A PROJECT REPORT ON

SOLAR ENERGY MESUREMENT SYSTEM

Submitted in partial fulfillment of the requirements For the award of the degree

BACHELOR OF ENGINEERING IN ELECTRICAL ENGINEERING

SUBMITTED BY

MOHAMMAD ALI SHAIKH (12EE48)

SADAF SHAIKH (14EE03)

FAISAL SIDDIQUE (11EE51)

Under The Guidiance of

ANKUR UPADHYAY

DEPARTMENT OF ELECTRICAL ENGINEERING

Anjuman-I-Islam Kalsekar Technical Campus

AFFILIATED TO MUMBAI UNIVERSITY

CERTIFICATE

This is to certify that the dissertation work entitled SOLAR ENERGY MESUERMENT SYSTEM is a bonafied work done under my guidance by

MOHAMMAD ALI SHAIKH (12EE48)

SADAF SHAIKH (14EE03)

FAISAL SIDDIQUE (11EE51)

submitted in partial fulfillment for the award of 'BACHELOR OF ENGINEERING (B.E)' in Electrical Engineering from Anjuman-I-Islam Kalsekar Technical Campus affliated to Mumbai University.During the academic year **2018-19**

(Head of the department, EE) **(Guide)**

EXTERNAL EXAMINER

CERTIFICATE OF APPROVAL

The foregoing dissertation entitled **"SOLAR ENERGY MESUREMENT SYSTEM"** is hereby approved as a creditable study of Electrical Engineering presented by

- Mohammad Ali Shaikh(12EE48)
- Sadaf Shaikh(14EE03)
- Faisal Siddiquie (11EE51)

In a manner satisfactory to warrant is acceptance as a pre-requisite to their Degree in Bachelor of Electrical Engineering.

Internal Examiner **External Examiner**

(Prof.AnkurUpadhyay)

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MOHAMMAD ALI SHAIKH (12EE48)

SADAF SHAIKH (14EE03)

FAISAL SIDDIQUE (11EE51)

DECLARATION

We declare that this written submission represents my ideas in my own words and where others ideas or words have been included;We have adequately cited and referenced the original sources. We also declared that we have adhered to all principles of academic honesty and integrity and have not represented or fabricated or falsified any idea/data/fact/source in my submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission have not been taken when needed.

Mohammad Ali Shaikh. Sadaf Shaikh Faisal Siddiquie

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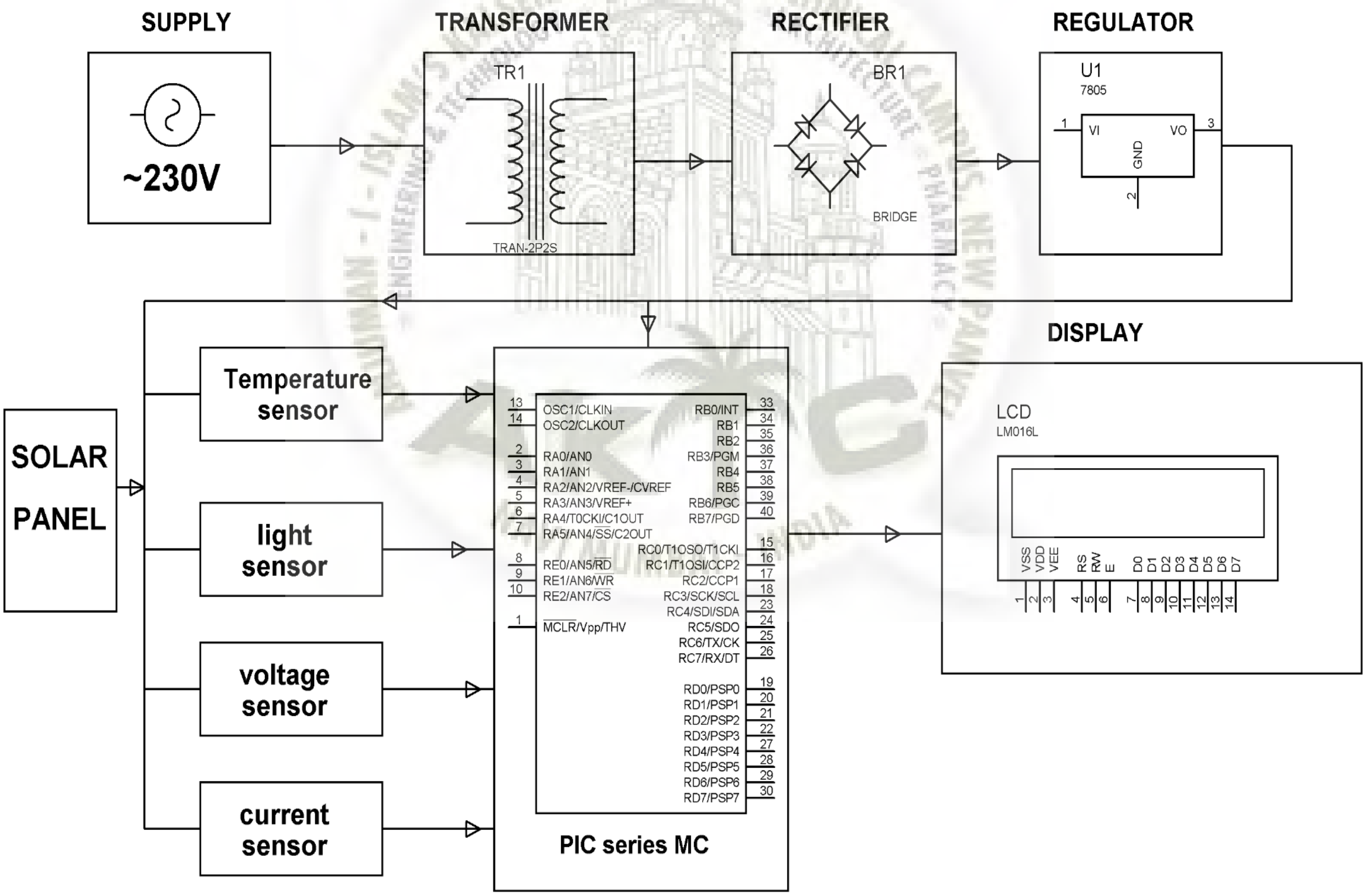
ABSTRACT

