IoT Based Variable Frequency Drive

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Abstract— This work aims at the design and development of an IoT based speed control of three- phase induction motor using MQTT Protocol. MQTT is a standard publish/subscribe protocol that is frequently used and supported by embedded devices, and is also common in machine-to-machine interactions. The developed system will be used for controlling the speed of three-phase induction motor which is used in the Ductable Industrial Air Cooler. The requirements of ductable industrial air cooler in various areas like Industries, textile and hosiery industry, hospitals, canteen, restaurants, hotels, agriculture and in educational institutions and schools, an etc.. This project is useful for enhancing the features of ductable industrial air cooler by replacing the ON/OFF remote control operation with the fully adjustable speed control using Android Application.

Keywords: IoT, 3–Phase Motor, MQTT

I. INTRODUCTION

In today's manufacturing industries, mechanical and electromechanical systems are driven by electric motors on the premises. The drivers of these motors are mostly on motor control and the predictive maintenance schedules of the motors are not calculated.

The impact created on human life by the Internet of Things will be as large as the internet has produced in the earlier decades, so the IoT is perceived as "the next of the internet". A part of the following enabling technologies are:

- Sensors and Actuators
- Wireless Sensor Network (WSN)
- Intelligent and Interactive Packaging (I2Pack)
- Real-time Embedded System
- Mobile Internet Access
- Cloud Computing
- Radio Frequency Identification (RFID)
- Machine-to-Machine (M2M) Communication
- Human Machine Interaction (HMI)

(IoT) Internet of Things is referred as the world-wide network system which connects all the smart objects together. It is the way in which all objects are enabled to be in touch with each other. Variable Frequency Drives (VFD) are the most important device used in all modern industries, used to operate and control the motors in industry at different speed depending on the requirement of the process of the work that has been carried out by the motors. VFD's are being controlled at the physical location, where the drives were installed. The control of motorat the physical location makes time consuming process and it increases the time for controlling the drives. To overcome this drawback a wireless technology has been utilized in this proposed project to monitor and control the speed of the motor. In this work an Internet of Thinks (IoT) is used to control the VFD.

II. HARDWARE AND SOFTWARE TOOLS

The essential components required for this system are micro-controller (ATmega8), ESP8266 Wi-Fi module, IGBT Gate Driver IC (IR2110), IGBT (FGA25N120) and Diodes (10A10). This system also demands the deep knowledge of software platform like Google Cloud, Linux, EAGLE, Proteus simulation software, Arduino IDE, MQTT messaging protocol for a machine to machine wirelessly communication.

III. DESIGN AND IMPLEMENTATION

The term PWM stands for "pulse width modulation" is a technique used in VFD. An inverter generates an AC voltage output from a DC input with the help of IGBT circuits (switching circuit) by generating single or multiple square pulses of voltage per half cycle to reproduce a sinusoidal wave. If the size of the pulses is varied, the output is said to be (PWM) pulse width modulated. To adjust the efficient output voltage the widths of all pulses are amplified or reduced while keeping the sinusoidal proportionality. With the help of PWM, we can only change the turn-on time of the pulses and the total time period T of the pulses remain the same. Hence by varying the turn-on time of pulses duty cycle of the pulses is adjusted.

A. Power Supply

There are following steps available for obtaining the three different voltages in this pro- to type. Components and corresponding voltage required are showing in the Table 3.1.

No.	Component Name	Required Voltage
1	ATmega8 micro-controller	5V
2	ESP8266 Wi-Fi module	3.3V
3	VDD of Driver IC IR2110	5V
4	VCC of Driver IC IR2110	12V
5	4-pin Optocoupler	5V
6	Potentiometer	5V

Table 3.1: Voltage Requirement of Controller and Driver Circuit Components

Figure 3.1 showing the single phase 230V AC supply is first stepped down by 230V/12V step-down transformer.

This 12V AC is then converted to DC by using a bridge rectifier.

The AC ripples presented in rectifier output are filtering out by a capacitor and the output of this filter is given to the input pin of voltage regulator 7812.

