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POWER BALANCING CONTROL FOR AC/DC MICROGRID USING RENEWABLE ENERGY SOURCES

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ABSTRACT
Power system plays important role for the generation of power from conventional sources, transmutation and distribution power at different consumer applications it will faces a so many problems. This can be overcome to implement the micro grid concept. The micro grid concept introduces the power is generated from the renewable energy sources like p.v wind, fuel cell, micro turbine etc will give signifying moment in near future. these power generating stations interconnected to form a micro grid system needed number of multiple reverse conversations (AC-DC or DC-AC) for consumer applications this results increase circuit complexity, cost and system have less reliability. The AC/DC micro grid concept introduces to reduces multiple reserve conversions and it will consists of both A.C and D.C networks connected to distribution generation through multi-bidirectional converters and to maintain stable operation of system by using proposed coordination schemes in the MATLAB simulink environment.

INTRODUCTION
The ever increasing energy consumption, the soaring cost and the exhaustible nature of fossil fuel, and the worsening global environment have created increased interest in green [renewable based energy sources] power generation systems. Wind and solar power generation are two of the most promising renewable power generation technologies. The growth of wind and photovoltaic (PV) power generation systems has exceeded the most optimistic estimation. Nevertheless, because different alternative energy sources can complement each other to some extent, multisource hybrid alternative energy systems (with proper control) have great potential to provide higher quality and more reliable power to customers than a system based on a single resource. Because of this feature, hybrid energy systems have caught worldwide research attention [1]. Photovoltaic (PV) generation systems and isolated wind-electric systems are considered among the renewable systems to be viable alternatives for the designer of such remote power supplies. Nevertheless, systems based on either wind or solar energy are unreliable due to seasonal and diurnal variations of these resources. The control of such a scheme is also far from straightforward, especially where there is a high wind penetration [2]. Furthermore, it decreases the advantage of clean and no pollution energy achieved from the renewable sources. A system that is based fully on renewable resources but at the same time reliable is necessary and hybrid wind and solar systems with small battery storage meet these requirements.

A hybrid scheme consists of wind driven by induction generator, PV array with power electronic convertors and power balancing controls are proposed in this paper for the purpose of reduces the reversible covert ions smooth power variation between sources and maintain stable operation in the system. The battery bank, which is charged during the daytime, will supply the inverter during the night to provide necessary reactive power for the induction generator. In sites where winds are strongest in the winter and spring but weaker in summer when solar irradiation reaches its peak, the proposed scheme with appropriate choice of the sizes of the PV array and wind-generator ensures almost an uninterruptible supply throughout the year [3].

GRID OPERATION
Wherever the basic main diagram of a AC/DC micro grid shows it will consists two renewable energy sources one is P.V the output of P.V array is connected to the boost converter.

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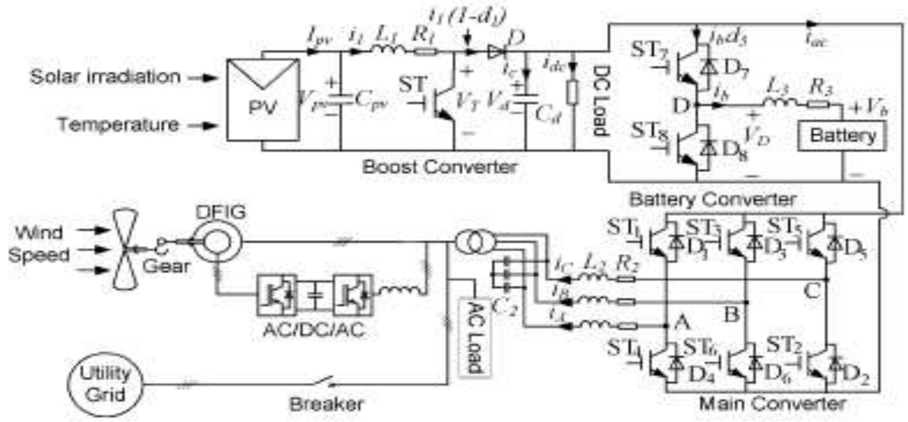

