"Performance Analysis of Induction Motor Fed from Hybrid Micro grid system"

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Abstract –*This Project presents a Drive fed from hybrid dc micro grid system. Power is fed from renewable energy source and AC source. Proper Coordination between the PV source and Grid is required for smooth operation. In this paper, appropriate control technique is used for providing adequate control via power electronics interface. The DC-DC boost converter is used on the PV side to attain the maximum power from the PV array. The Zeta controlling converter topologies used on the grid side which can help to co-ordinate and meet the output result. DC-AC voltage source converter is implemented to maintain the DC link voltage constant. The parameters are controlled in the synchronous reference frame PLL frame to make control easier. The Proposed system use for maintain continuity of supply, torque control smooth speed control of motor and harmonics reduction.*

Key Words: **Solar energy, photovoltaic array, DC-DC converter, Zeta Converter. voltage source converter, grid, maximum power point tracking (MPPT), induction motor. Synchronous reference frame PLL, Zeta Converter.**

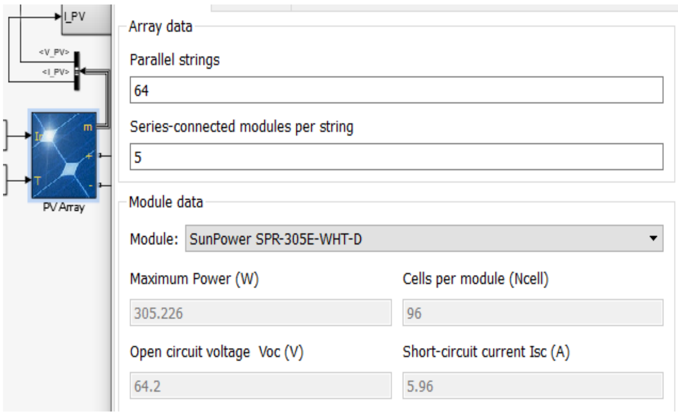
1. INTRODUCTION

Now days, to fulfil the supply growth demand we are on adopting more on the photovoltaic System (PV system). Photovoltaic are gaining popularity around the world as their price Declines and efficiency increases. Defining the hybrid system can be considered productive and gives uninterrupted power supply which helps in maintain the continuity of supply to share power to motor and managing the load on motor. This system is combination of on grid solar system and have the ability to feed surplus electricity into main grid. But during power delivery some issues/ challenges are monitored of power quality which will impact both the utility grid and other connected load. Challenges can be seen are like:- Solar is always varying or dynamic in nature. So, therefore voltage variations are hard to stabilize. The parameters considered are to be relating to multiple dimensional. A maximum power point tracking (MPPT) algorithm finds the ways of to the challenges gives maximum power for the operation of the PV system during variations of solar irradiance and ambient temperature. This model is projected for implementation of energy storage that can provide power supply, smooth out peak loads, smoothing of voltage and stand by generation in case of grid fault. Dc-dc converter converts input voltage into a desired dc-link voltage for the collaborating data downstream 3 phase dc-ac inverter. The output AC voltage in grid-connected applications (photovoltaic systems) should be "constant" in terms of amplitude and frequency a power electronic interface is required to link the DC source with the load and to make the output AC voltage adequate in terms of frequency, amplitude and phase. In order to achieve modelling and control of DC/AC converters are briefly presented in different reference frames (i.e., αβ- and dq-reference frames Developing algorithms for controlling drive using control strategies is used to achieve the desire performance of the motor

2. Study and Simulate of PV system:-

The photovoltaic process is "producing electricity directly from sunlight." To increase the utility number of PV cell are interconnected together called module. When modules are connected in series, their voltage is doubled while the current stays constant and when modules are connected in parallel, their current is doubled while the voltage stays constant. To achieve the desired voltage and current, modules are wired in series and parallel into what is called a PV array. The Block Diagram of PV system fed Drive (3 phase Induction Motor) shown in fig 1 consisting the DC /DC converter, VSI inverter, 3 phase Induction Motor with the control strategy used SRF control is presented for voltage regulation, reactive power (var) compensation, and harmonic filtering. Overall to study and analysis the drive (torque and speed).

