AUTOMATIC LEAK DETECTION IN DISTRIBUTION LINES AND pH MONITORING USING LABVIEW

A PROJECT REPORT

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DEDICATED TO

OUR PARENTS

ABSTRACT

ABSTRACT

A recent survey has found out that most pipelines, regardless of what they contain, begin to fail after a life span of 15-20 years. This happens because of leaks at poor construction joints, corrosion points and small structural material cracks and gradually progress to a catastrophic ending. Therefore an automatic pipeline leak detection system is very important in terms of system reliability and reduced inspection time.

The project precisely identifies the location of leaks on a distribution line, in this case a water distribution system. The identification involves a system where multiple flow sensors are placed along the length of the line and based on the variations in the flow characteristics, the leaks are pinpointed. Data from the remote location are transmitted to the main control station by RF technology. The system is based on Lab View that continuously monitors the sensor values and in the event of a leak, shuts down the entire line.

Also on the supply network, the system incorporates a facility for automatic pH correction. Using this module, the pH is continuously monitored and the system takes action if the pH values are not at the desired levels.

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ACRONYMS & ABBREVATIONS

LCD	-	Liquid Crystal Display
UART	-	Universal Asynchronous Receiver and Transmitter
CMOS	-	Complementary Metal Oxide Semiconductor
LED	-	Amplitude Shift keying
TX/RX	-	Transmitter / Receiver
RISC	-	Reduced Instruction Set Computer
TTL	-	Transistor Transistor Logic
ALE	-	Address Latch Enable
PC	-	Program Counter
DPTR	-	Data Pointer
IE	-	Interrupt Enable
PIC	-	Peripheral Interface Controller
EEPROM	-	Electrically Erasable Programmable Read Only Memory
POR	-	Power-On Reset
PWRT	-	Power-On Timer
OST	-	Oscillator Start-up Timer
WDT	-	Watch Dog Timer
ICSP	-	In Circuit Serial Programming
SSP	-	Synchronous Serial Port.

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CHAPTER 1

INTRODUCTION

.1 NEED OF THE PROJECT

Old and poorly constructed pipelines, inadequate corrosion protection, poorly maintained valves and mechanical damage are some of the factors contributing to leakage. One effect of water leakage, besides the loss of water resources, is reduced pressure in the supply system. Raising pressures to make up for such losses increases energy consumption. This rise in pressure makes leaking worse and has adverse environmental impacts. Of the many options available for conserving water, leak detection is a logical first step. If a utility does what it can to conserve water, customers will tend to be more cooperative in other water conservation programs, many of which hinge on individual efforts. A leak detection system can save millions of litres of water that are wasted due to these leaks. Leak detection is an opportunity to improve services to existing customers and to extend services to the population not served. In general, a 10 to 20 percent allowance for unaccounted-for water is normal. But a loss of more than 20 percent requires priority attention and corrective actions. However advances in technologies and expertise should make it possible to reduce losses and unaccounted- for-water to less than 10 percent. Therefore, a leak detection system is a very important part in a distribution line.

1.2 OBJECTIVE OF THE PROJECT

The main aim of the project is to provide a solution to the problem of leaks in distribution lines, in this case a water distribution system. It also incorporates a facility for continuous monitoring of the pH value of the water and take necessary action if it is not at desired levels. Using the leak detection system, in the event of a leak, the entire line is shut off and the operator is alerted with the exact location of the leak. The system aims to provide a solution that is efficient as well as economical. The leaks have to be found quickly and with minimum effort. Using a Lab View interface the sensor values are continuously monitored. The system allows the user to set a desired range for the pH and a tolerable range for the leaks. The system drastically reduces the time and many man-hours of effort that is now required for the identification of leaks in the water distribution lines, and thereby saving millions of litres of water that are now wasted because of leaks in the distribution lines.

Over the course of the project, the following were the main objectives:

- Acquire and save flow data, from the sensors along the pipeline, real time.
- Detect leaks in time by analyzing flow data.
- Locate leak points quickly and accurately when leak occurs.
- In this event, shut off the flow on the line.
- Replay history data for further analysis.
- System interface must be friendly and operation must be simple and intuitive.
- Monitor the pH value and take control action if it is not at desired levels.

CHAPTER 2

CASE STUDIES

.1 WATER SCARCITY AND ITS EFFECTS

- At any one time, half of the world's hospital beds are occupied by patients suffering from water-borne diseases.
- Over one-third of the world's population has no access to sanitation facilities.
- In developing countries, about 80% of illnesses are linked to poor water and sanitation conditions.
- 1 out of every 4 deaths under the age of 5 worldwide is due to a water-related disease.
- In developing countries, it is common for water collectors, usually women and girls, to have to walk several kilometers every day to fetch water. Once filled, pots and jerry cans weigh as much as 20kg (44lbs).

2.2 WHY WE HAVE A RESPONSIBILITY TO ACT

- Only 1% of the total water resources on earth are available for human use. While 70% of the world's surface is covered by water, 97.5% of that is salt water. Of the remaining 2.5% that is freshwater, almost 68.7% is frozen in ice caps and glaciers.
- Canada controls about 20% of the earth's fresh water.
- Up to 30% of fresh water supplies are lost due to leakage in developed countries, and in some major cities, losses can run as high as 40% to 70%.
- About 90% of sewage and 70% of industrial wastes in developing countries are discharged into water courses without treatment, often polluting the usable water supply.

- A person living in Sub-Saharan Africa uses about 10-20 (2.6-5.26 gallons) litres of water a day; on average, a Canadian uses 326 litres (86 gallons) a day.

2.3 CHINA FACES WATER CRISIS -- 300 MILLION DRINK UNSAFE WATER

About 300 million Chinese drink unsafe water tainted by chemicals and other contaminants according to a new report from the Chinese government. A leading government official said the greatest non-drought threat to China's water resources, is chemical pollutants and other harmful substances that contaminate drinking supplies for 190 million people.

2.4 WATER LOSS THROUGH LEAKS

The EPA estimates that more than a trillion gallons of water are lost annually nationwide through leaks occurring within our homes, with average residence losing 11,000 gallons a year this way.

Fixing a dripping tap can save as much as **5000 litres** a year – if everyone in the UK fixed their dripping taps we would save enough water to supply 120,000 for one day.

2.5 WATER LOSS WITH A FAUCET LEAK

30 drops/minute = 84 gallons/month = 1,008 gallons/year

60 drops/minute = 168 gallons/month = 2,016 gallons/year

90 drops/minute = 253 gallons/month = 3,036 gallons/year

120 drops/minute = 337 gallons/month = 4,044 gallons/year

As a consequence of leaks millions of litres of water are lost every day. The present system of leak detection in our country involves manual inspection of the line. This is very tedious and time consuming. Therefore it is important that the leak detection system is automated saving many man-hours of effort. In the present day the cost of water is on the upward trend and so saving the millions of litres of water that is lost everyday will make a big difference.

CHAPTER 3

METHODOLOGY

3.1 Leak Detection System

Fig 3.1 shows the general block diagram of our leák detection system in the distribution line .It consists of

1. Two tanks
2. Three flow sensors
3. Transmitter and Receiver section
4. PC controlled valve
5. ATMEL (89C51) controller
6. PC

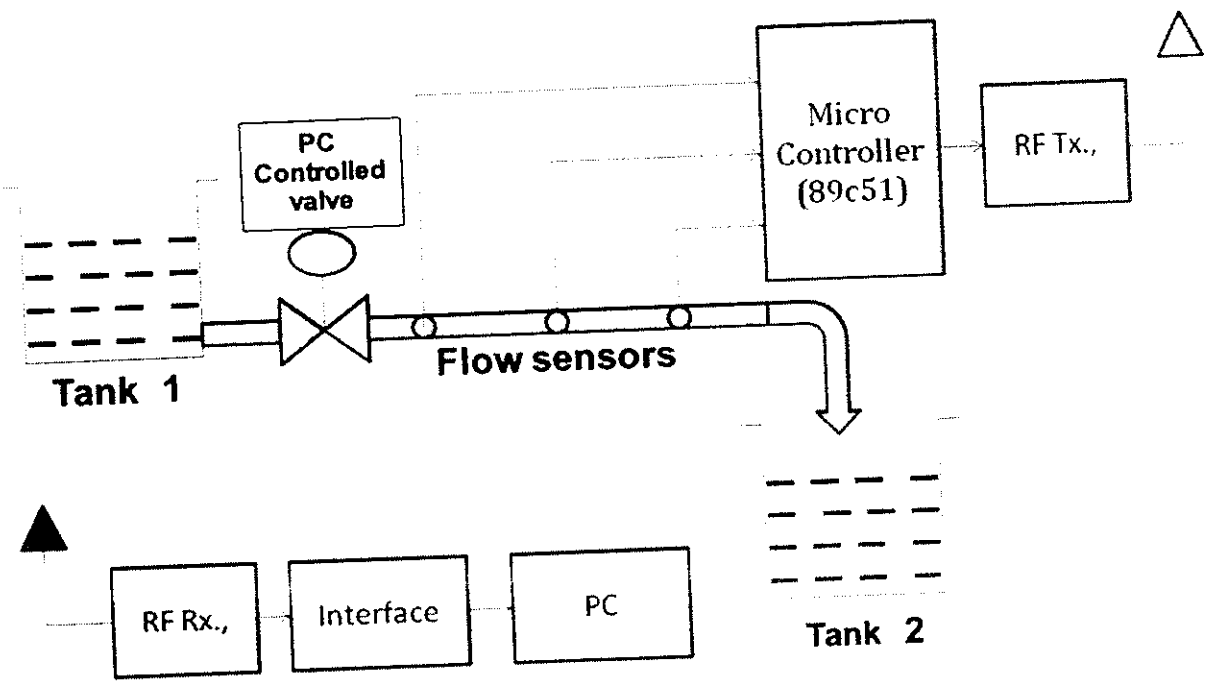


Fig 3.1 Block Diagram of the Leak detection system

In our leak detection system flow sensors are kept within the pipe which distributes the water. The flow values are transmitted to the controller using an RF transmitter, from where it is transmitted to the computer which controls the valve. Whenever there is leak detected, the valve will close and the distribution of water is stopped.

3.1.1FLOW SENSOR

A flow sensor is a device for sensing the rate of fluid flow whether it be a gas, steam, liquid or solid. Normally a flow sensor is the sensing element used in a flow meter, or a flow data logging device. The flow sensor can normally measure velocity, flow rate or totalized flow. Flow sensors are sometimes related to sensors called velocimeters that measure speed of fluids flowing through them. A flow sensor can work by direct measurement or inferential measurement. Several types of flow sensors are non-mechanical and normally work by the inferential method.

INLINE TURBINE FLOW SENSOR:

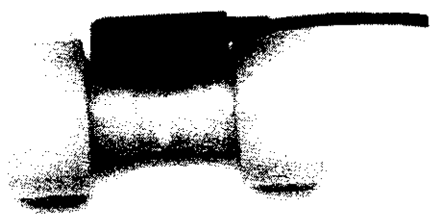


Fig 3.2 Inline turbine flow sensor

Specifications:

Physical Specifications

Pipe Diameter	0.50 inch
Mounting	In-line
End Fittings	In-line Threaded

Process Operating Conditions

Process Media Type	Liquid
Operating Pressure	130 to 232 psi
Media Temperature	68 to 158 F

Flow Performance Range

Meter Type	Volumetric Flow Meter
Liquid Volumetric Flow Rate	0.80 to 10.00 GPM
Accuracy	0.5000 ±%

Construction of flow meter:

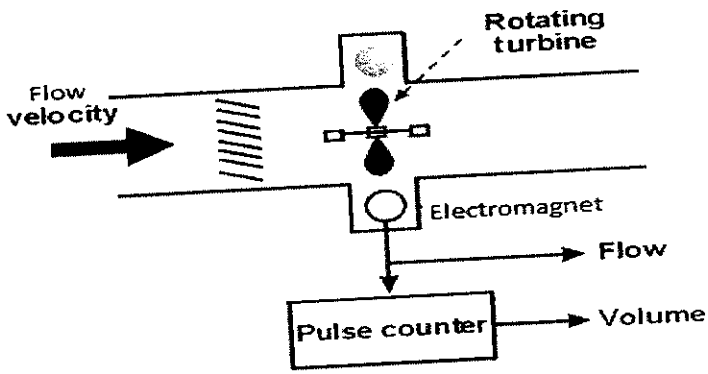


Fig 3.3 Construction of flow meter

PRINCIPLE OF TURBINE FLOWMETER OPERATION:

The flow meter is a volumetric measuring turbine type. The flowing fluid engages the vaned rotor causing it to rotate at an angular velocity proportional to the fluid flow rate. The angular velocity of the rotor results in the generation of an electrical signal (square wave type) in the pickup. The summation of the pulsing electrical signal is related directly to total flow. The frequency of the signal relates directly to flow rate. The vaned rotor is the only moving part of the flow meter.

APPLICATIONS:

- Turbine flow meters are used for blending processes, carbo - coolers, carbon dioxide injection equipment, flow -mixers, and beverage prep systems.
- It is used for critical flow measurements of glycol filled cooling systems typical in the communication industry.
- Other turbine flow meter applications include chemical processing, bubbler systems and cooling.

3.2 pH Monitoring System:

Fig 3.2 shows the block diagram of the pH monitoring system. It consists of

1. Glass electrode.
2. PIC microcontroller.
3. Solenoid Valve.
4. Transmitter and Receiver section.

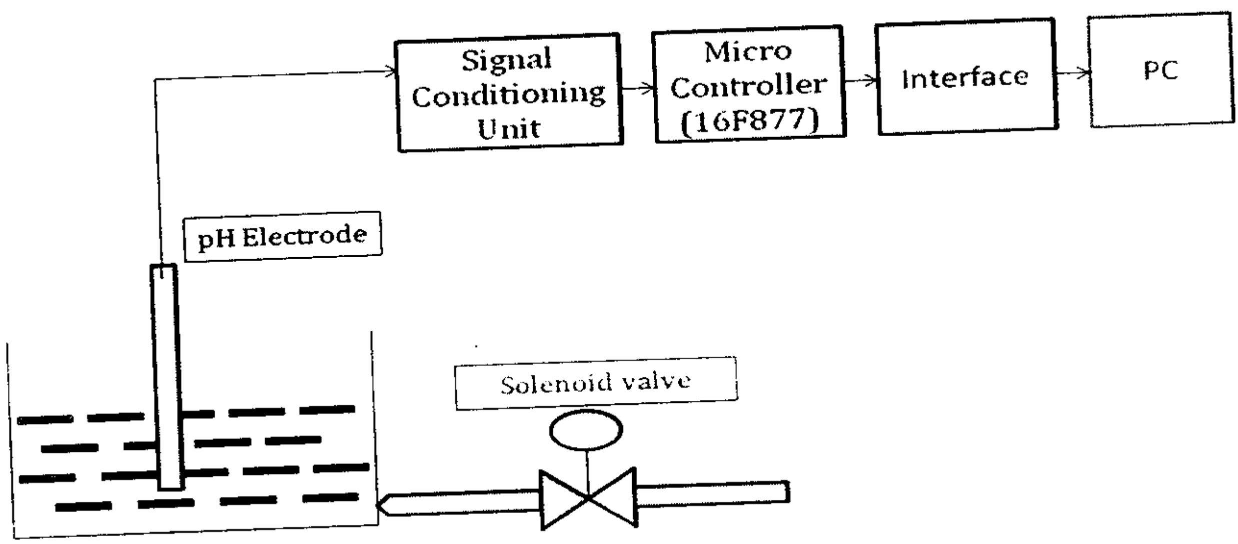
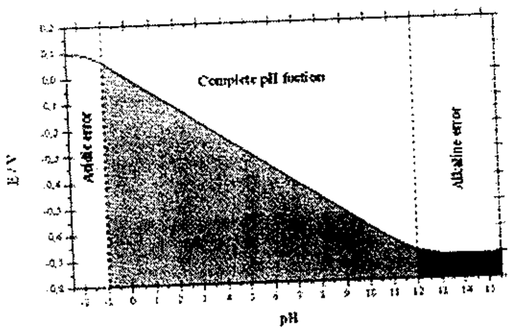


Fig 3.4 Block diagram of the pH monitoring system

In this section, pH is measured over a period of time. Whenever there is a hange from the nominal value, the solenoid valve closes until the pH is brought back to nominal valve. Solenoid valve cuts off the distribution of water. Solenoid valve is controlled by PC.

3.2.1Range of a pH glass electrode

The pH range at constant concentration can be divided into 3 parts:



Scheme of the typical dependence E-pH for ion-selective electrode

- Complete realization of general electrode function, where dependence of potential on pH has linear behavior and within which such electrode really works as ion-selective electrode for pH .

$$E = E^0 - \frac{2.303RT}{F}\text{pH}$$

- Alkali error range - at low concentration of hydrogen ions (high values of pH) contributions of interfering alkali metals (like Li, Na, K) are comparable with the one of hydrogen ions. In this situation dependence of the potential on pH become non-linear.

he effect is usually noticeable at pH > 12, and concentrations of lithium or odium ions of 0.1 moles per litre or more. Potassium ions usually cause less error han sodium ions.

- Acidic error range - at very high concentration of hydrogen ions (low values of pH) the dependence of the electrode on pH becomes non-linear and the the influence of the anions in the solution also becomes noticeable. These effects usually become noticeable at pH < 1.

There are different types of pH glass electrode, some of them have improved characteristics for working in alkaline or acidic media. But almost all electrodes have sufficient properties for working in the most popular pH range from pH=2 to pH=12. Special electrodes should be used only for working in aggressive conditions. Most of text written above is also correct for any ion-exchange electrodes.

3.2.2 Construction

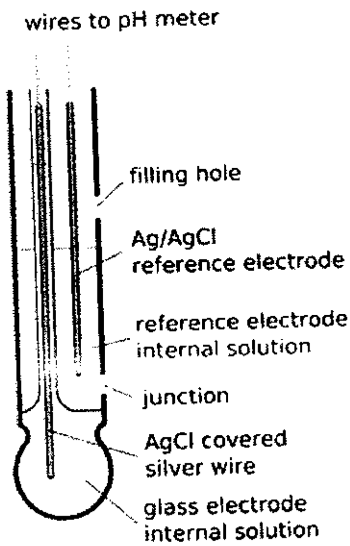


Fig 3.5 Construction of pH meter

cheme of typical pH glass electrode

1. A sensing part of electrode, a bulb made from a specific glass
2. Sometimes the electrode contains a small amount of AgCl precipitate inside the glass electrode
3. Internal solution, usually 0.1 mol/L HCl for pH electrodes or 0.1 mol/L MeCl for pMe electrodes
4. Internal electrode, usually silver chloride electrode or calomel electrode
5. Body of electrode, made from non-conductive glass or plastics.
6. Reference electrode, usually the same type as 4
7. Junction with studied solution, usually made from ceramics or capillary with asbestos or quartz fiber.

