Modeling and Simulation of Electrical Load Control System Using RF Technology

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***Abstract*— This paper presents a radio frequency based electrical load control system. By using a radio frequency, the electrical loads at a working place can be controlled wirelessly by using a transmitter remote. Any load can be switched on and off by pressing a key on the transmitter. The paper explicates the use of radio frequency signals for wireless control of electrical loads in a utility. By giving a 4-bit logic through the transmitter at most four loads can be controlled at a time. The receiver connected to the system receives the logic transmitted by the transmitter remote and the load control is done according to the received logic. Liquid Crystal Display has been used to display the information regarding the switching of electrical loads. The simulation of the system is done on Proteus Professional Software v 8.0. The system is working properly under normal conditions and Xilinx software has been used to test the accuracy of the system.**

***Keywords*— Microcontroller, Radio Frequency, Electric Load and Liquid Crystal Display**

I. INTRODUCTION

With modernization, new technologies are emerging every day. These innovative technologies have become an integral part of human life. Now days, use of modern control systems is in full swing. This paper presents design and simulation of the control of electric loads by using radio frequency. By controlling the key switching on the transmitter, controllability of the electric loads can be achieved. Microcontroller is used for achieving load control using radio frequency. A microcontroller is a type of microprocessor furnished in a single integrated circuit and needs minimum of support chips. With microcontrollers, almost any task can be accomplished in a more proficient and precise manner. Almost every automatically controlled device uses microcontroller for its operation. Some examples include implantable medical devices, remote systems, office devices, automatic home appliances, power controllers, toys and other smart systems [1]-[4].

Table 1 shows the microcontroller system. A microcontroller has a CPU in addition to a fixed amount of RAM, ROM, I/O ports and timer all on a single chip [5]-[7].

Table 1: Microcontroller System

CPU	RAM	ROM
I/O	TIMER	SERIAL COM

II. SYSTEM ARCHITECTURE

For the development of the system, PIC16F877A microcontroller is used. It is a 40-pin dip having low power consumption and high speed FLASH/EEPROM technology. It consists of 256 bytes EEPROM memory, two comparators, eight channels of 10-bit analog to digital converters, two capture/compare/PWM functions. The synchronous serial port in the microcontroller can be configured as either 3-wire Serial Peripheral Interface or the 2-wire Inter-Integrated Circuit bus and a Universal Synchronous Asynchronous Receiver Transmitter [8]. Fig.1 shows the pin configuration of the PIC16F877A:

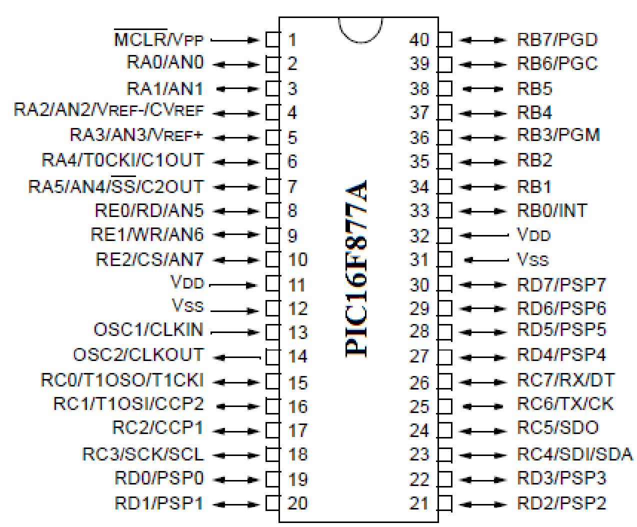

Fig. 1: Pin Configuration

In this paper, radio frequency has been used to control the electrical loads in a utility. There is a difficulty in conventional systems where switching is done manually and there is complexity of wiring. Any desired load can be switched on and off by pressing a key on the transmitter remote. A 4-bit logic is transmitted by pressing the key of the transmitter and the load controlling function is done accordingly. Table 2 shows the 4-bit transmitted logic and the switched mode status of the electrical loads.

