International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-8 Issue-11, September 2019

Different Converter Topologies for Solar Photovoltaic System with methods for Maximum Power Point Tracking Algorithms

Prasannati Kulkarni, S.P. Deshmukh

Abstract*: Renewable energy sources are becoming important for the production of electricity used in residential, commercial and industrial applications. These resources include non-conventional sources like solar, wind, hydro, biogas, tidal and biomass. All these are contributing in the production of electrical energy and also help in reducing the pollution by reducing the green gas emissions which were one of the reasons to reduce the use of conventional sources. Out of all of the above, the source which is gaining an importance and maximum usage is a solar energy. The reason behind its extensive use is it is freely available, abundant, non-pollutingin nature and its conversion without involving any rotating device. Combining the two systems increases the performance and efficiency of a particular system. Hence to improve its performance and use by two-fold, a solar system can be integrated with thermal, hydro or wind power system. Also, a suitable converter topology will be used along with an appropriate control algorithm. Solar energy changes as per irradiance and temperature in a day also one factor which reduces the power output is the partial shedding in cells. This will alleviate the conversion efficiency of solar system (About 20%). Many conventional and advanced algorithms are used for getting the optimum output from a solar system. Now days to get optimum energy from a solar system, soft computing algorithms are used in a system which are called as operating point tracking algorithms. This paper intended to emphasize on converter topologies and a brief introduction of MPPT algorithms.

Keywords: Distributed generation, Converter topology, MPPT algorithms, Perturb and Observe, Global maxima

I. INTRODUCTION

An energy source which will be inexpensive and has a ability to sustain is today's need due to the rapid changes in environmental conditions and global warming. Also, the fast increase in demand of the electricity should be accomplished with the continuity and less interruption [10]. By taking into account the noise, pollution, environmentally friendly factor and availability, solar photovoltaic system plays a vital and prominent role among other notable renewable energy sources. Its few remarkable advantages are, it has flexible characteristics, lower maintenance cost, longevity as well as abundancy [9]. PV systems are classified into 2 categories, stand alone and grid connected. Places where electrical installation is not feasible due to the locations which are away from utility grid, a stand-alone PV system is used.

Manuscript published on 30 September 2019.
***Correspondence Author(s)**
Prof. Prasannati Kulkarni, Asst. Prof. KC College of Engineering and Management studies and Research, Thane (w)
S.P. Deshmukh, Associate Dean Academic Program ICT Matunga, Mumbai

While the PV systems, which are connected to utility grids are in turn useful to the grids as they supply the grids at the time of black outs. Working of a stand-alone PV system totally rely on operating conditions and the maximum power extracted depends mainly on solar radiation levels, temperature as well as on load profile (type of loads connected). Generation of maximum power by a solar module will be located at a point on the current-Voltage and Power-Voltage characteristics which are called operating point. For the uniform solar radiations (G), only one operating power point will be seen on characteristics that is called as global operating power point. But for the situation of partial shedding of modules due to clouds, tree branches, snow or ice accumulation, dust or other neighbouring structures, a PV panel gives more than 1 MPP's and that are called as local or pseudo power points (LMPP). These pseudo operating points degrades the performance of a PV systems and the efficiency gets alleviated. To keep the track on maximum power point in a specified range, control algorithm is used in a PV system which will be working through an appropriate power interfacing device called converter. Different converter topologies are used to get operated the peak power point always at its maximum. Foremost work of the power converter will be to optimize match between module input impedance (Zin) and load output impedance (Zout) [12]. Whenever a perfect matching is there then only maximum power will be transferred to load from a PV panel. Without MPPT controller, module gives less efficiency. Hence an appropriate optimization algorithm is used which will tend to operate PV panel at its maximum operating point.

