"AN ENHANCED UNDERGROUND PIPELINE WATER LEAKAGE MONITORING AND DETECTION SYSTEM USING WIRELESS SENSOR NETWORK"

PROJECT REPORT

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BONAFIDE CERTIFICATE

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ABSTRACT

This project describes about the design and implementation of a water leakage monitoring and detection system to monitor and detect leak with the help of wireless networked sensors. The objective of this enhanced system is to detect possible underground water leakage for residential water pipes that are monitored from a PC. Therefore, a robust and reliable Wireless sensor network which composes small Printed Circuit Boards (PCB) , data from remote sensors of different types (acoustic, pressure, temperature, flow rate, etc.) are collected and monitored on a PC to detect the exact leakage position. Many nodes will be fixed across the pipe; leakage in each node will be monitored. Once a leak is detected, the water utility must take corrective action to minimize water losses in the water distribution system. Thus the proposed system will be used to save water and reduces the replacing cost.

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ABBREVIATIONS

PCB	Printed Circuit Board
WSN	Wireless Sensor Network
WSAN	Wireless Sensor and Actuator Network
CBM	Condition Based Maintenance
IP	Internet Protocol
ASHRAE	American Society Of Heating, Refrigerating and Air conditioning Engineers
SCU	System Control Unit
CPU	Central Processing Unit
ROM	Read Only Memory
RAM	Random Access Memory
ADC	Analog to Digital Converter

CMOS	Complementary Metal Oxide Semiconductor
RISC	Reduced Instruction Set Computer
EPROM	Erasable Programmable Read Only Memory
EEPROM	Electrically Erasable Programmable Read Only Memory
ICSP	In-Circuit Serial Programming
POR	Power-on Reset
PWRT	Power-up Timer
OST	Oscillator Start-up Timer
WDT	Watchdog Timer
SSP	Synchronous Serial Port
BOR	Brown-out Reset
FSR	File Selected Register
LCD	Liquid Crystal Display
WPAN	Wireless Personal Area Networking
LABVIEW	Laboratory Virtual Instrument Engineering Workbench
PLDS	Pipe Leakage Detection System

CHAPTER 1

GENERAL INTRODUCTION

Water represents a primary necessity for living things daily life and for an effective accomplishment of many industrial processes. In the modern world the issue of water is considered to be one of the largest and most serious challenges. Part of these challenges, one challenge is to limit the water leakage on pipeline. Water distribution can be enhanced from an engineering point of view, mainly by limiting the water waste that occurs along the path, between the source and the end-users. This challengeable task is unavoidable because of pipeline infrastructures and aging.

Leakages are mainly caused by generally aged and consequently breakable water distribution infrastructures. Leakage detection has historically assumed that all leaks rise to the surface and are visible. In fact, many leaks continue below the surface for long periods of time and remain undetected. As pipes are not directly visible and accessible, the identification of leakages is not obvious. Therefore, a robust and reliable Wireless sensor network is required to monitor leaks and detect the exact leakage position. Once a leak is detected, the water utility must take corrective action to minimize water losses in the water distribution system. Accurate location and repair of leaking water pipes in a supply system greatly reduces these losses. Thus the proposed system will be used to save water and reduces the replacing cost. The objective is to design and develop an enhanced system to detect the underground water leakage using wireless sensor network. Therefore, a robust and reliable Wireless sensor network is required to monitor leaks and detect the exact leakage position.

Once a leak is detected, the water utility must take corrective action to minimize water losses in the water distribution system. Accurate location and repair of leaking water pipes in a supply system greatly reduces these losses. Thus the proposed system will be used to save water and reduces the replacing cost. Reliable communication within the network is provided by ZigBee technology, which is built on top of IEEE 802.15.4 standard. More specifically, to collect and monitor data on a PC, three Printed Circuit Board (PCB) s, populated with the ZigBit 900 RF modules and a matched antenna are used. The ZigBit module featuring ultra small size and superior RF performance enables the board’s wireless connectivity and facilitates its functionality a as a node in the ZigBee network. The PCBs include temperature sensor. In addition, these PCBs support standard extension connectors to connect to external sensors such as acoustic sensor, pressure sensor and etc.

1.1 INTRODUCTION OF WSN

Wireless sensor networks (WSN), sometimes called wireless sensor and actuator networks (WSAN), are spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location as shown in fig 1.1. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on.

The WSN is built of "nodes" – from a few to several hundreds or even thousands, where each node is connected to one (or sometimes several) sensors. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting. A sensor node might vary in size from that of a shoebox down to the size of a grain of dust, although functioning "motes" of genuine microscopic dimensions have yet to be created. The cost of sensor nodes is similarly variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. The propagation technique between the hops of the network can be routing or flooding.

In computer science and telecommunications, wireless sensor networks are an active research area with numerous workshops and conferences arranged each year.

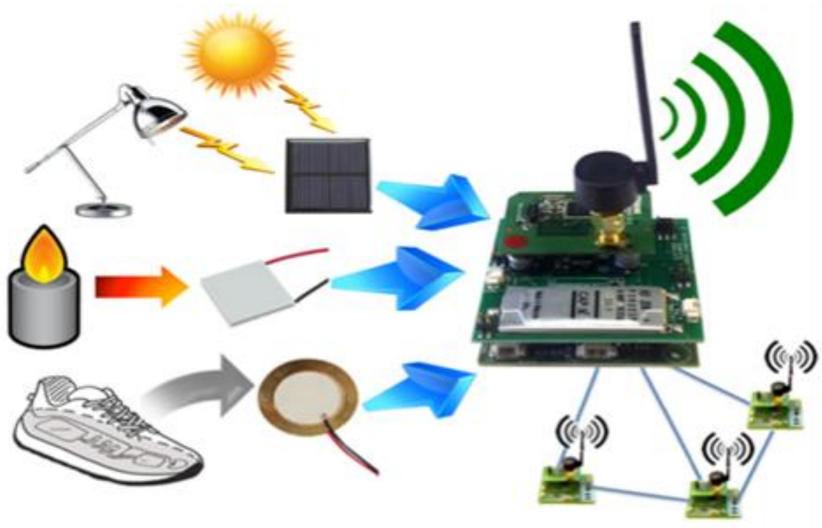


Fig1.1 Wireless sensor network

1.2 APPLICATIONS OF WSN

Area monitoring

Area monitoring is a common application of WSNs. In area monitoring, the WSN is deployed over a region where some phenomenon is to be monitored. A military example is the use of sensors detect enemy intrusion; a civilian example is the geo-fencing of gas or oil pipelines.

Health care monitoring

The medical applications can be of two types: wearable and implanted. Wearable devices are used on the body surface of a human or just at close proximity of the user. The implantable medical devices are those that are inserted inside human body. Possible applications include body position measurement, location of persons, overall monitoring of ill patients in hospitals and at homes.

Body-area networks can collect information about an individual's health, fitness, and energy expenditure.

Environmental/Earth sensing

There are many applications in monitoring environmental parameters, examples of which are given below. They share the extra challenges of harsh environments and reduced power supply.

Air pollution monitoring

Wireless sensor networks have been deployed in several cities to monitor the concentration of dangerous gases for citizens. These can take advantage of the ad hoc wireless links rather than wired installations, which also make them more mobile for testing readings in different areas.

Forest fire detection

A network of Sensor Nodes can be installed in a forest to detect when a fire has started. The nodes can be equipped with sensors to measure temperature, humidity and gases which are produced by fire in the trees or vegetation. The early detection is crucial for a successful action of the firefighters; thanks to Wireless Sensor Networks, the fire brigade will be able to know when a fire is started and how it is spreading.

Landslide detection

A landslide detection system makes use of a wireless sensor network to detect the slight movements of soil and changes in various parameters that may occur before or during a landslide. Through the data gathered it may be possible to know the impending occurrence of landslides long before it actually happens.

Water quality monitoring

Water quality monitoring involves analyzing water properties in dams, rivers, lakes and oceans, as well as underground water reserves. The use of many wireless distributed sensors enables the creation of a more accurate map of the water status, and allows the permanent deployment of monitoring stations in locations of difficult access, without the need of manual data retrieval.

Natural disaster prevention

Wireless sensor networks can effectively act to prevent the consequences of natural disasters, like floods. Wireless nodes have successfully been deployed in rivers where changes of the water levels have to be monitored in real time.

1.3 WSN Architecture

The most common WSN architecture follows the OSI architecture Model. The architecture of the WSN includes five layers and three cross layers. Mostly in sensor n/w we require five layers, namely application, transport, n/w, data link & physical layer. The three cross planes are namely power management, mobility management, and task management. These layers of the WSN are used to accomplish the n/w and make the sensors work together in order to raise the efficiency.