In this project we are using PV sub module Sun Power SPR=305E- WHT-D which consists of 96 cells connected in series to generate peak power equal 305 W. Module specifications parameters at standard test condition (1000 W/m^2, 35 °C). The array consists of 1 parallel strings, each one parallel string consists of three modules connected in series



P=305.226 x 5 x64

=97672.32

=Approx 98kW

PV Module Specification	
Electrical characteristics	**Sun Power SPR=305E-WHT-D**
Open-Circuit Voltage	**64.2**
Short-Circuit Current	**5.96**
Maximum Power Voltage	**54.7**
Maximum Power Current	**5.58**
Maximum Power	**305.226**

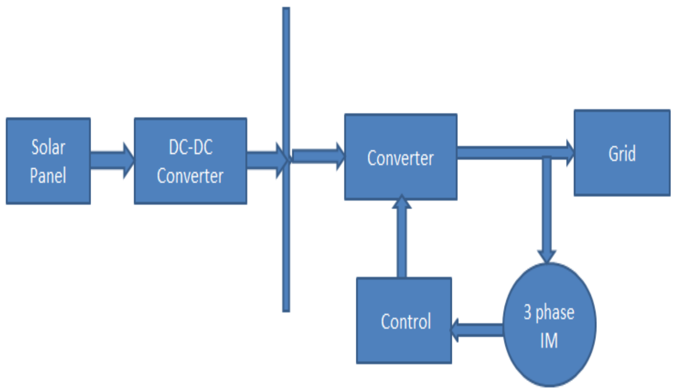


Fig-1: Block diagram of PV fed DRIVE (Induction Machine)

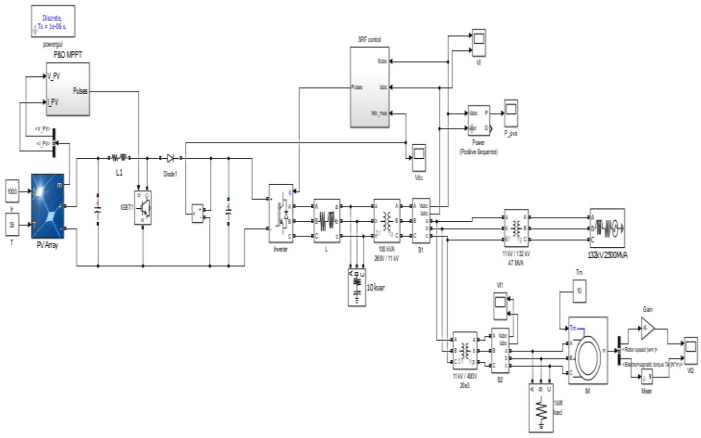


Fig-2: . MATLAB Simulink Model of PV fed DRIVE (Induction Machine)

2.1 SIMULATION RESULT OF PV SYSTEM:-

- Simulation results of the Matlab design of one single PV array.
- Referring from Fig 3 it can be observe that the maximum output power is giving near 1 kW at the output voltage of approximately 200v.
- At the same time, the output current at output voltage of 200v is around 6 amps.

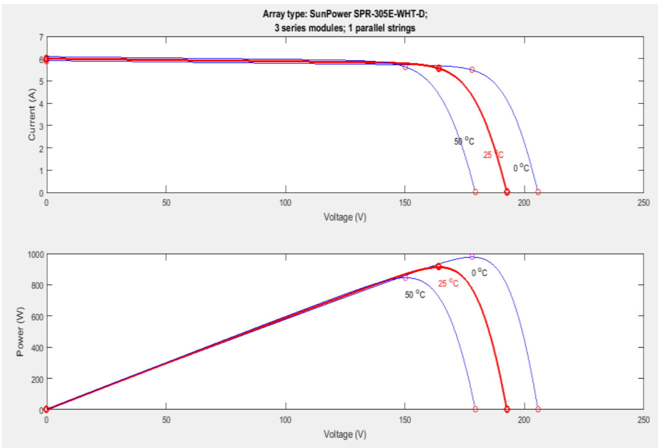


Fig-3: Power VS voltage and current VS voltage

The PV system is used to charge/discharge a battery bank with the MPPT algorithm. Maximum Power Point Tracking (MPPT) techniques are used to maintain the PV array's operating point at its maximum power point (MPP) and extract the maximum power available in PV arrays and to maximize the power generation of the PV system maximizes the output power of the load of the converter.

