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ROBOTIC CONTROL USING MOBILE PHONE

A PROJECT REPORT

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APRIL 2007

**DEDICATED TO
OUR PARENTS AND TEACHERS**

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BONAFIDE CERTIFICATE

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ABSTRACT

Robotic systems have advanced dramatically over the past few years. The automated systems were initially developed to reduce labour requirements, shorten working time, reduce costs, and improve quality. The current benefits such as placing or keeping workers out of dangerous work area have improved the workers environments and their morale. Since we are using service provider of the mobile, robot can be controlled from anywhere inspite of the distance. Initially the robots are controlled through remote control and via Internet, which are limited over short range and reduced mobility. Sophisticated mobile robots will act as a gateway in wireless networks, which allow human to control the robot through wireless communications. This project employs two mobile phones, one is inbuilt with the robot and other is provided to the user. The signals from the user's mobile is converted into 4 bit binary code by DTMF decoder which is fed into microcontroller which acts as de-multiplexer to produce control signals for switching the respective relays of dc motors in the robot. Hence the robotic movements are controlled by the user through mobile phone.

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LIST OF ABBREVIATIONS

SSR	Solid State Relays
EMF	Electro Magnetic Force
TTL	Transistor Transistor Logic
CMOS	Complementary Metal-Oxide-Semiconductor
DSR	Data Set Ready
TD	Transmitted Data
DTR	Data terminal ready
ADC	Analog to Digital Converter
RAM	Random Access Memory
ROM	Read Only Memory
EPROM	Erasable Programmable Read Only Memory
DTMF	Dual Tone Multi Frequency

1.OVERVIEW OF THE PROJECT

The basic goal of our project is to eliminate the need for human to involve directly in the hazardous work using a robot with an inbuilt mobile. When the inbuilt mobile is called, it is made to answer in auto answer mode. The robot's movements are controlled by the keys in the user's mobile. When the call is in progress between the inbuilt mobile and the user's mobile, the number pressed in user's mobile is transferred to the inbuilt mobile as signals. The DTMF IC (M8870) converts these signals into 4 bit binary code which is fed into microcontroller. This microcontroller acts as de-multiplexer by switching the respective relays of dc motors in the robot. Hence the robotic movements are controlled by the user through mobile phone.

CHAPTER 1

2.BLOCK DIAGRAM

This chapter provides information about the functions of various blocks in this project. The Fig 2.1 shows the Overall block diagram of robotic control using mobile phone.

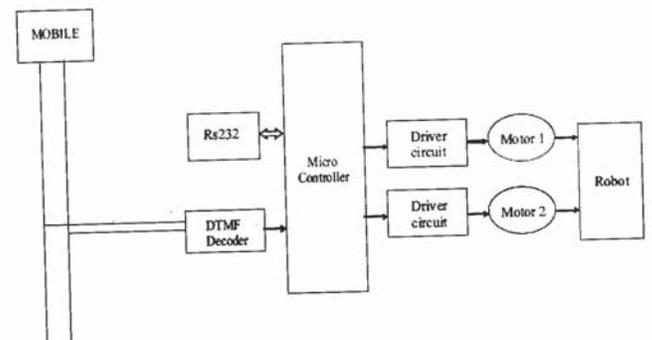


Fig 2.1 Overall block diagram

2.1 DTMF DECODER

The tones that are received by the inbuilt are fed as input to the DTMF decoder which decodes the DTMF tone in to four bit binary output.

CHAPTER 2

2.2 RS 232

The inbuilt mobile is interfaced with the DTMF decoder using RS 232 cable which carries the incoming signal to the DTMF decoder for decoding.

2.3 MICROCONTROLLER

The microcontroller receives the input signals from the DTMF decoder and demultiplexes those signals to perform the operations assigned to it.

2.4 RELAYS AND MOTORS

The relay gets activated when one of the outputs from the microcontroller is enabled and it will drive the motor in different directions.

2.5 ROBOT

This project employs a smart, compact robot designed to perform the following movements when a key is pressed in the mobile. The key operations are summarized in the table 2.1.

KEY OPERATIONS

KEYS	ROBOT MOVEMENTS
2	FORWARD
8	REVERSE
4	LEFT
6	RIGHT
5	STOP

Table 2.1 Various key operations

3. POWER SUPPLIES

3.1 INTRODUCTION

The present chapter introduces the operation of various power supplies used in this project. A 5v Power supply is required for Microcontroller and DTMF circuits. The relay circuits operate through 12v power supply.

The power supply circuits are built using filters, rectifiers, and voltage regulators. Starting with an ac voltage, a steady dc voltage is obtained by rectifying the ac voltage, then filtering to a dc level, and finally, regulating to obtain a desired fixed dc voltage. The regulation is usually obtained from an IC voltage regulator unit, which takes a dc voltage and provides a somewhat lower dc voltage, which remains the same even if the input dc voltage varies, or the output load connected to the dc voltage changes.

A block diagram containing the parts of a typical power supply and the voltage at various points in the unit is shown in fig 3.1. The ac voltage, typically 250V rms, is connected to a transformer, which steps that ac voltage down to the level for the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation. A regulator circuit can use this dc input to provide a dc voltage that not only has much less ripple voltage but also remains the same dc value even if the input dc voltage varies, or the load connected to the output dc voltage changes. This voltage regulation is usually obtained using one of a number of popular voltage regulator IC units.

CHAPTER 3

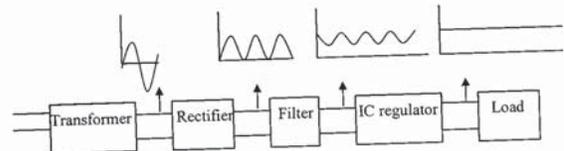


Fig 3.1 Block diagram of Power supply

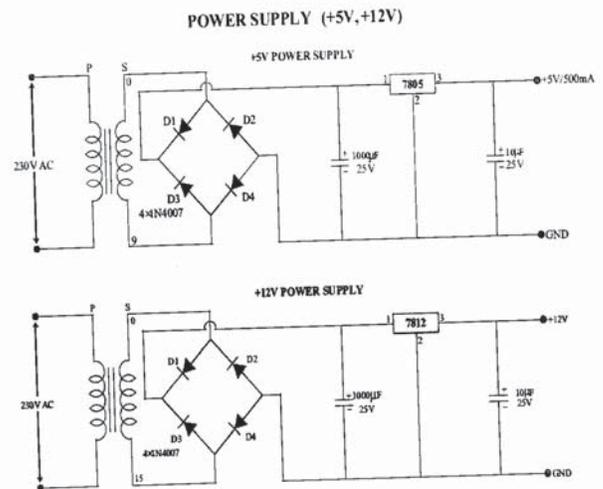


Fig 3.2 Power supply

3.2 Working principle of Power supply

Fig 3.2 shows power supply block which performs the operation of converting AC the supply to suitable DC voltages.

3.2.1 Transformer

The potential transformer will step down the power supply voltage (0-230V) to (0-6V) level. Then the secondary of the potential transformer will be connected to the precision rectifier, which is constructed with the help of op-amp. The advantages of using precision rectifier are it will give peak voltage output as DC, rest of the circuits will give only RMS output.

3.2.2 Bridge rectifier and filter

When four diodes are connected as shown in figure 3.3, the circuit is called as bridge rectifier. The input to the circuit is applied to the diagonally opposite corners of the network, and the output is taken from the remaining two corners.

There is a positive potential, at point A and a negative potential at point B during positive half cycle of input. The positive potential at point A will forward bias D3 and reverse bias D4.

The negative potential at point B will forward bias D1 and reverse D2. At this time D3 and D1 are forward biased and will allow current flow to pass through them; D4 and D2 are reverse biased and will block current flow.

The path for current flow is from point B through D1, up through RL, through D3, through the secondary of the transformer back to point B. This path is indicated by the solid arrows. Waveforms (1) and (2) in fig3.1 can be observed across D1 and D3.

One-half cycle later the polarity across the secondary of the transformer reverse, forward biasing D2 and D4 and reverse biasing D1 and D3. Current flow will now be from point A through D4, up through RL, through D2, through the secondary of T1, and back to point A. This path is indicated by the broken arrows. Waveforms (3) and (4) in fig3.1 can be observed across D2 and D4. The current flow through RL is always in the same direction. In flowing through RL this current develops a voltage corresponding to that shown waveform (5) in fig3.1. Since current flows through the load (RL) during both half cycles of the applied voltage, this bridge rectifier is a full-wave rectifier.

One advantage of a bridge rectifier over a conventional full-wave rectifier is that with a given transformer the bridge rectifier produces a voltage output that is nearly twice that of the conventional full-wave circuit.

3.2.3 IC Voltage Regulators

Voltage regulators comprise a class of widely used ICs. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device, and overload protection all in a single IC. Although the internal construction of the IC is somewhat different from that described for discrete voltage regulator circuits, the external operation is much the same. IC units provide regulation of either a fixed positive voltage, a fixed negative voltage, or an adjustably set voltage.

A power supply can be built using a transformer connected to the ac supply line to step the ac voltage to desired amplitude, then rectifying that ac voltage, filtering with a capacitor and RC filter, if desired, and finally regulating the dc voltage using an IC regulator. The regulators can be selected for operation with load currents from hundreds of milliamperes to tens of amperes corresponding to power ratings from milliwatts to tens of watts.

Three-terminal voltage regulators

Fig 3.3 shows the basic connection of a three-terminal voltage regulator IC to a load. The fixed voltage regulator has an unregulated dc input voltage, V_i , applied to one input terminal, a regulated output dc voltage, V_o , from a second terminal, with the third terminal connected to ground. For a selected regulator, IC device specifications list a voltage range over which the input voltage can vary to maintain a regulated output voltage over a range of load current. The specifications also list the amount of output voltage change resulting from a change in load current (load regulation) or in input voltage (line regulation).

