Simulation Model of Distributed Generation Systems in a Microgrid for THD Analysis

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Abstract : This study has been undertaken to investigate the determinants of stock returns in Karachi Stock Exchange (KSE) using two assets pricing models the classical Capital Asset Pricing Model and Arbitrage Pricing Theory model. To test the CAPM market return is used and macroeconomic variables are used to test the APT. The macroeconomic variables include inflation, oil prices, interest rate and exchange rate. For the very purpose monthly time series data has been arranged from Jan 2010 to Dec 2014. The analytical framework contains**.**

Index Terms **– Simulation, PV, Wind, mathematical model, THD**

1.0 INTRODUCTION

The world's fluctuating electrical supply is currently a major issue for everyone. We are aware that there must always be a solution to a problem. Electricity deregulation has created new opportunities for the design and development of small power plants. Where we may both produce and distribute energy As a result, it has several names over time, such as (DG). Then, numerous research and development of DG technology is carried out by numerous researchers in various states, behaviours, and load conditions, with various types of power generation sources, including non-renewable energy and renewable energy[1]. Additionally, hybrid energy systems are also carried out, and these systems are made with affordable, environmentally friendly, and reliable non-renewable energy. A tiny grid is an electrical system that contains several dispersed energy resources that may run in parallel inside the utility grid's perimeter. Numerous nations produce energy in sizable, centrally located facilities; nevertheless, power is frequently transmitted across great distances and may have a harmful impact on the environment

1.1 Literature Review

One of the hottest study areas at the moment is the hybrid wind-solar generation system that is connected to the power grid. The least expensive renewable energy source is wind, and solar energy has an advantage over other renewable sources since it is quiet and needs little upkeep. A wise method of power generation is provided by the integration of wind and solar power sources. The project's objectives these were difficulty of implementation and the potential for new areas of investigation. In compared to the massive generator in traditional power plants, micro-energy resources have a significantly smaller capacity[2]. In comparison to traditional power distribution systems, the frequency and voltage characteristic of electricity provided by micro grids is generally excellent. From either a grid perspective, the micro grid is run as a single managed unit inside the electricity system. Micro grid systems generate environmental advantages by utilizing low-carbon technologies. The uninterrupted power supply power cable increases regional dependability, lowers feeder losses, and supports regional voltage. Micro grids grid controlled by electronics. Solar and energy cells are the renewable energy sources that will be combined with a storage process to generate a DC micro grid and connected to the transmission network using a power semiconductor interconnection and microcontroller. Within those activities, the Super Capacitor and BESS are outfitted with the system for cutting down on power variations, enhancing power quality, and preserving power balance[3]. Thus, a review of the integration of wind and solar electricity for the micro grid is provided in this project together with super capacitor and storage battery for minimal output variations and storage of excess energy for later application. Its Superior Capacitors and Power converters are equipped with the system for reducing power fluctuations, improving system reliability, and maintaining power relationship within those operations. In order to minimize output changes and store extra energy for later use, a study of the integration of wind and solar power for the micro grid is offered in this project along with a mega capacitor and stored battery.

1.2 Research Motivation

- One of the hottest study areas at the moment is the hybrid wind-solar generation system that is connected to the grid.
- The absolute cheapest renewable energy source is wind, and solar energy has a benefit over other renewable power since it is quiet and needs little upkeep.
- A wise method of power generation is provided by the combination of solar and wind energy sources.
- The development's reasons were the difficulty of implementation and the new field of study.
- The strategy of micro grid is for constancy of power flow and can also be a better solution during outages
- The optimal control strategy focuses on lowering costs and enhancing robustness to load demand and renewable energy prediction mistakes while aiming for a continuous supply of electricity.

The research offers a novel micro grid power flow control for islanded micro grids that incorporates practical battery management features and proper coordination of various operating modes. This research focuses on designing a distributed EMS for the best performance of micro grids while taking into account the underlying power distribution networks and related constraints.

2.0 SYSTEM MODELLING

The This project focuses mostly on modelling solar and wind energy. In order to obtain a steady and desired output of PV current and voltage, the PV cells that are connected in series and parallel after modelling all of the PV cell's mathematical calculations. After the PV array is designed, a DC to DC boost converter connects the system's output, and then construct the boost converter such that the system's output is obtained as Frequency and voltage. The micro grid might be a tiny grid created specifically to supply power to indigenous populations. A micro grid is made up of several distributed generators (DGs), such as conventional generators and renewable power, together with energy storage systems[4]. Then, using the model, take a closer look at the wind power generating model. Following that, a wind turbine will provide a certain pitch angle, wind speed, and generator speed. Once we have a three-phase output from the Permanent Magnet Synchronous Generator, we attach the Ac power to dc power converters to the result of something like the PMSG. An affordable way for combining a highly reliable system and compensating for losses inside the system is called a DC microgrid.The output of the rectifier is DC, thus to obtain a high power.

2.1 Solar Cell

Solar cells, which are formed of silicon, are the fundamental parts of PV panels. A silicon p-n junction is often found in solar cells. When a lesser number of atoms from impurities are added to it, it is divided into two distinct layers. A photovoltaic (pv) system uses solar energy to generate electricity, and the PV cell is its fundamental component. In order to create PV panels or modules, cells are merged and grouped. Large solar arrays may be created by combining several PV panels. The combination of a number of samples linked in parallel or series, or the arrangement of a number of panels, makes up a solar array. The availability of traditional energy sources is dwindling and becoming more expensive every day. Once more, the severe environmental degradation is brought on by the widespread usage of conventional fossil fuels, which serve as the main source of energy. Here all the mathematical equations of the Solar PV cell is written by using which we are going to model the Solar Array.

Saturation Current.-

$$I_{o=}I_{rs} * \left(\frac{T}{T_n}\right)^3 * \exp[\left(\frac{q*E_gO\left(\frac{1}{T_{n-1}}-\frac{1}{T}\right)}{n*k}\right)] \quad (3.1)$$

$$I_{rs} = \left\{I_{sc}/\left[exp\left(\frac{q*V_{oc}}{n*N_S*K*T}\right)\right]\text{-}1\right\} \quad (3.2)$$

$$I_{ph} = [I_{sc} + \{K_i * (\mathrm{T} - 298)\} * \frac{\mathrm{G}}{100}] \quad (3.3)$$

$$\boldsymbol{I_{sh} = (V + I * R_s)/R_{sh}} \quad (3.4)$$

.

$$\mathrm{I}=\boldsymbol{I_{ph} - I_O * \left[exp\left\{\frac{V+(I.R_s)*q}{n*K*T*N_s}\right\} - 1\right] - I_{sh}} \quad (3.5)$$

Now using above equations we have some constants and the constant values are given below and i am using all the values with their respective equations for getting separate values. Along with getting separate output reference which should be satisfied according to the required of the output of a single solar cell so that all the combination of series and parallel of solar cell to make a PV array for which a desire combination techniques are used for the desire output value.

Table 3.1 Circuit specification of a solar module

Solar Module(36 W) Specification	
Rating	37.08 W
Current at peak	2.25 A
Voltage at peak	16.56 V
Short circuit current	2.55 A
Open circuit voltage	21.24 V
Total number of cells in parallel	1
Total number of cells in series	36

Now in the below table we are declare all the values of the constant use in the equations

Table 3.2 Constant values that are used in the solar equations

Name of Constant	Values
Ki	0.0032
Q	1.6e-19
K	1.38e-23
I	1.3
EgO	1.1
Rs	0.221
Tn	298
Ns	54
Voc	32.9
Isc	8.21

2.2 Modelling of Solar Module

Solar cells are combined in parallel and series to create a PV array. The image below depicts a straightforward representation of an analogous solar cell circuit. Numerous cells are combined in order to improve performance or rating. Solar cells are joined in parallel to enhance current, and they are linked in series to improve output voltage. Consequently, a specific PV array is made up of a number of PV modules that are connected both in series and in parallel. A module is made up of a number of solar cells coupled in parallel and series. The photoelectric cells underlies this state's operation. According to this effect, a silicon produces an electric current when it is contacted to electrical rays. Whenever a solar cell is exposed to light, some electron hole pairs are produced, which turns the solar energy into electricity.

