Power Control in AC Isolated Micro-grid with Renewable Energy Sources and Battery Energy Storage System for Industrial Applications

B.Sravani

M.Tech Student Scholar, Dept of EEE

BABA Institute of Technology & Sciences, P.M.Palem, Vizag, A.P, India

M.Saiganesh

Assistant Professor, Dept of EEE

BABA Institute of Technology & Sciences, P.M.Palem, Vizag, A.P, India

Abstract- Renewable energy sources (RES's) is the major sourceof electrical energy in future, the available renewable energysystems are solar, wind, fuel cell out of these solar system is mostpopularly used because this source hugely available in nature, thisrenewable energy source (RES) is most in demand foragricultural, industrial applications. In the agricultural fieldrenewable energy source (RES) is feeding the motor, to have highefficiency for the motor. Motor is design for high voltage, whereas to have high efficiency for solar system it is designed for lowvoltage.This paper explains the effective operation of Induction motor is based on the choice of suitable high voltage gain converter system that is fed to Induction Motor. The design and operation of proposed system that is fed to Induction Motor is simulated using MATLAB/SIMULINK.

Keywords: Battery, isolated micro grids, inverters, power control, renewable energy sources (RESs), state of charge (SOC).

I. INTRODUCTION

In a world of increasing energy demand, fossil fuels will eventually become depleted and renewable energy would then remain as the best alternative to satisfy world's hunger for energy. This alarming situation there by has made people all over the world concerned for depleting fossil fuels and this has resulted in increased inclination towards the alternate energy sources like the wind energy, solar energy, tidal and biomass etc [1-2] and amongst which solar and wind are on a high penetrations [3-4]. The fact that solar energy is renewable and also cleaner than any other energy produced from fossil fuels makes this resource of sustainable energy very important for the planet future.

The across the board mechanical utilization of enlistment motor (IM) has been animated throughout the years by their relative inexpensiveness, low upkeep and higher risk [7-9]. The control of IM variable speed drives frequently requires control of machine input voltage, which is ordinarily accomplished by utilizing a voltage source inverter. And also we have so many different types of controlling methods like as v/f, FOC, DTC, PDTCetc… respectively based upon industries requirements. The low cost applications usually adoptv/f scalar control when no particular performance is required. Variable-speed pumps, fans, air conditioners [10].

Here to run the Induction motor either home applications or mechanical applications we are relying on reasonable sources why in light of the fact that there is a need to save the oil subordinates and keeps up condition free [11]. The yield control acquired from renewable source is bolstered to a ultra capacitor through DC-DC converter and that converter must have the capability to permit the two headings of intensity flow between the ultra-capacitor and the DC interface, and also the capacity to increment or decline the voltage level in each control stream course; since the voltage level of the ultra-capacitor and the DC connect are different. Therefore, a DC-DC converter is used. In DC-DC converters, there are two modes of activity. The main mode is the boost mode, where the ultra capacitor is released to a higher voltage level at the DC interface; in the second mode, in particular the buck mode; here the overabundance power from the sustainable source charges Ultra capacitor [12-13].This paper clarifies the viable activity of Induction motor depends on the decision of reasonable high voltage gain converter framework that is bolstered to Induction Motor.

II. SYSTEM DESCRIPTION

Figure. 1 outlines the streamlined graph of an independent miniaturized scale matrix used to clarify the control procedure proposed in this paper. It comprises of a GFC, a GSC, and a battery bank. The sustainable power source, in this specific investigation, is a variable speed wind turbine coupled to a Parmenent magnet synchronous generator (PMSG). Contingent upon the framework measure, other vitality sources and other stockpiling vitality frameworks can be disseminated along the small scale matrix. The straightforwardness of this framework is valuable to demonstrate the possibility of the proposed control system without losing consensus.