3.2.4 Fixed Positive Voltage Regulators

The series 78 regulators provide fixed regulated voltages from 5 to 24 V. Figure 3.2 shows how one such IC, a 7812, is connected to provide voltage regulation with output from this unit of +12V dc. An unregulated input voltage V_i is filtered by capacitor C_1 and connected to the IC's IN terminal. The IC's OUT terminal provides a regulated +12V which is filtered by capacitor C_2 (mostly for any high-frequency noise). The third IC terminal is connected to ground (GND). While the input voltage may vary over some permissible voltage range, and the output load may vary over some acceptable range, the output voltage remains constant within specified voltage variation limits. These limitations are spelled out in the manufacturer's specification sheets. A table of positive voltage regulated ICs is provided in table 3.1

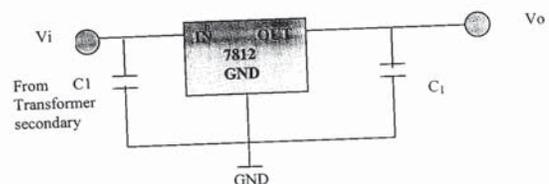


Fig 3.3 Positive voltage regulator

IC Part	Output Voltage (V)	Minimum V_i (V)
7805	+5	7.3
7806	+6	8.3
7808	+8	10.5
7810	+10	12.5
7812	+12	14.6

TABLE 3.1 Positive Voltage Regulators in 7800 series

3.3 FEATURES

- o Output current in excess of 1A
- o Output voltage of +5V / +12V
- o Internal thermal overload protection.
- o Short circuit protection.
- o Transistor safe operating area compensate



4. DUAL TONE MULTI FREQUENCY DECODER (DTMF)

DTMF signaling is quickly replacing the dual pulse signaling in the telephone networks world wide. Controlling of robot using DTMF technique is reliable surveillance and it is need of the current environment. The system should be easy to operate, efficient, cost effective & flexible for further improvements. In these days remotely operated vehicles are mostly needed in military applications, which can be implemented by DTMF DECODER.

The Deltona M-8870 is a full DTMF receiver that integrates both band split filter and decoder functions into a single 18-pin DIP or SOIC package. DTMF tone generation is shown in figure 4.1. Its filter section uses switched capacitor technology for both the high and low group filters and for dial tone rejection. Its decoder uses digital counting techniques to detect and decode all 16 DTMF tone pairs into a 4-bit code. External component count is minimized by provision of an on-chip differential input amplifier, clock generator, and latched tri-state interface bus. Minimal external components required include a low-cost 3.579545 MHz color burst crystal, a timing resistor, and a timing capacitor.

The new M-8870-02 provides a "power-down" option which, then enabled, drops consumption to less than 0.5mW. The -02 versions can also inhibit the decoding of fourth column digits.

CHAPTER 4

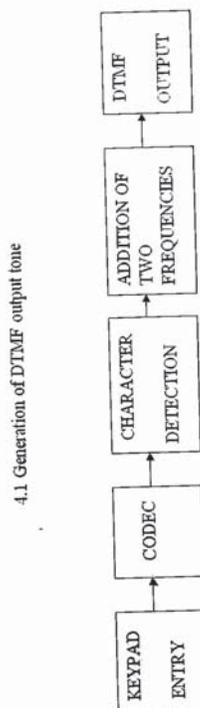


Fig-4.1

the frequency and duration of the received tones before passing the resulting 4-bit code to the output bus, which is shown in the table 4.1

4.2 M 8870

The Deltona M-8870 is a full DTMF receiver that integrates both band split filter and decoder functions into a single 18-pin DIP or SOIC package shown in fig 4.2. Manufactured using state-of-the-art CMOS process technology, the M-8870 offers low power consumption (35 mW max) and precise data handling. Its filter section uses switched capacitor technology for both the high and low group filters and for dial tone rejection. Its decoder uses digital counting techniques to detect and decode all 16 DTMF tone pairs into a 4-bit code. External component count is minimized by provision of an on-chip differential input amplifier, clock generator, and latched tri-state interface bus. Minimal external components required include a low-cost 3.579545 MHz color burst crystal, a timing resistor, and a timing capacitor.

M-8870 operating functions includes a band split filter that separate the high and low tones of the received pair, and a digital decoder that verifies both

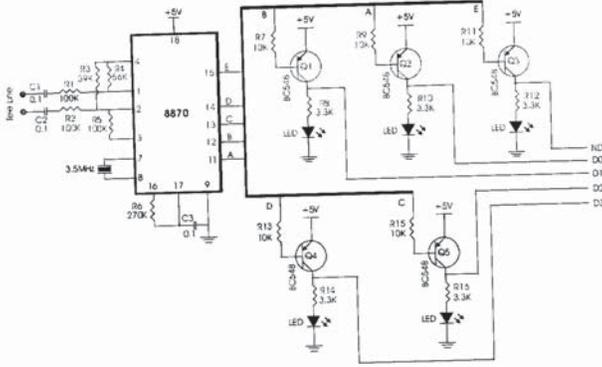


Fig 4.2 DTMF circuit

The new M-8870-02 provides a “power-down” option which, then enabled, drops consumption to less than 0.5mW. The -02 versions can also inhibit the decoding of fourth column digits.

M-8870 operating functions includes a band split filter that separate the high and low tones of the received pair, and a digital decoder that verifies both the frequency and duration of the received tones before passing the resulting 4-bit code to the output bus, which is shown in the table 4.1

F	F	KEY	OE	Q4	Q3	Q2	Q1
LOW	HIGH	(ref.)					
697	1209	1	H	0	0	0	1
697	1336	2	H	0	0	1	0
697	1477	3	H	0	0	1	1
770	1209	4	H	0	1	0	0
770	1336	5	H	0	1	0	1
770	1477	6	H	0	1	1	0
852	1209	7	H	0	1	1	1
852	1336	8	H	1	0	0	0
852	1477	9	H	1	0	0	1
941	1336	0	H	1	0	1	0
941	1209	.	H	1	0	1	1
941	1477	#	H	1	1	0	0
697	1633	A	H	1	1	0	1
770	1633	B	H	1	1	1	0
852	1633	C	H	1	1	1	1
941	1633	D	H	0	0	0	0
ANY	ANY	ANY	L	Z	Z	Z	Z

Table 4.1 Tone Decoding

H = High
L = Low
Z = High Impedance

DTMF is the generic name for pushbutton telephone signaling equivalent to the bell system’s touch-tone. Dual tone multi frequency (DTMF) signaling is quickly replacing dial-pulse signaling in telephone banking or electronic mail systems, in which the user can select options from a menu by sending signals from a telephone.

4.3 DTMF STANDARDS

The DTMF tone-signaling standard is also known as touch tone or MFPB (Multi-frequency push button). Bell labs for use by AT&T in the dial-pulse-signaling standard developed touch-tone. Each administration has defined its own DTMF specifications. They are all very similar to the CCITT standard, varying by small amounts in the guard bands allowed in frequency, power twist and talk-off.

Two tones are used to generate a DTMF digit. One tone is chosen out of four row tones, and the other is chosen out of four column tones. Two of eight tones can be combined so as to generate sixteen different DTMF digits. Of these sixteen keys, twelve are the familiar keys of a touch-tone keypad and four are reserved for future uses.

A 90-minute audiocassette tape to test DTMF decoders is available from Mite semiconductors. There also exist standard describing requirements for systems, which test DTMF systems. This standard is available from the IEEE as ANSI/IEEE standard 752-1986.

4.4 PIN FUNCTIONS

IN+: Non-inverting input connected to the front-end of the Differential amplifier

- IN -:** Inverting input. Connected to the front-end of the differential amplifier
- GS:** Gain select. It gives access to output of front-end amplifier for connection of feedback resistor.
- VREF:** Reference voltage output. May be used to bias the inputs at mid rail.
- INH*:** Inhibits detection of tones representing keys A, B,C and D
- PD*:** Power down. Logic high powers down the device and inhibits the oscillator
- OSC1:** Clock input. 3.579545MHZ crystal connected between these pins complete the internal oscillator.
- OSC2:** Clock input. 3.579545MHZ crystal connected between these pins complete the internal oscillator.
- VSS:** Negative power supply (normally connected to 0v)
- OE:** Three state output enable (input). Logic high enables the outputs Q1, Q4. Internal pull up.
- Q1, Q2:** Three state outputs. When enabled by OE,
- Q3, Q4:** Provides the code corresponding to the last valid tone pair received.
- StD :** Delayed steering output. Presents logic high when a received tone pair has been registered and the output latch is updated. Returns to logic low when the voltage on St/GT falls below Vtsi.
- Est:** Early steering output presents logic high immediately

when the digital algorithm detects a recognizable tone pair. Any momentary loss of signal condition will cause Est to return to logic low.

St/GT: Steering input/guard time output voltage greater than VTSt detected at St cause the device to register the detected tone pair and update the output latch. A voltage less than VTSt free the device to accept a new tone pair. The GT output acts to reset the external steering time constant, and its state is a function of Est and the voltage on St.

VDD: Positive power supply.

4.5 Features

- Low power consumption
- Adjustable acquisition and release times
- Central office quality and performance
- Power – down and inhibit modes (-0.2 version)
- Single 5 volt power supply
- Dial tone suppression

4.6 Applications

- Telephone switch equipment
- Mobile radio
- Remote control
- Remote data entry

CHAPTER 5

5. SERIAL COMMUNICATION

5.1 Introduction

Communication refers to meaningful exchange of information between the communicating entities. Therefore, in communication, it is concerned with all issues relating to exchange of information in the form of a dialog, e.g., dialog discipline, interpretation of messages, and acknowledgements.

