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GW OPTIMIZATION-BASED MPPT FOR SOLAR PHOTOVOLTAIC SYSTEM

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ABSTRACT

The most efficient and cleanest form of renewable energy source for effective power generation is the solar photovoltaic (PV) system. In recent years, solar energy generation has become an essential part of electric power applications. The power produced by the solar PV system is unstable, as it depends upon illumination and global climatic change. So as to get the uttermost efficacy the solar PV system must be guided at the maximum point. An efficient MPP tracking method has a vital function to play in upgrading the efficacy of a solar PV system. The operational point of the perturb and observe (P&O) approach swings about MPP at a steady state, resulting in power output variations. In this work, the Grey Wolf (GW) optimization-based MPPT is proposed. The GW is a Metaheuristic optimization technique that extracts the highest amount of energy from a solar PV system. The PV module's voltage and current are utilized as inputs and the duty ratio is the indeed output that has been obtained and it is been tested under different operating conditions. Depending on the fluctuations in input power, a DC/DC boost converter is utilized to increase the wattage of the output. To estimate the usefulness of this MPPT, the outcomes of GW are correlated with the P&O approach and outcomes demonstrate the GW MPPT gives better power output and its convergence time is faster than the P&O method for change in irradiation levels.

Keywords: solar photovoltaic systems, maximum power point, perturb and observe, meta-heuristic, grey wolf optimization.

1. INTRODUCTION

To help mankind, in order to overcome various issues, solar energy can be used. Solar energy is an inexhaustible energy source that has the possibility to help humanity. This power source is gaining favour due to its flexibility and the numerous welfare to the human resource and the surroundings. Flooding and hurricanes are increasing due to disrupted weather patterns and climatic changes in the natural world. Oceans are becoming more acidic because of the high amount of carbon dioxide levels in the airspace, which is harming aquatic life. The polar ice melts because of the moderately hot temperatures, the melting of the polar ice causes the sea levels to raise and limits wildlife habitats. Uneven rainfall and scarcity influence the employment and income of the poorest people all over the world and on agriculture also.

Sun energy uses solar illumination to generate electricity and it is the most clean and sustainable form of energy that is available on the earth. The electric current which is produced is based on the photoelectric phenomenon, which permits certain matters to absorb the photons on the sun's light and the electrons is been released. Despite the fact that **the** whole earth's median power at the surface in the form of sun illumination surpasses total current energy usage by 15,000 times, its low density and topographical and schedule time fluctuations make efficient utilisation difficult.

The sun's power has the potential to alleviate climate change. Solar energy has a lower carbon footprint, making it a safe option to burn fossil fuels for power generation, which pollutes the air, water, and land. Solar energy, in various forms, is the source of practically all energy on the planet, and mankind has trapped it in various ways.

Photovoltaic modules (PV) are increasingly exciting renewable energy resources due to qualities such as simple integration and DC power output with none of the extra equipment. Solar illumination and global climatic change are the operating conditions that vary the Tracking of the utmost point in the photoelectric system. Currently, the utmost electrical outlet tracking is often finished a spread of MPP algorithms.

The two groups can be sorted based on the methodology of MPPT techniques which is the direct and indirect methods. If the earlier calculated voltage and the current is taken into account and used it is an indirect method, and it is dependent on the panel. If the substantial MPP of the panel is taken into account it is a direct method and is independent of the panel.

The familiar direct method for the MPPT includes the approach of perturbation and observation (P&O) and also increment conduct technique (INC). The steady state, and the fluctuations of the operating point is the major issue of the perturb an observe method (P&O). The operating point instability also causes instability in power output. to overcome the instability issues here MPPT based on the Grey Wolf (GW) optimization is proposed.

In 2014, Seyedali Mirjalili composed the meta-heuristic optimization technique which was supported by socializing and the hunting tactics of the wolf, and the strong optimization method is named as the grey wolf optimization (GWO) technique, an irresistible optimization technique.

For the study of the GWO technique based on the MPPT method. The GWO technique is used to construct a simulation of a PV array intended using a DC/DC boost converter. It is modeled in MATLAB-SIMULINK 2019a and the functioning is been noted. The results are scrutinized and the suggested GWO MPPT approach had a quicker convergence rate and shorter MPP fluctuations than the P&O method.

