Novel energy efficient Solid State Voltage Regulator for Fan used in rehabilitation centers.
Dr. Narendra B Soni (Orcid ID: 0000-0002-7825-9456)
Associate Professor, UPES, Dehradun, India
nbsoni@ddn.upes.ac.in

Abstract: Electrical fans are most widely used appliance across the world. The domestic fans have low power rating and energy saving in a single fan is limited. However, but as the numbers of fans across the world are large in number there is a scope of saving energy in large. The present technologies have certain limitations as humming noise, low life etc. The proposed method is able to demonstrate the energy saving using the 'Integrated cycle control' method to control the speed of fans.

Key Words: Fan Regulator, Energy Saving, Solid State, Integral Cycle Control

Introduction: Today’s world is going through an era of technology. All the time we go through the current technological developments. We wake through the alarm and the day starts.

This continuous enhancement of technology has grown in multi folds. As the human being is depends on technology and machines, the physical work support of human being has been reduced. Man is becoming more and more dependant on machines.

As the requirement of machines is increasing, the prospectus of need of energy sources is increasing. The energy sources can be either electrical energy or may be petroleum etc, the demand is increasing. But at the same time the natural resources of energy are decreasing.

The electrical energy is a best form of energy. Though it is not naturally available, but conversion of any type of energy in to electrical energy and transmitting it is a best alternative among all types of energy sources due to its various advantages in transmission and utilization.

The electrical energy is generated by means of combustion of fossil fuels, using hydro energy or by any other means by which we can rotate the wheels of the turbines. But these natural resources are also diminishing over a period of time.

There is need of look for an alternative source of energy or the preserving the precious energy sources available. I believe in the latter. Preserving the energy is more generous than the generating energy by any other means.

It is possible to conserve energy by means of not utilizing it or by using it effectively (& efficiently), i.e. the optimal use of energy. Not using energy cannot be a solution, as the technology meant for utilization.
There is need of using energy effectively (& efficiently). There are different ways of effective use of energy. We can save energy by using the energy efficient devices or by using modern electronics devices for control of motors. We can conserve energy simply by switching ‘OFF’ the gazettes when they are not in use.

**Present Technology:** In the proposed scheme or a technology by which it is possible to save energy in control of electrical motors in particular house hold fans.

A present the speed of fan has been controlled by two means in general.

A) By decreasing the voltage across fan by decreasing its amplitude. This is achieved by two ways:

   i) By adding a resister in series with fan so that it will cause some voltage drop across the resistance and the resultant voltage across fan will decrease. This method has disadvantage of causing power loss across resistance.

   ii) In second method we can introduce a tapped inductor (transformer) to supply power to fan. The voltage across fan will decrease but it has a disadvantage losses occurred in inductor (or transformer) and low power factor.

B) In second method the voltage across fan is reduced by means of use of power electronics devices, say thyristors. By controlling the firing angle of Triac we can control the voltage across the fan. This method has the disadvantage of non-sinusoidal waveform across fan and hence causing harmonics and humming sound.

Both the methods are controlling speed but has inherent disadvantage.

**Proposed Method:** Consider a fan is rotating at normal speed without any control. Now if the power is switched ‘Off’ for a while and again put ‘On’ (i.e. OFF and ON the immediate action), it can be observed that there will not be much change in the speed of fan. Because, though during the time the fan is switched ‘OFF’ the fan (may be in fraction of seconds), the fan will not develop any (mechanical) torque but continue to rotate, due to its inertia. But during the time the fan is switched ‘OFF’ the electrical power will be saved.

Thus the variation of ‘ON’ & ‘OFF’ time that is duty cycle can be used to control the speed of fan. There will not be change in amplitude of applied voltage or there will not be clipping of waveform. The fan will rotate between two speeds (or say an average speed). This speed variation can be made smooth with frequent ‘OFF’ and ‘ON’ operations.

The advantage of this method is that we will save power completely during the ‘OFF’ time & there will not be even losses during that time. Where as, in previous two methods losses will take place due to continuation of supply, may be with reduced amplitude or so, but losses will take place.
Switching: The frequency of AC supply in India is 50 Hz. Each cycle takes 20 milliseconds. Suppose we supply 5 cycles contentiously and switch ‘OFF’ for 2 cycles, the effective voltage across fan would be that of 5 cycles over a period of 7 cycles. The mechanical torque generated by fan will be by 5 cycles and that will keep fan rotating for next two cycles, due to inertia (with minute decrease in speed). Obviously in next 5 cycles again speed will increase and fan continue to rotate with average speed, with 5 accelerating torque cycles and 2 de-accelerating torque cycles. If the number of cycles of accelerating torque and de-accelerating torques are varied accordingly the speed of fan will vary.

Refer fig 1 a, b, c, d, e, f, g to understand the waveform at each stage of circuit and the final voltage, current and speed of fan. The speed of fan is proportional to applied voltage.

Fig. 1 (a) to (g)
Circuit Diagram: The representative block diagram is as following. 555 timer is used as Voltage Controlled Oscillator (VCO) to vary the duty cycle and a Zero Crossing Detector (ZCD) is used to generate pulse at every zero crossing of input sine wave. The 555 timer output is ‘AND’ed with ZCD out put, thus giving output pulses for every Zero crossing and only during ‘ON’ time of timer. The output of ‘AND’ gate is used as firing pulses to Triac through OptoCoupler. Thus, Triac ‘ON’ for every ‘Zero’ crossing of AC cycle (both positive and Negative) as long as output of VCO is ‘On’ and will remain in off state when output of VCO is ‘Off’.