5.2 Issues in Communication

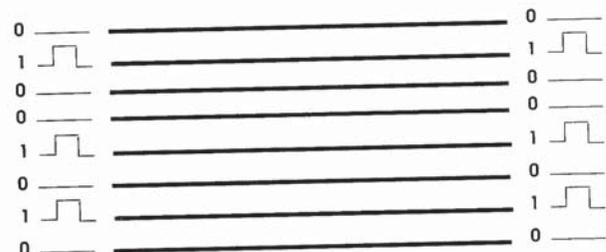
- Types of data communication
- Modes of data transmission
- Transmission Media
- Serial Interface standards

Data Transmission

- There is always the need to exchange data, commands and other control information between a computer and its terminals, or between two computers.
- This information is in the form of bits. Data transmission refers to the movement of bits over some physical medium connecting two or more digital devices.
- The two options of transmitting the bits are:
 - ✓ Parallel Communication
 - ✓ Serial Communication

Parallel Transmission

If more than 1 bit of information is transmitted over the data transmission medium at a time then it is considered as a parallel communication.



Serial Transmission

- The physical connection determines how many bits (1's or 0's) can be transmitted in a single instance of time.
- If only 1 bit of information can be transmitted over the data transmission medium at a time then it is considered a serial communication.



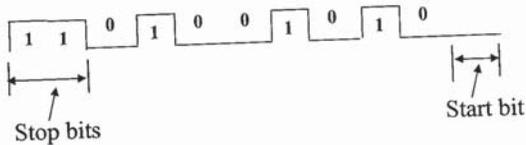
5.3 Modes of Serial Data Transmission

Asynchronous Transmission

- An action is called asynchronous when the agent performing an action does so whenever it wishes.
- Asynchronous transmission refers to the case when the sending Node commences transmission of bytes at any instant of time.
- Only one byte is sent at a time and there is no time relation between consecutive bytes, i.e., after sending a byte, the next byte can be sent after an arbitrary delay.

Start & Stop Bits In Asynch Serial Communication

- Due to the arbitrary delay between consecutive bytes, the time occurrences of the clock pulses at the receiving end need to be synchronized repeatedly for each byte.
- This is usually achieved by providing two extra bits, a Start bit at the beginning and a Stop bit at the end of a byte.



- Since useful communication is generally two way, a two-wire system is employed, one to transmit and one to receive.
- Signals are processed by determining whether they are positive or negative when compared with a ground.

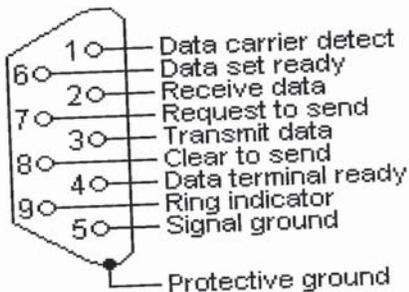


Fig 5.1 Pin diagram of RS 232

Synchronous Serial Transmission

- A synchronous action, unlike an asynchronous action, is carried out under the control of a timing source.
- In synchronous transmission, bits are always synchronized to a reference clock irrespective of the bytes they belong to. There are no Start or Stop bits.
- Bytes are transmitted in a Block in a continuous stream of bits.
- Continuous transmission of bits enables the receiver to extract the clock from the incoming electrical signal.

5.4 RS-232 Standard

- ✓ Most widely used serial I/O interfacing standard.
- ✓ Used in PCs and numerous types of equipments.
- ✓ It is not compatible with I/O voltage levels of TTL logic family

Voltage Levels in RS-232

- ✓ Logic high (1) represented as -3 to -25V.
- ✓ Logic low (0) represented as +3 to +25V.
- ✓ -3 to +3v not defined.

RS-232 Interface

RS-232 was introduced in 1960, and is currently the most widely used communication protocol. It is simple, inexpensive to implement, and though relatively slow; it is more than adequate for most simple serial communication devices such as keyboards and mice.

- RS-232 is a single-ended data transmission system, which means that it uses a single wire for data transmission.

PIN NO	SIGNAL
1	Carrier Detect (CD) (from DCE) Incoming signal from a modem
2	Received Data (RD) Incoming Data from a DCE
3	Transmitted Data (TD) outgoing Data to a DCE
4	Data Terminal Ready (DTR) Outgoing handshaking signal
5	Signal Ground Common reference voltage
6	Data Set Ready (DSR) Incoming handshaking signal
7	Request To Send (RTS) Outgoing flow control signal
8	Clear To Send (CTS) Incoming flow control signal
9	Ring Indicator (RI) (from DCE) Incoming signal from a modem

Table 5.1 Pin details

RS232 Control Lines

The RS232 standard describes the functions carried out by several control signals between the DTE and the DCE. The following control signals implement most of the important functions of an R232 DTE to DCE link.

Data terminal ready (DTR)

This is a signal from the DTE to the DCE. When asserted, DTR indicates that the DTE is ready to accept data from the DCE. In systems with a

modem, it maintains the connection and keeps the channel open. If DTR is negated, the communication path is broken. In everyday terms, negating DTR is the same as hanging up a phone.

Data set ready (DSR)

This is a signal from the DCE to the DTE, which indicates the readiness of the DCE. When this signal is asserted, the DCE is able to receive from the DTE. DSR indicates that the DCE (usually a modem) is switched on and is in its normal functioning mode (as opposed to its self-test mode).

Request to send (RTS)

This is a signal from the DTE to the DCE. When asserted, RTS indicates to the DCE that the DTE wishes to transmit data to it.

Clear to send (CTS)

This is a signal from the DCE to the DTE and, when asserted, indicates that the DCE is ready to receive data from the DTE.

Rxd

It is used to receive the serial data transmitted from the external Microcontroller or circuit.

Txd

It is used to transmit the serial data to the external Microcontroller or circuit from the PC.

5.5 MAX232

RS232 does not use the conventional 0 and 5v implemented in TTL and CMOS designs. Drivers have to supply +5 to +15v for logic 0 and -5 to -15v for logical 1; this is performed by IC MAX232. This means that extra power supplies are needed to drive the RS232 voltage levels. Typically a +12 and a -12v power supply are used to drive the RS232 outputs. The first level charge pump essentially doubles the standard +5v power supply to provide the voltage level necessary for driving logic0. A second charge pump inverts this voltage and provides the voltage level necessary for driving logic1. These two charge pumps allow the RS232 interface products to operate from a single +5v supply.

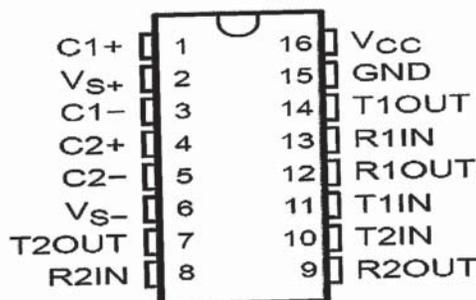


Fig 5.2 MAX232 Pin Diagram

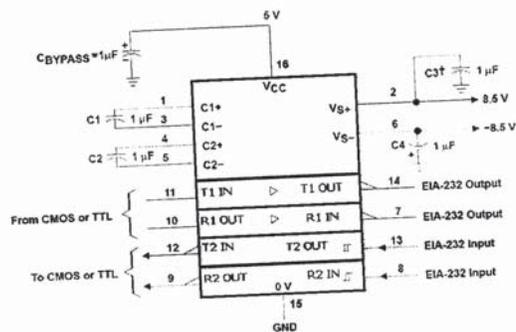


Fig 5.3 MAX232 Pin Diagram With Details

No.	Name	Purpose	Signal Voltage
1	C1+	+ connector for capacitor C1	capacitor should stand at least 16V
2	V+	output of voltage pump	+10V
3	C1-	- connector for capacitor C1	capacitor should stand at least 16V
4	C2+	+ connector for capacitor C2	capacitor should stand at least 16V
5	C2-	- connector for capacitor C2	capacitor should stand at least 16V
6	V-	output of voltage pump / inverter	-10V
7	T2out	Driver 2 output	RS-232
8	R2in	Receiver 2 input	RS-232
9	R2out	Receiver 2 output	TTL
10	T2in	Driver 2 input	TTL
11	T1in	Driver 1 input	TTL
12	R1out	Receiver 1 output	TTL
13	R1in	Receiver 1 input	RS-232
14	T1out	Driver 1 output	RS-232
15	GND	Ground	0V
16	VCC	Power supply	+5V

Table 5.2 MAX232 DIP Package Pin Layout

6. MICROCONTROLLER

6.1 Introduction to Microcontrollers

A Microcontroller consists of a powerful CPU tightly coupled with memory (RAM, ROM, or EPROM), various I/O features such as Serial Ports, Parallel Ports, Timer/Counters, Interrupt Controller, data acquisition interfaces, Analog to Digital Converter (ADC), Digital to Analog Converter (DAC), everything integrated on to a single Silicon Chip.

It does not mean that any microcontroller should have all the above said features on a chip, depending on the need and area of application for which it is designed. The on chip features present in it may or may not include all the individual sections said above. Any microcomputer system requires memory to store a sequence of instructions making up a program, parallel port or serial port for communicating with an external system, timer / counter for control purposes like generating time delays, Baud rate for the serial port, apart from the controlling unit called Central Processing Unit.

6.2 Advantages of Microcontrollers

If a system is developed with a microprocessor, the designer has to go for external memory such as RAM, ROM, or EPROM and peripherals and hence the size of PCB will be large enough to hold all the required peripherals. But the microcontroller has got all these peripheral facilities on a single chip so development of similar system with a microcontroller reduces PCB size and cost of the design.

CHAPTER 6

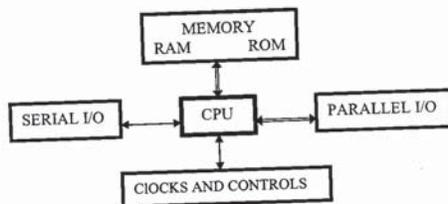


Fig 6.1 Block diagram of typical microcontroller

The block diagram in fig 6.1 shows a typical microcontroller, which is a true computer on a chip. The design incorporates all of the features found in a microprocessor arithmetic and logic unit, program counter, stack pointer and registers. It also has added the other feature needed to make a complete computer: RAM, ROM, serial ports, parallel ports counters and clock circuit.

