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Speed Control Of Transformer Cooler Control By Using PWM

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ABSTRACT : *In our regular used transformer temperature control by traditional method using analog temperature meter in Oil forced Air forced (OFAF) cooling system and in that system when temperature goes above the set temperature, cooling fan will on.*

One of the more common types of transformer cooling equipment is auxiliary fans. These can be used to keep the radiator tubes cool, thereby increasing the transformer's ratings. Fans should not be used constantly, but rather only when temperatures are such that extra cooling is needed. Automatic controls can be set up so that fans are turned on when the transformer's oil or winding temperature goes too high and therefore we are using the Microcontroller to sense the temperature from temperature sensor and when temperature goes above set limit, transformer cooler fan will on automatically and motor speed is depends on the temperature and using PWM (pulse width modulation) technique for speed control.

This paper represent a new kind of method toward controlling the speed of single phase ac motor automatically, the new method is calling the Pulse width modulation (PWM). A single phase ac induction motor controller is presented and PWM frequency control part of the operation is verified experimentally. The application for this ac motor controller is existing single phase ac induction motor less than ½ hp. The ac motor controller is VFD (variable frequency drive). The IGBT (insulated Gate Bipolar Transistor) are configured in a full H-bridge with unipolar voltage switching. A variable frequency output waveform is generated by inverter to run a motor at variable speed that is directly proportional to this range of frequencies. In this report, it will state the theoretical result that will obtained. Despite of that, it will also give the theoretical result though a simulation analysis process through a software program. In fact, this will also explain the operational of alternating current motor based on the theoretical method, which also include the component that was use to build the hardware.

Keywords - *Pulse width modulation, AC motor, inverter, gate driver.*

I INTRODUCTION

Losses in the transformer are of the order of 1% of its full load kW rating. These losses get converted in the heat thereby the temperature of the windings, core, oil and the tank rises. The heat is dissipated from the transformer tank and the radiator in to the atmosphere. Transformer cooling helps in maintaining the temperature rise of various parts within permissible limits. In case of Transformer, Cooling is provided by the circulation of the oil. Transformer Oil acts as both insulating material and also cooling medium in the transformer. For small rating transformers heat is removed from the transformer by natural thermal convection. For large rating transformers this type of cooling is not sufficient, for such applications forced cooling is used. As size and rating of the transformer increases, the losses increase at a faster rate. So oil is circulated in the transformer by means of oil pumps. Within the tank the oil is made to flow through the space between the coils of the windings. Several different combination of natural, forced, air, oil transformer cooling methods are available. The choice of picking the right type of transformer cooling method for particular application depends on the factors such as rating, size, and location. The main source of heat generation in transformer is its copper loss or I2R loss.

Numerous motor driven applications operate in our homes and businesses today (Transformer cooler fan, refrigerators, air condition, washers, dryers, basement water pump and etc.) Most of these appliances run on single phase ac induction motor less than ½ horsepower. And most of those motor lack a paper motor controller in order to run the motor more efficiently. Motor can run more efficiently b varying the speed of the motor to match load. Motor are rated to operate best at full load. A motor controller that can vary the speed of motor automatically as the load changes will save energy. Fifty percent of electrical energy is consumed by motor.
Therefore, the purpose of this paper is describe an ac motor controller that can be applied to existing single-phase ac induction motor appliances, and to demonstrate sinusoidal PWM (pulse width modulation) operation of design. The prototype of this design experimentally verifies the key concept of pulse waveform generation to produce the switching action of an inverter in order to form a synthesized sine wave that as induction motor.

The motor controller of this design is a PWM- inverter configuration. The dc voltage for circuit is taken from dc power supply. The PWM drives the gate of the power transistors in the inverter. The inverter synthesizes an ac sine wave from the dc voltage by the switching intervals are determined from the duration of the pulse from the PWM. The ac induction motor then synthesizes this chopped signal from the inverter into an ac waveform. The motor will then run at a speed proportional to the frequency of this signal. This design is intended to be an interface between the ac source and the motor in order to regulate the motor speed of an appliance to match the load efficiently. The load requirements are determined by feedback from sensors to the feedback from sensors to the PWM waveform generates.