The aim of this project is to measure solar cell parameters through multiple sensor data acquisition. In this project a solar panel is used which keeps monitoring the sunlight. Here different parameters of the solar panel like the light intensity, voltage, current and the temperature are monitored. The microcontroller used here is PIC16F8 family.

The light intensity is monitored using an LDR sensor, voltage by voltage divider principle, current by current sensor and temperature by temperature sensor. All these data are displayed on a 16X2 LCD interfaced to PIC microcontroller.

The power supply consists of a step down transformer 230/12V, which steps down the voltage to 12V AC. This is converted to DC using a bridge rectifier. The ripples are removed using a capacitive filter and it is then regulated to +5V using a voltage regulator 7805 which is required for the operation of microcontroller and other circuits.

PROJECT BLOCK DIAGRAM



HARDWARE COMPONENTS:

1. TRANSFORMER (230 – 12 V AC)
2. VOLTAGE REGULATOR (LM 7805)
3. RECTIFIER
4. FILTER
5. PIC MICROCONTROLLER (PIC 16F877A)
6. LCD DISPLAY
7. SOLAR PANEL
8. LM35
9. LDR
10. 1N4007
11. LED
12. RESISTOR
13. CAPACITOR

TRANSFORMER

Transformers convert AC electricity from one voltage to another with a little loss of power. Step-up transformers increase voltage, step-down transformers reduce voltage. Most power supplies use a step-down transformer to reduce the dangerously high voltage to a safer low voltage.

FIG 4.1: A TYPICAL TRANSFORMER

The input coil is called the primary and the output coil is called the secondary. There is no electrical connection between the two coils; instead they are linked by an alternating magnetic field created in the soft-iron core of the transformer. The two lines in the middle of the circuit symbol represent the core. Transformers waste very little power so the power out is (almost) equal to the power in. Note that as voltage is stepped down and current is stepped up.

The ratio of the number of turns on each coil, called the turn's ratio, determines the ratio of the voltages. A step-down transformer has a large number of turns on its primary (input) coil which is connected to the high voltage mains supply, and a small number of turns on its secondary (output) coil to give a low output voltage.

$$\text{TURNS RATIO} = (V_p / V_s) = (N_p / N_s)$$

Where,

V_p = primary (input) voltage.

V_s = secondary (output) voltage

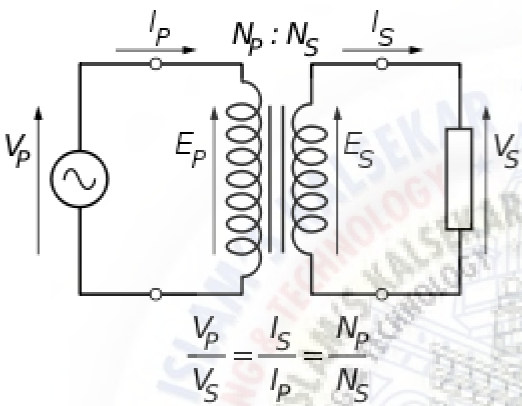
N_p = number of turns on primary coil

Ns = number of turns on secondary coil

Ip = primary (input) current

Is = secondary (output) current.

Ideal power equation



The ideal transformer as a circuit element

If the secondary coil is attached to a load that allows current to flow, electrical power is transmitted from the primary circuit to the secondary circuit. Ideally, the transformer is perfectly efficient; all the incoming energy is transformed from the primary circuit to the magnetic field and into the secondary circuit. If this condition is met, the incoming electric power must equal the outgoing power:

$$P_{\text{incoming}} = I_{\text{p}} V_{\text{p}} = P_{\text{outgoing}} = I_{\text{s}} V_{\text{s}},$$

Giving the ideal transformer equation

$$\frac{V_{\text{s}}}{V_{\text{p}}} = \frac{N_{\text{s}}}{N_{\text{p}}} = \frac{I_{\text{p}}}{I_{\text{s}}}.$$

Transformers normally have high efficiency, so this formula is a reasonable approximation.

