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Design and Control of Micro Grid Fed by Renewable Energy Generating Sources

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ABSTRACT

This work presents a control of a micro-grid at an isolated location fed from wind and solar based hybrid energy sources. The machine used for wind energy conversion is doubly fed induction generator (DFIG) and a battery bank is connected to a common DC bus of them. A solar photovoltaic (PV) array is used to convert solar power, which is evacuated at the common DC bus of DFIG using a DC-DC boost converter in a cost effective way. The voltage and frequency are controlled through an indirect vector control of the line side converter, which is incorporated with drop characteristics. It alters the frequency set point based on the energy level of the battery, which slows down over charging or discharging of the battery. The system is also able to work when wind power source is unavailable. Both wind and solar energy blocks have maximum power point tracking (MPPT) in their control algorithm.

KEYWORDS: *DFIG, DC, MPPT, PV*

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I. INTRODUCTION

A hybrid energy system comprises of two or more form of energy sources also known as hybrid system, has an advantage of tracking the BES demand and increasing reliability hybridizing is completely dependent on wind and solar energies. Each of them has a nature of being an alternative of every daily as well as yearly pattern. Scientist has honoured these hybrid systems on a way large scale. One of the developments applying wind generation is PMSG through which gearless configuration can be achieved, it requires 100% rated device in addition to costly machine. As per the MPPT, DFIG is preferred over SCIG because it has better outcomes. DFIG is used and also appreciated worldwide for presenting excellent results in combination with PV array. DFIG produces various speed operations with minimum power rated converters. In order to design system as micro grid all the things have to be compliances with the IEEE-519norms.As there are several places where electricity remains affected for 10-12 hours because of which these remote locations don't have access to electricity though they are connected by grids and also economic activities of inhabitants suffer a lot. In order to provide some relief to them the scientist have come up with an idea of withdrawing the energy from renewable natural resources such as solar, wind and biomass. By doing such activities dependency on grids (fossil power) gets curtailed. Wind and solar power sources remain preferable as compared to bio-mass because it backs to offer chain issue. Being natural components (i.e. wind or solar energies) have disadvantages too as they are dependent on nature which is completely unpredictable, power variability is also there, utilization capacity is not that good. Due to this reason autonomous system are not fully reliable thus firms cannot bond on them on the other hand if we talk about battery energy storage (BES) have advantages such as curtailing power fluctuations, energy is utilized as per the operation of its requirements. There is a tracking system known as MPPT developed to check running of operations, use of having wind energy generates of solar PV in order to generate more current from input resources. Wind power is the utilization of wind stream through wind turbines to precisely power generators for power. Wind power, as an option in contrast to consuming non-renewable energy sources, is abundant, sustainable, generally conveyed, clean, creates no ozone harming substance outflows during activity expends no water, and uses little land. The net consequences for the earth are far less tricky than those of non-sustainable power sources. Wind comprises of numerous individual wind turbines, which are associated with the electric power transmission arrange. Inland wind is a reasonable wellspring of electric power, serious with or in numerous spots less expensive than coal or gas plants. Seaward wind is steadier and more grounded than ashore and seaward homesteads have less visual effect, yet development and upkeep costs and significantly higher. Little coastal wind homesteads can take care of some viability into the grid or give electric power to confined off-grid areas. The main nature of DFIG is to decouple mechanical and electrical frequencies and creating variable speed operation possible. However rotary engine cannot operate in a fully speed but can operate in a manageable speed. Since the convertor here is smaller therefore the loses are not that huge.

II. RESEARCH OBJECTIVES

- Controlling and redesigning of a renewable energy based micro grid connected system.
- Extracting of more power from REGS and provision of quality power to the consumers
- Give the appropriate protection to the whole micro-gridsystem for a risk free and smooth operation of system.
- The performance of the system has been presented for change in input conditions for different type of load profiles.

III. RESEARCH METHODOLOGY

This research work will adopt a research methodology that combines the theory model with empirical evaluation and refinement of the proposed scheme on MATLAB simulation tool. MATLAB is a useful high-level development environment for systems which require mathematical modelling, numerical computations, data analysis, and optimization methods. This is because MATLAB consists of various toolboxes, specific components, and graphical design environment that help to model different applications and build custom models easier. Moreover, the visualization and debugging features of MATLAB are simple.

WIND TURBINE AND GEAR:

The driving torque for DFIG is provided by wind turbines. The value of the mechanical power value is given by:

$$P_m=0.5C_p\pi r^2\rho V^3 w$$

Power Coefficient, Cp = 0.4

$$A=\pi r^2$$

Blade Length, r =1=7.8m

A=3.14*7.8*7.8=191.037

Wind Speed, v = 13m/s. Air Density ρ = 1.23 kg/m³

$$P_m=0.5*0.4*191.37*1.23*13*13*13$$

$$P_m=103248.239=103KW$$

Here V_W, is Velocity and Wr is the radius if the used turbine. C_p is the coeff. Of performance. Neglecting losses, at a very high wind speed, the power of DFIG(Pe)is related to (Pag) which is air gap power.

$$P_C = \frac{P_{ag}}{(1+|S_{pmax}|)}$$

$S_{pmax}$is the slip with respect to the turbine speed, ωrm (-0.267). The speed of DFIG is the speed with respect to slip 0.3 to -0.267.

LINEAR TRANSFORMER:

Transformer is a device which transfers the electric energy from primary coil to the secondary coil with the principle of mutual induction, where there is no connection between the two coils. An AC can be increased or decreased as per desired output. In its construction as shown in figure, it consists of two coils namely the primary and the secondary coil which are separated from each other physically and are connected by the principle of mutual induction once the primary gets the input from a AC source. Thus, the two coils go under a mutual inductance. The basic transformer is shown in figure.