Table 2: Transmitted Logic

S.N 0	RB 4	RB 5	RB 6	RB 7	LOAD 1	LOAD 2	LOAD 3	LOAD 4
1.	0	0	0	0	ON	ON	ON	ON
2.	0	0	0	1	ON	ON	ON	OFF
3.	0	0	1	0	ON	ON	OFF	ON
4.	0	0	1	1	ON	ON	OFF	OFF
5.	0	1	0	0	ON	OFF	ON	ON
6.	0	1	0	1	ON	OFF	ON	OFF
7.	0	1	1	0	ON	OFF	OFF	ON
8.	0	1	1	1	ON	OFF	OFF	OFF
9.	1	0	0	0	OFF	ON	ON	ON
10.	1	0	0	1	OFF	ON	ON	OFF
11.	1	0	1	0	OFF	ON	OFF	ON
12.	1	0	1	1	OFF	ON	OFF	OFF
13.	1	1	0	0	OFF	OFF	ON	ON
14.	1	1	0	1	OFF	OFF	ON	OFF
15.	1	1	1	0	OFF	OFF	OFF	ON
16.	1	1	1	1	OFF	OFF	OFF	OFF

III. FUNCTIONAL BLOCK DIAGRAM

Fig.2 shows the functional block diagram of the system. Radio receiver is interfaced to the microcontroller to receive the transmitted logic and load controlling is done accordingly. Relay drivers are used to drive the relays, which in turn helps in switching of the loads. Liquid Crystal Display is used in the system to display the information regarding the switching status of the loads.

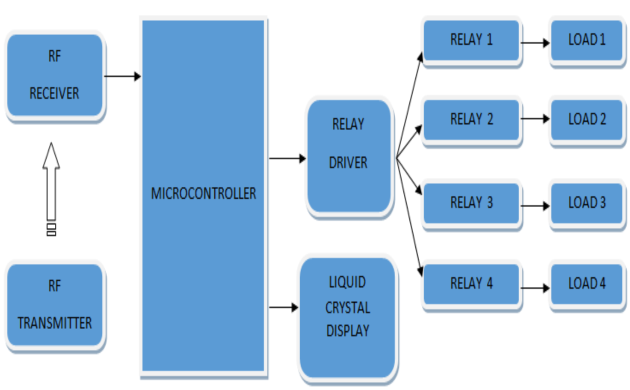

Fig. 2: Functional Block Diagram

The modeled system is very accurate for load control. The complexity of the wiring is reduced by adopting this system. This technology presents a centralized control system for the load switching. At most four loads can be controlled at a time.

IV. POWER SUPPLY

Microcontroller works on five volts power supply which is purely dc. Fig.3 shows the block diagram of the power supply required by the microcontroller.

The 230 V ac supply from the mains is supplied to the step-down transformer which steps it down to 12 V ac. This ac supply is converted into dc by bridge rectifier and the filter circuit is used for smoothening the voltage waveform thus produced. The smoothened voltage is then given to voltage regulator which regulates it to the desired voltage level i.e. five volts in this case and the output voltage is given to the microcontroller for its operation.

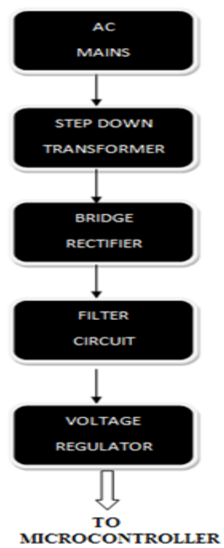

Fig. 3: Block Diagram of Power Supply

V. CIRCUIT SIMULATION

The simulation of the circuit has been done on Proteus Professional v 8.0 software package. The software of the system is written in embedded C language. Fig.4 shows the simulation schematic of the system.

Electrical loads such as agricultural pumps, fans, bulbs etc. are controlled wirelessly by the system designed here. The transmitter gives a 4-bit logic and the load devices are switched according to the logic received by the receiver. At most four electrical loads can be controlled at a time in the present system and it can be extended to the desired number of loads by changing the circuitry.

Register-transfer level (RTL) is the abstraction of a design in which synchronous digital circuits are modeled in terms of the flow of digital signals between digital registers and the logical operations on those signals. Fig.5 shows the RTL design of the proposed system.

