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Remotely Controllable Regulator for Line-Loads

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ABSTRACT

Daily used consumer electrical equipment such as Ceiling fans, Televisions, DVD players, Computers and etc. are controlled by many methods, but the wireless remote controlling systems extricate the inconvenience of controlling them manually, and IR remote controlling system is a very popular method among them. Resistive and inductive type loads driven by AC power are usually controlled manually using various techniques. An inexpensive IR remote and sensing circuitry with a controller system have been designed which enables the user to control both the level and the period of power supplied to the load as an alternate for commercially available expensive similar systems. Communication between the IR remote and the sensor is performed according to Series Infrared Controller (SIRC) protocol which is used in many commercially available IR remotes. The power supplied to the load is controlled by using a Triac. Since the time is considered for triggering, the conducting cycle of the Triac can be controlled to be within 0^o to 180^o. A seven segment display unit was also included to the design to indicate the supplied power Level and the turning OFF time of the load. PICmicro® 12F683 and 18F2550 microcontrollers were used to control the operation of the designed system.

Keywords: *Component; IR; SIRC; Remote; Control; PIC*

1.0 INTRODUCTION

Ceiling fans and incandescent light bulb are commonly found inductive and resistive type loads which are used in almost every house and industry nowadays and there are methods to control their operation manually using many ways.

Remote controlling systems were introduced to control electrical and electronic equipment's which people deal with day to day life since it is very convenient and allow the user to control the equipment from a distance. Remote controlling systems use many media to communicate between the remote and the device and use of Infrared (IR) light is one of the easy and inexpensive way of performing it.

The main task of this work is to design an inexpensive IR remote controlling system to control the power supplied to a line-load.

This design contains an IR remote, voltage regulator with IR sensor and a seven segment display unit to indicate the supplied power level and the sleep time of the connected resistive or inductive load.

The IR communication between remote and the device is performed according to Series Infrared Controlling (SIRC) protocol[1], which is used in most commercially available IR remotes. The power supplied to load was regulated using a controller circuitry which is designed to fit in to a standard sunk box. Peripheral interface controller (PIC) micro® 12F683[2] was used to design the IR remote and PIC micro® 18F2550[3] was used to control the power supplied to the line-load together with the seven segment display unit.

2.0 PROCEDURE

2.1 IR Communication via SIRC Protocol

12-bit version of the SIRC protocol was used to send data via IR lights in this design. Data is represented by different pulse widths in the SIRC protocol and the carrier wave frequency is 40kHz. The 12 bit stream consists of a Start bit followed by 7 Command bits which are followed by 4 Device bits as shown in Fig. 1.

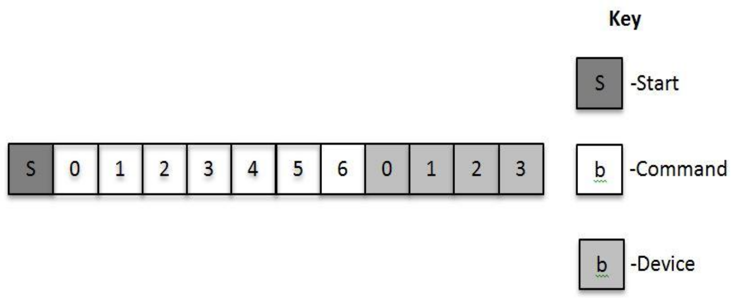

Fig. 1: Bit stream in SIRC 12-bit version

The representations of bits in SIRC protocol are shown in Fig. 2.

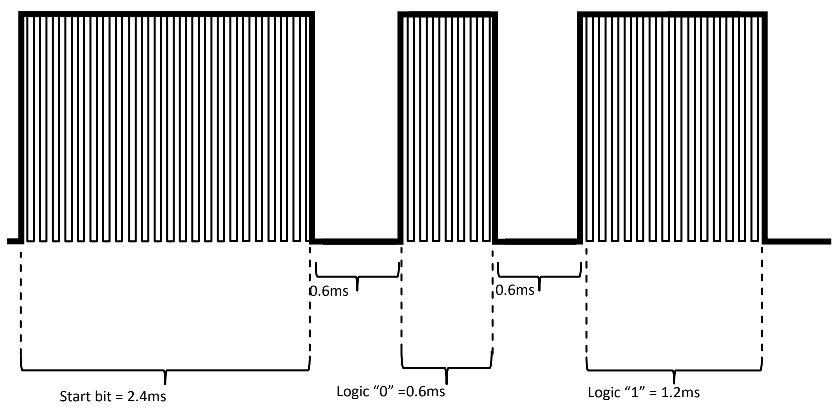

Fig. 2: The representation of bits in SIRC protocol

PIC 12F683 microcontroller was used to design the IR remote. By using the Pulse Width Modulation (PWM) module of that microcontroller, a 40kHz square wave signal was generated, then the desired pulses were sent by turning ON and OFF the PWM mode of the microcontroller for the relevant time periods to emit the 12 bit stream pattern in SIRC protocol. A schematic of the IR remote is shown in Fig. 3.