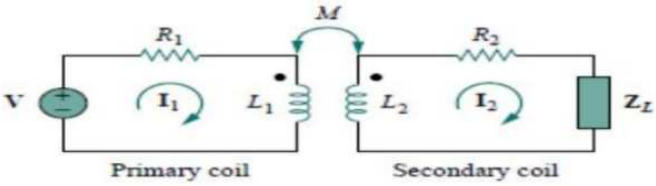

Figure 1.1: Coils of Linear Transformer.

A linear transformer is connected with the LSC (Line Side Converter) which in turn is connected to the load and stator. It also acts as neutral for a loads at 415 V. The max. absolute value of rotor slipis0.3 thus the max. rotor voltage Vrmax goes upto 125 V (0.3x4l5 V). The transformer has a voltage ratio 415/ 125 V. The transformer used must be such that it should satisfy the required kVA of load and the filters to get the max output voltage. Accordingly, a 2.4×10^5 kVA transformer is chosen which is capable of transferring the desired power along the connected loads and filters at highest time of the demand.

BATTERY SIZING:

A 100 kW micro-grid system is proposed in this thesis. it is designed for a constant output up to 12 hours. Taking 20% margin for power losses in the system during the transfer of energy, the required battery storage capacity becomes 1440 KW hr. At the DC voltage of 240 V, the Ampere-Hour (AH) rating of battery goes upto 6000 AH (1440, 000/240). This is achieved using 40 numbers of l2V, 150AH batteries divided equally into two parallel circuits. The battery banks can be easily operated between 2.25 V and 1.5 V per cell. This makes Vbmax and Vbmin to be 270 V and 216 V.

SOLAR PV SYSTEM:

The basic element of a PV array is the solar cell, and these are arranged such that they satisfy the followingcondition:

$$N_c = \frac{V_{dcm}}{V_{occ}}$$

$$V_{occ} = 0.64V$$

Open Circuit Voltage of PV Cell, V_{occ}	0.67V
Open Circuit Voltage of a model, V_{oc}	23.04V//64.2V
Total Current of Grid	400A
MPP Voltage of Module (V_{mp})	18.83V//54.7
Short Circuit Current of Module (I_{sc})	8.69A//5.96
MPP Current of Module (I_{mp})	8.04A//5.58
Module Power Rating	151Wp//305.226
uI_{sc}	0.04%/◦C//0.061745
uI_{oc}	-0.36%/◦C//-0.27269
PV modules in the Solar Block	66 Strings each having 5 PV modules
String Open Circuit Voltage, u_{soc}	207.36 V//250V
Capacity of Solar PV System	100KWp

Table 1.1: Technical Details of Solar Block.

Control of Solar Converter:

It is a DC-DC converter which is used to collect the max. power within the S-MPPT logic. The S-MPPT very sharply handle the cross over so that the solar system operates at MPP.

Control of LSC:

When these systems are designed practically it is observed that these wind turbine generates power only for 60-70% of the time, but our requirement is to designed such a micro grid when no wind energy is available. Thus the monitoring of *i*qs* and i*ds for the reference stator currents is very important and this is done with the help of LSC.

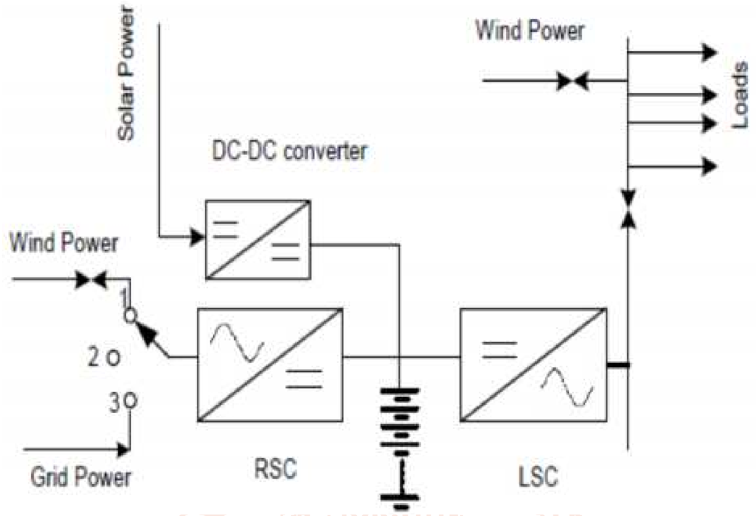

Figure 1.2: LSC (Load Side Converter)

MPPT Algorithms:

In electric circuits the MPPT algorithms are required for application of PV inverters because temperature and irradiation. So to obtain maximum power of Solar circuit is obtained using MPPT algorithm. Recently many techniques have been developed to find the MPP and these techniques are different from one another on the basis of sensors, cost, range, co reference control etc. These techniques have advantage of easy implementation but it also has drawbacks. In ordinary conditions the V-P curve has just a single maximum, so it's anything but an issue. Be that as it may, if the PV exhibit is somewhat concealed, there are different maxima in these bends.

