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Embedded Based PWM Inverter to Drive Induction Motor and Speed Control by Duty Cycle Control

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Abstract— The main aim of the proposed system is to design and develop an electronic system that can be used to control the speed of single phase induction motor by varying duty cycle. The present scheme employs Microcontroller to control the speed of Induction motor. The features which have made it attractive are improved sensitivity, advanced control capability, easy to develop, low cost and size. This system works on 12V DC supply which is converted to 230V AC with the help of push pull converter in order to drive the induction motor. The above system is assembled, tested and its performance are recorded for various duty cycle which varies the stator voltage of the induction motor which intern varies the speed of the motor.

1. INTRODUCTION.

Many industrial applications, however requires several speeds or continuously adjustable speed drive systems. Traditionally DC motors have been used in such adjustable speed drive systems. However DC motor is expensive requires frequent maintenance due to commutator, brushes and are prohibitive in hazardous atmospheres. Speed of single phase induction motor is generally controlled by controlling its stator voltage. This can be accomplished by following two methods. In resistance control method speed is changed by changing the value of an external resistance connected in series with motor. This method is easy to implement, but power loss in resistance, its physical size, and problems of durability and maintenance of resistance are some of the disadvantages.Because most single phase induction motors are fractional horse power rating, a Triac can be used to control voltage in both +Ve and -Ve half cycles. If firing angle alpha is changed, it changes the value of rms voltage applied to motor terminals. [1] It has been explained various methods of controlling the Squirrel cage induction motor .In one of the method it is stated that the speed can be controlled by varying the stator voltage at supply frequency using thyristor. This method of control is characterized by poor dynamic and static performance. New control approach [2] for AC motor drives which uses programmed PWM switching patterns over the complete range of output speed is presented. This scheme provides smooth operation during the required switching patterns changing transitions and guarantees high quality output voltage and current in AC motor load .Therefore most suitable for high performance high efficiency applications.

The proposed system is being designed to operate an AC induction motor on a rechargeable 12V DC lead acid battery and to control the speed of an AC induction motor by the PWM technique. Such a system is very useful in situations where AC main supply is not available and it is very essential to operate an AC induction motor. It can be used as an emergency stand by unit or it can be used as regular equipment. It is also very useful in rural and remote places where an AC main supply is not continuously available. This system can operate an AC motor from a solar panel also. This system can also be used to make use of solar energy for domestic, agriculture or Industrial purpose. In such a system, to utilize the naturally available solar energy, a solar panel placed in a open place collects the solar energy radiated in the form of light from the sun during day time and converts it into electrical energy and stores it into a rechargeable lead acid battery. Later when the energy is needed, it converts the electrical energy contained in a battery into AC 230V; 50Hz supply using a PWM inverter. This voltage can drive any means operated electrical equipment. In this system we are using a single-phase induction motor as load. This system also consists of protection circuits that safeguard the inverter and motor or any other load against any over voltages and over load. The complete system is designed around microcontrollers to achieve faster response and high accuracy.

2. WORKING OF SYSTEM.

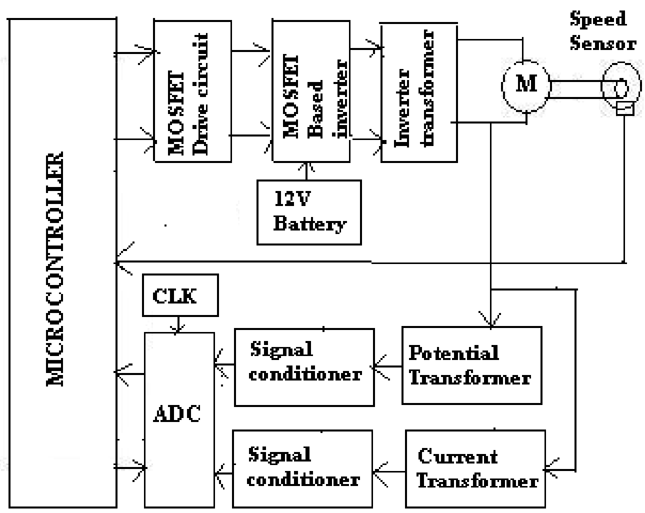

Figure 1: System Block Diagram

The microcontroller produces two complimentary PWM signals with required duty cycle to operate the inverter .It reads the voltages and currents form P.T and C.T through the ADC and displays them on LCD. It stops sending PWM signals to inverter if any of these parameters become abnormal. This is done to prevent damage to the inverter and motor. The output voltage from the inverter can be varied according to the requirement of the load. Varying duty cycle of the PWM signal, which controls the inverter output voltage, can vary the speed of the motor from minimum to maximum. It uses a MOSFET based inverter to generate AC 230V to adjust the speed of an AC motor to the desired set point by adjusting the output AC voltage. The inverter is constructed using six power MOSFETs three in each line. It uses a push pull configuration to generate AC voltage of positive and negative half cycles with a max value of 230V. The present system is designed to work with a ¼ H.P, 230V single phase induction motor.

