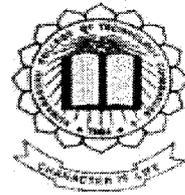




P-1426



# **PORTABLE ADDRESS BOOK KIT WITH DIALER AND VOICE RECORDER**

**A PROJECT REPORT**

*Submitted by*

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*In partial fulfillment for the award of the degree  
of*

**BACHELOR OF ENGINEERING  
IN**

**ELECTRICAL AND ELECTRONICS ENGINEERING**

**KUMARAGURU COLLEGE OF TECHNOLOGY, COIMBATORE**

**ANNA UNIVERSITY: CHENNAI 600 025**

**APRIL 2005**

**ANNA UNIVERSITY: CHENNAI 600 025**

**BONAFIDE CERTIFICATE**

Certified that this project report “**PORTABLE ADDRESS BOOK KIT  
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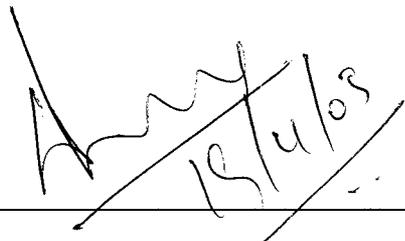
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(INTERNAL EXAMINER)



(EXTERNAL EXAMINER)

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## **ACKNOWLEDGEMENT**

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## ACKNOWLEDGEMENT

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**SYNOPSIS**

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## SYNOPSIS

This Project “PORTABLE ADDRESS BOOK KIT WITH DIALER AND VOICE RECORDER” aims to implement some of the features offered by the mobile phones, in our home phone.

The features, we have implemented here are

- ✓ ADDRESS BOOK
- ✓ DIALER
- ✓ VOICE RECORDER
- ✓ PASSWORD PROTECTION.

The Three main utilities to achieve the features are PIC Microcontroller (16f877), Memory chip (24c04A), Voice recorder (APR9600). The Whole process is mastered and controlled by Microcontroller program.

The principle of operation of the dialer is, tripping off the relays, respective to each numbers entered in sequence. The relays are connected to the corresponding numbers in the keypad of the telephone. Thus dialing effect is made same as that of the original one.

This project will make, the use of your phone a more comfortable one, with Single touch dialing, retrieval of messages, which are received and stored when unable to attend the call, grouping of Telephone numbers, and password security to the usage of this kit.

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**CHAPTER - 1**

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**UNDERSTANDING TELEPHONES**

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## UNDERSTANDING TELEPHONES

Although telephones and telephone company practices may vary dramatically from one locality to another, the basic principles underlying the way they work remain unchanged.

Every telephone consists of three separate subassemblies, each capable of independent operation. These assemblies are the speech network, the dialing mechanism, and the ringer or bell.

Together, these parts - as well as any additional devices such as modems, dialers, and answering machines - are attached to the phone line.

### 1.1 The Phone line

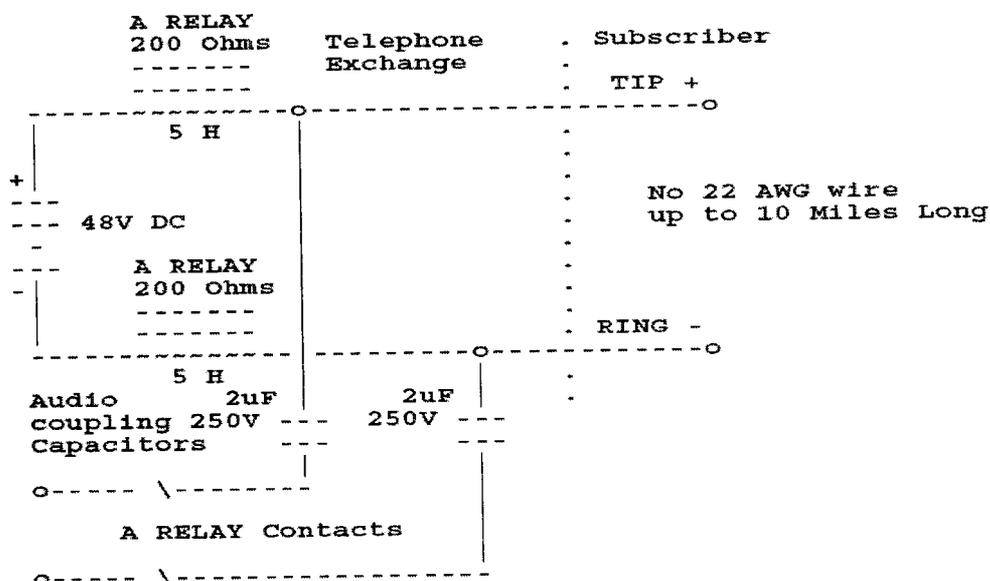
A telephone is usually connected to the telephone exchange by about three miles (4.83 km) of a twisted pair of 0.5 mm copper wires, known by your phone company as "*the loop*". Although copper is a good conductor, it does have resistance. The resistance of wire is 16.46 Ohms per thousand feet at 77 degrees F (25 degrees C). In the United States, wire resistance is measured in Ohms per thousand feet; telephone companies describe loop length in kilo feet (thousands of feet). In other parts of the world, wire resistance is usually expressed as Ohms per kilometer.

Because telephone apparatus is generally considered to be current driven, all phone measurements refer to current consumption, not voltage. The length of the wire connecting the subscriber to the telephone exchange affects the total amount of current that can be drawn by anything attached at the subscriber's end of the line. In the United States, the voltage applied to the line to drive the telephone is 48 VDC; some countries use 50 VDC. Note that telephones are peculiar in that the signal line is also the power supply line. The voltage is supplied by lead acid cells, thus assuring a hum-free

supply and complete independence from the electric company, which may be especially useful during power outages.

At the telephone exchange the DC voltage and audio signal are separated by directing the audio signal through 2 uF capacitors and blocking the audio from the power supply with a 5- Henry choke in each line. Usually these two chokes are the coil windings of a relay that switches your phone line at the exchange; in the United States, this relay is known as the "A" relay. The resistance of each of these chokes is 200 Ohms.

Fig 1. The Phone Line



We can find out how well a phone line is operating by using Ohm's law and an ammeter. The DC resistance of any device attached to the phone line is often quoted in telephone company specifications as 200 Ohms; this will vary in practice from between 150 to 1,000 Ohms. You can measure the DC resistance of your phone with an Ohmmeter. Note this is DC resistance, not impedance.

Using these figures you can estimate the distance between your telephone and the telephone exchange. In the United States, the telephone company guarantees you no lower current than 20 mA - or what is known to your phone company as a "long loop." A "short loop" will draw 50 to 70

mA, and an average loop, about 35 mA. Some countries will consider their maximum loop as low as 12 mA. In practice, United States telephones are usually capable of working at currents as low as 14 mA. Some exchanges will consider your phone in use and feed dial tone down the line with currents as low as 8 mA, even though the telephone may not be able to operate.

Although the telephone company has supplied plenty of nice clean DC direct to your home, don't assume you have a free battery for your own circuits. The telephone company wants the DC resistance of your line to be about 10 mega Ohms when there's no apparatus in use you can draw no more than 5microamperes while the phone is in that state. When the phone is in use, or "off hook," you can draw current, but you will need that current to power your phone, any current you might draw for other purposes would tend to lower the signal level.

The phone line has impedance composed of distributed resistance, capacitance, and inductance. The impedance will vary according to the length of the loop, the type of insulation of the wire, and whether the wire is aerial cable, buried cable, or bare parallel wires strung on telephone poles. For calculation and specification purposes, the impedance is normally assumed to be 600 to 900 Ohms. If the instrument attached to the phone line should be of the wrong impedance, you would get a mismatch, or what telephone company personnel refer to as "return loss." (Radio Amateurs will recognize return loss as SWR.) A mismatch on telephone lines results in echo and whistling, which the phone company calls "singing" and owners of very cheap telephones may have come to expect. A mismatched device can, by the way, be matched to the phone line by placing resistors in parallel or series with the line to bring the impedance of the device to within the desired limits. This will cause some signal loss, of course, but will make the device usable.

A phone line is balanced feed, with each side equally balanced to ground. Any imbalance will introduce hum and noise to the phone line and

increase susceptibility to RFI. The balance of the phone line is known to your telephone company as "longitudinal balance." If both impedance match and balance to ground are kept in mind, any device attached to the phone line will perform well, just as the correct matching of transmission lines and devices will ensure good performance in radio practice.

Most installations have another pair of wires, yellow and black. These wires can be used for many different purposes, if they are used at all. If you have two separate phone lines (not extensions) in your home, you will find the yellow and black pair carrying a second telephone line. In this case, black is "Tip" and yellow is "Ring." The above description applies to a standard line with a DC connection between your end of the line and the telephone exchange. Most phone lines in the world are of this type, known as a "metallic line." In a metallic line, there may or may not be inductance devices placed in the line to alter the frequency response of the line; the devices used to do this are called "loading coils." Other types of lines are party lines, which may be metallic lines but require special telephones to allow the telephone company to differentiate between subscribers. Very long lines may have amplifiers, sometimes called "loop extenders" on them. Some telephone companies use a system called "subscriber carrier," which is basically an RF system in which your telephone signal is heterodyned up to around 100 Khz and then sent along another subscriber's "twisted pair."

## **1.2 The Speech Network**

The speech network - also known as the "hybrid" or the "two wire/four wire network" - takes the incoming signal and feeds it to the earpiece and takes the microphone output and feeds it down the line. The standard network used all over the world is an LC device with a carbon microphone; some newer phones use discrete transistors or ICs.

One of the advantages of an LC network is that it has no semiconductors, is not voltage sensitive, and will work continuously as the voltage across the line is reduced. Many transistorized phones stop working

as the voltage approaches 3 to 4 Volts. when a telephone is taken off the hook, the line voltage drops from 48 Volts to between 9 and 3 Volts, depending on the length of the loop. If another telephone in parallel is taken off the hook, the current consumption of the line will remain the same and the voltage across the terminals of both telephones will drop.

While low levels of audio may be difficult to hear, overly loud audio can be painful. Consequently, a well designed telephone will automatically adjust its transmit and receive levels to allow for the attenuation - or lack of it - caused by the length of the loop. This adjustment is called "*loop compensation.*" In the United States, telephone manufacturers achieve this compensation with silicon carbide varistors that consume any excess current from a short loop.

Although some telephones using ICs have built-in loop compensation, many do not; the latter have been designed to provide adequate volume on the average loop, which means that they provide low volume on long loops, and are too loud on short loops. Various countries have different specifications for transmit and receive levels; some European countries require a higher transmit level than is standard in the United States so a domestically-manufactured telephone may suffer from low transmit level if used on European lines without modification. Because a telephone is a duplex device, both transmitting and receiving on the same pair of wires, the speech network must ensure that not too much of the caller's voice is fed back into his or her receiver. This function, called "sidetone," is achieved by phasing the signal so that some cancellation occurs in the speech network before the signal is fed to the receiver. Callers faced with no sidetone at all will consider the phone "dead."

### **1.3 The Dial**

There are two types of dials in use around the world. The most common one is called pulse, loop disconnect, or rotary; the oldest form of dialing, it's been with us since the 1920's. The other dialing method, more modern and much loved by Radio Amateurs is called Touch-tone, Dual

Tone Multi-Frequency (DTMF) or Multi-Frequency (MF) in Europe. In the U.S. MF means single tones used for system control.

Pulse dialing is traditionally accomplished with a rotary dial, which is a speed governed wheel with a cam that opens and closes a switch in series with your phone and the line. It works by actually disconnecting or "hanging up" the telephone at specific intervals. In practice, the make/break ratio does not seem to affect the performance of the dial when attached to a normal loop. Bear in mind that each pulse is a switch connect and disconnect across complex impedance, so the switching transient often reaches 300 Volts. Try not to have your fingers across the line when dialing.

Most pulse dialing phones produced today use a CMOS IC and a keyboard. Instead of pushing your finger round in circles, then removing your finger and waiting for the dial to return before dialing the next digit, you punch the button as fast as you want. The IC stores the number and pulses it out at the correct rate with the correct make/break ratio and the switching is done with a high-voltage switching transistor. Because the IC has already stored the dialed number in order to pulse it out at the correct rate, it's a simple matter for telephone designers to keep the memory "alive" and allow the telephone to store, recall, and redial the Last Number Dialed (LND). This feature enables you to redial by picking up the handset and pushing just one button.

Because pulse dialing entails rapid connection and disconnection of the phone line, you can "dial" a telephone that has lost its dial, by hitting the hook-switch rapidly. It requires some practice to do this with consistent success, but it can be done. A more sophisticated approach is to place a Morse key in series with the line, wire it as normally closed and send strings of dots corresponding to the digits you wish to dial. Touch tone, the most modern form of dialing, is fast and less prone to error than pulse dialing. Compared to pulse, its major advantage is that its audio band signals can travel down phone lines further than pulse, which can travel only as far as your local exchange. Touch-tone can therefore send signals around the

world via the telephone lines, and can be used to control phone answering machines and computers.

Most Radio Amateurs are familiar with DTMF for controlling repeaters and for accessing remote and auto phone patches. Bell Labs developed DTMF in order to have a dialing system that could travel across microwave links and work rapidly with computer controlled exchanges. Each transmitted digit consists of two separate audio tones that are mixed together. The four vertical columns on the keypad are known as the high group and the four horizontal rows as the low group; the digit 8 is composed of 1336 Hz and 852 Hz. The level of each tone is within 3 dB of the other, (the telephone company calls this "Twist").

Standard DTMF pad and Frequencies

|                        |        |                        |        |        |
|------------------------|--------|------------------------|--------|--------|
| {Low Group}<br>697Hz > | 1      | 2                      | 3      | A      |
| 770Hz >                | 4      | 5                      | 6      | B      |
| 825Hz >                | 7      | 8                      | 9      | C      |
| 941Hz >                | *      | 0                      | #      | D      |
|                        | 1209Hz | 1336Hz<br>(High Group) | 1477Hz | 1633Hz |

END

A complete touch-tone pad has 16 digits, as opposed to ten on a pulse dial. Besides the numerals 0 to 9, a DTMF "dial" has \*, #, A, B, C, and D. Although the letters are not normally found on consumer telephones, the IC in the phone is capable of generating them. The \* sign is usually called "star" or "asterisk." The # sign, often referred to as the "pound sign." is actually called an **octothorpe**. Although many phone users have never used these digits - they are not, after all, ordinarily used in dialing phone numbers. The one use of the octothorpe that may be familiar occurs in dialing international calls from phones in the United States. After dialing the

complete number, dialing the octothorpe lets the exchange know you've finished dialing. It can now begin routing your call; without the octothorpe, it would wait and "time out" before switching your call. When DTMF dials first came out they had complicated cams and switches for selecting the digits and used a transistor oscillator with an LC tuning network to generate the tones. Standard DTMF dials will produce a tone as long as a key is depressed. No matter how long you press, the tone will be decoded as the appropriate digit. The shortest duration in which a digit can be sent and decoded is about 100 milliseconds (ms).

It's pretty difficult to dial by hand at such a speed, but automatic dialers can do it. A twelve-digit long distance number can be dialed by an automatic dialer in a little more than a second - about as long as it takes a pulse dial to send a single 0 digit.

The output level of DTMF tones from your telephone should be between 0 and -12 dBm. In telephones, 0 dB is 1 milliwatt over 600 Ohms. So 0 dB is 0.775 Volts. Because your telephone is considered a 600 Ohm load, placing a voltmeter across the line will enable you to measure the level of your tones.

#### **1.4 The Ringer**

Simply speaking this is a device that alerts you to an incoming call. It may be a bell, light, or warbling tone. The telephone company sends a ringing signal which is an AC waveform. Although the common frequency used in the United States is 20 HZ, it can be any frequency between 15 and 68 Hz. Most of the world uses frequencies between 20 and 40 Hz. The voltage at the subscribers end depends upon loop length and number of ringers attached to the line; it could be between 40 and 150 Volts. Note that ringing voltage can be hazardous; when you're working on a phone line, be sure at least one telephone on the line is off the hook (in use); if any are not, take high voltage precautions. The telephone company may or may not remove the 48 VDC during ringing; Don't take chances.

The ringing cadence - the timing of ringing to pause - varies from company to company. In the United States the cadence is normally 2 seconds of ringing to 4 seconds of pause. An unanswered phone in the United States will keep ringing until the caller hangs up. But in some countries, the ringing will "time out" if the call is not answered. The most common ringing device is the gong ringer, a solenoid coil with a clapper that strikes either a single or double bell. A gong ringer is the loudest signaling device that is solely phone-line powered.



Modern telephones tend to use warbling ringers, which are usually ICs powered by the rectified ringing signal. The audio transducer is either a piezoceramic disk or a small loudspeaker via a transformer.

Ringers are isolated from the DC of the phone line by a capacitor. Gong ringers in the United States use a 0.47 uF capacitor. Warbling ringers in the United States generally use a 1.0 uF capacitor. Telephone companies in other parts of the world use capacitors between 0.2 and 2.0 uF. The paper capacitors of the past have been replaced almost exclusively with capacitors made of Mylar film. Their voltage rating is always 250 Volts.

Warbling ringers tend to draw less current than gong ringers, so changing from gong ringers to warbling ringers may help you spread the sound better. Frequency response is the second criterion by which a ringer is described. In the United States most gong ringers are electromechanically resonant. They are usually resonant at 20 and 30 Hz (+&- 3 Hz). The FCC refers to this as A so a normal gong ringer is described as REN 1.0A. The other common frequency response is known as type B. Type B ringers will respond to signals between 15.3 and 68.0 Hz. Warbling ringers are all type B and some United States gong ringers are type B. Outside the United States, gong ringers appear to be non-frequency selective, or type B.

Because a ringer is supposed to respond to AC waveforms, it will tend to respond to transients (such as switching transients) when the phone is hung up, or when the rotary dial is used on an extension phone. This is called "bell tap" in the United States; in other countries, it's often called

"bell tinkle." While European and Asian phones tend to bell tap, or tinkle, United States ringers that bell tap are considered defective. The bell tap is designed out of gong ringers and fine tuned with bias springs. Warbling ringers for use in the United States are designed not to respond to short transients; this is usually accomplished by rectifying the AC and filtering it before it powers the IC, then not switching on the output stage unless the voltage lasts long enough to charge a second capacitor.

**CHAPTER - 2**

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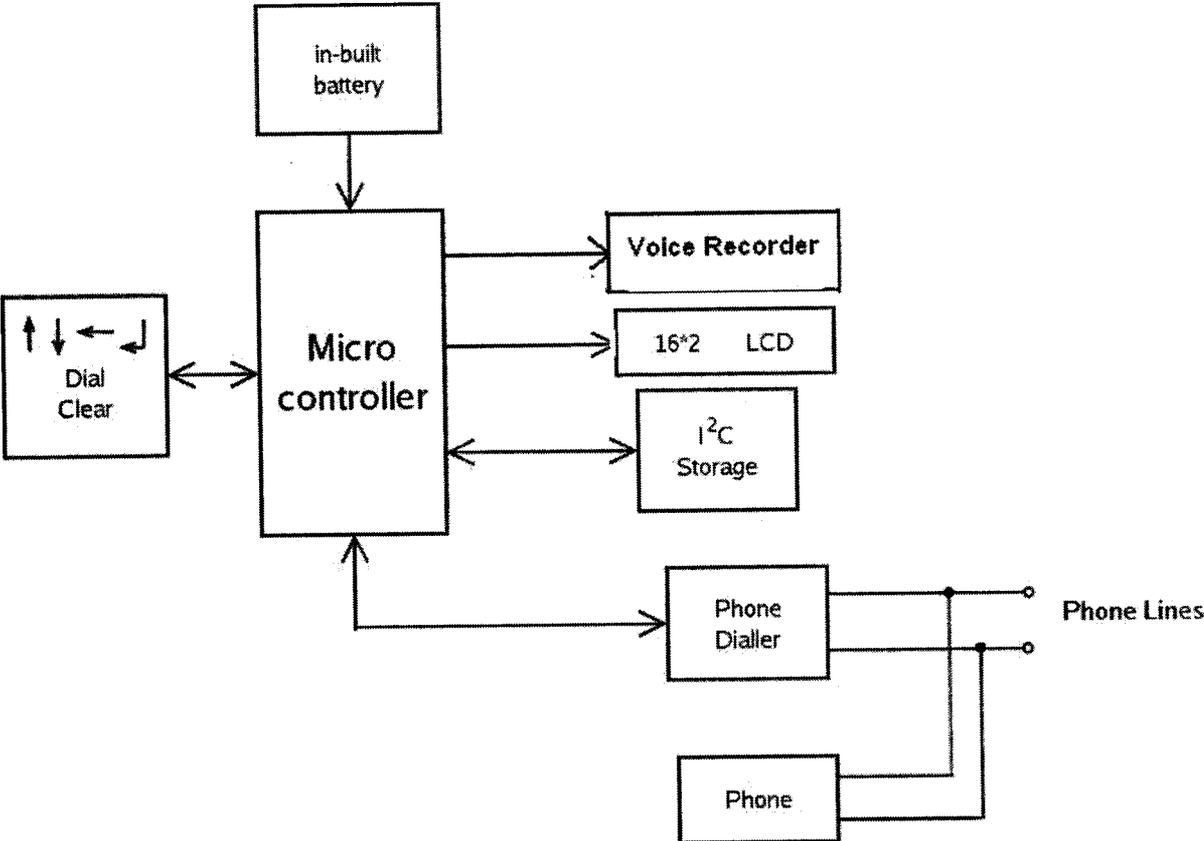
**INTRODUCTION**

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# INTRODUCTION

## 2.1 BLOCK DIAGRAM



## 2.2 ADDRESS BOOK

This is an Extended Memory part for our Phone. It stores the Name and Number of the individuals into its memory. It gets stored in the I<sup>2</sup>C memory and Microcontroller has a strong hand on it. Entries are stored in the 24c04A memory chip, which is an EEPROM (Electrically Erasable Programmable Read Only Memory) type memory. This type of storage facilitates us by retaining the data even after the power cutoff. So, same data can be accessed, when power supply is given. Only way of erasing the data in the chip is by supplying electrical pulses to the pins.

Entries are made through 4 button keyboard intended for this purpose. The purpose of the buttons can also be toggled to switch between the Names. The display is given in the 16\*2 display, i.e. it displays two lines of text for name and number respectively each with 16 characters of length. The display is interfaced with microcontroller and controls the display and saves them in the memory chip.

## 2.3 KEYBOARD

The Keyboard consists of four buttons

1. Increment – it is used to increase the displaying value and to switch between names
2. Decrement- it is used to decrease the displaying value
3. Dial – it is used to make a call and to shift the cursors between the lines
4. Shift – it is used to shift the cursors in the same line

In addition to this Toggle switch is present, which is used to changeover the purpose of the switch.

At first, cursor is placed in the right position using *shift* button, then entries are made using *increment/decrement* button. When cursor is placed in the NAME field and *increment* is pressed the display changes from 'A', 'B', 'C', 'D', ..... 'Z'. At the required letter it can be stopped and *shift* button is used to move cursor to the next position. Then again

*increment* is used to make the next entry. After entering the data, the cursor is switched over between lines to save the entry. Thus by this way required name can be entered into the memory.

When cursor is placed in the NUMBER field and *increment* is pressed the display changes from 0,1,2,3,.....9. The required number can be typed in. and *shift* button is used to move cursor to the next position. Then again *increment* is used to make the next entry. After entering the number dial button is used to send the data into the memory.

## **2.4 DIALER**

After storing the data into the memory, it is permanently stored in the chip, i.e. retaining it even when supply is switched off. Now the data can be viewed by switching between the names using *increment* button. To make a call, display is stopped in the required number and then dial button is pressed, now relays respective to the number entered in the sequence will trip and send signal to dialer section of the telephone. The relays are connected to the corresponding numbers in the keypad of the telephone. Thus it produces same effect as that of original dialing.

## **2.5 VOICE RECORDING**

This feature enables the user to receive messages and store them even when he is out of house. It comprises of APR9600 chip for voice recording purpose. Microcontroller will divert the control to the voice recorder after certain number of ringing, which is programmed now to be 10. Initially the Rec/Play toggle switch is placed in the Rec position then to hear the message it is kept in the Play position. When the telephone rings it will sense the ringing as a single pulse using Monostable circuit and Ringer detector circuit will sense these pulses and microcontroller program will increments the counter. After the counter reaches 10, it will trip off the **CRADLE** relay and it will also trigger voice recorder circuit to ready to store the messages leaved by the caller.

