

PC Based Wireless Control Of Toy Car

Somangshu Bagchi (B.Tech)

ABSTRACT

The Objective of the project is to construct a motor toy car that has the ability to capture the control signals transmitted by a PC's serial ports in order to propel itself to the intended direction. It was planned that the toy car shall be a four-wheeled device, the rotation of the wheels of which is controlled by the signals transmitted wirelessly in the desired direction where the each of the control signals is fed from the keyboard. The core of the assembly, which will control and co-ordinate the rotation of the wheels is a microcontroller chip named P89V51RD2.

The wireless embedded control has its important applications for remote monitoring of equipment, devices, intended locations. This project provides a basic platform for many potential applications such as wireless controlled car racing games, data logging etc. It can be use for search & rescue type operations. The scope of application of the microcontroller employed in this project is mainly in embedded real-time systems such as automatic control of equipment, machines, process in industry like robotics, 5*7 dot matrix LED.

INDEX TERMS

computer terminal, dc motor, max232 circuit, microcontroller, receiver, relay driver, serial port and cables, transmitter



1. INTRODUCTION

A Microcontroller (sometimes abbreviated μC , uC or MCU) is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Program memory in the form of NOR flash or OTP ROM is also often included on chip, as well as a typically small amount of RAM. Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications. Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, implantable medical devices, remote controls, office machines, appliances, power tools, and toys. By reducing the size and cost compared to a design that uses a separate microprocessor, memory, and input/output devices, microcontrollers make it economical to digitally control even more devices and processes.

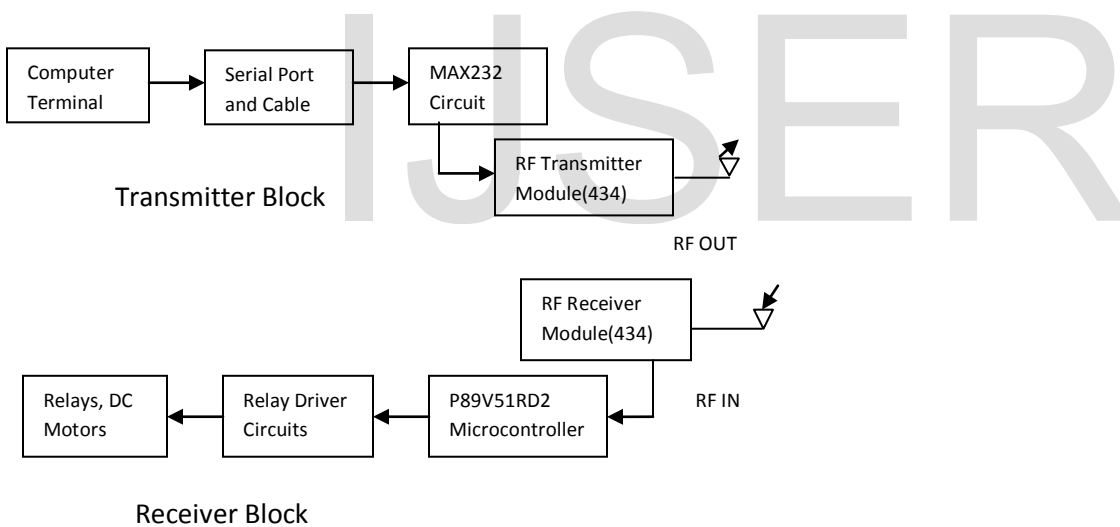


Fig. 1: Block Diagram of PC-based wireless control

The different stages for wireless control are:

1. Transmission of the control signals from a PC's serial port

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2. RF transmitter and receiver
3. Decoding of the received signals using the microcontroller
4. Motor drivers

Asynchronous serial communication is established between the computer and P89V51RD2 microcontroller through

wireless RF link. The microcontroller and computer are both synchronised with each other. The baud rate of data transfer is 1200.

The RF transmitter module actually collects binary signal from the data pin(which is connected to MAX232) and modulates this binary signal with amplitude-shift keying(ASK) digital modulation scheme by a carrier frequency of 434 MHz and transmits the data through the antenna.

