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Simulation and Comparative Study of Various Maximum Power Point Tracking Techniques

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Abstract –PV cell work at its full efficiency when it is operating at its maximum power point. The energy derived from the solar-cell is used to power the load. A DC-DC converter is used as an interface between the cell and the load. A boost converter is implemented to get boosted output voltage. Perturbation and Observation technique is a basic technique which is used to track the MPP. Fuzzy Logic Control (FLC), Artificial Neural Network (ANN), Particle Swarm Optimization (PSO) and Flower Pollination Algorithms (FPA) are some modern techniques which can to track the MPP more efficiently. This literature distinguishes different MPPT techniques.

Introduction –

The model of a basic PV cell is taken in this literature. The constant irradiation value of (500W/m2) and temperature of (25°C) is taken. It is vital to consider MPPT as it is needed for supplying maximum power to the load under varying environmental conditions.

Numerous analysts and industry delegates from all over the world have built up many MPPT techniques. Some main algorithms like perturb and observe (P&O) technique, fuzzy logic control, Artificial Neural Network, Particle Swarm Optimization and Flower Pollination Algorithms are implemented in this study with detailed explanation.

This paper focuses on comparing and looking at differentMPPT strategies like Perturb and Observe, Fuzzy Logic Control (FLC) , Artificial Neural Network (ANN), Particle Swarm Optimization (PSO) and Flower Pollination Algorithms (FPA). For simulation tasks and modeling of dc-dc converter and for detailed comparison, different MPPT methods are implemented.

System Description –

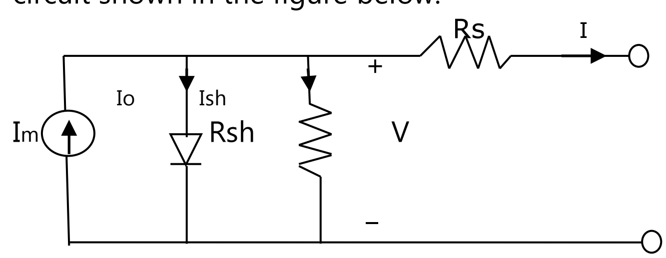
The whole model can be classified into:-

(a) Electrical force producing Solar PV framework

(b) DC/DC support converter

(c) MPPT procedures.

The PV cell can be represented by its basic electrical circuit shown in the figure below.



PV cell circuit

Here,

Io - diode leakage current

Im - module current

Ish - shunt current

V - outputvolatge

I - output current

According to Kirchhoff's law:

I= Im – Io – Ish ...Equation (1)

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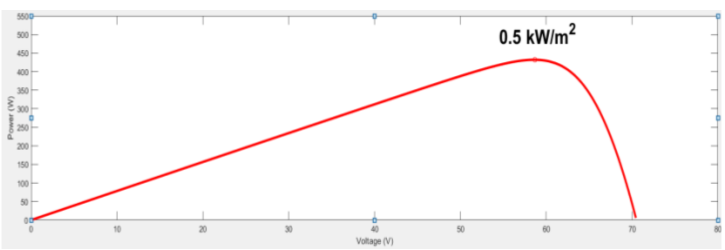
Im is given by

Im = Ipv – IoNp{exp(V + Rs(Ns/Np)/1)/ (VtaNs) } – 1 ...Equation (2)

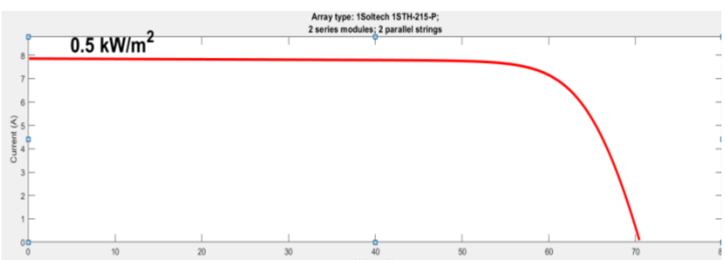
Np - Number of modules connected in parallel
Ns - Number of modules connected in series
a -Ideality factor
Ipv - PV current
Io - Reverse leakage current
Vt - Thermal voltage

The expressions of PV cell are simulated in MATLAB SIMULINK using 1 SOLTECH-STH-215-P module. Diagram shows the I-V and P-V graphs of the pv cell under constant irradiance and constanttemperature.

