International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 3, Issue 4, April 2013)

A Novel Implementation of Phase Control Technique for Speed Control of Induction Motor Using ARDUINO

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***Abstract* — Induction motors are the most widely used motors for appliances, industrial control and automation. However there arises a problem in voltage levels, which affects the speed of induction motor. As the voltage (V) is directly proportional to speed (N), we need to control the stator voltage which controls the speed proportionally. In this Paper a novel Open loop phase control method is developed by coding a program using ARDUINO software in which ARDUINO controller takes input from the user and generates firing pulses for the TRIAC which controls the speed of the Induction motor. The total process is executed with the help of an ARDUINO controller kit where ARDUINO and Tera-Term softwares are used for Micro Controller and for serial monitor. This results in variable speed control of Induction motor.**

Keywords* - *Phase control, Speed, Pulses, ARDUINO controller, Induction Motor.etc.,

I. INTRODUCTION

For general lighting purpose in shops, offices, houses, schools etc. single phase supply is commonly used. Based on this supply the motors which work on single phase A.C supply (A.C motors) are very popularly used instead of D.C. motors. Among These A.C motors single phase induction motors are widely used for numerous domestic and industrial applications like home appliances, industrial control, and automation as they are robust, reliable, and durable. These motors are the most widely used since their power ratings are very small. Hence, they are often called the workhouse of the motion industry.

It is very important to control the speed of induction motors for efficient control strategies and for reducing operation cost too. Before going for the various controlling methods we need to know the speed - torque characteristics. The speed torque characteristics of an induction motor is shown in the below Fig-1.

Having known the Torque-speed characteristic of the motor, its speed can be controlled in three methods.

i) Changing the number of poles
ii) Varying the input voltage at fixed frequency
iii) Varying both the input voltage and frequency accordingly.

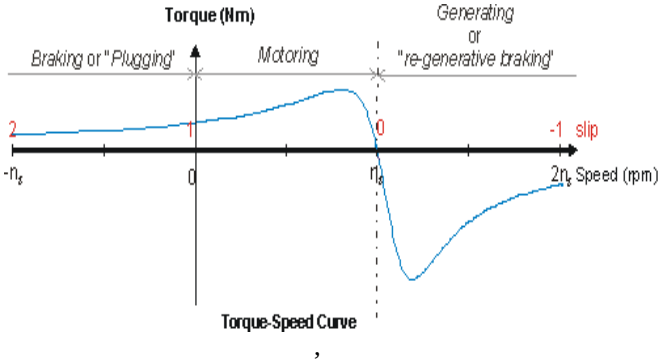

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Fig: 1 - Torque-Speed characteristic of induction motor

To maintain torque capability of the motor close to the rated torque at any frequency, the air gap flux, φag is maintained constant

The air gap voltage is related to φag and the frequency f which are represented as,

$$E_{ag}=k_1\varphi_{ag}f \quad \text{--- (1.1)}$$

$$\text{Input voltage, } Vs\approx k_1\,\varphi_{ag}*f \quad \text{--- (1.2)}$$

(or)

$$\varphi_{ag} = \text{constant} \approx Vs/f \quad \text{--- (1.3)}$$

where k1 is a constant

We shall be concentrating on the second method throughout the paper, beginning with analyzing the parameters of induction motor.

Induction motors require variable speed control to serve wide range of applications. Before last few decades all the process industries were making use of DC motors because speed control of DC motor is very easy when compared to AC motors.

But as we know that the main drawback of DC motor is maintenance problem. After the invention of Power electronic devices, DC motors are being replaced with induction motors, because speed control of Induction motors is very easy with Power electronic devices. When power is supplied to an induction motor at the recommended specifications, it runs at its rated speed. However, many applications need variable speed operations.

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For example, a washing machine may use different speeds for each wash cycle. Historically, mechanical gear systems were used to obtain those variable speeds. With the Recent developments in power electronic and control systems controlling of motor at variable speeds has become easier instead of mechanical gears. These electronic devices controls the motor speed and can reduce the system's average power consumption and noise generation of the motor.

II. Identification Of Problem

The problem of speed control of electrical motors in general induction motors in particular is of great importance. In number of industries motors must satisfy very strict speed requirements, both with respect to the range and smoothness of control and also with respect to economical operation. From the point of speed control, induction motors are inferior to dc motors. The speed of a DC shunt motor can be adjusted between wide range with good efficiency and speed regulation, but in Induction motor speed cannot be varied easily without losing efficiency and good speed regulation. Thus in this paper we are concerned about speed regulation of induction motor as main objective.

III. Aims And Objectives

In this paper a feasible solution for the speed control of induction motor using phase control technique is developed using ARUDINO. Which is used to solve some of the problems in the induction motor. They are as follows.

- Required variable speed can be reached.
- Better Performance can be achieved at variable speeds.
- Reduces the Cost occurred for the controlling as well as operating of induction motor.
- Easy and less time consuming for control.
- Flexibility in operation.
- Any number of induction motors can be controlled simultaneously.