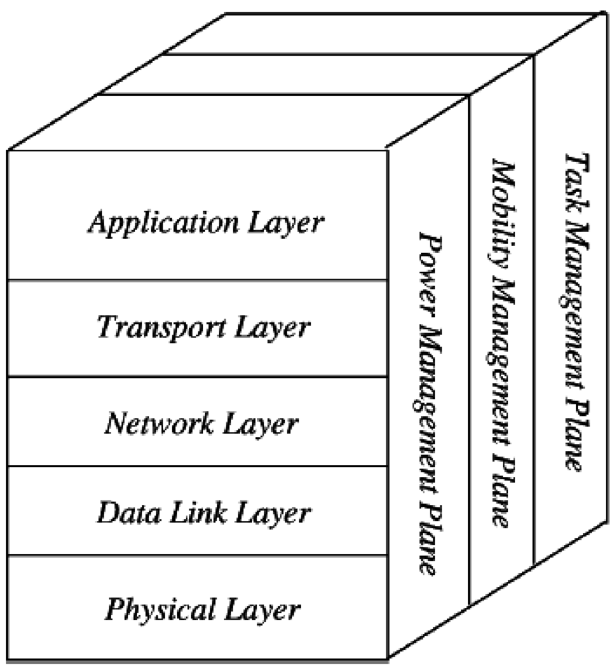


Fig1.3 Architecture of WSN

Application Layer

The application layer is liable for traffic management and offers software for numerous applications that convert the data in a clear form to find positive information. Sensor networks arranged in numerous applications in different fields such as agricultural, military, environment, medical, etc.

Transport Layer

The function of the transport layer is to deliver congestion avoidance and reliability where a lot of protocols intended to offer this function are either practical on the upstream. These protocols use dissimilar mechanisms for loss recognition and loss recovery. The transport layer is exactly needed when a system is planned to contact other networks.

Providing a reliable loss recovery is more energy efficient and that is one of the main reasons why TCP is not fit for WSN. In general, Transport layers can be separated into Packet driven, Event driven. There are some popular protocols in the transport layer namely STCP (Sensor Transmission Control Protocol), PORT (Price-Oriented Reliable Transport Protocol and PSFQ (pump slow fetch quick).

Network Layer

The main function of the network layer is routing, it has a lot of tasks based on the application, but actually, the main tasks are in the power conserving, partial memory, buffers, and sensor don't have a universal ID and have to be self-organized.

The simple idea of the routing protocol is to explain a reliable lane and redundant lanes, according to a convinced scale called metric, which varies from protocol to protocol. There are a lot of existing protocols for this network layer, they can be separate into; flat routing and hierarchal routing or can be separated into time driven, query-driven & event driven.

Data Link Layer

The data link layer is liable for multiplexing data frame detection, data streams, MAC, & error control, confirm the reliability of point–point (or) point–multipoint.

1.4 CHARACTERISTICS OF WSN

The main characteristics of a WSN include:

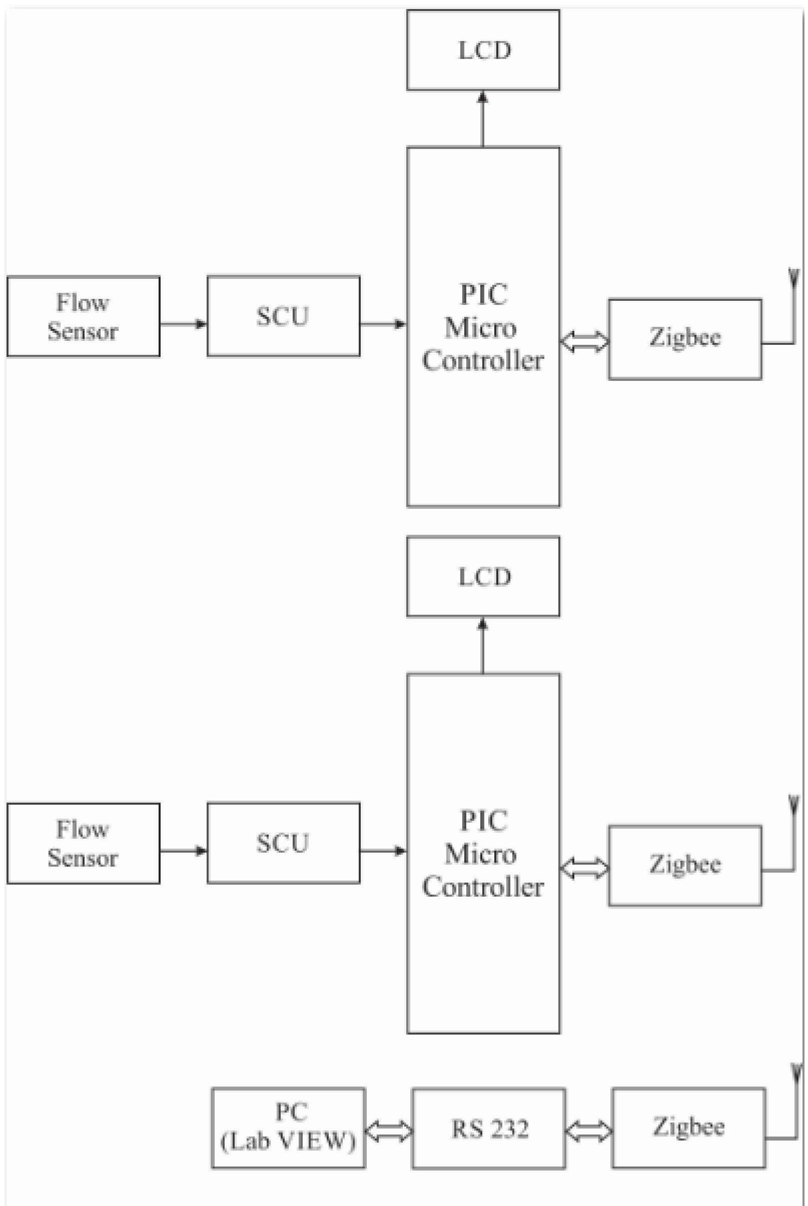
- Power consumption constraints for nodes using batteries or energy harvesting
- Ability to cope with node failures (resilience)
- Some mobility of nodes (for highly mobile nodes see MWSNs)
- Heterogeneity of nodes
- Scalability to large scale of deployment
- Ability to withstand harsh environmental conditions
- Ease of use
- Cross-layer design

CHAPTER 2

BLOCK DIAGRAM

2.1Flow Sensors

The flow sensor is made up of plastic and it can be attached with the plastic pipe and when it comes to the steel pipes and cement pipes the flow sensor will be made up of stainless steel



The flow sensor is attached with the microcontroller and the controller holds the components are capacitor, resistor, ac regulator, rectifier and diode. The senor has the three outputs wire each one hold on to the specific purpose. The red color wire has the positive voltage, black color wire gives the negative voltage, and white gives the pulse rate. Power supply is done through microcontroller and the communication is done through ZigBee for each sensors. ZigBee is a specification for a suite of high level communication protocols used to create personal area networks built from small, low-power digital radios. ZigBee is based on an IEEE 802.15 standard.

2.2 LCD

A liquid crystal display (LCD) is a thin, flat display device made up of any number of color or monochrome pixels arrayed in front of a light source or reflector. It is often utilized in battery-powered electronic devices because it uses very small amounts of electric power. LCD display unit is used to display the flow sensor rate with delay time. Using init () module is initialized and the interrupts are enabled. Input and output ports (port B, port C and port D) are initialized.

2.3 PIC Controller

PIC microcontrollers (Programmable Interface Controllers), are electronic circuits that can be programmed to carry out a vast range of tasks. They can be programmed to be timers or to control a production line and much more. They are found in most electronic devices such as alarm systems, computer control systems, phones, in fact almost any electronic device. Many types of PIC microcontrollers exist, although the best are probably found in the GENIE range of programmable microcontrollers. These are programmed and simulated by Circuit Wizard software. PIC Microcontrollers are relatively cheap and can be bought as pre-built circuits or as kits that can be assembled by the user.

2.4 ZigBee

ZigBee devices can transmit data over long distances by passing data through intermediate devices to reach more distant ones, creating a mesh network; i.e., a network with no centralized control or high-power transmitter/receiver able to reach all of the networked devices. The decentralized nature of such wireless ad hoc networks makes them suitable for applications where a central node can't be relied upon.

CHAPTER 3

HARDWARE DESCRIPTION

3.1 MICROCONTROLLER

CONCEPTS OF MICROCONTROLLER:

Microcontroller is a general purpose device, which integrates a number of the components of a microprocessor system on to single chip. It has inbuilt CPU, memory and peripherals to make it as a mini computer. A microcontroller combines on to the same microchip:

- The CPU core
- Memory(both ROM and RAM)
- Some parallel digital I/O

Microcontrollers will combine other devices such as:

- A timer module to allow the microcontroller to perform tasks for certain time periods.
- A serial I/O port to allow data to flow between the controller and other devices such as a PIC or another microcontroller.
- An ADC to allow the microcontroller to accept analogue input data for processing.

Microcontrollers are:

- Smaller in size
- Consumes less power
- Inexpensive

Micro controller is a standalone unit, which can perform functions on its own without any requirement for additional hardware like I/O ports and external memory.

The heart of the microcontroller is the CPU core. In the past, this has traditionally been based on a 8-bit microprocessor unit. For example Motorola uses a basic 6800 microprocessor core in their 6805/6808 microcontroller devices.

In the recent years, microcontrollers have been developed around specifically designed CPU cores, for example the microchip PIC range of microcontrollers.

3.1.1 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.

3.1.2 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.

3.1.3 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 PICstart plus development system includes PIC start plus development programmer and mplab ide.

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.

