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Comparison and Performance Analysis of Different MPPT Technique for Cost Effective Grid Connected Hybrid System

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Abstract- Now days, renewable energy sources are more demanding for better environmental aspects. In this paper the author discussed about the use of solar photovoltaic and wind power, which are crucial for grid-tied applications and battery charging. In the past, coal and petroleum were the main sources of electricity. Renewable energy resources are employed to reduce costs and environmental impacts. This paper design and extract the maximum power from DC sources working with different voltages by using solar and wind power generating equipment. Estimating the highest possible energy production from the photovoltaic system is essential to raise the power output of solar and wind systems alike. The maximum power point tracking (MPPT) method is applied in this work for hybrid energy systems. Maximum power perturbation, the incremental conductance approach, and observation were used in tests of the hybrid system. Using the MATLAB/Simulink platform, the P&O MPPT and incremental conductance performance were evaluated and their outcomes examined.

***Keywords* -** P&O MPPT, Grid, wind, Solar, Battery, DC to DC Converter

I.INTRODUCTIONS

Power is essential for both manufacturing and everyday life. There are four parts to the power system: producing power, transferring it, converting it, and using it. Minimal power requirements gearbox and setup can be challenging in island, woodland and remote agriculture settings [1-2]. Additionally, the plate will continue to have power disruptions due to storms and other catastrophic events. Concerns about global warming are quite real, and switching to renewable energy is a terrific way to cut emissions from fossil fuels. Building a renewable energy system off the grid is therefore required for these reasons. [3-4]. Providing sustainable power in places where traditional power grids are unable to deliver it is one advantage of combining various power sources. Although they are useful in many applications, hybrid energy systems have been offered as a solution to address their non-linearity and achieve crucial advancements [5-6]. In order to maximise production and energy management, hybridisation generally entails merging several energy and storage units in a single method. Wind solar hybrid systems combine renewable energy sources, such as solar and wind, to generate electricity [7-9].Small wind turbine generators and solar panels are used in this system's design to produce electricity.

Modelled after solar cells linked in series or parallel, a solar cell or panel can generate the necessary currents and energy [10-11].System design for solar intertie photovoltaic (PV) energy generation is not especially intricate. The panels that soak up the sun's rays and transform them into usable electricity come first. What you use in your house, the grid-compatible AC electricity, is really converted from the DC impulses that are sent into an inverter. For security purposes, we have integrated many switch boxes, which are linked together using conduit and cables [11-15].

The system can generate electricity for nearly the entire year because to the combination of wind and solar power. The Wind Solar Hybrid System includes a wind turbine and tower, solar panels, a charge controller, an inverter, batteries, wires, and photovoltaic cells [16-18]. The wind and solar hybrid system may produce electricity, which can then be used to charge batteries and power AC appliances via an inverter. The wind aero generator is supported by a tower at least 18 meters above ground level [19-20]. Because of its height, the aero-generator receives faster winds and generates greater power [21-22].

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The term "tertiary control" refers to the highest level of management in a hierarchical control system. This control architecture allows for the connection of more distributed power sources and enhances the system's flexibility. Additionally, this control technique can be used with different Microgrid methods, such as message models, island methods, load-bearing methods, or ways for minimising power generation based on the electronic power converter's specifications, the primary control level modifies the load allocation among the dispersed power sources. The second control resets and merges the DC band with the other grids; it also controls voltage fluctuations. Energy management falls under the purview of the third tier of control.[7].To fine-tune the output and power distribution among the distributed generators, the first control employs a pair of approaches. First, there are active load distribution methods, and second, there are passive control methods, which are concepts that are quickly becoming obsolete. Droop control is a popular tool for DC microgrid applications because it allows for more efficient load distribution across the power sources that are linked to the common bus. The droop concept in an AC microgrid refers to the variation in the reactive and working powers of a wall-mounted substation in relation to the output terminal's voltage and frequency.

[8-9], High voltage direct current (HVDC) transmission is reserved exclusively for DC systems with two terminals when discussing a DC microgrid. More than two terminals and at least one meshed DC line make up a DC transmission system, which is referred to as DC grid. All market actors, including renewable energy sources, must have wide access to a DC grid for it to be considered relevant. The distribution of commodities can be maintained without a communication infrastructure. Electric current and power and current activity are two ways to describe the electric current converter's defining features in a DC microgrid [10].With the help of the aforementioned technologies, a hybrid control system can boost performance and produce superior results.In [11-12], To ensure that autonomous DC microgrids run smoothly, a hybrid control approach is suggested. Central energy management makes use of a communication system to track converter state, mobility, and bus power. Use DC bus signalling technology as a backup monitoring approach in case of connection failure.

II.SIMULATION MODELLING OF VARIOUS CONTROLLER SCHEME

The Maximum Power Point Tracking (MPPT) algorithm is used in MATLAB Simulink to simulate wind and solar power systems. MATLAB is used to create models of wind turbines and solar panels. The solar panel takes two inputs: temperature and irradiance. In response to changes in temperature and sunlight, the solar cell produces voltage at its terminals for output. The solar panel is linked to the booster converter. The converter checks that the load's impedance is equal to or greater than the solar panels' impedance to guarantee that the load receives the greatest amount of power from the PV system. The boost converter receives the load. Solar panels are a kind of variable-output power source that can adapt to different loads. In order to achieve maximum power point tracking (MPPT), solar panels use a mix of incremental conductance, perturbation, and observational methods. It outperformed the P&O and incremental conductance methods statistically speaking for load, cost, and current/voltage.

Providing stable energy supply systems is one of the most fundamental requirements for every nation's socio-economic growth. This initiative is a development of a previously established hybrid solar-wind power system that harvests energy from both the sun and the wind. Electricity produced in this case by wind turbines and solar panels in the form of direct current (DC)

Renewable energy (RE) resources are now being utilised as substitutes for fossil fuels, which are becoming more expensive and polluting the environment. For an isolated Microgrid in particular, this study introduces a hybrid renewable energy system (HRES) to lessen the RE resources' reliance on weather-related changes. as it comes to HRES, the main sources of energy are solar and wind power, with backup systems such batteries and fuel cells (FCs) providing power as needed. Additionally, in case there is a power outage, the load requirement can be met using a diesel generator that has been installed as a backup system. The improvement of HRES through the integration of battery technology and diesel generator is the primary emphasis of this research. Maximal power point tracking (MPPT) control, an EMS, and optimal size were the three main components that were taken into account. Fig. 1 shows the results of a MATLAB/Simulink simulation that tested and validated a proposed hybrid perturbation and observation (P&O) and incremental conductance MPPT for a PV and wind system.