## 2.6 PASSWORD PROTECTION

This feature provides security to our auxiliary kit which is going to be connected to our telephone. It requests for a fixed password whenever the kit is made ON. It serves as protection from others to view our stored numbers. Also it protects from others to manipulate the numbers. It serves as a security for our kit.

At first, the kit will ask for the password to get an access into the memory.

Now, *increment* button is pressed to change the display from 0,1,2,.....9. Then *shift* button is used to move cursor to next position, again *increment* button is used to enter the password.

## **CHAPTER - 3**

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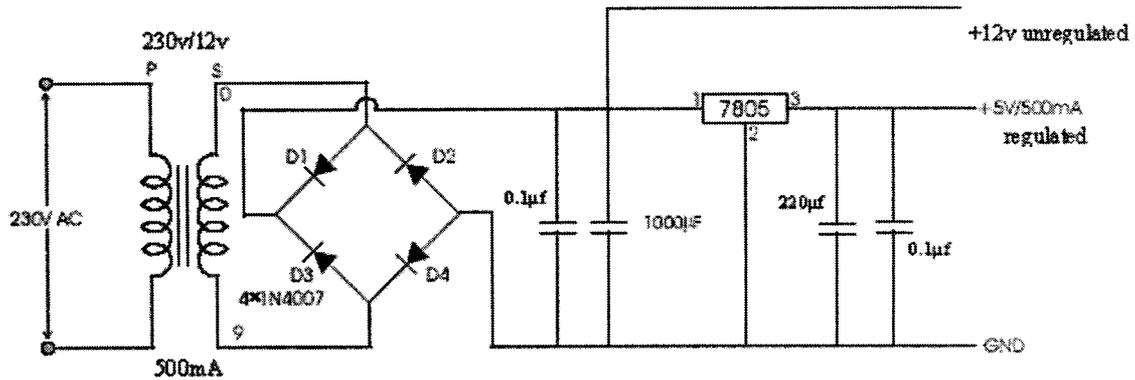
### **HARDWARE DESCRIPTION**

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### 3.1 Power supply:

The power supply circuit consists of:



#### 1. Transformer:

The transformer is used to step-down the voltage from 230vac to 12vac and it is designed to give a supply current of 500mA.

#### 2. Bridge rectifier:

The bridge rectifier is used to convert the 12vac to 12vdc supply. The full wave bridge rectifier is used to convert the ac supply into pulsating dc supply.

#### 3. Smoothing circuit:

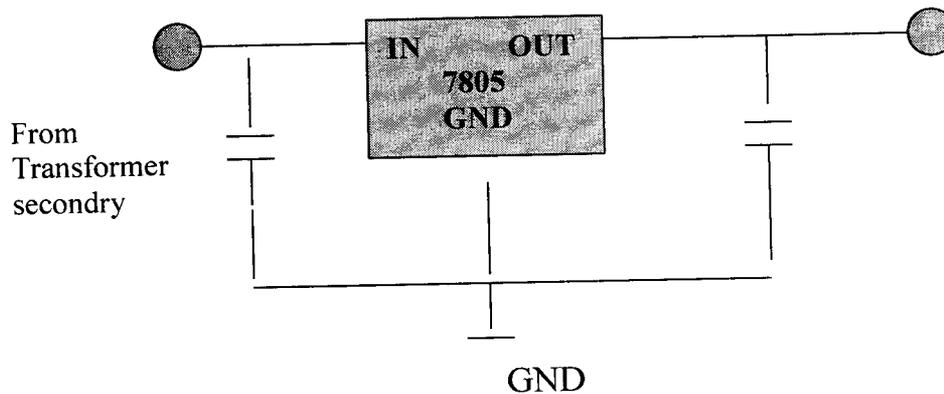
The output from the bridge rectifier is of pulsating ac voltage which is smoothed by the smoothing circuit. The smoothing circuit consists of capacitors to remove ripples from the dc supply line.

#### 4. FILTER:

The filter circuit used here is the capacitor filter circuit where a capacitor is connected at the rectifier output, and a DC is obtained across it. The filtered waveform is essentially a DC voltage with negligible ripples, which is ultimately fed to the load.

## 5. Regulator:

### Fixed Positive Voltage Regulators:



The series 78 regulators provide fixed regulated voltages from 5 to 24 V. An unregulated input voltage  $V_i$  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.

The regulator is a 3 terminal solid device. The 12vdc input is given to the regulator and the regulator output is fixed to 5v which will not exceed even though there is change in the input supply voltage. The o/p of the regulator is given to the circuits.

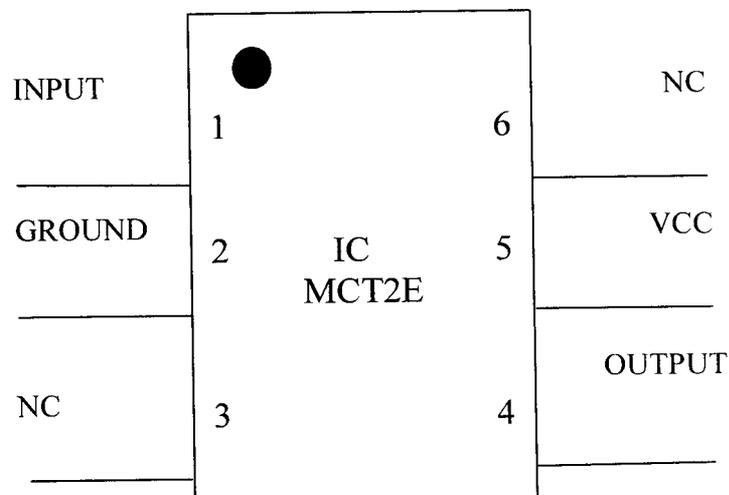
**TABLE Positive Voltage Regulators in 7800 series**

| <b>IC Part</b> | <b>Output Voltage<br/>(V)</b> | <b>Minimum Vi<br/>(V)</b> |
|----------------|-------------------------------|---------------------------|
| 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                      |

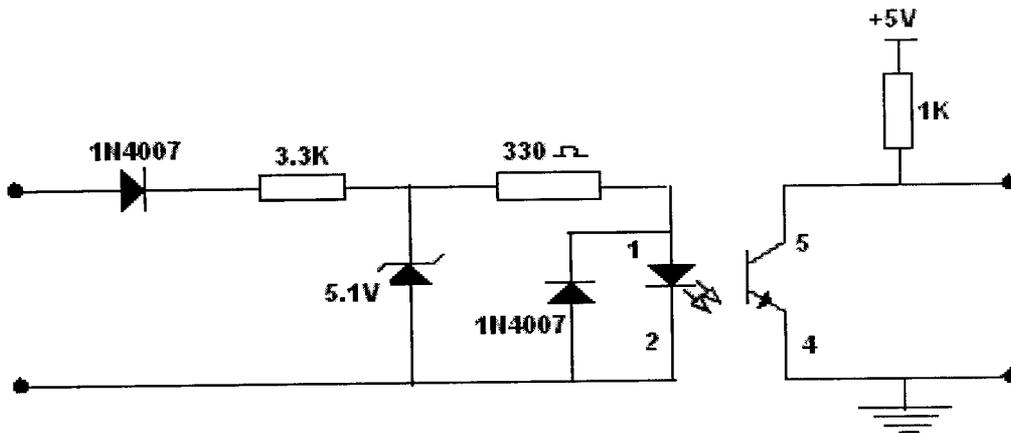
### 3.2 OPTO COUPLER

The proper isolation between input and output becomes very important in several of the digital and analog applications. The traditional methods isolation involves the use of such devices as capacitor, relays, transformers and opto couplers of these the Optocoupler provide an ideal combination of speed, OC response, high common mode noise for both analog and digital applications in industrial, medical and military products. Examples are logic isolations, line receivers, sensing circuits, power supply feed back, high voltage current monitoring, telephone, lines patient monitoring equipments, adaptive control, audio and video amplifiers, triggering of thyristors, and so on.

Optocoupler consists of an LED emitter and a photo sensor of transistor or diode type. The one that utilizes a phototransistor is limited in its improves the speed upto a hundred times that of a phototransistor coupler by reducing the base-collector capacitance. A high speed Optocoupler employs this as principle of operation.



### 3.3 RINGING PULSE DETECTOR



For the operation of the voice recorder, the microcontroller should trigger the cradle relay after specified number of rings. So, it should aware of ringing of the telephone, This circuit gives the output as a single pulse to the microcontroller for every ring of the telephone. Microcontroller will be programmed enough to sense these pulses and increment the counter, after counter reaches specified number it will trip off the cradle relay.

It consists of a Half wave rectifier at the input side. It consists of Zener diode of 5.1v to supply a constant voltage, Now the rectified and stable DC signal is send to the optocoupler. It is used for isolation purpose as a matter of safety. Then the output of the optocoupler is send to the Microcontroller with the current limiting resistor in series

### 3.4 RELAYS

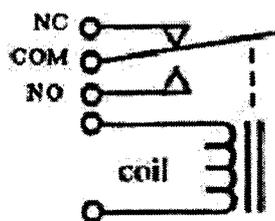


Figure 1

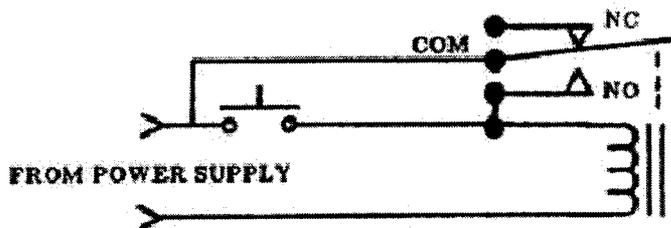


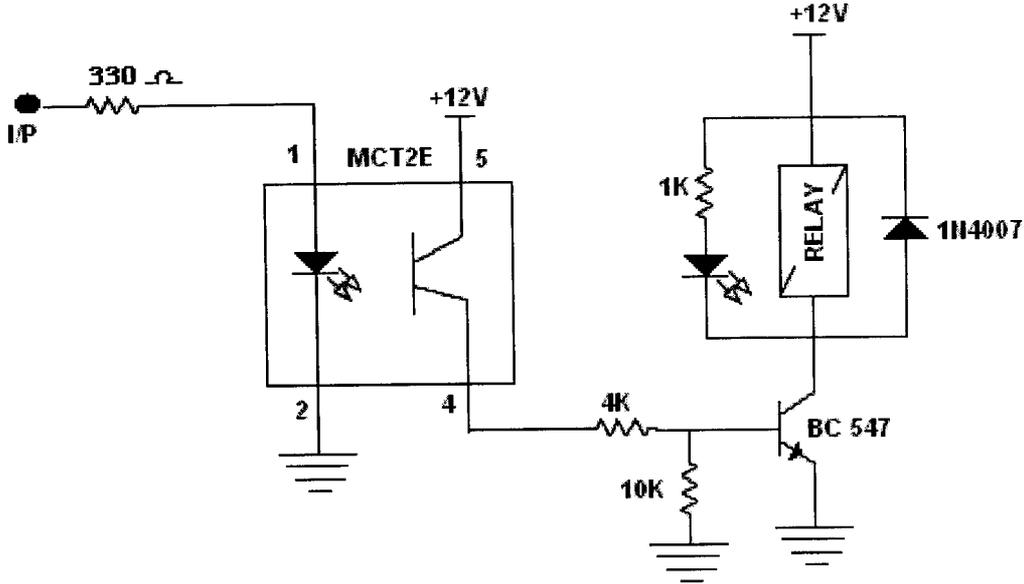
Figure 2

Early digital logic circuits employ relays to perform all of the required functions. A relay is constructed from three very basic components: an electromagnet, a switch, and a spring. But where most switches are activated by pushing a button or throwing a lever, the switch (or switches) in a relay change state when voltage is applied to the coil of the electromagnet. The voltage causes the iron core to become magnetized, which then pulls the metal switch contacts into position.

And when the voltage is removed, the spring takes over and pulls the contacts back. Most relays contain at least two switches, though some have as many as four or more, offering a wide range of possible circuit combinations.

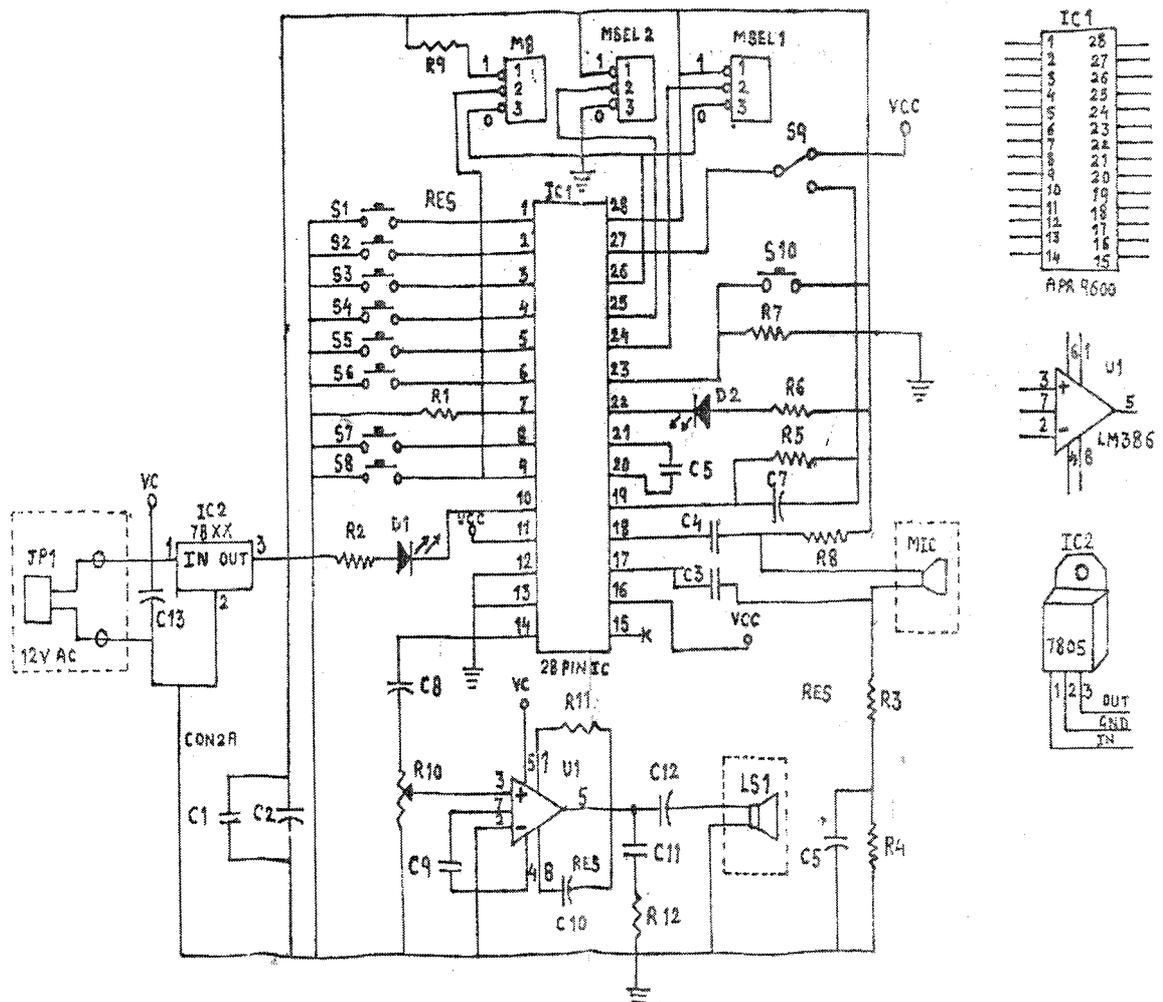
Since drawing a realistic picture of an electronic component is not always the most efficient way to convey a circuit, electronic engineers instead use a schematic diagram. Most schematic representations are really pretty close to what an equivalent picture might look like, and a relay is shown both ways for you to compare. Figure shows the schematic for a single-pole (one switch) double-throw relay. The term double-throw means that one element -- called the common -- will be connected to either of two possible contacts: normally open, or normally closed. That is, when the relay is at rest with no voltage applied to its coil, the common contact is connected to the normally closed contact. And when the relay is activated, the common will be connected to the normally open one instead.

# RELAY DRIVING CIRCUIT



An Optocoupler is placed in the initial stage of the circuit. It is used for isolation purpose as a matter of safety, as it supplies only the induced voltage, then the output is given to the transistor through the voltage divider bias. Whenever the signal arrives, it will ground the transistor thus closing the circuit, thus the relay will trip to Normally close position and the signal is sent to the telephone. It also consists of a Freewheeling diode for conduction of the reverse flow of current. In our project, there are thirteen such relays have been used. These relays will trip off and are used to send signals to the Microcontroller.

### 3.5 APR9600 SOUND RECORDER



APR9600 is a low-cost high performance sound record/replay IC incorporating flash analogue storage technique. Recorded sound is retained even after power supply is removed from the module. The replayed sound exhibits high quality with a low noise level. Sampling rate for a 60 second recording period is 4.2 kHz that gives a sound record/replay bandwidth of 20Hz to 2.1 kHz.

The IC can operate in one of two modes: serial mode and parallel mode. The APR9600 has a 28 pin DIP package. Supply voltage is between

4.5V to 6.5V. During recording and replaying, current consumption is 25 mA. In idle mode, the current drops to 1 mA. The oscillation resistor is chosen so that the total recording period is 60 seconds with a sampling rate of 4.2 kHz. The board measures 80mm by 55mm.

An 8-16 Ohm speaker is to be used with the module.

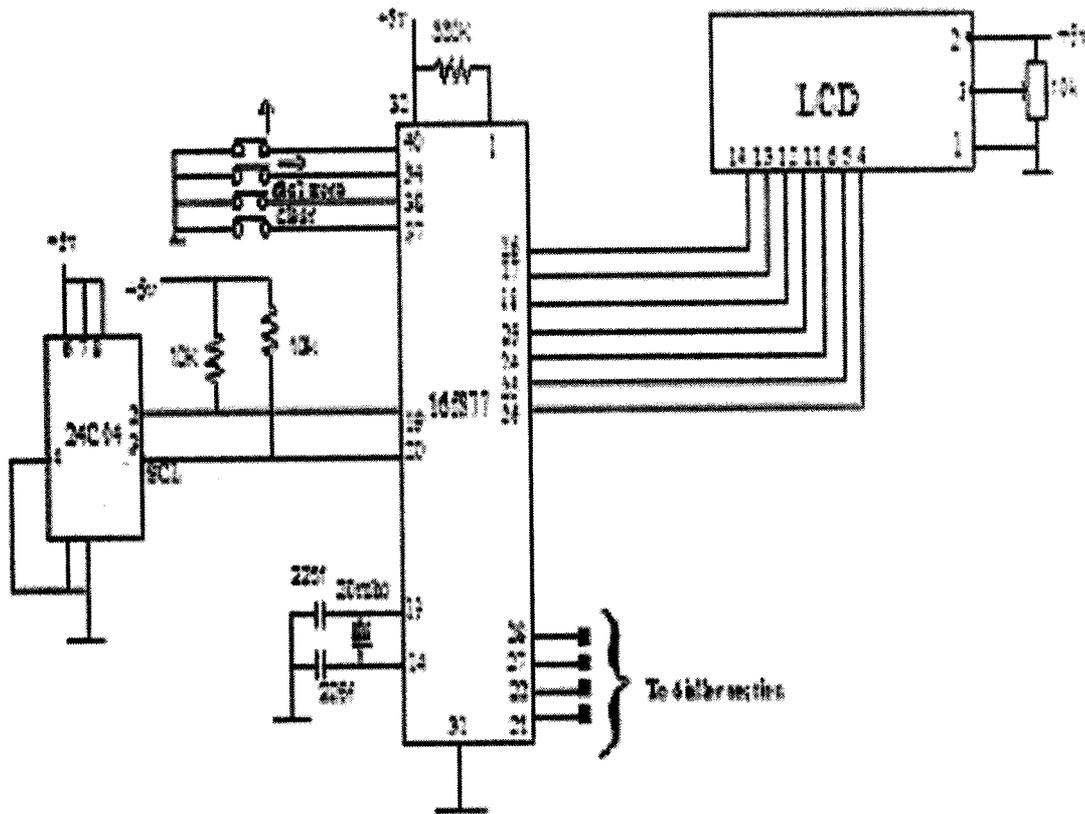
### SAMPLING RATES

The sampling rate is determined by the value of the OSC resistor (R8 in the circuit diagram). It can be adjusted by users to suit their specific requirements. The relationships amongst the resistance, sampling rate, bandwidth and recording period are shown in Table

**Table OSC resistances**

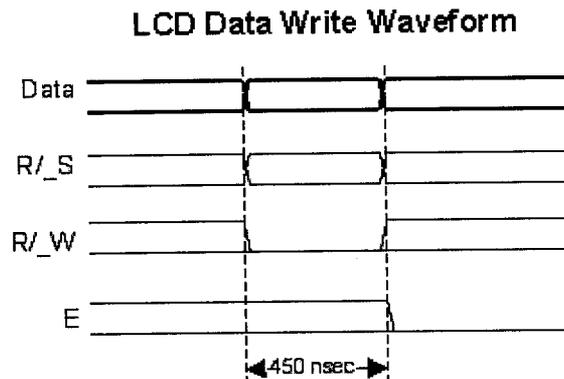
| <b>OSCR resistance<br/>[kOhm]</b> | <b>Sampling rate<br/>[kHz]</b> | <b>Bandwidth<br/>[kHz]</b> | <b>Recording time<br/>[Second]</b> |
|-----------------------------------|--------------------------------|----------------------------|------------------------------------|
| 44                                | 4.2                            | 2.1                        | 60                                 |
| 38                                | 6.4                            | 3.2                        | 40                                 |
| 24                                | 8.0                            | 4.0                        | 32                                 |

### 3.6 Circuit Description



This is the main circuit diagram of our project, microcontroller that we had used in our project (16f877) consists of five ports, we had used four of it our project. As shown in the diagram, pin 1 & 32 is given to  $V_{cc}$  i.e. 5v supply. Pin 32 is grounded. Crystal oscillator of 20  $M_{HZ}$  is connected to pin 23 & 24. The memory chip 24c04A is connected to pin 19 & 20. The four button keyboard intended specially for data entry in this project is interfaced with microcontroller through pins 36-40. This is the only port serving as an input in this project; all the others will act as a output port. LCD Display is interfaced with the microcontroller through pins 16,17,18,23,24,25,26. Here the data is inputed to the display by the pins 16,17,18,23, which are connected to pins 11,12,13,14 of LCD Display. Then pins 24, 25, 26 of microcontroller are connected to the pins 4, 5, 6 of LCD Display. The pins 21, 22, 27, 28 of microcontroller are reserved to act as a output port by connecting to the dialer section of the telephone.