If the voltage is increased, then the current is decreased by the same factor. The impedance in one circuit is transformed by the *square* of the turns ratio. For example, if an impedance Z_s is attached across the terminals of the secondary coil, it appears to the primary circuit to have an impedance of $(N_p/N_s)^2 Z_s$. This relationship is reciprocal, so that the impedance Z_p of the primary circuit appears to the secondary to be $(N_s/N_p)^2 Z_p$.

VOLTAGE REGULATOR 7805

Features

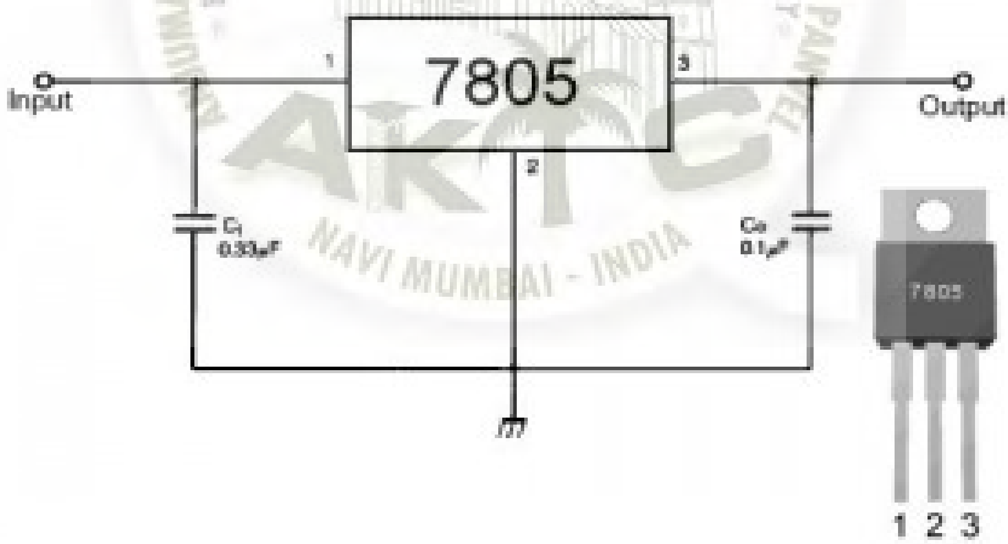
• Output Current up to 1A.

• Output Voltages of 5, 6, 8, 9, 10, 12, 15, 18, 24V.

• Thermal Overload Protection.

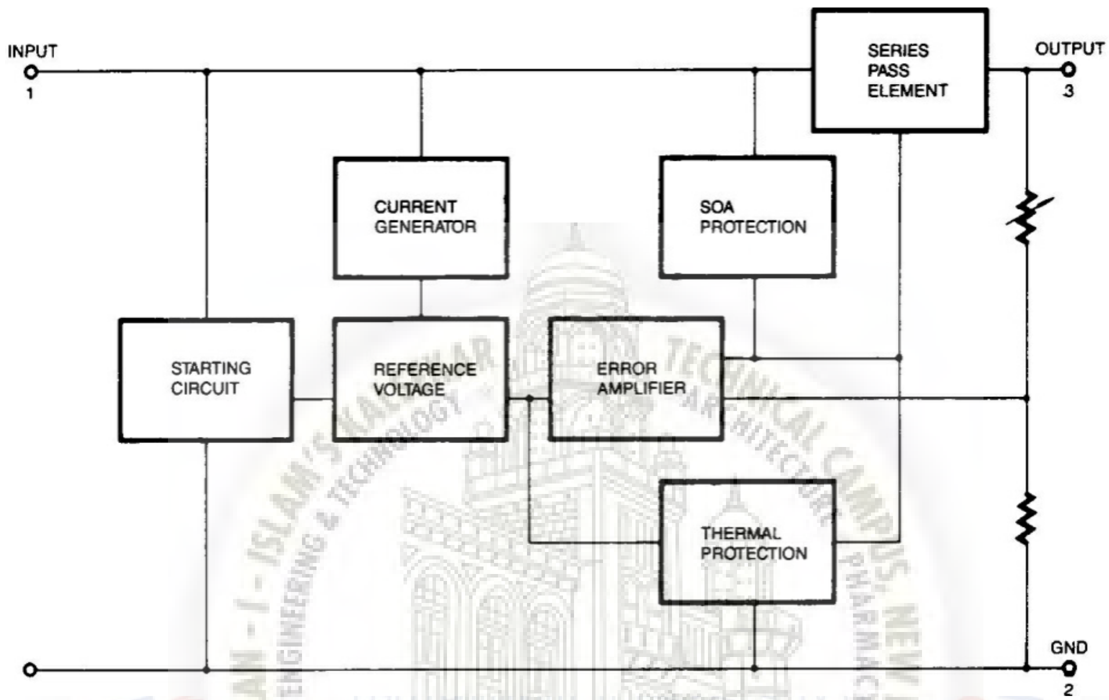
• Short Circuit Protection.

• Output Transistor Safe Operating Area Protection.



Description

The LM78XX/LM78XXA series of three-terminal positive regulators are available in the TO-220/D-PAK package and with several fixed output voltages, making them useful in a Wide range of applications. Each type employs internal current limiting, thermal shutdown and safe operating area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1A output Current. Although designed primarily as fixed voltage regulators, these devices can be



used with external components to obtain adjustable voltages and currents.