The hill-climbing technique named as the shape of the power-voltage (PV) curve. Sub-techniques including Perturb and Observe algorithm (P&O) . Methods with P&O algorithms increase their effectiveness. The P&O algorithm delivers the value of voltage and current from the solar photovoltaic array corresponding to the maximum power. A P&O method is the most simple, which moves the operating point toward the maximum power point periodically increasing or decreasing the PV array voltage

In the Power Vs Voltage characteristic of a PV module shown in We can observe that there exist single maxima i.e. a maximum power point associated with a specific voltage and current are supplied. The overall efficiency of a module is very low around 12%. So it is necessary to operate it at the crest power point so that the maximum power can be provided to the load irrespective of continuously changing environmental conditions. This increased power makes it better for the use of the solar PV module. A DC/DC converter which is placed next to the PV module extracts maximum power by matching the impedance of the circuit to the impedance of the PV module and transfers it to the load. Impedance matching can be done by varying the duty cycle of the switching elements.

2.2 MPPT PERTURB AND OBSERVE ALGORITHM :-

The efficiency of solar panel is improved by Maximum Power Point Tracking (MPPT) when they set to operate at point of maximum power. There are different techniques of MPPT.

The most popular techniques are:

- Incremental Conductance method,
- Perturb and Observe,
- Fuzzy logic,
- Neural networks.

We need to adjust the initial reference values in direction of increasing manner of output power and vice-versa. Until photovoltaic array reach the maximum power points same process repeats. The characteristic power curve for a PV array is shown in Figure 3.

If MPPT techniques considered it as a problem, then it finds the voltage VMP or current I and automatically under a given temperature and irradiance the PV array should get the maximum output power.

MPPT algorithms are typically used in the controller designs for PV systems. The algorithms account for factors such as variable irradiance (sunlight) and temperature to ensure that the PV system generates maximum power at all times.

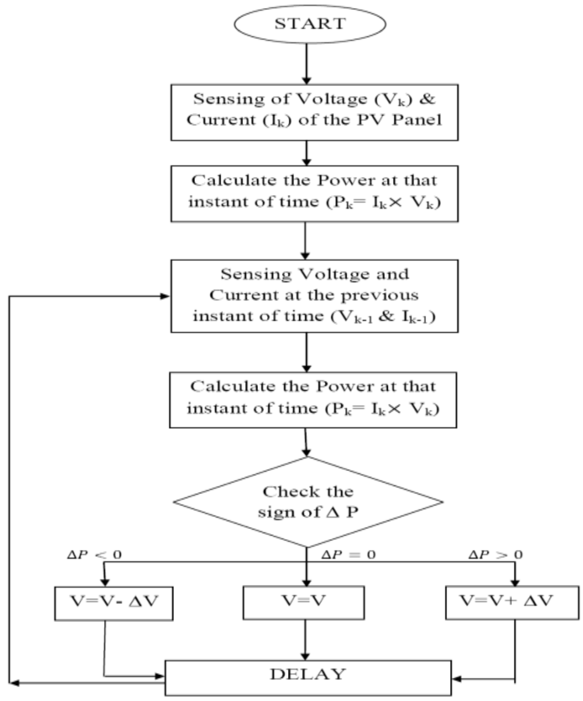


Fig-4: . MPPT using P & O Algorithm

2.3 MODELING OF DC-DC BOOST CONVERTER

A boost converter is used to step up the PV voltage generated to the set down value so that it could maintain with the DC link voltage along with the Maximum power extract from the PV module. Boost converter topology is shown in Fig. 5 MOSFET/IGBT can be used as a switch. Boost converter output is given as

$$Vo = Vin * \frac{1}{1-d}$$

$$d = \frac{Ton}{T}$$

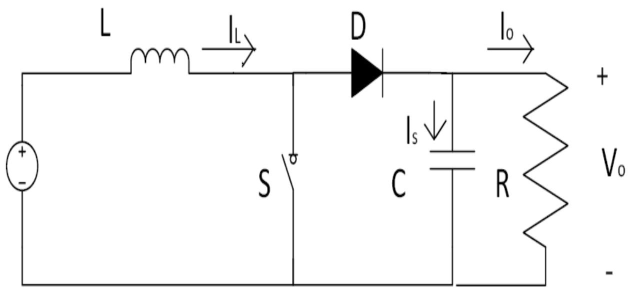


Fig-5: DC-DC basic boost converter

As a voltage source PV system voltage is used in this system .A boost inductor, to supply energy to the output side where the load is supported, an inductor will flip its voltage polarity to maintain current flow. MOSFETs, diodes and capacitors