2.2.1 Saturation Current

First, two constant blocks are taken and given the names 1 and Tn, respectively, before being connected to a math block. Next, a constant value of 1 and a temperature T input port are taken, and both are connected to a math block multiplier and divider. Finally, the output of both math functions is connected to a second math function with plus and minus. Once more, two constants with the names "n" and "k" are taken, they are linked to a multiplier, and the output is attached to another block of math function. A second multiplier is connected to two constant blocks called "q" and "EgO," and the output is connected to a third multiplier. After that, a constant Tn and an input T are taken, a division math function with cube function math block is connected, and the output of the exponential and cube is connected with a multiplier. Finally, a generate exponential function is connected to the output of the multiplier. The multiplier's output is now designated as "Io" after it has multiplied an input "Irs" twice (Saturation Current).

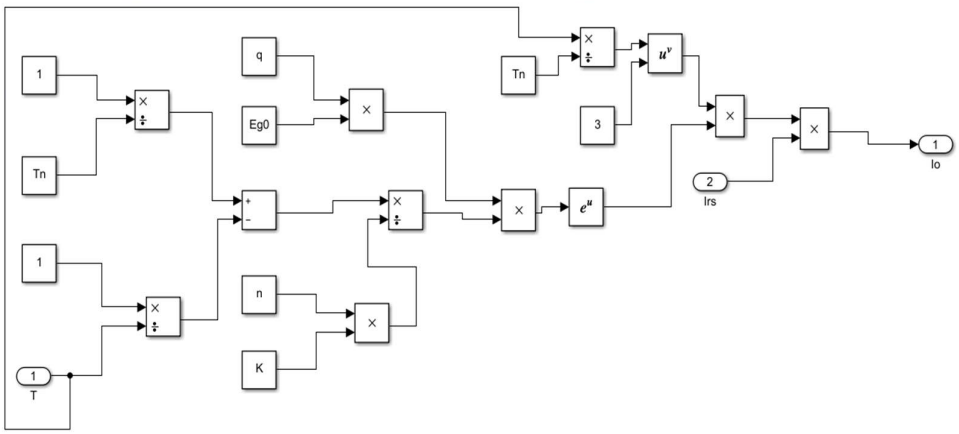


Figure 2.1 Simulation of Saturation Current

2.2.2 Reverse saturation current

Reverse Saturation is used. A multiplier block is connected to the first take two constant blocks now in use, "q" and "Voc." The output of the multiplier is connected to an exponential block, and the output of the block is connected to a summation and minus block for a constant 1. Then, 3 constants named n, Ns, and K with an input of T are connected to a multiplier, and the output of both multipliers is again connected to a math function block multiplier and divided operation. The block's output can be connected once again to a division and multiplier block with the constant input "Isc," and the math function block's output is designated as "Irs" (Reverse saturation current).

$$\boldsymbol{I_{rs}} = \left\{ \boldsymbol{I_{sc}} / \left[\boldsymbol{exp}\left(\frac{\boldsymbol{q * V_{oc}}}{\boldsymbol{n * N_s * K * T}} \right) \right] \text{-}1 \right\} \qquad (3.6)$$

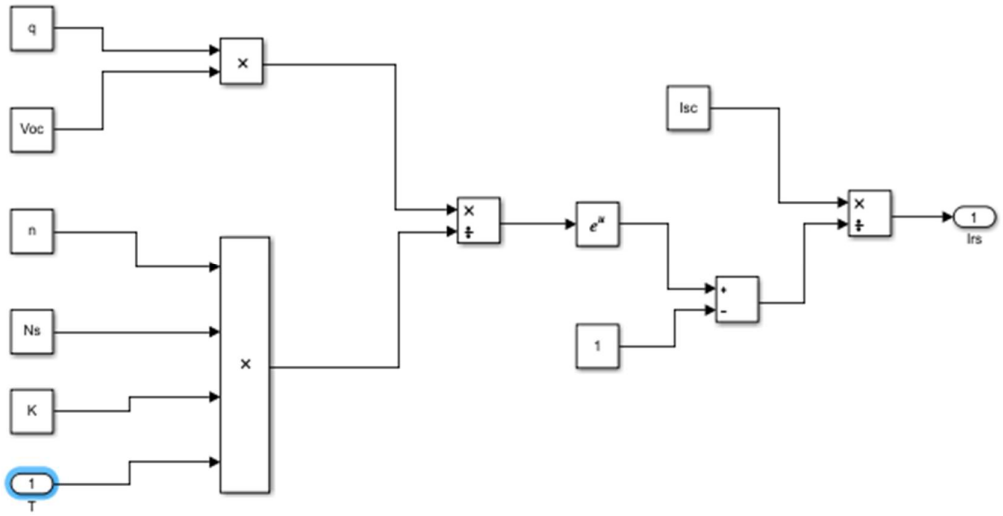


Figure 2.2: Simulation model of Reverse saturation Current

2.2.3 Photo current:-

The aforementioned function, called photocurrent, first converts temperature gradient into Fahrenheit by connecting input "T" with a fixed value of 298 through into the arithmetic functions pulse and minus. An accumulation block with a constant value "Isc" is connected to the output of the math function by a multiplier, and the summation block's output is then multiplied by an input "G" once again (Irradiance). The result of the math function block is designated as "Iph," and the multipliers block's output is once more divided by a fixed value of 1000. (Photo current).

2.2.4 Shunt current

For shut current, a multiplication blocks is first used to combine an input I and regular constant block known as Series Resistance "Rs", the Constant value "Rsh" has a value that is 415.405 Ohm,; the result of the block is then added to an input value "V" which is taken as an input from a constant step function which is mainly used as a step function which is mainly used to get a specific output of the Shut current so it is added with the result of the Current and Series Resistance. That used a summarizing block; the result of the summation block is then once again multiplied and divided by a constant "Rsh". Ish is used to represent the math function block's output (Shunt current).

$$I_{sh} = (V + I * R_s)/R_{sh} \qquad (3.7)$$

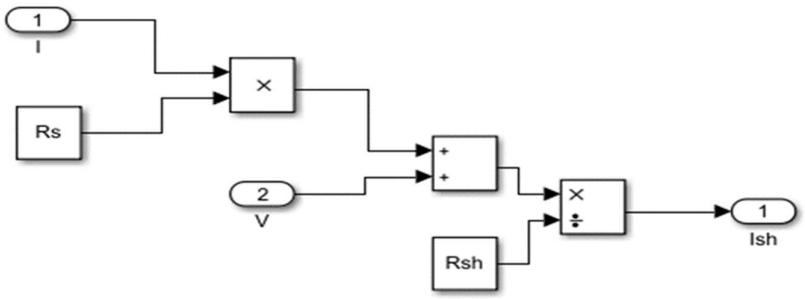


Figure 2.3 Simulation model of Shunt Current

2.2.5 PV CURRENT

$$I = I_{ph} - I_O * \left[exp\left\{\frac{V+(I.R_S)*q}{n*K*T*N_s}\right\} - 1\right] - I_{sh} \qquad (3.8)$$

2.2.6 Wind Turbine

Turbines with two or three blades are also being developed. Great velocity and high performance of the rotors were prerequisites for effective energy generation. Reduced carbon emissions may be accomplished in part by using renewable energy sources like wind energy.

$$P_O = \frac{1}{2}(\textbf{air mass per unit time})(\textbf{wind velocity})^2 \quad (3.9)$$

$$= \frac{1}{2}(\rho A V_w)(V_w)^2$$

$$= \rho A V_w{}^2$$

The above equation is for power available in the wind, but it is different from power transferred from the wind turbine. According to above wind turbine equation all the values that are find to be the air mass density to the unit time with the velocity of the follow of the wind which is mainly find according with the system for getting the total power out of the wind turbine.

