ENERGY EFFICIENT INTELLIGENT BLDC FAN WITH AUTOMATIC FEATURES

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ABSTRACT

A brushless DC MOTOR (BLDC MOTOR) is a synchronous electric motor which runs on the supply of direct current electricity. In these motors there is a linear relationship between current and torque and also in between voltage and rpm of BLDC motor. This linear characteristic is the main reason for which BLDC motor give excellent result in the conventional ceiling fans. In this paper we present the compatibility of BLDC motor for application of ceiling fans along with the comparative study of performances on various factors of BLDC motor driven fan and results have been compared. It is proved that efficiency of BLDC motor driven fan is comparatively higher compared to other fans. Also we implement an intelligent BLDC fan which automatically turns on in presence of human using PIR sensor and automatically regulate speed based on ambient temperature of surroundings.

INTRODUCTION

Ceiling fan is one of the major domestic appliances which runs for hours and consumes a huge amount of residential power consumption. Due to the factors such as the environmental and availability of raw materials the process of generation of energy is very much limited in India. Due to this major reason there is a need for conservation of the available sources for power generation. The following table shows the energy consumption in various sections.

Sl No.	SEGMENTS	% OF TOTAL
1	Heavy Industries	25.1
2	Transportation	31.6
3	Agriculture	2.2
4	Residential	26.8

TABLE 1 : Energy Consumption in various sections

According to the above table it is very much understood that residential sector is where the maximum conservation can be made possible in comparison to this the other sectors are so much commercialized that it is not neither possible nor is there sufficient incentive to introduce and sustain any large conservation of energy through other alternate energy efficient equipments in these sectors. So this paper has focused specifically on ceiling fans which sells more than 30million units per annum with an installed base of more than 250million units in India. Further, when the residential consumption was thoroughly studied, it was found that, total consumption of power by the ceiling fans amounts to 6%, which is more than that of TV and fridge combined use.

Overhead ceiling fans are often left on when occupants leave rooms. Thus, the fans can consume unnecessary power in unoccupied rooms. Another problem occurs when newly arriving occupants to new rooms and/or to darkened rooms have to search for hard to find wall toggle switches and/or overhanging chains to turn on the ceiling fans. Warm and/or stuffy rooms can be very uncomfortable to newly arriving occupants, who would have to wait for

the rooms to cool down and circulate airflow. Further, turning on and off several fans in a home or building is often so inconvenient that fans are left on.

During summer nights especially, the room temperature is initially quit high, as time passes, the temperature starts dropping. Also, after a person falls asleep, the metabolic rate of one's body decreases, and one is expected to wake up from time to time to adjust the speed of the Fan. So, an efficient automatic Fan speed control system that automatically changes the speed level according to the change in environment / room temperature was implemented to solve the problems associated in Fan speed manual control system.

With this paper, using BLDC fan to reduce the power consumption of the ceiling fans by 50% without affecting its performance as well as reducing the energy consumption by automatically regulating speed based on ambient temperature, along with other features are described.

Why BLDC for ceiling fan?

Ceiling fans used today runs on the AC motors and they consume enormous power. These AC running fan fans are not only power consuming but they have rpm control by the help of capacitor or resistor based regulators and there is loss in itself to some extent so they are not efficient. Moreover the RPM control is by controlling the voltage and it becomes very difficult and challenging to have constant rpm based on AC mains supply due to voltage fluctuations of the mains. AC motors further results in power factor (PF) degradation.

The air flow is based on the blade size & rpm of fan and does not change due to any other factor. By using BLDC motor based ceiling fan we can generate same amount of air flow with less of energy usage along with improving the power factor. BLDC motor ceiling fan has much better efficiency and excellent constant RPM control in comparison to conventional ceiling fan as it operates out of fixed DC voltage.

III. WORKING

The BLDC motor has permanent magnet that makes it more efficient and expensive in comparison to conventional motor. It is capable of providing large amount of torque over a vast speed range. BLDC motors do not have brushes and must be electronically commutated. They also require sensors to indicate rotor position to the electronic drive. An electronic drive circuit uses a micro-computer. BLDC motors are powered by a DC electric source via an integrated inverter, which produces an AC electric signal to drive the motor. In this context, AC does not imply a sinusoidal waveform but rather a bi-directional current with no restriction on waveform. This is done with the help of electronic commutator. Commutation is the act of changing the motor phase currents at the appropriate times to produce rotational torque this commutation is achieved by using semiconductor switches. An electrical current power a permanent magnet that causes the motor to move, so no physical commutator is necessary.