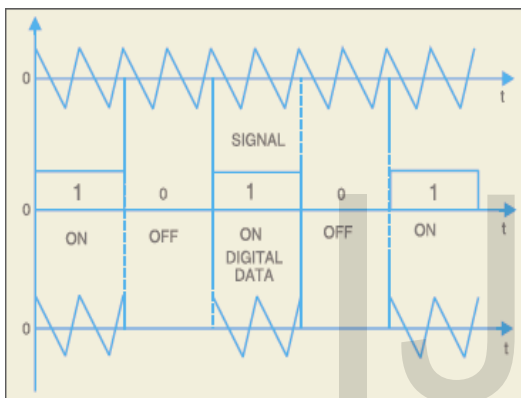


Fig. 2: ASK-modulated Signal

The ASK receiver module receives 434 MHz signal and demodulates it. The baseband signal is a 10 bit digital signal with first bit as start bit, the following eight bits as data bits and the last bit as stop bit. The received data is sent to the microcontroller.

Table 1: ASK Module Specification

Details	Specifications
Frequency	434 MHz
Transmitter	Saw-filter-based ASK hybrid transmitter
Transmitter supply voltage	3-12 V
Receiver	ASK superheterodyne receiver with PLL synthesizer and crystal oscillator

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Receiver supply voltage	5V
Receiver supply current	2.3 mA
Output power	4-16 dBm
Data rate	200 bps to 3 kbps depending on the supply

1.1 PROJECT OBJECTIVE:

The project deals with the construction of a toy car and the working of the navigation system. The purpose of the system is to track the different control signals at the different instants of time generated by PC's serial port so as to cause the movement of the system to the intended direction. It is also the objective of this project to detect the obstacles in the course of its movement and avoid those.

2. METHODOLOGY:

2.1 PROBLEM DEFINITION:

The system under consideration shall be a fully automated microcontroller based embedded system in the form of a robotic vehicle. The navigation is based on the transmission of control signals of a specific frequency from the keyboard. The primary challenge of the project is to convert the control signal to Analog voltage signal which in turn will be fed to the microcontroller through an Analog to Digital Converter (ADC). The output from the microcontroller will finally drive the motors necessary for the locomotion of the vehicle.

Differential steering is such one type of locomotion chosen for the vehicle. In this type of locomotion, spinning on the vehicle's axis is accomplished by moving one wheel in one direction and the other in the opposite direction. A sharp turn is accomplished by stopping one wheel while moving the other and a shallower turn is also accessible by moving one wheel at a lower speed making the robot to turn in the direction of the slower wheel.

2.2 PLANNING AND APPROACH:

The basic working principle of the robotic vehicle is quite simple. The four relays control four motors of the toy car. Two relays control the forward and the reverse rotations of a motor. The left two motors are connected in parallel and so are the two motors of the right. So the two motors are controlled simultaneously using two relays. Here the motors are PMDC motor (12 V, 50 rpm dc). The +12 V terminal of the battery is connected to normally open (N/O) contacts of all the relays and the ground terminal is connected to normally-closed (N/C) contacts of the relays.

PLANNING:

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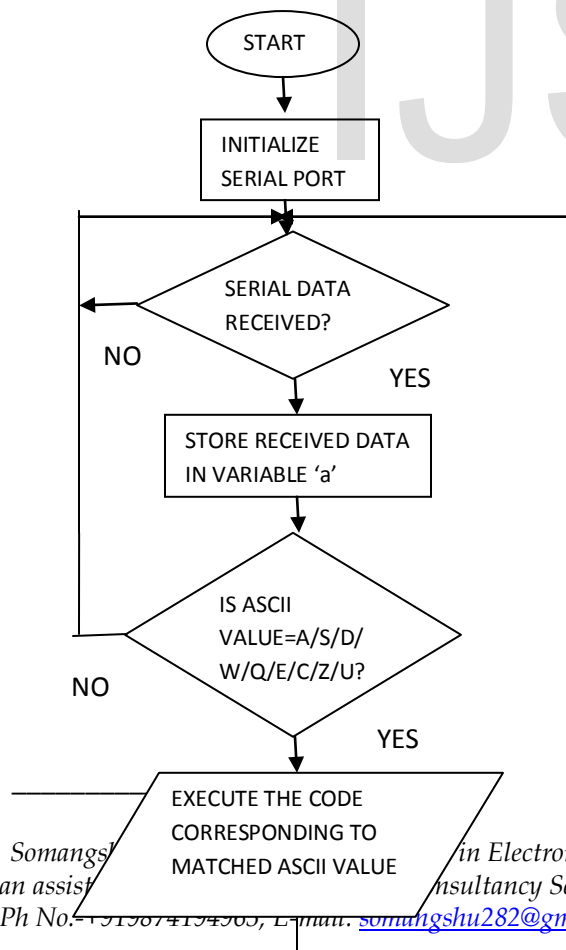
First, a microcontroller P89V51RD2 is taken, the key feature of which is its X2 mode operation (6 clocks per machine cycle) to achieve twice the throughput at the same clock frequency. Timer 1 is used in mode 2(8 bit auto-reload). It is used to set the baud rate to 1200. After TH1 is set, it starts running until P89V51RD2 is made off. It waits until it receives a start bit. After receiving a start bit, it receives 8 bit data and places the data in SBUF register. Then the framing error is checked. If there is a framing error, the byte received is discarded. Otherwise the contents of SBUF register is compared to the ASCII code of alphabets W, S, D, A, Q, E, C, Z and U. When the match is found, the operation related to each alphabet is executed. Then the toy car stops or moves in a particular direction as per this value.

