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Thyristor Power Controlled Fed DomesticLoads Using Microcontroller

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ABSTRACT

This paper is designed to control AC power to a loads by using firing angle control of thyristor. Efficiency of such power control is very high compared to any other method. The project uses zero crossing point of the waveform which is detected by a comparator whose output is then fed to the microcontroller. The microcontroller provides required delayed triggering control to a pair of SCRs through opto-isolator interface. Finally, the power is applied to the load through the SCRs in series. This project uses a microcontroller AT89C52 which is interfaced through a controller switch for increasing or decreasing the AC power to the load. A lamp, fan and some other loads is used whose varying intensity demonstrates the varying power to the loads. The varying power results in variation in speed of the loads.

Keywords—*triac; optocoupler;8051 series microcontroller; Voltage regulator;*

I. INTRODUCTION

The Thyristor power controlled fed domestic loads using microcontroller is to design an electronic circuit which can control intensity of an electric bulb and speed of a fan using regulator or using serial port interface. RMS voltage across a triac is related to the RMS voltage of the mains according to the following relation. Vrms(load) = Vrms(mains) (1- θ/π)0.5 Here, θ is the firing angle of the triac measured from the zero crossing point. Thus by changing the firing angle we can regulate the voltage across the load. Hence we can vary the intensity/speed of the light/ fan. If θ is zero i.e. if triac is fired at the zero crossing, then maximum power is transferred to the load similarly if triac is fired at the peak of the cycle (i.e. θ= π/2) then only half of the power is transferred to the load. We are also monitoring the attenuated unregulated DC input voltage using an ADC, so as to provide voltage regulation against the mains voltage. For regulation against the mains frequency we are changing the instance of firing of the triac. The improvement of the power electronics devices, the power flow to the motor is controlled by the switching action of the power switches MOSFET, TRIAC, IGBT, etc. The nature of the speed control required an industrial drive depends upon its type. The drives required continuous variation of speed throughout the operation of the speed. The TRIAC is used for firing angle control. At starting speed is manually set. When firing angle is set and then display by the seven segment display.

If difference is maximum, decreasing the firing angle and speed increases and matches the set speed. In this paper, domestic load control system is discussed. The device is able to control different home appliances within a particular range. The circuit is connected to any home appliances (lamp, fan, motor, etc.) to make the appliance switch on/off and regulate the fan speed from a regulator.

Most of the electrical appliances used at domestic loads require AC power for their operation. This AC power or AC current is given to the appliances through the switching operation of some power electronic switches. For a smooth operation of the loads, it is necessary to control the AC power to them.

This is achieved in turn by controlling the switching operation of the power electronic switches, like an SCR.The firing angle is varied by using the opto-isolator connected the thyristor. Thus the load voltage and power to the load will varies accordingly as shown in Fig-1 below.

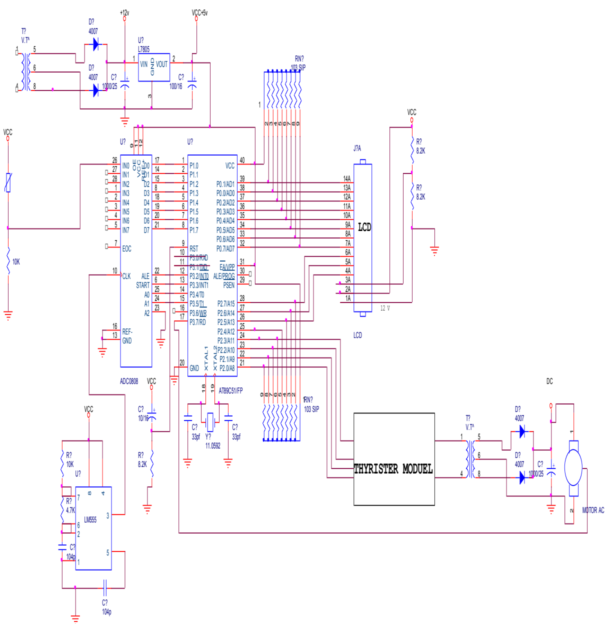


Figure 1: Proposed configuration of the thyristor power controlled fed domestic loads using microcontroller.