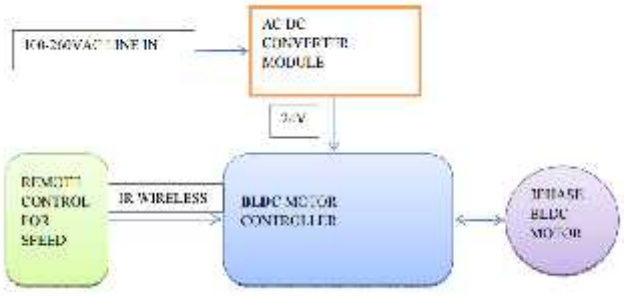

Fig 3: BLDC Motor controller – block diagram.

• First block in the above diagram is representing the supply mains or we can say an active source from where we are getting 100-260 Volts alternating current (a.c) power supply.

• Second block is representing the AC to DC converter which converts the AC we are getting from the supply mains to DC so that BLDC motor can starts its working, after get converting to DC it provides constant voltage of 24 volts DC and thisvoltage is then supplied to the BLDC motor controller.

• Next block is of BLDC motor controller, this device consists of arotor position decoder for proper commutation sequencing, temperature compensated reference capable of supplying sensor power, frequency programmable sawtooth oscillator, three open collector top drivers, and three high current totem pole bottom drivers ideally suited for driving power MOSFETs. Also included are protective features consisting of undervoltage lockout, cyclebycycle current limiting with a selectable time delayed latchedshutdown mode, internal thermal shutdown, and a unique fault output that can be interfaced into microprocessor controlled systems. Typical motor control functions include open loop speed, forward orreverse direction, run enable, and dynamic braking. But this device does not work until a triggering is not applied to it, switching speed of this device is so high that the output voltage is in a form of 3-phase a.c or we can see pulsating d.c.

• Next block is a remote control for speed, this is a wireless device which works by means of infrared wave through which triggering is done, and this remote helps us to start the motor controller and to control the speed of the controller.

• Next block is a 3-phase BLDC motor which is connected to thecontroller which provides power to the motor to work

IV. BLDC MOTOR ADVANTAGES

If you're still not sure whether or not this motor is right for you, here is a basic breakdown of some of the primary advantages of BLDC motor.

• High speed operation – A BLDC motor can operate at speeds above 10,000 rpm under loaded and unloaded conditions.

• Responsiveness and quick acceleration – Inner rotor BLDC motors have low rotor inertia, allowing them to accelerate, decelerate, and reverse direction quickly.

• High power density – BLDC motors have the highest running torque per cubic inch of any DC motor.

• High reliability – BLDC motors do not have brushes, meaning they are more reliable and have life expectancies of over 10,000 hours. This results in fewer instances of replacement or repair and less overall down time for your project

Comparison of Ordinary, 5 star rated and BLDC fan

In this project we compared different parameters of the 3 fans. They are:

Input Power

SPEED(rpm)	BLDC FAN(watt)	FIVE STAR FAN(watt)	ORDINARY FAN(watt)
140	3.8	13	14
210	7.7	24	25
270	13.8	30	39
310	22.7	40	48
360	35.8	55	76

TABLE 2: Input power of various fans at different speed.

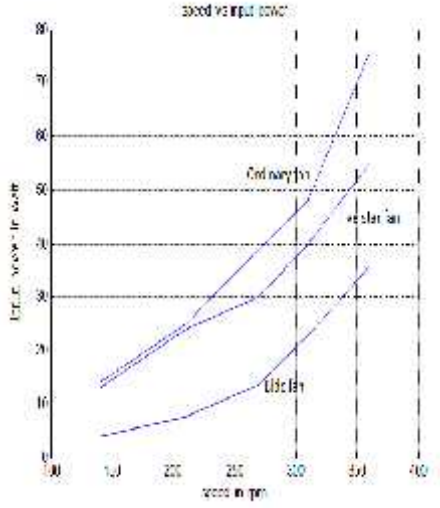

Fig : speed vs input power

Airflow in cfm

TABLE 3: Air Flow of various fans at different speed.

SPEED(rpm)	BLDC FAN(cfm)	FIVE STAR FAN(cfm)	ORDINARY FAN(cfm)
140	467	420	434
210	267	200	234
270	200	160	167
310	134	95	109
360	100	28	34

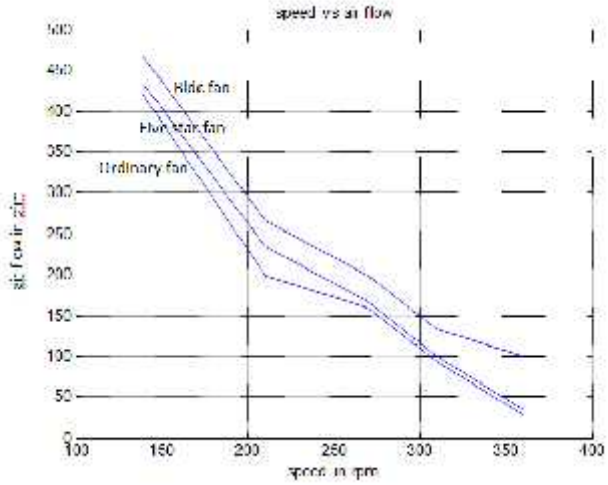

Fig4 : speed vs air flow

Service value/Air flow efficiency

TABLE 4: Air Flow Efficiency of various fans at different speed.