Figure1.Block diagram of AC/DC micro grid

A capacitor is supplies the high frequency ripples of P.V output voltage .the energy storage battery is connected to the D.C bus through DC-DC boost converter. The rated voltage of D.C bus is 400v respectively. Another renewable energy device is wind generation with DFIG is connecting to ac sources through A.C bus. Three phase bidirectional DC/AC main converter wit R-L-C connected between DC bus and AC bus. The hybrid grid can operate in two modes one is grid-tied mode and isolated mode the present work is did in grid-tied mode the boost converter and WTG are controlled to provide the maximum power. The main converter is to provide stable dc bus voltage and required reactive power and to exchange power between the ac and dc buses. When the output power of the dc sources is greater than the dc loads, the converter acts as an inverter and injects power from dc to ac side. When the total power generation is less than the total load at the dc side, the converter injects power from the ac to dc side. When the total power generation is greater than the total load in the hybrid grid, it will inject power to the utility grid.

MODELLING OF P.V SYSTEM

Generally, a PV module comprises of a number of PV cells connected in either series or parallel the classical equation of a PV cell describes the relationship between current and voltage of the cell (neglecting the current in the shunt resistance of the equivalent circuit of the cell) as

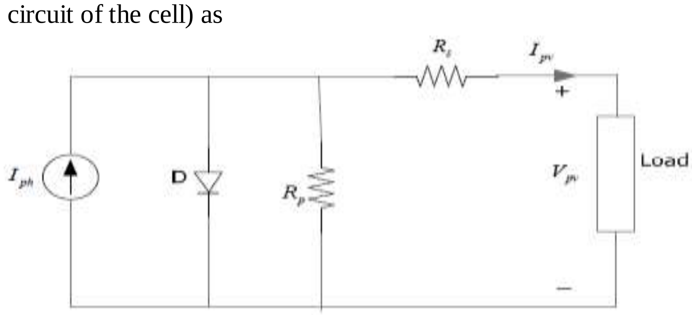

Figure2. Equivalent circuit of PV cell

$$I_{ph} = I_L - I_O\left[\exp\left(\frac{V_{ph} + R_{se} I_{ph}}{A}\right) - 1\right]$$

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$$I_O = n_p I_{ph} - n_p I_{rs} \left[\exp\left(\frac{K_o V}{n_s} \right) - 1 \right]$$

Where *I*o denotes the PV array output current, *V* is the PV output voltage, is the cell photocurrent that is proportional to solar irradiation, is the cells reverse saturation current that mainly depends on the temperature, is a constant, *n* and are the numbers of series strings and parallel strings in the PV array, respectively.

MPPT (P&O method)

Define Perturb-and-observe (P&O) method is dominantly used in practical PV systems for the MPPT control due to its simple implementation, high reliability, and tracking efficiency. Shows the flow chart of the P&O method [4-5]. The present power *P (k)* is calculated with the present values of PV voltage *V (k)* and current *I (k)*, and is compared with the previous power *P (k-1)*. If the power increases [6-7], keep the next voltage change in the same direction as the previous change.