For irradiance of 500 Watt per meter square the ideal Pmaxis 431.9 Watt and Vmpp is 58 Volts.



P-V Graph



I-V Graph

The PV array is connected to the boost converter to get a high boosted voltage.The calculated ratings

DESRIPTION	RATINGS
SWITCHING FREQUENCY	25000Hz
VOLTAGE RIPPLE	5%
CURRENT RIPPLE	3%
CAPACITOR	0.1mF
INDUCTOR	2 mH
RESISTIVE LOAD	20 Ω

MPPT CONTROL STRATEGIES –

(a.) PERTURB AND OBSERVE

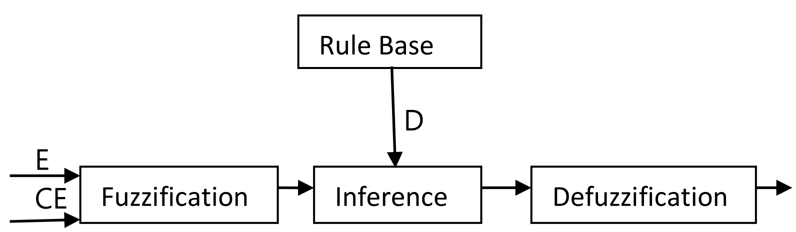
P&O is a simple and easy-to-design MPPT process. It only uses one voltage sensor unit to sense the voltage value of the PV array, so the cost of completion is low and the process is simple. The MPPT algorithm has a low time complexity, but it does not stop disquieting on both directions of the MPP. The current power and voltage values are compared to the previous values in this comparison and thus duty cycle is calculated.Perturbation and Observation principle is simply as follows:

1) If the power and voltage changes are both positive, the duty cycle should decrease.

2) If the difference between the power (ΔP) and voltage changes (ΔV) is negative, the duty cycle can increase.

(b.) FUZZY LOGIC CONTROL

Recently, FLC is introduced for maximum power point tracking in the PV system. The different processes of a fuzzy logic controller are as shown in the Figure below. FLC controllers are very advantageous as well as robust.



The two inputs i.e. change of error (CE) and error (E) are defined as,

$$E(K) = \frac{Ppv(K)-Ppv(K-1)}{Vpv(k)-Vpv(K-1)} \quad \text{...Equation (3)}$$

CE(K) = E(K)-E(K-1) ...Equation (4)

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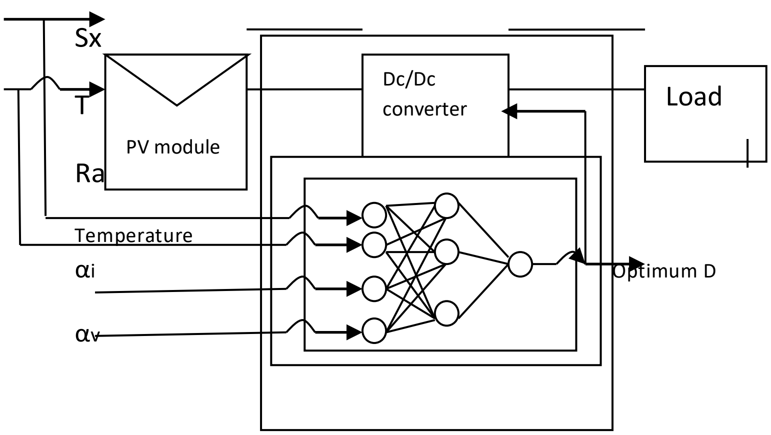
The Instantaneous power of PV array is P_{PV}.Fuzzy inference is processed using Mamdani's method. Defuzzification is done to find out the duty cycle.