SPEED (rpm)	BLDC FAN(cfm)	FIVE STAR FAN(cfm)	ORDINARY FAN(cfm)
140	13.34	8.68	5.78
210	7.6	4	3.12
270	5.71	3.34	2.22
310	3.8	2	1.33
360	2.87	0.68	0.453

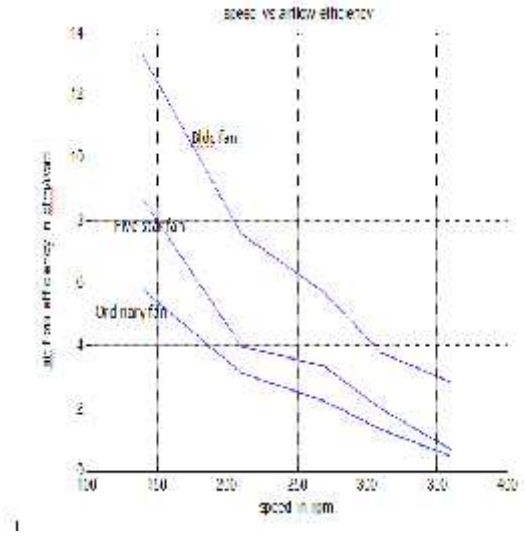

Fig 5: speed vs air flow efficiency

Cost Analysis

For BLDC Fan

For 1hr – 0.035 KWh

Our observation is for 10hours: 10hr – 0.35 KWh

For one month: 0.35 * 30 = 10.5 KWh

For one year: 10.5*12 = 126unit

Cost of one unit = Rs.5.5/-(say)

Total cost = Rs.693

For Five Star Fan

For 1hr – 0.050 KWh

Our observation, for 10hours: 10hr – 0.50 KWh

For one month: 0.50*30 = 15 KWh

For one year : 15*12 = 180unit

Cost of one unit = Rs.5.5/-(say)

Total cost = Rs.990

For Ordinary Fan

For 1hr – 0.075 KWh

Our observation, for 10hours: 10hr – 0.75 KWh

For one month: 0.75*30 = 22.5 KWh

For one year: 22.5*12 = 270unit

Cost of one unit = Rs.5.5/-(say)

Total cost = Rs.1485

So we can conclude that,

Electricity charges for usage of 16 hours every day @ Rs.5.50 per unit.

ORDINARY FAN – Rs.1485

BLDC FAN - Rs. 693

SAVINGS PER YEAR = Rs.792

No. of years	BLDC FAN (cost in rupees)	FIVE STAR FAN (cost in rupees)	ORDINARY FAN (cost in rupees)
1	693	990	1485
2	1386	1980	2970
3	2079	2970	4455
4	2772	3960	5940
5	3465	4950	7425

TABLE 5 : Cost of power usage of various fans for consecutive 5 years.

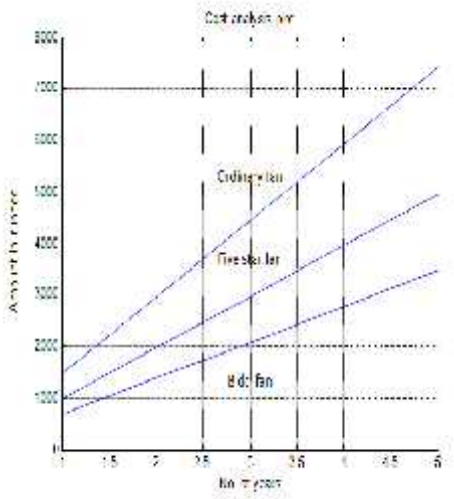

Fig 6 : Power consumption of various fans for consecutive 5 years

AUTOMATIC FEATURES

- Ceiling fans normally runs throughout night. Normally , temperature at night is much higher than temperature in the morning. So a fan is running at full speed irrespective of the surrounding temperature which leads to power wastage. Also normally in company offices, overhead ceiling fans are often left on when occupants leave rooms. Thus, the fans can consume unnecessary power in unoccupied rooms.In this project , in order to enhance the utility of BLDC fan we have automated the BLDC fan with the help of a PIR(Passive Infra-Red) sensor to detect the present of a human being and a Temperature sensor to regulate speed depending on the ambient temperature to enhance the power saving in ceiling fan.

