# An Embedded Platform for GSM/CDMA Controlled Surveillance Robot

**By**

**Puneet Dhawan - 041005**
**Anupam Prasad - 041110**



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**DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING**
**JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY - WAKNAGHAT**

# CERTIFICATE

*This is to certify that the work entitled, "**An Embedded Platform for GSM/CDMA Controlled Surveillance Robot**" has been submitted by **Puneet Dhawan** and **Anupam Prasad.***

*In partial fulfillment for the award of degree of Bachelor of Technology in Electronics and Communication of Jaypee University of Information Technology has been carried out under my supervision. This work has not been submitted partially or wholly to any other University or institute for the award of this or any other degree or diploma*

Mr. Rohit Sharma.
(Project Guide)

Dr.Sunil V Bhooshan
(Head of the Department)

## ACKNOWLEDGMENT

No Project or task can be successfully completed without the help of those people who act as "guiding light" helping to smoothen out the rough edges, providing the inspiration when you feel you have reached a spot you can't seem to get out of.

We are extremely grateful to Mr. Rohit Sharma, our respected teacher for his guidance and motivation. His thinking and straight forward attitude have inspired us to complete this project under stiff time limits.

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PUNEET DHAWAN

Anupam Prasad
ANUPAM PRASAD

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## ABSTRACT

*This project proposes an 8-bit embedded controller interfaced with vehicular robot whose movements are controlled with GSM/CDMA based mobile phone. The 8-bit microcontroller is interfaced with GSM/CDMA mobile phone which receives the command signals from other CDMA/GSM/landline telephone networks. The controller is programmed to control the movement of two DC motors of robot through hands free port of the mobile phone using signal from GSM/CDMA/landline network. The control mechanism is based on DTMF tones generated by a mobile phone when the number keys are pressed. To keep track of the movements of the robot, a wireless video link is set.*

# INTRODUCTION TO ROBOTICS

## What is the first thing that comes to mind when you think of a robot?

For many people it is a machine that imitates a human—like the androids in Star Wars, Terminator and Star Trek: The Next Generation. However much these robots capture our imagination, such robots still only inhabit Science Fiction. People still haven't been able to give a robot enough 'common sense' to reliably interact with a dynamic world. However, Rodney Brooks and his team at MIT Artificial Intelligence Lab are working on creating such humanoid robots.

The type of robots that you will encounter most frequently are robots that do work that is too dangerous, boring, onerous, or just plain nasty. Most of the robots in the world are of this type. They can be found in auto, medical, manufacturing and space industries. In fact, there are over a million of these type of robots working for us today.

Some robots like the Mars Rover Sojourner and the upcoming Mars Exploration Rover, or the underwater robot Caribou help us learn about places that are too dangerous for us to go. While other types of robots are just plain fun for kids of all ages. Popular toys such as Techno Polly or AIBO-ERS 220 seem to hit the store shelves every year around Christmas time.

And as much fun as robots are to play with, robots are even much more fun to build. In Being Digital, Nicholas Negroponte tells a wonderful story about an eight year old, pressed during a televised premier of MIT Media Lab's LEGO/Logo work at Hennigan School. A zealous anchor, looking for a cute sound bite, kept asking the child if he was having fun playing with LEGO/Logo. Clearly exasperated, but not wishing to offend, the child first tried to put her off. After her third attempt to get him to talk about fun, the child, sweating under the hot television lights, plaintively looked into the camera and answered, "Yes it is fun, but it's hard fun."

## But what exactly is a robot?

As strange as it might seem, there really is no standard definition for a robot. However, there are some essential characteristics that a robot must have and this might help you to decide what is and what is not a robot. It will also help you to decide what features you will need to build into a machine before it can count as a robot.

A robot has these essential characteristics:

- Sensing First of all your robot would have to be able to sense its surroundings. It would do this in ways that are not un-similar to the way that you sense your surroundings. Giving your robot sensors: light sensors (eyes), touch and pressure sensors (hands), chemical sensors (nose), hearing and sonar sensors (ears), and taste sensors (tongue) will give your robot awareness of its environment.
- Movement A robot needs to be able to move around its environment. Whether rolling on wheels, walking on legs or propelling by thrusters a robot needs to be able to move. To count as a robot either the whole robot moves, like the Sojourner or just parts of the robot moves, like the Canada Arm.
- Energy A robot needs to be able to power itself. A robot might be solar powered, electrically powered, battery powered. The way your robot gets its energy will depend on what your robot needs to do.

- Intelligence A robot needs some kind of "smarts." This is where programming enters the pictures. A programmer is the person who gives the robot its 'smarts.' The robot will have to have some way to receive the program so that it knows what it is to do.

A robot is a system that contains sensors, control systems, manipulators, power supplies and software all working together to perform a task. Designing, building, programming and testing a robots is a combination of physics, mechanical engineering, electrical engineering, structural engineering, mathematics and computing. In some cases biology, medicine, chemistry might also be involved. A study of robotics means that students are actively engaged with all of these disciplines in a deeply problem-posing problem-solving environment.

# EXISTING SCENARIO

- PROJECT ALPHA: This project was started by the US defense academy. Its aim was to design unmanned robots that can go on the war fields and fight instead human soldiers.

  Thus preventing the humans from getting killed. The loss of a machine is much much less as compared to loss of a living being.

  One of the major robots created by this academy is "The SWORD".

- SWORD: It is a machine that is sent to stand in the place of a man and kill people. These devices are not autonomous. For some, this would disqualify them from being true robots. However, the military and the manufacturer both refer to the SWORDS device as a robot, and it certainly fit common usage.

  SWORD robots are more accurate than human soldiers; the gun is mounted on a stable platform and fired electronically, eliminating trigger recoil, anticipation problems and timing the breathing cycle when firing. At present, the SWORD robot is operated with a thirty-pound control unit with two joysticks, buttons and a video screen

- "The robots will take on a wide variety of forms, probably none of which will look like humans," explained Dr. Russ Richards, Project Alpha's director.

# LIMITATIONS OF THE EXISTING MODELS

- VERY LIMITED RANGE OF CONTROL

- AT ALL TIME NEED A HUMAN SUPERVISOR TO GUIDE THEM THEIR PATH TO THE DESTINATION

# OUR MODEL

- GSM CONTROL FOR THE ROBOTIC DEVICE TO OVERCOME THE RANGE PROBLEM

- VERY SIMPLE AND CONTROLLED MOVEMENT OF THE ROBOT ACCORDING TO THE WISH OF USER

- ATTACHED CAMERA IN FRONT OF THE ROBOT WILL HELP THE USER TO MONITOR THE ARTICLES APPEARINF IN FRONT OF THE ROBOT TO GUIDE THE ROBOT ACCORDINGLY

- THE CONTINUOSMOVING VIDEO SEND BY THE CAMERA CAN EASILY BE VIEWED BY THE USER ON THE TELEVISION SCREEN

# DTMF GUIDE

In DTMF there are 16 distinct tones. Each tone is the sum of two frequencies: one from a low and one from a high frequency group. There are four different frequencies in each group.

Your phone only uses 12 of the possible 16 tones. If you look at your phone, there are only 4 rows (R1, R2, R3 and R4) and 3 columns (C1, C2 and C3). The rows and columns select frequencies from the low and high frequency group respectively. Thus to decipher what tone frequency is associated with a particular key, look at your phone again. Each key is specified by its row and column locations. For example the "2" key is row 0 (R1) and column 1 (C2). The exact value of the frequencies are listed in Table 3 below:

TABLE 3: DTMF Row/Column Frequencies

| | |
|---|---|
| **LOW-FREQUENCIES** | |
| ROW # | FREQUENCY (HZ) |
| R1: ROW 0 | 697 |
| R2: ROW 1 | 770 |
| R3: ROW 2 | 852 |
| R4: ROW 3 | 941 |
| **HIGH-FREQUENCIES** | |
| COL # | FREQUENCY (HZ) |
| C1: COL 0 | 1209 |
| C2: COL 1 | 1336 |
| C3: COL 2 | 1477 |
| C4: COL 3 | 1633 |
| C4 not used in phones | |

Thus using the above table, "2" has a frequency of 770 + 1336 = 2106 Hz The "9" is row 2 (R3) and column 2 (C3) and has a frequency of 852 + 1477 = 2329 Hz.

The following graph is a captured screen from an oscilloscope. It is a plot of the tone frequency for the "1" key.

You can see that the DTMF generated signal is very distinct and clear. The horizontal axis is in samples. The frequency of the tone is about 1900 Hz - close to the 1906 Hz predicted by Table 3 (697+1209).

## DTMF Generator/Decoder

The photo depicts a DTMF generator/decoder pair you can build in an afternoon or two. Dual-tone-multi-frequency (DTMF, also known as touch-tone) are the audible sounds you hear when you press keys on your phone.

The tone generator (top) uses the 5589 chip and a DIP switch. You can actually hear the tones through the speaker. The bottom circuit uses the 8870 to decode a tone and display its associated number on the 7-segment LED.

Touch-tone is familiar to many (telephone), it is a mature technology, and readily available with off-the-shelf, single-chip, low-cost components. For these reasons DTMF is often used in remote control applications that typically use telephones (e.g. accessing your messages from an answering machine, retrieving your account balance info from your bank's database).