At output pin of the voltage regulator IC-7812, getting a constant 12V DC which can be used for VCC of IR2110 gate driver IC and other ICs in the Figure 4.3 used for converting 12V into 5V DC.

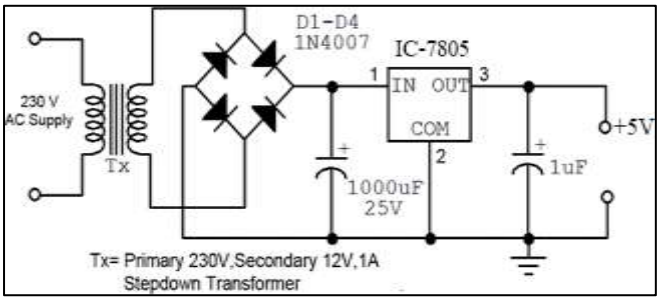


Fig. 3.1: 12V DC Power Supply

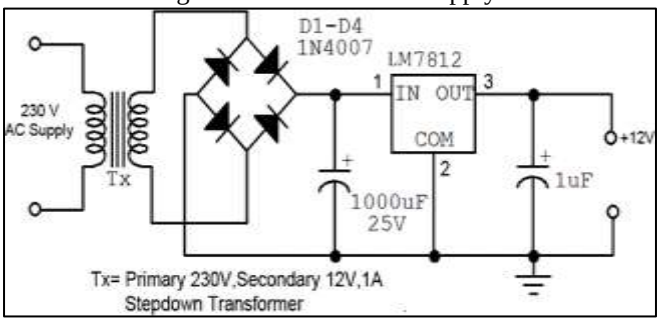


Fig. 3.2: 5V DC Power Supply

B. Converter

In this prototype, the application of the 1-phase uncontrolled rectifier as shown in the Figure 4.5 is for converting the single phase 230V AC supply into 310V DC. This high voltage output of the 1-phase uncontrolled rectifier given as input to the three-phase VFD.

C. Inverter Circuit

The three-phase inverter circuit shown in the Figure 3.3 is used for variable frequency drive (VFD) applications and for high power demands like HVDC power transmission. A basic three-phase inverter consists of three 1-phase inverter switches each joined to one of the three load terminals which are showing in the Figure 4.8 hardware circuit three-phase inverter. For the most of the control scheme, the control of the three switches is ordered so that one switch operates at each 60-degree point of the fundamental output waveform. This generates a line-to-line output waveform which has six steps.

