A HYBRID DPP ARCHITECTURE BASED DMPPT SCHEME TO EXTRACT MAXIMUM POWER DURING PARTIAL SHADING CONDITION

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Abstract *— An importance of the energy is imperative in a society where the human lives in causing an exponentially increasing energy demand by degrees, while the fossil fuels are at verge of extermination. This indiscriminate tapping of fossil fuels resulting in many undesired consequences which predominantly incorporate ominous situations for the environment. To avoid these problems, resulting from the exploitation of fuels; utilization of renewable energies could be the best possible solution. Amongst numerous energy resources, solar energy is one of the best resources because of its availability at almost everywhere in the earth and direct conversion of solar energy into electrical energy. Since, it is envisaged to play an indispensable role in future electricity mix of the world, so emphasize is given to the research and utilization of the solar energy around the world. The solar cells are expensive, and the efficiency is low, so it becomes necessary to harvest the maximum available power so in this work, a fuzzy-logic technique is employed to track the maximum power point under static as well as dynamic conditions. Also, to validate the result a comparison has been made to conventional MPPT techniques which reflect the superiority of proposed methodology over the conventional methods. For the power conversion stage, boost converter is employed.*

Keywords **- Photovoltaic cells, MPPT, Solar cell, DMPPT, semiconductor.**

I. INTRODUCTION

In current scenario, Energy consumption per capita is increasing day by day in developing countries which is a kind of indicator of living standard and growing economy.

Unanticipated use of energy in renewable share has changed scenario for the energy sector Solar cell converts the sun light into electrical energy. This phenomenon was discovered by Alexandre Edmond Becquerel in 1839. The history of solar photovoltaic cell begins in 1876, William Grylls Adams and his student Richard Day discovered that when sunlight falls on selenium, it generates the electricity. Selenium's cell was not very efficient still it was proved that light can be converted into electricity without heat or moving parts. Later in 1941, Russell Ohl invented the solar cell. To improve the telecommunication capabilities Australia used solar cells in microwave tower. In recent scenario, Solar Energy is playing an important role to get clean and green energy that's why different types of solar cells technologies have been developed [13].

As we probably are aware, the productivity of a PV cell is little. So to make it effective, a few techniques are to be embraced. These strategies fundamentally adjust the heap and source impedance. One such Mechanism is the Maximum Power Point Tracking (MPPT). It is a method utilizing which we can get the most extreme conceivable power point from the changing nonlinear source.

The DMPPT schemes uses the additional DC-DC converters along with main DC-DC or DC-AC converter. These additional converters are connected to the individual PV panel that's why each PV panel is capable to work on their maximum power point.

II. WORKING OF SOLAR CELL

Photovoltaic cells are built with the aid of exceptional on hand semiconductors via using specific manufacturing process. When the mild falls on the cell it outcomes cost carriers that generate an electric source, charges are originated when the power reachable in the incident photon has capability to damage the covalent electrons of the fabric used and this process of era of cost with the aid of breaking covalent bonds will be affected by using the used semiconductor fabric and also the traits of the incident light. Generally, the PV procedure can be illustrated as the consumption of photo voltaic irradiation, the manufacturing and movement of charge carriers at the p-n terminal and the storage of the electric energy at the output of the PV system.

The technique of starting place of electric powered power is dependent on the flux of current light source and the capacity of consumption of the semiconductor material, the potential of absorption relies upon in the main on the semiconductor characteristics like band gap, on the reflectance of the cells surface (that depends on the shape and manner of the surface), intrinsic concentration of carriers of the semiconductor, on the electronic mobility, recombination rate, on the temperature [14].

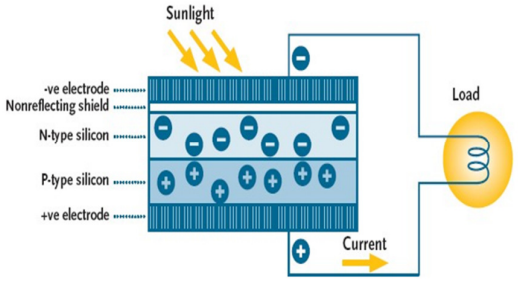


Figure 1.1. Working of Solar Cell

Solar cells are characterized and compare with each other with four parameters; Voc, Isc, FF and η Figure 3.5. shows all parameters with their curve.

