A PC OPERATED REMOTE CONTROLLED ROBOTIC ARM

A PROJECT REPORT

Submitted by

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Under the guidance of

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The report of the project work submitted by the above students in partial fulfillment for the award of Bachelor of Engineering degree in Electrical & Electronics Engineering of Anna University were evaluated and confirmed to be report of the work done by the above students.

18/4/05

(INTERNAL EXAMINER) **(EXTERNAL EXAMINER)**

DEDICATED

TO

THE ALMIGHTY

ACKNOWLEDGEMENT

The satisfaction that accompanies the successful completion of any task would be incomplete without mentioning the people who gave us constant guidance and support.

We would like to express our deep sense of gratitude towards our project guide **Mrs.K.Malarvizhi, B.E.,** (Senior Lecturer, Department of EEE) who guided us throughout the project and encouraged us to successfully complete our work. Our thanks to her for the immense help and guidance that she provided during the entire course of our project.

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ABSTRACT

ABSTRACT

The prototype project described in this abstract is immensely useful for industrial automation purposes and to a variety of other significant areas where the presence of humans can be harmful. The robotic arm described here can operate under remote control for operating radius of more than 300 metres and above depending upon the transmission power of the equipment used. The arm has only 2 axes of freedom to move but can be easily upgraded as required by the application for which it is utilized. Each of the motors used are controlled simultaneously using a single microcontroller and a dedicated RF transmission channel is maintained for the control of the motors. The robot is provided with a electromagnet for lifting magnetic material. A Liquid Crystal Display (LCD) panel displays the current operation being done by the robot. The control signals from the computer are sent through the Audio out socket of the computer. The controlling software used is designed using Visual Basic 6.0 that helps the user to operate the robot in guided mode.

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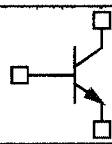
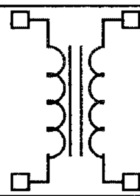
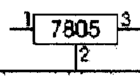
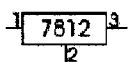
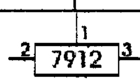
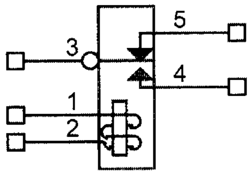
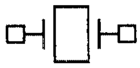
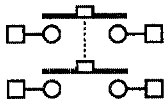
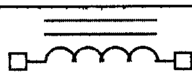
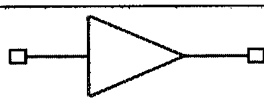
LIST OF SYMBOLS

S.NO	***SYMBOLS***	***NAME***
1		RESISTOR
2		CAPACITOR
3		ANTENNA
4		INDUCTOR
5		NPN TRANSISTOR
6		SWITCH
7		TRANSFORMER
8		GROUND
9		AC VOLTAGE SOURCE
10		LM7805 VOLTAGE REGULATOR
11		LM7812 VOLTAGE REGULATOR
12		LM7912 VOLTAGE REGULATOR
13		DIODE
14		ZENER DIODE

15		RELAY
16		LED
17		CRYSTAL
18		PUSHBUTTON-DPST
19		STEPPER MOTOR COIL
20		7407 BUFFER

LIST OF ABBREVIATIONS

S.NO	*ABBREVIATION*	*EXPANSION*
1	AC	Alternating Current
2	AF	Audio Frequency
3	AM	Amplitude Modulation
4	ASK	Amplitude Shift Keying
5	BCD	Binary Coded Decimal
6	DC	Direct Current
7	DIP	Dual Inline Package
8	DPST	Double Pole Single Throw
9	DTMF	Dual Tone Multiple Frequency
10	HMOS	Hybrid Metal Oxide Semiconductor
11	IC	Integrated Circuit
12	LCD	Liquid Crystal Display
13	PC	Personal Computer
14	RAM	Random Access Memory
15	RF	Radio Frequency
16	RMS	Root Mean Square
17	SPST	Single Pole Single Throw

1. *INTRODUCTION*

INTRODUCTION

"Life is Invaluable "

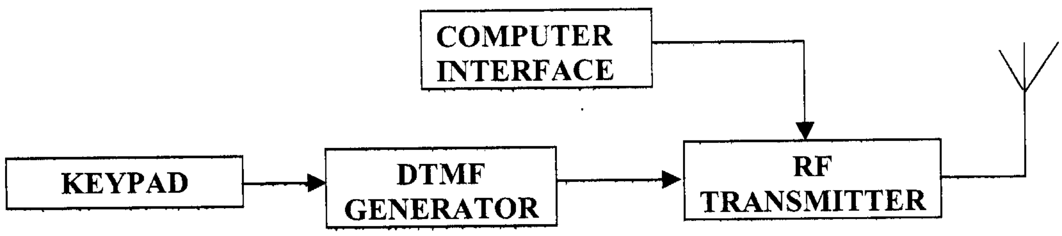
Safety is of utmost importance in all walks of life. Robotics and automation has to a great extent reduced the direct *RISK FACTOR* faced in numerous situations. Right from the moderator rod controls in nuclear power plants to factory assembly units to chemical research laboratories and even to the extent of bomb diffusion, robots have become indispensable. However to emphasize safety with automation procedures, the major constraint has been the capital cost involved in the initial investment.

The "**A PC OPERATED REMOTE CONTROLLED ROBOTIC ARM**" addresses both the safety issues and financial aspects. Automation and distance (remote operation greater than *300 metres* of radius) ensures safety. Step drives (Stepper motors) ensures the simple and down to earth financial needs. The project's front-end uses a *Visual Basic 6.0* interface. The concept of *Dual Tone Multiple Frequency (DTMF®)* signals transmitted by frequency modulation in the high radio frequency of 433MHz is being adopted here for remote control.

We have used DTMF concept in robotic arm control using a computer in which usually serial communication is used, instead of which we have used DTMF tone switching technique.

2. TRANSMITTER BLOCK

FIG 1. BLOCK DIAGRAM OF TRANSMITTER CIRCUIT



2.1 KEYPAD:

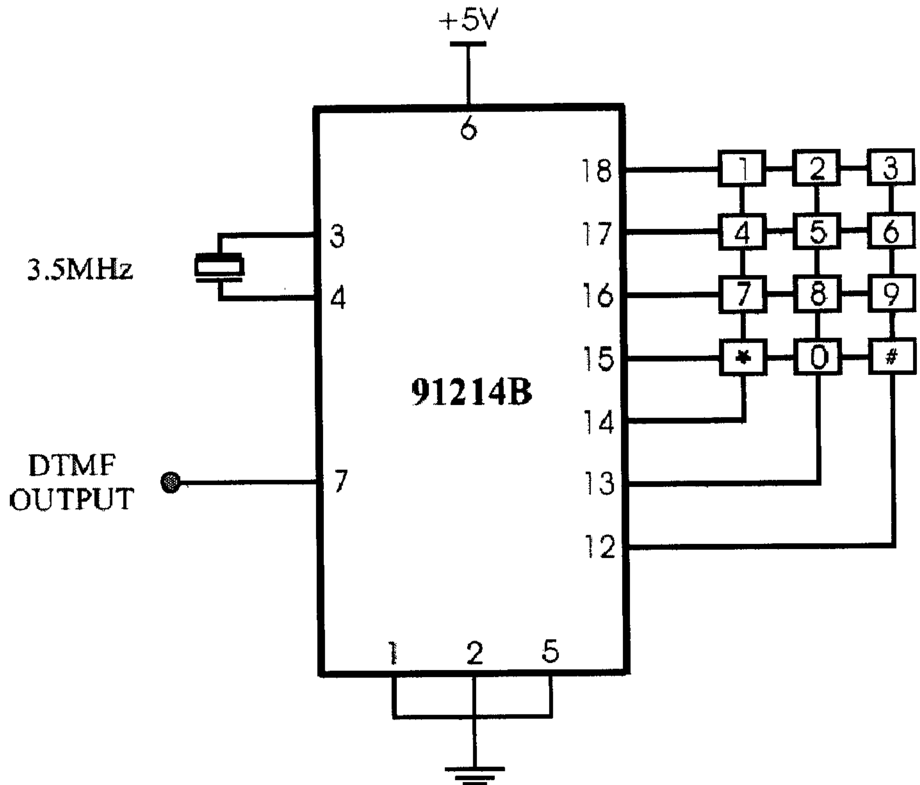
The keypad consists of eight keys for controlling the motors and the electromagnet. Two keys are provided for controlling the direction of rotation of the motor((i.e) UP and DOWN or CLOCKWISE and ANTI-CLOCKWISE). A stop key is provided for stopping the motor at the current location. The electromagnet can be switched ON and OFF using two keys. The individual keys in the keypad consist of a simple Double Pole Single Throw (DPST) switch. The arrangement of the keys is in a Matrix structure.

2.2 DTMF ENCODER:

The circuit used here is a basic one used for driving the UM-91214-B (which is the same one that is used in telephones). This IC is used to generate the Dual Tone Multiple Frequency (*DTMF*) signals used to control the robot via RF transmissions. This remote control unit has 8 channels, which can be easily extended to 12. Usually remote control circuits make use of infrared light to transmit control signals. Their use is thus limited to a very confined area and line-of-sight. However, this circuit makes use of radio frequency to transmit the control signals and hence it can be used for control from almost anywhere in the control area. Here we make use of DTMF (dual-tone multi frequency) signals (used in telephones to dial the digits) as the control codes. The DTMF tones are used for frequency modulation of the carrier. This IC requires 3 volts for its operation. This is provided by a simple zener diode voltage regulator, which converts 9 volts into 3 volts for use by this IC. For its time base, it requires a quartz crystal of 3.58 MHz, which is easily available from electronic component shops. Pins 1 and 2 are used as chip select and DTMF mode select pins respectively. When the row and column pins (12 and 15) are shorted to each other, DTMF tones corresponding to digit 1 are output from its pin 7. Similarly, pins 13, 16 and 17 are additionally required to dial digits 2, 4 and 8. Rest of the pins of this IC may be left as they are. The output of IC1 is given to the input of this transmitter circuit which effectively frequency modulates the carrier and transmits it in the air. Four key switches (DPST push-to-on spring loaded) are required to transmit the desired DTMF tones. The switches when pressed generate the specific tone pairs as well as provide power to the transmitter circuit simultaneously. This way when the transmitter unit is not in use it consumes no power at all and the battery lasts much longer.

FIG 2. CIRCUIT DIAGRAM OF DTMF ENCODER

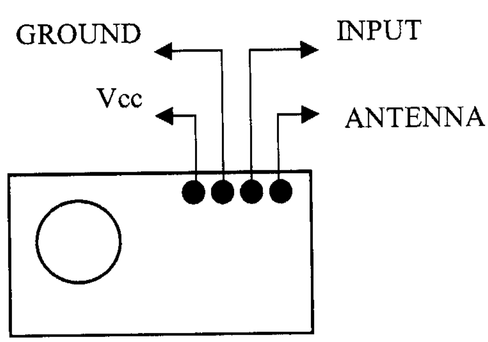
(SHOWN WITH 4 DPST SWITCHES)



2.3 RADIO FREQUENCY TRANSMITTER:

An antenna of 10 to 15 cms (4 to 6 inches) length will be needed to provide adequate range. The antenna is also necessary because the transmitter unit has to be housed in a metallic cabinet to protect the frequency drift caused due to stray EM fields. The circuit consists of a preamplifier that serves two purposes, to give reasonably well-defined input impedance and provide isolation between the oscillations of the super regenerator and the antenna, reducing unwanted radiation. The super-regenerator input is applied to the tank circuit via a small value capacitor to minimize the loading of the circuit. The non-linearity of the device when operated in this mode also detects the AM signals and the output is taken at the biasing resistor and is low pass filtered using an RC network.

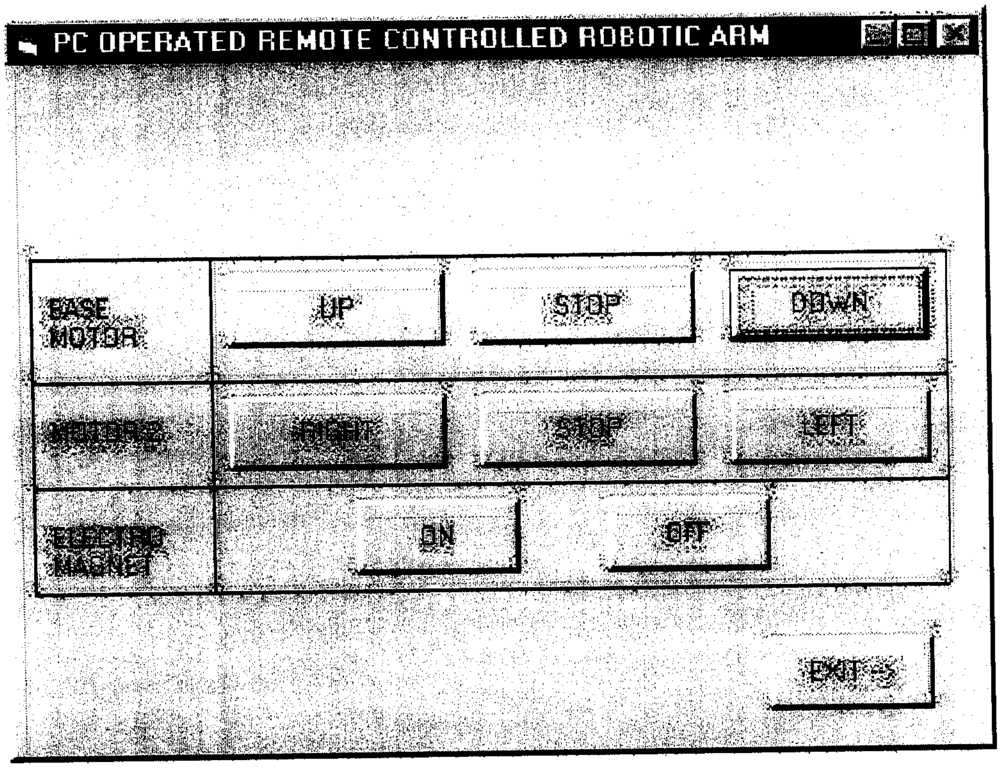
FIG 3. RADIO FREQUENCY TRANSMITTER



2.4 COMPUTER INTERFACE:

The Computer interface is designed using Visual Basic 6.0. The principle used in the interfacing is that the Dual Tone Multiple Frequency sounds are pre-recorded as audio files in the computer. What happens in the program when we press a control button is that, the corresponding audio file is accessed as bit stream by the application. The bit stream is used to play back sound by the Windows Media Player which is embedded as a component in the application. The radio frequency transmitter, which works on the same principle as explained in the preceding explanation, is plugged into the audio out socket of the computer. Hence whenever we press a control button in the interfacing application, the RF transmitter transmits the corresponding DTMF tone.