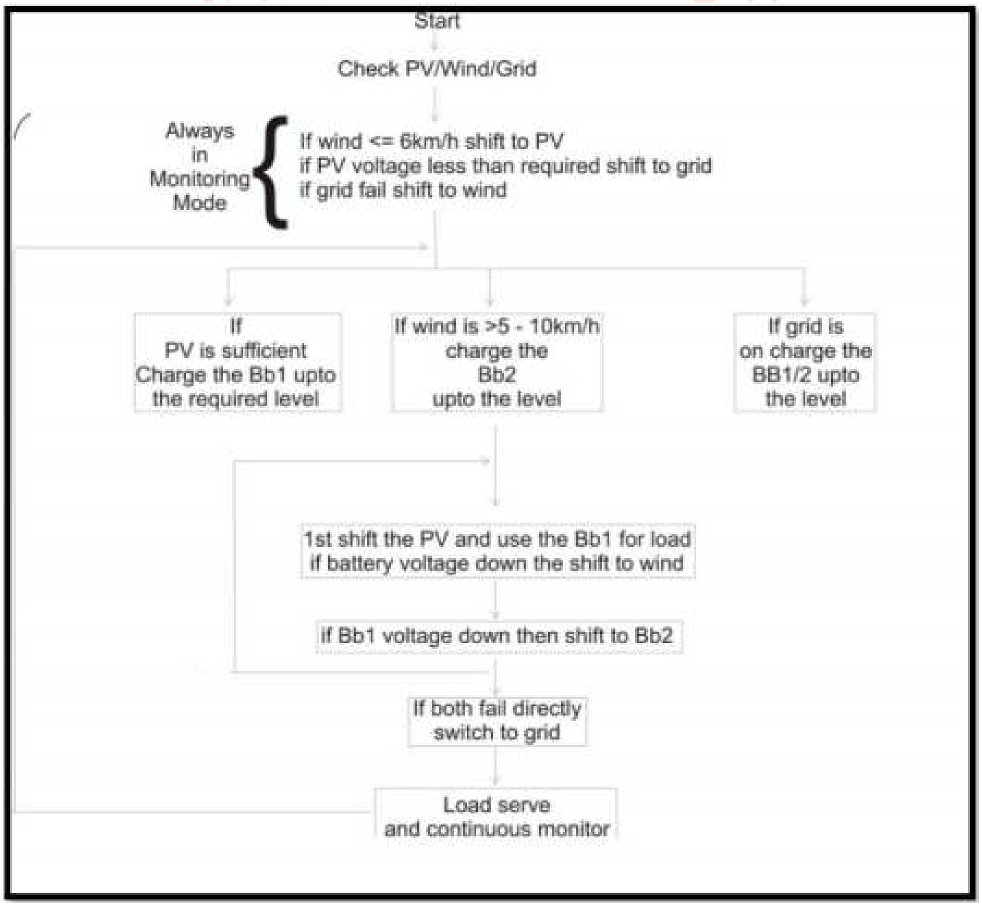

Figure 1.3:Solar MPPT Algorithm.

IV. RESULTS AND DISCUSSION

The results obtained during simulation on Matlab tool are presented below:

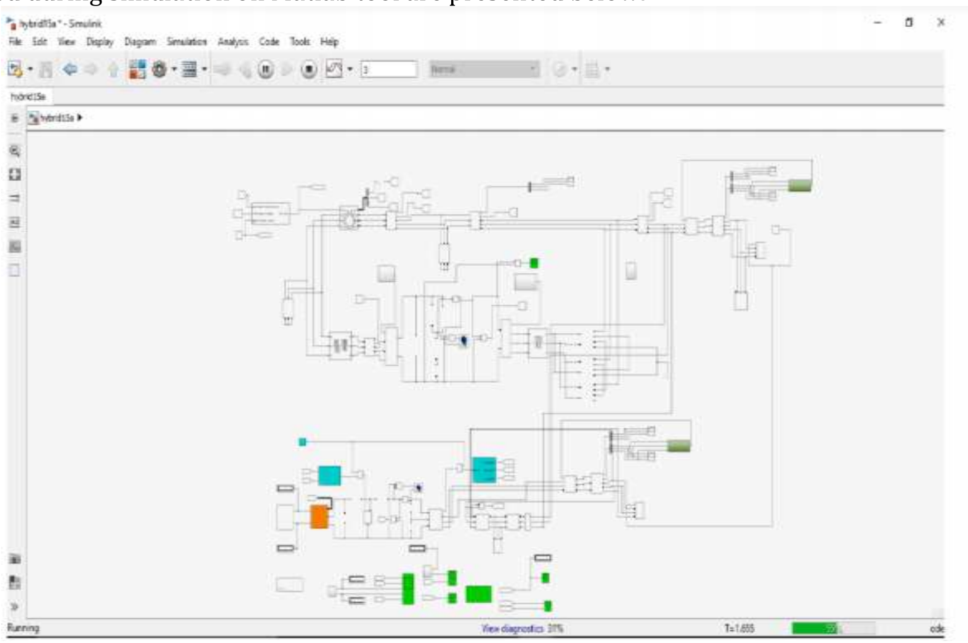

Figure 1.4: Simulation Model of Micro-Grid fed by REGS.

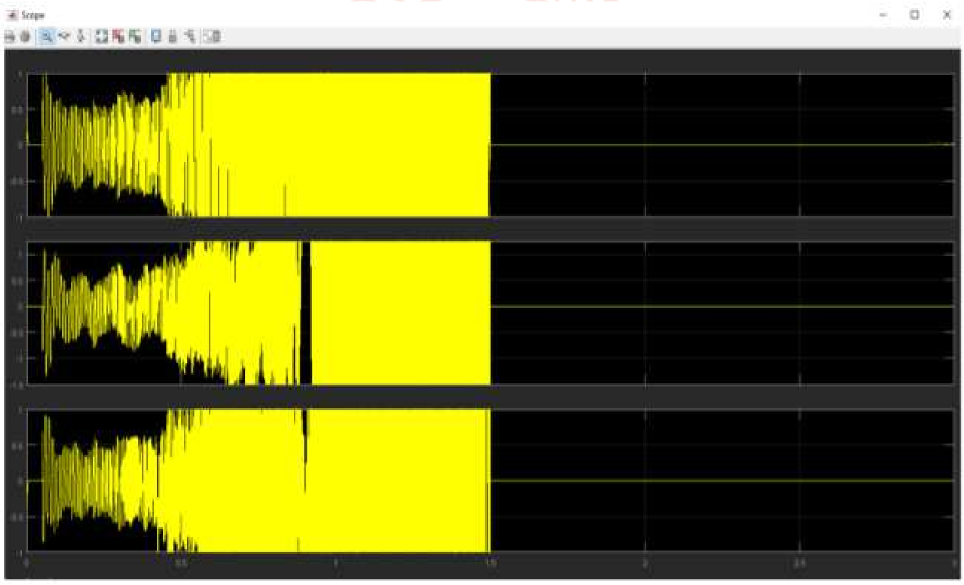

Figure 1.5: Three Phase Output Voltage of Wind Energy Source.