SM0038[4] IR module was used to sense the emitted IR signal and the output of it was fed to the external interrupt pin of the PIC 18F2550 microcontroller. Since the IR module has an active low output the receiving IR signal at the external interrupt pin of the microcontroller will be an inverted one of that emitted. The IR signal was decoded with the use of the Timer2 module of PIC 18F2550 microcontroller. The Timer2 module was set to issue interrupt in every 0·6 ms after detecting a falling at external interrupt pin of the microcontroller. Thereafter the external interrupt pin was set to detect rising edges till a registry was filled with 12 bits from the emitted IR signal. Simultaneously a counter was programmed to count the number of interrupts issue from the Timer2 module and it was also programmed to reset at next rising edge. If a Start bit was received correctly the counter value will equate to "4". Similarly the counter value will be "3" and "2" for correctly received Logic "1" and "0" respectively. Thus considering the counter value**,** the IR signal emitted in SIRC protocol was decoded.

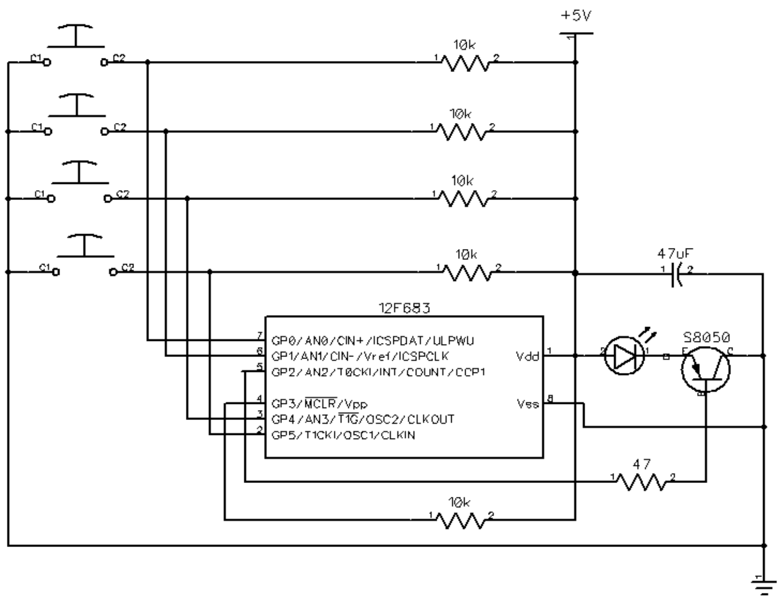

Fig. 3: Schematic of the IR remote

2.2 Line-Load supplying power controlling

For this design BT139[5] Triac was used to control the power supplied to the load. A voltage boost should be given to the gate terminal of the Triac for it to start conduct between its two main terminals. Timer1 Module of PIC 18F2550 microcontroller was used to control the triggering angle of the Triac to control the conducting cycle of the supplied sinusoidal wave in order to control the power supplied to the line-load. A reduced sinusoidal signal of the input 230 V with 50 Hz wave was fed to the microcontroller and the zero crossing point of the sinusoidal signal was detected. A predefined value was inserted to the Timer1 according the power level. Timer1 counts up to 65535 from that predefined value and issues an interrupt at the overflow. Since the time is considered to trigger the Triac the conducting cycle can be controlled to be within 0^o to 180^o. Four different power levels were obtained by four different triggering angles for loads whose supplying power is 230 V with frequency 50 Hz. The Triac was driven through a MOC3021[6] optocoupler to isolate the controlling circuit from main power supply of 230 V.

2.3 Sleep timer

A sleep Timer was included to the design as an additional feature using the Timer0 Module of PIC 18F2550 microcontroller. The triggers issuing from the microcontroller to drive the Triac was programmed to stop after a certain period of times to stop the ceiling fan rotation using the time takes for Timer0 module to count up to a specific values which were loaded in to a register of the microcontroller.

2.4 7-Segment display unit

A seven segment display unit was included to design to show the supplied power level and the Sleep Timer of the load using a 74HC595[7] shift register. Two seven segment display units were used in this design to display two numbers in two 7 segments at the same time they were switched by the PIC 18F2550 microcontroller so that human eye cannot identify the blinking of it.

Fig. 4 shows a schematic of the controlling system.