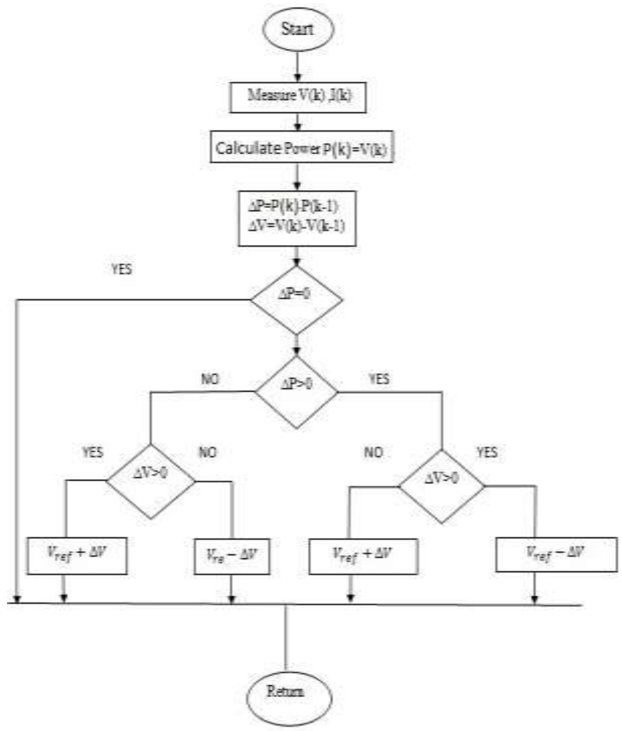

Figure3. Flow chart for MPPT algorithm.

Dynamic Modeling of Boost Converter

The main objective of the boost converter is to track the maximum power point of the PV array by regulating the solar panel terminal voltage using the power voltage characteristic curve.

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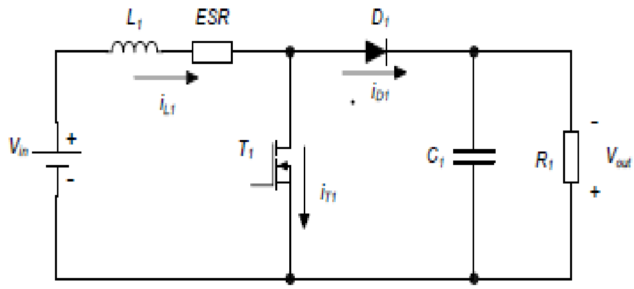

Figure 4. Boost Converter

$$Vin - L\frac{di_1}{dt -}(1-D)V_C - ESRi_1 = 0$$

$$i_{D1} = i_{C1} + i_{L1}$$

$$\begin{bmatrix} \dot{i}_{L_1} \\ \dot{v}_{C_1} \end{bmatrix} = \begin{bmatrix} \frac{-ESR}{L_1} & \frac{-(1-D)}{L_1} \\ \frac{1-D}{C_1} & \frac{-1}{R_1C_1} \end{bmatrix} \begin{bmatrix} i_{L_1} \\ v_{C_1} \end{bmatrix} + \begin{bmatrix} \frac{1}{L_1} \\ 0 \end{bmatrix} [V_{in}]$$

$$[V_{Out}] = [0 \quad 1]\begin{bmatrix} i_{L_1} \\ v_{C_1} \end{bmatrix} + [0][V_{in}]$$

Modeling of battery

Battery acts as a constant voltage load line on the PV array and is charged both by PV array and induction generator .the battery is modeled as a nonlinear voltage source whose output voltage depends not only[8-9] on the current but also on the battery state of charge(SOC), which is non linear function of the current and time

$$V_b = V_O + R_b i_b - K\frac{Q}{Q + \int i_b dt} + A\exp(i_b dt)$$

MODELLING OF WIND TURBINE

The power captured by the WG blades *P*m is a function of the blade shape, the pitch angle, and the radius and the rotor speed of rotation. Where ρ is the air density (typically 1.25 kg/m3), β is the Pitch angle (in degrees), $Cp\ (\lambda, \beta)$ is the wind-turbine power Coefficient, *R* is the blade radius (in meters), and *V* is the wind Speed (in m/s). The term λ is the tip-speed ratio [10].

$$P_m = P_w \times C_p(\lambda, \beta)$$

$$P_w = 0.5\rho AU^3$$

$$C_p(\lambda, \beta) = C_1\left[\frac{C_2}{\lambda_i} - C_3\beta - C_4\right]e^{\frac{-C_5}{\lambda_i}} + C_6\lambda$$

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$$\lambda = \frac{\omega r}{U} = \left[\frac{\frac{2\pi Nr}{60}}{U} \right]$$

$$\frac{1}{\lambda_i} = \frac{1}{\lambda + 0.08\beta} - \frac{0.035}{\beta^3 + 1}$$

MPPT Algorithm concert for wind energy system:

The algorithm uses the HCS methodology power management to track the maximum power points of wind energy systems under fluctuating conditions. The main problems in existing power extraction methods are 1) customization, 2) speed, and 3) wasted power. The proposed algorithm provides a solution to these problems. The proposed algorithm main concept is to enable flexible, fast and efficient maximum power extraction. The concept is t quickly determine the maximum power point by using the turbine fundamental tip-speed ratio equation in conjunction with the HCS methodology for each turbine there is one TSR that will always in maximum power transfer.

