A Remote Controlled Motorized White Board Cleaner

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Abstract

Teaching and learning in schools have been done over the years by writing on boards and different methods of cleaning writing boards have been developed in the past. This paper presents the design and construction of a remote controlled motorized white board cleaner. The system consists of four basic units: the remote control and transmitter unit, the receiver unit, pulse generator/ control unit and the cleaner unit. The operation of the system is centered on AT89552 microcontroller and is such that when the remote button is pressed within the range of 20 meters to the board, the cleaner cleans the board. The speed and direction of the cleaner is also controlled via the remote control. The system makes the teaching efficient and flexible.

Keywords: *Remote control, board, cleaner, motorized, teaching, microcontroller.*

Introduction

The history of teaching dates back to the very beginning of mankind and from the early man experience and knowledge were passed down from generation to generation. This was evident in the ability of our ancestors to survive and make tools out of stones and woods (Microsoft Encarta 2009). The materials used in teaching have also evolved alongside with the teaching and learning methods. Writings were earlier done on sand, walls, slates made out of wood, chalkboards and in recent times on white boards and electronic boards. The white board has been largely adopted into many other sectors of human endeavor besides teaching because of its many advantages over the chalkboard (Wikipedia 2012a, 2012b). In the most recent times, wireless remote controls have found great applications in the field of robotics engineering and this is displayed in the use of remotes to control the movements of robots and their body parts. Other areas of application include cable and satellite boxes, digital videodisc players and home audio receivers. In an average household, a remote control is being used at least once or twice in an hour (Horowitz 1995). To facilitate effective and efficient teaching with white boards, different methods of cleaning the boards have been employed. In this paper, the design and implementation of a white board with motorized cleaner is presented as an introduction to the automation of the teaching process easing and reducing the task of clearing the board as it cleans itself via a remote control mechanism which is an improvement introduced by Ogirima (2007).

System Description

The schematic diagram is shown in Fig.1. It consists of a remote control system unit. This unit is made of HT12E encoder and 433 MHz RF transmitter. The encoder is used to generate the signal that is then transmitted through the transmitter to the receiver. The receiver unit is composed of 433 MHz RF receiver and HT12D decoder that decodes the transmitted signal. A pulse width modulation generator is used to modulate the signal from the decoder, the signal is then fed into the input port of the controller unit.
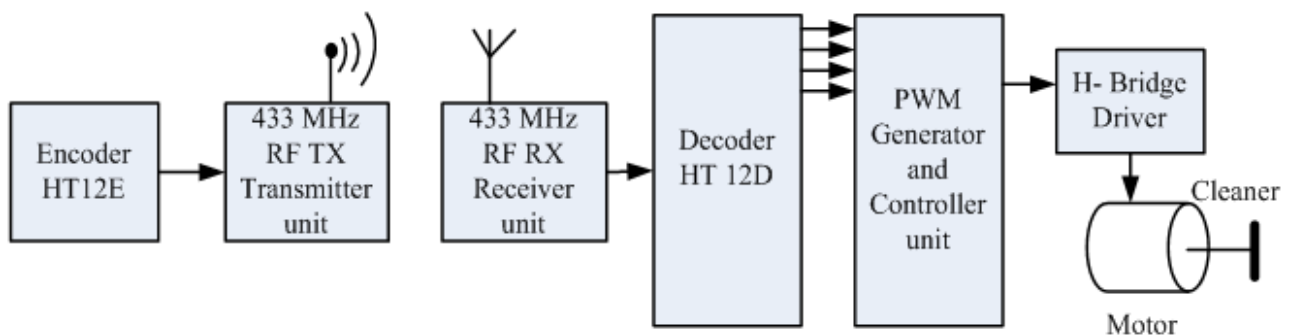
Fig. 1. Block diagram of remote controlled motorized white board cleaner.

The controller unit controls the speed and rotation of the motor through H-bride driver which is used to drive the DC motor to which the cleaner is attached. The cleaner was designed in such a way that the bi-directional rotation of the motor translates to the cleaner which then results in the horizontal movement of the cleaner. When the cleaner reaches the end of the board, the limit sensor at the end of the board detects it and sends a signal to the controller unit which then causes the motor to stop rotating in that direction. The power supply unit supplies power to the other units.