2. BLOCK DIAGRAM

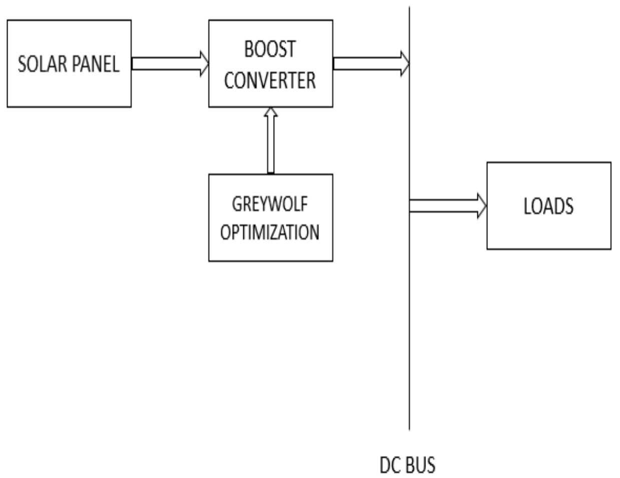

Figure-1. Suggested technique's block diagram.

The suggested technique is depicted as a layout in Figure-1. The solar power is obtained from the solar panel with numerous irradiances and temperature. The two inputs of the GWO technique are the voltage and current values of the electrical device and therefore the output of the system is going to be the duty cycle and also the obtained duty cycle is used to trigger the PWM generator in the boost circuit. The boost converter produces the most power, which is then delivered to the DC loads.

A. Solar Panel

Solar energy is the cleanest form of renewable energy available abundantly on nature. The solar PV panel collects the solar energy available and converts it into electricity. The power output of the solar depends upon the irradiation, temperature, and the location of the panel placed. The solar cells can be connected in both series and parallel to produce more energy.

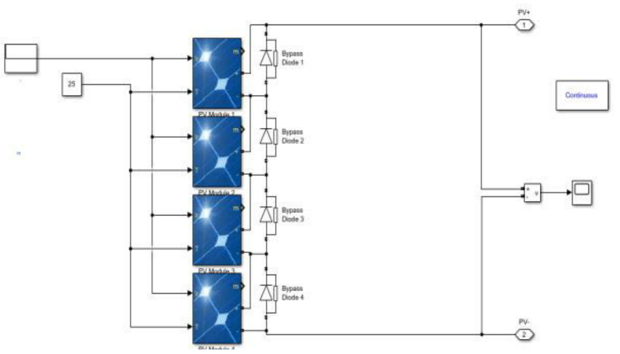

Figure-2. Solar PV panel series connection.

Figure-2 shows the series connection of 4 panels where one panel's positive terminal is connected to the second panel's negative terminal. The temperature and irradiance are given as inputs and the voltage and current are the outputs. The step input is given for irradiance.

B. Boost Converter

The most common type of DC-DC converter could be a boost converter. The converter's goal is to improve the voltage level. It is used to improve the input voltage. Figure-3 represents the traditional boost converter circuit. A voltage source, inductor, switch, diode, and a capacitor make up the circuit.

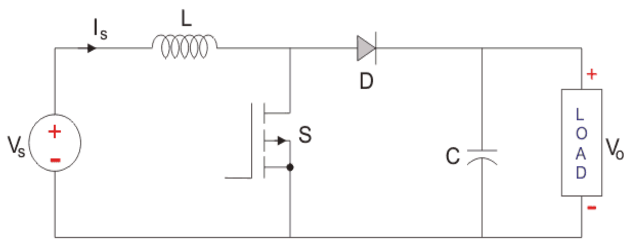

Figure-3. Traditional boost converter circuit.

When the PWM generator turns on the switch, the current goes via the inductor L, which stores the energy. When the switch is turned off, the load receives both the inductor stored energy and the source voltage, resulting in a load voltage that is greater than the source voltage.

