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SOLAR BASED SPEED CONTROL OF SINGLE PHASE INDUCTION MOTOR

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The concept presented here is innovative which is very useful for industries to vary the speed of an induction motor from minimum speed to maximum speed. The main objective of this project work is to utilize free power source of solar energy to drive the induction motor. For which a high power rechargeable battery is used and thereby the system can be energized when required. PWM (Pulse Width Modulation) based on open loop technology is used to vary the speed of motor in which the duel output duty cycle delivered by the oscillator circuit can be varied very linearly to vary the motor speed. PWM is a method of reducing the average power delivered by an electrical signal. In which chopper technique will be employed to vary the on and off timings of duty cycle by which motor speed will be varied linearly. If the on time and off time or same (50% duty cycle), the motor will be rotated at maximum speed, similarly keeping the on time as 10% and whereas the off time is 90%, the motor will be rotated at minimum speed.

For demo purpose, a high speed induction motor is used and its speed will be controlled. The oscillator circuit is designed with 3524 chip, it generates duel inverted ac pulses and there by the drive stage is configured in push – pull mode of amplifier. Power MOSFET's are used in drive stage so that switching losses can be reduced, no-load current can be decreased, by which efficiency can be increased. Since the oscillator frequency is adjusted to 50Hz, main output transformer is designed using iron core. Since the system contains 12V battery, the drive stage and its main output transformer are designed to generate 220V AC approximately.

Major Building blocks: Main oscillator circuit built with PWM IC 3524 that generates AC pulses at 50Hz frequency, Z44 NPN power Mosfets, 12V- 10Watts solar panel, high power rechargeable battery, main output inverter transformer, induction motor, Fast charger, heat sink, etc.

INTRODUCTION

In general an induction motor is a constant speed motor and depending up on its ratings in no load or full load conditions change in speed of the motor is quite small. Speed of a DC motor can be varied easily with good efficiency, but in case of induction motors, it is little complicated due to the power losses or poor efficiency. As induction motors are widely used in industries for different applications, its speed may require varying according to the application. Different speed control methods of induction motor are in use, but in this project work, the most popular technology of PWM is implemented to vary the speed of induction motor from minimum to maximum linearly. In general ac to ac control circuits are in use for single phase ac motors, but in this project work a low voltage 12v DC source is used to generate a high voltage of 220v ac and PWM technology is used to vary the speed linearly. Since the application is to utilize the free power source of solar energy, here 12v solar panel is used for demo purpose. Since it is a prototype module, lower rating panel is used and its output is used to charge a high power rechargeable battery of 12V and 7.5 Ah. The basic oscillator circuit is constructed with PWM IC 3524 operates at 12v DC source and generates ac pulses to drive the power drive stage designed with power Mosfets and inverter transformer. The detailed description of PWM based inverter circuit is explained in following chapters.

In general in industries, induction motors are among the most widely used electric motors that are helping engineers to convert electrical energy in to mechanical energy and these ac motors work by the principle of electromagnetic induction. Electric current in the rotor is obtained from the rotating magnetic field in the stator winding and this electric current is then used in producing the desired shaft rotation. Induction motors offer several advantages such as simple construction, durability, high efficiency, and starting torque. However the difficulty is how to control its speed, in this regard this project work is designed to control the speed using simple technique of PWM – Pulse Width Modulation.

One major aspect of the project work is, using solar energy to drive the induction motor and controlling its speed. The conventional energy supplied by the electricity department is depended up on thermal power stations, in some places nuclear power plants are in use, both are not safe, they are hazardous to environment and hence it is essential to utilize solar energy to create green energy source. In this regard this project work is taken up, which is aimed to utilize solar energy for driving the induction motor.

The Solar Power System designed with power MOSFETS and PWM chip is aimed to utilize solar energy, by which any low power induction motor can be used and it can be energized when

required. This system is very useful for rural areas where the availability of main power source is critical. Since it is a prototype module, the solar panel & battery used here is not sufficient to run the motor continuously, to run the motor continuously huge rating panels and batteries are essential. The solar power system designed here can be utilized to drive a maximum load of 200 Watts. The prototype module contains all required devices including 10W panel & 7AH rechargeable battery, which makes the system as real working. The first & important application is to energize the induction motor and control its speed linearly. For this purpose single phase supply source is generated from 12V battery.

