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SOLAR PV SYSTEM USING BSCA BASED MPPT FOR ON AND OFF GRID

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Abstract: The photovoltaic (PV) maximum power point tracking (MPPT) based on biological swarm chasing behavior is proposed to increase the MPPT performance for a module-integrated PV power system. Each Module is viewedas a particle, and as a result, the maximum power point is viewed as the movingtarget. Thus, every PV module can chase the maximum power point (MPP) automatically. Comparing with a typical perturb and observe (P&O) MPPT method, the MPPT efficiency (η-MPPT) is improved about 12.19% in transientstate by the proposed MPPT as theoretical prediction. One of the most popular swarm intelligence paradigms is the particle swarmoptimization (PSO), which is basically developed through the simulation of social behavior of bird flocking and fish schooling. PSO is a global optimization algorithm for dealing with problems on which a point or surface in an n- dimensional space represents a best solution. Particles move through the problemspace, then, a certain fitness criterion evaluates them. Several areas have adoptedthe idea that swarms can solve complex problems.The PV module can automatically chase the MPP by proposed bio-MPPT algorithm. One sampling time is required to decide accurately the MPP trackingdirection. The bio-MPPT algorithm build in the master controller runs and command operating voltages. Irradiation and temperature are automaticallyrecorded in the bio-MPPT controller. The MPPT behavior of the proposed bio- MPPT is still confused with partial shadow effect.

INTRODUCTION

Photovoltaic (PV) technology has developed rapidly over the last two decades to a broadly-based global activity. Apart from the solar panels, the coretechnology associated with PV systems is an “inverter” unit that converts the solar output electrically compatible with the utility grid. This allows direct grid connection and provides the highest system flexibility and expandability. However, this may cause the panel output current to become time varying or even pulsating, that cannot stabilize the operating point. This proposes a buck- boost-derived converter that integrates the functions of the MPP tracker and current shaper. Low component count and the use of low-voltage-rating capacitor are the key advantages. The output current harmonics are also less sensitive to the storage capacitor value.
MPP tracking is based on the switching frequency modulation. Shaping ofthe output current is based on controlling the converter’s output pulse duration such that its average value is proportional to the required current reference in each switching cycle. In this MPPT method based on biological swarm trackingbehaviour is proposed to make all modules cooperatively to obtain sufficient in formation in one sampling time to decide accurately the MPP tracking direction.

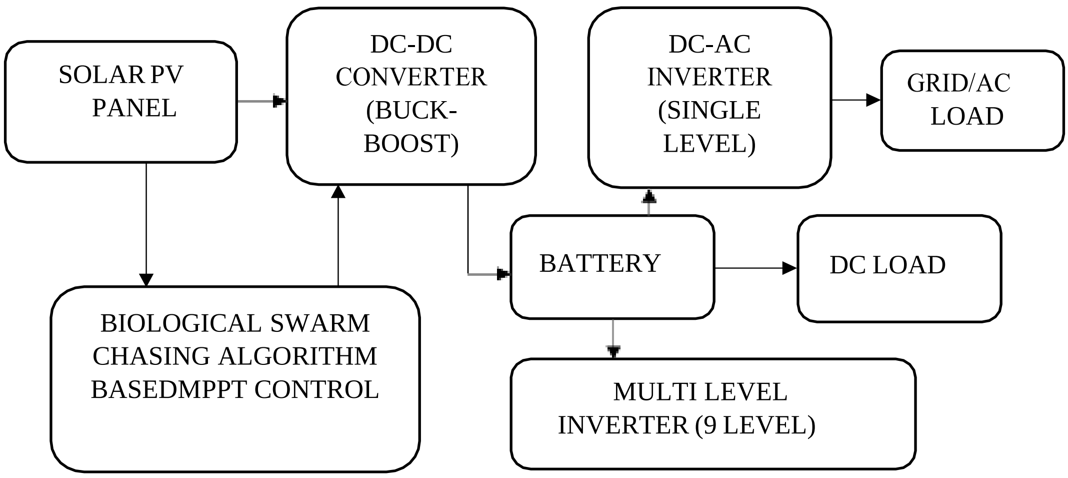

Figure:1 Block Diagram of Proposed System

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In the proposed Bio-MPPT-based PV power system, each PV module is viewed as a particle, and the MPP is viewed as the moving target. Every PV module is designed to chase the MPP automatically by using the Bio-MPPT algorithm. In this prototype, each module consists of a 50 W PV panel and a buckboost converter that is controlled by a master or a slave controller. In order to verify the effect of rapidly changing irradiation conditions, a ramp profile of irradiation is used, which starts from 120 W/m2, stops at 1000 W/m2, and decrease to 350 W/m2 with a constant slope. In this experiment, the temperatureis 25 ◦C. The output power curves of the proposed Bio-MPPT method and the typical P&O MPPT method are depicted.

BUCK-BOOST CONVERTER

DC-DC converters are also known as Choppers. Here we will have a look at Buck Boost converter which can operate as a DC-DC Step-Downconverter or a DC-DC Step-Up converter depending upon the duty cycle. The input voltage source is connected to a solid-state device. The second switch usedis a diode. The diode is connected, in reverse to the direction of power flow fromsource, to a capacitor and the load and the two are connected in parallel. The buck-boost converter circuit diagram is shown in figure:4.7.

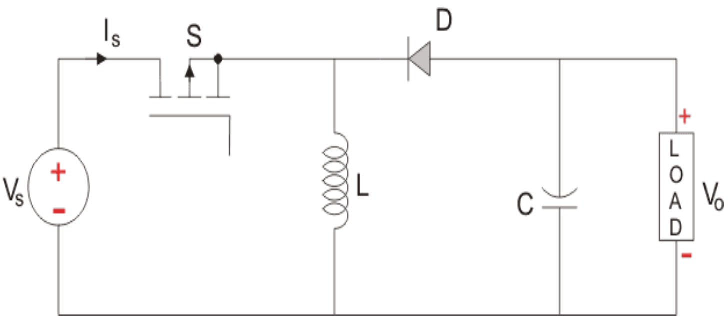

Figure:2 Buck-Boost Converter Circuit Diagram

The controlled switch is turned on and off by using Pulse Width Modulation (PWM). PWM can be time based or frequency based. Frequency based modulation has disadvantages like a wide range of frequencies to achievethe desired control of the switch which in turn will give the desired output voltage. Time based Modulation is mostly used for DC-DC converters. It is simple to construct and use.