FIG 4. COMPUTER INTERFACE FOR ROBOTIC ARM:



2.4.1 VISUAL BASIC CODE FOR COMPUTER INTERFACE:

```
Private Sub Command1_Click()
MediaPlayer1.Open ("C:\P\DTMF\1.wav")
End Sub

Private Sub Command2_Click()
MediaPlayer1.Open ("C:\P\DTMF\2.wav")
End Sub

Private Sub Command3_Click()
MediaPlayer1.Open ("C:\P\DTMF\3.wav")
End Sub

Private Sub Command4_Click()
MediaPlayer1.Open ("C:\P\DTMF\4.wav")
End Sub

Private Sub Command5_Click()
MediaPlayer1.Open ("C:\P\DTMF\5.wav")
End Sub

Private Sub Command6_Click()
MediaPlayer1.Open ("C:\P\DTMF\6.wav")
End Sub


Private Sub Command7_Click()
MediaPlayer1.Open ("C:\P\DTMF\7.wav")
```

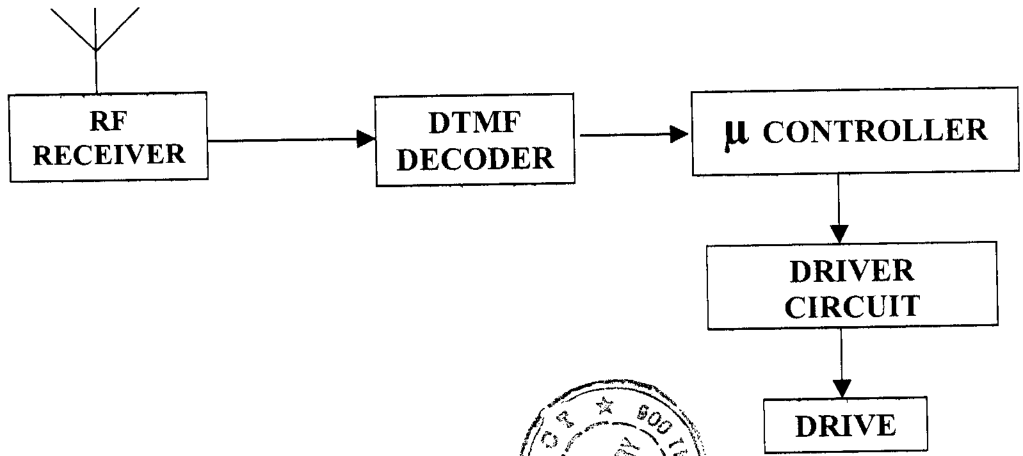
```
End Sub

Private Sub Command8_Click()
MediaPlayer1.Open ("C:\P\DTMF\8.wav")
End Sub

Private Sub Command9_Click()
End
End Sub
```

3. *RECEIVER BLOCK*

FIG 5. BLOCK DIAGRAM OF RECEIVER CIRCUIT

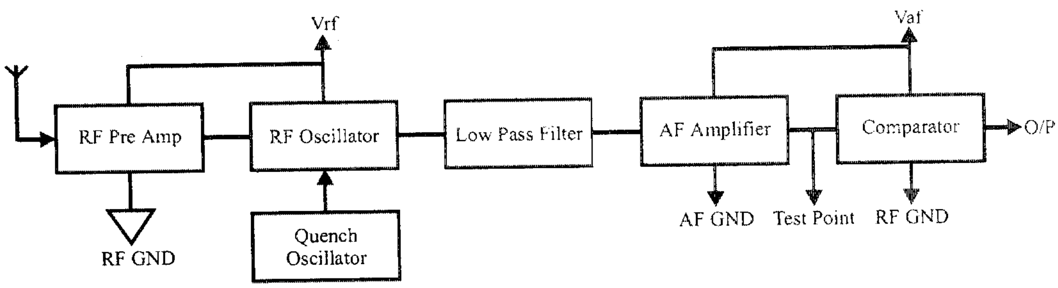


3.1 RADIO FREQUENCY RECEIVER:

This super regenerative receiver is manufactured on a high quality ceramic substrate using a combination of printer, thick film and surface mount components. The receiver is a pre-amplified design with external antenna input. The design used bipolar devices for both pre amplifier and self-quenched super regenerator. The receiver has no integral shielding.

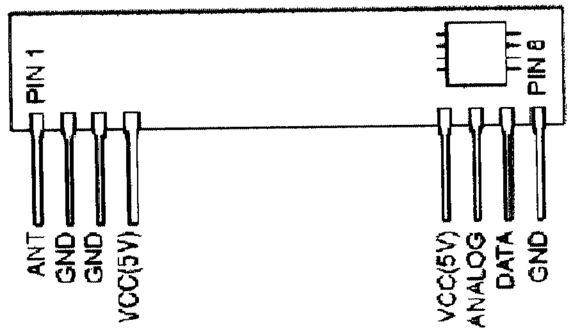
The manufacturers block diagram of the receiver can be seen in Figure.

FIG 6. BLOCK DIAGRAM OF RF RECEIVER



The circuit consists of a preamplifier that serves two purposes, to give reasonably well-defined input impedance and provide isolation between the oscillations of the super regenerator and the antenna, reducing unwanted radiation. The super-regenerator input is applied to the tank circuit via a small value capacitor to minimize the loading of the circuit. The oscillations are self-quenched, despite the block diagram suggesting otherwise. The non-linearity of the device when operated in this mode also detects the AM signals and the output is taken at the biasing resistor and is low pass filtered using an RC network.

FIG 7. CIRCUIT DIAGRAM OF RF RECEIVER



BRIEF SPECIFICATION:

- 433.92 MHz FM Super-Heterodyne Receiver
- SAW Front End Filter, Image Rejection 50dB
- Single 3V to 6V Supply Voltage
- 13mA Current Consumption
- Range up to 300m in open ground, 75m in buildings

3.2 M-8870 DTMF RECEIVER:

The Teltone 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. 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.

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.

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

3.3 FUNCTIONAL DESCRIPTION:

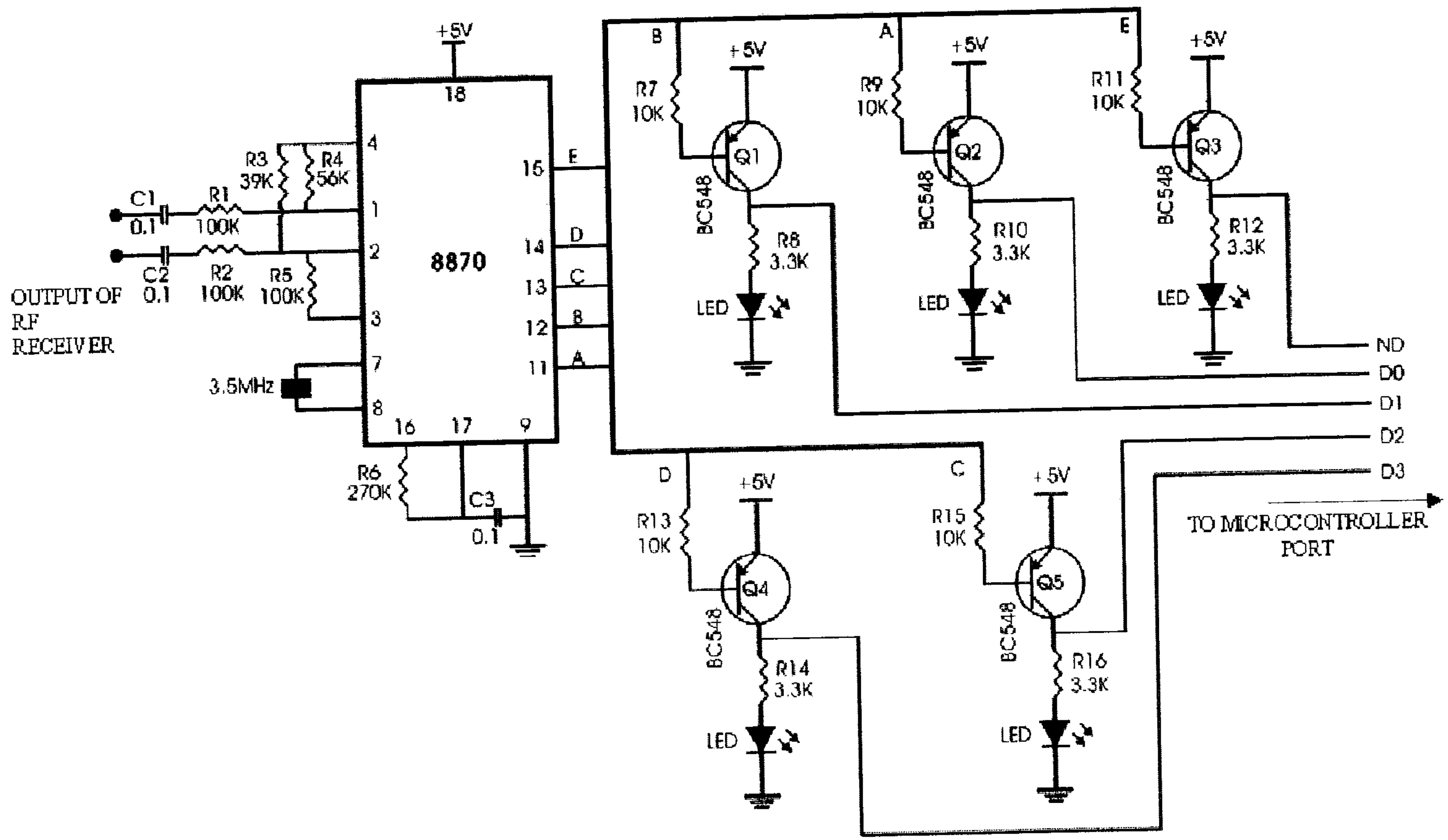
M-8870 operating functions includes a band split filter that separate the high and low tones of the received pair, and a digital decoder that verifies both frequencies and duration of received tones before passing the resulting 4-bit code to the output bus.

Table 1 : DTMF DECODER BCD CODES

F LOW	**F HIGH**	**KEY (ref.)**	**OE**	**Q4**	**Q3**	**Q2**	**Q1**
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

H = High
L = Low
Z = High Impedance

Fig 8. M-8870 CONNECTION TO MICROCONTROLLER INPUT

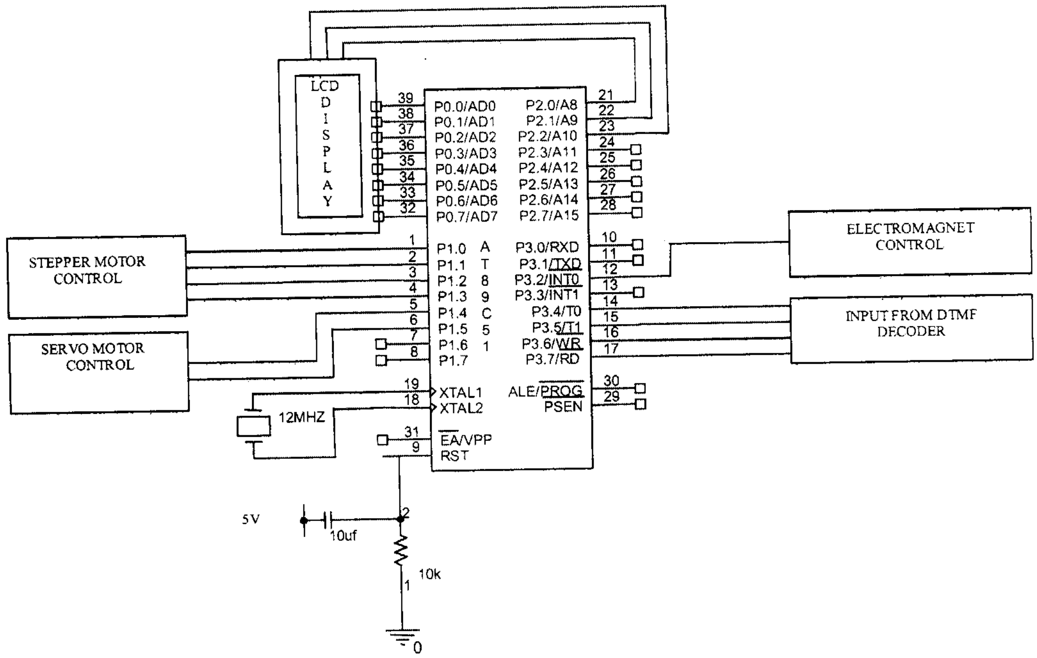


4. *MICROCONTROLLER*

4.1 MICROCONTROLLER:

The field of microcontroller has grown in the past decade to encompass and provide firm theoretical backgrounds for a large number of individual areas. The Atmel – AT 89c51 is a micro controller built on HMOS technology. Besides the primary features of the controller are as follows 4k program memory and 128 bytes data memory on chip. It has four register banks and 64 kb each program and external RAM addressability. It has as 1 micro second instruction cycle with a 12 MHz crystal. 32 bi-directional input output lines are organized as 8 bit ports. It also features multiple mode high speed programmable serial port , two multiple mode 16 bit timers which can also be utilized as counters. Two level interrupt structures are in built with priority. Full depth stack for subroutine return linkage also provide data storage. The ports and the registers are both bit and byte addressable. Binary, decimal, octal and hexadecimal arithmetic operations can be done. Signed overflow detection in arithmetic operations and parity computation during serial communication can both be done.