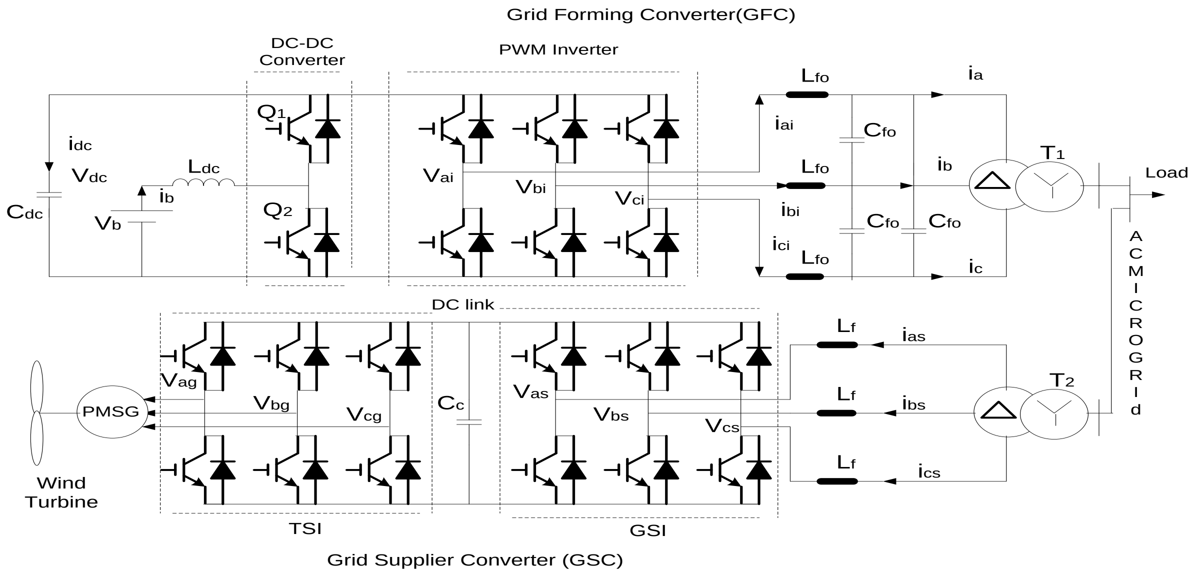


Figure 1. Simplified diagram of the studied micro-grid

The GFC is a bidirectional converter framed by a Pulse width Modulation (PWM) three-stage inverter and a dc– dc converter that works in a buck mode when the battery bank is undercharge or in a lift mode when it is under release. The PWM inverter controls the magnitude and frequency of micro grid.

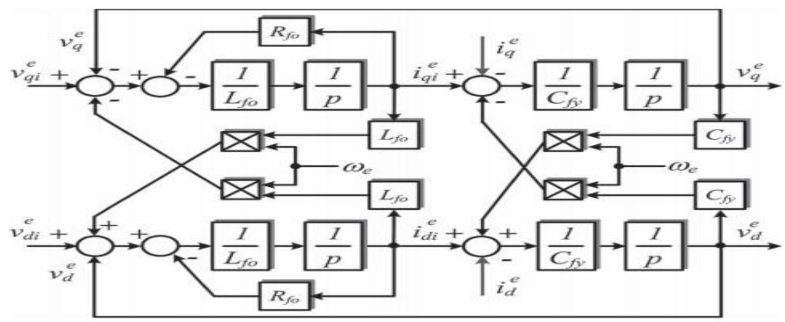


Figure 2. Block diagram of LC filter implemented in a synchronous reference frame

Voltage, while the dc–dc buck or boost converter is used tocontrol the voltage at the dc bus capacitor (Cdc) which is the dc bus voltage as well as the charging and discharging of thebattery bank.

The GSC is used to control the power generated by the renewable energy source. In this particular example, the converteris formed by a conventional back-to-back topology [12]. It hasa grid-side PWM inverter (GSI) and a wind turbine-side PWMinverter (TSI). The GSI is used to control the dc-link voltageof the back-to-back topology, and the TSI is used to controlthe power generated by the wind turbine based on a maximum power point tracker (MPPT) algorithm.

III. GRID FORMER CONVERTER

A. Control of the Microgrid Voltage and Frequency

The microgrid voltage controller utilizes the customary design executed on a synchronous dq reference outline, with an inward current circle and an external voltage circle [7]. The frequency and voltage reference esteems are determined utilizing a droop control technique as an element of the dynamic and reactive powers, individually, at the framework previous converter terminals. The dq model of the LC channel in the delta side of transformer T1(see Figure. 1) is utilized to structure the control circles of the GFC. The block outline of this model is appeared in Fig. 3, where Rfo is the identical arrangement opposition of the channel inductor Lfo; ωe is the microgrid recurrence in radians every second, the super script "e" means factors in the dq synchronous reference casing, ied and ie q are the dq flows in the delta side of transformerT1; Cfy is the per-stage equal capacitance of the LC filter and is equivalent to 3Cfo; and vqe and vde are the dq voltages in the capacitors of the LC channel. The subscript I means the yield factors of the GFC PWM inverter. All the square diagrams shown in this paper utilize the administrator p = d/dt. In view of the model introduced in Figure. 2, an inward present loop and an external voltage circle were structured, as outlined in Figure. 3.