The RXD pin of the microcontroller P89V51RD2 is connected to the data pin of the 434 MHz ASK module receiver. So the microcontroller detects the transmitted data at its pin 10(RXD). The logic of the flowchart deciding the movement of the robot shall be burnt in the form of an appropriate program into the controller. The output from the microcontroller although logically correct is not enough to drive a 12V dc motor. So I used a motor driver chip L293D that steps up the voltage level from the microcontroller output in order to drive the motor.

APPROACH:

The following diagram shows the flowchart of the program. The program is written in C and is compiled

using KEIL C software. The HEX code generated is burnt into the chip using FLASH MAGIC programming software from NXP semiconductors.



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Fig. 3: Flow-chart of the program

Before sending the data from the PC, it is needed to check which com port is connected to the circuit. Set the baud rate of the com port to 1200, stop bit to 1 and data bits to 8. The settings need to be done in 'DEVICE MANAGER' option in the desktop. Now the serial communication software TERMINAL v1.9b is run, the com port is selected and the afore-mentioned settings are done. After completing all the settings and component assembly, the power supply to the

transmitter and receiver circuits is switched on. TERMINAL v1.9b software is run and the connection is activated by pressing 'Connect' button followed by W, S, D, A, Q, E, C, Z and U key on the keyboard. The ASCII code corresponding to that key will be transmitted serially in a 10-bit binary datastream.

CONTROLLING THE TOY CAR

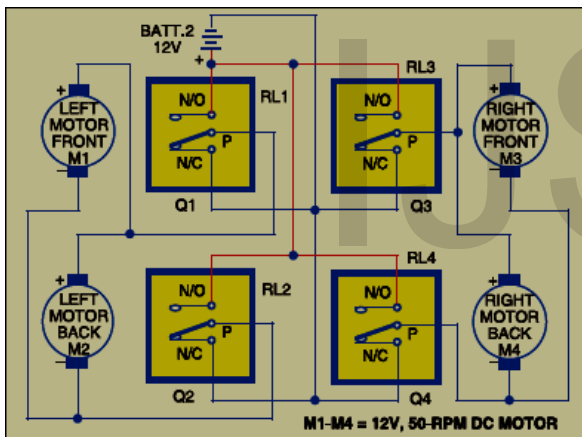


Fig. 4: Relay connections to motors

'W' forward movement ($Q1=1, Q2=0, Q3=1, Q4=0$): The toy car moves forward when all the motors move clockwise. When you type 'W' character from the keyboard, the microcontroller generates 1010 bits at its port pins p1.1 through p1.4. This signal is sent to the relay driver section T1 through T4.

'S' backward movement ($Q1=0, Q2=1, Q3=0, Q4=1$): Backward movement takes place when all the motors move anticlockwise.

'D' right drift ($Q1=1, Q2=0, Q3=1, Q4=0$ (for 54 ms) and $Q1=1, Q2=0, Q3=0, Q4=0$ (for 108 ms)): Right drift is possible by rotating the left motors at a high speed and the right motors at a low speed. This is possible with pulse-width modulated (PWM) pulse given to the right motors. The right motors are given a pulse train of 33 percent duty cycle so that these rotate at one-third speed of the left motors.

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'A' left drift ($Q1=1, Q2=0, Q3=1, Q4=0$ (for 54 ms) and $Q1=0, Q2=0, Q3=1, Q4=0$ (for 108 ms)): Left drift is possible by routing the right motors at a high speed and the left motors at a low speed. The left motors are given a pulse train of 33 percent duty cycle so that these rotate at one-third speed of the right motors.