II. System Configuration

The design of the wiring connections of the thyristor power controlled fed domestic loads using microcontroller. From the circuit 5V DC and 12V DC is required to drive the all the components. The mains give the 230V AC. So first we step down the 230V AC in to 12V AC by using step down transformer. Then the output is given to the full wave rectifier as given in the circuit diagram.

The rectifier is eliminating the negative peek voltage of the input voltage. The output of the rectifier is the pulsating dc as shown in the block diagram of the rectifier. The error pulses are eliminated by using the capacitor filter. Then the output at the parallel of the capacitor is the 12V DC. But the Micro Controller is work on 5V DC so convert the 12V DC in the 5V DC we are using regulator (7805). The output of the regulator is constant irrespective of the input voltage.

III. Control Scheme

The AT89C52 is a low-power, high-performance CMOS 8-bit microcomputer with 8K bytes of Flash programmable and erasable read only memory (PEROM). The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard 80C51 and 80C52 instruction set and pinout. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel AT89C52 is a powerful microcomputer which provides a highly-flexible and cost-effective solution to many embedded control. The microcontroller generic part number actually includes a whole family of microcontrollers that have numbers ranging from 8031to 8751 and are available in N-Channel Metal Oxide Silicon (NMOS) and Complementary Metal Oxide Silicon (CMOS) construction in a variety of package types.

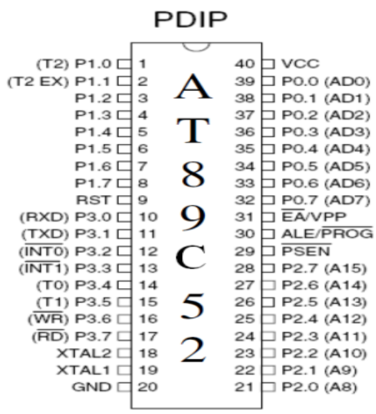


Figure 2: Pin Diagram of AT89C52 microcontroller

with 4Kbytes of Flash Programmable and Erasable Read Only Memory (PEROM). The device is manufactured using Atmel's high density nonvolatile memory technology and is compatible with the industry standard MCS-51 instruction set and pinout. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel AT89C52 is a powerful microcomputer which provides a highly flexible and cost effective solution to many embedded control applications.

The AT89C52 provides the following standard features: 4 Kbytes of Flash, 256 bytes of RAM, 32 I/O lines, two 16-bit timer/counters, a five vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator and clock circuitry. In addition, the AT89C52 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port and interrupt system to continue functioning. The Power down Mode saves the RAM contents but freezes the oscillator disabling all other chip functions until the next hardware reset.

Port 0:

Port 0 is an 8-bit open drain bidirectional I/O port. As an output port each pin can sink eight TTL inputs. When 1s are written to port 0 pins, the pins can be used as high-impedance inputs. Port 0 may also be configured to be the multiplexed low order address/data bus during accesses to external program and data memory. In this mode P0 has internal pull-ups. Port 0 also receives the code bytes during Flash programming, and outputs the code bytes during program verification. External pull-ups are required during program verification

Port 1:

Port 1 is an 8-bit bi-directional I/O port with internal pull-ups. The Port 1 output buffers can sink/source four TTL inputs. When 1s are written to Port 1 pins they are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 1 pins that are externally being pulled low will source current (IIL) because of the internal pull-ups. Port 1 also receives the low-order address bytes during Flash programming and program verification.

Port 2:

Port 2 is an 8-bit bidirectional I/O port with internal pull-ups. The Port 2 output buffers can sink/source four TTL inputs. When 1s are written to Port 2 pins they are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 2 pins that are externally being pulled low will source current (IIL) because of the internal pullups. Port2 emits the high-order address byte during fetches from external program memory and during accesses to external data memory that use 16-bit addresses (MOVX A,@DPTR). In this application it uses strong internal pull-ups when emitting 1s. During accesses to external data memory that uses 8-bit addresses (MOVX A, @RI), Port 2 emits the contents of the P2 Special Function Register. Port 2 also receives the high-order address bits and some control signals during Flash programming and verification.