In this figure, "∧" signifies evaluated parameters, and GDID1 is the exchange work used to decouple at the example moments the effect of the aggravations because of the heap flows ieq, ied and the cross-coupling due to vqe and vde. ZOH implies zero-order hold (hook). In a general sense, the current on the inductance Lf0

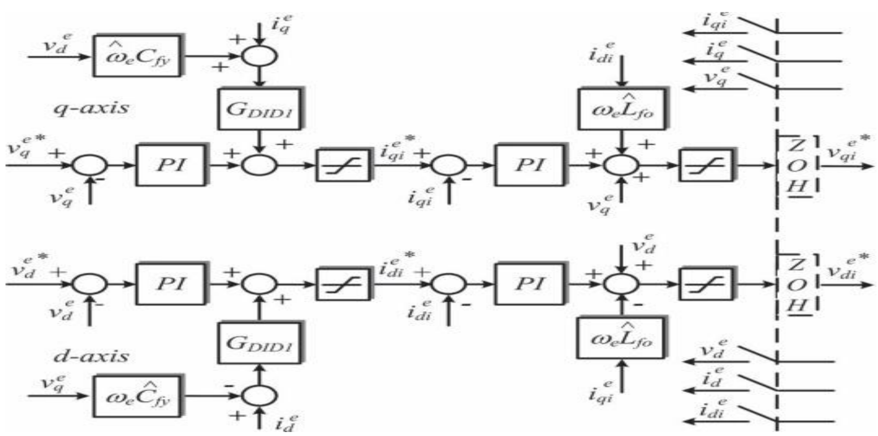


Figure 3. Block diagram of the micro-grid voltage controller.

is controlled in order to regulate the voltage on the capacitanceCf0, independently whether the power flux is from the PWM inverter to the micro-grid or vice versa. The voltage reference values for the voltage controllers can be constant, generally equal to the nominal value of the micro-grid voltage, or can be calculated based on a droop control strategy. In this paper, the voltage reference was fixed in 220 V (rms line voltage in the delta side of T1).

B. Control of the Bidirectional DC–DC Converter

The dc– dc converter (in GFC) is utilized to control the voltage in the capacitor Cdc. The activity of the controller of the dc– dc converter can be viewed as equal to interfacing a controlled voltage source, with mean esteem Vct, between the xy terminals of the converter circuit, as appeared in Fig. 4(a) and (b).If the misfortunes in the converter are not considered, the voltage on Cdc depends just on the contrast between the influence at the battery bank terminals (Pb) and (Pinv) which is the influence at the terminals of the delta side of the separation transformer T1,which is sure when the influence transition is from the inverter to the grid and negative despite what might be expected. This is appeared in Fig. 4(c).Therefore, the dynamic condition for vdc can be composed as in(1), where wdc is a helper variable characterized by wdc = v2dc

$$\frac{1}{2}C_{dc}\frac{dv_c^2}{dt} = \frac{1}{2}C_{dc}\frac{d\omega_{dc}}{dt} = P_b - P_{inv} \tag{1}$$

From (1) and Figure. 4, the dc bus voltage controller of theGFC can be designed with an inner current loop to control thebattery bank current (ib) and an outer voltage loop to controlthe voltage over the capacitor Cdc, as illustrated in Fig. 6.

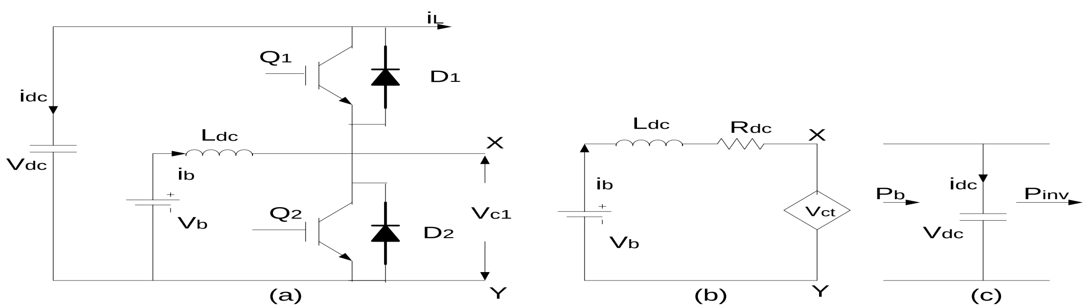


Figure 4. DC–DC converter average model: (a) Original circuit, (b) equivalent average circuit of inductor and battery bank, and (c) average modelof the bus dc.