Dutycycle output is processed by using center of gravity method.The fuzzy rule base matrix which is used in this literature is given as follows:

(E , CE)	NB	NS	Z	PS	PB
NB	PB	PS	NS	NS	NB
NS	PS	PS	NS	PB	NB
Z	NB	NB	NS	PS	PB
PS	NS	NS	PB	NB	PS
PB	NS	NS	PB	PB	PB

(c.)ARTIFICIAL NEURAL NETWORK

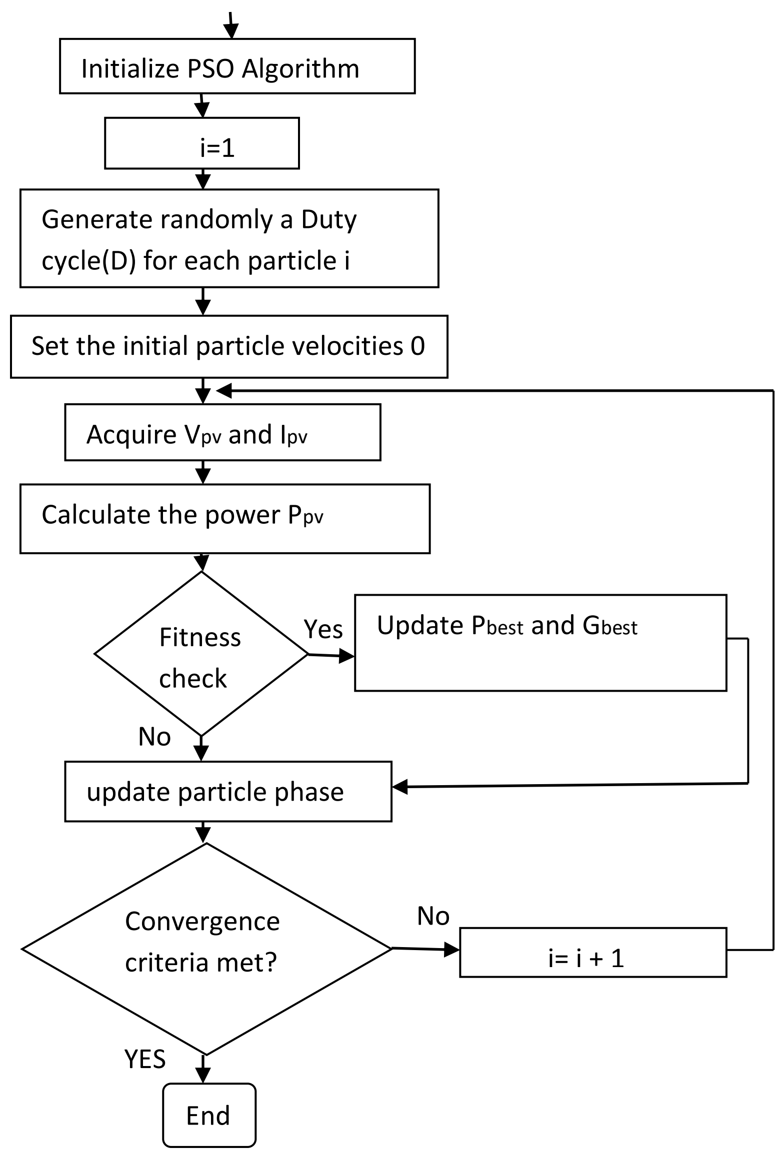
The ANN is trained using NNTOOL BOX in Matlab. Data set of Temperature and irradiation varying between 25-50°C and 200-1200W/m2 respectively is given as input to neural network and their corresponding Vmpp values are obtained from P-V array plots.



(d.) PARTICLE SWARM OPTIMISATION

The Particle Swarm Optimization explores the Search-Space, and can be utilized to decide the segments a gs needed to streamline a particular Objective Function. The operation starts with a random selection, proceeds with a search for ideal solutions through prior iterations, and assesses the solution quality through the wellness/fitness. The PSO controller is appropriate for the deduction of the worldwide ideal. It is a basic algorithm, and has a high following precision.

The principle of the PSO algorithm is shown in the following flowchart.