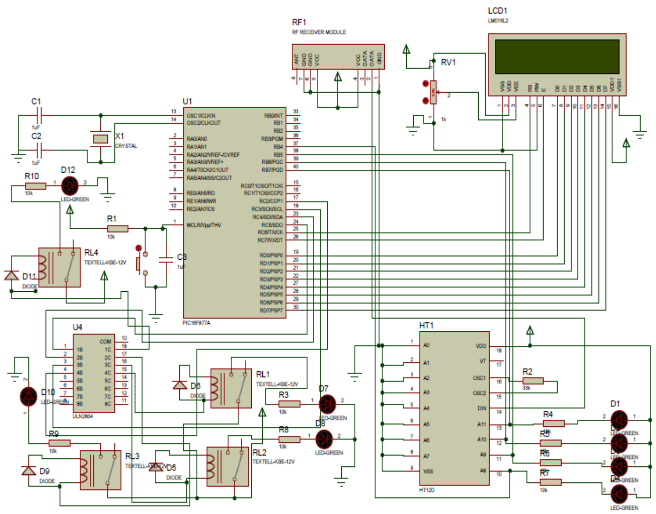

Fig. 4: Simulation Schematic

Fig. 5: RTL of the system

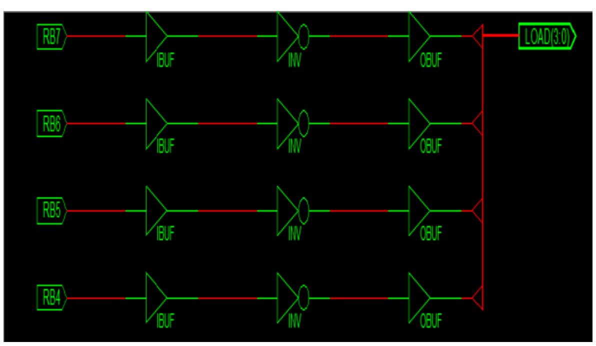

Fig. 6: Technology Diagram

Fig. 6 shows the technology diagram of the system in which transmitter logic is implemented by using buffers and gates. By pressing a key on the transmitter, a 4-bit logic is generated and the load control at the receiver end is accomplished.

Testbench waveform of the system is shown in Fig.7 which has been obtained through Xilinx software v10.1. The simulation has been done for 1000 ns and the load controlling is shown when appropriate logic is applied by the transmitter. The simulation has been done several times and the system is working properly under normal conditions.

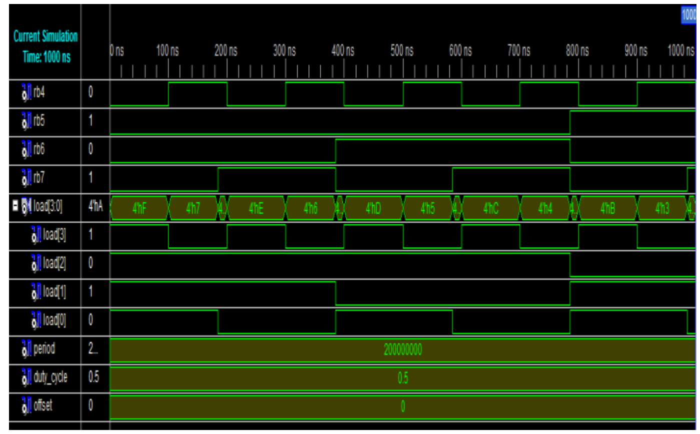

Fig. 7: Testbench Waveform

VI. RESULTS

The design presented in the paper is tested extensively and the simulation is working properly. The system is tested using Xilinx software to validate the accuracy. The transmitter remote is used to control the loads wirelessly sitting at a centralized location. By pressing a switch on the transmitter, a 4 bit logic is generated which is encoded by HT12E encoder and transmitted. At receiver's end, a decoder HT12D is present which decodes the received logic and is used to achieve controllability of the electrical loads. The logic generated by pressing keys on the transmitter is shown in Table 2. Realization of the logic has been done by gates and buffers and is shown in Fig. 6 The testbench waveform is shown in Fig.7 to authenticate the precision of system.

VII. CONCLUSIONS

The design presented in this paper is accurate and appropriate for modern day needs. Controllability of the electrical loads in a utility is achieved by pressing a key on the transmitter and all this happens wirelessly. The difficulties associated with the wiring are reduced as the control system presented here is wireless. The system is working properly and the simulation is working in good agreement with the testbench results.

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