Remote Control and Transmitter Unit

This unit is made up of the TWS-433 MHZ transmitter and HT12E encoder. The RF transmitter operates at 433 MHz and has an output that is up to 8 mW using amplitude modulation (AM) technique and operates between 5 V - 12 V DC. The 2^{12} encoder (HT12E) consists of a series of CMOS LSIs for remote control system applications. It is capable of encoding information consisting of N address bits and 12 - N data bits. Each address/data input was set to one of the two logic states. The programmed addresses/data are transmitted together with the header bits via RF transmission medium upon receipt of a trigger signal. The push buttons are used to send the appropriate signal to the receiver that causes the cleaner to function.

The configuration of the transmitter and encoding unit is shown in Fig. 2.

Receiver and Decoding Unit

This unit is made up of the RWS-433 MHz receiver and HT12D decoder. The RF receiver operates at 433 MHz and has sensitivity of 3 µV. The receiver uses amplitude modulation (AM) technique, operates between 4.45 V - 5.5 V DC and has both linear and digital outputs. For this system, only the digital output was utilized and fed into the input pin of the decoder. The receiver has the provision for an antenna in order to increase the coverage area, however, it was not used for this system because it is made to be used indoors. The 2^{12} decoder (HT12D) consists of a series of CMOS LSIs for remote control system applications.

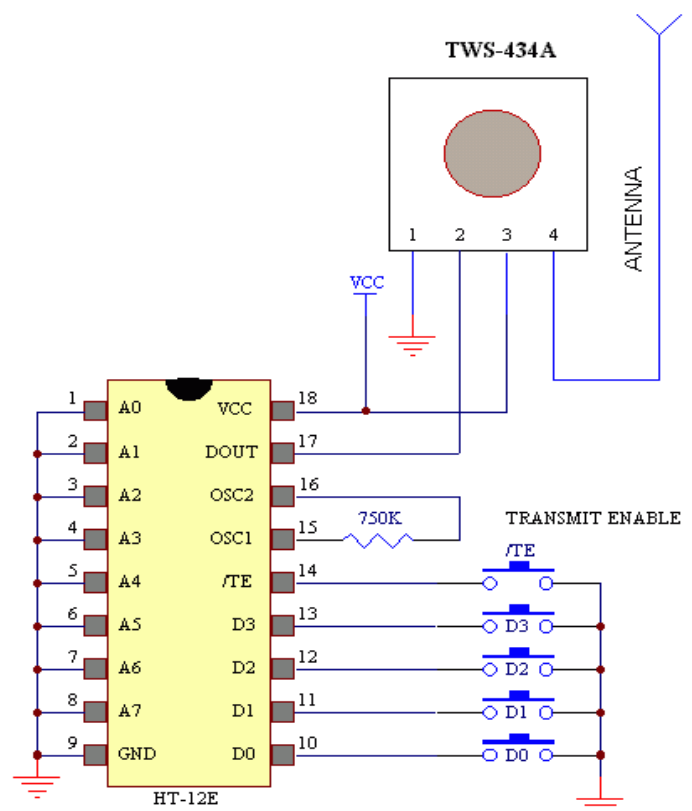The circuit configuration of the receiver and decoding unit is shown in Fig. 3.

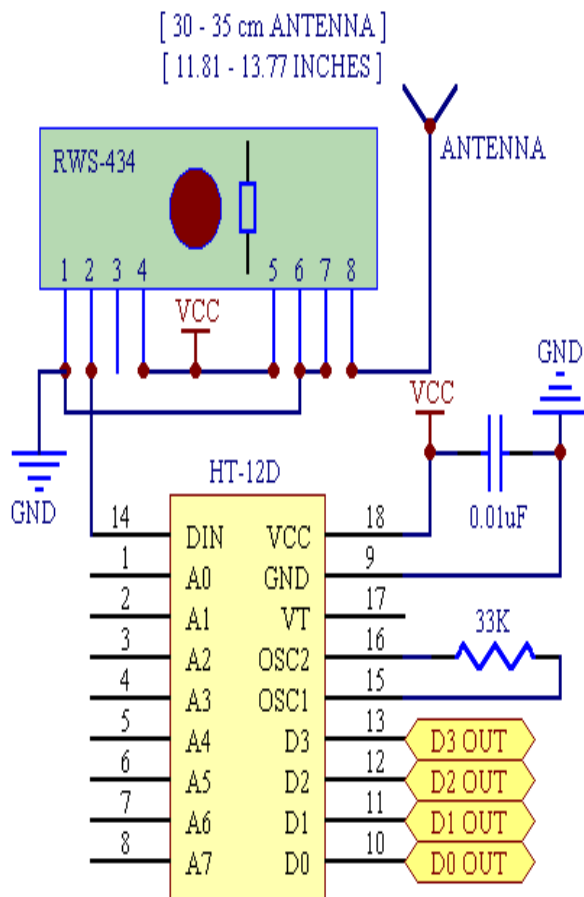Fig. 2. The remote control with push buttons.