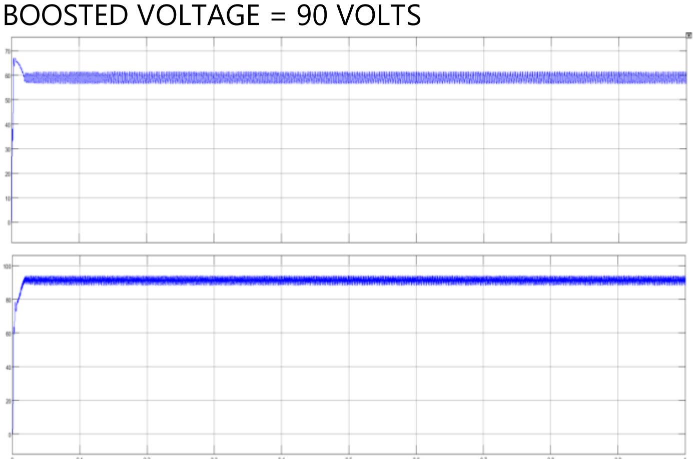
(e.) FLOWER POLLINATION ALGORITHM

All of the initial pollens must be spread throughout the entire duty cycle spectrum, and the entire power-duty cycle curve (P-D curve) must be searched. For the global quest, the best pollen number m selection is critical. The probability of finding the global optimal solution increases as the number m is increased, yet the convergence time increases.

The flower pollination algorithm has been shown to be efficient in finding global optimal solutions in a short amount of time. It's been commonly used to solve nonlinear optimization problems in recent years. In comparison to other approaches, the FP algorithm is easy to modify and has less parameters.The conversion probability parameter can be used to enforce dynamic conversion between global and local search, and thus the balance between global and local search is well solved. It also outperforms PSO in terms of convergence speed.

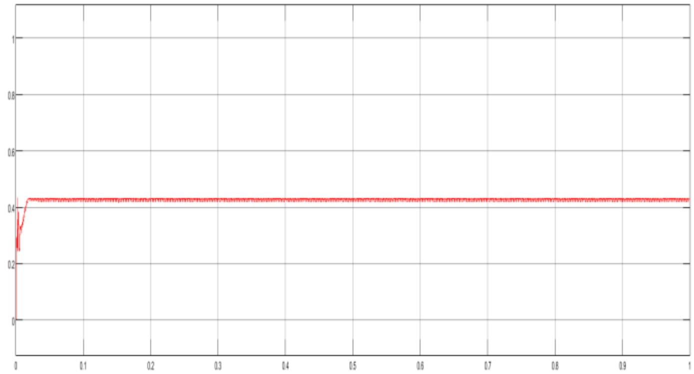
SIMULATION RESULTS AND COMPARISONS –

(a.)P&O ALGORITHM :
INPUT VOLTAGE =60 VOLTS
BOOSTED VOLTAGE = 90 VOLTS



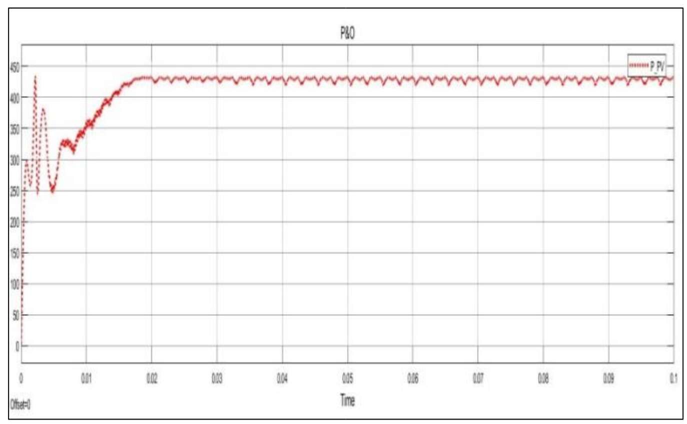
Voltage time graph

Maximum Power =424.78 Watt(Run for 1 Second)



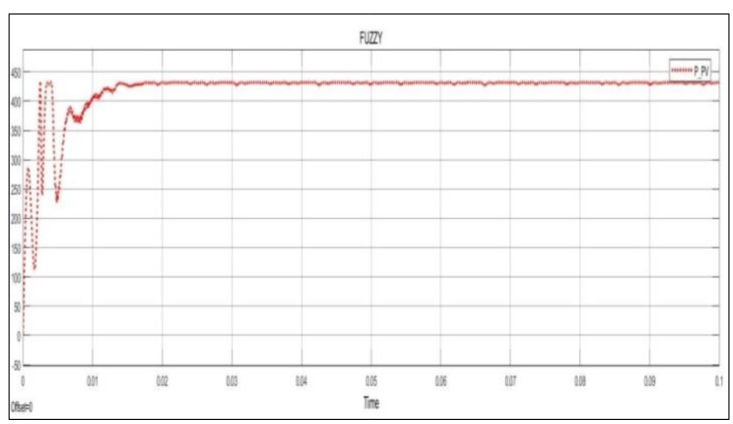
Power time graph

TRANSIENT PERIOD of 0.1 second (Slow Time response)