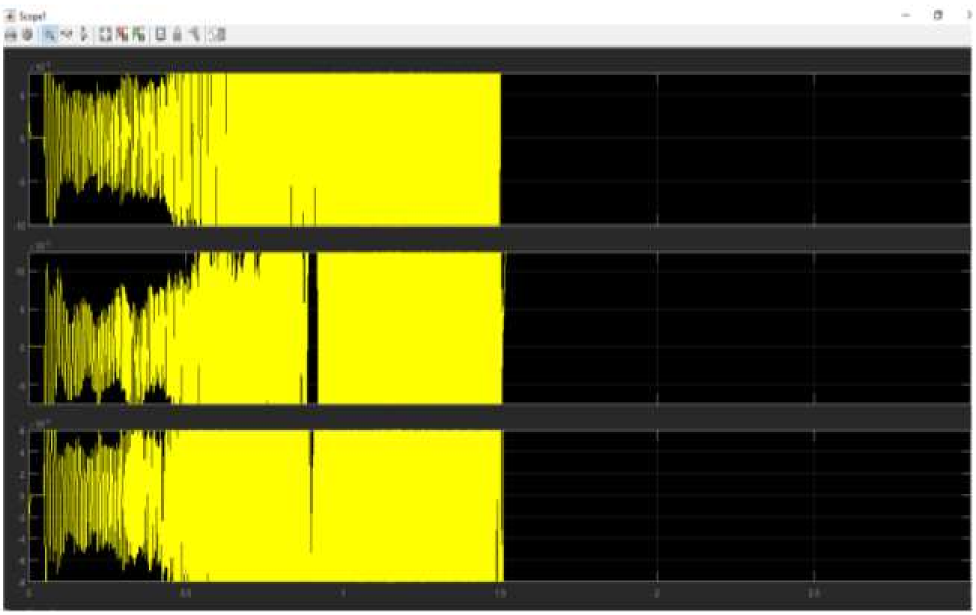

Figure 1.6: Three Phase Output Current of Wind Energy Source.

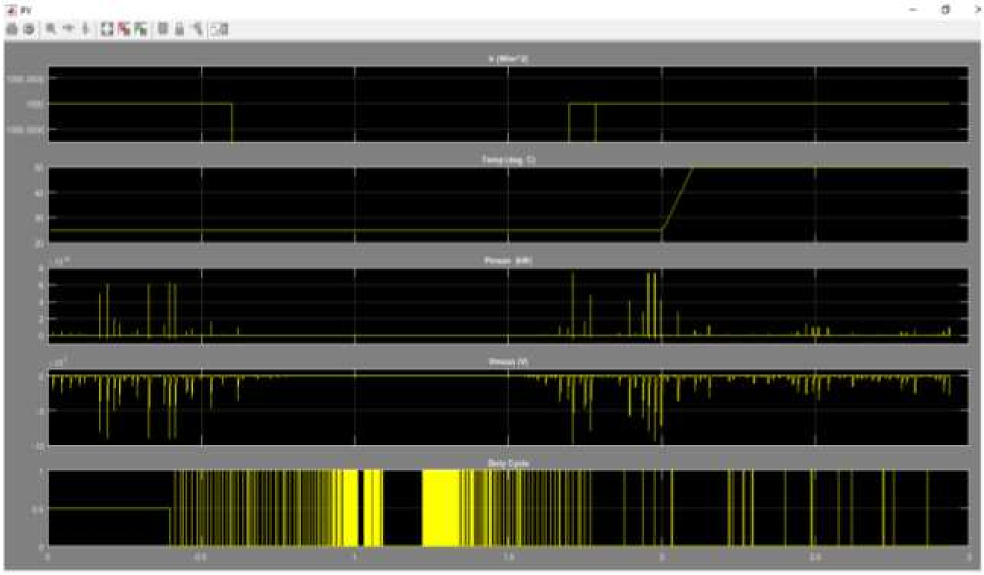

Figure 1.7: Photovoltaic Output Characteristics.

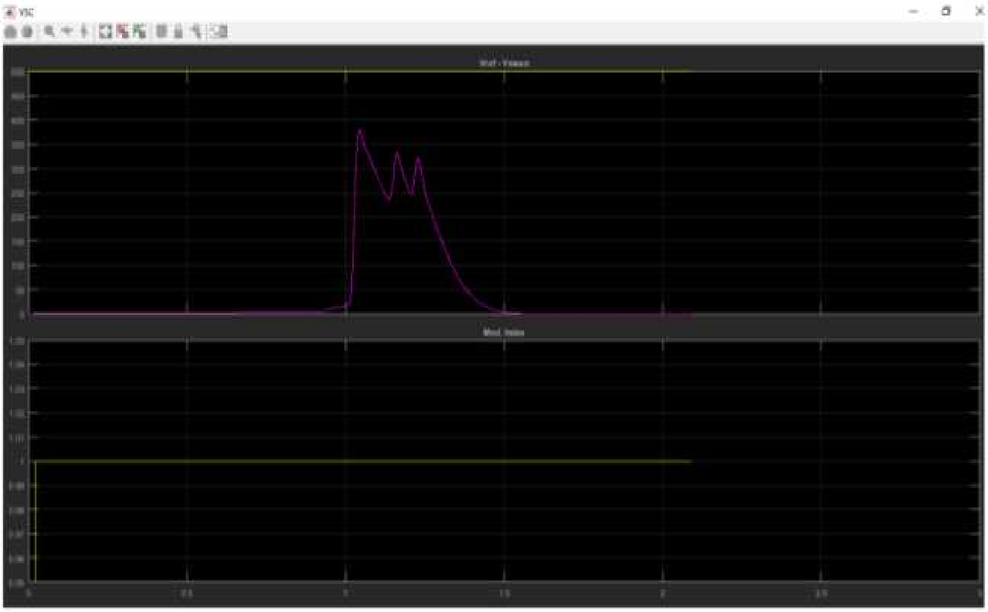

Figure 1.8: Out Characteristics of Voltage Source Converter (VSC)