![Fig 2 Block Diagram](image)

Circuit Description: A ‘555’ timer is uses as Voltage Controlled Oscillator. The out put of ‘555’ timer can be controlled by varying the resistance R_a and R_b. Thus we can control the ‘ON’ and ‘OFF’ timings of the fan. Refer Fig. 3. The output of this ‘555 as shown in Fig 1(b) timer is given to an AND gate No. 7408.

![Circuit Description](image)
ZCD is supplied with a center tap step down transformer of 230:5 V is used from the same supply of the fan. The out of transformer has been given to the LM 741 used as Zero Crossing Detector through two diodes as shown in fig.4. These diodes will bypass the positive and negative cycles of AC wave. However, as LM741 is acting as open loop amplifier, during every zero crossing the amplifier will generate a pulse and thus it will act as Zero Crossing Detector (ZCD) and will generate pulses as shown in fig 1 (c).

The diodes will pass the positive part of AC cycle and clip the negative part of AC cycle. The arrangement will cause diode D₁ to conduct for positive half cycle of AC mains (as on primary side) and diode D₂ will conduct for the Negative half cycle of AC mains (as on primary side).

ZCD will generate pulses at a time duration of 10 ms (for 50 Hz supply).

The width and amplitude of the pulses generated should be sufficient to trigger the Triac. The width of pulse should be more than the turn ‘ON’ time of Triac.

These train of pulses, each equally placed at a distance of 10 ms are ANDed with the output of ‘555’ timer Fig 1 (b).
The output of AND gate will be high as long both the inputs are high. Hence, as long as the output of ‘555’ timer is high there will be train of pulses at the output of AND Gate. These pulses will used to trigger the Triac. As the pulses are generated at ‘Zero’ of every half cycle, that complete half cycle will appear across load (fan).

When the output of the ‘555’ timer is low, the output of AND gate will also go low zero. As the pulse is not generated, Trice will not be fired at next half cycle that causes voltage across fan Zero.

This train of pulses is given to an isolating transformer or opto-coupler. They are used to isolate the high power and low power circuit. The output of isolating transformer/opto-coupler (same as input) is given to Triac.

![Fig 6 Main Power Circuit](image)

The Triac is connected in series with fan and supply. As soon as Triac is triggered the supply voltage will appear across fan and fan will be developing mechanical torque. The triggering instance of Triac is always at zero degrees for the cycle to which it is to be triggered. Thus always that complete half wave will appear across fan.

The sequence of operation is as follows: The ‘ON’ and ‘OFF’ timing of ‘555’ timer is adjusted by varying R_a. A potentiometer of suitable value is used as R_a. The frequency of out put of ‘555’ timer is maintained between half Hz (HIGH for 10 millisecond in every one 1 second) to 100 Hz (HIGH for complete 1 second).

The output of ‘555’ timer is such that, it is high for 10 ms, out of 1 second, (that is generating a pulse of, pulse width of 10 ms in one second) and remains LOW during remaining time (990 ms). This output is ANDed with output of ‘OR’ gate. The out put of AND gate will be one pulse in one second and so on. Thus the Triac will be triggered only for 1 half-cycle in every second and so-on and the voltage across fan will be minimum (almost zero).

Now, when the output of ‘555’ timer is high for complete one second, and it is ANDed with output of ‘OR’ gate, the out put of AND gate will be hundred pulses in one second and so on. Thus the Triac will be triggered for all the cycles (half cycles) in one second and the voltage across fan will be maximum (supply voltage) voltage.
The voltage across the fan can be varied between maximum and minimum, the by varying $R_1$ of VCO. The Duty cycle can vary output of VCO such that it will ‘ON’ and ‘OFF’ for required durations.

For example say, VCO will remain high 60 millisecond and ‘OFF’ for say 40 milliseconds than output of AND gate will 6 pulses and the for 40 milliseconds no pulses and so on. Thus thyristor will be triggered for first 6 half cycles and remain blocked for next 4 half cycles. Thus the effective voltage across fan will be of 6 half cycles (3 cycles) in every 10 half cycles (5 cycles).

The effective voltage is controlled by the ‘ON’ and ‘OFF’ timing, not by reducing the amplitude. Thus during the ‘OFF’ time, there is no power supplied to fan but the fan is continuously rotating (with gradually decreasing speed) and we have saved the energy by utilizing the inertia of fan.

The graph of speed variation of fan would be shown as in fig.1(g).

This method has definite advantage of energy conservation. The Disadvantage of the method could be the pulsating torque developed. This pulsating torque effect can be neglected as the inertia of fan will not cause to decrease in speed drastically. The second method, by which pulsating torque can be reduced, is by using distributed ON and OFF operations. Like suppose if want say 70 % of voltage to be across fan, then instead giving 70 ‘ON’ simultaneous pulses and 30 ‘OFF’ simultaneous pulses, it is recommended to supply two ‘ON’ pulses and one ‘OFF’ pulse and so on for a second and then follow on. Thus, there will total around 67 ‘ON’ pulses distributed and 33 ‘OFF’ pulses distributed.

The starting current of electrical motors is normally very high. But such problem will not occur, as the fan is continuously in motion during ‘OFF’ cycles also.

**Conclusion:** This method of ‘On’-‘Off’ cycle control will have distinct advantage of reduced losses and hence energy consumption. The various waveforms for the proposal as shown in fig 1 (a) to 1 (g).

**References:**


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