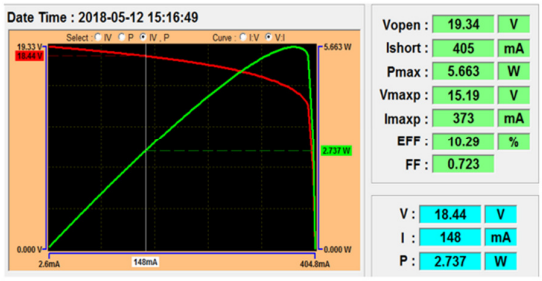


Figure 1.2. Practical P-V and I-V of Solar Cell

III. Maximum Power Point Tracking (MPPT)

As we probably are aware, the productivity of a PV cell is little. So to make it effective, a few techniques are to be embraced. These strategies fundamentally adjust the heap and source impedance. One such Mechanism is the Maximum Power Point Tracking (MPPT). It is a method utilizing which we can get the most extreme conceivable power point from the changing nonlinear source. In PV framework the present versus voltage attributes is non-direct one. Thus it is exceptionally hard to be utilized with the heap for different applications. So by utilizing MPPT strategies we can transform it to a straight one, use them easily for further task. A boost converter is likewise associated pursued by the MPPT, whose obligation cycle is fluctuated utilizing MPPT control circuit. A boost converter is utilized on the heaping side and a PV panel is utilized as a contribution to the converter.

The electrical vitality from the photovoltaic cell is at present viewed as the best option of the customary sources as the photovoltaic cell is a characteristic vitality source that is progressively good since it is free, copious and clean. Notwithstanding every one of the benefits of photovoltaic for the age of electrical vitality, the proficiency of vitality transformation is low and the underlying expense for its usage is high, in this manner it is basic to utilize strategies to extricate the maximal power structure these boards for viable activity and to accomplish maximal effectiveness in a task. A traditional PV panel fundamentally changes over just 30 to 40 % of the incident sun-powered radiation into electrical vitality, in this way the execution and the expense and execution of photovoltaic framework can be improved by utilizing maximum power point tracking.

Photovoltaic (PV) panels have non-direct qualities of output voltage and output current which is dictated by sun based light conditions, surrounding temperature and electrical burden attributes in this manner the innovations of changing the area of the maximal power point must be created in the use of MPPT control so as to make the PV board get the ideal productivity from the sun oriented vitality at the diverse working conditions as these conditions for the activity of the PV panel will change ceaselessly and hence the maximum power point will likewise change.

IV. MPPT Algorithm

A PV grid associated framework comprises of sun based cells, a DC-DC boost converter, and a DC-AC inverter. The MPPT calculation controls the obligation cycle of the boost converter. Accessible power from daylight changes because of progress in natural condition. The proficiency of PV cells can be expanding by utilizing different MPPT calculation that tracks the most extreme power point task. The two most well-known procedures are Perturb and Observe (P&O) and Incremental Conductance (IC). Fuzzy logic (FL) and Neuro-fuzzy (NF) systems speak to two classes of canny control frameworks [34] [35].

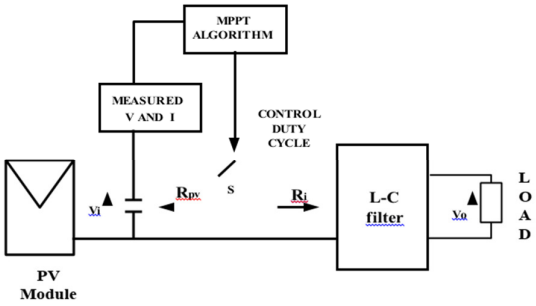


Figure 1.3. Block Diagram of the MPPT algorithm along with the circuit

V. PROBLEM ASSOCIATED WITH CONVENTIONAL MPPT TECHNIQUES

Oscillations; There is oscillation in duty cycle during change of irradiance (decrease or increase). Trap Between Local maxima and Global Maxima;

Whenever two or more than two maxima points present, conventional MPPT cannot differentiate the local maxima and global maxima. It gets trap between global maxima and local maxima point. Poor performance at low Irradiance; During low irradiance performance of conventional MPPT algorithm gets poor

VI. DMPPT AND DIFFERENT DMPPT ARCHITECTURE

The DMPPT schemes uses the additional DC-DC converters along with main DC-DC or DC-AC converter. These additional converters are connected to the individual PV panel that's why each PV panel is capable to work on their maximum power point.
The main advantages of DMPPT schemes are:

- Each panel give optimum power
- Less power consumption by converter because they work during occurrence mismatch condition
- Very low burden on processor
- Installation is very simple and effective

MPP can be broadly classified as:

- Voltage equalisation based approximate MPP
- Model based
- True/Exact

VII. MODEL BASED MPP

Every solar PV cell or panel is tested for standard conditions. They give maximum power at standard condition. Output of every solar PV panel depends on the insolation level and temperature. Light generated current is directly proportional to the insolation level and has positive coefficient; on the other hand, voltage decrease with respect to increase in temperature and has negative coefficient. So such scheme uses the standard condition as a reference point of voltage and these schemes are not required to power information of each panel. With the passage of time performance of these schemes get intermittent.

VIII. BI-DIRECTIONAL FLYBACK BASED ISOLATED PORT SUBMODULE DPP OPTIMIZER SCHEME

The main motto of this scheme is to maintain the equal level of primary's and secondary's voltage of the distributed power processing converters. To achieve mentioned motto, BFCs have been used with a fixed duty cycle of 50%. Block diagram is given in figure 5.7. If turns ratio is 1:1; input voltage is Vpri; output voltage is Vsec; and duty cycle is D, According to proposed scheme, secondary side of the converter will connect in parallel. So, secondary side voltage of all BFC will be same.

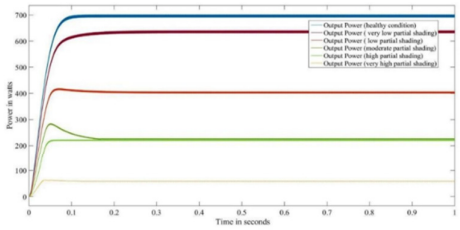
DMPPT Architecture	
Full Power Processing	**Differential Power Processing**
Series connection • Buck-converter • Boost-converter • Buck-Boost Converter	***Current Source Based structure*** • Single ended structure • Bypass Structure
Parallel connection • Micro Inverter • High Voltage Gain Converter	***Voltage Source structure*** • with fronted converter structure • without fronted converter structure • Virtual series connected structure
Hybrid connection • Series parallel connection • Total cross tied connection • Bridge link connection	***Others*** • Hybrid • Nested

TABLE 1.1. DIFFERENT DMPPT ARCHITECTURE

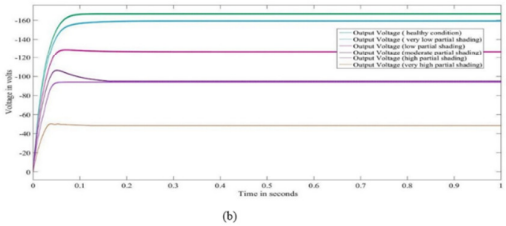
IX. PROPOSED SCHEME (DMPPT) & RESULT

Results of proposed scheme are better than the conventional maximum power point tracking and shown in figure 1.4. In this scheme every group is working on own MPP point.

- At very low partial shading; generated power is more than the other schemes.
- Low partial shading; generated power is less than the other schemes.
- Medium partial shading; generated power is more than the other schemes.
- High partial shading; generated power is more than the other schemes.
- Very high partial shading; generated power is more than other scheme.



(a)



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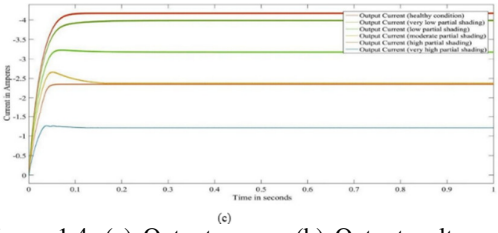

(c)

Figure 1.4. (a) Output power (b) Output voltage and (c) Output current; of proposed scheme

X. CONCLUSIONS

At no partial shading condition performance of all type schemes is almost same. Whenever partial shading increases, the performance of conventional MPPT scheme gets poor. At very low irradiance and very high partial shading conventional scheme losses their control. Conventional MPPT schemes need a very good processor because all power is handled by only one converter and it has high work load. There are very high switching losses in practical conditions. Whenever any connection breaks, entire power will be lost. All mentioned problem is solved by using distributed maximum power point tracking. At very low irradiance and very high partial shading DMPPT does not lose their control. They need a medium type of processor because all power is not handled by one converter. There are very low switching losses because converters work during the partial shading condition or mismatching conditions; all other time converter will be off state. Whenever any connection breaks, entire power does not loss. Previous DMPPT schemes have high number of sensors; this proposed scheme reduces the number of sensors by making the group of panel. This scheme can be costly for low power installation but as the power demand increases cost of the proposed scheme will be reduce.