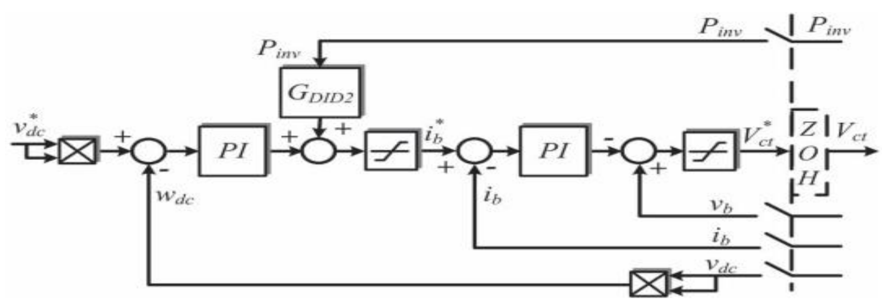


Figure 5. Block diagram of the voltage controller of the dc–dc converter.

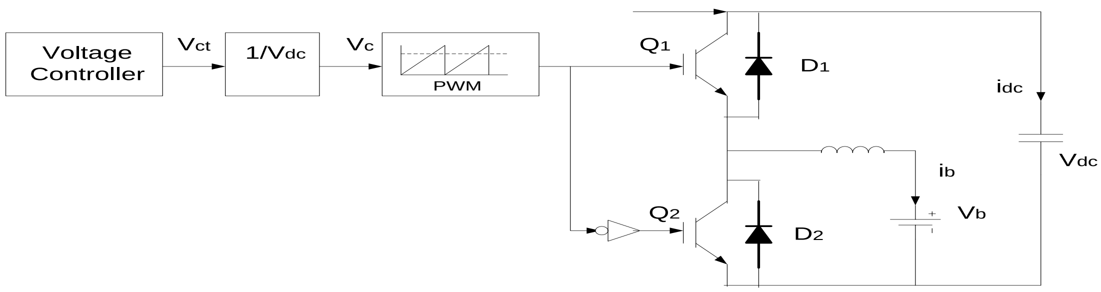


Figure 6. Block diagram of the commands for the switches of the dc–dc converter.

GDID2 is utilized to decouple the power unsettling influence from the output of the inverter over the dc transport voltage. The yield of the voltage controller (Vct) is the reference an incentive for the PWM square used to create the control flag forQ1 or Q2 switches, as appeared in Figure. 6 [4].In Figure. 6, when Pinv is certain, the battery bank supplies the load, and the dc– dc converter works on the lift mode using the Q2 switch and D1 diode. Then again, when Pinv is negative, the dc– dc converter works on the buck mode using the Q1 switch and D2 diode.

IV. GRID SUPPLIER CONVERTER

A. Control of the Injected Current in the Microgrid andthe Voltage at the DC Bus

In this paper, the GSI of the GSC (see Figure. 1) is used tocontrol the dc bus voltage of the back-to-back topology. Thiscontroller uses an inner current loop to control the injectedcurrent in the microgrid.The current controller is implemented in a dq synchronous reference frame aligned with the microgrid positive sequencevoltage vector. The converter variable synchronization is doneby using a synchronous phase-locked loop (PLL) that has asecond-order resonant filter tuned for the fundamental frequency of the microgrid.

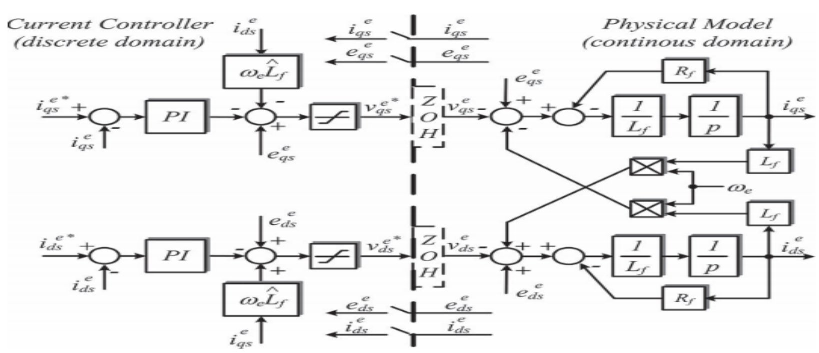


Figure 7. Block diagram of the control of the injected current in the micro-grid by the GSC.