(b.)FUZZY LOGIC CONTROL

INPUT VOLTAGE =60 VOLTS
BOOSTED VOLTAGE = 90 VOLTS



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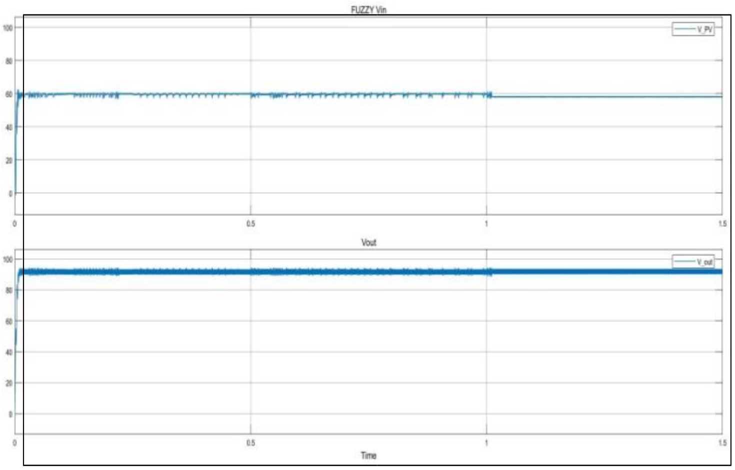
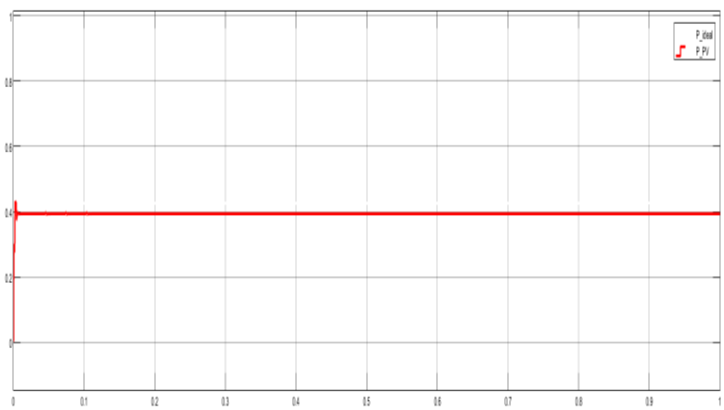
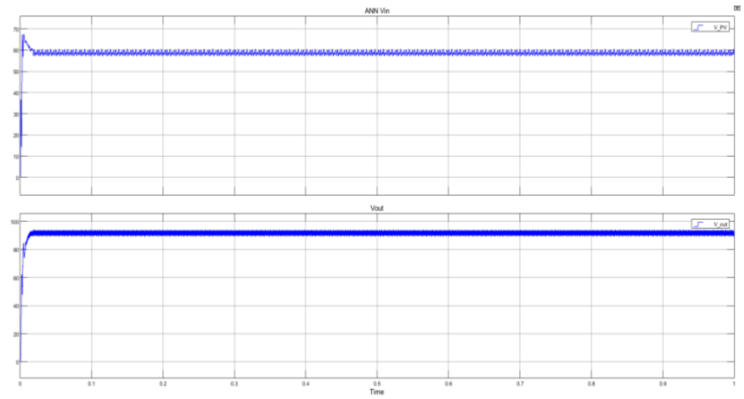


Maximum Power = 428.6 Watt (Run for 1 Second)



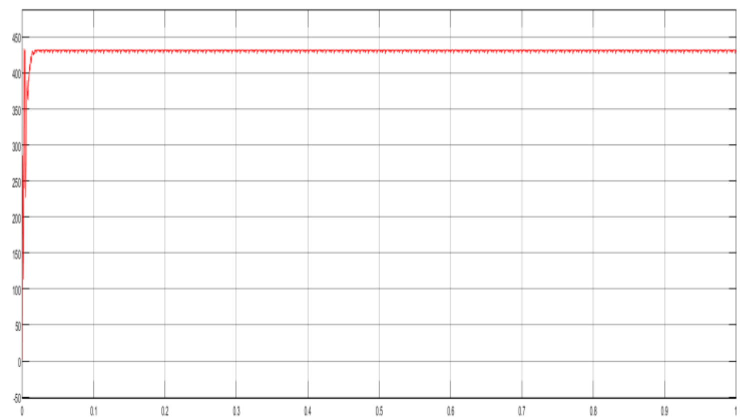
TRANSIENT PERIOD of 0.1 second (Moderate Time response)

