Design of Single Stage & Two Stage Conversion of PV System for VSI Fed Induction Motor Drive under Varying Temperature and Irradiance using LabVIEW

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Abstract

In this paper, under varying the temperature and irradiance, the comparison between single stage and two stage conversion of PV system using LabVIEW has been proposed. Due to clean energy and less impact on the environment, now a day's solar energy is preferred most and represented by PV (photo voltaic) cell. PV cell, inverter and induction motor have been designed using LabVIEW and the converter is designed using NI multisim. The simulated result shows the characteristics like torque, speed, current and flux by varying temperatures and irradiance. These results are presented and validated.

1. INTRODUCTION

In early days the energy is produced by using stones that is nothing but the heat energy and light energy. In India the significant hotspot for delivering electrical energy is only the warm (coal) energy, where in the process the steam energy is created and this is utilized to run turbine and afterward generator created energy at last and this is circulated to homes and industry application reason. Around 70% energy is delivered in this situation just yet as the customary energy sources like petrol; coal and gas are draining step by step and furthermore effect sly affect the climate as carbon prints are created and consequently prompting green house gases. The non-sustainable power sources are draining step by step so the need is to focus and zero in on the environmentally friendly power sources like sun oriented, flowing, wind and so forth, as the sunlight based energy is perfect and more plentiful, much fixation is on the PV cell. It enjoys a few benefits like less upkeep, long life time and simplicity of establishment.

2. MATHEMATICAL ANALYSIS OF PV CELL

The One-diode model is the most simple and famous model used for PV cells. The ideal one-diode PV cell equivalent circuit model is represented by a constant current source and a P-N junction diode as shoran in Fig.1. The photocurrent Iph, is the amount of current produced by the electron-hole pairs generated by the impinging sunlight. This phenomenon is called as photovoltaic effect. The ohmic losses occur in the cell due to series resistance Rs and shunt resistance Rsh. In ideal case, Rs is 0 and Rsh is ∞. From the Fig.l, it is clear that the diode forward bias current and the current through shunt resistance is supplied by photocunent Iph. And only the remaining current flows through load via series resistance Rs.

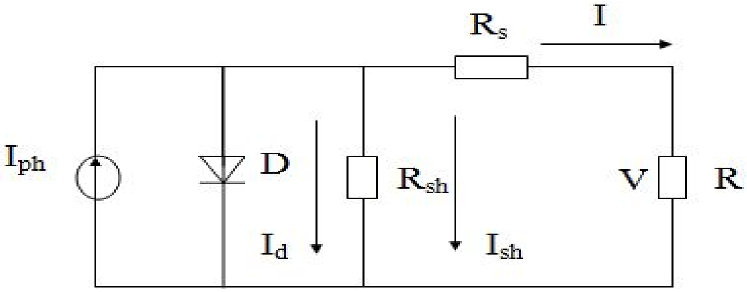


Fig.1. equivalent circuit model of a Single diode PV cell

Terminology:

T_c=cell temperature in Kelvin
T_r=Reference temperature, 298.15 Kelvin
I_{ph}≈I_{sc}=short circuit current at T_c and irradiance G(W/m^2)
I_d=Diode current in Amperes
I_{sh}=Current through shunt resistance R_{sh} in Amperes
I_o=Reverse saturation current at T_c in Amperes
I=Output current of cell in Amperes
V=Output voltage of cell in Volts
V_{ocr}=Open circuit voltage in Volts at T_r
I_{scr}=Short-circuit current in Amperes at T_r
K=Boltzmann's constant=1.38×10^{-23}Joules/Kelvin
q=Electron charge=1.60×10^{-19}Coloumb
n=Diode ideality factor (between 1 and 2)

Using the Kirchhoff's current law for the single diode circuit model as shown in Fig1,

$$I = I_{ph} - I_d - I_{sh} \quad (2)$$

The current through the diode I_d is given by,

$$I_d = I_o\left[\exp\left(\frac{v_d q}{nKT_C}\right) - 1\right] \quad (3)$$

Diode voltage V_d is given by,

$$V_d = IR_S + V \quad (4)$$

The equation (Current-Voltage (I-V)) for the single diode equivalent circuit for the PV cell is,

$$I = I_{SC} - I_o\left[\exp\left\{\frac{(V + IR_S)q}{nKT_C}\right\} - 1\right] - \frac{V + IR_S}{R_{sh}} \quad (5)$$

2.1 Single Stage & Two Stage Conversion

PVs can be interfaced either through a single-stage dc/ac converter or through a two-stage dc/dc converter followed by a dc/ac converter. First in single stage process direct conversion of the dc voltage from PV cell to ac by using an inverter is done, the efficiency is more in this type of conversion since it has only one stage for conversion so the name.