The HCS concept is essentially an “observe and perturb” concept used to traverse the natural power curve of trine. In this thesis, the algorithm generates the reference sped by measuring the output power of the wind energy conversion system’ and adjustment the system’s operating point accordingly

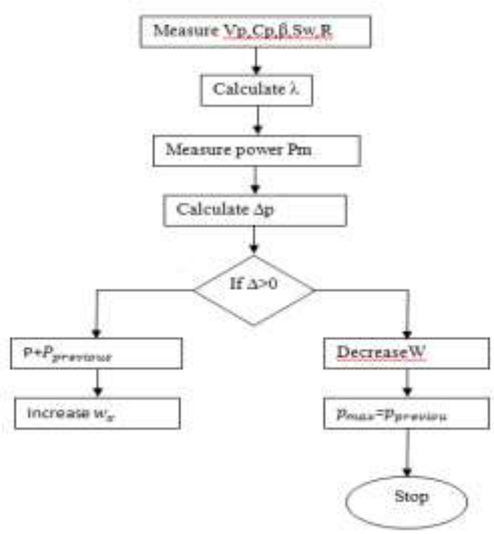

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Figure 5. Flow chart for maximum power point tracking for wind

MODELING OF DFIG

In general the machine variables that dictate performance are functions of rotor speed, load and the machine parameters. Since the various inductances in three phase are time varying with rotor position [11-12], reference analysis is often used to reduces the complexity of analysis. In case of the induction machine possible reference frames are stationary reference frame, rotor reference frame. Usually, the machine variables are firstly transformed to their own reframe and then those are transferred to required reference frame [13-14].

$$V_{qs} = (R_s + pL_{ss})i_{qs} + \omega_c L_s i_{ds} + pL_m i_{qr} + \omega_c L_m M i_{dr}$$

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Impact Factor (PIF): 2.243

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$$V_{ds} = -\omega_c L_s i_{qs} + (R_s + pL_s) i_{ds} - \omega_c L_m i_{qr} + pL_m i_{dr}$$
$$V_{qr} = pL_m i_{qs} + (\omega_c - \omega_r) L_m i_{ds} + (R_s + pL_r) i_{qr} + (\omega_c - \omega_r) L_r i_{dr}$$
$$V_{dr} = -(\omega_c - \omega_r) L_m i_{qs} + pL_m i_{ds} - (\omega_c - \omega_r) L_r i_{qr} + (R_s + pL_r) i_{dr}$$

$$i_{ds} = -\left(\frac{L_m}{L_r}\right) i_{dr} \qquad p = \frac{d}{dt} \qquad \sigma = \left(\frac{\left(L_s L_r - L_m^2\right)}{L_s L_r}\right)$$