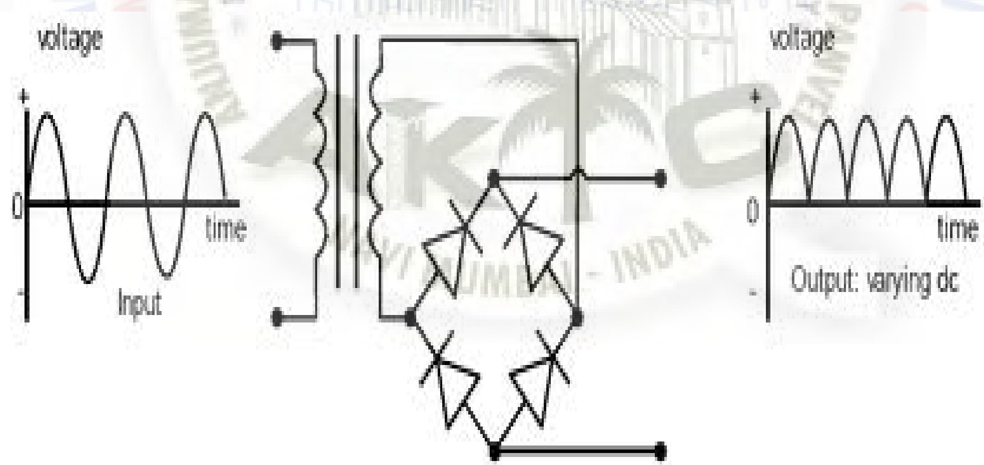
Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Input Voltage (for V_O = 5V to 18V) (for V_O = 24V)	V_I V_I	35 40	V V
Thermal Resistance Junction-Cases (TO-220)	$R_{\theta JC}$	5	°C/W
Thermal Resistance Junction-Air (TO-220)	$R_{\theta JA}$	65	°C/W
Operating Temperature Range (KA78XX/A/R)	T_{OPR}	0 ~ +125	°C
Storage Temperature Range	T_{STG}	-65 ~ +150	°C

TABLE 4.2(b): RATINGS OF THE VOLTAGE REGULATOR

RECTIFIER

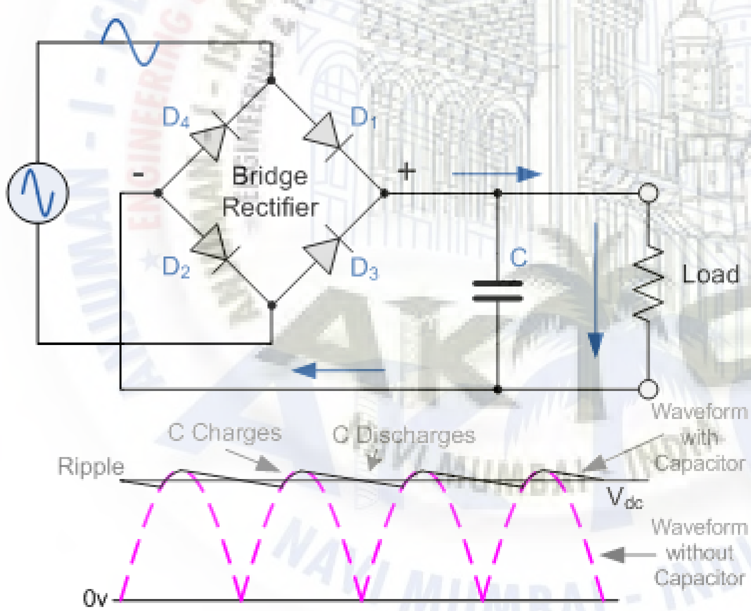
A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), current that flows in only one direction, a process known as rectification. Rectifiers have many uses including as components of power supplies and as detectors of radio signals. Rectifiers may be made of solid state diodes, vacuum tube diodes, mercury arc valves, and other components. The output from the transformer is fed to the rectifier. It converts A.C. into pulsating D.C. The rectifier may be a half wave or a full wave rectifier. In this project, a bridge rectifier is used because of its merits like good stability and full wave rectification. In positive half cycle only two diodes(1 set of parallel diodes) will conduct, in negative half cycle remaining two diodes will conduct and they will conduct only in forward bias only.



FILTER

Capacitive filter is used in this project. It removes the ripples from the output of rectifier and smoothens the D.C. Output received from this filter is constant until the mains voltage and load is maintained constant. However, if either of the two is varied, D.C. voltage received at this point changes. Therefore a regulator is applied at the output stage.

The simple capacitor filter is the most basic type of power supply filter. The use of this filter is very limited. It is sometimes used on extremely high-voltage, low-current power supplies for cathode-ray and similar electron tubes that require very little load current from the supply. This filter is also used in circuits where the power-supply ripple frequency is not critical and can be relatively high. Below figure can show how the capacitor changes and discharges.