### 3.7 LCD Interface



| Pins   | Description                        |
|--------|------------------------------------|
| 1      | Ground                             |
| 2      | Vcc                                |
| 3      | Contrast Voltage                   |
| 4      | "R/S" _Instruction/Register Select |
| 5      | "R/W" _Read/Write LCD Registers    |
| 6      | "E" Clock                          |
| 7 - 14 | Data I/O Pins                      |

The interface is a parallel bus, allowing simple and fast reading/writing of data to and from the LCD. This waveform will write an ASCII Byte out to the LCD's screen. The ASCII code to be displayed is eight bits long and is sent to the LCD either four or eight bits at a time. If four bit mode is used, two "nybbles" of data (Sent high four bits and then low four bits with an "E" Clock pulse with each nybble) are sent to make up a full eight bit transfer. The "E" Clock is used to initiate the data transfer within the LCD. Sending parallel data as either four or eight bits are the two primary modes of operation. While there are secondary considerations and

modes, deciding how to send the data to the LCD is most critical decision to be made for an LCD interface application. Here, in our project Data is sent at four bits at a time. Four bit mode requires a minimum of six bits. To wire a microcontroller to an LCD in four bit mode, just the top four bits (DB4-7) are written to. The "R/S" bit is used to select whether data or an instruction is being transferred between the microcontroller and the LCD. If the Bit is set, then the byte at the current LCD "Cursor" Position can be read or written. When the Bit is reset, either an instruction is being sent to the LCD or the execution status of the last instruction is read back

The different instructions available are shown in the table below:

| R/S | R/W | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | Instruction/Description  |
|-----|-----|----|----|----|----|----|----|----|----|--|
| 4   | 5   | 14 | 13 | 12 | 11 | 10 | 9  | 8  | 7  | Pins   |
| 0   | 0   | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | Clear Display  |
| 0   | 0   | 0  | 0  | 0  | 0  | 0  | 0  | 1  | *  | Return Cursor and LCD to Home Position                           |
| 0   | 0   | 0  | 0  | 0  | 0  | 0  | 1  | ID | S  | Set Cursor Move Direction  |
| 0   | 0   | 0  | 0  | 0  | 0  | 1  | D  | C  | B  | Enable Display/Cursor  |
| 0   | 0   | 0  | 0  | 0  | 1  | SC | RL | *  | *  | Move Cursor/Shift Display  |
| 0   | 0   | 0  | 0  | 1  | DL | N  | F  | *  | *  | Set Interface Length   |
| 0   | 0   | 0  | 1  | A  | A  | A  | A  | A  | A  | Move Cursor into CGRAM   |
| 0   | 0   | 1  | A  | A  | A  | A  | A  | A  | A  | Move Cursor to Display   |
| 0   | 1   | BF | *  | *  | *  | *  | *  | *  | *  | Poll the "Busy Flag"   |
| 1   | 0   | D  | D  | D  | D  | D  | D  | D  | D  | Write a Character to the Display at the Current Cursor Position  |
| 1   | 1   | D  | D  | D  | D  | D  | D  | D  | D  | Read the Character on the Display at the Current Cursor Position |

The bit descriptions for the different commands are:

"\*" - Not Used/Ignored. This bit can be either "1" or "0"

Set Cursor Move Direction:

ID - Increment the Cursor After Each Byte Written to Display if Set

S - Shift Display when Byte Written to Display

Enable Display/Cursor

D - Turn Display On(1)/Off(0)

C - Turn Cursor On(1)/Off(0)

B - Cursor Blink On(1)/Off(0)

Move Cursor/Shift Display

SC - Display Shift On(1)/Off(0)

RL - Direction of Shift Right(1)/Left(0)

Set Interface Length

DL - Set Data Interface Length 8(1)/4(0)

N - Number of Display Lines 1(0)/2(1)

F - Character Font 5x10(1)/5x7(0)

Poll the "Busy Flag"

BF - This bit is set while the LCD is processing

Move Cursor to CGRAM/Display

A - Address

Read/Write ASCII to the Display

D - Data

For most applications, there really is no reason to read from the LCD. I usually tie "R/W" to ground and just wait the maximum amount of time for each instruction (4.1 msec for clearing the display or moving the cursor/display to the "home position", 160 usecs for all other commands). As well as making my application software simpler, it also frees up a microcontroller pin for other uses. Different LCDs execute instructions at different rates and to avoid problems later on (such as if the LCD is changed to a slower unit), I recommend just using the maximum delays given above.

In describing how the LCD should be initialized in four bit mode, I will specify writing to the LCD in terms of nybbles. This is because initially, just single nybbles are sent (and not two, which make up a byte and a full instruction). As I mentioned above, when a byte is sent, the high nybble is sent before the low nybble and the "E" pin is toggled each time four bits is sent to the LCD. To initialize in four bit mode:

1. Wait more than 15 msec after power is applied.
2. Write 0x03 to LCD and wait 5 msec for the instruction to complete
3. Write 0x03 to LCD and wait 160 usecs for instruction to complete
4. Write 0x03 AGAIN to LCD and wait 160 usecs (or poll the Busy Flag)
5. Set the Operating Characteristics of the LCD
  - o Write 0x02 to the LCD to Enable Four Bit Mode

Once the initialization is complete, the LCD can be written to with data or instructions as required. Each character to display is written like the control bytes, except that the "R/S" line is set

**CHAPTER - 4**

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**PIC MICROCONTROLLER**

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## **4.1 Introduction**

The microcontroller is the core of the project. The microcontroller has internal memory to store the code lock number. It reads the keyboard value and compares the number stored in the memory; if both the keyboard input and the memory of the microcontroller are equal the micro controller gives the output signal.

### **Oscillator:**

The oscillator is formed with a crystal and capacitors to generate the resonant frequency. The microcontroller program counter increments for each 12 clock cycles, because the c51 core set takes 12 clock cycles to execute a command.

### **Keyboard:**

The keyboard is input device to the microcontroller to enter the code lock number. It consists of 10 push buttons. I.e. push to on type. If the switch is closed a +5V signal is given to the microcontroller.

### **I<sup>2</sup>C Card:**

The i2c card is used to feed the secret code lock number to the microcontroller. it consists of an i2c EEPROM ic to store the values of the code locks

### **Relay Driver:**

The relay driver is used to drive the relay. It connected to the circuit. The relay is used to switch the output load on/off. the relay consumes higher current around 100mA, and the microcontroller gives an O/P of only 20mA maximum. So a transistor driver is connected in between the microcontroller and the relay to turn the relay on/off.

**Relay:**

The relay is an electro mechanical device, which is used to isolate control circuits and the power circuit and also to switch higher power loads such as door control motors, solenoid coils etc.

**Power supply:**

The power supply circuit consists of:

**1. Transformer:**

The transformer is used to step-down the voltage from 230vac to 12vac and it is designed to give a supply current of 500mA.

**2. Bridge rectifier:**

The bridge rectifier is used to convert the 12vac to 12vdc supply. The full wave bridge rectifier is used to convert the ac supply into pulsating dc supply.

**3. Smoothing circuit:**

The output from the bridge rectifier is of pulsating ac voltage which is smoothed by the smoothing circuit. The smoothing circuit consists of capacitors to remove ripples from the dc supply line.

**4. Regulator:**

The regulator is a 3 terminal solid device. The 12vdc input is given to the regulator and the regulator output is fixed to 5v which will not exceed even though there is change in the input supply voltage. The o/p of the regulator is given to the circuits.

## **PIC Microcontroller Core Features:**

### **INTRODUCTION**

- High-performance RISC CPU
- Only 35 single word instructions to learn
- All single cycle instructions except for program branches which are two cycle
- Operating speed: DC - 20 MHz clock input  
DC - 200 ns instruction cycle
- Up to 8K x 14 words of Flash Program Memory,  
Up to 368 x 8 bytes of Data Memory (RAM)  
Up to 256 x 8 bytes of EEPROM data memory
- Pin out compatible to the PIC16C73/74/76/77
- Interrupt capability (up to 14 internal/external
- Eight level deep hardware stack
- Direct, indirect, and relative addressing modes
- Power-on Reset (POR)
- Power-up Timer (PWRT) and  
Oscillator Start-up Timer (OST)
- Watchdog Timer (WDT) with its own on-chip RC Oscillator for reliable operation
- Programmable code-protection
- Power saving SLEEP mode
- Selectable oscillator options
- Low-power, high-speed CMOS EPROM/EEPROM technology
- Fully static design
- In-Circuit Serial Programming (ICSP) via two pins
- Only single 5V source needed for programming capability
- In-Circuit Debugging via two pins
- Processor read/write access to program memory
- Wide operating voltage range: 2.5V to 5.5V
- High Sink/Source Current: 25 mA

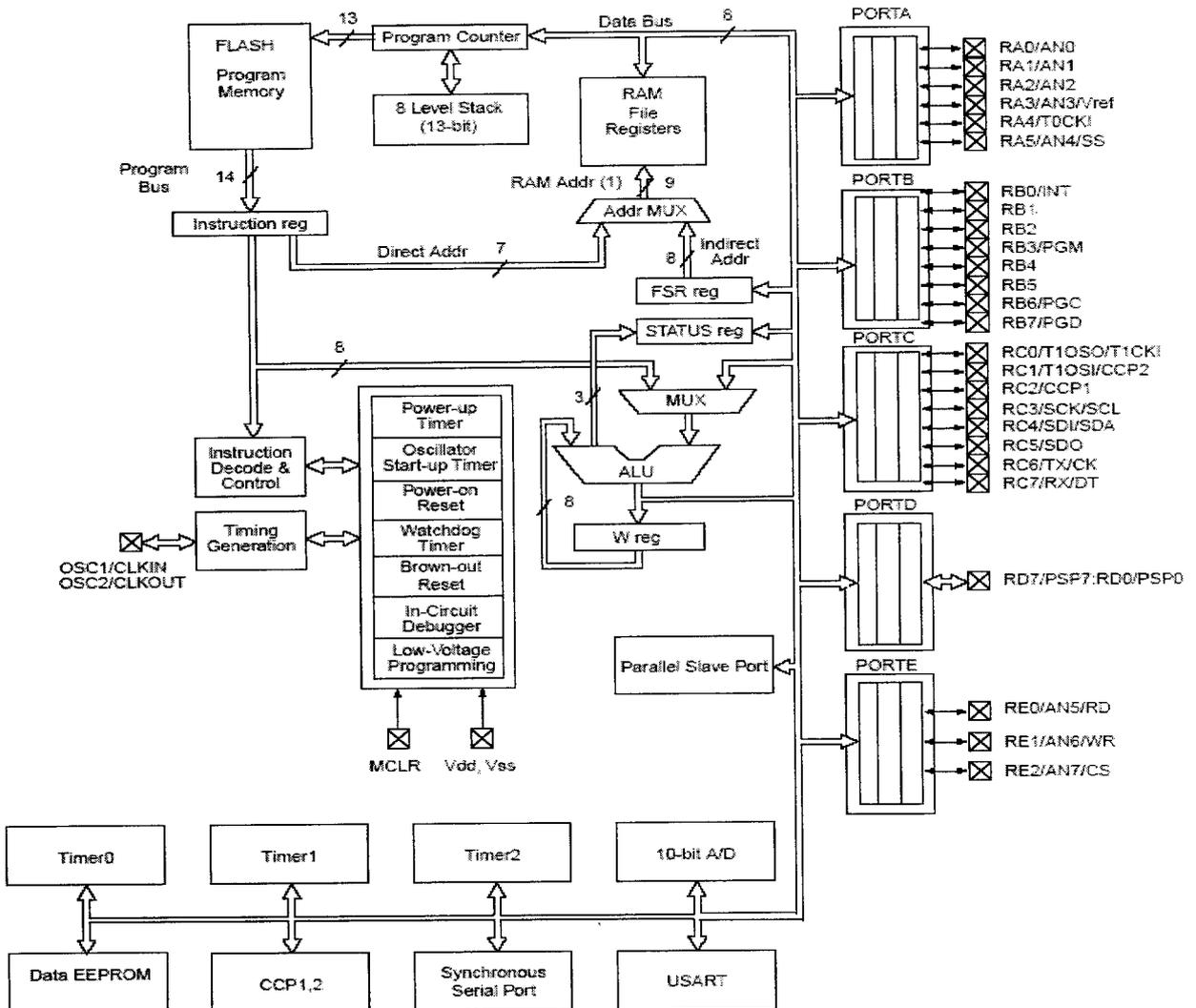
- Commercial and Industrial temperature ranges
- Low-power consumption:
  - < 2 mA typical @ 5V, 4 MHz
  - 20mA typical @ 3V, 32 kHz
  - < 1mA typical standby current

#### **Peripheral Features:**

- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler, can be incremented during sleep via external crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Two Capture, Compare, PWM modules
  - Capture is 16-bit, max resolution is 12.5 ns,
  - Compare is 16-bit, max resolution is 200 ns,
  - PWM max. resolution is 10-bit
- 10-bit multi-channel Analog-to-Digital converter
- Synchronous Serial Port (SSP) with SPI. (Master Mode) and I2C. (Master/Slave)
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with 9-bit address detection.
- Parallel Slave Port (PSP) 8-bits wide, with external RD, WR and CS controls (40/44-pin only)
- Brown-out detection circuitry **for Brown-out Reset (BOR)**

## 4.2 ARCHITECTURE OF PIC 16F877

| Device    | Program Flash | Data Memory | Data EEPROM |
|-----------|---------------|-------------|-------------|
| PIC16F874 | 4K            | 192 Bytes   | 126 Bytes   |
| PIC16F877 | 8K            | 368 Bytes   | 256 Bytes   |

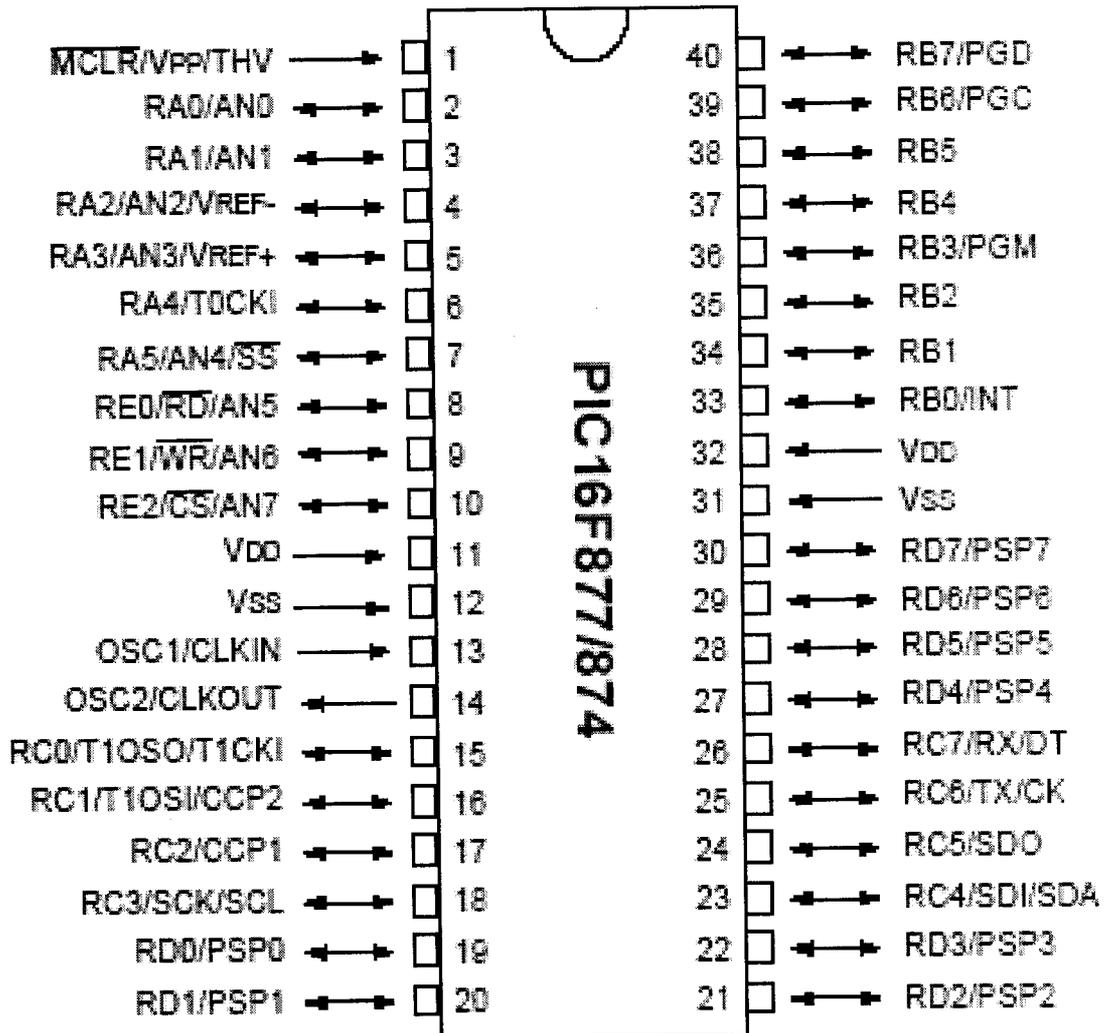


Note 1: Higher order bits are from the STATUS register.

| DEVICE     | PROGRAM FLASH | DATA MEMORY | DATA EEPROM |
|------------|---------------|-------------|-------------|
| PIC 16F877 | 8K            | 368 Bytes   | 256 Bytes   |

# 16f877 PIC MICROCONTROLLER

## PDIP



## PIN OUT DESCRIPTION

| Pin Name      | DIP Pin# | PLCC Pin# | QFP Pin# | I/O/P Type | Buffer Type            | Description  |
|---------------|----------|-----------|----------|------------|------------------------|--|
| OSC1/CLKIN    | 13       | 14        | 30       | I          | ST/CMOS <sup>(4)</sup> | Oscillator crystal input/external clock source input.  |
| OSC2/CLKOUT   | 14       | 15        | 31       | O          | —                      | Oscillator crystal output. Connects to crystal or resonator in crystal oscillator mode. In RC mode, OSC2 pin outputs CLKOUT which has 1/4 the frequency of OSC1, and denotes the instruction cycle rate.   |
| MCLR/VPP/THV  | 1        | 2         | 18       | I/P        | ST                     | Master clear (reset) input or programming voltage input or high voltage test mode control. This pin is an active low reset to the device.  |
| RA0/AN0       | 2        | 3         | 19       | I/O        | TTL                    | PORTA is a bi-directional I/O port.<br>RA0 can also be analog input0<br>RA1 can also be analog input1<br>RA2 can also be analog input2 or negative analog reference voltage<br>RA3 can also be analog input3 or positive analog reference voltage<br>RA4 can also be the clock input to the Timer0 timer/counter. Output is open drain type.<br>RA5 can also be analog input4 or the slave select for the synchronous serial port.               |
| RA1/AN1       | 3        | 4         | 20       | I/O        | TTL                    |  |
| RA2/AN2/VREF- | 4        | 5         | 21       | I/O        | TTL                    |  |
| RA3/AN3/VREF+ | 5        | 6         | 22       | I/O        | TTL                    |  |
| RA4/T0CKI     | 6        | 7         | 23       | I/O        | ST                     |  |
| RA5/SS/AN4    | 7        | 8         | 24       | I/O        | TTL                    |  |
| RB0/INT       | 33       | 36        | 8        | I/O        | TTL/ST <sup>(1)</sup>  | PORTB is a bi-directional I/O port. PORTB can be software programmed for internal weak pull-up on all inputs.<br>RB0 can also be the external interrupt pin.<br>RB3 can also be the low voltage programming input<br>Interrupt on change pin.<br>Interrupt on change pin.<br>Interrupt on change pin or In-Circuit Debugger pin.<br>Serial programming clock.<br>Interrupt on change pin or In-Circuit Debugger pin.<br>Serial programming data. |
| RB1           | 34       | 37        | 9        | I/O        | TTL                    |  |
| RB2           | 35       | 38        | 10       | I/O        | TTL                    |  |
| RB3/PGM       | 36       | 39        | 11       | I/O        | TTL                    |  |
| RB4           | 37       | 41        | 14       | I/O        | TTL                    |  |
| RB5           | 38       | 42        | 15       | I/O        | TTL                    |  |
| RB6/PGC       | 39       | 43        | 16       | I/O        | TTL/ST <sup>(2)</sup>  |  |
| RB7/PGD       | 40       | 44        | 17       | I/O        | TTL/ST <sup>(2)</sup>  |  |

Legend: I = input O = output I/O = input/output P = power  
 — = Not used TTL = TTL input ST = Schmitt Trigger input

### Note

1. This buffer is a Schmitt Trigger input when configured as an external interrupt
2. This buffer is a Schmitt Trigger input when used in serial programming mode.
3. This buffer is a Schmitt Trigger input when configured as general purpose I/O and a TTL input when used in the Parallel Slave Port mode (for interfacing to a microprocessor bus).
4. This buffer is a Schmitt Trigger input when configured in RC oscillator mode and a CMOS input otherwise.

| Pin Name        | DIP Pin# | PLCC Pin#  | QFP Pin#    | I/O/P Type | Buffer Type           | Description  |
|-----------------|----------|------------|-------------|------------|-----------------------|--|
| RC0/T1OSO/T1CKI | 15       | 16         | 32          | I/O        | ST                    | PORTC is a bi-directional I/O port.<br>RC0 can also be the Timer1 oscillator output or a Timer1 clock input.<br>RC1 can also be the Timer1 oscillator input or Capture2 input/Compare2 output/PWM2 output.<br>RC2 can also be the Capture1 input/Compare1 output/PWM1 output.<br>RC3 can also be the synchronous serial clock input/output for both SPI and I <sup>2</sup> C modes.<br>RC4 can also be the SPI Data In (SPI mode) or data I/O (I <sup>2</sup> C mode).<br>RC5 can also be the SPI Data Out (SPI mode).<br>RC6 can also be the USART Asynchronous Transmit or Synchronous Clock.<br>RC7 can also be the USART Asynchronous Receive or Synchronous Data. |
| RC1/T1OSI/CCP2  | 16       | 18         | 35          | I/O        | ST                    |  |
| RC2/CCP1        | 17       | 19         | 36          | I/O        | ST                    |  |
| RC3/SCK/SCL     | 18       | 20         | 37          | I/O        | ST                    |  |
| RC4/SDI/SDA     | 23       | 25         | 42          | I/O        | ST                    |  |
| RC5/SDO         | 24       | 26         | 43          | I/O        | ST                    |  |
| RC6/TX/CK       | 25       | 27         | 44          | I/O        | ST                    |  |
| RC7/RX/DT       | 26       | 29         | 1           | I/O        | ST                    |  |
| RD0/PSP0        | 19       | 21         | 38          | I/O        | ST/TTL <sup>(3)</sup> | PORTD is a bi-directional I/O port or parallel slave port when interfacing to a microprocessor bus.  |
| RD1/PSP1        | 20       | 22         | 39          | I/O        | ST/TTL <sup>(3)</sup> |  |
| RD2/PSP2        | 21       | 23         | 40          | I/O        | ST/TTL <sup>(3)</sup> |  |
| RD3/PSP3        | 22       | 24         | 41          | I/O        | ST/TTL <sup>(3)</sup> |  |
| RD4/PSP4        | 27       | 30         | 2           | I/O        | ST/TTL <sup>(3)</sup> |  |
| RD5/PSP5        | 28       | 31         | 3           | I/O        | ST/TTL <sup>(3)</sup> |  |
| RD6/PSP6        | 29       | 32         | 4           | I/O        | ST/TTL <sup>(3)</sup> |  |
| RD7/PSP7        | 30       | 33         | 5           | I/O        | ST/TTL <sup>(3)</sup> |  |
| RE0/RD/AN5      | 8        | 9          | 25          | I/O        | ST/TTL <sup>(3)</sup> | PORTE is a bi-directional I/O port.<br>RE0 can also be read control for the parallel slave port, or analog input5.<br>RE1 can also be write control for the parallel slave port, or analog input6.<br>RE2 can also be select control for the parallel slave port, or analog input7.  |
| RE1/WR/AN6      | 9        | 10         | 26          | I/O        | ST/TTL <sup>(3)</sup> |  |
| RE2/CS/AN7      | 10       | 11         | 27          | I/O        | ST/TTL <sup>(3)</sup> |  |
| V <sub>SS</sub> | 12,31    | 13,34      | 6,29        | P          | —                     | Ground reference for logic and I/O pins.   |
| V <sub>DD</sub> | 11,32    | 12,35      | 7,28        | P          | —                     | Positive supply for logic and I/O pins.  |
| NC              | —        | 1,17,28,40 | 12,13,33,34 |            | —                     | These pins are not internally connected. These pins should be left unconnected.  |

Legend: I = input O = output I/O = input/output P = power  
 — = Not used TTL = TTL input ST = Schmitt Trigger input

### Note

1. This buffer is a Schmitt Trigger input when configured as an external interrupt.
2. This buffer is a Schmitt Trigger input when used in serial programming mode.
3. This buffer is a Schmitt Trigger input when configured as general purpose I/O and a TTL input when used in the Parallel Slave Port mode (for interfacing to a microprocessor bus).
4. This buffer is a Schmitt Trigger input when configured in RC oscillator mode and a CMOS input otherwise.

### 4.3 I/O PORTS

Some pins for these I/O ports are multiplexed with an alternate function for the peripheral features on the device. In general, when a peripheral is enabled, that pin may not be used as a general purpose I/O pin.