This tutorial will not discuss telephone interfacing. Rather it will give you a basic working foundation which you can build upon. The generator/decoder above are tethered together by a single wire. But you can expand upon this foundation for wireless remote control using a microphone. For longer distances maybe you can add a pair of walkie-talkies, generating audible tones into one, and decoding with the other.

Another possibility is to use infrared (IR). Since tones are just electrical pulses, you can replace the speaker with an IR emitter and add an IR detector to the decoder.

Yet another experiment is to interface either the generator or the emitter or both to a PC or embedded microprocessor (e.g. 8051, PIC or Stamp). In this scenario, the PC or a peripheral, through touch-tones, can respond and control.

If you are familiar with how telephones work, the basic circuit might also help you to build devices the respond to your call. For example, you can build upon the decoder and add relays to control household devices that respond when you call your home.

# GSM/CDMA THEORY

## GSM

Global System for Mobile communications (GSM: originally from *Group Special Mobile*) is the most popular standard for mobile phones in the world. Its promoter, the GSM promoters estimates that 82% of the global mobile market uses the standard. GSM is used by over 2 billion people across more than 212 countries and territories. Its ubiquity makes international roaming very common between mobile phone operators, enabling subscribers to use their phones in many parts of the world. GSM differs from its predecessors in that both signaling and speech channels are digital call quality, and thus is considered a *second generation (2G)* mobile phone system. This has also meant that data communication was easy to build into the system.

The ubiquity of the GSM standard has been advantageous to both consumers (who benefit from the ability to roam and switch carriers without switching phones) and also to network operators (who can choose equipment from any of the many vendors implementing GSM). GSM also pioneered a low-cost alternative to voice calls, the short message service (SMS, also called "text messaging"), which is now supported on other mobile standards as well.

## GSM Technical details

GSM is a cellular network, which means that mobile phones connect to it by searching for cells in the immediate vicinity. GSM networks operate in four different frequency ranges. Most GSM networks operate in the 900 MHz or 1800 MHz bands. Some countries in the Americas (including Canada and the United States) use the 850 MHz and

1900 MHz bands because the 900 and 1800 MHz frequency bands were already allocated.

The rarer 400 and 450 MHz frequency bands are assigned in some countries, notably Scandinavia, where these frequencies were previously used for first-generation systems.

In the 900 MHz band the uplink frequency band is 890–915 MHz, and the downlink frequency band is 935–960 MHz this 25 MHz bandwidth is subdivided into 124 carrier frequency channels, each spaced 200 kHz apart. Time Division Multiplexing is used to allow eight full-rate or sixteen half-rate speech channels per radio frequency channel. There are eight radio timeslots (giving eight burst periods) grouped into what is called a TDMA frame. Half rate channels use alternate frames in the same timeslot. The channel data rate is 270.833 Kbit/s, and the frame duration is 4.615 ms.

The transmission power in the handset is limited to a maximum of 2 watts in GSM850/900 and 1 watt in GSM1800/1900.

GSM has used a variety of voice codecs to squeeze 3.1 kHz audio into between 5.6 and 13 kbit/s. Originally, two codecs, named after the types of data channel they were allocated, were used, called half rate (5.6 kbit/s) and full rate (13 kbit/s). These used a system based upon linear predictive coding (LPC). In addition to being efficient with bitrates, these codecs also made it easier to identify more important parts of the audio, allowing the air interface layer to prioritize and better protect these parts of the signal.

GSM was further enhanced in 1997 with the enhanced full rate (EFR) codec, a 12.2 kbit/s codec that uses a full rate channel. Finally, with the development of UMTS, EFR was refectories into a variable-rate codec called AMR- Narrowband, which is high quality and robust against interference when used on full rate channels, and less robust but still relatively high quality when used in good radio conditions on half-rate channels.

There are five different cell sizes in a GSM network—macro, micro, pico, femto and umbrella cells. The coverage area of each cell varies according to the implementation environment. Macro cells can be regarded as cells where the base station antenna is installed on a mast or a building above average roof top level. Micro cells are cells whose antenna height is under average roof top level; they are typically used in urban areas. Picocells are small cells whose coverage diameter is a few dozen meters; they are mainly used indoors. Femtocells are cells designed for use in residential or small business environments and connect to the service provider's network via a broadband internet connection. Umbrella cells are used to cover shadowed regions of smaller cells and fill in gaps in coverage between those cells.

Cell horizontal radius varies depending on antenna height, antenna gain and propagation conditions from a couple of hundred meters to several tens of kilometers. The longest distance the GSM specification supports in practical use is 35 kms (22 mi). There are also several implementations of the concept of an extended cell, where the cell radius could be double or even more, depending on the antenna system, the type of terrain and the timing advance.

Indoor coverage is also supported by GSM and may be achieved by using an indoor picocell base station, or an indoor repeater with distributed indoor antennas fed through power splitters, to deliver the radio signals from an antenna outdoors to the separate indoor distributed antenna system. These are typically deployed when a lot of call capacity is needed indoors, for example in shopping centers or airports. However, this is not a prerequisite, since indoor coverage is also provided by in-building penetration of the radio signals from nearby cells.

The modulation used in GSM is Gaussian minimum shift-keying (GMSK), a kind of continuous-phase frequency shift keying. In GMSK, the signal to be modulated onto the carrier is first smoothed with a Gaussian low-pass filter prior to being fed to a frequency modulator, which greatly reduces the interference to neighboring channels (adjacent channel interference).

## Network structure

GSM system seen by the customer is large and complicated in order to provide all of the services which are required. It is divided into a number of sections and these are each covered in separate articles.

- The Base station subsystem (the base stations and their controllers).
- The Network and Switching Subsystems (the part of the network most similar to a fixed network). This is sometimes also just called the core network.
- The GPRS Core Network (the optional part which allows packet based Internet connections).
- All of the elements in the system combine to produce many GSM services such as voice calls and SMS.

## GSM security

GSM was designed with a moderate level of security. The system was designed to authenticate the subscriber using a pre-shared key and challenge response. Communications between the subscriber and the base station can be encrypted. The development of UMTS introduces an optional USIM, that uses a longer authentication key to give greater security, as well as mutually authenticating the network and the user - whereas GSM only authenticated the user to the network (and not vice versa). The security model therefore offers confidentiality and authentication, but limited authorization capabilities, and no non-repudiation.

GSM uses several cryptographic algorithms for security. The A5/1 and A5/2 stream ciphers are used for ensuring over-the-air voice privacy. A5/1 was developed first and is a stronger algorithm used within Europe and the United States; A5/2 is weaker and used in other countries. Serious weaknesses have been found in both algorithms: it is possible to break A5/2 in real-time with a cipher text-only attack, and in February 2008, Pico Consulting, Inc revealed its ability and plans to commercialize FPGAs that allow A5/1 to be broken with a rainbow table attack. The system supports multiple algorithms so operators may replace that cipher with a stronger one.



## CDMA

Code division multiple access (CDMA) is a channel access method utilized by various radio communication technologies. It should not be confused with the mobile phone called cdmaOne and CDMA2000 (which are often referred to as simply "CDMA"), that use CDMA as their underlying channel access method.

One of the basic concepts in data communication is the idea of allowing several transmitters to send information simultaneously over a single communication channel. This allows several users to share a bandwidth of frequencies. This concept is called multiplexing. CDMA employs spread-spectrum technology and a special coding scheme (where each transmitter is assigned a code) to allow multiple users to be multiplexed over the same physical channel. By contrast, time division multiple access (TDMA) divides access by time, while frequency division multiple access (FDMA) divides it by frequency. CDMA is a form of "spread spectrum" signaling, since the modulated coded signal has a much higher bandwidth than the data being communicated.

An analogy to the problem of multiple access is a room (channel) in which people wish to communicate with each other. To avoid confusion, people could take turns speaking (time division), speak at different pitches (frequency division), or speak in different directions (spatial division). In CDMA, they would speak different languages. People speaking the same language can understand each other, but not other people. Similarly, in radio CDMA, each group of users is given a shared code. Many codes occupy the same channel, but only users associated with a particular code can understand each other.

Code Division Multiple Access (CDMA) is a digital air interface standard, claiming eight to fifteen times the capacity of traditional analog cellular systems. It employs a commercial adaptation of a military spread-spectrum technology. Based on spread spectrum theory, it gives essentially the same services and qualities as wire line service. The primary difference is that access to the local exchange carrier (LEC) is provided via a wireless phone.

