IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

MULTIPORT CONVERTER FOR STANDALONE PHOTOVOLTAIC SYSTEM

[1]Lenka Divya, [2]Dr. R. Srinu Naik, [3]Y. Chittemma, [4]S. Naveena

[1]PG Scholar, [2]Associate Professor, [3]Assistant Professor, [4]Research Scholar

Department of Electrical and Electronic Engineering,

Andhra University, Visakhapatnam, India

Abstract: Design of high frequency magnetics is crucial as it demands specific optimum leakage inductance or series inductances for rated operation. . Leakage inductance of Phase shifted dc-dc Dual Active Bridge (DAB) or Triple Active Bridge (TAB) converters transformer or series inductors act as the energy transferring element A significant part of the thesis work presented here focuses on leakage inductance modelling and optimized design of transformers for phase shifted converters. Photovoltaic (PV) as Renewable Energy Source (RES) so, by using MAXIMUM POWER POINT TRACKING(MPPT) control strategy we can extract maximum power from PV ARRAY and voltage regulator is developed to regulate the DC voltage at DC grid.

Index Terms **- TAB, Multiport converter, Photovoltaic, MPPT, Voltage Regulator.**

I. INTRODUCTION

In present years, renewable energy sources and Electric Vehicles have been predominantly used. Renewable energy systems include, but are not limited to Photovoltaic, wind power, biomass, hydro, and geothermal systems. The rooftop PV system is a common and essential energy source for residentials loads. Other than battery EVs and hybrid EVs, many fuel cell EVs. Different types of energy and storage, electrical systems are connected become integrated energy systems (IES). For example, household appliances connect PVs and storage

DC-DC converters are one of the most important technologies for future DC grids. Direct current (DC) grids have more advantages over alternating current (AC) grids, such as potentially higher efficiencies, and no need of extra components like filter parameters. DC grid offers accurate control techniques for power flow with high reliability. Dual Active Bridge (DAB), an isolated bidirectional dc-dc converter, has been used in many applications. It has advantages such as a bidirectional power with high efficiency but PV array as input act as unidirectional and night times interrupted power supply. However, it can only connect two ports thus, many DAB converters need to be used to connect different elements to the DC-bus in the IES. Moreover, it may require a communication bus to control power flow. Therefore, the Triple Active Bridge (TAB) converter was proposed to connect one more element by adding one more port to the DAB converter.

The primary goal of this project is to develop the model of the bidirectional DC-DC converter which is a multiport converter. Here, multiport converter is developed using TAB converter using three limb high frequency transformer. Transformer connected with full bridge which is operated in phase shifted with equal on time and off time of switches. To develop a closed loop control strategy to extract maximum power from photovoltaic system and determine the maximum achievable closed loop performance parameters. To implement the proposed voltage regulator at DC grid to maintain voltage and power consumption.

II. THEORY

Multiport isolated DC-DC converter for stand alone photovoltaic system is designed with three full bridges and three limb high frequency transformer. Here, different sources are integrated with TAB converter ports. Solar panel is connected to port-1, DC grid is connected to port-2 and energy storage system (Battery) connect two port-3. The three-limb high frequency transformer have different transformer ratio.

The block mainly consists of three blocks

- PV with MPPT,
- TRIPLE ACTIVE BRIDGE and
- CONTROL STRATEGY for TAB

PV with MPPT:

Photovoltaic offer consumers the ability to generate electricity in a pure, easy, and reliable way. Photovoltaic systems are comprised of photovoltaic cells, devices that convert light energy directly into electricity. PV cells convert light directly into electricity without any global warming effect. Equivalent Model of PV cell is shown below:

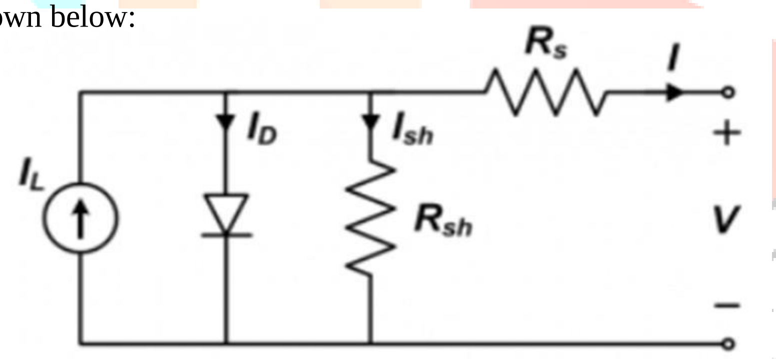

Fig.1 Diode model of PV cell

$$I = I_L - I_D - I_{sh}$$

Where I= Output current of PV cell,

I_L = *Photo generated current,*

I_D = *Diode current,*

I_{sh} = Shunt current

According to the principles encapsulated within the Shockley diode equation, the flow of current that undergoes diversion through the diode can be elegantly conceptualized and expressed in the following manner:

$$I_D = I_o\,(exp(q(v + IRs)\backslash mKT) - 1)$$

MPPT control

Theory of maximum power point tracking (MPPT) is individual feature to the area of Photovoltaic Systems, and hence brings a unique application of power electronics to the area of PV's. The concepts of MPPT are equally valid for cells, modules, and arrays, although MPPT usually is employed at PV module/array level. The solar cell can be characterized by an I-V curve. Interconnecting several solar cells in series or in parallel merely increases the overall voltage and/or current but does not change the shape of the I-V curve. Therefore, for understanding the concept of MPPT, it is sufficient to consider the I-V curve of a solar cell. The I-V curve is dependent on the module temperature on the irradiance. For example, an increasing irradiance leads to an increased current and slightly increased voltage. The operating point (I, V) corresponds to a point on the power-voltage (P-V) curve. To generate the maximum power output at a different irradiance values and temperature values, in hill type P-V curve maximum of the point is the operating point which is called the maximum power point (MPP). This process is called Maximum Power Point Tracking or MPPT. The devices that perform this process are called MPP trackers. We have implemented of MPP tracking using P&O algorithm.

Perturb and observe(P&O) algorithm

In this project the MPPT is developed using perturb and observe algorithm also have another name hill climbing algorithm. In this algorithm, a perturbation is provided to the voltage at that the module is currently driven. This perturbation in voltage will lead to a change in the power output. If an increasing voltage leads to an increasing in power, the operating point is at a lower voltage than the MPP, and hence further voltage perturbation towards higher voltages is required to reach the MPP. In contrast, if an increasing voltage leads to decreasing power, further perturbation towards lower voltages is required to reach the MPP. Hence, the algorithm will converge towards the MPP over several perturbations A problem with this algorithm is that the operating point is never steady at the MPP but meandering around the MPP. If very small perturbation steps are used around the MPP, this meandering, however, can be minimized. Additionally, the P&O algorithm struggles from rapidly changing illuminations. For example, if the illumination (and hence the irradiance) changes in between two sampling instants in the process of convergence, then the algorithm essentially fails in its convergence efforts. This wrong assumption is detrimental to the speed of convergence of the P&O algorithm, which is one of the critical figures of merit for MPPT techniques. Thus, drastic changes in weather conditions severely affect the efficiency of the P&O algorithms. The algorithm flow chart and state flow diagram are given below.

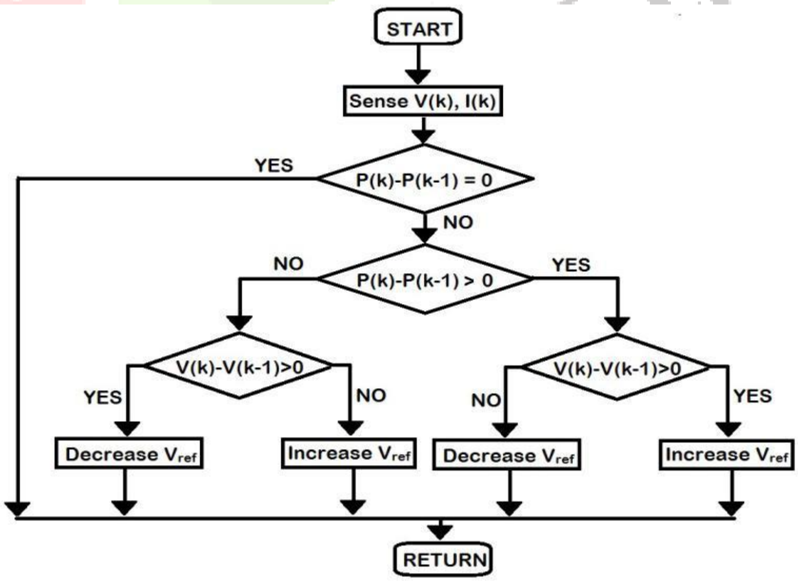

Fig.2 Conceptual flowchart of the P &O algorithm

TRIPLE ACTIVE BRIDGE:

The triple-active-bridge (TAB) converter was proposed to connect one more Full bridge as one more port to the DAB converter by using three limb transformer. The advantages of the DAB converter can be kept in the TAB converter. Moreover, it is not only applicable to one more port but also enables flexible power transmission between three port. This shows that three DAB converters are required to achieve flexible power transmission between three elements, which is achieved by only one TAB converter. Also, the communication between the three elements is not necessary when using the TAB converter. Therefore, the control of the total system is more straightforward. In addition, in comparison to other multiport converters, the TAB converter has the advantage by using a transformer, which not only converts the voltage ratio but also improves the safety of the system. Therefore, the TAB converter is proposed for many applications in IES and DC grid.