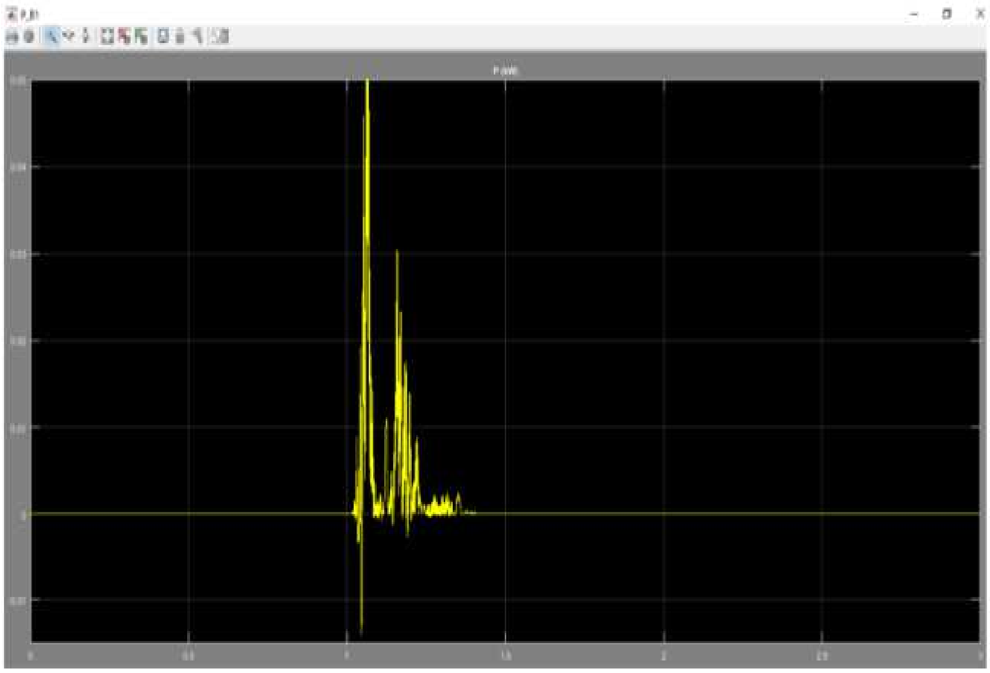

Figure 1.9: Output Photo Photo Voltaic in KW (Pkw)

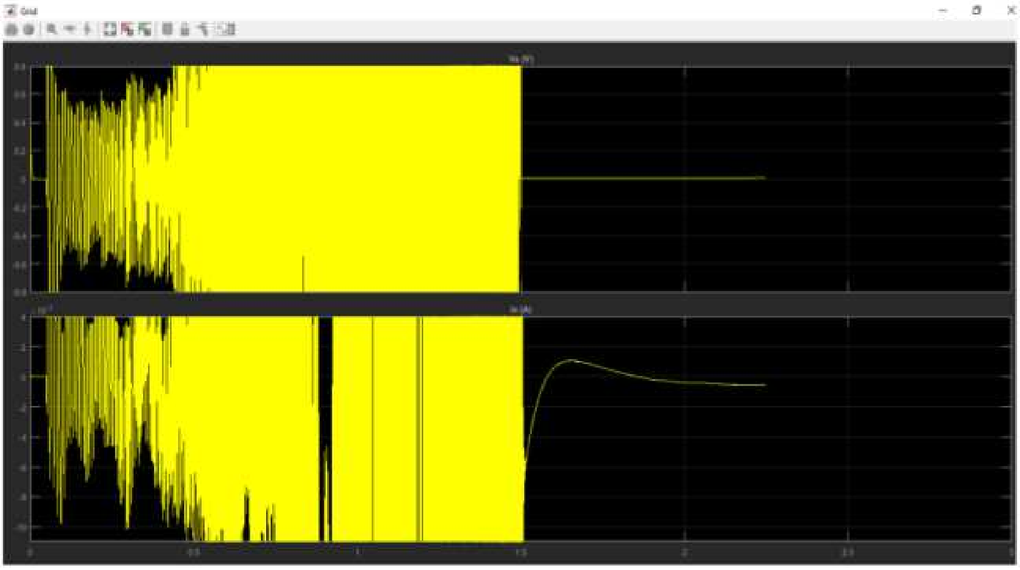

Figure 1.10: Grid Voltage and Current.