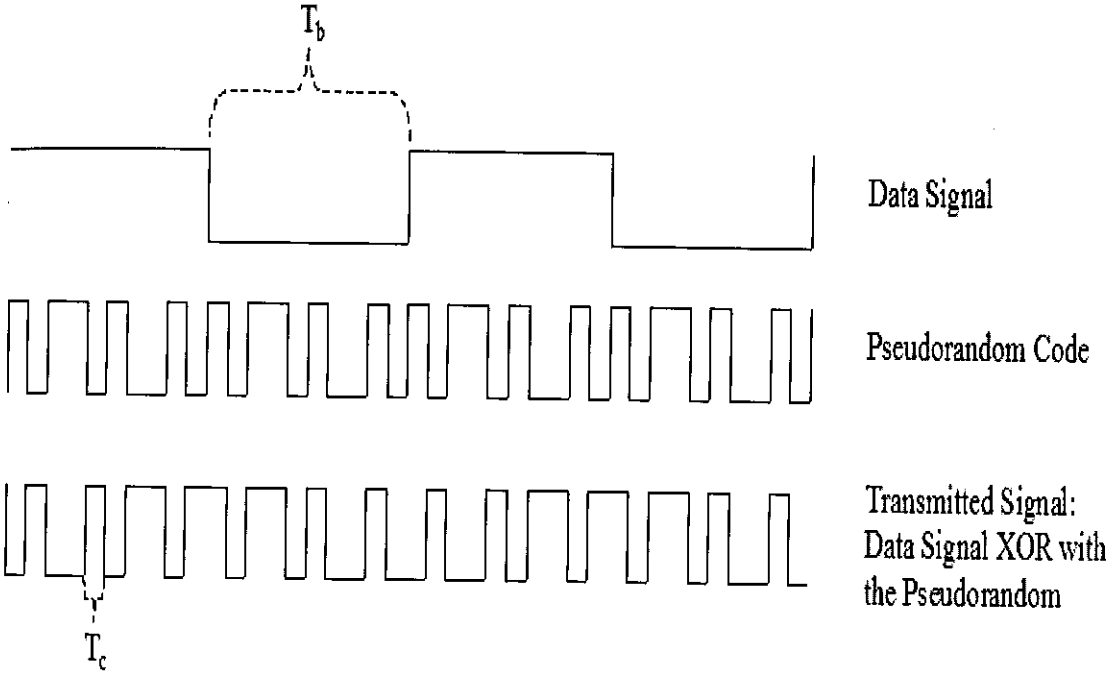
Though CDMA's application in cellular telephony is relatively new, it is not a new technology. CDMA has been used in many military applications, such as:

- Anti-jamming (because of the spread signal, it is difficult to jam or interfere with a CDMA signal).
- Ranging (measuring the distance of the transmission to know when it will be received).
- Secure communications (the spread spectrum signal is very hard to detect).

CDMA is a spread spectrum technology, which means that it spreads the information contained in a particular signal of interest over a much greater bandwidth than the original signal. With CDMA, unique digital codes, rather than separate RF frequencies or channels, are used to differentiate subscribers. The codes are shared by both the mobile station (cellular phone) and the base station, and are called pseudo-random code sequences. Since each user is separated by a unique code, all users can share the same frequency band (range of radio spectrum). This gives many unique advantages to the CDMA technique over other RF techniques in cellular communication.

### Technical details

Each user in a CDMA system uses a different code to modulate their signal. Choosing the codes used to modulate the signal is very important in the performance of CDMA systems. The best performance will occur when there is good separation between the signal of a desired user and the signals of other users. The separation of the signals is made by correlating the received signal with the locally generated code of the desired user. If the signal matches the desired user's code then the correlation function will be high and the system can extract that signal. If the desired users code has nothing in common with the signal the correlation should be as close to zero as possible (thus eliminating the signal); this is referred to as cross correlation. If the code is correlated with the signal at any time offset other than zero, the correlation should be as close to zero as possible. This is referred to as auto-correlation and is used to reject multi-path interference. The signal graph is shown below:



# EMBEDDED SYSTEMS

An embedded system is a special-purpose computer system designed to perform one or a few dedicated functions, often with real-time computing constraints. It is usually *embedded* as part of a complete device including hardware and mechanical parts. In contrast, a general-purpose computer, such as a personal computer, can do many different tasks depending on programming. Embedded systems control many of the common devices in use today.

Since the embedded system is dedicated to specific tasks, design engineers can optimize it, reducing the size and cost of the product, or increasing the reliability and performance. Some embedded systems are mass-produced, benefiting from economies of scale.

Physically, embedded systems range from portable devices such as digital watches andMP3 players, to large stationary installations like traffic lights, factory controllers, or the systems controlling nuclear power plants. Complexity varies from low, with a single microcontroller chip, to very high with multiple units, peripherals and networks mounted inside a large chassis or enclosure.

In general, "embedded system" is not an exactly defined term, as many systems have some element of programmability. For example, Hand-held computers share some elements with embedded systems — such as the operating systems and microprocessors which power them — but are not truly embedded systems, because they allow different applications to be loaded and peripherals to be connected.

## 2051 MICROCONTROLLER

The 2051 is a 20 pin version of the 8051. It is a low-voltage, high-performance CMOS 8-bit microcomputer with 2K bytes of Flash programmable and erasable read only memory. Atmel manufactures the chip using high-density nonvolatile memory technology. The 2051 and is compatible with the industry-standard MCS-51 instruction set. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel 2051 is a powerful microcontroller. It provides a very flexible, cost-effective solution to many embedded control applications.

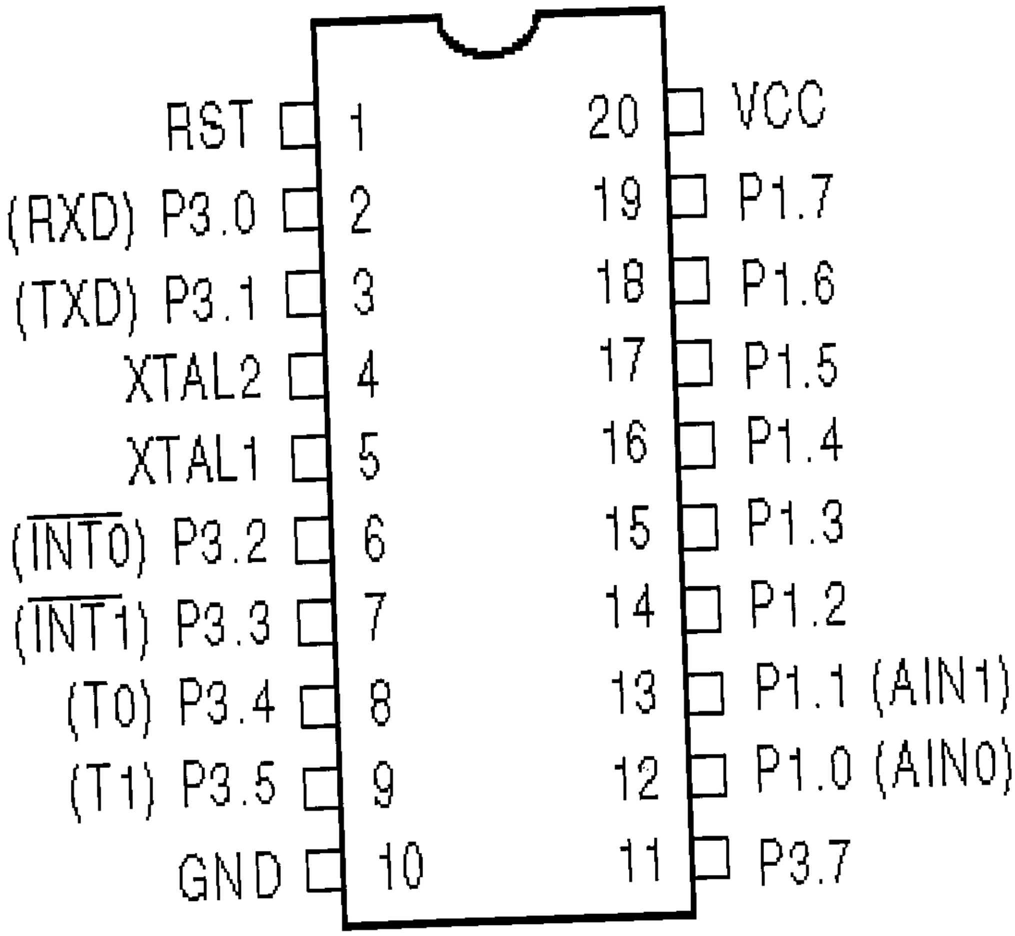
### Operational features of the 2051

The 2051 features Compatibility with MCS-51 ™ Products, 2K Bytes of Reprogrammable Flash Memory with 1,000 Write/Erase Cycles. The operating range of the 2051 is 2.7V to 6V. Among these features, the 2051 also contains the following features:

- Fully Static Operation: 0 Hz to 24 MHz
- Two-level Program Memory Lock
- 128 x 8-bit Internal RAM
- 15 Programmable I/O Lines
- Two 16-bit Timer/Counters
- Six Interrupt Sources
- Programmable Serial UART Channel

- Direct LED Drive Outputs
- On-chip Analog Comparator
- Low-power Idle and Power-down Modes

2051 Pin-out and Description



## Pin Description

### VCC

Supplies voltage and power.

### GND

Ground.

### PORT 1

Port 1 is an 8-bit bi-directional I/O port. Port pins P1.2 toP1.7 provide internal pull-ups. P1.0 and P1.1 require external pull-ups. P1.0 and P1.1 also serve as the positive input (AIN0) and the negative input (AIN1), respectively, of the on-chip precision analog comparator. The Port 1 output buffers can sink 20mA and can drive LED displays directly. When 1s are written to Port 1 pins, they can be used as inputs. When pins P1.2 to P1.7 are used as inputs and are externally pulled low, they will source current (IIL) because of the internal pull-ups. Port 1 also receives code data during Flash programming and verification.