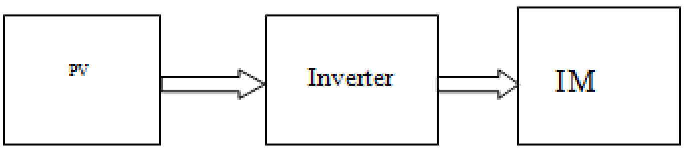


Fig2. Single Stage Conversion

The phase voltages are calculated by the following equations.

$$V_{An} = \frac{2V_{Ao}}{3} - \frac{V_{Bo}}{3} - \frac{V_{Co}}{3} \quad (11)$$

$$V_{Bn} = \frac{2V_{Bo}}{3} - \frac{V_{Co}}{3} - \frac{V_{Ao}}{3} \quad (12)$$

$$V_{Cn} = \frac{2V_{Co}}{3} - \frac{V_{Ao}}{3} - \frac{V_{Bo}}{3} \quad (13)$$

2.2. Two Stage Conversion:

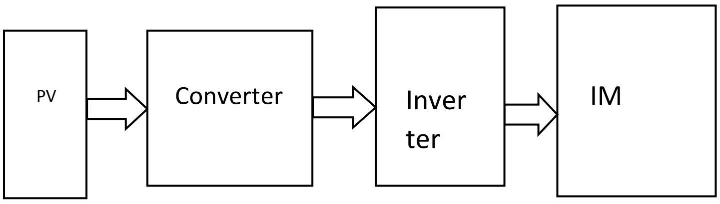


Fig 3. Two Stage Conversion

In the two stage conversion an intermediate device called converter is present in between the PV and an inverter.

Converter is a device which is usually used to convert the unregulated dc voltage to the regulated dc voltage.

3. INDUCTION MOTOR MODELLING

a) . The converted matrix is used to analyze the steady state and transient performances. Assumptions:

- Uniform air gap
- Balanced rotor and stator windings, with sinusoidally distributed mmf
- Inductance vs. Rotor position is sinusoidal, and
- Saturation and parameter changes are neglected

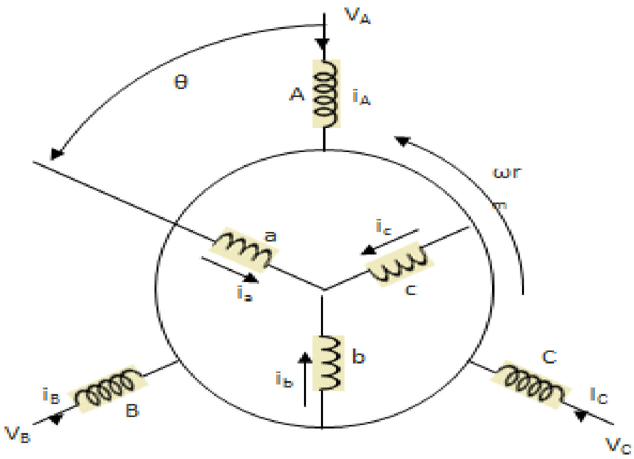


Fig.4 Stator and rotor axes

The stator and rotor equations are

Stator equations

$$\left.\begin{aligned} v_A &= i_A R_s + \frac{d\psi_A}{dt} \\ v_B &= i_B R_s + \frac{d\psi_B}{dt} \\ v_C &= i_C R_s + \frac{d\psi_C}{dt} \end{aligned}\right\} \quad (14)$$

Rotor equations

$$\left.\begin{aligned} v_a &= i_a R_r + \frac{d\psi_a}{dt} \\ v_b &= i_b R_r + \frac{d\psi_b}{dt} \\ v_c &= i_c R_r + \frac{d\psi_c}{dt} \end{aligned}\right\} \quad (15)$$

The above equations are in the form $\left(\frac{d}{dt}\right)$ $v = iR + p(Li)$
where p is the differential operator
The physical basis for the development of this transformation is the equivalence of mmf and invariance of power.

$$\begin{bmatrix} v_d \\ v_q \\ v_0 \end{bmatrix} = \frac{2}{3}\begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{bmatrix}\begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix}$$