REFERENCES

[1] Abhishek Kumar, Suresh Kumar Gawre, Malay Sarkar and Suresh Gosula, “A Real-Time Comparative Data Analysis of Different Types of Solar Panels during Partial Shading with Distinct Tilt Angle”, 15th IEEE International Conference INDICON,2018. (In Press)

[2] A.R. Hasimah, M. N. Khalid, and Y. H. Mohammad, "Assessment of PV cell performance under actual Malaysia operating condition," in Proc. Australasian Universities Power Engineering Conference, 2009, pp. 1-5.

[3] Sobhnath Singh, Non-Conventional Energy Resources, First edition Delhi; Pearson publication India, 2017.

[4] World Energy Council, “World Energy Resources 2016”,2016. [Online] Available; http://www.worldenergy.org > 2016/10. [Accessed; March 2019]

[5] Indian Environment Portal, “Energy Statistics 2018”,2018. [Online] Available; http://www.indianenvironmentportal.org.in/content/453406/energy-statistics-2018/. [Accessed; March 2019]

[6] Santiago Silvestre, Aissa Chouder, and Engin Karatepe , " Automatic fault detection in grid connected PV system", Solar energy 94(2013), pp. 119-127, 2013.

[7] J.D.B. Rodriguez, E. Franco, G. Petrone, C.A.R. Paja and G. Spagnuolo, “Maximum power point tracking architecture for photovoltaic system in mismatching condition: Review”, IET Power Electron, 2014, Vol 7, issue 6, pp 1396-1413.

[8] Bendib, B & Belmili, Hocine & Krim, Fateh. (2015). “A survey of the most used MPPT methods: Conventional and advanced algorithms applied for photovoltaic systems”, Renewable Sustainable Energy Rev. 45. 637-648. 10.1016/j.rser.2015.02.009.

[9] Guanying Chua, Huiqing Wena, Lin Jiangb, Yihua Hub and Xingshuo Lia: “Bidirectional flyback based isolated-port submodule differential power processing optimizer for photovoltaic applications” Solar Energy, 2017, pp. 929–940.

[10] Dipankar Debnath, Pronoy De and Kishore Chatterjee: “Simple scheme to extract maximum power from series connected photovoltaic modules experiencing mismatched operating conditions” IET Power Electron., 2016, Vol. 9, Iss. 3, pp. 408-416.

[11] Delavaripour, Hossein & Mirzaeian Dehkordi, Behzad & Zarchi, Hossein & Adib, Ehsan. (2018). “Increasing Energy Capture from Partially Shaded PV String Using Differential Power Processing”, IEEE Transactions on Industrial Electronics. PP. 1-1. 10.1109/TIE.2018.2883271.

[12] J. Biswas, A. M. Kamath, A. K. Gopi and M. Barai, "Design, Architecture, and Real-Time Distributed Coordination DMPPT Algorithm

for PV Systems," in IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 6, no. 3, pp. 1418-1433, Sept. 2018.

[13] Victoria C. "The History of Solar Power", https://www.experience.com/advice/careers/ideas/the-history-of-solar-power/.

[14] S. Poshtkouhi, V. Palaniappan, M. Fard, and O. Trescases, "A general approach for quantifying the benefit of distributed power electronics for fine grained MPPT in photovoltaic applications using 3-D modeling," IEEE Trans. Power Electron., vol. 27, no. 11, pp. 4656–4666, Nov. 2012.

[15] M. Bagher, M. M. A. Vahid, and M. Mohsen, "Types of Solar Cells and Application," American Journal of Optics and Photonics, vol. 3, no. 5, pp. 94-113, 2015.

[16] S. Solanki, and H. K. Singh, Anti-reflection and Light Trapping in c-Si Solar Cells. Singapore: Springer, 2017, pp. 17-42.

[17] Greentumble, "Most Efficient Solar Panels on the Market 2018," Dec. 2017. [Online]. Available: https://greentumble.com/most-efficient-solar-panels-on-the-market. [Accessed: Aug. 2018].