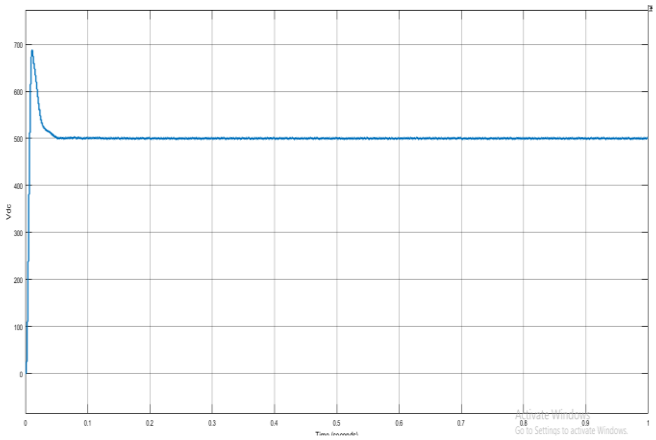


Fig-6: Output waveform of the boost converter

The boost converter is set to the voltage that will be constant for the stand alone time. Fig 6. Shows that the voltage has been upto 500 Volts.

As Discussed in the section above in 2.1,2.2,2.3 the following result can be seen in the below characteristic of motor fed from PV system, behavior against Speed VS Time and Torque VS Time that both settles at 0.2 sec

DC-DC boost converter used operate the PV panel at maximum power point, and boost the DC voltage level to the appropriate level so that it is easily converted into the desired AC voltage. As PV voltage varies frequently , MPPT is used maximise the power to the appropriate vale as discussed above and boost converter provides the control of the PV panel output voltage , his will maintain the input voltage of the inverter.

2.5 GRID CONNECTED INVERTER

The PV System can be connected to the 3 Phase grid via a DC-DC converter and a Voltage control Voltage Source Inverter (VSI) to convert the DC Voltage to 3 phase AC as the Grid is a 3 phase AC Source. VSI are largely used because of its high efficiency, compact size and good control on power flow.

It also provide Synchronization with the grid, Control of active and reactive power flow into the system , Control of DC link Voltage and harmonic reduction due to the converter connected can be helpful as the efficiency of the VSI is high.

In this paper to transform, the grid voltage and current into 2 dimensional we have taken the help of *abc* to *dq* transformation Synchronous rotating reference frame

2.6 SYNCHRONOUS REFERENCE FRAME PLL (SRF PLL)

As the load drive used is the Induction motor which is the nonlinear load in which the current waveform does not take the shape of the applied voltage waveform and cannot describe the relation between voltage and current which in turn produces harmonics and affect the power system component.

The synchronous reference frame theory performs the operation in steady-state or transient state as well as for generic voltage and current waveforms. It allows controlling the active power filters in real-time system. The basic function of the PLL is to measure

Phase angle (ϴ) from the angular frequency (ω) of the grid Voltage. In the SRF PLL the voltages of the

3 phases of the Grid (Ea, Eb, Ec) which are separated in phase by an angle of 120 degree from each other are converted into dq reference frame in a two stage transformation process i.e abc frame to αβ reference frame to dq reference frame The transformation block diagram is shown in fig 7.