3.1 Two-axis Induction Motor:

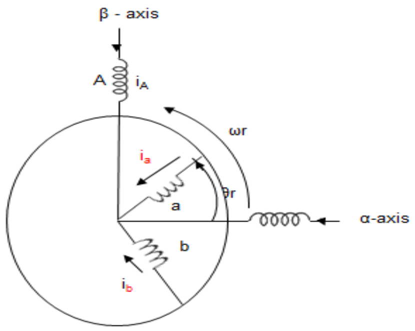


Fig.5.A two-phase induction motor with stator and rotor windings

The terminal voltages of the stator and rotor windings are

$$v_{\alpha s} = R_{\alpha} i_{\alpha s} + p(L_{\alpha\alpha} i_{\alpha s}) + p(L_{\alpha\beta} i_{\beta s}) + p(L_{\alpha a} i_{ar}) + p(L_{\alpha b} i_{br})$$
$$v_{\beta s} = R_{\beta} i_{\beta s} + p(L_{\beta\beta} i_{\beta s}) + p(L_{\beta\alpha} i_{\alpha s}) + p(L_{\beta a} i_{ar}) + p(L_{\beta b} i_{br})$$
$$v_{ar} = R_{a} i_{ar} + p(L_{aa} i_{ar}) + p(L_{a\beta} i_{\beta s}) + p(L_{a\alpha} i_{\alpha s}) + p(L_{ab} i_{br})$$
$$v_{br} = R_{b} i_{bs} + p(L_{bb} i_{br}) + p(L_{b\beta} i_{\beta s}) + p(L_{b\alpha} i_{\alpha s}) + p(L_{ba} i_{ar})$$

The self-inductances are independent of angular positions, hence they are constants

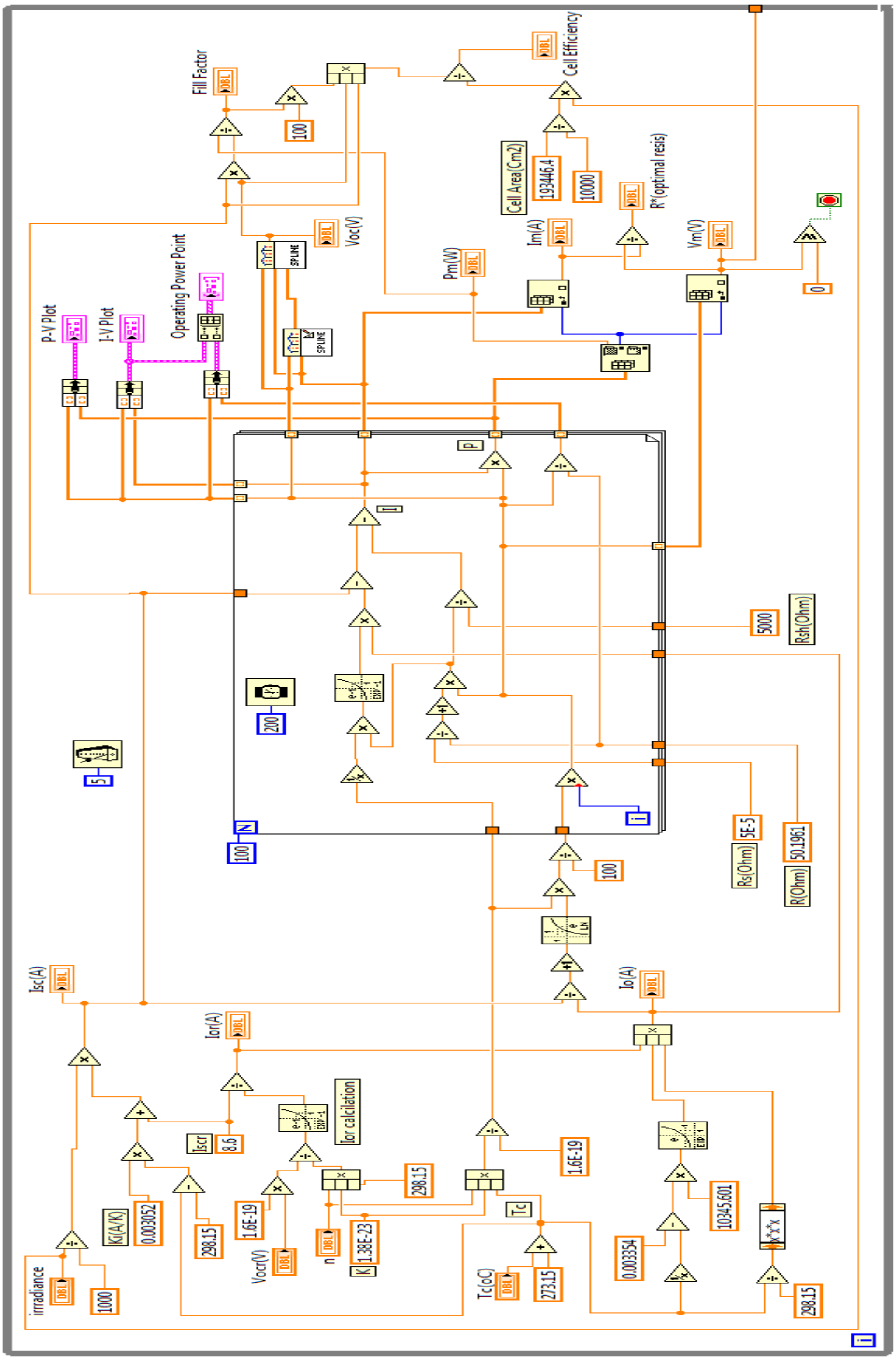
$$L_{\alpha a} = L_{a\alpha} = L_m \cos\theta_r$$
$$L_{\alpha b} = L_{b\alpha} = -L_m \sin\theta_r$$
$$L_{a\beta} = L_{\beta a} = -L_m \sin\theta_r$$
$$L_{\beta b} = L_{b\beta} = L_m \cos\theta_r$$

