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Design and Implementation of Automatic Speed Control of Ceiling Fan through PWM Technique with Optocoupler to Reduce Energy Consumption

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***Abstract*—The evolution of automation and innovations helps in diverse field. This helps to create human lives much easier. It tend to produce various automatic devices. These devices must include the control system to improve the automation in the equipment. The important equipment used in our day to day life is the ceiling fan. This is the largely used equipment. The conventional system includes manual speed control. To enhance automation in the system, the proposed system is implemented to replace the conventional system with automatic speed control system. This helps to automatically control the speed of the fan based upon the surrounding temperature. This is sensed through the use of sensors. This includes pulse width modulation techniques with brushless permanent magnet DC motors and microcontroller. Here PIC microcontrollers are used for controlling and processing. Thus these techniques are employed for the automatic detection of ceiling fan. This leads in the reduction of energy consumption and reduced cost.**

Keywords—Automatic speed control, sensors, PWM power convertors, microprocessor, control, power grids, power generation control, energy consumption

I. INTRODUCTION

The modern decade are looking forward with advanced innovations and automations. The automation is a technique of adopting the machines to perform and function without the aid of humans. The automations play a versatile role in various sectors. These automations helps to make human lives much easier. The pros of automation includes reduced operational cost and increased production in the system [1]–[3].

The advent of newer innovations in the automation of machinery is due to the increased cost parameter and demand. Thus the automations provides an optimum solution for the constraints in various sectors. The automation in diverse fields are introduced due to the evolution of digitalization. This enhances the productivity in the industrial and production sectors [4]–[7]. This helps to increase the standard and quality of the equipment's. This helps in the innovation of robotic technology. This is the combination of hardware and software system with communication technology. These leads to the increase in automation system in motion in a single platform. These automations play a prominent role in the development of various equipment's to improve the standard of living. These innovations helps in the control and monitoring parameters to enhance the performance and functioning of the equipment's and its life time [8]–[10].

The automations are differentiated into fixed, programmable and flexible automation systems. These are based upon the performance and functioning of the system. The automations in the electrical sectors helps to control and monitoring the consumption of power with respect to time. This leads to automatically control the electrical equipment's using the control devices. This leads to obtain a balanced in the supply system thereby maintaining the demand side management. Thus the automation refers to the usages of the information through the electronic components. This includes the control and monitoring of the system through remote places with implementing the two way communication system. Thus the automation is implemented through the integration of various components in a sequential manner [7], [11], [12].

In automation, the communication network and the control system shows a significant part in the analysis and functioning. In the power sectors, the automations are monitored by the SCADA systems. This helps to monitor the overall functioning of the system. In power system, the monitoring and controlling of the power distribution helps in the reduction of outrages. The control system provides instructions to perform accordingly. The components to improve automation includes motor and drive system, safety devices, controllers and communication technology. In

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industrial sectors, the mechanical devices that aid in the control of speed includes pulleys, various gear system and clutch system. These systems are controlled and monitored through control devices and communication protocols. This leads to proper functioning through the aid of automation system. The automation in the power system enhances the home energy management system. There are various equipment's used in our day to day life. The most important equipment includes the fan [13]–[16].

Nearly 25% of the energy consumption in the electricity bill is occupied by the fan. The automation system is used in the operation of fan. In conventional methods, the fan is available with manual speed control devices. This helps to control the speed based upon the need through manually.

The proposed system includes the speed control of ceiling fan through involving automations in the system. It is demonstrated as the conversion of non-adjustable speed to adjustable speed drive system. The speed control helps in many ways through production and economic benefits. The speed control includes various methodologies. This includes controlling the speed of the fan through detecting the surrounding temperature. They can adjust automatically through the prevailing weather conditions. The speed control is defined as the decreasing or increasing the working performance of the equipment. This is done through the voluntary change in load. The change of speed varies with various equipment's based upon the range and operating speed. The speed control of ceiling fan includes the determination of external temperature to function accordingly [17]–[19].