II. PV CELL EQUIVALENT CIRCUIT AND MATHEMATICAL MODELLING

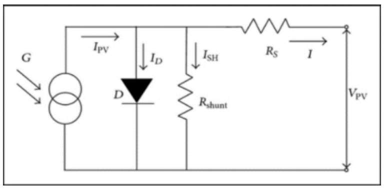

Fig. 1 PV cell Equivalent circuit [1]

Diode current is given by,

$$\boldsymbol{Id = I[exp(q(V + Irs)/KT)) - 1]} \text{---------------------(1)}$$

Output current of a solar cell I,

$$\boldsymbol{I = IL - Id - Ish} \text{ ---------- (2)}$$

Putting the value of I_d and Ish, I will be

Retrieval Number: J12020881019/19©BEIESP
DOI: 10.35940/ijitee.J1202.0981119
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

$$I = I_{ph} - I_{sat}\left[\exp\left(\frac{q(V+IR_s)}{AkT}\right)-1\right] - \frac{V+IR_s}{R_p}$$

Where,

I- load side current (A)

I_{ph}-photon current

I_{sat}- saturation current of a diode (A)

q- charge of an electron-1.6*10^{-19} C

A- Diode ideality factor

k- Boltzmann's constant -1.38*10^{-23} J/K

T- Temperature of a cell (^{0}K)

Rs- Resistance in series (Ω)

R_p- Resistance in parallel (Ω)

V- Output voltageof a solar Cell

III. SOLAR CELL / MODULE CHARACTERISTICS UNDER STC

A. Current -Voltage Characteristics under Uniform Solar Irradiance

I-V characteristics for the Photovoltaic cell totally depend upon solar insolation (G), thermal condition and type of load. Hence the output current varies according to the different solar radiation values, but the output voltage V remains almost constant. For the temperature change voltage varies but current remain almost constant [13]. The 2 main parameters of the characteristics are Isc (short circuit current) and Voc. Isc is value of current which has voltage value is zero and Voc is value of voltage which has zero cell current. Maximum values of voltage and current can be identified from the readings taken and denoted as Vmp and Imp. Location where Vmp, Imp meets is called peak operating point [12]. Load line will be drawn which will be the junction of current-voltage and power-voltage characteristics. To calculate this output resistance, formula used is Rmp/R_T=Vmp/Imp. Fill factor (FF) is one of the notable factor for a photovoltaic module. Given by the ratio of maximum power to product of Voc and Isc. It is useful in evaluating the performance of any panel.

FF=Imp. Vmp/Isc.Voc it should be always near to 1

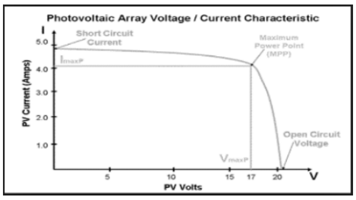

Fig.2 Current –voltage cell performance under uniform irradiance and STC [12]

solar irradiance affects the cell/module characteristics. Reduction in radiation levels droops down the curve and the standard test value for G is Kw/m^2. Below this value the output power generated by the cell/module reduces. Accordingly, Voc reduces.

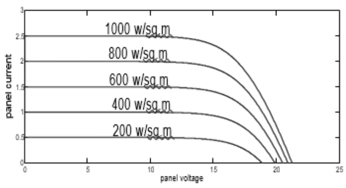

Fig.3 Current –voltage cell performance under Different irradiance levels [4]

B. Power-Voltage curves a Photovoltaic Cell under Uniform Solar Irradiance (G)

For the particular insolation, growing module voltage raises panel output power, reaches peak value and reduced to zero. At a particular operating the output gain for the photovoltaic module attends its highest value, that point will be the true operating point/global operating point for solar panel. Loads at the output side are of variable nature, so the MPP is never fixed for any panel. It gets varied as load changes. For promoting PV module at its maximum efficiency, optimization algorithm will be opted. It always keeps the operating peak to work at its best and always tend to operate the panel with the maximum efficiency [4].

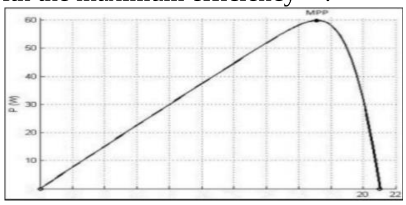

Fig.4 P-V Performance of a PV cell under uniform insolation

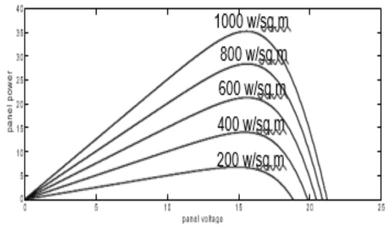

Fig.5 Performance of a PV cell under diverse radiation levels[4]

