Design and Development of an Infrared Remote-Controlled Queue Management System

Md Istiak Khan, Abdullah Ibn Masud, Md Habibur Rahman
Dept. of Electrical & Electronic Engineering
University of Dhaka, Dhaka-1000, Bangladesh

Abstract— Queue management system helps service providers to manage customers in an efficient way. In this paper, design and development of an infrared (IR) remote controlled queue management system has been described. Use of IR remote makes the system more efficient and prevent cluttering of wires for large systems. This developed system supports the NEC protocol based infrared remotes. The circuit for the system has been designed based on the microcontroller ATmega328p. Three 7-segment displays have been used to show the output. One 7-segment display shows the counter number and two others show the serial number of the customer to be served. As the number of I/O pins of ATmega328p is limited, only 4 pins have been used for interfacing 7-segment displays using time division multiplexing. To store the data for three 7-segment displays three 4-bit registers have been used. The outputs of these registers have been decoded by BCD to 7-segment decoder IC and fed to the display units. A program has been developed using C programming language that provides the intelligence of the system. The performance of the system has been studied and it is found that the system works properly without any interruption of noise. The coverage range of the IR remote has been measured and it has been found that it works properly from a distance of 7 meters.

Index Terms— Control system; Queue management system; IR Remote; NEC; Microcontroller; ATmega328p.

1 Introduction

Queue management system is widely used in business places like banks, customer care centers and hospitals to manage the queue of their customers. It helps save time for both the customers and the business. It also increases operational efficiency of the service providers.

A portable wireless low-cost queue management system will allow companies to manage their queue of customers efficiently and improve productivity. It will also remove the clutter of wires as well as provide ease of installation and maintenance. In large companies or banks where there are multiple queues providing service to customers, a conventional fixed wire system causes multiple problems such as wire cluttering and difficulty in maintenance and recovery in case of system failures. A wireless system nullifies these problems. Infrared remote is a low-cost solution for wirelessly sending the input signals for queue management systems. In our daily lives, we use infrared remote to control television set or DVD player. These same remotes can be used for wireless queue management systems. Although there are wireless queue management system technologies, none is available in the local market and the price is quite high if imported. The designed system provides a locally made solution at a low cost. The system can be manufactured in large quantity for marketing as the device is cost efficient.

Although there is no previous work on infrared remote-controlled queue management systems there are various works based on infrared remote and queue management. Jinsoo Han et al. [1] worked on an efficient home energy management system based on ZigBee communication and infrared remote controls. Saeed Uz Zaman Khan et al. [2] developed a TV remote controller based home appliance manager. E.M.C. Wong et al. [3] worked on an infrared remote controlled electronic display system. I. G. A. P. R. Agung et al. [4] worked on speed control for DC motor using infrared remote control. YC Wu et al. [5] developed a web-based infrared remote-control system for energy management of aggregated air conditioners. Mohammed Ghazal et al. [6] developed an IoT smart queue management system with real-time queue tracking. Ren Fengyuan et al. [7] worked on speeding up the responsiveness of active queue management system. ZhangCheng Xue et al. [8] designed electronic locks based on infrared remote-control with MCU. Mohammad Maquisi et al. [9] developed a digital infrared remote-control system for CATV applications. Timo Hamalainen et al. [10] worked on secure infrared remote-control systems for automotive applications

2 System Design

A simplified block diagram of the system is given in Fig.1. Firstly, in queue management system companies have to keep track of their queue of customers. Thus, a token booth is to be set up which will provide tokens to the customers to form an orderly queue. Customers will arrive and take tokens from the token booth. Afterwards, customers will wait for their turn in the waiting area. Every counter servicing the customers will each have an IR remote present at the counter. When a counter is freed the person operating the counter will send an IR signal via pressing a button on the remote. The Operator will press the numbered button that coincides with their counter number e.g. an operator serving at counter number 3 will press the button "3" of the IR remote. The IR remote will then send a ignal according to the protocol governing the IR communication. The sent signal will be received by an IR receiver and the output of the IR receiver will be fed to the microcontroller. The microcontroller will process the input signal and provide appropriate output signals. Then the output signals of the microcontroller will be fed to the data buffer and decoder circuit.