This is done through the sensors. The sensors are used to analyze the external physical parameters. This helps to function of equipment through the sensed data. The important component includes motors. There are various motors used in the equipment in which the permanent magnet synchronous motor are largely used due to its various significances. It is a light weight motor with reduced structure, lower cost, improved torque-current ration and higher efficiency. The components of permanent magnet motor incudes rotor with permanent magnets. They does not produce any heat in the interior and exterior surfaces. Due to the absence of brushes, it does not tend to create mechanical damage to the motors [20]–[22].

This helps to protect the motor from reducing the winding failure. This is the smart way of power saving with lower maintenance cost parameter. Their structure are smaller when compared to the universal motors. The permanent magnet brushless DC motor consumes lesser power. They must be equipped with proper safety and control mechanism. The motor includes must have to adopt both the short circuit protection and overload protection. In some cases, the motors with the controllable devices are self-protected. Hence this does not require any external protecting devices. The safety and protection of the equipment's are the important factor. The microprocessor is used for the purpose of processing and controlling. The PWM (Pulse Width Modulation) techniques is a control technique that provides the analog signal obtained through the microcontroller. This is obtained through the time duration of on and off of the devices. These time duration between these two parameters are referred as duty cycle. The PMW signals are generated through a comparator. These signals provides the pulse that are generated in a square waveform. This helps in the conversion of the signals into a discrete portions. The comparator helps to compare the signals and produces the square waveform.

The pulse width modulation are classified in to trail edge, lead edge and pulse center edge modulation techniques. The Pulse width modulation helps in regulating the voltage and hence they are used to regulate the speed of the motors. This also helps to dissolve the heat through the attachment of fan inside the system in computers.

The PMW techniques produces accurate results with higher response time duration. This helps the motor to produce maximum torque even when the motor operates at reduced speed. It also helps to reduce the radio frequency interference. The optocoupler are used for safety purposes. This helps to separate the circuits that send signals. It perform in both AC and DC signals. They functions with reduced noise parameter. It is used for driving the permanent magnet brushless DC motor. The ultrasonic sensor and temperature sensor are included to sense the sound and temperature of the surrounding environment. This senses the information and proceeds to process further. This is used in the sensors to detect the availability of the physical systems. This sends the signals through light. This helps to prevent the signal from rapid high voltages that damages the equipment. This is also known as photocoupler. This can be used as a switching device and can be used as an electronic devices. The controlling devices helps to reduce the electricity consumption. This helps to reduce the electricity bills.

II. Proposed System

The proposed system consists of microcontrollers, optocoupler, temperature and ultrasonic sensor with motors. The permanent magnet brushless DC motor are used.

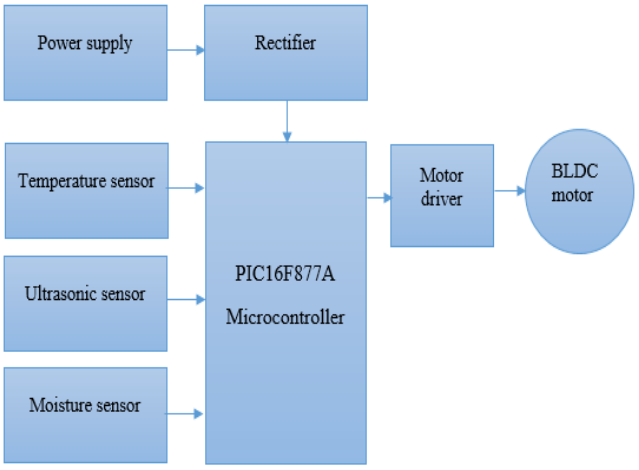

Fig 1: Proposed system

The figure 1 represents the proposed system.

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The components of permanent magnet brushless DC motor includes a fan blade attached with a permanent magnets with electromagnetic coils, rotor with rotor core section, stator, windings and bearing support.

