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AC POWER CONTROL USING ANDROID CELLPHONE WITH LCD DISPLAY

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ABSTRACT:
The paper conducts the study of control of AC power to a load by using firing angle control of thyristor. Efficiency of such power control is very high compared to any other method. Remote operation is achieved by any smart-phone/Tablet etc., with Android OS, upon a GUI (Graphical User Interface) based touch screen operation. The operation 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 exercise uses a microcontroller from 8051 family which is interfaced through a Bluetooth device, which receives signal from Android application device for increasing or decreasing the AC power to the load. A lamp is used in place of an induction motor whose varying intensity demonstrates the varying power to the motor. The varying power results in variation in speed of the motor.
The experiment can be further enhanced by using direct 230 volt supply instead of 12 volt AC to the bridge rectifier for achieving higher voltage control for charging number of batteries in series.

KEYWORDS: Bridge rectifier, 7805/03 voltage regulator, ATMEGA328 microcontroller, SCR, MOC3021 optocoupler, LCD display

1. INTRODUCTION:

Electrical appliances are becoming more and more advanced these days. The increasing demand for more sophisticated domestic products can, in part, be met by providing the user with some form of electronic power control. This control can be used, for example, to adjust the suction of a vacuum cleaner, the brightness of room lighting or the speed of food mixers and electric drills.
It might be assumed that the cost of the electronics would be high, but this is not necessarily the case. With triacs and thyristors it is possible to produce high performance mains controllers which use only a few simple components. The following notes give details of some typical control circuits and highlight areas for special attention when adapting the designs for specific applications.
The use of light dimmers, once the prerogative of entertainment centers, has now become widespread in the home. It is necessary to ensure that the component parts of these units are simple and reliable so that they are compatible with the domestic environment.
The glass passivated BT138 triac meets these requirements. Firstly, it has a peak non-repetitive on-state current handling capability of up to 90 A which means it can easily withstand the inrush current that occurs when a cold lamp is switched on. It can also withstand high voltage bidirectional transients and its low thermal impedance minimizes heatsink requirements.

2. SYSTEM OVERVIEW:

The various components of the system are mentioned below:

2.1 MICROCONTROLLER:

Microcontroller Atmega328 is a High Performance, Low Power AVR 8-Bit Microcontroller. It possesses an advanced RISC architecture. Throughput is 20MIPS at 20Mhz. Performs fully static operation. Memory comprises of 4/8/16/32 KB of in-System self-programmable flash program memory. Talking of its peripheral features it has two 8-bit timer/counters with separate prescaler and compare mode, one 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and capture mode, real time counter with separate oscillator, six PWM Channels, 8-channel 10-bit ADC, and programmable serial USART. It has an operating voltage range of 1.8V to 5.5V whereas temperature range is -40^{o}C to85^{o}C.

2.2 VOLTAGE REGULATOR:

The LM78XX/LM78XXA series of three-terminal positive regulators are available in the TO-220/D-PAK package and with several fixed output voltages, like 5,6,8,9,10,12,15,18 etc making them useful in a Wide range of applications. Each type employs internal current limiting, thermal shutdown and safe operating area protection, making it essentially indestructible. The metal fin extended outside the package acts as heat sink. If adequate heat sinking is provided, they can deliver over 1A output Current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents.

2.3 THYRISTOR:

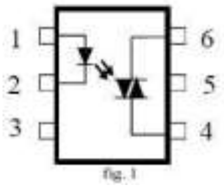
A silicon-controlled rectifier (or semiconductor-controlled rectifier) is a four-layer solid state device that controls current. The name "silicon controlled rectifier" or SCR is General Electric's trade name for a type of thyristor. The SCR was developed by a team of power engineers led by Gordon Hall and commercialized by Frank W. "Bill" Gutzwiller in 1957.