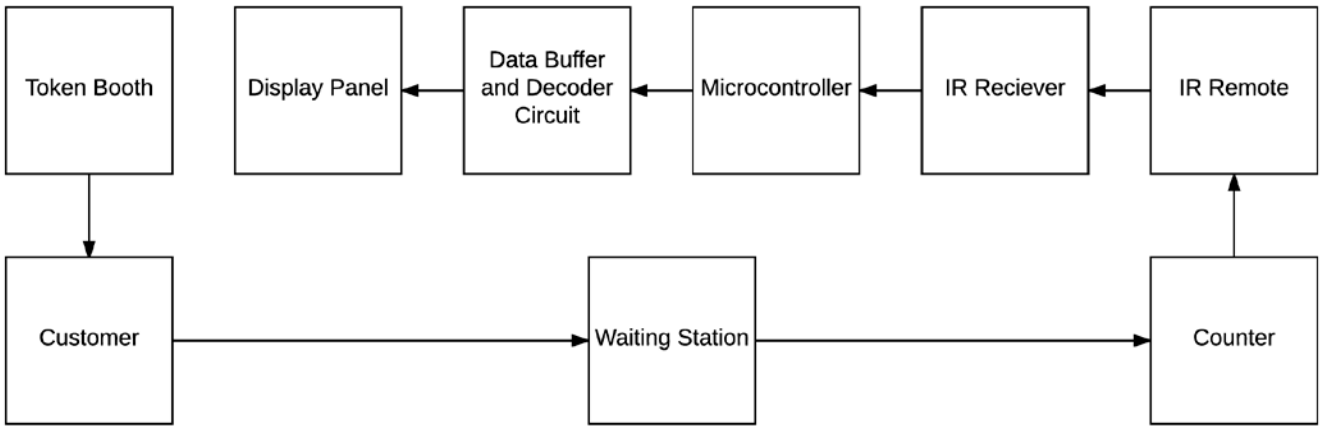

Fig. 1. Block Diagram of the System

Next, the output of the data buffer and decoder circuit will be sent to the display panel. Display panel will show the serial number of the customer to be served and the counter number that will serve the customer. Development of the token booth, waiting station and the counter area are not part of this paper. These will be set up by the individual companies using the system. All sections of the system and their operating principle are discussed below in detail:

2.1 IR Remote

The main technology used in home remote controls is infrared (IR) light. The signal between an IR remote control handset and the device it controls consists of pulses of infrared light. Infrared remote has many advantages and has integrated itself in our daily lives. There are different protocols which governs IR communication. In this system, the NEC protocol is used.

2.2 IR Receiver

IR receiver receives the signal sent from the IR remote. In this system, receiver IC TSOP1738 has been used. TSOP1738 contains an IR band pass filter with center frequency around 38kHz. So, the receiver only receives IR signal modulated at 38kHz frequency. TSOP1738 then demodulates the signal to retrieve the original message signal. Finally, the receiver IC inverts the message signal to produce the output signal [10].

2.3 Microcontroller

Microcontroller provides the main intelligence of the system. Received IR signal from the IR remote is provided to microcontroller for processing by TSOP1738. Microcontroller processes this received signals and deduces which button was pressed on the IR remote and produces output signals accordingly. In this system, ATmega328p microcontroller is used.

2.4 Data Buffer and Decoder Circuit

As I/O pins of ATmega328p are limited instead of directly interfacing 7-segment display with microcontroller, data buffer and decoder circuit has been placed in the middle. By using data buffer and decoder circuit only 4 output data pins and 3 control pins are needed whereas directly interfacing the 7-segment display would have needed a total of 21 output data pins.

As data buffer, the IC 74LS175 has been used which contains four D type flip-flops [11]. First, the 4 output data signals are fed in parallel to three 74LS175 IC. Also, three control signals from the microcontroller are fed to the three clock inputs of the three flip-flop ICs. By using the control signals, latching of data to a flip-flop IC can be controlled. Only when the control signal produces a clock signal the output data signals are latched to the data buffer.

The output signals of the data buffers are fed into a BCD to 7-segment decoder IC. IC 74LS47 has been used as decoder. This IC takes the BCD input and provides appropriate output to drive the 7-segment display. The output signals of three flip-flop ICs are fed into three BCD to 7-segment decoder ICs. The output of the decoder ICs drive three seven segment displays which are used for counter number display and serial number display.

