Designing a Novel ANN Optimized Converter for Photovoltaic Solar System

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***Abstract*--This paper suggests a novel full bridge electric power converter for photovoltaics solar system. DC/DC converters in photovoltaics actually theatres a very vital role in training of power systems. The dc/dc converter is placed in circuit to give a relentless output voltage under numerous functioning conditions of PV Cell. First of all MPP of the PV cell is find out by using P& O algorithm and then voltage rating is designated to the power switch. Photovoltaics PCS should provide high efficiency when placed in time changing diverse operating conditions. A novel dc/dc converter is projected to gratify Photovoltaics Power Conditioning System condition. The planned system is studied and verified through in MATLAB/SIMULINK. In next part the same proposed converter is optimised with Artificial neural networks on different architectures so that we best optimum output is received from the PV cell.**

Keywords--PV cell, solar irradiation, Maximum power point tracking (MPPT), power conditioning system, Artificial Neural Networks.

I. INTRODUCTION

The usage of renewable sources of energy is enlarging day by day as a result of incessant growth in energy feasting and continuous decay of fossil fuels [1], [2]. From all the renewable energy resources solar energy comes out to one of the best promising sources because of abundance of availability, low maintenance can be easily operated with no restriction in location as it is available everywhere and above all is that it is eco-friendly method of energy generation – a pollution free energy source [4]. By watching the todays world environmental conditions renewable sources are the best decisions for energy generation. Energy generation from solar energy is one of the reckless and speedy growing technologies from all other renewable resources. PV energy employs a Photovoltaic cell that converts sunlight directly into electricity. PV system has less operating cost, it has low maintenance and is pollution free these are some conditions that put PV technologies on the topmost position of all the energy generation methods. Every technology has some drawbacks also. Some are also associated with this too as low efficiency (5-10%), in winters and in rainy season sun is not available every-time which makes energy production irregular and installation cost is little bit high.

Maximum power point tracking is to be done as PV panel exhibits a non-linear characteristic using different MPP algorithms [3], [5]-[8]. Few drawbacks are also listed as partial shading, aging of PV cells, varying temperature and solar isolation and dissimilarities in solar panel energy productions.

For the PV system designing PV modules are packed with solar cells then linked with electric power converters. These modules later get connected in numerous panels. The PV module has non- linear V-I characteristics. To get thoroughgoing power from the PV panel MPP is tracked which in turn depends upon environmental conditions like temperature and solar isolations. MPP is point in PV panel's V-I characteristics at which output power is maximum. Under partial shading conditions the V-I characteristics varies as the input to the panel i.e. solar isolation keeps on varying as a result of which maximum output from the panel is not obtained and it reduces the efficiency of the system.

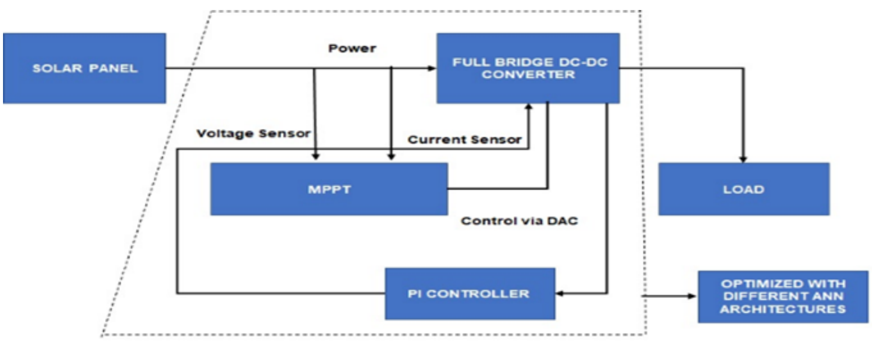

Fig.1. Basic Block Diagram of the Projected Work

There should be perfect match between PV module and the load. This matching is important to get extreme power from the PV module. For matching the load to Photovoltaic module. DC-DC converter is required which regulates the voltage and current continuously and finds the operating point accordingly. DC-DC converter is the electric power converts the voltage received from the photovoltaic cells that can either be higher or lower than the required output to a controlled DC output voltage. For this task extremely competent DC-DC Converter is employed. For the best utilization of solar energy received from the solar cells, the energy is imposed on the solar collectors constructed with the cylindrical lens type panels for the collection of energy. Converter having high frequency are used in the PV system that not only lessens the size of the photovoltaics PCS but helps in storing the energy downstream the load connections. Separate controllers are also provided in the system for the best working of the converters. The output voltage from the photovoltaic system is controlled by the DC-DC Converter. This paper proposes full bridge electric power converter which is further connected to a feedback control system and later on the whole system is optimized by Artificial neural networks by using different architectures like feedforward back propagation, elman etc.as shown in Fig.1.