FIG 9. OVERALL LAYOUT DIAGRAM FOR MICRO CONTROLLER CONNECTIONS



PORT CONNECTIONS IN MICROCONTROLLER:

PORT 0: PORT 0 DRIVES THE LC DISPLAY
PORT 1: STEPPER MOTOR IS DRIVEN FROM THE FOUR LSB BITS
PORT1: PINS 1.4 AND 1.5 ARE USED TO DRIVE THE SERVO MOTOR CONTROL RELAYS
PORT 2: PINS 2.0,2.1,2.2 ARE USED TO SEND THE CONTROL SIGNALS
PORT 3: INPUT IS GOT FROM THE FOUR MSB BITS
PORT 3: PIN 3.2 IS CONNECTED TO CONTROL THE ELECTROMAGNET

4.2 AT-89c51 MICROCONTROLLER PROGRAM:

```
#include<reg51.h>
void disp_all();
void read(unsigned char);
void write(unsigned char);
void lcd_init(void);
void lcd_dis(unsigned char *,unsigned char);
void chk();
void rotate(unsigned char *,unsigned int,unsigned char);
void delay(unsigned int,unsigned char);
unsigned char var,dtmf,forward_var,reverse_var;
unsigned char left,right;
sbit rs     = P2^0;
sbit rw     = P2^1;
sbit en     = P2^2;
sbit ndata=P3^3;
sbit relay=P3^2;
sbit forward=P1^4;
sbit reverse=P1^5;
main()
{
 forward=reverse=relay=0;
 lcd_init();
 disp_all();
 delay(65000,1);
 delay(65000,1);
 while(1)
 {
  while(ndata==1);
```

```
while(ndata==0);
dtmf=P3&0xF0;
if(dtmf==0x80)
{
 read(0x01);
 read(0x80);
 lcd_dis("    UP        ",16);
 forward_var=1,reverse_var=0;
 forward=1,reverse=0;
}
else if(dtmf==0x40)
{
 read(0x01);
 read(0x80);
 lcd_dis("    STOP      ",16);
 forward_var=0,reverse_var=0;
 forward=reverse=0;
}
else if(dtmf==0xc0)
{
 read(0x01);
 read(0x80);
 lcd_dis("   DOWN       ",16);
 forward_var=1,reverse_var=1;
 reverse=1,forward=1;
}
else if(dtmf==0x20)
{
 read(0x01);
```

```
read(0x80);
lcd_dis("    LEFT        ",16);
if(left==0)
{
 while(dtmf!=0XA0)
 {
  while(ndata==1)   {   rotate("\x05\x09\x0a\x06",4000,1);  }
  while(ndata==0)   {   rotate("\x05\x09\x0a\x06",4000,1);  }
  dtmf=P3&0xF0;
  left=1;
  right=0;
 }
 read(0x01);
 read(0x80);
 lcd_dis("    STOP        ",16);
}
}
else if(dtmf==0x60)
{
 if(right==0)
 {
  read(0x01);
  read(0x80);
  lcd_dis("    RIGHT       ",16);
  while(dtmf!=0XA0)
  {
   while(ndata==1)   {   rotate("\x06\x0a\x09\x05",4000,1);  }
   while(ndata==0)   {   rotate("\x06\x0a\x09\x05",4000,1);  }
   dtmf=P3&0xF0;
```

```
 right=1;
 left=0;
 }
 read(0x01);
 read(0x80);
 lcd_dis("    STOP       ",16);
 }
}
else if(dtmf==0xe0)
{
 read(0x01);
 read(0x80);
 lcd_dis("ELECTROMAGNET ON",16);
 relay=1;
}
 else if(dtmf==0x10)
 {
  read(0x01);
  read(0x80);
  lcd_dis("  ELECTROMAGNET ",16);
  read(0xC0);
  lcd_dis("      OFF     ",16);
  relay=0;
 }
}
}
void rotate(unsigned char *fr_rw,unsigned int nop,unsigned char nop1)
{
unsigned char y;
```

```
for(y=0;y<5;y++)
{
 P1=fr_rw[y];
 delay(nop,nop1);
 }
}
void delay(unsigned int del,unsigned char dell)
{
unsigned char j;
 for(j=0;j<dell;j++)
 {
  while(del--);
 }
 }
 void disp_all()
 {
 read(0x01);
 read(0x80);
 lcd_dis("    ROBOTIC     ",16);
 read(0xc0);
 lcd_dis("      ARM       ",16);
 }
 void lcd_init()
 {
  read(0x38);
  read(0x01);
  read(0x06);
  read(0x0c);
  }
```

```
void read(unsigned char add)
{
 P0=add;
 rs=rw=0;
 en=1;
 delay(125,1);
 en=0;
 delay(125,1);
}
void write(unsigned char dat)
{
 P0=dat;
 rs=en=1;
 rw=0;
 delay(125,1);
 en=0;
 delay(125,1);
}
void lcd_dis(unsigned char *mess,unsigned char n)
{
 unsigned char i;
 for(i=0;i<n;i++)
  {
   write(mess[i]);
   delay(125,1);
  }
 }
```

5. STEPPER MOTOR DRIVER CIRCUIT

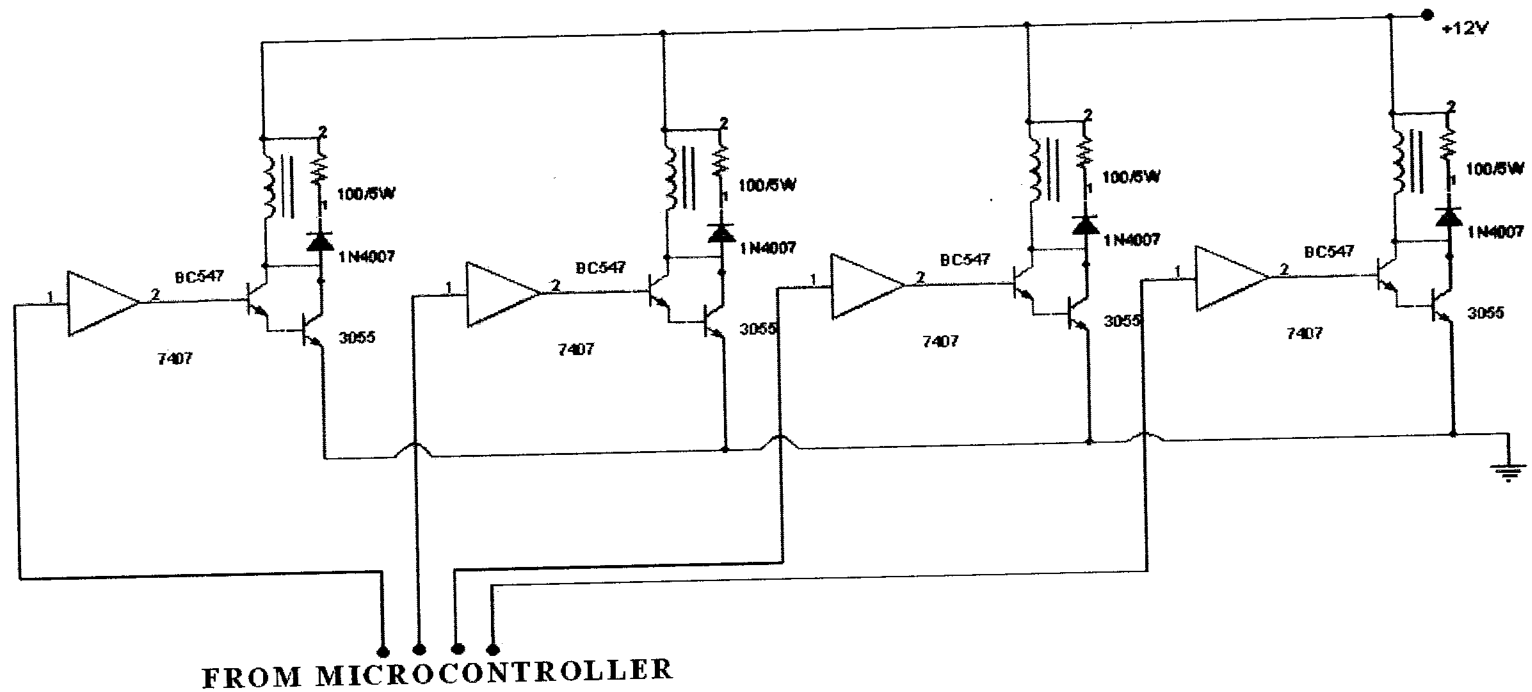
5.1 STEPPER MOTOR DRIVER CIRCUIT:

The Stepper motor has four energizing coils. When we energize the alternate phases of stepper motor, the shaft of Stepper motor starts running in forward Direction. When we energize it in opposite phases, the motor starts running in the reverse direction.

The four coils of stepper motor are energized by using ports of the micro controller. Since the micro controller output voltage and current cannot drive the coils of a 12V stepper motor, a two phase switching strategy is adopted to match the ratings suitably using two transistors.

As said, the power transistor is switched by using NPN transistor. Resistors are used for current limiting purpose. Diodes are used to avoid reverse currents. When sending corresponding data for energizing the coils of stepper motor from micro controller, first the NPN transistors are switched. Hence by switching the NPN transistors, we can switch on the Power transistor. By switching power transistors we can energize the coils of stepper motor.

FIG 10. STEPPER MOTOR DRIVER CIRCUIT



5.2 STEPPER MOTOR:

A unique type of motor useful for moving things in small increments is the stepper motor. Instead of rotating smoothly around and around as most motors do, stepper motors rotate or step from one fixed position to the next. Common step sizes range from 0.9° to 30°. A stepper motor is stepped from one position to the next by changing the currents through the fields in the motor. The two common field connections are referred to as two-phase and four-phase. In our project we are using four phase stepper motor. The buffers are inverting, a high on an output pin turns on current to a winding.

TABLE II – STEPPER MOTOR STEP SEQUENCE

STEP	*SW4*	*SW3*	*SW2*	*SW1*
1(5)	0	1	0	1
2(9)	1	0	0	1
3(A)	1	0	1	0
4(6)	0	1	1	0
1(5)	0	1	0	1

CLOCKWISE DIRECTION ↓

COUNTER CLOCKWISE DIRECTION ↑

Consider the four phases as SW1, SW2, SW3 & SW4.If SW1 and SW2 are turned on. Turning off SW2 and turning on SW4 will cause the motor to rotate one step of 1.8° clockwise. Changing to SW4 and SW3 on will cause the motor to rotate another 1.8° clockwise. Changing to SW3 and SW2 on will cause another step. After that, changing to SW2 and SW1 on again will cause another step clockwise. We can repeat the sequence until the motor has rotated as many steps clockwise as we want. To step the motor counter clockwise, work through the switch sequence in the reverse direction. In either case the motor will be held in its last position by the current through the coils.

To take the first step clockwise from SW2 and SW1 being on, the pattern of 1's and 0's is simply rotated one bit position around to the right. The 1 from SW1 is rotated around into bit 4. To take the next step the switch pattern is rotated one more bit position. To step counter clockwise the switch pattern is rotated left one bit position for each step desired. Suppose 00110011 is loaded into ACC and output this to the switches. Duplicating the switch pattern in the upper half of ACC will make stepping easy. To step the motor clockwise, just rotate this pattern right one bit position and output it to the switches. To step counter clockwise, rotate the switch pattern left one bit position and output it. After output one-step code just wait for a few milliseconds before output another step command, because the motor can only step so fast. Maximum stepping rates for different types of steppers vary from a few hundred steps per second to several thousand steps per second. To achieve high stepping rates the stepping rate is slowly increased to thc maximum, then it is decreased as the desired number of steps is approached.

To add a stepper motor to the robot add the clamp diodes across each winding to save the transistors from inductive kicks and the current limiting resistors (R1 & R2). For low stepping rates, this would work fine. However for higher stepping rates and more torque while stepping, we use a higher supply voltage and current-limiting resistors R1 and R2. The motor we used here has a nominal voltage rating of 5.5V. This means we could have designed the circuit to operate with voltage of about 6.5V on the emitters of the driver transistors (5.5V for the motor plus 1V for the drop across the transistor) for low stepping rates, this would work fine. However, for higher stepping rates and more torque while stepping, we use a higher supply voltage and current -limiting resisters as shown. The point of this is that by adding series resistance, we decrease L/R time constant. This allows the current to change more rapidly in the windings. For the motor we used, the current per winding is 0.88A. Since only one winding on each resistor is ever on at a time, 6.5V/0.88A gives a resistor value of 6.25Ω. To be conservative we used 8Ω, 10-W resistors. The optional transistor switch and diode connection to the +5V supply are used as follows. When not stepping, the switch to +12V is off so the motor is held in position by the current from the +5V supply. Before we send a step command, we turn on the transistor to +12V to give the motor more current for stepping. When stepping is done we turn off the switch to +12V, and drop back to the +5V supply. This cuts the power dissipation.

Stepper motors have the following benefits:

- Low cost
- Ruggedness
- Simplicity in construction
- High reliability
- No maintenance
- Wide acceptance
- No tweaking to stabilize
- No feedback components are needed
- They work in just about any environment
- Inherently more failsafe than servo motors.

There is virtually no conceivable failure within the stepper drive module that could cause the motor to run away. Stepper motors are simple to drive and control in an open-loop configuration. They only require four leads. They provide excellent torque at low speeds, up to 5 times the continuous torque of a brush motor of the same frame size or double the torque of the equivalent brushless motor. This often eliminates the need for a gearbox. A stepper-driven system is inherently stiff, with known limits to the dynamic position error.

6. SERVO MOTOR

6.1 SERVO MOTOR:

What is a servo? This is not easily defined or self-explanatory since a servomechanism, or servo drive, does not apply to any particular device. It is a term, which applies to a function or a task. The function, or task, of a servo can be described as follows. A command signal, which is issued from, the user's interface panel comes into the servo's "positioning controller". The positioning controller is the device, which stores information about various jobs or tasks. It has been programmed to activate the motor/load, i.e. change speed/position.