The small-signal waveforms from the PWM shape the high voltage sinusoidal output waveform that runs motor. The sine wave determines the frequency of the output wave applied to the load. The triangle wave determines the switching frequency by the IGBT (Insulated Gate Bipolar Transistor) of the inverter. The resulting pulse from the comparison of sine and triangle waves turn on the switches. The speed of the motor varies in direct relationship to the frequency.

1. Objective

- To study about PWM and ac motor controller operation.
- To construct an ac motor controller from scratch with as many base components as possible.
- To demonstrate the sinusoidal PWM operation of the inverter part of the design that runs an ac motor at variable speeds.
- To control speed of single-phase AC motor

II. SYSTEM DESIGN

This system design will briefly review the relevant issues of motor controller design. This chapter will also explain the component that been used as part in this projects. Figure1 below is a block diagram of the ac motor controller.

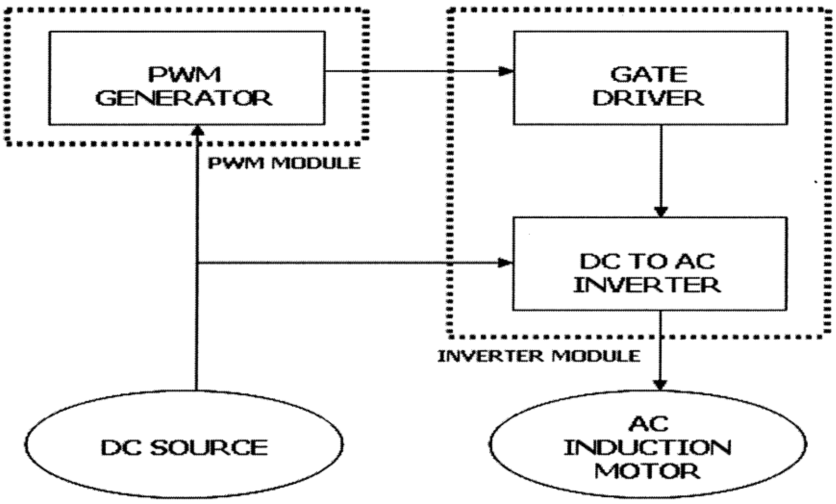

Figure 2.1: Block diagram of the ac motor controller

2.1 AC Motor Speed

The speed of an ac induction motor depends on the two factors that is the number of motor poles and the frequency of the applied power. The speed of induction motor is dependent on motor design. The synchronous speed (the speed at which the stator field rotates) is determined by the frequency of the input ac power and the number of poles in the stator. Greater the number of poles, the slower the synchronous speed. Higher the frequency of applied voltage, the higher the synchronous speed. AC Motor speed, RPM=120*frequency / Number of poles.

2.2 PWM Generator

The purpose of the PWM component of the controller is to generate pulse that trigger the transistor switches of the inverter. The pulse-width modulated signal is created by comparing a fundamental sine wave from a sine-wave generator with a carrier triangle wave from a triangle wave generator as shown in fig. below.

The variable width pulse from the PWM drives the gate of the switching transistors in the inverter and controls the duration and frequency that these switches turn on and off. The frequency of the fundamental sine wave of the PWM determines the frequency of the output voltage of the inverter. The frequency of the carrier triangle wave of the PWM determines the frequency of the transistor switches and the resulting number of square notches in the output waveform of the inverter.

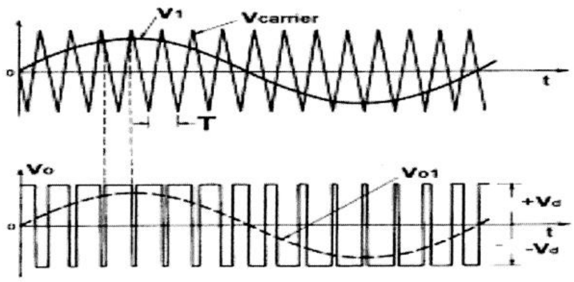

Figure 2.2: PWM operation. The square from the PWM is superimposed on the sine and triangle waves as shown in this figure. The pulse is high duration the inverter when the sine wave is greater than the triangle wave.