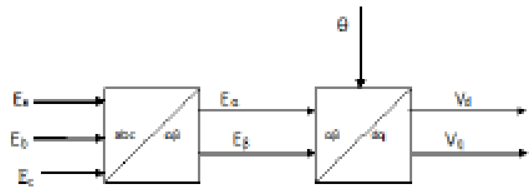


Fig-7: SRF Phase locked loop

The Three phase voltages of the grid is given in equation (1)

$$E_a = E_m \cos \omega_{grid} t$$

$$E_b = E_m \cos(\omega_{grid} t - 2\pi/3) \qquad (1)$$

$$E_c = E_m \cos(\omega_{grid} t + 2\pi/3)$$

Where $\omega_{grid} t = \Theta_{grid}$

Appling the Clark Transformation (abc → αβ

Transformation) we get equation (2).

$$\begin{bmatrix} E\alpha \\ E\beta \end{bmatrix} = \frac{2}{3} \begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} Ea \\ Eb \\ Ec \end{bmatrix} \qquad (2)$$

Substituting the values of E_a, E_b, and E_c in equation

(2) we get equation (3) as follows.

$$\begin{bmatrix} E_\alpha \\ E_\beta \end{bmatrix} = E_m \begin{bmatrix} Cos\theta_{grid} \\ -Sin\theta_{grid} \end{bmatrix} \quad (3)$$

Appling the Parks Transformation (αβ →dq Transformation) we get equation (4).

$$\begin{bmatrix} E_d \\ E_q \end{bmatrix} = \begin{bmatrix} Cos\theta & -Sin\theta \\ Sin\theta & Cos\theta \end{bmatrix} \begin{bmatrix} E_\alpha \\ E_\beta \end{bmatrix} \quad (4)$$

Here the αβ is the stationary two dimensional reference frame and the dq is the two dimensional reference frame rotating with some angular velocity. To achieve the Grid synchronization we will have to synchronize the rotation of the dq axis to that of the three phase voltages of the grid which are rotation at an angular speed of ωgrid .

Simplifying the Parks transformation we get equation

(5).

Ed = Em Cos (Ɵgrid- Ɵ)

Eq = Em Sin (Ɵgrid-Ɵ) (5)

To achieve grid synchronization the Ɵ must be equal to Ɵgrid and thereby equalizing the inverter output voltage frequency and phase with that of the grid voltage. So if Ɵgrid = Ɵthen

Ed = Em and Eq = 0. (6)

But it if a very small error persists i.e if (Ɵgrid- Ɵ) is very small and nearly equal to zero then

Sin (Ɵgrid- Ɵ) =(Ɵgrid-Ɵ) (7)

So Eq = Em (Ɵgrid- Ɵ) (8)

So we can get the angular frequency as given in equation (9).

$$\omega = \frac{d\,\theta}{dt} = CE_q \quad (9)$$

Where C is the transfer function of the PI controller.

Hence by designing the proper controller we can

successfully track the grid utility Frequency (ω grid)

and phase (Ɵ grid).

Taking the Laplace transformation of equation (9)

we get equation (10).

s Ɵ (s) = C(s) Em(Ɵ grid(s)- Ɵ (s)) (10)

Representing this expression in Block Diagram form

we get fig 8.

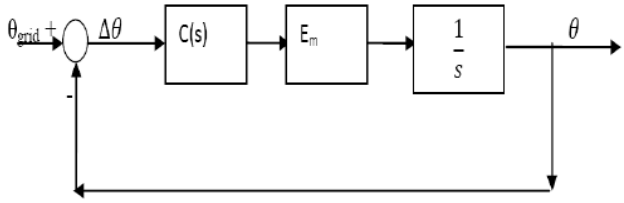


Fig-8: .Linearized model of the PLL

From the above equation we can see that for grid Synchronization Eq must be set to Zero. Doing this we get the overall PLL control structure as given in the following block diagram in Fig 9. Here ω o is the fundamental frequency of the grid in rad/s. Here Eq* is the reference set point voltage of Eq.

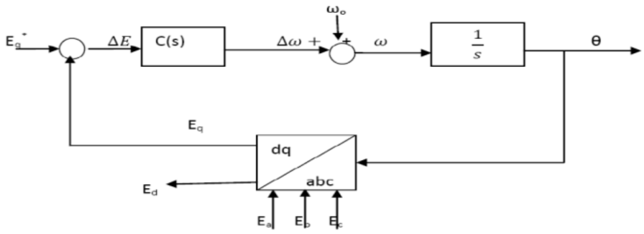


Fig-9: Overall PLL control structure.