A typical modern pH probe is a combination electrode, which combines both the glass and reference electrodes into one body. The bottom of a pH electrode balloons out into a round thin glass bulb. The pH electrode is best thought of as a tube within a tube. The inside most tube (the inner tube) contains an unchanging saturated KCl and a 0.1 mol/L HCl solution. Also inside the inner tube is the cathode terminus of the reference probe. The anodic terminus wraps itself around the outside of the inner tube and ends with the same sort of reference probe as was on the inside of the inner tube. Both the inner tube and the outer tube contain a reference solution but only the outer tube has contact with the solution on the outside of the pH probe by way of a porous plug that serves as a salt bridge.

- The details of this section describe the functioning of two separate types of glass electrodes as one unit. It needs clarification.

his device is essentially a galvanic cell. The reference end is essentially the inner ube of the pH meter, which for obvious reasons cannot lose ions to the urrounding environment (as a reference is good only so long as it stays static hrough the duration of the measurement). The outer tube contains the medium, which is allowed to mix with the outside environment (and as a consequence this tube must be replenished with a solution of KCl due to ion loss and evaporation).

The measuring part of the electrode, the glass bulb on the bottom, is coated both inside and out with a ~10 nm layer of a hydrated gel. These two layers are separated by a layer of dry glass. The silica glass structure (that is, the conformation of its atomic structure) is shaped in such a way that it allows Na^+ ions some mobility. The metal cations (Na^+) in the hydrated gel diffuse out of the glass and into solution while H^+ from solution can diffuse into the hydrated gel. It is the hydrated gel, which makes the pH electrode an ion selective electrode.

H^+ does not cross through the glass membrane of the pH electrode, it is the Na^+ which crosses and allows for a change in free energy. When an ion diffuses from a region of activity to another region of activity, there is a free energy change and this is what the pH meter actually measures. The hydrated gel membrane is connected by Na^+ transport and thus the concentration of H^+ on the outside of the membrane is 'relayed' to the inside of the membrane by Na^+.

All glass pH electrodes have extremely high electric resistance from 50 to 500 MΩ. Therefore, the glass electrode can be used only with a high input-impedance measuring device like a pH meter, or, more generically, a high input-impedance voltmeter which is called an electrometer.

CHAPTER 4

COMPONENTS AND DESCRIPTION

.TMEL (89C51)

.1 INTRODUCTION

AT89C51 is the 40 pins, 8 bit Microcontroller manufactured by Atmel group. It is the flash type reprogrammable memory. Advantage of this flash memory is we can erase the program within few minutes. It has 4kb on chip ROM and 128 bytes internal RAM and 32 I/O pin as arranged as port 0 to port 3 each has 8 bit bin .Port 0 contain 8 data line(D0-D7) as well as low order address line(AO-A7).

Port 2 contain higher order address line (A8-A15). Port 3 contains special purpose register such as serial input receiver register SBUF, interrupt INT0,INT1 and timers T_0 , T_1 many of the pins have multi functions which can be used as general purpose I/O pins (or) Special purpose function can be decided by the programmer itself.

4.1.1 CORE FEATURES OF 89C51:

- 4K Bytes of In-System Reprogrammable Flash Memory

  Endurance: 1,000 Write/Erase Cycles
- Fully Static Operation: 0 Hz to 24 MHz
- Three-Level Program Memory Lock
- 128 x 8-Bit Internal RAM
- 32 Programmable I/O Lines
- Two 16-Bit Timer/Counters
- Six Interrupt Sources

The AT89C51 is a low-power, high-performance CMOS 8-bit microcomputer with 4K bytes of Flash Programmable and Erasable Read Only Memory (PEROM). The device is manufactured using Atmel is high density nonvolatile memory technology and is compatible with the industry standard MCS-51™ instruction set and pin out.

The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel AT89C51 is a powerful microcomputer which provides a highly flexible and cost effective solution to many embedded control applications

The 89C51 consist of:

- Eight-bit CPU with registers A (the accumulator) and B
- Program counter (PC)
- Data pointer (DPTR)
- Flags and the Program Status Word (PSW)
- Eight-bit stack pointer (SP)
- Internal ROM or EPROM or FLASH ROM
- Internal RAM of 256bytes(128bytes general purpose):
- Four register banks, each containing eight registers
- Two 16-bit timer / counter: T0 and T1
- Full duplex serial data receiver/transmitter; SBUF
- Interrupts
- Oscillator and clock circuits

.1.2 ARCHITECTURE OF AN 89C51 MICROCONTROLLER

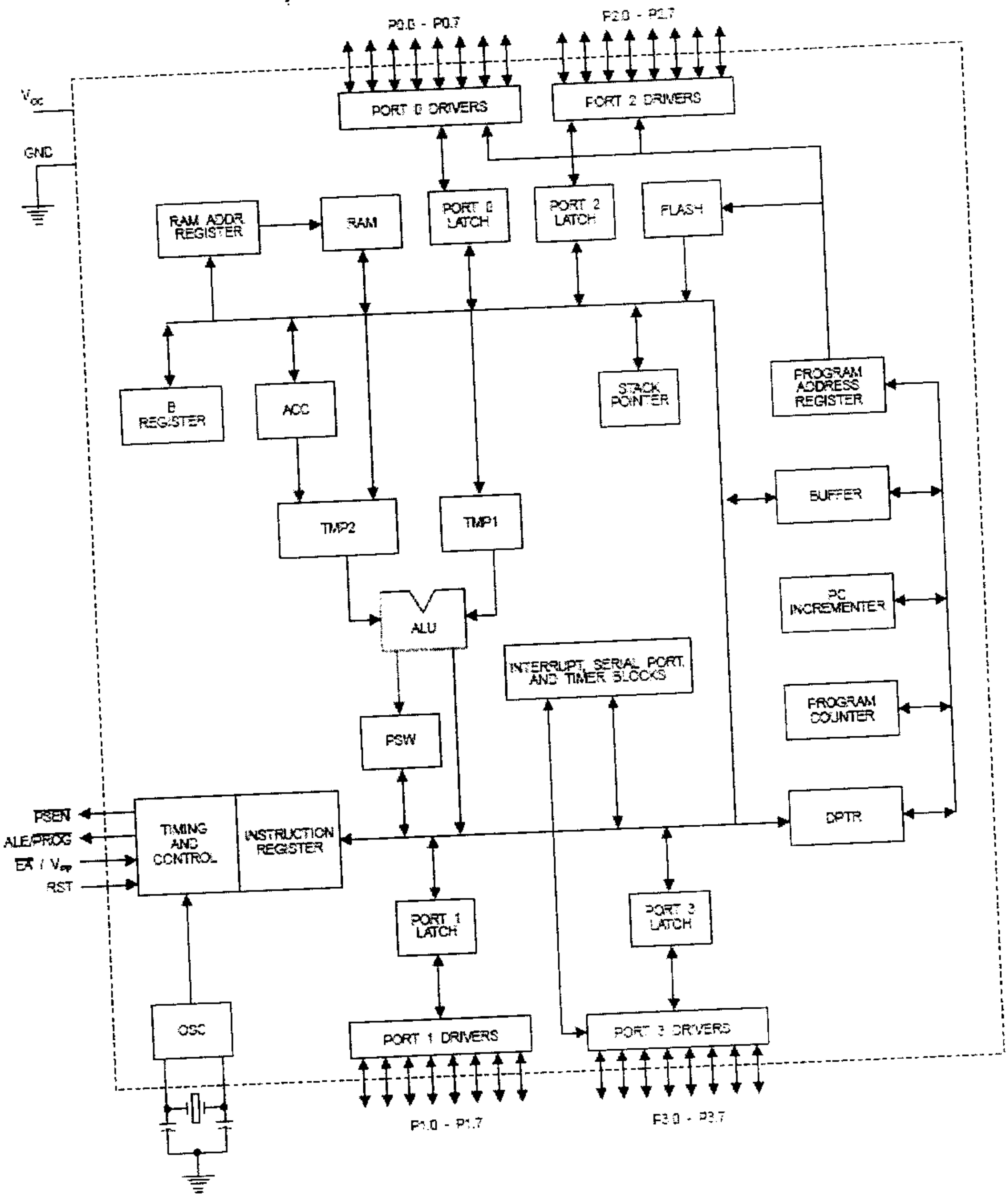


Fig 4.1 Architecture of 89C51 Microcontroller

.1.3PIN OUT DIAGRAM OF THE 89C51

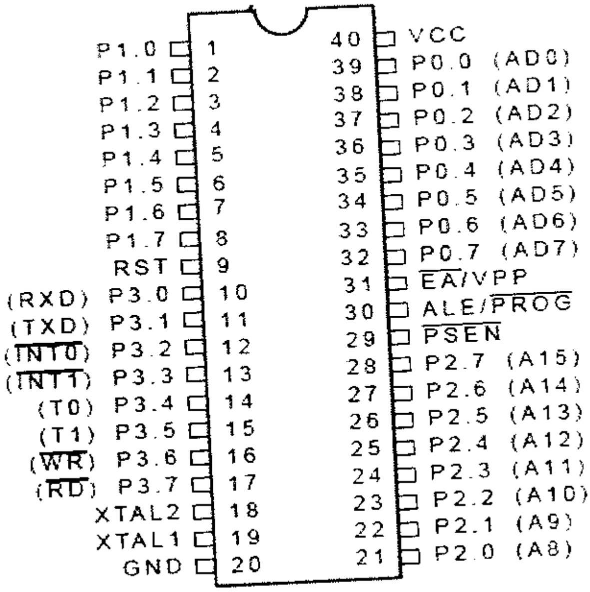


Fig 4.2 Pin diagram of 89C51 Micro Controller

CPU REGISTERS

The 89C51 contain 34 general-purpose, or working, registers. Two of these, registers A and B hold results of many instructions, particularly for arithmetical and logical operations. The other 32 are arranged as part of internal RAM in four banks, Bank0-Bank3, of eight registers each.

PROGRAM COUNTER (PC)

The 89C51 contain two 16-bit registers: the program counter (PC) and the data pointer (DPTR). Each is used to hold the address of a word in memory.

Program instruction bytes are fetched from locations in memory that are addressed by the PC. Program ROM may be on the chip at addresses 000h to FFFh, external to the chip for address that exceed FFFh, or totally external for all address from 0000h to FFFFh.

The PC is automatically incremented after every instruction byte is fetched and may also be altered by certain instructions. The PC is the only register that does not have an internal address.

The Program Counter (PC) is a 2-byte address that tells the 89C51 where the next instruction to execute is found in memory. When the 89C51 is initialized PC always starts at 0000h and is incremented each time an instruction is executed. It is important to note that PC isn't always incremented by one. Since some instructions require 2 or 3 bytes the PC will be incremented by 2 or 3 in these cases.

DATA POINTER (DPTR)

The DPTR register is made up of two 8-bit registers, named DPH and DPL, which are used to furnish memory addresses for internal and external code access and external data access. The DPTR is under the control of program instructions name, DPH and DPL. DPTR does not have a single internal address; DPH and DPL are each assigned an address.

The Data Pointer (DPTR) is the 89C51's only user-accessible 16-bit (2-byte) register. DPTR, as the name suggests, is used to point to address something like HL register pair in 8085 microprocessor. It is used by a number of commands that allow the 89C51 to access external memory and internal memory.

While DPTR is most often used to point to data in external memory, many programmers often take advantage of the fact that it's the only true 16-bit register available. It is often used to store 2-byte values that have nothing to do with memory locations.

PIC (16F877)

.2 INTRODUCTION TO PIC:

The microcontroller that has been used for this project is from PIC series. PIC microcontroller is the first RISC based microcontroller fabricated in CMOS (complementary metal oxide semiconductor) that uses separate bus for instruction and data allowing simultaneous access of program and data memory.

The main advantage of CMOS and RISC combination is low power consumption resulting in a very small chip size with a small pin count. The main advantage of CMOS is that it has immunity to noise than other fabrication techniques.

PIC (16F877):

Various microcontrollers offer different kinds of memories. EEPROM, EPROM, FLASH etc. are some of the memories of which FLASH is the most recently developed. Technology that is used in pic16F877 is flash technology, so that data is retained even when the power is switched off. Easy Programming and Erasing are other features of PIC 16F877.

PIC START PLUS PROGRAMMER:

The PIC start plus development system from microchip technology provides the product development engineer with a highly flexible low cost microcontroller design tool set for all microchip PIC micro devices. The PIC start plus programmer gives the product developer ability to program user software in to any of the supported microcontrollers. The PIC start plus software running under mplab provides for full interactive control over the programmer.

4.2.1 SPECIAL FEATURES OF PIC MICROCONTROLLER:

CORE FEATURES:

- 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:

  < 2mA 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,

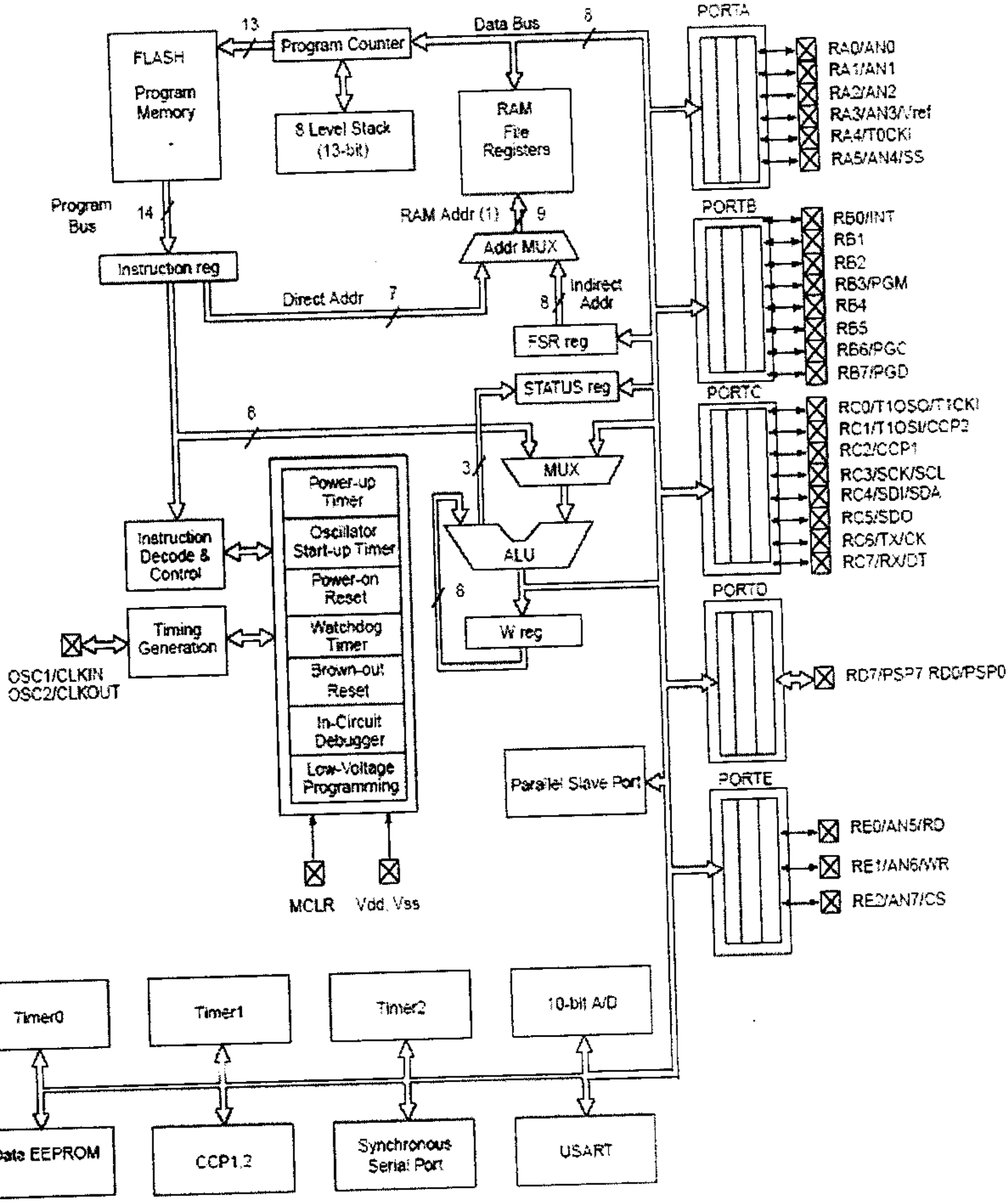
  PWM max. resolution is 10-bit
- 10-bit multi-channel Analog-to-Digital converter
- Synchronous Serial Port (SSP) with SPI. (Master Mode) and I2C. (Master/Slave)
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with

  9- Bit addresses detection.
- Brown-out detection circuitry **for Brown-out Reset (BOR)**

4.2.2 ARCHITECTURE OF PIC 16F877:

The complete architecture of PIC 16F877 is shown in the figure. The Table shown below gives details about the specifications of PIC 16F877. The complete pin diagram of the IC PIC 16F877 is shown in the figure.

Fig 4.3 Architecture of PIC 16F877



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

4.3 TRANSMITTER AND RECEIVER

4.3.1 RF TRANSMITTER

he TWS-434 and RWS-434 are extremely small, and are excellent for applications requiring short-range RF remote controls. The transmitter module is only 1/3 the size of a standard postage stamp, and can easily be placed inside a small plastic enclosure.

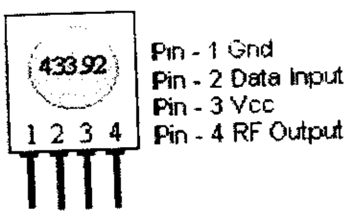
FEATURES

TWS-434: The transmitter output is up to 8mW at 433.92MHz with a range of approximately 400 foot (open area) outdoors. Indoors, the range is approximately 200 foot, and will go through most walls.....

Fig4.4

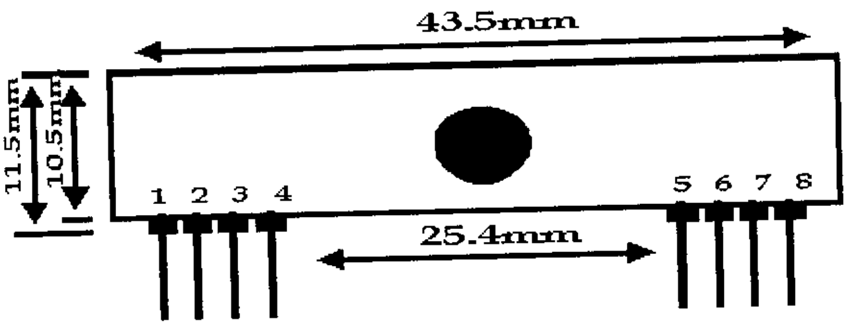
TWS-434A

The TWS-434 transmitter accepts both linear and digital inputs, can operate from 1.5 to 12 Volts-DC, and makes building a miniature hand-held RF transmitter very easy. The TWS-434 is approximately the size of a standard postage stamp.