'Q' sharp forward left turn ($Q1=0, Q2=0, Q3=1, Q4=0$): The toy car moves to the left in the forward direction when the left motors are static and the right motors move clockwise.

'E' sharp-forward right turn ($Q1=1, Q2=0, Q3=0, Q4=0$): The car moves to the right sharply in the forward direction when the left motors move clockwise and the right motors are static.

'C' sharp-backward left turn ($Q1=0, Q2=0, Q3=0, Q4=1$): Sharp left turn takes place when the left motors move anticlockwise. The car moves to the left sharply in the backward direction.

'Z' sharp-backward right turn ($Q1=0, Q2=1, Q3=0, Q4=0$): The car moves to the right sharply in the backward direction when the left motors move anticlockwise and the right motors are static.

'U' stop ($Q1=0, Q2=0, Q3=0, Q4=0$): To stop the car, all the motors should be static.

2.2.1 PROJECT DESIGN

1. PC - Many ports are available at the base of PC in order to send data to the connected peripherals by the serial ports. The serial port is based on IEEE RS-232 standard, which defines voltage and baud rates. The RS-232 standard serial port has 9 pins having different functions for transmitting and receiving data.

2. Controller- The microcontroller has different specific voltage levels for data logic 0 and logic 1, so we have to convert the RS-232 standard signal level into controller TTL signal level by MAX-232 converter. P89V51RD2 is an 80C51 microcontroller with 64 kB flash, 1024 bytes of data RAM, 32 I/O ports, three 16-bit timers/counters and two pins for serial data transmission and reception. TH1 is used for serial communication. It is operated with an 11.0592 MHz crystal. A variety of control mechanisms can be used for the purpose of controlling this vehicle. However due to time and space restrictions it was decided to use a microcontroller for the purpose. The microcontroller generates suitable control signals to guide the vehicle in the proper direction.

3. The Driver- This portion is required to bring about a proper interfacing between the microcontroller and the dc motors. It steps up the output signal from the microcontroller to a fairly large level for driving the motors. Control signals from the microcontroller energise or de-energise the relays i.e when a control signal makes a pin of P89V51RD2 high, the transistor connected to it conducts to energise the corresponding relays.

Here, 12 V terminal of the battery is connected to normally- open(N/O) contacts of all the relays and the ground terminal is connected to normally-closed(N/C) contacts of the relays. When all the relays are not energized, positive and negative ends of all the motors connect to the ground terminal of the battery, so the motors will not rotate.

4. Motor- If all the relays energise, ends of the motors connect to 12V and the motors don't rotate. If any one of the relays energizes, one end of the respective motor connects to +12 V and the other end to the ground. This makes the motor rotate. Energization of the relay decides clockwise or anti-clockwise movement of the motor.

Q1 output from the microcontroller is fed to the base of the transistor T1.

When Q1 is high, T1 conducts and relay RL1 energizes to make the pole (p) shift towards N/O contact. This connects +12V to the positive terminal of motor M1 on front left of the toy car.

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When Q2 is high, transistor T2 conducts and relay RL2 energizes to make the pole (p) shift towards N/O contact. This connects +12V to the positive terminal of motor M1 on left back of the toy car.

When Q3 is high, transistor T3 conducts and relay RL3 energizes to make the pole (p) shift towards N/O contact. This connects +12V to the positive terminal of motor M1 on right front of the toy car.

When Q4 is high, transistor T4 conducts and relay RL4 energizes to make the pole (p) shift towards N/O contact. This connects +12V to the positive terminal of motor M1 on right back of the toy car.

2.2.2 A GENERAL DESCRIPTION OF THE COMPONENT USED:

MICROCONTROLLER:

8051 microcontroller is 40 pin chip. It is operated with 11.0592 MHz crystal. The advantage of using a microcontroller is the factor that no separate I/O interfacing devices need to be incorporated in the circuit. The microcontroller as we know has a 8 bit microprocessor along with I/O devices.