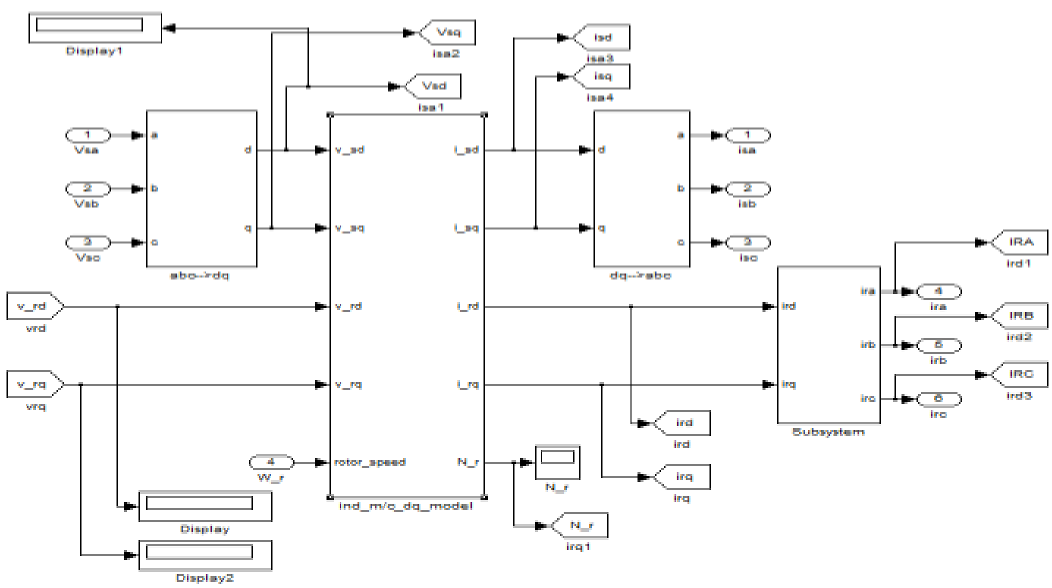

Figure 6. Simulink diagram of DFIG.

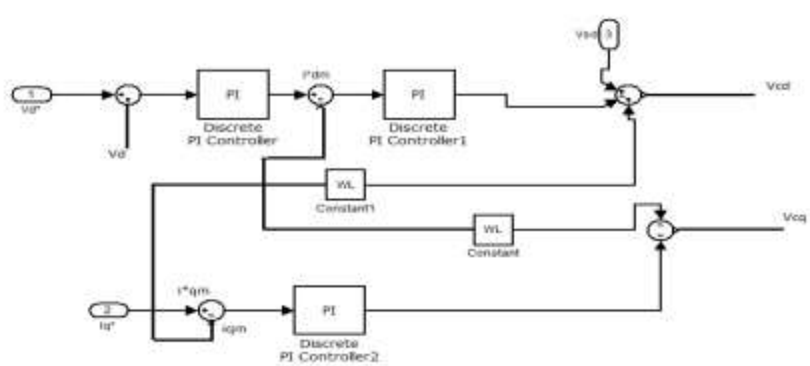

Figure 7. Control block diagram of main converter.

Proposed coordination control of the grid-connected mode:

When micro grid operates in the grid-connected mode, the main objective of the HVDC (ac/dc/ac) converter of the double-fed induction generator is to regulate the rotor side current to achieve maximum power point tracking and boost is to track the maximum power from P.V array by regulating the terminal voltage and which are synchronize with

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corresponding grid. the main converter is designed to operate bidirectional to incorporate complementary characteristics of wind and solar sources and to maintain a stable dc-link voltage for variable DC load and to synchronize with the AC link utility system.

The role of the battery acts as a constant voltage load line on the PV array and is charged both by the IG and PV array. Under conditions of low wind speed, the induction generator is isolated from the system and the load is fed by the PV array and the battery. The load is fully supplied by the battery in situations where there is inadequate wind speed and irradiation [15]. During nights and under high wind penetration, the IG supplies the load, the excess energy if any being used to change the battery being fully charged and unable to accept this excess energy on other hand, during the daytime, in the event of the battery being disconnected to prevent overcharging, the IG and PV array feed the load. In such conditions, the PV array in addition to supplying power to the load also provides the needed reactive power to the IG. it should be noted that when the battery is disconnected from system to prevent a voltage collapse, it is required to operate the PV array as a voltage source by load shedding if necessary. The battery would be deeply discharged only in the event of long duration of both low wind speed and irradiation, and hence, is not subjected to cyclic charging and discharging unlike in PV alone or wind alone systems[16].