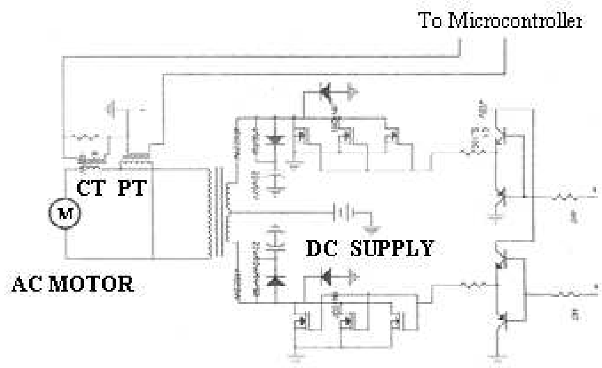

Figure 2: Circuit of MOSFET Inverter.

In proposed system the main source of energy is a battery. This battery of 12V DC capacity is connected to the primary of transformer .The microcontroller is meant to produce two complementary PWM signals and also meant to control all parameters like ADC, LCD display, Sensors, etc. As we increase duty cycle, the microcontroller generates PWM signals that drive the one branch of MOSFET’s in conduction, when these MOSFETs conduct the ½ (half) cycle is produced at the secondary of the main transformer. This main transformer is connected to the induction motor. As complementary PWM signals are generated the alternate MOSFETs branches conduct alternatively resulting in the production of sinusoidal wave on the secondary of the main transformer as shown in figure 2. This sine wave signal is given to the motor for rotation. Thus, the MOSFETs and the transformers with the help of PWM signal is able to covert a DC signal into a AC signal that can drive any AC machines of capacity 230V. Thus motor rotate as we increase the duty cycle. By varying the duty cycle, we can increase or decrease the speed. Thus we can control the speed of induction motor. The potential transformer as connected in the circuit measures the voltage. The microcontroller when it comes to know that over voltage occurred it stops generating PWM signal. Thus, it provides over voltage protection to the circuit. Similarly, we can have over current protection. LCD displays parameter values i.e., speed, load voltage, load current and duty cycles. The speed is sensed by the microcontroller using speed sensor. This sensed speed will be displayed on the LCD display using microcontroller. Detailed sequence of operations of system is shown in the below flowcharts.

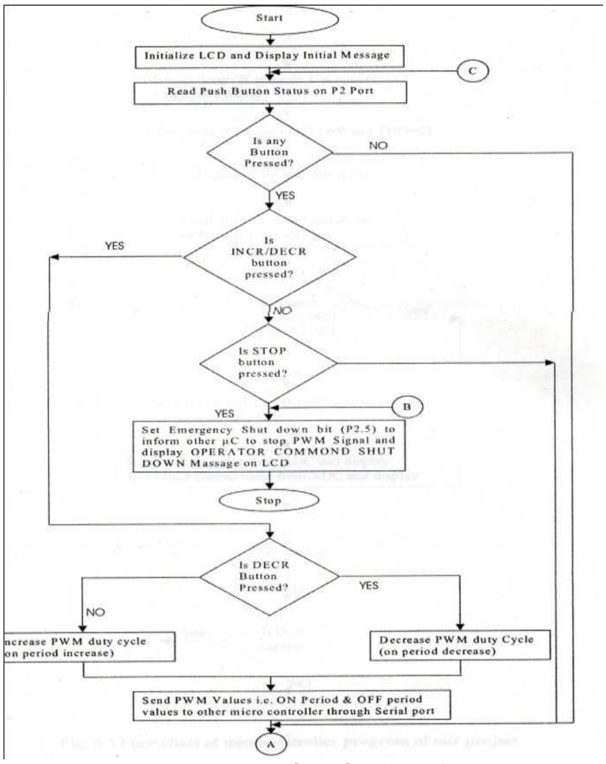

Fig 3: Flow Chart (Part 1)