The signal then passes into the servo control or "amplifier" section. The servo control takes this low power level signal and increases, or amplifies, the power up to appropriate levels to actually result in movement of the servo motor/load.

AC servomotors are typically permanent magnet synchronous motors that often have low torque-to-inertia ratios for high acceleration ratings. AC servomotors have an output shaft that can be positioned by sending a coded signal to the motor. As the input to the motor changes, the angular position of the output shaft changes as well. Generally, AC servomotors are small but powerful for their size and easy to control. Induction and gear motor types are some common forms of AC servomotors.

AC servomotors vary by AC voltage and frequency. International voltage levels, such as those common in Asia and Europe, use 50Hz power. AC servo motors and other components using 400Hz power are primarily used for aerospace applications.

AC servomotors are either single phase or three phase. Standard commercial and residential power is single phase, meaning one sinusoidal or other alternating voltage pattern. Three phase power contains three simultaneous sinusoidal or other alternating voltage patterns, typically 120° out of phase with each other. Higher power efficiency and smoothness of operation is possible with three phase operation. Three phase power is most typically used for industrial or high power motors.

AC servomotors vary according to shaft speed, continuous current, continuous torque, and continuous power output. The shaft speed is the no-load rotational speed of the output shaft at a rated terminal voltage. The continuous current is the maximum rated current that can be supplied to the motor windings without overheating. The continuous torque is the output torque capability of the motor under constant running conditions. The continuous output power is the mechanical power provided by the motor output. With multi-speed AC servomotors, motor speed can be continuously adjusted or set at discrete speeds within the operating range. With reversible AC servomotors, motors can be run in both clockwise and counterclockwise directions with approximately the same operating characteristics.

AC servomotors are either cylindrical or square, open or enclosed, and available in a variety of housing sizes and diameters. Drip-proof motors contain ventilation openings that are designed so that drops of liquid or solid particles falling vertically from any angle within 15 degrees cannot enter the motor. Dust-proof AC servo motors protect against dust infiltration with features such as total enclosure and labyrinth seals for shafts.

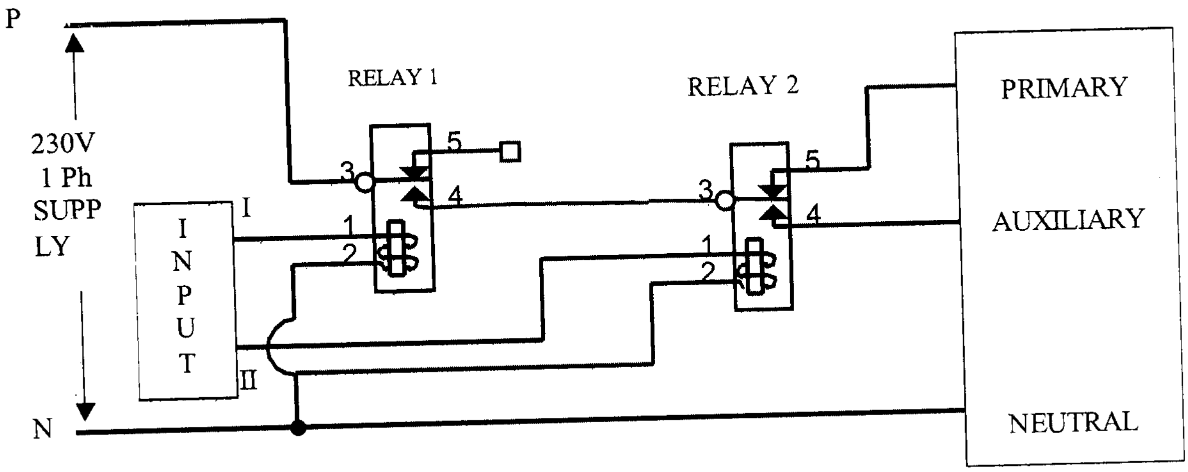
6.2 RELAY:

The transistor BC547 is used to switch on the relay. The control signal is given to the base terminal of the transistor. The collector is attached to the relay coil. Relays are electromechanical devices. There are two types of relay contacts.

1. Normally closed
2. Normally opened

When the controller output from the input is high the transistor will be in the ON state, so relay is energized. When the controller output from the PC is low the transistor will be in the OFF state, so the relay is de-energized and the supply contacts will be with normally open terminal. When the relay is de-energized the contacts will be with normally closed terminal. So according to the controller output the supply contacts will be either with normally open or normally closed terminals.

FIG 11. SERVO MOTOR CONTROL CIRCUIT :



In the control circuit shown above two control bits are used to control the rotation of the servomotor. Although servo motors are normally used in applications that involve position sensing, no such sensors are used here due to the simplicity of the application. Hence it is an open loop control. Relay 1 is used here as a power switch (i.e) only if the coil of relay 1 is energized will the supply be given to the circuit. Hence when relay 1 is switched on, the normally open terminal is connected to the power supply (230V, 50Hz).

Relay connections for the Relay 2 is such that the circuit for Primary coil of the servo motor is connected to the Normally closed terminal. When the relay 2 is energized it completes the circuit between the power supply and the Normally open terminal. In this case the normally open terminal is connected to the servo motor's Auxiliary winding.

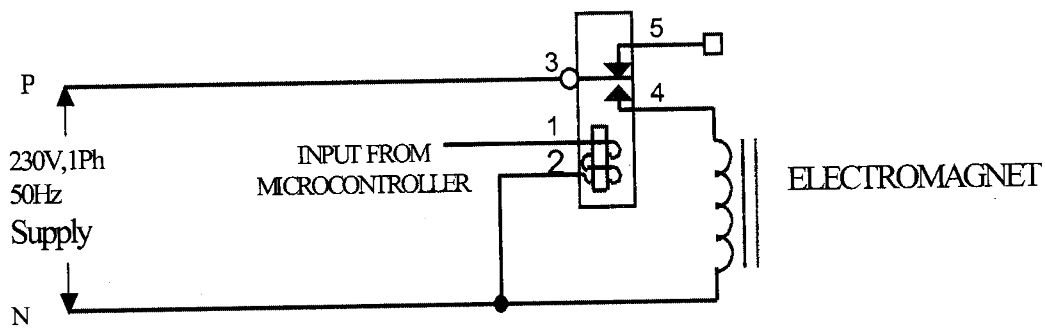
Hence when relay 1 is energized and relay 2 is not , then the servo motor rotates in the forward direction. When relay 2 is also simultaneously energized then the circuit connections are such that the supply is connected to the auxiliary winding and hence in this case the motor rotates in the reverse direction.

7. ELECTROMAGNETIC GRIPPER

7.1 ELECTROMAGNETIC GRIPPER:

The electromagnet used here is a simple Transformer , modified to our customized needs. The transformer used here is of the rating 230V/5V and can carry a maximum current of 500mA. The secondary winding of the transformer is removed so that it acts as a simple electromagnet. The electromagnet can be used for picking up magnetic materials. The described arrangement can be very easily replaced with a mechanical gripper working on similar lines of operation.

Fig 12. ELECTROMAGNETIC GRIPPER



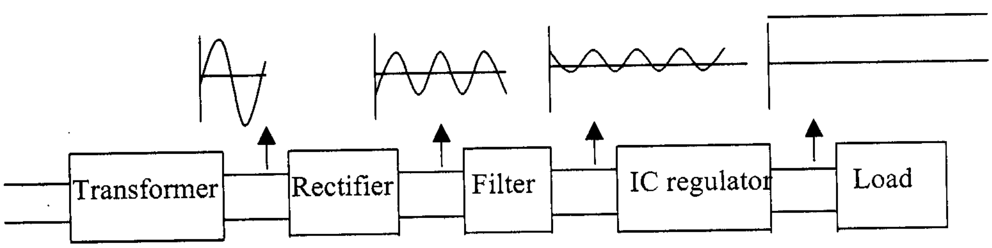
8. *POWER SUPPLIES*

8.1 POWER SUPPLIES:

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 19.1. The ac voltage, typically 120 V 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 somewhat, 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.

FIG 13. GENERAL BLOCK DIAGRAM OF DC REGULATED POWER SUPPLES



8.2 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 a 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 milli amperes to tens of amperes, corresponding to power ratings from milliwatts to tens of watts.

8.2.1 THREE-TERMINAL VOLTAGE REGULATORS:

The fixed voltage regulator has an unregulated dc input voltage, Vi, applied to one input terminal, a regulated output dc voltage, Vo, 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).

8.2.2 FIXED POSITIVE VOLTAGE REGULATORS:

The series 78 regulators provide fixed regulated voltages from 5 to 24 V. Figure 15 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 Vi is filtered by capacitor C1 and connected to the IC's IN terminal. The IC's OUT terminal provides a regulated + 12V which is filtered by capacitor C2 (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.

TABLE III : Positive Voltage Regulators in 7800 series

IC Part	**Output Voltage (V)**	**Minimum Vi (V)**
7805	+5	7.3
7806	+6	8.3
7808	+8	10.5
7810	+10	12.5
7812	+12	14.6
7815	+15	17.7
7818	+18	21.0
7824	+24	27.1

Fig 14. AC RECTIFER CIRCUIT (+5 V)