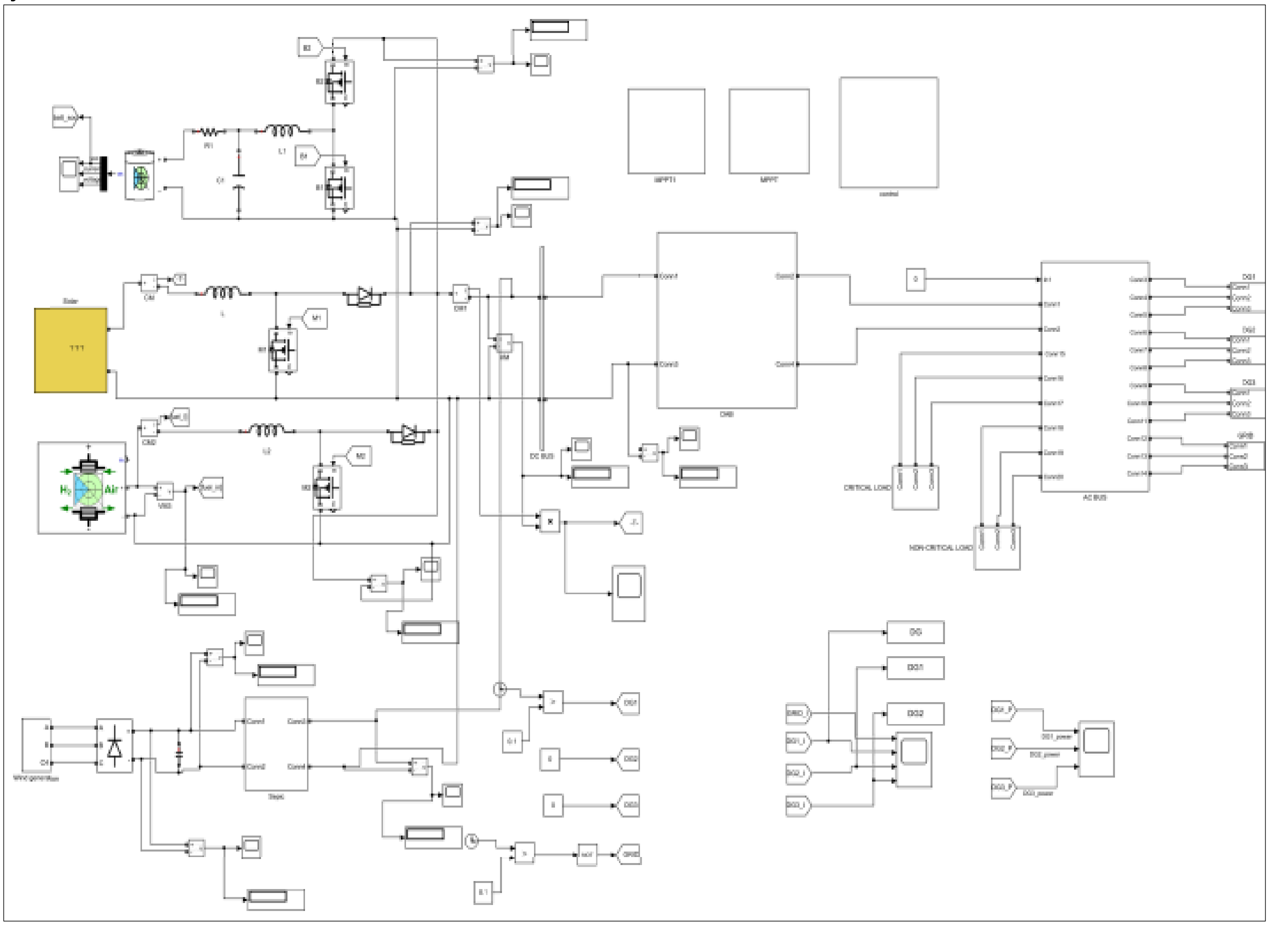

Figure 1: Simulink Model of Proposed System

The combination of conventional generators and storage systems with renewable energy (RE) resources is becoming more common as a result of technological advancements and falling costs. This allows for the supply of load demand while simultaneously reducing fuel consumption, increasing efficiency, and reducing the environmental pollution problem. In addition, electrifying rural areas and islands using standalone hybrid renewable energy systems (HRES) may be less expensive than extending the grid.A diesel generator served as a backup system to carry the load in the case of inclement weather, while the battery served as the energy storage system that supplies power in the event of insufficiency. Evaluation of developing hybrid renewable hydrogen energy systems, with a focus on their potential for electrifying remote and island communities Diesel generators, which are now used to power most distant places, have the potential to greatly harm our ecosystem. Renewable energy sources, such as HRESs, will likely become more affordable as new technology emerge, paving the way for their widespread adoption in the interest of sustainable development.

(A) Simulation on Incremental and Conductance technique Based Hybrid Energy

A solar-wind hybrid system's total efficiency can be enhanced with the use of maximum power point tracking (MPPT). This tracking approach is useful for wind and solar power since it allows them to use less effort while producing more energy. One way to keep an eye on how much power Wind Energy Conversion Systems (WECS) are putting out is via a maximum power point tracking controller. There are three major categories of maximum power point tracking (MPPT) controllers used in wind energy: power signal feedback (PSF), tip speed ratio (TSR), and hill-climb search (HCS) [13].
When harnessing solar electricity, these help us follow the sun's rays in a way that maximises our output. Because the module is not physically moved, the Maximum Power Point Tracking system is an electronic system that tracks the supreme power point automatically; it is not a mechanical device. System

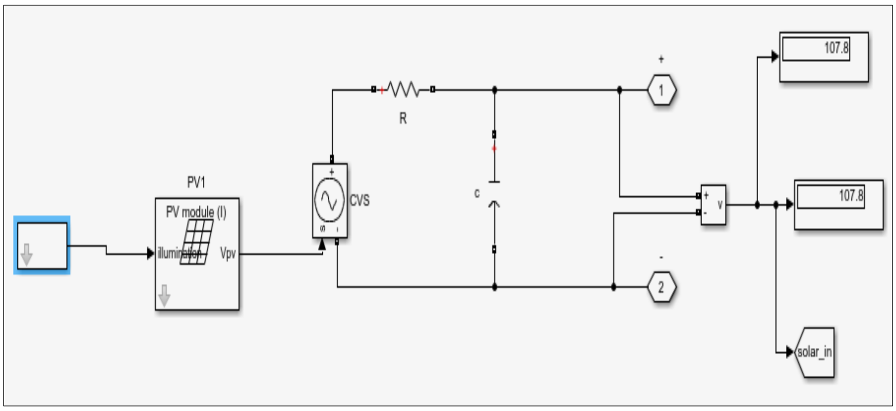

Figure 2: Solar Simulink Model

(B) Wind Turbine (PMSG Scheme)

The sun's uneven heating of Earth's surface is the source of wind. Clean power is generated by transforming the kinetic energy of the airstream by means of wind turbines. The rotor of a wind turbine takes the kinetic energy of the wind as it spins the blades and turns them into rotary motion, which in turn drives the generator. When the wind speed becomes too high, the rotor of most turbines will spin uncontrollably unless an automatic over-speed-governing device is used. Either your electricity company can link your tiny wind system to the grid, or you can install it independently (off-grid). Because of this, compact wind electric systems are a viable option for remote places that do not have access to the power grid. Both constant and variable speeds are possible for a wind turbine to operate in. Generators with a fixed speed turbine can be linked directly to either the grid or a load. To make the frequency and power of a variable speed turbine constant, electrical gadgets are used. Thanks to variable speed wind turbines, it is now feasible to continually adjust the wind turbine's rotating speed in relation to the wind speed.

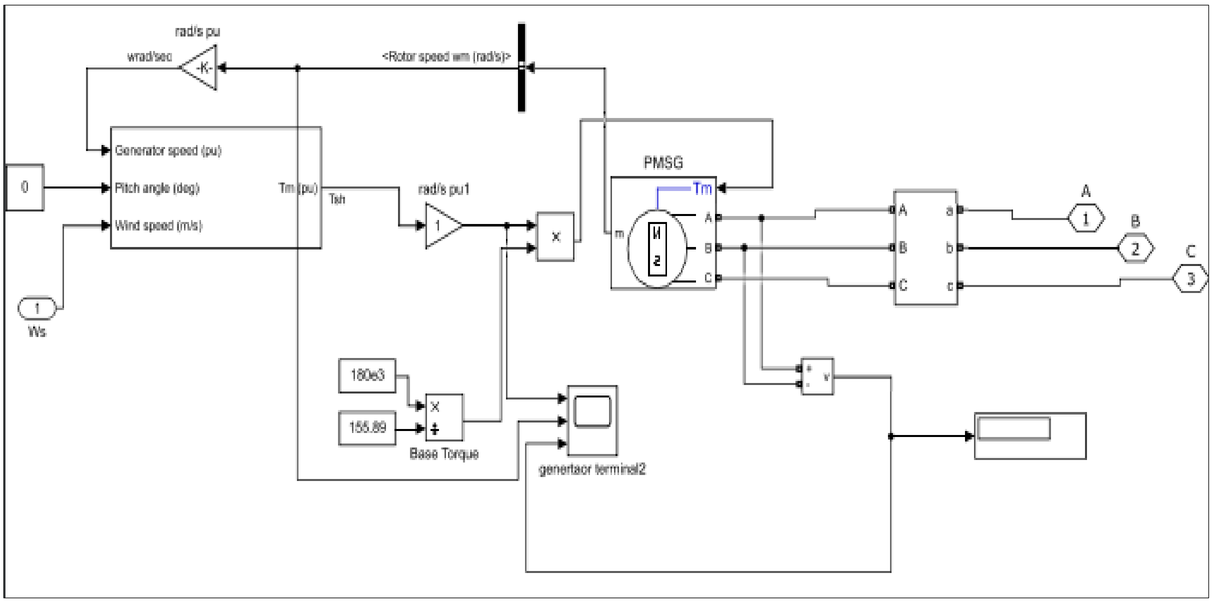

Figure 3: PMSG Model

A tower-mounted wind turbine is the main component of an electric wind system, which allows it to harness larger winds. Figure 3 shows the balance-of-system components that are required by modest wind power systems, in addition to the turbine and tower.