CONTROL STRATEGY FOR TAB:

The model is first used to determine the most appropriate controller structure for the TAB converter, and its intrinsic performance limits identified. Based on these limits, techniques for maximising the closed loop regulator performance for transient changes in reference command as well as load changes are presented.

By integrating both MPPT and DC voltage regulator we can operate the TAB converter in most efficient way. Both control strategy generates some delay angle that port pulses to be shifted that delay angle is given to PWM generator. PWM generator output pulses with duty cycle as 50% and phase shifted are given to port-1 & port-2. the control strategy block diagram is given below.

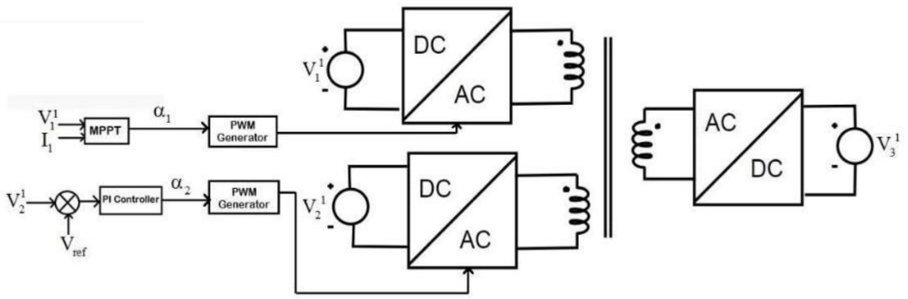

Fig. 3 Control strategy block diagram for TAB converter

V1 ’, I1 are Voltage and current of solar panel connected to port 1of TAB Converter.

V2‘ is port 2 (DC grid) output voltage of TAB Converter.

III. SIMULATION

The Circuit is integrated into one circuit and simulated in MATLAB with certain parameter values. The main objective is to focus power flow between ports, extraction maximum power from photovoltaic and regulate the output voltage at DC grid.