IV. Developed Model.

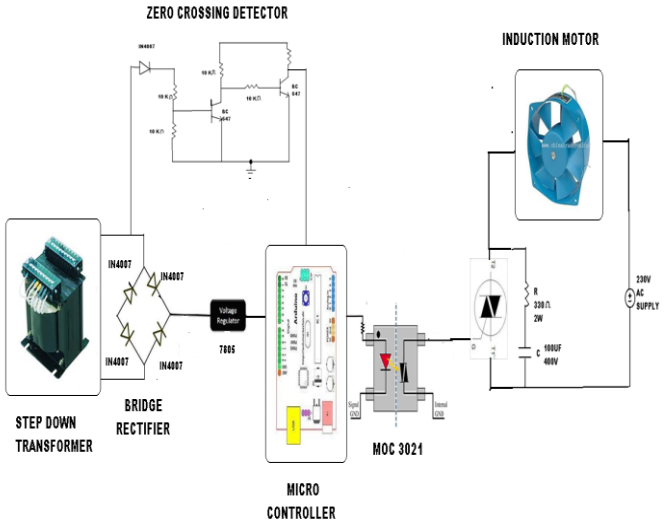

Fig:2 Practical Implementation of Phase Control Technique

The base speed of the induction motor is directly proportional to the supply voltage and the number of poles of the motor. Since the number of poles is fixed by design, the best way to vary the speed of the induction motor is by varying the supply voltage. This is exactly what phase control technique tries to achieve.

In this technique the speed of the induction motor can be controlled by controlling stator voltage. Zero crossings of stator voltage is detected by ZCD and generates square pulses proportionally. These pulses acts as interrupts for the ARDUINO controller (ATMEGA168) and generates firing pulses for the TRIAC. To avoid the reversal of current an Opto coupler (MOC3021) is placed in between the controller and TRIAC.TRIAC is a power electronic device which conducts based on the gate pulses it receives rather than the supply voltage, TRIAC is connected in series with the motor, and hence by controlling the gate pulses of the TRIAC, speed of the induction motor is controlled smoothly and effectively with less power consumption.

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V. IMPLEMENTED TECHNOLOGY

ARDUINO is used to create prototypes, its underlying hardware works at the same level of sophistication that engineers employ to build embedded devices. People already working with

Micro-Controllers are also attracted to ARDUINO because of its agile development capabilities and its facility for quick implementation of ideas.

ARDUINO is best known for its hardware, but we also need software to program that hardware. Both the hardware and the software are called "ARDUINO." The combination enables us to create projects that sense and control the physical world. The software is free, open source, and cross-platform.

Tera-Term is the open-source, free software implemented, terminal emulator (Communications) program. It emulates between different types of terminals. It supports telnet, Serial port Connections. It also has a built in macro scripting language and few other plug-ins.

In this it is very easy to specify the maximum serial port number (maximum value of n for COMn) to be listed in the New connection and Serial port dialog boxes. To specify the maximum number, edit the MaxComPort line in the [Tera Term] section of the setup file like the following.

MaxComPort=<maximum serial port number>

--- (1.4)

The maximum serial port number cannot be less than 4 even if the actual maximum number is less than 4.

Default:
MaxComPort=4

--- (1.5)

The ARDUINO Board along with the IC ATMEGA - 168 is shown in the below figure which is very import in implementation of the phase control technique for controlling speed of the induction motor.

Fig: 3 Arduino Controller Along with ATMEGA-168

VI. CODE EXPLANATION

The proposed method in this paper is implemented using ARDUINO Software by coding. Brief explanation of the code is as follows:

```
volatile char start_firing;   // flag to decides  whether
firing
                                    should start or not//
const int pin = 11;          // input pin to moc 3021//
volatile int shifttime, holdtime;
void setup()
   {
    serial.begin(9600);
    pinmode(pin, output);
    digitalwrite(pin, low);
    attachinterrupt (1, zerocrosser_falling, change);
   // this is an interrupt declaration for arduino
    saying to detect change of value on pin 3 //
   // when ever value is changed function
       zerocrosser_falling( ) is called //
 serial.println("start");
    }
void loop()
   {
     if(yes == start_firing)
     {
     firing();              // calling firing function //
     start_firing = no;
      }
     }
void zerocrosser_falling( )
// flag decides firing should start//
   {
   start_firing = yes;
    }
   void firing()
   {
   Previoustimearrival = currenttimearrival;
      //firing function starts//
   currenttimearrival = millis();
   timeperiod=(currenttimearrival-
                  previoustimearrival);
    if(0 == shifttime)
    {
              digitalwrite (pin, low);
    }
     //gives no firing pulse to moc 3021//
    else if(1 == shifttime)
    {
```