Resultant Output Waveform

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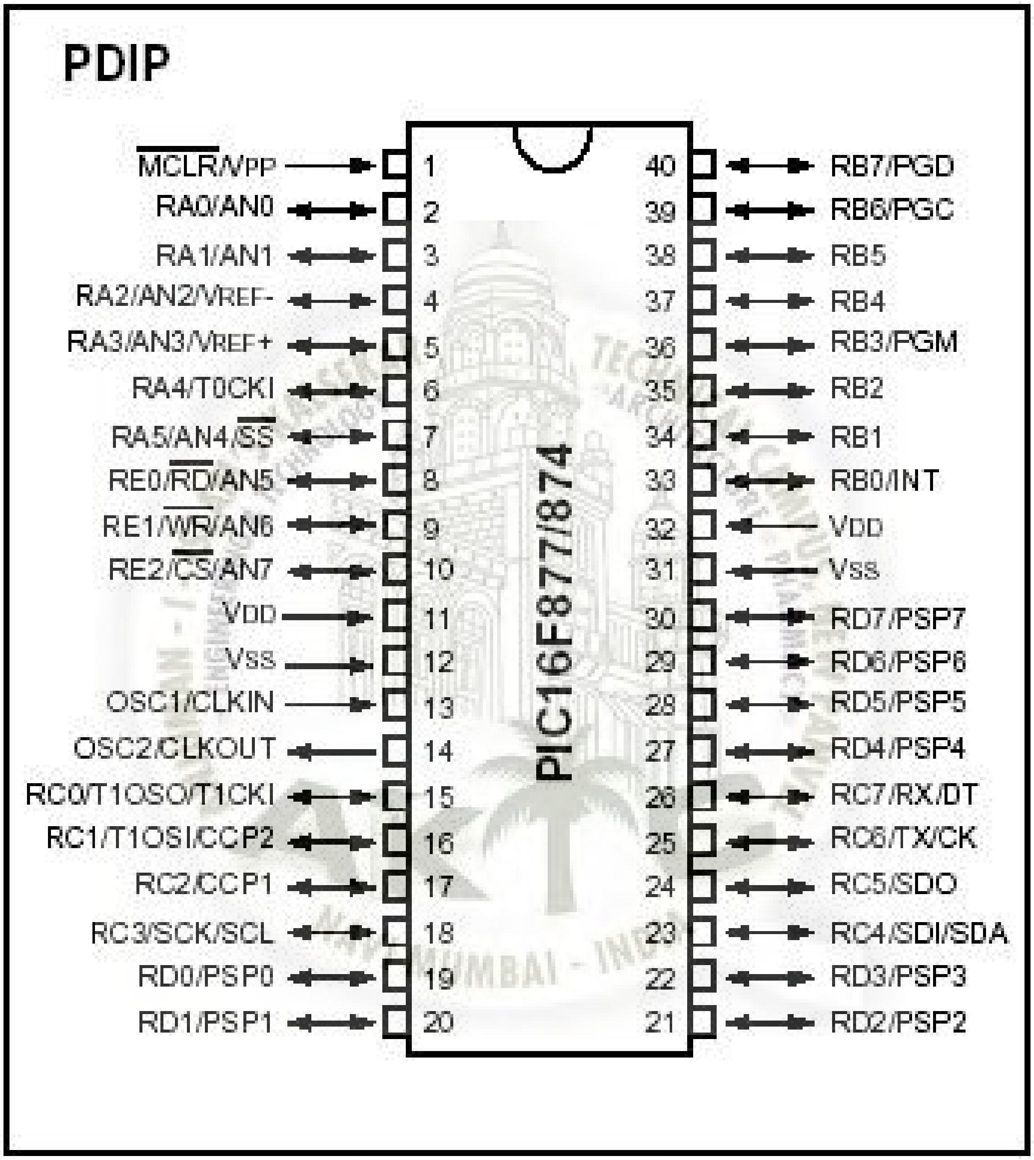
MICRO CONTROLLER PIC16F877A

28/40/44-Pin Enhanced Flash Microcontrollers



High-Performance RISC CPU:

- Only 35 single-word instructions.
- 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 other 28-pin or 40/44-pin, PIC16CXXX and PIC16FXXX microcontrollers.

Special Microcontroller Features:

• 100,000 erase/write cycle Enhanced Flash program memory typical.

• 1,000,000 erase/write cycle Data EEPROM memory typical.

• Data EEPROM Retention > 40 years.

• Self-reprogrammable under software control.

• In-Circuit Serial Programming™ (ICSP™) via two pins.

• Single-supply 5V In-Circuit Serial Programming.

•Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation.

• Programmable code protection.

• Power saving Sleep mode.

• Selectable oscillator options.

• In-Circuit Debug (ICD) via two pins.

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

• Synchronous Serial Port (SSP) with SPI™ (Master mode) and I^2C™ (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).

Analog Features:

- 10-bit, up to 8-channel Analog-to-Digital Converter (A/D)
- Brown-out Reset (BOR)
- Analog Comparator module with:
  - i) Two analog comparators.
  - ii) Programmable on-chip voltage reference (VREF) module.
  - iii) Programmable input multiplexing from device inputs and internal voltage reference.
  - iv) Comparator outputs are externally accessible.

CMOS Technology:

• Low-power, high-speed Flash/EEPROM technology.

• Fully static design.