IV. PV CELL PERFORMANCE UNDER PARTIAL SHADING CONDITIONS

Among various reasons such as aging, disconnection, weather conditions and shading alleviates the output yield from a solar module, sectional/fragmentary shedding is the main reason. Partial shading takes place due to tree branches, birds, neighbouring structures, ice/snow accumulation and cloud cover over the panel. Due to this in outdoor solar systems all or some of the solar cells got shadowed which results in an uneven insolation condition. If the modules joined in cascade then for the partial shading condition, few PV cells which receives uniform radiance operates at optimum efficiency, while the cells which are under partial shedding operates with the reverse voltage. This resulting reverse power effect generates an adverse effect of power consumption and in turn weakens a peak power gain from a sectionaly shadowed unit. Exposure of shadowed PV cells more and more to the excess reverse bias voltage may cause formation of 'hot spots' on a module. This happens due to the presence of bypass diode in parallel with a solar cell or module. Bypass diode is mainly used to alleviate the negative effects of partial shading conditions, but due the presence of bypass and blocking diodes multiple peaks got generated in the performance characteristics. These multiple peaks are called local maximum power points (LMMP's)/Pseudo power points [9]. Out of number of local and one global MPP, a control algorithm works to fix up the highest operating point (MPP).

Retrieval Number: J12020881019/19©BEIESP
DOI: 10.35940/ijitee.J1202.0981119
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

A. Current –Voltage performance for the PV Cell under Partially Shaded Condition

In partially shaded cases current-voltage curves of the shadowed and non-shadowed photovoltaic cells of a particular module or in case of array, partially shaded modules and non-shaded modules is different. Peak power point degrades if a single cell from a module or a particular module from the array gets partially shaded. Also, if a shaded module is connected in series with the unshaded one then an additional loss will take place as the current for the serially joined arrays will gets impacted by the shadowed PV cell. Cell failure is more in case of partial shading [11]

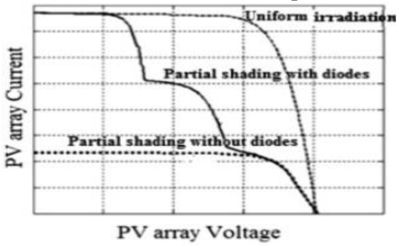

Fig. 6 Current-voltage performance for a Photovoltaic module in case of partial shading

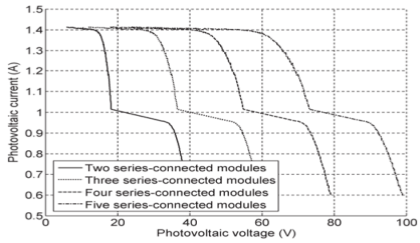

Fig. 7 Current-voltage performance of cascaded modules [11]

B. Power-Voltage performance of Solar Cell for Partially Shaded Condition

In a P-V curve for a solar cell / module due to the partially shaded cells multiple peaks occurs which are nothing but the local maximum power points (pseudo points). No any local point representing the real global peak power point. Hence a control algorithm must be such that it should stick for real maximum power point. In case of practical photo voltaic applications partial shading creates more difficulty in tracking MPP.

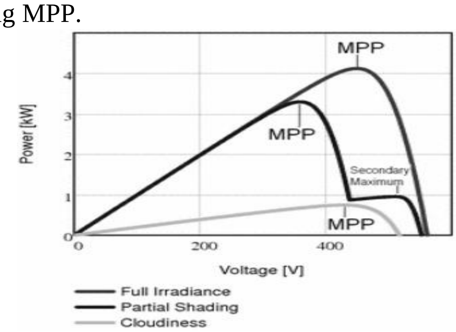

Fig. 8 Power-Voltage performance for a Photovoltaic module for Partially Shaded Condition

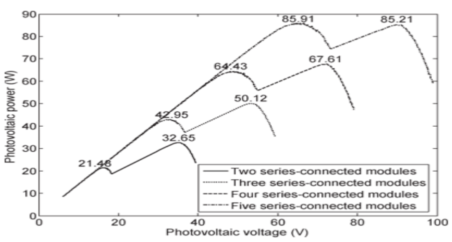

Fig. 9 P-V characteristics of a PV array under partial shading condition for series connected modules[11]

