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Simulation of Vector Control of Induction Motor Powered by Solar Panel

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Abstract: *Solar panel is widely used in industrial applications. In this paper, DC-DC topology is used to increase the output of solar panel. This DC-DC converted voltage can convert into AC voltage by integrating an inverter which converts dc to ac by means of space vector pulse width modulation (SVPWM) technique. Design of this paper directly coupled to get the voltage from solar cell panel, DC –DC Boost converter, full bridge space vector pulse width modulation inverter, of an induction motor. The FOC vector control is used to control the speed. This is implemented using MATLAB simulink.*

Keywords: Solar panel

I. Introduction

Global warming is a known problem that affects the entire world. Carbon dioxide emission from vehicles and power plants are affecting the global temperature and climate. Solar panel is being employed around the world in most recent years. It is widely used in many applications. We know that the efficiency of solar panel is about 16% to 18%. Advance research to improve the efficiency of solar panel is going in various laboratories. Solar panel as a power source to run an induction motor. A DC-DC converter is considered as a DC equivalent to an AC transformer. Since the output of solar panel is very low, boost regulator provide an output voltage greater than input voltage. In this boost converter, maximum power point tracking (MPPT) is used to track the maximum radiations from sun. MPPT helps to track the maximum radiation and absorb the maximum energy by solar panels. The input current regulator is continuous also has low switching loss and high efficiency. The PWM inverter converts the dc voltage to the ac voltage and given to an induction motor.

Classical controllers (PI, PID) are widely used in industry while more advanced techniques of control, such as adaptive controllers are less used in industry. This is due to the fact that: Classical controllers are simpler to implement and their algorithms are easier. Parameter tuning of classical controllers is hard task for manipulation.

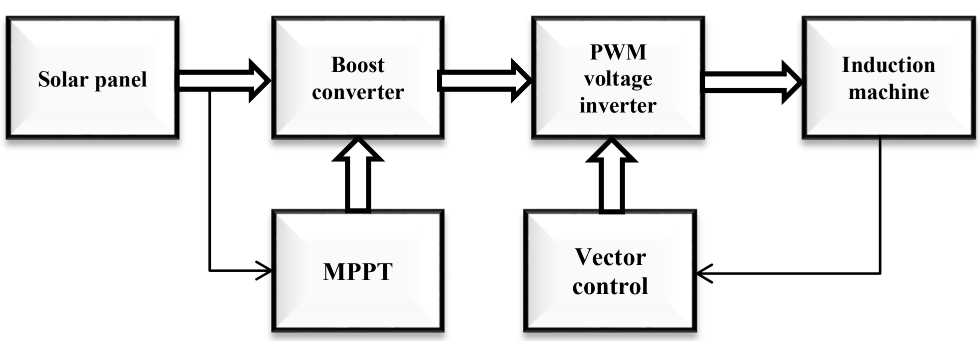

Figure 1.1: Block Diagram of Proposed system

In spite of the fact that these controllers present an attractive solution for many industrial applications, they have some limitations. Many industries are unsatisfied with the obtain performance of the classical controllers. The main cases where classical controllers become under optional can be explained by:

Presence of large non-linear dynamics in the system makes the classical controller incapable to compensate for this important non linearity. Important variation of noise in the regulation loop, for example: sensors noise. Operating domain (point) variation which makes necessary the controller gain re-adaptation.

The vector control is one of the types of speed control of an induction motor is implemented to generate the speed, torque and current of an induction motor. The direct vector control depends on the generation of unit vector signals from the stator or air gap flux signals. The air gap signals can be measured directly or estimated from the stator voltage or current signals. The stator flux components can be directly computed from stator quantities. In these systems, rotor speed is not required for obtaining rotor field angle information. Here, the actual motor currents are converted to synchronously rotating frame currents using park transformation. The resulting dc quantities are compared with the reference d-axis and q-axis components. The outputs of the controller are used to generate the pulse width modulated signals for switching the devices in the inverter bridge feeding the motor.