A microcontroller is a general purpose device, but one that is meant to read data, to perform limited calculations on that data and control its environment based on those calculations. The prime use of a microcontroller is to control the operation of a machine using a fixed program that is stored in ROM and that does not change over the lifetime of the system. The microcontroller is connected with getting data from and to its own pins. The architecture and instruction set are optimized to handle data in bit and byte size. Usually a single design that can be used in as many applications as possible is done. The microprocessor design accomplishes this goal by having a very flexible and extensive range of multi byte instructions. Much of the activity in the microprocessor has to do moving code and data from external memory of the Central Processing Unit. The architecture features working

registers that can be programmed to take part in the memory access process, and the instruction set is aimed at expediting this activity in order to improve throughput. The pins that connect the microprocessor to external memory are unique, each having a single function.

6.3 8051 Microcontrollers

The Intel 8051 is a Harvard architecture single chip microcontroller (μ C) which was developed by Intel in 1980 for use in embedded systems. It was extremely popular in the 1980s and early 1990s, but today it has largely been superseded by a vast range of enhanced devices with 8051-compatible processor cores that are manufactured by more than 20 independent manufacturers including Atmel, Infineon Technologies, Maxim IC (via its Dallas Semiconductor subsidiary), NXP (formerly Philips Semiconductor), Winbond, Silicon Laboratories, Texas Instruments and Cypress Semiconductor. Intel's official designation for the 8051 family of μ Cs is MCS 51.

Intel's original 8051 family was developed using NMOS technology, but later versions, identified by a letter "C" in their name, e.g. 80C51, used CMOS technology and were less power-hungry than their NMOS predecessors - this made them eminently more suitable for battery-powered devices.

6.4 AT89C51 (Atmel)

6.4.1 Key Features

Key features of AT89C51 is summarized in the table 6.1.

Key Features	AT89C51
Operating Frequency	0-24MHz
FLASH program memory (8-bit words)	4K
Internal RAM (8-bit words)	128 Bytes
Interrupts	6
I/O Ports	Port 0,1,2,3 (32 lines)
Timers/Counters (16-bit words)	Timer 0,1
Serial Communications	Port 3
Parallel Communication	Port 0,1,2
Packaging	40-pin DIP

Table 6.1 Features of AT89C51

6.4.2 Functional Description

Fig 6.1 shows the functional block of microcontroller AT89C51, whose blocks are explained below.

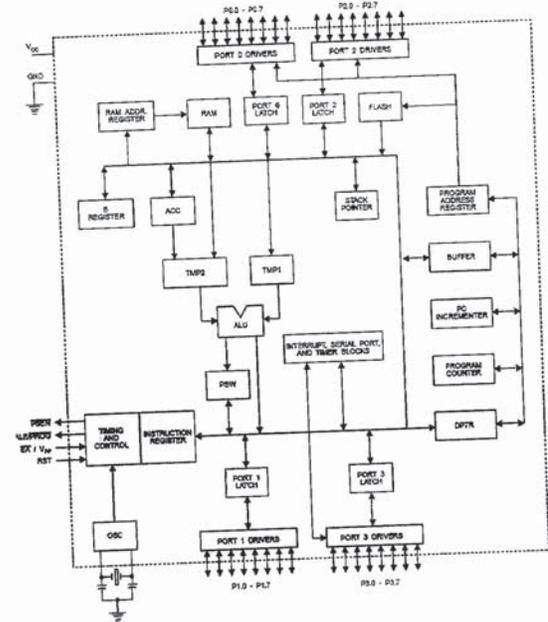


Fig 6.3 Block diagram of AT89C51

The AT89C51 is a low-power, high-performance CMOS 8-bit microcomputer with 4K bytes of Flash programmable and erasable read only memory (PEROM). The endurance of the ROM is 1000 Write/Erase cycles. The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard MCS-51 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel AT89C51 is a powerful microcomputer which provides a highly-flexible and cost-effective solution to many embedded control applications.

6.4.3 External Data Memory

Since the internal data memory in AT89C51 is only 128 bytes, external data memory of 8k has been used. The RAM used is a 28 pin DIP (KM6264B).

Features

- 8Kx8 bit Low Power CMOS Static RAM
- Process Technology: CMOS
- Organization: 8K x 8
- Power Supply Voltage: Single 5V ± 10%
- Low Data Retention Voltage: 2V(Min)
- Three state output and TTL Compatible

PROGRAMMING

7.1 Introduction

Programming is the major part, which is the basis of controlling the robot. The programming for microcontroller AT9C51 is done using KLIN C then it is burnt to the IC using hexacode converter, because it is easier method than coding directly to microcontroller. In this coding is done of individual buttons in mobile which is recognized by its 4 bit binary code.

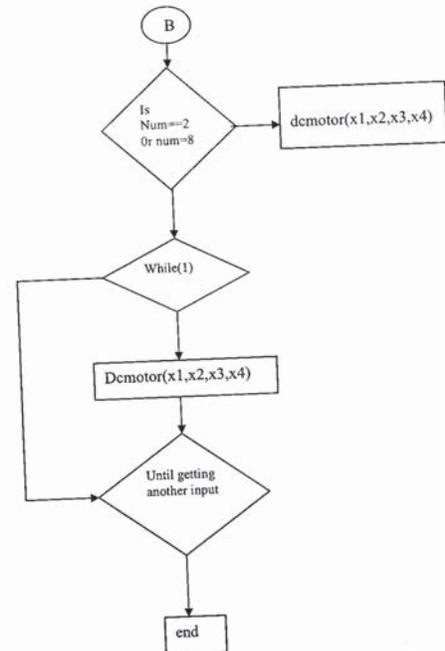
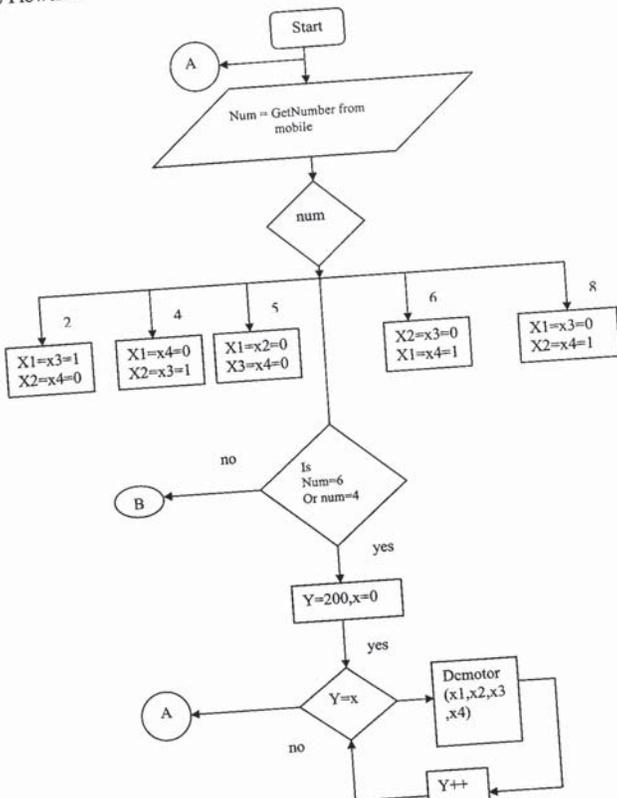
7.2 Algorithm

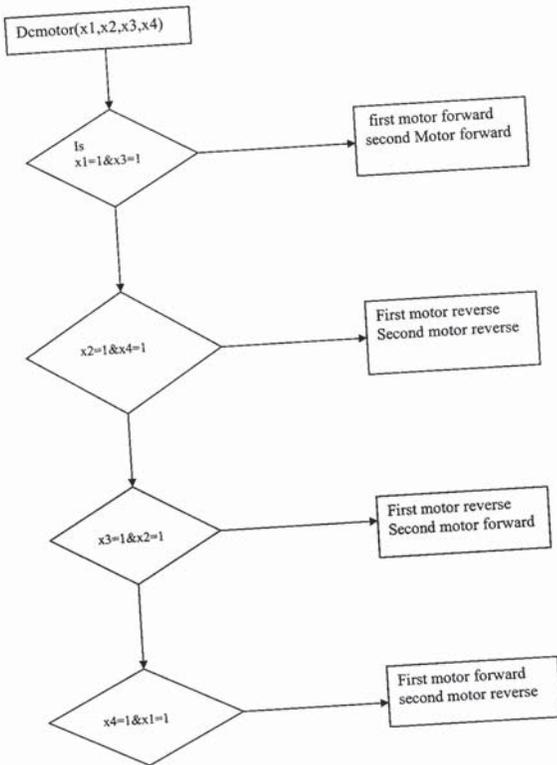
- First and the foremost step is declaring variables for the relay functions and the DC motor operation.
- Variables for relays are declared as X_1, X_2, X_3, X_4 and for motor it is DC motor.
- The value of input is checked whether it is 4 or 6, and then a delay count of 200 is initialized which is responsible for turning movement of the robot
- Loop is performed until the value of x is equal to y .
- If the input is 2 or 8 then the DC motor function is called and executed until the next button is pressed I the user's mobile.

Relay function

- If 2 is the input to the inbuilt mobile X_1 and X_3 values are 1, X_2 and X_4 values are 0, then both the motors rotate in forward direction
- If the input is 8 then X_2 and X_4 values are 1, X_1 and X_3 values are 0, then the motors rotates is reverse direction
- If the input is 4 then X_1 and X_4 values are 1, X_2 and X_3 values are 0, then the M_1 rotates forward and M_2 in reverse direction, so that the robot turns 90 degrees to the left.
- If the input is 6 then X_2 and X_3 values are 1, X_1 and X_4 values are 0, then the M_2 rotates forward and M_1 in reverse direction, so that robot turns 90 degrees to the right.
- If the input is 5 then all the relay values is set 0.

7.3 Flowchart





CHAPTER 8

8. RELAYS

8.1 Introduction

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field, which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are double throw (change over) switches.