Mode-I: Switch is ON, Diode is OFF,

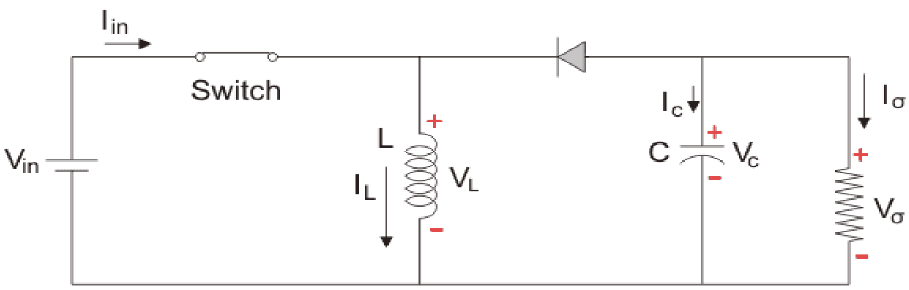

Figure:3 Mode-I Buck-Boost Converter

The buck-boost converter mode-I is shown in figure:4.8. The Switch is ON and therefore represents a short circuit ideally offering zero resistance to theflow of current so when the switch is ON all the current will flow through the switch and the inductor and back to the DC input source. The inductor stores charge during the time the switch is ON and when the solid state switch is OFF the polarity of the Inductor reverses so that current flows through the load and through the diode and back to the inductor. So, the direction of current through the inductor remains the same.

Mode-II: Switch is OFF, Diode is ON,

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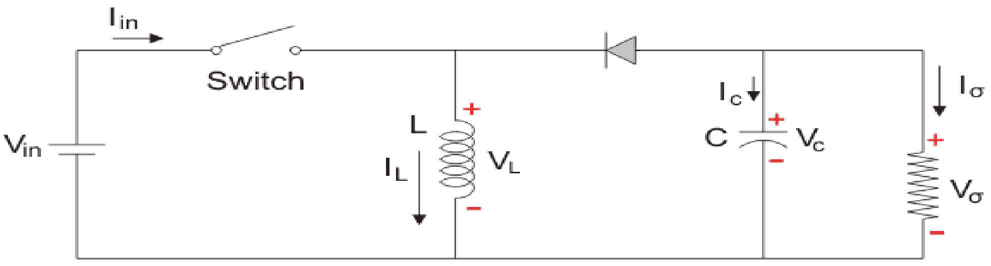

Figure:4 Mode-II Buck-Boost Converter

The buck-boost converter mode-II is shown in figure:4. The inductor current in steady state rises from a value with a positive slope to a maximum value during the ON state and then drops back down to the initial value with a negative slope. Therefore, the net change of the inductor current over any one complete cycle is zero.

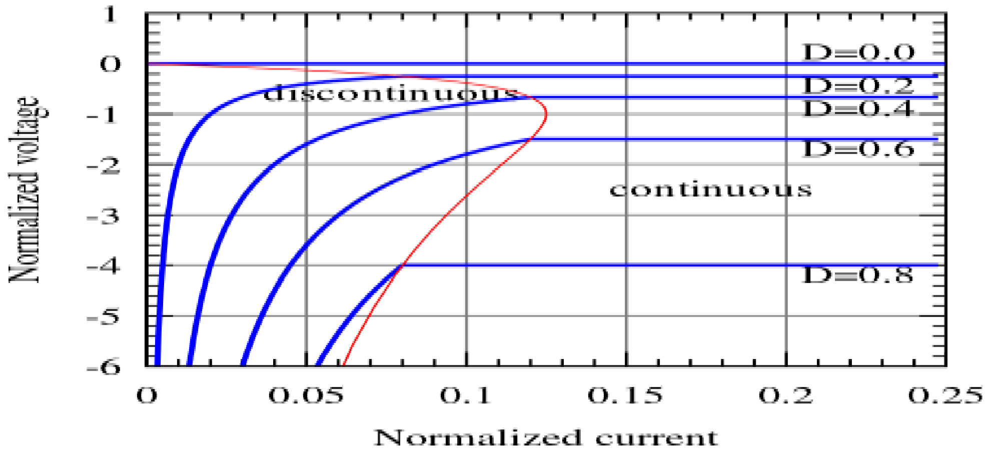

Figure:5 Continuous and Discontinuous Output Waveform

We know that D varies between 0 and 1. If D > 0.5, the output voltage is larger than the input; and if D < 0.5, the output is smaller than the input. But if D = 0.5 the output voltage is equal to the input voltage. The continuous and discontinuous output of buck-boost converter is shown in figure:5.

DIODE BRIDGE RECTIFIER

Rectifier circuits can control half wave or full wave according to the application dependency. The main difference between conventional rectifier andbridge rectifier is that it produces almost double the output voltage as a full wavecenter-tapped transformer rectifier using the same secondary voltage. In center tapped rectifier each diode uses only one-half of the transformer secondary voltage, so the DC output is comparatively small, also it is difficult to locate thecenter-tap on secondary winding of the transformer and the diodes used must have high Peak-inverse voltage. The diode bridge rectifier circuit diagram is shown in figure:6.

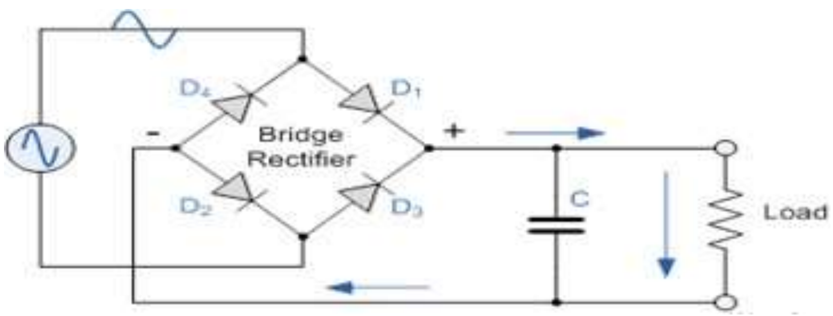

Figure:6 Diode Bridge Rectifier Circuit Diagram

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During the positive half cycle of the supply, diodes D1 and D2 conductin series while diodes D3 and D4 are reverse biased and the current flows through the load During the negative half cycle of the supply, diodes D3 and D4 conduct in series, but diodes D1 and D2switch “OFF” as theyare now reverse biased.

NINE-LEVEL INVERTER

Now a day, electronic devices are very sensitive with harmonics. The needs for a free harmonic and high rating power source is increased to meet therequirement from the industries. This project is to eliminate THD using 9 level cascaded H-bridge of multilevel DC–AC inverter. An Inverter can be broadly classified into single level inverter and multilevel inverter. The result of 9 Cascaded H-Bridge Multilevel Inverter level THD value are compared with 2 level inverter and 5 level Cascaded H-Bridge Multilevel Inverter. The nine-levelinverter circuit diagram is shown in figure:7.