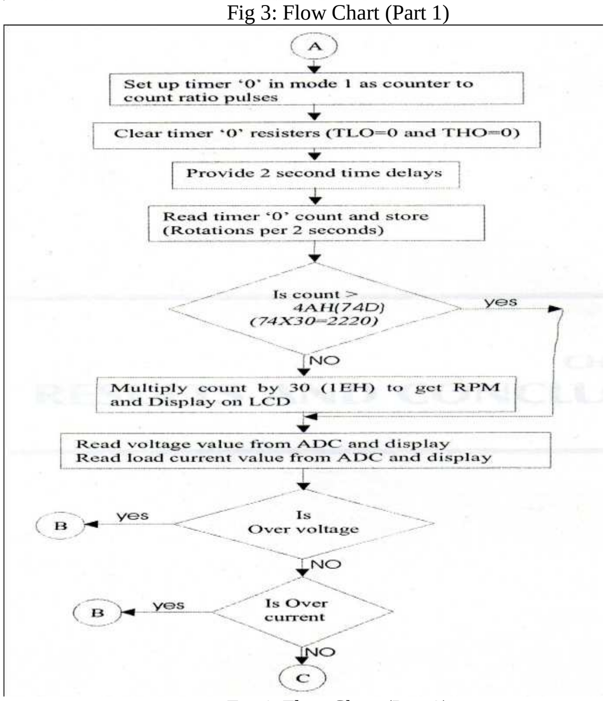

Fig 4: Flow Chart (Part 2)

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3. RESULTS.

The embedded based PWM inverter to drive induction motor and speed control by duty cycle control has been implemented successfully. The test is done to observe the over voltage and over current protection at desired values at the same time we have obtained the following result by varying the duty cycle. At no load condition, with 200gm , 400gm and 800gm loads, we obtained the following result as shown in graph.