Additional Information on I/O ports may be found in the ICmicro™ Mid-Range Reference Manual,

#### **PORTA and the TRISA Register**

PORTA is a 6-bit wide bi-directional port. The corresponding data direction register is TRISA. Setting a TRISA bit (=1) will make the corresponding PORTA pin an input, i.e., put the corresponding output driver in a Hi-impedance mode. Clearing a TRISA bit (=0) will make the corresponding PORTA pin an output, i.e., put the contents of the output latch on the selected pin. Reading the PORTA register reads the status of the pins whereas writing to it will write to the port latch. All write operations are read-modify-write operations. Therefore a write to a port implies that the port pins are read; this value is modified, and then written to the port data latch. Pin RA4 is multiplexed with the Timer0 module clock input to become the RA4/T0CKI pin. The RA4/T0CKI pin is a Schmitt Trigger input and an open drain output. All other RA port pins have TTL input levels and full CMOS output drivers. Other PORTA pins are multiplexed with analog inputs and analog VREF input. The operation of each pin is selected by clearing/setting the control bits in the ADCON1 register (A/D Control Register1).

The TRISA register controls the direction of the RA pins, even when they are being used as analog inputs. The user must ensure the bits in the TRISA register are maintained set when using them as analog inputs.

## PORT A Function

| Name         | Bit# | Buffer | Function   |
|--------------|------|--------|--|
| RA0/AN0      | bit0 | TTL    | Input/output or analog input   |
| RA1/AN1      | bit1 | TTL    | Input/output or analog input   |
| RA2/AN2      | bit2 | TTL    | Input/output or analog input   |
| RA3/AN3/VREF | bit3 | TTL    | Input/output or analog input or VREF   |
| RA4/T0CKI    | bit4 | ST     | Input/output or external clock input for Timer0<br>Output is open drain type   |
| RA5/SS/AN4   | bit5 | TTL    | Input/output or slave select input for synchronous serial port or analog input |

Legend: TTL = TTL input, ST = Schmitt Trigger input

## SUMMARY OF REGISTERS ASSOCIATED WITH PORTA

| Address | Name   | Bit 7 | Bit 6 | Bit 5                         | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 | Value on:<br>POR,<br>BOR | Value on all<br>other resets |
|---------|--------|-------|-------|-------------------------------|-------|-------|-------|-------|-------|--------------------------|------------------------------|
| 05h     | PORTA  | —     | —     | RA5                           | RA4   | RA3   | RA2   | RA1   | RA0   | --0x 0000                | --0u 0000                    |
| 85h     | TRISA  | —     | —     | PORTA Data Direction Register |       |       |       |       |       | --11 1111                | --11 1111                    |
| 9Fh     | ADCON1 | —     | —     | ADFM                          | —     | PCFG3 | PCFG2 | PCFG1 | PCFG0 | --0- 0000                | --0- 0000                    |

Legend: x = unknown, u = unchanged, - = unimplemented  
locations read as '0'. Shaded cells are not used by PORTA.

## PORTB and the TRISB Register

PORTB is an 8-bit wide bi-directional port. The corresponding data direction register is TRISB. Setting a TRISB bit (=1) will make the corresponding PORTB pin an input, i.e., put the corresponding output driver in a hi-impedance mode. Clearing a TRISB bit (=0) will make the corresponding PORTB pin an output, i.e., put the contents of the output latch on the selected pin. Three pins of PORTB are multiplexed with the Low Voltage Programming function; RB3/PGM, RB6/PGC and RB7/PGD. The alternate functions of these pins are described in the Special Features Section. Each of the PORTB pins has a weak internal pull-up. A single control bit can turn on all the pull-ups. This is performed by clearing bit

RBPU (OPTION\_REG<7>). The weak pull-up is automatically turned off when the port pin is configured as an output. The pull-ups are disabled on a Power-on Reset.

Four of PORTB's pins, RB7:RB4, have an interrupt on change feature. Only pins configured as inputs can cause this interrupt to occur (i.e. any RB7:RB4 pin configured as an output is excluded from the interrupt on change comparison). The input pins (of RB7:RB4) are compared with the old value latched on the last read of PORTB. The "mismatch" outputs of RB7:RB4 are OR'ed together to generate the RB Port Change Interrupt with flag bit RBIF (INTCON<0>). This interrupt can wake the device from SLEEP. The user, in the interrupt service routine, can clear the interrupt in the following manner:

a) Any read or write of PORTB. This will end the mismatch condition.

b) Clear flag bit RBIF. A mismatch condition will continue to set flag bit RBIF. Reading PORTB will end the mismatch condition, and allow flag bit RBIF to be cleared. The interrupt on change feature is recommended for wake-up on key depression operation and operations where PORTB is only used for the interrupt on change feature. Polling of PORTB is not recommended while using the interrupt on change feature. This interrupt on mismatch feature, together with software configurable pull-ups on these four pins, allow easy interface to a keypad and make it possible for wake-up on key depression

## PORT B FUNCTIONS

| Name    | Bit# | Buffer                | Function   |
|---------|------|-----------------------|--|
| RB0/INT | bit0 | TTL/ST <sup>(1)</sup> | Input/output pin or external interrupt input. Internal software programmable weak pull-up.   |
| RB1     | bit1 | TTL                   | Input/output pin. Internal software programmable weak pull-up.   |
| RB2     | bit2 | TTL                   | Input/output pin. Internal software programmable weak pull-up.   |
| RB3/PGM | bit3 | TTL                   | Input/output pin or programming pin in LVP mode. Internal software programmable weak pull-up.  |
| RB4     | bit4 | TTL                   | Input/output pin (with interrupt on change). Internal software programmable weak pull-up.  |
| RB5     | bit5 | TTL                   | Input/output pin (with interrupt on change). Internal software programmable weak pull-up.  |
| RB6/PGC | bit6 | TTL/ST <sup>(2)</sup> | Input/output pin (with interrupt on change) or In-Circuit Debugger pin. Internal software programmable weak pull-up. Serial programming clock. |
| RB7/PGD | bit7 | TTL/ST <sup>(2)</sup> | Input/output pin (with interrupt on change) or In-Circuit Debugger pin. Internal software programmable weak pull-up. Serial programming data.  |

Legend: TTL = TTL input, ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.

2: This buffer is a Schmitt Trigger input when used in serial programming mode.

## SUMMARY OF REGISTERS ASSOCIATED WITH PORTB

| Address   | Name        | Bit 7                         | Bit 6  | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 | Value on:<br>POR,<br>BOR | Value on all<br>other resets |
|-----------|-------------|-------------------------------|--------|-------|-------|-------|-------|-------|-------|--------------------------|------------------------------|
| 06h, 106h | PORTB       | RB7                           | RB6    | RB5   | RB4   | RB3   | RB2   | RB1   | RB0   | xxxx xxxx                | uuuu uuuu                    |
| 86h, 186h | TRISB       | PORTB Data Direction Register |        |       |       |       |       |       |       | 1111 1111                | 1111 1111                    |
| 81h, 181h | OPTION_ REG | RBPUP                         | INTEDG | T0CS  | T0SE  | PSA   | PS2   | PS1   | PS0   | 1111 1111                | 1111 1111                    |

Legend: x = unknown, u = unchanged. Shaded cells are not used by PORTB.

## PORTC and the TRISC Register

PORTC is an 8-bit wide bi-directional port. The corresponding data direction register is TRISC. Setting a TRISC bit (=1) will make the corresponding PORTC pin an input, i.e., put the corresponding output driver in a hi-impedance mode. Clearing a TRISC bit (=0) will make the corresponding PORTC pin an output, i.e., put the contents of the output

latch on the selected pin. PORTC is multiplexed with several peripheral functions

(Table-3.5). PORTC pins have Schmitt Trigger input buffers.

When the I2C module is enabled, the PORTC (3:4) pins can be configured with normal I2C levels or with SMBUS levels by using the CKE bit (SSPSTAT <6>).

When enabling peripheral functions, care should be taken in defining TRIS bits for each PORTC pin. Some peripherals override the TRIS bit to make a pin an output, while other peripherals override the TRIS bit to make a pin an input. Since the TRIS bit override is in effect while the peripheral is enabled, read-modify write instructions (BSF, BCF, XORWF) with TRISC as destination should be avoided. The user should refer to the corresponding peripheral section for the correct TRIS bit settings.

## PORTC FUNCTIONS

| Name            | Bit# | Buffer Type | Function   |
|-----------------|------|-------------|--|
| RC0/T1OSO/T1CKI | bit0 | ST          | Input/output port pin or Timer1 oscillator output/Timer1 clock input                           |
| RC1/T1OSI/CCP2  | bit1 | ST          | Input/output port pin or Timer1 oscillator input or Capture2 input/Compare2 output/PWM2 output |
| RC2/CCP1        | bit2 | ST          | Input/output port pin or Capture1 input/Compare1 output/PWM1 output                            |
| RC3/SCK/SCL     | bit3 | ST          | RC3 can also be the synchronous serial clock for both SPI and I <sup>2</sup> C modes.          |
| RC4/SDI/SDA     | bit4 | ST          | RC4 can also be the SPI Data In (SPI mode) or data I/O (I <sup>2</sup> C mode).                |
| RC5/SDO         | bit5 | ST          | Input/output port pin or Synchronous Serial Port data output                                   |
| RC6/TX/CK       | bit6 | ST          | Input/output port pin or USART Asynchronous Transmit or Synchronous Clock                      |
| RC7/RX/DT       | bit7 | ST          | Input/output port pin or USART Asynchronous Receive or Synchronous Data                        |

Legend: ST = Schmitt Trigger input

## SUMMARY OF REGISTERS ASSOCIATED WITH PORTC

| Address | Name  | Bit 7                         | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 | Value on: POR, BOR | Value on all other resets |
|---------|-------|-------------------------------|-------|-------|-------|-------|-------|-------|-------|--------------------|---------------------------|
| 07h     | PORTC | RC7                           | RC6   | RC5   | RC4   | RC3   | RC2   | RC1   | RC0   | xxxx xxxx          | uuuu uuuu                 |
| 87h     | TRISC | PORTC Data Direction Register |       |       |       |       |       |       |       | 1111 1111          | 1111 1111                 |

Legend: x = unknown, u = unchanged.

## PORTD and TRISD Registers

This section is not applicable to the 28-pin devices. PORTD is an 8-bit port with Schmitt Trigger input buffers. Each pin is individually configurable as an input or output.

PORTD can be configured as an 8-bit wide microprocessor Port (parallel slave port) by setting control bit PSPMODE (TRISE<4>). In this mode, the input buffers are TTL.

## PORTD FUNCTIONS

| Name     | Bit# | Buffer Type           | Function  |
|----------|------|-----------------------|---|
| RD0/PSP0 | bit0 | ST/TTL <sup>(1)</sup> | Input/output port pin or parallel slave port bit0 |
| RD1/PSP1 | bit1 | ST/TTL <sup>(1)</sup> | Input/output port pin or parallel slave port bit1 |
| RD2/PSP2 | bit2 | ST/TTL <sup>(1)</sup> | Input/output port pin or parallel slave port bit2 |
| RD3/PSP3 | bit3 | ST/TTL <sup>(1)</sup> | Input/output port pin or parallel slave port bit3 |
| RD4/PSP4 | bit4 | ST/TTL <sup>(1)</sup> | Input/output port pin or parallel slave port bit4 |
| RD5/PSP5 | bit5 | ST/TTL <sup>(1)</sup> | Input/output port pin or parallel slave port bit5 |
| RD6/PSP6 | bit6 | ST/TTL <sup>(1)</sup> | Input/output port pin or parallel slave port bit6 |
| RD7/PSP7 | bit7 | ST/TTL <sup>(1)</sup> | Input/output port pin or parallel slave port bit7 |

Legend: ST = Schmitt Trigger input TTL = TTL input

Note 1: Input buffers are Schmitt Triggers when in I/O mode and TTL buffer when in Parallel Slave Port Mode.

## SUMMARY OF REGISTERS ASSOCIATED WITH PORTD

| Address | Name  | Bit 7                         | Bit 6 | Bit 5 | Bit 4   | Bit 3 | Bit 2                     | Bit 1 | Bit 0 | Value on:<br>POR,<br>BOR | Value on all<br>other<br>resets |
|---------|-------|-------------------------------|-------|-------|---------|-------|---------------------------|-------|-------|--------------------------|---------------------------------|
| 08h     | PORTD | RD7                           | RD6   | RD5   | RD4     | RD3   | RD2                       | RD1   | RD0   | xxxx xxxx                | uuuu uuuu                       |
| 88h     | TRISD | PORTD Data Direction Register |       |       |         |       |                           |       |       | 1111 1111                | 1111 1111                       |
| 89h     | TRISE | IBF                           | OBF   | IBOV  | PSPMODE | —     | PORTE Data Direction Bits |       |       | 0000 -111                | 0000 -111                       |

Legend: x = unknown, u = unchanged, - = unimplemented read as '0'. Shaded cells are not used by PORTD.

## PORTE and TRISE Register

PORTE has three pins RE0/RD/AN5, RE1/WR/AN6 and RE2/CS/AN7, which are individually configurable as inputs or outputs. These pins have Schmitt Trigger input buffers.

The PORTE pins become control inputs for the microprocessor port when bit PSPMODE (TRISE<4>) is set. In this mode, the user must make sure that the TRISE<2:0> bits are set (pins are configured as digital inputs). Ensure ADCON1 is configured for digital I/O. In this mode the input buffers are TTL.

PORTE pins are multiplexed with analog inputs. When selected as an analog input, these pins will read as '0's. TRISE controls the direction of the RE pins, even when they are being used as analog inputs. The user must make sure to keep the pins configured as inputs when using them as analog inputs.

### PORTE FUNCTIONS

| Name       | Bit# | Buffer Type           | Function  |
|------------|------|-----------------------|---|
| RE0/RD/AN5 | bit0 | ST/TTL <sup>(1)</sup> | Input/output port pin or read control input in parallel slave port mode or analog input:<br>RD<br>1 = Not a read operation<br>0 = Read operation. Reads PORTD register (if chip selected)     |
| RE1/WR/AN6 | bit1 | ST/TTL <sup>(1)</sup> | Input/output port pin or write control input in parallel slave port mode or analog input:<br>WR<br>1 = Not a write operation<br>0 = Write operation. Writes PORTD register (if chip selected) |
| RE2/CS/AN7 | bit2 | ST/TTL <sup>(1)</sup> | Input/output port pin or chip select control input in parallel slave port mode or analog input:<br>CS<br>1 = Device is not selected<br>0 = Device is selected                                 |

Legend: ST = Schmitt Trigger input TTL = TTL input

Note 1: Input buffers are Schmitt Triggers when in I/O mode and TTL buffers when in Parallel Slave Port Mode.

### SUMMARY OF REGISTERS ASSOCIATED WITH PORTE

| Addr | Name   | Bit 7 | Bit 6 | Bit 5 | Bit 4   | Bit 3 | Bit 2                     | Bit 1 | Bit 0 | Value on:<br>POR,<br>BOR | Value on all<br>other resets |
|------|--------|-------|-------|-------|---------|-------|---------------------------|-------|-------|--------------------------|------------------------------|
| 09h  | PORTE  | —     | —     | —     | —       | —     | RE2                       | RE1   | RE0   | ---- -xxx                | ---- -uuu                    |
| 89h  | TRISE  | IBF   | OBF   | IBOV  | PSPMODE | —     | PORTE Data Direction Bits |       |       | 0000 -111                | 0000 -111                    |
| 9Fh  | ADCON1 | —     | —     | ADFM  | —       | PCFG3 | PCFG2                     | PCFG1 | PCFG0 | --0- 0000                | --0- 0000                    |

Legend: x = unknown, u = unchanged, - = unimplemented read as '0'. Shaded cells are not used by PORTE.

## MEMORY ORGANISATION

There are three memory blocks in each of the PIC16f877 MUCs. The program memory and Data Memory have separate buses so that concurrent access can occur.

### 4.4 PROGRAM MEMORY ORGANISATION

The PIC16f877 devices have a 13-bit program counter capable of addressing 8K \* 14 words of FLASH program memory. Accessing a location above the physically implemented address will cause a wraparound.

The RESET vector is at 0000h and the interrupt vector is at 0004h.

### DATA MEMORY ORGANISATION

The data memory is partitioned into multiple banks which contain the General Purpose Registers and the special functions Registers. Bits RP1 (STATUS<6>) and RP0 (STATUS<5>) are the bank selected bits.

| RP1:RP0 | Banks |
|---------|-------|
| 00      | 0     |
| 01      | 1     |
| 10      | 2     |
| 11      | 3     |

Each bank extends up to 7Fh (1238 bytes). The lower locations of each bank are reserved for the Special Function Registers. Above the Special Function Registers are General Purpose Registers, implemented as static RAM. All implemented banks contain special function registers. Some frequently used special function registers from one bank may be mirrored in another bank for code reduction and quicker access.

### GENERAL PURPOSE REGISTER FILE

The register file can be accessed either directly or indirectly through the File Selected Register (FSR).

# PIC16F877 REGISTER FILE MAP

|                                      |     |                                      |     |                                      |      | File Address                         |      |
|--------------------------------------|-----|--------------------------------------|-----|--------------------------------------|------|--------------------------------------|------|
| Indirect addr. <sup>(*)</sup>        | 00h | Indirect addr. <sup>(*)</sup>        | 80h | Indirect addr. <sup>(*)</sup>        | 100h | Indirect addr. <sup>(*)</sup>        | 180h |
| TMR0                                 | 01h | OPTION_REG                           | 81h | TMR0                                 | 101h | OPTION_REG                           | 181h |
| PCL                                  | 02h | PCL                                  | 82h | PCL                                  | 102h | PCL                                  | 182h |
| STATUS                               | 03h | STATUS                               | 83h | STATUS                               | 103h | STATUS                               | 183h |
| FSR                                  | 04h | FSR                                  | 84h | FSR                                  | 104h | FSR                                  | 184h |
| PORTA                                | 05h | TRISA                                | 85h |                                      | 105h |                                      | 185h |
| PORTB                                | 06h | TRISB                                | 86h | PORTB                                | 106h | TRISB                                | 186h |
| PORTC                                | 07h | TRISC                                | 87h |                                      | 107h |                                      | 187h |
| PORTD <sup>(1)</sup>                 | 08h | TRISD <sup>(1)</sup>                 | 88h |                                      | 108h |                                      | 188h |
| PORTE <sup>(1)</sup>                 | 09h | TRISE <sup>(1)</sup>                 | 89h |                                      | 109h |                                      | 189h |
| PCLATH                               | 0Ah | PCLATH                               | 8Ah | PCLATH                               | 10Ah | PCLATH                               | 18Ah |
| INTCON                               | 0Bh | INTCON                               | 8Bh | INTCON                               | 10Bh | INTCON                               | 18Bh |
| PIR1                                 | 0Ch | PIE1                                 | 8Ch | EEDATA                               | 10Ch | EECON1                               | 18Ch |
| PIR2                                 | 0Dh | PIE2                                 | 8Dh | EEADR                                | 10Dh | EECON2                               | 18Dh |
| TMR1L                                | 0Eh | PCON                                 | 8Eh | EEDATH                               | 10Eh | Reserved <sup>(2)</sup>              | 18Eh |
| TMR1H                                | 0Fh |                                      | 8Fh | EEADRH                               | 10Fh | Reserved <sup>(2)</sup>              | 18Fh |
| T1CON                                | 10h |                                      | 90h |                                      | 110h |                                      | 190h |
| TMR2                                 | 11h | SSPCON2                              | 91h |                                      | 111h |                                      | 191h |
| T2CON                                | 12h | PR2                                  | 92h |                                      | 112h |                                      | 192h |
| SSPBUF                               | 13h | SSPAD                                | 93h |                                      | 113h |                                      | 193h |
| SSPCON                               | 14h | SSPSTAT                              | 94h |                                      | 114h |                                      | 194h |
| CCPR1L                               | 15h |                                      | 95h |                                      | 115h |                                      | 195h |
| CCPR1H                               | 16h |                                      | 96h |                                      | 116h |                                      | 196h |
| CCP1CON                              | 17h |                                      | 97h | General Purpose Register<br>16 Bytes | 117h | General Purpose Register<br>16 Bytes | 197h |
| RCSTA                                | 18h | TXSTA                                | 98h |                                      | 118h |                                      | 198h |
| TXREG                                | 19h | SPBRG                                | 99h |                                      | 119h |                                      | 199h |
| RCREG                                | 1Ah |                                      | 9Ah |                                      | 11Ah |                                      | 19Ah |
| CCPR2L                               | 1Bh |                                      | 9Bh |                                      | 11Bh |                                      | 19Bh |
| CCPR2H                               | 1Ch |                                      | 9Ch |                                      | 11Ch |                                      | 19Ch |
| CCP2CON                              | 1Dh |                                      | 9Dh |                                      | 11Dh |                                      | 19Dh |
| ADRESH                               | 1Eh | ADRESL                               | 9Eh |                                      | 11Eh |                                      | 19Eh |
| ADCON0                               | 1Fh | ADCON1                               | 9Fh |                                      | 11Fh |                                      | 19Fh |
|                                      | 20h |                                      | A0h |                                      | 120h |                                      | 1A0h |
| General Purpose Register<br>96 Bytes |     | General Purpose Register<br>80 Bytes |     | General Purpose Register<br>80 Bytes |      | General Purpose Register<br>80 Bytes |      |
|                                      |     | accesses<br>70h-7Fh                  |     | accesses<br>70h-7Fh                  |      | accesses<br>70h - 7Fh                |      |
| Bank 0                               | 7Fh | Bank 1                               | FFh | Bank 2                               | 17Fh | Bank 3                               | 1FFh |

■ Unimplemented data memory locations, read as '0'.

\* Not a physical register.

Note 1: These registers are not implemented on 28-pin devices.

2: These registers are reserved, maintain these registers clear.

## 4.5 INSTRUCTION SET SUMMARY

Each PIC 16f877 instruction is a 14-bit word, divided into an OPCODE which specifies the instruction type and one or more operand which further specify the operation of the instruction. The PIC16F877 instruction set summary in table 12 lists **byte-oriented**, **bit-oriented**, and **literal and control** operations. Table 11 shows the opcode field descriptions.

For **byte-oriented** instructions, 'f' represents a file register designator and 'd' represents a destination designator. The file register designator specifies which file register is to be used by the instruction. The destination designator specifies where the result of the operation is to be placed. If 'd' is zero, the result is placed in the w register. If 'd' is one, the result is placed in the file register specified in the instruction.

For **bit-oriented** instructions, 'b' represents a bit field designator which selects the number of the bit affected by the operation, which 'f' represents the address of the file in which the bits are located.

For literal and control operations, 'k' represents an eight or eleven bit constant or literal value.

## OPCODE FIELD DESCRIPTIONS

| Field           | Description   |
|-----------------|---|
| f               | Register file address (0x00 to 0x7F)  |
| w               | Working register (accumulator)  |
| b               | Bit address within an 8-bit file register   |
| k               | Literal field, constant data or label   |
| x               | Don't care location (= 0 or 1)<br>The assembler will generate code with x = 0. It is the recommended form of use for compatibility with all Microchip software tools. |
| d               | Destination select; d = 0: store result in W,<br>d = 1: store result in file register f.<br>Default is d = 1  |
| PC              | Program Counter   |
| $\overline{TO}$ | Time-out bit  |
| $\overline{PD}$ | Power-down bit  |



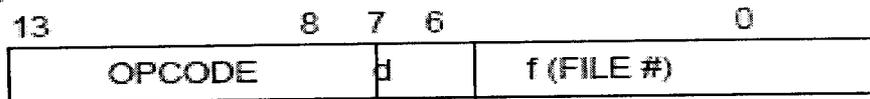
The instruction set is highly orthogonal and is grouped into three basic categories:

- **Byte-oriented** operations
- **Bit-oriented** operations
- **Literal and control** operations

All instructions are executed within one single instruction cycle, unless a conditional test is true or the program counter is changed as a result of an instruction. In this case, the execution takes two instruction cycles with the second cycle executed as a NOP. One instruction cycle consists of four oscillator periods. Thus, for an oscillator frequency of 4 MHz, the normal instruction execution time is 1 ms. If a conditional test is true or the program counter is changed as a result of an instruction, the instruction execution time is 2 ms.