TWS-434 Pin Diagram

RWS-434: The receiver also operates at 433.92MHz, and has a sensitivity of 3uV. The RWS-434 receiver operates from 4.5 to 5.5 volts-DC, and has both linear and digitaloutputs.



pin 1 : Gnd
pin 2 : DigitaL Output
pin 3 : Linear Output
pin 4 : Vcc
pin 5 : Vcc
pin 6 : Gnd
pin 7 : Gnd
pin 8 :Ant (About 30 - 35 cm)

Fig 4.5

CHARACTERISTICS:

RF TRANSMITTER:

Modulation : ASK

Operating Voltage : 2 – 12 VDC

RF RECEIVER:

Modulation : ASK

Operating Voltage : 3.3 – 6 VDC

4.3.2 FUNCTION OF A TRANSMITTER:

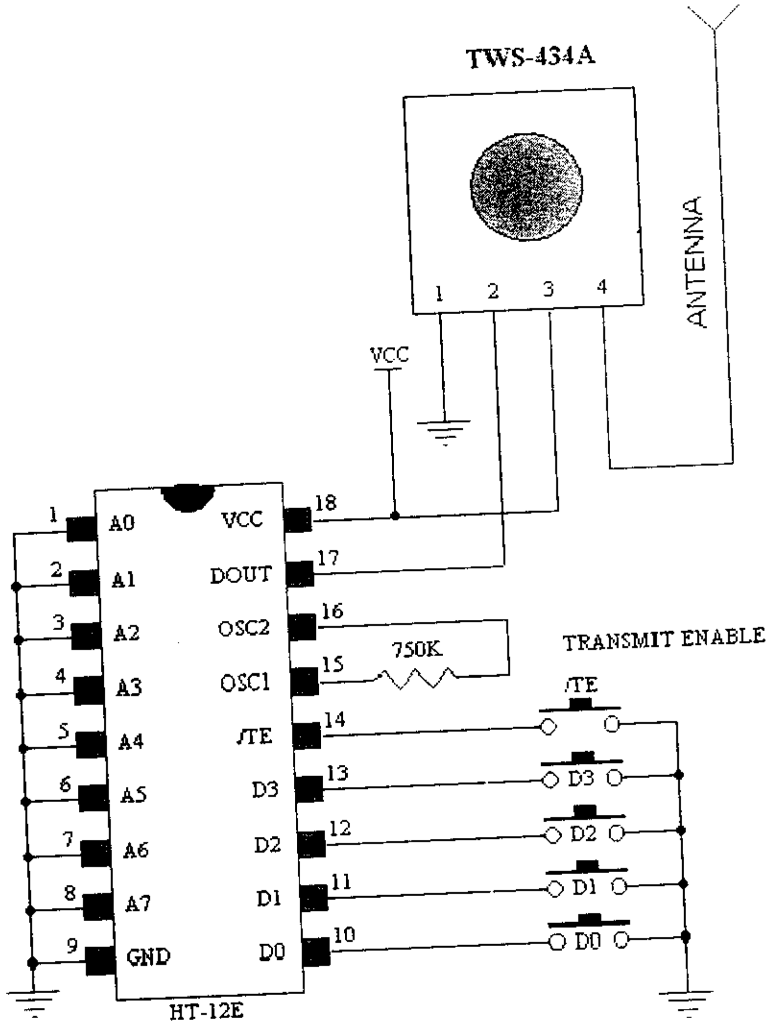


Fig .4.6 Transmitter Section

The transmitter module could be effectively used by maintaining the allowable range of signal specifications and also by maintaining the optimum operating conditions specified for the efficient working. Also the output power level in dB is found to be quite appropriate for efficiency in signal detection by the use of a tuned receiver in the vicinity of about 50m from the transmitter.

4.3.3 FUNCTION OF A RECEIVER:

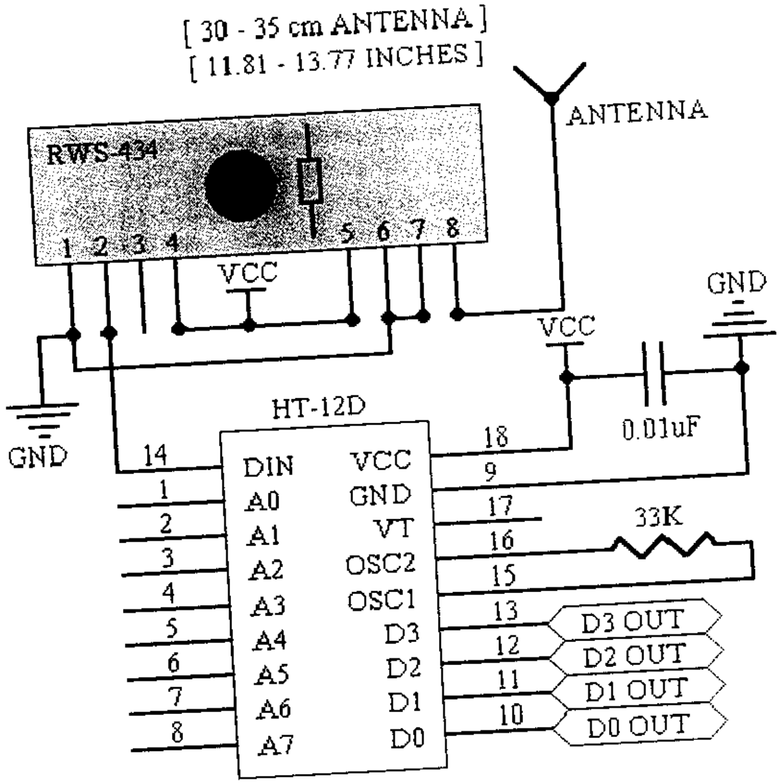


Fig 4.7 Receiver Section

The receiver module could be effectively used by maintaining the allowable range of signal specifications and also by maintaining the optimum operating conditions specified for the efficient working. Also the sensitivity of the receiver in dB is found to be quite appropriate for efficiency in signal reconstruction a signal from the transmitter at a vicinity of the receiver.

4.4 POWER SUPPLY

4.4.1 IC VOLTAGE REGULATORS:

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

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

4.4.2 THREE-TERMINAL VOLTAGE REGULATORS:

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

4.4.3 Fixed Positive Voltage Regulators:

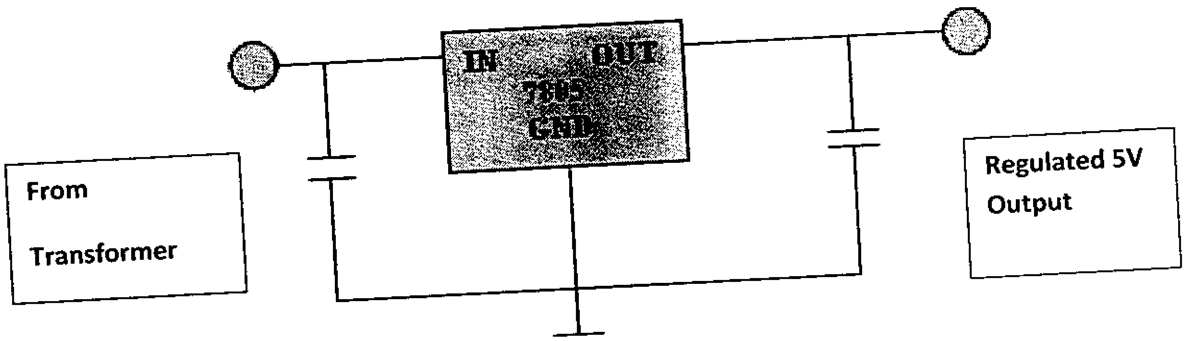


Fig 4.8 Fixed Positive Voltage Regulators

The series 78 regulators provide fixed regulated voltages from 5 to 24 V. As shown how one such IC, a 7812, is connected to provide voltage regulation with output from this unit of +12V dc. An unregulated input voltage Vi is filtered by capacitor C1 and connected to the IC's IN terminal. The IC's OUT terminal provides a regulated + 12V which is filtered by capacitor C2 (mostly for any high-frequency noise). The third IC terminal is connected to ground (GND). While the input voltage may vary over some permissible voltage range, and the output load may vary over some acceptable range, the output voltage remains constant within specified voltage variation limits. These limitations are spelled out in the manufacturer's specification sheets. A table of positive voltage regulated ICs is provided below.

TABLE 4.1 : Positive Voltage Regulators in 7800 series

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

4.5 RELAY

A **relay** is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism, but other operating principles are also used. Relays find applications where it is necessary to control a circuit by a low-power signal, or where several circuits must be controlled by one signal.

4.5.1 BASIC OPERATION:

A simple electromagnetic relay, such as the one taken from a car in the first picture, is an adaptation of an electromagnet. It consists of a coil of wire surrounding a soft iron core, an iron yoke, which provides a low reluctance path for magnetic flux, a movable iron armature, and a set, or sets, of contacts.

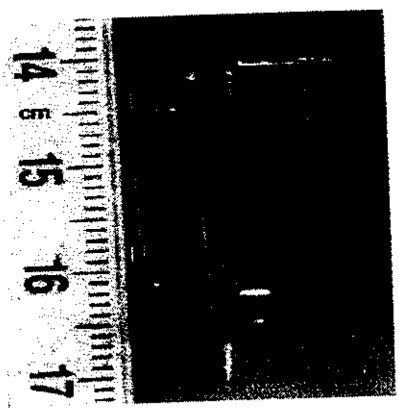


Fig 4.9 Relay

When an electric current is passed through the coil, the resulting magnetic field attracts the armature and the consequent movement of the movable contact or contacts either makes or breaks a connection with a fixed contact. If the set of contacts was closed when the relay was De-energized, then the movement opens the contacts and breaks the connection, and vice versa if the contacts were open.

When the current to the coil is switched off, the armature is returned by a force, approximately half as strong as the magnetic force, to its relaxed position.

4.5.2 RELAY DRIVER CIRCUIT:

Driving Relays:

Using the outputs of the HT-12D or HT-648L decoder ICs to drive relays is quite simple. Here are schematics showing how to drive relays directly from the data-output pins of the decoder.

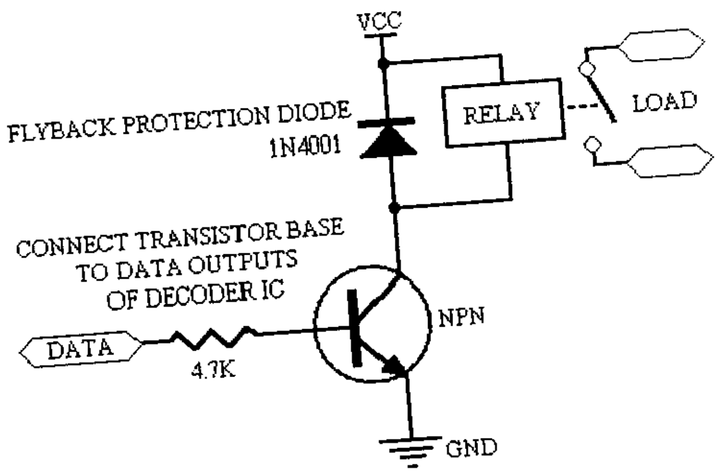


fig4.10

NPN Relay Driver Circuit

4.5.3 APPLICATIONS:

- Control a high-voltage circuit with a low-voltage signal, as in some types of modems or audio amplifiers,
- Control a high-current circuit with a low-current signal, as in the starter solenoid of an automobile,
- Detect and isolate faults on transmission and distribution lines by opening and closing circuit breakers (protection relays).

CHAPTER 5

HARDWARE IMPLEMENTATION

5.1 ENCODER WITH RF TRANSMITTER

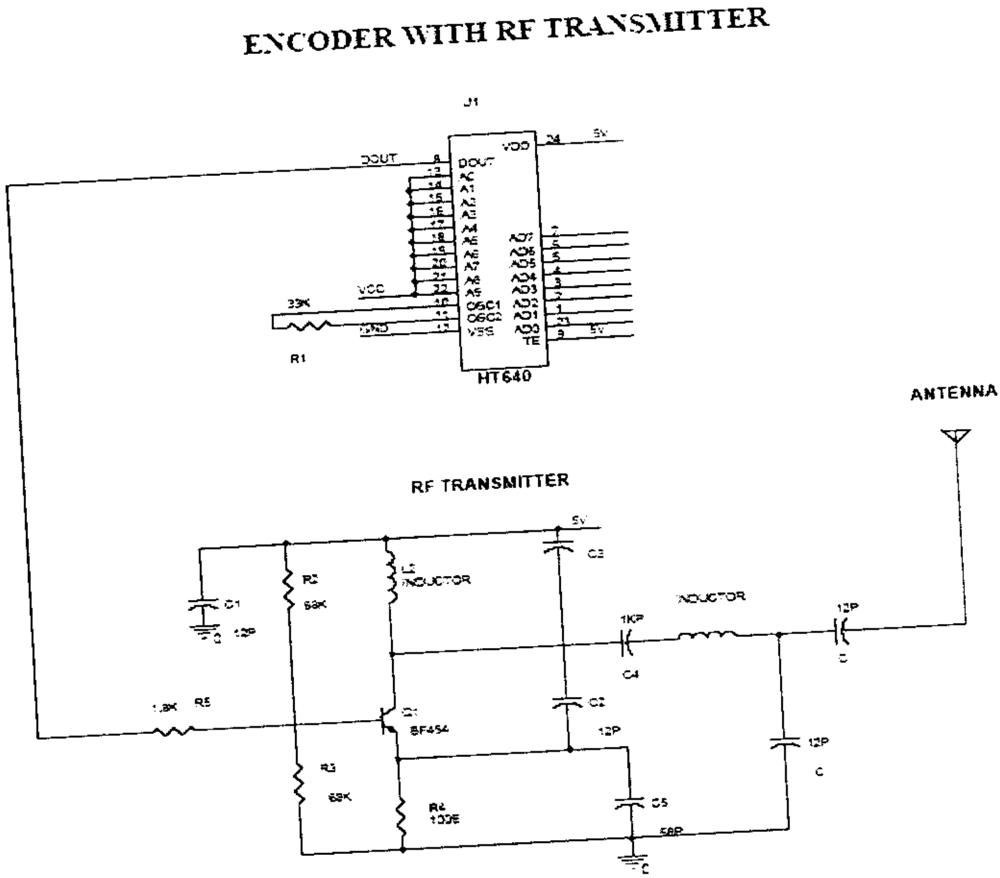


Fig:5.1 Encoder with RF transmitter

5.1.1 Encoder:

In this circuit HT 640 is used as encoder. The 3^{18} encoders are a series of CMOS LSIs for remote control system application. They are capable of encoding 18 bits of information which consists of N address bit and 18-N data bits. Each address/data input is externally trinary programmable if bonded out.

It is otherwise set floating internally. Various packages of the 3^{18} encoders offer flexible combination of programmable address/data is transmitted together with the header bits via an RF or an infrared transmission medium upon receipt of a trigger signal.

The capability to select a TE trigger type further enhances the application flexibility of the 3^{18} series of encoders. In this circuit the input signal to be encoded is given to AD7-AD0 input pins of encoder. Here the input signal may be from key board, parallel port, microcontroller or any interfacing device. The encoder output address pins are shorted so the output encoded signal is the combination of (A0-A9) address signal and (D0-D7) data signal. The output encoded signal is taken from 8^{th} which is connected to RF transmitter section.

5.1.2 RF Transmitter:

Whenever the high output pulse is given to base of the transistor BF 494, the transistor is conducting so tank circuit is oscillated. The tank circuit is consists of L2 and C4 generating 433 MHz carrier signal. Then the modulated signal is given LC filter section. After the filtration the RF modulated signal is transmitted through antenna.

5.2 DECODER WITH RF RECEIVER

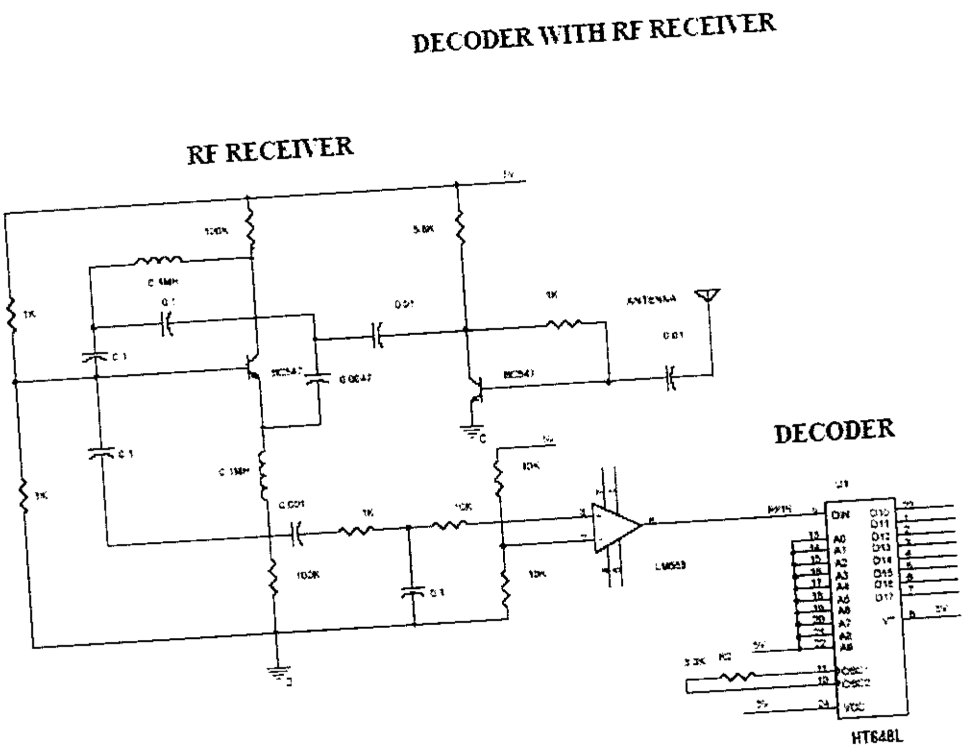


FIGURE : 5.2 Decoder with RF Receiver

5.2.1 Decoder:

In this circuit HT648 is used as decoder. The 3^{18} decoder are a series of CMOS LSIs for remote control system application. They are paired with 3^{18} series of encoders. For proper operation a pair of encoder/decoder pair with the same number of address and data format should be selected. The 3^{18} series of decoder receives serial address and data from that series of encoders that are transmitted by a carrier using an RF or an IR transmission medium. It then compares the serial input data twice continuously with its local address. If no errors or unmatched codes are encountered, the input data codes are decoded and then transferred to the output pins. The VT pin also goes high to indicate a valid transmission.