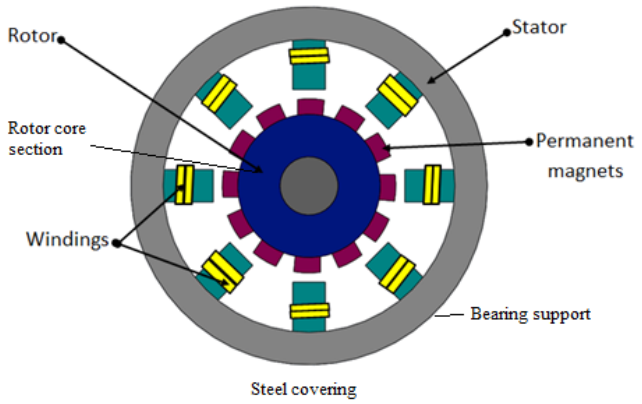

Fig 2: BLDC motor

The figure 2 represents the permanent magnet brushless DC motor. This contains four electromagnetic coils. The functioning of the electromagnetic coils function in combined pairs. In which the pair of A and C forms one phase and B and D forms the second phase. The rotor position is used to monitor the hall effect sensor. The rpm form the fan is monitored from the hall sensor through feedback. The conventional method is replaced through the proposed system. The power consumption is reduced through the optimization of the commutation angle. This helps to sustain the efficiency of the brushless DC motor[23]–[25].

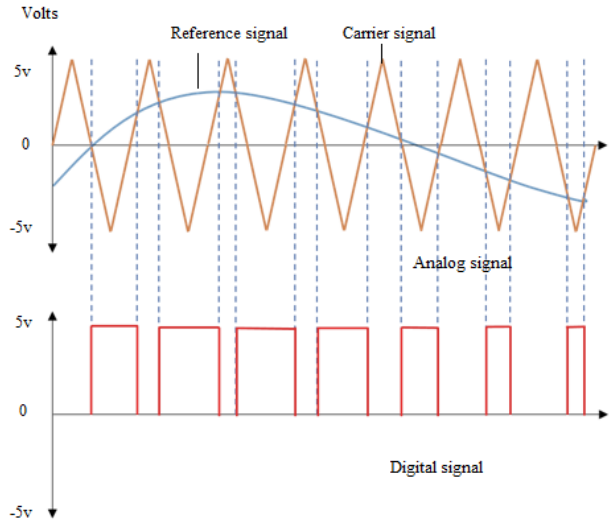

Fig 3: PWM signal

The figure 3 represents the pulse width modulation signal. They helps to regulate the functioning and speed control of fan externally through adjusting the duty cycles. It helps to obtain the results accurately. The duty cycle of the PWM is calculated as follows.

Duty cycle = T1/T* 100

Frequency Fpwm = 1/(TON+TOFF)

Vout = Vmax * duty cycle

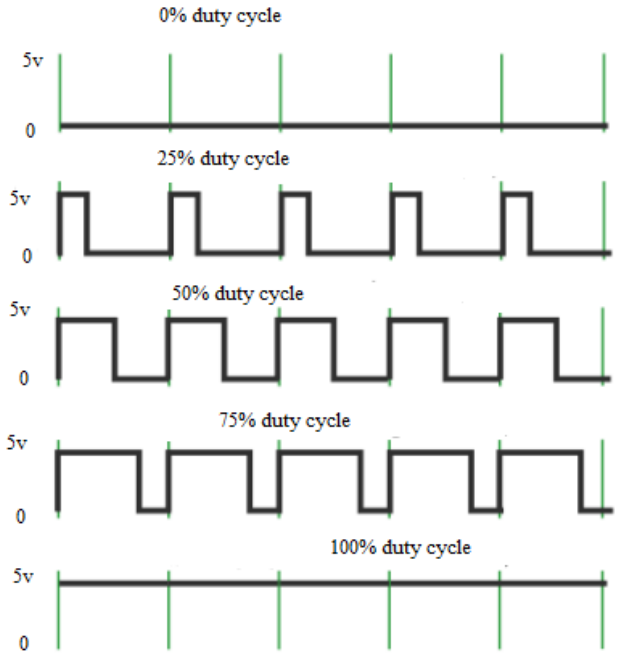

Fig 4: PWM with duty cycles

The figure 4 represents the PWM with duty cycles. The physical parameters are more important to be sustain in limit to intensification of the operational efficiency of the equipments. The sensor helps to function the equipments without any deviation in performance. The ultrasonic sensor is used to detect the sound signal and proceeds to the microcontroller whereas the temperature sensor (LM 35) is used to detect the surrounding temperatue through which the speed of the ceiling fan gets adjusted. The pulse width modulation is a digital parameter used to achieve the signal between 0 and 1. This is obtained through the duty cycle i.e is the amount of time interval at which the digital signal remains active. In the conventional methods, the potentiometer is used for speed control. This is replaced through the proposed system with increased automation in the system. It is denoted in percentage. The information is projected through the LCD display. This is a dot matrix liquid crystal display that is used to represent the alphanumerical characters and various symbols.