The pin configurations are listed below:

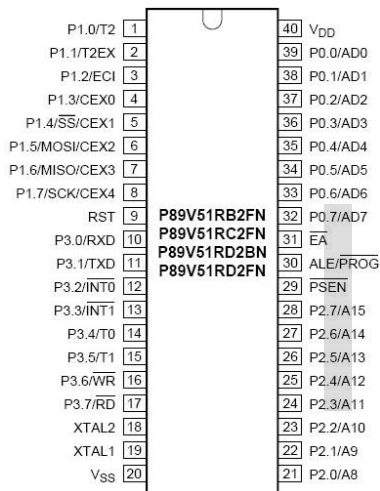


Fig. 5: Pin Configuration of Microcontroller

1-8: Port1- each of these pins can be used as either input or output according to the needs.

Pins 1 and 2 have special functions associated

with timer2.

9: Reset Signal - A high on this input halts the MCU and clears all the registers.

10-17: Port3- As port 1 each of these pins can be used as universal input or output.

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10: RXD-Serial input for asynchronous communication

11: TXD- serial output for asynchronous communication.

12-13-input for interrupt 0 and 1

14-15- clock input of counter 0 and 1

16-17- signal for writing and reading

18-19- Input and output of internal oscillator.

20: Ground

21-28: Port2- If external memory is not present pins of port2 act as universal input/output. If external memory is present, this is the location of the higher address byte.

29: PSEN-Microcontroller activates this bit upon each reading of byte from program memory.

30: Before each reading of the external memory microcontroller sends the lower bytes of the address register to port0 and activates the output ALE.

31: A low on this pin designates the port2 and port3 for transferring address regardless of the presence of internal memory.

32-39: Port0- Similar to port the pins of port 0 can be used as universal input/output if external memory is not used. In case of external memory, this behaves as the lower bit of address.

40: Power

DRIVER:

The output signal from a microcontroller ranges between 0 and 5V. It is impossible to drive a 12V motor with this output because of the difference in voltage levels. So a device is required that shall step up the voltage level from 5V to 12V so that the motors can be operated with it. Such a device is called a motor driver. The internal circuit of any motor driver IC reveals the fact that a motor driver simply functions as a buffer switch. On one terminal of the switch 12V is supplied. The input signal of 5V to the driver functions as the controlling parameter of the switch. In the presence of this signal the switch closes to transmit the 12V to the other terminal of the switch that is connected with the motor. Upon receiving this 12V signal the motor turns. Apart from this, the driver protects the microcontroller from the back emf produced by the rotating motors. This protection is necessary because such a back emf might erase the program from the microcontroller completely.

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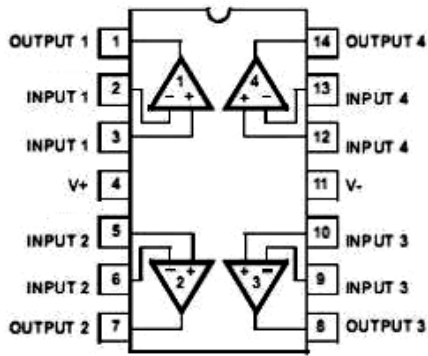


Fig.6: Internal circuit of LM324

MOTOR

There are many different kinds of DC motors, but they all work on the same principle. They turn current into pulses of magnetism, which they use to turn a rotor. There are many different kinds of electric motors namely brushed dc motors and brushless dc motors. Basically motors are generators, and one can be converted into the other. When motors operate they produce an emf, just like generators do. It is called a back emf, and does not immediately appear when they are initially turned on. The back emf works to reduce the current in the loop, thus slowing the motor down, and gets larger as the speed of the motor increases. This causes the power requirements of the motor to also increase, especially under loads that are very large. This contributes to energy waste and inefficiency in their operation. That is exactly why a driver is needed. It blocks the back emf produced by the motor from interfering with the microcontroller program.

Table 2: RS232 to TTL Level Conversion

RS232 line type and logic level	RS232 voltage	TTL voltage to/from MAX232
Data transmission (Rx/Tx) logic 0	+3 V to +15 V	0 V
Data transmission (Rx/Tx) logic 1	-3 V to -15 V	5 V
Control signals (RTS/CTS/DTR/DSR) logic 0	-3 V to -15 V	5 V
Control signals (RTS/CTS/DTR/DSR) logic 1	+3 V to +15 V	0 V

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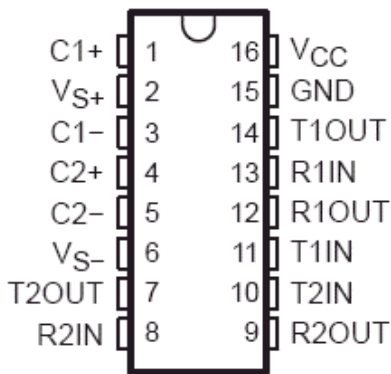


Fig. 7: Pin configuration of MAX232

P89V51RD2

The device is compatible with the industry-standard 80C51 instruction set and pinout. The flash program memory supports both parallel programming and in serial in-system programming (ISP). It is also in-application programmable, allowing the flash program memory to be reconfigured even when the application is running. P89V51RD2 is a powerful microcontroller which provides a highly flexible and cost-effective solution to many embedded control applications.