The mutual inductances between the stator and rotor windings are a function of the rotor position, and they are assumed to be sinusoidal functions the voltage equations of the induction motor in the equivalent two-axis model are θ_r

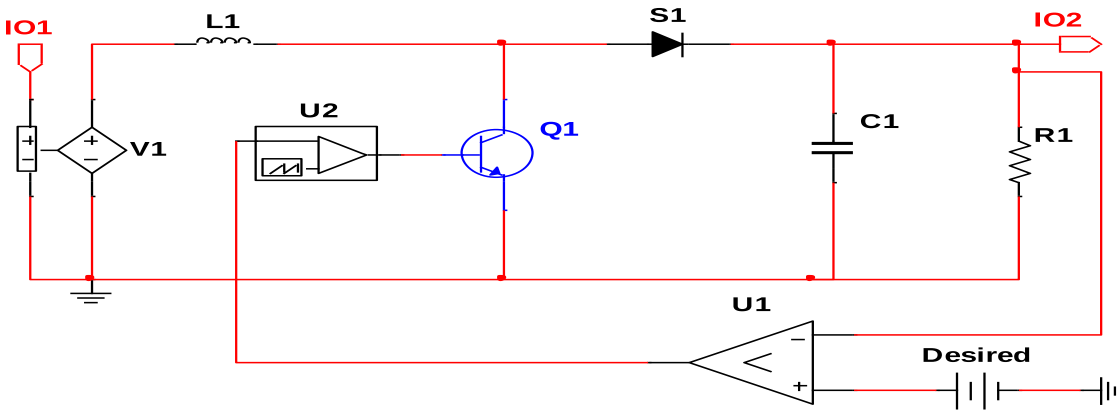
$$L_{\alpha\alpha} = L_{\beta\beta} = L_s \qquad L_{\alpha\beta} = L_{\beta\alpha} = 0$$
$$L_{aa} = L_{bb} = L_r \qquad L_{ab} = L_{ba} = 0$$