2.4 SIMULATION RESULT OF PV FED DRIVE (INDUCTION MACHINE)

The modeling of the relevant system in Simulink is presented in fig 2. As discussed in above sections the components connected are used to achieve uninterrupted smooth operation of the drive. In the fig 9. shows the characteristics of speed vs time and toque vs time.. As per the calculations and the observation the result can be seen in the characteristics showing :

Speed of 1460 RPM settle at 0.2 sec. and

Torque of 98N/m^2 settle at 0.2 sec.

Which will help persisting the efficiency of the motor.

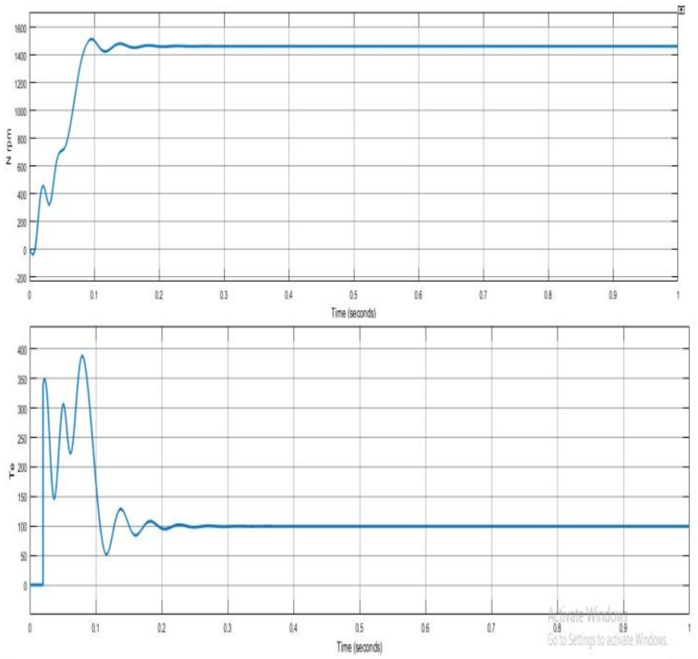


Fig-9: Speed VS Time and Torque VS Time Model of PV fed DRIVE (Induction Machine)

3. STUDY AND SIMULATION MODEL OF HYBRID MICRO GRID FOR MOTOR:-

PV system connected in parallel with Other AC source which is converted in to DC by using Zeta converter and formed DC grid output of DC grid fed input to the inverter which converted to AC and Fed to Induction motor for their operation .In case of no or less output From PV system continuity can be maintained by another system.

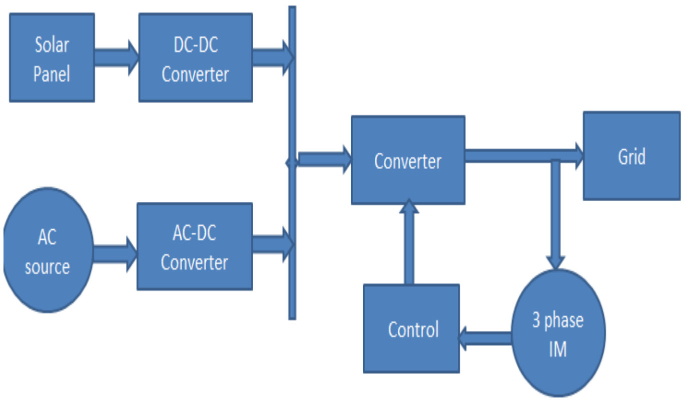


Fig-10: Block diagram of the overall system

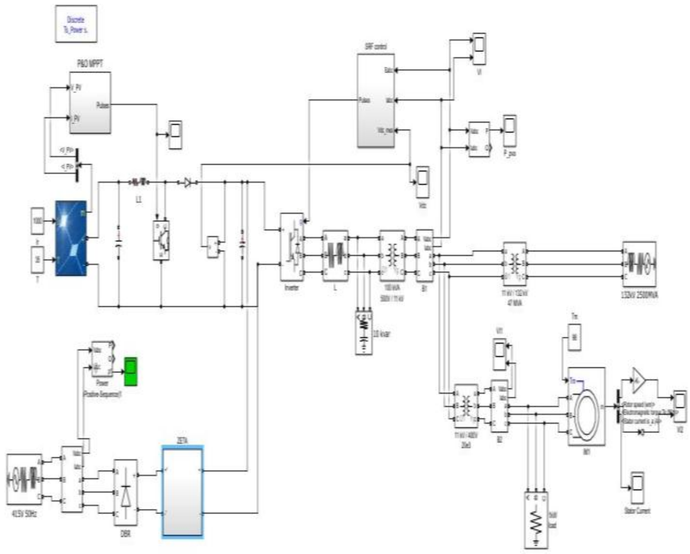


Fig-11: Simulation model of the hybrid micro grid fed motor

The Three phase output of the grid is converted to ripple DC by the use of DBR (Diode bridge rectifier). The converted DC voltage is fed to ZETA converter which is a DC-DC converter, making the rippled DC to constant DC with the use of a buck inductor.