2.5 Display Panel

Three 7-segment displays are used as the display panel. One of them is used to show the counter number that is ready to serve the customer. Two other 7-segmnents are used in conjunction to display the serial number.

2.6 Interconnection of Different Units

The complete circuit of the system is shown in Fig. 2. The output from the IR receiver TSOP1738 is connected to pin 14 of the ATmega328p. 4 output data signals are coming from the microcontroller pins 23,24,25,26. And the 3 control signals are coming from the microcontroller pins 15, 16 and 17. These data and control signals are fed to the data buffer and decoder circuit. Finally, the output of the data buffer and decoder circuit are fed to the display panel.

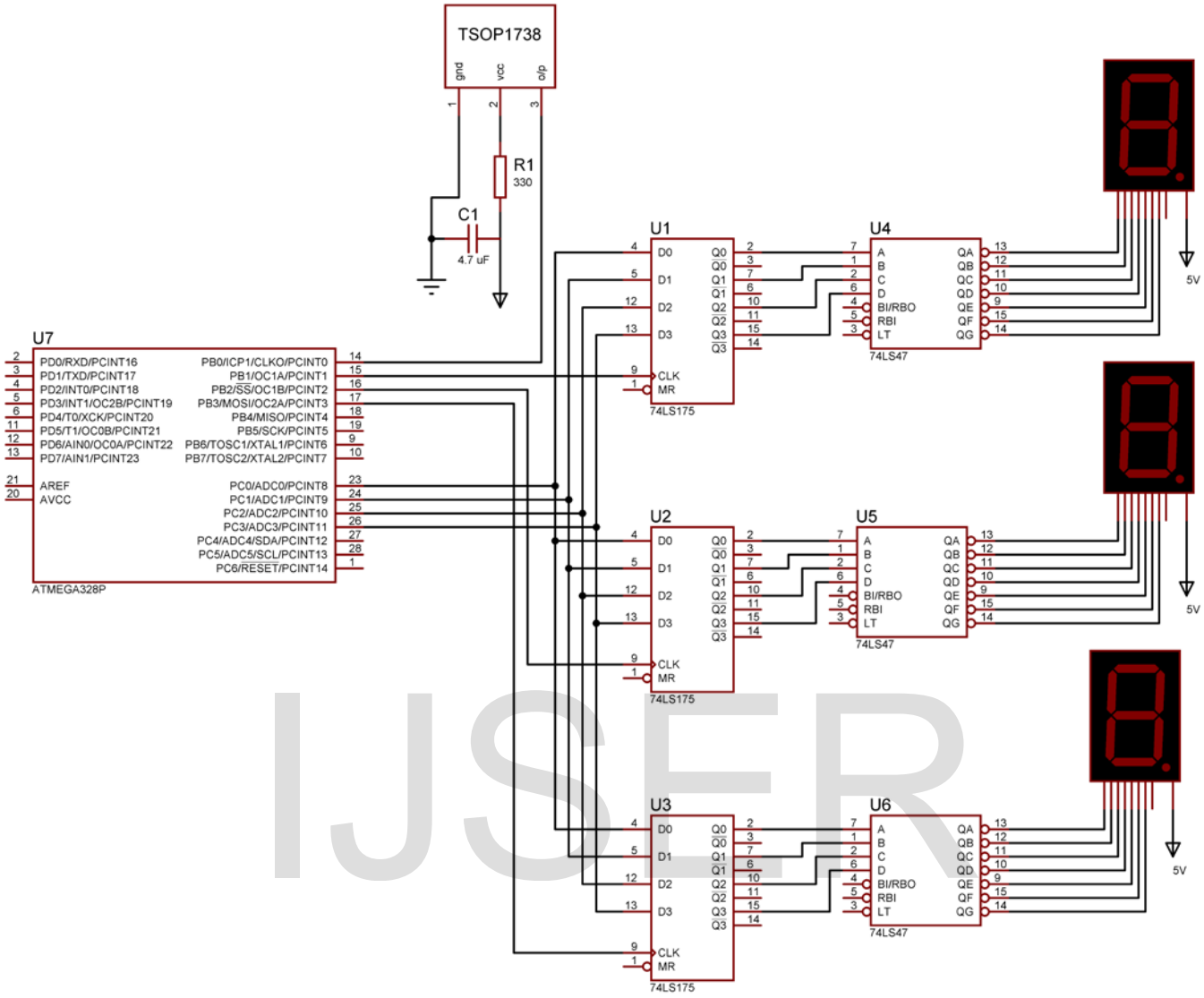

Fig. 2. Complete Circuit of the System

2.7 Software Design

Firstly, the output signal sent by the IR receiver must be decoded to determine which button was pressed on the IR remote. This system supports NEC protocol for IR communication. NEC protocol uses pulse encoding of the message bits. NEC transmission frame consists of a start pulse burst, 8-bit address of the receiving device, 8-bit logical inverse of the address, 8-bit command. 8-bit logical inverse of the command and an end pulse burst. If any key on the remote controller is continually pressed, a repeat code will be sent around 40ms after the pulse burst that signified the end of the transmission frame. The repeat code will continue to be sent out at 108ms intervals until the key is finally released [14]. To control the display panel, it is necessary to know what data is sent after the different buttons of the IR remote is pressed. After decoding the IR signal the commands associated with different buttons have been observed with an array of LED. In Table I, decoded command for various buttons of the IR remote is shown.