The 3^{18} decoders are capable of decoding 18 bits of information that consists of N bits of address and 18-N bits of data. To meet various applications they are arranged to provide a number of data pins whose range is from 0 t08 and an address pin whose range is from 8 to 18. In addition, the 3^{18} decoders provide various combinations of address/ data numbering different package. In this circuit the received encoded signal is 9th pin of the decoder. Now the decoder separate the address (A0-A9) and data signal (D0-D7). Then the output data signal is given to microcontroller or any other interfacing device.

5.2.2 RF Receiver:

The RF receiver is used to receive the encoded data which is transmitted by the RF transmitter. Then the received data is given to transistor which acts as amplifier. Then the amplified signal is given to carrier demodulator section in which transistor Q1 is turn on and turn off conducting depends on the signal. Due to this the capacitor C14 is charged and discharged so carrier signal is removed and saw tooth signal is appears across the capacitor. Then this saw tooth signal is given to comparator. The comparator circuit is constructed by LM558. The comparator is used to convert the saw tooth signal to exact square pulse. Then the encoded signal is given to decoder in order to get the decoded original signal.

5.3 RS 232:

RS232 SERIAL COMMUNICATION

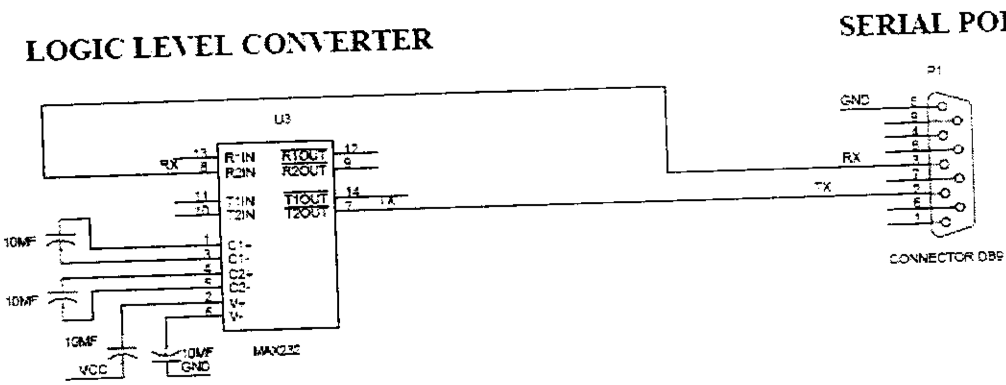


Fig : 5.3 RS232 Serial Communication

In telecommunications, **RS-232** is a standard for serial binary data interconnection between a *DTE* (Data terminal equipment) and a *DCE* (Data Circuit-terminating Equipment). It is commonly used in computer serial ports.

5.3.1 Scope of the Standard:

The Electronic Industries Alliance (EIA) standard RS-232-C [3] as of 1969 defines:

- Electrical signal characteristics such as voltage levels, signaling rate, timing and slew-rate of signals, voltage withstand level, short-circuit behavior, maximum stray capacitance and cable length
- Interface mechanical characteristics, pluggable connectors and pin identification

- Functions of each circuit in the interface connector
- Standard subsets of interface circuits for selected telecom applications

The standard does not define such elements as character encoding (for example, ASCII, Baudot or EBCDIC), or the framing of characters in the data stream (bits per character, start/stop bits, parity). The standard does not define protocols for error detection or algorithms for data compression.

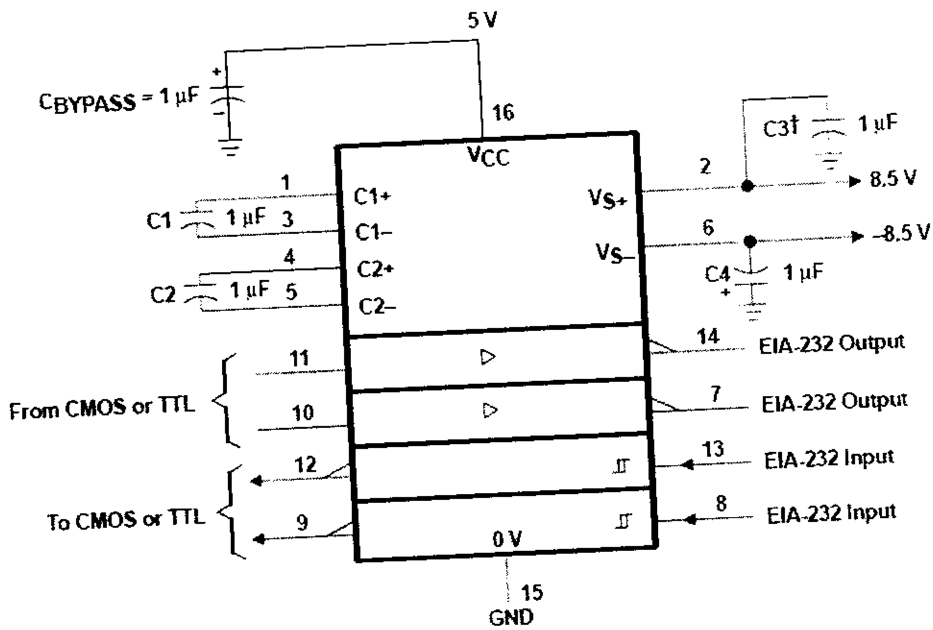
The standard does not define bit rates for transmission, although the standard says it is intended for bit rates lower than 20,000 bits per second. Many modern devices can exceed this speed (38,400 and 57,600 bit/s being common, and 115,200 and 230,400 bit/s making occasional appearances) while still using RS-232 compatible signal levels.

Details of character format and transmission bit rate are controlled by the serial port hardware, often a single integrated circuit called a UART that converts data from parallel to serial form. A typical serial port includes specialized driver and receiver integrated circuits to convert between internal logic levels and RS-232 compatible signal levels.

5.3.2 Circuit working Description:

In this circuit the MAX 232 IC used as level logic converter. The MAX232 is a dual driver/receiver that includes a capacive voltage generator to supply EIA 232 voltage levels from a single 5v supply. Each receiver converts EIA-232 to 5v TTL/CMOS levels. Each driver converts TLL/CMOS input levels into EIA-232 levels.

5.3.3 APPLICATION INFORMATION:



† C3 can be connected to VCC or GND.

Applications:

- TIA/EIA-232-F
- Battery-Powered Systems
- Terminals
- Modems
- Computers

5.4 pH METER

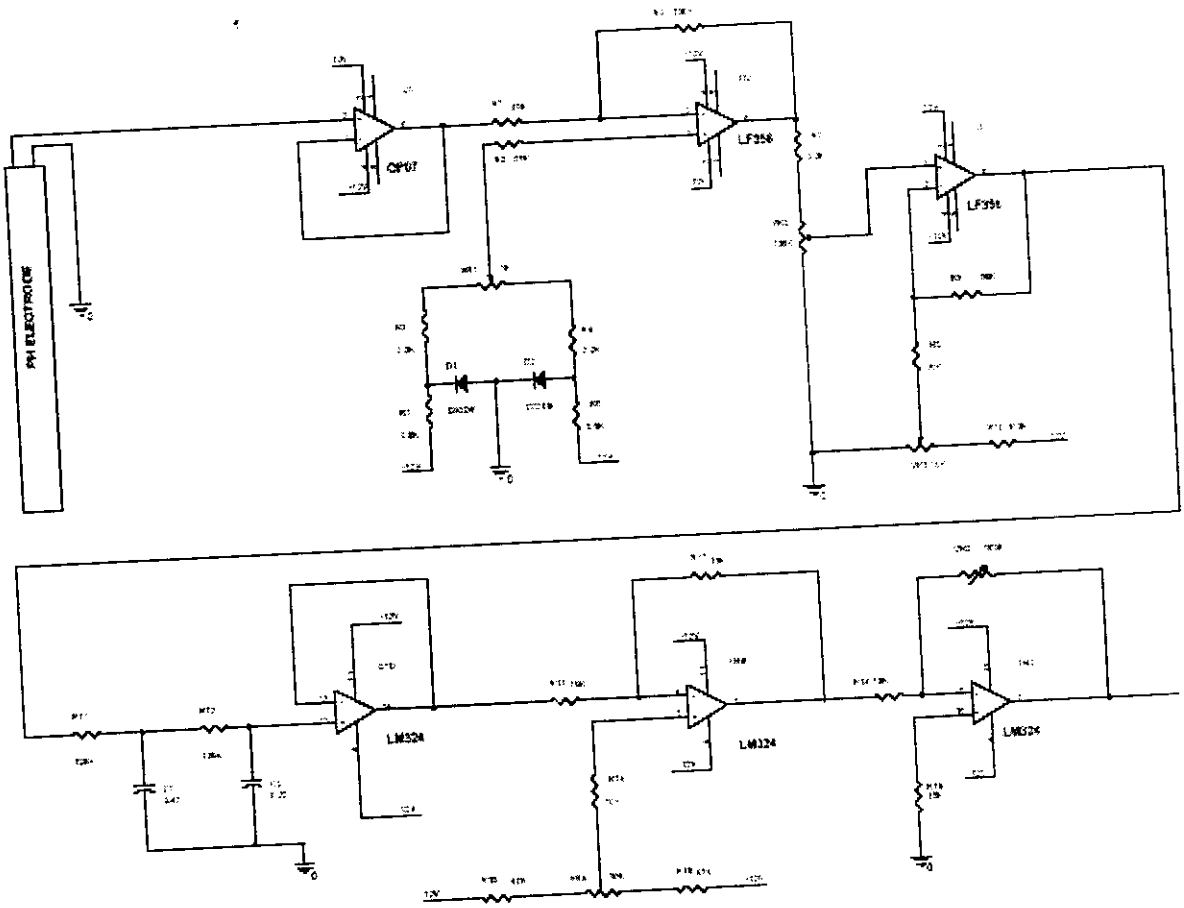


Figure:5.4 pH monitoring circuit diagram

5.4.1 Circuit Description

This circuit is designed to measure the pH level in the water. The pH electrode is used to measure the pH level. Depending on the pH level in the water it generates the corresponding voltage signal. This voltage signal is in the range of mV so it is amplified by the operational amplifier. The amplifier is constructed by the OP07 operational amplifier. Then the amplified signal is given to inverting input terminal of the operational amplifier.

The amplifier is constructed by LF356 operational amplifier. Then the +12v to -12v reference signal is generated by the pair diodes D1 and D2 which is given to non inverting input terminal.

Then the output signal is given to filter section in which the noise signal in the output is filtered. The filter section is constructed by the LM324 operational amplifier and the capacitor C1 and C2. Then the noise free signal is given to comparator in which the pH level is compared with reference level then the final voltage given to gain amplifier in which the variable resistor is connected in the feedback path. Then final gain voltage is given to related circuit in order to find the pH level in the water.

CHAPTER 6

SOFTWARE IMPLEMENTATION

6.1 Lab VIEW

Lab VIEW (Laboratory Virtual Instrument Engineering Workbench) is a graphical programming language that uses icons instead of lines of text to create applications. In contrast to text-based programming languages, where instructions determine the order of program execution, Lab VIEW uses dataflow programming, where the flow of data through the nodes on the block diagram determines the execution order of the VIs and functions. VIs, or virtual instruments, is Lab VIEW programs that imitate physical instruments.

In Lab VIEW, you build a user interface by using a set of tools and objects. The user interface is known as the front panel. You then add code using graphical representations of functions to control the front panel objects. This graphical source code is also known as G code or block diagram code. The block diagram contains this code. In some ways, the block diagram resembles a flowchart.

Lab VIEW is integrated fully for communication with hardware such as GPIB, VXI, PXI, RS-232, RS-485, and data acquisition control, vision, and motion control devices. Lab VIEW also has built-in features for connecting your application to the Internet using the Lab VIEW web server and software standards such as TCP/IP networking and ActiveX.

Using Lab VIEW, you can create 32-bit compiled applications that give you the fast execution speeds needed for custom data acquisition, test, measurement, and control solutions. You also can create stand-alone executables and shared libraries, like DLLs, because Lab VIEW is a true 32-bit compiler.

Lab VIEW contains comprehensive libraries for data collection, analysis, presentation, and storage. Lab VIEW also includes traditional program development tools. You can set breakpoints, animate program execution, and single-step through the program to make debugging and development easier.

Lab VIEW also provides numerous mechanisms for connecting to external code or software through DLLs, shared libraries, ActiveX, and more. In addition, numerous add-on tools are available for a variety of application needs.

6.1.1 Why Lab VIEW?

Lab VIEW empowers you to build your own solutions for scientific and engineering systems. Lab VIEW gives you the flexibility and performance of a powerful programming language without the associated difficulty and complexity.

Lab VIEW gives thousands of successful users a faster way to program instrumentation, data acquisition, and control systems. By using Lab VIEW to prototype, design, test, and implement your instrument systems, you can reduce system development time and increase productivity by a factor of 4 to 10.

6.2 ALGORITHM FOR LEAK DETECTION SYSTEM :

STEP 1: Start

STEP 2: Set the tolerance range for the leaks in the lab view interface.

STEP 3: Read flow values from Sensor A, Sensor B and Sensor C

STEP 4: Transmit the flow values from the remote station to the main control station using RF technology.

STEP 5: Using a PIC interface or a DAQ card, acquire data on to the computer.

STEP 6: Using the predetermined formulae calculate the percentage of leaks between the flow sensors.

$$\alpha = (F_a - F_b)/F_a * 100$$

$$\beta = (F_b - F_c)/F_b * 100$$

STEP 7: Find out if the leaks are outside the tolerable range using the conditions.

$$F_b < (1\text{-}0.01\alpha)*F_a$$

$$F_c < (1\text{-}0.01\beta)*F_b$$

STEP 8: IF Yes, stop the distribution on the line by switching off the pump.

ELSE no action.

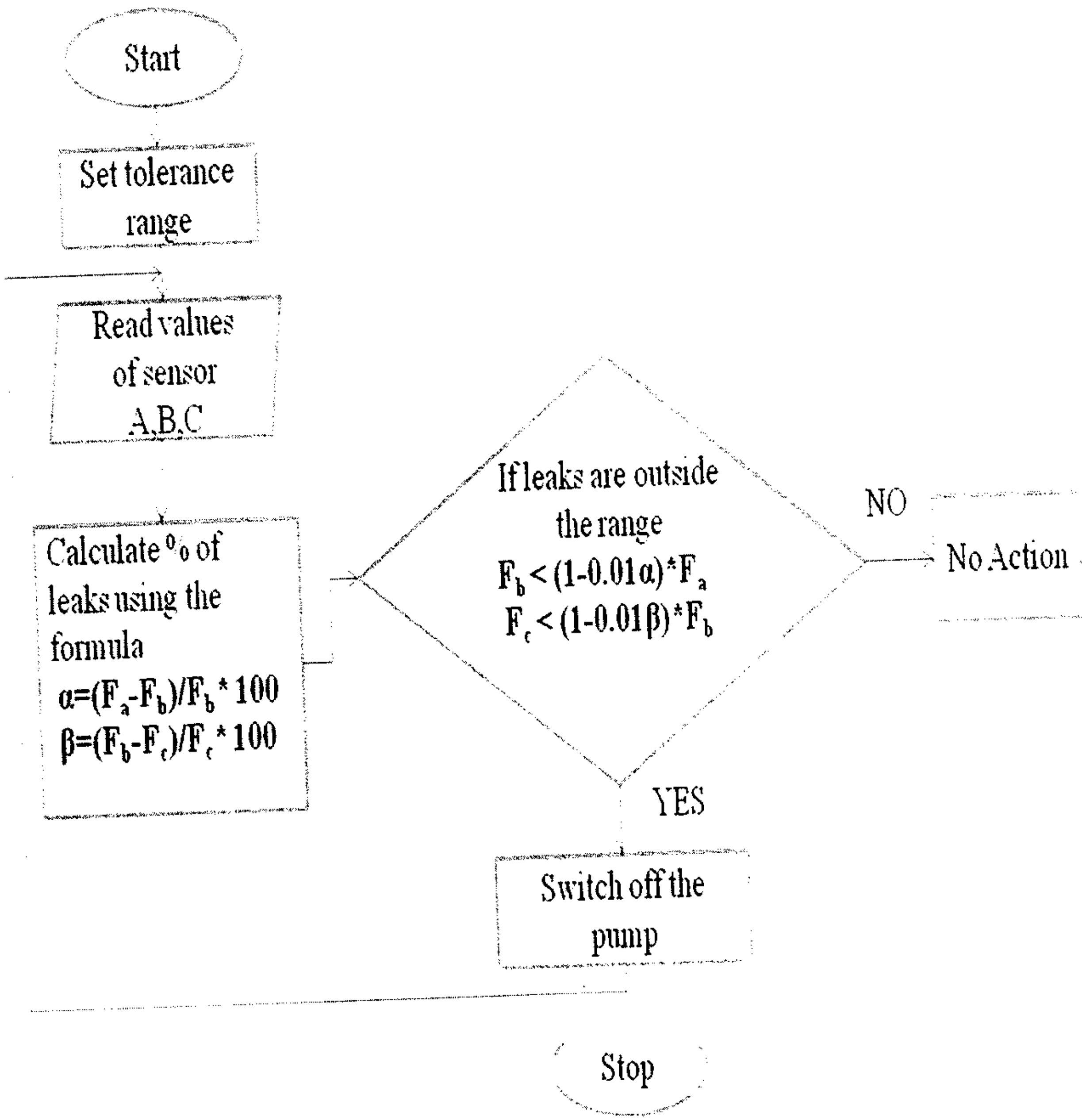
STEP 9: GOTO Step 3.

STEP 10: END.

F_a = Flow Sensor A; F_b = Flow Sensor B; F_c = Flow Sensor C

α = Percentage of leak between A&B; β= Percentage of leak between B&C

6.2.1 FLOW CHART FOR LEAK DETECTION SYSTEM:



6.3 ALGORITHM FOR pH MONITORING SYSTEM:

STEP 1: Start

STEP 2: Set the range of pH in the Lab View interface.

STEP 3: Get the pH value from the pH electrode.

STEP 4: Transmit the pH value from remote station to main control station using RF Technology.