Relays allow one circuit to switch a second circuit, which can be completely separate from the first. There is no electrical connection inside the relay between the two circuits the link is magnetic and mechanical.

8.2 Relay connections

The relay's switch connections are usually labeled COM, NC and NO

1. COM common, always connect to this, it is the moving part of the switch.
2. NC normally closed, COM is connected to this when the relay coil is off.
3. NO normally open, COM is connected to this when the relay coil is on

Connect to COM and NO if you want the switched circuit to be on when the relay coil is on. Connect to COM and NC if you want the switched circuit to

8.3 Working

The coil of a relay passes a relatively large current, most chips cannot supply large output currents so it may be necessary to use a transistor to switch the larger current required for the output devices such as relays.

A resistor R_B is required to limit the current flowing into the base of the transistor and prevent it being damaged. However, R_B must be sufficiently low to ensure that the transistor is thoroughly saturated to prevent it overheating, that is particularly important if the transistor is switching a large current ($>100\text{mA}$). A safe rule is to make the base current I_B about five times larger than the value which should just saturate the transistor?

8.3.1 Back EMF

When current to the coil is switched off the magnetic field around the coil collapses very quickly. This can cause a phenomenon called "Back emf" where a high voltage 'spike' is produced of opposite polarity to the current originally driving the coil. This reverse voltage 'spike' can damage other components in the interface. To avoid this problem a 'signal' diode is connected across the coil of the relay so that any Back emf is safely 'shorted' out and never reaches the rest of the components.

8.3.2 Protection diode

If the load is a motor, relay or solenoid (or any other device with coil) a diode must be connected across the load to protect the transistor (and chip) from the load when it is switched off. The diagram shows how this is connected 'backwards' so that it will normally NOT conduct. Conduction only occurs when the load is switched off, at this moment current tries to continue flowing 'backwards' and is harmlessly diverted through the diode. Without the

diode no current could flow and the coil would produce a damaging high voltage 'spike' in its attempt to keep the current flowing.

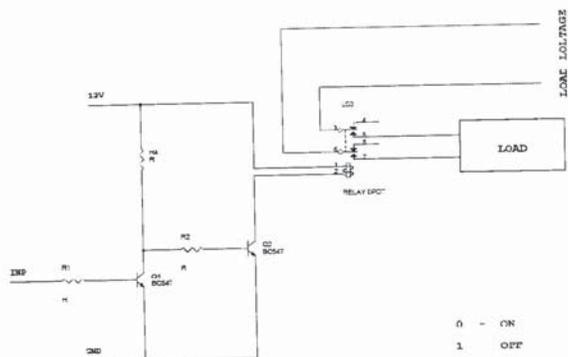


Fig 8.1 Relay circuit

8.4 Relay operation

Relay have two circuits: A control circuit and a load circuit. The control circuit have a small control coil while the load circuit has a switch. The coil controls the operation of the switch. A 4-pin relay

8.4.1 Energized (on)

Current flowing through the control circuit coil (pins 1 and pin 3) creates a small magnetic field, which causes the switch to close, pins 2 and 4. The switch, which is the part of the load circuit, is used to control an electrical

circuit that may connect to it. Current now flows through pins 2 and 4 shown in red. when the relay are energized.

8.4.2 De-energized (off)

When current stops are flowing through the control circuit, pins 1 and 3, the relay become de energized. Without the magnetic field, the switch opens and current is prevented from flowing through Pins 2 and 4. The relay is now OFF.

8.5 Reed relay overview

A reed relay consists of a coil wrapped around a reed switch. The switch is composed of two overlapping ferromagnetic blades (called reeds) that are hermetically sealed within an inert-gas-filled glass capsule. When current flows through the coil, a magnetic field is produced that pulls the two reeds together. This completes a signal path through the relay, when the coil is de-energized; the spring force in the reeds pulls the contacts apart.

Reed relays have several advantages over traditional armature-based electromechanical relays. Reeds are generally smaller, allowing for greater density on a board. The lower mass of the reeds compared to larger armatures means they can actuate faster than electromechanical relays. Reed relay cycle speeds are such as 10 times faster than electromechanical relays. Also, there is less actuation stress on a reed switch so that mechanical lifetimes of up to 1 billion cycles are possible. All of these advantages could also be achieved with solid-state relays (SSR). Reeds however, have the added advantage of low contact resistance, allowing them to carry larger currents than SSRs.

Reeds also have better linearity, bandwidth and isolation than solid-state relays.

In this project we employ four reed relays as shown in figure 8.2, that are connected to the output pins namely 3,5,6,7 and 9 of the microcontroller. When the tone input is fed, the decimal output from the DTMF activates the corresponding relays. The relays then drive the motors that are connected to it for the movement of the robot in different directions.



Fig 8.2 relays



9. DC MOTORS

9.1 Introduction

A series DC motor has its armature and field connected in a series circuit. These type motors normally drive loads that require high torque and do not require precise speed regulation. Series DC motors are ideal for traction work where the load requires a high breakaway torque. Such are locomotives, hoists, cranes, automobile starters, or oil drilling applications. Starting torque developed in series motors normally ranges between 300% and 375% of full load, but attain 500% of full load torque. These motors deliver this high starting torque. These motors deliver this high starting torque because their magnetic field operates below saturation.

9.2 Principle of operation

An electric motor is a machine, which converts electric energy into mechanical energy. It is based on the principle of Fleming's left hand rule. An increase in load results in an increase in both armature and field current. As a result, the armature flux and field flux increase simultaneously. Since the torque developed in DC motors is dependent upon the interaction of armature and field flux, torque increases by the square of current increase. Speed regulation in series motors is inherently less precise than in shunt motors. If motor load diminishes, current flowing in both the armature field circuits reduces as well, effecting a reduction in flux density.

This results in a greater increase in speed than realized in shunt motors. Removal of mechanical load from series motors results in indefinite speed increase whereby centrifugal forces generated by the armature eventually destroy the motor. In this project DC motor is used to control the movement

of robot. Each motor can be controlled by a separate relay switch that allows functions such as forward, backward, left & right

So when we press

-number 2 in the mobile then robot moves in forward direction

-number 8 in the mobile then robot moves in backward direction

-number 4 in the mobile then robot moves in left direction

-number 6 in the mobile then robot moves in right direction

-number 5 in the mobile then robot stops.

9.3 Relay connections to motor

The relay, which drives the motor, has six connections to it. If a positive power supply enters at B & the switch is set to top most position, so left hand connection to the motor becomes positive so the motor runs in one direction. If the switch is then set to lowest position, the supply is crossed over and right hand connection to the motor becomes positive and motor runs in other direction. The switching on one relay will result in the motor turning other way.



Fig 9.1 Mini DC Motor

9.4 Mini DC motors

The motor being dissected here is a simple electric motor as shown in figure 9.1 motors. This is small a motor, about as big around as a dime. Outside there is the steel can that forms the body of the motor, an axle, a nylon end cap and two battery leads. If the battery leads of the motor up are hooked to a flashlight battery, the axle will spin. On reversing, the leads will spin in the opposite direction.

9.5 Advantages of DC motors

DC motors provide excellent speed control for acceleration and deceleration with effective and simple torque control. The fact that the power supply of a DC motor connects directly to the field of the motor allows for precise voltage control, which is necessary with speed and torque control applications.

DC motors perform better than AC motors on most traction equipment. They are also used for mobile equipment like golf carts, quarry and mining equipment. DC motors are conveniently portable and well suited to special applications, such as industrial tools and machinery that is not easily run from remote power sources.

CONCLUSION & FUTURE SCOPE OF THE PROJECT

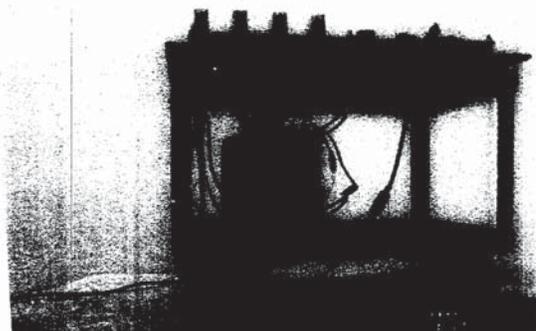
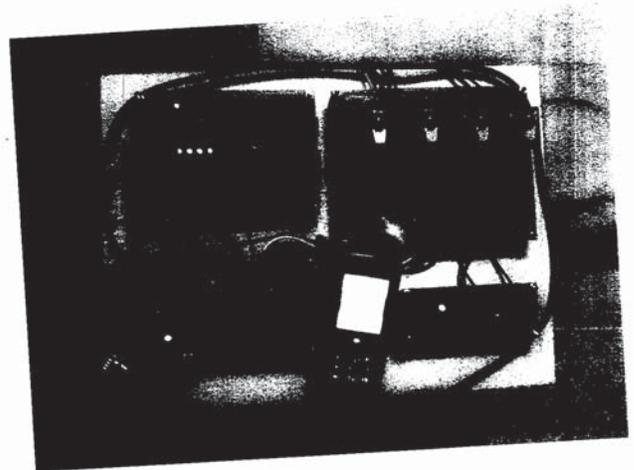
10.1 CONCLUSION