Here 16x2 LCD display is used. This is a form of digital system used for demonstration. It displays the room temperature. They are seven segment in nature. They are largely used due to flexibility in programming and are much economical in nature. This is accompanied with two registers. These are called command and data. The command register is used to save the command in the LCD. The initialization and predefining the data are done through the command instructions. They helps to perform various instructions. The data register is used to save the data that are need to be projected on the display unit. The data is the ASCII values that are needed to be proejected on the display of the LVD display. The consumption of energy is

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increasing rapidly due to the rise in demand. This must be maintained to limit the demand side management.

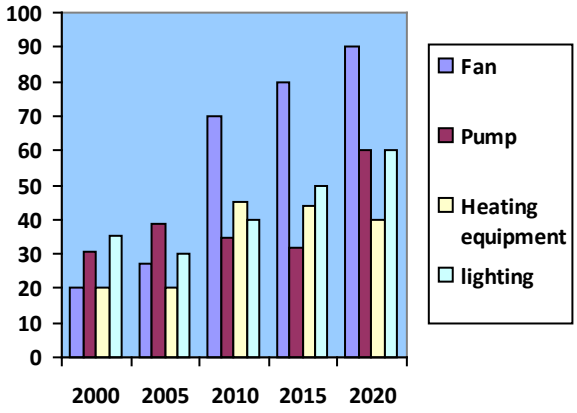

Fig 5 : Energy consumption

The figure 5 demonstrates the amount of increasing energy consumption annually. To balance the energy consumption, the smart automation techniques are employed. The smart meter is used to record and maintain the energy consumption. This is obtained throught the automation techniques. The smart meter records the consumptions of power and indicate them frequently. This helps to reduce the usage of power and electricity bills. The smart meter record the consumption of electricity and monitors them through involving machine learning techniques. The energy consumption is implemented by the forecast of the aforementioned data that are progressed to the preprocessing technique. This includes the preprocessing of the obtained data. They are proceeded with the optimization techniques. This helps to obtain a clean dataset. This includes two major modalities such as fitness function and crossover.

The data are pre-processed and evaluated with fitness function to obtain the desired outcome. This helps to limit the over usage of equipments. It also helps to function automatically based upon setting the operating time of the fan in prior. Thus the smart meter helps to make the functioning of the ceiling fan as fully automated in nature.

TABLE I. OPERATING CONDITION

Sl.no	Room temperature	Accuracy	Fan speed
1	32.8	87%	Medium
2	25.9	87%	Low
3	67.9	97%	High
4	45.9	92%	Low
5	59.1	85%	Medium
6	82.3	91%	High

The table I represents the functioning of ceiling fan based on the temperature in the surrounding atmosphere.

III. SIMULATION RESULTS AND OUTCOME

The proposed automatic speed control of ceiling fan is implemented in MATLAB Simulink is calculate and monitor the performance of the system.

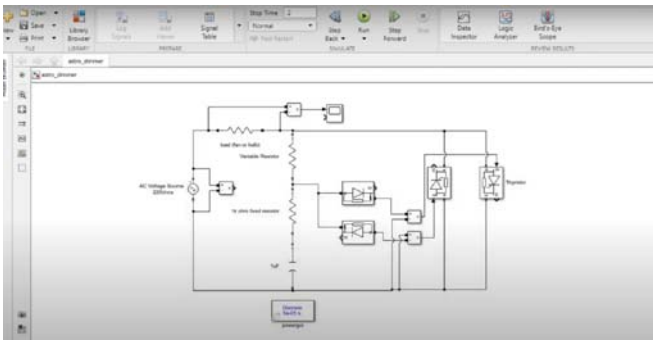

Fig 6: Simulation diagram

The figure 6 demonstrates the simulation diagram in MATLAB. This includes the analysis of speed of the ceiling fan and proceeded to control the speed using microcontroller. The input power supply to the microcontroller is 5v. The conversion of analog to digital signal is done through ADC. The sensed output is given to the microcontroller. This helps to obtain the control signals. The system is operated through varying the duty cycle that helps to change the speed of the fan based upon the temperature around the surrounding system.