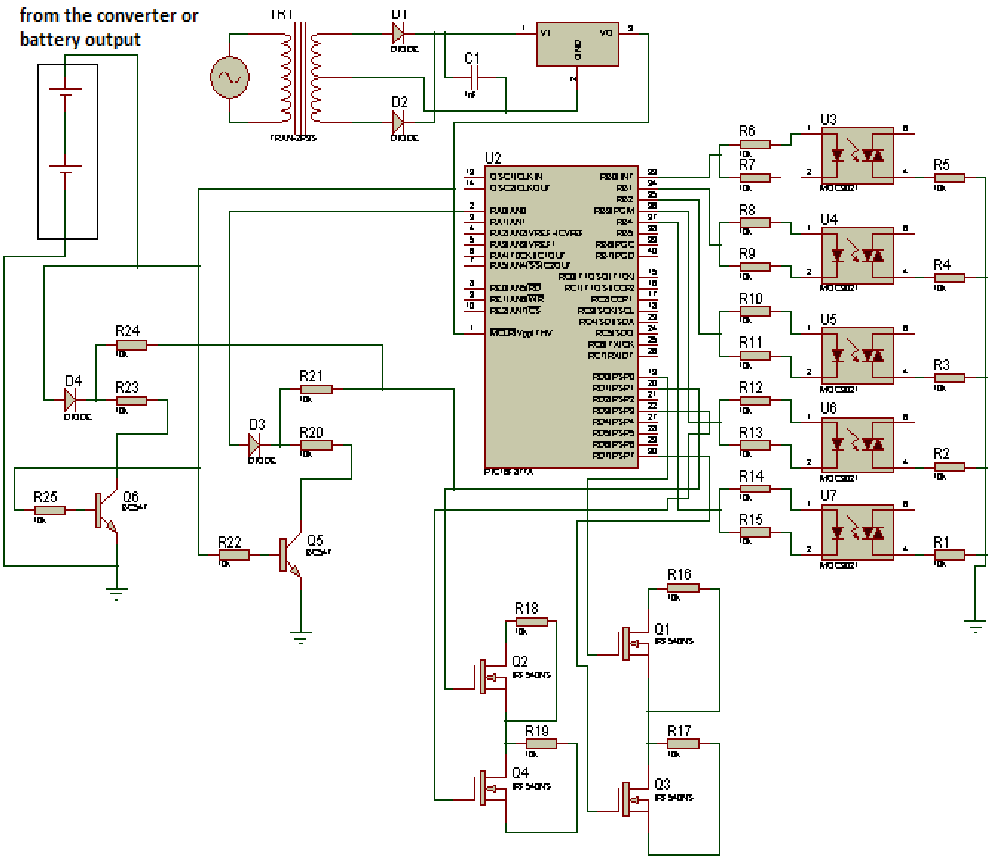

Figure:7 Nine-level Inverter Circuit Diagram

The compared multilevel inverter to a single level inverter has advantages like minimum harmonic distortion and higher power output. An implementation of cascaded H-Bridge topology and a sinusoidal pulse with modulation, synthesize a higher quality output power especially with multilevelconfiguration. Ac loads require constant or adjustable voltages at their input
terminals. When such loads are fed by inverters, it’s essential that output voltageof the inverters is so controlled as to fulfill the requirements of AC loads.
This involves coping with the variation of DC input voltage, for voltageregulation of inverters and for the constant volts/frequency control requirement.The multilevel inverter is meant to generate a preferred ac voltage waveform from dc voltages. The nine-level inverter output waveform is shown in figure:8.

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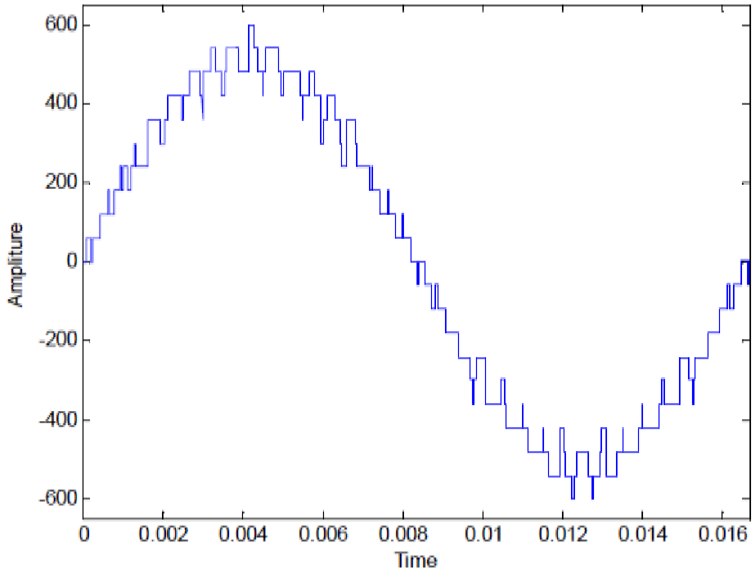

Figure:8 Nine-level Inverter Output Waveform

Arduino Coding

```
void setup() {

// initialize digital pin LED_BUILTIN as an output.pinMode(8, OUTPUT);
pinMode(9, OUTPUT); pinMode(10, OUTPUT);pinMode(11, OUTPUT);
}
// the loop function runs over and over again forevervoid loop() {
digitalWrite(8, HIGH); digitalWrite(9, HIGH); digitalWrite(10, HIGH);digitalWrite(11, HIGH);delay(1);
digitalWrite(8, LOW); digitalWrite(9, HIGH); digitalWrite(10, HIGH);digitalWrite(11, HIGH);delay(1);
digitalWrite(8, LOW); digitalWrite(9, LOW); digitalWrite(10, HIGH);digitalWrite(11, HIGH);delay(1);
digitalWrite(8, LOW); digitalWrite(9, LOW); digitalWrite(10, LOW);digitalWrite(11, HIGH);delay(1);
digitalWrite(8, LOW); digitalWrite(9, LOW); digitalWrite(10, LOW);digitalWrite(11, LOW);delay(1);
digitalWrite(8, LOW); digitalWrite(9, LOW); digitalWrite(10, LOW);digitalWrite(11, HIGH);delay(1);
digitalWrite(8, LOW); digitalWrite(9, LOW); digitalWrite(10, HIGH);digitalWrite(11, HIGH);delay(1);
digitalWrite(8, LOW); digitalWrite(9, HIGH); digitalWrite(10, HIGH);digitalWrite(11, HIGH);delay(1);
digitalWrite(8, HIGH); digitalWrite(9, HIGH); digitalWrite(10, HIGH);digitalWrite(11, HIGH);delay(1);
}
```

GRID SYNCHRONIZATION

Synchronization is the process of matching the voltage and frequency ofa generator or other source to a running network. An AC generator cannot deliverpower to an electrical grid unless it is running at the same frequency as the network. If two segments of a grid are disconnected, they cannot exchange AC power again until they are brought back into exact synchronization.