### PORT 3

Port 3 pins P3.0 to P3.5, P3.7 are seven bi-directional I/O pins with internal pull-ups. P3.6 is hard-wired as an input to the output of the on-chip comparator and is not accessible as a general purpose I/O pin. The Port 3 output buffers can sink 20mA. When 1s are written to Port 3 pins they are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 3 pins that are externally being pulled low will source current (IIL) because of the pull-ups. Port 3 also serves the functions of various special features of the AT89C2051 as listed below:

| Port Pin | Alternate Functions |
|---|---|
| P3.0 | RXD (serial input port) |
| P3.1 | TXD (serial output port) |
| P3.2 | $\overline{INT0}$ (external interrupt 0) |
| P3.3 | $\overline{INT1}$ (external interrupt 1) |
| P3.4 | T0 (timer 0 external input) |
| P3.5 | T1 (timer 1 external input) |

Port 3 also receives some control signals for Flash programming and verification.

<u>RST</u>

Reset input. All I/O pins are reset to 1s as soon as RST goes high. Holding the RST pin high for two machine cycles while the oscillator is running resets the device.

## Restrictions on Instructions

The AT89C2051 and is the economical and cost-effective member of Atmel's family of microcontrollers. Therefore, it contains only 2K bytes of flash program memory. It is fully compatible with the MCS-51 architecture, and can be programmed using the MCS-

51 instruction set. However, there are a few considerations one must keep in mind when utilizing certain instructions to program this device. All the instructions related to jumping or branching should

be restricted such that the destination address falls within the physical program memory space of the device, which is 2K for the AT89C2051. This should be the responsibility of the software programmer. For example, LJMP 7E0H

would be a valid instruction for the AT89C2051 (with 2K of memory), whereas LJMP 900H would not.

## 1. Branching instructions

*LCALL, LJMP, ACALL, AJMP, SJMP, JMP @A+DPTR*

These unconditional branching instructions will execute correctly as long as the programmer keeps in mind that the destination branching address must fall within the physical boundaries of the program memory size (locations 00H to 7FFH for the 89C2051). Violating the physical space limits may cause unknown program behavior.

CJNE [...], DJNZ [...], JB, JNB, JC, JNC, JBC, JZ, JNZ

With these conditional branching instructions the same rule above applies. Again, violating the memory boundaries may cause erratic execution.

For applications involving interrupts the normal interrupt service routine address locations of the 80C51 family architecture have been preserved.

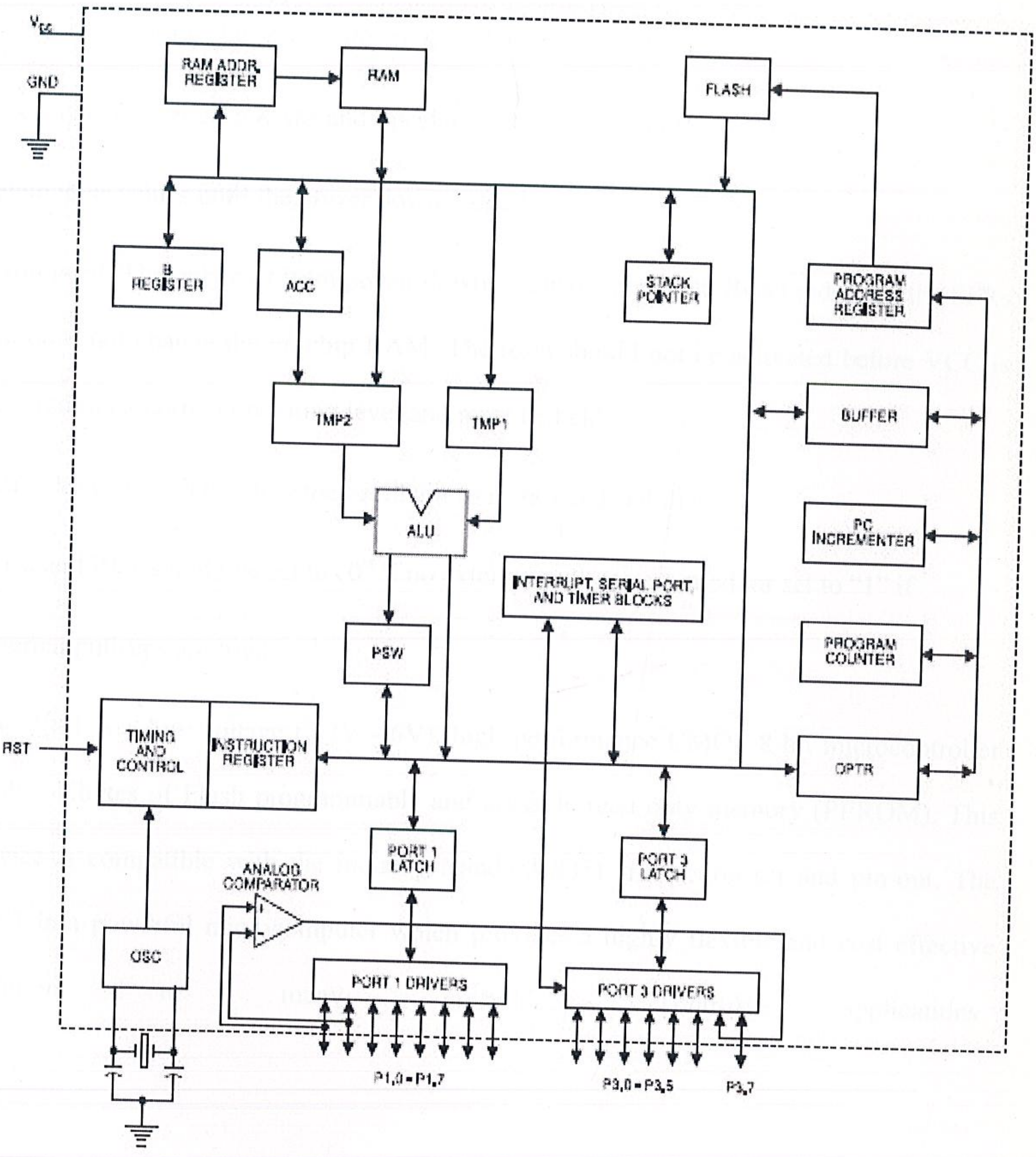
## 2. MOVX-related instructions, Data Memory

The 2051 contains 128 bytes of internal data memory. Thus, in the 2051 the stack depth is limited to 128 bytes, the amount of available RAM. External DATA

Memory access is not supported in this device, nor is external PROGRAM memory execution. Therefore, no MOVX [...] instructions should be included in the program. A typical 80C51 assembler will still assemble instructions,

even if they are written in violation of the restrictions mentioned above. It is the responsibility of the controller user to know the physical features and limitations of the device being used and adjust the instructions used correspondingly.

# BLOCK DIAGRAM OF 2051



## Power-down Mode

In the power down mode the oscillator is stopped, and the Instruction that invokes power down is the last instruction Executed. The on-chip RAM and Special Function Registers retain their values until the power down mode is terminated. The only exit from power down is a hardware reset. Reset redefines the SFRs but does not change the on-chip RAM. The reset should not be activated before VCC is restored to its normal operating level and must be held active long enough to allow the oscillator to restart and stabilize.

P1.0 and P1.1 should be set to "0" if no external pull-ups are used, or set to "1" if external pull-ups are used.

The 2051 is a low voltage (2.7V - 6V), high performance CMOS 8-bit microcontroller with 2 Kbytes of Flash programmable and erasable read only memory (PEROM). This device is compatible with the industry standard 8051 instruction set and pin-out. The 2051 is a powerful microcomputer which provides a highly flexible and cost effective solution to many embedded control applications.

In addition, the 2051 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port and interrupt system to continue functioning. The Power down Mode saves the RAM contents but freezes the oscillator disabling all other chip functions until the next hardware reset.