For optimum generation of electric power the PV Panels need to be maintained or positioned normal always to the incident radiation. This technique, known as Solar tracking, is therefore essential for improved system performance and efficiency. The resulting increase in efficiency is significant enough to make the tracking a viable proportion in-spite of the enhancement in the system cost. As this system is designed as prototype module, here panel is set to a fixed angle and it will not move according to the Sun direction. The panel used in the project work can deliver a maximum power (12 X 0.7 = 8.4 Watts) under the bright Sun.

Solar energy, with its virtually infinite potential and free availability, represents a non-polluting and endless or inexhaustible energy source which can be developed to meet the energy needs of mankind in a major way. The high cost, fast depleting fossil fuels and the public concern about the eco-friendly power generation of power have led to a surge of interest in the utilization of solar energy. To evaluate the energy potential at particular place, detailed information on its availability is essential. These include data on solar intensity, spectrum, incident angle and cloudiness as a function of time.

Cheaper and more efficient solar panels and the other method is by improving the efficiency of the system by optimizing the operating conditions. Another important factor is long life of the panel.

LITERATURE SURVEY

The country faces a huge gap between its energy generation and its needs. About two-thirds of villages are electrified due to geographical and economic factors. Solar PV technology due to the installation costs and losses, eliminating workplace can create the potential for a large through innovation [2] attractive methods of these power quality problems in order to solve an alternative drive system in this paper exercise proposed standard volt / matrix converters with induction motors. Matrix Converters are a relatively new to develop AC voltage controllers that provide output voltage

to control the undesirable power at the input as well as the uncontrolled event while maintaining output [3]. Therefore a heavy DC connection capacitor may otherwise avoid the need for a conventional drive system [4] except that the AC serves as a stand-alone induction motor drive concession for converting the AC to an advanced power-quality drive. This paper has proposed an alternative matrix converter (MC) based driving method so that power quality issues that are associated with conventional VSDs [5] can be solved. Notwithstanding improving the source side force quality, single stage AC additionally uncovers the upsides of AC transformation, for example, grid converter-driven induction motor drives, dispensing with the requirement for about vitality sparing components, directional and decrease [6].

FUNCTIONAL DESCRIPTION

The functional description of the project work is explained in this chapter. For better understanding, the total module is divided into various blocks and each block explanation is provided here. The diagrams (block diagram and circuit diagram) of this project work are provided in the next chapter. The following is the description of the overall function or operation of the project work.

1. INDUCTION MOTOR:

An **induction motor** or **asynchronous motor** is an AC electric motor in which the electric current in the rotor needed to produce torque is obtained by electromagnetic induction from the magnetic field of the stator winding. An induction motor can therefore be made without electrical connections to the rotor. An induction motor's rotor can be either wound type or squirrel-cage type..

Fig.1.INDUCTION MOTOR

2. SOLAR PANEL:

Solar photovoltaic systems use solar energy to produce electricity. The term **photovoltaic** is composed of "photo", the Greek root for "light", and "volt", a common measurement of electricity named after Alessandro Volta, a scientist renowned for his research on electricity. Together, these terms literally mean "light electricity". Photovoltaic technology can be referred to in short as **photovoltaics** or **PV**. Photovoltaic technology relies on the electrical properties of certain materials known as **semiconductors**. When hit by sunlight, a semiconductor material responds by creating an electrical charge which can then be transferred to anything that uses electricity. These semiconductors are produced in the form of **cells**, which can then be assembled in groups in a **panel**. There are many different types of panels available, and each has its particular advantages. Individual panels are often used to charge batteries that power small or remote electric equipment. Depending on the amount of electricity needed, these panels can then be connected in an **array** to provide larger amounts of electricity to a building or other large user of electricity.

Fig.2.SOLAR PANEL

3. Z44 POWER MOSFET

. A **Power MOSFET** is a specific type of metal oxide semiconductor field-effect transistor (MOSFET) designed to handle large amounts of power. Compared to the other power semiconductor devices, its main advantages are high commutation speed and good efficiency at low voltages.