II. MODELLING OF PHOTO VOLTAIC MODULE AND MPPT TRACKING

Photovoltaic cell is a small diode that is considered to do the photovoltaic effect. The word -PV means the impartial working manner of the photodiode where the current present in it is completely owed by the light energy falling on the cells from the sun. The beauty of PV system is that it converts the solar light into electricity. PV-cells works at typical voltage between 0.5 to 0.8 V. it is pollution free, sound free method of generating electricity. A basic model of Photovoltaic cell is represented in Fig.2.Photocurrent is the output of Photovoltaic Cell; which can be determined by load current which in turn depends upon on solar irradiation. An exponential equation used for the solar cells is specified in the work.

$$I'' = I'_{PV} - I'_D - I'_{SH} \qquad (1)$$

Equation (1) represents the current in load.

$$U'_{SH} = U' + I''R''_{SH} \qquad (2)$$

Equation (2) represents shunt branch voltage.

$$I'_{SH} = \frac{U'_{SH}}{R''_{SH}} = \frac{U' + I''R''_{SH}}{R''_{SH}} \qquad (3)$$

Equation (3) represents shunt branch current.

Diode current is given by Shockley equation as:

$$I''_D = I'_0 \left[e^{\frac{U'_{SH}}{n_1 V_{T1}}} - 1 \right]$$

$$V_{T1} = \frac{k}{q} T_0$$

Adding the above equations, we get

$$I'' = I'_{PV} - I'_0 \left[e^{\frac{U'_{SH}}{n_1 V_{T1}}} - 1 \right] - \frac{U' + I''R''_{SH}}{R''_{SH}} \qquad (4)$$

Here equation.4. signifies the characteristic equation of Photovoltaic Cell.

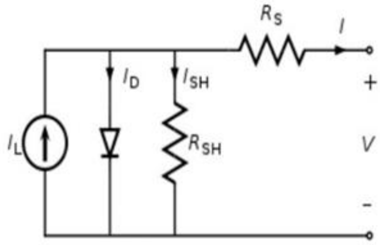

Fig.2. Model of PV Cell

Here:
I''= Load current
I'_D= diode current
I'_{PV}= PV current
I''_{SH}= shunt resistor current
R''_S= series resistance equivalence
R''_{SH}= shunt resistance equivalence
U'= load voltage
U'_{SH}= shunt voltage

To receive maximum output from the PV cells either the module can be coupled in series or in parallel creating a PV array. If the PV array is connected in series best opted connection of the module then they will receive same level of solar isolations. PV module connected with PV cells connected in series are shown in Fig.3.

Fig.3. PV Module with series connection of PV Cells

The proficiency of the PV module is very less of about 13% which is not desired hence for the practical application of the PV energy commercially, the efficiency of the PV cell has to increased and the PV module should be operated at maximum power point then only maximum power can be delivered to the output side under changing environmental conditions like solar isolation, temperature etc.. While calculating the MPP of the PV module following points should be kept in mind and can be taken under consideration as:

- System must have high tracking speed.
- High stability.
- Ease in handling.
- Less in cost.
- High system stability.
- Quick response to the changing environmental conditions.

From MPP, calculation of output voltage is done and it can be used in more than one solar panels. There should be a proper match between the load impedence and the output power, it can be achieved by changing the duty cycles. MPP algorithms uses numerous types of logical circuits for searching the maximum power of the photovoltaic modules. There are many techniques used in extracting the maximum power likewise [10].

- P&O algorithm,
- Inc & cond algorithm.
- Parasitic capacitance.
- Constant voltage method for MPP.
- Constant current for MPP.
- Current sweep method
- DC link capacitor droop control method.
- Load current or Load voltage Maximization.
- Linear Current Control
- State based MPPT

Here Fig.4. represents the V-I characteristics of the module and also shows the MPP in the respective characteristics.