Fig. 3. Receiver and decoding unit.

For proper operation, a pair of Holtek 2^{12} encoder/decoder with the same number of addresses and data format was chosen. The 2^{12} decoder receives serial addresses and data from the programmed 2^{12} encoder that are transmitted by a carrier using RF transmission medium.

The decoder compares the serial input data three times continuously with its local addresses. If no error or unmatched codes are found, the input data codes are decoded and then transferred to the output pins. The VT pin also goes high to indicate a valid transmission. The decoder is capable of decoding information that consists of N address bits and $12 - N$ data bits. The output of the decoder is fed into the pulse width generator.

Pulse Width Generator and Control Unit

The unit was built around AT89S52 microcontroller, which was programmed using C language to perform the basic function of controlling the speed and direction of rotation

of the motorized cleaner. The microcontroller is a low-voltage, high-performance CMOS 8-bit microcomputer with 2K 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 MCS-51 instruction set. The idle mode stops the CPU while allowing the RAM, timer/counters, serial port and interrupt system to continue functioning, while the power-down mode saves the RAM contents but freezes the oscillator disabling all other chip functions until the next hardware reset.

The AT89S52 microcontroller was configured such that the outputs from the decoding unit are fed into the microcontroller via port 3 (P3.0, P3.1, P3.4, P3.5 and P3.7). Whenever a signal is received and decoded, the microcontroller carries out the function that corresponds to that particular signal (rotate the motor clockwise or counterclockwise, increase or decrease the speed of rotation of the motor) as specified by the program burned into the controller memory.

The inputs from the sensor to P1.6 and P1.7 enable the controller to detect when the cleaner has gotten to the end of the board in order to send an interrupt signal that will cause the controller to reverse the rotation of the motor back to its original position.

Clock Source (Oscillator Characteristics)

The on-chip oscillator on the microcontrollers was used as the clock source for the CPU. This was achieved by connecting a capacitor between the crystal 1 (XTAL1 input) and crystal 2 (XTAL2 output) pins of the microcontroller. The 12 MHz crystal was used, it generates 12,000,000 pulses in one second. Normally, the AT89S52 compactable microcontroller executes one instruction in 12 clock pulses (Kuleshov and Lakota 1988).

Software Development

The software needed to run the control process of this system was developed using C language in the Keil® μVision3 window. The programmer code was then written into the chip. Keil® μVision3 is an Integrated

Development Environment (IDE) that helps write, compile, and debug embedded programs. After the successful compilation of the program, it was then tested using the integrated debugger in Keil® µVision3. To start the debugger, "Debug"=>"Start/Stop Debug Session" is selected from the pull-down menus. Figs. 4 and 5 show the system flowchart and Keil® µVision3 window. Once the power supply of the system is turned on, the microcontroller initializes its ports and the process of clearing the board starts.

The Cleaning Unit

The board was made from plywood covered with Formica. The frame of the board was made with rectangular pipes that were welded together to form the support for the board. An aluminum roller track was placed in the frame to allow the free movement of the cleaner on it. The cleaner was made with plywood covered with foam.

The cleaner was designed in such a way that the bi-directional rotation of the motor is translated to the cleaner which then results in the horizontal cleaning movement of the cleaner. The cleaner was fixed to the board tightly and held by the aluminum track inside the frame.