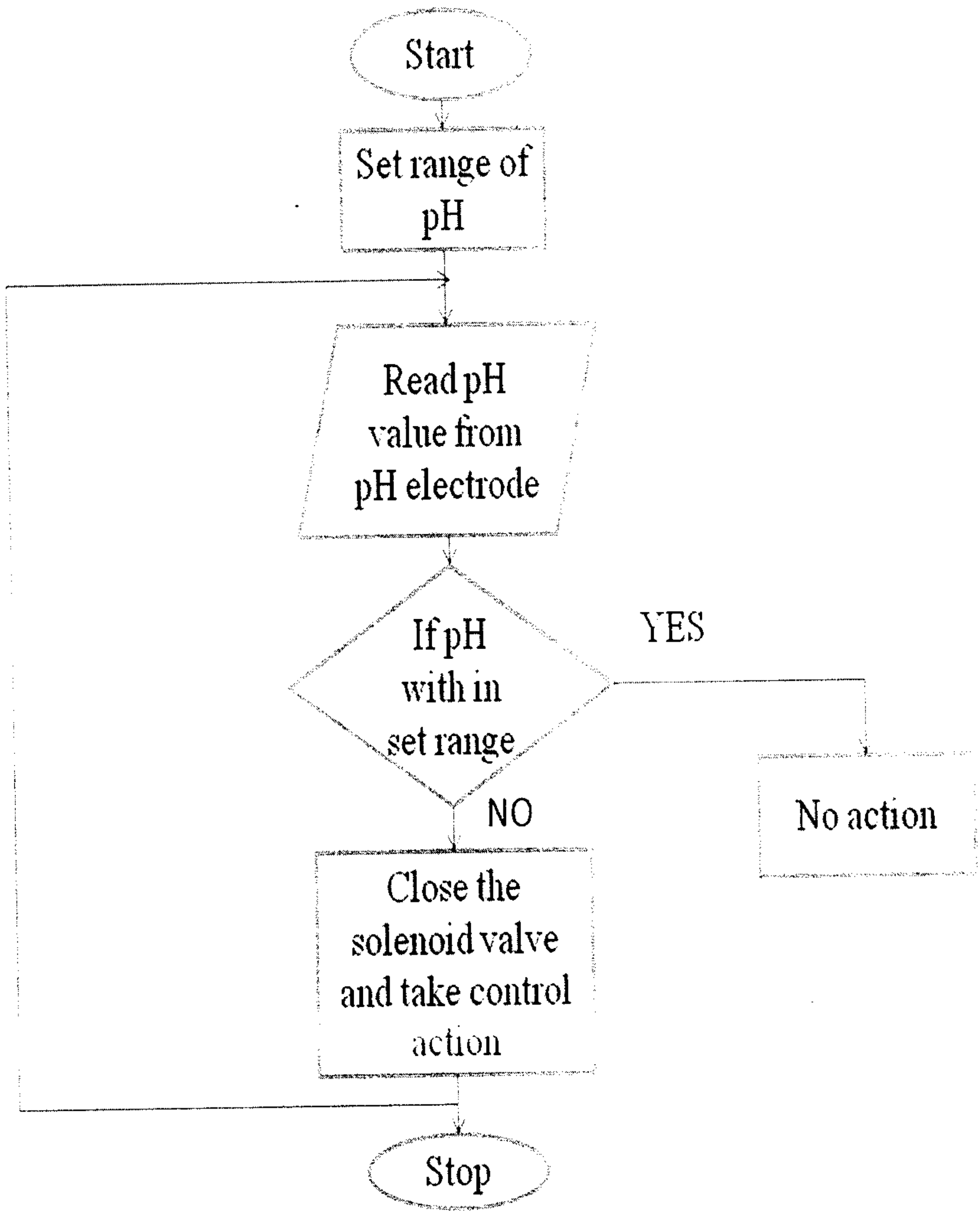
STEP 5: Using a PIC interface or a DAQ card acquire data onto the computer.

STEP 6: IF pH is outside the set range the closed solenoid valve AND take control action ELSE no action.

STEP 7: GOTO Step 3.

STEP 8: END.

6.3.1 FLOW CHART FOR pH MONITORING SYSTEM:



CHAPTER 7

TEST DATA

TABLE 7.1 : 20% LEAK BETWEEN B & C

Time (Sec)	Flow Sensor A	Flow Sensor B	Flow Sensor C	Control Signal
5	184	179	170	100
10	180	178	174	100
15	186	176	164	100
20	188	174	162	100
25	182	179	164	100
30	180	180	168	100
35	179	179	162	100
40	178	179	160	100
45	186	174	158	100
50	182	176	156	100
55	180	178	154	100
60	179	179	146	100
65	178	180	148	100
70	180	174	146	100
75	179	172	144	100
80	182	178	142	100
85	184	180	140	100
90	140	130	110	0
95	99	78	56	0
100	20	16	9	0

FIGURE 7.1: LEAK BETWEEN B & C (20% TOLERANCE)

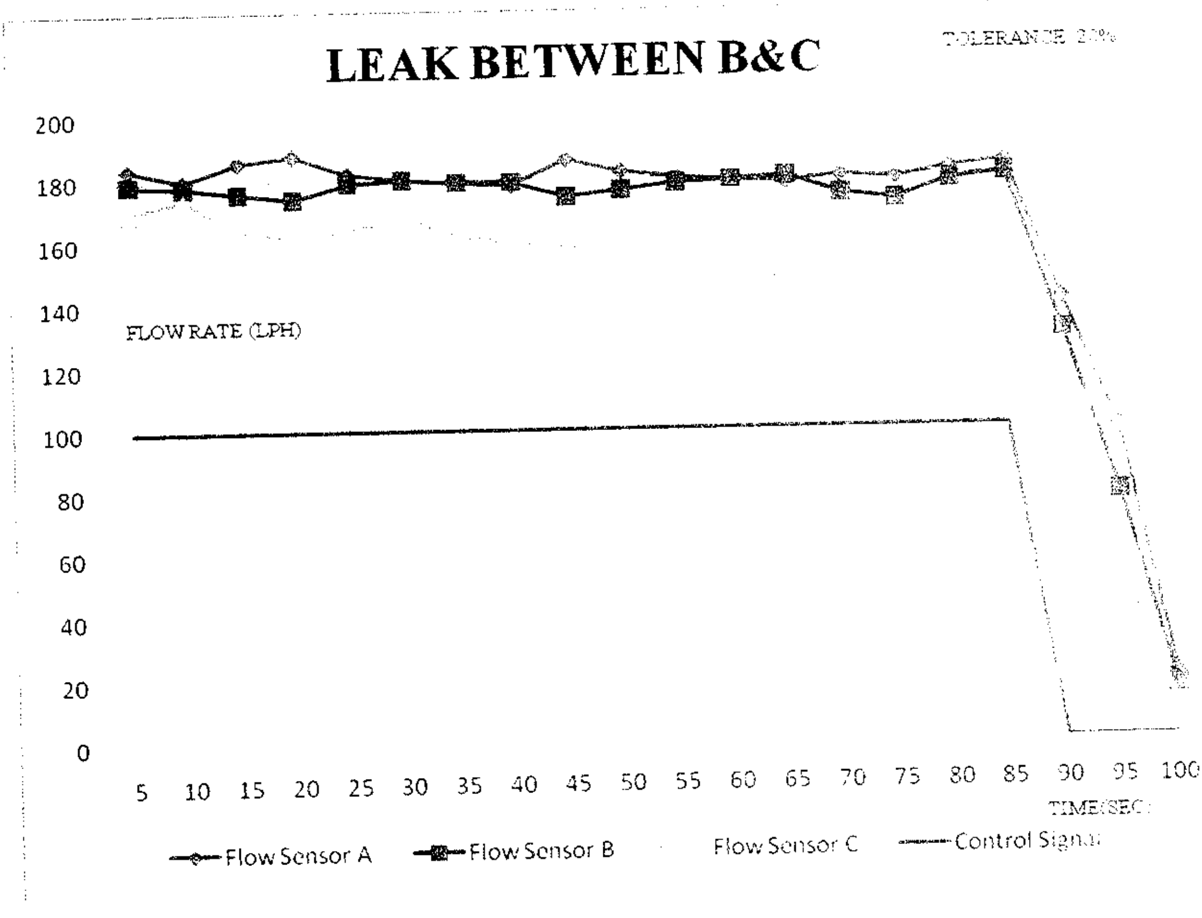


TABLE 7.2: 25% LEAK BETWEEN B & C

Time (Sec)	Flow Sensor A	Flow Sensor B	Flow Sensor C	Control Signal
5	184	179	170	100
10	180	178	174	100
15	186	176	164	100
20	188	174	162	100
25	182	179	164	100
30	180	180	168	100
35	179	179	162	100
40	178	179	160	100
45	186	174	158	100
50	182	176	156	100
55	180	178	154	100
60	179	179	146	100
65	178	180	148	100
70	180	174	146	100
75	179	172	144	100
80	182	178	138	100
85	184	180	133	100
90	140	130	105	0
95	99	78	50	0
100	20	16	8	0

FIGURE 7.2: LEAK BETWEEN B & C (25% TOLERANCE)

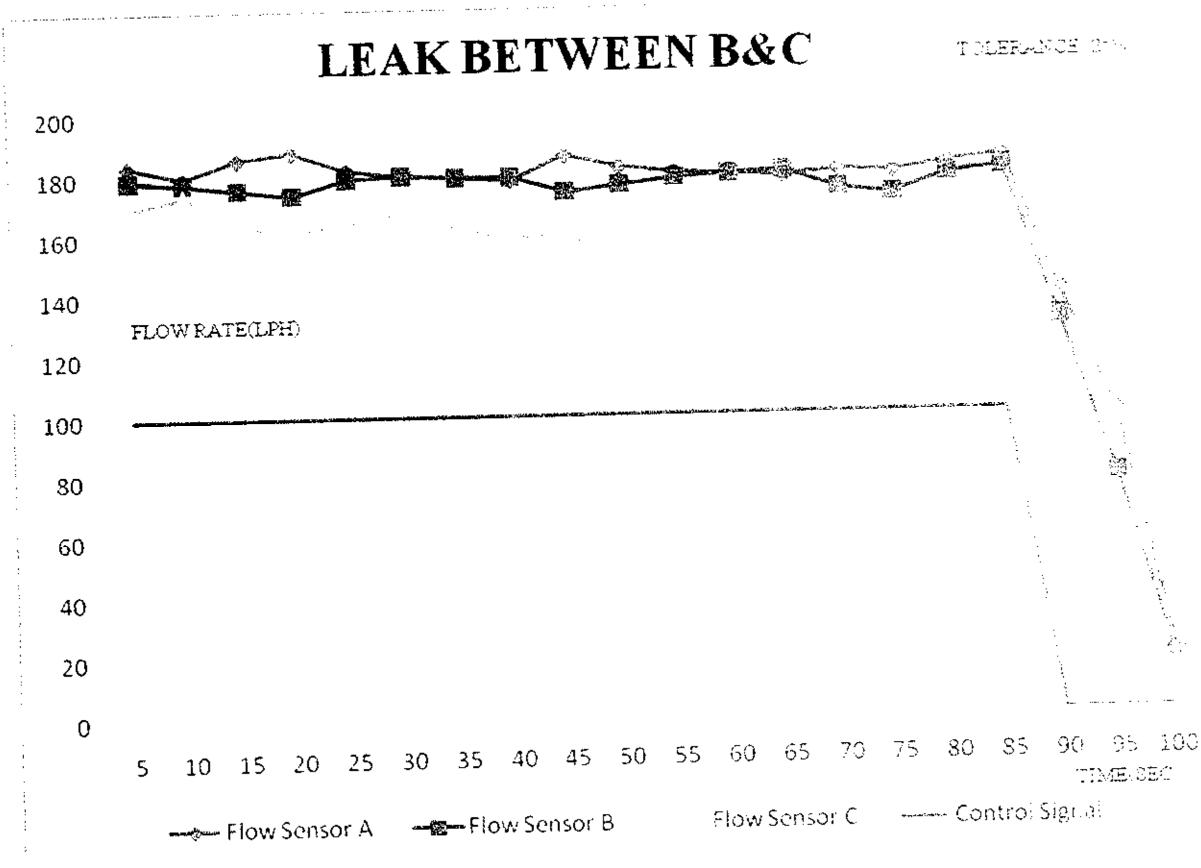


TABLE 7.3: 10% LEAK BETWEEN A & B

Time (Sec)	Flow Sensor A	Flow Sensor B	Flow Sensor C	Control Signal
5	184	179	170	100
10	180	178	174	100
15	186	176	164	100
20	188	174	162	100
25	182	179	164	100
30	180	180	168	100
35	179	179	162	100
40	178	179	160	100
45	186	174	158	100
50	182	176	156	100
55	180	178	154	100
60	179	179	146	100
65	178	180	148	100
70	180	174	146	100
75	179	172	144	100
80	182	168	142	100
85	184	165	140	100
90	140	125	110	0
95	99	73	56	0
100	20	12	9	0

FIGURE 7.3: LEAK BETWEEN A&B (10% TOLERANCE)

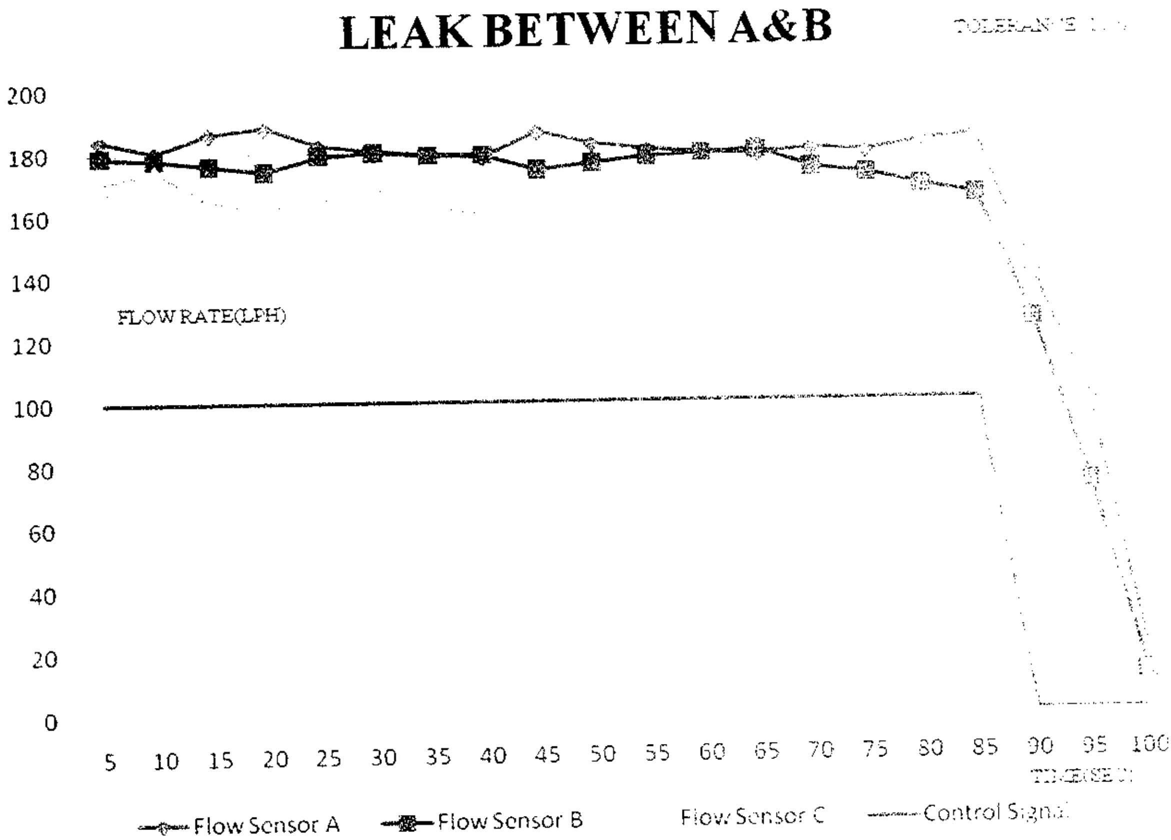


TABLE 7.4: 15% LEAK BETWEEN A&B

Time (Sec)	Flow Sensor A	Flow Sensor B	Flow Sensor C	Control Signal
5	184	179	170	100
10	180	178	174	100
15	186	176	164	100
20	188	174	162	100
25	182	179	164	100
30	180	180	168	100
35	179	179	162	100
40	178	179	160	100
45	186	174	158	100
50	182	176	156	100
55	180	178	154	100
60	179	179	146	100
65	178	176	148	100
70	180	174	146	100
75	160	140	110	0
80	140	110	93	0
85	110	95	70	0
90	90	72	46	0
95	65	50	20	0
100	18	10	5	0

FIGURE 7.4 : LEAK BETWEEN A&B (15% TOLERANCE)