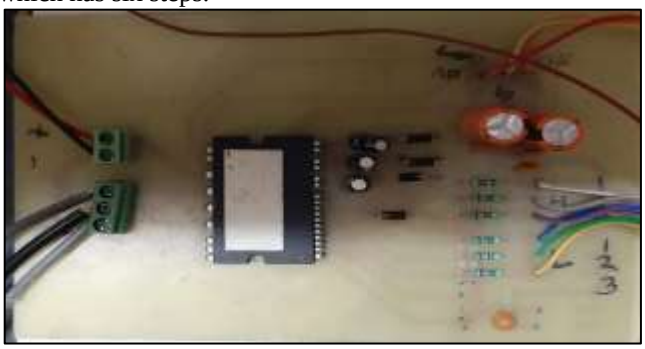


Fig. 3.3: Hardware Circuit of Three Phase Inverter

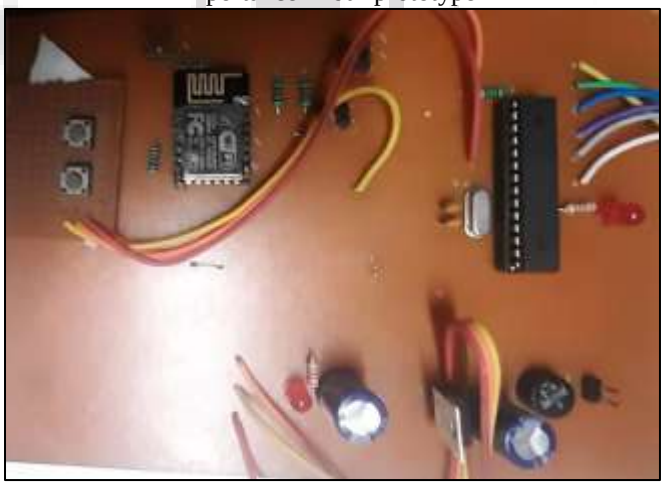
IV. Design of Driver Circuit

A. Micro-Controller Circuit

The ATmega8 micro-controller is the brain of this system and the Table 4.1 showing the useful pin and their application according to the system requirement. In this circuit we used two controller first one is ATmega8 micro-controller and the second one is ESP8266 Wi-Fi module. The ATmega8 AVR micro-controller developed by Atmel starting in 1996 is a family of microcontrollers and this controller handle the main code for switching the IGBTs circuit. The ESP8266 controller handle the changes made by user for controlling the speed of the motor and generate the interrupt signal for the main ATmega8 micro- controller. Figure 4.1 showing the pcb of ATmega8 micro-controller circuit.

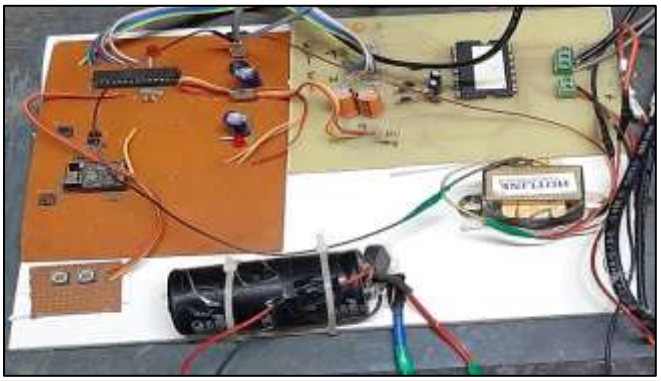
No.	Component Name	Requirement in Prototype
1	ATmega8 micro-controller pin number 9	PWM pin to convert other pulses in pwm form
2	ATmega8 micro-controller pin number 3,4,5,6,7 and 8	To generate six pwm pulses
3	ATmega8 micro-controller pin number 2	To receive interrupt signal from ESP8266 GPIO4
4	ESP8266 Wi-Fi module pin number GPIO4	To generate interrupt signal for AT-mega8 INT0
5	ESP8266 Wi-Fi module pin number GPIO5	To check the status of switch continuously
6	ESP8266 Wi-Fi module pin number ADC	To convert potentiometer output in digital form and generate interrupt ac-cording it for manually control

Table 4.1: Controller Circuit Components and their Importance in our prototype

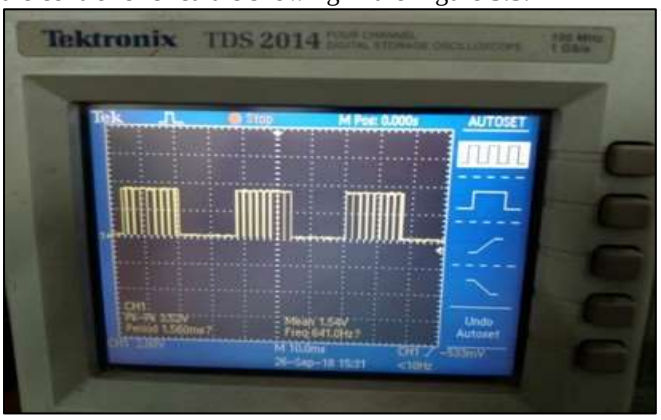


V. Experimentation and Results

The Figure 5.1 and 5.2 showing the experiment set-up of three-phase VFD. This three- phase VFD tested on 3-phase, 1/2 hp, 2-pole, 415V. The 1/4 hp DC motor taken as load for the testing of this system.



The ATmega8 micro-controller is useful to generated the IGBTs triggering pulses. The DSO outputs of the controller circuit is showing in the Figure 5.3.



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