Schematic diagram

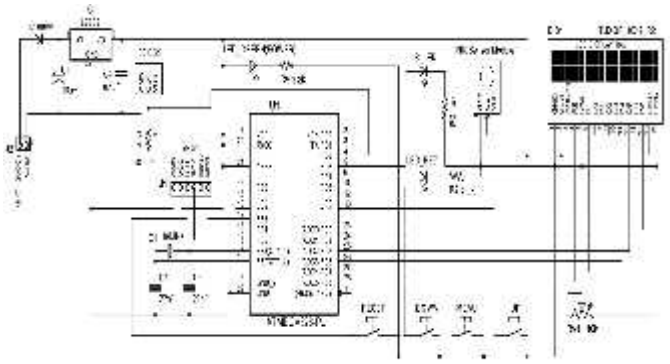

Fig 7: Schematic Diagram

Components

- Micro-controller-ATMEGA.328 PU
- PIR sensor- HC-SR501
- Temperature sensor- DS18B20
- Voltage Regulator- IC L7805
- Crystal Oscillator- 16 MHz
- LCD Display
- Dc Input- upto 12V can be supplied
- Switches, Diode, Capacitors , Resistors, LEDs including IR LED

Working

The DC input (<12V) given is regulated by IC L7805. The microcontroller ATMEGA.328-PU serves as the brain of the system. It is used to store the assembly language program of the system; it also controls, coordinates and manages all the activities of the system.PIR sensor HC-SR501 is used to detect the presence of a moving object;

as soon as it detects, it communicates it with the micro-controller.Temperature sensor DS18B20 reads the ambient temperature of the surrounding and communicates it with the micro-controller, which further processes the received data. The Liquid Crystal Display (LCD) is used by the microcontroller to communicate to the outside world. It displays the Fan speed as well as the room temperature at any point in time. 'MENU' switch is used to obtain the various levels of temperature, in this case 5 levels.'UP' and 'DOWN' switches are used to increase and decrease temperature in each levels. 'RESET' switch resets all the temperature to default value. Communication with the BLDC fan is done with the help of an IR LED. Thus, when entering the range of PIR sensor, the BLDC fan automatically turns on and depending on ambient temperature of surrounding, it automatically regulates its speed. Thereafter, on leaving the range of PIR sensor, fan automatically turns off.

Main advantage: - User friendly

:-More Power saving

Cost analysis of intelligent bldc fan

Normal BLDC fan (observed: 10pm-8am)

1hr – 0.035 KWh

Our observation, for 10hours:

10hr – 0.35 KWh

For one month: 10.5 KWh

For one year: 10.5*12 = 126unit

Cost of one unit = Rs.5.5/-(say)

Total cost = Rs.693/-

BLDC Fan in Intelligent mode (observed: 10pm-8am)

1hr – 0.031 KWh (0.030KWh-0.033KWh

Our observation, for 10hours:

10hr – 0.31 KWh

For one month: 9.3KWh

For one year: 9.3*12 = 111.6unit

Cost of one unit = Rs.5.5/-(say)

Total cost = Rs.613.8

Total profit = Rs.693-Rs.613=Rs.80/year

Conclusion

The paper proves that BLDC fan is much more efficient than ordinary fan and 5 star rated fan and hence to implement Microcontroller based automatic BLDC Fan speed regulation (using temperate sensor). The designed system automatically turns on/off in presence/absence of a human being and controls the speed of BLDC Fan (ceiling Fan) according to changes in room temperature .A PIR sensor is used to sense the presence of a human being and this information is send to the microcontroller for processing. This indoubtedly makes the Intelligent BLDC fan. A temperature sensor (DS18B20) is used to sense the room temperature and it is directly coupled to the Analogue to Digital Converter (ADC) whom major task is to convert the analogue data from

the temperature sensor to its digital equivalent required by the microcontroller for further processing. The microcontroller serves as the brain of the system. It is used to store all the assembly language program of the system; it also controls, coordinates and manages all the activities of the system. All the components that made up the system are directly or indirectly connected to it to achieve the designed project. The Liquid Crystal Display (LCD) is used by the microcontroller to communicate to the outside world. It displays the Fan speed as well as the room temperature at any point in time. The speed of the Fan increases with the increase in room temperature and decreases with decrease in room temperature. Normally people tend to cover themselves and let the Fan run at the same speed. This results in several types of illness in people and also causes wastage of electricity due to Fan being operated at speed more than required, thus spending 80~100 watts whereas the desired Fan speed was the speed corresponding to 20 ~ 30 watts electricity consumption. This causes wastage of electricity along with resulting illness. Therefore, we decided to work out a solution for controlling Fan speed (automatically). The designed system is economical and easy to operate across people of all age range. The system performs the operation in an effective and efficient way. The system is very useful for all areas where temperature variation overnight is considerably high. Finally, the designed system is a remarkable breakthrough in monitoring and control system technology and should be adopted in order to explore all its numerous benefits.

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