II. SOLAR PANEL

A photovoltaic cell, commonly called a solar cell or solar panel, is the technology used to convert solar energy directly into electrical energy. A PV cell is essentially a large diode that produce a voltage when expose to sunlight. The PV generator is a non linear device. The electric model of a solar system is composed of diode, two resisters and current generator. The cells are connected in series and in parallel combinations in order to form an array of the desired voltage and power levels. The I–V and P–V characteristics of the solar-cell generator for two insulation levels. The relation between the current (I) and voltage (V) is given by,

$$I = Il - Io\left(Exp\frac{V+IRs}{A} - 1\right)$$

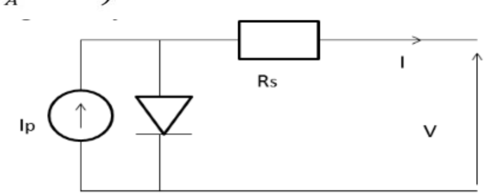

Fig 2.1: Equivalent circuit of solar cell

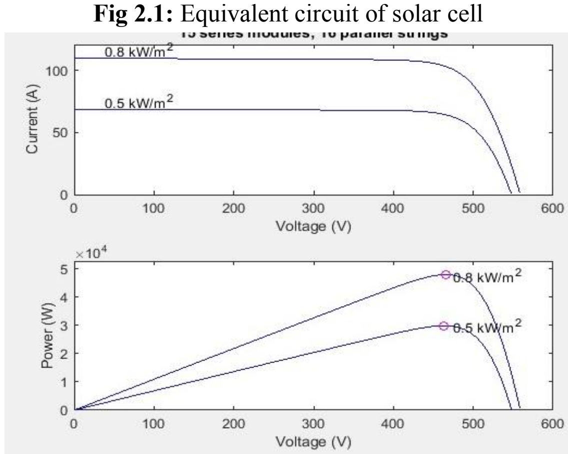

Fig 2.2: VI and PV characteristics of Solar panel

Fig 2.2 shows the characteristics of solar panel depends on the irradiation and temperature. Each curve has a maximum power point, which is the optimal operating point for the efficient use of solar panel.

III. BOOST CONVERTER

Boost converter is a power electronic circuit which gives the output voltage is greater than the input voltage. It consists of dc input voltage, boost inductor, controlled switch, diode, filter capacitor and load resistance. When the switch is on state, the current in the boost inductor increases linearly and the diode is off at that time and the same time the inductor stores the energy. When the switch is off, the energy stored in the inductor is released through the diode to the output RC circuit. The output voltage is the sum of the input voltage and the inductor voltage. Maximum power point tracking (MPPT) is very important in solar power application because it helps track maximum power at each and every instant, thus improving the efficiency of the system and helps to reduce the cost of the solar panel. Using Faraday's law for the boost inductor is given by,

$$VsKT = (Vo - Vs)(1 - K)T$$

From which the dc voltage transfer function turns out to be,

$$Mv = \frac{Vo}{Vs} = \frac{1}{1-K}$$

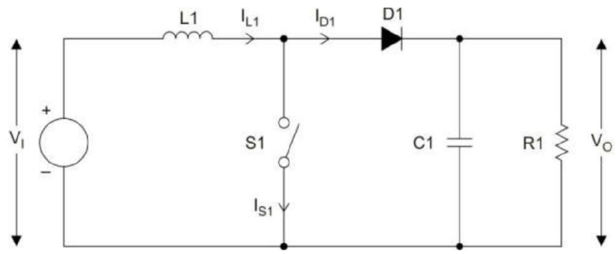

Fig 3.1 circuit diagram of boost converter

IV. Three Phase Voltage Source Inverter

The voltage source inverters are widely used in power supply, renewable energy, marine and military applications. If the input DC is a voltage source, the inverter is called as voltage source inverter. It is important that they are designed to be robust and efficient, especially in remote areas and renewable energy applications.