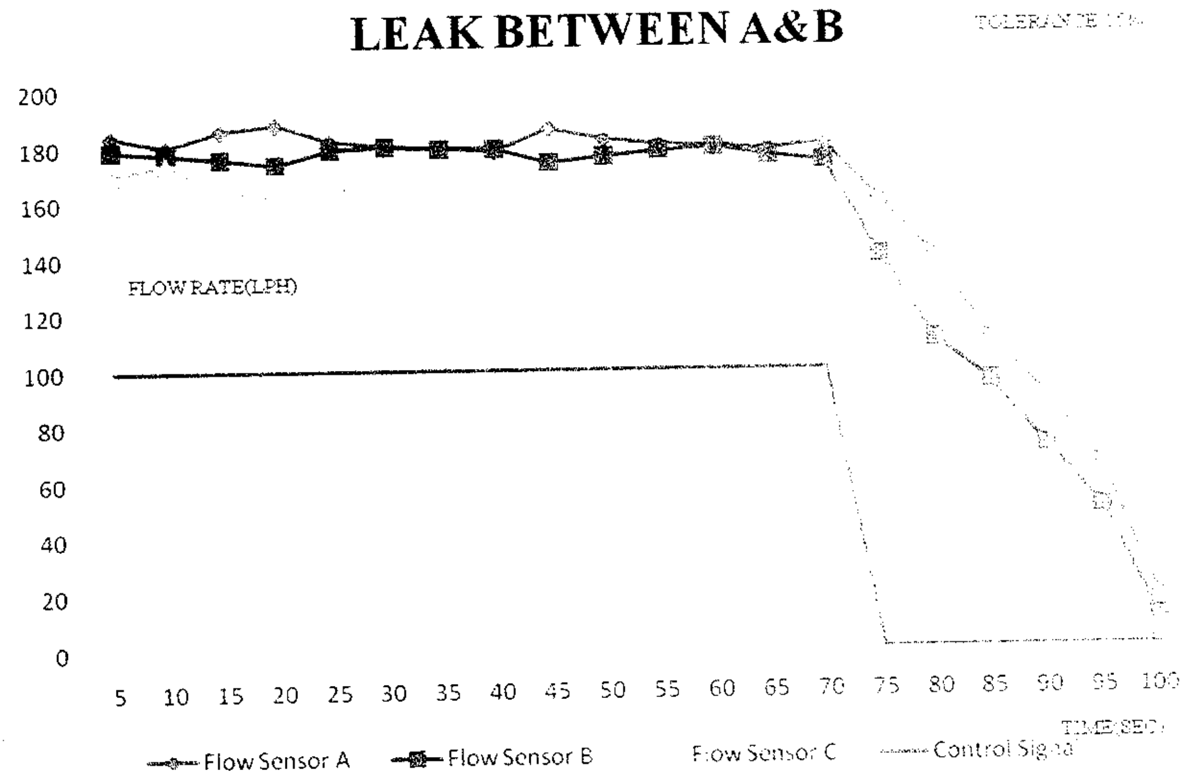


FIGURE 7.5: Ph Monitoring: WHEN WATER IS ACIDIC

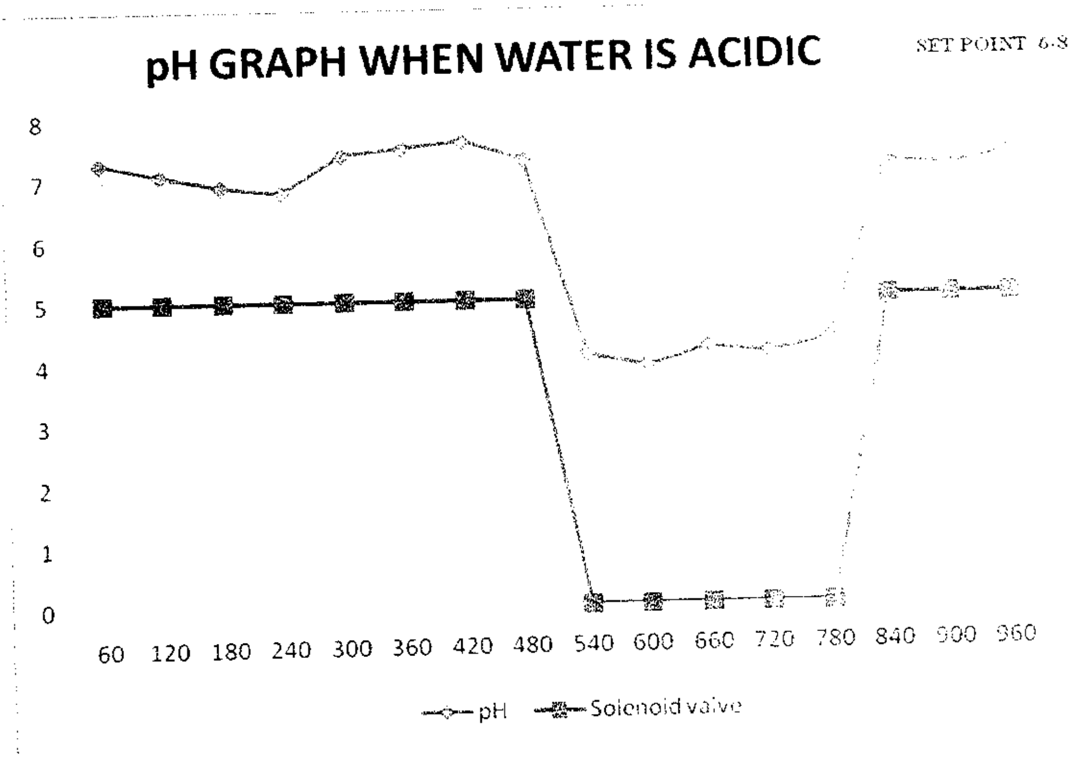
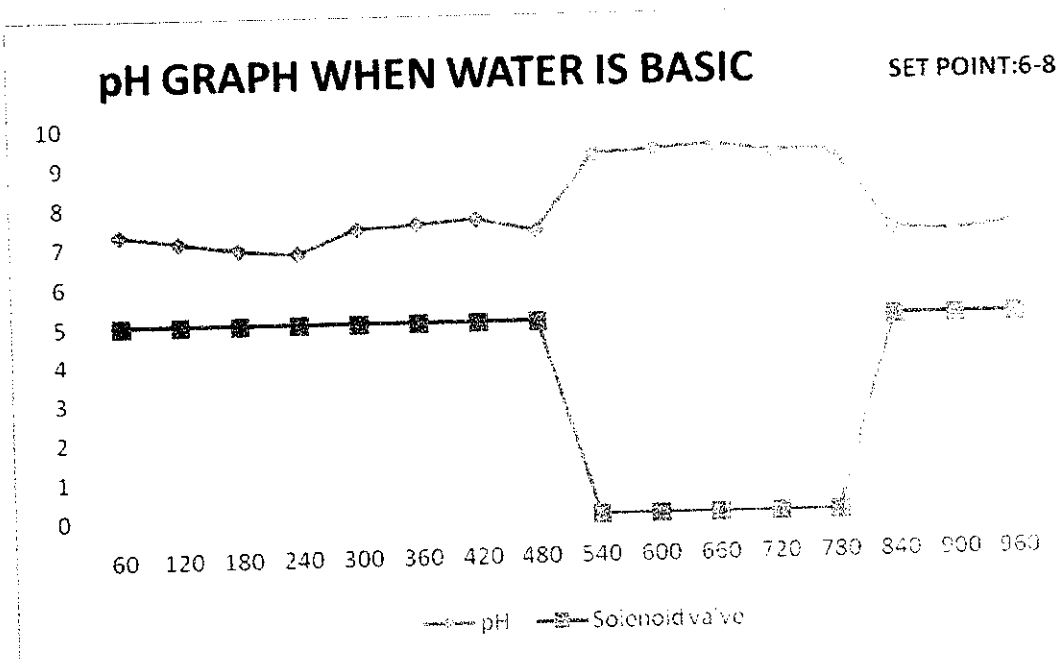


FIGURE 7.6: pH Monitoring: WHEN WATER IS BASIC



8. CONCLUSION

Thus this model successfully detects and controls the leaks in distribution lines. By implementing our project to real time applications, major leaks can be avoided and millions of litres of water can be saved. This method also provides the greatest assurance that in a worst case scenario a leak will be detected in a timely manner, the leak location will be identified and the distribution will be shutoff.

9. BIBLIOGRAPHY

IEEE PAPERS USED FOR REFERENCE

- Development of Pipeline Leak Detection System based on Lab VIEW
  Hu Qiong, Fan Shidong.
- Chlorination Control in a Large Water Treatment Works by
  T. J. Kingham & T. M. Hoggart.

WEBSITES REFERRED

- http://www.pipelineleakdetection.com
- http://www.alphaleak.com
- http://www.primayer.co.uk

BOOKS REFERRED

- Leak detection methods for water distribution pipes by Osama Hunaidi, Robert Patrison, Kristian Stewart.
- Intelligent Leak detection system by Taylor.K.

APPENDICES

CODING- ATMEL (89C51)

```
#include <AT89X51.H>
#include "smcl_lcd8.h"
#include"AT_serial.h"

sbit f1=P1^0;
sbit f2=P1^1;
sbit f3=P1^2;

bit c1,c2,c3;
unsigned char t1,t2,t3,a,sec;

void main()
{
Lcd8_Init();
Lcd8_Display(0x80,"   FLOW COUNTER ",16);
Lcd8_Display(0xc0,"                ",16);
Serial_Init(110);
ES=0;
TMOD=0x21;
EA=1;ES=0;
ET0=1;TR0=1;

while(1)
```

```
{
if(!f1 && !c1) c1=1;
else if(f1 && c1){c1=0;t1++;}

if(!f2 && !c2) c2=1;
else if(f2 && c2){c2=0;t2++;}

if(!f3 && !c3) c3=1;
else if(f3 && c3){c3=0;t3++;}

if(a>=60)
                    {
                    a=0;
//                  sec++;
//                  Lcd8_Decimal3(0x80,sec);
                    Lcd8_Decimal3(0xc0,t1);
                    Lcd8_Decimal3(0xc6,t2);
                    Lcd8_Decimal3(0xcD,t3);
                    Serial_Out('*');
                    Serial_Out((t1/100)+0x30);
     Serial_Out(((t1%100)/10)+0x30);
     Serial_Out(((t1%100)%10)+0x30);
     Serial_Out((t2/100)+0x30);
     Serial_Out(((t2%100)/10)+0x30);
     Serial_Out(((t2%100)%10)+0x30);
```

```
 Serial_Out((t3/100)+0x30);
 Serial_Out(((t3%100)/10)+0x30);
 Serial_Out(((t3%100)%10)+0x30);
 Serial_Out('#');
 Delay(1000);
 t1=t2=t3=0;
 a=0;
}

}
}

void timer0(void) interrupt 1
{
a++;
}
```

CODING- PIC (16F877)

```
#include<pic.h>
#include"pic_adc.h"
#include"lcd.h"

#define r1 RC0
#define r2 RB0
#define r3 RB1
unsigned char cur,cur1,cur2,scur,scur1,scur2,k,count,v[15],dat[8],i,sval,fset;
void Serial_Init();
void Serial_Out(unsigned char);

void main()
{
ADCON1=0X09;
TRISD=TRISB=0;
TRISC=0x80;
TRISA=0XFF;
r2=r3=1;
Lcd8_Init();
Serial_Init();
r1=1;
Lcd8_Display(0x80," Leaks Identify ",16);
Lcd8_Display(0XC0,"& Auto Clorinatn",16);
Delay(65000);
```

```
k=0;
/*
Lcd8_Display(0x80," Set Values.... ",16);
Lcd8_Display(0XC0,"                ",16);
scur=EEPROM_READ(0x30);
scur1=EEPROM_READ(0x31);
scur2=EEPROM_READ(0x31);
Lcd8_Decimal3(0Xc0,scur);
Lcd8_Decimal3(0XC7,scur1);
Lcd8_Decimal4(0XCC,scur2);
Delay(65000);Delay(20000);
*/
k=0;i=0;
Lcd8_Display(0x80,"  Waiting For   ",16);
Lcd8_Display(0XC0,"    Value       ",16);
while(i<=7)
{
Lcd8_Decimal3(0xCd,i);
}
Delay(30000);
sval=((dat[1]-0x30)*100)+((dat[2]-0x30)*10)+((dat[3]-0x30));
fset=((dat[5]-0x30)*100)+((dat[6]-0x30)*10)+((dat[7]-0x30));
Lcd8_Display(0x80," Flow Set :     ",16);
Lcd8_Display(0XC0,"Ph Set Val:     ",16);
Lcd8_Decimal3(0xCC,sval);
```

```
Lcd8_Decimal3(0x8C,fset);
Delay(30000);
r1=0;k=i=0;
v[0]=dat[0]=0;
Lcd8_Display(0x80," PH Value:      ",16);
Lcd8_Display(0XC0,"FA:  B:  C:  ",16);

while(1)
{
cur=Adc8_Cha(0);
Lcd8_Decimal3D(0X8A,cur);

if((cur<(sval-10)) || (cur>(sval+10))) r2=1;
else r2=0;
count++;
if(count>25)
{
RCIE = 0;CREN = 0;
r1=1;Delay(20000);
//                          Lcd8_Display(0x80,"Sending Data....",16);
//                          Lcd8_Display(0XC0,"                ",16);
count=0;
Serial_Out('P');
Serial_Out((cur/100)+0x30);
Serial_Out(((cur%100)/10)+0x30);
```

```
Serial_Out(((cur%100)%10)+0x30);
Serial_Out('A');
Serial_Out((scur/100)+0x30);
Serial_Out(((scur%100)/10)+0x30);
Serial_Out(((scur%100)%10)+0x30);
Serial_Out('B');
Serial_Out((scur1/100)+0x30);
Serial_Out(((scur1%100)/10)+0x30);
Serial_Out(((scur1%100)%10)+0x30);
Serial_Out('C');
Serial_Out((scur2/100)+0x30);
Serial_Out(((scur2%100)/10)+0x30);
Serial_Out(((scur2%100)%10)+0x30);
Delay(65000);
RCIE = 1;CREN = 1;
r1=0;
}
if(k>9)
{
Lcd8_Display(0x80," Data Received. ",16);
Lcd8_Display(0XC0,"                ",16);
k=0;
scur=((v[1]-0x30)*100)+((v[2]-0x30)*10)+((v[3]-0x30));
scur1=((v[4]-0x30)*100)+((v[5]-0x30)*10)+((v[6]-0x30));
scur2=((v[7]-0x30)*100)+((v[8]-0x30)*10)+((v[9]-0x30));
```

```
v[0]=0;k=0;
Lcd8_Display(0x80," PH Value:      ",16);
Lcd8_Display(0XC0,"FA:   B:   C:   ",16);
Lcd8_Decimal3(0Xc3,scur);
Lcd8_Decimal3(0XC8,scur1);
Lcd8_Decimal3(0XCD,scur2);
k=0;
if(((scur1+fset)<scur) || ((scur2+fset)<scur1)) r3=1;
else r3=0;
}
}
}
void Serial_Init()
{
SPBRG = 141;          // for 110 baud rate
BRGH = 0;                     // baud rate low
SYNC = 0;                     // asynchronous mode
SPEN = 1;                     // serial port enable
TXEN = 1;                     // tx enable
GIE=1;
PEIE=1;
RCIE = 1;                             // interrupt set
CREN = 1;                     // rx enable
}
void Serial_Out(unsigned char val)
```

```
{
TXREG =val;
while(!TXIF);
TXIF = 0;
}
void interrupt func(void)
{
if(RCIF==1)
{
RCIF=0;
v[k]=RCREG;
dat[i]=RCREG;
if(v[0]=='*')
{
k++;
}
else k=0;
if(dat[0]=='S')
{
i++;
}
else i=0;
}
}
```

DATASHEETS

PIC16F87X

28/40-pin 8-Bit CMOS FLASH Microcontrollers

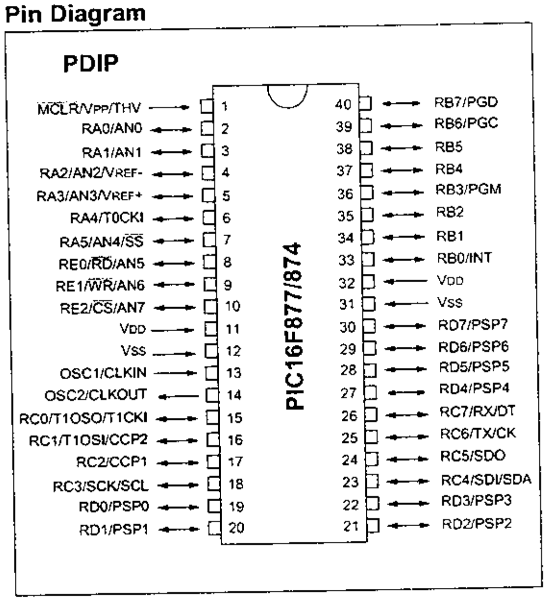
Devices Included in this Data Sheet:

- PIC16F873
- PIC16F874
- PIC16F876
- PIC16F877

Microcontroller Core Features:

- 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
- Pinout compatible to the PIC16C73B/74B/76/77
- Interrupt capability (up to 14 sources)
- 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 FLASH/EEPROM technology
- Fully static design
- In-Circuit Serial Programming™ (ICSP) via two pins
- Single 5V In-Circuit Serial Programming capability
- In-Circuit Debugging via two pins
- Processor read/write access to program memory
- Wide operating voltage range: 2.0V to 5.5V
- High Sink/Source Current: 25 mA
- Commercial and Industrial temperature ranges
- Low-power consumption:
  - < 2 mA typical @ 5V, 4 MHz
  - 20 μA typical @ 3V, 32 kHz
  - < 1 μA typical standby current

Pin Diagram

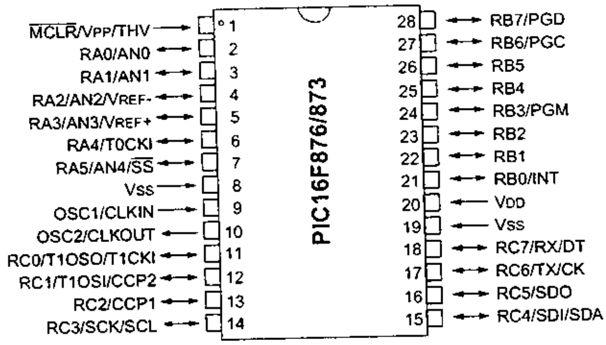


Peripheral Features:

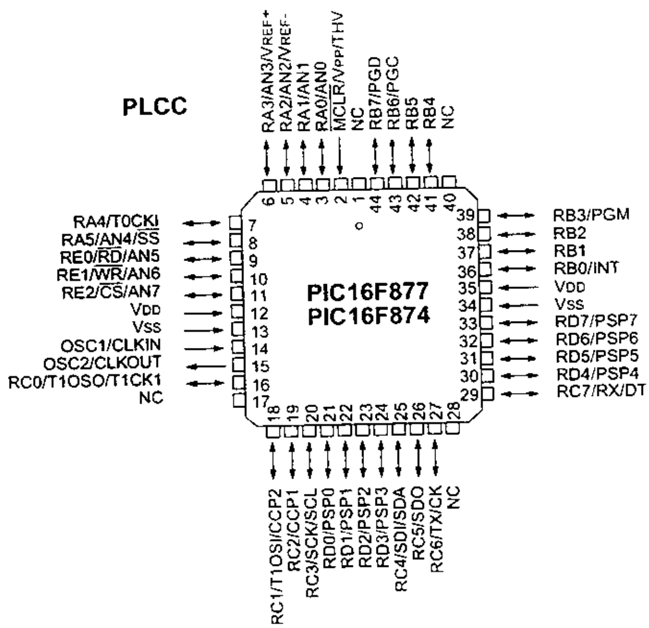
- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler, can be incremented during sleep via external crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Two Capture, Compare, PWM modules
  - Capture is 16-bit, max. 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 I^{2}C™ (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)