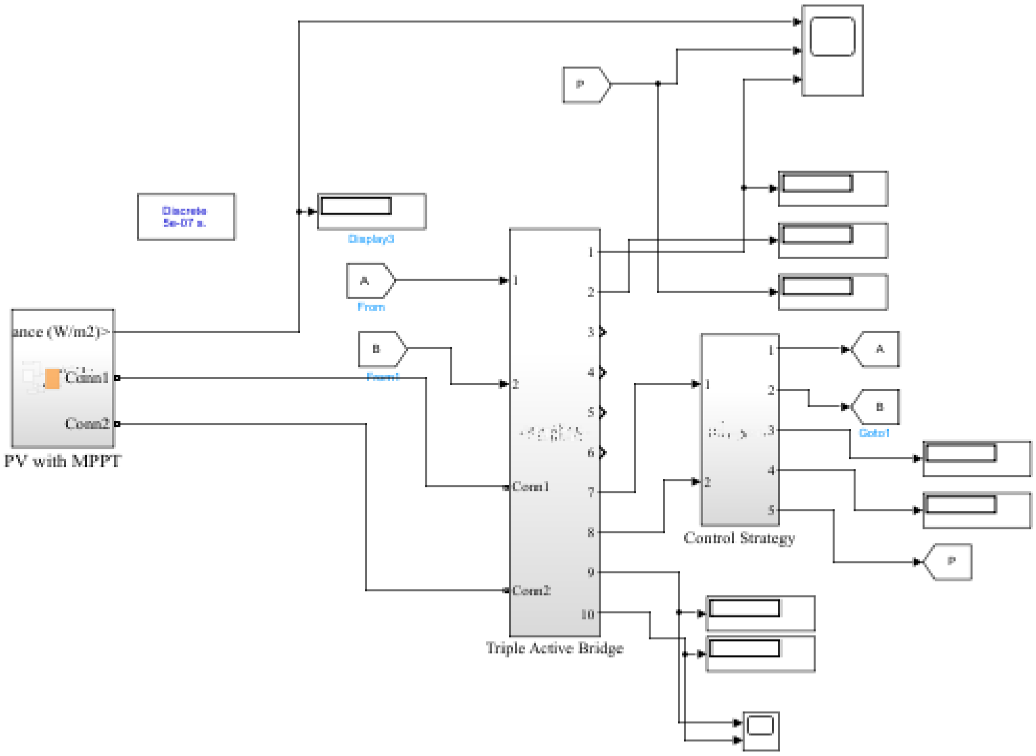

Fig.4 Simulink model of Multiport isolated standalone photovoltaic system

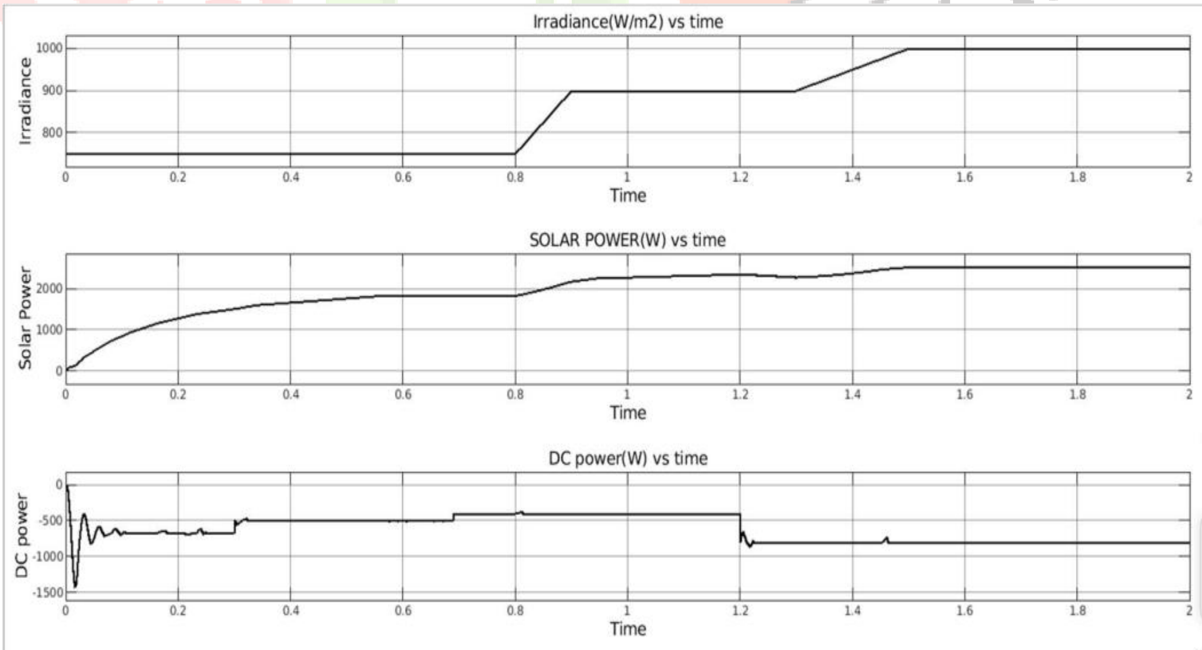

Fig.5 Simulation result of PV power and voltages

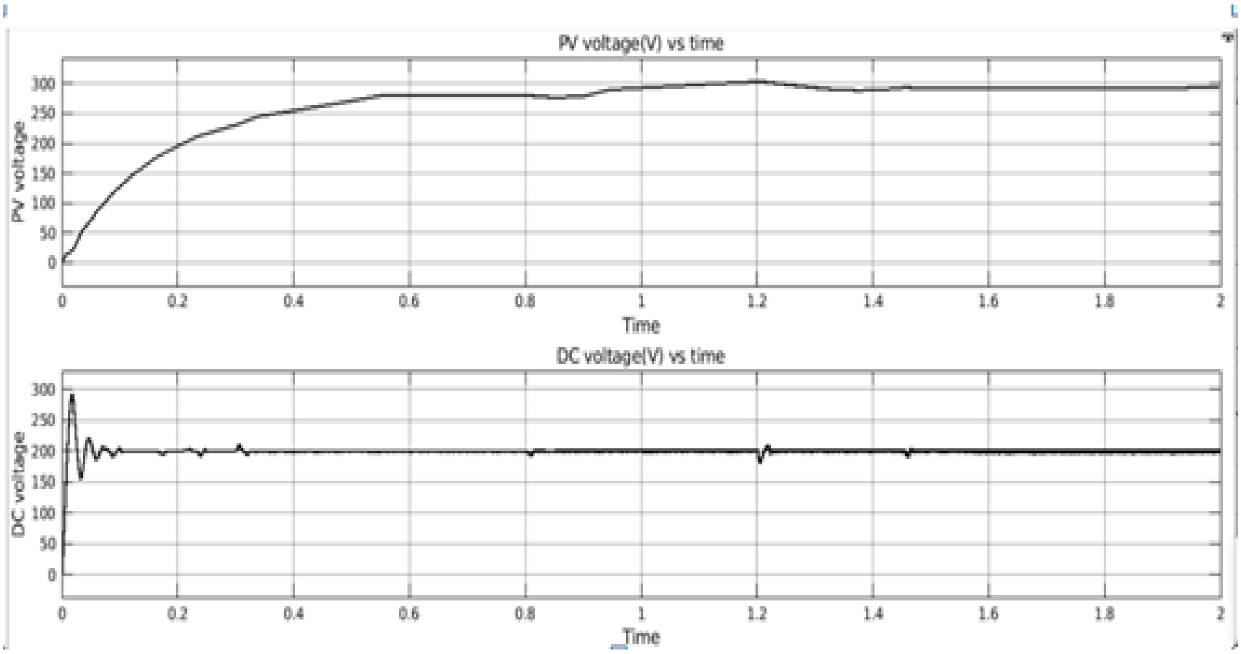

Fig.6 Voltage across DC grid and PV pane

Here PV panel is connected to variable irradiance and constant temperature. In simulation Temperature is kept at 25 degree and irradiance at initial irradiance is kept at 700 up to 0.8 sec later is gradually increased to 900 at 0.9 sec later it up to 1.3 sec from that point up to 1.4 sec irradiance gradually increase from 900 to 1000 later it kept to constant up to 2 sec.

From the results, the DC grid voltage is settling time at starting is 0.1 sec. then when there is change in load or change in irradiance there is disturbance in dc grid voltage that tasking to settle is 20msec. In simulation irradiance is variable with time and DC grid is designed with variable resistance with respect time. In the simulation result the solar power is at initially it is taking 0.5 sec to settle and later it is varying according to irradiance.

IV. Summary and Conclusions

The TAB converter is considered a promising circuit for next-generation DC grid and integrated energy systems, which have vast market prospects. The advantages of the TAB converter include multiple interfacing ports with isolation, achievable implementation of centralized controls, and improved flexibility of electric systems. By using full bridge, we design the circuit for high power application. So far, we discussed the power flow between ports and equivalent circuit model. The power flow between port is depends on leakage inductance and transformer ratio and phase shifted angle of pulses. By using closed loop control strategy from PV maximum power is extracted at different irradiance and temperature and by using voltage regulation voltage is maintained and power flow is depending