It shares with the IGBT an isolated gate that makes it easy to drive. It was made possible by the evolution of CMOS technology, developed for manufacturing Integrated circuits in the late 1970s. The power MOSFET shares its operating principle with its low-power counterpart, the lateral MOSFET. The power MOSFET is the most widely used low-voltage switch. It can be found in most

power supplies, inverters, DC to DC converters, and low voltage motor controllers. In general this device is used for amplifying or switching electronic signals. The basic principle of the device was first proposed by Julius Edgar Lilienfeld in 1925. In Mosfets, a voltage on the oxide-insulated gate electrode can induce a conducting channel between the two other contacts called source and drain. The channel can be of n-type or p-type, and is accordingly called an NMOSFET or a PMOSFET (also commonly nMOS, pMOS). It is by far the most common transistor in both digital and analog circuits, though the bipolar junction transistor was at one time much more common.

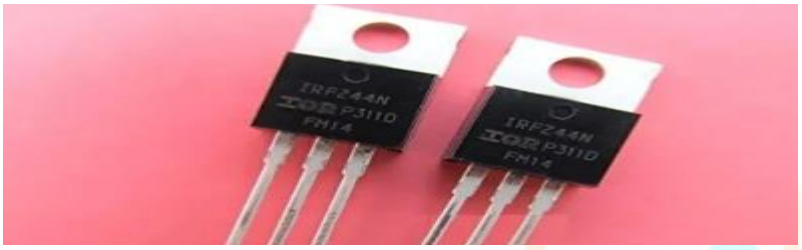


Fig .3 Z44 POWER MOSFET.

4. INVERTER TRANSFORMER

The main output transformer used in the driver stage is designed to deliver 0.35 amps current at the secondary. This is a step up transformer and the primary of this transformer is designed for 12V.

This is a centre tapped primary transformer and the primary is wounded with by-filler winding, i.e., the primary is wounded with two copper enamelled wires simultaneously. Starting of the one winding is clubbed with ending of another wire to form a centre tap. The advantage of adopting by-filler winding concept at primary side of the transformer is to maintain the accurate balance; there by the current flowing through both sections of primary remains equal.

Fig.4. INVERTER TRANSFORMER

5. LEAD ACID BATTERY

This device can be called as chemical voltage source; a chemical voltage source is one of the most important sources of electrical energy. It is a self-contained voltage source and does not need any outside energy. When the battery is discharged it is supposed to be charged with suitable power

source either from solar panel or from mains supply, i.e. single phase conventional energy source. The electrical energy supplied by a chemical source of voltage is produced by chemical action within the source itself. Chemical voltage sources normally exist in the form of batteries and cells of various types. These batteries are extensively used for mobile applications.

Lead-Acid Battery

These Batteries are maintenance free. There is no need to add water. Battery performance and service life are greatly affected by the charging method. There are various different charging methods: constant voltage charging, constant current charging, tapered current charging and some combination systems. Batteries can be charged by any of those methods. However, constant voltage charging combined with limited current is recommended for obtaining maximum capacity and service life together with acceptable recharge times and economy. Here the battery is charged with constant voltage source.

6. SG 1C 3524 Regulating Pulse Width Modulation

Pulse-width modulation (**PWM**), or **pulse-duration modulation** (**PDM**), is a method of controlling the average power delivered by an electrical signal. The average value of voltage (and current) fed to the load is controlled by switching the supply between 0 and 100% at a rate faster than it takes the load to change significantly. The longer the switch is on, the higher the total power supplied to the load. Along with maximum power point tracking (MPPT), it is one of the primary methods of reducing the output of solar panels to that which can be utilized by a battery. PWM is particularly suited for running inertial loads such as motors, which are not as easily affected by this discrete switching. The goal of PWM is to control a load; however, the PWM switching frequency must be selected carefully in order to smoothly do so.