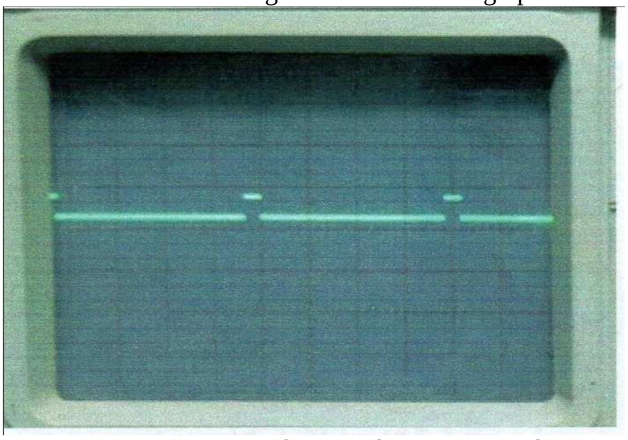

Fig 5: PWM Signal Generated at 16% Duty Cycle

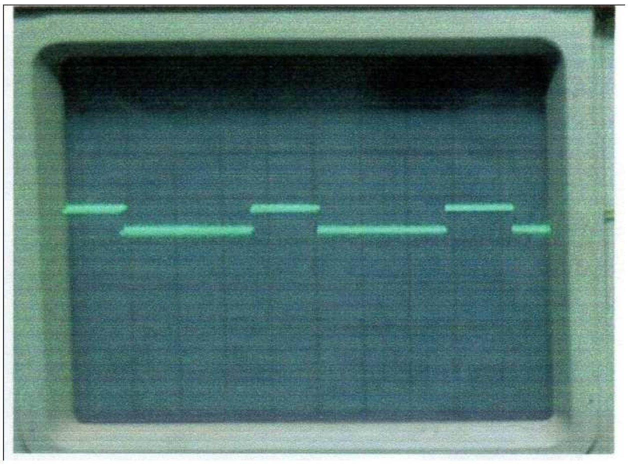

Fig 6: PWM Signal Generated at 34% Duty Cycle

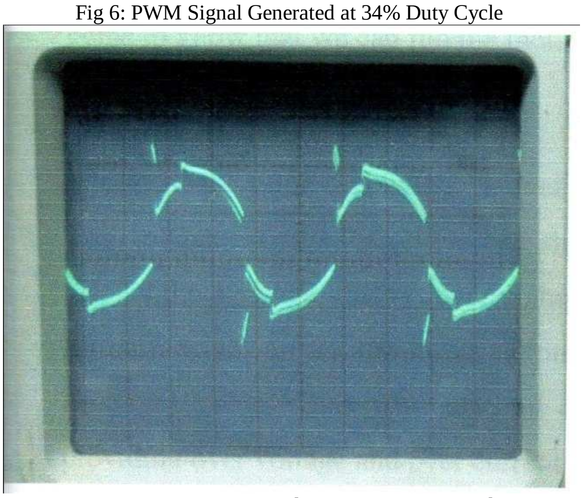

Fig 7: Inverter Output Voltage at 34% Duty Cycle

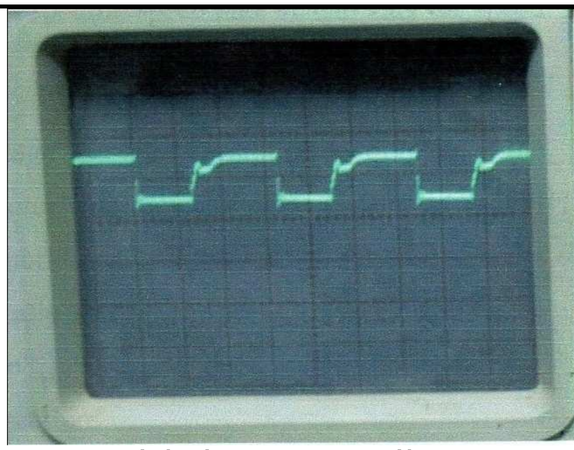

Fig 8: Clock Pulses to ADC Generated by 555 Timer

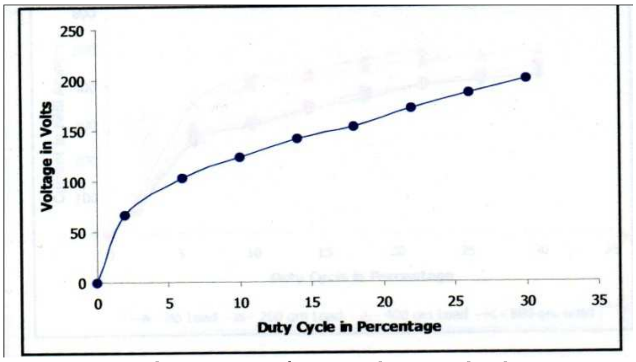

Fig 9: Characteristics of Duty Cycle Vs Load Voltage

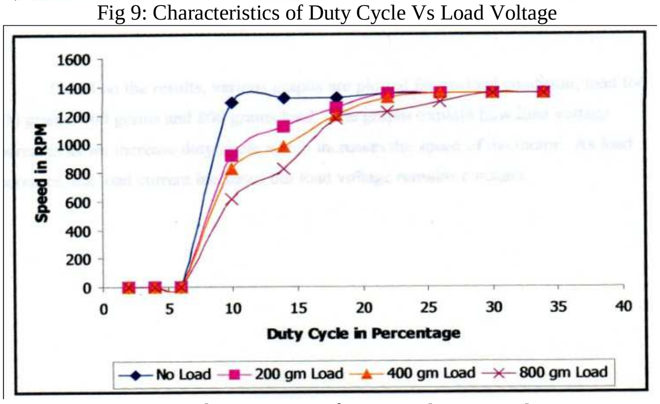

Fig 10: Characteristics of Duty Cycle Vs Speed

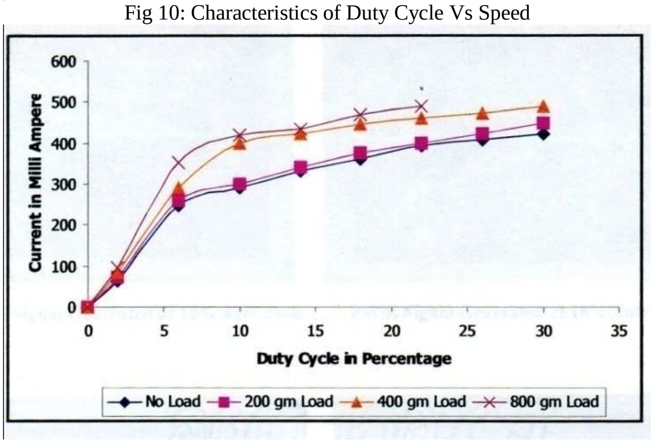

Fig 11: Characteristics of Duty Cycle Vs Load Current

4. CONCLUSION.

After successful implementation of embedded based PWM inverter to drive induction motor to control speed by duty cycle control, we conclude that system can run an AC motor with specific speed and also we can vary the speed of AC motor. The system can be used when AC supply is not available and it is essential to operate AC motor. In this system we have over voltage and over current protection. Using MOSFETs in the system we have achieved more advantages such as fast switching, less power dissipation compare to other switching devices.

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