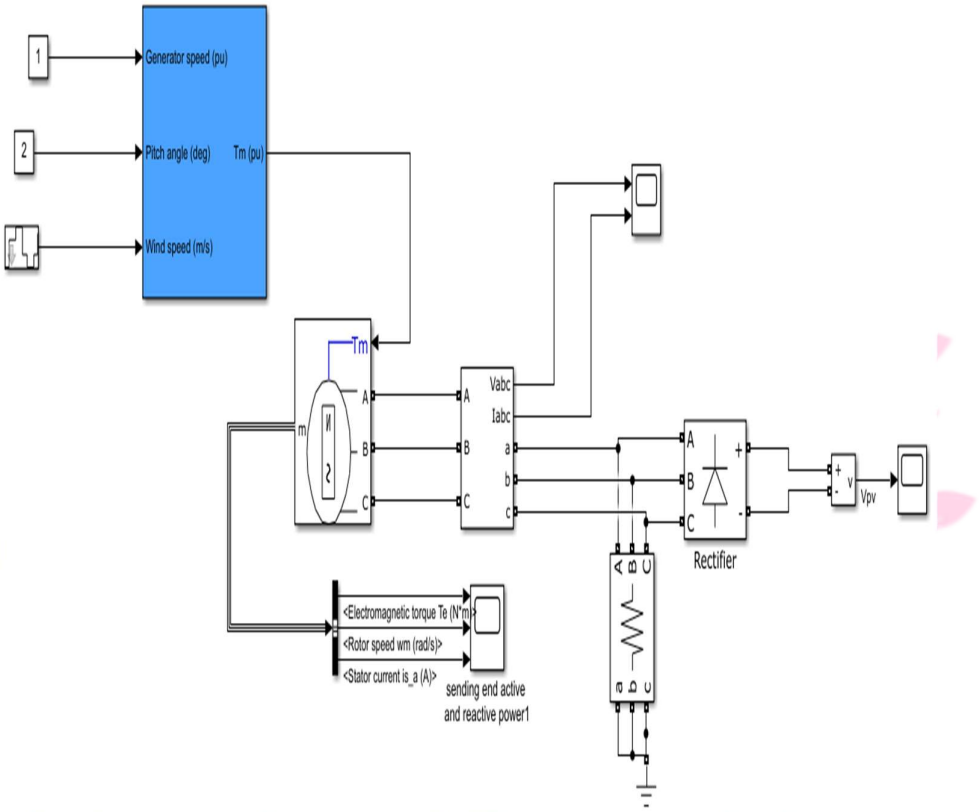


Figure 2.3Wind turbine Simulation in MATLAB

3.0 COMBINED PV- WIND AND BATTERY SYSTEM

A combined wind-PV hybrid production system makes use of both solar and wind energy to produce electricity. Individual renewable energy sources like the wind and sun behave randomly. Solar energy is present all during the day, but because of the sun's strength and the unpredictable shadows cast by clouds, birds, trees, etc., the solar irradiation levels change. These factors contribute to the unreliability and low utilization of solar energy.

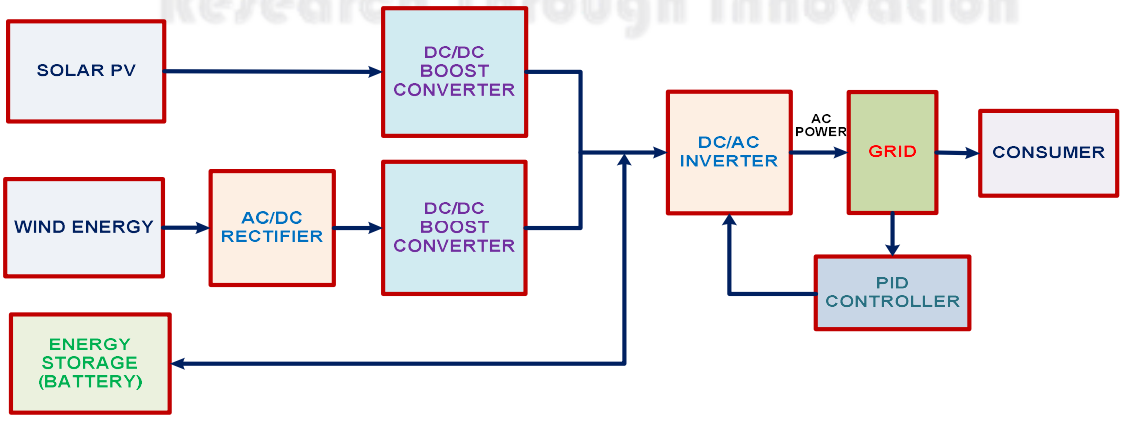


Figure 3.1 Block diagram of the whole system

Therefore, using a hybrid generating system is preferable to using a single wind or solar power system. Therefore, it outweighs the drawbacks of a single system. The hybrid generating system's grid interface increases system dependability. Simulation of Solar Module:

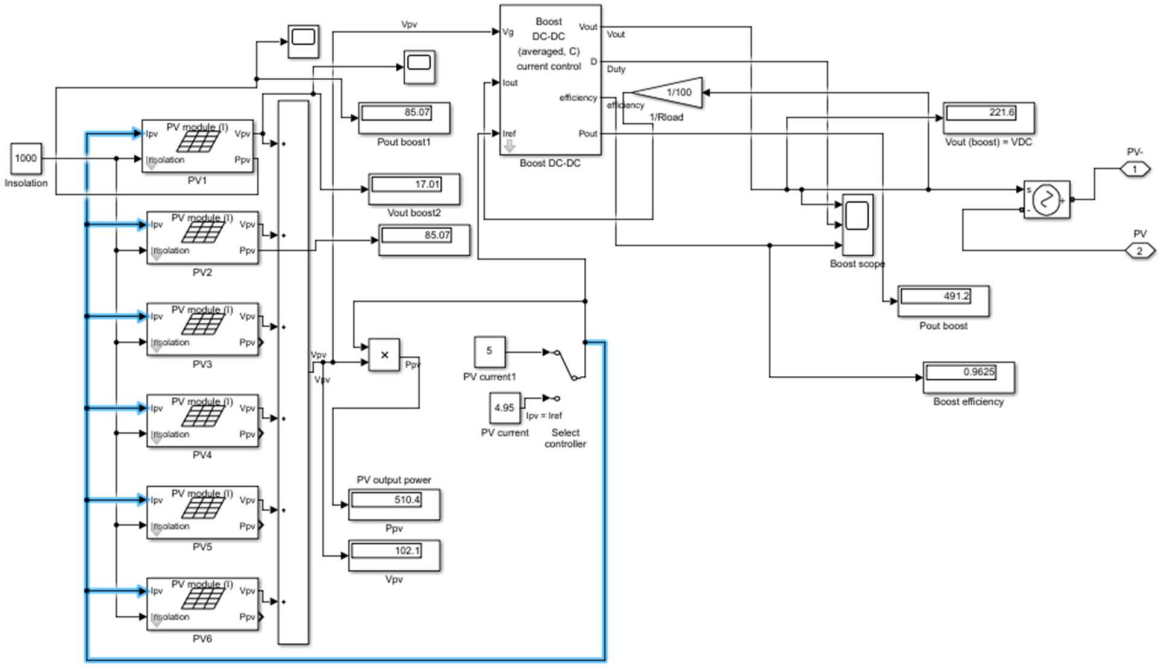


Figure 3.2 Simulation of PV module

In the simulation it is shown that SIX PV array are connected in series and then all the module are given with a constant irradiance with 1000 and Constant current supply that is varies with Iref to Ipv i.e 5 to 4.95. The module is designed such a way that the output of the PV array is voltage and Power, the value of a single array is power 85.07watt and the voltage is 17.01v so that the total output of the 6 PV array together are power 510.4 W and Voltage is 102.1W. for getting a desire output of the voltage of the total solar module in between 220 to 230 I connect a DC to DC boost converter and the converter is designed in such a way that we are getting the output of boosted voltage, power with duty cycle and efficiency so that all the value are created here by taking the input of

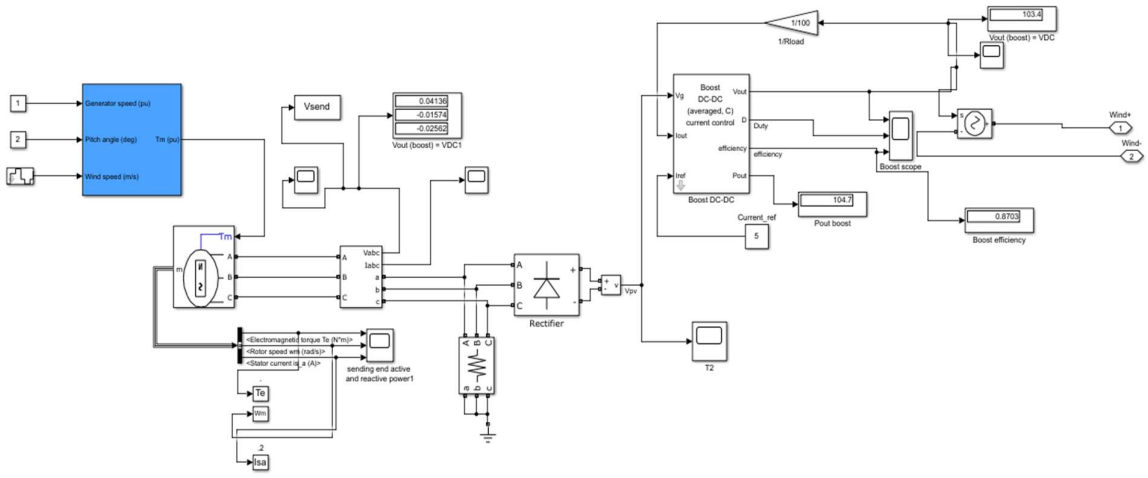


Figure 3.3 Simulation of PV module with Boost Converter

Voltage and output current and the reference current so that the output current is calculated by the output voltage and power using a gain factor so that it can be called as a closed loop path after doing all the boost operation we are getting the output as 221.6 a constant dc supply and the power output is 491.2 and the efficiency is almost 0.9625. and we are taking the whole system output is only voltage positive and negative terminal which is possible by only connecting a controlled voltage and then taking the output as

two output port that is positive port of voltage and the negative port of the voltage. Mainly we are taking the dc output from PV and then connecting a DC to DC boost converter and then taking the Output

3.1 Simulation of PV, Wind and Battery combined system

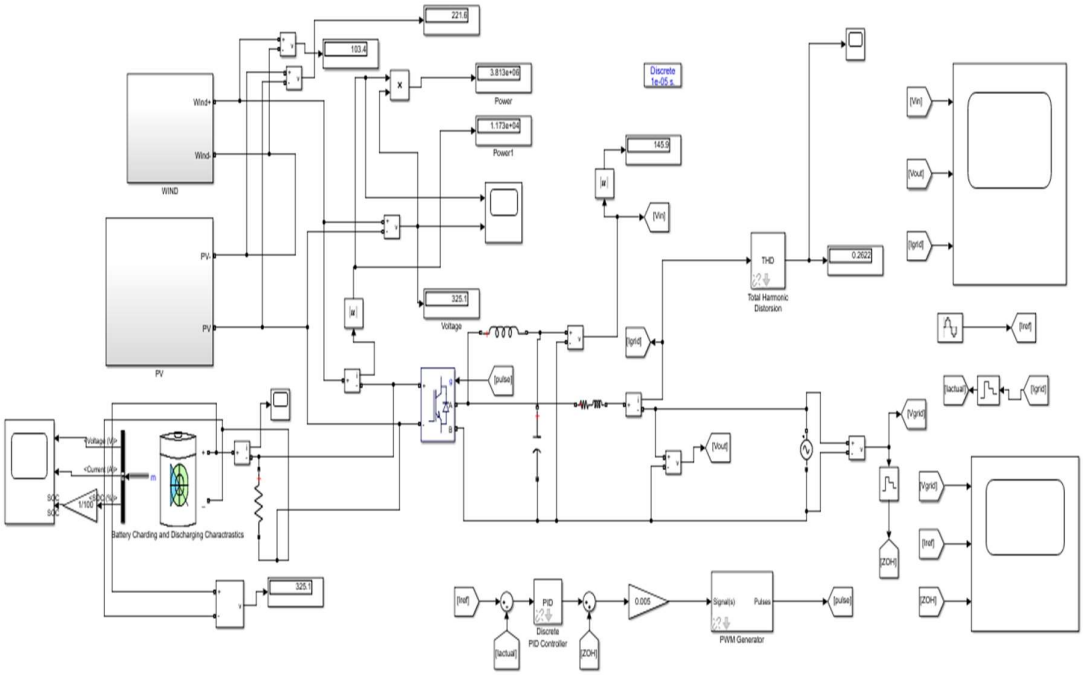


Figure 3.4: PV, Wind and Battery based Micro grid

3.2 Simulation of Wind Energy

In the above simulation the wind turbine is first given with respective inputs such as speed of the wind, respective pitch angles of the turbine blaze then the generator speed. Then the torque of the wind mill given to machine which is permanent magnet synchronous machine act as a generator here converted into Permanent Magnet Synchronous Generator (PMSG). The output of the PMSG is 3 phase output so a three phase measuring device is connected to take the output of the 3 phase voltage and current.

In the above system all the previously designed PV system and the Wind system are both connected in series so the battery can directly connected and then the battery can act as a source and can also act as load depending upon the battery value. Then the supply is given to the universal bridge where the get pulse are controlled by a PI control and then the output is given to the filters where we use mainly LC filter for the filtering the output of the universal bridge so when we are planning for the giving the output of the universal bridge to a THD calculator mainly designed by using the fast Fourier equations that are RMS value, Mean value and mag Fourier phase so that we can calculate the Total Harmonics distortion so that all the values that are calculated and plotted and such that we can do the grid side THD analysis for Voltage as well current for finding out such systems to given input to grid. All the value output are taken and shown in their respective scope and we can find out all the values are normal and for finding out the system and then for getting the actual current we are using the zero order hold of the grid side current and a sine wave is taken for the reference of the PWM get pulse generator.