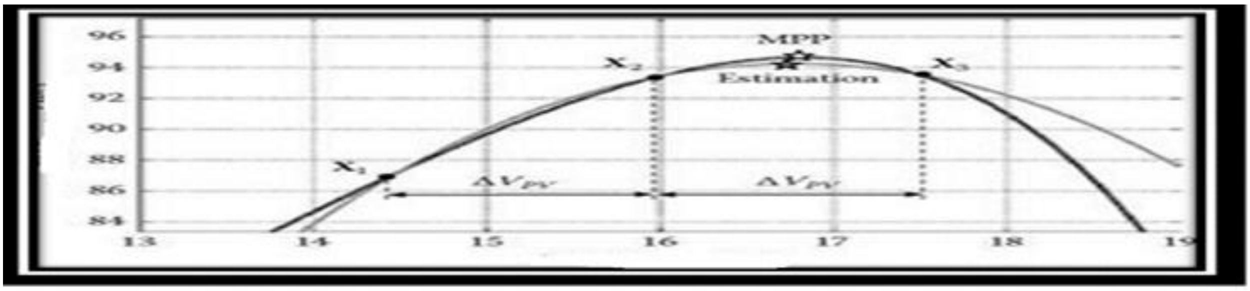

Fig. 4. V-I characteristics of PV module and denotes the MPP

All techniques and methodologies represented in th flow chart, till date all are used for tracking MPP.ANN is now a days is used to optimise the controller e.g. Hill Climb,Inc Cond.Combination of ANN with FLC with P&O is mostly utilised now a days by the researchers working with Soft Computing.As in most of the cases hybrid controllers proves to be the best performing controllers as equated with the stand alone methods.

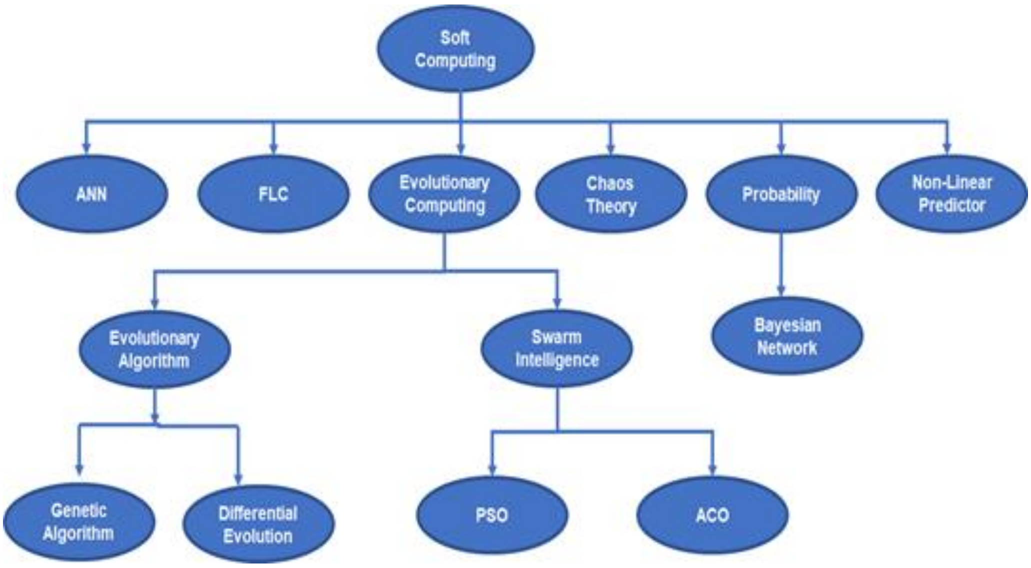

Fig. 5. Techniques of soft computing For PV Cell MPPT

III. Electric Power Converter with Controller

Electric power converter works as a crossing point between the load and the module, extensively employed in motors and drives to convert deregulated input into a controlled DC output at a essential voltage level [7]. A converter is placed in the PV system for the below listed reasons:

- To control the input voltage at the mpp of the PV cell.
- To give perfect match between PV module and the load.
- DC-DC Converter linked with transformers are extremely chosen because of the following topologies:
  - Effortlessness to get regulated controlled output voltage as of the transformer feature to step up/step down the voltage levels.
  - Considerable efficiency (80-95%).