After receiving signal, the microcontroller checks to see which button was pressed. Then, it provides appropriate output signal so that counter number display shows the pressed button number and serial number display is incremented each time. The counter number display unit can show from digit 0 to 9. The serial number display unit can show a two-digit number from 00 to 99. After serial 99 the display reverts to 00. One of the 7-segment displays shows the digit of the tenth position and the other one shows the digit of the unit (one) position of the serial number. So, the output signals must be sent accordingly. To achieve this feature, the variable holding the value of the serial number is modulo divided by 10 and the remainder value is displayed at ones' place. For tens' place the variable is first integer divided by 10, then it is again modulo divided by 10 and the remainder is displayed at tens' place.

TABLE 1
DECODED COMMAND FOR VARIOUS BUTTONS OF REMOTE

Button Pressed	Decoded Command (In Hexadecimal Form)
0	6897
1	30CF
2	18E7
3	7A85
4	10EF
5	38C7
6	5AA5
7	42BD
8	4AB5
9	52AD
Continuously pressing a single button	FFFF

3 RESULTS & DISCUSSIONS

After checking the circuit design and programming the microcontroller the different units are connected on a bread-board to implement the system. Then the system has been tested under various conditions. The initial state of the system is shown in Fig. 3(a). Fig. 3(b), shows the condition of the system after it is just started, and no input IR signal is sent to the system. In this condition both the serial number and counter number display will show zero. After that, pressing any button between "0" to "9' on the IR remote will show the value of button pressed in the counter number display and increment the value of serial number display by 1. Largest serial number displayed is 99. Pressing any button one more time will reset the serial display to 00.