The square pulse waveform that is formed from the sine and triangle a wave drives the gates of the transistor switches in the inverter and controls the duration and frequency that these switches turn on and off. The dotted lines sine wave in figure represents both the low voltage PWM generated sine wave, and the also the high voltage output waveform from the inverter that drives the motor.

2.3 GATE DRIVER

TA and TB are the IGBT switching transistors. DA and DB are free-wheeling diodes. Free-wheeling diodes are used to clamp the motors kickback voltage, as well as to steer the motors current during normal PWM operation.

The gate driver receives the logic-level control signal generated by the PWM and then conditions to drive the gates of the power transistors of the inverter. The drivers provide a floating ground for the high-side switching of the IGBT in a full H-bridge configuration. The gate voltage must be higher than the emitter voltage for high-side switching. The input components have to be level-shifted from common to the emitter voltage. This is accomplished by charging a bootstrap capacitor, which is composed of a capacitor and diode network that gates the high-side IGBT. The gate driver also provides fast switching edges, by minimizing turn-on and off times, in order to prevent the IGBT from operating in a high dissipation mode and overrating.

2.4 DC-TO-AC INVERTER

The purpose of the inverter is to convert the dc signal into an ac signal with a variable frequency. The output waveform from the inverter is a series of square waves that the motor as a sine wave because the inductance of the motor smoothes out this waveform. The amplitude of synthesized sine wave is determined by the width of these square waves. The relative widths of these square waves represent the applied voltage. The wider the width and the narrower the notches between the width, the higher the amplitude of the synthesized sine wave because more voltage is being applied.

2.4.1 H-Bridge

The inverter consists of an H-bridge, which is a configuration of power transistors. A full H-bridge for single-phase application using IGBT for the power transistors is shown in figure below.

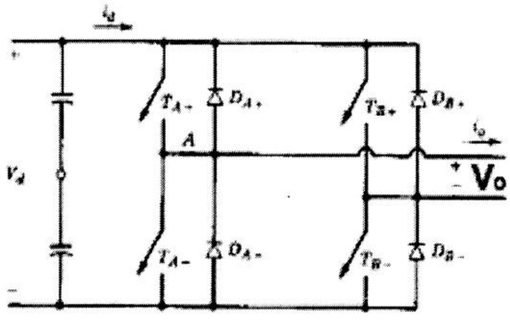

Figure 2.4.1: Single phase full H-bridge inverter. The switches are IGBT.

2.4.2 SWITCH.

The symbol for the transistor switch in inverter that the PWM controls is shown in figure below

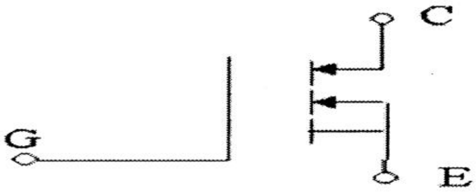

Figure 2.4.2: Power transistor (IGBT) that does the switching in the inverter. The gate is turned on by applying 15Vdc to G. Current than conducts from C to E

The high-voltage dc signal from the rectifier is applied to the collector (C). When the pulse from the PWM arrives at the gate(G), the switch is turned on and transistor conducts for the pulse.

2.5 Component

The component is the main part that determined the circuit's condition in order that it would work accordingly. In the designing process of the project, there are two modules which we need to considering, and that is the PWM Module and the Inverter Module. Below this are the components that we used in each of the module.

2.5.1 PWM Module

In these very own modules, there is a couple of component that can be applied to this paper The selection of needed component has to be accordance and match the real function toward the result of the major output. In this module, the wave will be generating to produce the PWM sinusoidal. Next would be the list of the component that were used in these paper, even though there are several type of circuit that been applied to this paper the function and working method is the same and it's only different in it's connection in every component to produce the different wave form.

2.5.2 LM 741 (Op-Amp)

The LM741 is a high performance monolithic amplifier constructed on a single chip. It is intended for a wide range of analog applications. The application of the regulator includes:

- Summing amplifier
- Voltage follower
- Integrator
- Active filter
- Function generator

The high gain and wide range of operating voltages provide superior performances in integrator, summing amplifier and general feedback applications. The internal compensation network insure stability in closed loop circuits.