Inductor inbuild in the transformer stores the input energy (energy obtained from the magnetic field) for some time and then emits out the same energy at the variable voltage levels to get a controlled output voltage from the PV Cell.

For the battery operated device, high running time is required which is obtained from the highly efficient converters. If a DC-DC Converter operating at high frequency is present then it not only reduces the losses(switching and conduction) but also decreases the size of magnetic circuit.In this paper use of MOSFET is introduced in spite of flywheel diodes and this done only by PWM methods that are phase shifted as it both regulates and control the output voltage[9]. For switching power supplies DC-DC Converters are generally preferred. They are extensively used in residential solar systems to get required output power. To propose and to design DC-DC Converters with high efficiency many methodologies are being discussed and the main requirements to be fulfilled to get a desired DC-DC Converter are as follows:

- Less stress in the devices.
- Low losses i.e. high efficiency.
- Ripple current should be as low as possible.

A converter can use as many switches as it can in order to govern the output voltage by putting as many as control signals. The projected DC-DC converter which is phase shifted full bridge will likely to give maximum efficiency with, less soft ripples voltage and current and remarkable rise in the available power even in varying solar isolations.

A. *Investigation of Full bridge converter.*

Here full bridge DC-DC Converter is forecasted, and its waveform is also represented in Fig.6.

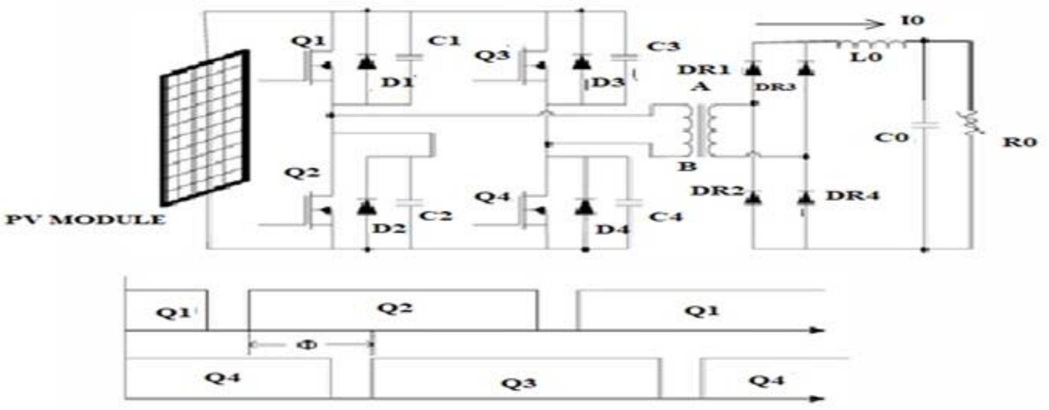

Fig.6. Phase shifted waveform of full bridge converter.

In these outlined figures primaryone is called as the leading leg and another one is called as the lag leg(phase-shifted).If one leg of the Full Bridge inverter with a phase shift conducts w.r.t. another leg switches. Subsequently the freewheeling interval it starts up the power delivery then the leading and the inverter leg switches on automatically. Here is one trailing led of the inverter that stops the power transfer interval. The cause of energy is the leakage inductance of the transformer that moves the charge and is variable for both the legs. The output inductor from the converter is the main source of energy for the lagging leg. As PWM increases, switching losses started playing a vital role in the power dissipation of the converter, hence soft switching methodologies are employed to reduce the losses. Here are countless techniques to find the output power of the PV array while in this proposed work constant voltage method is employed to optimize the output power from the PV array.The maximum power point controller finds out the open circuit voltage and fixes the reference voltage as per the requirement. The main function of MPPT is to find and to set the Vref and it is repeated again and again as the input changes , the output voltage changes accordingly. One more controller is also present in the circuitcalled as PI controller that will control the input voltage of the converter. Its main function is to reduce the errors between the Vref and the voltage being measured by altering the duty cycles. The PI controller provides stability to the system with fast settling rate and quick response to input variables.