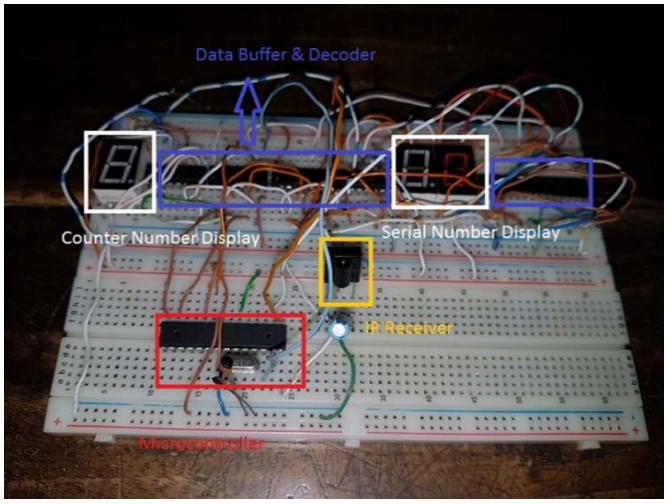

Fig. 3. System in Initial Condition

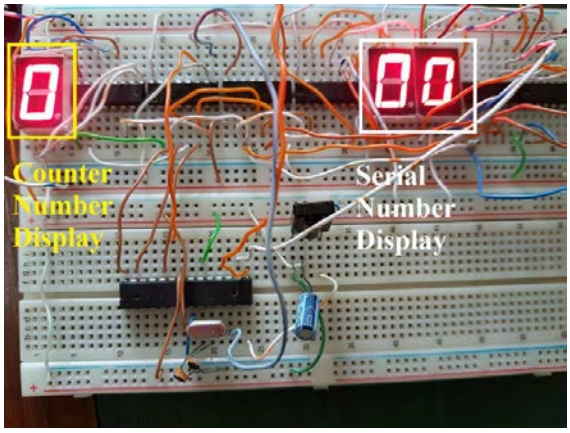

Fig. 4. System in Post-Initial Condition

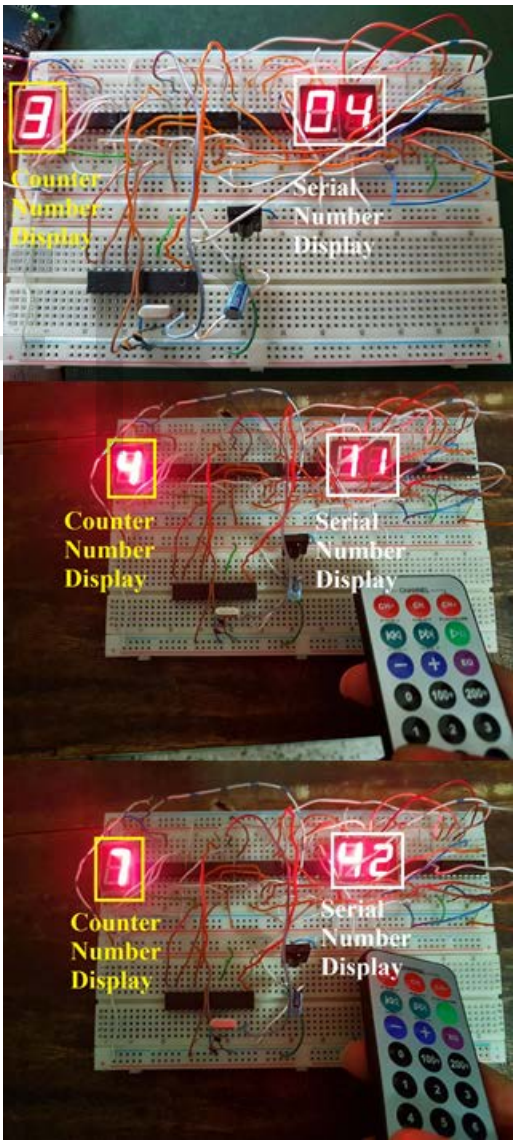

Fig. 5. System in Various Conditions

Maximum range of the system has been studied from various angles. For reference the angle straight from the IR re-

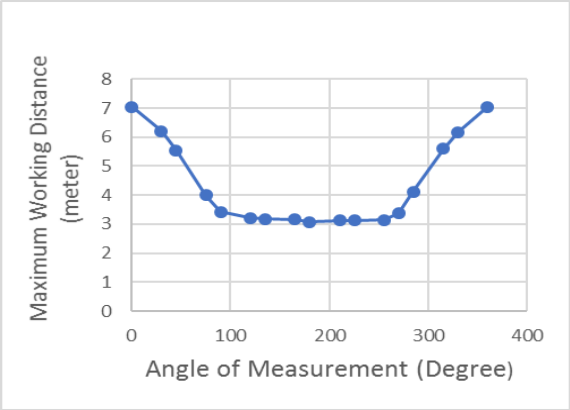

Fig. 6. Maximum Range of the System

ceiver is taken as 0°. Subsequent angles are calculated in a counter clockwise fashion. Plotted graph with the obtained data is shown in Fig. 5.

4 Conclusions

Infrared remote-controlled queue management system is a low cost wireless system for queue management. Range is a big issue for this kind of system. In large areas if the counter is too far away from the receiver the system may not work well or not work at all. To counter this problem, the IR receiver should be placed close to the counter and multiple sensor can be used in parallel. In very large areas IR repeater may be used to repeat the signal. Multiple IR repeater may be placed between final receiver and remote located at the counter. Mass production of this system is possible for commercial use. As this kind of technology is not available in the local market and the cost of this system is very low, this type of system is readily usable and will be in high value when introduced to the market. This system is designed for standalone queue management system. In future same type of system can be designed for advanced and centralized queue management systems. It is possible to introduce preliminary IR remote configuration so that the system works for any IR remote available in the market. The designed device can be configured to work with smart phones in the future as every smart phone now has built in IR blasters.

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