A direct current (DC) generator can be connected to a power network byadjusting its open-circuit terminal voltage to match the network voltage, by either adjusting its speed or its field excitation. The exact engine speed is not critical. However, an AC generator must match both the amplitude and the timing of the network voltage, which requires both speed and excitation to be systematically controlled for synchronization. In modern grids, synchronizationof generators is carried out by automatic systems.

MPPT-PROPOSED ALGORITHM

Swarm intelligence is an artificial intelligence technique involving the study of collective behavior in decentralized systems. One of the most popular swarm intelligence paradigms is the particle swarm optimization (PSO), which is basically developed through the simulation of social behavior of bird flockingand fish schooling. PSO is a global

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optimization algorithm for dealing with problems on which a point or surface in an n-dimensional space represents a best solution. Potential solutions are plotted in this space and seeded with an initial velocity. Particles move through the problem space, then, a certain fitnesscriterion evaluates them. As time goes by, particles accelerate toward those with better fitness. Several areas have adopted the idea that swarms can solve complexproblems. The term swarms refer to a large group of simple components that work together to achieve a goal and to produce significant results. Unfortunately,a typical PSO is used to solve these problems that the targets (i.e., optimal solutions) are time invariable. On the other hand, the target (i.e., MPP) of a PV MPPT problem is time variable.

Next, evaluate the fitness of each particle according to the given final objective function (i.e., fitness function) at last and current times (i.e., time n − 1 and n). If the fitness value fi (n − 1) at time n − 1 is better than the fitness valuefi (n) at time n, the best particle Pi, best is set as the fitness value fi (n − 1) and the Pi, best location is set on the current location. Otherwise, the best particle Pi,best is set as the fitness value fi (n − 1) and the Pi, best location is not changed.It is clear that the I the module's Pi, best can be written as (1),

$$P_{i,best} = MAX\{f_i(n-1), f_i(n)\},\ i = 1, 2, \ldots, N. \quad (1)$$

After that, the best group G best is replaced by the maximum value of all best particle Pi, best written as (2), and then the G best location is updated,

$$G_{best} = MAX\{P_{i,beat}\ |I=1, 2..., N\}. \quad (2)$$

Finally, the new velocity and position of the I the particle can be obtainedaccording to (3) and (4), respectively,

$$S_i(n+1) = w\,S_i(n) + C_1 rand[P_{i,best} - X_i(n)] + C_2 r\ and\ [G_{best} - X_i(n)] \quad (3)$$

$$X_i(n+1) = X_i(n) + S_i(n+1) \quad (4)$$

In which, Si (n + 1) and Si (n) represent the velocities of the itch particleat times n + 1and n respectively is the inertia weight; C1 is the cognitive component; C2 is the social component; rand [] is a randomizer to generate a random real value bounded in [0,1]; and Xi (n + 1) and Xi (n) represents the positions of the itch particle at times n + 1 and n, respectively. Equation (3) shows the velocity update, according to its previous velocity Si (n), the distancebetween the previous position Xi (n) and Pi, best, and the distance between the previous position Xi (n) and G best. This indicates that the biological swarm chasing algorithm tracks two best Pi, best and G best at the same time. In order to avoid this problem in the proposed Bio-MPPT, the distance Di, k between thenew particle position Xi (n + 1) and others particle positions X k (n + 1) |k=1, i−1 are measured and shown as (5).

If the distance D I, k is larger than a presetting small distance d, the position of the itch particle is updated. Otherwise, the position of the itch particle is not updated as represented in (6) to make each particle have a minimumdistance d.

$$D_{i,k} = |X_i(n+1) - X_k(n+1)\ |k=1..., i-1\ | \quad (5)$$

$$X_i(n+1) = D_{i,k} \le d,\ X_i(n)\_D_{i,k} > d,\ X_i(n+1) \quad (6)$$

This means the chasing direction of the I the particle is suitable; however, it is not perfect. Thus, the next position Xi (n + 1) is not only affected by the own inertia but also strongly affected by the G best to modify the chasingdirection. The flow chart of BSC Algorithm is shown in figure:10.

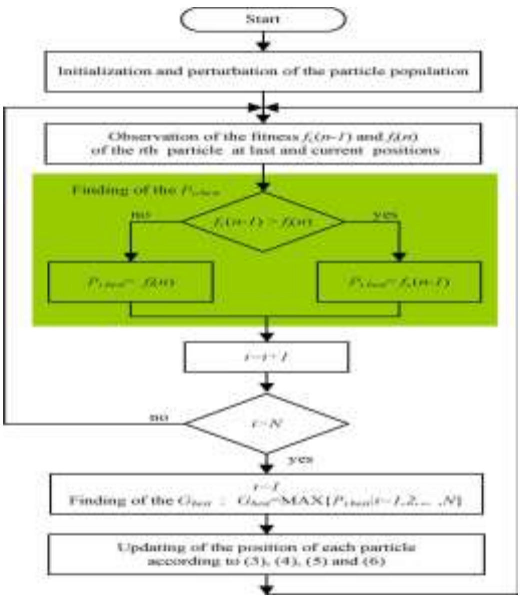

Figure:9 Biological Swarm Chasing Algorithm Flowchart

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CIRCUIT DIAGRAM
The circuit diagram is shown in figure:11.