Port 3:

Port 3 is an 8-bit bidirectional I/O port with internal pull-ups. The Port 3 output buffers can sink/source four TTL inputs. When 1s are written to Port 3 pins they are pulled high bythe internal pull-ups and can be used as inputs. As inputs, Port 3 pins that are externally being pulled low will source current (IIL) because of the pull-ups. Port 3 also serves the functions of various special features of the AT89C52 microcontroller.

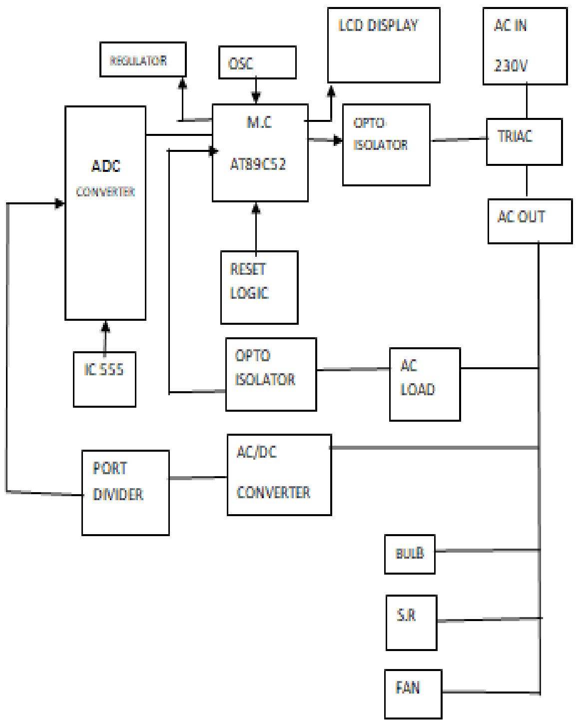


Figure 3: Block diagram of thyristor power controlled fed domestic loads using microcontroller.

thyristor controlled device by using the firing angle it consists of power supply unit with bridge rectifier used to convert 230V input supply to 12V output. And it is connected to the voltage regulator to regulate 5V DC. zero voltage reference is used to compare the output voltage. optoisolator is coupled with the antiparallel thyristor to vary the firing angle.

The circuit diagram shows the wiring connections of the thyristor power controlled fed domestic loads using microcontroller. From the circuit 5V DC and 12V DC is required to drive the all the components. The mains give the 230V AC. So first we step down the 230V AC in to 12V AC by using step down transformer. Then the output is given to the full wave rectifier as given in the circuit diagram.

The rectifier is eliminating the negative peek voltage of the input voltage. The output of the rectifier is the pulsating dc as shown in the block diagram of the rectifier. The error pulses are eliminated by using the capacitor filter. Then the output at the parallel of the capacitor is the 12V DC. But the Micro Controller is work on 5V DC so convert the 12V DC in the 5V DC we are using regulator (7805).The output of the regulator is constant irrespective of the input voltage.

The Microcontroller requires the preset logic circuit for protection of the internal program and internal clock when in the power failure. A sudden change in the power may cause data error. These types of the errors will corrupt the internal program. For this purpose we must use reset logic. The reset logic circuit contains one capacitor and a resistor. This arrangement is shown in the Microcontroller circuit.