3.1.4 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:

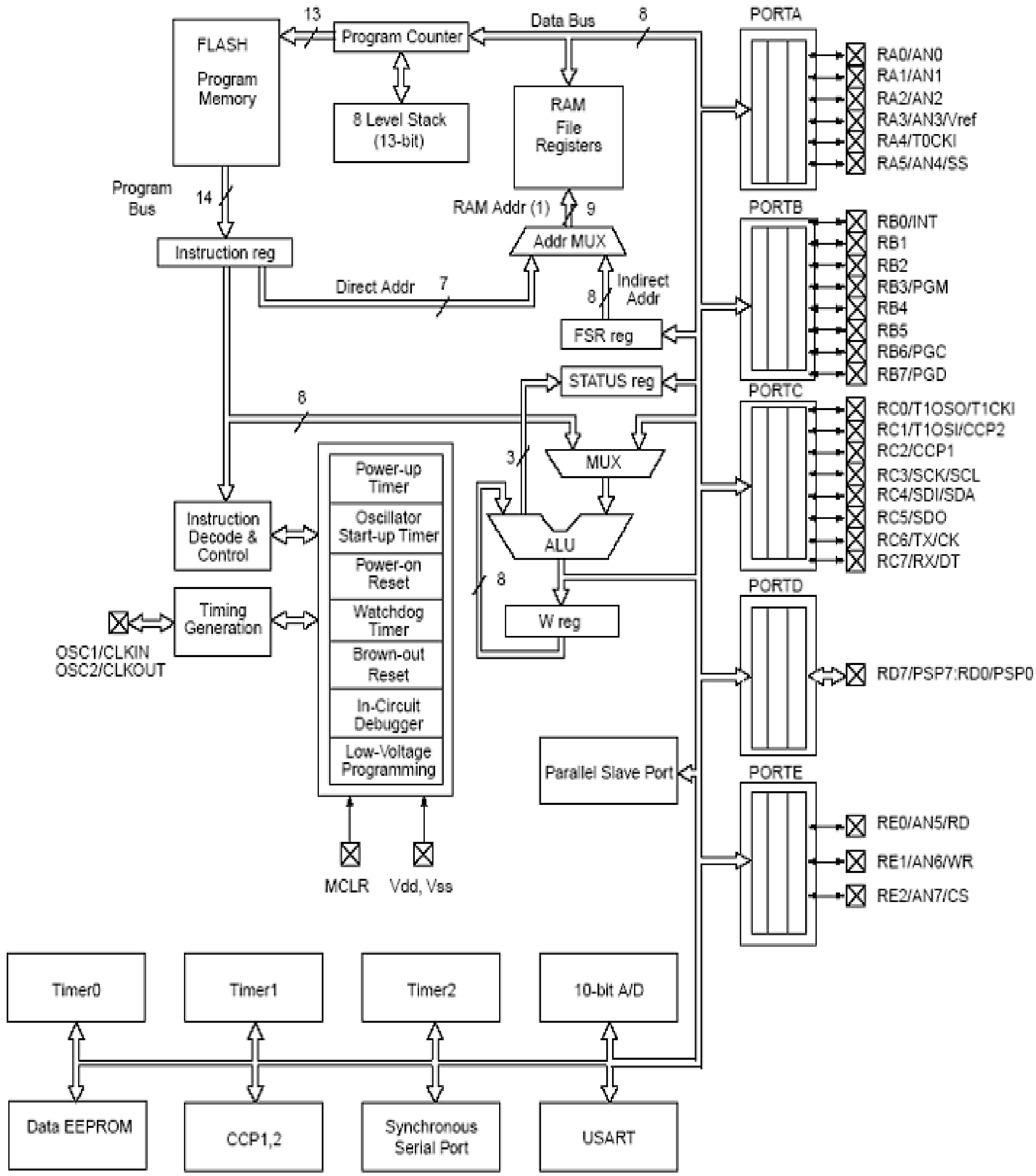
  2mA typical @ 5V, 4 MHz

  20mA typical @ 3V, 32 kHz

  1mA typical standby current

3.1.5 PIC ARCHITECTURE

The complete architecture of PIC 16F877 is shown in the fig 3.1.6 Table 3.1.7 gives details about the specifications of PIC 16F877. Fig 3.1.7 shows the complete pin diagram of the IC PIC 16F877.



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

Fig3.1.5 PIC Architecture

3.1.6 PIN DIAGRAM OF PIC

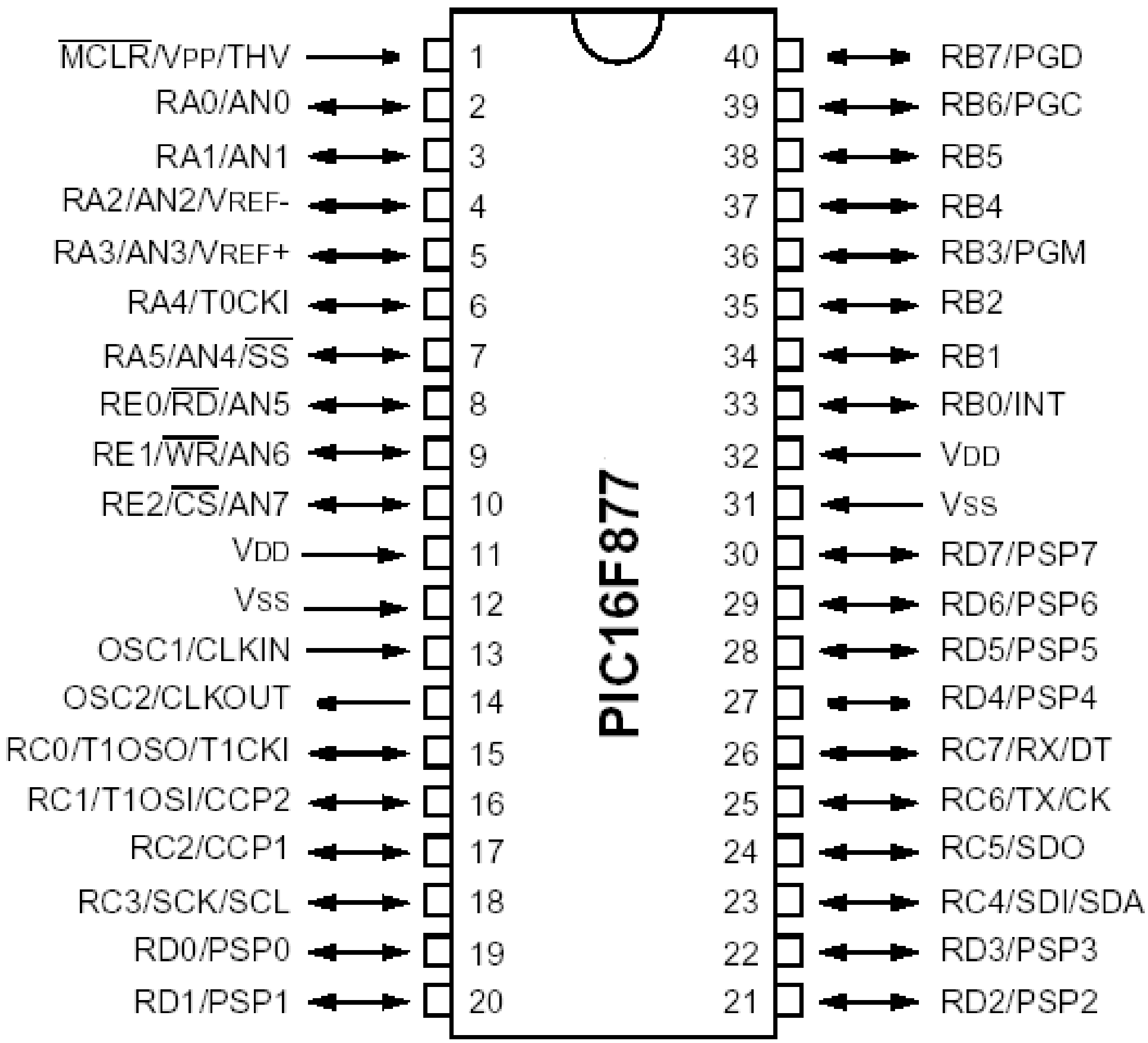


Fig3.1.6 Pin diagram of PIC

Pin Name	DIP Pin#	PLCC Pin#	QFP Pin#	I/O/P Type	Buffer Type	Description
OSC1/CLKIN	13	14	30	I	ST/CMOS[4]	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.
$\overline{MCLR}$/V_{PP}/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.
						PORTA is a bi-directional I/O port.
RA0/AN0	2	3	19	I/O	TTL	RA0 can also be analog input0
RA1/AN1	3	4	20	I/O	TTL	RA1 can also be analog input1
RA2/AN2/V_{REF-}	4	5	21	I/O	TTL	RA2 can also be analog input2 or negative analog reference voltage
RA3/AN3/V_{REF+}	5	6	22	I/O	TTL	RA3 can also be analog input3 or positive analog reference voltage
RA4/T0CKI	6	7	23	I/O	ST	RA4 can also be the clock input to the Timer0 timer/counter. Output is open drain type.
RA5/$\overline{SS}$/AN4	7	8	24	I/O	TTL	RA5 can also be analog input4 or the slave select for the synchronous serial port.
						PORTB is a bi-directional I/O port. PORTB can be software programmed for internal weak pull-up on all inputs.
RB0/INT	33	36	8	I/O	TTL/ST[1]	RB0 can also be the external interrupt pin.
RB1	34	37	9	I/O	TTL	
RB2	35	38	10	I/O	TTL	
RB3/PGM	36	39	11	I/O	TTL	RB3 can also be the low voltage programming input
RB4	37	41	14	I/O	TTL	Interrupt on change pin.
RB5	38	42	15	I/O	TTL	Interrupt on change pin.
RB6/PGC	39	43	16	I/O	TTL/ST[2]	Interrupt on change pin or In-Circuit Debugger pin. Serial programming clock.
RB7/PGD	40	44	17	I/O	TTL/ST[2]	Interrupt on change pin or In-Circuit Debugger pin. Serial programming data.