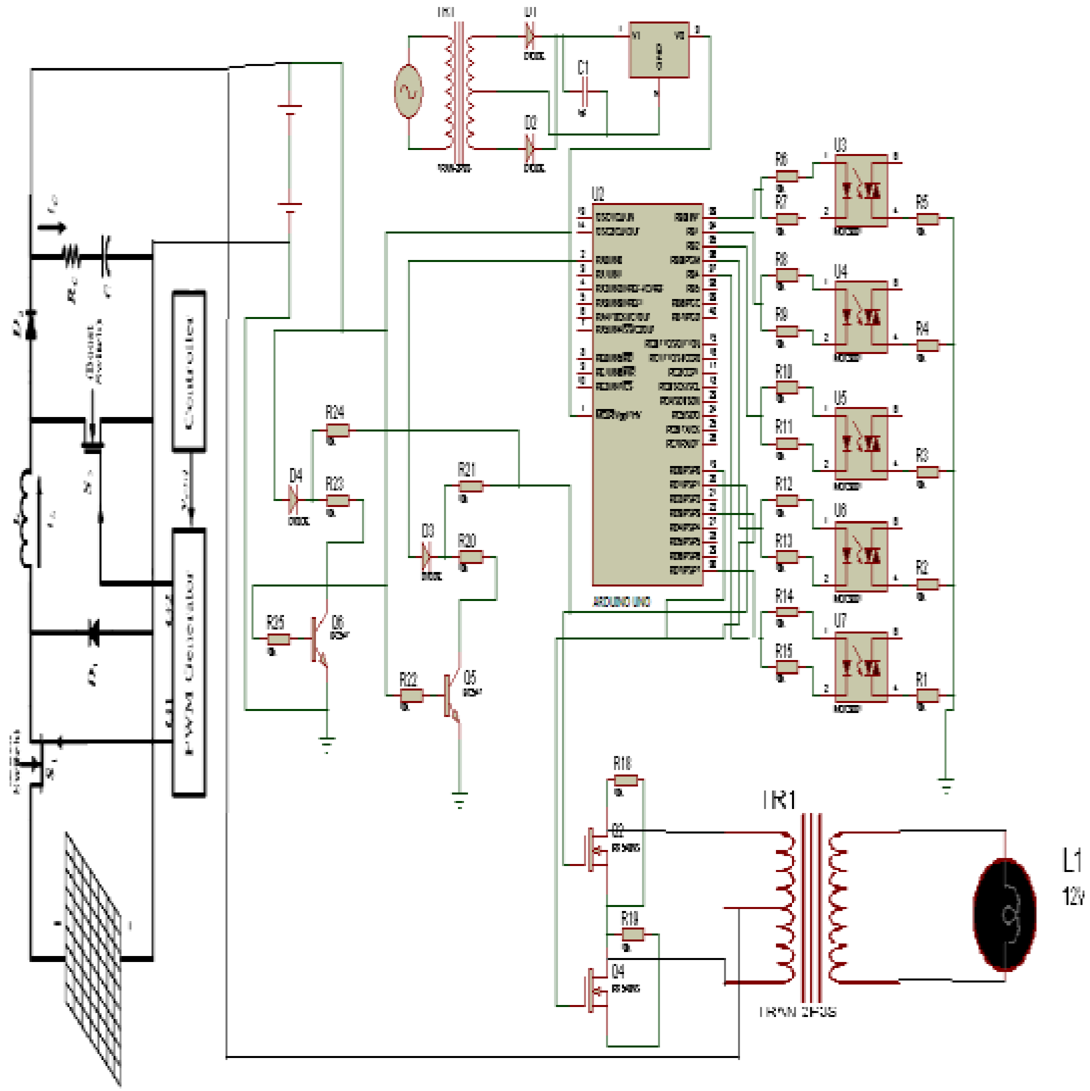

Figure:10 Circuit Diagram

MATLAB R2014a SIMULATOR
MATLAB is a technical computing environment for high-performance numeric computation and visualization, produced by The Math's Works Inc. It includes a number of subject specific toolboxes as well as a dynamic system simulation package, Simulink.

MATLAB is a high-performance language for technical computing. Itintegrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation.

MATLAB is an interactive system whose basic data element is an array thatdoes not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix and vector formulations, in afraction of the time it would take to write a program in a scalar non-interactive language such as C or FORTRAN.

Typical uses include:
- Math and computation
- Algorithm development
- Modeling, simulation, and prototyping
- Data analysis, exploration, and visualization

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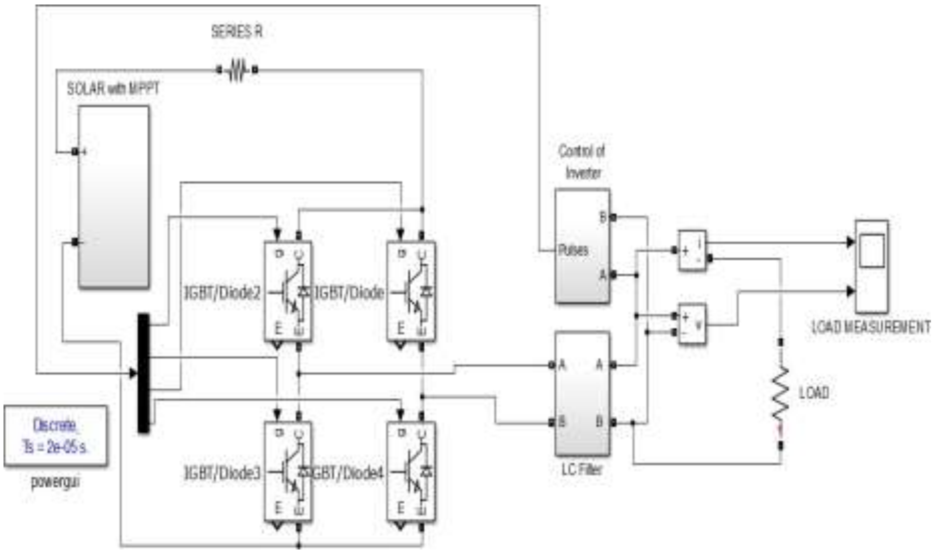
- Scientific and engineering graphics

MODELLING AND SIMULATION

MATLAB has several auxiliary Toolboxes distributed by Math works, Inc., which are useful in constructing models and simulating dynamical systems.These include the System Identification Toolbox, the Optimization Toolbox, andthe Control



System Toolbox. There is also a specialized application, Simulink, which is useful in modular construction and real time simulation of dynamical systems. The proposed system Simulink model is shown in figure:5.1.

Figure:12 Proposed System Simulink Model

ALGORITHMS SIMULATION RESULTS

Incremental Conductance

1) Simulink Model

The Simulink model of INC is shown in figure:5.2.

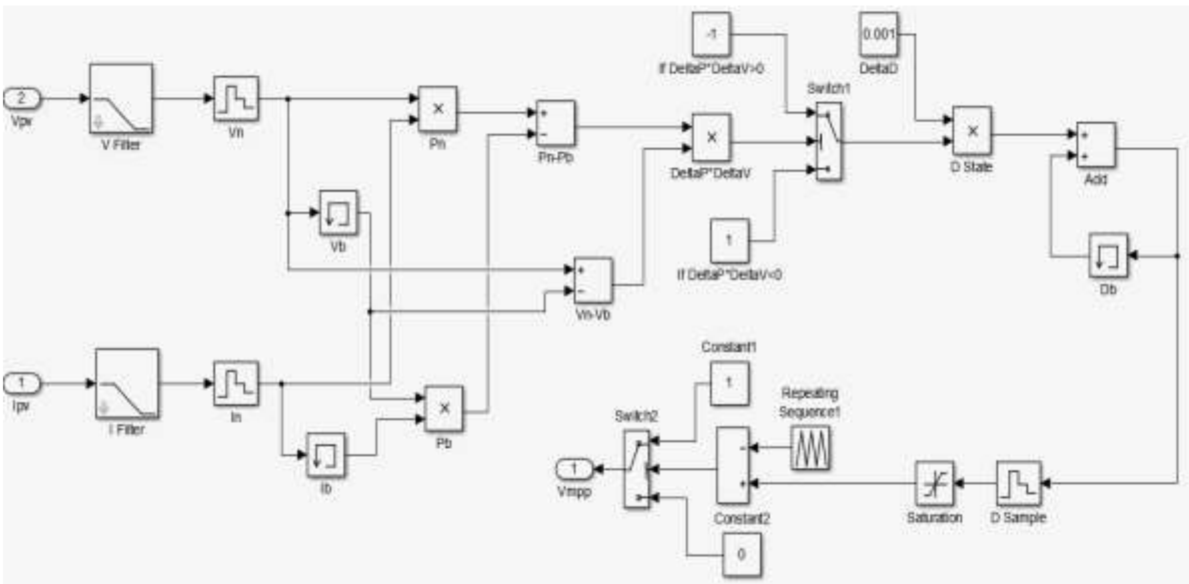


Figure:13 Incremental Conductance Simulink

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2) Simulation Output

The simulation output of INC is shown in figure:13.