The proposed controls are applied to the boost converter, main converter, and wind energy system's for the power balancing between the AC sources, DC sources, and utility grid under varying load conditions .this thesis the main converter is plays important role it will acts as a voltage source to proved a stable voltage and frequency for the grid and operates either in inverter or converter under varying load conditions for smooth power balancing between the AC links and DC links. The battery converter operates either in discharging or charging condition based on the power balance in system. The power under varying load and supply conditions should be balanced as

$$Pac + Ppv = Pb + PdcL$$
$$Ps = Pw - PacL - Pw$$

SIMULATION RESULTS

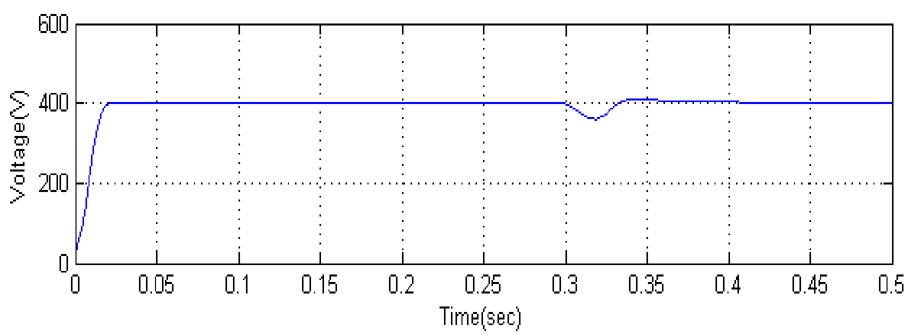

Figure 8. PV output voltage

Fig.8.shows the output voltage of PV array corresponding solar irradiation it will increases at 0.025 to 0.3 voltage constant using P&O method. At the period of 0.3 to 0.0325 voltage drop occur during the load and source condition .the boost controller quickly recovers this drop and gives constant voltage.

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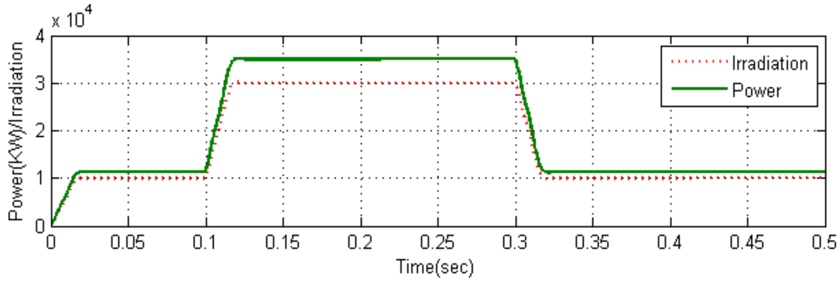

Figure 9. PV output power and sola irradiation

Fig.9. shows the output power of PV is correspondingly increases with solar irradiation. Output power is increases 12kw to 37kw due to changing the temperature. When temperature is fixed at 0.12sec to 0.3sec power generation is fixed.

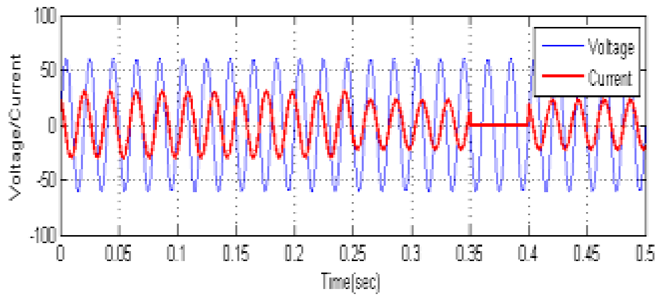

Figure 10. AC side voltage and current wave forms of the main converter with constant irradiation

Fig.10. shows the voltage and current of main converter. The current amplitude from 0 to 0.3sec is higher than remaining time period means dc generation is higher then the dc lord at the time power is injected from dc to ac grid before 0.3s and 0.4s is reversed.

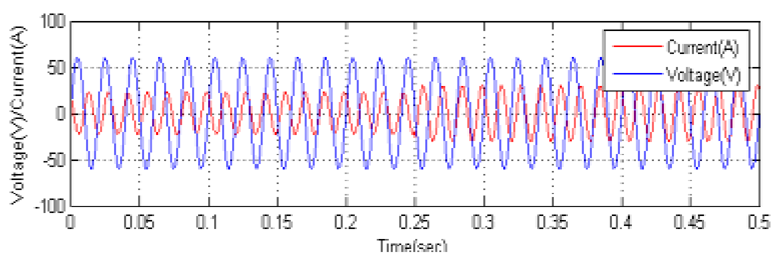

Figure.11. AC side voltage and current wave forms of the main converter with constant irradiation and variable load

Fig.11. shows the voltage and current of main converter. The current amplitude from 0 to 0.25sec and 0.25 to 0.4sec is different time periods means dc generation is less than the dc locd at the time power is injected before 0.3s and 0.4s is reversed.