4. DESIGN & SIMULATED RESULTS

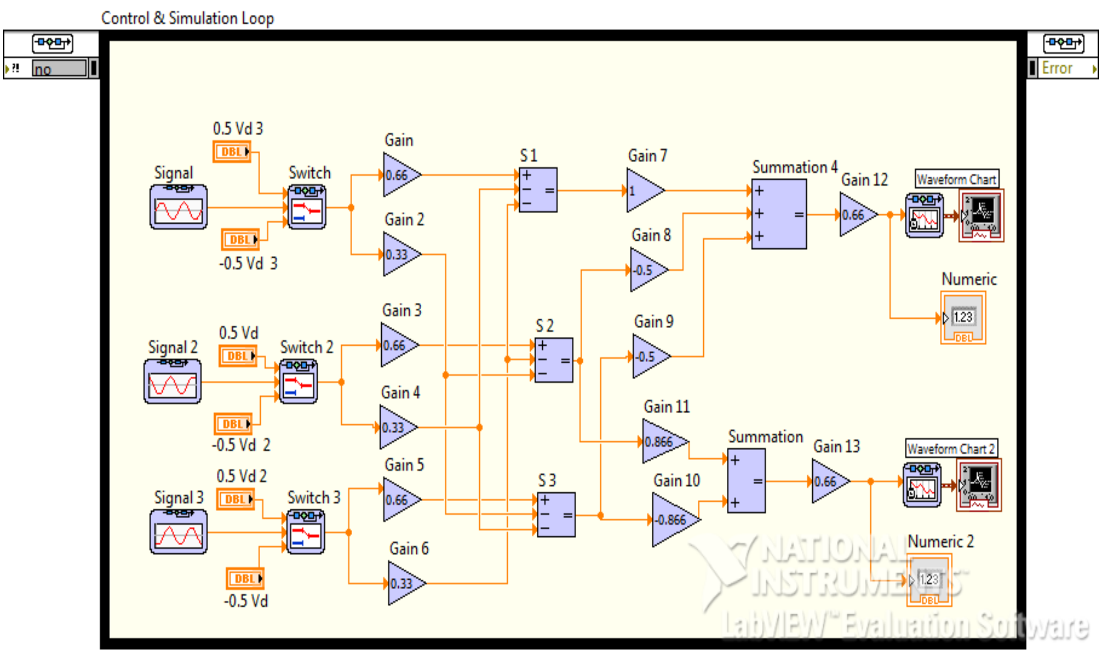
4.1 PV Cell Deign in LabVIEW:



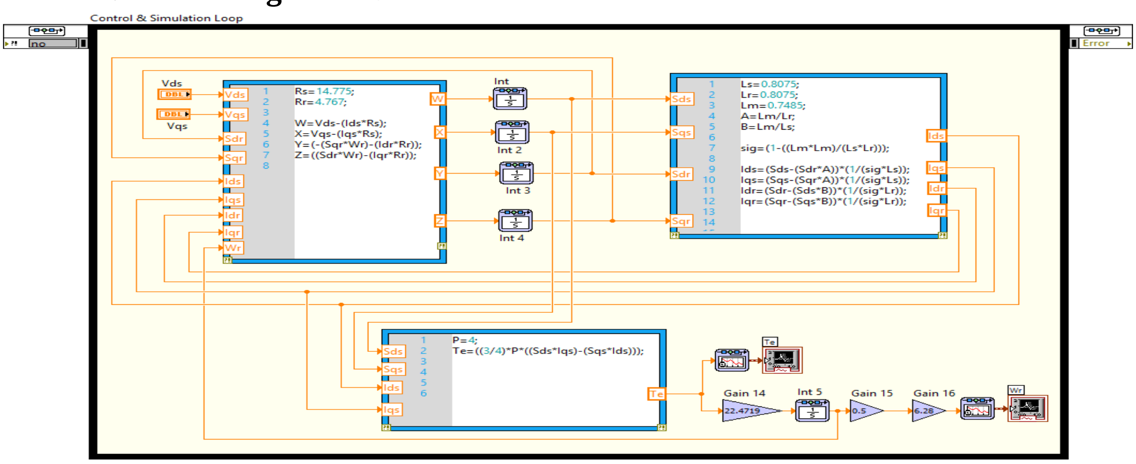
4.2 Boost Converter



4.3 Inverter & transformation to Two phase

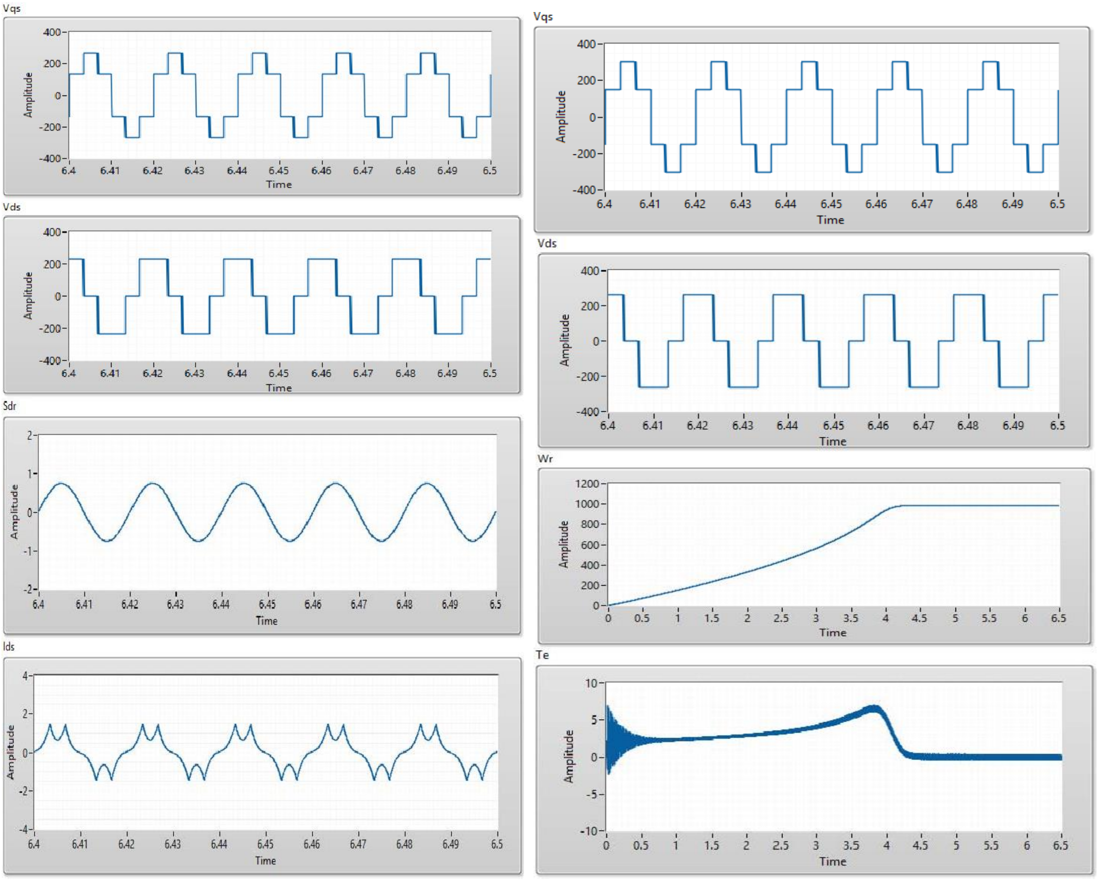


4.4 Modelling of Induction Motor

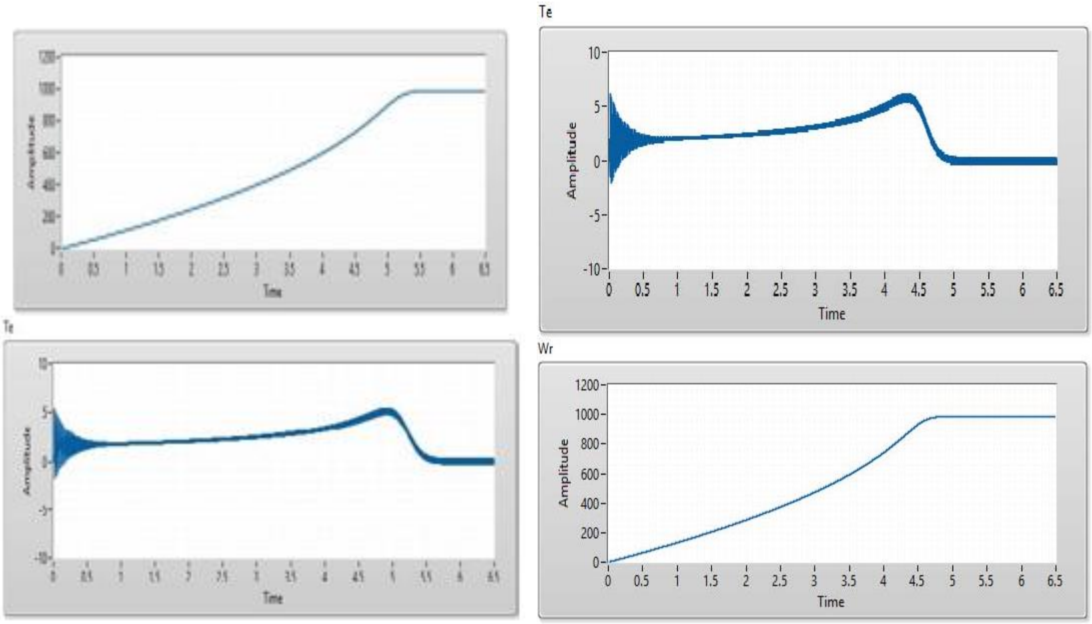


4.5 P-V & I-V CHARACTERISTICS

(A) Fixed Temperature and Variable Irradiance:Tc=25^{0}C & G=1000(W/m²)