# LIST OF COMPONENTS USED

ICs-

IC 8870 (1)

IC 74154 (1)

89C2051 (1)

OPTOCOUPLERS

PC 817 (4)

FREQUENCY CRYSTALS-

3.58 MHz (1)

12 MHz (1)

TRANSISTORS-

NPN transistor BC 548 (4)

PNP transistor BC 558 (4)

RESISTORS-

470 ohm (4)

4.7 K ohm (4)

1 K ohm (4)

22 K ohm (2)

100 K ohm (1)

10 K ohm (4)

L.E.D. (2)

## CAPACITORS-

1000 mf (1)

10 mf (1)

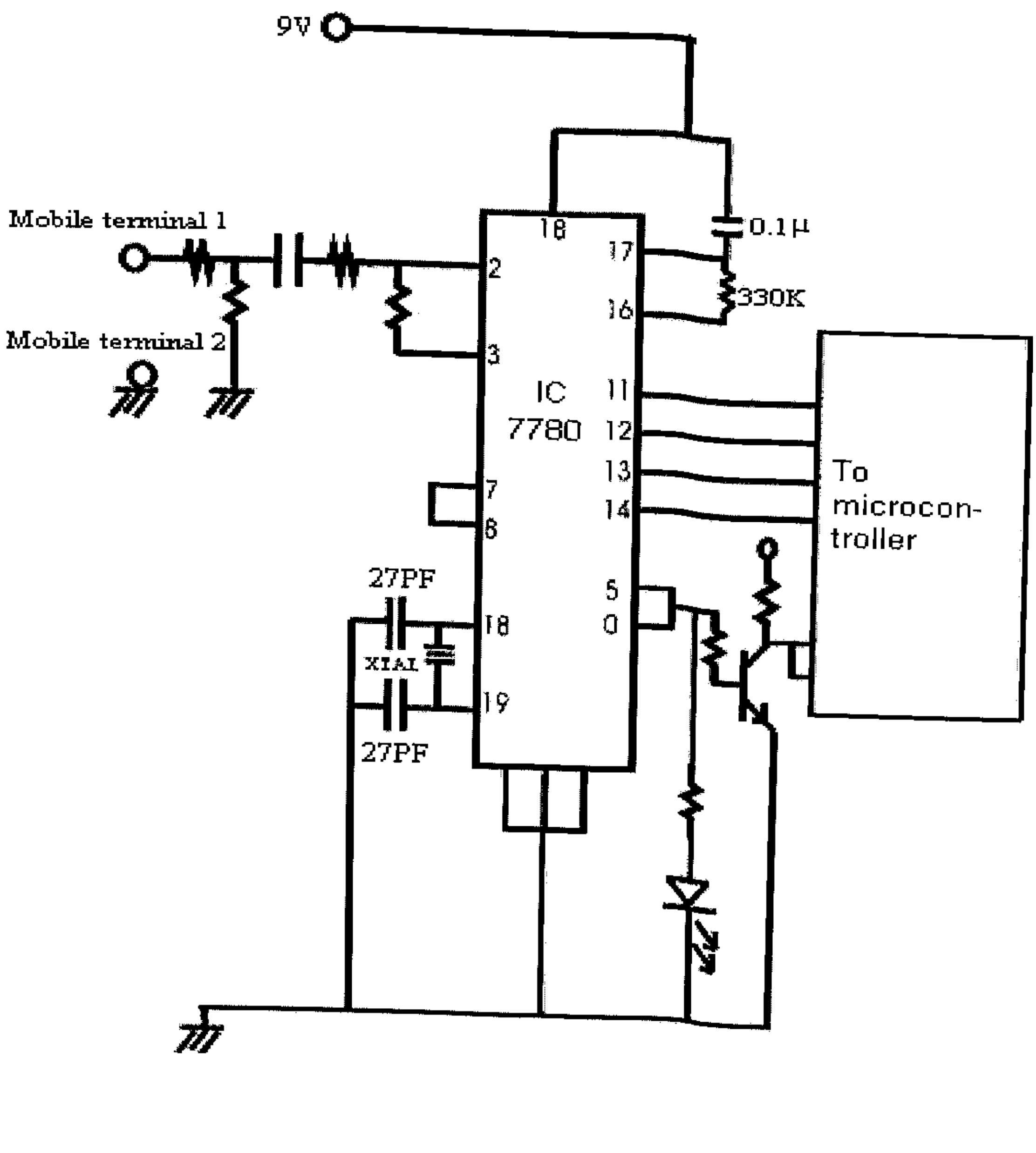
1 mf (104) (2)

22 pf (2)

## MOTORS-

DC MOTOR (GEARED) (2)

# DTMF (ANALOG) TO BCD (DIGITAL) CONVERSION



## IC 8870 DTMF-BCD CONVERTER

IC 8870 is used in our model for mobile interface. By using this IC we decode the DTMF pulses from the mobile phone through hands-free port and by using this IC we convert these pulses into BCD signal.

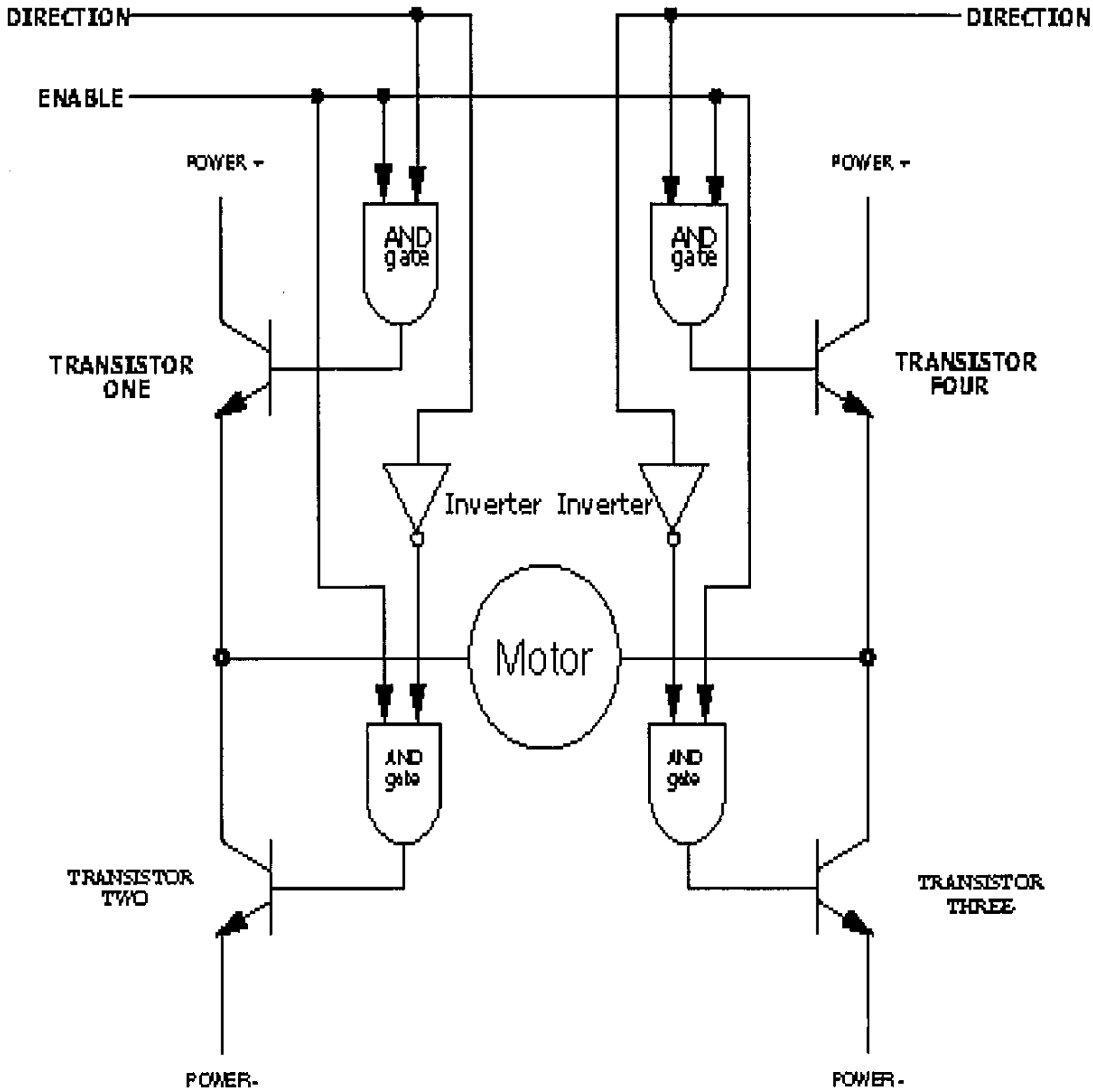
## IC 74154 DEMULTIPLEXER

A demultiplexer (DEMUX) basically reverses the multiplexing function. It takes digital information from one line and distributes it to a given number of output lines. For this reason, the demultiplexer is also known as a data distributor. Decoders can also be used as demultiplexers. A $2^n$ bit demultiplexer will have 'n' number of select lines. There may be special ports to enable and disable the demultiplexer. In this model, IC 74154, a 16-pin demultiplexer, is used with 4 select lines.

IC 74154 basically converts the BCD signal into decimal signal for further use with the microcontroller. It converts the 4-bit data into 16-bit output. Here in this model there is no use of entire 16 output pins, so we use only 4 output.

# THE H-BRIDGE LOGIC

H-bridge logic basically provides a forward and reverse mechanism to the motor.