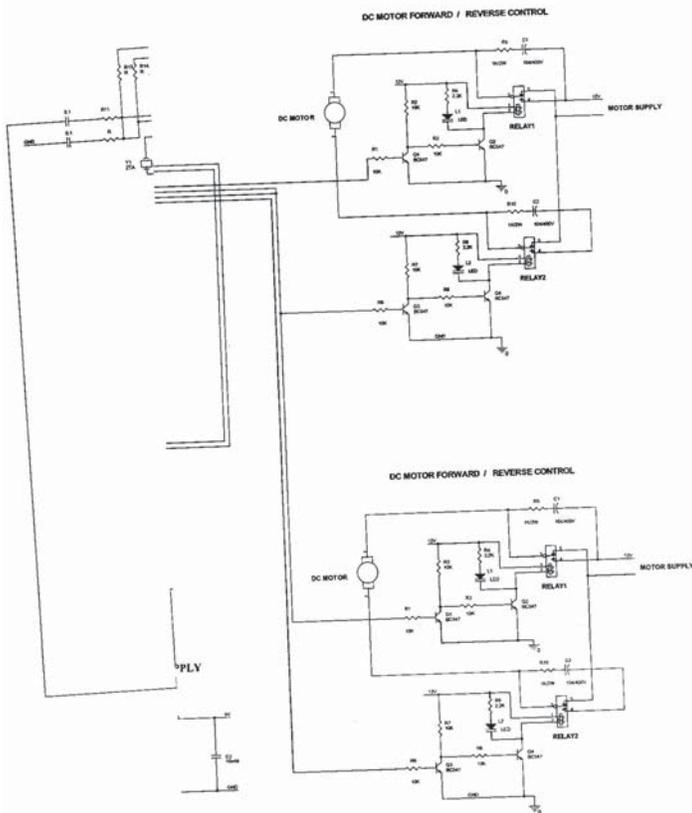
Due to advent of robotics, which has helped man to reduce labour and danger, there has been a vast improvement in industrial and technical field. This project brings a still more advanced and advantageous implementation of a mobile based robot system. The robot employs an inbuilt mobile that respond to a mobile, which can be operated by the user. It is implemented successfully by controlling the robot to move in different directions in addition pick and drop mechanisms can also be employed. This feature is most helpful in hazardous work situations such as chemical plants or nuclear plants, which risks the life and health oh the labourers involved. We believe that this endeavor would go a long way in leading help in the field of wireless communication.

CHAPTER 10

10.2 FURURE SCOPE OF THE PROJECT

This innovative project can be further extended by using a camera mobile inbuilt in the robot which captures the image and set it to the user defining the where about of the robot. Sensors can also be used to sense the objects or to overcome the hurdles on its way and to place the objects in the respective area.





APPENDIX 1

PCB DESIGN

Design and Fabrication of Printed circuit boards

INTRODUCTION:

Printed circuit boards, or PCBs, form the core of electronic equipment domestic and industrial. Some of the areas where PCBs are intensively used are computers, process control, telecommunications and instrumentation.

MANUFACTURING:

The manufacturing process consists of two methods; print and etch, and print, plate and etch.

The production of multi layer boards uses both the methods. The inner layers are printed and etch while the outer layers are produced by print, plate and etch after pressing the inner layers.

SOFTWARE:

The software used in our project to obtain the schematic layout is MICROSIM.

PANELISATION:

Here the schematic transformed in to the working positive/negative films. The circuit is repeated conveniently to accommodate economically as many circuits as possible in a panel, which can be operated in every sequence of subsequent steps in the PCB process. This is called penalization. For the PTH boards, the next operation is drilling.

DRILLING:

PCB drilling is a state of the art operation. Very small holes are drilled with high speed CNC drilling machines, giving a wall finish with less or no smear or epoxy, required for void free through hole plating.

PLATING:

The heart of the PCB manufacturing process. The holes drilled in the board are treated both mechanically and chemically before depositing the copper by the electro less copper plating process.

ETCHING:

Once a multilayer board is drilled and electro less copper deposited, the image available in the form of a film is transferred on to the out side by photo printing using a dry film printing process. The boards are then electrolytically plated on to the circuit pattern with copper and tin. The tin-plated deposit serves an etch resist when copper in the unwanted area is removed by etching machines with chemical

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- Serial Port Complete: Programming and Circuits for RS-232 and RS-485 Links and Networks By: Janet Louise Axelson.

etchants. The etching machines are attached to an automatic dosing equipment, which analyses and controls etchants concentrations.

SOLDERMASK:

Since a PCB design may call for very close spacing between conductors, a solder mask has to be applied on the both sides of the circuitry to avoid the bridging of conductors. The solder mask ink is applied by screening. The ink is dried, exposed to UV, developed in a mild alkaline solution and finally cured by both UV and thermal energy.

HOT AIR LEVELLING:

After applying the solder mask, the circuit pads are soldered using the hot air leveling process. The bare bodies fluxed and dipped in to a molten solder bath. While removing the board from the solder bath, hot air is blown on both sides of the board through air knives in the machines, leaving the board soldered and leveled. This is one of the common finishes given to the boards. Thus the double sided plated through whole printed circuit board is manufactured and is now ready for the components to be soldered.



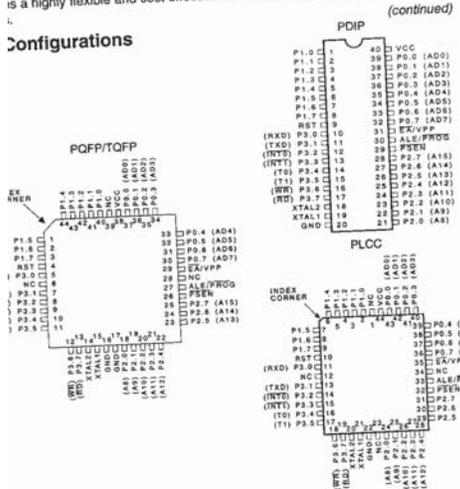
8-Bit Microcontroller with 4K Bytes Flash

AT89C51

- Compatible with MCS-51™ Products
- 4K Bytes of In-System Reprogrammable Flash Memory
- 1,000 Write/Erase Cycles
- Static Operation: 0 Hz to 24 MHz
- Level Program Memory Lock
- 8-Kbit Internal RAM
- Programmable I/O Lines
- 2-Byte Timer/Counters
- Interrupt Sources
- Programmable Serial Channel
- Power Idle and Power Down Modes

Description
 The AT89C51 is a low-power, high-performance CMOS 8-bit microcomputer with 4K Bytes of Flash Programmable and Erasable Read Only Memory (PEROM). The device is manufactured using Atmel's high density nonvolatile memory technology compatible with the industry standard MCS-51™ instruction set and pinout. The AT89C51 allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with a monolithic chip, the Atmel AT89C51 is a powerful microcomputer which is a highly flexible and cost effective solution to many embedded control applications.

Configurations



0265F-A-12/97

AT89C51

The AT89C51 provides the following standard features: 4K Bytes of Flash, 128 bytes of RAM, 32 I/O lines, two 16-bit timers, a five vector two-level interrupt architecture, a multiplexed serial port, on-chip oscillator and clock circuitry. In addition, the AT89C51 is designed with static logic to reduce power consumption and supports two selectable power saving modes. The Idle Mode allows the CPU while allowing the RAM, timer/counters, port and interrupt system to continue functioning. The Power Down Mode saves the RAM contents but freezes all other chip functions until the next reset.

Description

Port 0: Port 0 is an 8-bit open drain bidirectional I/O port. As an input port each pin can sink eight TTL inputs. When written to port 0 pins, the pins can be used as high-impedance inputs. Port 0 may also be configured to be the multiplexed low address/data bus. During accesses to external program and data memory in this mode P0 has internal pullups.

Port 1: Port 1 is an 8-bit bidirectional I/O port with internal pullups. Port 1 output buffers can sink/source four TTL inputs. When written to port 1 pins they are pulled high by the internal pullups and can be used as inputs. As inputs, port 1 pins that are externally being pulled low will source current (I_{OL}) because of the pullups.

Port 2: Port 2 is an 8-bit bidirectional I/O port with internal pullups. Port 2 output buffers can sink/source four TTL inputs. When written to port 2 pins they are pulled high by the internal pullups and can be used as inputs. As inputs, port 2 pins that are externally being pulled low will source current (I_{OL}) because of the internal pullups.

Port 3: Port 3 is an 8-bit bidirectional I/O port with internal pullups. Port 3 output buffers can sink/source four TTL inputs. When written to port 3 pins they are pulled high by the internal pullups and can be used as inputs. As inputs, port 3 pins that are externally being pulled low will source current (I_{OL}) because of the pullups.

Port 3 also serves the functions of various special features of the AT89C51 as listed below:

Port Pin	Alternate Functions
P3.0	RXD (serial input port)
P3.1	TXD (serial output port)
P3.2	INT0 (external interrupt 0)
P3.3	INT1 (external interrupt 1)
P3.4	T0 (timer 0 external input)
P3.5	T1 (timer 1 external input)
P3.6	WR (external data memory write strobe)
P3.7	RD (external data memory read strobe)

RST: Reset input. A high on this pin for two machine cycles while the oscillator is running resets the device.

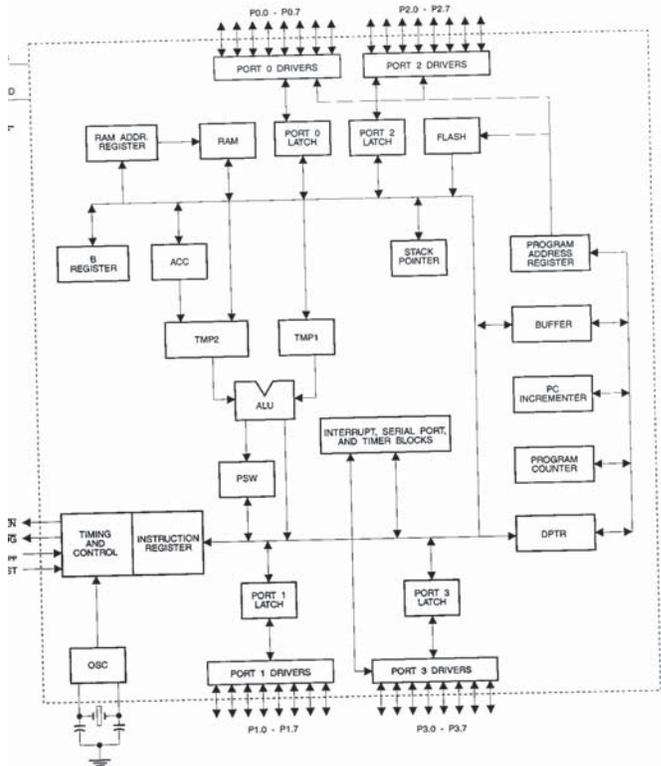
ALE/PROG: Address Latch Enable output pulse for latching the low byte of the address during accesses to external memory. This pin is also the program pulse input (PROG) during Flash programming.