IV. Artificial Neural Networks

ANN is the assembly of fake neurons that copies a biotic brain.Chiefly, it includes hidden,input and output layers.A possible structure of ANN, made-to-order for MPPT as represented in Fig.7.The inputs given to the arrays are temperature, wind, speed and irradiance or any combination of these input parameters. The output so obtained can be in the form of voltage, current, and can be changed by varying the duty cycle which is required for the optimization of the controllers. Nodes can be changed manually and are defined by user.

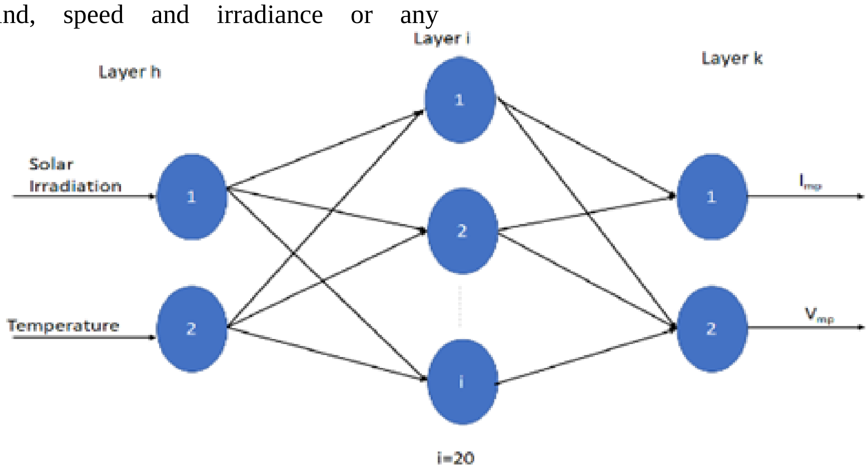

Fig. 7. A typical ANN Assembly for MPPT

The facility of ANN to calculate the MPP is subject to the hidden layer algorithm an how sensibly the network is trained.Sometimes the network has to be trained to track the solar cell MPP auurately for months or for even years.In the training part ,the neurons are weighted so as to bout the input-output corelation of patterns.It is significant that if ANN is modelled and trained at a desired value of PV cell and at specific meterological conditions than it will not correspond accurately for different conditions.

V. Results and Discussions

The scheme represented in Fig.1.is simulated and analysed on MATLAB, then it is optimized on Artificial Neural Networks. The module is made up of 2 parallel interconnected PV arrays. To each array made up of series connected 6 Photovoltaic assemblies.Each assembly comprises of 28 solar cells in series..The output if fed to the full bridge DC-DC converter phase shifted and the maximum power point tracking controller is made from the PI controller , then whole system is optimized with ANN with architecture 1 i.e. Hopfield neural network as shown in Fig.8. with data division is random ,training is done with Levenberg-marquardth for checking the performance mean squared error(mse is taken) as represented in Fig.8.training performance results training state results ,error histograms and confusion matrix are also represented in Figs.9.10.11.12 resp. but the architecture 1 gives accuracy of 56% but inaccuracy of 43% which is not advisable hence we shift to another architecture of ANN and a graph a plotted with architecture no. with accuracy which depicts that by using back propagation learning method of ANN tool will gives us best optimum results for the proposed work as shown in Fig 13 .An output voltage vs current plot is represented in Fig.14 load change variations starts from 10% to 20% at t= 0.04seconds.