## GENERAL FORMAT FOR INSTRUCTIONS

### Byte-oriented file register operations

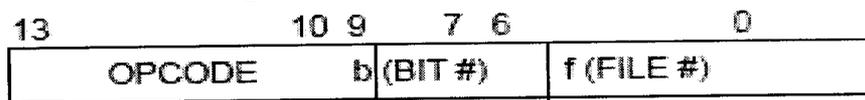


d = 0 for destination W

d = 1 for destination f

f = 7-bit file register address

### Bit-oriented file register operations

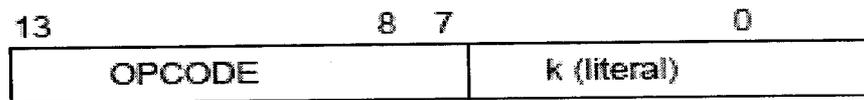


b = 3-bit bit address

f = 7-bit file register address

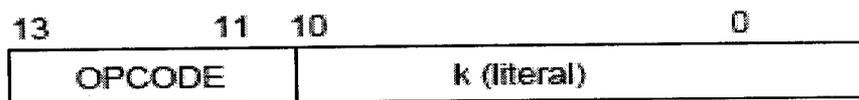
### Literal and control operations

#### General



k = 8-bit immediate value

#### CALL and GOTO instructions only



k = 11-bit immediate value

# 16F877 INSTRUCTION SET

| Mnemonic,<br>Operands                         | Description | Cycles                       | 14-Bit Opcode |    |      | Status<br>Affected | Notes |        |       |
|---|-------------|------------------------------|---------------|----|------|--------------------|-------|--------|-------|
|   |             |                              | MSb           |    | LSb  |                    |       |        |       |
| <b>BYTE-ORIENTED FILE REGISTER OPERATIONS</b> |             |                              |               |    |      |                    |       |        |       |
| ADDWF   | f, d        | Add W and f                  | 1             | 00 | 0111 | dfff               | ffff  | C,DC,Z | 1,2   |
| ANDWF   | f, d        | AND W with f                 | 1             | 00 | 0101 | dfff               | ffff  | Z      | 1,2   |
| CLRF  | f           | Clear f                      | 1             | 00 | 0001 | 1fff               | ffff  | Z      | 2     |
| CLRWF   | -           | Clear W                      | 1             | 00 | 0001 | 0xxxx              | xxxxx | Z      |       |
| COMF  | f, d        | Complement f                 | 1             | 00 | 1001 | dfff               | ffff  | Z      | 1,2   |
| DECF  | f, d        | Decrement f                  | 1             | 00 | 0011 | dfff               | ffff  | Z      | 1,2   |
| DECFSZ  | f, d        | Decrement f, Skip if 0       | 1(2)          | 00 | 1011 | dfff               | ffff  |        | 1,2,3 |
| INCF  | f, d        | Increment f                  | 1             | 00 | 1010 | dfff               | ffff  | Z      | 1,2   |
| INCFSZ  | f, d        | Increment f, Skip if 0       | 1(2)          | 00 | 1111 | dfff               | ffff  |        | 1,2,3 |
| IORWF   | f, d        | Inclusive OR W with f        | 1             | 00 | 0100 | dfff               | ffff  | Z      | 1,2   |
| MOVF  | f, d        | Move f                       | 1             | 00 | 1000 | dfff               | ffff  | Z      | 1,2   |
| MOVWF   | f           | Move W to f                  | 1             | 00 | 0000 | 1fff               | ffff  |        |       |
| NOP   | -           | No Operation                 | 1             | 00 | 0000 | 0xxx0              | 0000  |        |       |
| RLF   | f, d        | Rotate Left f through Carry  | 1             | 00 | 1101 | dfff               | ffff  | C      | 1,2   |
| RRF   | f, d        | Rotate Right f through Carry | 1             | 00 | 1100 | dfff               | ffff  | C      | 1,2   |
| SUBWF   | f, d        | Subtract W from f            | 1             | 00 | 0010 | dfff               | ffff  | C,DC,Z | 1,2   |
| SWAPF   | f, d        | Swap nibbles in f            | 1             | 00 | 1110 | dfff               | ffff  |        | 1,2   |
| XORWF   | f, d        | Exclusive OR W with f        | 1             | 00 | 0110 | dfff               | ffff  | Z      | 1,2   |
| <b>BIT-ORIENTED FILE REGISTER OPERATIONS</b>  |             |                              |               |    |      |                    |       |        |       |
| BCF   | f, b        | Bit Clear f                  | 1             | 01 | 00bb | bfff               | ffff  |        | 1,2   |
| BSF   | f, b        | Bit Set f                    | 1             | 01 | 01bb | bfff               | ffff  |        | 1,2   |
| BTFSC   | f, b        | Bit Test f, Skip if Clear    | 1(2)          | 01 | 10bb | bfff               | ffff  |        | 3     |
| BTFSS   | f, b        | Bit Test f, Skip if Set      | 1(2)          | 01 | 11bb | bfff               | ffff  |        | 3     |
| <b>LITERAL AND CONTROL OPERATIONS</b>         |             |                              |               |    |      |                    |       |        |       |
| ADDLW   | k           | Add literal and W            | 1             | 11 | 111x | kddd               | kddd  | C,DC,Z |       |
| ANDLW   | k           | AND literal with W           | 1             | 11 | 1001 | kddd               | kddd  | Z      |       |
| CALL  | k           | Call subroutine              | 2             | 10 | 0kdk | kddd               | kddd  |        |       |
| CLRWDT  | -           | Clear Watchdog Timer         | 1             | 00 | 0000 | 0110               | 0100  | TO,PD  |       |
| GOTO  | k           | Go to address                | 2             | 10 | 1kdk | kddd               | kddd  |        |       |
| IORLW   | k           | Inclusive OR literal with W  | 1             | 11 | 1000 | kddd               | kddd  | Z      |       |
| MOVLW   | k           | Move literal to W            | 1             | 11 | 00xx | kddd               | kddd  |        |       |
| RETFIE  | -           | Return from interrupt        | 2             | 00 | 0000 | 0000               | 1001  |        |       |
| RETLW   | k           | Return with literal in W     | 2             | 11 | 01xx | kddd               | kddd  |        |       |
| RETURN  | -           | Return from Subroutine       | 2             | 00 | 0000 | 0000               | 1000  |        |       |
| SLEEP   | -           | Go into standby mode         | 1             | 00 | 0000 | 0110               | 0011  | TO,PD  |       |
| SUBLW   | k           | Subtract W from literal      | 1             | 11 | 110x | kddd               | kddd  | C,DC,Z |       |
| XORLW   | k           | Exclusive OR literal with W  | 1             | 11 | 1010 | kddd               | kddd  | Z      |       |

**Note 1:** When an I/O register is modified as a function of itself ( e.g., MOVF PORTB, 1), the value used will be that value present on the pins themselves. For example, if the data latch is '1' for a pin configured as input and is driven low by an external device, the data will be written back with a '0'.

- 2: If this instruction is executed on the TMR0 register (and, where applicable, d = 1), the prescaler will be cleared if assigned to the Timer0 Module.
- 3: If Program Counter (PC) is modified or a conditional test is true, the instruction requires two cycles. The second cycle is executed as a NOP.

## **CHAPTER - 5**

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### **CONCLUSION**

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## CONCLUSION

Thus our project “PORTABLE ADDRESS BOOK KIT WITH DIALER AND VOICE RECORDER” have been designed and implemented successfully.

In this project, we had implemented the features using electronic circuits, by understanding the concepts right. It can be made simpler using the embedded techniques. In our project, we had used more number of relays, making the circuit larger, which can be made simpler using the IC 91217, a serial input DTMF generator IC.

This project can be further enhanced with implementing auto answering technique, which will make our home phone a more advantaged than mobile phones.

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**APPENDIX**

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## APPENDIX – I

### PROGRAM CODING

```
#include <pic.h>
#include <f87x.h>
#include <lcd_d.h>
#include <flash.h>
#include <stdio.h>
```

```
#define cradle      RC0
#define key_0      RC2
#define key_1      RC3
#define key_2      RC1
#define key_3      RC4
#define key_4      RC5
#define key_5      RC6
#define key_6      RC7
#define key_7      RB0
#define key_8      RB1
#define key_9      RB2
#define record     RE0
```

```
unsigned int delay;
```

```
unsigned char main_address_l, main_address_h, x, lne, INDEX, ring;
```

```
bit put_name, display_data, enter_ra0, data_dis;
```

```
bit leave, enter;
```

```
void hardware_setup( void);
```

```
void save_data( unsigned char data );
```

```
void get_address( void );
```

```
void display_message( void );
void dial_out( void );
void password_startup( void );
void record_delay( void );
```

```
main()
{
    hardware_setup();
    while(1)
    {
        if( RA0 && enter_ra0 )
        {
            ring++;
            enter_ra0 = 0;
            sprintf( LCD_TABL, "Ringing...  %01u", ring );
            display_2();
            for( delay = 0; delay <= 65000; delay++ );
        }
        if( !RA0 )
        {
            enter_ra0 = 1;
        }
        if( ring >= 10 )
        {
            cradle = 1;
            record = 1;
            record_delay();
            record = 0;
            cradle = 0;
            ring = 0;
        }
    }
}
```

```

if( RA1 )
{
if( data_dis )
{
display_data = 1;
INDEX = 1;
display_message();
line = 1;
data_dis = 0;
}
if( RBIF )
{
if( put_name )
{
display_data = 1;
display_message();
LCD_FLAG = 0;
out( LCD_CAR = 0Xc3 );
LCD_FLAG = 1;
out( LCD_CAR = ( '0' + INDEX ) );
lcd_put_cursor( 1, 6 );
put_name = 0;
x = 6;
if( line == 1 )
{
line = 2;
LCD_TABL[x] = '0';
}
else
{

```

```

line = 1;
LCD_TABL[x] = 'A';
}
}
if( !RB4 )
{
if( !RB7 )
{
if( line == 1 )
{
if( ((LCD_TABL[x] >= 'A') && (LCD_TABL[x] <= 'Z')) ||
((LCD_TABL[x] >= '0') && (LCD_TABL[x] <= '9')) || ( LCD_TABL[x]
== ' ' ))
{
if( LCD_TABL[x] == ' ' )
{
LCD_TABL[x] = '0';
}
else if( LCD_TABL[x] == '9' )
{
LCD_TABL[x] = 'A';
}
else if( LCD_TABL[x] == 'Z' )
{
LCD_TABL[x] = ' ';
}
else
{
LCD_TABL[x]++;
}
}
}
}
}

```

```

else
{
LCD_TABL[x] = ' ';
}
}
else
{
if( ( LCD_TABL[x] >= '0' ) && ( LCD_TABL[x] <= '9' ) )
{
if( LCD_TABL[x] == ' ' )
{
LCD_TABL[x] = '0';
}
else if( LCD_TABL[x] == '9' )
{
LCD_TABL[x] = '0';
}
else
{
LCD_TABL[x]++;
}
}
else
{
LCD_TABL[x] = '0';
}
}
if( line == 1 )
{
LCD_FLAG = 0;

```

```

out( LCD_CAR = 0x80+x );
LCD_FLAG = 1;
out( LCD_CAR = LCD_TABL[x] );
}
else
{
LCD_FLAG = 0;
out( LCD_CAR = 0xc0+x );
LCD_FLAG = 1;
out( LCD_CAR = LCD_TABL[x] );
}
lcd_put_cursor( lne, x );
}
if( !RB6 )
{
if( x == 15 )
{
x = 6;
}
else
{
x++;
}
lcd_put_cursor( lne, x );
}
if( !RB5 )
{
if( line == 1 )
{
get_address();
save_data(1);

```

```

display_data = 1;
display_message();
line = 2;
for( x = 6; x <= 15; x++ )
{
LCD_TABL[x] = “ “;
}
x = 6;
LCD_TABL[x] = ‘0’;
}
else
{
get_address();
save_data(2);
display_data = 1;
display_message();
line = 1;
for( x = 6; x <= 15; x++ )
{
LCD_TABL[x] = “ “;
}
x = 6;
LCD_TABL[x] = ‘A’;
}
lcd_put_cursor( lne, x );
}
}
else
{
put_name = 1;
lcd_cursor_off();

```

```

if( !RB7 )
{
if( INDEX < 10 )
{
INDEX++;
display_data = 1;
}
}
if( !RB6 )
{
if( INDEX > 0 )
{
INDEX--;
display_data = 1;
}
}
get_address();
display_message();
if( !RB5 )
{
dial_out();
}
}
for( delay = 0; delay <= 65000; delay++ );
for( delay = 0; delay <= 65000; delay++ );
RBIF = 0;
}
}
else
{
if( !data_dis )

```



```

/*    for( main_address_h = 0x10; main_address_h <= 0x11;
main_address_h++ )
    {
        for( main_address_l = 0; main_address_l <= 0Xff;
main_address_l++ )
            {
                flash_write( main_address_h, main_address_l, 0, 'R' );
            }
    }*/
data_dis = 1;
}

```

```

void save_data( unsigned char data )
{
    unsigned char z, temp_main_address_l;
    temp_main_address_l = main_address_l;
    if( data == 1 )
    {
        for( z = 6; z <= 15; z++ )
        {
            if( ((LCD_TABL[z] >= 'A') && (LCD_TABL[z] <= 'Z')) ||
((LCD_TABL[z] >= '0') && (LCD_TABL[z] <= '9')) )
            {
                flash_write( main_address_h, temp_main_address_l, 0,
LCD_TABL[z] );
            }
            else
            {
                flash_write( main_address_h, temp_main_address_l, 0, ' ');
            }
            temp_main_address_l++;
        }
    }
}

```

```

    }
    }
    else if( data == 2 )
    {
        temp_main_address_1 = main_address_1 + 10;
        for( z = 6; z <= 15; z++ )
        {
            if( (LCD_TABL[z] >= '0') && (LCD_TABL[z] <= '9') )
            {
                flash_write( main_address_h, temp_main_address_1, 0,
LCD_TABL[z] );
            }
            else
            {
                flash_write( main_address_h, temp_main_address_1, 0, ' ');
            }
            temp_main_address_1++;
        }
    }
}

```

```

void get_address( void )
{
    switch( INDEX )
    {
        case 0:
        {
            main_address_h = 0x11;
            main_address_1 = 0x60;
            break;
        }
    }
}

```

```
case 1:  
{  
main_address_h = 0x10;  
main_address_l = 0x20;  
break;  
}
```

```
case 2:  
{  
main_address_h = 0x10;  
main_address_l = 0x40;  
break;  
}
```

```
case 3:  
{  
main_address_h = 0x10;  
main_address_l = 0x60;  
break;  
}
```

```
case 4:  
{  
main_address_h = 0x10;  
main_address_l = 0x80;  
break;  
}
```

```
case 5:  
{  
main_address_h = 0x10;  
main_address_l = 0xa0;  
break;  
}
```

```
case 6:
```

```
{
    main_address_h = 0x10;
    main_address_l = 0xc0;
    break;
}
case 7:
{
    main_address_h = 0x10;
    main_address_l = 0xe0;
    break;
}
case 8:
{
    main_address_h = 0x11;
    main_address_l = 0x00;
    break;
}
case 9:
{
    main_address_h = 0x11;
    main_address_l = 0x20;
    break;
}
case 10:
{
    main_address_h = 0x11;
    main_address_l = 0x40;
    break;
}
}
```

```

void display_message( void )
{
    unsigned char temp_main_l, a;
    if( display_data )
    {
        get_address();
        temp_main_l = main_address_l;
        sprintf(LCD_TABL,"Name:      ");
        display_1();
        sprintf(LCD_TABL,"No. :      ");
        display_2();
        display_data = 0;
        for( a = 6; a <= 15; a++ )
        {
            LCD_TABL[a] = " ";
        }
        for( a = 6; a <= 15; a++ )
        {
            LCD_TABL[a] = flash_read( main_address_h, temp_main_l );
            temp_main_l++;
            LCD_FLAG = 0;
            out( LCD_CAR = 0x80 + a );
            LCD_FLAG = 1;
            out( LCD_CAR = LCD_TABL[a] );
        }
        for( a = 6; a <= 15; a++ )
        {
            LCD_TABL[a] = " ";
        }
        temp_main_l = main_address_l + 10;
    }
}

```

```

for( a = 6; a <= 15; a++ )
{
LCD_TABL[a] = flash_read( main_address_h, temp_main_l );
temp_main_l++;
display_2();
}
LCD_FLAG = 0;
out( LCD_CAR = 0Xc3 );
LCD_FLAG = 1;
out( LCD_CAR = ( '0' + INDEX ) );
}
}

```

```

void dial_out( void )
{
    unsigned int dly;
    unsigned char f, a, temp_main_address_l;
    sprintf( LCD_TABL, "Dialling...  " );
    display_2();
    get_address();
    temp_main_address_l = main_address_l + 10;
    cradle = 1;
    for( f = 6; f <= 15; f++ )
    {
        for( dly = 0; dly <= 65000; dly++ );
        for( dly = 0; dly <= 65000; dly++ );
        a = flash_read( main_address_h, temp_main_address_l );
        temp_main_address_l++;
        LCD_FLAG = 0;
        out( LCD_CAR = 0Xcf );
        LCD_FLAG = 1;
    }
}

```

```

out( LCD_CAR = a );
switch( a )
{
case '0':
{
key_0 = 1;
for( dly = 0; dly <= 65000; dly++ );
for( dly = 0; dly <= 65000; dly++ );
key_0 = 0;
break;
}
case '1':
{
key_1 = 1;
for( dly = 0; dly <= 65000; dly++ );
for( dly = 0; dly <= 65000; dly++ );
key_1 = 0;
break;
}
case '2':
{
key_2 = 1;
for( dly = 0; dly <= 65000; dly++ );
for( dly = 0; dly <= 65000; dly++ );
key_2 = 0;
break;
}
case '3':
{
key_3 = 1;
for( dly = 0; dly <= 65000; dly++ );

```

```
for( dly = 0; dly <= 65000; dly++ );  
key_3 = 0;  
break;  
}  
case '4':  
{  
key_4 = 1;  
for( dly = 0; dly <= 65000; dly++ );  
for( dly = 0; dly <= 65000; dly++ );  
key_4 = 0;  
break;  
}  
case '5':  
{  
key_5 = 1;  
for( dly = 0; dly <= 65000; dly++ );  
for( dly = 0; dly <= 65000; dly++ );  
key_5 = 0;  
break;  
}  
case '6':  
{  
key_6 = 1;  
for( dly = 0; dly <= 65000; dly++ );  
for( dly = 0; dly <= 65000; dly++ );  
key_6 = 0;  
break;  
}  
case '7':  
{  
key_7 = 1;
```

```

    for( dly = 0; dly <= 65000; dly++ );
    for( dly = 0; dly <= 65000; dly++ );
    key_7 = 0;
    break;
}
case '8':
{
key_8 = 1;
for( dly = 0; dly <= 65000; dly++ );
for( dly = 0; dly <= 65000; dly++ );
key_8 = 0;
break;
}
case '9':
{
key_9 = 1;
for( dly = 0; dly <= 65000; dly++ );
for( dly = 0; dly <= 65000; dly++ );
key_9 = 0;
break;
}
default:
{
break;
}
}
}
cradle = 0;
sprintf( LCD_TABL, "Dialled....  ");
display_2();
}

```

```

void password_startup( void )
{
    unsigned char menu_value[3], menu, digit, incr, device;
    unsigned int dly;
    leave = 0;
    enter = 0;
    while( !leave )
    {
        LCD_FLAG = 0; out( LCD_CAR = 0x0E );
        if( digit == 0 )
        {
            LCD_FLAG = 0; out( LCD_CAR = 0x8A );
        }
        else if( digit == 1 )
        {
            LCD_FLAG = 0; out( LCD_CAR = 0x8B );
        }
        else if( digit == 2 )
        {
            LCD_FLAG = 0; out( LCD_CAR = 0x8C );
        }
        //flag = 0; out( car = 0x08 );
        if( RBIF )
        {
            if( !RB7 )
            {
                if( incr != 9 )
                {
                    incr++;
                }
            }
        }
    }
}

```

```

else
{
incr = 0;
}
menu_value[digit] = incr;
}
if( !RB6 )
{
if( digit != 2 )
{
digit++;
}
else
{
digit = 0;
}
}
if( !RB5 )
{
if( ( menu_value[0] == 9 ) && ( menu_value[1] == 0 ) && (
menu_value[2] == 1 ) )
{
leave = 1;
}
else
{
leave = 0;
}
}
for( dly = 0; dly <= 65000; dly++ );
for( dly = 0; dly <= 65000; dly++ );

```

```

    enter = 1;
    RBIF = 0;
    }
    if( enter )
    {
        sprintf( LCD_TABL, "Password: %1u%1u%1u ", menu_value[0],
menu_value[1], menu_value[2] );
        display_1();
        enter = 0;
    }
}

```

```

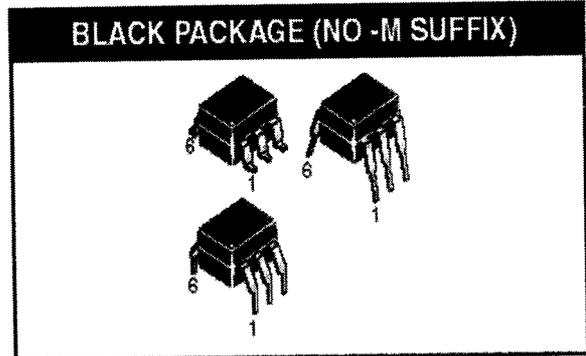
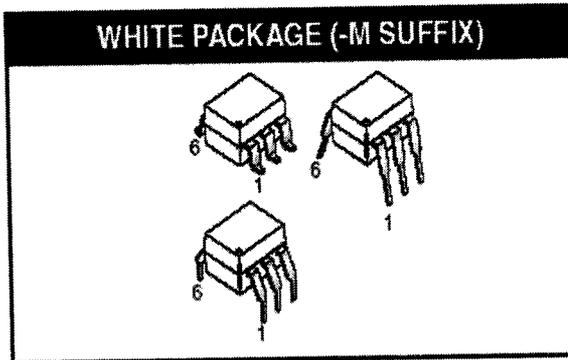
void record_delay( void )
{
    unsigned int q, qq;
    for( q = 0; q <= 7; q++ )
    {
        for( qq = 0; qq <= 65000; qq++ );
    }
}

```

## APPENDIX – II

### DATA SHEETS

# PHOTOTRANSISTOR OPTOCOUPLERS



## DESCRIPTION

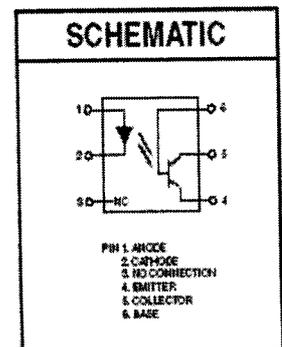
The MCT2XXX series optoisolators consist of a gallium arsenide infrared emitting diode driving a silicon phototransistor in a 6-pin dual in-line package.