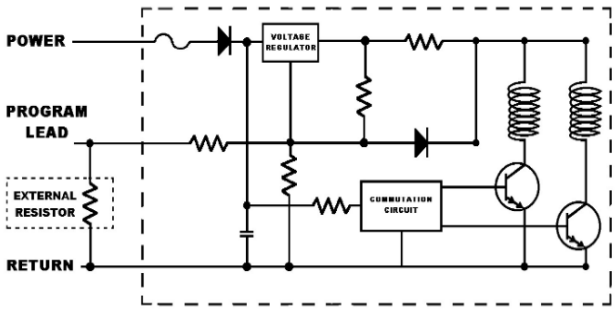

Fig 7: Regulation of fan speed

The figure 7 represents the regulation of fan speed. The proposed system is adopted to replace the use of tripot and potentiometer. The automatic speed control is implemented in simulation through adjusting the temperature to determine the routine of the ceiling fan. The speed is differentiated into three categories such as medium, low and high speed. These are based upon the room temperature. These automatic adjustment helps in proper functioning of the ceiling fan through the use of sensors. Thus the waveforns helps to observe the performance analysis.

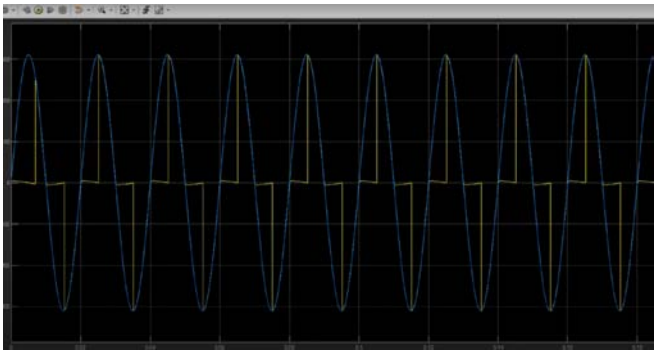

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Fig 8: PWM waveform

The figure 8 represents the PWM waveform.

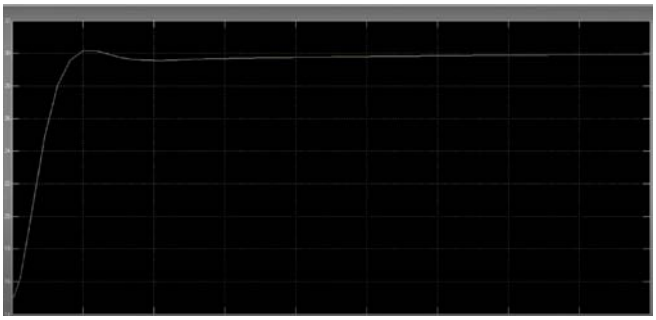

Fig 9: Energy consumption and monitoring

The figure 9 represents the energy consumption and monitoring. Through by adopting the proposed system the energy utility can be balanced. This helps to maintain the demand side management. Thus the energy consumption can be reduced and maintained stable through the pulse width modulation technique.

IV. Hardware Implementation

The PIC microcontroller is used for controlling and processing in which it can be easily write and erase numerous times because it adopts the FLASH memory technology. The PIC microcontroller are versatile in functioning and thus it is inexpensive in nature. This includes 40 pins whereas the 33 pins are developed for input and output. They have versatile applications ranging from sensors, safety devices and automation systems. This can function upto 20MHz frequency with instruction set. The operating voltage lies between 4.2 to 5.5 v respectively. It is available in four IC packaging with any internal oscillator in the unit. The PIC6F877A is obtained with low power high performance functioning CPU, providing with microcontroller of 8 bit with 8k bytes of programmable flash memory, maximum user application, extensive accessibility, presented with unrestricted enlargement tools. Various data such as the frequency, data and transmission codes are saved and identified in EPROM. They are flexible to operate and user friendly in nature.