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```
            digitalwrite (pin, high);
  }
// gives  firing pulse to moc3021//
  else
  {
       delaymicroseconds(shifttime);
        digitalwrite(pin,  high);
        delaymicroseconds(500);
        digitalwrite(pin,  low);
  }
   void checkserialInput(   )
{
    char received;
    if (Serial.available())
    {
     received=Serial.read();
  //designates the shift time period based on the input
     received from the serial port//
       switch((received))
       {
           case '9':  shifttime = 1;
           break;
           case '8':  shifttime = 1000;
          break;
        }
//like wise for each case specific shift time
         will be designated//
       }
        serial.print("speed : ");
        serial.println(received);
        } // End of the Program after attaining the
        required speed for variation in the voltage.
```

VII. RESULTS

Developed model for speed of the induction motor is shown in the below figure -4

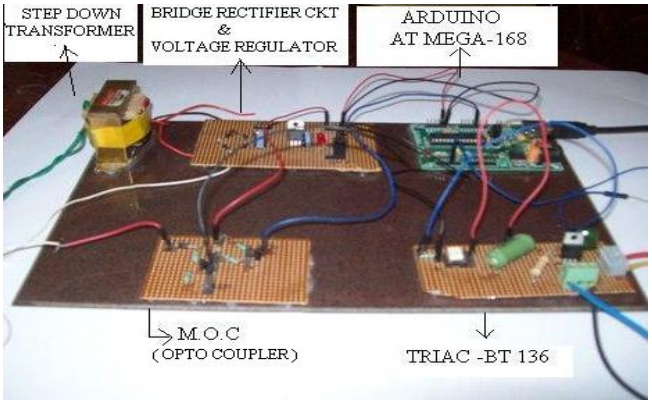

Fig: 4 Developed Kit For Speed Control Using Phase Control Technique

The proposed controlling method using ARDUINO for controlling of induction motor is firstly explained with the help of a lamp load (resistive load) .In the below figure the lamp glows when the supply is given but controlling action is done by the TRIAC based on the code(Cases from 1-9) .

In the below figure -5 at the out of the TRIAC the lamp load is connected similarly as shown in the fig-2.(Circuit Diagram) .

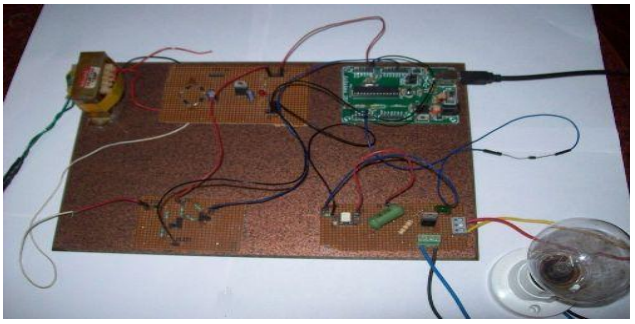

Fig: 5 Proposed Kit for Controling of resistive Load.

For an input between ‘one’ and ‘nine’ variable voltage pulses will be generated by ARDUINO this controlled firing pulses are fed to the TRIAC in order to control the speed of induction motor. The resultant output will be as follows.

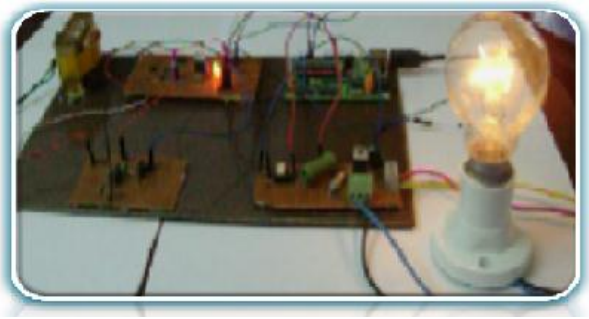

Fig : 6. Result analysis for an input ‘3’ (Case-3)

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In the same way by connecting the induction motor in the place of the resistive load (lamp load) we can control the speed of the induction motor (developed model).

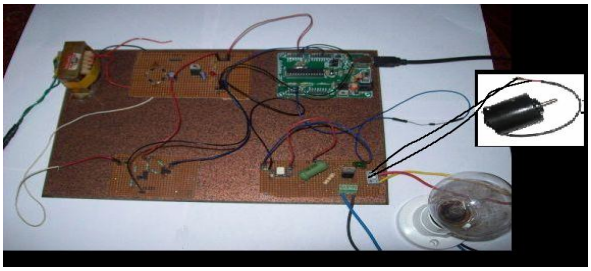

Fig : 7. Result analysis for induction motor

Note: From the above results we cannot obtain the characteristics of the induction motor as we get in the MATLAB. To obtain the characteristics of the load, again we need to interface the controller kit to MATLAB.

VIII. Futur Scope

In This paper we have implemented the Developed system on a single Induction motor.

- In future we are planning to implement the same system for controlling of three phase induction motor with some design considerations.
- At the same time we can control the speed of different motors at a time (all at a time) by increasing the output ports on the TRIAC board.
- Even by consider the frequency term and maintaining the V/F ratio as constant. We can implement the V/F method for controlling of induction motor.

IX. Conclusion

It can be concluded that the Speed of the induction motor can be controlled by controlling the pulses from the ARDUINO, which are fed to the TRIAC through MOC. This TRIAC generates the controlling pulses for controlling of induction motor. Thus Variable speeds can be obtained by controlling the phase voltage through voltage regulator, ARDUINO, MOC & TRIAC.

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