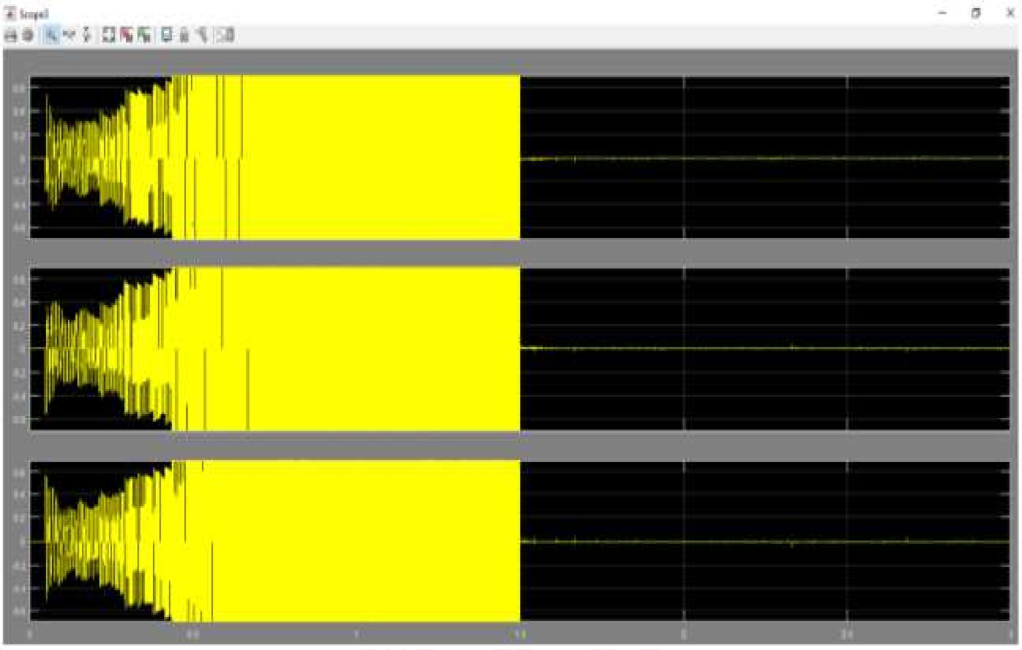

Figure 1.11: Output Voltage of photovoltiac System

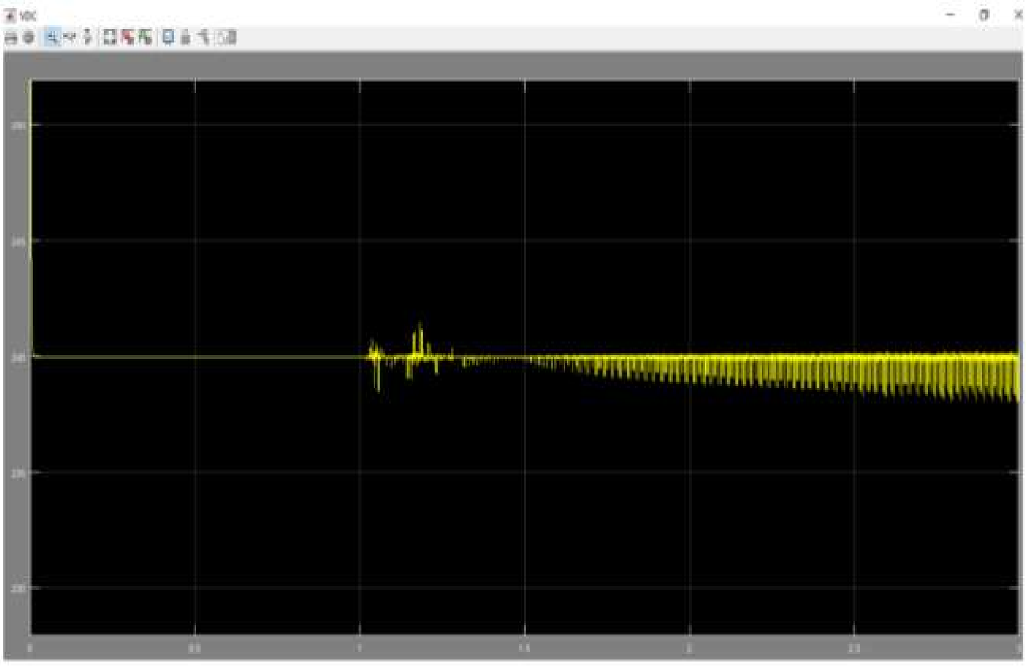

Figure 1.12: VDC of Photovoltaic System.

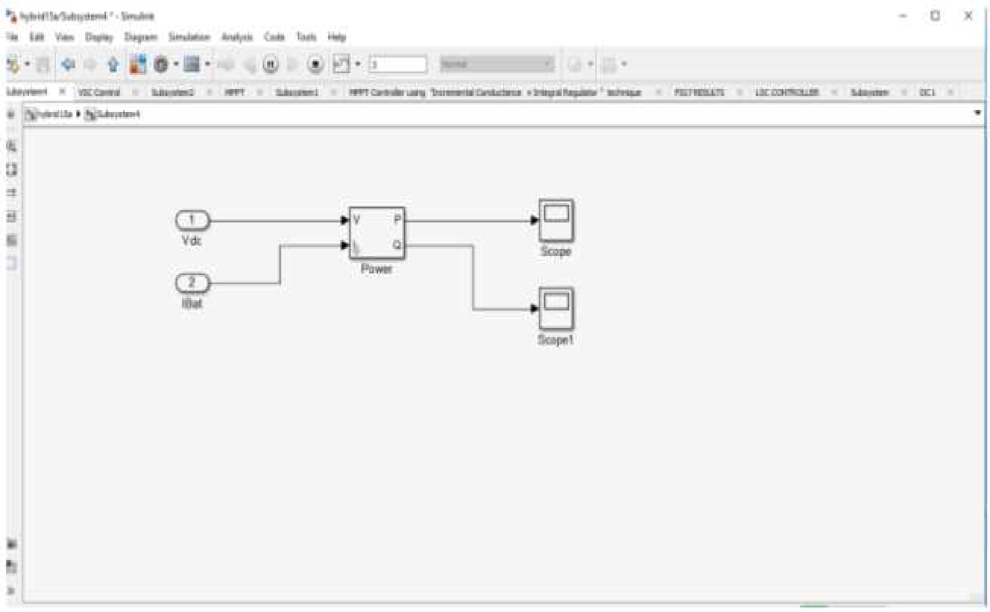

Figure 1.13: Internal Battery Charging Circuit.