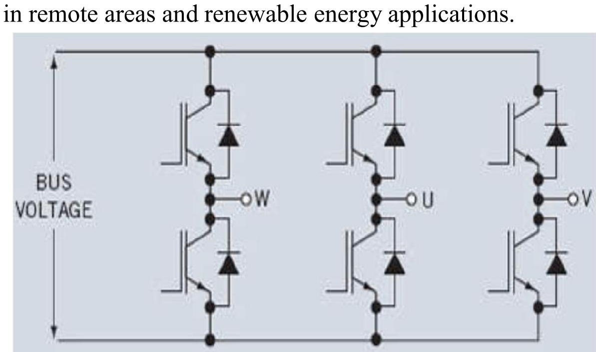

Fig 4.1 Three Phase Voltage Source Inverter circuit

The figure 4.1 shows the three phase voltage source inverter. The full bridge three phase inverter consists of dc voltage source, six semiconducting switches and a load. The semiconducting switching nowadays are BJT, IGBT, Thyristor and GTO. The diodes provide as an alternate path for the load current if the power switches are turned off. Control of the circuit is accomplished by varying the turn on time of the upper and lower MOSFET of each inverter leg with the provision of never turning ON both at the same time, to avoid a short circuit of DC bus. The control pulse to the swatches may be generated by either microcontroller or DSP. A variable voltage can be obtained by varying the input dc voltage and maintaining the gain of the inverter constant. On the other hand, if the dc input voltage is fixed then variable output voltage can be obtained by varying the gain of the inverter. This can be accomplished by pulse width modulation (PWM) technique within the inverter. PWM means the width of the square pulse in positive and negative halves can be adjusted according to the RMS of the output obtained.

V. Three Phase Induction Motor

In this project simulation three phase squirrel cage induction motor is used. It is a type of three phase induction motor which functions based on the principle of electromagnetism. It is called a 'squirrel cage' motor because the rotor inside of it known as a 'squirrel cage rotor' looks like a squirrel cage. One big advantage of a squirrel cage motor is how easily change its speed-torque characteristics. Squirrel cage induction motors are used a lot in industry – as they are reliable , self- starting and easy to adjust.

5.1 Vector Control

A. Control Architecture

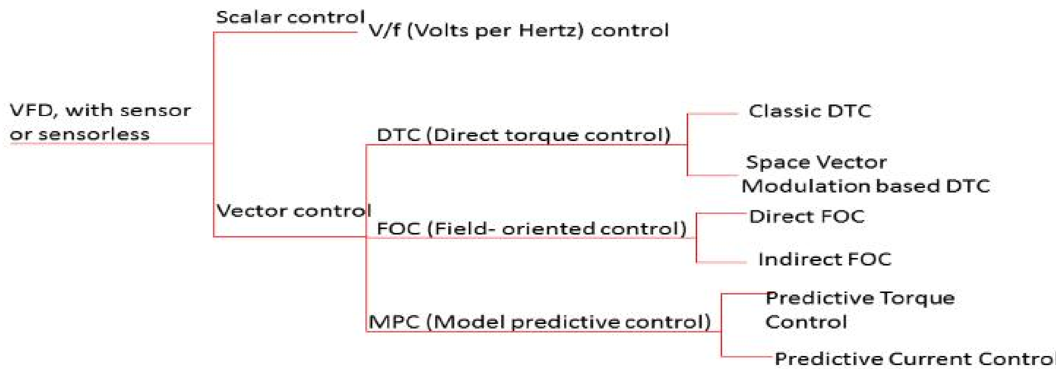

Fig 5.1 control architecture

The figure 5.1 shows the classification of control methods under variable frequency drives. In this paper direct field-oriented control (FOC) method is used to control the speed of induction motor, it is also known as vector control.

VI. Principle of Vector Control

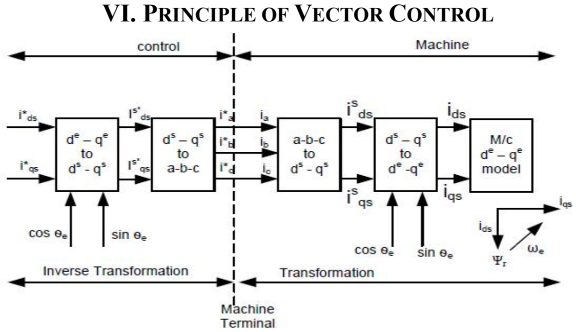

Fig 6.1 Vector control implementation principle

The basic principles of vector control implementation can be explained with the help of fig.6.1 where the machine model is represented in a synchronously rotating reference frame. The inverter is omitted from the figure, assuming that its current gain is unity. It generate currents i{b h, and ic as dictated by the corresponding command currents ia *, h *, and ic * from the controller. The machine terminal phase currents ia, h, and ic are converted to id/ and iq/ components by 3ifJ/2ifJ transformation. These are then converted to synchronously rotating reference frame by the unit vector components cos 8e and sin 8e before applying to the de-qe machine model. The controller makes two stages of inverse transformation so that the control currents ids * and iqs * correspond to the machine currents ids and iqs respectively. Also the unit vector ensures the correct alignment of current ids with the flux vector $ r and iqs perpendicular to it.

Vector control (or field oriented control) offers more precise control of ac motors compared to scalar control. They are therefore used in high performance drives where oscillations in air gap flux linkages are intolerable. In scalar control there is an inherent coupling effect because both torque and flux are functions of voltage or current and frequency.