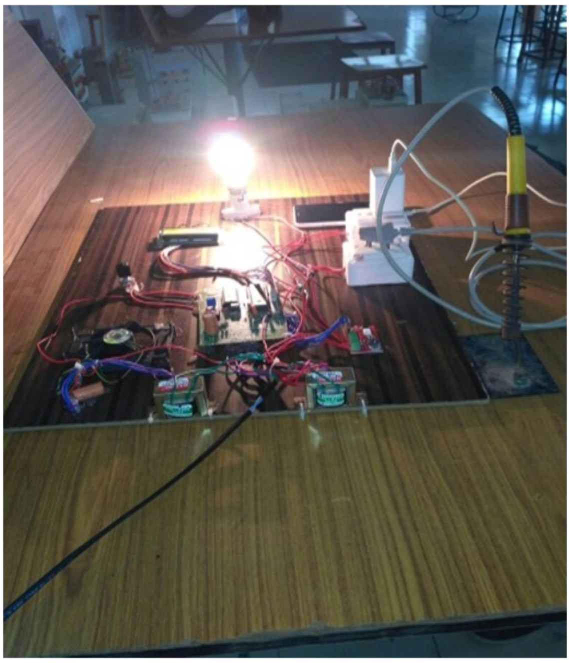
XTAL1 and XTAL2 are the input and output, respectively. An inverting amplifier which is configured an on-chip oscillator, as shown in Figure 2. Either a quartz crystal or ceramic resonator may be used. To drive the device from an external clock source, XTAL2 should be left unconnected while XTAL1 is driven as shown in Figure 2. There are no requirements on the duty cycle of the external clock signal, since the input to the internal clocking circuitry is through a divide-by-two flip-flop, but minimum and maximum voltage high and low time specifications must be observed.

The driver circuit generally made by using one transistor and one relay. The driver circuit is mainly operated by the Micro Controller. The Micro controller changes the state of the output pin from the low to high i.e., from '0' level to the '1' level. By using this sequence to control the base of the transistor. The transistor will act as ON/OFF switch corresponding to the input of the base. If the base current of the transistor will high the transistor is under ON condition else it is in OFF state. These conditions will be used to control the relay.

The basic information of this total circuit is display in the LCD display. This display can display the alphanumeric information related to the conditions of the relay with respect to the PC data. This display is having 16 pins. In this 1st pin is GND 2nd pin is Vcc and 3rd pin is contrast after that 3 pins are used control the data to display the data in which location can be set by these pins. The 15th and 16th pins are used for the back light LED. The remaining 8 pins of the display are for data. These pins are used to transfer the data that is to be displayed.

IV Hardware Implementation

AC power control with thyristor using microcontrolle is designed to control AC power flow across load is shown in Fig -4. This project is designed using AT89C52 microcontrolle and Zero crossing detection circuit. Phase angle control method is used for AC power control with thyristor. Thyristor is used as a switch to control flow of power. AT89C52 microcontroller is used to detect zero crossin and to generate pulse signals at a specific angle for thyristor. Here loads require 230V power supply but microcontroller used requires 5V supply. So the supply is being given to step down transformer acts as full wave rectifier. The output is given to voltage regulator LM358. The IC regulates delivers 5V constant dc voltage to microcontroller. A zero crossing detector is being placed across the full wave rectifier. It generates pulses only when the output is zero. Thus zero voltage generates the pulses at zero crossing detector. A diode is grounded at anode in between zero crossing detectors and the fullwave rectifier. If there is any voltage then it make diode gets activated to make voltage zero. The step-down transformer is also given by the 230V, 50Hz ac supply to the motor through TRIAC and optocoupler. The TRIAC and optocoupler are being used to control the firing angle of the input voltage pulse.



(a) Hard ware design at $\alpha=10^0$

(b) Hard ware design at α=90⁰

Figure 4: Hardware Implementation Circuit

This thyristor controlled power system works on the principle of firing angle change of the thyristor. When the firing angle is changed then the output is changed. This system has two switched one for switch on this system and one for firing angle change switch. This system is powered on directly from power supply and we would be checked this system by checking the brightness of the output bulb. When this system is switched on and press the firing angle switch then the comparator compare the two inputs and gives the signal to the microcontroller. The microcontroller in which set the delay time of firing angle through the programming language and then the microcontroller gives the delayed signal to the optocoupler then the optocoupler gives the firing signal to the thyristor. Based on this firing angle the thyristor on or off and then this thyristor on or off the output load. The firing angle is changed by changing the delay time and when the delay time is change then the output power is changed. The output power is inversely proportional to the delay time means when the delay is increase then the output power decrease. Here we would be check this system by changing the firing angle. When the firing angle is change then the output power is changed and then the brightness of the lamp is also changed.