3.3 Pv System Connected Microgrid

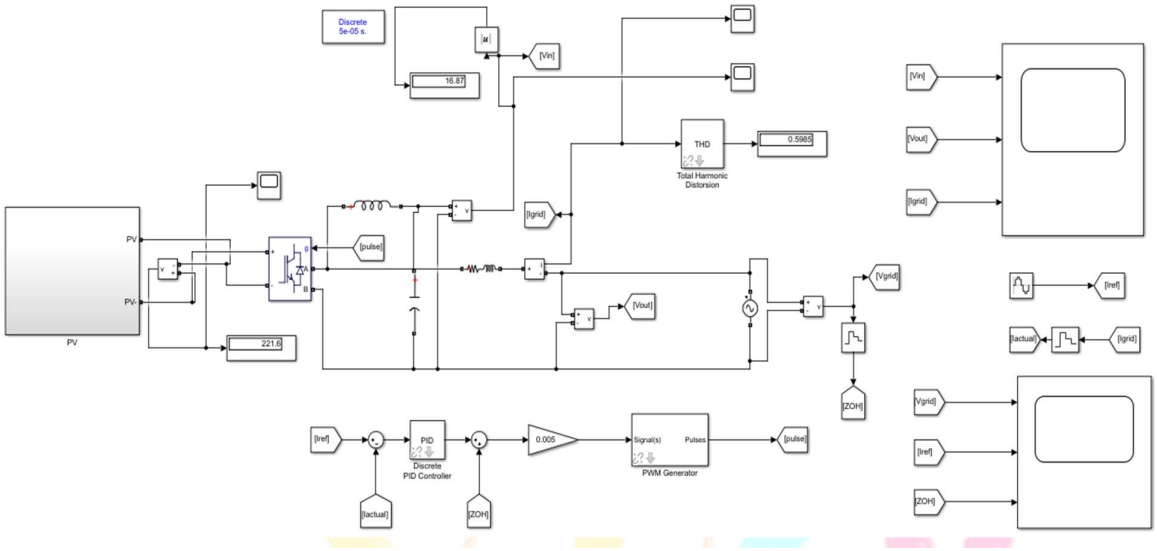


Figure 3.5 : Simulation of system connected Microgrdi

In the above system we designed a micro grid mainly using the PV energy system we are only using the single system that is PV for giving supply to the grid. Then the supply is given to the universal bridge, where the get pulse are controlled by a PI control, and the output is given to the filters, where we primarily use an LC filter to filter the output of the universal bridge. When we are planning to give the output of the universal bridge to a THD calculator, which is primarily designed by utilizing fast Fourier equations that are RMS value, Mean value, and mag Fourier phase so that we can calculate the Total Harmonics distortion. THD analysis for Voltage as well current for finding out such systems to given input to grid. .All the value output are taken and shown in their respective scope and we can find out all the values are normal and for finding out the system and then for getting the actual current we are using the zero order hold of the grid side current and a sine wave is taken for the reference of the PWM get pulse generator. with single phase by connecting a rectifier circuit. Then the supply is given to the universal bridge, where the get pulse are controlled by a PI control, and the output is given to the filters, where we primarily use an LC filter to filter the output of the universal bridge.

4.0 RESULTS AND DISSCUSSION

All the output results from different section of the simulation is taken into account which we get after simulation and results are display here

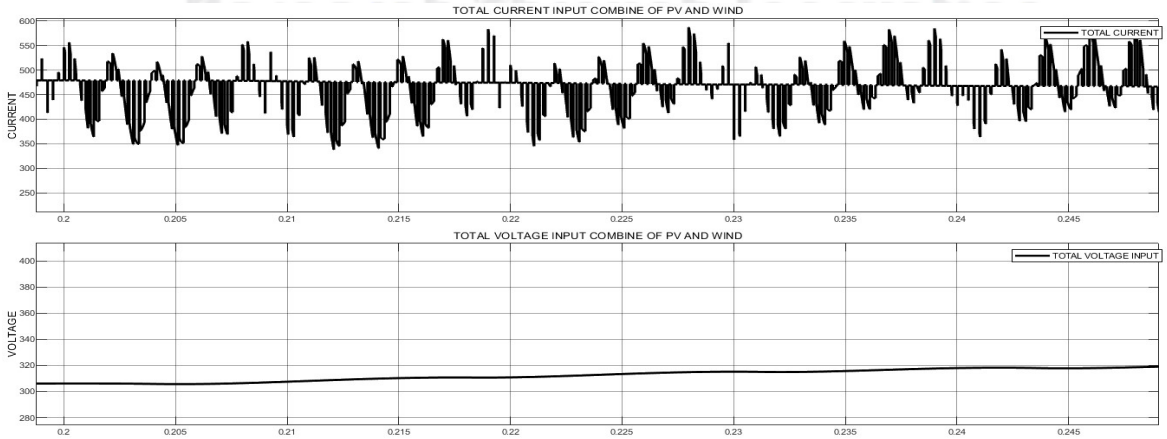


Figure 4.1 Total Current And Voltage From Pv And Wind Combination

In the above scope output we are displaying the total output of the PV and WIND energy system which are connected in series and the total voltage and current are display there for a certain time interval in dc supply in display in that scope