V. OPERATING POINT AND DC TO DC POWER CONVERTER

At peak operating point solar module is extracting a maximum power and supplying it to the load. This concept depends on the fact of maximum power transfer theorem i.e. when $Z_{in}=Z_l$, load will get a maximum power (Pmax). DC-DC converter which is a power interface/power conditioning device between solar module and load fulfils aimed to transmitting superlative power from photovoltaic array to output side. They are used in applications where there is a requirement of average load voltage whose value may ismore than or less than the source voltage [12]. Duty cycle (D) is an important parameter which can be changed to vary the input impedance and matched it with load impedance. This matching is done at the peak point called MPP. Numerous techniques/algorithms are adopted to change the duty ratio. Hence the MPPT device will be connected to power conditioner block, where converter block duty ratio will gets changed depending on MPPT output.

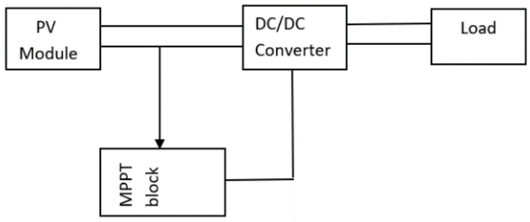

Fig. 10Power conditioning block with MPPT

Various types are classified for the converter according to their design specifications, position of components, switching devices output and input voltage relationship and values of voltage, current and power generated by each, DC-DC converters are having following 3 basic types,[12]

1) Step down/Buck converter
2) Step up/Boost converter
3) Combination step up and step down/Buck-boost
4) SEPIC(inverted buck boost)
5) Cuk converter

DC-DC converters are used a switch mode controller for changing input DC value of the voltage, which is not regulated, into output DC voltage which will be in a controlled from. This will be achieved using pulse width modulation technique and the switches used are generally BJT, power BJT, MOSFET, or IGBT. Along with the semiconductor switching devices, L-C filter is used converter circuit for the filtering purpose. Each power converter has some advantages and disadvantages which depends on the application used at load side[16]. All the above said converters show the different regions of operation of the MPP and load line which varies with duty cycle (D).

1) Buck converter-load side voltage always less as compared to source side voltage and load current greater as compared to source current.

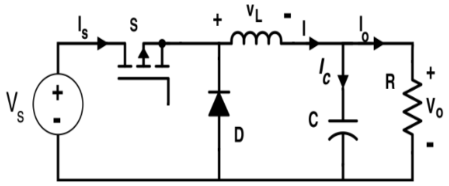

Fig. 11 Step down Converter

The conversion ratio for buck converter is

$\frac{Vo}{Vin} = \frac{Iin}{I0} = D$-- (1)

From eq. 1$Vin = \frac{V0}{D}$ and $Iin = I0 * D$------------------- (2)

Rin – input resistance of converter can be calculated

$Rin = Vin/Iin$=$\frac{\frac{V0}{D}}{I0} * D$=$\frac{V0}{Io}/D^2$=$R0/D^2$------------------- (3)

Where $R_o$is load resistance. Duty cycle D changes from zero to ∞ (i.e.0 to 1). Therefore Rin will changes from ∞ to Ro according to the change in duty cycle from 0 to 1.If R_{MPP}will not come within range of values permitted for R_{in} then MPP catching is not be possible, it is only possible for $R_L \leq R_{MPP}$values. Range of R_{in} values are shown in a figure.

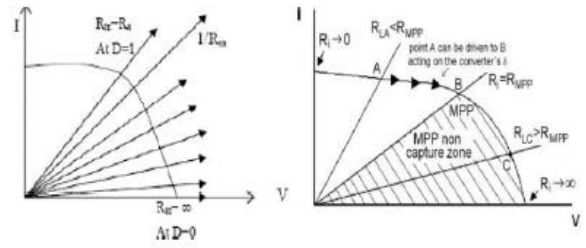

Fig. 12Operatingregion for R_{in} for step down converter and MPP tracking zone [12]

Working: According to the circuit of buck converter, when the s/w is closed, there is a current which takes its pathvia s, L, load. Hence the input voltage Vs is totally applied to load. But if the switch is in off state, stored energy in an inductor will generate the current and voltage .Due to this stored energy, inductor current flows through the load which is discontinuous in nature. And the voltage coming across the load side is less than the input voltage Vin hence in step down converter load side gain in terms of voltage will be always smaller as compared to source potential. Also, it requires bigger costlier capacitor for refining out the disconnected source current from photovoltaic array [11]. For this reason, buck converter is not much used in MPPT algorithms as a power interface for solar system.