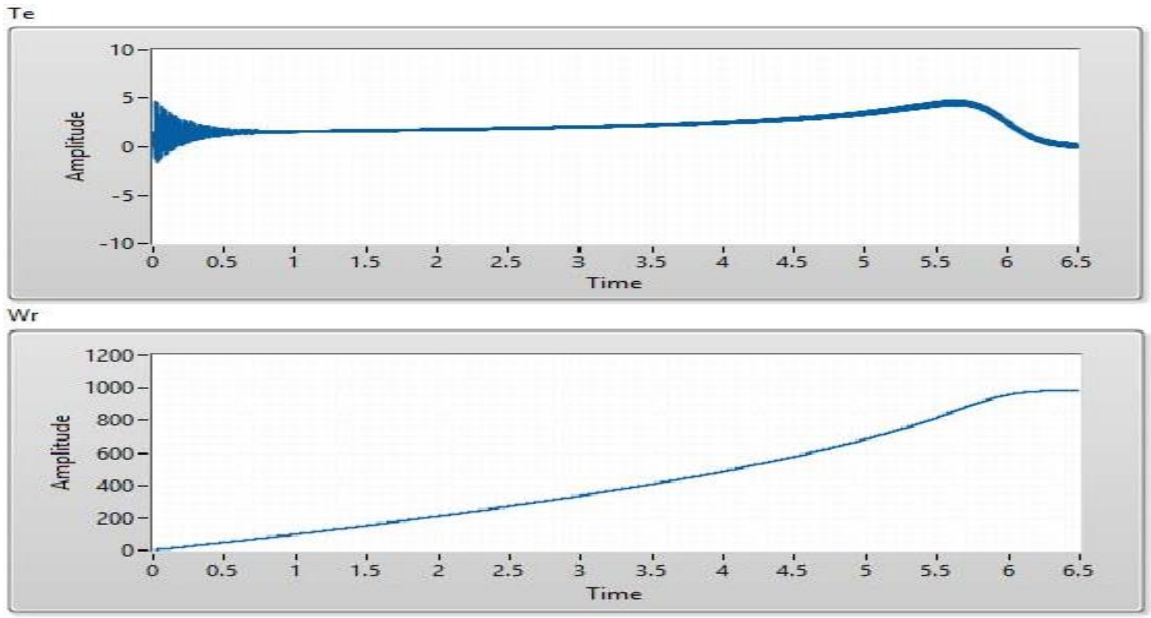
(B)



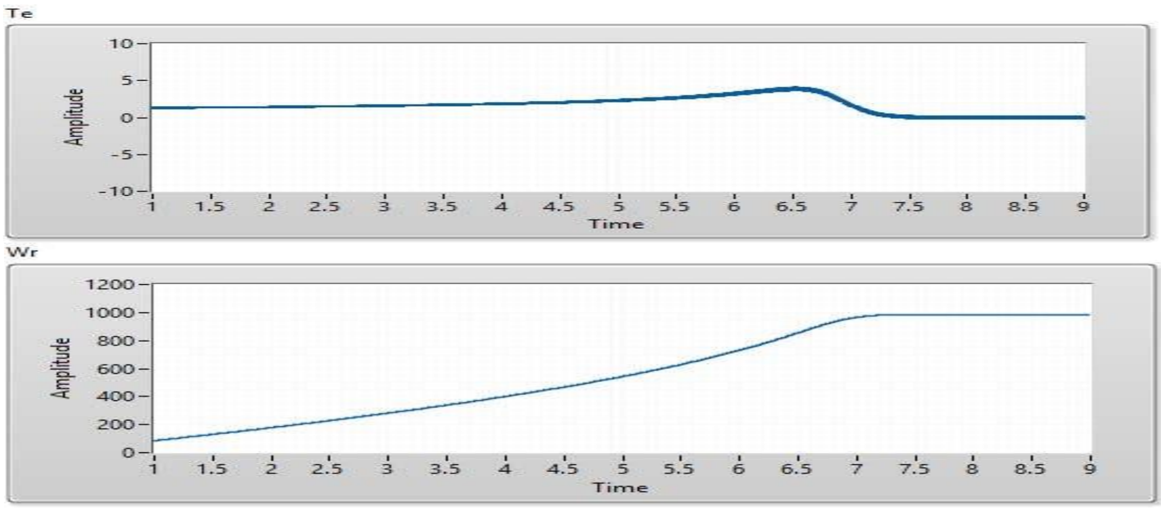
(C) Variable Temperature and fixed Irradiance