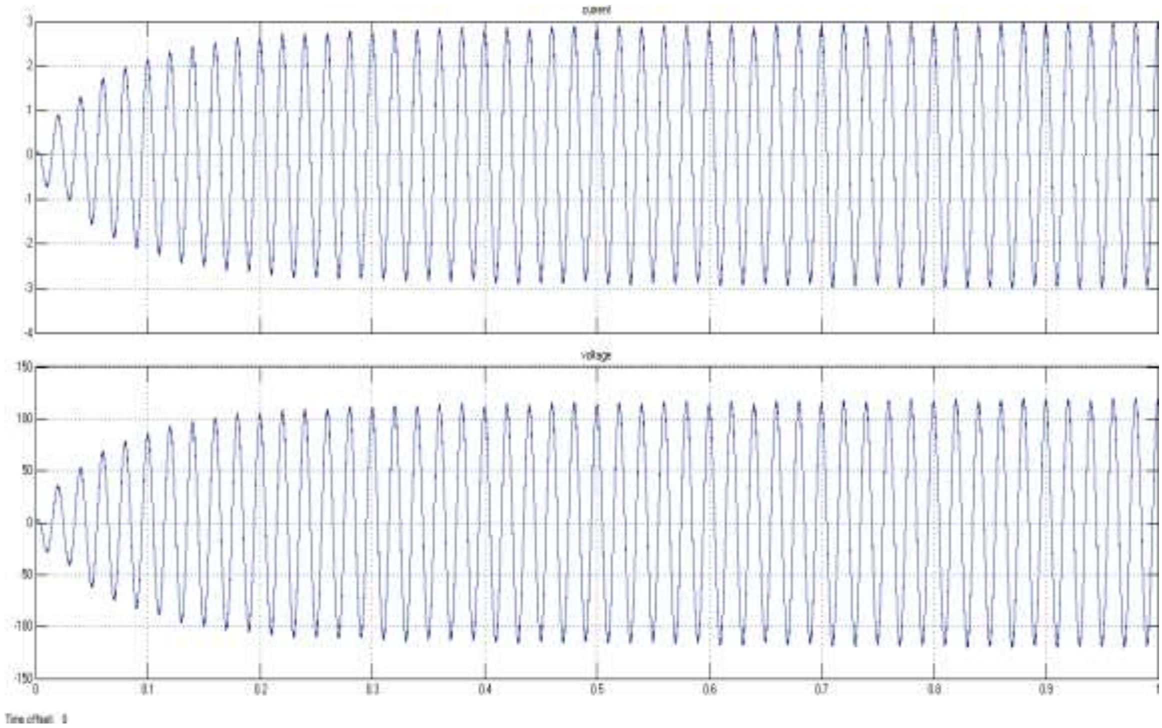

Figure:14 Incremental Conductance Simulation Output

Perturb and Observe

3) Simulink Model

The Simulink model of P and O is shown in figure:15.

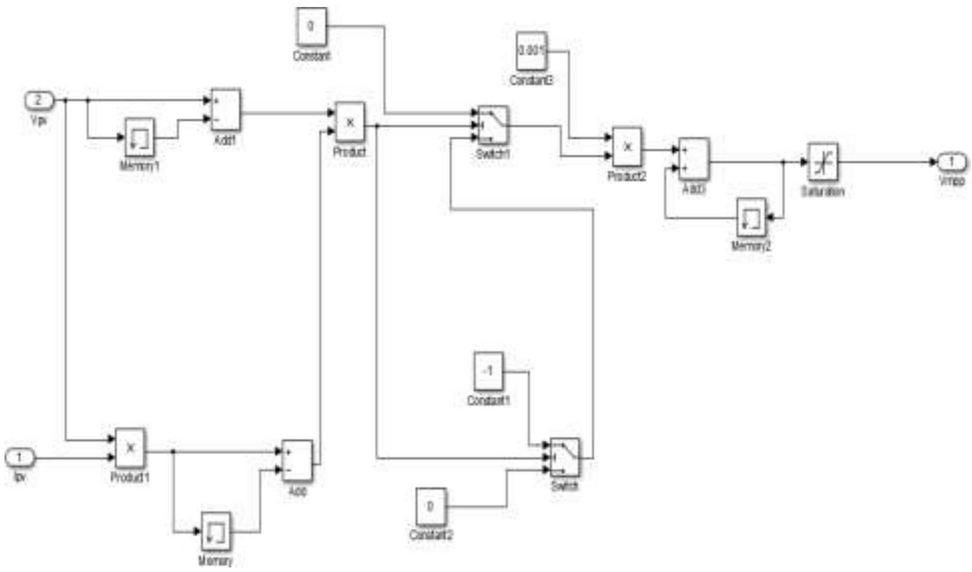

Figure:15 Perturb and Observe Simulink

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4) Simulation Output

The simulation output of P and O is shown in figure:16.