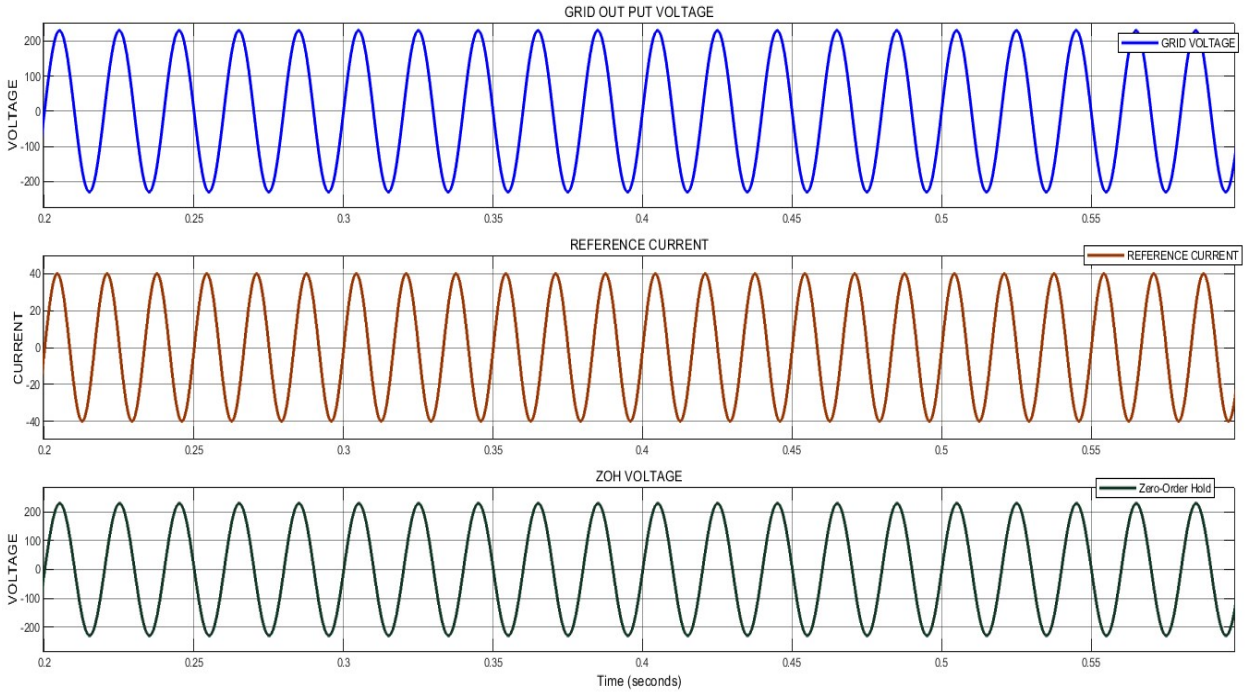


Figure 4.2 All the Output of input grid voltage, Output Grid Voltage and Current

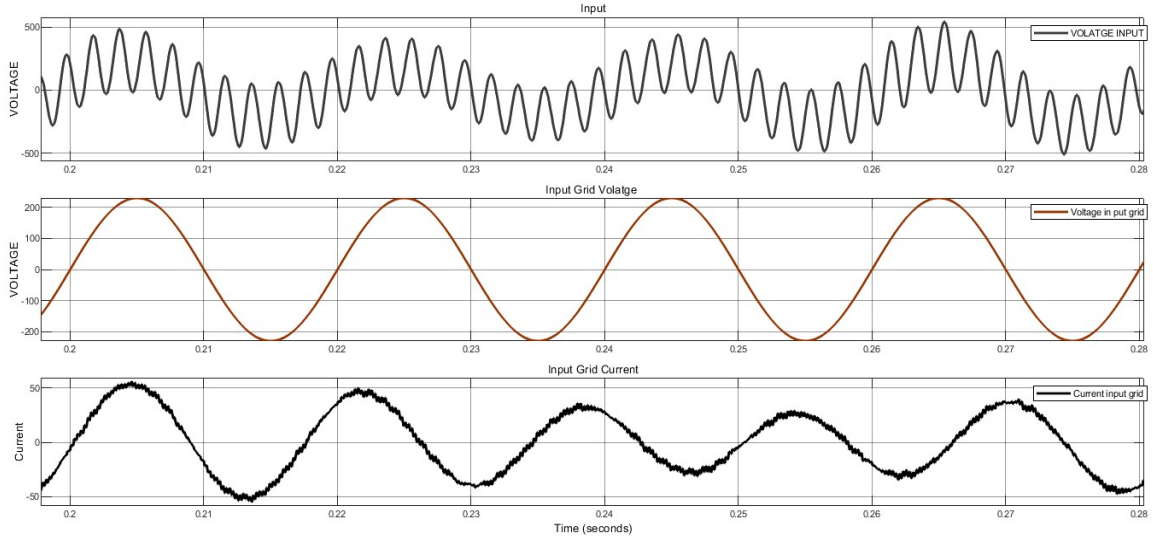


Figure 4.3 All Output Grid Voltage, Reference Current and Zero Order Hold Voltage

In this scope output we are getting the total input voltage to the Grid after doing filter with Low pass filter LC and the total output getting in the output side of the grid which is mainly working in terms of certain interval of the time for the output of Voltage and Current in the grid side.

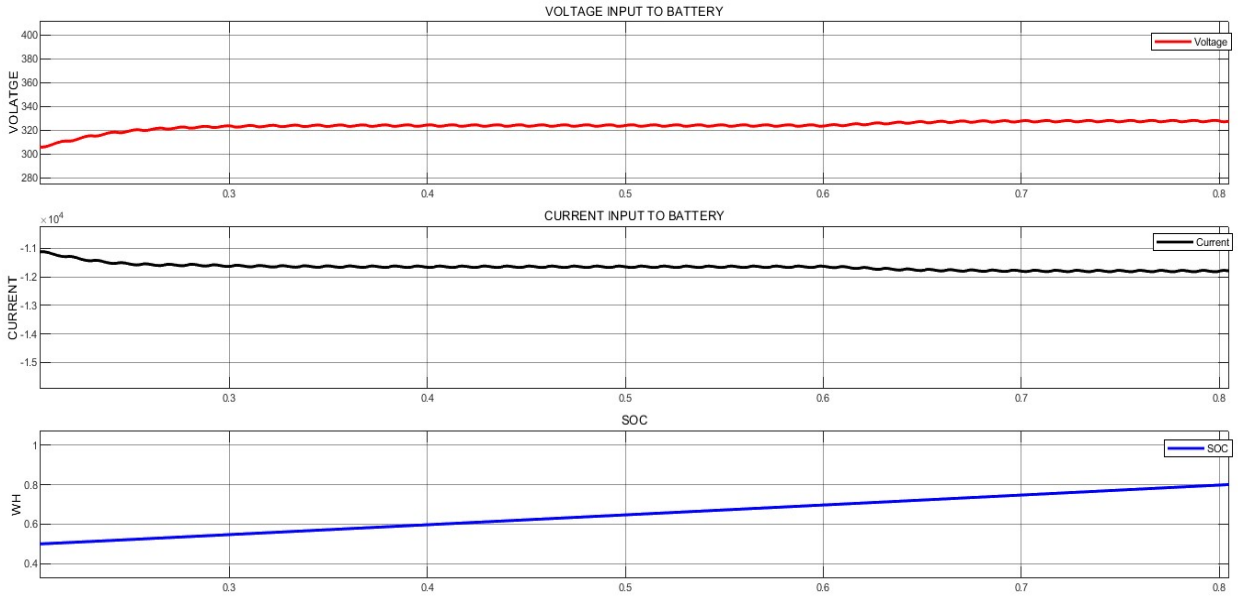


Figure 4.4 Battery acting as Source (Discharging Condition)

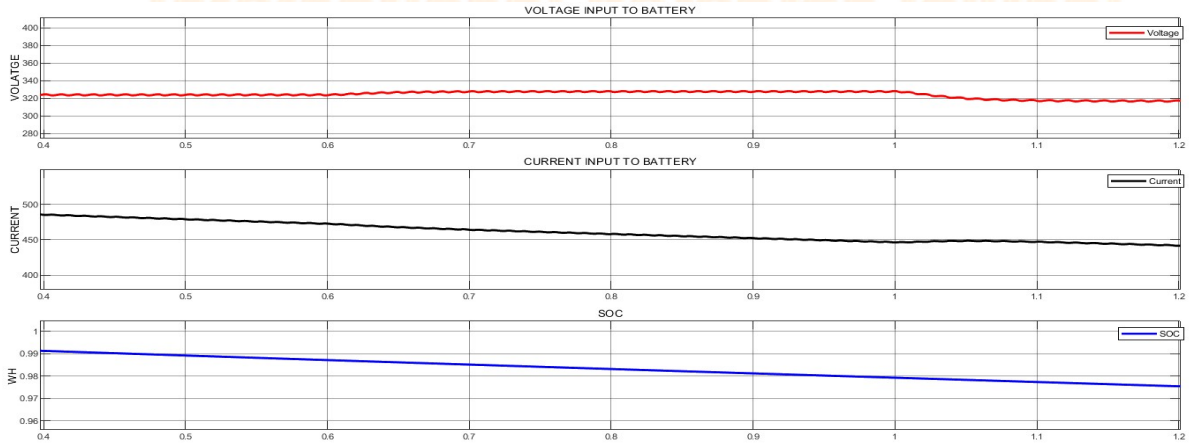
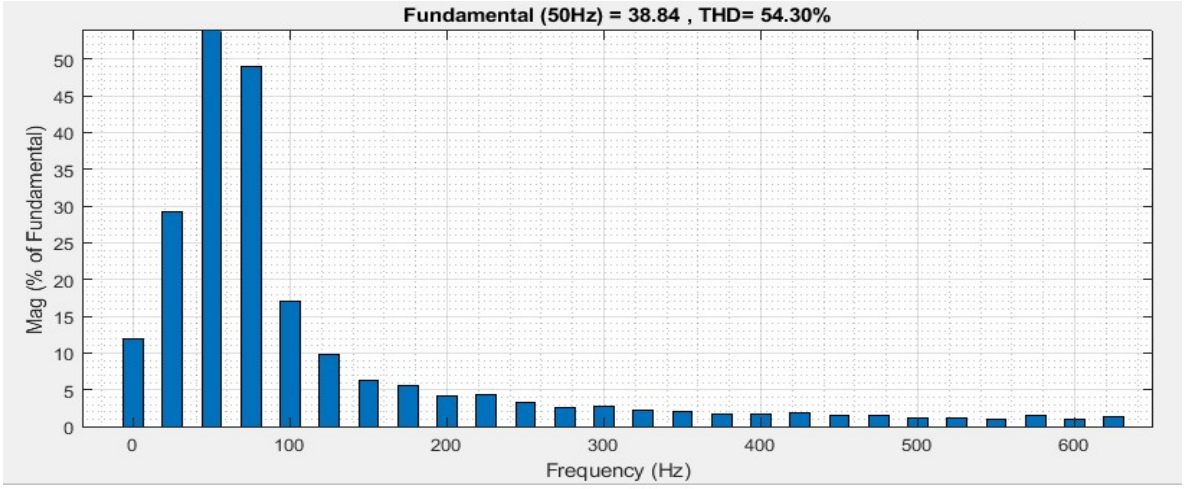