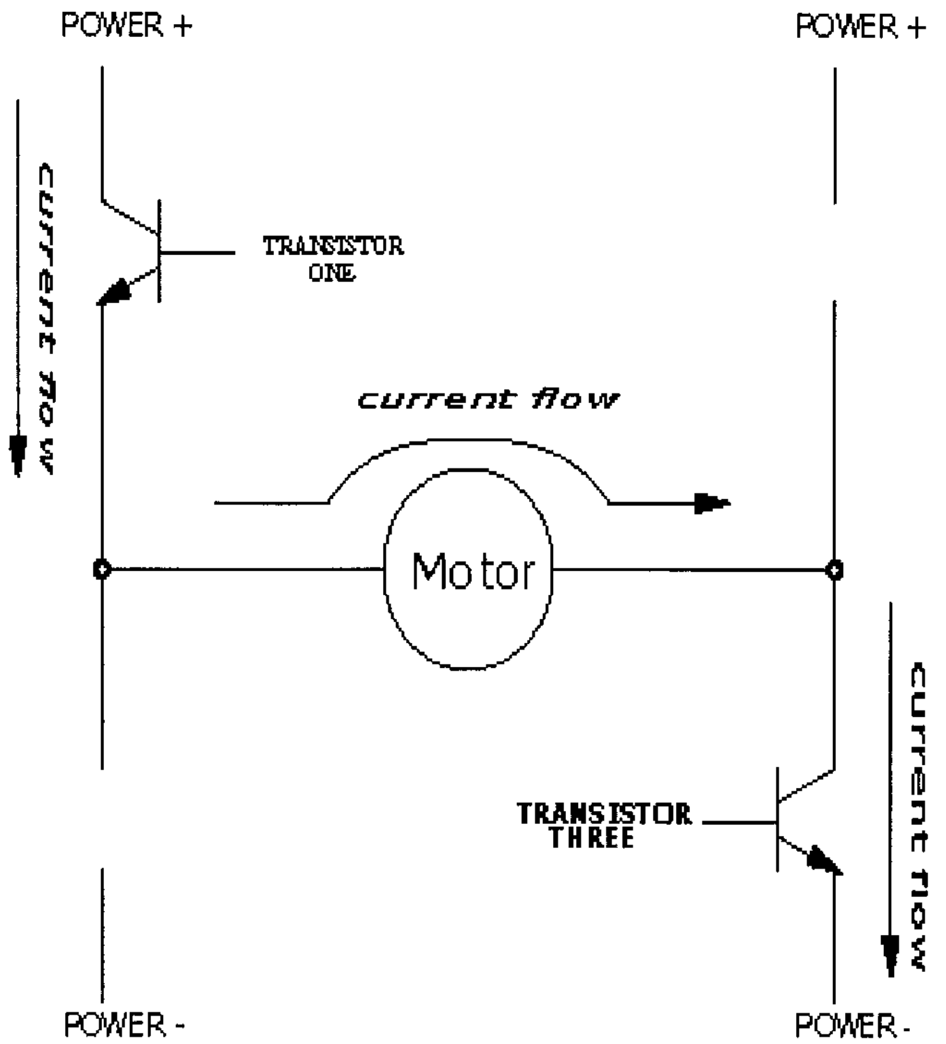


H-Bridge is a popular circuit for driving DC motors (ordinary or gear-head). It's called that because it looks like the capital letter 'H' on classic schematics. The great ability of an H-bridge circuit is that the motor can be driven forward or backward at any speed, optionally using a completely independent power source. In this circuit two of four transistors are selectively enabled to control current flow through a motor. Opposite pair of transistors (Transistor One and Transistor Three) is enabled, allowing current to flow through the motor. The other pair is disabled, and can be thought of as out of the circuit.

By determining which pair of transistors is enabled, current can be made to flow in either of the two directions through the motor. Because permanent-magnet motors reverse their direction of turn when the current flow is reversed, this circuit allows bidirectional control of the motor.

In this circuit, the internal inverters ensure that the vertical pairs of transistors are never enabled simultaneously. The *Enable* input determines whether or not the whole circuit is operational. If this input is false, then none of the transistors are enabled, and the motor is free to stop. By turning on the *Enable* input and controlling the two *Direction* inputs, the motor can be made to turn in either direction.

If both direction inputs are the same state (either true or false) and the circuit is enabled, both terminals will be brought to the same voltage (Power + or Power - , respectively). This operation will actively brake the motor, due to a property of motors known as *back-emf*, in which a motor that is turning generates a voltage counter to its rotation. When both terminals of the motor are brought to the same electrical potential, the back-emf causes resistance to the motor's rotation.

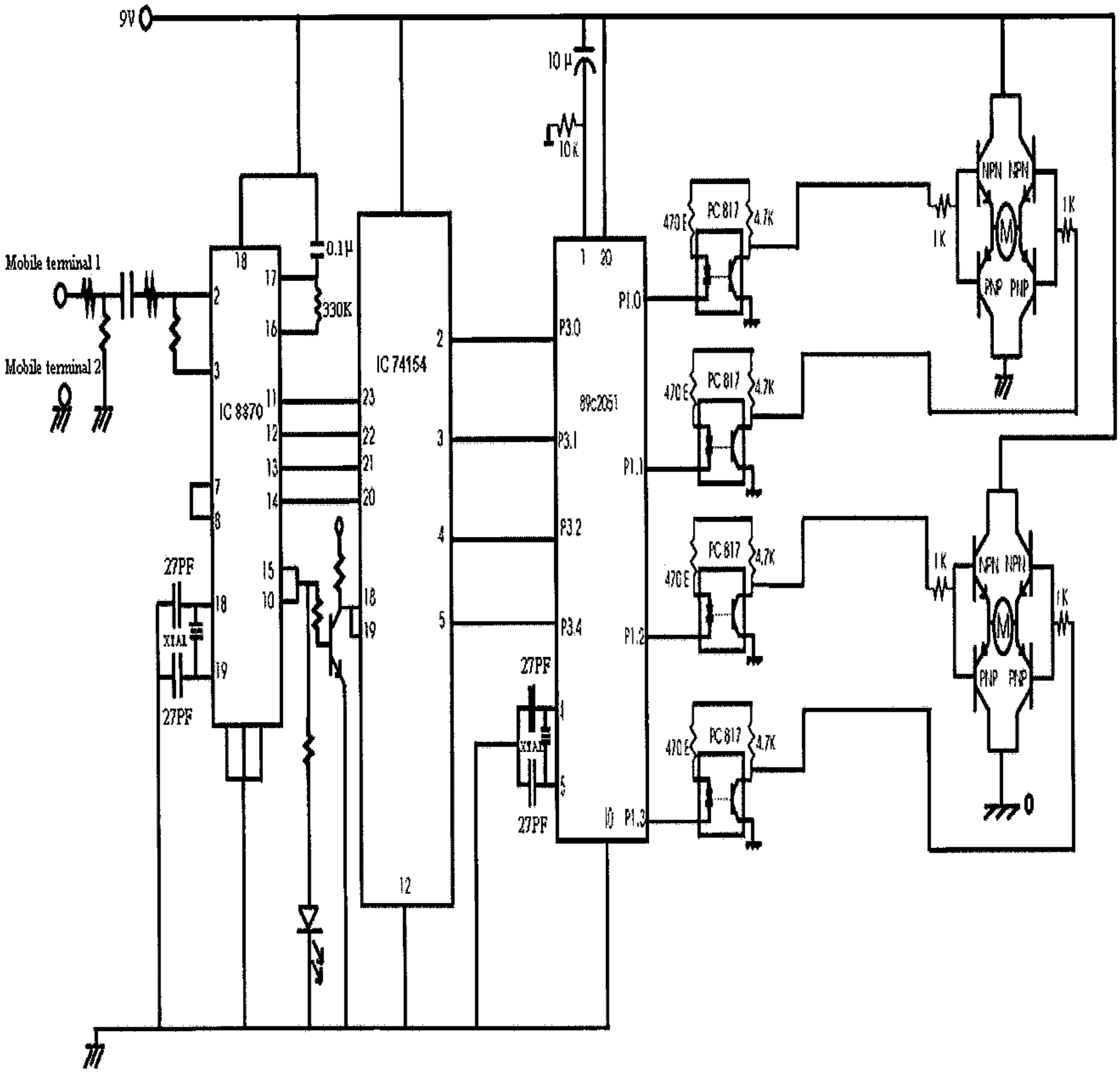

POWER +
POWER +
current flow
TRANSISTOR
ONE
current flow
Motor
TRANSISTOR
THREE
current flow
POWER -
POWER -

# ALGORITHM

- Step 1: Initialize P1.0, P1.1, P1.2, P1.3 (output ports) to 0.
- Step 2: If P3.0 = 0, jump to step 6, to *move forward.*
- Step 3: If P3.1 = 0, jump to step 8, to *move backward.*
- Step 4: If P3.2 = 0, jump to step 10, to *turn left.*
- Step 5: If P3.3 = 0, jump to step 12, to *turn right.*
- Step 6: Jump to step 1.
- Step 7: Set values as -> P1.0 = 1, P1.1 = 0, P1.2 = 0, P1.3 = 1.
- Step 8: Hold these values for a moment (*Call Delay*).
- Step 9: Jump to step 1.
- Step 10: Set values as -> P1.0 = 0, P1.1 = 1, P1.2 = 1, P1.3 = 0.
- Step 11: Hold these values for a moment (*Call Delay*).
- Step 12: Jump to step 1.

- Step 13: Set values as -> P1.0 = 1, P1.1 = 1, P1.2 = 0, P1.3 = 1.
- Step 14: Hold these values for a moment (*Call Delay*).
- Step 15: Jump to step 1.
- Step 16: Set values as -> P1.0 = 1, P1.1 = 0, P1.2 = 1, P1.3 = 1.
- Step 17: Hold these values for a moment (*Call Delay*).
- Step 18: Jump to step 1.