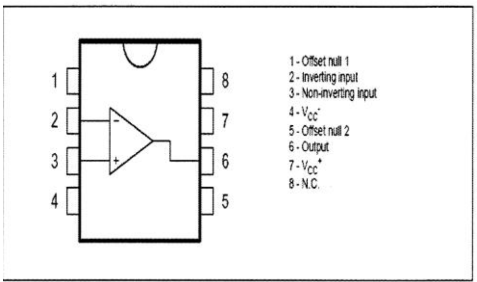

Figure 2.5.2: pin connections

2.5.3 LM 311 (Comparator)

The LM 311 are voltage comparators that have input currents nearly a thousand times lower devices. They are also designed to operate over a wider range of supply voltage from standard $^{+}_{-}$ 15V op amp supplies down to the single 5V supply used for IC logic. Their output is compatible with RTL, DTL and TTL as well as MOS circuits. As 50 mA.

Both the input and the outputs of LM 311 can be isolated from the system ground, and the output can be drive load referred to ground, the positive supply or the negative supply. Offset balancing and strobe capability are provided and output can be wire OR'ed. The LM311 has a temperature range of 0^oC to 70^oC

a. Pin construction (top view)

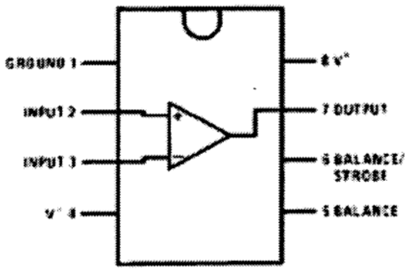

Figure 3.5.1.2: Pin connections

2.5.4 Inverter Module

There is a couple of component that been used in the Inverter Module. During the selection of the component it is very crucial that it would be appropriate and according to the function of the module toward the final output. Through this module, its can only gain control of the pulse signal that come from PWM module to from the exact PWM sinusoidal so that it can be applied to the motor.

III. ADVANTAGES OF PWM

The main advantage of PWM is that power loss in the switching devices is very low. When a switch is off there is practically no current, and when it is on, there is almost no voltage drop across the switch. Power loss, being the product of voltage and current, is thus in both cases close to zero. PWM works also well with digital controls, which, because of their on/off nature, can easily set the needed duty cycle. Using pulse width modulation has several advantages over analog control. Using PWM to dim a lamp would produce less heat than an analog control that converts some of the current to heat. Also, if you use PWM, the entire control circuit can be digital, eliminating the need for digital-to-analog converters. Using digital control lines will reduce the susceptibility of your circuit to interference. Finally, motors may be able to operate at lower speeds if you control them with PWM. When you use an analog current to control a motor, it will not produce significant torque at low speeds. The magnetic field created by the small current will be too weak to turn the rotor. On the other hand, a PWM current can create short pulses of magnetic flux at full strength, which can turn the rotor at extremely slow speeds.

The technology has become more pervasive as low cost microcontrollers incorporate PWM control. Microcontrollers offer simple commands to vary the duty cycle and frequencies of the PWM control signal. PWM is also used in communications to take advantage of the higher immunity to noise provided by digital signals. So by getting these pulses generated by a microcontroller we can increase the efficiency, accuracy and thus the reliability of the system. Most commonly used microcontroller is 8051 that has been used in this project for production of pulse.

IV. CONCLUSION

It is quite clear from the above discussion that speed control of AC motor using PWM may be a comprehensive system that controls the speed of motor by giving instruction to the microcontroller to reduce the mutual work. The technology save the money too and gives a return on investment.

This system have a great deal in money in common with one another, 230V is used in this process of speed control of AC motor. Implementation of this process is easy. Using this technique, by changing some changes in the circuit we can implement this in industries. So by using microcontroller we control the speed of AC motor using Transistor. By applying PWM pulse to base of Transistor, the speed of the motor varies. We used an LCD for displaying the varying speed of the AC motor and keypad for varying the speed. If we press up or down key, microcontroller varies the duty cycle of the PWM accordingly so that the average power will vary resulting variation in the speed.

Finally we conclude that this method is one of the best methods for controlling the speed of AC motor.

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