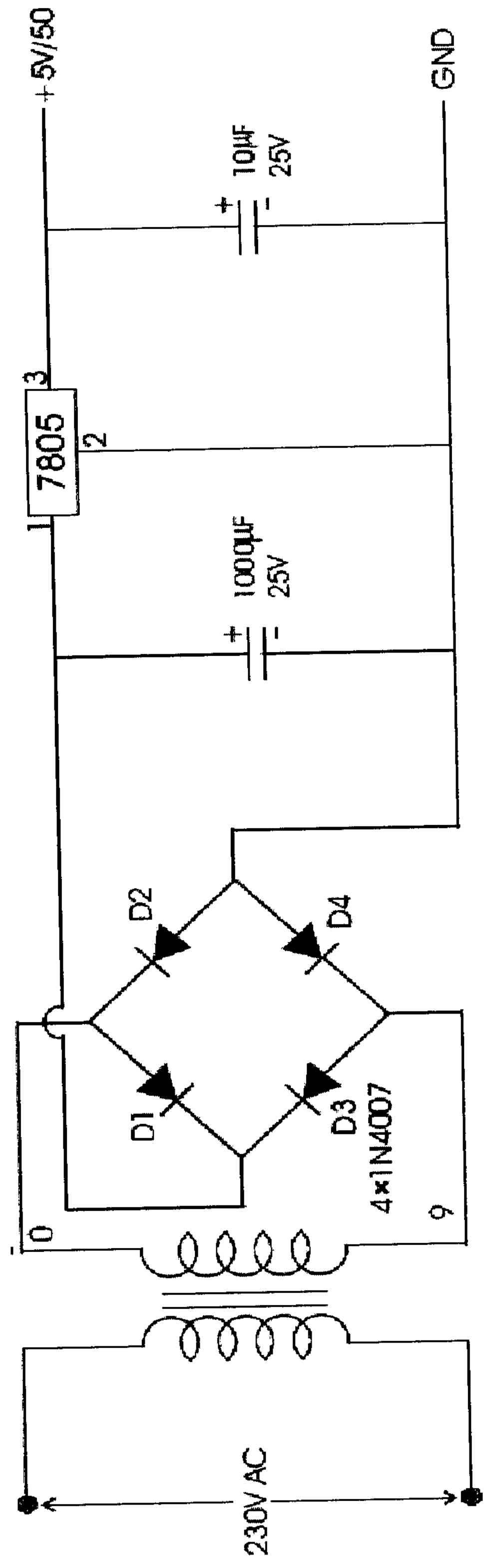


FIG. 15. AC RECTIFIER CIRCUIT +12V / -12V

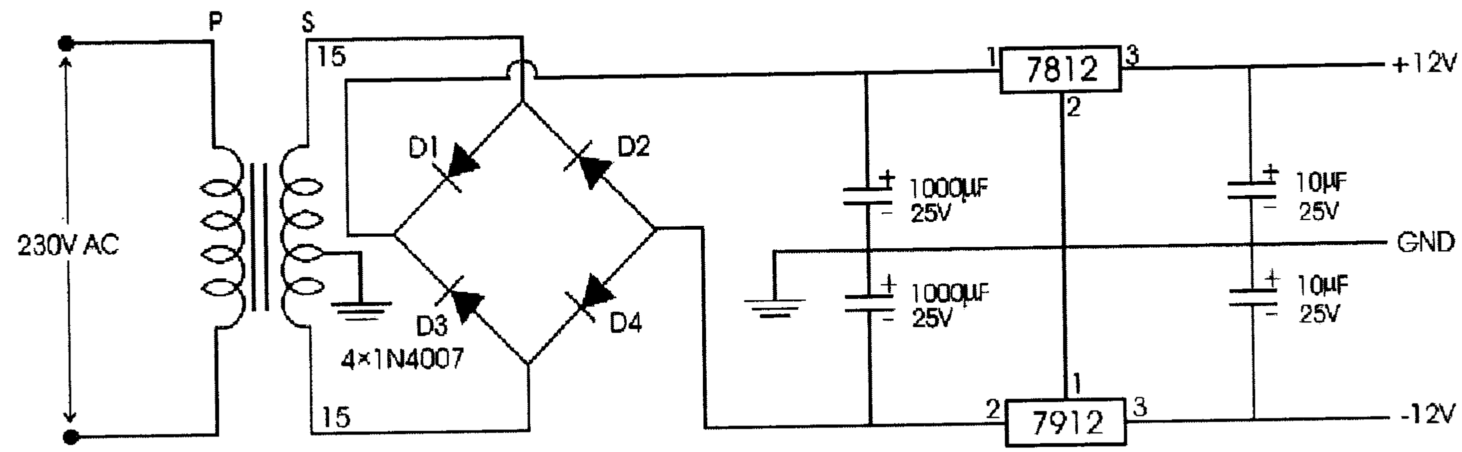
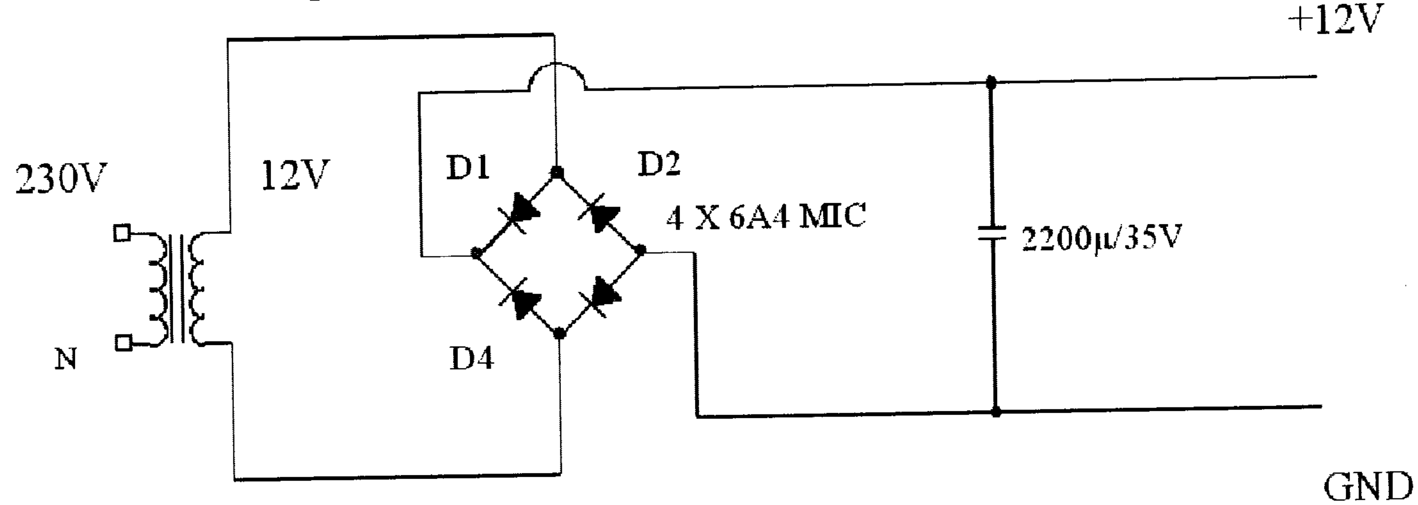


Fig 16. STEPPER MOTOR POWER SUPPLY CIRCUIT



9. CONCLUSION

CONCLUSION:

Thus the wireless control of robotic arm by using pc as well as remote has been achieved. This prototype model has been constructed with a stepper motor and a servomotor for two axes movements.

The stepper motor enables the arm to rotate in either in clockwise or anticlockwise direction. The servomotor is used for vertical movement of the arm. An electromagnetic gripper is provided for picking and placing magnetic materials.

The above project can be further enhanced in the following ways:

- Inclusion of motors for multi axes movement.
- Closed loop control can be achieved by using suitable sensors and limit switches.
- Automation mode can be achieved by suitable program with closed loop control.

APPLICATIONS:

- Pick and place operation of magnetic materials in industries.
- Can be used for PCB mounting once automation mode is completed.
- Working in hazardous areas where human presence is dangerous with the help of pc control.

10. APPENDICES

Features

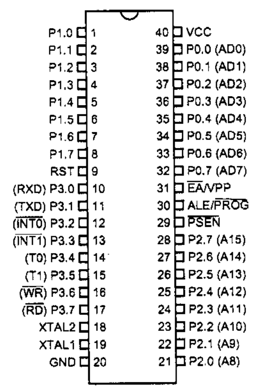
- Compatible with MCS-51™ Products
- 4K Bytes of In-System Reprogrammable Flash Memory
  - Endurance: 1,000 Write/Erase Cycles
- Fully Static Operation: 0 Hz to 24 MHz
- Three-level Program Memory Lock
- 128 x 8-bit Internal RAM
- 32 Programmable I/O Lines
- Two 16-bit Timer/Counters
- Six Interrupt Sources
- Programmable Serial Channel
- Low-power Idle and Power-down Modes

Description

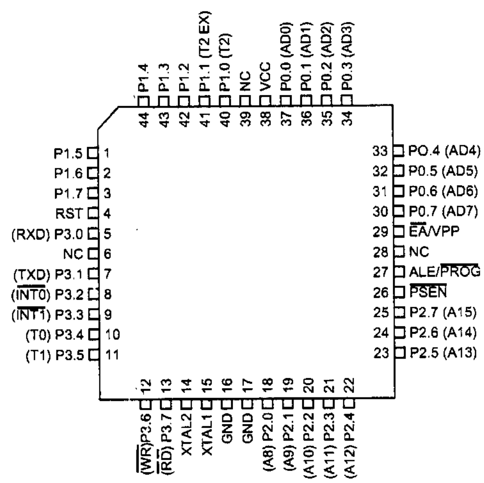
The AT89C51 is a low-power, high-performance CMOS 8-bit microcomputer with 4K bytes of Flash programmable and erasable read only memory (PEROM). The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard MCS-51 instruction set and pinout. 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.

Pin Configurations

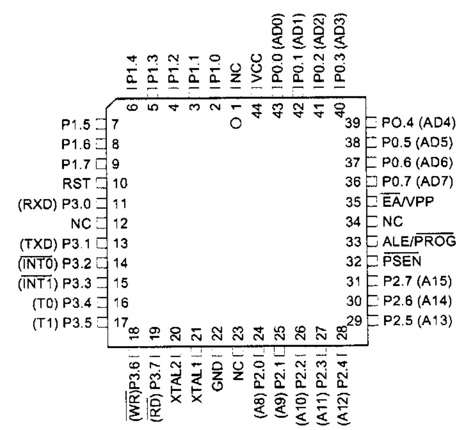
PDIP



PQFP/TQFP



PLCC



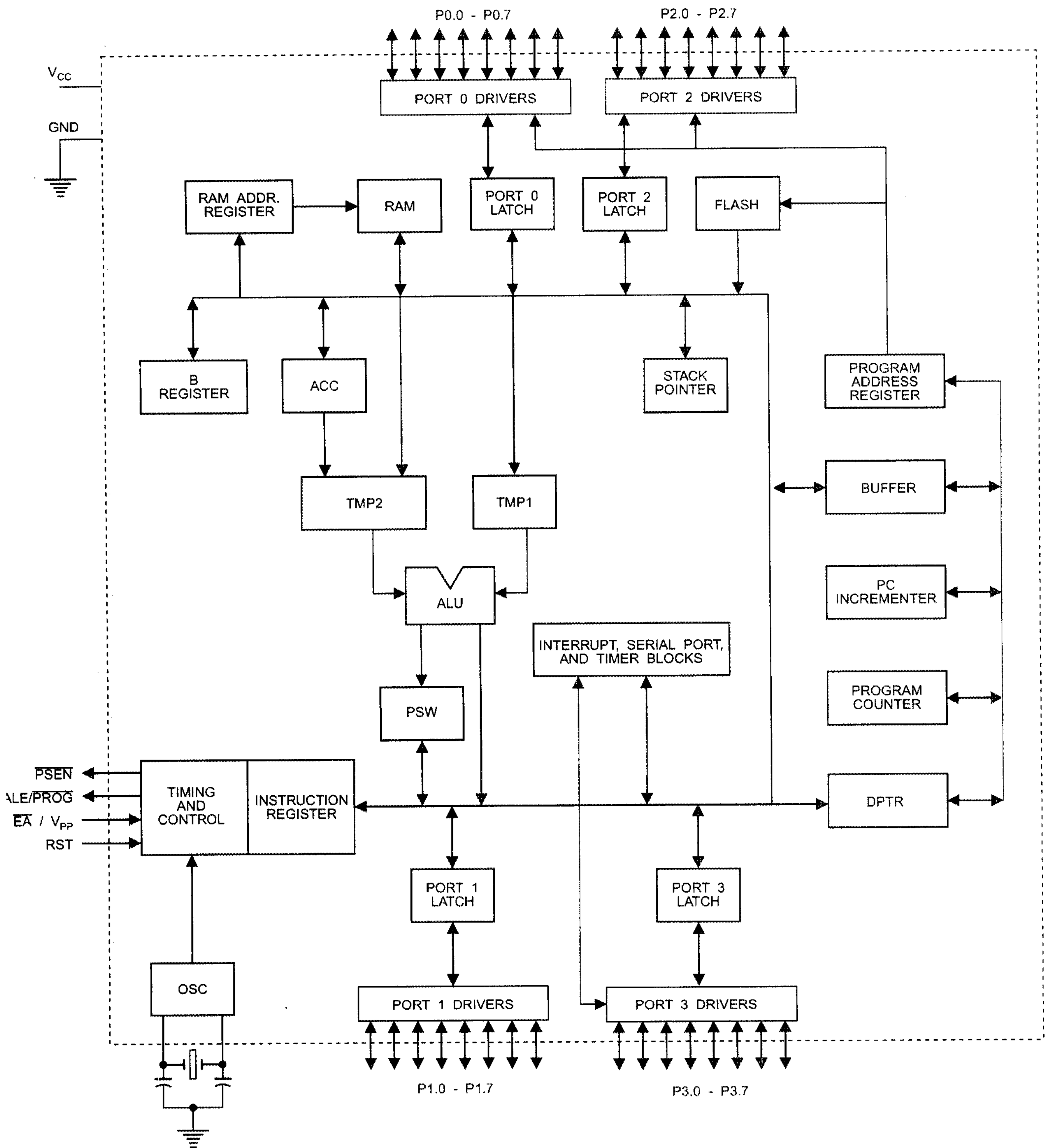
8-bit Microcontroller with 4K Bytes Flash

AT89C51

Not Recommended for New Designs. Use AT89S51.

Rev. 0265G–02/00

Block Diagram



The AT89C51 provides the following standard features: 4K bytes of Flash, 128 bytes of RAM, 32 I/O lines, two 16-bit timer/counters, a five vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator and clock circuitry. In addition, the AT89C51 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.

Pin Description

VCC

Supply voltage.

GND

Ground.

Port 0

Port 0 is an 8-bit open-drain bi-directional I/O port. As an output port, each pin can sink eight TTL inputs. When 1s are 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-order address/data bus during accesses to external program and data memory. In this mode P0 has internal pullups.

Port 0 also receives the code bytes during Flash programming, and outputs the code bytes during program verification. External pullups are required during program verification.

Port 1

Port 1 is an 8-bit bi-directional I/O port with internal pullups. The Port 1 output buffers can sink/source four TTL inputs. When 1s are 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_{IL}) because of the internal pullups.

Port 1 also receives the low-order address bytes during Flash programming and verification.

Port 2

Port 2 is an 8-bit bi-directional I/O port with internal pullups. The Port 2 output buffers can sink/source four TTL inputs. When 1s are 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_{IL}) because of the internal pullups.

Port 2 emits the high-order address byte during fetches from external program memory and during accesses to external data memory that use 16-bit addresses (MOVX @ DPTR). In this application, it uses strong internal pullups when emitting 1s. During accesses to external data memory that use 8-bit addresses (MOVX @ RI), Port 2 emits the contents of the P2 Special Function Register.

Port 2 also receives the high-order address bits and some control signals during Flash programming and verification.

Port 3

Port 3 is an 8-bit bi-directional I/O port with internal pullups. The Port 3 output buffers can sink/source four TTL inputs. When 1s are 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_{IL}) 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	$\overline{\text{INT0}}$ (external interrupt 0)
P3.3	$\overline{\text{INT1}}$ (external interrupt 1)
P3.4	T0 (timer 0 external input)
P3.5	T1 (timer 1 external input)
P3.6	$\overline{\text{WR}}$ (external data memory write strobe)
P3.7	$\overline{\text{RD}}$ (external data memory read strobe)

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

RST

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

ALE/$\overline{\text{PROG}}$

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 ($\overline{\text{PROG}}$) during Flash programming.

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.

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.

$\overline{\text{PSEN}}$

Program Store Enable is the read strobe to external program memory.

When the AT89C51 is executing code from external program memory, $\overline{\text{PSEN}}$ is activated twice each machine cycle, except that two $\overline{\text{PSEN}}$ activations are skipped during each access to external data memory.

$\overline{\text{EA}}$/VPP

External Access Enable. $\overline{\text{EA}}$ 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. Note, however, that if lock bit 1 is programmed, $\overline{\text{EA}}$ will be internally latched on reset.

$\overline{\text{EA}}$ should be strapped to V_{CC} for internal program executions.

This pin also receives the 12-volt programming enable voltage (V_{PP}) during Flash programming, for parts that require 12-volt V_{PP}.

XTAL1

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

XTAL2

Output from the inverting oscillator amplifier.

Oscillator Characteristics

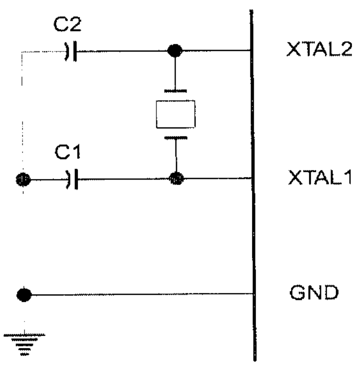
XTAL1 and XTAL2 are the input and output, respectively, of an inverting amplifier which can be configured for use as an on-chip oscillator, as shown in Figure 1. Either a quartz crystal or ceramic resonator may be used. To drive the device from an external clock source, XTAL2 should be left unconnected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

Idle Mode

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

It should be noted that when idle is terminated by a hard ware 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

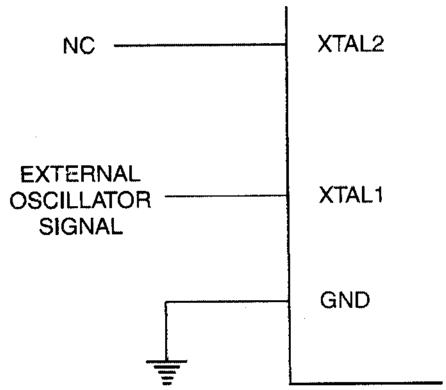


Note: C1, C2 = 30 pF ± 10 pF for Crystals
= 40 pF ± 10 pF for Ceramic Resonators

Status of External Pins During Idle and Power-down Modes

Mode	Program Memory	ALE	$\overline{\text{PSEN}}$	PORT0	PORT1	PORT2	PORT3
Idle	Internal	1	1	Data	Data	Data	Data
Idle	External	1	1	Float	Data	Address	Data
Power-down	Internal	0	0	Data	Data	Data	Data
Power-down	External	0	0	Float	Data	Data	Data

Figure 2. External Clock Drive Configuration



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 V_{CC} is restored to its normal operating level and must be held active 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 $\overline{EA}$ 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 $\overline{EA}$ be in agreement with the current logic level at that pin in order for the device to function properly.