Modes of operation are:

In the normal "off" state, the device restricts current to the leakage current. When the gate-to-cathode voltage exceeds a certain threshold, the device turns "on" and conducts current. The device will remain in the "on" state even after gate current is removed so long as current through the device remains above the holding current. Once current falls below the holding current for an appropriate period of time, the device will switch "off" If the gate is pulsed and the current through the device is below the holding current, the device will remain in the "off" state. SCRs are mainly used in devices where the control of high power, possibly coupled with high voltage, is demanded. Their operation makes them suitable for use in medium to high-voltage AC power control applications, such as lamp dimming, regulators and motor control.

2.4 OPTOISOLATOR (MOC 3021):

An optocoupler/optoisolator allows two circuits to exchange signals yet remain electrically isolated. This is usually accomplished by using light to relay the signal. The standard optocoupler circuits design uses a LED shining on aphototransistor-usually it is anpn transistor and not pnp. The signal is applied to the LED, which then shines on the transistor in the IC. The light is proportional to the signal, so the signal is thus transferred to the photo-transistor. In this project we have an opto-coupler MOC3021 an LED diac type combination. Additionally while using this IC with microcontroller and one LED can be connected in series with IC LED to indicate when high is given from micro controller such that we can know that current is flowing in internal LED of the opto-IC. When logic high is given current flows through LED from pin 1 to 2 So in this process LED light falls on DIAC causing 6 & 4 to close. During each half cycle current flows through gate, series resistor and through opto-diac for the main thyristor / triac to trigger for the load to operate.



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2.5 RECTIFIER:

A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), current that flows in only one direction, a process known as rectification. Rectifiers have many uses including as components of power supplies and as detectors of radio signals.

Rectifiers may be made of solid state diodes, vacuum tube diodes, mercury arc valves, and other components. The output from the transformer is fed to the rectifier. It converts A.C. into pulsating D.C. The rectifier may be a half wave or a full wave rectifier. In this project, a bridge rectifier is used because of its merits like good stability and full wave rectification. In positive half cycle only two diodes(1 set of parallel diodes) will conduct, in negative half cycle remaining two diodes will conduct and they will conduct only in forward bias only.

2.6 FILTERS:

Capacitive filter is used in this project. It removes the ripples from the output of rectifier and smoothens the D.C. Output received from this filter is constant until the mains voltage and load is maintained constant. However, if either of the two is varied, D.C. voltage received at this point changes. Therefore a regulator is applied at the output stage.

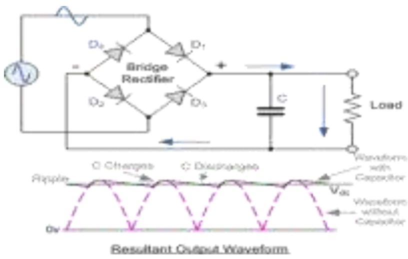

Fig.2

2.7 CRYSTAL OSCILLATOR:

The 16 MHz Crystal Oscillator module is designed to handle off-chip crystals that have a frequency of 4–16 MHz. The crystal oscillator's output is fed to the System PLL as the input reference. The oscillator design generates low frequency and phase jitter, which is recommended for USB operation.

The overall block diagram of the system has been mentioned below:

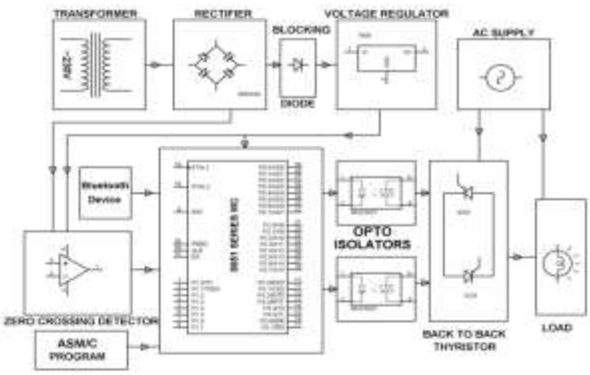

FIG. 3

3. SYSTEM WORKING:

3.1 THYRISTOR TRIGGERING:

Unless a GATE pulse is applied, an SCR remains in the non-conducting state for any voltage applied across its terminals (obviously till the applied voltage doesn't cross forward break over voltage, the FBO). A sufficiently high GATE pulse will result in SCR turning on much below FBO. As such current in the SCR will be determined only by the external voltage applied to its terminals till the load current is above holding current (which has been mentioned before). Considering the case with AC supply at its terminals after GATE pulse application, it turns off at AC supply reducing to zero. This is also called natural line commutation.

3.2 FIRING ANGLE CONTROL:

Microcontroller marks the instances where the AC supply crosses zero voltage mark. In firing angle control, SCR gate pulse is given between the time of two consecutive zero crossing. Between a zero crossing and gate firing, SCR is off and no power conducts through load. After gate triggering and nest zero crossing SCR is on and power conducts through load. Thus the average power through the load is varied. In our experiment, the firing angle is controlled by command given by the operator through an IP proxy created on an android cellphone which connects to the base device by making a Wi-Fi connection.
The command is provided to the microcontroller which triggers the SCR.

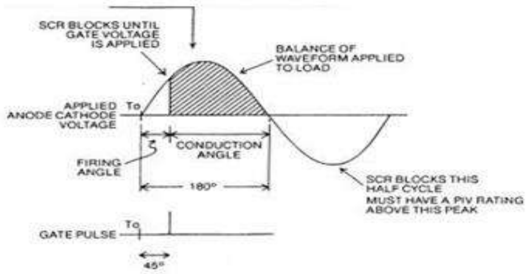

Fig.4

3.3 ELECTRICAL ISOLATION:

SCR triggering provided by microcontroller, which operates around 5V, whereas external powers handled by it are of the order of 220V To prevent any damage to the controller circuitry due to any voltage spike or anomaly in the mains, the controller circuit is electrically isolated From the mains via optoisolator. MOC3021 can provide electrical isolation of the range of 1000V.

4. RESULT:

The whole circuitry was tested against a set of varying firing angles and results were as expected. For lesser firing angle SCR triggered quickly and greater power flows through load, resulting in greater motor speed or greater bulb intensity (as in our case) and vice-versa.
The various formulas for output loads are:

- RMS Output (Load) Voltage

$$V_{O(RMS)} = \left[\frac{n}{2\pi(n+m)} \int_0^{2\pi} V_m^2 \sin^2 \omega t . d(\omega t) \right]^{1/2}$$

$$V_{O(RMS)} = \frac{V_m}{\sqrt{2}} \sqrt{\frac{n}{(m+n)}} = V_{i(RMS)}\sqrt{k} = V_S\sqrt{k}$$

$$V_{O(RMS)} = V_{i(RMS)}\sqrt{k} = V_S\sqrt{k}$$

Where $V_S = V_{i(RMS)}$ = RMS value of input supply voltage.

- Duty Cycle

$$k = \frac{t_{ON}}{T_O} = \frac{t_{ON}}{(t_{ON}+t_{OFF})} = \frac{nT}{(m+n)T}$$

Where, $k = \frac{n}{(m+n)}$ = duty cycle (d).

- RMS Load Current

$$I_{O(RMS)} = \frac{V_{O(RMS)}}{Z} = \frac{V_{O(RMS)}}{R_L}; \quad \text{for a resistive load } Z = R_L.$$

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5. CONCLUSION:

This AC power control system has numerous applications in the domestic as well as industrial areas. From light dimmers, mixers, grinders speed control to induction motor and drill speed control, thyristors have found ways in many of these systems. Its only imperative to further the research in this direction and upgrade the technology. Furthermore, modern day wireless technologies like IOT and Bluetoothetc means remote control from a faraway distance is easily possible. This increases its scope and helps in better resolving of safety issues.

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