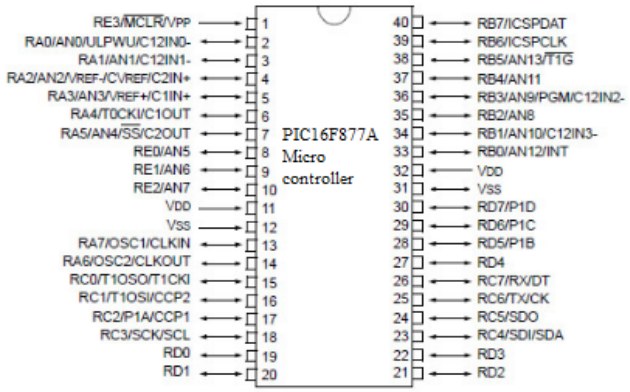

Fig 10: PIC16F877A

The figure 10 represents the pin diagram configuration of PIC16F877A microcontroller. They are used to obtain simpler programming with interfacing which helps to perform numerous task. The EPROM and EEROM are initiated for the end-user to perform the task much convenient manner through digital signal processing. The PIC microcontrollers are largely used in both industrial and domestic purposes due to its lower cost and easier functioning performance.

```
#include<htc.h>
#include<pic.h>
#define _XTAL_FREQ   20000000
void rundutycycle(unsigned int x );
#define s1           RA0
#define s2           RA1
#define s3           RA2
#define s4           RA3
#define s5           RA4
#define s6           RA5
void main()
{
ADCON1=0x06;             //All pins as digital
        TRISA=0b111111;          //PortA as Input
        TRISC2  = 0;             //Make CCP1 pin as output
CCP1CON = 0x0C;          //Configure CCP1 module in PWM mode
PR2   = 0xFF;            //Configure the Timer2 period
rundutycycle(512);
}
```

Fig 11: Programming code

The figure 11 represents the programming code for PIC microcontroller. The three fundamental step for programming a microcontroller includes writing programming code on computer, then used to compile the code with the compiler and finally helps to upload the compiled version in the microcontroller. The generation of code for the PIC microcontroller include various stages. The first step includes building the hardware. This is the primary step for program coding in microcontroller. Then obtaining software. The XC8 compiler and MPLAB X IDE are used by the instructions. The another set involves the configuration of oscillator and used to set the configuration bits in the system. The C programming language is used for the programming of PIC microcontroller.

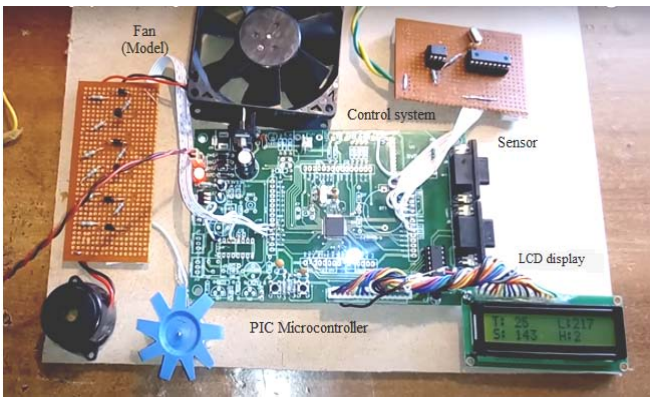

Fig 12 : Hardware implementation

The figure 12 represents the hardware implementation of the planned system. The functioning of the system factors are projected in the LCD display. Through the control and monitor of microcontrollers through the sensed data helps to operate the ceiling fan automatically.

V. Conclusion

The advancement in the technology helps to make lives much sophisticated. The proposed system implement the automatic speed control of ceiling fan. This is enhanced through the use of pulse width modulation techniques. They are done through various devices that are performed through sensing the surrounding conditions. They are integrated with the control system with communication technology. The speed of the motor is measured by the power electronic devices that leads to regulate the speed of the ceiling fan. Thus the PMW technique with optocoupler helps to obtain the automatic speed control which leads in the decline of energy consumption.

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