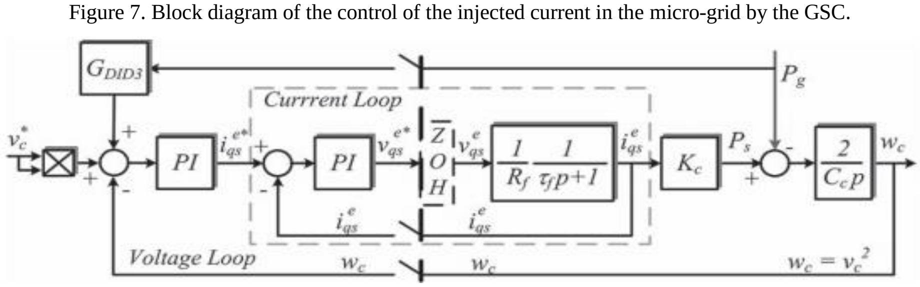


Figure 8. Block diagram of the dc bus voltage controller for the GSC.

This PLL additionally has a module to extract the prompt positive and negative symmetrical components of the voltage of the microgrid [13]. The PLL was tuned dependent on its little flag examination demonstrate for a band width of 100 Hz. The square outline of the present controller together with the channel (Lf) show in a synchronous reference outline is shown in Figure. 8, where Rf is the proportionate arrangement obstruction of the inductor Lf, ieqs and ieds are the flows in the delta side of transformer T2, and eeqs and eeds are the dq hub segments of the microgrid voltage. The embraced current direction references are equivalent to those appeared in Figure. 1.If the misfortunes in the GSI and in the inductor Lf are neglected, the variety of the vitality put away in the capacitor Cc is equal to the distinction between the dynamic influence got from the microgrid (Ps) and the dynamic influence produced by the wind turbine (Pg). Utilizing the tradition of Figure. 2, this can be expressed as in

$$\frac{1}{2} c_c \frac{d\omega_c}{dt} = P_s - P_g;\ \omega_c = v_c^2 \tag{2}$$

For a dq synchronous reference frame aligned with themicrogrid voltage vector, it follows that ee ds = 0. Therefore,Psis equal to (3/2) Esieqs, with Es being the magnitude ofthe phase voltage, considered constant in this application. By defining Kc equal to (3/2Es), the dynamic equation for thecapacitor Cc is presented in

$$\frac{d\omega_c}{dt} = \frac{2}{c_c} \left(k_c i_{qs}^2 - P_g \right) \tag{3}$$

The block diagram for the dc bus voltage controller is illustrated in Fig. 8. GDID3 is the transfer function used to decoupleat the sample instants the effect of the disturbances due to Pg, and τf is the time constant Lf /Rf. The output of the voltagecontroller is the reference current (ieqs∗) for the inner current loop.