## FEATURES

- UL recognized (File # E90700)
- VDE recognized (File # 94766)
  - Add option V for white package (e.g., MCT2V-M)
  - Add option 300 for black package (e.g., MCT2.300)
- MCT2 and MCT2E are also available in white package by specifying -M suffix, eg. MCT2-M

## APPLICATIONS

- Power supply regulators
- Digital logic inputs
- Microprocessor inputs



**ELECTRICAL CHARACTERISTICS** ( $T_A = 25^\circ\text{C}$  Unless otherwise specified.)

| Individual Component Characteristics |   |            |  |     |       |      |               |
|--------------------------------------|---|------------|--|-----|-------|------|---------------|
| Parameter                            | Test Conditions   | Symbol     | Device   | Min | Typ** | Max  | Unit          |
| EMITTER                              | Input Forward Voltage<br>( $I_F = 20\text{ mA}$ )   | $V_F$      | MCT2/-M<br>MCT2E/-M<br>MCT271<br>MCT2200<br>MCT2201<br>MCT2202 |     | 1.25  | 1.50 | V             |
|                                      |   |            | MCT210   |     | 1.33  |      |               |
| Reverse Leakage Current              | $(V_R = 3.0\text{ V})$  | $I_R$      | MCT2/-M<br>MCT2E/-M<br>MCT271<br>MCT2200<br>MCT2201<br>MCT2202 |     | 0.001 | 10   | $\mu\text{A}$ |
|                                      |   |            | MCT210   |     |       |      |               |
| DETECTOR                             | Collector-Emitter Breakdown Voltage<br>( $I_C = 1.0\text{ mA}, I_F = 0$ )<br>( $T_A = 0-70^\circ\text{C}$ ) | $BV_{CEO}$ | ALL  | 30  | 100   |      | V             |
|                                      |   |            | MCT210   |     |       |      |               |
| Collector-Base Breakdown Voltage     | $(I_C = 10\text{ }\mu\text{A}, I_F = 0)$  | $BV_{CBO}$ | MCT2/-M<br>MCT2E/-M<br>MCT271<br>MCT2200<br>MCT2201<br>MCT2202 | 70  | 120   |      | V             |
|                                      |   |            | MCT210   | 30  |       |      |               |
| Emitter-Collector Breakdown Voltage  | $(I_E = 100\text{ }\mu\text{A}, I_F = 0)$   | $BV_{ECO}$ | MCT2/-M<br>MCT2E/-M<br>MCT271<br>MCT2200<br>MCT2201<br>MCT2202 | 7   | 10    |      | V             |
|                                      |   |            | MCT210   | 6   | 10    |      |               |
| Collector-Emitter Dark Current       | $(V_{CE} = 10\text{ V}, I_F = 0)$<br>$(V_{CE} = 5\text{ V}, T_A = 0-70^\circ\text{C})$                      | $I_{CEO}$  | ALL  |     | 1     | 50   | nA            |
|                                      |   |            |  |     |       | 30   | $\mu\text{A}$ |
| Collector-Base Dark Current          | $(V_{CB} = 10\text{ V}, I_F = 0)$   | $I_{CBO}$  | ALL  |     |       | 20   | nA            |
| Capacitance                          | $(V_{CE} = 0\text{ V}, f = 1\text{ MHz})$   | $C_{CE}$   | ALL  |     | 8     |      | pF            |

\*\* Typical values at  $T_A = 25^\circ\text{C}$

| TRANSFER CHARACTERISTICS (Cont.)  |   |                       |                    |     |       |     |               |
|---|---|-----------------------|--------------------|-----|-------|-----|---------------|
| AC Characteristic   | Test Conditions   | Symbol                | Device             | Min | Typ** | Max | Unit          |
| Saturated turn-on time  | $(I_F = 16 \text{ mA}, R_L = 1.9\text{k}\Omega, V_{CC} = 5 \text{ V})$<br>(Fig. 20) | $t_{on}$              | MCT271             |     | 1.0   |     | $\mu\text{s}$ |
| Saturated turn-off time<br>(Approximates a typical TTL interface)           |   | $t_{off}$             |                    |     | 48    |     |               |
| Saturated turn-on time  | $(I_F = 16 \text{ mA}, R_L = 4.7\text{k}\Omega, V_{CC} = 5 \text{ V})$<br>(Fig. 20) | $t_{on}$              |                    |     | 1.0   |     |               |
| Saturated turn-off time<br>(Approximates a typical low power TTL interface) |   | $t_{off}$             |                    |     | 98    |     |               |
| Saturated rise time   | $(I_F = 16 \text{ mA}, R_L = 560\Omega, V_{CC} = 5 \text{ V})$<br>(Fig. 20, 21)     | $t_r$                 | MCT210             |     | 1.0   |     |               |
| Saturated fall time   |   | $t_f$                 |                    |     | 11    |     |               |
| Saturated propagation delay - high to low                                   | $(I_F = 16 \text{ mA}, R_L = 2.7\text{k}\Omega)$ (Fig. 20, 21)                      | $T_{PD} \text{ (HL)}$ |                    |     | 1.0   |     |               |
| Saturated propagation delay - low to high                                   |   | $T_{PD} \text{ (LH)}$ |                    |     | 50    |     |               |
| Non-saturated turn on time  | $(I_C = 2 \text{ mA}, V_{CC} = 10 \text{ V}, R_L = 100\Omega)$<br>(Fig. 20)         | $T_{ON}$              | MCT2200            |     | 2     | 10  |               |
| Non-saturated turn off time   |   | $T_{OFF}$             | MCT2201<br>MCT2202 |     | 2     | 10  |               |
| Non-saturated rise time   | $(I_C = 2 \text{ mA}, V_{CC} = 5 \text{ V}, R_L = 100\Omega)$<br>(Fig. 20)          | $t_r$                 | MCT210             |     | 2     |     |               |
| Non-saturated fall time   |   | $t_f$                 |                    |     | 2     |     |               |
| Non-saturated turn-on time  | $(I_C = 2 \text{ mA}, V_{CC} = 5 \text{ V}, R_L = 100\Omega)$<br>(Fig. 20)          | $t_{on}$              | MCT271             |     | 2     | 7   |               |
| Non-saturated turn-off time   |   | $t_{off}$             |                    |     | 2     | 7   |               |

\*\* Typical values at  $T_A = 25^\circ\text{C}$

| ISOLATION CHARACTERISTICS      |  |           |           |      |     |                   |  |
|--------------------------------|--|-----------|-----------|------|-----|-------------------|--|
| Characteristic                 | Test Conditions  | Symbol    | Min       | Typ* | Max | Units             |  |
| Input-Output Isolation Voltage | (Non '-M', Black Package) ( $f = 60 \text{ Hz}, t = 1 \text{ min}$ ) | $V_{ISO}$ | 5300      |      |     | $\text{Vac(rms)}$ |  |
|                                | ('-'M', White Package) ( $f = 60 \text{ Hz}, t = 1 \text{ sec}$ )    |           | 7500      |      |     | $\text{Vac(pk)}$  |  |
| Isolation Resistance           | $(V_{I-O} = 500 \text{ VDC})$  | $R_{ISO}$ | $10^{11}$ |      |     | $\Omega$          |  |
| Isolation Capacitance          | $(V_{I-O} = \&, f = 1 \text{ MHz})$                                  | $C_{ISO}$ |           | 0.5  |     | $\text{pF}$       |  |
|                                | ('-'M' White Package)  |           |           | 0.2  | 2   | $\text{pF}$       |  |

Note

\* Typical values at  $T_A = 25^\circ\text{C}$

# TYPICAL PERFORMANCE CURVES

Fig. 1 LED Forward Voltage vs. Forward Current (Black Package)

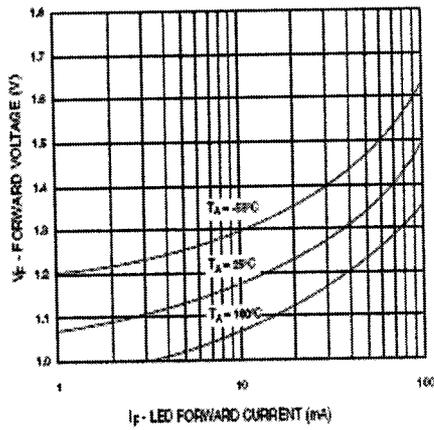


Fig. 2 LED Forward Voltage vs. Forward Current (White Package)

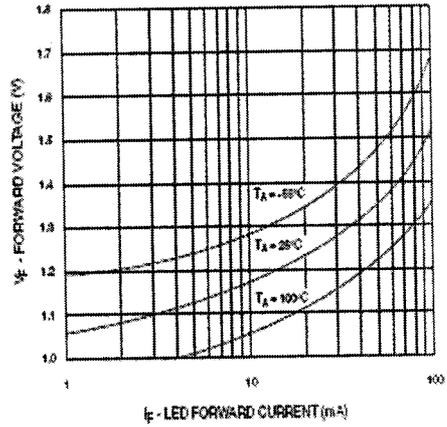


Fig. 3 Normalized CTR vs. Forward Current (Black Package)

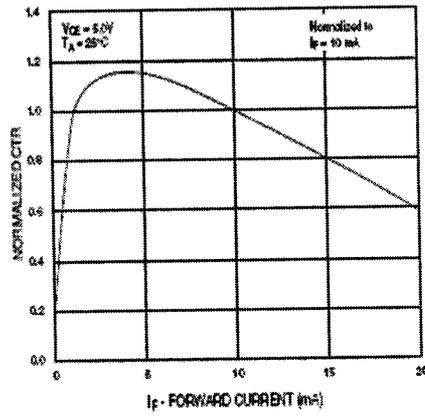


Fig. 4 Normalized CTR vs. Forward Current (White Package)

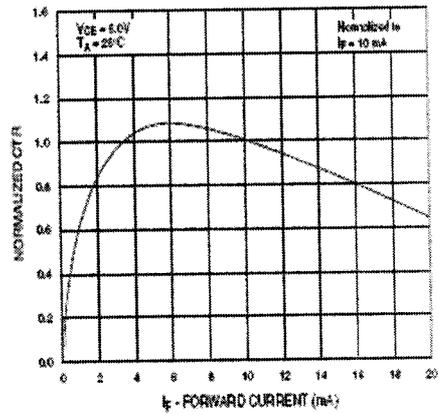


Fig. 5 Normalized CTR vs. Ambient Temperature (Black Package)

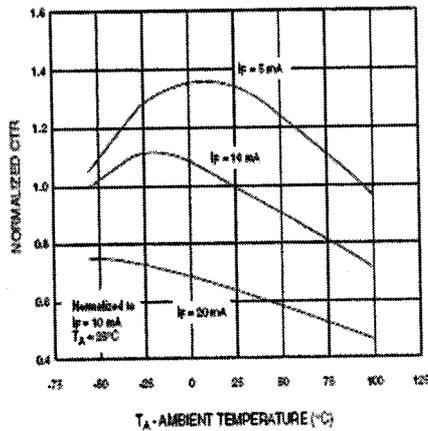
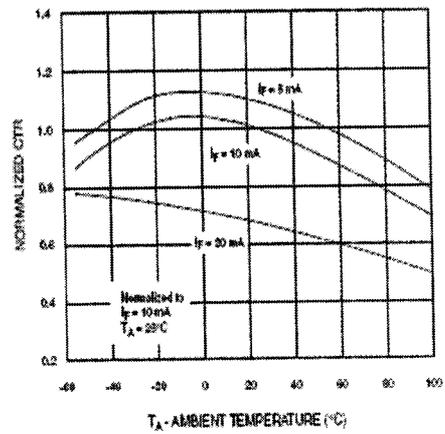


Fig. 6 Normalized CTR vs. Ambient Temperature (White Package)





# 24C04A

## 1.0 ELECTRICAL CHARACTERISTICS

### 1.1 Maximum Ratings\*

|  |                    |
|--|--------------------|
| VCC.....   | 7.0V               |
| All inputs and outputs w.r.t. VSS .....          | -0.6V to Vcc +1.0V |
| Storage temperature .....                        | -65°C to +150°C    |
| Ambient temp. with power applied.....            | -65°C to +125°C    |
| Soldering temperature of leads (10 seconds)..... | +300°C             |
| ESD protection on all pins.....                  | 4 kV               |

\*Notice: Stresses above those listed under "Maximum ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

TABLE 1-1: PIN FUNCTION TABLE

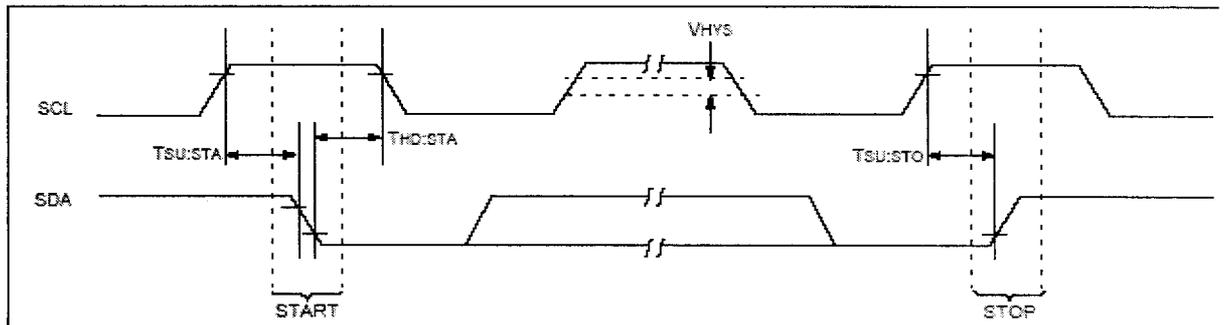
| Name   | Function                                      |
|--------|---|
| A0     | No Function - Must be connected to Vcc or Vss |
| A1, A2 | Chip Address Inputs                           |
| Vss    | Ground  |
| SDA    | Serial Address/Data I/O                       |
| SCL    | Serial Clock                                  |
| WP     | Write Protect Input                           |
| Vcc    | +5V Power Supply                              |

TABLE 1-2: DC CHARACTERISTICS

| Vcc = +5V (±10%)                        |              | Commercial (C): Tamb = 0°C to +70°C    |           |       |   |
|---|--------------|--|-----------|-------|---|
|   |              | Industrial (I): Tamb = -40°C to +85°C  |           |       |   |
|   |              | Automotive (E): Tamb = -40°C to +125°C |           |       |   |
| Parameter                               | Symbol       | Min.                                   | Max.      | Units | Conditions  |
| Vcc detector threshold                  | VTH          | 2.8                                    | 4.5       | V     |   |
| SCL and SDA pins:                       |              |  |           |       |   |
| High level input voltage                | VIH          | Vcc x 0.7                              | Vcc + 1   | V     |   |
| Low level input voltage                 | VIL          | -0.3                                   | Vcc x 0.3 | V     |   |
| Low level output voltage                | VOL          |  | 0.4       | V     | IOL = 3.2 mA (SDA only)   |
| A1 & A2 pins:                           |              |  |           |       |   |
| High level input voltage                | VIH          | Vcc - 0.5                              | Vcc + 0.5 | V     |   |
| Low level input voltage                 | VIL          | -0.3                                   | 0.5       | V     |   |
| Input leakage current                   | ILI          | —                                      | 10        | µA    | VIN = 0V to Vcc   |
| Output leakage current                  | ILO          | —                                      | 10        | µA    | VOUT = 0V to Vcc  |
| Pin capacitance<br>(all inputs/outputs) | CIN,<br>COUT | —                                      | 7.0       | pF    | VIN/VOUT = 0V (Note)<br>Tamb = +25°C, f = 1 MHz                             |
| Operating current                       | ICC          | —                                      | 3.5       | mA    | FCLK = 100 kHz, program cycle time = 1 ms,<br>Vcc = 5V, Tamb = 0°C to +70°C |
|   | Write<br>ICC | —                                      | 4.25      | mA    | FCLK = 100 kHz, program cycle time = 1 ms,<br>Vcc = 5V, Tamb = (I) and (E)  |
|   | Write<br>ICC | —                                      | 750       | µA    | Vcc = 5V, Tamb = (C), (I) and (E)   |
|   | Read<br>ICC  | —                                      | 750       | µA    | Vcc = 5V, Tamb = (C), (I) and (E)   |
| Standby current                         | ICCS         | —                                      | 100       | µA    | SDA=SCL=Vcc=5V (no PROGRAM active)<br>WP/TEST = Vss, A0, A1, A2 = Vss       |

Note: This parameter is periodically sampled and not 100% tested

FIGURE 1-1: BUS TIMING START/STOP



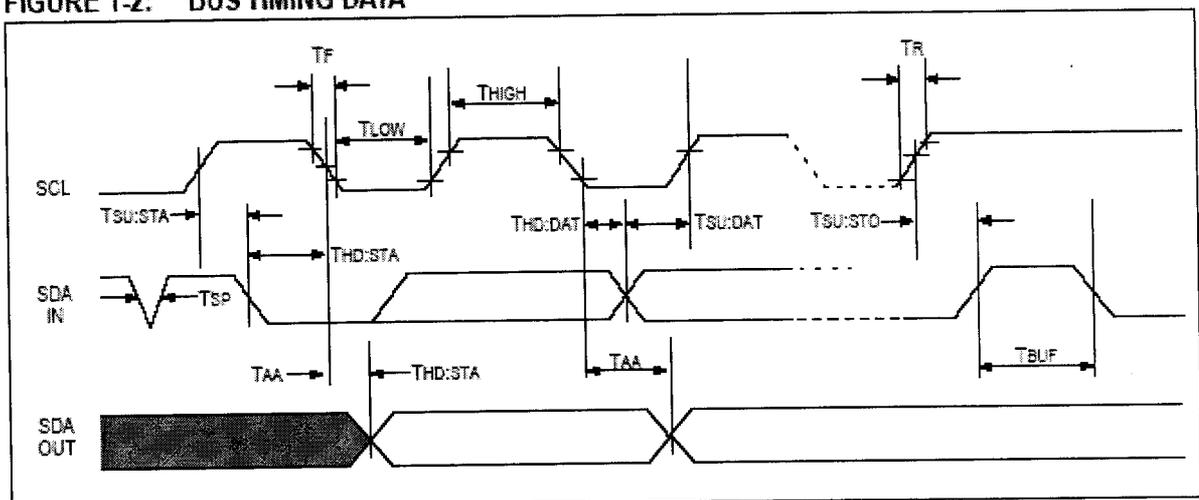
**TABLE 1-3: AC CHARACTERISTICS**

| Parameter                                     | Symbol  | Min. | Typ       | Max.   | Units    | Remarks   |
|---|---------|------|-----------|--------|----------|---|
| Clock frequency                               | FCLK    | —    | —         | 100    | kHz      |   |
| Clock high time                               | THIGH   | 4000 | —         | —      | ns       |   |
| Clock low time                                | TLOW    | 4700 | —         | —      | ns       |   |
| SDA and SCL rise time                         | TR      | —    | —         | 1000   | ns       |   |
| SDA and SCL fall time                         | TF      | —    | —         | 300    | ns       |   |
| START condition hold time                     | THD:STA | 4000 | —         | —      | ns       | After this period the first clock pulse is generated          |
| START condition setup time                    | TSU:STA | 4700 | —         | —      | ns       | Only relevant for repeated START condition                    |
| Data input hold time                          | THD:DAT | 0    | —         | —      | ns       |   |
| Data input setup time                         | TSU:DAT | 250  | —         | —      | ns       |   |
| Data output delay time                        | TAA     | 300  | —         | 3500   |          | (Note 1)  |
| STOP condition setup time                     | TSU:STO | 4700 | —         | —      | ns       |   |
| Bus free time                                 | TBUF    | 4700 | —         | —      | ns       | Time the bus must be free before a new transmission can start |
| Input filter time constant (SDA and SCL pins) | Ti      | —    | —         | 100    | ns       |   |
| Program cycle time                            | Twc     | —    | .4<br>.4N | 1<br>N | ms<br>ms | Byte mode<br>Page mode, N=# of bytes                          |
| Endurance                                     | —       | 1M   | —         | —      | cycles   | 25°C, Vcc = 5.0V, Block Mode (Note 2)                         |

Note 1: As transmitter the device must provide this internal minimum delay time to bridge the undefined region (minimum 300 ns) of the falling edge of SCL to avoid unintended generation of START or STOP conditions.

2: This parameter is not tested but guaranteed by characterization. For endurance estimates in a specific application, please consult the Total Endurance Model which can be obtained on our website.

**FIGURE 1-2: BUS TIMING DATA**



## 10.0 PIN DESCRIPTION

### 10.1 A0, A1, A2 Chip Address Inputs

A0 is not used as a chip select bit and must be tied to either Vss or Vcc. The levels on the remaining two address inputs(A1, A2) are compared with the corresponding bits in the slave address. The chip is selected if the compare is true. These inputs must be connected to either Vss or Vcc.

These two address inputs allow up to four 24C04A's can be connected to the bus

### 10.2 SDA Serial Address/Data Input/Output

This is a bidirectional pin used to transfer addresses and data into and data out of the device. It is an open drain terminal, therefore the SDA bus requires a pull-up resistor to Vcc (typical 10K $\Omega$ ).

For normal data transfer, SDA is allowed to change only during SCL LOW. Changes during SCL HIGH are reserved for indicating the START and STOP conditions.

### 10.3 SCL Serial Clock

This input is used to synchronize the data transfer from and to the device.

### 10.4 WP Write Protection

This pin must be connected to either Vcc or Vss. If tied to Vcc, write operations to the upper memory block will not be executed. Read operations are possible.

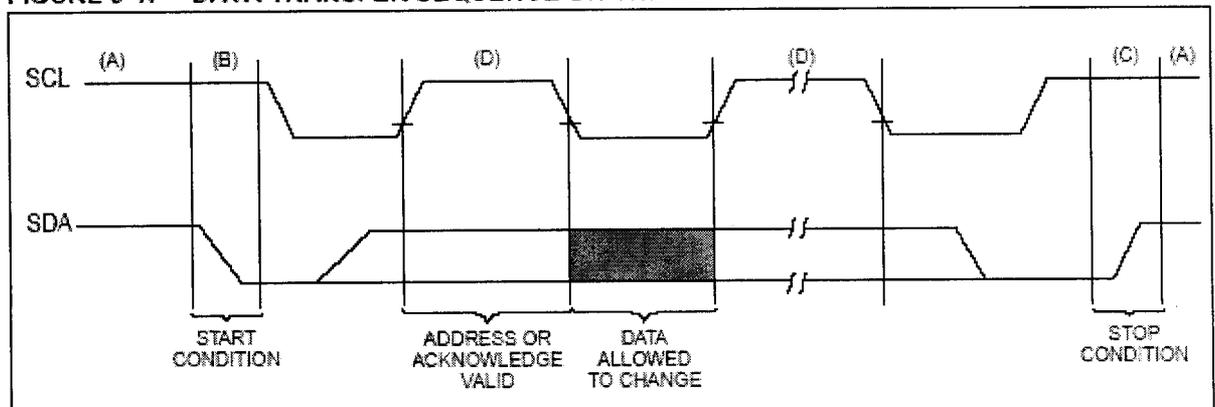
If tied to Vss, normal memory operation is enabled (read/write the entire memory).

This feature allows the user to assign the upper half of the memory as ROM which can be protected against accidental programming. When write is disabled, slave address and word address will be acknowledged but data will not be acknowledged.

**Note 1:** A "page" is defined as the maximum number of bytes that can be programmed in a single write cycle. The 24C04A page is 8 bytes long.

**Note 2:** A "block" is defined as a continuous area of memory with distinct boundaries. The address pointer can not cross the boundary from one block to another. It will however, wrap around from the end of a block to the first location in the same block. The 24C04A has two blocks, 256 bytes each.