3. GREY WOLF OPTIMIZATION ALGORITHM

In 2014, Syedali Mirjalili founded the grey wolf optimization algorithm. GWO focuses on the grey wolves' leadership pecking order and the trapping operation. These grey wolfs always live in groups. These grey wolves are characterized as (alpha) wolf, (beta) wolf, (delta) wolf, and (omega) wolf. Where the (alpha) wolf is taken into account because the finest solution and (beta) wolf is the second finest solution and delta wolf is the third finest solution and the omega wolf is the opposite candidate solution.

The three major steps for GWO optimization are hunting, chasing, attacking, and encircling the prey. The alpha wolf is considered the finest solution. In every iteration, the beta wolf and delta wolf position is updated and the alpha wolf position is updated at every iteration and decided to attack the target.

$$\vec{S} = |\vec{C} \cdot \overrightarrow{Gp}(t) - \vec{G}(t)|$$
$$\vec{G}\,(t+1) = \overrightarrow{Gp}(t) - \vec{B} \cdot \vec{S}$$

$\vec{S}$ is the interspace between the hunter and the prey.$\overrightarrow{Gp}$is the prey's vector position. t represents the iteration value.

$$\vec{B} = 2\vec{a} \cdot \overrightarrow{r1} - \vec{a}$$
$$\vec{D} = 2 \cdot \overrightarrow{r2}$$

The values of vector B and vector D can be calculated from the above equations respectively.

The B and D vectors can update their position in each iteration and when the B value gets increased the wolf does not attack the prey and only the approach to prey is accomplished when the value is diminished.r1, and r2 are the random vectors whose values are [0, 2].

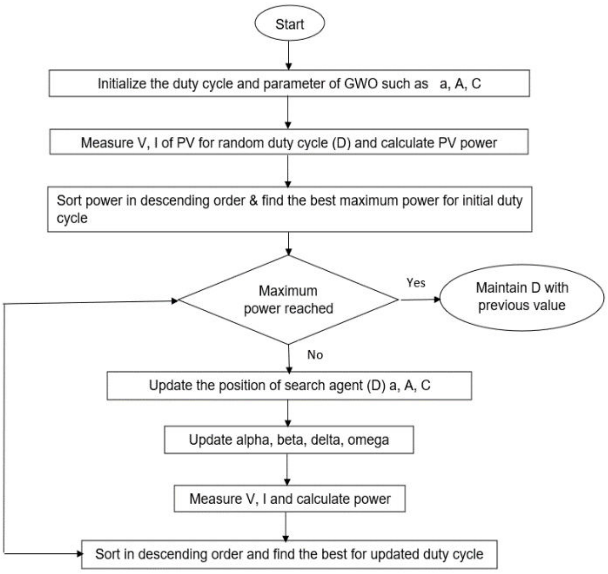

Figure-4. Flow chart for GWO.

The duty ratio is estimated using this GWO technique, which reads the voltage (V) and current (I) values continuously. Depending upon the operating conditions, the boost converter and PWM signal connected across the PV panel are managed.

The two inputs and outputs are provided by GWO MPPT. As said before the current (I) and the voltage (V) are read continuously and the first output which is calculated according to GWO optimization is alpha power(W) and the second output is the duty ratio which is computed using GWO optimization to produce the greatest output power.

4. RESULTS OF THE SIMULATION

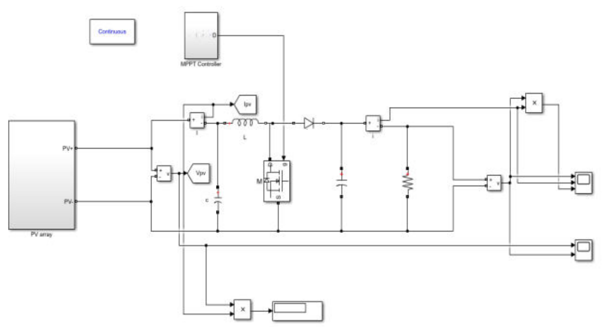

Figure-5. Circuit diagram.

PV model with boost converter in MATLAB/SIMULINK utilizing grey wolf algorithm (GWO) is shown in Figure-5.

