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DESIGN OF TEMPERATURE BASED SPEED CONTROL SYSTEM USING ARDUINO MICROCONTROLLER

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ABSTRACT

This article describes the design of fan speed control system based on variation of room temperature, using an Arduino microcontroller. The speed of the mono phase A. C Fan is made to vary, according to the room temperature conditions, as detected by the use of a temperature sensor. The variation in the recordings of the temperature sensor is used as an input to the Arduino microcontroller. Hence forth, the microcontroller excites the circuit responsible for driving the fan.

Keywords: Mono-phase, Temperature sensor, Self-regulatory mechanism, Arduino.

INTRODUCTION

Manifold advancements in the field of technology and science are being witnessed by mankind today. Due to these advancements sophisticated, smart and intelligent systems are being developed every day. In the development of these smart systems, microcontrollers play an extremely vital role. The sensor controlled technique of varying the speed of a single-phase A.C fan is used in this project. For lighting and general purposes in homes, offices, shops, small factories single phase system is widely used as compared to three phase system as the single phase system is more economical and the power requirement in most of the houses, shops, offices are small, which can be easily met by single phase system. The single phase motors are simple in construction, cheap in cost, reliable and easy to repair and maintain. Due to all these advantages the single phase motor finds its application in vacuum cleaner, fans, washing machine, centrifugal pump, blowers, small toys etc. It is to be noted that the A.C motor is not directly connected with microcontroller because a microcontroller cannot supply current for the working of an A.C motor.

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System model

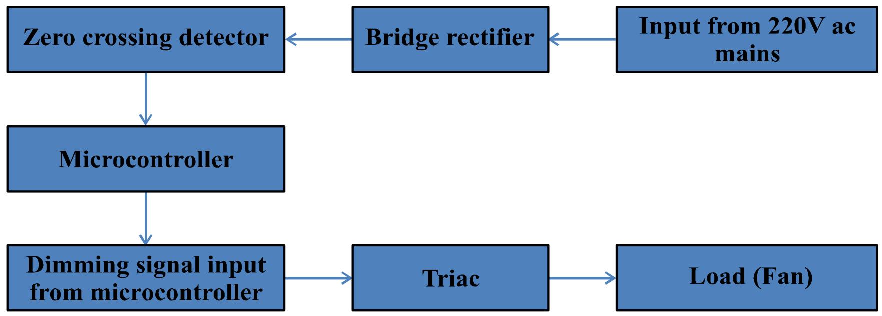

Fig. 1: Block diagram

Fig. 1 shows the system model used in this work. Zero crossing detector output given as input to microcontroller. Control signal for triac is taken from microcontroller. Fig. 2 shows the circuit diagram of this system model.

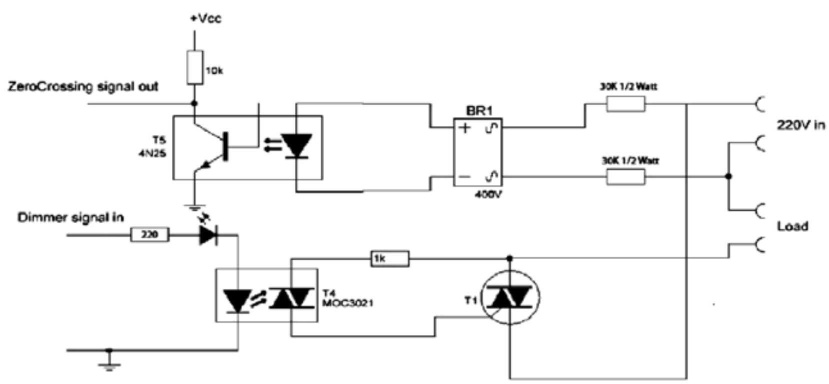

Fig. 2: Circuit diagram

Resistances of 1-watt power rating are used as it is considerably higher than the actual value of power dissipated in each of the resistances.1000 Volts bridge rectifier is made using 1N4001 PN diode[2]. It is used to convert the ac input supply to dc supply which in turn will light up the LED of the 4N25 opto-coupler[3]. The 4N25 opto-coupler is used as a circuit isolator. Here, it isolates the 220V ac supply input block from the Arduino microcontroller. It is used as a safety providing device (protects delicate components). As soon as the LED of the opto-coupler switches off at the zero crossing, a pulse of 5V is generated. A 10kΩ resistor (pull down) is connected in series with the collector of the transistor[4] present in the opto-coupler, to prevent it from getting damaged by high magnitude supply inputs. Chopping action of Triac is given in Fig. 3.