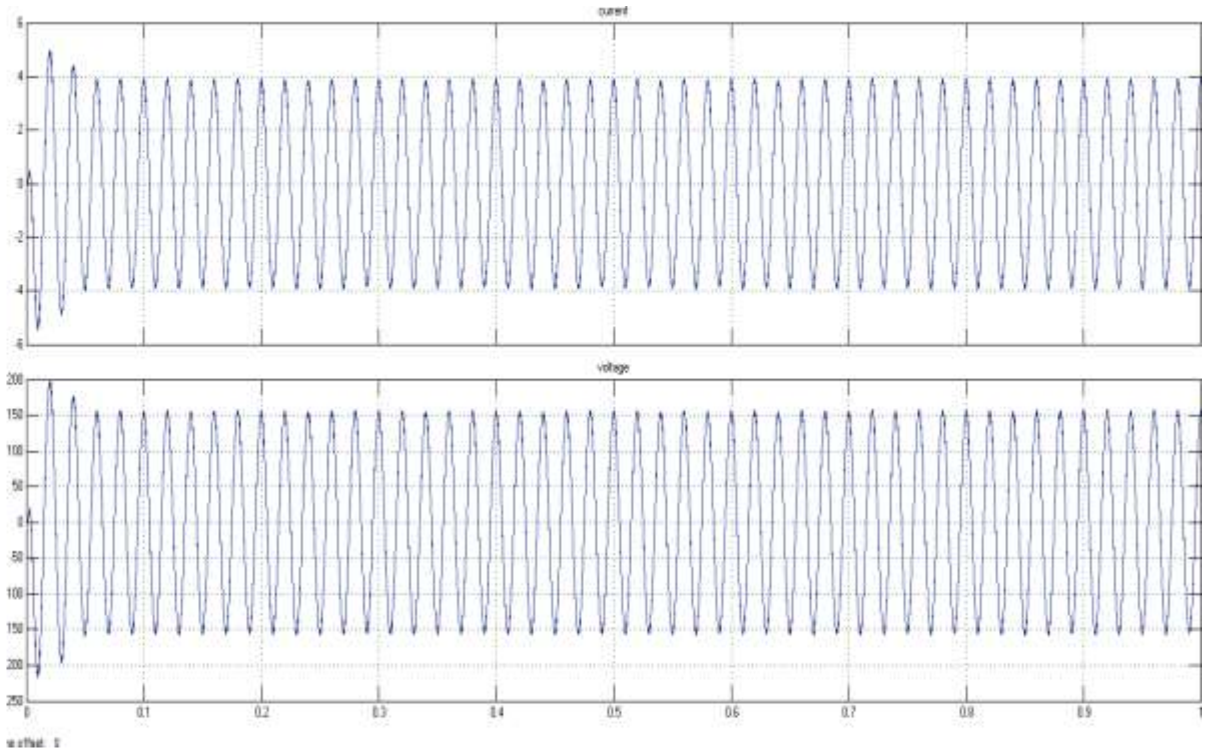

Figure:16 Perturb and Observe Simulation Output

Biological Swarm Chasing

5) Simulink Model

The Simulink model of BSCA is shown in figure:17.

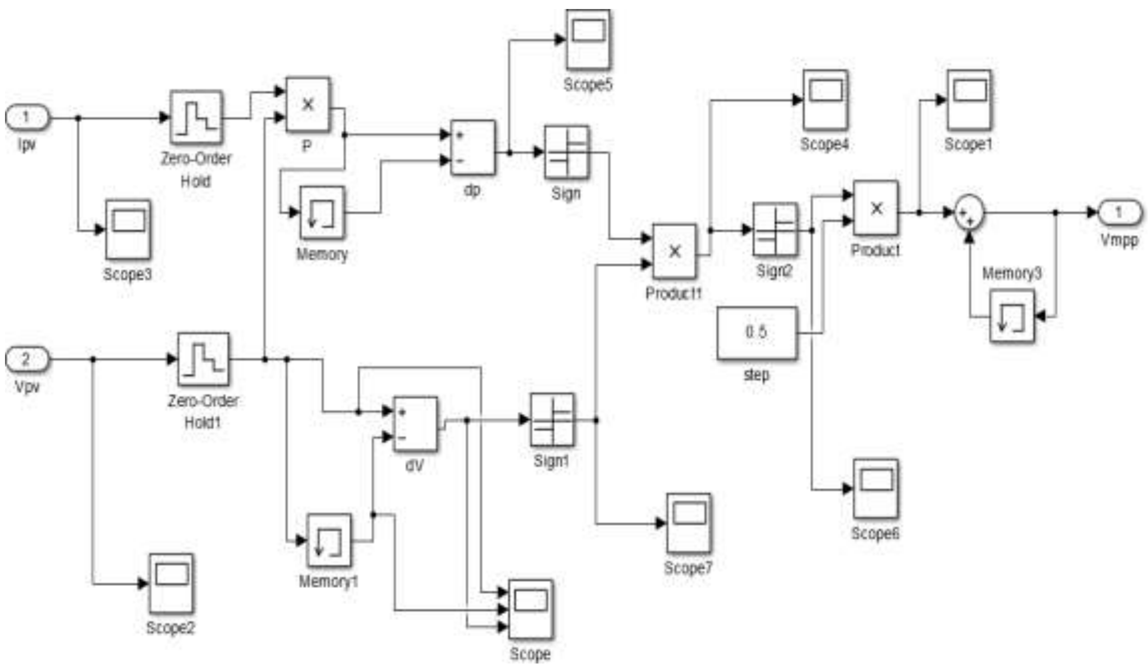

Figure:17 Biological Swarm Chasing Simulink

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6) Simulation Output

a) Solar PV Model Output

The simulation output of solar PV model is shown in figure:18.

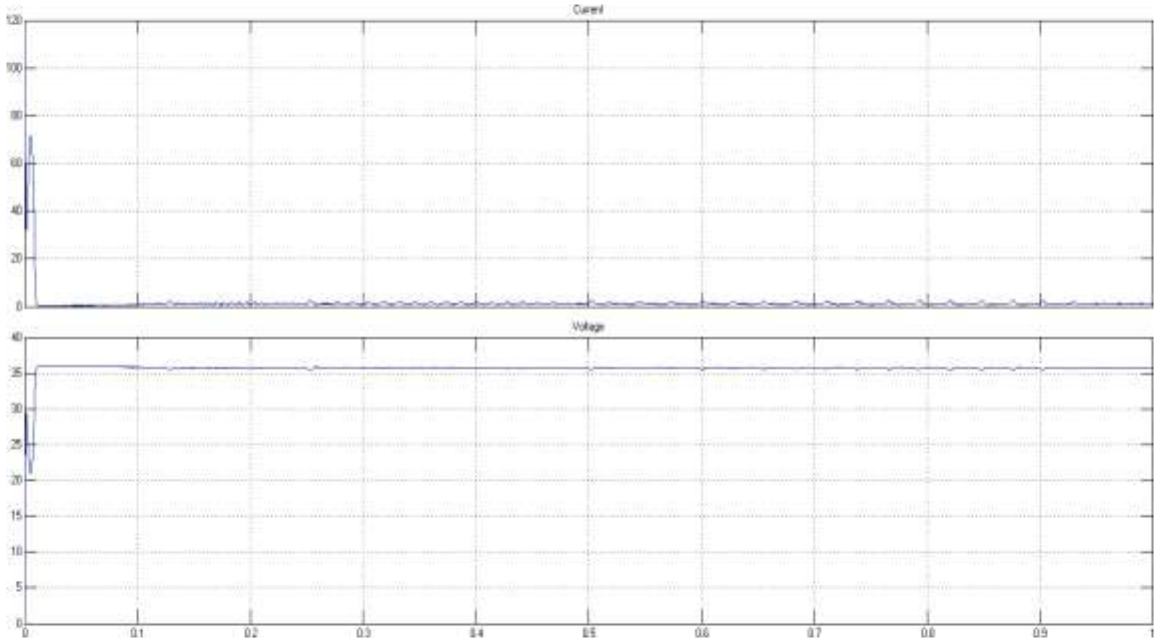

Figure:18 Simulation Output of Solar PV Model

b) Converter Model Output

The simulation output of converter model is shown in figure:19.