By measuring the voltage and current, the PV module's power may be estimated. The PV module voltage and current are used as the intake for the GW algorithm. The GW algorithm modifies the duty cycle of the switch based on volts and amps from the photovoltaic module, resulting in an adjustment of reflected load impedance dependent on the PV array's power output. The duty cycle is the obtained result, which is checked under various operating situations. To compensate for fluctuations in input power, the output power is been adjusted using the DC/DC boost converter.

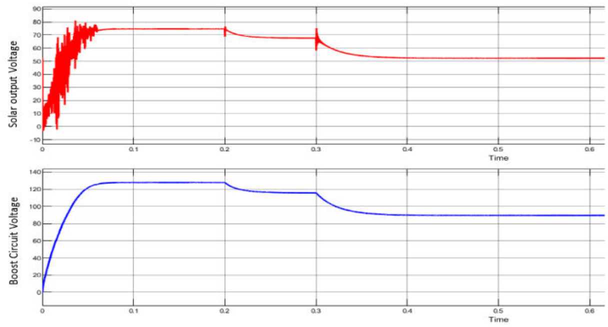

Figure-6. Voltage and boost circuit Voltage for GWO.

With varying irradiances of 1000, 800, and 600 watts/square meter individually. Figure-6 illustrates the solar panel voltage and the boost circuit voltage utilizing GWO.

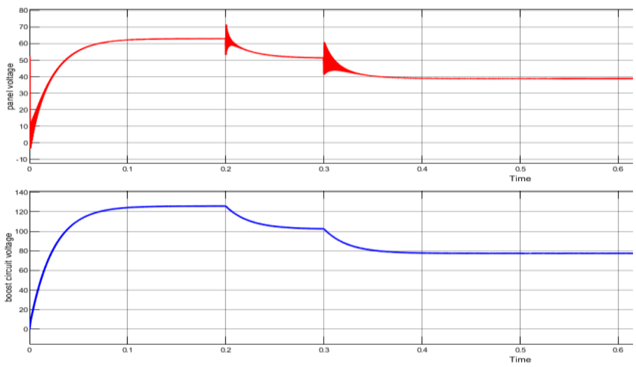

Figure-7. Voltage and boost circuit Voltage for P&O.

With varying irradiances of 1000, 800, and 600 watts/square meter individually. Figure-7 illustrates the solar panel voltage and the boost circuit voltage utilizing P&O.

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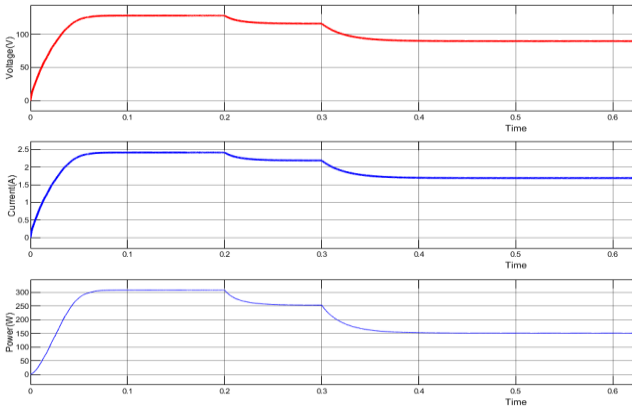

Figure-8. Power output for GWO.

Figure-8 shows the boost circuit voltage, current, and the power output for GWO for different irradiances 1000, 800 and 600 watt/square meter individually.

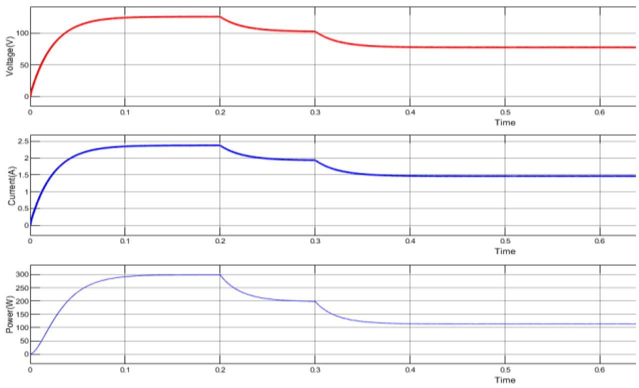

Figure-9. Power output for P&O.