• Wide operating voltage range (2.0V to 5.5V).

• Commercial and Industrial temperature ranges.

• Low-power consumption.

Device	Program Memory		Data SRAM (Bytes)	EEPROM (Bytes)	I/O	10-bit A/D (ch)	CCP (PWM)	MSSP		USART	Timers 8/16-bit	Comparators
	Bytes	# Single Word Instructions						SPI	Master I²C			
PIC16F873A	7.2 K	4096	192	128	22	5	2	Yes	Yes	Yes	2/1	2
PIC16F874A	7.2 K	4096	192	128	33	8	2	Yes	Yes	Yes	2/1	2
PIC16F876A	14.3 K	8192	368	256	22	5	2	Yes	Yes	Yes	2/1	2
PIC16F877A	14.3 K	8192	368	256	33	8	2	Yes	Yes	Yes	2/1	2

PIC16F873A/876A devices are available only in 28-pin packages, while PIC16F874A/877A devices are avail- able in 40-pin and 44-pin packages. All devices in the PIC16F87XA family share common architecture with the following differences:

- The PIC16F873A and PIC16F874A have one-half of the total on-chip memory of the PIC16F876A and PIC16F877A.
- The 28-pin devices have three I/O ports, while the 40/44-pin devices have five.
- The 28-pin devices have fourteen interrupts, while the 40/44-pin devices have fifteen.
- The 28-pin devices have five A/D input channels, while the 40/44-pin devices have eight.
- The Parallel Slave Port is implemented only on the 40/44-pin devices.

Memory Organization

There are three memory blocks in each of the PIC16F87XA devices. The program memory and data memory have separate buses so that concurrent access can occur and is detailed in this section. The EEPROM data memory block is detailed in Section 3.0 “Data EEPROM and Flash Program Memory”. Additional information on device memory may be found in the PIC micro Mid-Range MCU Family Reference Manual (DS33023).

Program Memory Organization

The PIC16F87XA devices have a 13-bit program counter capable of addressing an 8K word x 14 bit program memory space. The PIC16F876A/877A devices have 8K words x 14 bits of Flash program memory, while PIC16F873A/874A devices have 4K words x 14 bits. Accessing a location above the physically implemented address will cause a wraparound.

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

LIQUID CRYSTAL DISPLAY (LCD)

Description:

This is the example for the Parallel Port. This example doesn't use the Bi-directional feature found on newer ports, thus it should work with most, if not all Parallel Ports. It however doesn't show the use of the Status Port as an input for a 16 Character x 2 Line LCD Module to the Parallel Port. These LCD Modules are very common these days, and are quite simple to work with, as all the logic required running them is on board.

Pros:

- Very compact and light
- Low power consumption
- No geometric distortion
- Little or no flicker depending on backlight technology
- Not affected by screen burn-in
- No high voltage or other hazards present during repair/service
- Can be made in almost any size or shape
- No theoretical resolution limit

LCD Background:

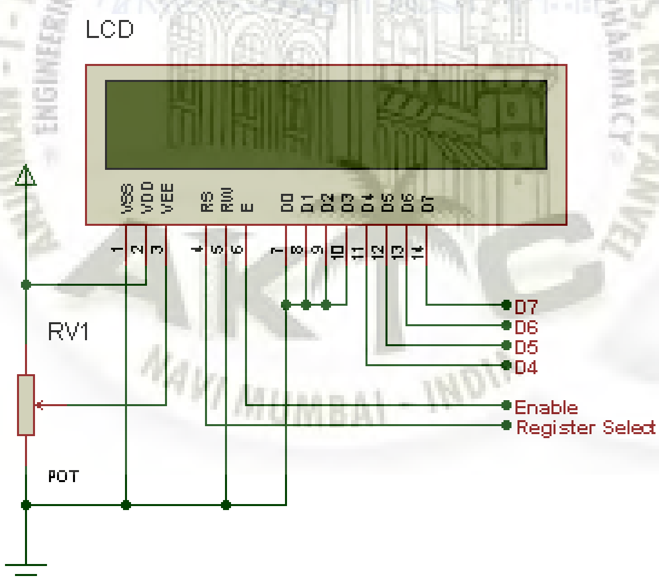
Frequently, an 8051 program must interact with the outside world using input and output devices that communicate directly with a human being. One of the most common devices attached to an 8051 is an LCD display. Some of the most common LCDs connected to the 8051 are 16x2 and 20x4 displays. This means 16 characters per line by 2 lines and 20 characters per line by 4 lines, respectively.

Fortunately, a very popular standard exists which allows us to communicate with the vast majority of LCDs regardless of their manufacturer. The standard is referred to as HD44780U, which refers to the controller chip which receives data from an external source (in this case, the 8051) and communicates directly with the LCD.

FIG 4.10: LCD

44780 LCD BACKGROUND

The 44780 standard requires 3 control lines as well as either 4 or 8 I/O lines for the data bus. The user may select whether the LCD is to operate with a 4-bit data bus or an 8-bit data bus. If a 4-bit data bus is used the LCD will require a total of 7 data lines (3 control lines plus the 4 lines for the data bus). If an 8-bit data bus is used the LCD will require a total of 11 data lines (3 control lines plus the 8 lines for the data bus).