: I = input O = output I/O = input/output P = power

— = Not used TTL = TTL input ST = Schmitt Trigger input

Tab3.1.6 Pin configuration of PIC

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.

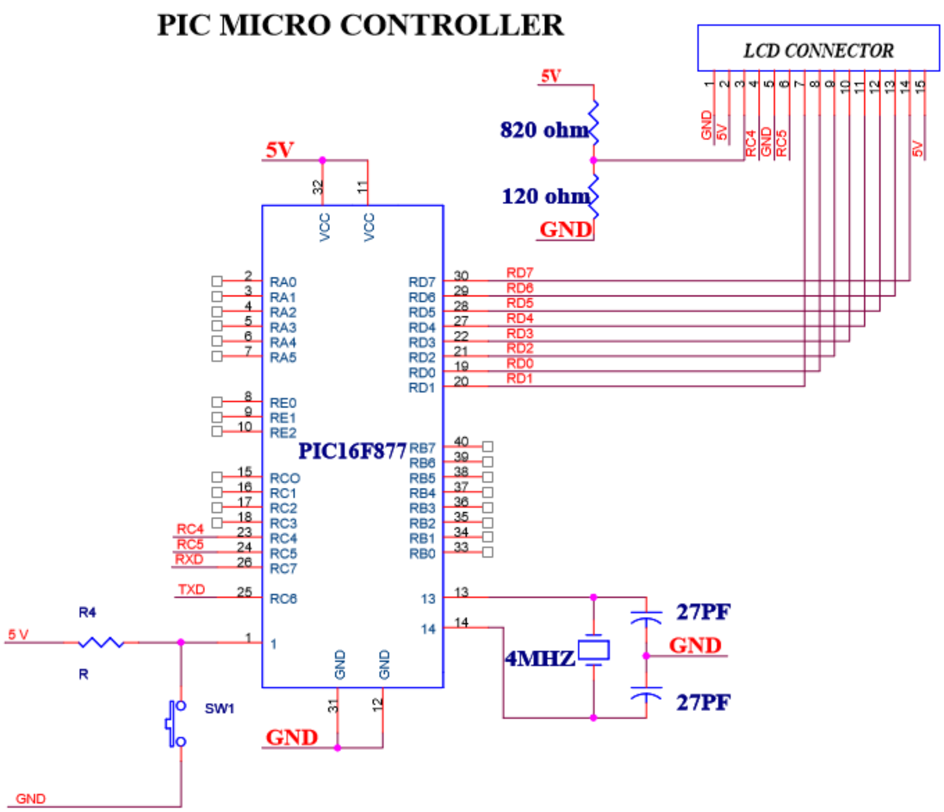


Fig3.1.1 PIC controller

3.2 FLOW SENSOR

Fig3.2 Flow sensor

The fig3.2 shows the flow sensor.A flow sensor is a device for sensing the rate of fluid flow. Typically a flow sensor is the sensing element used in a flow meter, or flow logger, to record the flow of fluids. As is true for all sensors, absolute accuracy of a measurement requires a functionality for calibration. There are various kinds of flow sensors and flow meters, including some that have a vane that is pushed by the fluid, and can drive a rotary potentiometer, or similar device.

Other flow sensors are based on sensors which measure the transfer of heat caused by the moving medium. This principle is common for microsensors to measure flow.

Flow meters are related to devices called velocimeters that measure velocity of fluids flowing through them. Laser-based interferometry is often used for air flow measurement, but for liquids, it is often easier to measure the flow. Another approach is Doppler-based methods for flow measurement. Hall effect sensors may also be used, on a flapper valve, or vane, to sense the position of the vane, as displaced by fluid flow.

The flow sensor is used to detect the flow of liquid in a pipe per unit time. It works on the basis of hall effect principle. Flow through the pipe results in rotation of the paddle wheel of the flow sensor which is proportional to the flow velocity and to the flow rate in the pipe. The flow can be measured based on the rate of discharge.

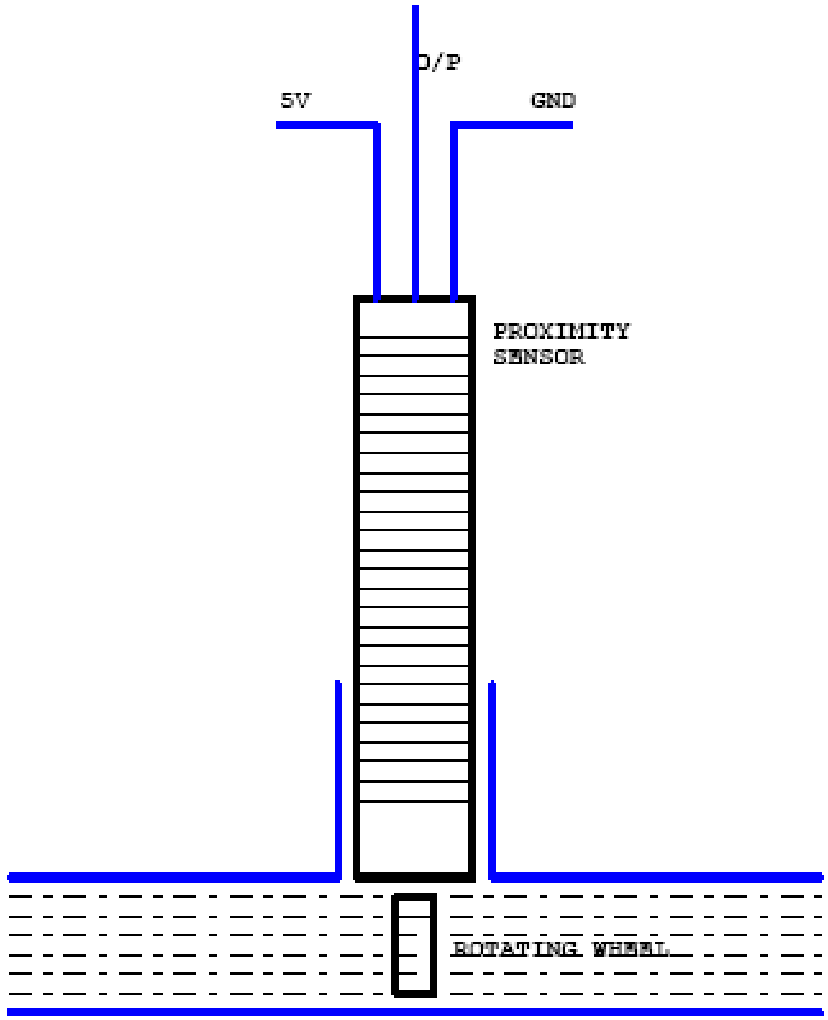


Fig3.2a Working of flow sensor

Fig 3.2a tells the working of a flow sensor. Here the rotating wheel is fixed in the inside pipe where the water flow has to be measured. When the water flows through the pipe with pressure, the wheel rotates.

The wheel rotation is monitored by the proximity sensor. Rotating wheel is nothing but a Plus shape magnet. The proximity sensor is delivered the output in the form of pulse when it detects the magnetic flux.

This is given to microcontroller. The microcontroller counts the pulse which is equal to rate of water flow in the pipe. This circuit is mainly used to monitoring the water flow and maintains the set level using control circuit.

3.2.1 APPLICATIONS

- HVAC: Hot and Cold Water, Fire Systems, and Thermal Energy Monitoring.
- Irrigation: Water Management.
- Water Treatment: Chlorination, Desalination and Mechanical Filtration Plants, Chemical Injection Systems.
- Refineries: Fire and Cooling Systems
- Power Generation: Boiler Feed Water, Steam Condensate, Process Water and Water Balancing.

3.3 LCD

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display as shown in fig 3.3.1is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

A **16x2 LCD** means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.