In this paper, direct vector control is used. The direct vector control depends on the generation of unit vector signals from the stator or air gap flux signals. Their air gap signals can be measured directly or estimated from the stator voltage or current signals. The stator flux components can be directly computed from stator quantities. In these systems, rotor speed is not required for obtaining rotor field angle information. Here, the actual motor currents are using park transformation. The resulting dc quantities are compared with the reference d-axis and q-axis components.

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VII. Simulation And Results

In this simulation, the PWM inverter input voltage is fed from the solar panel. The output of solar panel is very low to run the motor; hence boost converter with MPPT is implanted. From the boost converter, it will give the voltage supply to the PWM inverter. the induction motor is fed by a current controlled PWM inverter with six semiconductor switching devices.

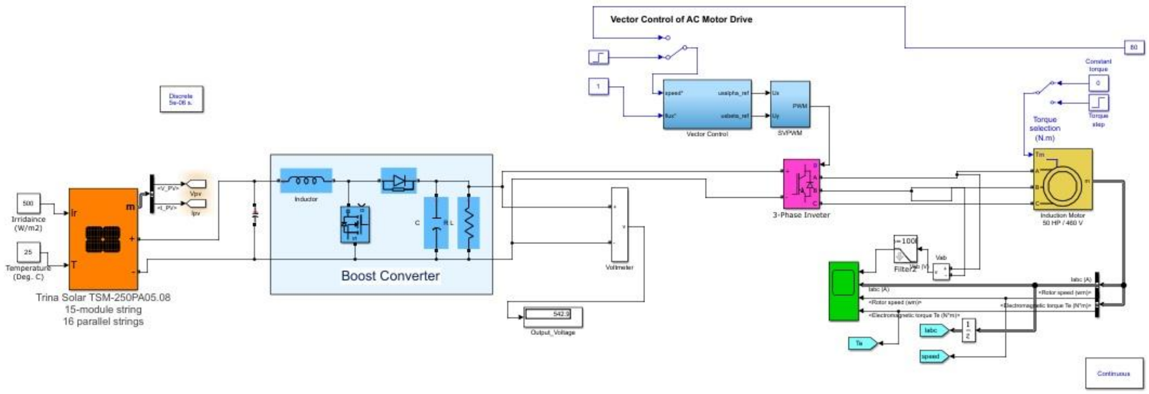

Fig 7.1 speed control of induction motor by vector control