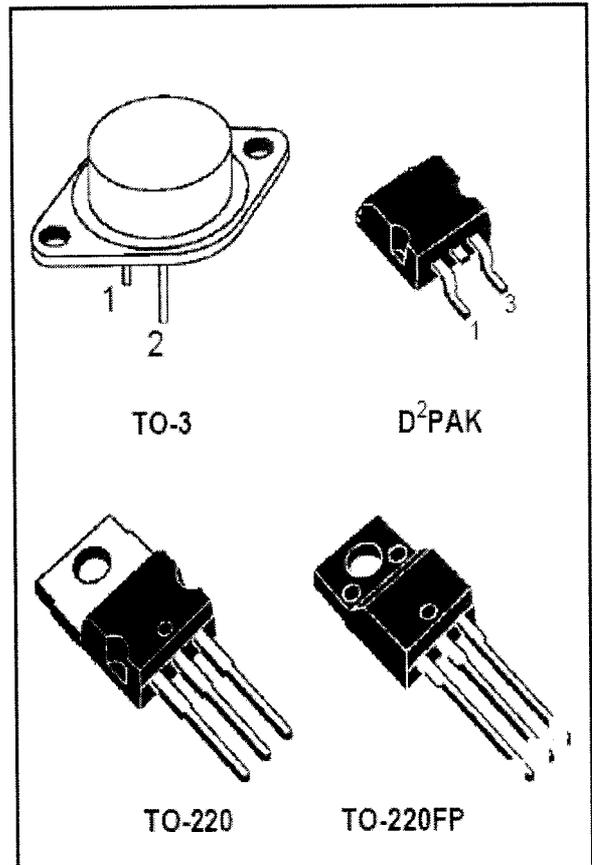
FIGURE 3-1: DATA TRANSFER SEQUENCE ON THE SERIAL BUS



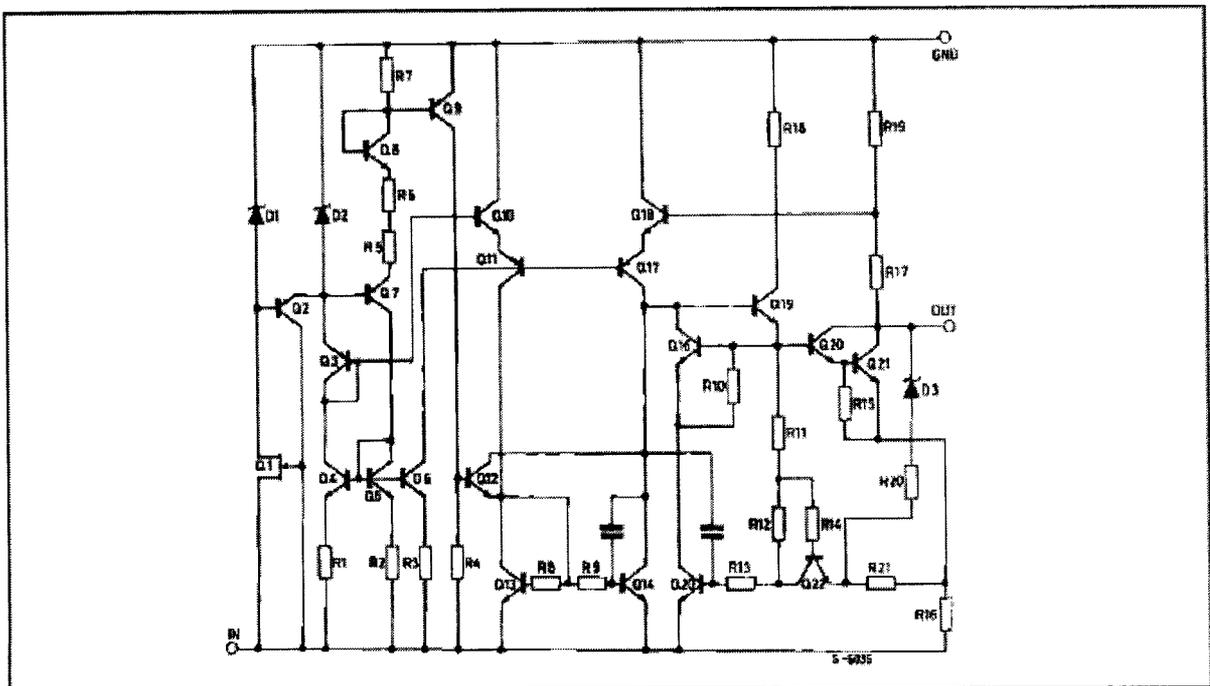
- OUTPUT CURRENT UP TO 1.5 A
- OUTPUT VOLTAGES OF -5; -5.2; -6; -8; -9; -12; -15; -18; -20; -22; -24V
- THERMAL OVERLOAD PROTECTION
- SHORT CIRCUIT PROTECTION
- OUTPUT TRANSITION SOA PROTECTION

### DESCRIPTION

The L7900 series of three-terminal negative regulators is available in TO-220, TO-220FP, TO-3 and D<sup>2</sup>PAK packages and several fixed output voltages, making it useful in a wide range of applications. These regulators can provide local on-card regulation, eliminating the distribution problems associated with single point regulation; furthermore, having the same voltage option as the L7800 positive standard series, they are particularly suited for split power supplies. In addition, the -5.2V is also available for ECL system. If adequate heat sinking is provided, they can deliver over 1.5A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents.



### SCHEMATIC DIAGRAM



# L7900

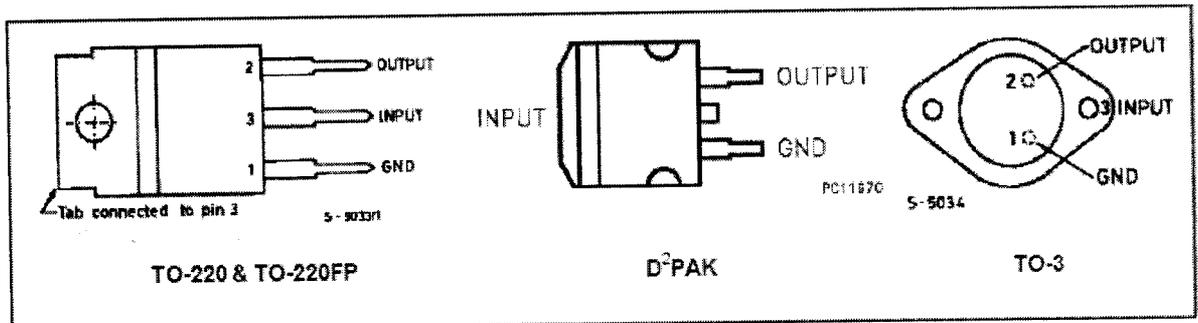
## ABSOLUTE MAXIMUM RATINGS

| Symbol    | Parameter   | Value              | Unit |
|-----------|---|--------------------|------|
| $V_i$     | DC Input Voltage (for $V_o = 5$ to 18V)<br>(for $V_o = 20, 24V$ ) | -35<br>-40         | V    |
| $I_o$     | Output Current  | Internally limited |      |
| $P_{tot}$ | Power Dissipation   | Internally limited |      |
| $T_{op}$  | Operating Junction Temperature Range                              | 0 to 150           | °C   |
| $T_{stg}$ | Storage Temperature Range   | - 65 to 150        | °C   |

## THERMAL DATA

| Symbol        | Parameter                               | D <sup>2</sup> PAK | TO-220 | TO-220FP | TO-3 | Unit |
|---------------|---|--------------------|--------|----------|------|------|
| $R_{thj-ca}$  | Thermal Resistance Junction-case Max    | 3                  | 3      | 5        | 4    | °C/W |
| $R_{thj-amb}$ | Thermal Resistance Junction-ambient Max | 62.5               | 50     | 60       | 35   | °C/W |

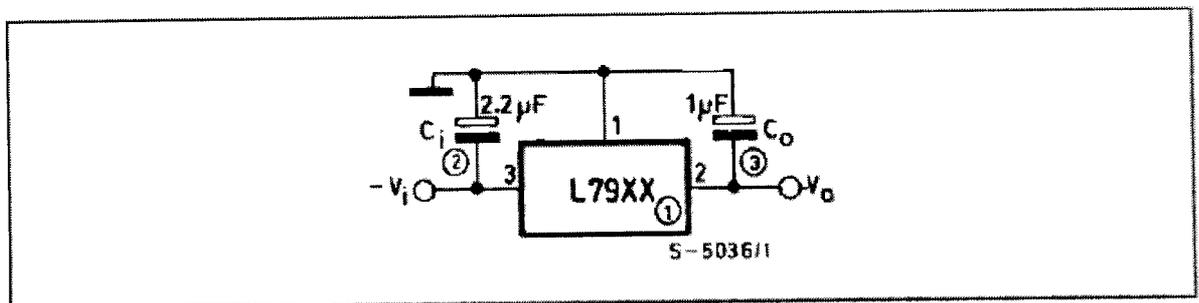
## CONNECTION DIAGRAM AND ORDERING NUMBERS (top view)



| Type   | TO-220  | D <sup>2</sup> PAK (*) | TO-220FP | TO-3    | Output Voltage |
|--------|---------|------------------------|----------|---------|----------------|
| L7905C | L7905CV | L7905CD2T              | L7905CP  | L7905CT | -5V            |
| L7952C | L7952CV | L7952CD2T              |          | L7952CT | -5.2V          |
| L7906C | L7906CV | L7906CD2T              | L7906CP  | L7906CT | -6V            |
| L7908C | L7908CV | L7908CD2T              | L7908CP  | L7908CT | -8V            |
| L7912C | L7912CV | L7912CD2T              | L7912CP  | L7912CT | -12V           |
| L7915C | L7915CV | L7915CD2T              | L7915CP  | L7915CT | -15V           |
| L7918C | L7918CV | L7918CD2T              | L7918CP  | L7918CT | -18V           |
| L7920C | L7920CV | L7920CD2T              | L7920CP  | L7920CT | -20V           |
| L7922C | L7922CV | L7922CD2T              |          | L7922CT | -22V           |
| L7924C | L7924CV | L7924CD2T              | L7924CP  | L7924CT | -24V           |

(\*) AVAILABLE IN TAPE AND REEL WITH "-TR" SUFFIX

## APPLICATION CIRCUIT



**ELECTRICAL CHARACTERISTICS FOR L7905C** (refer to the test circuits,  $T_J = 0$  to  $150$  °C,  
 $V_i = -10V$ ,  $I_o = 500$  mA,  $C_i = 2.2$   $\mu$ F,  $C_o = 1$   $\mu$ F unless otherwise specified)

| Symbol                        | Parameter                | Test Conditions   | Min.  | Typ. | Max.      | Unit     |
|-------------------------------|--------------------------|---|-------|------|-----------|----------|
| $V_o$                         | Output Voltage           | $T_J = 25$ °C   | -4.8  | -5   | -5.2      | V        |
| $V_o$                         | Output Voltage           | $I_o = -5$ mA to $-1$ A $P_o \leq 15$ W<br>$V_i = 8$ to $20$ V                | -4.75 | -5   | -5.25     | V        |
| $\Delta V_o^*$                | Line Regulation          | $V_i = -7$ to $-25$ V $T_J = 25$ °C<br>$V_i = -8$ to $-12$ V $T_J = 25$ °C    |       |      | 100<br>50 | mV<br>mV |
| $\Delta V_o^*$                | Load Regulation          | $I_o = 5$ to $1500$ mA $T_J = 25$ °C<br>$I_o = 250$ to $750$ mA $T_J = 25$ °C |       |      | 100<br>50 | mV<br>mV |
| $I_d$                         | Quiescent Current        | $T_J = 25$ °C   |       |      | 3         | mA       |
| $\Delta I_d$                  | Quiescent Current Change | $I_o = 5$ to $1000$ mA  |       |      | 0.5       | mA       |
| $\Delta I_d$                  | Quiescent Current Change | $V_i = -8$ to $-25$ V   |       |      | 1.3       | mA       |
| $\frac{\Delta V_o}{\Delta T}$ | Output Voltage Drift     | $I_o = 5$ mA  |       | -0.4 |           | mV/°C    |
| $e_N$                         | Output Noise Voltage     | $B = 10$ Hz to $100$ KHz $T_J = 25$ °C  |       | 100  |           | $\mu$ V  |
| SVR                           | Supply Voltage Rejection | $\Delta V_i = 10$ V $f = 120$ Hz  | 54    | 60   |           | dB       |
| $V_d$                         | Dropout Voltage          | $I_o = 1$ A $T_J = 25$ °C<br>$\Delta V_o = 100$ mV                            |       | 1.4  |           | V        |
| $I_{sc}$                      | Short Circuit Current    |   |       | 2.1  |           | A        |

**ELECTRICAL CHARACTERISTICS FOR L7912C** (refer to the test circuits,  $T_J = 0$  to  $150$  °C,  
 $V_i = -19V$ ,  $I_o = 500$  mA,  $C_i = 2.2$   $\mu$ F,  $C_o = 1$   $\mu$ F unless otherwise specified)

| Symbol                        | Parameter                | Test Conditions  | Min.  | Typ. | Max.       | Unit     |
|-------------------------------|--------------------------|--|-------|------|------------|----------|
| $V_o$                         | Output Voltage           | $T_J = 25$ °C  | -11.5 | -12  | -12.5      | V        |
| $V_o$                         | Output Voltage           | $I_o = -5$ mA to $-1$ A $P_o \leq 15$ W<br>$V_i = -15.5$ to $-27$ V            | -11.4 | -12  | -12.6      | V        |
| $\Delta V_o^*$                | Line Regulation          | $V_i = -14.5$ to $-30$ V $T_J = 25$ °C<br>$V_i = -16$ to $-22$ V $T_J = 25$ °C |       |      | 240<br>120 | mV<br>mV |
| $\Delta V_o^*$                | Load Regulation          | $I_o = 5$ to $1500$ mA $T_J = 25$ °C<br>$I_o = 250$ to $750$ mA $T_J = 25$ °C  |       |      | 240<br>120 | mV<br>mV |
| $I_d$                         | Quiescent Current        | $T_J = 25$ °C  |       |      | 3          | mA       |
| $\Delta I_d$                  | Quiescent Current Change | $I_o = 5$ to $1000$ mA   |       |      | 0.5        | mA       |
| $\Delta I_d$                  | Quiescent Current Change | $V_i = -15$ to $-30$ V   |       |      | 1          | mA       |
| $\frac{\Delta V_o}{\Delta T}$ | Output Voltage Drift     | $I_o = 5$ mA   |       | -0.8 |            | mV/°C    |
| $e_N$                         | Output Noise Voltage     | $B = 10$ Hz to $100$ KHz $T_J = 25$ °C   |       | 200  |            | $\mu$ V  |
| SVR                           | Supply Voltage Rejection | $\Delta V_i = 10$ V $f = 120$ Hz   | 54    | 60   |            | dB       |
| $V_d$                         | Dropout Voltage          | $I_o = 1$ A $T_J = 25$ °C<br>$\Delta V_o = 100$ mV                             |       | 1.1  |            | V        |
| $I_{sc}$                      | Short Circuit Current    |  |       | 1.5  |            | A        |

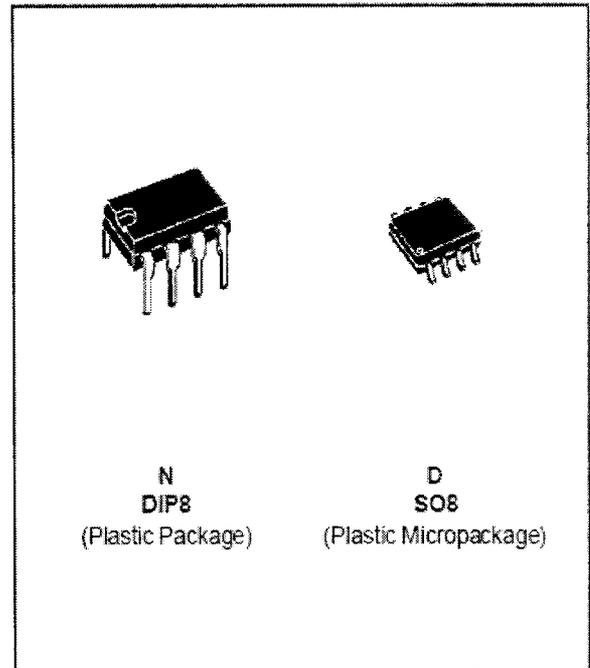
# NE555

## GENERAL PURPOSE SINGLE BIPOLAR TIMERS

- LOW TURN OFF TIME
- MAXIMUM OPERATING FREQUENCY GREATER THAN 500kHz
- TIMING FROM MICROSECONDS TO HOURS
- OPERATES IN BOTH ASTABLE AND MONOSTABLE MODES
- HIGH OUTPUT CURRENT CAN SOURCE OR SINK 200mA
- ADJUSTABLE DUTY CYCLE
- TTL COMPATIBLE
- TEMPERATURE STABILITY OF 0.005% PER°C

### DESCRIPTION

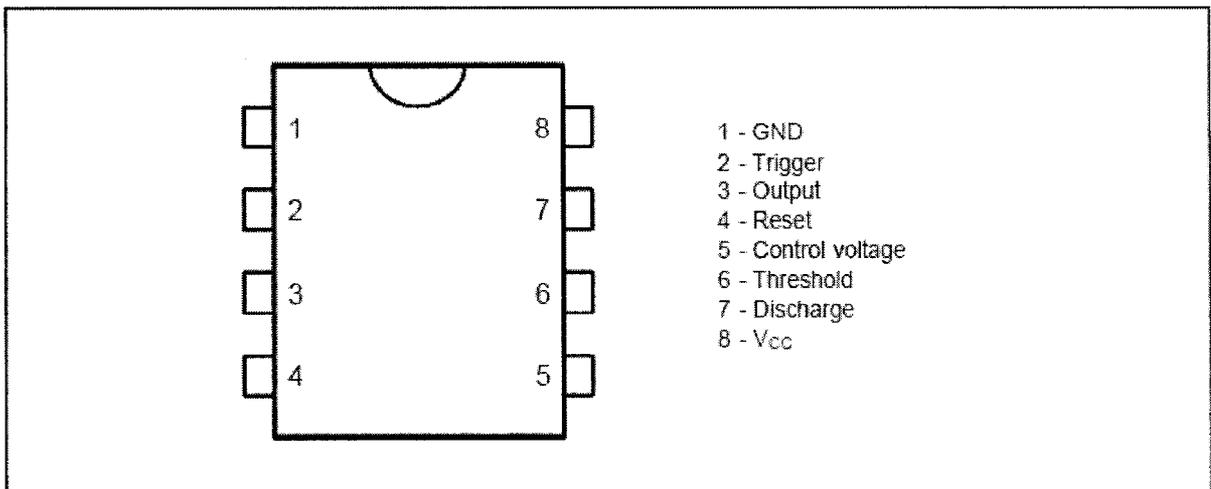
The NE555 monolithic timing circuit is a highly stable controller capable of producing accurate time delays or oscillation. In the time delay mode of operation, the time is precisely controlled by one external resistor and capacitor. For a stable operation as an oscillator, the free running frequency and the duty cycle are both accurately controlled with two external resistors and one capacitor. The circuit may be triggered and reset on falling waveforms, and the output structure can source or sink up to 200mA. The NE555 is available in plastic and ceramic minidip package and in a 8-lead micropackage and in metal can package version.



### ORDER CODES

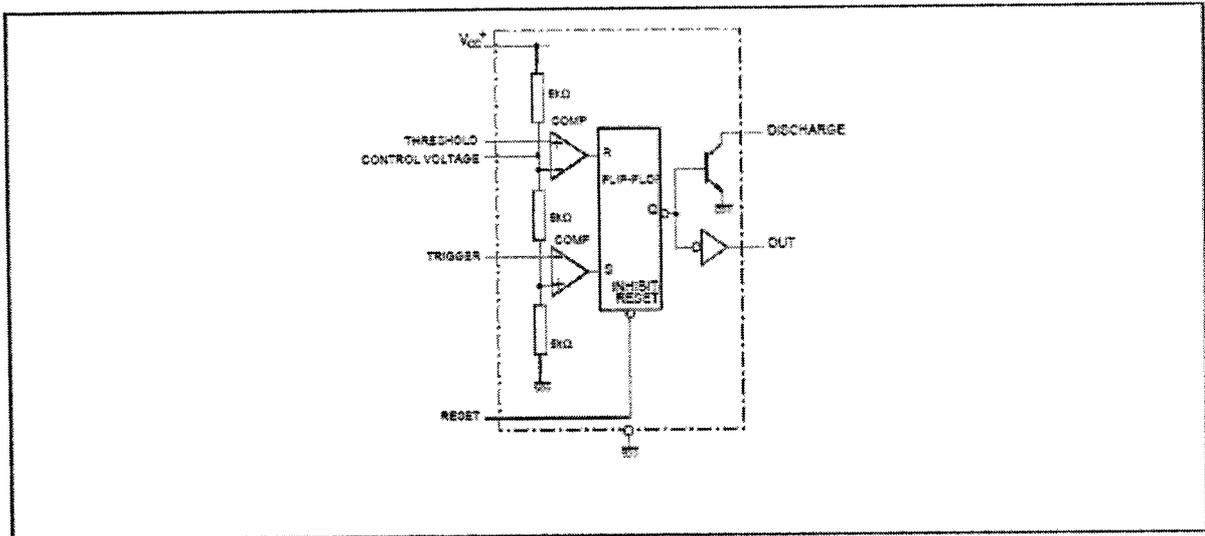
| Part Number | Temperature Range | Package |   |
|-------------|-------------------|---------|---|
|             |                   | N       | D |
| NE555       | 0°C, 70°C         | •       | • |
| SA555       | -40°C, 105°C      | •       | • |
| SE555       | -55°C, 125°C      | •       | • |

### PIN CONNECTIONS (top view)

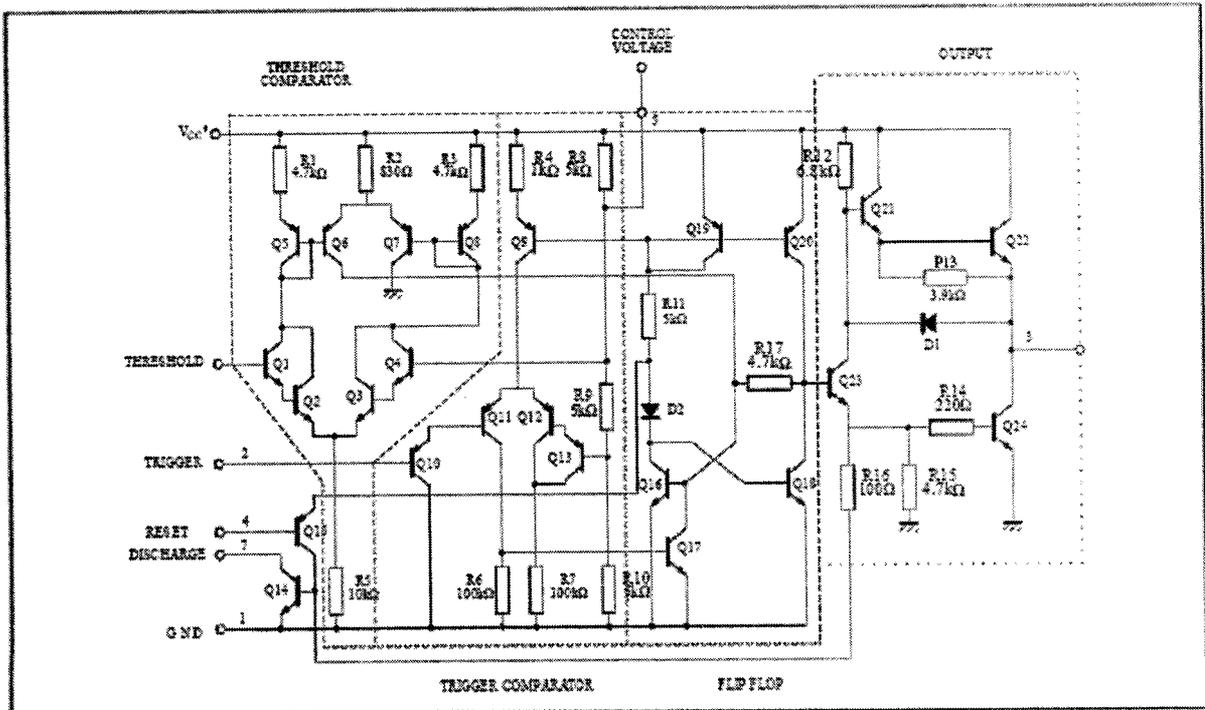


# NE555/SA555/SE555

## BLOCK DIAGRAM



## SCHEMATIC DIAGRAM



## ABSOLUTE MAXIMUM RATINGS

| Symbol            | Parameter                            | Value                               | Unit                                |    |
|-------------------|--------------------------------------|-------------------------------------|-------------------------------------|----|
| V <sub>cc</sub>   | Supply Voltage                       | 18                                  | V                                   |    |
| T <sub>oper</sub> | Operating Free Air Temperature Range | for NE555<br>for SA555<br>for SE555 | 0 to 70<br>-40 to 105<br>-55 to 125 | °C |
| T <sub>j</sub>    | Junction Temperature                 | 150                                 | °C                                  |    |
| T <sub>stg</sub>  | Storage Temperature Range            | -65 to 150                          | °C                                  |    |

## OPERATING CONDITIONS

| Symbol   | Parameter             | SE555     | NE555 - SA555 | Unit |
|--|-----------------------|-----------|---------------|------|
| $V_{CC}$                                       | Supply Voltage        | 4.5 to 18 | 4.5 to 18     | V    |
| $V_{th}$ , $V_{trig}$ , $V_{cl}$ , $V_{reset}$ | Maximum Input Voltage | $V_{CC}$  | $V_{CC}$      | V    |