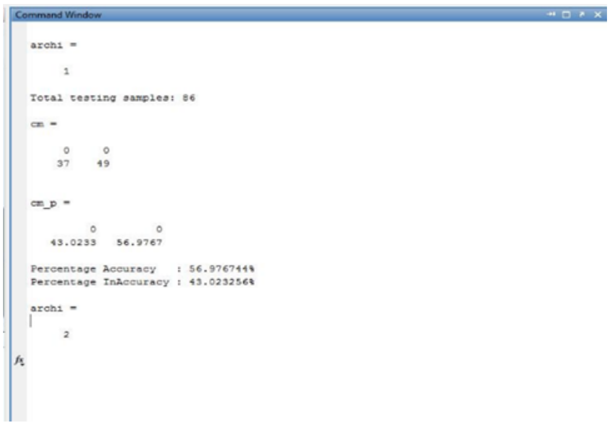

Fig. 8. Sample testing with architecture 1

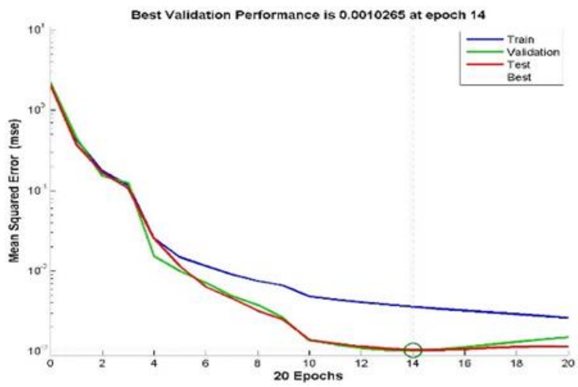

Fig.9. Training performance results with Architecture 1

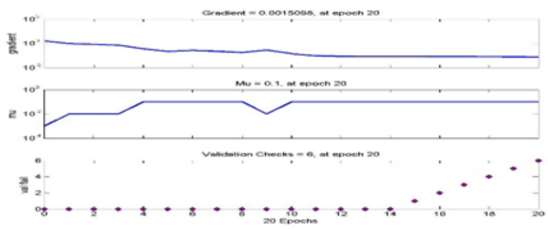

Fig. 10. Training state results of Architecture 1

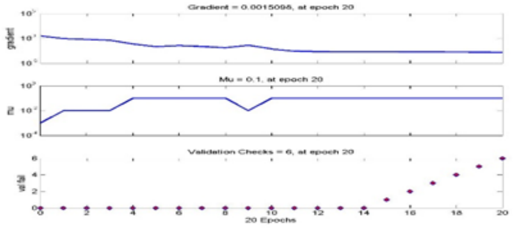

Fig. 11. Error histogram results of Architecture 1

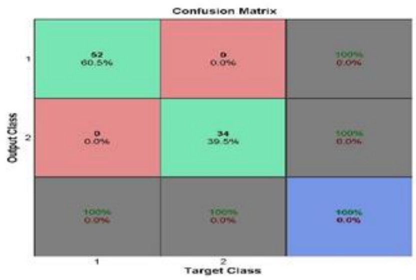

Fig.12. confusion Matrix of Architecture 1

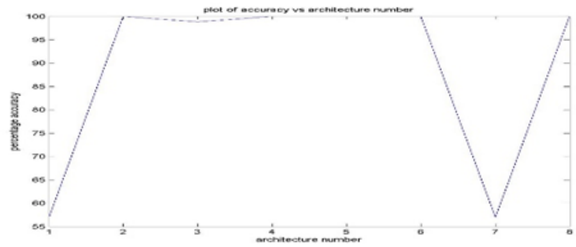

Fig 13. Graphical representation of Architecture number vs percentage accuracy.

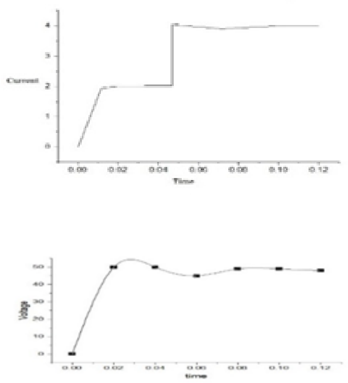

Fig.14. Graphical plot of output voltage and current w.r.t. time

VI. CONCLUSION

DC-DC converter is employed at the power controlling stage. Proper phase shifting is done by PI controller connected with the full bridge converter. After that the system is optimized with soft computing methods of ANN which depicts that by employing soft computing methods in the pre-existing system it increases the system efficiency, gives fast settling time to the system and also increases the power handling ability of the system. In forthcoming researches, matters like designing the optimal control, dual input operations and its control and its paraphernalia caused by dead zone time and discontinuous alternating currents will be discussed.

APPENDIX

Parameters	*Values*
Frequency	2×10^{2}Khz
Output voltage	50V
inductor	40×10^{3}H
capacitor	1×10^{-3}F
Voltage band gap,Vg	1.6 eV
short circuit current, Isc	3.75A
charge,q	1.6×10^{-19}C
Photocurrent,IL	0.000021A
Boltzman Constant,k	1.38×10^{-23}J/K^{-1}
Temperature,T	40^{0}C

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