Control Sensor

This unit comprises of two identical light dependent resistance (LDR) sensors positioned at the two extremes of the board. The sensor unit works on the principle of variation in resistance due to change in light intensity. The sensors circuit is designed using light dependent resistor (LDR) and 555 timer operating in monostable mode (Brophy 1983). Whenever the cleaner comes across the LDR, its resistance increases due to the reduction of the light intensity on it and this then triggers the monostable multivibrator that generates a pulse that is fed into the microcontroller. The voltage rating of the circuit is based on 5 V. Fig. 6 shows the circuit diagram.
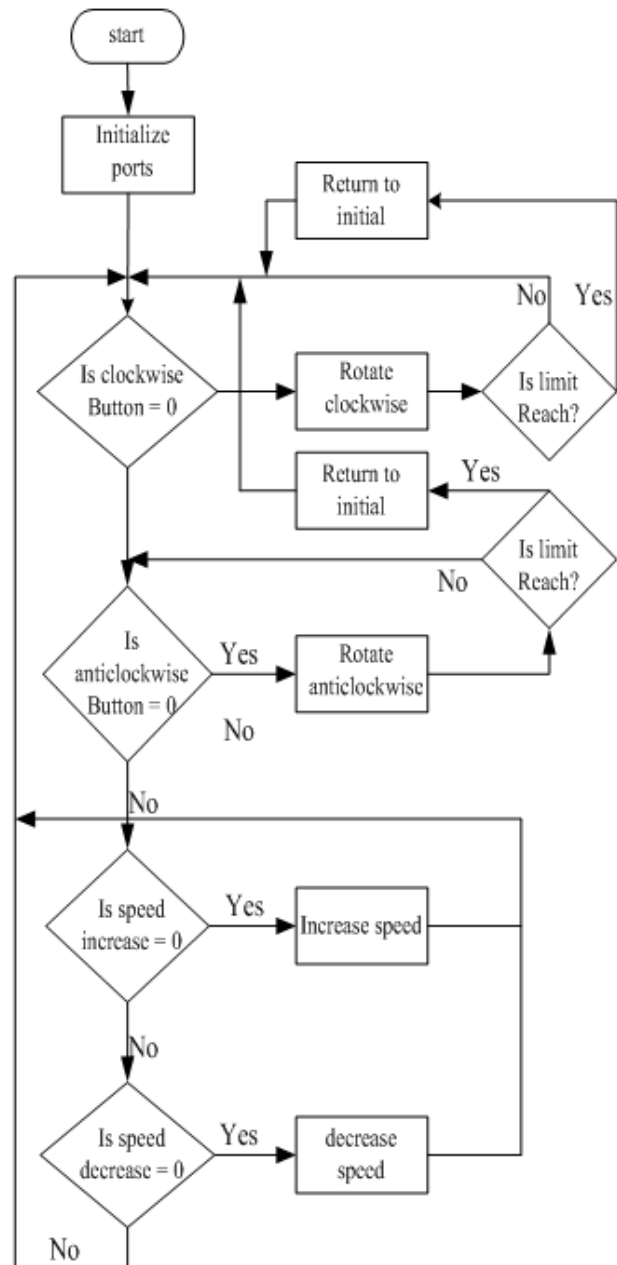

Fig. 4. The system flowchart.