V. MATLAB/SIMULATION RESULTS

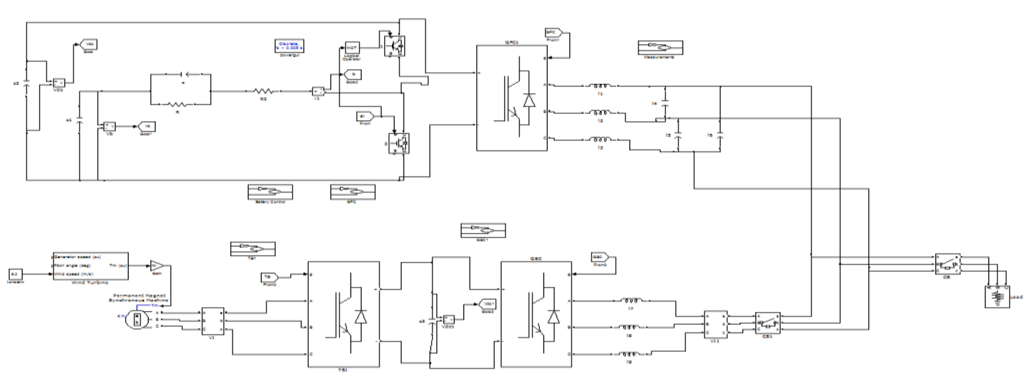
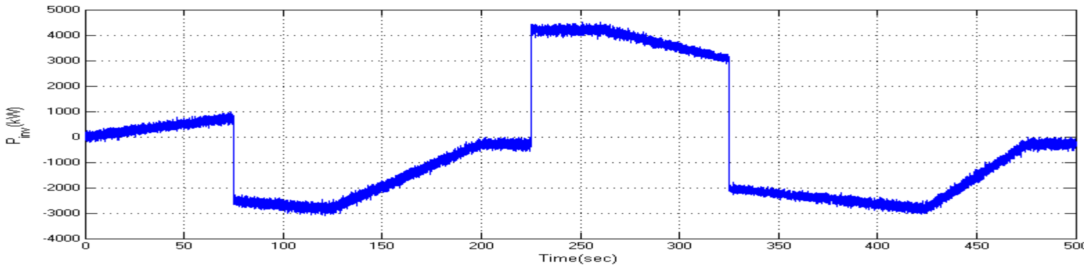
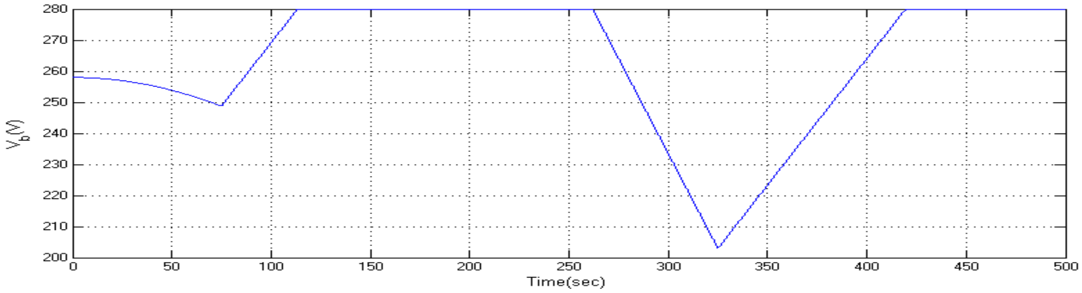


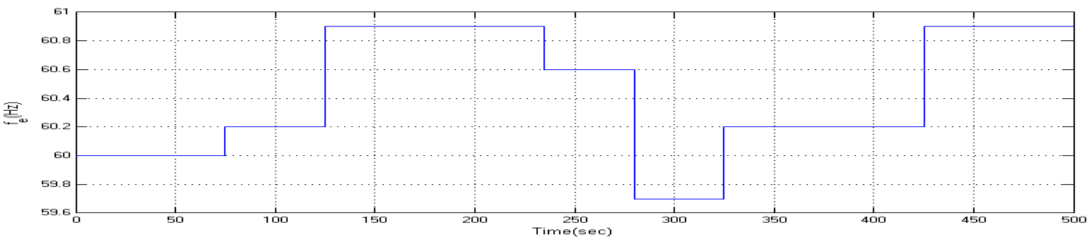
Figure 9.Matlab/Simulation Model of Constant Wind Speed.



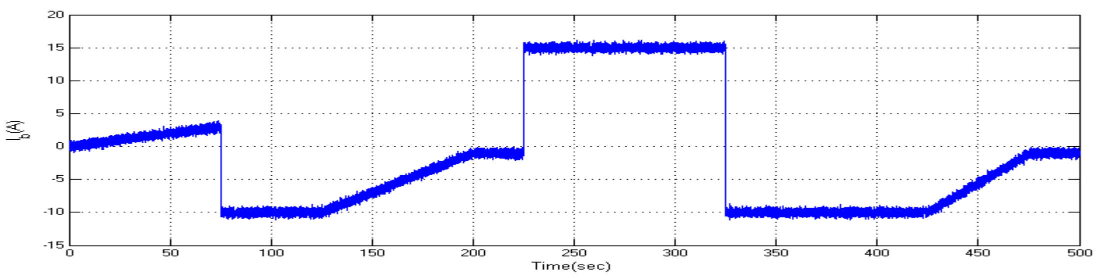
(a)



(b)



(c)



(d)

Figure 10. Operation with a constant wind speed of 9.2 m/s: (a) Power at the GFC terminals, (b) battery bank voltage, (c) micro grid frequency, and (d) battery current.