1.Tc=-5^{0}C & G=1000(W/m²)

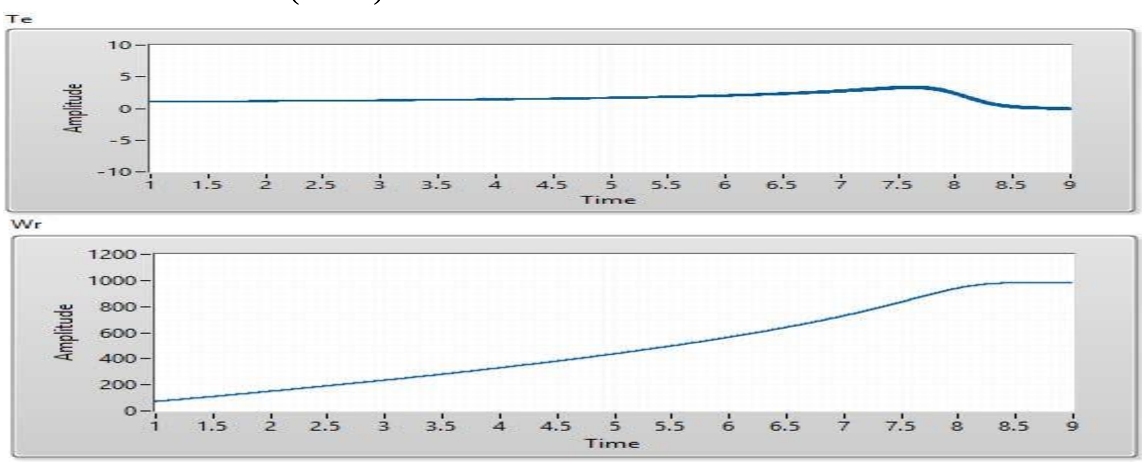
3. Tc=40^{0}C & G=1000(W/m²)

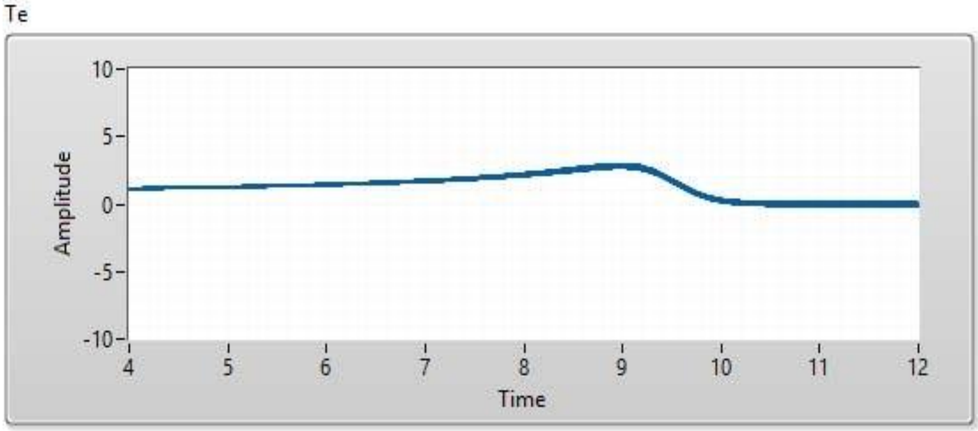


4. Tc=55^{0}C & G=1000(W/m²)



5.Tc=70^{0}C & G=1000(W/m²)





The observation plainly shows that at whatever point the temperature is expanded then result of pv framework diminishes and furthermore it requires some investment to arrive at consistent state force and speed as well as the other way around however at whatever point the irradiance is expanded then result of pv increments and invests in some opportunity to arrive at consistent state since irradiance has direct impact on result of pv system.For single stage more pv cells are required and for two phase less number are required and control intricacy issue is kept away from.

CONCLUSION

In this paper a clear study and comparison has been demonstrated on PV system for single stage and two stage conversions by using LabVIEW. The models are constructed using LabVIEW VI's and Math Script. Due to clean energy and less impact on the environment, now a day's solar energy is preferred most and represented by PV (photo voltaic) cell. PV cell, inverter and induction motor have been designed using LabVIEW and the converter is designed using NI muhisim. The simulated result shows the characteristics like torque, speed, current and flux by varying temperatures and irradiance. These results are presented and validated.

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