The output voltage across the LDR is obtained from

$$V_o = [R_2/(R_1 + R_2)]V_{CC}. \qquad (1)$$

With illumination, the resistance $R_1 = 2$ kΩ. Without illumination, the resistance $R_1 = 20$ kΩ. R_2 is a variable resistor and in this design it is preset at 10 kΩ. Therefore, from Eq. (1):
   - With illumination
     $V_o = [10/(2 + 10)] \times 5 = 4.55$ V; and
   - Without illumination
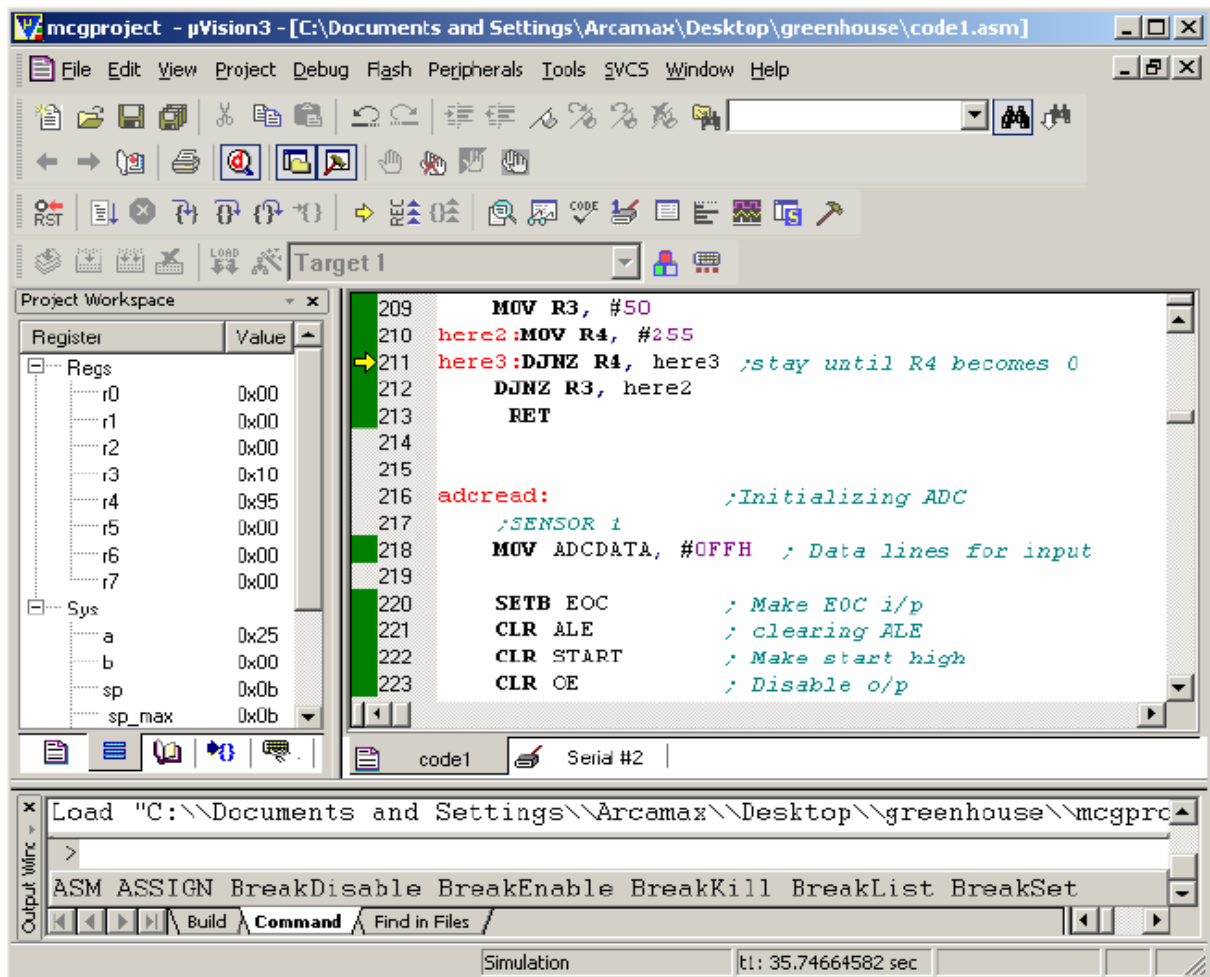 $V_o = [10/(20 + 10)] \times 5 = 5/3 = 1.66$ V.
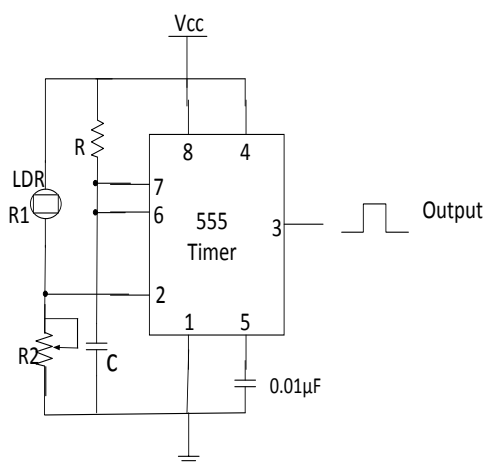
Fig. 5. Keil® μVision3 debugger window.

Fig. 6. LDR sensor using 555 timer.

The multivibrator generates an output when the voltage in pin 2 of the 555 timer falls below $V_{CC}/3$ (trigger voltage). The output pulse width at pin 3 of the monostable vibrator is given by the expression

$$T = 1.1\ RC, \qquad (2)$$

where: T = pulse width in seconds; R = resistance between V_{CC}, pins 6 and 7 in Ohms; and C = capacitance between pins 6, 7 and ground in Farads.

