A Solar Panel Based Inverter for Powering Medical Equipment and Emergency Equipment

Sananda Biswas
Dept of Electrical Engineering
Brainware Group of Institutions, SDET, Barasat, Kolkata 700124

Abstract- *This paper deals with the design and a prototype development of an inverter to feed AC power to medical equipment and inductive load. The design is most suitable for a remote area where there is non-availability of electrical power or there is blackout of electrical power which is required for the basic need of human life. The AC power generated can be utilized for running medical equipment, refrigerator, a pump, mobile charging, emergency irrigation and lighting. This paper demonstrates the application of a submersible pump used for irrigation purpose. The inverter is fed from a 12 V rechargeable lead acid battery, which is charged through solar panel. The basic intention of this research work is to run emergency equipment in a remote area where there is no electric power supply or where there is problem in distribution system.*

The solar panel (cell) is used to charge the battery and the panel shall be mounted on the terrace of the building. The inverter is driven with power from the battery.

An inverter has been designed to run a 1 hp induction motor coupled with a submersible pump. The motor is started with low voltage with v/f control. Gradually the full voltage is applied and motor runs at rated speed. After an operation of a preset time, the motor is stopped.

Keywords- Medical equipment, Pulse Width Modulation, Solar panel, Variable Voltage Variable Frequency drive, Photo voltaic module

I. INTRODUCTION

A prototype solar panel based inverter has been developed feed AC power to medical equipment and inductive load. The design is most suitable for a remote area where there is non-availability of electrical power or there is blackout of electrical power which is required for the basic need of human life. The AC power generated can be utilized for running medical equipment, refrigerator, a pump, mobile charging, emergency irrigation and lighting. This paper demonstrates the application of a submersible pump used for irrigation purpose. The inverter is fed from a 12 V rechargeable lead acid battery, which is charged through solar panel. The basic intention of this research work is to run emergency equipment in a remote area where there is no electric power supply or where there is problem in distribution system.

In remote area where there is non-availability of electric power, it is often required to run emergency medical equipment and emergency equipment. A diesel generator set is not an ideal solution as this is not environmental friendly and requires running expenditure. A system has been designed and developed using solar cell based inverter to overcome this problem. A lead acid battery has been chosen to store the electrical energy which shall be used to drive the pump. The battery shall be charged by solar cell throughout the day. In the evening when the battery is fully charged, the battery shall be connected with the inverter and pump shall be operated. The operating period of the pump shall depend on the charge stored on the Lead Acid type rechargeable battery. For efficient operation, the solar cell shall be kept on the roof top and battery with inverter can be kept near the pump. In this particular experiment, the rechargeable battery chosen is 12 V, 75 AH. With this battery, a 1 hp pump can be operated for 30 min efficiently. The submersible pump used for this experiment is 1 hp, 10 stage, 25 mm outlet size, suitable to draw water at flow rate of 24 – 90 liters per min, with 42 – 11 m head. The motor for this pump is a squirrel cage induction suitable for 180-240 V power supply, 50 Hz, single phase, capacitor start and capacitor run type motor. We have chosen lead acid battery as this type of battery can supply high surge current which is required for starting of the induction motor. The another advantage of lead acid battery is that it is easily available in remote places (A car battery of a motor cycle batter can also be used in emergency situation to run the pump).

II. DESIGN CONSIDERATION

The schematic diagram of the system is shown in Fig.1. The integrated system consists of solar panel, Lead Acid rechargeable battery, Micro controller board, Voltage regulator to supply 5 V from 12 V to the microcontroller board, Power amplifier, Centre tapped transformer and squirrel cage induction motor. The sub systems are as described below;

Solar panel: The solar panel used for this experiment is having an approximate dimension of 780 mm X 1580 mm. The power developed by the solar panel in normal sunlight is 220 W. The open circuit voltage for this solar panel is 52 V and short circuit current of 5 Amps. When the solar panel is under operation for charging the battery, the switch S1 shall be closed and switch S2 shall be open.