(c.)ANN
INPUT VOLTAGE =60 VOLTS
BOOSTED VOLTAGE = 90 VOLTS



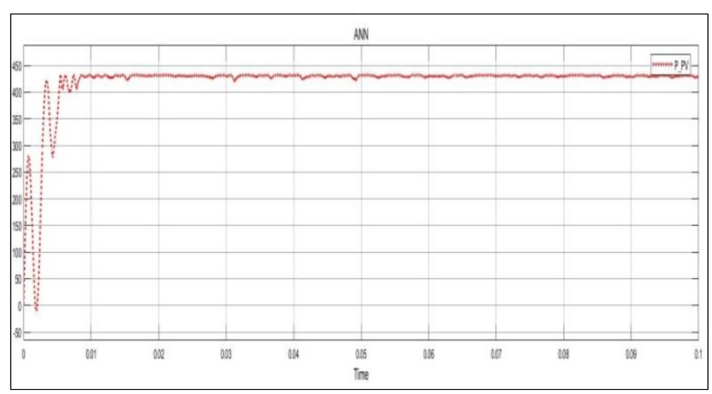
Voltage time graph

Maximum Power = 430.8Watt (Run for 1 Second)



Power time graph

TRANSIENT PERIOD of 0.1 second (Fast Time response)



(d.)PSO ALGORITHM
INPUT VOLTAGE =60 VOLTS
BOOSTED VOLTAGE = 90 VOLTS

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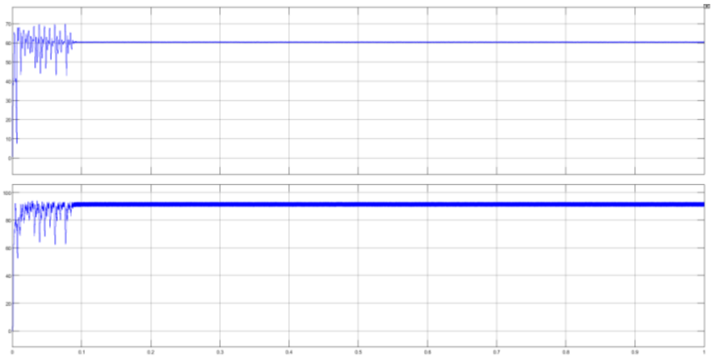
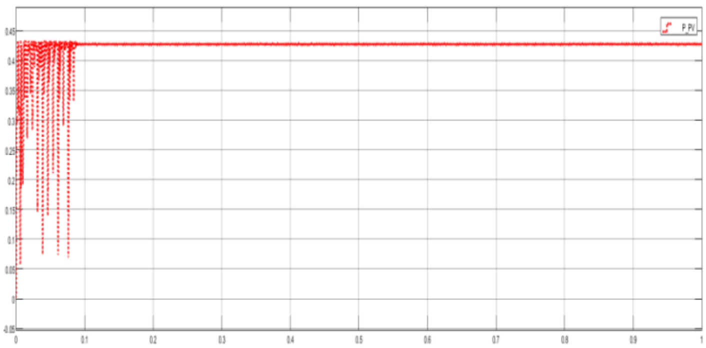


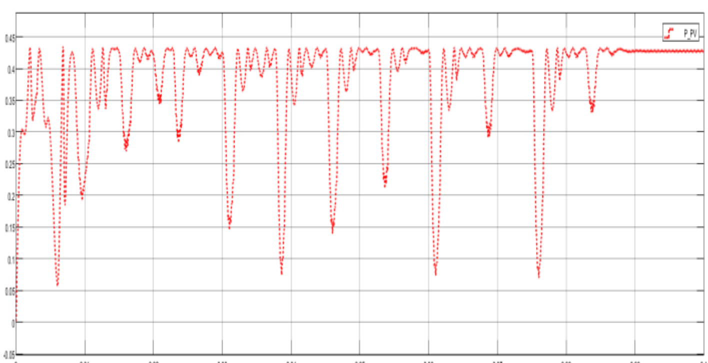
Voltage time graph

Maximum Power = 426.69 Watt (Run for 1 Second)