Lock Bit Protection Modes

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

CLARE

M-8870
DTMF Receiver

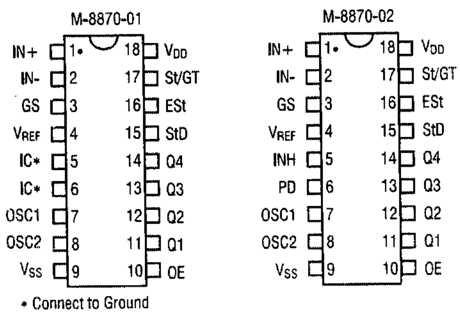
Features

- Low Power Consumption
- Adjustable Acquisition and Release Times
- Central Office Quality and Performance
- Power-down and Inhibit Modes (-02 only)
- Inexpensive 3.58 MHz Time Base
- Single 5 Volt Power Supply
- Dial Tone Suppression

Applications

- Telephone switch equipment
- Remote data entry
- Paging systems
- Personal computers
- Credit card systems

Pin Configuration



Description

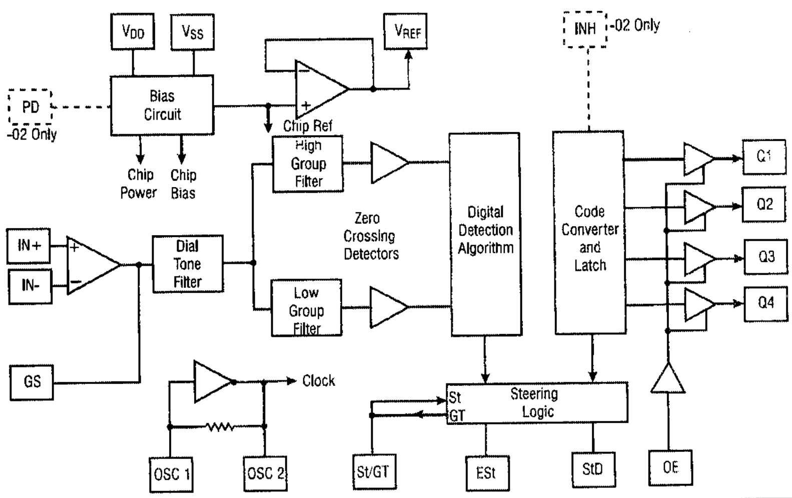
The M-8870 is a full DTMF Receiver that integrates both bandsplit filter and decoder functions into a single 18-pin DIP or SOIC package. Manufactured using CMOS process technology, the M-8870 offers low power consumption (35 mW max) and precise data handling. Its filter section uses switched capacitor 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.

The M-8870-02 provides a "power-down" option which, when enabled, drops consumption to less than 0.5 mW. The M-8870-02 can also inhibit the decoding of fourth column digits (see Tone Decoding table on page 5).

Ordering Information

M-8870-01	18-pin plastic DIP
M-8870-01SM	18-pin plastic SOIC
M-8870-01SMTR	18-pin plastic SOIC, tape and reel
M-8870-02	18-pin plastic DIP, power-down, option
M-8870-02SM	18-pin plastic SOIC, power-down, option
M-8870-02T	18-pin plastic SOIC, power-down option, tape and reel

Block Diagram



Absolute Maximum Ratings

Power supply voltage (V_{DD} - V_{SS})	V_{DD}	6.0 V max
Voltage on any pin	V_{DC}	V_{SS} -0.3, VDD +0.3
Current on any pin	I_{DD}	10 mA max
Operating temperature	T_A	-40°C to + 85°C
Storage temperature	T_S	-65°C to + 150°C

Note:
Exceeding these ratings may cause permanent damage. Functional operation under these conditions is not implied.

Absolute Maximum Ratings are stress ratings. Stresses in excess of these ratings can cause permanent damage to the device. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this data sheet is not implied. Exposure of the device to the absolute maximum ratings for an extended period may degrade the device and effect its reliability.

DC Characteristics

Operating supply voltage	V_{DD}	4.75	-	5.25	V	-
Operating supply current	I_{DD}	-	3.0	7.0	mA	-
Standby supply current (see Note 3)	$I_{DD}Q$	-	-	100	µA	PD=V_{DD}
Power consumption	P_O	-	15	35	mW	f = 3.579 MHz, V_{DD} = 5.0 V
Low level input voltage	V_{IL}	-	-	1.5	V	-
High level input voltage	V_{IH}	3.5	-	-	V	-
Input leakage current	I_{IH}/I_{IL}	-	0.1	-	µA	V_{IN} = V_{SS} or V_{DD} (see Note 2)
Pullup (source) current on OE	I_{SO}	-	6.5	15.0	µA	OE = 0 V
Input impedance, signal inputs 1, 2	R_{IN}	8	10	-	mΩ	@ 1 kHz
Steering threshold voltage	V_{TSt}	2.2	-	2.5	V	-
Low level output voltage	V_{OL}	-	-	0.03	V	No load
High level output voltage	V_{OH}	V_{DD} - 0.03	-	-	V	No load
Output low (sink) current	I_{OL}	1.0	2.5	-	mA	V_{OUT} = 0.4 V
Output high (source) current	I_{OH}	0.4	0.8	-	mA	V_{OUT} = V_{DD} - 0.4 V
Output voltage V_{REF}	V_{REF}	2.4	-	2.7	V	No load
Output resistance V_{REF}	R_{OR}	-	10	-	kΩ	-

*Typical figures are at 25°C and are for design aid only; not guaranteed and not subject to production testing.

Operating Characteristics - Gain Setting Amplifier

Input leakage current	I_N	-	± 100	-	nA	V_{SS} < V_{IN} < V_{DD}
Input resistance	R_{IN}	4	-	-	MΩ	-
Input offset voltage	V_{OS}	-	± 25	-	mV	-
Power supply rejection	PSRR	50	-	-	dB	1 KHz
Common mode rejection	CMRR	55	-	-	dB	-3.0V < V_{IN} < 3.0V
DC open loop voltage gain	A_{VOL}	60	-	-	dB	-
Open loop unity gain bandwidth	f_C	1.2	1.5	-	MHz	-
Output voltage swing	V_O	3.5	-	-	V_{P-P}	RL ≈ 100 KΩ to V_{SS}
Tolerable capacitive load (GS)	C_L	-	-	100	pF	-
Tolerable resistive load (GS)	R_L	-	-	50	kΩ	-
Common mode range	V_{CM}	2.5	-	-	V_{P-P}	No load

*Typical figures are at 25°C and are for design aid only; not guaranteed and not subject to production testing.
Notes:
1. All voltages referenced to V_{SS} unless otherwise noted. For typical values, V_{DD} = 5.0V, V_{SS} = 0V, TA = 25°C.

Functional Description

M-8870 operating functions (see block diagram on page 1) include a bandsplit filter that separates 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.

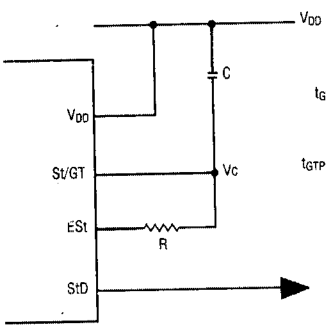
Filter

The low and high group tones are separated by applying the dual-tone signal to the inputs of two 6th order switched capacitor bandpass filters with bandwidths that correspond to the bands enclosing the low and high group tones. The filter also incorporates notches at 350 and 440 Hz, providing excellent dial tone rejection. Each filter output is followed by a single-order switched capacitor section that smooths the signals prior to limiting. Signal limiting is performed by high-gain comparators provided with hysteresis to prevent detection of unwanted low-level signals and noise. The comparator outputs provide full-rail logic swings at the frequencies of the incoming tones.

Decoder

The M-8870 decoder uses a digital counting technique to determine the frequencies of the limited tones and to verify that they correspond to standard DTMF frequencies. A complex averaging algorithm is used to protect against tone simulation by extraneous signals (such as voice) while tolerating small frequency variations. The algorithm ensures an optimum combination of immunity to talkoff and tolerance to interfering signals (third tones) and noise. When the detector recognizes the simultaneous presence of two valid tones (known as signal condition), it raises the Early Steering flag (ESt). Any subsequent loss of signal condition will cause ESt to fall.

Basic Steering Circuit



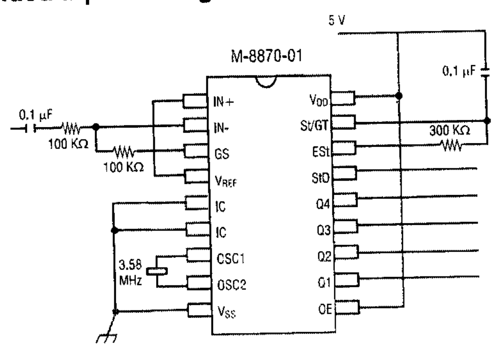
$$t_{GTA} = (RC)\,Ln\left[\frac{V_{DD}}{(V_{TSt})}\right]$$

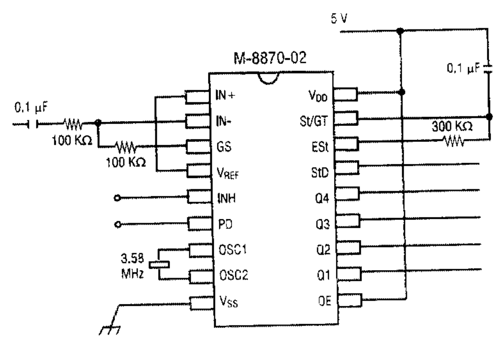
$$t_{GTP} = (RC)\,Ln\left[\frac{V_{DD}}{(V_{DD} - V_{TSt})}\right]$$

Steering Circuit

Before a decoded tone pair is registered, the receiver checks for a valid signal duration (referred to as character-recognition-condition). This check is performed by an external RC time constant driven by ESt. A logic high on ESt causes VC (see block diagram on page 1) to rise as the capacitor discharges. Provided that signal condition is maintained (ESt remains high) for the validation period (t_{GTF}), V_C reaches the threshold (V_{TSt}) of the steering logic to register the tone pair, thus latching its corresponding 4-bit code (see DC Characteristics on page 2) into the output latch. At this point, the GT output is activated and drives V_C to V_{DD}. GT continues to drive high as long as ESt remains high. Finally, after a short delay to allow the output latch to settle, the delayed steering output flag (StD) goes high, signaling that a received tone pair has been registered. The contents of the output latch are made available on the 4-bit output bus by raising the three-state control input (OE) to a logic high. The steering circuit works in reverse to validate the interdigit pause between signals. Thus, as well as rejecting signals too short to be considered valid, the receiver will tolerate signal interruptions (dropouts) too short to be considered a valid pause. This capability, together with the ability to select the steering time constants externally, allows the designer to tailor performance to meet a wide variety of system requirements.

Single-Ended Input Configuration





All resistors are ± 1% tolerance.
All capacitors are ± 5% tolerance.

Pin Functions

1	IN+	Non-inverting input	Connections to the front-end differential amplifier.
2	IN-	Inverting input	
3	GS	Gain select. Gives access to output of front-end amplifier for connection of feedback resistor.	
4	V_{REF}	Reference voltage output (nominally VDD/2). May be used to bias the inputs at mid-rail.	
5	INH*	Inhibits detection of tones representing keys A, B, C, and D.	
6	PD*	Power down. Logic high powers down the device and inhibits the oscillator. Internal pulldown.	
7	OSC1	Clock input	3.579545 MHz crystal connected between these pins completes the internal oscillator.
8	OSC2	Clock output	
9	VSS	Negative power supply (normally connected to 0 V).	
10	OE	Tri-statable output enable (input). Logic high enables the outputs Q1 - Q4. Internal pullup.	
11-14	Q1, Q2, Q3, Q4	Tri-statable data outputs. When enabled by OE, provides the code corresponding to the last valid tone pair received (see Tone Decoding table on page 5).	
15	StD	Delayed steering output. Presents a 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 VTSt.	
16	ESt	Early steering output. Presents a logic high immediately when the digital algorithm detects a recognizable tone pair (signal condition). Any momentary loss of signal condition will cause ESt to return to a logic low.	
17	St/GT	Steering input/guard time output (bidirectional). A voltage greater than VTSt detected at St causes the device to register the detected tone pair and update the output latch. A voltage less than VTSt frees 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. (See Common Crystal Connection on page 5).	
18	V_{DD}	Positive power supply. (Normally connected to +5V.)	