Figure 4.5 Battery acting as Load (Charging Condition)

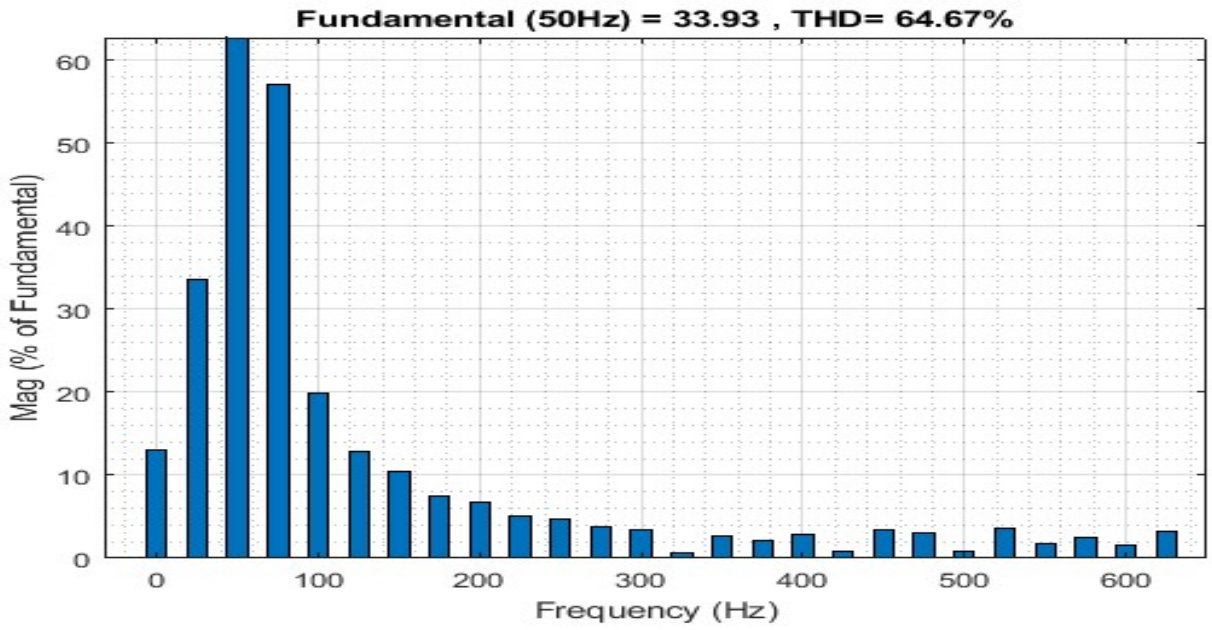
In the above scope of the battery we are know that the battery used in the simulation can work in bidirectional act as source or can act as Load means storage device. Here in the scope output we are getting that the battery is act a Load which is under charging condition, and the total voltage and current input to battery system