OSCON: In normal operation ALE is emitted at a constant rate of 1/6 the oscillator frequency, and may be used for external timing or clocking purposes. Note, however, that one ALE pulse is skipped during each access to external data memory.

PSEN: If desired, ALE operation can be disabled by setting bit 0 of SFR location 8EH. With the bit set, ALE is active only during a MOVX or MOVC instruction. Otherwise, the pin is weakly pulled high. Setting the ALE-disable bit has no effect if the microcontroller is in external execution mode.

Mode: In sleep mode, the CPU puts itself to sleep while all the peripherals remain active. The mode is invoked by setting bit 0 of SFR location 8EH. The content of the on-chip RAM and all the special function registers remain unchanged during this mode. The idle mode can be terminated by any enabled interrupt or by a hardware reset.

Diagram



The AT89C51 is executing code from external program memory, PSEN is activated twice each machine cycle except that two PSEN activations are skipped during access to external data memory.

Access Enable: EA must be strapped to GND in order to enable the device to fetch code from external program memory locations starting at 0000H up to FFFFH. However, if lock bit 1 is programmed, EA will be latched on reset.

EA should be strapped to V_{CC} for internal program execution. EA also receives the 12-volt programming enable voltage (V_{PP}) during Flash programming, for parts that require V_{PP}.

The inverting oscillator amplifier and input to the internal clock operating circuit. The input to the inverting oscillator amplifier.

Oscillator Characteristics

XTAL1 and XTAL2 are the input and output, respectively, of the inverting amplifier which can be configured for use as a quartz crystal oscillator, as shown in Figure 1. Either a quartz crystal or ceramic resonator may be used. To drive the crystal from an external clock source, XTAL2 should be left unconnected while XTAL1 is driven as shown in Figure 2. There are no requirements on the duty cycle of the external signal, since the input to the internal clocking circuitry is a divide-by-two flip-flop, but minimum and maximum voltage high and low time specifications must be observed.

Mode

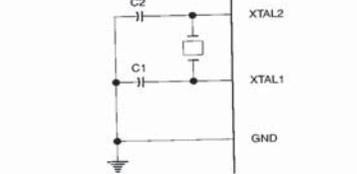
In sleep mode, the CPU puts itself to sleep while all the peripherals remain active. The mode is invoked by setting bit 0 of SFR location 8EH. The content of the on-chip RAM and all the special function registers remain unchanged during this mode. The idle mode can be terminated by any enabled interrupt or by a hardware reset.

Functions of External Pins During Idle and Power Down Modes

Mode	Program Memory	ALE	PSEN	PORT0	PORT1	PORT2	PORT3
Normal	Internal	1	1	Data	Data	Data	Data
	External	1	1	Float	Data	Address	Data
Power Down	Internal	0	0	Data	Data	Data	Data
	External	0	0	Float	Data	Data	Data

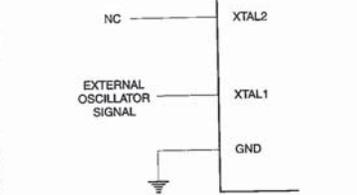
It should be noted that when idle is terminated by a hardware reset, the device normally resumes program execution, from where it left off, up to two machine cycles before the internal reset algorithm takes control. On-chip hardware inhibits access to internal RAM in this event, but access to the port pins is not inhibited. To eliminate the possibility of an unexpected write to a port pin when Idle is terminated by reset, the instruction following the one that invokes Idle should not be one that writes to a port pin or to external memory.

Figure 1. Oscillator Connections



Note: C1, C2 = 30 pF ± 10 pF for Crystals = 40 pF ± 10 pF for Ceramic Resonators

Figure 2. External Clock Drive Configuration





Power Down Mode

Power down mode the oscillator is stopped, and the on-chip RAM and Special Function Register values until the power down mode is terminated. The only exit from power down is a hardware reset. The reset should not be activated before V_{CC} is at its normal operating level and must be held long enough to allow the oscillator to restart and stabilize.

Program Memory Lock Bits

On the chip are three lock bits which can be left unprogrammed (U) or can be programmed (P) to obtain the additional features listed in the table below:

When lock bit 1 is programmed, the logic level at the EA pin is sampled and latched during reset. If the device is powered up without a reset, the latch initializes to a random value, and holds that value until reset is activated. It is necessary that the latched value of EA be in agreement with the current logic level at that pin in order for the device to function properly.

Bit Protection Modes

Program Lock Bits			Protection Type
LB1	LB2	LB3	
U	U	U	No program lock features.
P	U	U	MOVX instructions executed from external program memory are disabled from fetching code bytes from internal memory, EA is sampled and latched on reset, and further programming of the Flash is disabled.
P	P	U	Same as mode 2, also verify is disabled.
P	P	P	Same as mode 3, also external execution is disabled.

Programming the Flash

The AT89C51 is normally shipped with the on-chip Flash memory array in the erased state (that is, contents = FFH) ready to be programmed. The programming interface is either a high-voltage (12-volt) or a low-voltage programming enable signal. The low voltage programming mode provides a convenient way to program the C51 inside the user's system, while the high-voltage programming mode is compatible with conventional third party Flash or EPROM programmers.

The AT89C51 is shipped with either the high-voltage or low-voltage programming mode enabled. The respective pin marking and device signature codes are listed in the following table.

Side Mark	V _{pp} = 12V	V _{pp} = 5V
AT89C51	xxxx	AT89C51
Signature	(030H)=1EH (031H)=51H (032H)=FFH	xxxx-5 yyyyw (030H)=1EH (031H)=51H (032H)=05H

AT89C51 code memory array is programmed byte-by-byte in either programming mode. To program any non-0 byte in the on-chip Flash Memory, the entire memory must be erased using the Chip Erase Mode.

Programming Algorithm: Before programming the AT89C51, the address, data and control signals should be set up according to the Flash programming mode table and Figures 3 and 4. To program the AT89C51, take the following steps:

1. Input the desired memory location on the address lines.
2. Input the appropriate data byte on the data lines.
3. Activate the correct combination of control signals.
4. Raise EA/V_{pp} to 12V for the high-voltage programming mode.
5. Pulse ALE/PROG once to program a byte in the Flash array or the lock bits. The byte-write cycle is self-timed and typically takes no more than 1.5 ms. Repeat steps 1 through 5, changing the address and data for the entire array or until the end of the object file is reached.

Data Polling: The AT89C51 features Data Polling to indicate the end of a write cycle. During a write cycle, an attempted read of the last byte written will result in the complement of the written datum on P0.7. Once the write cycle has been completed, true data are valid on all outputs, and the next cycle may begin. Data Polling may begin any time after a write cycle has been initiated.

Ready/Busy: The progress of byte programming can also be monitored by the RDY/BSY output signal. P3.4 is pulled low after ALE goes high during programming to indicate BUSY. P3.4 is pulled high again when programming is done to indicate READY.



Figure 3. Programming the Flash

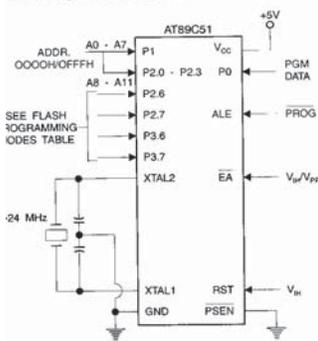
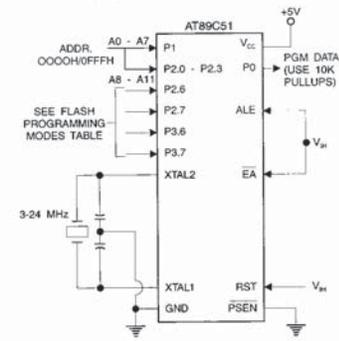


Figure 4. Verifying the Flash



Flash Programming and Verification Characteristics

= 0°C to 70°C, V_{CC} = 5.0 ± 10%

Symbol	Parameter	Min	Max	Units
V _{pp} ⁽¹⁾	Programming Enable Voltage	11.5	12.5	V
I _{pp} ⁽¹⁾	Programming Enable Current		1.0	mA
f _{osc}	Oscillator Frequency	3	24	MHz
t _{AVGL}	Address Setup to PROG Low		48t _{CLCL}	
t _{HAX}	Address Hold After PROG		48t _{CLCL}	
t _{DGL}	Data Setup to PROG Low		48t _{CLCL}	
t _{HDX}	Data Hold After PROG		48t _{CLCL}	
t _{HSH}	P2.7 (ENABLE) High to V _{pp}		48t _{CLCL}	
t _{HGL}	V _{pp} Setup to PROG Low	10		µs
t _{HSL} ⁽¹⁾	V _{pp} Hold After PROG	10		µs
t _{LGH}	PROG Width	1	110	µs
t _{QV}	Address to Data Valid		48t _{CLCL}	
t _{LQV}	ENABLE Low to Data Valid		48t _{CLCL}	
t _{HQZ}	Data Float After ENABLE	0	48t _{CLCL}	
t _{HBL}	PROG High to BUSY Low		1.0	µs
t _{WC}	Byte Write Cycle Time		2.0	ms

Program Verify: If lock bits LB1 and LB2 have not been programmed, the programmed code data can be read back the address and data lines for verification. The lock bits are not verified directly. Verification of the lock bits is achieved by observing that their features are enabled.

Chip Erase: The entire Flash array is erased electrically using the proper combination of control signals and by pulling ALE/PROG low for 10 ms. The code array is written with all "1"s. The chip erase operation must be executed before the code memory can be re-programmed.