2) Boost converter – load potential will be always larger as compared to source potential. Load current will be less as compared to source current.

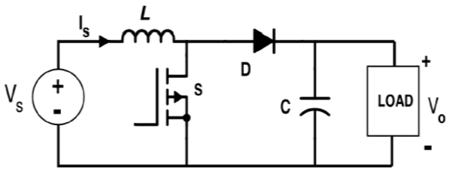

Fig. 13 Step up Converter [18]

The conversion ratio for boost converter is

$V0/Vin = Iin/I0 = 1/1 - D$------------------------------- (1)

From eq. 1 $vin = V0 * (1 - D)$ and $Iin = I0/(1 - D)$-- (2)

Rin – input resistance of converter can be calculated

$Rin = \frac{Vin}{Iin} = V0 * (1 - \frac{D}{I0})/(1 - D) = R0(1 - D2)$--------
(3)

The MPP tracking system changes R_{in}, and tries to achieve R_{in}=R_{MPP}.But this is impossible if the value of R_{MPP}not coming under the range allowed for R_{in} therefore achieving is bit difficult MPP ifR_L<R_{MPP}, and the catching of MPP is only possible for $R_L \geq R_{MPP}$values.

If variation of $R_{in}$is from R_o to zero according to the variation in D from zero to 1 correspondingly

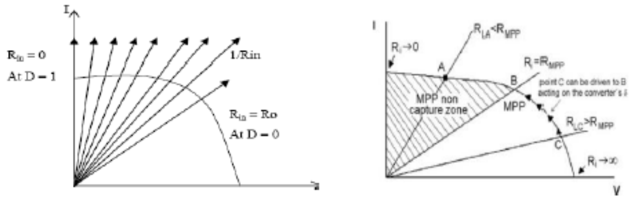

Fig. 14 Operating region of Rin for step up converters and MPP tracking zone [12]

Working: After closing s/wpn junction diode attains reverse biased mode of operation due to which there is a linear increment in current which will start flowing through L and s/w. After opening the s/w pn junction diode attains a forward biased mode and L releases stored energy and afterword current starts flowing via L and C. In this way process gets repeated which results in stepping up of the voltage transferred to load [17]

3) Step up and step-down converter – this converter shows the combine effect of step down and step up converter in its operation. Load voltage can be raised or lowered by keeping the reference source voltage,making change in duty ratio.

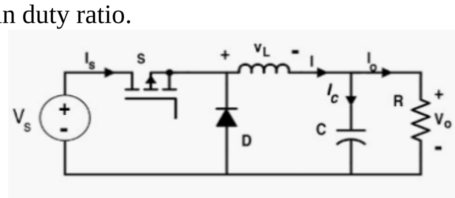

Fig. 15 Buck-Boost converter

Conversion proportion for step-up step-down converter,

$V0/Vin = Iin/I0 = D/(1 - D)$ ----------------------------
(1)

From eq. 1 $Vin = Vo/(1 - D)/D$ and $Iin = I0 * (D/(1 - D))$--- (2)

Rin – source resistance is evaluated

$Rin = \frac{Vin}{Iin} = R0(1 - D2/D2)$ ---------------------------- (3)

Variation of R_{in} from ∞ to zero accordingly D changes from zero to 1

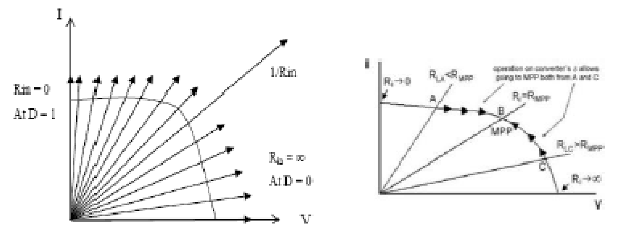

Fig. 16Range of Rin for step-up step-down converter and MPP tracking zone [12]

Retrieval Number: J12020881019/19©BEIESP
DOI: 10.35940/ijitee.J1202.0981119
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

It permits MPP cover up in both ways. Rin will be of any value using this type of converter. Due to which the PV system can catch MPP irrespective of present radiation alignment with $R_L$this helps in achieving good MPP-catching efficiency. MPP will be achieved for variety of $R_L$value, irrespective of the relationship between R_L and R_{MPP}.