# COMPLETE SCHEMATIC OF THE ROBOT



# WORKING AND EXPLAINATION OF THE CIRCUIT

A wireless video camera is connected to the robot head to keep track of its movements. A video link is thus established and a live view is generated on a TV screen with which the camera receiver is connected. The camera is run by a 9V battery. The microcontroller and the two other ICs are powered by the same 9V battery.As shown in Fig. 8, the three ICs are configured with the respective circutary and frequecny crystals.The overall operation is implementd as follows

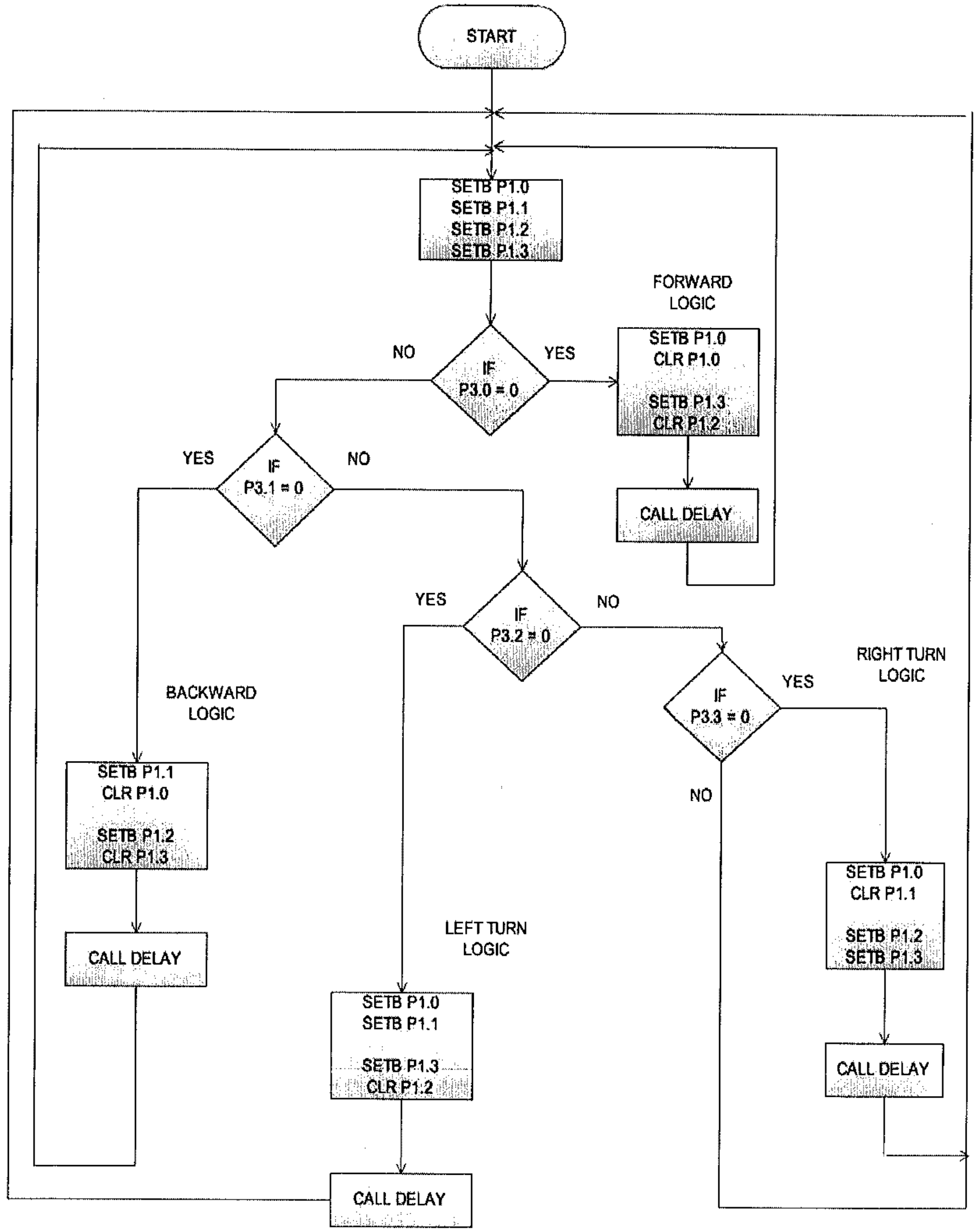
- The user dials the number of the receiving mobile phone that is connected to the robot through its handfree port.
- The receiver phone is set on auto-answer. So, after a few seconds of dialing, the connection is established.
- The user now gives instructions through his mobile phone by pressing certain number keys on the key-pad of his mobile phone. The table below shows the useful keys :

Table 1

| KEY-PAD NUMBER | FUNCTION PERFORMED |
| --- | --- |
| 2 | Move Forward |
| 4 | Turn Left |
| 5 | Move Backward |
| 6 | Turn Right |

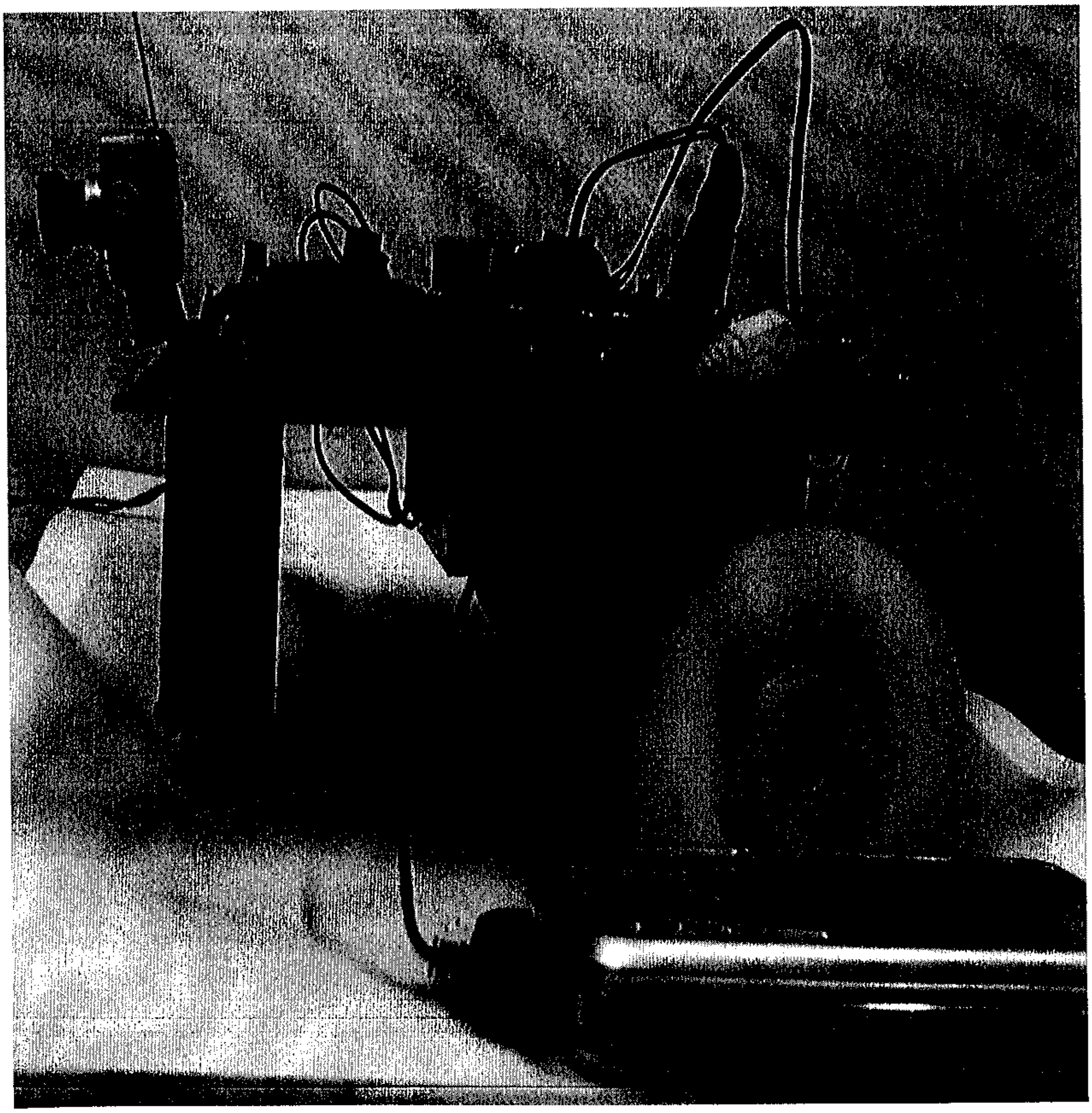
- The corresponding DTMF tone is sent through the phone network ( ref. Fig. 1).
- The receiver phone receives this DTMF tone and it is sent to the DTMF to BCD converter through the handsfree port.
- The DTMF toBCD converter decodes the frequecy and gives the corresponding BCD code as output which goes to the input ports of the demultiplexer.
- The demultiplexer uses the 4-bit BCD code as its select lines. Thus, if the BCD code is 0010, the output of the DEMUX is LOW on the output pin 2 (ACTIVE LOW). Similarly, for BCD codes 0100, 0101, 0110 will result in ACTIVE LOW output at pins 4,5,6 respectively.
- These output pins of the DEMUX are connected to the input ports of the microcontroller.
- The microcontroller is programmed to perform specific operations with respect to these inputs :Forward, Backward, Left and Right (ref. table 1) through the H-Bridge.