Reading the Signature Bytes: The signature bytes are read by the same procedure as a normal verification of the array. The signature bytes are read by pulling ALE/PROG low for 10 ms. The code array is written with all "1"s. The chip erase operation must be executed before the code memory can be re-programmed.

(030H) = 1EH indicates manufactured by Atmel
(031H) = 51H indicates 89C51
(032H) = FFH indicates 12V programming
(032H) = 05H indicates 5V programming

Programming Interface

Every code byte in the Flash array can be written and the entire array can be erased by using the appropriate combination of control signals. The write operation cycle is self-timed and once initiated, will automatically time itself to completion.

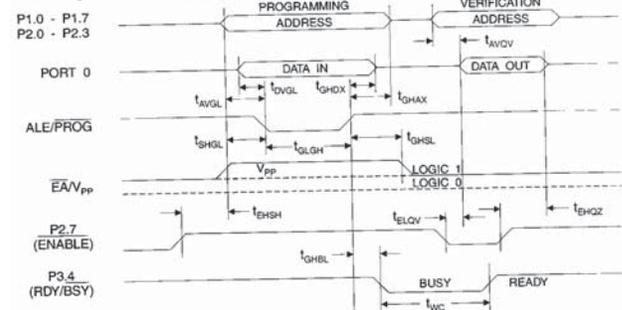
All major programming vendors offer worldwide support for the Atmel microcontroller series. Please contact your local programming vendor for the appropriate software revision.

Flash Programming Modes

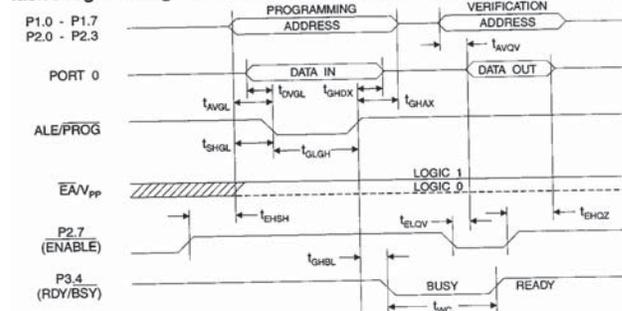
Mode	RST	PSEN	ALE/PROG	EA/V _{pp}	P2.6	P2.7	P3.6	P3.7
Write Code Data	H	L		H/12V	L	H	H	H
Read Code Data	H	L	H	H	L	L	H	H
Write Lock	Bit - 1	H		H/12V	H	H	H	H
	Bit - 2	H		H/12V	H	H	L	L
	Bit - 3	H		H/12V	H	L	H	L
Chip Erase	H	L		H/12V	H	L	L	L
Read Signature Byte	H	L	H	H	L	L	L	L

Note: 1. Chip Erase requires a 10-ms PROG pulse.

Flash Programming and Verification Waveforms - High Voltage Mode (V_{pp} = 12V)



Flash Programming and Verification Waveforms - Low Voltage Mode (V_{pp} = 5V)



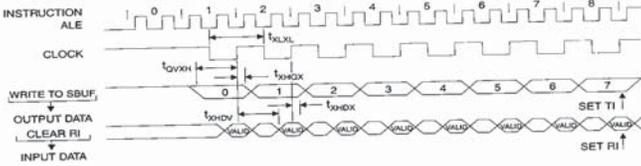


Serial Port Timing: Shift Register Mode Test Conditions

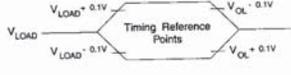
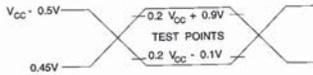
V_{CC} = 5.0 V ± 20%; Load Capacitance = 80 pF

Symbol	Parameter	12 MHz Osc		Variable Oscillator		Units
		Min	Max	Min	Max	
t _{CLK}	Serial Port Clock Cycle Time	1.0		12 _{CLCL}		μs
t _{OVH}	Output Data Setup to Clock Rising Edge	700		10 _{CLCL} -133		ns
t _{OHX}	Output Data Hold After Clock Rising Edge	50		2 _{CLCL} -117		ns
t _{HDX}	Input Data Hold After Clock Rising Edge	0		0		ns
t _{HVD}	Clock Rising Edge to Input Data Valid		700		10 _{CLCL} -133	ns

Shift Register Mode Timing Waveforms



AC Testing Input/Output Waveforms⁽¹⁾ Float Waveforms⁽¹⁾



Note: 1. AC Inputs during testing are driven at V_{CC} - 0.5V for a logic 1 and 0.45V for a logic 0. Timing measurements are made at V_{IH} min. for a logic 1 and V_{IL} max. for a logic 0.

Note: 1. For timing purposes, a port pin is no longer floating when a 100 mV change from load voltage occurs. A port pin begins to float when 100 mV change from the loaded V_{OH}/V_{OL} level occurs.

Ordering Information

Speed (MHz)	Power Supply	Ordering Code	Package	Operation Range		
12	5V ± 20%	AT89C51-12AC	44A	Commercial (0°C to 70°C)		
		AT89C51-12JC	44J			
		AT89C51-12PC	40P6			
				AT89C51-12QC	44Q	Industrial (-40°C to 85°C)
				AT89C51-12AI	44A	
				AT89C51-12JI	44J	
				AT89C51-12PI	40P6	Automotive (-40°C to 105°C)
				AT89C51-12QI	44Q	
				AT89C51-12AA	44A	
				AT89C51-12JA	44J	Commercial (0°C to 70°C)
				AT89C51-12PA	40P6	
				AT89C51-12QA	44Q	
16	5V ± 20%	AT89C51-16AC	44A	Commercial (0°C to 70°C)		
		AT89C51-16JC	44J			
		AT89C51-16PC	40P6			
				AT89C51-16QC	44Q	Industrial (-40°C to 85°C)
				AT89C51-16AI	44A	
				AT89C51-16JI	44J	
				AT89C51-16PI	40P6	Automotive (-40°C to 105°C)
				AT89C51-16QI	44Q	
				AT89C51-16AA	44A	
				AT89C51-16JA	44J	Commercial (0°C to 70°C)
				AT89C51-16PA	40P6	
				AT89C51-16QA	44Q	
20	5V ± 20%	AT89C51-20AC	44A	Commercial (0°C to 70°C)		
		AT89C51-20JC	44J			
		AT89C51-20PC	40P6			
				AT89C51-20QC	44Q	Industrial (-40°C to 85°C)
				AT89C51-20AI	44A	
				AT89C51-20JI	44J	
				AT89C51-20PI	40P6	Commercial (0°C to 70°C)
				AT89C51-20QI	44Q	

Ordering Information

Speed (MHz)	Power Supply	Ordering Code	Package	Operation Range		
24	5V ± 20%	AT89C51-24AC	44A	Commercial (0°C to 70°C)		
		AT89C51-24JC	44J			
		AT89C51-24PC	44P6			
				AT89C51-24QC	44Q	Industrial (-40°C to 85°C)
				AT89C51-24AI	44A	
				AT89C51-24JI	44J	
				AT89C51-24PI	44P6	Commercial (0°C to 70°C)
				AT89C51-24QI	44Q	

Package Type	
44A	44 Lead, Thin Plastic Gull Wing Quad Flatpack (TQFP)
44J	44 Lead, Plastic J-Leaded Chip Carrier (PLCC)
40P6	40 Lead, 0.600" Wide, Plastic Dual Inline Package (PDIP)
44Q	44 Lead, Plastic Gull Wing Quad Flatpack (PQFP)

APPENDIX 3

PROGRAM

```
#include <AT89X51.H>

void ser_init();
void ser_out(unsigned char);
unsigned char c,v[30],s,r,v,j,a,x;
unsigned char ring,dtmp;
void app_cntr();
void delay(unsigned int);

sbit le_for=P1^0;
sbit le_rev=P1^1;
sbit rg_rev=P1^2;
sbit rg_for=P1^3;

sbit nkey=P1^4;

void left();
void right();
void stop();
void reverse();
void forward();

void main()
{
    stop();
    ser_init();
    while(1)
    {
        EA=ES=1;
        if(j>24) app_cntr();
    }
}
```

```

{
EA=ES=0;
ser_out('A'); //call attend command
ser_out('T');
ser_out('A');
ser_out(0x0d);
del();del();

xx:

while(nkey==0);
while(nkey==1);

dtmf=P2&0x0f;

if(dtmf==0x02) forward();

else if(dtmf==0x08) reverse();

else if(dtmf==0x05) stop();

else if(dtmf==0x06) right();

else if(dtmf==0x04) left();

else if(dtmf==0x09) // key 9
{
EA=ES=0;
ser_out('A'); //call terminated command
ser_out('T');
ser_out('H');
ser_out(0x0d);
EA=ES=1;
goto last;
}
goto xx;
last:
j=1;
}

```

```

void reverse()
{
le_for=0; //on
le_rev=1;
rg_for=0; // reverse()
rg_rev=1;
}

void forward()
{
le_for=1;
le_rev=0;
rg_for=1; // forward()
rg_rev=0;
}

void stop()
{
le_for=1; //off
le_rev=1;
rg_for=1; //STOP
rg_rev=1;
}

void right()
{
le_for=1;
le_rev=0; // on
rg_for=0; //right
rg_rev=1;
for(s=0;s<4;s++) del();
delay(65000);
stop();
}

void left()
{
le_for=0;
le_rev=1; // off
rg_for=1; // left()
rg_rev=0;
}

```

```

for(s=0;s<4;s++) del();
delay(65000);
stop();
}

void ser_int(void) interrupt 4
{
if (RI)
{
RI=0;
v[j]=SBUF;
j++;
if(j>100)j=1;
}
}

void ser_out(unsigned char rr)
{
SBUF=rr;
delay(200);
SCON=0x58;
delay(8000);
}

void ser_init()
{
TH1=0xfd; ///TH1=0xFd; 9600 baud rate 12Mhz
TMOD=0x20;
TR1=1;
delay(200);
SCON=0x58;
}

void delay(unsigned int de)
{
while(de--);
}

```