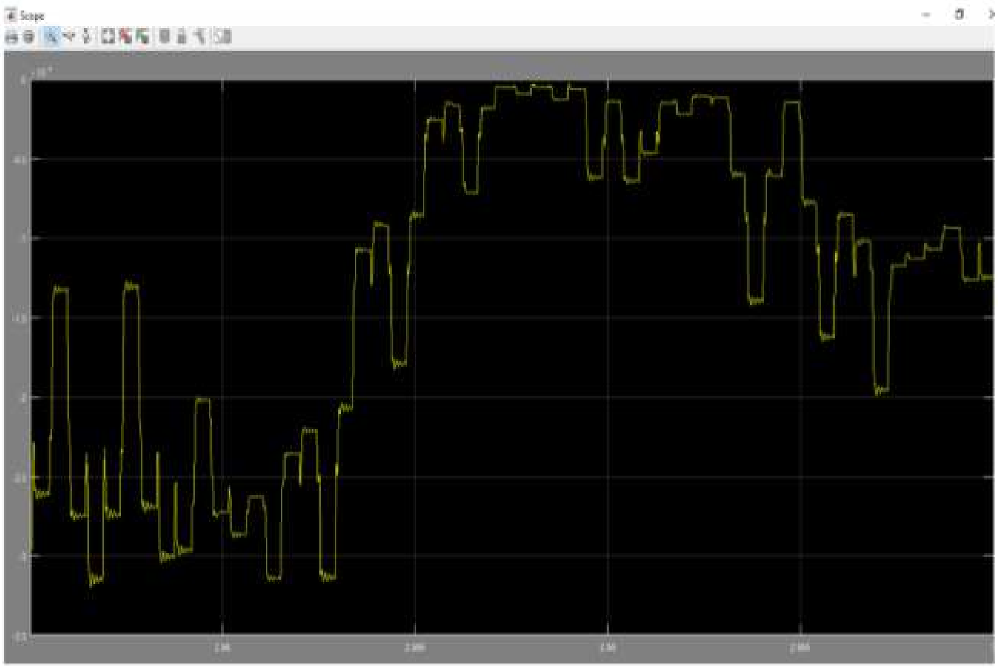

Figure 1.14: Output Voltage of Battery.

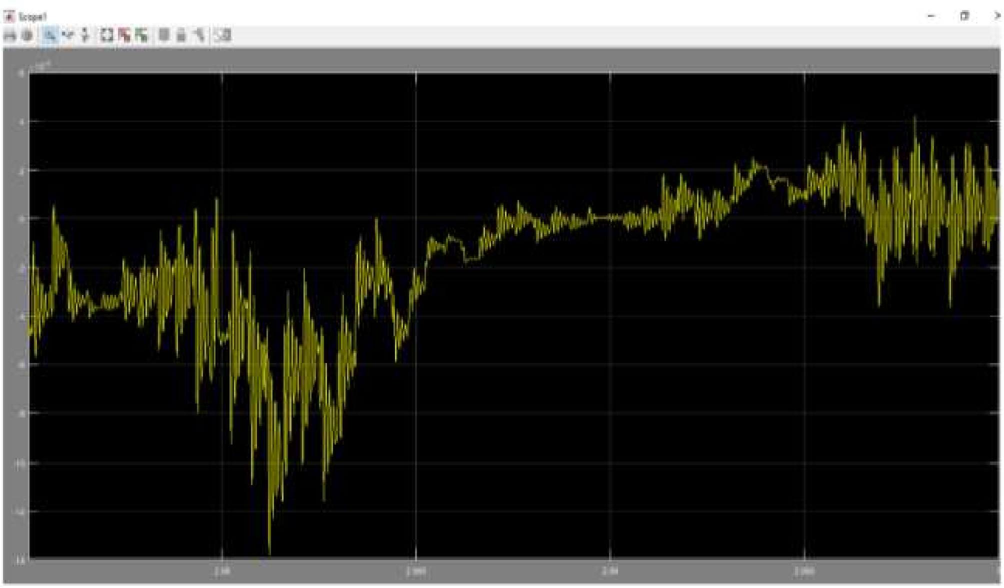

Figure 1.15: Output Voltage ofBattery.

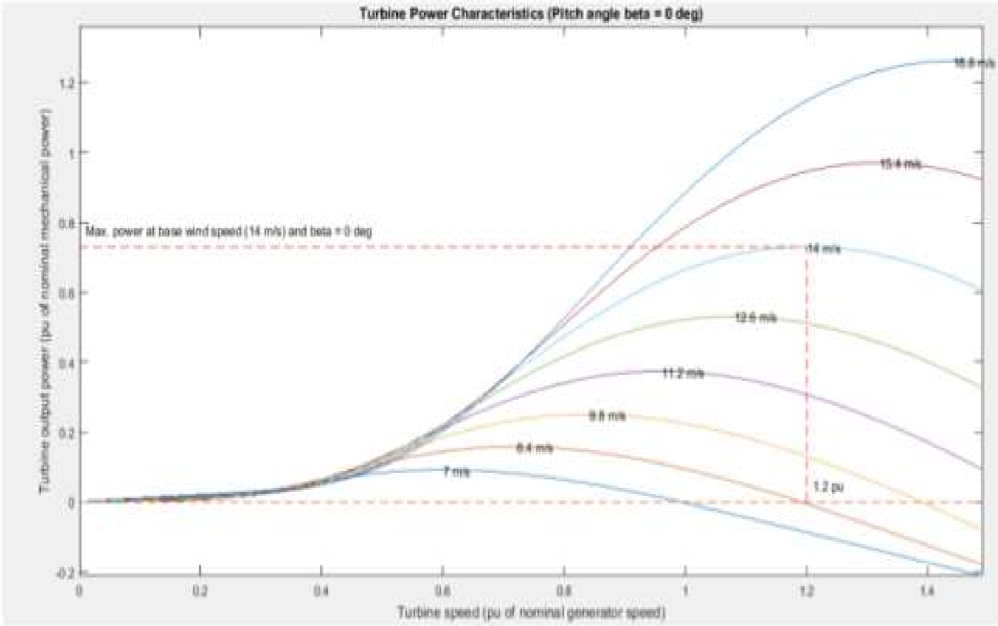

Figure 1.16: Speed and Output Power Characteristics of Wind Turbine.