* -02 only. Connect to V_{SS} for -01 version

Guard Time Adjustment

Where independent selection of signal duration and interdigit pause are not required, the simple steering circuit of Basic Steering Circuit is applicable. Component values are chosen according to the formula:

$$t_{REC} = t_{DP} + t_{GTP}$$
$$t_{GTP} @ 0.67\ RC$$

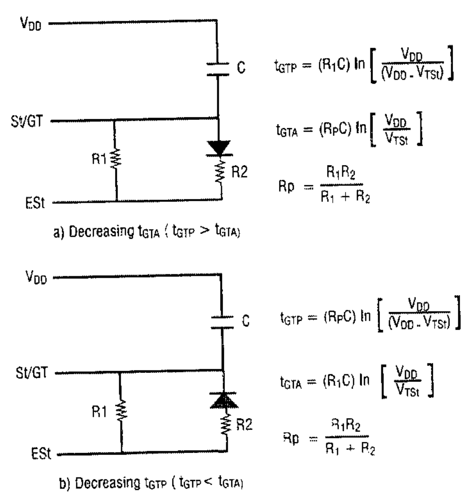
The value of tDP is a parameter of the device and tREC is the minimum signal duration to be recognized by the receiver. A value for C of 0.1 μF is recommended for most applications, leaving R to be selected by the designer. For example, a suitable value of R for a t_{REC} of 40 ms would be 300 kΩ. A typical circuit using this steering configuration is shown in the Single - Ended Input Configuration on page 4. The timing requirements for most telecommunication applications are satisfied with this circuit. Different steering arrangements may be used to select independently the guard times for tone-present (t_{GTP}) and tone-absent (t_{GTA}). This may be necessary to meet system specifications that place both accept and reject limits on both tone duration and interdigit pause.

Guard time adjustment also allows the designer to tailor system parameters such as talkoff and noise immunity. Increasing t_{REC} improves talkoff performance, since it reduces the probability that tones simulated by speech will maintain signal condition long enough to be registered. On the other hand, a relatively short t_{REC} with a long t_{DO} would be appropriate for extremely noisy environments where fast acquisition time and immunity to dropouts would be required. Design information for guard time adjustment is shown in the Guard Time Adjustment below.

Power-down and Inhibit Mode (-02 only)

A logic high applied to pin 6 (PD) will place the device into standby mode to minimize power consumption. It

Figure 5 Guard Time Adjustment



stops the oscillator and the functioning of the filters. On the M-8870-01 models, this pin is tied to ground (logic low).

Inhibit mode is enabled by a logic high input to pin 5 (INH). It inhibits the detection of 1633 Hz. The output code will remain the same as the previous detected code (see Pin functions table on page 4). On the M-8870-01 models, this pin is tied to ground (logic low).

Input Configuration

The input arrangement of the M-8870 provides a differential input operational amplifier as well as a bias source (V_{REF}) to bias the inputs at mid-rail. Provision is made for connection of a feedback resistor to the op-amp output (GS) for gain adjustment.

In a single-ended configuration, the input pins are connected as shown in the Single - Ended Input Configuration on page 3 with the op-amp connected for unity gain and V_{REF} biasing the input at $1/2V_{DD}$. The Differential Input Configuration bellow permits gain adjustment with the feedback resistor R_5.

DTMF Clock Circuit

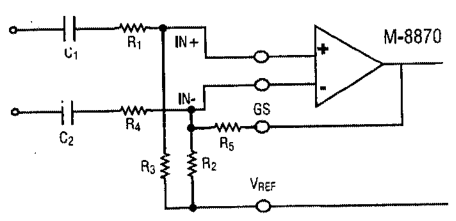
The internal clock circuit is completed with the addition of a standard 3.579545 MHz television color burst crystal. The crystal can be connected to a single M-8870 as shown in the Single - Ended Input Configuration on page 3, or to a series of M-8870s. As illustrated in the Common Crystal Connection below, a single crystal can be used to connect a series of M-8870s by coupling the oscillator output of each M-8870 through a 30 pF capacitor to the oscillator input of the next M-8870.

Tone Decoding

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	S	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

L = logic low, H = logic high, Z = high impedance

Differential Input Configuration



Differential Input Amplifier
$C_1 = C_2 = 10$ nF
$R_1 = R_4 = R_5 = 100$ KΩ
$R_2 = 60$ KΩ, $R_3 = 37.5$ KΩ

$R_3 = \frac{R_2 R_5}{R_2 + R_5}$

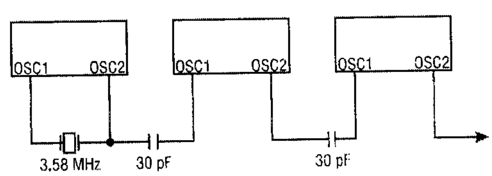
Voltage Gain (Av diff) = $\frac{R_5}{R_1}$

All resistors are ± 1% tolerance.
All capacitors are ± 5% tolerance.

Input Impedance

$(Z_{INDIFF}) = 2\sqrt{R_1^2 + \left(\frac{1}{\omega C}\right)^2}$

Common Crystal Connection



Radiotronix

RCT-XXX-AS

Low-Cost SAW-stabilized surface mount

OOK RF transmitter

Typical Applications

- Remote Keyless Entry (RKE)
- Remote Lighting Controls
- On-Site Paging
- Asset Tracking
- Wireless Alarm and Security Systems
- Long Range RFID
- Automated Resource Management

Features

- 315/418/433.92 MHz versions
- Low Cost
- .5-12V operation
- 5mA current consumption at 3V
- Small size
- 0dBm output power at 3V • 4800 baud operation

Description

The RCT-433-AS is ideal for remote control applications where low cost and longer range are required. The transmitter operates from a 1.5-12V supply, making it ideal for battery-powered applications. The transmitter employs a SAW-stabilized oscillator, ensuring accurate frequency control for best range performance. Output power and harmonic emissions are easy to control, making FCC and ETSI compliance easy. The manufacturing-friendly SMT style package and low-cost make the RCT-433-AS suitable for high volume applications.

Ordering Information • Remote Keyless Entry (RKE) • Remote Lighting Controls • On-Site Paging • Asset Tracking • Wireless Alarm and Security Systems • Long Range RFID • Automated Resource Management • 315/418/433.92 MHz versions • Low Cost • .5-12V operation • 5mA current consumption at 3V • Small size: .30" x .4" • 0dBm output power at 3V • 4800 baud operation The RCT-433-AS is ideal for remote control applications where low cost and longer range are required. The transmitter operates from a 1.5-12V supply, making it ideal for battery-powered applications. The transmitter employs a SAW-stabilized oscillator, ensuring accurate frequency control for best range performance. Output power and harmonic emissions are easy to control, making FCC and ETSI compliance easy. The manufacturing-friendly SMT style package and low-cost make the RCT-433-AS suitable for high volume applications.

315 MHz RCT-315-AS 418 MHz RCT-418-AS 433.92 MHz RCT-433-AS Domestic and international orders: Mouser Electronics 1-800-346-6873 (http://www.mouser.com) Canadian orders: Haltronics Ltd. 1-800-387-7969 (http://www.haltronicsltd.com/) For a Radiotronix Representative in your area please visit www.radiotronix.com and visit our corporate information page.

RCT-XXX-AS Low-Cost SAW-stabilized surface mount OOK RF transmitter

Pin Out Diagram

Pin Description

Pin No.	Pin Name	Description
1	ANT	50 ohm antenna output. The antenna port impedance affects output power and harmonic emissions. An L-C low-pass filter may be needed to sufficiently filter harmonic emissions.
2	GND	Transmitter ground. Connect to ground plane.
3	DATA	Digital data input. This input is CMOS compatible and should be driven with CMOS level inputs.
4	VCC	Pin 4 provides operating voltage for the transmitter. VCC should be bypassed with a .01uF ceramic capacitor and filtered with a 4.7uF tantalum capacitor. Noise on the power supply will degrade transmitter noise performance.

Absolute Maximum Ratings

Parameter	**Min**		**Max**	**Units**
Power Supply and All Input Pins	All Input	-0.3	+15	VDC
Storage Temperature	Temperature	-50	100	°C
Soldering Temperature (10sec)1	Temperature	NA	350	°C

***NOTES** 1) Hand Solder Only. The Transmitter is not suitable for IR reflow or hot air soldering.*

Detailed Electrical Specifications

Parameter (General)	**Symbol**	**Min**	**Typ.**	**Max**	**Units**	**Notes**
Operating Voltage	V_{cc}	1.5	3.0	12	Volts DC	
Operating Current DATA=VCC	I_{cc}	---	4.5	---	mA	@3V
Operating Current DATA=GND	Icc	---	100	---	uA	@3V
Frequency Accuracy	TOL_{fc}	-75	0	+75	Khz	@3V
Center Frequency	F_c	---	315.0 418.0 433.92	---	MHz	RCT-315-AS RCT-418-AS RCT-433-AS
Output Power		---	0		dBm	@3V
Baud Rate – NRZ		DC	---	4800	BPS	

Theory of Operation

OOK Modulation

OOK modulation is a binary form of amplitude modulation. When a logical 0 (data line low) is being sent, the transmitter is off, fully suppressing the carrier. In this state, the transmitter current is very low, less than 1mA.

When a logical 1 is being sent, the carrier is fully on. In this state, the module current consumption is at its highest, about 4.5mA with a 3V power supply.

OOK is the modulation method of choice for remote control applications where power consumption and cost are the primary factors. Because OOK transmitters draw no power when they transmit a 0, they exhibit significantly better power consumption than FSK transmitters.

OOK data rate is limited by the start-up time of the oscillator. High-Q oscillators which have very stable center frequencies take longer to start-up than low-Q oscillators. The start-up time of the oscillator determines the maximum data rate that the transmitter can send.

DESIGN HINT "Using the RCT-XXX-AS with a microcontroller UART": Data should be inverted when using the transmitter with a UART. The normal marking state of a UART is a logic 1, which will cause constant transmission. By inverting the data, the transmitter will be off in a marking state and on in a spacing state (logical 0), ensuring that the transmitter is on only when data is being sent. The output of the receiver would also need to be inverted to properly recover data.

SAW stabilized oscillator

The transmitter is basically a negative resistance LC oscillator whose center frequency is tightly controlled by a SAW resonator. SAW (Surface Acoustic Wave) resonators are fundamental frequency devices that resonate at frequencies much higher than crystals.

Radiotronix

RCR-XXX-RP

Low cost 315/418/433.92 MHz Super-RegenASK/OOK Receiver

Typical Applications

- Remote Keyless Entry (RKE)
- Remote Lighting Controls
- On-Site Paging
- Asset Tracking
- Wireless Alarm and Security Systems
- Long Range RFID
- Automated Resource Management

Features

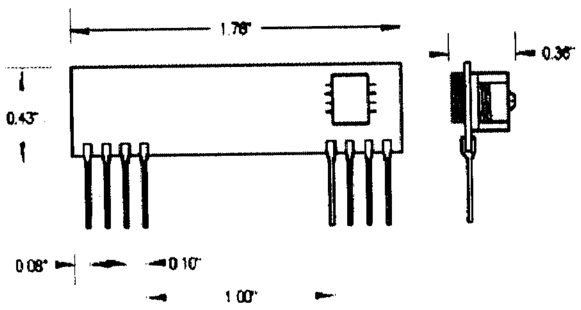
- Low Cost
- 3MHz receiving bandwidth – works with any LC or SAW based transmitter
- 5V operation
- 4.5mA current drain
- No External Parts are required
- Small Size: 1.76" x .43"
- 4800 baud operation

Description - i -

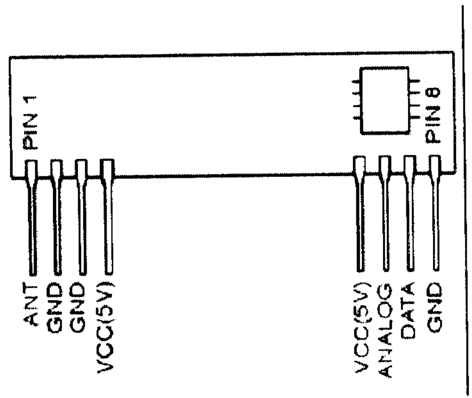
Embedding the wireless future..

The RCR-XXX-RP is ideal for short-range remote control applications where cost is a primary concern. The receiver module requires no external RF components except for the antenna. It generates virtually no emissions, making FCC and ETSI approvals easy. The super-regenerative design exhibits exceptional sensitivity at a very low cost. A SAW filter can be added to the antenna input to improve selectivity for applications that require robust performance.
The manufacturing-friendly SIP style package and low-cost make the RCR-XXX-RP suitable for high volume applications.

RCR-XXX-RP Super-Regen ASK/OOK Receiver Data Sheet



Mechanical Drawing



Pinout Diagram

Absolute Maximum Ratings

Rating	Value	Units
Power Supply and All Input Pins	-0.3 to +12	VDC
Storage Temperature	-50 to +100	°C
Soldering Temperature (10 sec)	350	°C

Electrical Characteristics

Operating Voltage	V_{cc}	4.5	5.0	5.5	VDC	None
Operating Current	I_{cc}	--	4.5	--	MA	None
Reception Bandwidth	BW_{rx}	--	3.0	--	MHz	None
Center Frequency	F_c	--	315	--	MHz	RCR-315-RP
	F_c	--	418	--	MHz	RCR-418-RP
	F_c	--	433.92	--	MHz	RCR-433-RP
Sensitivity	None	--	-109	--	dBm	None
Baud Rate – NRZ	None	1200	--	4800	bps	None
Baud Rate – PWM	None	120	--	2400	Bps	None
Audio Bandwidth	BW_{audio}	.15	--	2.8	KHz	None
Selectivity	None		TBD		TBD	TBD
Operating Temperature	T_{op}	-20	--	+70	°C	TBD

Pin Description

Pin	Name	Description
1	ANT	50 Ω antenna input.
2	GND	Receiver Ground. Connect to ground plane.
3	GND	Receiver Ground. Connect to ground plane.
4,5	V_{cc} (5v)	Pins 4 and 5 are electrically connected and provide operating voltage for the receiver. VCC can be applied to either or both. VCC should be bypassed with a .01µF ceramic capacitor and filtered with a 4.7µF tantalum capacitor. Noise on the power supply will degrade receiver sensitivity.
6	ANALOG	Analog receiver output. This is the audio signal prior to the data slicer.
7	DATA	Digital data output. This output is capable of driving one TTL or CMOS load. It is a CMOS compatible output.
8	GND	Receiver Ground. Connect to ground plane

Theory of Operation

Super-Regenerative AM Detection

The RCR-XXX-RP uses a super-regenerative AM detector to demodulate the incoming AM carrier.A super-regenerative detector is a gain stage with positive feedback greater than unity so that it oscillates. An RC-time constant is included in the gain stage so that when the gain stage oscillates, the gain will be lowered over time proportional to the RC time constant until the oscillation eventually dies. When the oscillation dies, the current draw of the gain stage decreases, charging the RC circuit, increasing the gain, and ultimately the oscillation starts again. In this way, the oscillation of the gain stage is turned on and off at a rate set by the RC time constant. This rate is chosen to be super-audible but much lower than the main oscillation rate. Detection is accomplished by measuring the emitter current of the gain stage. Any RF input signal at the frequency of the main oscillation will aid the main oscillation in restarting. If the amplitude of the RF input increases, the main oscillation will stay on for a longer period of time, and the emitter current will be higher. Therefore, we can detect the original baseband signal by simply low-pass filtering the emitter current. The average emitter current is not very linear as a function of the RF input level. It exhibits a 1/ln response because of the exponentially rising nature of oscillator start-up. The steep slope of a logarithm near zero results in high sensitivity to small input signals.