In this system, the zero-crossing point of the waveform is detected by a comparator whose output is then fed to the microcontroller. Then, it provides the required delayed triggering control to a pair of SCRs through an opto-isolator interface in between the controller and SCRs. Finally, the power is applied to the load through the SCRs. The controller is used for increasing or decreasing the AC power to the loads whose varying intensity illustrates the reduced power to the motor. The variation in the speed of the motor depends on the reduced power. This power control topology or technique has high performance and efficiency as compared to the other power control techniques. In this technique, the voltage would be detecting at every precise moment of time and then the thyristor would be triggered at any voltage. By doing this the power can be controlled easily. Here we would be made this thyristor controlled power system with the help of single phase transformer, Bridger rectifier, voltage regulator, semiconductor switch SCR, microcontroller AT89C52 which is belongs to pic family, comparator and optocoupler or opto-isolator.

Mathematical analysis:

The input supply voltage of the thyristor system is presented below with consolidated Experimental calculations in table 1

$$V_s = V_m \sin\omega t = \sqrt{Vs \sin\omega t}$$

The output voltage and current across the load is given below

$$V_0 = VL = V_m \sin\omega t;$$
$$V_0(rms)^2 = VL^2 = \int_0^{2\Pi} VL^2 d(\omega t)$$
$$V_0(rms) = V_s \sqrt{\frac{1}{\Pi}(\Pi - \alpha) + \sin\frac{2\alpha}{2}}$$

System efficiency=system output%input wattage;

i) When $\alpha=10^0$

$$V_0\ (rms) = V_s\sqrt{\frac{1}{\Pi}(\Pi - 10) + sin\frac{2*10}{2}}$$

$V_0(rms)$ =219V
$I_0(amp)$ =219/100=2.19A;
P=VI=219*2.19=479.61W;

ii) When $\alpha=20^0$

$$V_0(rms) = V_s\sqrt{\frac{1}{\Pi}(\Pi - 20) + sin\frac{2*20}{2}}$$

$V_0(rms)$ =218V
I_0 (amp) =218/100=2.18A;
P=VI=218*2.18=475.24W;

iii) When $\alpha=40^0$

$$V_0(rms) = V_s\sqrt{\frac{1}{\Pi}(\Pi - 40) + sin\frac{2*40}{2}}$$

$V_0(rms)$ =203V
$I_0(amp)$ =203/100=2.03A;
P=VI=203*2.03=412.09W;

iv) When $\alpha=60^0$

$$V_0(rms) = V_s\sqrt{\frac{1}{\Pi}(\Pi - 60) + sin\frac{2*60}{2}}$$

$V_0(rms)$ =183V
$I_0(amp)$ =183/100=1.83A;
P=VI=183*1.83=334.89W;

v) When $\alpha=70^0$

$$V_0(rms) = V_s\sqrt{\frac{1}{\Pi}(\Pi - 70) + sin\frac{2*70}{2}}$$

$V_0(rms)$ =163V
I_0 (amp) =163/100=1.63A;
P=VI=163*1.63=265.69W;

vi) When $\alpha=90^0$

$$V_0(rms) = V_s\sqrt{\frac{1}{\Pi}(\Pi - 90) + sin\frac{2*90}{2}}$$

$V_0(rms)$ =123V
I_0 (amp) =123/100=1.23A;
P=VI=123*1.23=151.29W;

V. CONCLUSION

Thyristor power control is the one of the method to control the power. This method is the effective and efficient method to control the power for domestic loads by using thyristor at the presence of microcontroller. Power can be changed by adjusting firing angle as per we required. This is better to make the life of people easy and save electricity.

Table1: Experimental Calculations

S. No	Firing angle (deg)	Voltage V_0(volts)	Speed (rps)	Current I_0(amps)	Power W(watts)	efficiency η(%)
1	10	219	143	2.19	479.61	90.66
2	20	218	142	2.18	475.24	89.83
3	40	203	132	2.03	412.09	77.89
4	60	183	121	1.83	334.89	63.30
5	70	163	89	1.63	265.69	50.22
6	90	123	75	1.23	151.29	28.59

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