## ELECTRICAL CHARACTERISTICS

$T_{amb} = +25^{\circ}\text{C}$ ,  $V_{CC} = +5\text{V}$  to  $+15\text{V}$  (unless otherwise specified)

| Symbol                     | Parameter  | SE555       |            |             | NE555 - SA555 |            |             | Unit                                |
|----------------------------|--|-------------|------------|-------------|---------------|------------|-------------|-------------------------------------|
|                            |  | Min.        | Typ.       | Max.        | Min.          | Typ.       | Max.        |                                     |
| $I_{CC}$                   | Supply Current ( $R_L = \infty$ ) (- note 1)   |             |            |             |               |            |             | mA                                  |
|                            | Low State $V_{CC} = +5\text{V}$  |             | 3          | 5           |               | 3          | 6           |                                     |
|                            | High State $V_{CC} = +5\text{V}$   |             | 10         | 12          |               | 10         | 15          |                                     |
|                            | Timing Error (monostable)<br>( $R_A = 2\text{k}\Omega$ to $100\text{k}\Omega$ , $C = 0.1\mu\text{F}$ )                               |             |            |             |               |            |             | %<br>ppm/ $^{\circ}\text{C}$<br>%/V |
|                            | Initial Accuracy - (note 2)  |             | 0.5        | 2           |               | 1          | 3           |                                     |
|                            | Drift with Temperature   |             | 30         | 100         |               | 50         |             |                                     |
|                            | Drift with Supply Voltage  |             | 0.05       | 0.2         |               | 0.1        | 0.5         |                                     |
|                            | Timing Error (astable)<br>( $R_A, R_B = 1\text{k}\Omega$ to $100\text{k}\Omega$ , $C = 0.1\mu\text{F}$ ,<br>$V_{CC} = +15\text{V}$ ) |             |            |             |               |            |             | %<br>ppm/ $^{\circ}\text{C}$<br>%/V |
|                            | Initial Accuracy - (note 2)  |             | 1.5        |             |               | 2.25       |             |                                     |
|                            | Drift with Temperature   |             | 90         |             |               | 150        |             |                                     |
|                            | Drift with Supply Voltage  |             | 0.15       |             |               | 0.3        |             |                                     |
| $V_{CL}$                   | Control Voltage level  |             |            |             |               |            |             | V                                   |
|                            | $V_{CC} = +15\text{V}$<br>$V_{CC} = +5\text{V}$  | 9.6<br>2.9  | 10<br>3.33 | 10.4<br>3.8 | 9<br>2.6      | 10<br>3.33 | 11<br>4     |                                     |
| $V_{th}$                   | Threshold Voltage  |             |            |             |               |            |             | V                                   |
|                            | $V_{CC} = +15\text{V}$<br>$V_{CC} = +5\text{V}$  | 9.4<br>2.7  | 10<br>3.33 | 10.6<br>4   | 8.8<br>2.4    | 10<br>3.33 | 11.2<br>4.2 |                                     |
| $I_{th}$                   | Threshold Current - (note 3)   |             | 0.1        | 0.25        |               | 0.1        | 0.25        | $\mu\text{A}$                       |
| $V_{trig}$                 | Trigger Voltage  |             |            |             |               |            |             | V                                   |
|                            | $V_{CC} = +15\text{V}$<br>$V_{CC} = +5\text{V}$  | 4.8<br>1.45 | 5<br>1.67  | 5.2<br>1.9  | 4.5<br>1.1    | 5<br>1.67  | 5.6<br>2.2  |                                     |
| $I_{trig}$                 | Trigger Current ( $V_{trig} = 0\text{V}$ )   |             | 0.5        | 0.9         |               | 0.5        | 2.0         | $\mu\text{A}$                       |
| $V_{reset}$                | Reset Voltage - (note 4)   | 0.4         | 0.7        | 1           | 0.4           | 0.7        | 1           | V                                   |
| $I_{reset}$                | Reset Current  |             |            |             |               |            |             | mA                                  |
|                            | $V_{reset} = +0.4\text{V}$<br>$V_{reset} = 0\text{V}$  |             | 0.1<br>0.4 | 0.4<br>1    |               | 0.1<br>0.4 | 0.4<br>1.5  |                                     |
| $V_{OL}$                   | Low Level Output Voltage   |             |            |             |               |            |             | V                                   |
|                            | $V_{CC} = +15\text{V}$ , $I_{O(sink)} = 10\text{mA}$   |             | 0.1        | 0.15        |               | 0.1        | 0.25        |                                     |
|                            | $I_{O(sink)} = 50\text{mA}$  |             | 0.4        | 0.5         |               | 0.4        | 0.75        |                                     |
|                            | $I_{O(sink)} = 100\text{mA}$   |             | 2          | 2.2         |               | 2          | 2.5         |                                     |
|                            | $I_{O(sink)} = 200\text{mA}$   |             | 2.5        |             |               | 2.5        |             |                                     |
|                            | $V_{CC} = +5\text{V}$ , $I_{O(sink)} = 8\text{mA}$   |             | 0.1        | 0.25        |               | 0.3        | 0.4         |                                     |
| $I_{O(sink)} = 5\text{mA}$ |  | 0.05        | 0.2        |             | 0.25          | 0.35       |             |                                     |
| $V_{OH}$                   | High Level Output Voltage  |             |            |             |               |            |             | V                                   |
|                            | $V_{CC} = +15\text{V}$ , $I_{O(source)} = 200\text{mA}$  |             | 13         | 12.5        |               | 12.75      | 12.5        |                                     |
|                            | $I_{O(source)} = 100\text{mA}$   |             | 3          | 13.3        |               | 2.75       | 13.3        |                                     |
|                            | $V_{CC} = +5\text{V}$ , $I_{O(source)} = 100\text{mA}$   |             | 3          | 3.3         |               | 3.3        |             |                                     |

- Notes :**
- Supply current when output is high is typically 1mA less.
  - Tested at  $V_{CC} = +5\text{V}$  and  $V_{CC} = +15\text{V}$ .
  - This will determine the maximum value of  $R_A + R_B$  for +15V operation the max total is  $R = 20\text{M}\Omega$  and for 5V operation the max total  $R = 3.5\text{M}\Omega$ .

ELECTRICAL CHARACTERISTICS (continued)

| Symbol         | Parameter  | SE555 |           |            | NE555 - SA555 |           |            | Unit    |
|----------------|--|-------|-----------|------------|---------------|-----------|------------|---------|
|                |  | Min.  | Typ.      | Max.       | Min.          | Typ.      | Max.       |         |
| $I_{dis(off)}$ | Discharge Pin Leakage Current (output high) ( $V_{dis} = 10V$ )  |       | 20        | 100        |               | 20        | 100        | nA      |
| $V_{dis(sat)}$ | Discharge pin Saturation Voltage (output low) - (note 5)<br>$V_{CC} = +15V, I_{dis} = 15mA$<br>$V_{CC} = +5V, I_{dis} = 4.5mA$ |       | 180<br>80 | 480<br>200 |               | 180<br>80 | 480<br>200 | mV      |
| $t_r$          | Output Rise Time   |       | 100       | 200        |               | 100       | 300        | ns      |
| $t_f$          | Output Fall Time   |       | 100       | 200        |               | 100       | 300        | ns      |
| $t_{off}$      | Turn off Time - (note 6) ( $V_{reset} = V_{CC}$ )  |       | 0.5       |            |               | 0.5       |            | $\mu s$ |

Notes : 5. No protection against excessive Pin 7 current is necessary, providing the package dissipation rating will not be exceeded.  
6. Time measured from a positive going input pulse from 0 to  $0.6 \times V_{CC}$  into the threshold to the drop from high to low of the output trigger is tied to threshold.

Figure 1 : Minimum Pulse Width Required for Trigering

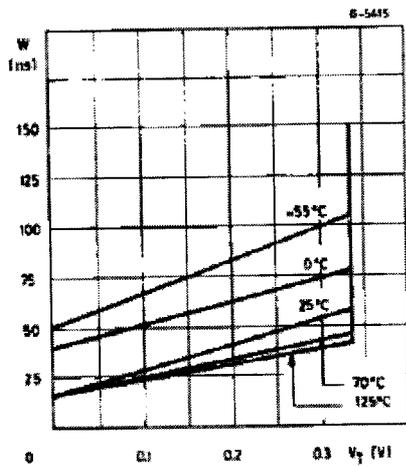


Figure 3 : Delay Time versus Temperature

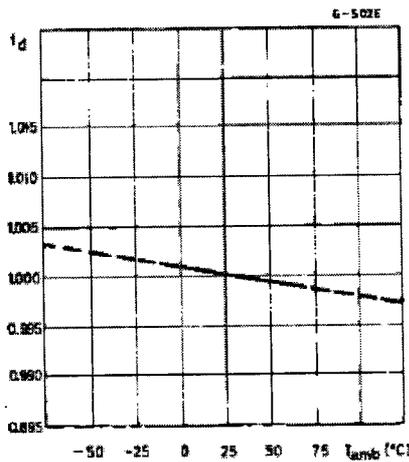


Figure 2 : Supply Current versus Supply Voltage

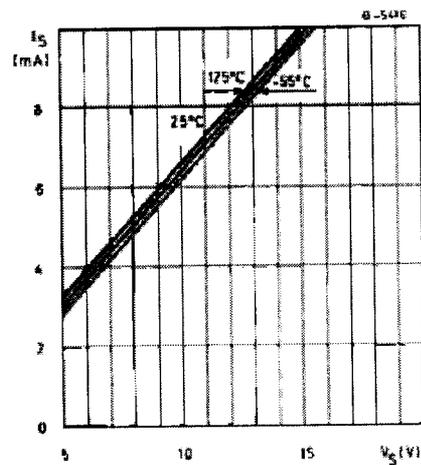
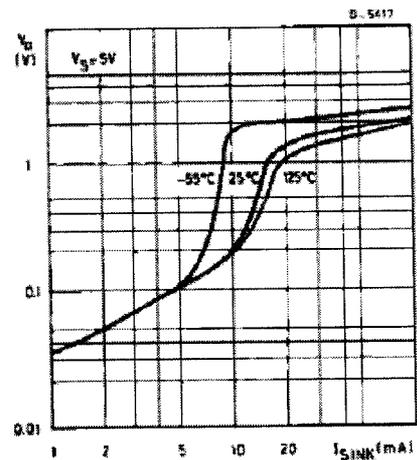


Figure 4 : Low Output Voltage versus Output Sink Current



# BC547

## NPN general purpose transistors

## BC546; BC547; BC548

### FEATURES

- Low current (max. 100 mA)
- Low voltage (max. 65 V).

### APPLICATIONS

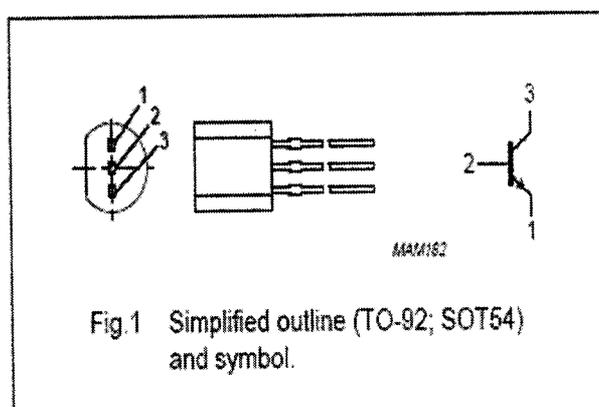
- General purpose switching and amplification.

### DESCRIPTION

NPN transistor in a TO-92; SOT54 plastic package.  
PNP complements: BC556, BC557 and BC558.

### PINNING

| PIN | DESCRIPTION |
|-----|-------------|
| 1   | emitter     |
| 2   | base        |
| 3   | collector   |



### QUICK REFERENCE DATA

| SYMBOL    | PARAMETER                 | CONDITIONS  | MIN. | MAX. | UNIT |
|-----------|---------------------------|---|------|------|------|
| $V_{CBO}$ | collector-base voltage    | open emitter  |      |      |      |
|           | BC546                     |   | –    | 80   | V    |
|           | BC547                     |   | –    | 50   | V    |
| $V_{CEO}$ | collector-emitter voltage | open base   |      |      |      |
|           | BC546                     |   | –    | 65   | V    |
|           | BC547                     |   | –    | 45   | V    |
|           | BC548                     |   | –    | 30   | V    |
| $I_{CM}$  | peak collector current    |   | –    | 200  | mA   |
| $P_{tot}$ | total power dissipation   | $T_{amb} \leq 25\text{ }^{\circ}\text{C}$                     | –    | 500  | mW   |
| $h_{FE}$  | DC current gain           | $I_C = 2\text{ mA}; V_{CE} = 5\text{ V}$                      |      |      |      |
|           | BC546                     |   | 110  | 450  |      |
|           | BC547                     |   | 110  | 800  |      |
|           | BC548                     |   | 110  | 800  |      |
| $f_T$     | transition frequency      | $I_C = 10\text{ mA}; V_{CE} = 5\text{ V}; f = 100\text{ MHz}$ | 100  | –    | MHz  |

**LIMITING VALUES**

In accordance with the Absolute Maximum Rating System (IEC 134).

| SYMBOL           | PARAMETER                     | CONDITIONS                       | MIN. | MAX. | UNIT |
|------------------|-------------------------------|----------------------------------|------|------|------|
| V <sub>CB0</sub> | collector-base voltage        | open emitter                     |      |      |      |
|                  | BC546                         |                                  | –    | 80   | V    |
|                  | BC547                         |                                  | –    | 50   | V    |
|                  | BC548                         |                                  | –    | 30   | V    |
| V <sub>CE0</sub> | collector-emitter voltage     | open base                        |      |      |      |
|                  | BC546                         |                                  | –    | 65   | V    |
|                  | BC547                         |                                  | –    | 45   | V    |
|                  | BC548                         |                                  | –    | 30   | V    |
| V <sub>EB0</sub> | emitter-base voltage          | open collector                   |      |      |      |
|                  | BC546                         |                                  | –    | 6    | V    |
|                  | BC547                         |                                  | –    | 6    | V    |
|                  | BC548                         |                                  | –    | 5    | V    |
| I <sub>C</sub>   | collector current (DC)        |                                  | –    | 100  | mA   |
| I <sub>CM</sub>  | peak collector current        |                                  | –    | 200  | mA   |
| I <sub>BM</sub>  | peak base current             |                                  | –    | 200  | mA   |
| P <sub>tot</sub> | total power dissipation       | T <sub>amb</sub> ≤ 25 °C; note 1 | –    | 500  | mW   |
| T <sub>stg</sub> | storage temperature           |                                  | –65  | +150 | °C   |
| T <sub>j</sub>   | junction temperature          |                                  | –    | 150  | °C   |
| T <sub>amb</sub> | operating ambient temperature |                                  | –65  | +150 | °C   |

**Note**

1. Transistor mounted on an FR4 printed-circuit board.

**THERMAL CHARACTERISTICS**

| SYMBOL              | PARAMETER                                   | CONDITIONS | VALUE | UNIT |
|---------------------|---|------------|-------|------|
| R <sub>th j-a</sub> | thermal resistance from junction to ambient | note 1     | 0.25  | K/mW |

**Note**

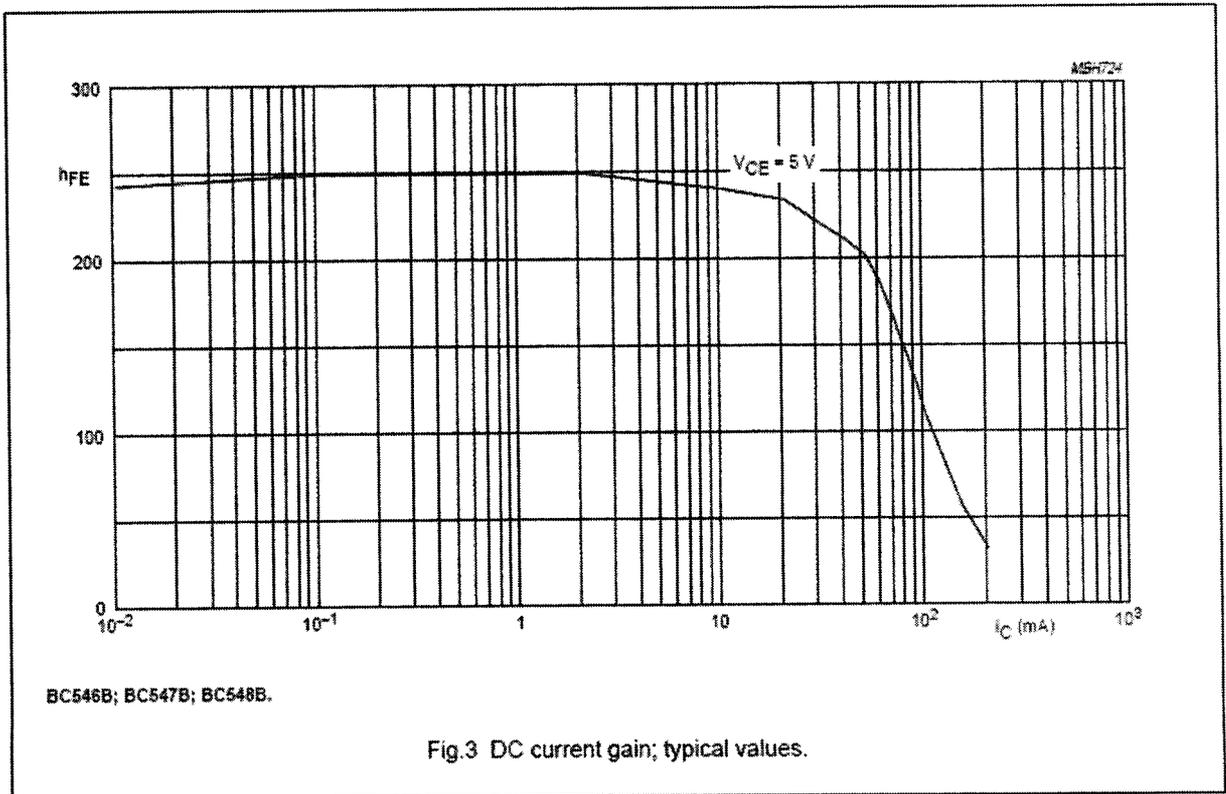
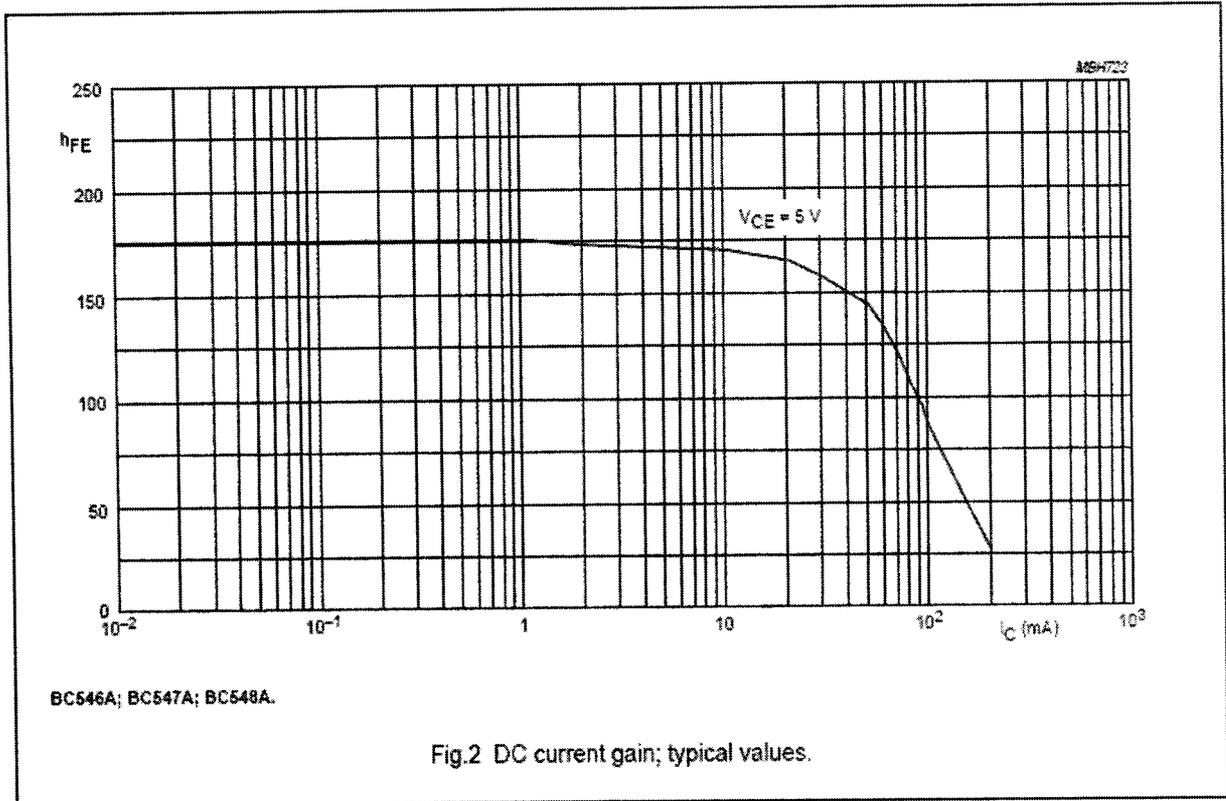
1. Transistor mounted on an FR4 printed-circuit board.

**CHARACTERISTICS** $T_j = 25\text{ }^\circ\text{C}$  unless otherwise specified.

| SYMBOL      | PARAMETER  | CONDITIONS  | MIN. | TYP. | MAX. | UNIT          |
|-------------|--|---|------|------|------|---------------|
| $I_{CBO}$   | collector cut-off current  | $I_E = 0; V_{CB} = 30\text{ V}$   | –    | –    | 15   | nA            |
|             |  | $I_E = 0; V_{CB} = 30\text{ V}; T_j = 150\text{ }^\circ\text{C}$  | –    | –    | 5    | $\mu\text{A}$ |
| $I_{EBO}$   | emitter cut-off current  | $I_C = 0; V_{EB} = 5\text{ V}$  | –    | –    | 100  | nA            |
| $h_{FE}$    | DC current gain<br>BC546A; BC547A; BC548A<br>BC546B; BC547B; BC548B<br>BC547C; BC548C                          | $I_C = 10\text{ }\mu\text{A}; V_{CE} = 5\text{ V};$<br>see Figs 2, 3 and 4  | –    | 90   | –    |               |
|             |  |   | –    | 150  | –    |               |
|             |  |   | –    | 270  | –    |               |
| $h_{FE}$    | DC current gain<br>BC546A; BC547A; BC548A<br>BC546B; BC547B; BC548B<br>BC547C; BC548C<br>BC547; BC548<br>BC546 | $I_C = 2\text{ mA}; V_{CE} = 5\text{ V};$<br>see Figs 2, 3 and 4  | 110  | 180  | 220  |               |
|             |  |   | 200  | 290  | 450  |               |
|             |  |   | 420  | 520  | 800  |               |
|             |  |   | 110  | –    | 800  |               |
|             |  |   | 110  | –    | 450  |               |
| $V_{CEsat}$ | collector-emitter saturation voltage   | $I_C = 10\text{ mA}; I_B = 0.5\text{ mA}$   | –    | 90   | 250  | mV            |
|             |  | $I_C = 100\text{ mA}; I_B = 5\text{ mA}$  | –    | 200  | 600  | mV            |
| $V_{BEsat}$ | base-emitter saturation voltage  | $I_C = 10\text{ mA}; I_B = 0.5\text{ mA};$ note 1   | –    | 700  | –    | mV            |
|             |  | $I_C = 100\text{ mA}; I_B = 5\text{ mA};$ note 1  | –    | 900  | –    | mV            |
| $V_{BE}$    | base-emitter voltage   | $I_C = 2\text{ mA}; V_{CE} = 5\text{ V};$ note 2  | 580  | 660  | 700  | mV            |
|             |  | $I_C = 10\text{ mA}; V_{CE} = 5\text{ V}$   | –    | –    | 770  | mV            |
| $C_c$       | collector capacitance  | $I_E = I_C = 0; V_{CB} = 10\text{ V}; f = 1\text{ MHz}$   | –    | 1.5  | –    | pF            |
| $C_e$       | emitter capacitance  | $I_C = I_E = 0; V_{EB} = 0.5\text{ V}; f = 1\text{ MHz}$  | –    | 11   | –    | pF            |
| $f_T$       | transition frequency   | $I_C = 10\text{ mA}; V_{CE} = 5\text{ V}; f = 100\text{ MHz}$   | 100  | –    | –    | MHz           |
| F           | noise figure   | $I_C = 200\text{ }\mu\text{A}; V_{CE} = 5\text{ V};$<br>$R_S = 2\text{ k}\Omega; f = 1\text{ kHz}; B = 200\text{ Hz}$ | –    | 2    | 10   | dB            |

**Notes**

- $V_{BEsat}$  decreases by about 1.7 mV/K with increasing temperature.
- $V_{BE}$  decreases by about 2 mV/K with increasing temperature.



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## REFERENCES

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