The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

3.3.1 PIN DIAGRAM

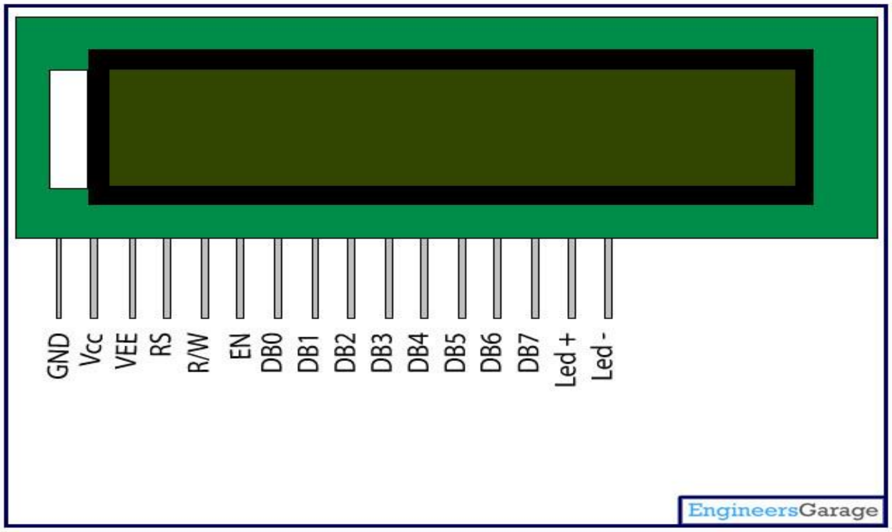


Fig3.3.1 Pin diagram of LCD

3.3.2 PIN DESCRIPTION

Pin No	Function	Name
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Contrast adjustment; through a variable resistor	V_{EE}
4	Selects command register when low; and data register when high	Register Select
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7	8-bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight V_{CC} (5V)	Led+
16	Backlight Ground (0V)	Led-

Fig3.3.2 Pin description of LCD

3.4 ZIGBEE

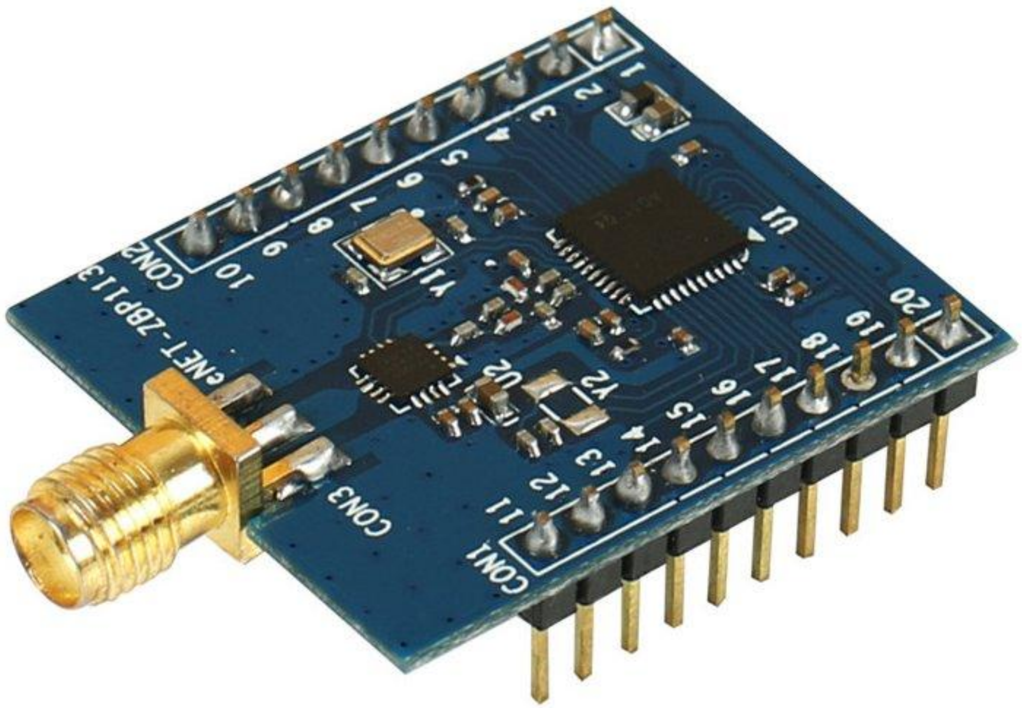


Fig3.4 ZIGBEE board

The fig3.4 describes the ZigBee board. The mission of the ZigBee Working Group is to bring about the existence of a broad range of interoperable consumer devices by establishing open industry specifications for unlicensed, untethered peripheral, control and entertainment devices requiring the lowest cost and lowest power consumption communications between compliant devices anywhere in and around the home.

The ZigBee specification is a combination of HomeRF Lite and the 802.15.4 specification. The spec operates in the 2.4GHz (ISM) radio band - the same band as 802.11b standard, Bluetooth, microwaves and some other devices. It is capable of connecting 255 devices per network. The specification supports data transmission rates of up to 250 Kbps at a range of up to 30 meters. ZigBee's technology is slower than 802.11b (11 Mbps) and Bluetooth (1 Mbps) but it consumes significantly less power.

3.4.1 GENERAL CHARACTERISTICS

- Dual PHY (2.4GHz and 868/915 MHz)
- Data rates of 250 kbps (@2.4 GHz), 40 kbps (@ 915 MHz), and 20 kbps (@868 MHz)
- Optimized for low duty-cycle applications (<0.1%)
- CSMA-CA channel access Yields high throughput and low latency for low duty cycle devices like sensors and controls
- Low power (battery life multi-month to years)
- Multiple topologies: star, peer-to-peer, mesh
- Addressing space of up to:
  - 18,450,000,000,000,000,000 devices (64 bit IEEE address)
  - 65,535 networks
- Optional guaranteed time slot for applications requiring low latency
- Fully hand-shaked protocol for transfer reliability
- Range: 50m typical (5-500m based on environment)

ZigBee is an established set of specifications for wireless personal area networking (WPAN), i.e. digital radio connections between computers and related devices.

WPAN Low Rate or ZigBee provides specifications for devices that have low data rates, consume very low power and are thus characterized by long battery life. ZigBee makes possible completely networked homes where all devices are able to communicate and be controlled by a single unit.

3.4.2 DEVICE TYPES

There are three different ZigBee device types that operate on these layers in any self-organizing application network. These devices have 64-bit IEEE addresses, with option to enable shorter addresses to reduce packet size, and work in either of two addressing modes – star and peer-to-peer.

1. **The ZigBee coordinator node**: There is one, and only one, ZigBee coordinator in each network to act as the router to other networks, and can be likened to the root of a (network) tree. It is designed to store information about the network.

2. **The full function device FFD**: The FFD is an intermediary router transmitting data from other devices. It needs lesser memory than the ZigBee coordinator node, and entails lesser manufacturing costs. It can operate in all topologies and can act as a coordinator.

3. **The reduced function device RFD**: This device is just capable of talking in the network; it cannot relay data from other devices. Requiring even less memory, (no flash, very little ROM and RAM), an RFD will thus be cheaper than an FFD. This device talks only to a network coordinator and can be implemented very simply in star topologyas shown in fig3.4.2.,

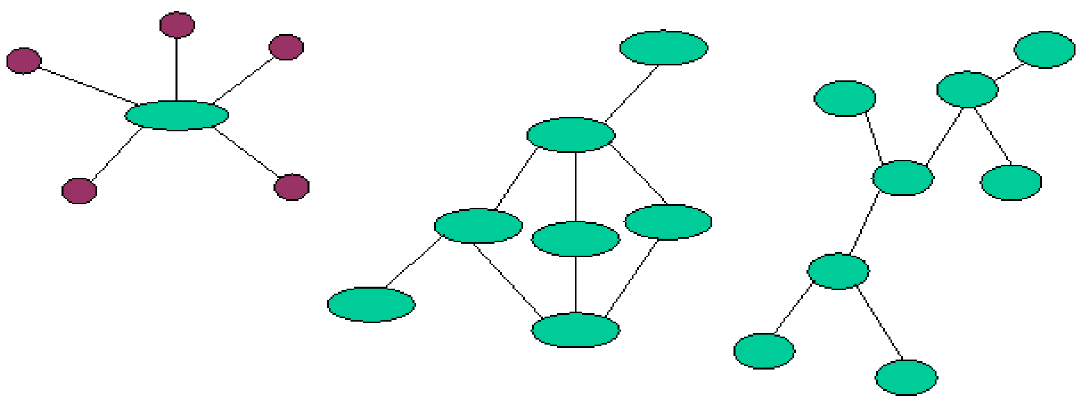


Fig3.4.2 Topologies

3.4.3 TRAFFIC TYPES

ZigBee/ addresses three typical traffic types. MAC can accommodate all the types.

1. **Data is periodic**: The application dictates the rate, and the sensor activates checks for data and deactivates.

2. **Data is intermittent**: The application, or other stimulus, determines the rate, as in the case of say smoke detectors. The device needs to connect to the network

only when communication is necessitated. This type enables optimum saving on energy.

3. **Data is repetitive**: The rate is fixed a priori. Depending on allotted time slots, called GTS (guaranteed time slot), devices operate for fixed durations.

3.4.4 ZIGBEE MODES

ZigBee employs either of two modes, beacon or non-beacon to enable the to-and-fro data traffic. Beacon mode is used when the coordinator runs on batteries and thus offers maximum power savings, whereas the non-beacon mode finds favour when the coordinator is mains-powered.

In the beacon mode as shown in fig 3.4.4, a device watches out for the coordinator's beacon that gets transmitted at periodically, locks on and looks for messages addressed to it. If message transmission is complete, the coordinator dictates a schedule for the next beacon so that the device ‘goes to sleep'; in fact, the coordinator itself switches to sleep mode.

While using the beacon mode, all the devices in a mesh network know when to communicate with each other. In this mode, necessarily, the timing circuits have to be quite accurate, or wake up sooner to be sure not to miss the beacon. This in turn means an increase in power consumption by the coordinator's receiver, entailing an optimal increase in costs.