Working: operation of step-up step-down converter mainly depends on the opposition from L due to abrupt changes in source current. In closed position of s/w, L accumulates energy from source side in the form of magnetic energy and releases it when switch is opened. Considering the capacitor for load side to be sufficiently large for getting RC time constant high. This ensures with the comparison with switching period that in steady state a constant load voltage $V_o(t) = V_o$(constant) prevail at load terminals.

4) SEPIC converter-

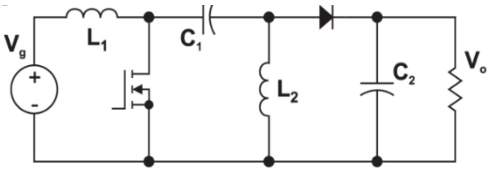

Fig. 17 Single ended Primary Inductor Converter [2]

This converter allows the voltage at its load side sometimes larger than, smaller than, or same to equal to the input voltage. Control transistor regulates the load voltage using its duty cycle. It is nothing but a step-up converter followed by a step-up step-down converter. Its output possesses same voltage polarity as input while its output is not inverted. The coupling capacitor connected in the circuit works as a confinement for load and source side.MPP catching in this type is easier and simpler due to the lesser source ripple current.

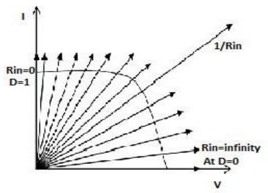

Fig. 18 Operating Area of SEPIC Converter [2]

With simplicity because of low input ripple current. This type is most decisive as compared to step-up step-down converter [2].

Working: in the stable mode, average potential at C1i.e V_{c1}will be same as input voltage V_{in}. As capacitance C1 blocks direct current, average current of it will be I_{c1}zero. This makes only L2 the source of DC load current. Hence current via L2 ie.I_{L2}will be equal to load current. Voltage equation is given by,

$$V_{in}=V_{c1}+V_{l1}+V_{l2}$$

As average voltage $V_{c1}= V_{in}$, $V_{l1}=V_{l2}$. The ripple currents of 2 inductors are equal in magnitude due to similarity of 2 voltages in their magnitudes. Hence average currents are added together as

$$I_{D1}=I_{l1}-I_{L2}$$

After closing s/w S1 I_{L1} raises and I_{L2} becomes negative. Energy required to raise I_{L1} is the energy from source voltage. In a closed condition of s/w s1 instantaneous voltage V_{L1} will be approximately V_{in} and V_{L2} is approximately $-V_{C1}$. Hence to increase the value of I_{L2}, D1 is opened so that capacitor C1 can give energyand store it in L2. I_L is supplied by C2. Hence a bias voltage in a circuit will be considered in dc state, and then closing the s/w S1. After opening s/w S1 current I_{C1} will becomes equal to current I_{L1}. As per the characteristics of inductor to not allow the instantaneous current change, I_{L2} starts flowing in negative direction and it never reverses its direction. This negative I_{L2} will add to the I_{L1} so that there is increment in current given to the load. According to KCL, $I_{D1} = I_{C1}- I_{L2}$. Conclusion is if S1 is off, power is supplied to the load from both L2 and L1. C1is charged by L1 during this off cycle (as C2 by L1 and L2), and recharge L2 during the following on cycle.

5) Cuk converter

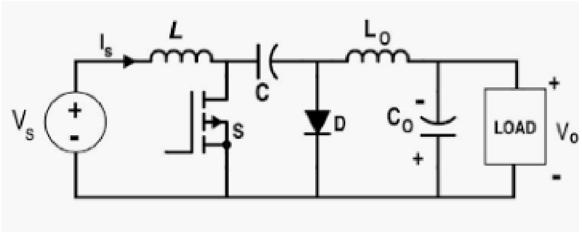

Fig. 19Cuk Converter

In this type load voltage can be more or less than the source voltage, with load voltage having reverse polarity of the input voltage. L on the source side works as a filter to prevent high harmonic current. Amount of energy transmitted to L by this converter is related with the capacitor C. Optimization algorithms are used to control the position of MPP in a solar system. These algorithms help in fixing location of MPP always in such way that, system will operate at its optimum level and will give optimum efficiency. Output of mppt block is given to converter block to change the duty cycle. Following are some of the computational control algorithms for the solar system (conventional and advanced)