# FLOW CHART OF THE MICROCONTROLLER ASSEMBLY LANGUAGE PROGRAM

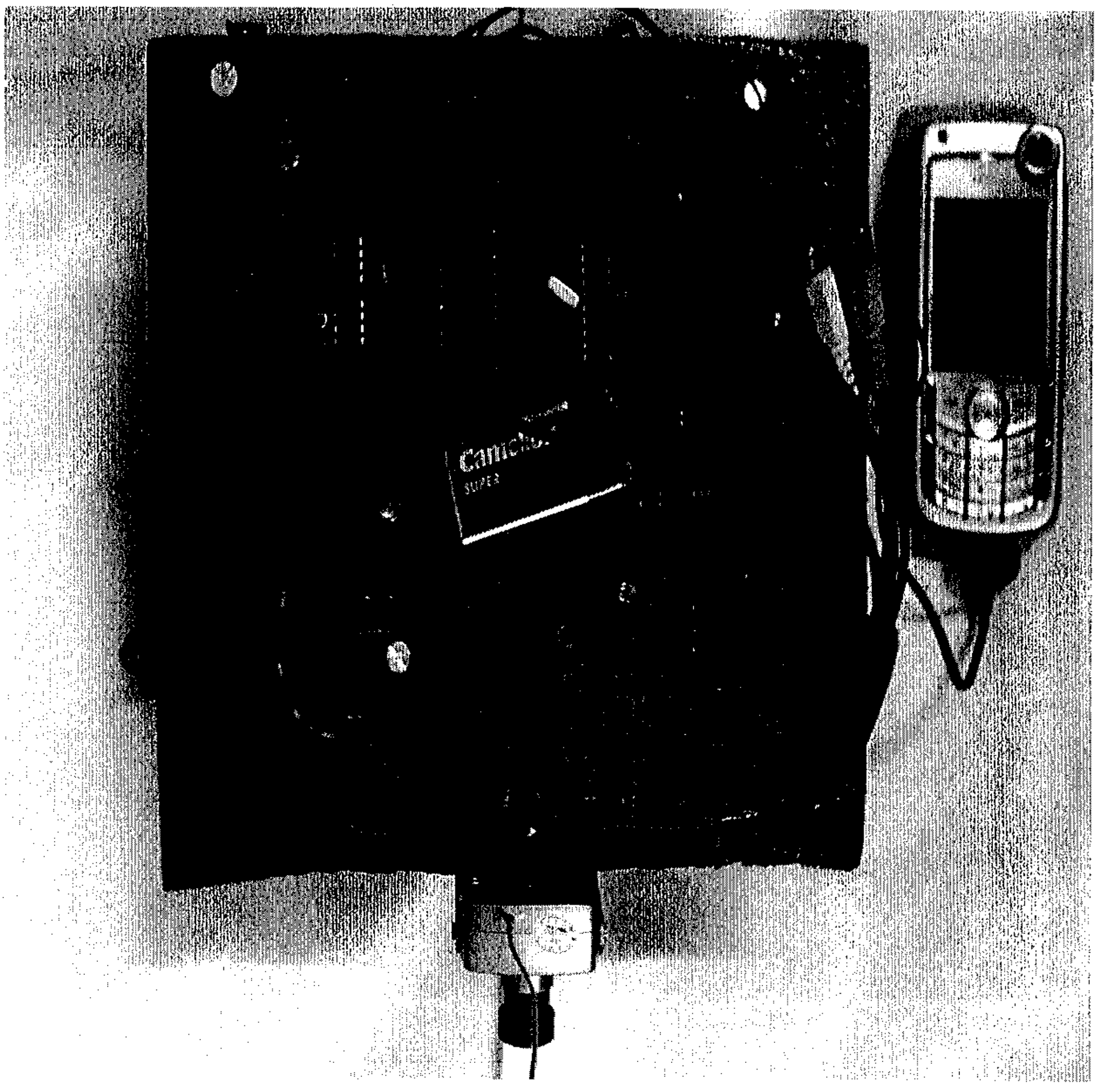


# ACTUAL PICTURES OF THE ROBOT

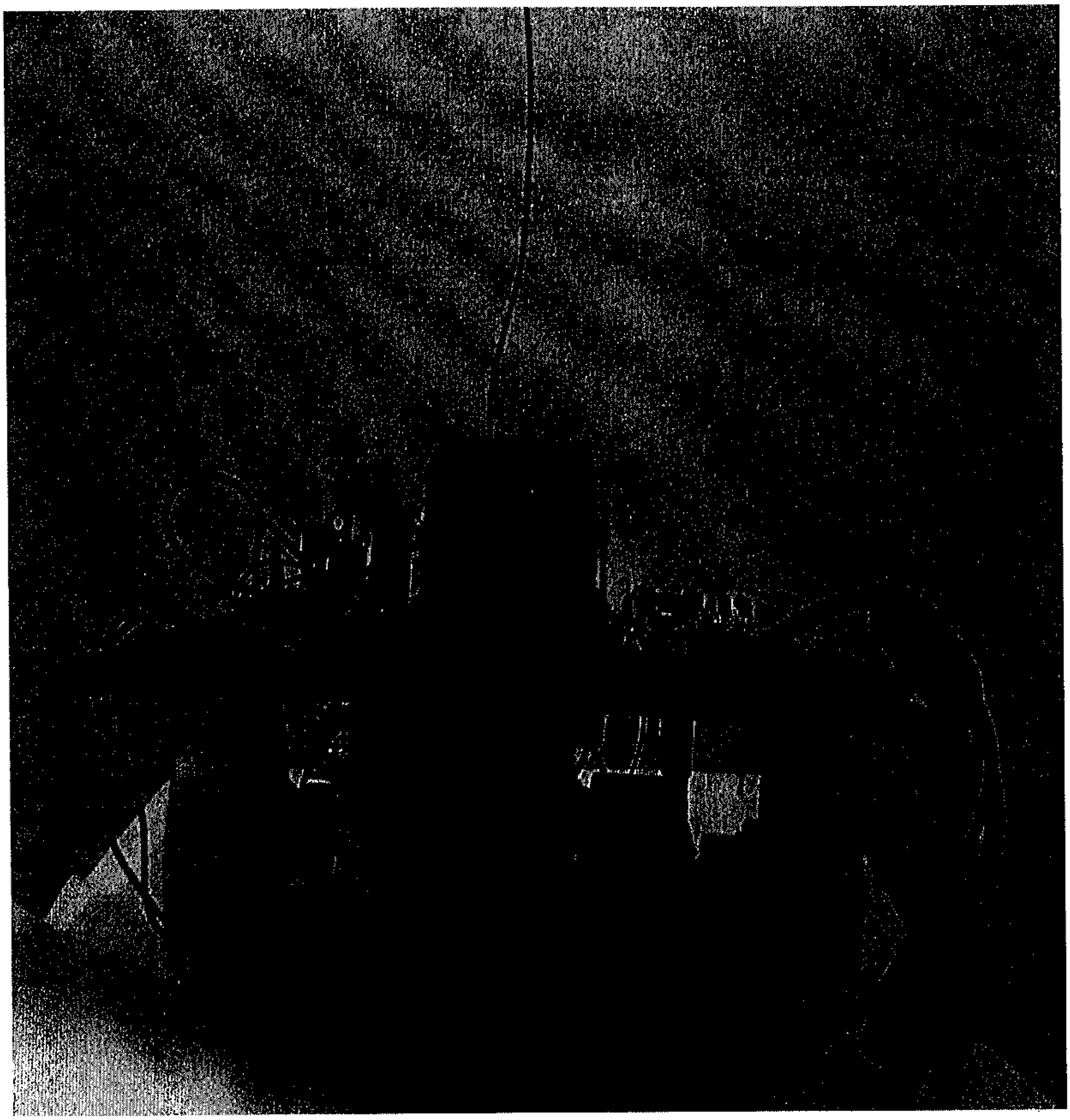
SIDE VIEW



TOP VIEW



FRONT VIEW



# APPLICATIONS

This prototype is very useful in the following applications:

1) Spying

2) Mining

3) Defence applications

4) Exploration

# CONCLUSION

The necessary code has been made and downloaded in microcontroller by using appropriate software. The analog instructions received by the receiving mobile phone were successfully converted into digital strobes as interrupt signals to the microcontroller through DTMF to BCD converter IC. The actuation of the motor is driven by the output ports of the microcontroller.

The proposed work has following advantages over the existing models:

1) The robot can be controlled from anywhere on the globe.
2) A number of devices can be controlled through a dedicated output port bits by writing the individual controlling algorithm for each device.
3) The system is not bulky as the programming device is a microcontroller instead of a personal computer.
4) Depending upon the requirement of output device the microcontroller can be reprogrammed.
5) The present work takes the advantage of using existing GSM, CDMA, landline telephone network, thereby, reducing the added cost of installation of a separate dedicated network.
6) This also overcomes the range limitation of Bluetooth.
7) The entire design uses a network of existing telephone providers, thus minimizing the cost substantially.

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