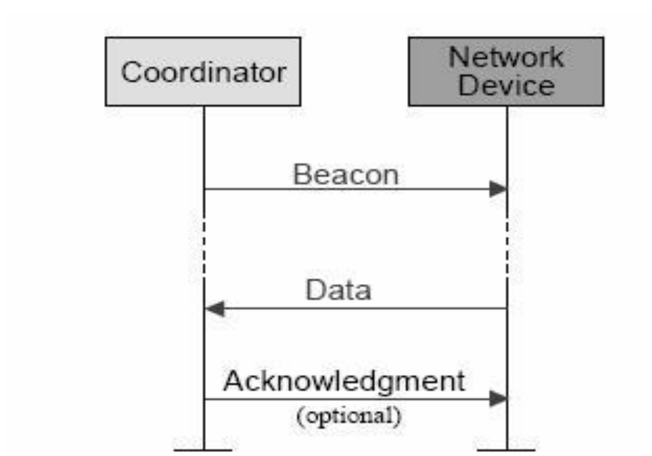


Fig3.4.4 Beacon Network Communication

The non-beacon mode as shown in fig 3.4.4a will be included in a system where devices are ‘asleep' nearly always, as in smoke detectors and burglar alarms. The devices wake up and confirm their continued presence in the network at random intervals.

On detection of activity, the sensors ‘spring to attention', as it were, and transmit to the ever-waiting coordinator's receiver (since it is mains-powered). However, there is the remotest of chances that a sensor finds the channel busy, in which case the receiver unfortunately would ‘miss a call'.

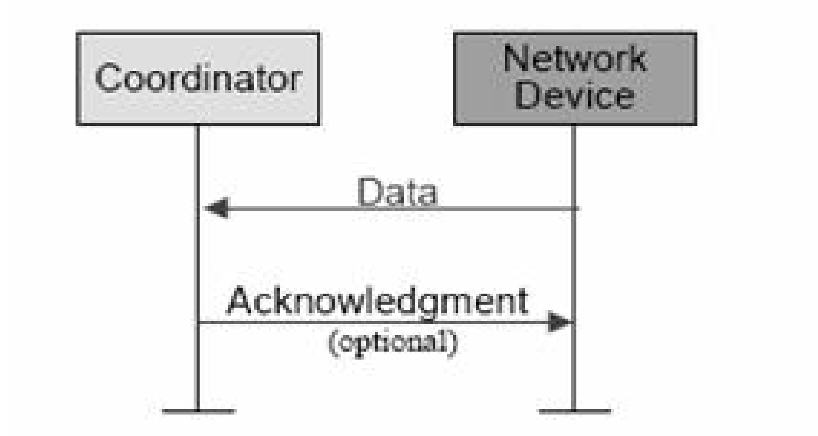


Fig3.4.4a Non-Beacon Network Communication

The functions of the Coordinator, which usually remains in the receptive mode, encompass network set-up, beacon transmission, node management, storage of node information and message routing between nodes.

The network node, however, is meant to save energy (and so ‘sleeps' for long periods) and its functions include searching for network availability, data transfer, checks for pending data and queries for data from the coordinator as shown in fig 3.4.4b.,

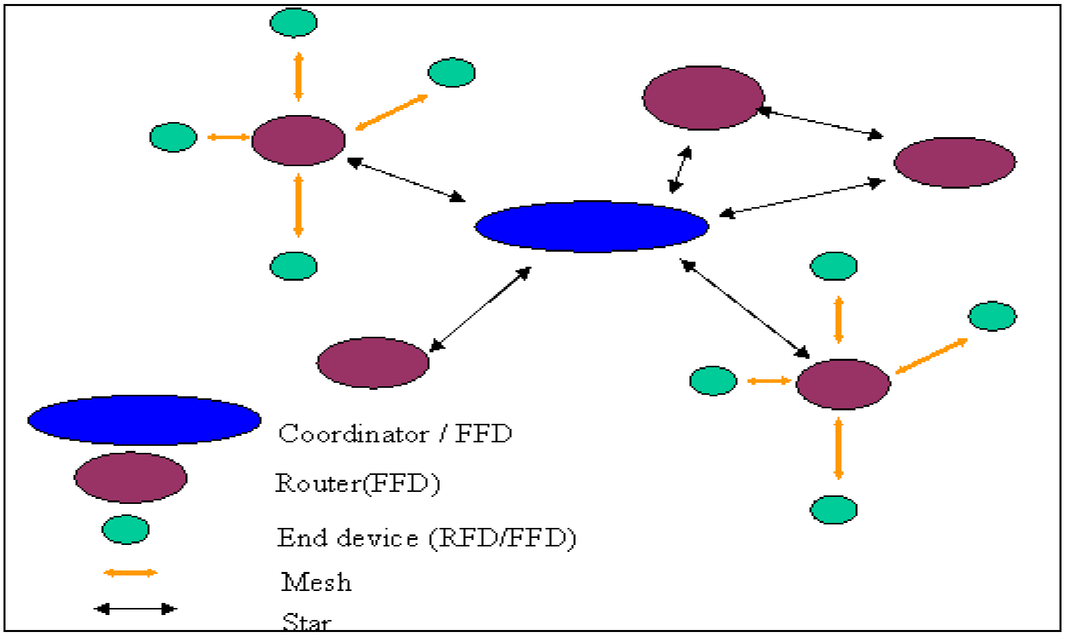


Fig3.4.4b ZIGBEE network model

For the sake of simplicity without jeopardizing robustness, this particular IEEE standard defines a quartet frame structure and a super-frame structure used optionally only by the coordinator.

3.4.5 FRAME STRUCTURE

The four frame structures are

- Beacon frame for transmission of beacons
- Data frame for all data transfers
- Acknowledgement frame for successful frame receipt confirmations
- MAC command frame

These frame structures and the coordinator's super-frame structure play critical roles in security of data and integrity in transmission.

All protocol layers contribute headers and footers to the frame structure, such that the total overheads for each data packet range are from 15 octets (for short addresses) to 31 octets (for 64-bit addresses).

The coordinator lays down the format for the super-frame for sending beacons after every 15.38 ms or/and multiples thereof, up to 252s. This interval is determined a priori and the coordinator thus enables sixteen time slots of identical width between beacons so that channel access is contention-less. Within each time slot, access is contention-based. Nonetheless, the coordinator provides as many as seven GTS (guaranteed time slots) for every beacon interval to ensure better quality.

3.4.6 ZIGBEE PIN DIAGRAM

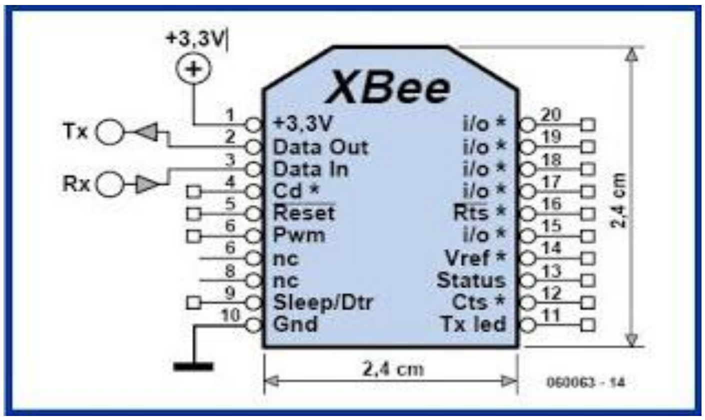


Fig3.4.6 Pin diagram of ZIGBEE

APPLICATIONS:

- The ZigBee Alliance targets applications "across consumer, commercial, industrial and government markets worldwide".
- Unwired applications are highly sought after in many networks that are characterized by numerous nodes consuming minimum power and enjoying long battery lives.
- ZigBee technology is designed to best suit these applications, for the reason that it enables reduced costs of development, very fast market adoption, and rapid ROI.
- Airbee Wireless Inc has tied up with Radio crafts AS to deliver "out-of-the-box" ZigBee-ready solutions; the former supplying the software and the latter making the module platforms. With even light controls and thermostat producers joining the ZigBee Alliance, the list is growing healthily and includes big OEM names like HP, Philips, Motorola and Intel.

3.5 POWER SUPPLY

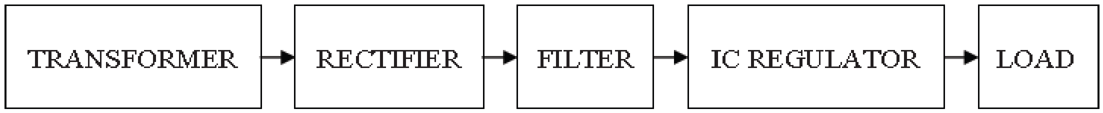


Fig3.5 Block diagram of Power supply

A power supply can be built using a transformer connected to the ac supply line to step the ac voltage to desired amplitude, then rectifying that ac voltage, filtering with a capacitor, if desired, and finally regulating the dc voltage using an IC regulator. A rectifier may be defined as an electronic circuit for converting AC voltage or current into a unidirectional voltage or current. A Resistor is electronic element. It has a known value of resistance of resistor. It is specially designed to introduce a desired amount of resistance in a circuit.