Fig 6. IC 3524 Regulating pulse width modulation

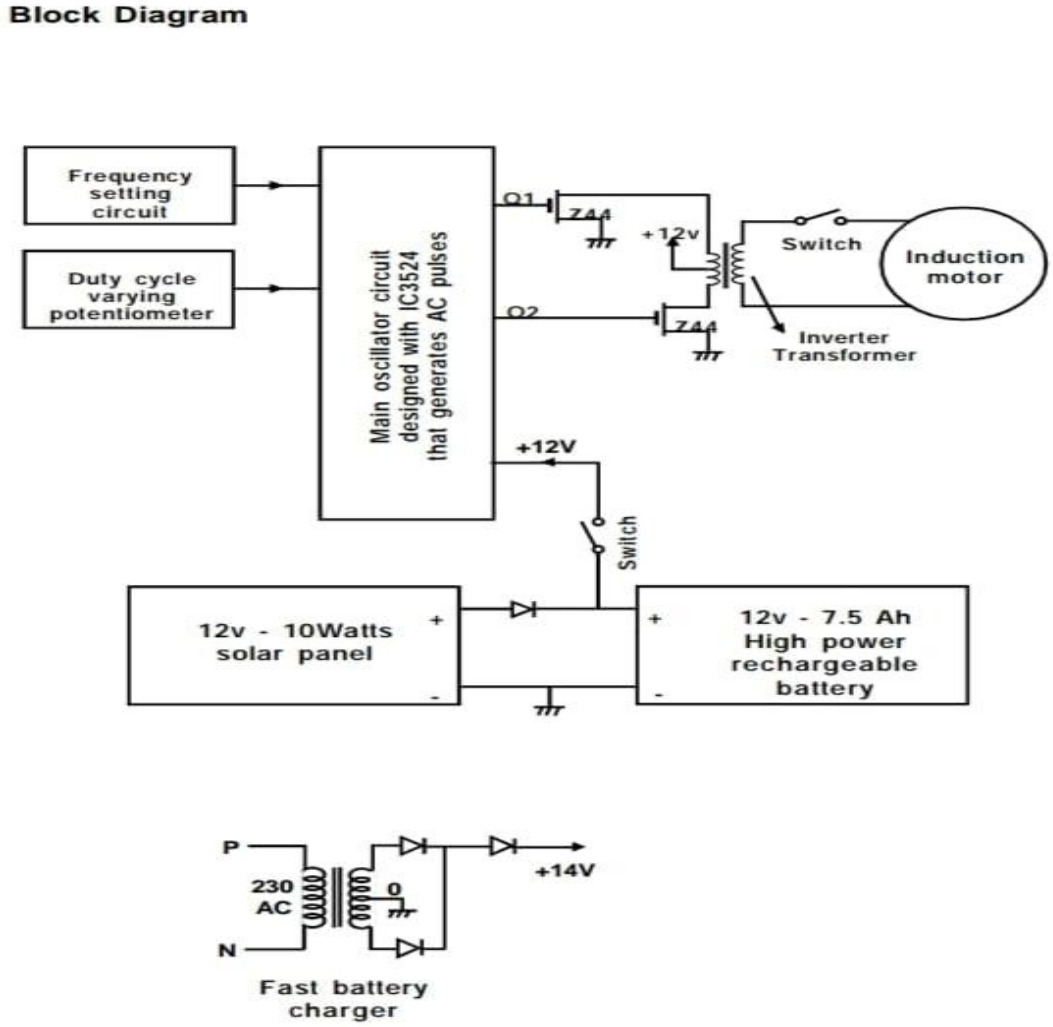


Fig7.Block Diagram

Power Source Description

The system designed here utilizes solar power. As long as the solar energy is available, the battery will be charged at different current ratings. As the output of panel is variable, it may not be stable. If the Sun is bright, the panel can deliver maximum output current of 800ma at around 12V.

Solar Energy

In today's climate of growing energy needs and increasing environmental concern, alternatives to the use of non-renewable and polluting fossil fuels have to be investigated. One such alternative is solar energy. Solar energy is quite simply the energy produced directly by the sun and collected where required. The sun creates its energy through a thermonuclear process that converts about 650,000,000 tons of hydrogen to helium every second. The process creates heat and electromagnetic radiation.

The heat remains in the sun and is instrumental in maintaining the thermonuclear reaction. The electromagnetic radiation (including visible light, infra-red light, and ultra-violet radiation) streams out into space in all directions. Only a very small fraction of the total radiation produced reaches the Earth. The radiation that does reach the Earth is the indirect source of nearly every type of energy used today. The exceptions are geothermal energy, and nuclear fission and fusion.

Photovoltaic Cells

Photovoltaic cells, which convert light directly into electricity, have become commonplace on devices such as calculators and watches. There are a number of technologies in development with the aim of making PV more economic for electrical power generation. All use semiconductor materials like those used in silicon chips.