The P89V51RD2 provides the standard following features:

64K bytes of on-chip flash program memory, 1024 bytes of RAM, 32 I/O lines, programmable watchdog timer, 12 clock or 6 clock mode selection via ISP or software, 8 interrupt sources with four priority levels, three 16 bit timers/counters. The control strategy is fed by burning a suitable program into the microcontroller.

IC7805

7805 is a voltage regulator which receives voltage between 9-12 volts and provides 5 volts steady supply to the circuit components. It supplies power to MAX232. The pin 2 of the regulator IC is connected to the ground. Here it is connected to 3.9V zener diode. The 5V supply from 7805 regulator IC powers the RF ASK transmitter module through its pin 3.

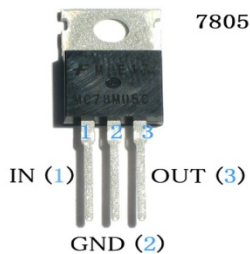


Fig. 8: Configuration of IC7805

Table 3: Items and Components Details

Item Name	Value/Details
Resistance R1	470ohm
R2	470ohm
R3	8.2kohm

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R4	470ohm
R5	470ohm
R6	470ohm
R7	470ohm
TX-434	434 MHz
RX-434	434 MHz
Capacitor C1	0.1uF ceramic
C2	10uF electrolytic
C3	10uF electrolytic
C4	10uF electrolytic
C5	10uF electrolytic
C6	0.1uF electrolytic
C7	10uF electrolytic
Transistor T1 SL100	nnp
T2 SL100	nnp
T3 SL100	nnp
T4 SL100	nnp
IC1	MAX232 RS-232 Level converter
IC2,IC4 7805	5V Regulator
IC3 P89V51RD2	8051 Microcontroller
Relay RL1-RL4	12V, single changeover
Xtal1 crystal oscillator	11.0592 MHz
Batt.1PP3 battery	9V
Batt.2SMF battery	12V, 4.5Ah
LED1	Red
LED2	Green
Diode D1-D4 1N4007	Rectifier Diode
S1,S2	On-off toggle switch
S3	Tactile Switch
M1-M2 DC motor	12V, 50 rpm

3. CIRCUIT DESIGN:

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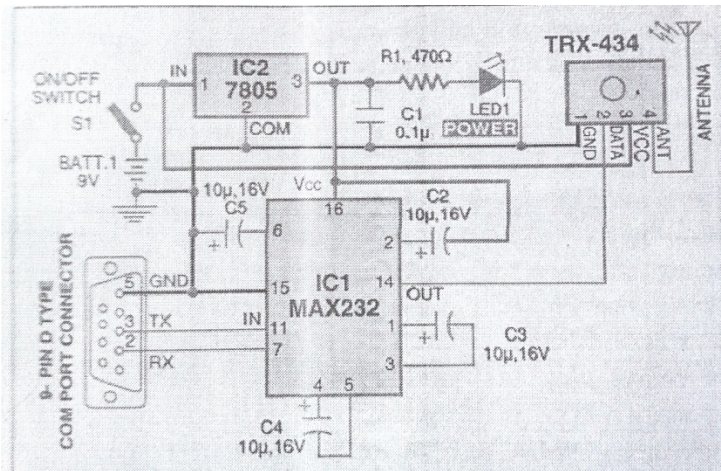


Fig. 9: Transmitter section

The transmitter output is up to 8mW at 433.92MHz with a range of approximately 400 foot (open area) outdoors. Indoors, the range is approximately 200 foot, and will go through most walls.

The TWS-434 transmitter accepts both linear and digital inputs, can operate from 1.5 to 12 Volts-DC, and makes building a miniature hand-held RF transmitter very easy.

The T434 is approximately the size of a standard postage stamp.