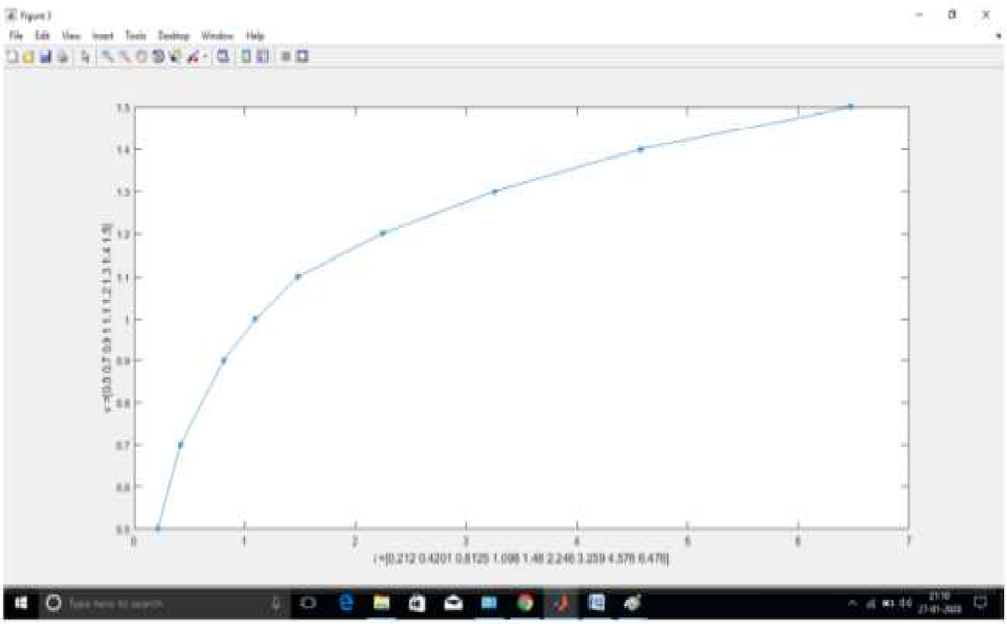

Figure 1.17: V-I Characteristics of Doubly Fed Induction Generator.

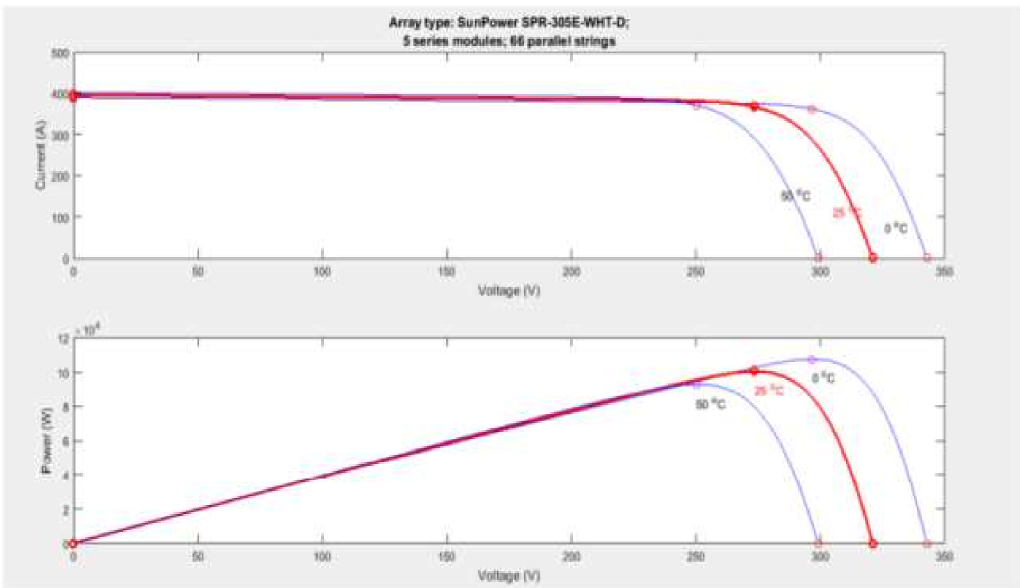

Figure 1.18: V-I and Power Vs Voltage Characteristics of Solar Plate.

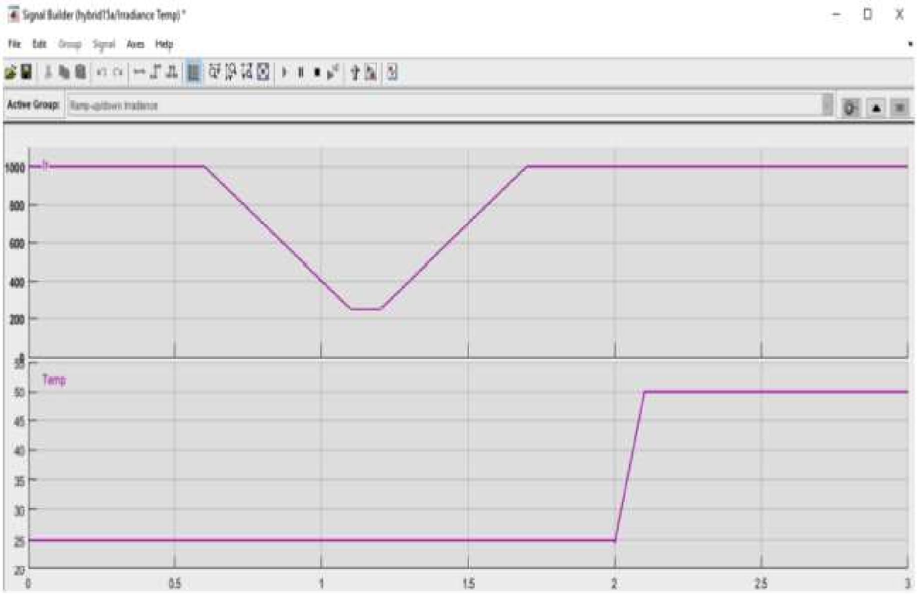

Figure 1.19: Irrediance vs Time and Temperature Characteristics of Solar Plate.

V. CONCLUSION

The proposed micro-grid framework based on input from REGS has been discovered appropriate for meeting load prerequisite of a remote disconnected area containing hardly any family units. REGS includes wind and solar vitality squares, which are intended to extricate the greatest force from the sustainable power sources and simultaneously, it gives quality capacity to the user. The framework has been intended for complete mechanized activity.

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