Figure-9 shows the boost circuit voltage, current and power output for P&O for different 1000, 800, and 600 watts/square meters individually.

Table-1. Comparison between GWO and P&O.

PARAMETERS	P&O ALGORITHM			GWO		
Irradiation (W/m^2)	1000	800	600	1000	800	600
Voltage(V)	125	100	80	130	118	90
Current(A)	2.4	2	1.5	2.45	2.3	1.7
Settling time(s)	0.1	0.27	0.4	0.06	0.2	0.313
Power(W)	300	200	113	310	250	150
Theoretical Power(W)	320	256	160	320	256	160
Power(W) difference between theoretical and proposed algorithm	1000	800	600	1000	800	600

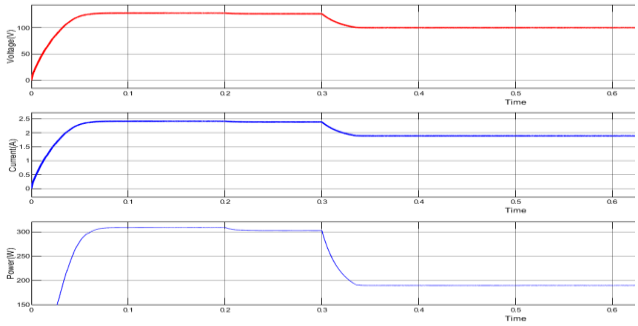

Figure-10. Power output for GWO in partial shading.

Figure-10 shows the boost circuit voltage, current and power output for GWO in partial shading conditions. Where the step input is given only to one panel. The constant temperature is 25 ˚C and the different irradiances are 1000, 900, and 600 watts/square meter individually.

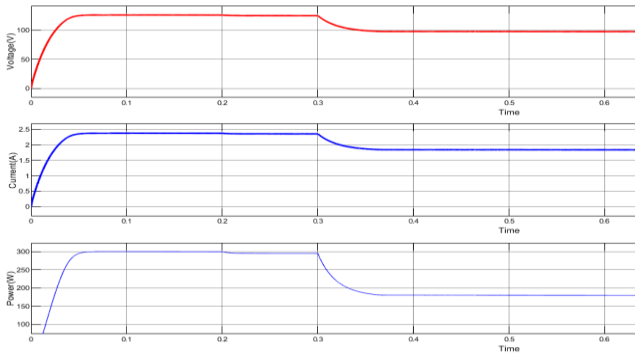

Figure-11. Power output for P&O in partial shading.

Figure-11 shows the boost circuit voltage, current and power output for P&O in partial shading conditions. Where the step input is given only to one panel. The constant temperature is 25 ˚C and the different irradiances given are 1000, 900, and 600 watt/square meter individually.

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Table-2. Comparability between GWO and P&O in partial shade condition.

PARAMETERS	P&O ALGORITHM			GWO		
Irradiation (W/m^2)	1000	900	600	1000	900	600
Voltage(V)	125	115	98	130	118	100
Current(A)	2.4	2.3	1.8	2.45	2.35	1.9
Settling time(s)	0.1	0.21	0.35	0.06	0.201	0.33
Power(W)	300	290	180	310	298	190
Theoretical Power(W)	320	300	280	320	300	280
Power(W) difference between theoretical and proposed algorithm	20	10	100	10	2	90

5. CONCLUSION AND FUTURE SCOPE

The meta-heuristic optimization technique for getting the most power out of a solar photovoltaic system is the GW optimization technique. In MATLAB/Simulink, the suggested system is built and simulated to examine how it works in various operating scenarios. The GWO-based MPPT algorithm takes the amps and volts of the PV array as inputs and outputs the duty ratio of the converter. The performance of the GWO approach is collated with that of the P&O, as well as simulation results achieved. The performance of the GWO approach is collated with that of the P&O, as well as simulation results achieved. The proposed system power output is 3.22% higher and the settling time is 4% faster when in contrast to the P&O technique even in case of different solar irradiation and partial shading conditions and therefore GWO based MPPT exhibits superior performance than the PO method. For future studies, the efficiency of the MPPT under partial shading conditions can be improved.

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