A) Conventional methods- these are also called as real time algorithm as these methods uses actual data in a system like voltage, current, and power for the working. The following MPPT algorithms can be applied on PV based system. They have advantages like less oscillation, faster response, simplicity in operational so tracking of MPP by them for fast changing atmospheric conditions in real-time is good [17]

1)Perturb &observe (P and O)
Adaptive P&O
Variable step size P&O
Multivariable P&O
Variable perturbation size adaptive P&O
PSO based P&O
2)INC
Modified Incremental Conductance
Variable step size Incremental Conductance
Improved variable step size INC
Power incremental based INC
Modified adopted INC

Retrieval Number: J12020881019/19©BEIESP
DOI: 10.35940/ijitee.J1202.0981119
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

B) Soft computing / advanced/intelligent methods- these methods are useful in to tracking the MPP along with rapid response & lesser fluctuations.[17]

1) FLC based MPPT
2) NN
3) Particle swarm optimization
4) Grey wolf algorithm
5) Ant colony
6) Bat algorithm
7) Artificial bee colony
8) Sudoku puzzle-based algorithm
9) Microprocessor based algorithm

Comparative analysis of various converters and performance parameters are given in the below mentioned tables.

Table I. step-up, step-down, step-up step-down comparison

step-up	step-down	step-up step-down
Power Factor correction is high	Power Factor correction is poor	Power Factor correction is high
$V_o > V_{in}$	$V_o < V_{in}$	$V_o$free
filter of small size is needed	filter of large size is needed	filter of large size is needed
Switching voltage is V_o	Switching voltage rating isV_{in}	Switching voltage rating is n $V_o + V_{in}$

Table II. Comparison between step-up step-down, sepic and cuk converters

Specification	step-up step-down	**Sepic**	**Cuk**
Performance of MPPT	ideal	ideal	ideal
Components used	Less	more	more
Facility of Control	Confined	Non confined	
array current	Disconnected	regular	
Method of Current scaling	difficult	smooth	smooth
System transients	more	Moderate	Less
Efficiency of tracking	Poor	Moderate	More

VI. CONCLUSION

Proper converter selection is a crucial point, to enhance working of photovoltaic system. Hence the comparison between different converter topologies is discussed in the paper. The paper focuses on different conventional and advanced methods of MPPT algorithms used for getting optimum power point as per the performance of the solar system and also studied correct power interface circuit for the application. It has been found that a step-up step-down converter is a best suitable power interface for this and soft computing methods gives better MPP results traditional techniques.