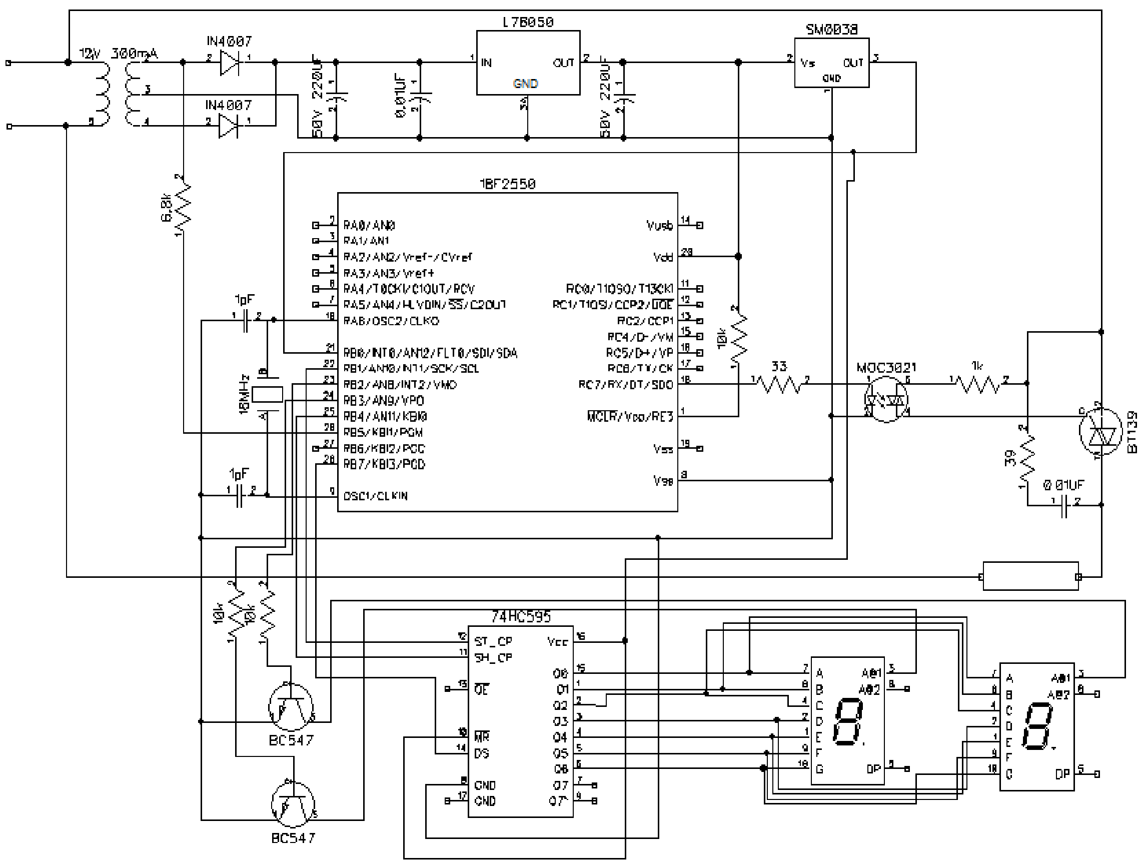

Fig. 4: Schematic of the Controlling unit

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3.0 RESULTS AND DISCUSSION

The designed load power regulating system was tested for both ceiling fans and incandescent lights and it functioned perfectly for both devices independent from the load applied. The IR remote was tested and it functioned very well within the range of 10 m from the sensor.

The designed load power regulator was connected to a ceiling fan and the power consumption of it was measured with the rotation speed of the ceiling fan. The power consumption of manually controlled capacitive type and inductive type ceiling fan regulators were measured with the rotation speed of the same ceiling fan and the results are shown in Table 1. Since the least count of the used Wattage meter and RPM meter is ± 1 the maximum deviation is considered as 1. After plotting linear fits of wattage vs RPM from the obtained data, it was noted that there is no significant difference in the power consumption in this designed than the other two compared ones. But when the rotation speed is higher the ceiling fan produced more RPM for less power when using the designed ceiling fan regulator. It was also noted that the variation of wattage vs RPM for the designed ceiling fan regulator is very linear than the other compared systems. The linear fits for power consumption against rotation speed of the ceiling fan are shown in Fig. 5.