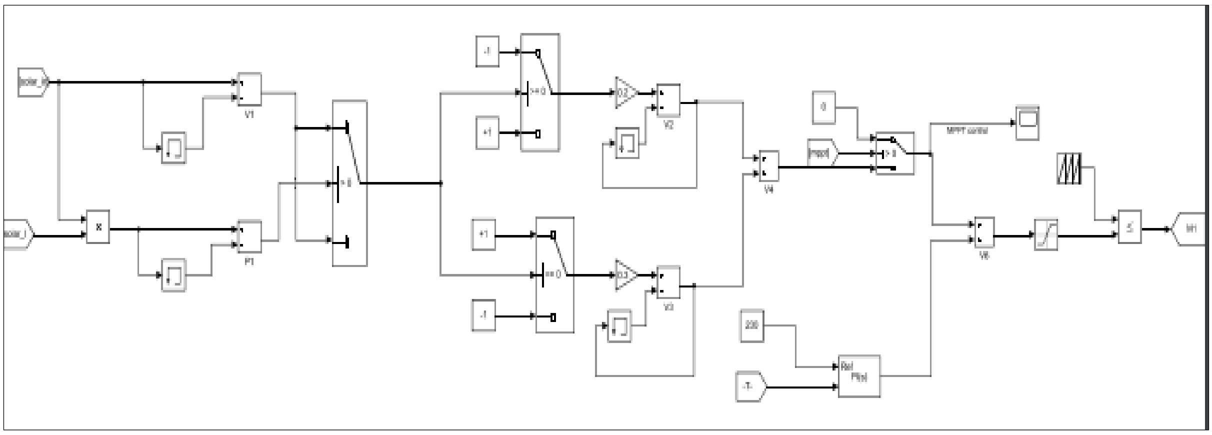

Figure 4 MPPT for solar system

Figure 4 shows the hybrid PV-battery power storage system's command and control network. Two control loops—one for voltage and one for current—make up this system. The voltage loop exists on one end; the current loop exists on the other. Inside the current control loop, there also are three current loops: two for the battery and one for the DQG İbat (battery side converter duty ratio). In order to keep the DC connection voltage Vdc at the specified value, the external voltage control loop is used. By keeping the DC link voltage constant and the DC link source current equal to the load current, this control makes sure that the resulting electric power balances the load. It is in the outer loop that the PID controller operates. Therefore, the dc-link reference current Idc is generated by the dc-link voltage Vdc. After that, we take the reference output PV current (iPVref) and deduct the reference dc-link current. As a result, the generated reference battery current will be generated. Among the three loops, the inner one has the highest corner frequency.

As so, the inner loop is faster than the outside loop. The main influencing factor of the response speed of the controller is its corner frequency. By zeroing the Kd value of the PID controller—which is 32/2=16—one generates the corner frequency. Value of inner loop PI controller is 0.4165/(8.33)50. Thus, the inner loop corresponds with a greater corner frequency more than the outer loop. We may thus conclude that the DC link voltage hits the reference value second and the current loop first. The output of a PV cell can be adjusted in reaction to variations in the source power or irradiation as well as the load [14].

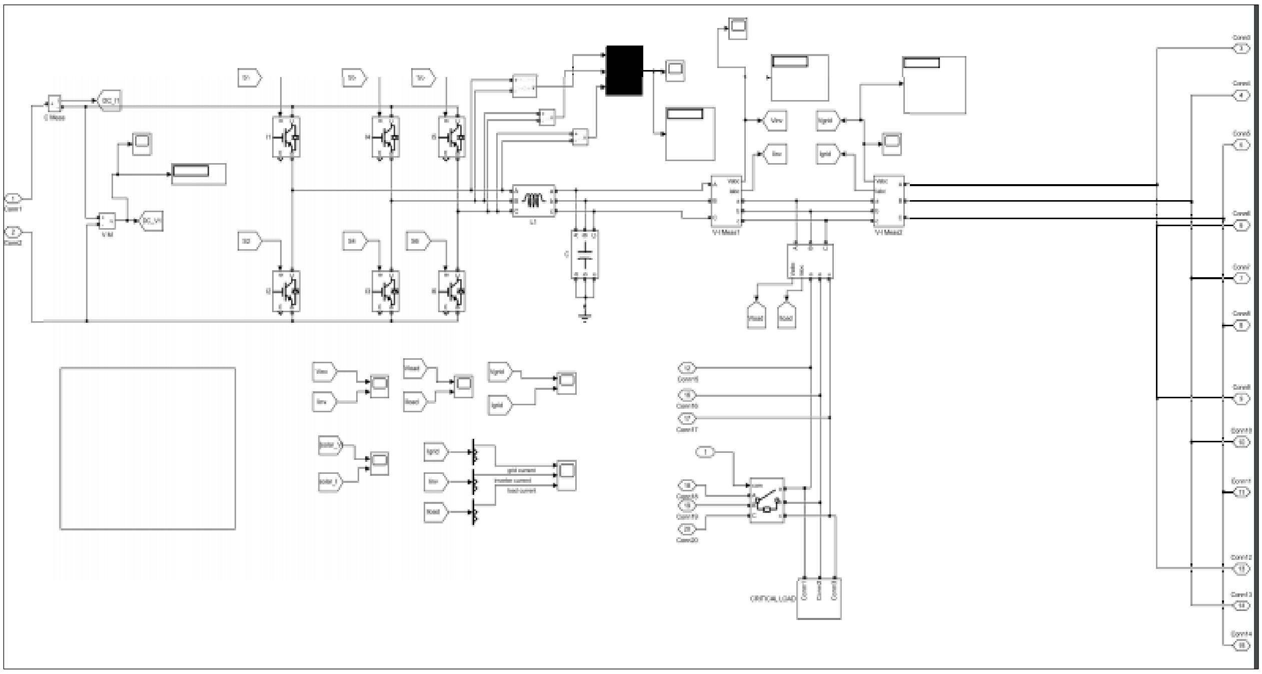

Figure 5 AC Bus Systems

Internal neutral point connecting to the stator windings is wye-oriented. The back-EMF waveform of the three-phase machine might be sinusoidal or trapezoidal. Both circular and salient-pole rotors are possible in a sinusoidal machine. A spherical trapezoidal machine is the shape it takes. The Sinusoidal back EMF machine comes with a variety of pre-set models that you can choose from. As it spins backwards around the rotor, the five-phase machine produces a sinusoidal reverse electromagnetic field (EMF).

(C) Diesel Generator

With this part, you may simulate a wind turbine with a variable pitch. A measure of efficiency Depending on wind speed, rotational speed, and pitch angle (beta), the mechanical output power of the turbine is determined by Cp, which is then divided by wind power. At zero beta, Cp reaches its maximum. Select the wind turbine's power characteristics to view its specifications at the chosen pitch angle. The ratio of the generator's output speed to its fundamental speed is one input. Asynchronous generators have the synchronous speed as their base speed. The speed at which a permanent-magnet generator produces nominal voltage in the absence of a load is known as its base speed. The second parameter is an abbreviation for "blade pitch angle" measured in degrees. The third variable is the wind speed, which is given in meters per second. One unit of generator ratings, which are the output, is equal to the torque applied on the generator-shaft-[15].