[18] D. Flood, "Solar energy white paper-where we are now and what's ahead," 2012. [Online]. Available: http://www.natcoresolar.com/core/wp-content/uploads/2014/04/Solar-Energy-White-Paper.pdf. [Acc- essed: Aug. 2018].

[19] SANYO Semiconductors, "Amorphous Silicon Solar cells/Amorphous Photosensors," media.digikey.com, 2007-2011. [Online]. Available: https://media.digikey.com/pdf/DataSheets/SanyoEnergy/Amorphous_Br.pdf. [Accessed: Aug. 2018].

[20] H. Trabish, "The Lowdown on the Safety of First Solar's CdTe Thin Film," greentechmedia.com,Mar. 2012. [Online]. Available: https://www.greentechmedia.com/articles/read/how-safe-is-first-solar- s-cdte-thin-film. [Accessed: Aug. 2018].

[21] R. Mullins, "Cadmium: The Dark Side of Thin-Film?" gigaom.com, Sept. 2008. [Online]. Available: https://gigaom.com/2008/09/25/cadmium-the-dark-side-of-thin-film. [Accessed: Aug. 2018].

[22] Wikipedia, "Copper Indium Gallium Selenide Solar Cells," Aug. 2018. [Online]. Available: https://en.wikipedia.org/wiki/Copper_indium_g - allium_selenide_solar_cells. [Accessed: Aug. 2018].

[23] Global Solar Inc., "Technology," globalsolar.com. [Online]. Available: http://www.globalsolar.com/technology. [Accessed: Aug. 2018].

[24] Di Wei, "Review: Dye-Sensitized Solar Cells," International Journal Mol. Science, vol. 11, no. 3, pp. 1103-1113, 2010.

[25] TCI EUROPE N.V., "Organic solar cells (opv) materials," tcichemicals.com. [Online]. Available: https://www.tcichemicals.com/eshop/en/be/category_index/12802. [Accessed: Aug. 2018].

[26] H. Tributsch, "Dye sensitization solar cells: a critical assessment of the learning curve,"

[27] Coordination Chemistry Reviews, vol. 248, no. 13–14, pp. 1511-1530, 2004.

[28] F. C. Krebs, and K. Norrman, "Analysis of the Failure mechanism for a stable organic photovoltaic during 10,000h of testing," Progress in Photovoltaics: Research and Applications, vol. 15, pp. 697-712, 2007.

[29] Y. Shoji, K. Akimoto, and Y. Okada, "Self-organized InGaAs/GaAs quantum dot arrays for use in the high-efficiency intermediate-band solar cell," Journal of Physics D: Applied Physics, vol. 46, no. 2, 2012.

[30] Jannat, M. F. Rahman, and M. S. H. Khan, "A Review study of Organic PV cell," IJSER, vol. 4, no. 1, 2013.

[31] Nicholas Brown, "Solar Junction Breaks Concentrated Solar World with 43.5% efficiency," cleantechnica.com, Apr. 2011. [Online]. Available: https://cleantechnica.com/2011/04/19/solar-junction-break- s-concentrated-solar- world-record-with-43-5-efficiency. [Accessed: Aug. 2018].

[32] M. Kacira, M. Simsek, Y. Babur, and S. Demirkol, "Determining optimum tilt angles and orientations of photovoltaic panels," Renewable energy, vol. 29, no. 8, pp.1265-1275, 2004.

[33] M. Davarifar, A. Rabhi, A. Hajjaji, E. Kamal, and Z. Daneshifar, "Partial Shading Fault Diagnosis in PV System With Discrete Wavelet Transform (DWT)," in Proc. 3rd

International Conference on Renewable Energy Research and Applications, 2014, pp. 810-814.

[34] MECO Instruments, “Solar PV analyser (Photo-voltaic I-V curve tester),” 9009 datasheet, mecoinst.com. [Online]. Available: https://-www.mecoinst.com/uploads/products/manual-online/solar-module-a- alyser-manual.pdf. [Accessed: Aug. 2018].

[35] Chetan Singh Solanki, “Solar Photovoltaics - Fundamentals, Technologies and Applications”, Third edition, India; Prentice Hall India Learning Private Limited, 2015.

[36] M. Abouzeid, V. Sood and M. Youssef, "A comparative study of a PV-MPPT grid-integrated system under different control techniques," 2015 IEEE Electrical Power and Energy Conference (EPEC), London, ON, pp. 256-261, 2015.

[37] Daniel William Hart, Power Electronics, New York: McGraw-Hill, 2011.