Pin Diagrams

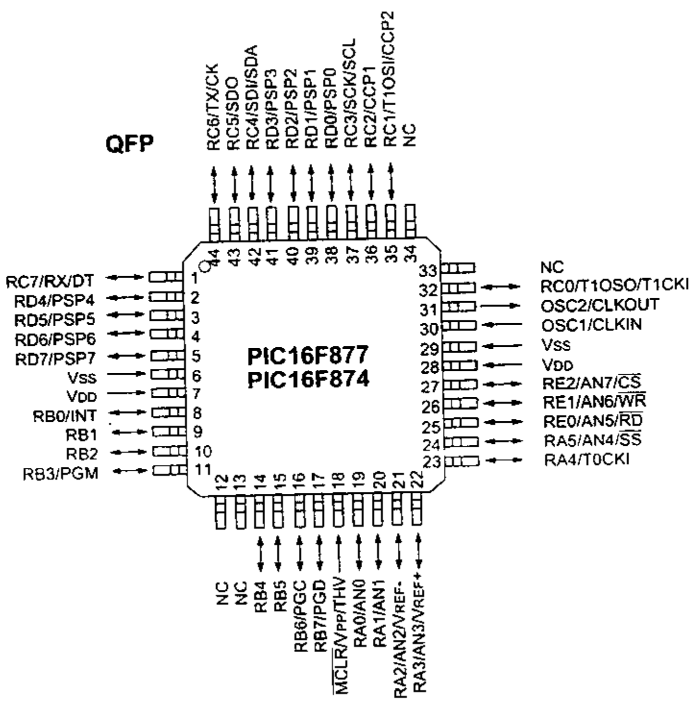
DIP, SOIC



PLCC



QFP



Key Features PICmicro™ Mid-Range Reference Manual (DS33023)	PIC16F873	PIC16F874	PIC16F876	PIC16F877
Operating Frequency	DC - 20 MHz	DC - 20 MHz	DC - 20 MHz	DC - 20 MHz
Resets (and Delays)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)
FLASH Program Memory (14-bit words)	4K	4K	8K	8K
Data Memory (bytes)	192	192	368	368
EEPROM Data Memory	128	128	256	256
Interrupts	13	14	13	14
I/O Ports	Ports A,B,C	Ports A,B,C,D,E	Ports A,B,C	Ports A,B,C,D,E
Timers	3	3	3	3
Capture/Compare/PWM modules	2	2	2	2
Serial Communications	MSSP, USART	MSSP, USART	MSSP, USART	MSSP, USART
Parallel Communications	—	PSP	—	PSP
10-bit Analog-to-Digital Module	5 input channels	8 input channels	5 input channels	8 input channels
Instruction Set	35 Instructions	35 Instructions	35 Instructions	35 Instructions

atures

- ompatible with MCS-51™ Products
- K Bytes of In-System Reprogrammable Flash Memory
  - Endurance: 1,000 Write/Erase Cycles
- ully Static Operation: 0 Hz to 24 MHz
- hree-Level Program Memory Lock
- 28 x 8-Bit Internal RAM
- 2 Programmable I/O Lines
- wo 16-Bit Timer/Counters
- ix Interrupt Sources
- rogrammable Serial Channel
- ow Power Idle and Power Down Modes

8-Bit Microcontroller with 4K Bytes Flash

AT89C51

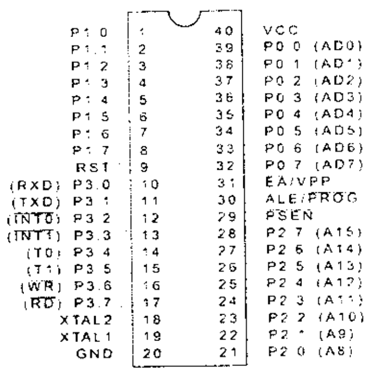
escription

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

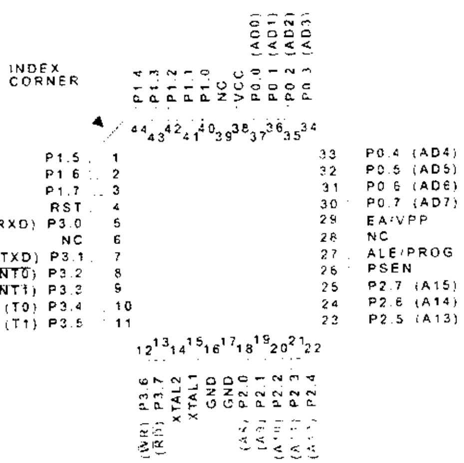
(continued)

in Configurations

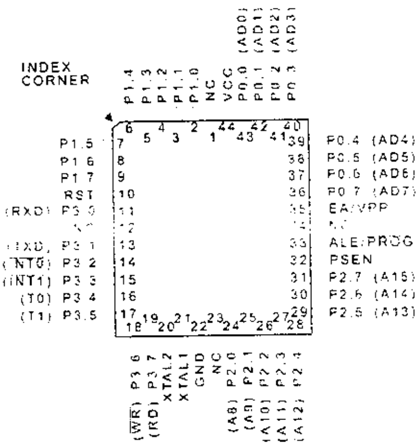
PDIP



PQFP/TQFP

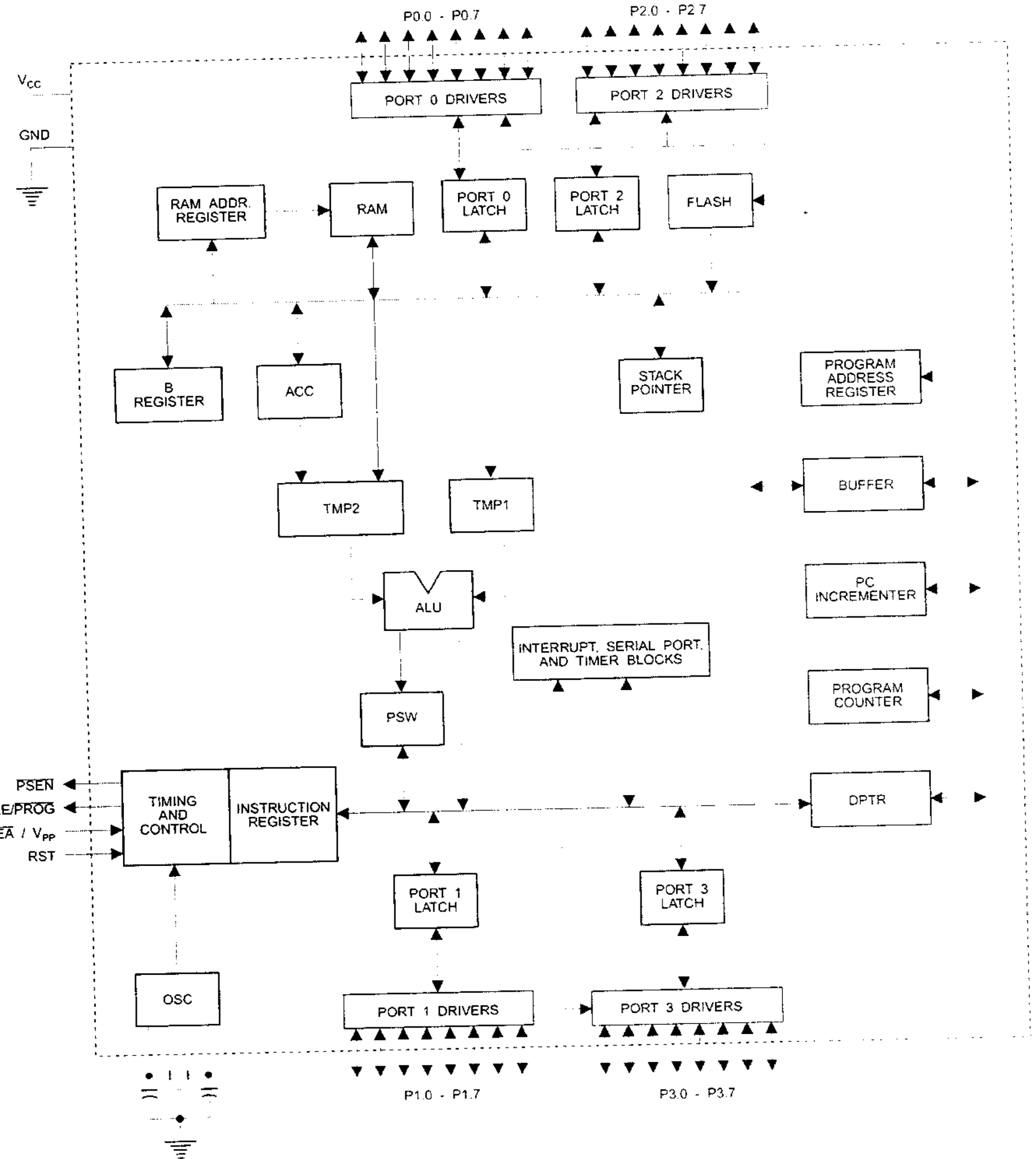


PLCC



0265F-A-12/97

Block Diagram



ure 3. Programming the Flash

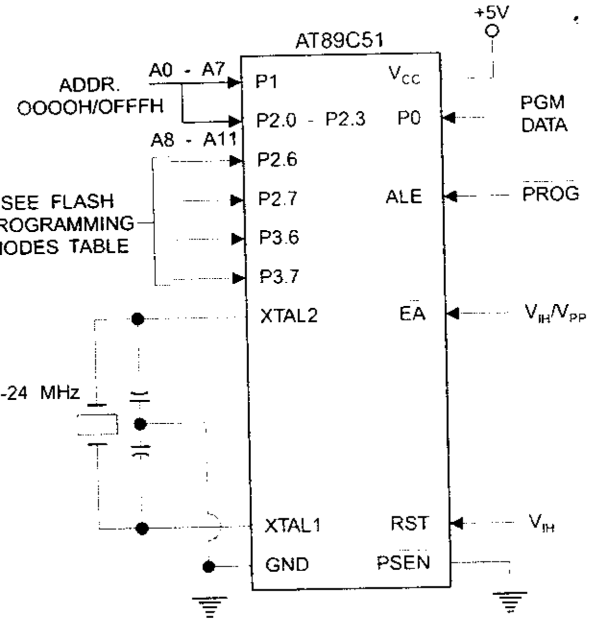
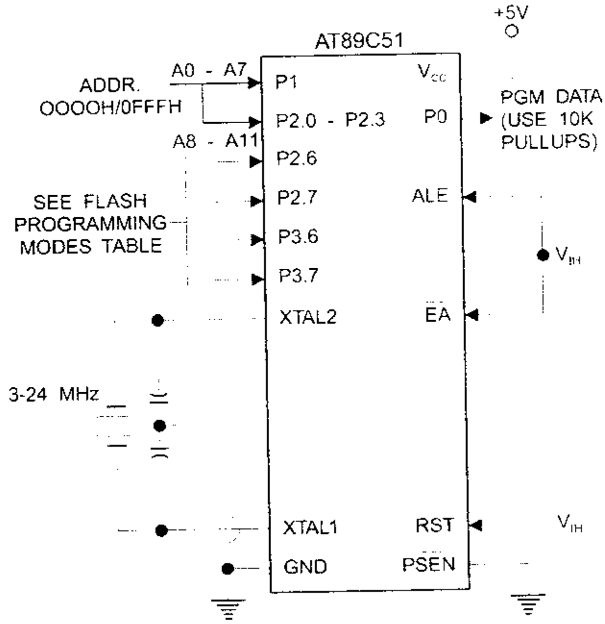


Figure 4. Verifying the Flash



lash Programming and Verification Characteristics

= 0°C to 70°C, V_{CC} = 5.0 ± 10%

ymbol	Parameter	Min	Max	Units
$/_{PP}$[1]	Programming Enable Voltage	11.5	12.5	V
$_{PP}$[1]	Programming Enable Current		1.0	mA
$/t_{CLCL}$	Oscillator Frequency	3	24	MHz
$_{AVGL}$	Address Setup to PROG Low	$48t_{CLCL}$		
$_{GHAX}$	Address Hold After PROG	$48t_{CLCL}$		
$_{DVGL}$	Data Setup to PROG Low	$48t_{CLCL}$		
t_{GHDX}	Data Hold After PROG	$48t_{CLCL}$		
t_{EHSH}	P2.7 (ENABLE) High to V_{PP}	$48t_{CLCL}$		
t_{SHGL}	V_{PP} Setup to PROG Low	10		µs
t_{GHSL}[1]	V_{PP} Hold After PROG	10		µs
t_{GLGH}	PROG Width	1	110	µs
t_{AVQV}	Address to Data Valid		$48t_{CLCL}$	
t_{ELQV}	ENABLE Low to Data Valid		$48t_{CLCL}$	
t_{EHQZ}	Data Float After ENABLE	0	$48t_{CLCL}$	
t_{GHBL}	PROG High to BUSY Low		1.0	µs
t_{WC}	Byte Write Cycle Time		2.0	ms

Iote: 1. Only used in 12-volt programming mode.

FAIRCHILD SEMICONDUCTOR®

www.fairchildsemi.com

LM2902,LM324/LM324A,LM224/ LM224A

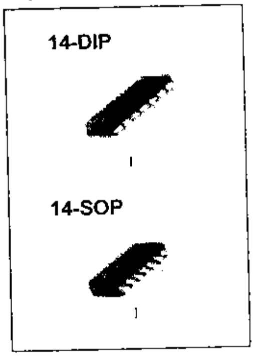
Quad Operational Amplifier

Features

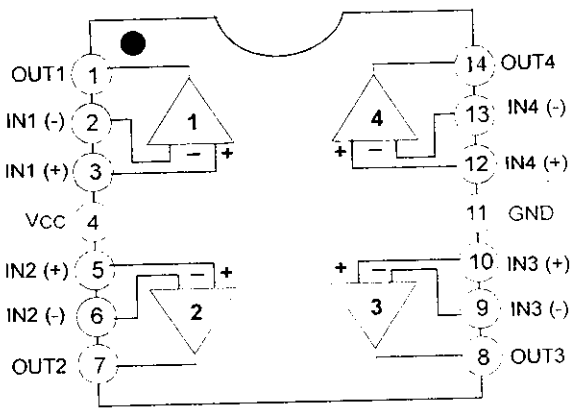
- Internally Frequency Compensated for Unity Gain
- Large DC Voltage Gain: 100dB
- Wide Power Supply Range:
  LM224/LM224A, LM324/LM324A : 3V~32V (or ±1.5 ~ 15V)
  LM2902: 3V~26V (or ±1.5V ~ 13V)
- Input Common Mode Voltage Range Includes Ground
- Large Output Voltage Swing: 0V to VCC -1.5V
- Power Drain Suitable for Battery Operation

Description

The LM324/LM324A,LM2902,LM224/LM224A consist of four independent, high gain, internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide voltage range. Operation from split power supplies is also possible so long as the difference between the two supplies is 3 volts to 32 volts. Application areas include transducer amplifier, DC gain blocks and all the conventional OP-AMP circuits which now can be easily implemented in single power supply systems.



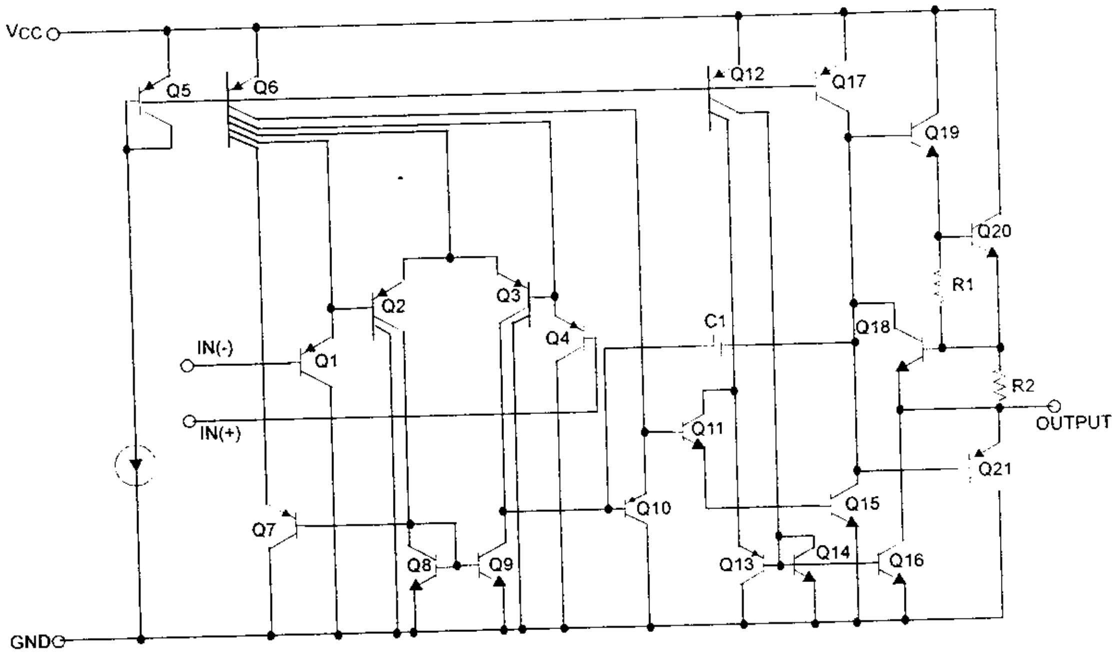
Internal Block Diagram



Rev. 1.0.3

Schematic Diagram

(One Section Only)



Absolute Maximum Ratings

Parameter	Symbol	LM224/LM224A	LM324/LM324A	LM2902	Unit
Power Supply Voltage	V_{CC}	±16 or 32	±16 or 32	±13 or 26	V
Differential Input Voltage	$V_{I(DIFF)}$	32	32	26	V
Input Voltage	V_I	-0.3 to +32	-0.3 to +32	-0.3 to +26	V
Output Short Circuit to GND $V_{CC} \leq 15V$, $T_A=25°C$(one Amp)	-	Continuous	Continuous	Continuous	-
Power Dissipation, $T_A=25°C$ 14-DIP 14-SOP	P_D	1310 640	1310 640	1310 640	mW
Operating Temperature Range	T_{OPR}	-25 ~ +85	0 ~ +70	-40 ~ +85	°C
Storage Temperature Range	T_{STG}	-65 ~ +150	-65 ~ +150	-65 ~ +150	°C

Thermal Data

Parameter	Symbol	Value	Unit
Thermal Resistance Junction-Ambient Max. 14-DIP 14-SOP	$R\theta ja$	 95 195	°C/W

Electrical Characteristics

(V_{CC} = 5.0V, V_{EE} = GND, T_A = 25 °C, unless otherwise specified)

Parameter	Symbol	Conditions	LM224			LM324			LM2902			Unit
			Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
Input Offset Voltage	V_{IO}	V_{CM} = 0V to V_{CC} -1.5V $V_{O(P)}$ = 1.4V, R_S = 0Ω	-	1.5	5.0	-	1.5	7.0	-	1.5	7.0	mV
Input Offset Current	I_{IO}	-	-	2.0	30	-	3.0	50	-	3.0	50	nA
Input Bias Current	I_{BIAS}	-	-	40	150	-	40	250	-	40	250	nA
Common-Mode Input Voltage Range	$V_{I(R)}$	Note1	0	-	V_{CC} -1.5	0	V_{CC} -1.5	-	0	-	V_{CC} -1.5	V
Supply Current	I_{CC}	R_L = ∞, V_{CC} = 30V (all Amps)	-	1.0	3	-	1.0	3	-	1.0	3	mA
		R_L = ∞, V_{CC} = 5V (all Amps) (V_{CC} = 26V for LM2902)	-	0.7	1.2	-	0.7	1.2	-	0.7	1.2	mA
Large Signal Voltage Gain	G_V	V_{CC} = 15V, R_L≥2KΩ $V_{O(P)}$ = 1V to 11V	50	100	-	25	100	-	-	100	-	V/mV
Output Voltage Swing	$V_{O(H)}$	Note1, R_L = 2KΩ	26	-	-	26	-	-	22	-	-	V
		Note1, R_L = 10KΩ	27	28	-	27	28	-	23	24	-	V
	$V_{O(L)}$	V_{CC} = 5V, R_L≥10KΩ	-	5	20	-	5	20	-	5	100	mV
Common-Mode Rejection Ratio	CMRR	-	70	85	-	65	75	-	50	75	-	dB
Power Supply Rejection Ratio	PSRR	-	65	100	-	65	100	-	50	100	-	dB
Channel Separation	CS	f = 1KHz to 20KHz	-	120	-	-	120	-	-	120	-	dB
Short Circuit to GND	I_{SC}	-	-	40	60	-	40	60	-	40	60	mA
Output Current	I_{SOURCE}	$V_{I(+)}$ = 1V, $V_{I(-)}$ = 0V V_{CC} = 15V, $V_{O(P)}$ = 2V	20	40	-	20	40	-	20	40	-	mA
	I_{SINK}	$V_{I(+)}$ = 0V, $V_{I(-)}$ = 1V V_{CC} = 15V, $V_{O(P)}$ = 2V	10	13	-	10	13	-	10	13	-	mA
		$V_{I(+)}$ = 0V, $V_{I(-)}$ = 1V V_{CC} = 15V, $V_{O(R)}$ = 200mV	12	45	-	12	45	-	-	-	-	μA
Differential Input Voltage	$V_{I(DIFF)}$	-	-	-	V_{CC}	-	-	V_{CC}	-	-	V_{CC}	V

Note :

1. V_{CC}=30V for LM224 and LM324 , V_{CC} = 26V for LM2902

December 2001

National Semiconductor

LF155/LF156/LF256/LF257/LF355/LF356/LF357 JFET Input Operational Amplifiers

General Description

These are the first monolithic JFET input operational amplifiers to incorporate well matched, high voltage JFETs on the same chip with standard bipolar transistors (BI-FET™ Technology). These amplifiers feature low input bias and offset currents/low offset voltage and offset voltage drift, coupled with offset adjust which does not degrade drift or common-mode rejection. The devices are also designed for high slew rate, wide bandwidth, extremely fast settling time, low voltage and current noise and a low 1/f noise corner.