Power Supply Unit

The power supply unit is designed to function as an uninterrupted power supply (UPS) source that supplies constant voltages of 12 V and 5 V DC even when there is outage from the public power system. The power supply unit for this work features a 240 V/18 V, 0.5 A step down transformer, a full wave bridge rectifier, voltage regulators (7815, 7812, 7805 regulator ICs), filter capacitor (1,000 μF and 10 μF), a silicon controlled rectifier (SCR) which is basically a rectifier with a control system and a 12 V battery which is being charged. The charging current of the battery is given by the expression

$I = (V - E_b)/R,$ (3)

where: I = charging current; R = total circuit resistance including the internal resistance of the battery; E_b = back EMF (12 V) of the battery; and V = charging voltage.

The maximum charging current of the battery used in this project is given as 1.35 A

this is supported by Theraja and Theraja (2002). Using a 15 V charging voltage and neglecting the internal resistance of the battery, from Eq. (3) $R = (15 - 12)/1.35 = 2.22 \ \Omega$. The detailed circuit arrangement for the power supply system is shown in Fig. 7.
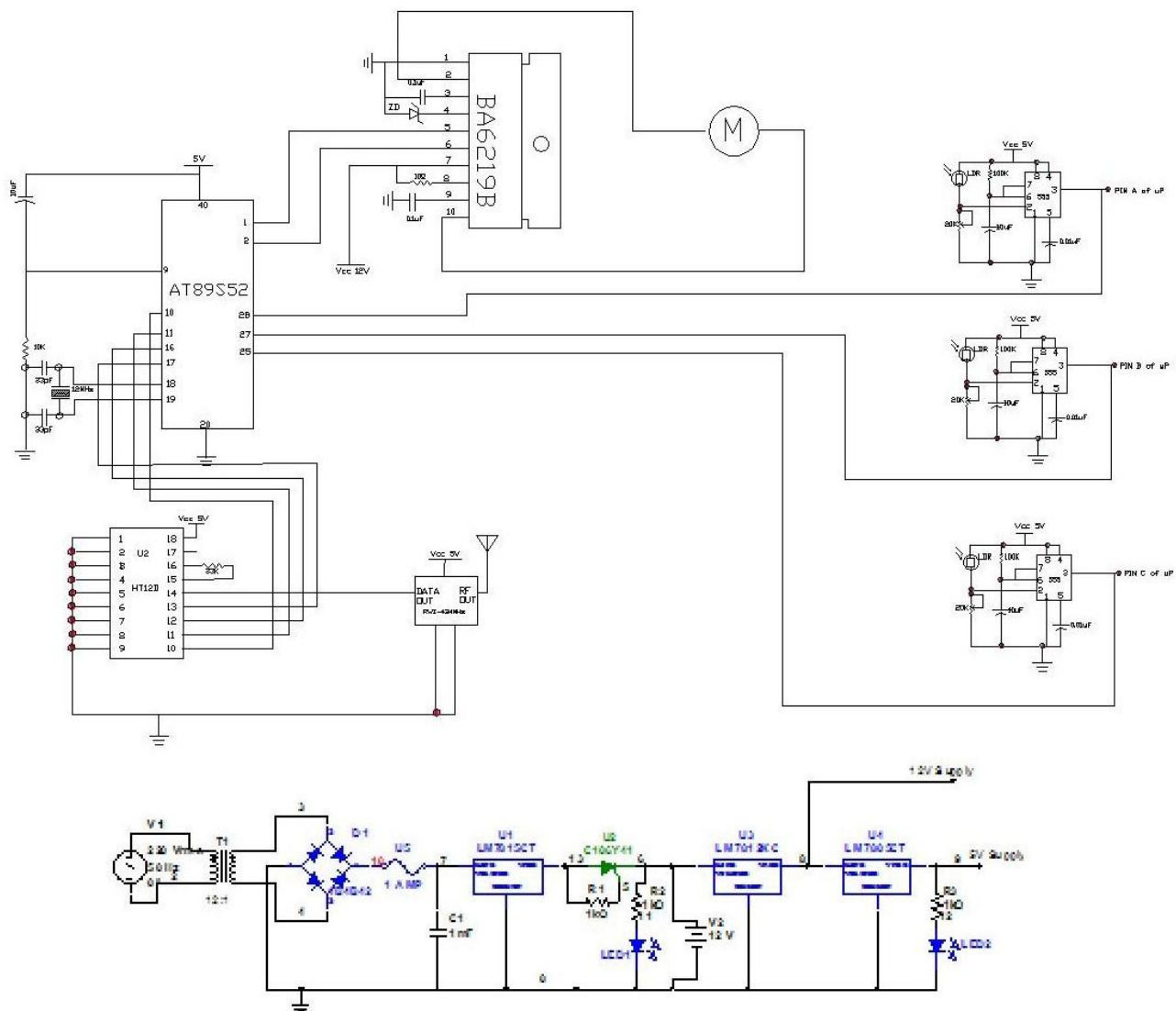