Data Slicer

The data slicer converts the baseband analog signal from the super-regenerative detector to a CMOS/TTL compatible output. Because the data slicer is AC coupled to the audio output, there is a minimum data rate. AC coupling also limits the minimum and maximum pulse width.

Typically, data is encoded on the transmit side using pulse-width modulation (PWM) or non-return-to-zero (NRZ). The most common source for NRZ data is from a UART embedded in a micro-controller. Applications that use NRZ data encoding typically involve microcontrollers. The most common source for PWM data is from a remote control IC such as the HC-12E from Holtek. Data is sent as a constant rate square-wave. The duty cycle of that square wave will generally be either 33% (a zero) or 66% (a one). The data slicer on the RCR-XXX-RP is optimized for use with PWM encoded data, though it will work with NRZ data if certain encoding rules are followed.

Power Supply

The RCR-XXX-RP is designed to operate from a 5V power supply. It is crucial that this power supply be very quiet. The power supply should be bypassed using a 0.01uF low-ESR ceramic capacitor and a 4.7uF tantalum capacitor. These capacitors should be placed as close to the power pins as possible. The RCR-XXX-RP is designed for continuous duty operation. From the time power is applied, it can take up to 750mSec for the data ouput to become valid.

Antenna Input

Pin 1 is a 50 ohm antenna input. It will support most antenna types, including printed antennas integrated directly onto the PCB. The performance of the different antennas varies. Any time a trace is longer than 1/8th the wavelength of the frequency it is carrying, it should be a 50 ohm microstrip.

Ordering Information

RCR-315-RP	RCR-315-RP
RCR-418-RP	RCR-418-RP
RCR-433-RP	RCR-433-RP

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. Tone/Pulse switchable
. 32 digit capacity for redialing
. Automatic mixed redialing (last number redial) of pulse to DTMF with multiple automatic access pauses
. PABX auto-pause is 2.2 seconds
. DTMF Timing:
Manual dialing: minimum duration for bursts and pauses
Redialing: calibrated timing
. Hands-Free control function

General Description

The UM91214/15 is a single-chip, silicon gate, CMOS integrated circuit with an on-chip oscillator for a 3.58MHz crystal or ceramic resonator. It provides a dialing pulse (DP) or dual tone multi-frequency (DTMF) dialing. A standard 4 x 4 matrix keyboard can be used to support either DP or DTMF modes.

. Wide operating voltage range: 2V to 5.5V
. Key-in beep tone output
. Digits dialed manually after redialing are ascadable and stored as additional digits for the next redialing
. Uses inexpensive ceramic resonator (3.58 MHz)
. Two versions for different telephone systems
. Built-in power up reset circuit
. Four extra function keys: flash, pause, redial and DP or DTMF mixed dialing
. 4 x 4 (or 2 x 8) keyboard can be used
. Low standby current

Up to 32 digits can be saved in the on-chip RAM for redialing. In the DTMF mode, a short minimum tone duration and minimum intertone pause allows rapid dialing. Maximum tone duration depends on the key depression time during manual dialing.

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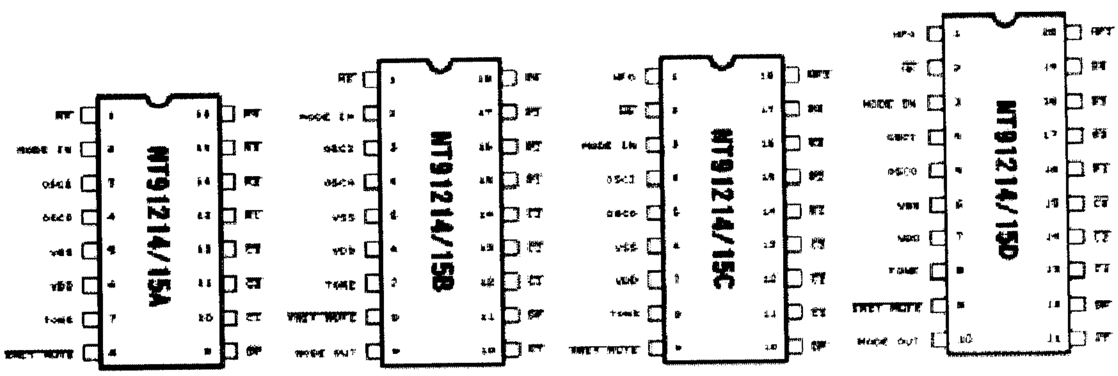
Pin Configurations

a. 16-Pin Package

b. 18-Pin Packages
(i) Key Tone Output
(ii) Hands-Free Control

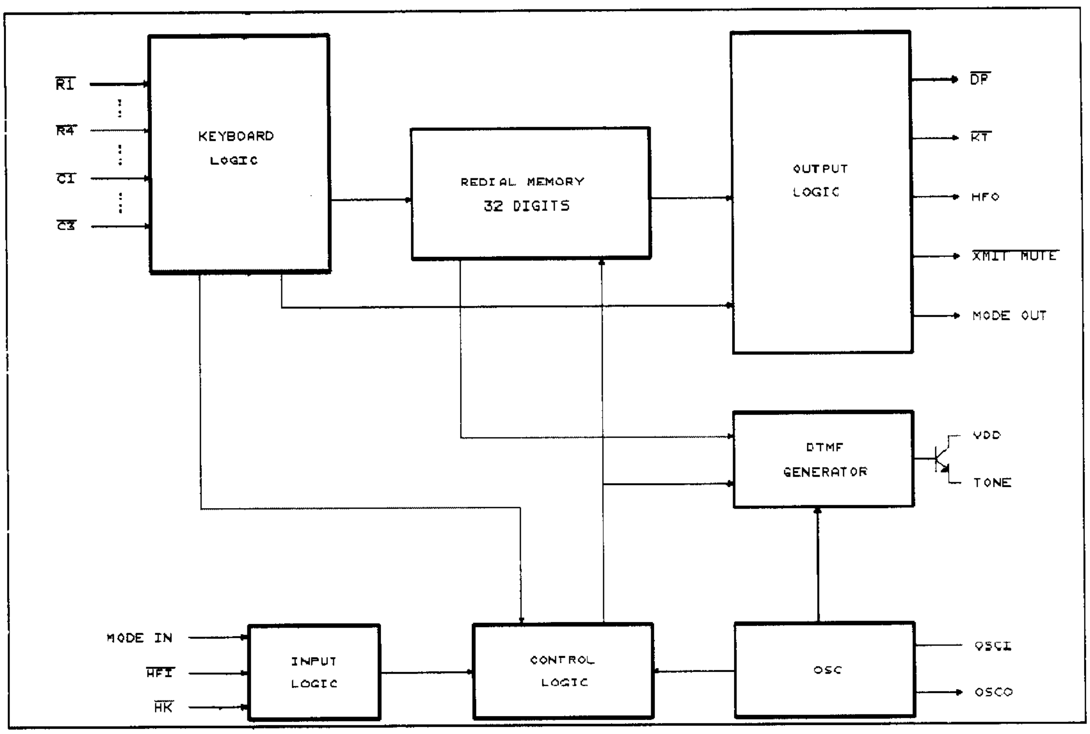
c. 20-Pin Package



Keyboard Assignments

1	2	3	F1	$\overline{R1}$
4	5	6	F2	$\overline{R2}$
7	8	9	P	$\overline{R3}$
*/T	0	#	RD	$\overline{R4}$
$\overline{C1}$	$\overline{C2}$	$\overline{C3}$	GND	

1. */T -- In PULSE mode this key works as Pulse → DTMF key (T key). In DTMF mode the key works as * key. */T key will occupy one memory digit in either use.
2. F1 -- Flash key. The break time is 297 ms or 96 ms (NT91214/15 respectively)
3. F2 -- Flash key for break time 640 ms
4. P -- Pause key (2.2 seconds)
5. RD -- One key redial key
6. # -- In PULSE mode this key input is neglected. In DTMF mode this key works as # key.



Absolute Maximum Ratings*

Supply Voltage (VDD). . . . .≤ 6.0V
Input Voltage (V_{IN}) . . . . . .VSS - 0.3V to VDD + 0.3V
Output Voltage (V_{OUT}) . . . VSS - 0.3V to VDD + 0.3V
Output Voltage (V_{OUT})(DP , XMIT MUTE) . . . ≤1.2V
Tone Output Current (I_{TONE}) . . . . ≤50mA
Power Dissipation (P_D) . . . . ≤500mW
Operating Temperature (Top). . . . . . -20°C to +70°C
Storage Temperature (Tstg). . . . . . -40°C to +150°C

*Comments

Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to this device. These are stress ratings only. Functional operation of this device at these or any other conditions above those indicated in the operational sections of this specification is not implied or intended. Exposure to the absolute maximum rating conditions for extended periods may affect device reliability.

DC Electrical Characteristics (VDD = 3.5V, VSS = 0V, Fosc = 3.579MHz, Top = 25°C)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions		Test KT.
Operating Voltage	VDD	2.0		5.5	V	PULSE mode		A
		2.0		5.5		TONE mode		
Memory Retention Current	I_{MR}		0.05	0.4	μA	VDD = 1.0V, HK = VDD All outputs unloaded		-
Operating Current	I_{DDP}		0.32	1.0	mA	Pulse mode	All outputs unloaded	A
	I_{DDT}		0.6	2.0		Tone mode		
Standby Current	Iso		0.03	0.05	μA	HK = VDD = 1.5V	All outputs unloaded, no key selected	A
			0.5	10		HK = VSS		
R1 - R4 Input Current	I_R		115		μA			C
Tone out Voltage	V_{OC}	584	730	876	mVp-p	Column	VDD = 3.5V R_L = 5K	D
	V_{OR}	456	570	684		Row		
HFO Drive Current	$\lvert I_{OH1} \rvert$	0.4	2		mA	VDD = 3.5V V_{OH} = VDD - 0.4V		B
HFO,KT,MODEOUT XMITMUTE Sink Current	I_{OL1}	0.9	5.3		mA	VDD = 3.5V V_{OL} = 0.4V		B
DP Sink Current	I_{OL2}	1.1	5.3		mA	VDD = 3.5V , V_{OL} = 0.4V		B
Distortion	DIS%		1	5	%	* see note below		

* Note: $$DIS\% = \frac{100 * (V_1^2 + V_2^2 + \ldots + V_n^2)^{1/2}}{(V_{IL}^2 + V_{IH}^2)^{1/2}}$$

1. V_1. . . . V_n are the intermodulation or the harmonic frequencies in the 500Hz to 3400Hz band.
2. V_{IL} and V_{IH} are the individual frequency components of the DTMFsignal.

AC Characteristics (VDD = 3.5V, VSS = 0V, Fosc = 3.579MHz, Top = 25°C, unless otherwise specified.)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions	
Make Time	T_M		33.3		ms	10pps	M/B = 1/2
			40.0				M/B = 2/3
			16.7			20pps	M/B = 1/2
			20.0				M/B = 2/3
Break Time	T_B		66.6		ms	10pps	M/B = 1/2
			60.0				M/B = 2/3
			33.3			20pps	M/B = 1/2
			30.0				M/B = 2/3
Inter-digit Pause Time	T_{IDP}		824		ms	10pps	
			458			20pps	
Pause Time	T_{PAU}		2.2		sec		
Auto-redial Break Time	T_{AOBK}		2.2		sec	* Optional	
Delay time Key valid to Signal Out	T_D		0		ms		
Key-in Debounce	T_{KD}		21		ms		
Key Release Debounce Time	T_{KLD}		5.2		ms		
Key-in Tone Duration	T_{KTD}		23		ms		
Key-in Tone Frequency	F_{KT}		437		Hz		
Minimum Tone Duration Time	T_{MFD}		94		ms		
Min. Tone Inter-digit Pause	T_{TIDP}		96		ms		
Redial Tone Duration	T_{MFDR}		94		ms		
Redial Tone Inter-digit Duration	T_{TIDPR}		96		ms		

Comparisons of Specified vs. Actual Tone Frequencies

R/C	Spec.	Actual	Error (%)	Unit	Conditions
R1	697	699.1	+0.31	Hz	Fosc = 3.579MHz
R2	770	771.5	+0.19	Hz	
R3	852	852.3	+0.03	Hz	
R4	941	942.0	+0.10	Hz	
C1	1,209	1,215.7	+0.57	Hz	
C2	1,336	1,331.7	-0.32	Hz	
C3	1,477	1,471.9	-0.35	Hz	

Ordering Information

Part No.	Key Tone	Hands-Free Control	Dial Rate	M/B Ratio	Flash		Package
					F1	F2	
UM91214A	N.A.	N.A.	10/20pps	1/2			16L DIP
UM 91214B	A	N.A.					18L DIP
UM 91214C	N.A.	A					18L DIP
UM 91214D	A	A					20L DIP
UM 91215A	N.A.	N.A.	10pps	1/2 2/3 selectable	96 ms	640 ms	16L DIP
UM 91215B	A	N.A.					18L DIP
UM 91215C	N.A.	A					18L DIP
UM 91215D	A	A					20L DIP

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5. www.dialabc.com