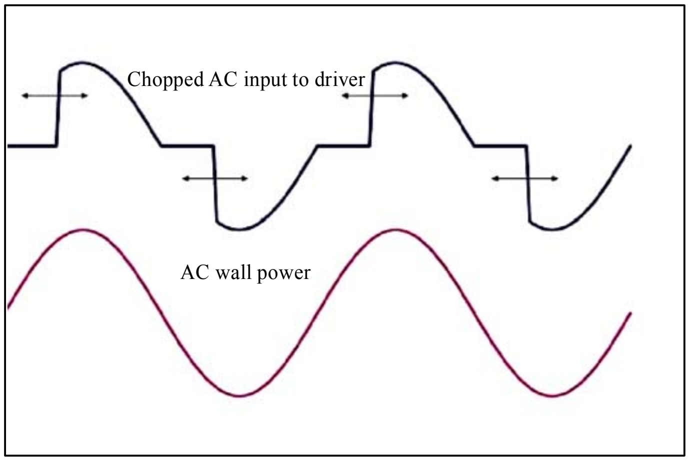

Fig. 3: Chopping action of Triac

An Arduino microcontroller[1] is used to open the triac[5] for a finite number of microseconds. The major problem which arises is that it is unpredictable to ascertain as to when the triac should be opened and therefore the dimming is unpredictable. A reference point is required in the input sinusoidal wave. To tackle this issue, a zero crossing detector circuit is used to convey to the Arduino microcontroller as to when the sinusoidal input reaches zero. Opening the triac for the desired number of microseconds from the zero crossing position gives the required delay in the input signal. This method is called ac phase control. We detect this with an Arduino and place in interrupts to time the trigger circuits precisely in synchronization with these zero crossing events. Fig. 4 indicates the delay action of triac.

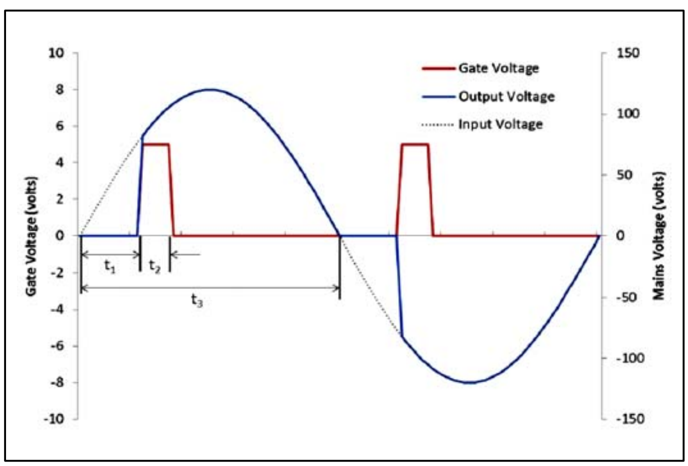

Fig. 4: Delay action of Triac

Once a zero crossing is detected, the triac remains switched off for a controlled time (t1). The longer the delay time is; the less power the ac circuit receives. Once the off time- t1 has elapsed, the microcontroller turns on the triac by applying a voltage to the gate. The triac will remain on even after the gate voltage has been removed. It will turn off if the gate voltage reaches zero (the next time the input ac wave crosses zero). Therefore, it is important that the triac turns off inside the half wave (t3). The duration of the gate pulse (t2) is determined by the minimum requirement of the triac. If this pulse is too short the triac will not fire. Once the second zero crossing occurs, since there is no gate voltage, the triac remains off until triggered again in the next half cycle. The net result is that certain parts of the input wave are chopped out resulting in lower average power. The Dimming signal obtained is fed to the MOC3021[7] opto-coupler. The interrupt routine feeds a signal of a specific length to one of the I/O pins. The I/O pin signal goes back to our circuit and opens the LED and a MOC3021 that triggers the Opto-Thyristor[8] briefly. The LED in series with the MOC3021 indicates if there is any current going through the MOC3021. The opto-coupler is further attached to a snubber circuit. The snubber circuit consists of an additional resistor and capacitor. This circuit protects the triac from the high voltage generated from an inductive load.

Mathematical analysis

This section deals with a complete mathematical analysis used in this model and the related expression. Resistances of 1-watt power ratings are used in the input supply circuitry as they are considerably higher than the actual value of power dissipated in each of the resistances. And the results are verified after implementation.

$$\text{Power dissipated} = \frac{(220\text{V})^2}{33\text{k} + 33\text{k}} = 0.7 \text{ W (Approx)}$$

The peak inverse voltage of the bridge rectifier used in the input supply circuitry is given by, PIV = $\sqrt{2} \times \text{Vp}$ = 330V. Therefore, a 1000V bridge rectifier is used.Arduino timer and interrupts are used to control the timings of the triac gate. For a half cycle, t(half) = 10 ms.

The dimming is arbitrarily varied from 0-128 steps by the triac. Therefore, every interrupt is of 10 ms, and each interrupt is further subdivided into- = $\left(\frac{10000}{128}\right)$ us = 78 (approx. 75).