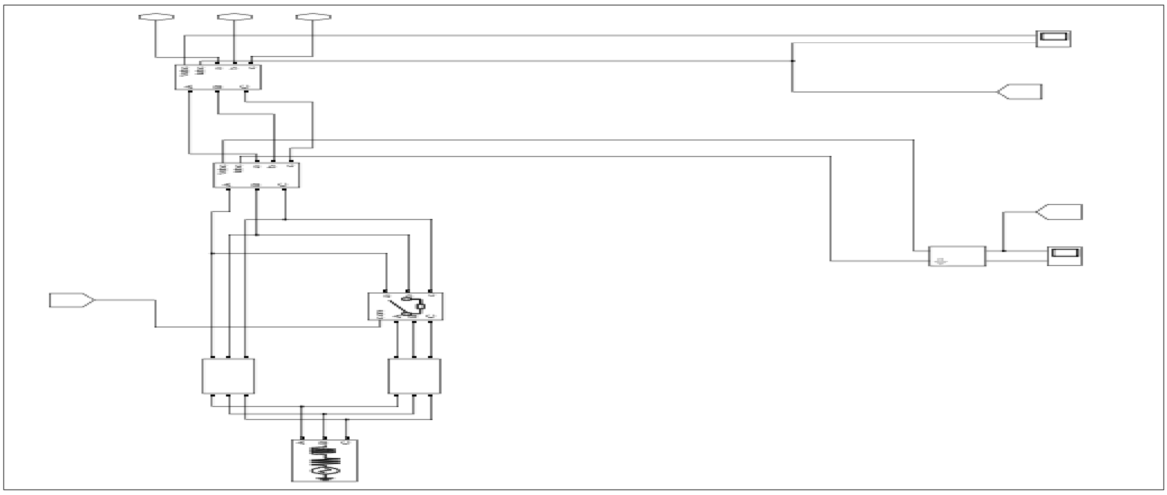

Figure 6 DG System

The diesel engine and governor, or DG set, is a device that takes the energy from diesel oil, the fuel, and turns it into mechanical energy. Then, the governor takes that mechanical energy and turns it into electrical energy. A mechanical or electrical device that regulates the fuel intake in order to automatically manage the engine speed is called a governor. To keep the turbine running at its intended speed, the engine controller employs a straightforward speed governor. The speed governor regulates the engine's fuel supply via a signal that controls the throttle. After reviewing the literature, four models were chosen and evaluated to determine which one is the most efficient in presenting a dynamic analysis of the DG [16–18] and is also the most versatile in terms of the technologies it can be utilised with. Results from the simulations, which are conducted in MATLAB/Simulink, will not be shared at this venue. At the end of this section, we present a Simulink-developed model that meets all of the criteria, including the ability to integrate supercharging, the structure of the model, and the communication between the mechanical and electrical parts of the DG. The model is described using Simulink physical equations. Its mathematical model and physical properties define it. Modelling the synchronous machine and grid connection requires the electrical component, which is derived from physical rules like the Park transformation. The combustion process in a diesel engine takes the mass flow of air into account, and the speed regulator operates in the rack position to control the injection of fuel into the cylinders. With the use of CAES, optimising the air/fuel ratio improves combustion efficiency and fuel economy. Establishes a three-phase parallel RLC load. The voltages and currents can be output by the block in either volts and amperes or per-unit quantities. Power of induction reactive QL (positive variate): Proactive power (in watts): 100 Figure 6 displays the inductive reactive power (QL) as a positive variable.

III. ANALYSIS OF SIMULATION RESULTS UNDER VARIOUS CONDITIONS

Table 1 Simulation parameter

Simulation ParametersValue	Values
KP	40
Turbine time constant,	0.05
Governor time constant,	0.025
electrical generator (V.A.):	8.5e3/0.9
Engine time delay Td (s)	-0.024
Nominal power	2e+006
Voltage	400
Frequency	50
Field current	100
Open circuit voltage, Voc	0.62
Short circuit current,	7.57
PV output	230Kw/44I
Wind power	4.5
Base wind speed (m/s):	12
Load power P (W)	100

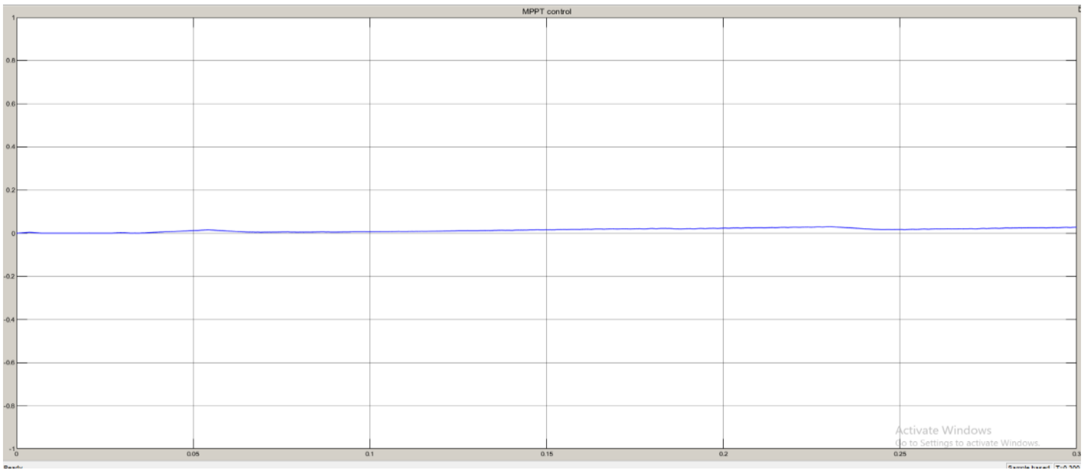

Figure 7 MPPT Output

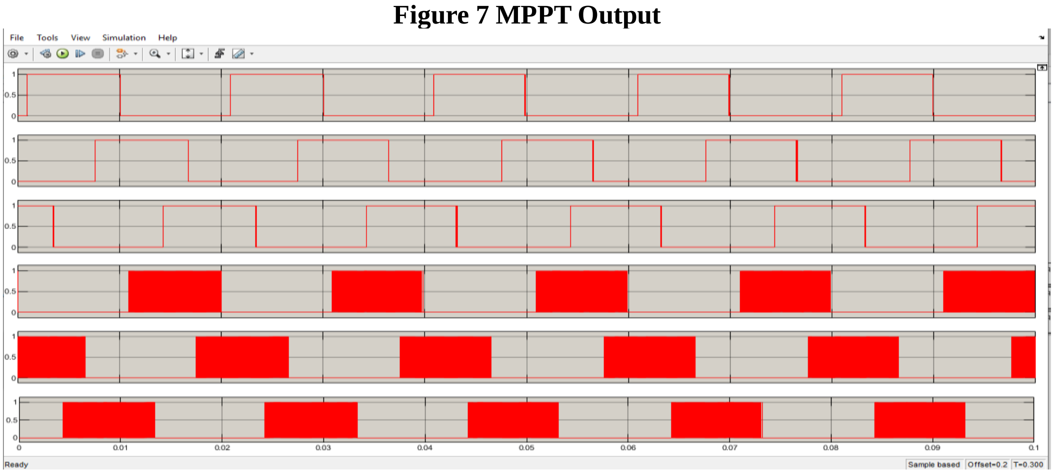

Figure 8 Switching Pulsesat fixed cycles

the amount of power corresponding to the power that needs to be output is switched on to extract it from the input

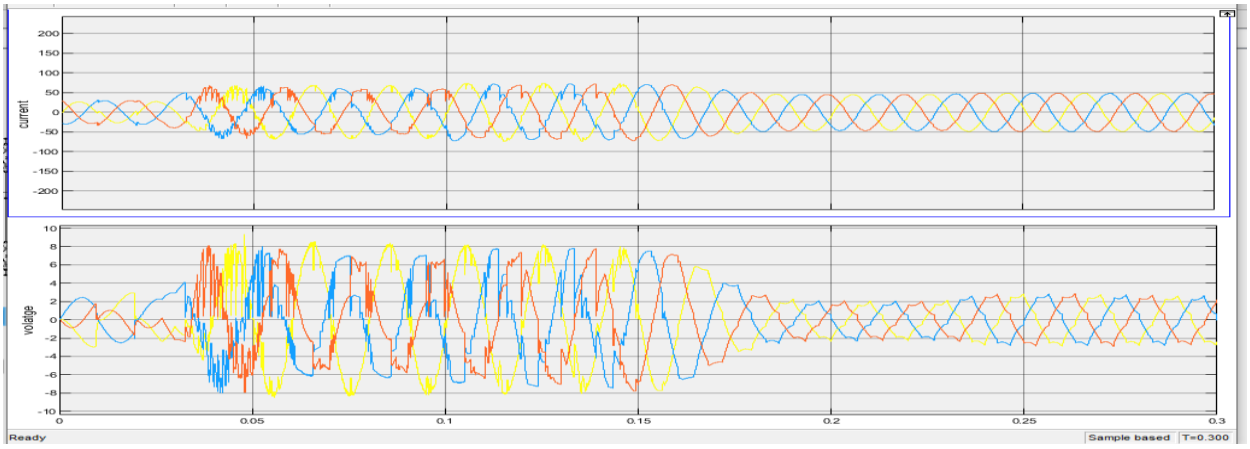

Figure 9 Grid Voltages and Current

the Grid voltage often keeps fluctuating between the maxima and minima due to varied loads that grids are confronted with