on load or indirectly current flowing through the ports. Derived power flow equations not taking count of power losses of semiconductor switches and high frequency transformer. MPPT algorithm is developed using perturb and observe method we can go to further algorithms and voltage regulation is not a dynamic model. Due to increase of renewable energy sources TAB or further multiport converters useful for uninterrupted power supply by using energy storage devices.

References

[1] J. Lowitzsch, "Investing in a Renewable Future-Renewable Energy Communities Consumer (Co-) Ownership and Energy Sharing in the Clean Energy Package", EEJ, vol. 9, pp. 45, 2020.

[2] R Powe. Chattopadhyay, G. Gohil, S. Bhattacharya, "Split-winding type three limb core structured HF transformer for integrating PV and energy storage (ES),' in proc. IEEE Applied t Electronics Conference and Exposition (APEC), 2017, pp, 299-3004

[3] S.Zou, J. Lu and A. Khaligh, "Modelling and control of a triple-active-bridge converter," in IET Power Electronics.

[4] Dual Active Bridge Converter with PWM Control in Solid State Transformer Application by Chenhao Nan approved by Raja ayyanar

[5] Solar Photovoltaics: Fundamentals, Technologies, and Applications" by Chetan Singh Solanki.

[6] "Grid Integration of Solar Photovoltaic Generation" by Bijay Baran Saha and Rajat Majumder: This book discusses various DC-DC converter topologies and their applications in PV integration.

[7] Textbooks on power electronics or advanced power converter topologies may have sections or chapters dedicated to the Triple Active Bridge converter. Check books by authors specializing in power electronics, such as Ned Mohan, Muhammad H. Rashid, or Juan M. Ruiz

[8] Y. C. Liu and Y. M. Chen, "A systematic approach to synthesizing multi-input dc-dc converters," IEEE Transactions on Power Electronics, vol. 24, no. 1, pp. 116–127, Jan. 2009, ISSN: 0885-8993. DOI: 10.1109/TPEL.2008.2009170