The three control lines are referred to as EN, RS, and RW.

The EN line is called "Enable." This control line is used to tell the LCD that you are sending it data. To send data to the LCD, your program should make sure this line is low (0) and then set the other two control lines and/or put data on the data bus. When the other lines are completely ready, bring EN high (1) and wait for the minimum amount of time required by the LCD datasheet (this varies from LCD to LCD), and end by bringing it low (0) again.

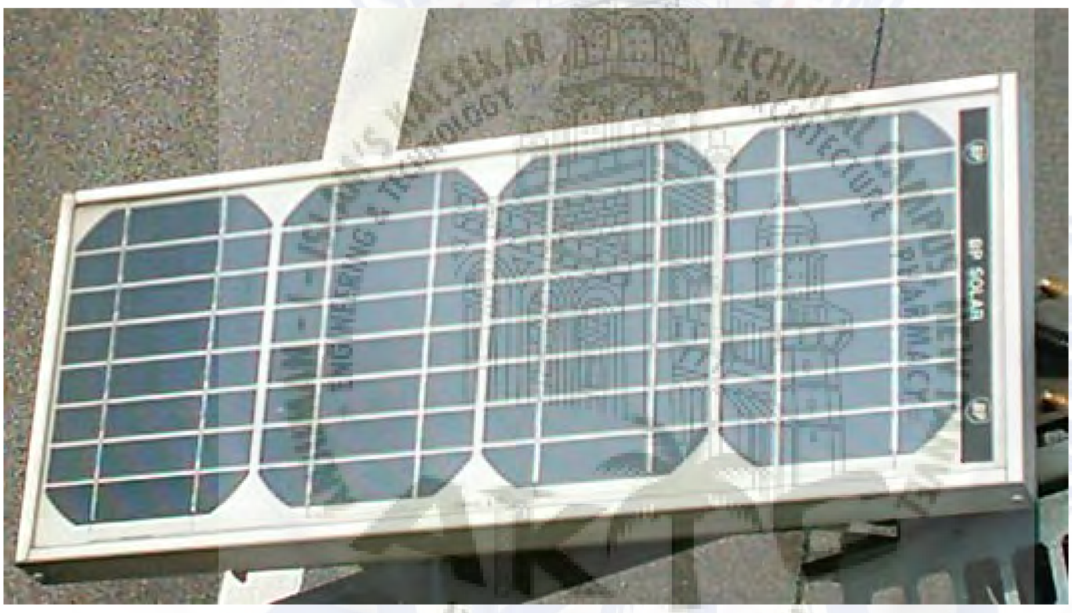
The RS line is the "Register Select" line. When RS is low (0), the data is to be treated as a command or special instruction (such as clear screen, position cursor, etc.). When RS is high (1), the data being sent is text data which should be displayed on the screen. For example, to display the letter "T" on the screen you would set RS high.

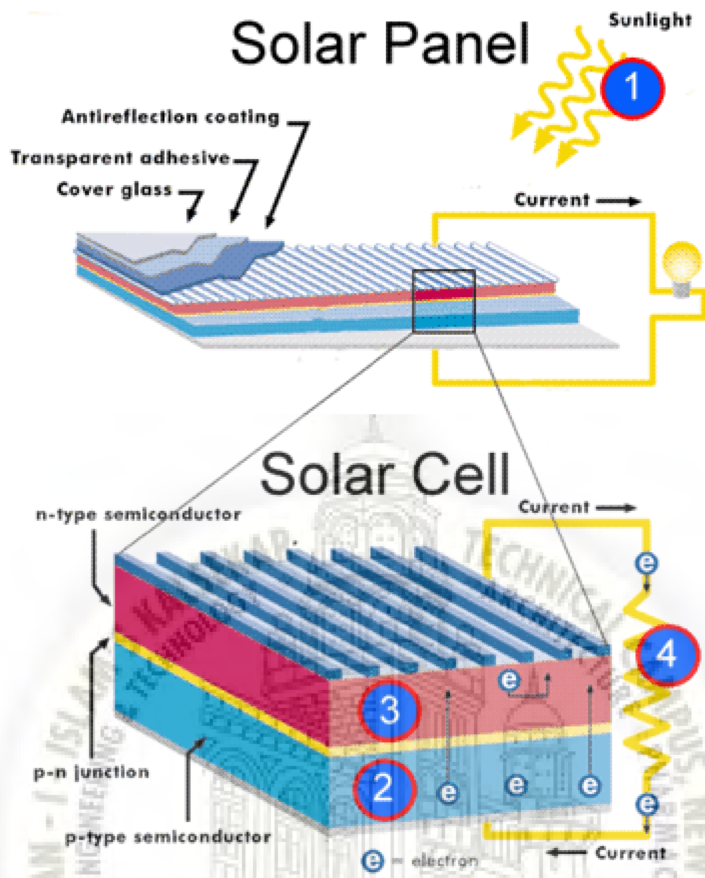
The RW line is the "Read/Write" control line. When RW is low (0), the information on the data bus is being written to the LCD. When RW is high (1), the program is effectively querying (or reading) the LCD. Only one instruction ("Get LCD status") is a read command. All others are write commands--so RW will almost always be low .Finally, the data bus consists of 4 or 8 lines (depending on the mode of operation selected by the user). In the case of an 8-bit data bus, the lines are referred to as DB0, DB1, DB2, DB3, DB4, DB5, DB6, and DB7.