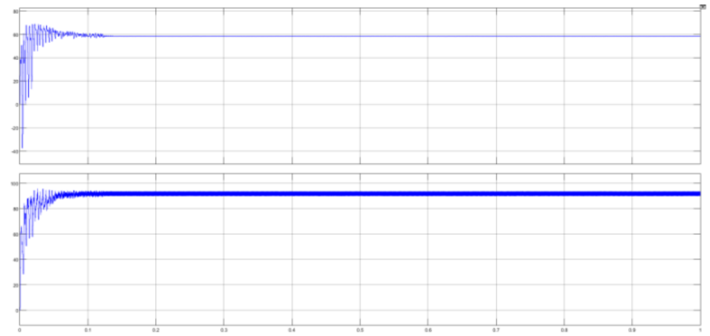


Power time graph

TRANSIENT PERIOD of 0.1 second (Slowest Time response)

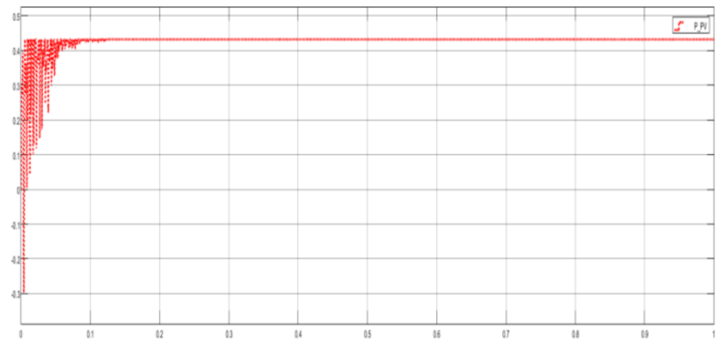


(e.) FLOWER POLLINATION ALGORITHM
INPUT VOLTAGE =60 VOLTS
BOOSTED VOLTAGE = 90 VOLTS



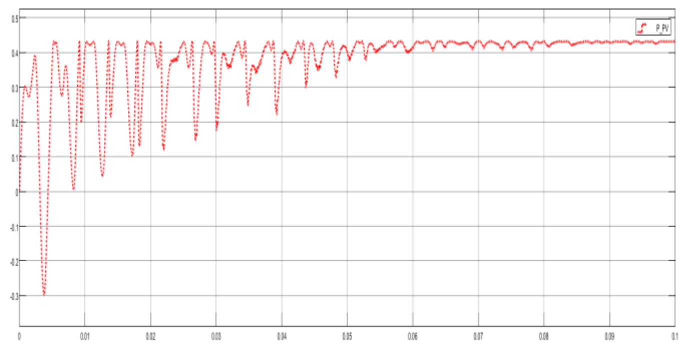
Voltage time graph

Maximum Power = 427.23 Watt (Run for 1 Second)



Power time graph

TRANSIENT PERIOD of 0.1 second (Slow Time response)



	TRANSIENT RESPONSE	**COMPLEXITY**	**POWER CONSUMPTION**
P&O	SLOW	SIMPLE	LESS EFFICIENT
FLC	FAST	COMPLEX	HIGH EFFICIENT
ANN	VERY FAST	VERY COMPLEX	VERY HIGH EFFICIENT
PSO	SLOWEST	COMPLEX METAHEURISTIC TECHNIQUE	EFFICIENT
FPA	SLOW	COMPLEX METAHEURISTIC TECHNIQUE	EFFECIENT

CONCLUSION

This paper shows the detailed comparison of different maximum power point tracking controllers. It can be seen from the graph that the time response in reaching maximum power point is fastest in the ANN controller and time response in the FLC controller is moderate while P&O controller has slow time response. PSO controller has the slowest time response. All the controllers are successfully tracking ideal maximum power i.e. 431.9Watt.

ANN is the most efficient technique achieving power point followed by fuzzy controller and then P&O algorithm. P&O is a simple technique while Fuzzy and ANN are two very complex modern techniques. PSO and FPA are two complex met heuristic techniques. FPA is better than PSO in convergence speed.

Hence ANN has most power consumption and is the most efficient algorithm.

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