Overview of the technology

Sunlight is composed of photons containing energy which correspond to the different wavelengths of the solar spectrum. When photons strike a PV cell, their energy is transferred to an electron in the semiconductor material of the cell. With this extra energy, the electron is then able to escape from its normal position in the atom creating a "hole", which will become part of a current in an electrical circuit.

Hardware details

The IC’s and other important components used in this project work are procured from the Hyderabad Electronics Market. The details or data sheets of the active devices are down loaded from the vaious websites.

The following are the IC and other important components used in this project work

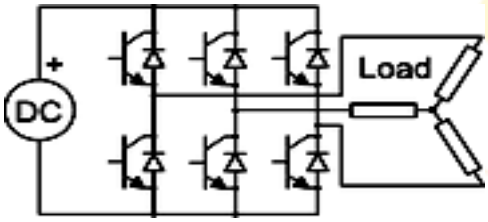
1) SG IC 3524 Regulating Pulse Width Modulation
2) Z44 Power MOSFET
3) Mains output transformer

Description of Inverter

An **inverter** is an electrical device that converts direct current (DC) to alternating current (AC); the converted AC can be at any required voltage and frequency with the use of appropriate transformers, switching, and control circuits.

Static inverters have no moving parts and are used in a wide range of applications, from small switching power supplies in computers, to large electric utility high-voltage direct current applications that transport bulk power. Inverters are commonly used to supply AC power from DC sources such as solar panels or batteries.

Three phase inverters



3-phase inverter with connected load

To construct inverters with higher power ratings, two six-step three-phase inverters can be connected in parallel for a higher current rating or in series for a higher voltage rating. In either case, the output waveforms are phase shifted to obtain a 12-step waveform. If additional inverters are combined, an 18-step inverter is obtained with three inverters etc. Although inverters are usually combined for the purpose of achieving increased voltage or current ratings, the quality of the waveform is improved as well.

RESULT:

Fig I) Circuit kit before Turn ON switch of power system.

Fig ii) Circuit kit after Turn ON changing bulb glow and speed of induction motor in power system.

CONCLUSION

The project work **"Solar based speed control of single phase induction motor"** is successfully designed tested and a demo unit is fabricated. Since it is a demonstration unit, a low power inverter is designed which can able to deliver a maximum current of 800 milliamps at 220V at the system output. But for the practical applications, a higher rating inverter can be designed which can be used to drive heavy duty motors.

The main purpose of the project work is to control the motor speed linearly by varying duty cycle. The PWM IC used here is having duel inverted output by which the drive stage is designed with NPN power Mosfets and it is configured in push-pull mode of operation by which switching losses can be minimized and high efficiency can be obtained from the power system. In our trail runs we found that greater than 80% efficiency is achieved. As the power system is designed to deliver less power, protection circuits are not included. In general the higher rating inverters are equipped with thermal protection over load cut off circuits, etc. With the help of a load monitoring circuit often designed with CT, the load applied to the inverter will be monitored continuously, whenever the load exceeds more than the rated value, immediately system will be shut-down. After reducing the load and by activating the reset button power will be resumed. Similarly thermal protection system also protects the power system burning due to the over temperature. These are the features to be added in our feature work.

FUTURE SCOPE

The future scope for solar-based speed control of single-phase induction motors presents several promising avenues for research and development. One direction involves enhancing the efficiency and reliability of control algorithms by leveraging advancements in artificial intelligence and machine learning techniques, such as neural networks and reinforcement learning, to optimize motor performance under dynamic operating conditions. Additionally, integrating energy storage systems, such as batteries or supercapacitors, with solar-powered motor drives could improve system stability and enable continuous operation during periods of low

solar irradiance. Exploring innovative materials and design methodologies for solar panels and power electronics converters holds potential for increasing energy conversion efficiency and reducing system costs. Furthermore, the integration of Internet of Things (IoT) technologies and cloud-based monitoring systems could enable remote monitoring, diagnostics, and predictive maintenance of solar-powered motor drive systems, enhancing their reliability and lifespan. Overall, future research endeavors should focus on advancing the technological capabilities, scalability, and cost-effectiveness of solar-based motor drive solutions to accelerate their widespread adoption in diverse industrial and residential applications.

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