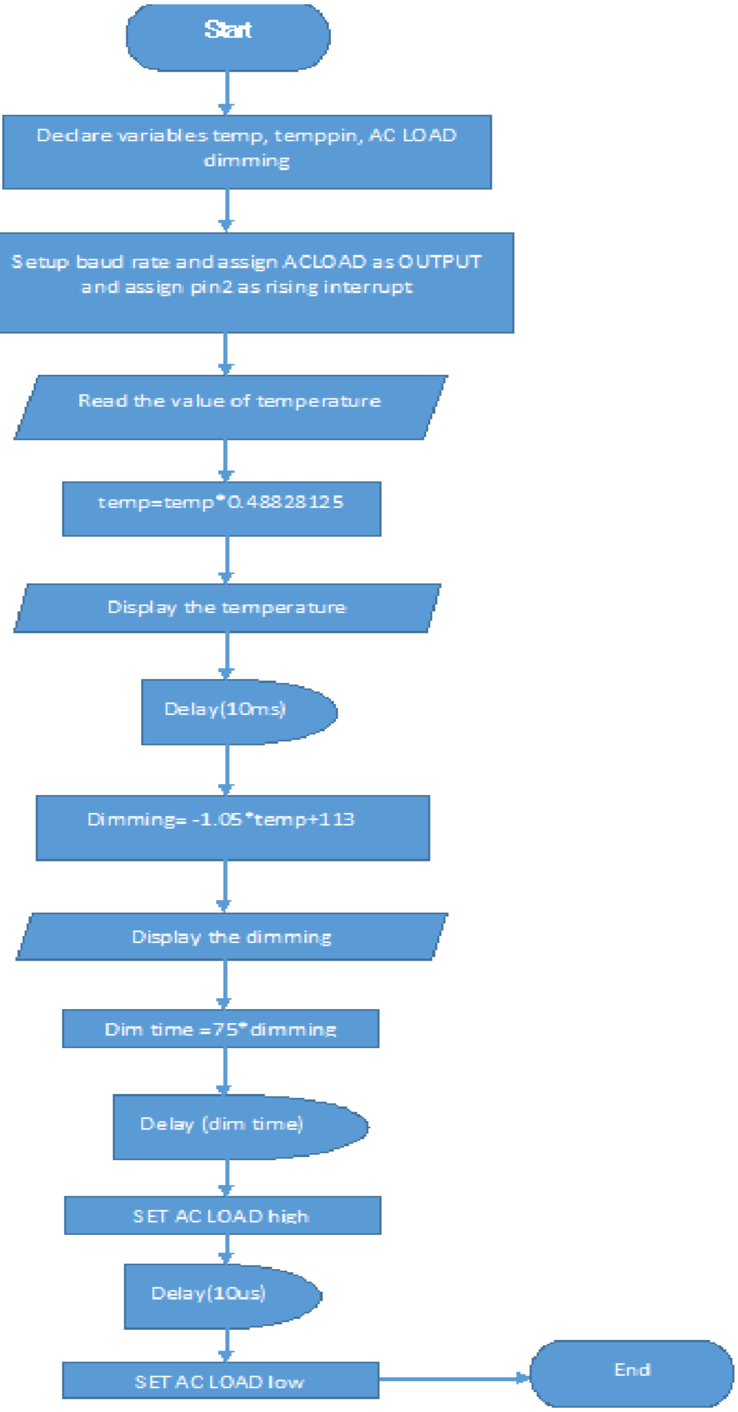

Fig. 5: Flow chart

RESULTS AND DISCUSSION

LM35[6] is a temperature sensor which is powered up using Arduino microcontroller. It has an output voltage linearly proportional to the Celsius temperature. The temperature which this sensor can measure is -55□C to 150□C. The variations in the dimming time with changing temperature is represented by the following tables. Table 1 gives information about dimming variable for various temperature values.

Table 1: Readings Obtained from Arduino Serial Monitor

Temperature	Dimming time (us)	Temperature	Dimming time (us)
30	82	54	56
31	80	55	55
32	79	56	54
33	78	57	53
34	77	58	52
35	76	59	51
36	75	60	50
37	74	61	49
38	73	62	48
39	72	63	47
40	71	64	46
41	70	65	45
42	69	66	44
43	68	67	43
44	67	68	42
45	66	69	41
46	65	70	40
47	64	71	38
48	63	72	37
49	62	73	36

Cont…

Temperature	Dimming time (us)	Temperature	Dimming time (us)
50	61	74	35
51	59	75	34
52	58	76	33
53	57	77	32
		78	31
		79	30
		80	29

Table 2: Variation of fan speed with temperature

Temperature	Speed
< 30°C	Fan does not work
30°C-80°C	Varies linearly
> 80°C	Does not vary

From the above tables, we infer that the dimming (delay) variable decreases linearly with rise in temperature. The decrease in the delay time results in higher power dissipation across the load and consequently increases the fan speed.

CONCLUSION

Using this fan design, the power consumption is reduced as the speed of fan is varied according to the temperature conditions. This design of controlling fan speed is appropriate according to modern needs and the self-regulatory mechanism is proposed as a viable alternative to manual fan speed controlling systems i.e. regulators. Temperature based automatic control systems can be used in the field of Internet of Things (IoT), to design intricate electronic circuits, which can potentially solve real life problems.

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