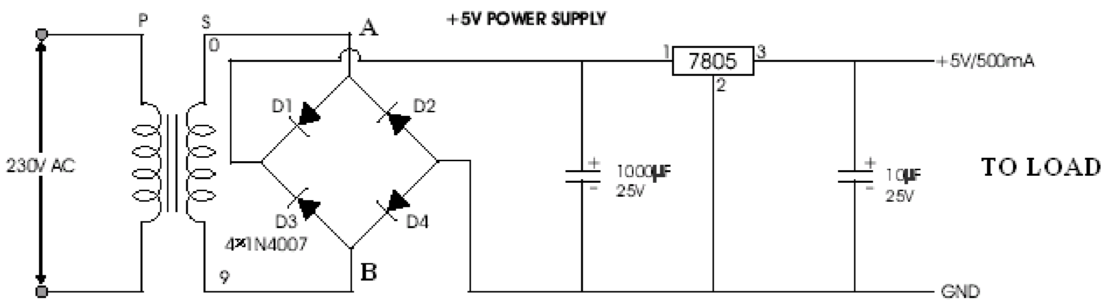


Fig3.5a Schematic diagram of power supply

3.5.1WORKING PRINCIPLE

3.5.2 TRANSFORMER

The potential transformer will step down the power supply voltage (0-230V) to (0-9V) level. If the secondary has less turns in the coil then the primary, the secondary coil's voltage will decrease and the current or AMPS will increase or decreased depend upon the wire gauge. **This is called a STEP-DOWN**

transformer. Then the secondary of the potential transformer will be connected to the rectifier.

3.5.3 BRIDGE RECTIFIER

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

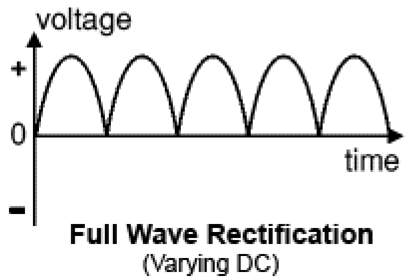


Fig3.5.3

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

This bridge rectifier always drops 1.4Volt of the input voltage because of the diode. We are using 1N4007 PN junction diode, its cut off region is 0.7Volt.

So any two diodes are always conducting, total drop voltage is 1.4 volt.

3.5.4 FILTER

If a Capacitor is added in parallel with the load resistor of a Rectifier to form a simple Filter Circuit, the output of the Rectifier will be transformed into a more stable DC Voltage.

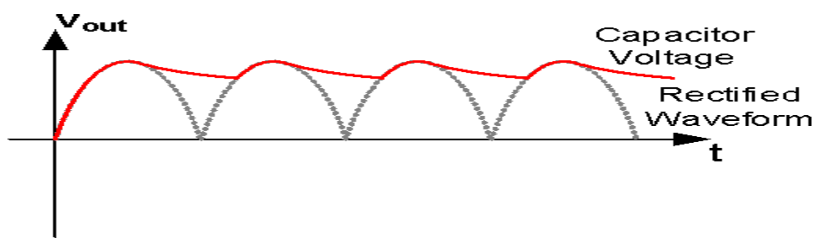


Fig3.5.4 Rectifieroutput

At first the capacitor is charged to the peak value of the rectified Waveform. Beyond the peak, the capacitor is discharged through the load until the time at which the rectified voltage exceeds the capacitor voltage. Then the capacitor is charged again and the process repeats itself.

3.5.5 IC VOLTAGE REGULATOR

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. IC units provide regulation of either a fixed positive voltage, a fixed negative voltage, or an adjustably set voltage.

Component description

1)Input
2)Ground
3)Output

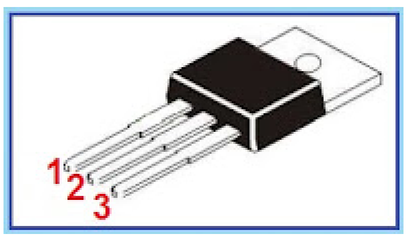
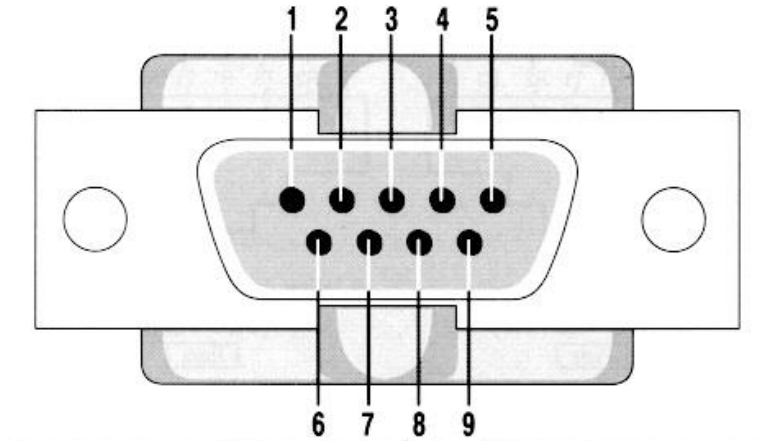


Fig3.5.5 Regulator

3.6 RS232

In telecommunications, **RS-232** as in fig3.6., 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.



Pin	Signal	Pin	Signal
1	Data Carrier Detect	6	Data Set Ready
2	Received Data	7	Request to Send
3	Transmitted Data	8	Clear to Send
4	Data Terminal Ready	9	Ring Indicator
5	Signal Ground		

Fig3.6 Pin diagram of RS232

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 levelsas shown in fig 3.6a.,

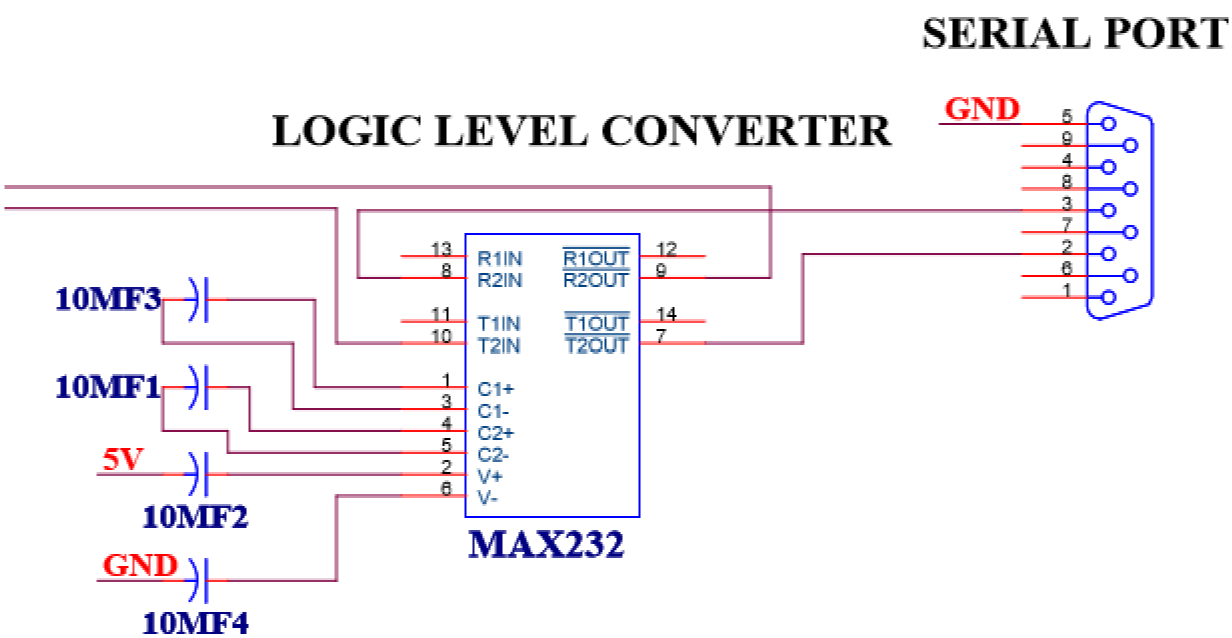


Fig3.6a RS232 Serial communication

CHAPTER 4

SOFTWARE DESCRIPTION

LABVIEW (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, LABVIEW 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 LABVIEW programs that imitate physical instruments.

In LABVIEW, 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.

LABVIEW 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. LABVIEW also has built-in features for connecting your application to the Internet using the LABVIEW web server and software standards such as TCP/IP networking and ActiveX.

Using LABVIEW, 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 LABVIEW is a true 32-bit compiler.

LABVIEW contains comprehensive libraries for data collection, analysis, presentation, and storage. LABVIEW 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.

4.1LABVIEW FEATURE

LABVIEW 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.

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

LABVIEW gives thousands of successful users a faster way to program instrumentation, data acquisition, and control systems. By using LABVIEW 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.

For more than 20 years, NI LABVIEW graphical development has revolutionized the development of scalable test, measurement, and control applications. Regardless of experience, engineers and scientists can rapidly and cost-effectively interface with measurement and control hardware, analyze data, shared results, and distribute systems.

4.1.1 VIRTUAL INSTRUMENTS

LABVIEW programs are called virtual instruments, or VIs, because their appearance and operation imitate physical instruments, such as oscilloscopes and multimeters. Every VI uses functions that manipulate input from the user interface or other sources and display that information or move it to other files or other computers.

A VI contains the following three components:

- **Front panel**—Serves as the user interface.
- **Block diagram**—Contains the graphical source code that defines the functionality of the VI.
- **Icon and connector pane**—Identifies the interface to the VI so that you can use the VI in another VI. A VI within another VI is called a subVI. A subVI corresponds to a subroutine in text-based programming languages.