Key Features:

1. Frequency: 433.92 MHz
2. 5 - 12V Single Supply Operational
3. OOK / ASK Data Format
4. Up to 9.6 kbps data rate
5. 4 Pin compact size module
6. + 5 dbm out put power (12 V, Vcc)

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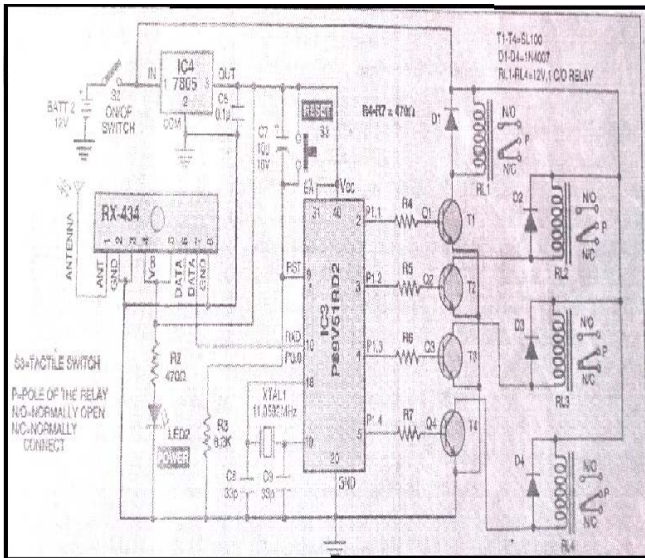


Fig. 10: Receiver section

RWS-434: The receiver also operates at 434 MHz, and has a sensitivity of 3uV. The RWS-434 receiver operates from 4.5 to 5.5 volts-DC, and has both linear and digital outputs.

Note: For maximum range, the recommended antenna should be approximately 35cm long. To convert from centimeters to inches -- multiply by 0.3937. For 35cm, the length in inches will be approximately 35cm x0.397=13.7795 inches long. We tested these modules using a 14", solid wire, and reached a range of over 400 foot, results may vary depending on surroundings.

Key Features:

1. Miniature Size
2. Wide Operating Range
3. Low Power Consumption
4. Improved Data Transmission
5. No Alignment Required
6. No External Components PIN Configuration and Size

Software Program:

Keil (MicroVision 2)

The Keil C51 Cross Compiler is an ANSI C Compiler that is written specifically to generate fast, compact code for the 8051 microcontroller family. The C51 Compiler generates object code that matches the efficiency and speed of assembly programming. Software Development Cycle in Keil. When we use the Keil Software tools, the project development cycle is roughly the same as it is for any other software development project.

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The program is written in C and is compiled using Keil C software. A hex code is generated.

Visual Basic:

Microsoft Visual Basic is the fastest and easiest way to create applications for Microsoft Windows. Whether you are an experienced professional or brand new to Windows programming, Visual Basic provides you with complete set of tools to simplify rapid application development. The "Visual" part refers to the method used to create the Graphical User Interface (GUI). Beginners can create useful applications by learning just a few of the keywords, yet the power of the language allows professionals to accomplish anything that can be accomplished using any other Windows programming language.

Flash Magic:

The HEX code generated using Keil software is burnt into the chip using Flash Magic programming software from NXP (Philips) semiconductor.

NXP Semiconductors produce a range of Microcontrollers that feature both on-chip Flash memory and the ability to be reprogrammed using In-System Programming technology. Flash Magic is Windows software from the Embedded Systems Academy that allows easy access to all the ISP features provided by the devices. These features include:

- Erasing the Flash memory (individual blocks or the whole device)
- Programming the Flash memory
- Modifying the Boot Vector and Status Byte
- Reading Flash memory
- Performing a blank check on a section of Flash memory
- Reading the signature bytes
- Reading and writing the security bits
- Direct load of a new baud rate (high speed communications)
- Sending commands to place device in Bootloader mode

Under Windows, only one application may have access the COM Port at any one time, preventing other applications from using the COM Port. Flash Magic only obtains access to the selected COM Port when ISP operations are being performed. This means that other applications that need to use the COM Port, such as debugging tools, may be used while Flash Magic is loaded.