Lead Acid battery: The battery used in this experiment is 12 V, 75 AH. The Amp-Hour capacity of the batter is selected in such a way to run a 1 hp motor for around 30 min. A 1 hp capacity, capacitor start capacitor run squirrelly cage induction motor operated at 230 V, with a power factor of 0.7 shall draw 4.63 A of current. With motor loading and considering other losses, we consider steady state motor current to be 6 amps. Thus, at 12 V level, current drawn from the battery shall be (6 *230/12) 115 Amps. Therefore battery can supply this current for (75/115)*60 min = 39.13 min. With safer side, we can thus operate the pump for 30 min.

Speed setting panel: A speed setting panel has been designed through which we can start the pump with low speed and gradually we can increase to full speed. Starting with a lower speed is an advantageous as initial inrush current drawn by the motor shall be less. Normally, starting current of an induction motor is 5 to 7 times than the full load current. High starting current of the motor shall give rise to voltage dip of the battery. In order to reduce the high starting current of the induction motor, we have adopted to start the motor at lower voltage and then gradually we can increase the voltage to rated voltage. Initially, during starting, the magnetizing component of the current flowing through the stator is proportional to the applied voltage and is independent of the load. These facilities are programmed in the microcontroller and depending on the situation; we can adopt a starting method.

III. PWM INVERTER FOR SINGLE PHASE INDUCTION MOTOR

The PWM inverter consists of four sub modules as under;
.

PIC Microcontroller: The pulse width modulated inverter is designed around a PIC microcontroller 18F4520. PIC refers to Peripheral Interface Controller. The device has 32 KB Program memory. The microcontroller is having an inbuilt PWM module which is used directly in this application.

Voltage regulator: This microcontroller operates on 5 V DC. This 5 V DC power is obtained from 12 V DC supply through a voltage regulator. The regulator is built up around the IC LM 7805. This is a 3 pin IC, where input is 7-35 volts and output is 4.8 to 5.2 volt. It can supply an output current of 1.5 A which is most suitable for microcontroller operation.

Transistor driver: Two complementary low voltage transistor (BD 139 and BD 140) has been used as push-pull configuration to process the microcontroller output. BD139 is NPN type whereas BD140 is PNP type. This transistor output feds the base of power transistor.

Power Amplifier: Power amplifier is designed around power MOSFET, IRF640. This transistor can supply a continuous drain current of 18 A at 25^oC. At 110^oC, it drain current shall be 11 A. For design consideration we consider a drain current of 15 A at 40^oC. Since at 12 V level, we require 115 A of current, we have to connect 8 such MOSFET is parallel to supply 115 A of current. All the MOSFETs are mounted on heat sink.

Transformer: A center tapped transformer with primary of 12-0-12 V and secondary of 230 V has been used for increasing the voltage from 12 V AC to 230 V AC. The transformer VA rating should be 1380 VA. The designed value should be taken as 1500 VA. The primary winding shall carry a current of 115 A and accordingly the copper wire size and transformer size is calculated

IV. EXPERIMENTAL RESULT

Experiment has been conducted to generated AC power with variable voltage and variable frequency. During running with an inductive load and resistive load, the waveform of the AC output has been observed and stored in oscilloscope as shown in Fig 2. The basic Pulse Width Modulated output from microcontroller and final AC output across the motor terminal is shown in the waveform.

V. CONCLUSIONS

With the above experiment we can conclude that it is possible to run emergency medical equipment using solar based inverter in places where there is no electric power distribution or there is blackout of electrical power. This equipment shall be fed from a lead acid battery with an inverter. The lead acid battery shall be charged using solar panel. With the calculation given in this paper, it is possible to run a 1 hp load for 30 min using a 75 Amp-hour battery.

REFERENCES

[1] Tabish Nazir Mir and Abdul Hamid Bhat, "Comparative Analysis of Pulse Width Modulated Voltage Source Inverter Fed Induction Motor Drive and Matrix Converter Fed Induction Motor Drive" 1st IEEE international conference on Power Electronics, Intelligent control and energy systems, ICPEICES-2016
[2] Abdul Shavan and R N Sharma, "Water Consumption Patterns in Domestic Households in Major cities", Economic and Political weekly, June 9, 2007.
[3] Asoke Kumar Paul, I Banerjee, B K Santra and N Neogi, "Adjustable speed drives for rolling mill applications", Steel India, March 2008, Vol. 30, No. 2, pp 46-50, Published by Steel Authority of India Limited.