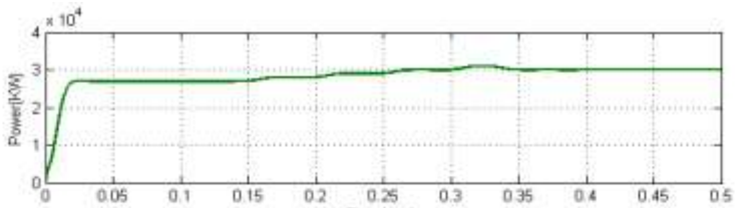

Figure12. Output power of doubly fed induction generator

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The Fig.12. shows out power of DFIG is closely increased form 27kw to 30kw corresponding wind at a period of 0.35sec to 0.5sec it constant .between the period of 0.16sce to 0.35sec occurs power oscillations due changing the wind by using the wind MPPT track maximum power.

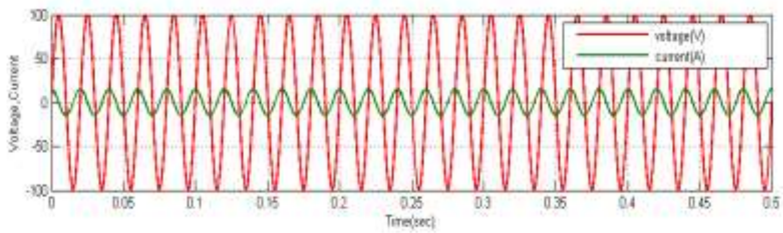

Figure.13. voltage and current wave's of the main converter at power balancing condition

TABLE I. ***PARAMETERS FOR PHOTOVOLTAIC PANEL***

symbol	Description	Value
V_{oc}	Rated open circuit voltage	403
q	Electron charge	1.602×10^{-19}C
A	Ideality factor	1.50
k	Boltzman constant	1.38×10^{-23} J/K
R_s	Series resistance of a PV cell	
R_p	Parallel resistance of a PV	
I_{sso}	Short-circuit current	3.27A
T_r	Reference temperature	301.18 K
E_{gap}	Energy of a band gap for silicon	1.1e V
n_p	Number of cells in parallel	40
n_s	Number of cells in series	900
S	Solar radiation level	0 - 1000 W/m^2
T	Surface temperature of the PV	350K

TABLE II. PARAMETERS OF DFIG

Symbol	Description	Value
P_{nom}	Nominal Voltage	50 kw
V_{nom}	Nominal Power	400v
R_s	Stator resistance	0.00706
R_r	Rotor resistance	pu
L_s	Stator inductance	0.171 pu
L_r	Rotor inductance	0.005 pu
L_m	Mutual inductance	0.156 pu
J	Rotor inertial constant	2.9 pu
n_p	Number of poles	3.1 s
V_{dc_nom}	Number of DC voltage of AC/DC/AC converter	6 800 V
P_m	Nominal mechanical power	45 kw

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CONCLUSION

This paper simply provides the alternative energy solution for different consumer applications. The design and developed of AC/DC micro grid for power system configuration is done in MATLAB/SIMULINK environment. In this paper reduces the process of AC/DC and DC/AC conversions in individual AC or DC grid. Although MPPT algorithm is used to harness maximum power from DC source .Here proposed controllers are developed for all converter to maintain the stable system under various resource and load changing conditions and coordinate power exchange power between the DC and AC grid. future work this paper modeling of fuel cell using MATLAB/SIMULINK environment this can be interconnecting to AC/DC micro grid and coordinately operate the system and implementing in Indian military applications.

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