REFERENCES

1. S. Gomathy, S. Saravanan, S. Thangavel. "Design and Implementation of Maximum Power Point Tracking (MPPT) algorithm for a standalone PV system. Elixir International Journal pp. 11110-11114 (2012)
2. S.B.Parmar, B.S. Shah. "Application of Global Maximum Power Point Tracking (MPPT) in Solar PVArray" International Journal for Research in Applied Science and Engineering Technology. Vol. 5 Issue V (2017)
3. Pooja Sharma, Vivek Agarwal. "Exact Maximum Power Point Tracking of Grid Connected Partially Shaded PV source Using Current Compensation Concept". IEEE transactions, Vol. 29, no. 9 (2014)
4. Anoop K, M Nandkumar. "A Novel Maximum Power Point Tracking Method based on Particle Swarm Optimization combined one cycle control". IEEE transaction (2018)
5. Kok Soon Tey, Saad Mekhilef, Mehdi Seyedmahmoudian. "Implementation of Bat Algorithm as Maximum Power Point Tracking Technique for Photovoltaic System under Partial Shading conditions" IEEE transaction (2018)
6. R. Boukenoui, A Mellit. "Applications of Improved Versions of Fuzzy Logic Based Maximum Power Point Tracking (MPPT) for controlling Photovoltaic Systems" Springer Nature Singapore, Solar Photovoltaic Power Plants, Power Systems (2019)
7. Deepak Verma, Savita Nema, A.M. Shandilya, Soubhagya .K. Dash. "Maximum Power Point Tracking (MPPT) Techniques: Recapitulation in Solar photovoltaic systems" Renewable and sustainable energy reviews, Elsevier pp 1018-1034 (2015)
8. Umashankar Patel, DhaneshwariSahu, DeepkiranTirkey. "Maximum Power Point Tracking using Perturb and Obsereve Algorithm and compare with another Algorithm" International Journal of Digital Application and Contemporary Research, Vol 2, issue 2 (2013)
9. Mohammad mehadi Seyed mohamoudiyan, Arsh Mohamadi, Swarna Kumary, Aman MaungThan, Alex Stojsevski. "A Comparative study Procedure and state of Art of Conventional Maximum Power Point Tracking (MPPT) Techniques for Photovoltaic System" ijcee (2014)
10. Sumedha Sengar, "Maximum Power Point Tracking algorithms for Photovoltaic System: a Review" International Review of Applied Engineering Research. Vol 4, No 2 pp. 147-154 (2014)
11. Weidong Xiao, Nathan Ozog, Willium G. Dunford "Topology study of Photovoltaic Interface for Maximum Power Point Tracking" IEEE Transactions on Industrial Electronics vol 54. No 3 (2007)
12. V.C. Kotak, Preti Tyagi. "DC to DC Converter in Maximum Power Point Tracker" International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering. Vol 2, Issue 12. (2013)
13. Boualem Bendib, Hocine Belmili, Fateh Krim. "A Survey of most used MPPT methods: Conventional and advanced algorithms applied for photovoltaic systems" Renewable and sustainable energy reviews- Elsevier. pp 637-648 (2015)
14. Weldong Xiao, W.G. Dunford. "Topology Study of Photovoltaic Interface for Maximum Power Point Tracking" IEEE Transactions on Industrial Electronics (2007)
15. Natarajan Pandiayarajan, Ranganath Muthu, RamaprabhaRamabadran. "Application of Circuit Model for Photovoltaic Energy Conversion System" International Journal of Photoenergy, Research Gate (2012)
16. Afroz Pasha, Jayakumar.N, Thiruvonasundari.D. "Performance Analysis of Dc-Dc Converters and Comparative Study of Buck -Boost with SLLB Converter by Using SPV Based INC MPPT Technique". Performance Analysis of Dc-Dc Converters and Comparative Study of Buck -Boost with SLLB Converter by Using SPV Based INC MPPT Technique. Vol 4, Issue 08 (2017)
17. S Saravanan, N Ramesh Babu. "Performance Analysis of Boost and Cuk Converter in MPPT based PV System" IEEE, International Conference on Circuit, Power and Computing Technologies. (2015)
18. Saurabh Kumar1, Rajat Kumar2, Navdeep Singh3. "Performance of Closed Loop SEPIC Converter with DC-DC Converter for Solar Energy System" IEEE (2017)

AUTHORS PROFILE

S. P. Deshmukh, PhD (Tech), M.E. Production Engg. BE (Production Engg, Mumbai university) is currently working as Professor and Associate Dean of Academic programs in Institute of Chemical Technology, Mumbai. He has successfuly Handled2Consultancy Project. He has Presented and Published papers for different International and national conferences and journals (No.43). he was winning team member of Global Competition on Sustainability by Wipro India Earthian award JAN 2014 and 2015. Research Area-Material Engineering, Energy, Solar Energy, Analysis of Plastics using CAD/CAE, Non-conventional energy, Heat transfer theory. Life member of prestigious and re known professional societies like Indian Institute of Industrial Engineers and Institute of Research Engineers and doctors.

International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-8 Issue-11, September 2019

Prof. Prasannati Kulkarni- Pursuing PhD (Tech) Institute of Chemical Technology in the department of General Engineering. (Mumbai). Asst Prof in K. C. College of Engg. Thane since 2015. Worked as Assistant Professor and as a Lecturer in various renown Institutes in Mumbai and Thane. Published and presented papers (No.17) in several national and International conferences and journals. Research Area- renewable energy, solar hybrid systems etc.

Retrieval Number: J12020881019/19©BEIESP
DOI: 10.35940/ijitee.J1202.0981119
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)