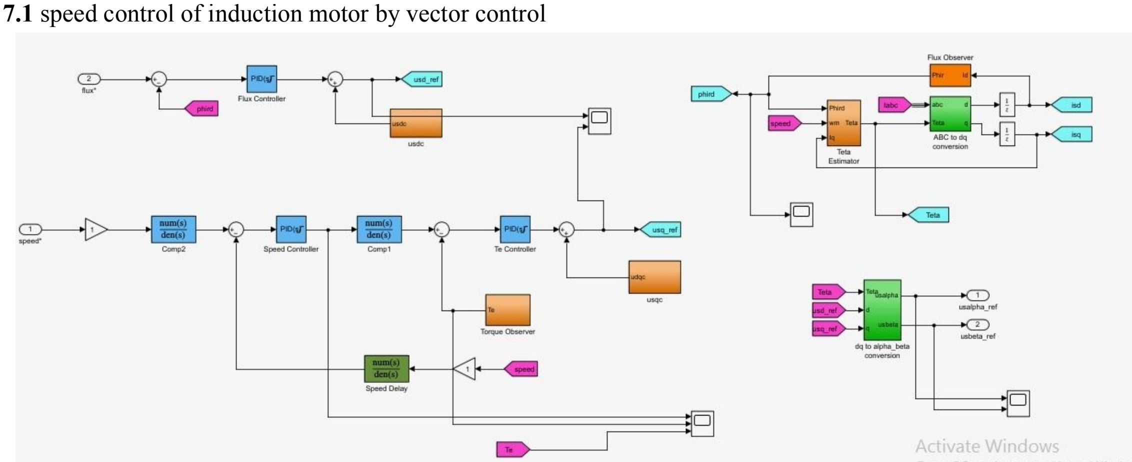

Fig 7.2 Simulation of vector control

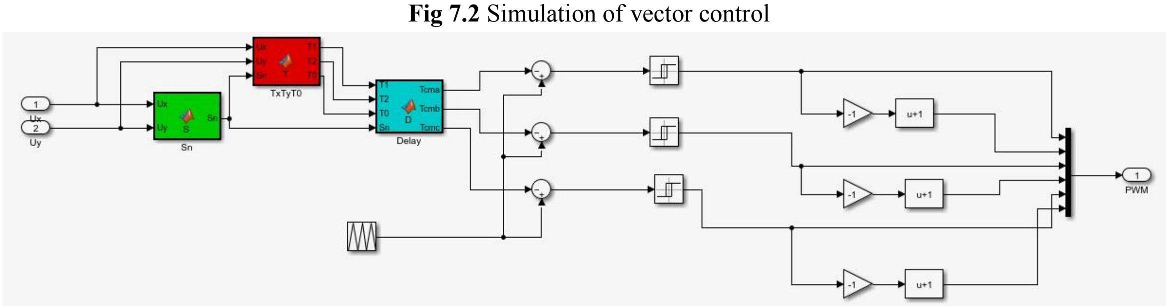

Fig 7.3 simulation of space vector PWM

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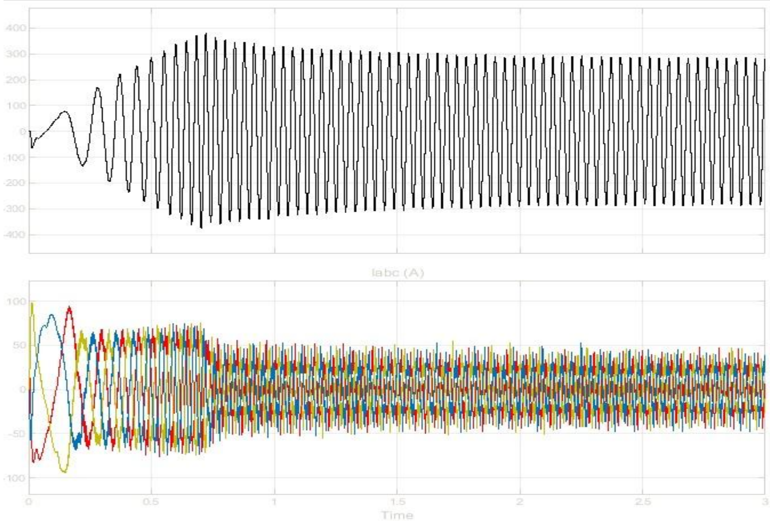

Fig 7.4 Result of voltage and current of induction motor

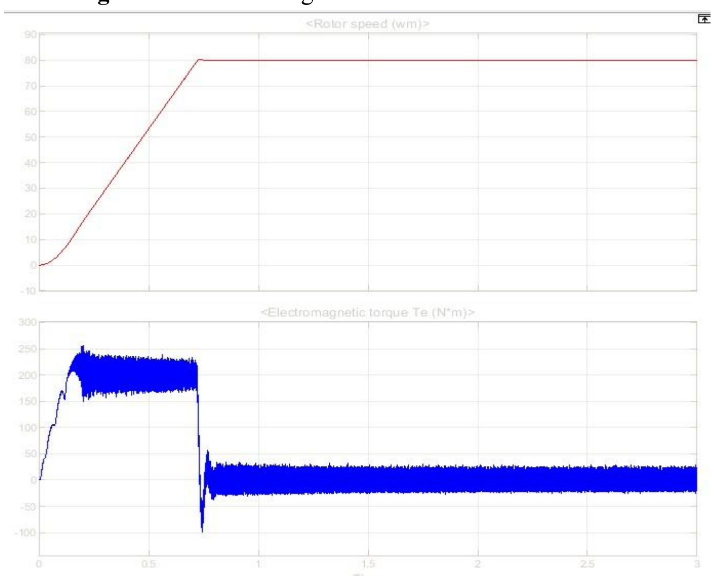

Fig 7.5 Result of the Speed (80) and Torque of induction motor at constant input

The output voltage current, voltage, speed and torque is shown in above figures 7.4 &7.5.The voltage of boost converter obtain 713 V which is feed to three phase inverter by SVPWM. By using MATLAB, we will get the result of speed of an induction motor 80 rad/sec which is shown in figure 7.5.

VIII. Conclusion

The work simulated in this paper shows the possibility of utilizing solar panel to supply a three phase induction motor through the three phase inverter. I conclude that this paper will be contributing to the analysis of solar panel to run an induction motor by means of boost converter with MPPT and SVPWM inverter.

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