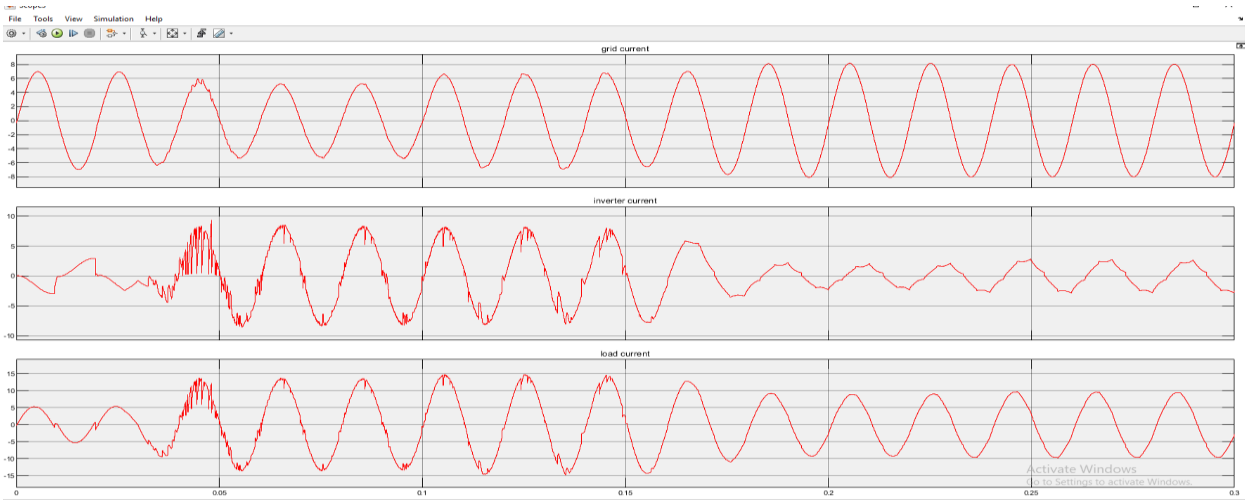

Figure 10 Grid, Load and Inverter Current

These loads create varied currents through the impedance of the feeder to create fluctuating voltage drops

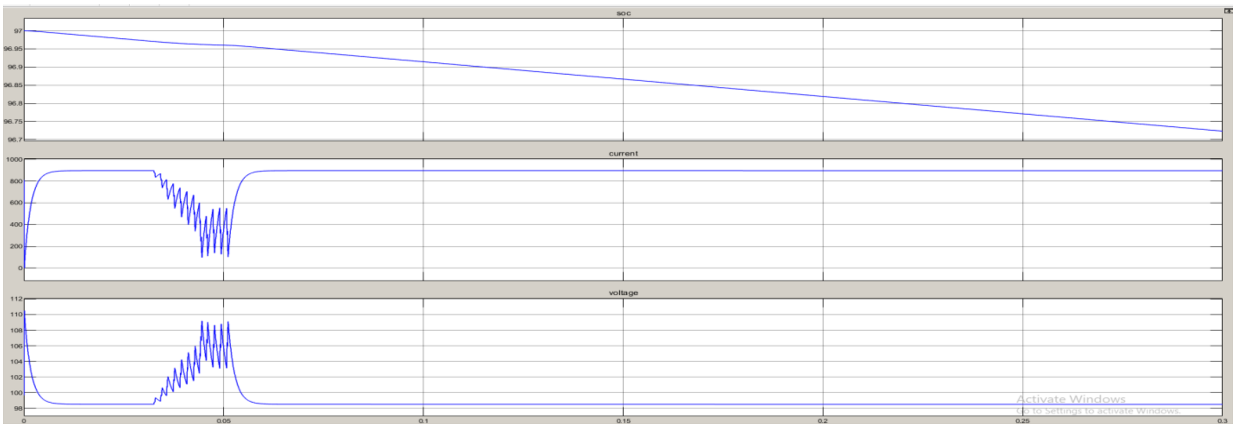

Figure 11Battery Output

The SOC might have a value anywhere from zero to one hundred percent. Up until the battery voltage reached its maximum, the cell was charged using the continuous current mode. The charge proceeded to the constant thereafter. As illustrated in Figure 11,

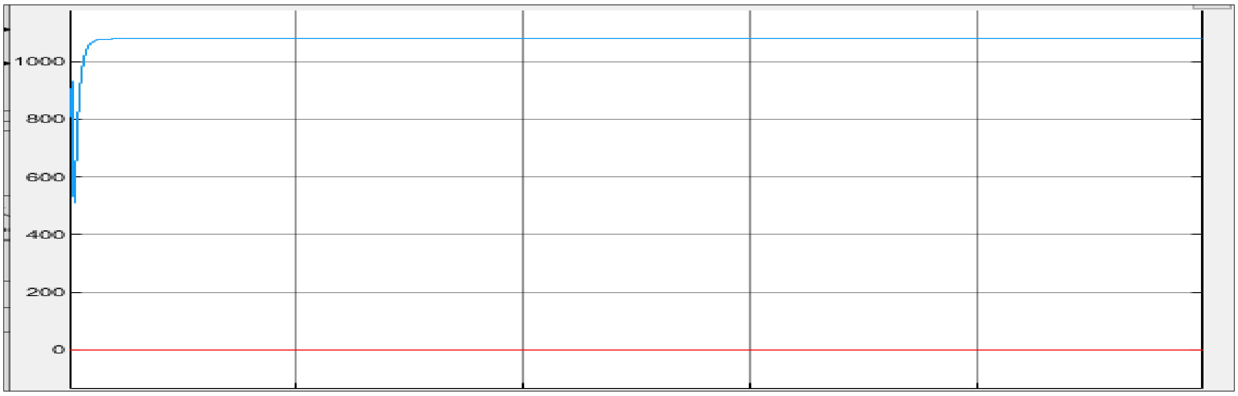

Figure 12 Solar Output

The energy generated by one photovoltaic PV cell is shown in figure 12 Solar output exhibiting photovoltaic voltage. Every PVcell generates open-circuit voltage.

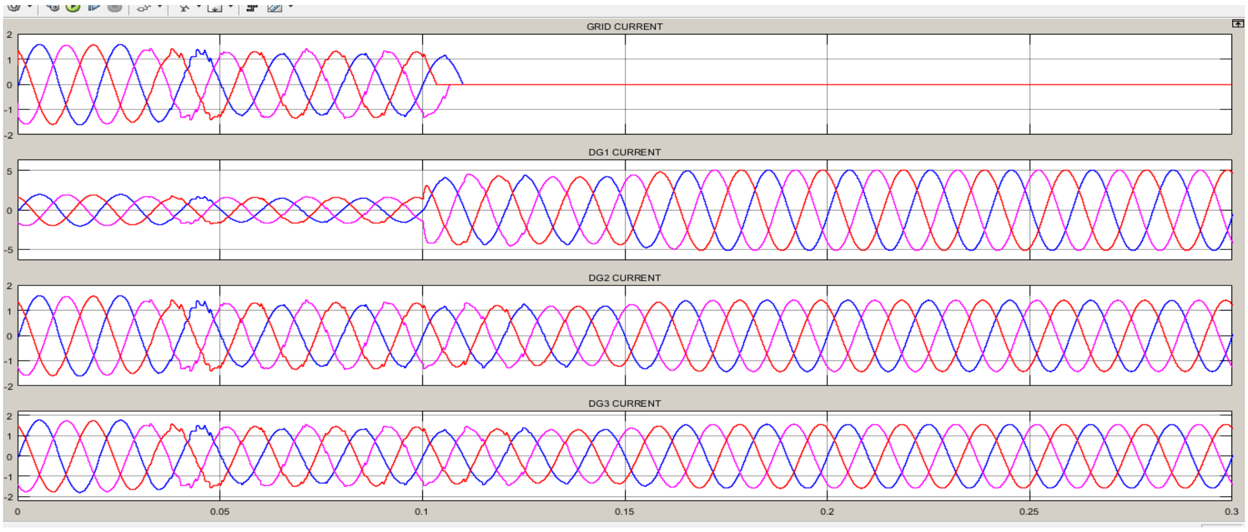

Figure 14 Grid, DG1, DG2, DG3 Current

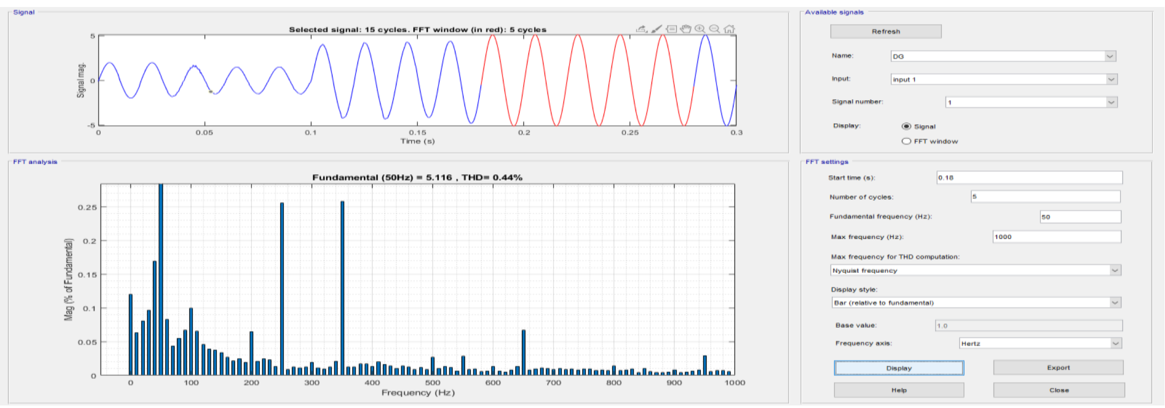

Fig 15 THD performance of incremental and conductance MPPT

(A) MPPT Simulation Result of Perturb and Observation

Most systems of solar and wind energy conversion apply the Perturb and Observe method.
The voltage and current output of a photovoltaic system are monitored at two separate but consecutive intervals. To calculate the power, two successive intervals are utilised. The relationship between voltage and power can be expressed as dP/dV. A positive slope dP/dV indicates an increase in the duty cycle, while a negative slope indicates a reduction. So, the voltage and power are both set to their highest possible levels. The highest power point is achieved under these conditions when the slope dP/dV=0. This is an ongoing issue. Measurements must be obtained continually and the expected change in power and voltage must be made in order to implement control measures. Maximal power point matching (MPPT) occurs when the load side impedance is matched with the solar PV impedance. The duty cycle is adjusted according to the impedance. The previous chapter introduced the algorithm and flow diagram of this MPPT. This is the algorithm's flowchart:

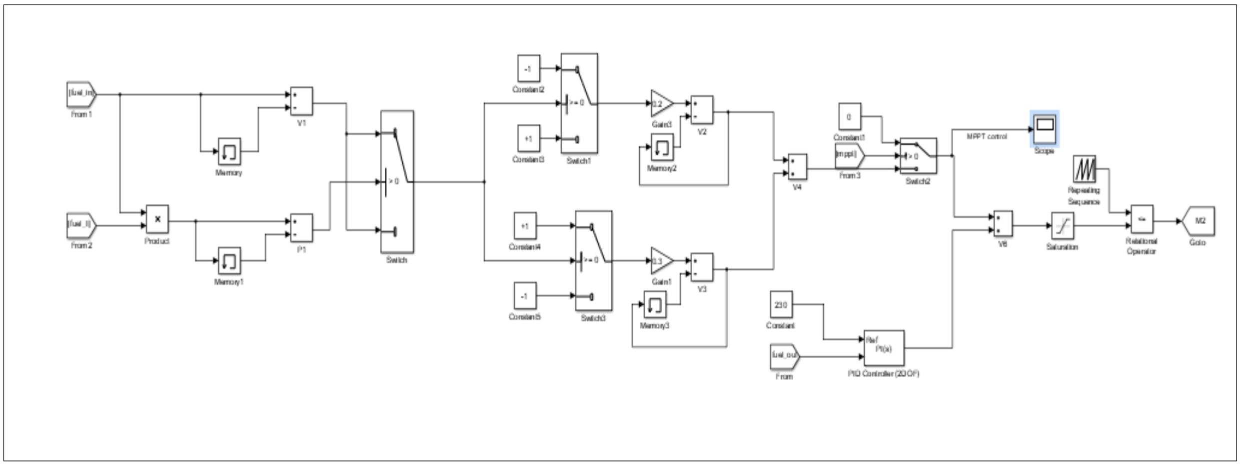

Figure 16 Perturb and Observation Block

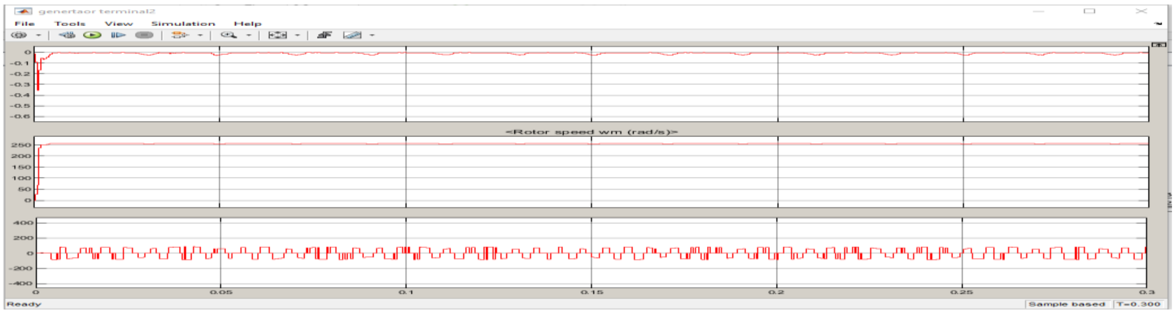

Figure 17-Wind and Rotor Speed

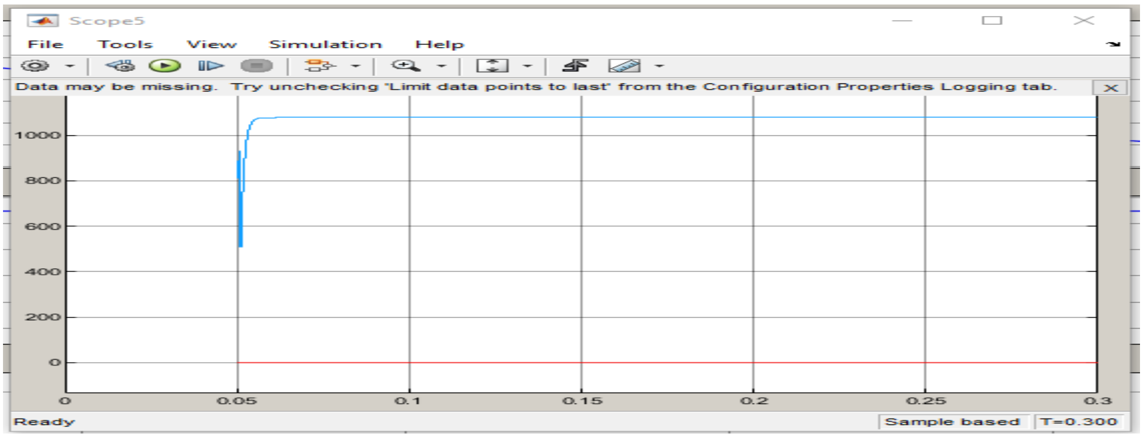

Figure 18 Solar Output

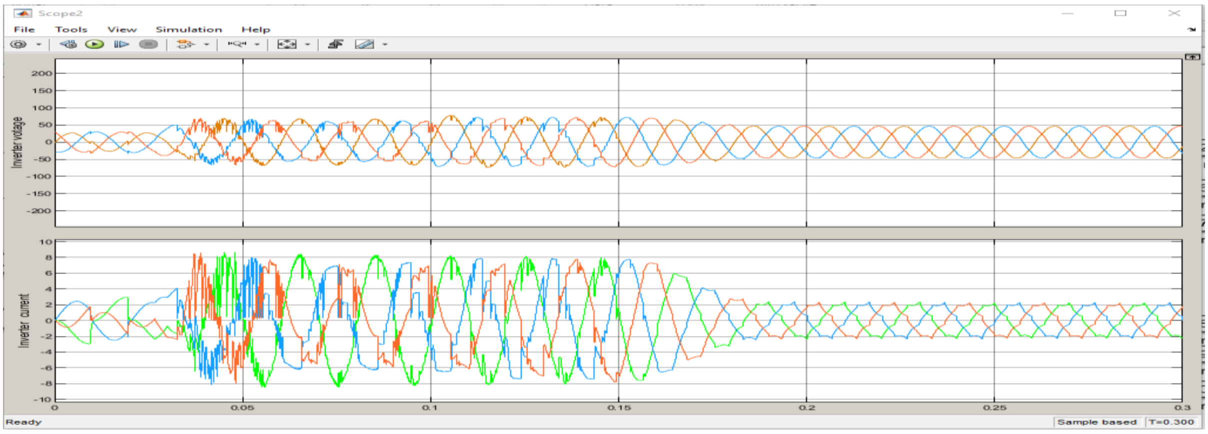

Figure 19 inverter voltage and current

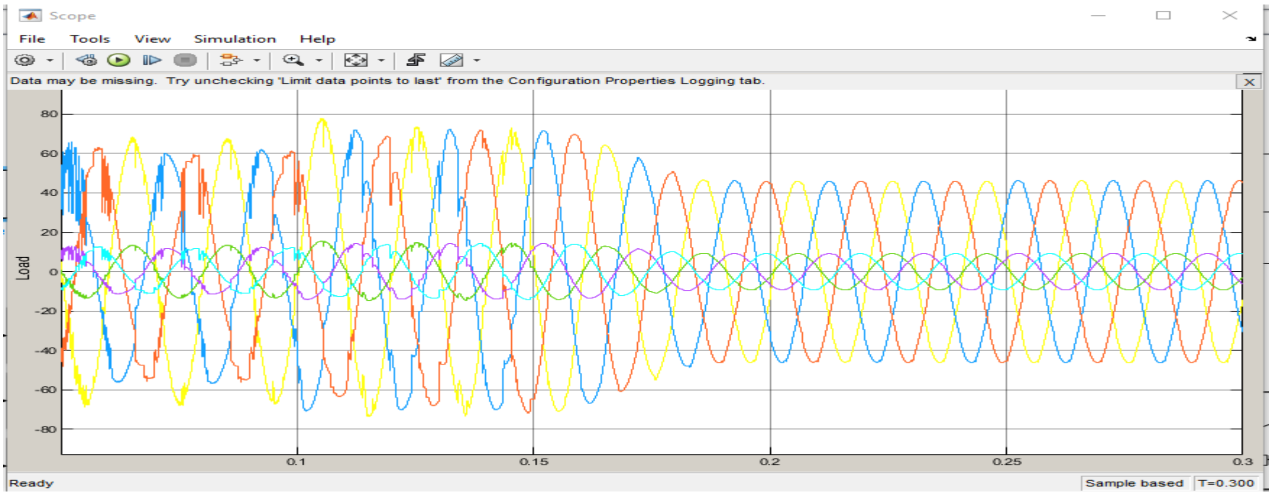

Figure 20 load voltage and current

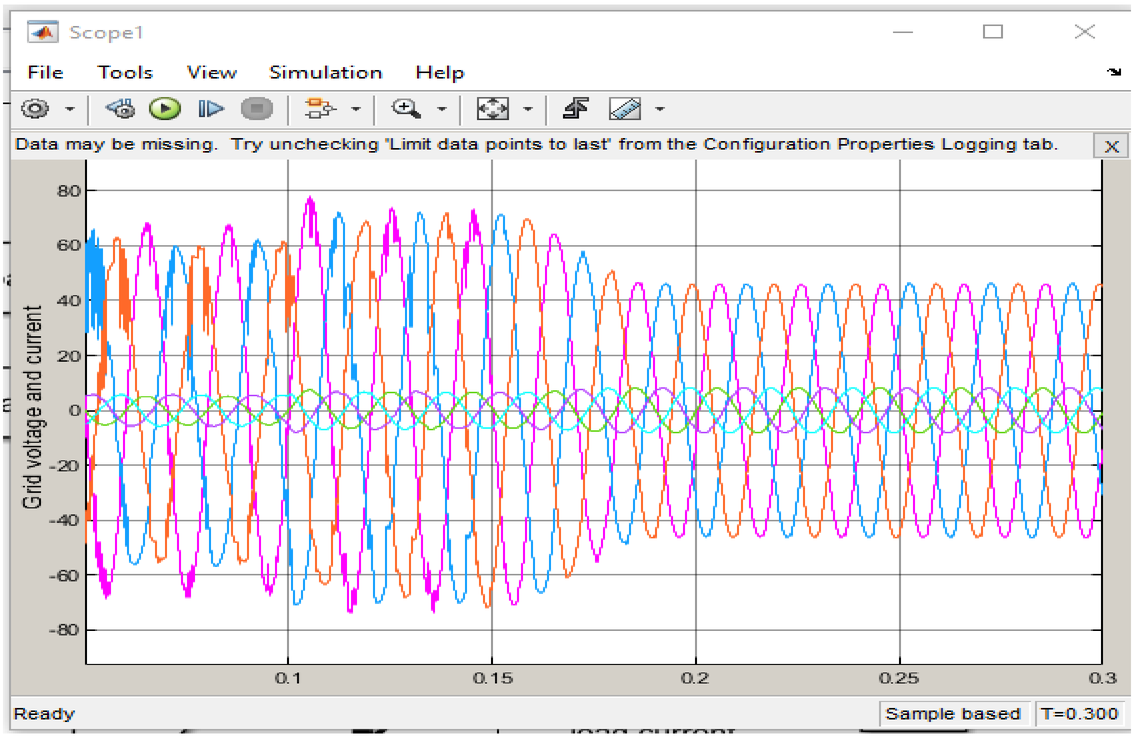

Fig 21 grid voltage and current

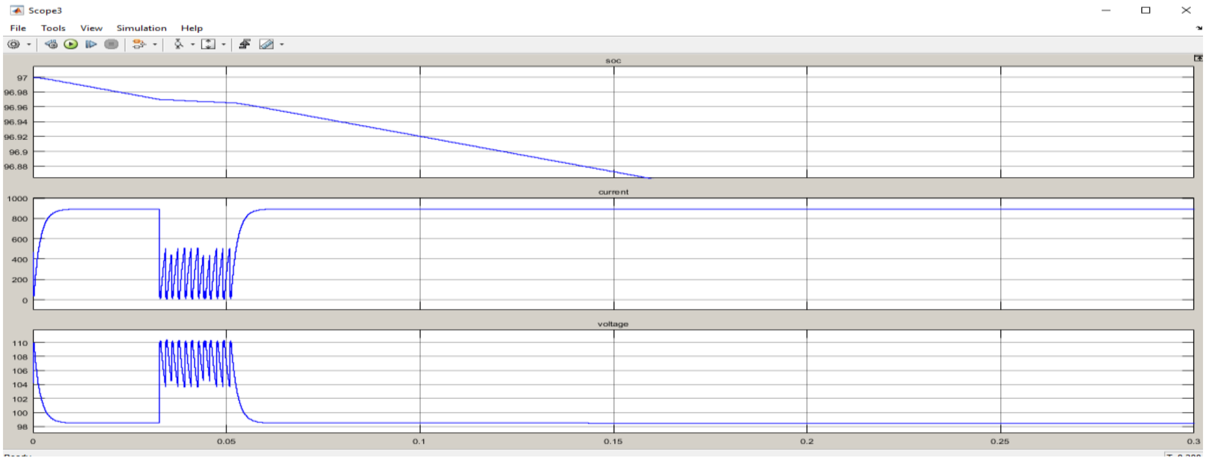

Figure 22 Battery Output

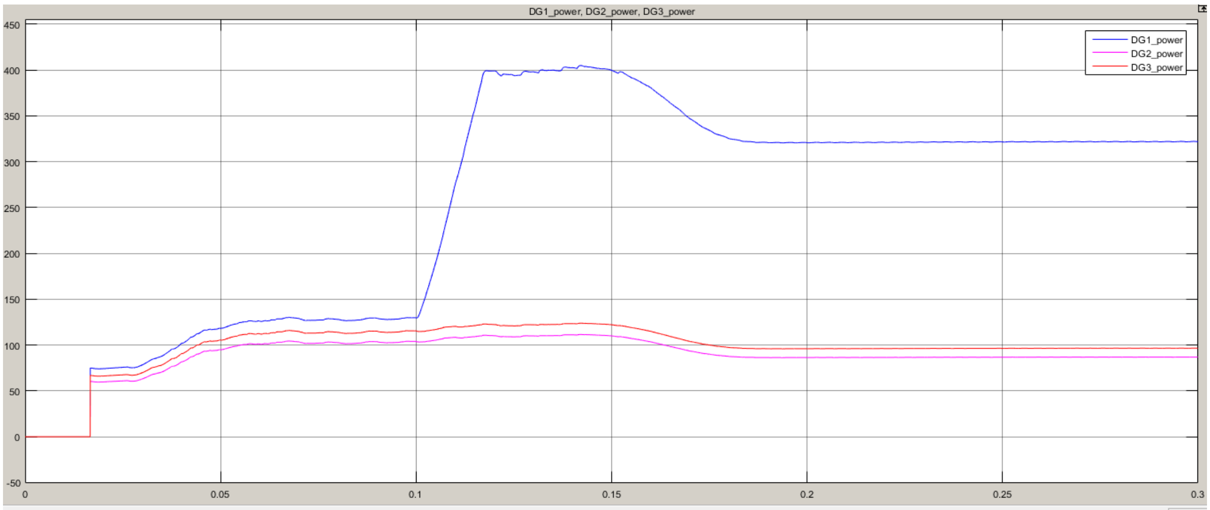

Figure 23 DG1, DG2, DG3 Power Output

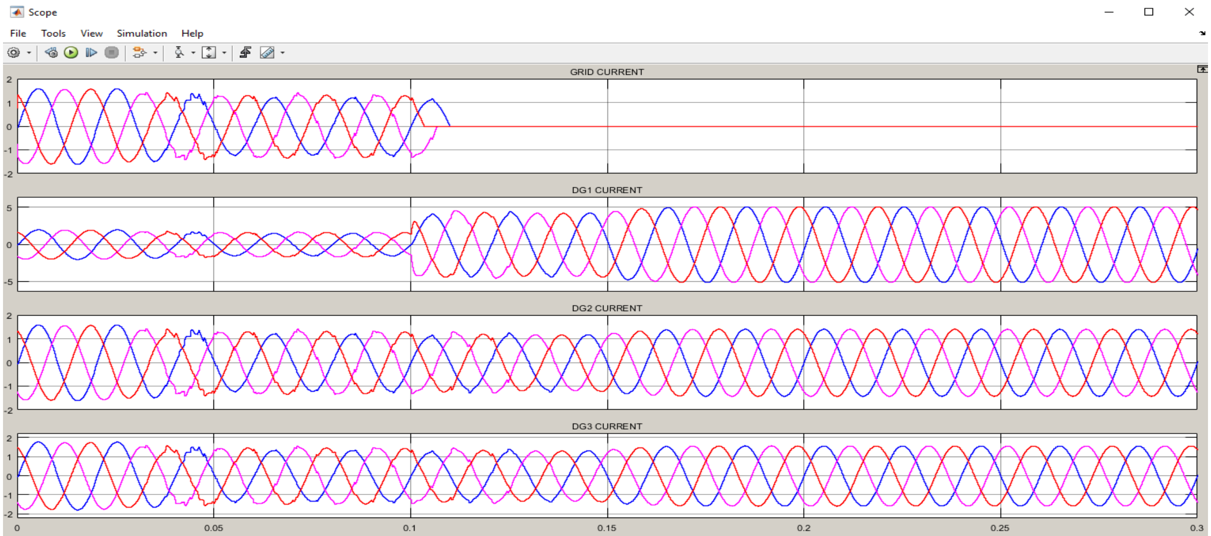

Figure 24 Grid Current, DG1, DG2, DG3 Output Current

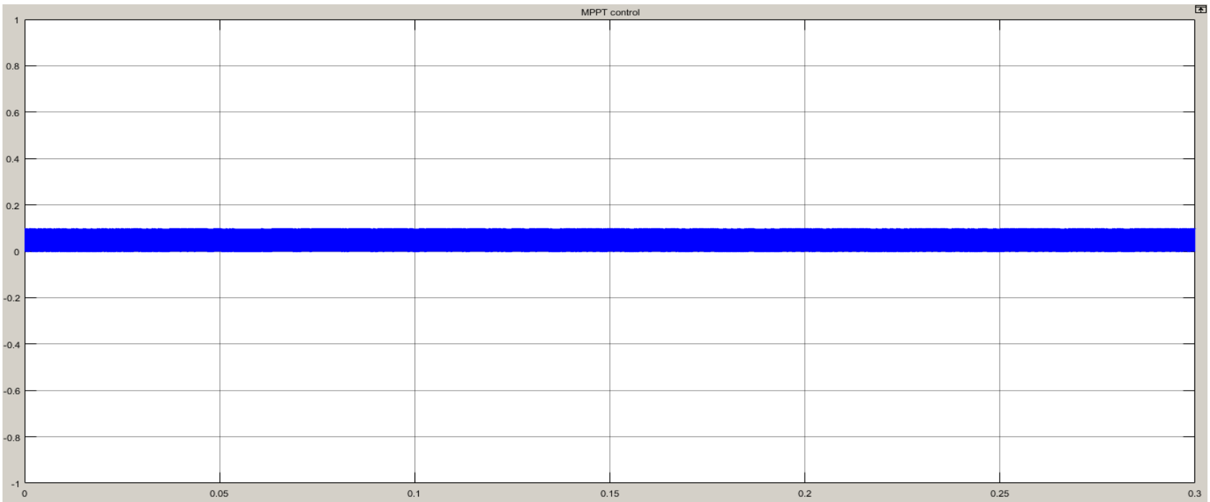

Figure 25 MPPT Control Output

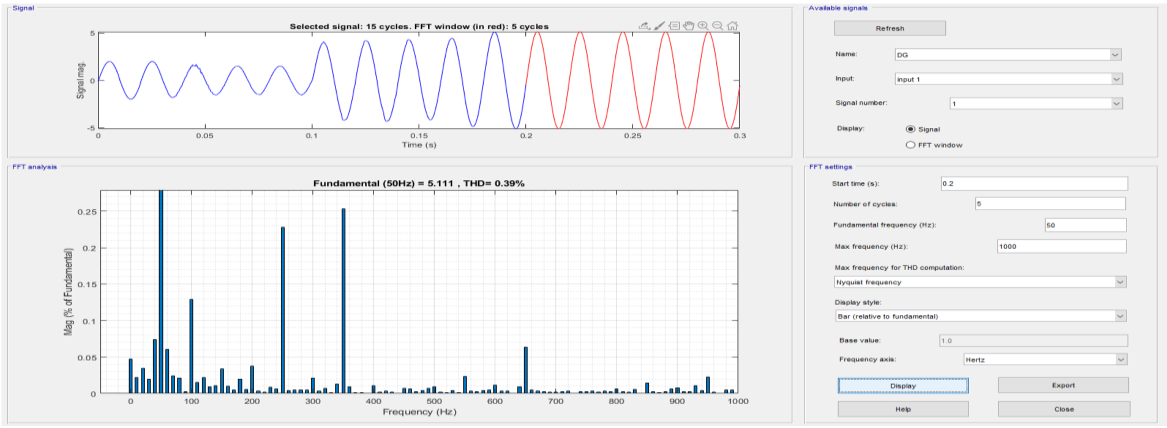

Figure 26 THD performance of perturb and observation MPPT

Power quality metrics were enhanced in the THD analysis conducted in a MATLAB/SIMULINK environment as a result of the hybrid-based grid integration system's overall performance. Table 2 displays the results of comparing the proposed MPPT method to the current MPPT method.

Table 2 Comparison with existing work

Techniques	MPPT	THD
EXISTING TECHNIQUE	Fuzzy logic control	2.20%
PROPOSED TECHNIQUE	Perturb and observation	0.39%
	Incremental and conductance	0.44%

IV. CONCLUSIONS

Conventional energy resources have a substitute source in renewable energy. In far-off places where conventional energy cannot be delivered, renewable energy sources are the main ones available. This thesis investigates the MPPT based solar-wind