Features

Advantages

- Replace expensive hybrid and module FET op amps
- Rugged JFETs allow blow-out free handling compared with MOSFET input devices
- Excellent for low noise applications using either high or low source impedance—very low 1/f corner
- Offset adjust does not degrade drift or common-mode rejection as in most monolithic amplifiers
- New output stage allows use of large capacitive loads (5,000 pF) without stability problems
- Internal compensation and large differential input voltage capability

Applications

- Precision high speed integrators
- Fast D/A and A/D converters
- High impedance buffers
- Wideband, low noise, low drift amplifiers
- Logarithmic amplifiers
- Photocell amplifiers
- Sample and Hold circuits

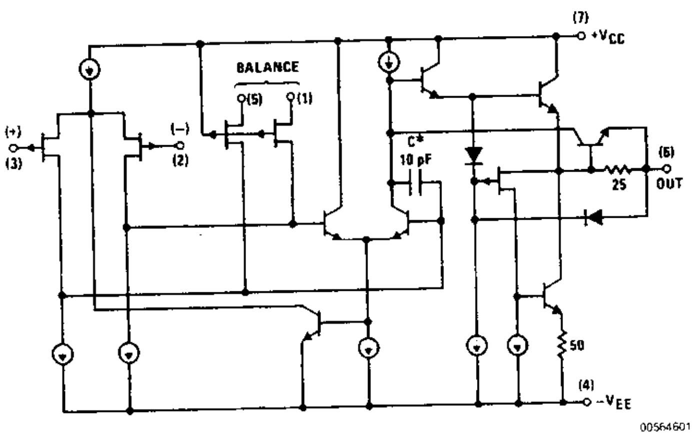
Common Features

- Low input bias current: 30pA
- Low Input Offset Current: 3pA
- High input impedance: $10^{12}\Omega$
- Low input noise current: $0.01\ pA/\sqrt{Hz}$
- High common-mode rejection ratio: 100 dB
- Large dc voltage gain: 106 dB

Uncommon Features

	LF155/ LF355	LF156/ LF256/ LF356	LF257/ LF357 (A_V=5)	Units
■ Extremely fast settling time to 0.01%	4	1.5	1.5	µs
■ Fast slew rate	5	12	50	V/µs
■ Wide gain bandwidth	2.5	5	20	MHz
■ Low input noise voltage	20	12	12	$nV/\sqrt{Hz}$

Simplified Schematic



*3pF in LF357 series.

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DC Electrical Characteristics (Continued)

(Note 3)

Symbol	Parameter	Conditions	LF155/6			LF256/7 LF356B			LF355/6/7			Units
			Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
	Input Bias Current	T_J=25°C, (Notes 3, 5)		30	100		30	100		30	200	pA
		$T_J \le T_{HIGH}$			50			5			8	nA
N	Input Resistance	T_J=25°C		10^{12}			10^{12}			10^{12}		Ω
OL	Large Signal Voltage Gain	V_S=±15V, T_A=25°C V_O=±10V, R_L=2k	50	200		50	200		25	200		V/mV
		Over Temperature	25			25			15			V/mV
O	Output Voltage Swing	V_S=±15V, R_L=10k	±12	±13		±12	±13		±12	±13		V
		V_S=±15V, R_L=2k	±10	±12		±10	±12		±10	±12		V
CM	Input Common-Mode Voltage Range	V_S=±15V	±11	+15.1		±11	±15.1		+10	+15.1		V
				−12			−12			−12		V
MRR	Common-Mode Rejection Ratio		85	100		85	100		80	100		dB
SRR	Supply Voltage Rejection Ratio	(Note 6)	85	100		85	100		80	100		dB

DC Electrical Characteristics

T_A = T_J = 25°C, V_S = ±15V

Parameter	LF155		LF355		LF156/256/257/356B		LF356		LF357		Units
	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	
Supply Current	2	4	2	4	5	7	5	10	5	10	mA

AC Electrical Characteristics

T_A = T_J = 25°C, V_S = ±15V

Symbol	Parameter	Conditions	LF155/355	LF156/256/ 356B	LF156/256/356/ LF356B	LF257/357	Units
			Typ	Min	Typ	Typ	
SR	Slew Rate	LF155/6: A_V=1,	5	7.5	12		V/μs
		LF357: A_V=5				50	V/μs
GBW	Gain Bandwidth Product		2.5		5	20	MHz
t_s	Settling Time to 0.01%	(Note 7)	4		1.5	1.5	μs
e_n	Equivalent Input Noise Voltage	R_S=100Ω f=100 Hz	25		15	15	$nV/\sqrt{Hz}$
		f=1000 Hz	20		12	12	$nV/\sqrt{Hz}$
i_n	Equivalent Input Current Noise	f=100 Hz	0.01		0.01	0.01	$pA/\sqrt{Hz}$
		f=1000 Hz	0.01		0.01	0.01	$pA/\sqrt{Hz}$
C_{IN}	Input Capacitance		3		3	3	pF

Notes for Electrical Characteristics

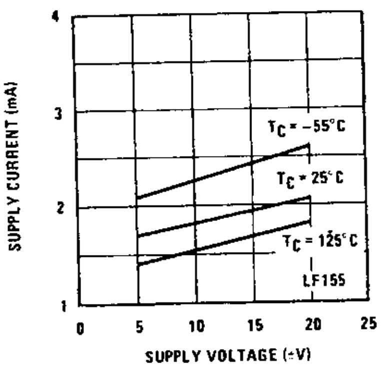
Note 1: The maximum power dissipation for these devices must be derated at elevated temperatures and is dictated by T_{JMAX}, θ_{JA}, and the ambient temperature, T_A. The maximum available power dissipation at any temperature is $P_D=(T_{JMAX}-T_A)/\theta_{JA}$ or the 25°C P_{dMAX}, whichever is less.

Note 2: Unless otherwise specified the absolute maximum negative input voltage is equal to the negative power supply voltage.

Note 3: Unless otherwise stated, these test conditions apply:

Typical DC Performance Characteristics Curves are for LF155 and LF156 unless otherwise specified. (Continued)

Supply Current



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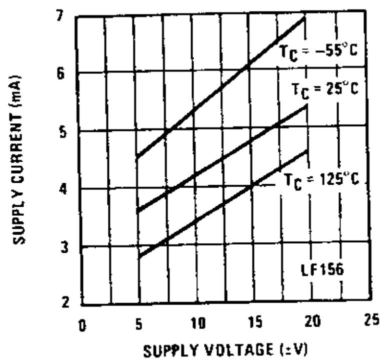
Supply Current



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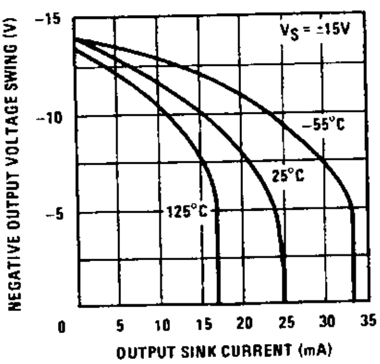
Negative Current Limit



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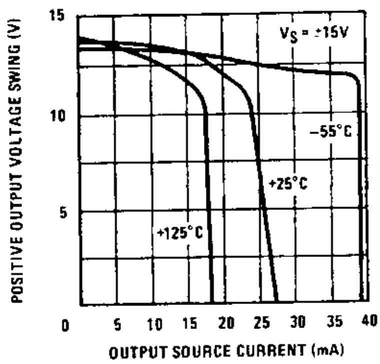
Positive Current Limit



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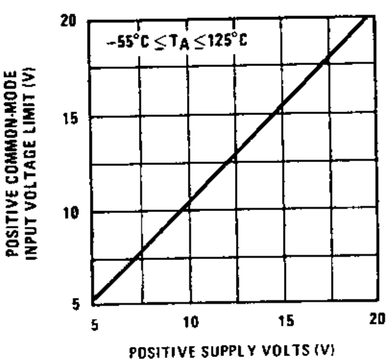
Positive Common-Mode Input Voltage Limit



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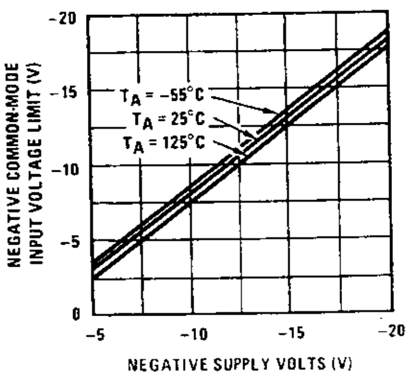
Negative Common-Mode Input Voltage Limit



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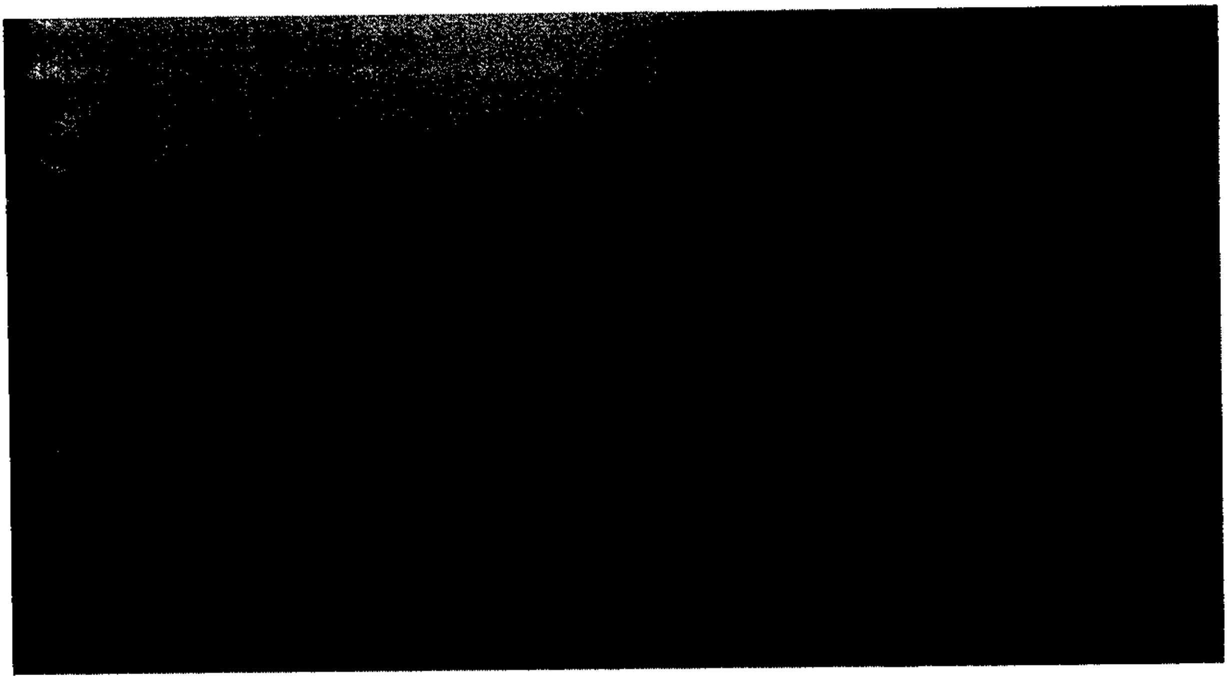
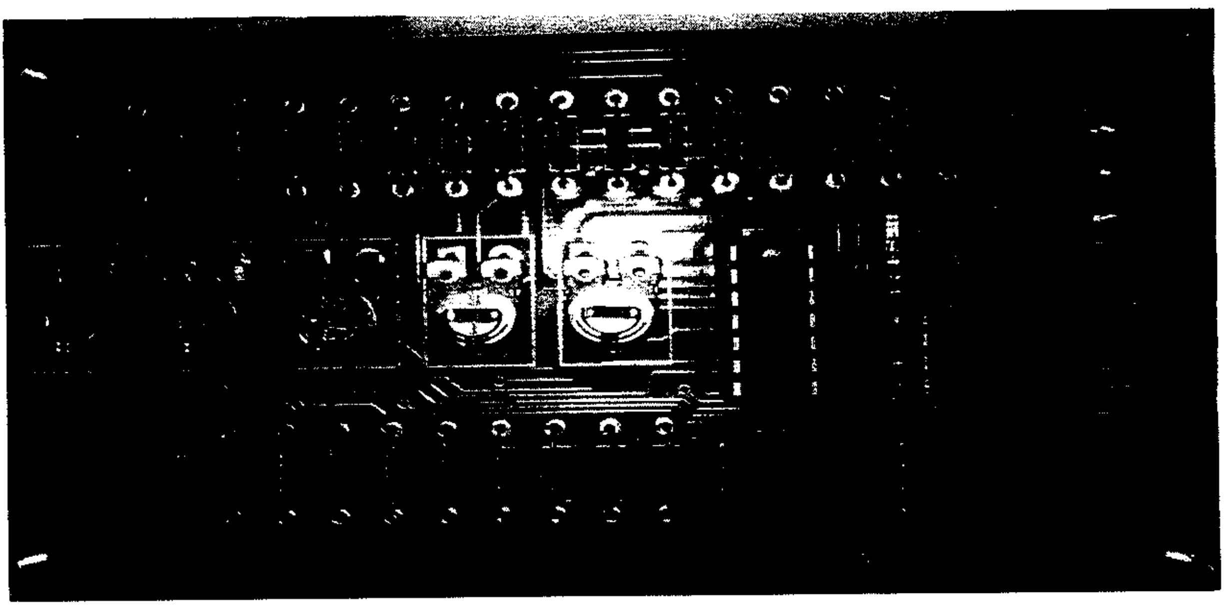
PHOTOGRAPHS

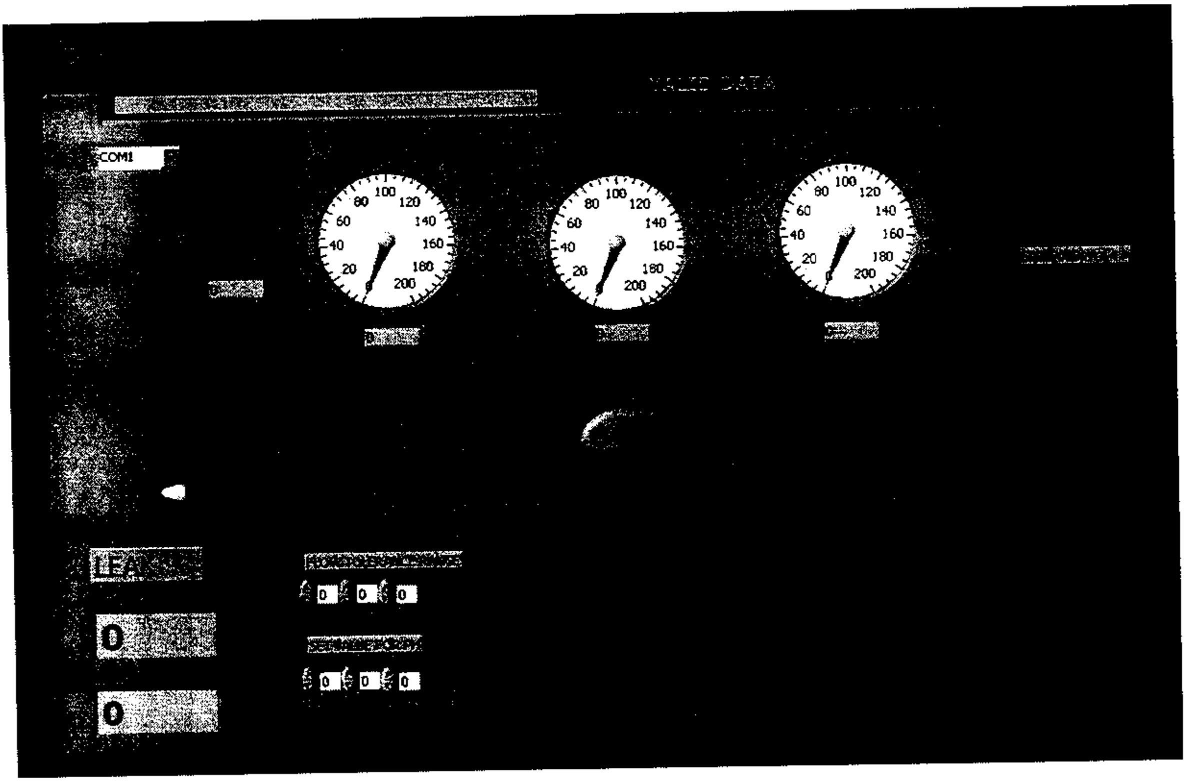
FLOW SENSOR CONNECTION



pH CONNECTION DIAGRAM



LAB VIEW AS FRONT PANEL



BLOCK DIAGRAM PANEL OF LABVIEW