Fig. 7. Circuit diagram of a remote controlled motorized white board cleaner.

Construction

The system was constructed in modules as designed and later put together on completion to simplify the construction, testing and maintenance. Figure 8 shows the handheld remote, Fig. 9 shows the main circuit under construction, and Fig. 10 shows the board with the cleaner in place. A prototype of the system

was initially constructed on a breadboard, tested until it started working properly, and then transferred to a Vero board. All the ICs were mounted in the same direction on the IC sockets already soldered to the Vero board in order to simplify the connections and replacement of any faulty IC. The entire system circuit was laid out carefully to minimize eventual errors and to ease the troubleshooting.

Fig. 8. The handheld remote.

Fig. 9. The main circuit while under construction.

Fig. 10. The board with the cleaner in place.

Testing and Results

After the completion of the construction, the followig tests were carried out with a multimeter which was used to check the continuity and connectivity of the circuit. The polarity of the components was tested and checked. Also, measurements of the voltages, resistances and currents were taken and compared with the design values. The transmitter and receiver circuits were tested to ensure that a proper communication is established between the two circuits. It was observed that the coverage area within which the transmitter and receiver communicated perfectly was limited to 20 meters. The microcontroller was then tested alongside with the sensors and motor driver units to ensure its functionality. Further tests were carried out after mounting the circuit on the board with the motor and cleaner in place. The circuit was then activated and the remote control button pressed to start the cleaning of the board. When the remote button was pressed, the output from the receiver was observed to have gone low, that is, 0 V. This sends a low signal to the input port of the microcontroller that activates the motor driver which then drives the cleaner that clears the board. It was seen that the outputs of the sensors were triggered whenever the cleaner gets to the ends of the board. This caused the microcontroller to reverse the direction of motion of the cleaner and bring it to a stop at the center of the board being the initial position of the cleaner.

Conclusion

A remote controlled motorized white board cleaner has been designed, constructed and tested. The results obtained from the tests carried out shows that the system cleans the board when the remote control button was pressed within the range of 20 meters. Hence, a remote controlled motorized white board cleaner could be used in lecture theatres and seminar rooms to facilitate the effective and efficient teaching using white boards. Further improvements can be done on this system. If a stepper motor is used to replace the DC motor, it can divide a full rotation into a large number of steps. The motor's position can therefore be controlled precisely without any feedback mechanism as long as the motor is carefully sized to the application which will improve the efficiency of the cleaning system.

References

Brophy, J.J. 1983. Basic Electronics for Scientists. McGraw Hill, New York, NY, USA.

Kuleshov, V.S. and Lakota, N.A. 1988. Remotely Controlled Robots and Manipulators. Mir Publications, Moscow, Russia.

Microsoft Encarta. 2009. History of Education. Microsoft Corporation, Redmond, WA, USA.

Ogirima, M.A. 2007. Design and Construction of a Motorized White Board Cleaner. Final Year Project Report, Department of Mechanical Engineering, Federal University of Technology, Minna, Niger State, Nigeria.

Theraja, B.L.; and Theraja, A.K. 2002. A Textbook of Electrical Technology. 23rd ed. S. Chand and Company Ltd., New Delhi, India.

Wikipedia. 2012a. Chalkboard Design. Available: <http://www.wikipedia.org/wiki/Chalkboard#Design>.

Wikipedia. 2012b. Whiteboard History. Available: <http://www.wikipedia.org/wiki/Whiteboard#History>.