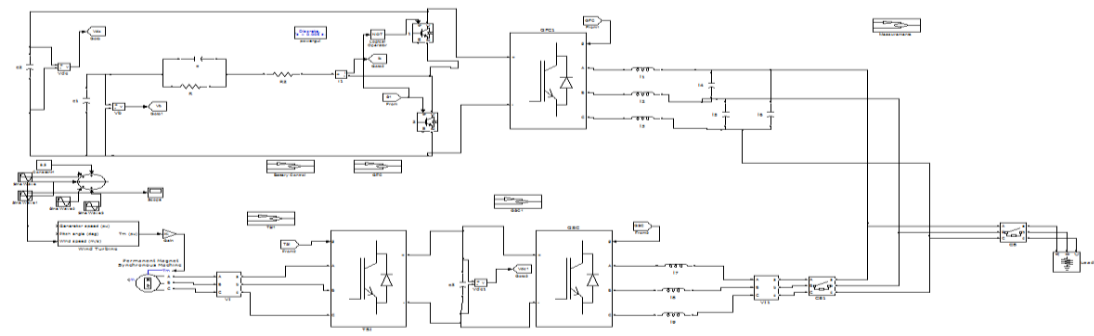
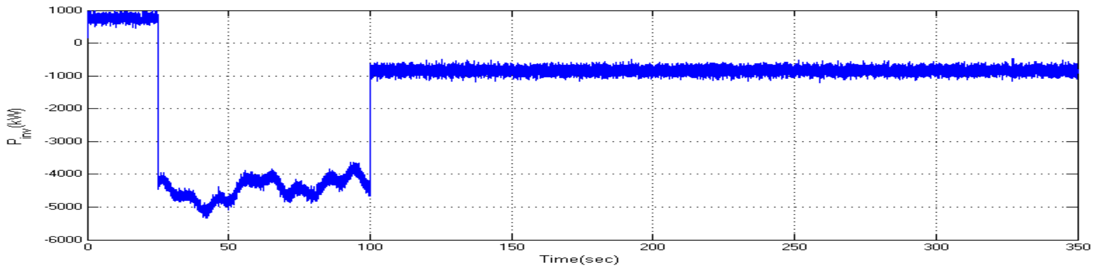
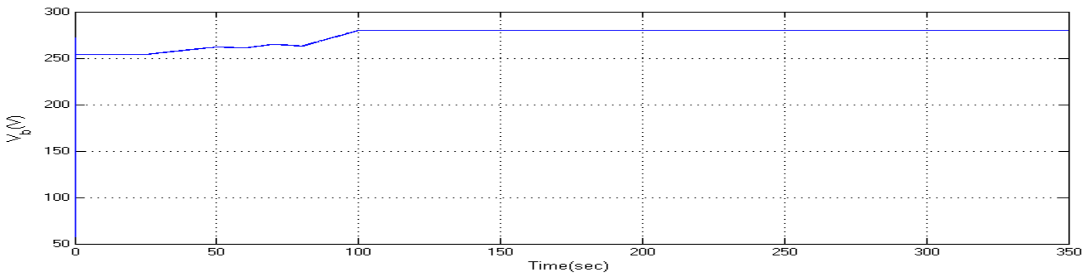


Figure 11.Matlab/Simulation Model of Variable Wind Speed.



(a)



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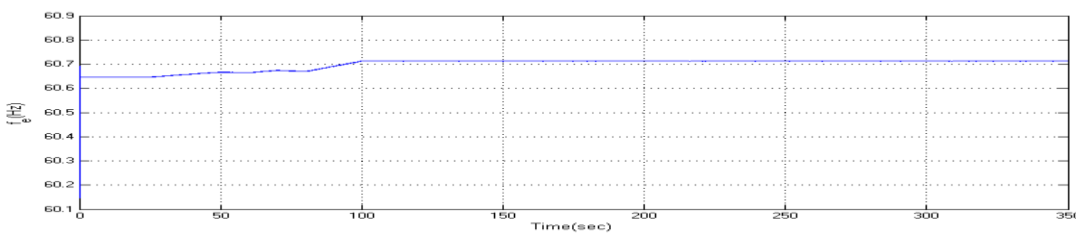
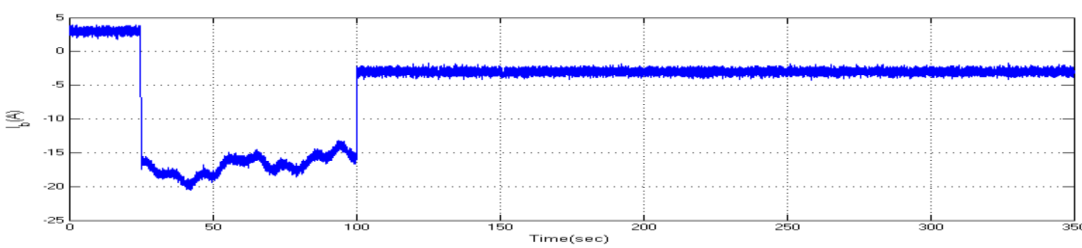


(c)



(d)

Figure 12. Operation with variable wind speed: (a) Power at the GFC terminals, (b) battery bank voltage, (c) micro grid frequency, and (d) battery current.