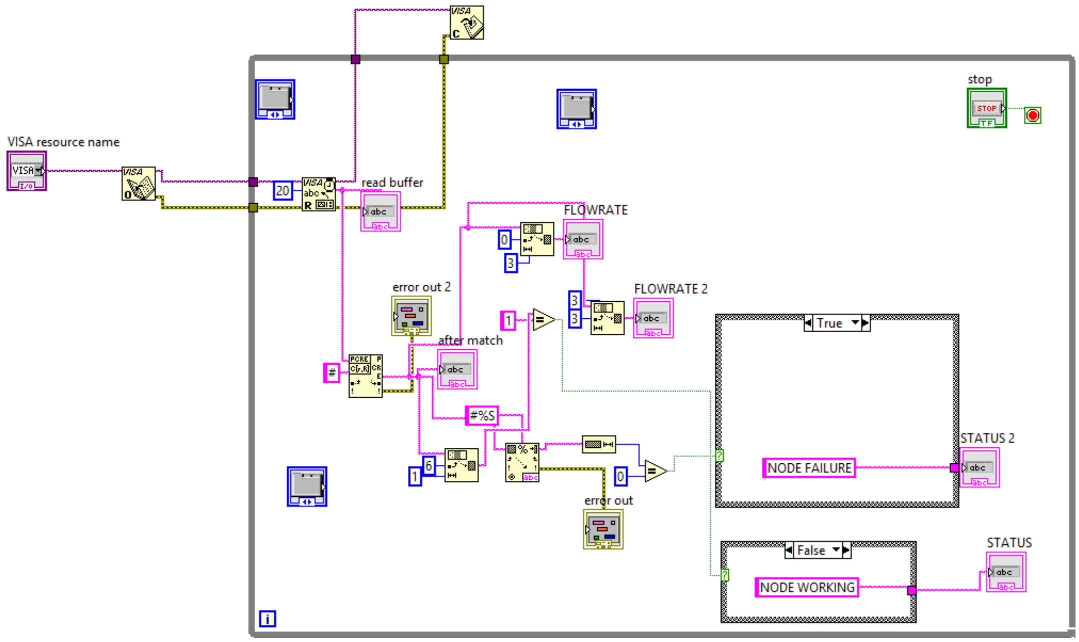


Fig4.1 Working process in LABVIEW

CHAPTER 5

WORKING MODEL

Flow sensor is used to measure the flow of the water between two points, if a leak happens in a place anywhere between two sensors the flow rate of the second sensor drops. Thus the microcontroller detects the drop in the flow rate and intimate about the leak. Transmitter and receiver module constructed using PIC Microcontroller. Communication between the two modules is done by ZIGBEE wireless communication.

The transmitter has the flow sensor which monitors the flow rate. The flow rate is transmitted by a time interval of 1 second. In the receiver side the flow rate values are compared if there is a change in the flow rate value. Then it sends an alarm signal. Though low-powered, Zigbee devices can transmit data over long distances by passing data through intermediate devices to reach more distant ones, creating a mesh network; i.e., a network with no centralized control or high-power transmitter/receiver able to reach all of the networked devices. The decentralized nature of such wireless ad hoc networks makes them suitable for applications where a central node can't be relied upon.

Flow sensor to measure the flow of the water between two points, if a leak happens in a place anywhere between this two sensors the flow rate of the second sensor drops. Thus the microcontroller detects the drop in the flow rate and intimate about the leak. The paper uses two modules Transmitter and receiver. Both modules are constructed using PIC Microcontroller. Communication between the two modules is done by ZIGBEE wireless communication. The transmitter has the flow sensor which monitors the flow rate. The flow rate is transmitted by a time interval of 1 second. In the receiver side the flow rate values are compared if there is a change in the flow rate value.

A Resistor is used either to control the flow of current to produce a desired voltage drop. It is the most common component used in electronic and electrical circuits. A capacitor is an electrical device for storing electrical energy. The stored electrical energy is released in the form of a current .The capacitor consists of two metallic surface separated by insulator and insulating material which may air or liquid or solid. This insulating material is called the dielectric.

CHAPTER 6

RESULTS AND DISCUSSION

The flow rate in both the nodes are detected and compared with each other. If there is any difference viewed in the flow rate on LCD, then the leakage in that particular node is displayed through monitoring system. The working module is shown in fig 6.1.,

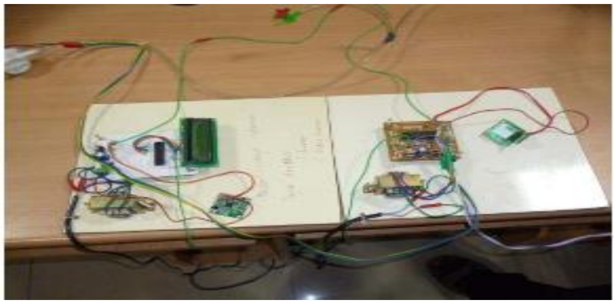


Fig6.1 Working model image

The working and failure condition of two nodes can be viewed through LABVIEW software. The output obtained on LABVIEW is shown in fig 6.1a.,

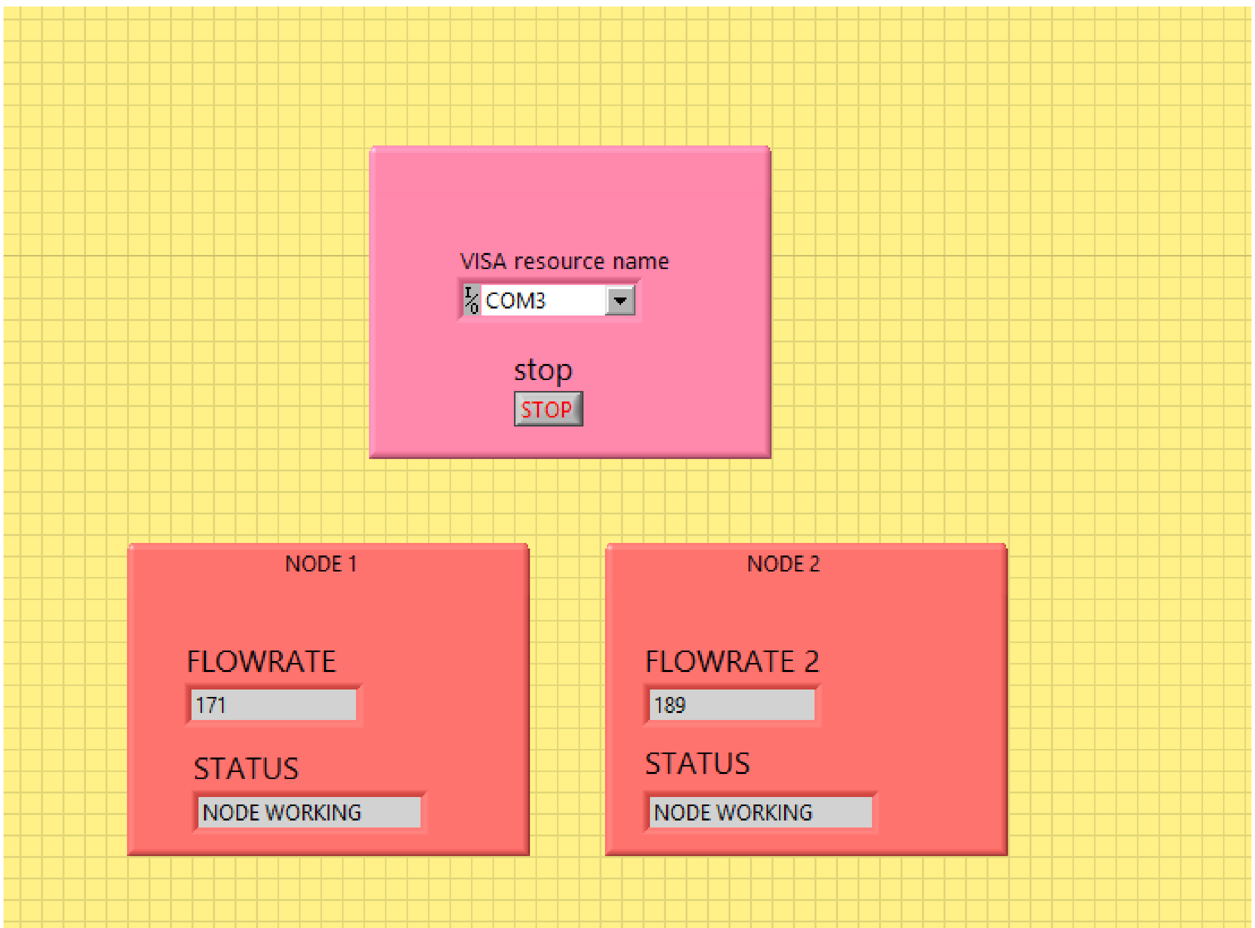


Fig6.1a LABVIEW output

CHAPTER 7

CONCLUSION

Thus the proposed system technology and equipment play a major part in reducing a utility's water losses. Large volumes of losses are from transmission Mains and are traditionally difficult to detect. Some of the technologies for finding such losses have been around for many years, and some are relatively new, harnessing the rapid development in technology, instrumentation, interpretation and communications. This has enabled the utility engineer to adopt a 'multi-sensor' approach, utilizing the whole range of technology and selecting an appropriate mix of equipment for specific network characteristics, site locations and type of leak. A pipe leakage detection system (PLDS) experimental station for testing technique for future applications was established at PVC pipe and is designed to accommodate different types of pipe and leak configurations. Leak detection experiments to help local utilities to implement the technology necessary to pinpoint leaks in the water distribution system and reduce water loss.

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