hybrid energy system including boost converter. An MPPT algorithm is applied to raise the hybrid system's conversion efficiency. The necessary duty ratio to manage the boost converter under erratic weather circumstances is found via perturb and observe method and incremental behaviour. In this paper, a thorough investigation of solar, wind, and PMSG modelling has been undertaken. In terms of both dynamic and static performance, the simulation results show that the combination of the generator-side inverter controller, pitch angle controller, and grid-side inverter controller works quite well. The generator wind turbine may be operated efficiently by following the highest power setting. Keeping the DC-link voltage constant allows for decoupling management of the active and reactive power sources. In this way, the output will become the grid's optimal power source. Power storage devices, wind turbines constructed from permanent synchronous generators, and photovoltaic (PV) panels are also a part of the solar design. Using augmented conductivity technology, MPPT is applied to wind and photovoltaic energy systems. After MPPT, the PV array is linked to a DC-DC converter amplifier and subsequently to a standard bus network. The current fuzzy MPPT controller is compared to THD, incremental and conductance MPPT methods, and the suggested method in this virtual experiment. The suggested methods outperform the current ones in terms of THD. The continuous operation of power generating is affected by environmental factors and climatic fluctuations. To mitigate this, a hybrid PV-Wind model is suggested, as the production of a single renewable energy source is not enough to meet load demand. A boost converter to reduce inverter anomalies and an incremental based maximum power point tracking (MPPT) technique allow for effective tracking of solar energy. Power from wind turbines that use permanent magnet synchronous generators has a sinusoidal alternating current (AC) waveform. The grid is able to meet the demands by combining the two energy sources.

In the future, we want to apply optimization-based supreme power point tracking (MPPT) methods to solar, wind, and hybrid power generating systems in order to get the most power out of them and send it to the load. While the project is effective for continuous power generation, the total systems performance is affected by power quality difficulties. Voltage sag, voltage swell, harmonics, and transients are power quality concerns that primarily diminish the quality of power output from renewable sources like wind and solar.

Using more power-hungry electronics also affects the energy output, which causes variations. Static compensators and series-type LC filters (UPQC) are two methods that have shown promise in resolving power quality issues. Harmonic elimination, power factor correction, and load balancing are all made easier using DSTATCOM. Stability is ensured by utilising STATCOM. To estimate power for a continuous energy supply, modern ways of recording solar and wind data are required. The resources can be tracked using various MPPT approaches.

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