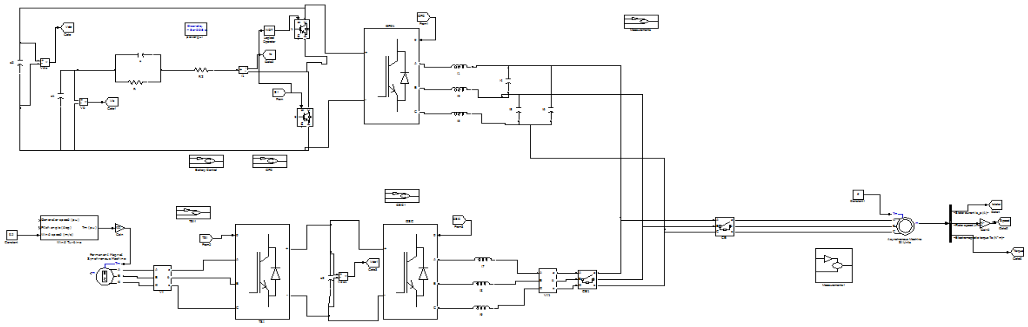


Figure 13.Matlab/Simulation Model of Induction motor connected system

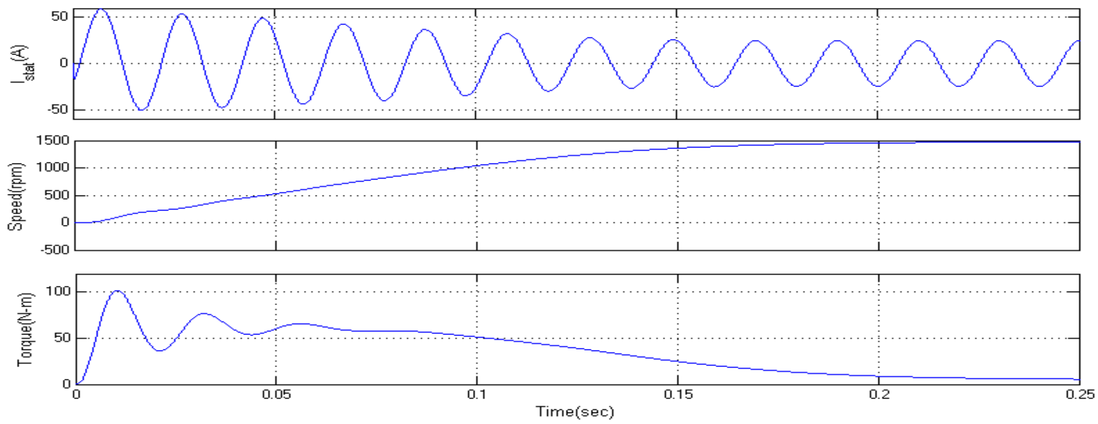


Figure 14. Stator current, Speed and Torque Characteristics of Induction Motor

VIII. CONCLUSION

This paper has focused on the PV and wind energy systemfed induction motor drive. As thesolar has significant potential among all the renewable energyresources, solar power modules should be installed in domesticand industries for electrification or various applications whichare listed. This strategy does not need wired communication between the distributed renewable sources nor dump loads to dissipate the surplus of generated power in the microgrid. These technical advantages make the proposed strategy a promising tool to increase the viability and reliability of the renewable power generation system installed in isolated and remote communities. Although a wind turbine has been used to demonstrate the validity of the proposed strategy, it is also valid regardless of the power source existing in the isolated microgrid. The proposed strategy calculates the amount of power that must be generated at each time by each source in order to keep the balance of energy into the microgrid.By utilizing PV and wind energy system for IMspeed control, losses can be reduced, power supply problemscan be reduced, motor heating and stress can be reduced, increases efficiency, high saving in energy, low maintenance,and long life and improves the process of control. Thus thedeveloped model is robust and energy saving system.

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