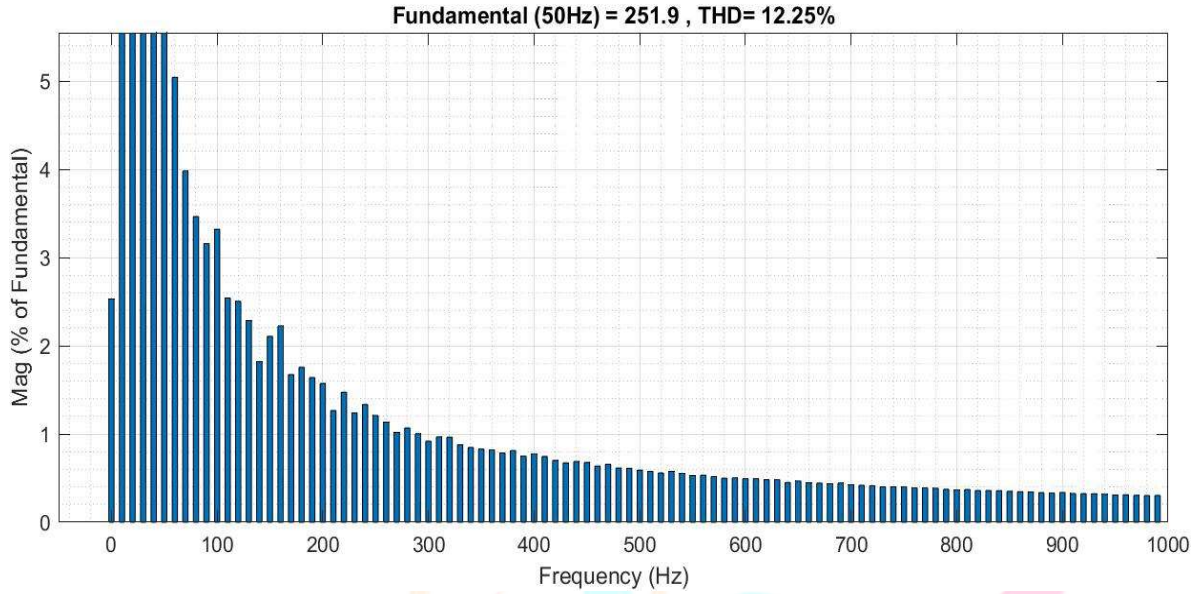
4.1 THD Results Of Combined Microgrid

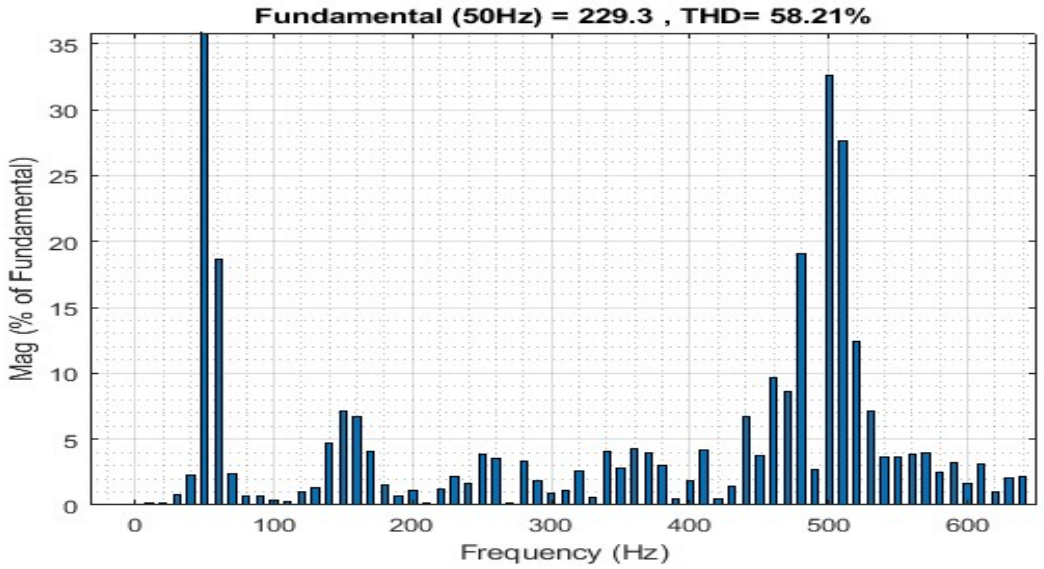


In the above two bar chat we are finding out total THD of both Voltage and Current in of Combined Source (PV, WIND and BATTERY) Connected Micro grid whose result is taken in a fundamental frequency of 50Hz with the total highest maximum frequency is 650 hz and getting the THD of voltage is 54.30% and Current THD is 12.25%.

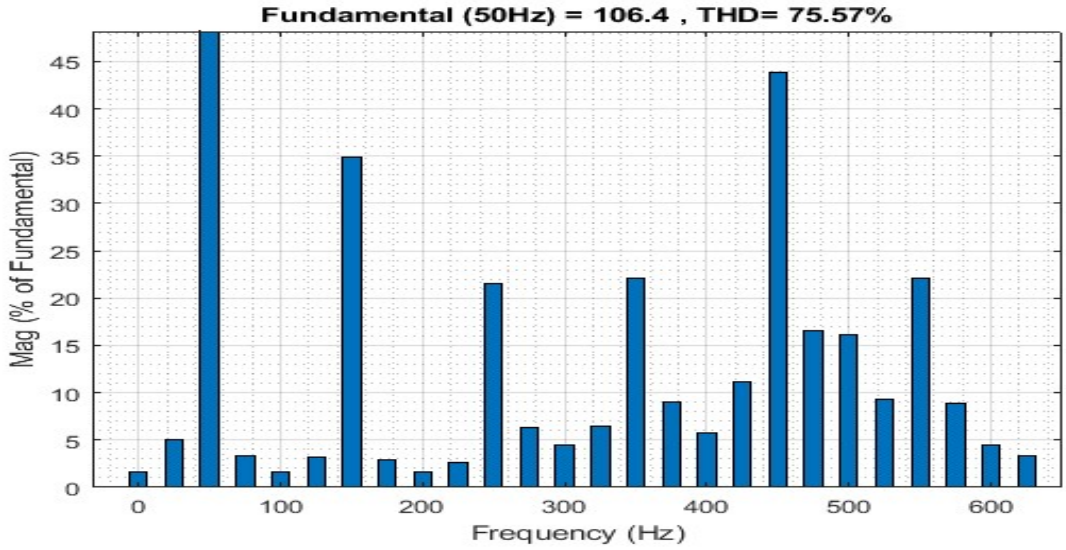
4.2 THD Results Of Pv Source Connected Microgrid







In the above two bar chat we are finding out total THD of both Voltage and Current in of Individual Source (PV) Connected Micro grid whose result is taken in a fundamental frequency of 50Hz with the total highest maximum frequency is 650 hz and getting the THD of voltage is 58.21% and Current THD is 64.67%.

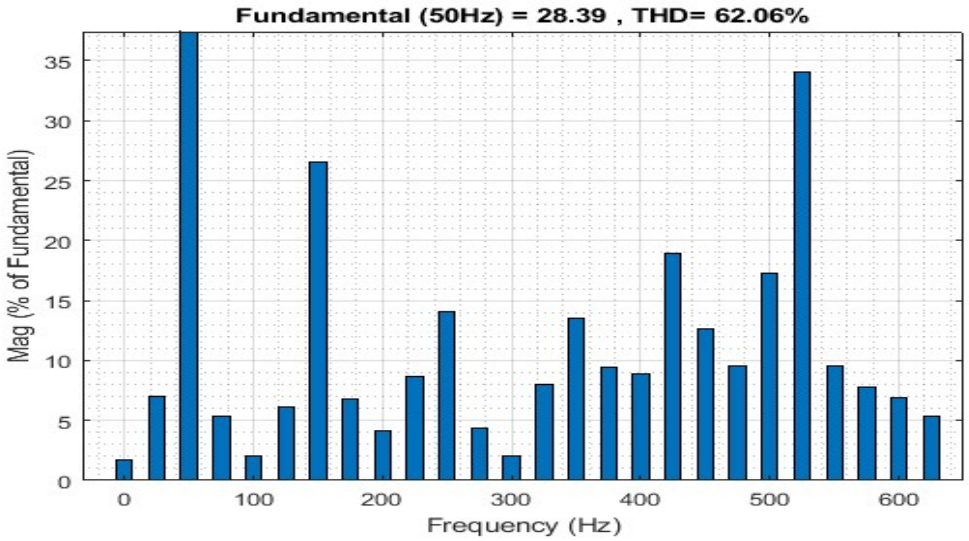


4.3 THD Results Of Wind Source Connected Microgrid

In the above two bar chat we are finding out total THD of both Voltage and Current in of Individual Source (WIND) Connected Micro grid whose result is taken in a fundamental frequency
In the above two bar chat we are finding out total THD of both Voltage and Current in of Individual Source (WIND) Connected Micro grid whose result is taken in a fundamental frequency of 50Hz with the total highest maximum frequency is 650 hz and getting the THD of voltage is 75.57% and Current THD is 26.87%.

SYSTEM	*CURRENT THD (in %)*	*VOLTAGE THD (in %)*
WIND	26.87	75.57
SOLAR	58.21	64.67
BATTERY	16	62.06
COMBINED SOURCE	12.25	54.30

In the above two bar chat we are finding out total THD of both Voltage and Current in of Individual Source (BATTERY) Connected Micro grid whose result is taken in a fundamental frequency of 50Hz with the total highest maximum frequency is 650 hz and getting the THD of voltage is 62.06% and Current THD is 16.00%.



From the above table we are getting the results that by calculating all the THD of current and voltage for combined source micro grid as well as individual source micro grid are taken into account and by comparing all the system with their THD values we find that PV Energy Source based micro grid has the highest THD values for Current THD followed by Wind, Battery and at last combined source micro grid has the least Current THD of 12%. Then for voltage THD the highest THD is found in the wind system based micro grid and then followed by solar, Battery and at last Combined Source. At the end we get the result as all the combined source micro grid are much reliable and high efficiency.

CONCLUSION

In the MATLAB simulation, all the operation of PV wind and battery based Micro grid (MG) has been simulated with the operation of all type of Converters and rectifier for calculating all the output and getting some desire values the system is used special designed boost converters. MPPT of all the system like wind and PV are taken in calculation. In the wind energy system the PMSG is used for converting wind energy into AC source of 3 phase and then convert the ac to dc by using a rectifier circuit. All the source are used here have the dc output and then the system is connected in series and the bidirectional battery is connected and then combined output of voltage supplied to MG through the universal bridge and at the end all the gate pulse is controlled by a discrete PID controller and then the THD is also calculated and then an individual source connected circuit is designed for PV, WIND, BATTERY at the all the THD of 4 system are in terms of Voltage and Current THD are calculated and plotted with the system at the end it taken into the analysis and result generate in the systems.

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