The MOSFET switch provide in the ZETA converter switches according to the duty ratio given by the PI controller for which the input is given from the error value of the reference and measured output DC value of the ZETA converter. It a closed loop control system with feedback PI controller circuit and the switching frequency of the ZETA converter is 45 kHz.

The converted DC voltage form the ZETA converter is fed to the DC bus where PV model connected output of DC grid maintained to constant value of 500V.

Inverted output is fed to motor and speed. Torque and Stator current parameter with closed loop controlled monitored for full load torque.

3.1 INDUCTION MOTOR:

AC motors are widely used motors in all applications these days due to low cost, robustness, reliability and low maintenance. It is advisable to have Solar panels which deliver a power almost 2 to 3 times the rating of the motor.

The rating of Induction motor used in this project is specified below in the table for suitable operation for which is to be controlled and provide a smooth operation

Induction motor Specification	
Rotor Type	Squirrel cage
Rating	20HP (15 kW)
Voltage	400V
Speed	1460 RPM
Torque	98 N/m2
Maximum Power	305.226

3.2 SIMULATION RESULT OF HYBRID FED DRIVE (INDUCTION MACHINE)

Simulation model of the hybrid micro grid fed motor is presented in the fig 11, which shows the co-ordination with the PV system switches automatically to AC supply when it reaches below the setup voltage, converting AC/DC using zeta converter giving good result and maintained as constant voltage that links proper with DC link among the other converting topology

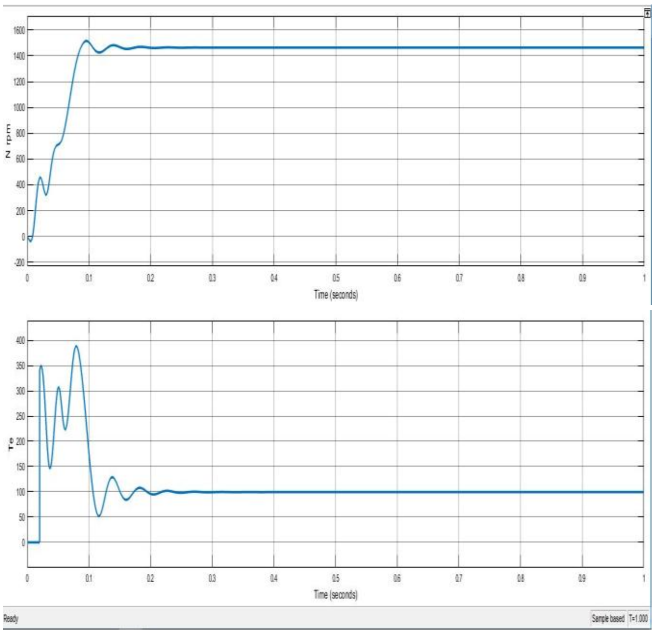


Fig-12: Speed VS Time and Torque VS Time characteristic of hybrid micro grid fed motor

4. CONCLUSIONS:-

The simulation result of the PV System fed to the IM was taking a settling time of 0.2 sec for the Speed 1460 RPM and Torque 98N/m^2 , With the control strategy using SRF and DC-DC boost converter topology converter topology Whereas the time taken to perform IM was the same when added with hybrid system, that stables at 0.2 sec for Speed 1460 RPM and Torque 98N/m^2. With the control strategy using SRF and Zeta converter topology which That was needed to get co-ordinated same stable supply working standalone without disturbing the other system achieving the smooth speed and torque reducing the burden, harmonics, appropriate control methods of the motor, with suitable architecture and so achieved with this model. And remaining extra power generated can be forwarded to the grid.

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