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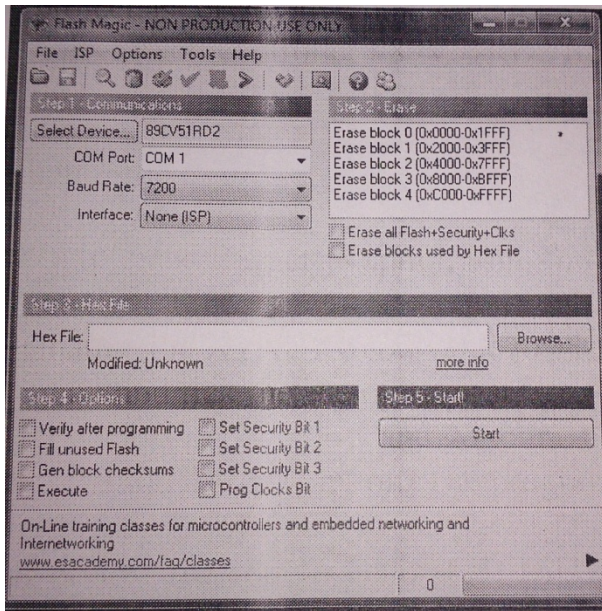


Fig. 11: Screenshot of Flash Magic Window

4. TESTING

Before sending the data from my PC, I checked which com port is connected to the circuit. I set the baud rate of the com port to 1200, stop bit to 1 and data bits to 8. I selected 'Device Manager' option from my desktop PC to do these settings, ran a serial communication software such as Terminal v1.9b, selected the com port and made the aforementioned settings. After completing all the settings and component assembly, I switched on the power supply to the transmitter and receiver circuits. Ran Terminal v1.9b software and activated the connection by pressing 'Connect' button followed by W, S, D, A, Q, E, C, Z or U key on the keyboard. The ASCII code corresponding to that key transmitted serially in a 10-bit (1 start bit+8 data bits for ASCII code+1 stop bits) binary datastream. The toy car moved as per the input from the keyboard.

Since a large number of components were driven from single 5V supply extracted from a 7805 chip, some abrupt voltage drops were observed during testing. These drops became more frequent on using a 9V battery. So in its stead a 12V supply from an SMPS was used. The voltage was found to be quite uniform throughout the circuit in that case.

5. MEASUREMENTS, RESULTS AND DISCUSSION

After the fabrication of the entire circuit it was tested. While testing, the outputs of the different blocks of the circuit were measured using a multimeter.

Table 4: Measurement Results

Component	Input Voltage	Input Current	Output Voltage	Output Current
Microcontroller	3.1V	47mA	4.43V	.19mA

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Driver	4.3V	.20mA	10.14V	-----
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It must be noted that all the above data were tabulated while the concerned component was not connected with the next component in the circuit. When such a connection is made a certain quantity of voltage drop occurs that leads to a reduction in voltage and current levels as from the data given above.

The response time of the system is found to be reasonably fast within limits of experimental error. After making all the measurements and correcting all the occurring errors to the maximum extent possible, the breadboard circuit was finally installed in the vehicle. The circuit spanned an area of four breadboards.

6. CONCLUSION

This project gives us a great deal of knowledge about the technology of wireless control, ASK modulation, working of clocks and the relays to drive the DC motors, the insight features of the microcontroller P89V51RD2. This type of device (microcontroller) provides us with the working of chips and the relays driven by it through a relay-driver circuitry.

The main part is the control of the toy car by rotating the wheels in different directions with the help of DC motors. In this project as soon as the TH1 timer triggers the relay, a conducting path is established between the terminals of the load and hence the device is turned on. The PMDC motors are isolated from the controlling circuit by the relays to protect the microcontroller and other low-current devices from relatively high-current driven motors.

Parallel programming mode supported by the flash memory offers gang programming at high speed, reducing programming costs and time to market. ISP allows a device to be reprogrammed in the end product under software control. The capability to field/update the application firmware makes a wide range of applications possible.

FUTURE SCOPE

Intelligent mobile robot cars must often operate in an unstructured environment cluttered with obstacles and with many possible action paths to accomplish a variety of tasks.

The project provides a simple design which can be used in various situations and areas with little additions to meet specific goals.

The areas of application of this project are as follows:

Military: to do rescue operations, mine detection, patrolling in enemy territory etc.

Wild Life Research: to reach in areas like snake holes, burrows, caves and dens for studying animals in their natural environment without disturbing them.

Search & Rescue: to reach rough terrain, under debris etc to search for trapped victims.

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Security: in malls, parking lots, buildings and basements for detecting bombs & other such threats.

Industries: to move materials and goods from one place to other.

At Home: as a luxury product to get things at the click of mouse buttons.

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