PV- module embedded application for partial shading. An in-depth theoretical analysis of this topology is made in order to show its adaptability to the PV and its potential against partial shading. It is then designed, tested, and validated in a real PV module under partial shading. Finally, it is compared with other PV-module-embedded application. This system organized as follow.

II. PV MODULE

A PV module can be considered a voltage-controlled current source connected in parallel with a diode .The output current depends on the available sunlight and the temperature of the module. Its output characteristics may be described by a graph called current–voltage (I–V) curve. The unit used to measure the available power which can be drawn from the sun is called irradiance. To maximize the power output of the PV plant, either its current or its voltage is controlled to stay as long and as close as possible to the maximum power point (MPP) . The algorithm that guarantees this optimum output is called maximum power point tracker (MPPT).It is associated with the PE dc/dc converter connected to the plant.

III. PV MISMATCH

An Overview PV mismatch is the difference between the expected and actual power outputs of a PV module orplant. It can be classified according to its sources as internal or external. Internal mismatch is caused by imperfections within PV modules or cells, such as aging, poor solder bonds, impurities in the silicon crystal, or variability in production. External mismatch has its sources outside of the PV modules, such as interconnections and converter losses or shadows . Many researchers are dedicated to improve the efficiency of inverters or proposing different topologies associated with more efficient MPP tracking algorithms . This focuses its study on external mismatch caused by partial shading and the PV-module-embedded PE topologies dedicated to its mitigation.

IV. PROBLEM OF THE PARTIAL SHADING IN PV MODULES

A PV module is partially shaded when the light cast upon some of its cells is obstructed by some object, creating a shadow. In this paper, a shadow is considered to have a shape and opacity. The opacity of the shadow is called shading factor (SF), varying from zero to one. An SF of zero means that all the available irradiance shines on the PV module. On the contrary, an SF of one means that all available irradiance is filtered by the shadow before reaching the PV module. The shape of the shadow is determined by its length and width. The number of shaded cells or cell groups connected in parallel determines the width of the shadow. Its length represents the number of shaded cells or cell groups connected in series. The cells composing the PV modules studied in this work are all considered to be connected in series. Thus, their shadows have no width. The shaded PV cells will produce less current than the others, which will lead to one of the two scenarios.

1) The other cells impose their current over the shaded cells, making them work under negative voltage, dissipating power and risking destruction.

2) The MPPT will track the current of the shaded cells, imposing it over the others and making them produce less energy. To protect the shaded cells from being destroyed and to minimize losses in power production, Pv modules are equipped with bypass diodes. They prevent the shaded cells from working under reverse voltage by short-circuiting them, thus allowing the other cells to work at their normal current. However, bypass diodes deform the I–V curves while activated, interfering with the MPPT. This makes the tracking of the MPP impossible for simple algorithms. Some authors have proposed many tracking algorithms in an effort to compensate this phenomenon. Other authors have proposed PE topologies directly embedded to the PV module.

V. PROPOSED SYSTEM HARDWARE

Elements of Block Diagram:

- Solar Cell
- Voltage Booster
- Microcontroller
- LCD Display

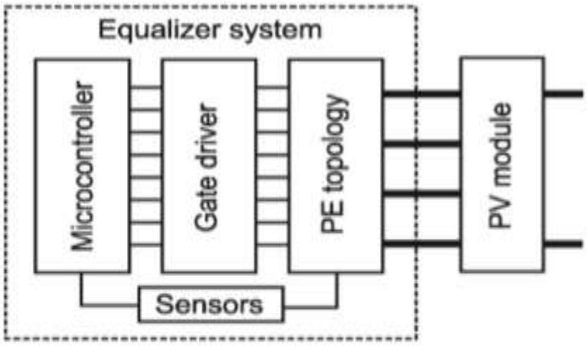

Fig -1: Block Diagram of Project

The Block Diagram gives an overview of the proposed system and its associated PV module. It is called equalizer system, being composed of four parts:

1) The microcontroller that stores the control algorithm of the system

2) The gate driver, which translates the commands from the microcontroller into higher currents that can activate the transistors

3) The PE topology presented hereinafter

4) The sensors, which capture the information needed by the control algorithm.

Proposed PE Topology

The topology proposed in this paper is shown in Fig. Even though it is similar to the battery equalizer in , their functionalities , sizing, and limits are different. The step-up dc/dc converter and its MPPT control technique are modeled in this part by a current source. The topology and its implementation challenges are analyzed. The proposed equalizer has eight transistors (K2–K9), ten diodes (D1–D10), four capacitors (CI–CIV), and an inductor (L). The PV module is represented by four cell groups (PVI–PVIV). The transistors are voltage bidirectional but current unidirectional due to the diodes, which impose one single current flow. Its single inductor can be charged by the available voltage of any unshaded cell group(s). The stored energy is then used to support the shaded cell group(s) by connecting the inductor in parallel to them, thus creating a alternative path to the excess MPPT current. In normal operating conditions, the switching pattern imposes rapid variations in voltage and current to the cells. To filter these, each cell group has a capacitor connected to it.

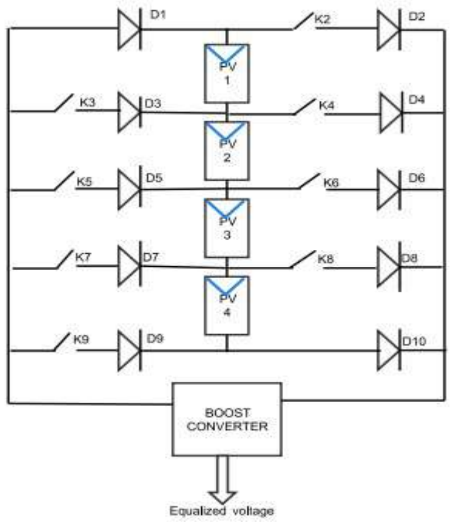

Fig -2: Block Diagram of PE Topology

VI. RESULTS

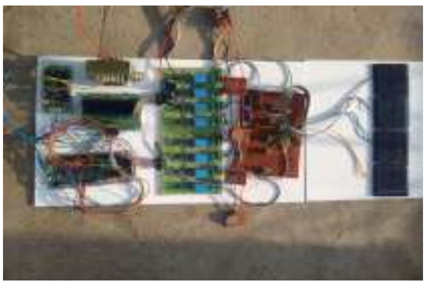

Fig -2: Circuit of solar cell power equalizer

Fig – 3: Multimeter showing Output of the circuit

VII. CONCLUSIONS

An embedded PE structure designed for compensating the effect of partial shading in PV modules has been studied in this paper. Its topology is based on a battery equalizer, giving it its name: PV equalizer.

VIII. ACKNOWLEDGEMENT

It gives us a great pleasure in presenting “Power Equalizer Application For Partially Shaded Solar Cell” as our B.E project.

Even the best efforts are waste, without the proper guidance and advice of our project guide Prof. Pooja Shinde for the consistent guidance, co=operation, inspiration, practical approach and constructive criticism, which provided us the need impetus to work hard.

It is with great pleasure and efforts that we are able to complete this project. We have tried our best to complete it in all respects.