Table 1: Results of wattage and RPM of the tested ceiling fan regulators

Inductive type ceiling fan regulator		Capacitive type ceiling fan regulator		Designed ceiling fan regulator	
Wattage (W)	RPM	Wattage (W)	RPM	Wattage (W)	RPM
38 ± 1	128 ± 1	13 ± 1	72 ± 1	11 ± 1	68 ± 1
54 ± 1	156 ± 1	20 ± 1	100 ± 1	34 ± 1	128 ± 1
57 ± 1	180 ± 1	30 ± 1	124 ± 1	43 ± 1	156 ± 1
64 ± 1	200 ± 1	49 ± 1	160 ± 1	72 ± 1	248 ± 1
72 ± 1	244 ± 1	74 ± 1	248 ± 1	-	-

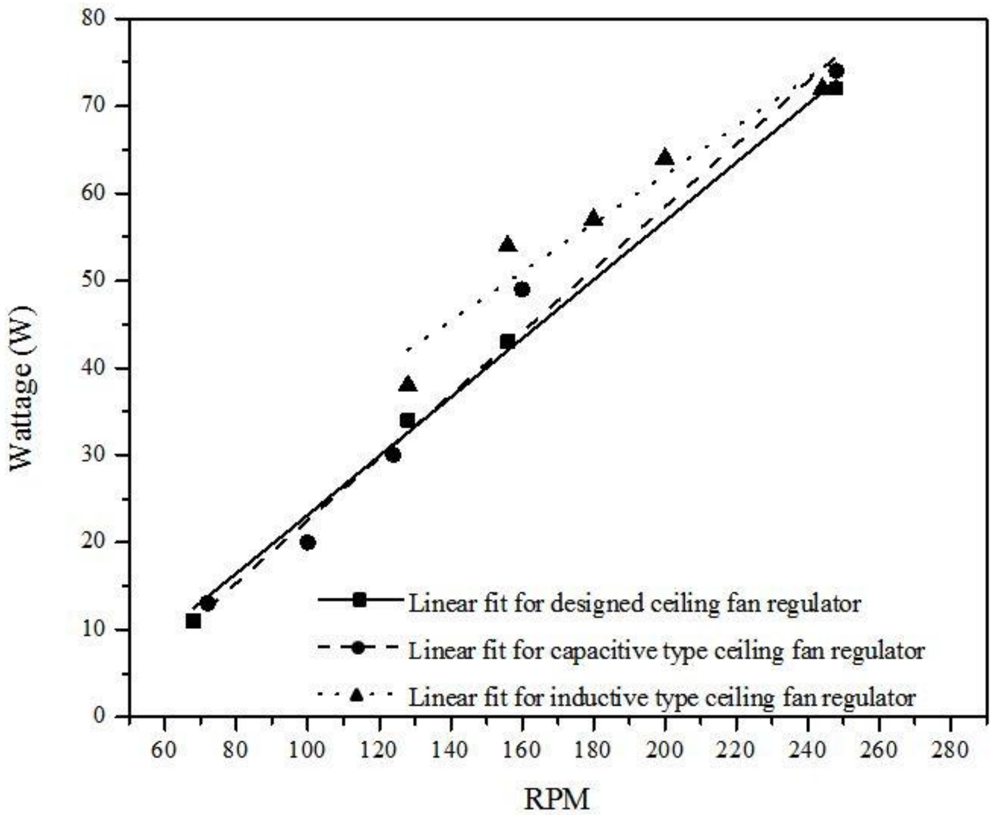

Fig. 5: The linear fits for the wattage vs the rotating speed for different type of ceiling fan regulators

4.0 CONCLUSIONS

The designed regulator is capable to perform the functions such as regulating the power supply to the line-load, turning OFF the supplied power after a pre-set time period (Sleep Time), and indication of speed level and the sleep time.

All the components used in the construction are commercially available in the open market. Therefore, it will be practically feasible to construct this line-load power regulator for resistive and inductive type loads, and the component cost in the open market is less than LKR 1,300.

From the linear fits drawn for the capacitive type, inductive type, and designed regulators, it is evident that the variation of wattage vs RPM for the designed regulator is much linear than the other compared ones. Also since this device controls the power by chopping out part of the signal it can be used to any line-loads. This device is isolated from the main power supply by using a transformer and an optocoupler so the controlling unit is very well protected.

Furthermore, introducing more Triacs and some other peripherals, this device can be developed to control several channels simultaneously

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REFERENCES

1. http://www.sbprojects.com/knowledge/ir/sirc.php (2012)
2. Microchip, *8-Pin Flash – Based, 8-Bit CMOS Microcontroller with nanoWatt Technology*, “PIC12F683 datasheet”, (2007)
3. Microchip, *28-Pin, High Performance, Enhanced Flash, USB Microcontroller with nanoWatt Technology*, “PIC18F2550 datasheet”, (2009)
4. Thermoelectric Products, *Infrared Receiver Module*, “SM0038 datasheet”, 2003
5. Philips Semiconductors, *Triacs*, “BT139 series datasheet”, (Sep. 1997 (Revised Jan. 2000))
6. Texas Instruments, *Optocouplers/Optoisolators*, “MOC3020 THRU MOC3023 datasheet”, (Oct. 1986 (Revised Oct. 1995))
7. Philips Semiconductors, *8-bit serial in, serial or parallel-out Shift Register with latches; 3-state*, “74HC595 datasheet”, (Jun. 1998 (Revised Jun. 2003))