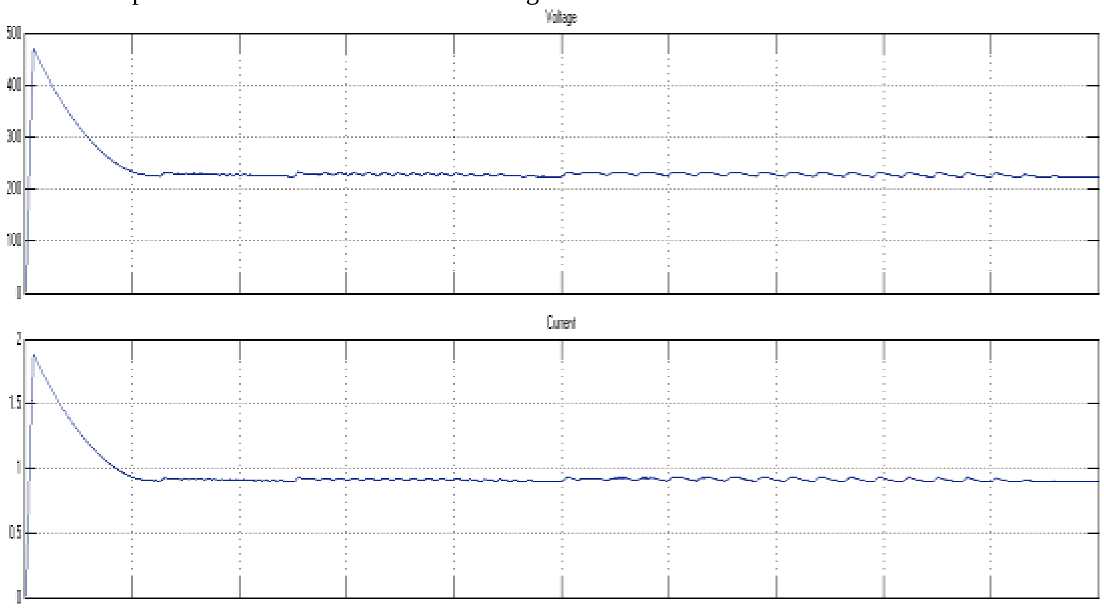

Figure:5.8 Simulation Output of Converter Model

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c) Inverter Model Output

The simulation output of inverter model is shown in figure:19.

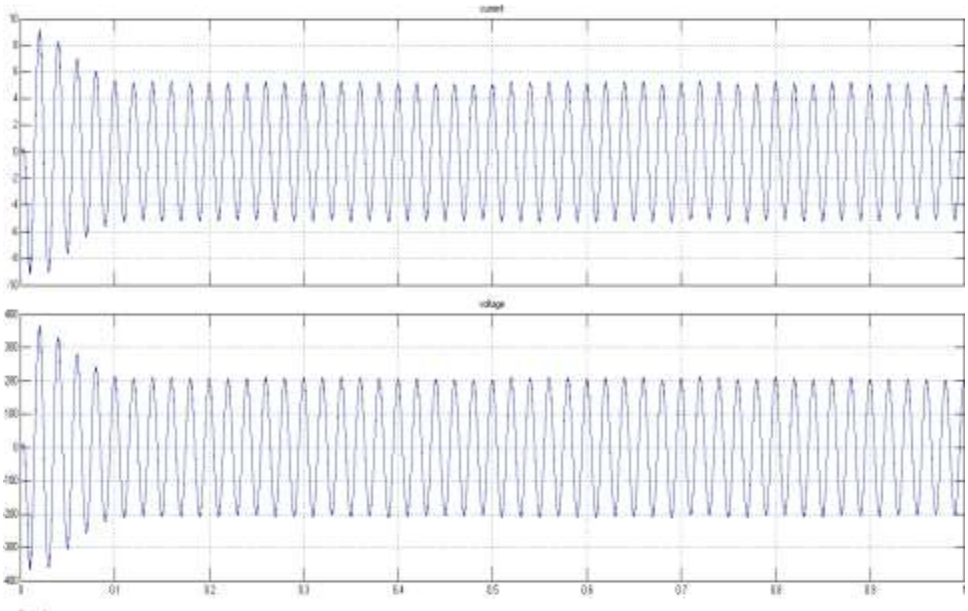

Figure:19 Biological Swarm Chasing Simulation Output

RESULT AND DISCUSSION

The proposed algorithm effectively tracks the global optima of power value.The topology proves to be more efficient in both cost and gain. Losses are highlyreduced with proposed inverter model. Existing MPPT algorithms like P&O andINC fails to track the optimal value under partial shaded conditions. Theproposed optimization technique overcomes this problem. Thus, overall efficiency is improved with the proposed techniques.

Comparative Analysis of Algorithm Parameters

Comparative analysis of algorithm parameters is shown in table:1.

ALGORITHM	FREQUENCY	VOLTAGE	CURRENT	POWER
INC	19KHz	100V	3A	300W
P&O	20KHz	150V	4A	600W
BSCA	22KHz	200V	5A	1000W

Table:1 Comparative Analysis of Algorithm ParametersAlgorithms Efficiency

Algorithms Efficiency is shown in table:2.

ALGORITHM	EFFICIENCY
PSO	85%
INC	87%
P&O	90%
BSCA	95%

Table:2 Algorithms Efficiency

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CONCLUSION AND FUTURE SCOPE

CONCLUSION

A solar PV array and to regulate the output DC voltage, a DC-DC boost converter is controlled using biological swarm chasing technique. The control and implementation of solar PV energy has been presented. A single-phase and a capacitor energy storage system at DC bus are used for regulating voltage andfrequency at load terminals. A buck-boost converter has been used in between solar PV array and DC bus of VSC to achieve maximum power point tracking. These has also been controlled for load leveling. Current transformer to measureload on single phases of our company which is provided to us from Grid. PWMsignal is generated by feeding a reference and a carrier signal through a comparator which creates the output signal based on the difference between thetwo inputs. The reference is a sinusoidal wave at the frequency of the desired output signal.

FUTURE SCOPE

✓ By using nine-level inverter, the system is more efficient. In future, we will use high level of inverters to improvement the performance of the system.

✓ In future, we also going to creating a renewable energy from solar panelsand to grid integration system, by using Bio- MPPT algorithm.

✓ In most of the system, they cannot able to use an actual rate of energy produced by the system. But in this system, it can able to utilize the actualenergy produced by the system. (i.e., the inverter produces a 130V powerof energy we can use full amount of power in this system).

✓ In future, to use a high level of inverters for producing the sinusoidal waveform for easy grid synchronization.

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