SOLAR PANEL

A **solar panel** (**photovoltaic module** or **photovoltaic panel**) is a packaged interconnected assembly of solar cells, also known as *photovoltaic cells*. The solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications.

Because a single solar panel can only produce a limited amount of power, many installations contain several panels. A photovoltaic system typically includes an array of solar panels, an inverter, may contain a battery and interconnection wiring





<u>**How Solar Panels Work**</u>

Photovoltaic (PV) cells are formed from a wafer of semi-conductor material and although there are now several types in production using different materials, the most common semi-conductor used is silicon.

Pure crystalline silicon is a poor electrical conductor but treat it with tiny quantities of an impurity, either phosphorous or arsenic (a process called "doping") and enough electrons of these materials are freed to enable a current to pass through. Electrons are negatively charged so this type of silicon is called N-Type.

Dope silicon with gallium or boron and "holes" are created in the crystalline lattice where a silicon electron has nothing to bond with. These holes can conduct electrical current and the lack of an electron creates a positive charge so this type of silicon is therefore called P-Type. Both types of silicon are modest electrical conductors, hence the name semiconductors.

Put a layer of each kind together in a wafer, such as in a PV cell, and the free electrons in the N side migrate towards the free holes on the P side. This causes a disruption to the electrical neutrality where the holes and electrons mix at the junction of the two layers. Eventually a barrier is formed preventing the electrons from crossing to the P side and an electrical field is formed, separating both sides. This electrical field acts as a diode, allowing electrons to pass from the P side to the N side, but not vice versa.

Expose the cell to light, and the energy from each photon (light particle) hitting the silicon, will liberate an electron and a corresponding hole. If this happens within range of the electric field's influence, the electrons will be sent to the N side and the holes to the P one, resulting in yet further disruption of electrical neutrality. Apply an external pathway connecting both sides of the silicon wafer and electrons will flow back to their original P side to unite with the holes sent there by the electric field.

This flow of electrons is a current; the electrical field in the cell causes a voltage and the product of these two is power.

Several factors affect the efficiency of a solar cell. Some cells, mainly ones made from a single material, are only efficient in certain light wavelengths. Single material cells can at the very most expect to convert about 25% of the light hitting it to electrical power.

TEMPERATURE SENSOR(LM35)

Features

- n Calibrated directly in ˚ Celsius (Centigrade)
- n Linear + 10.0 mV/˚C scale factor
- n 0.5˚C accuracy guarantee able (at +25˚C)
- n Rated for full −55˚ to +150˚C range
- n Suitable for remote applications
- n Low cost due to wafer-level trimming
- n Operates from 4 to 30 volts
- n Less than 60 µA current drain
- n Low self-heating, 0.08˚C in still air
- n Nonlinearity only ±1/4˚C typical
- n Low impedance output, 0.1 for 1 mA load

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1/4˚C at room temperature and ±3/4˚C over a full −55 to +150˚C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 µA from its supply, it has very low self-heating, less than 0.1˚C in still air. The LM35 is rated to operate over a −55˚ to +150˚C temperature range, while the LM35C is rated for a −40˚ to +110˚C range (−10˚ with improved accuracy). The LM35 series is available packaged in hermetic

TO-46 transistor packages, while the LM35C, LM35CA, and LM35D are also available in the plastic TO-92 transistor package. The LM35D is also avail- able in an 8-lead surface mount small outline package and a plastic TO-220 package.

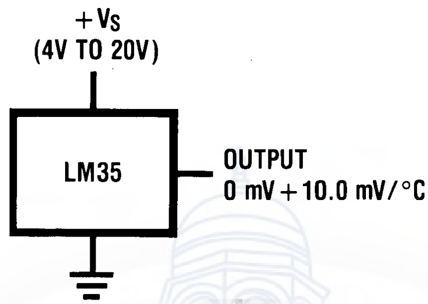


Fig 4.10: Basic Centigrade Temperature Sensor (+2˚C to +150˚C)

Applications:

- The LM35 can be applied easily in the same way as other integrated circuit temperature sensors. It can be glued or cemented to a surface and its temperature will be within about 0.01˚C of the surface temperature.
- This presumes that the ambient air temperature is almost the same as the surface temperature; if the air temperature were much higher or lower than the surface temperature, the actual temperature of the LM35 die would be at an intermediate temperature between the surface temperature and the air temperature. This is especially true for the TO-92 plastic package, where the copper leads are the principal thermal path to carry heat into the device, so its temperature might be closer to the air temperature than to the surface temperature.
- To minimize this problem, be sure that the wiring to the LM35, as it leaves the device, is held at the same temperature as the surface of interest. The easiest way to do this is to cover up these wires with a bead of epoxy which will insure that the leads and wires are all at the same temperature as the surface, and that the LM35 die's temperature will not be affected by the air temperature.

LDR

A **photoresistor** or **light dependent resistor** (LDR) is a resistor whose resistance decreases with increasing incident light intensity. It can also be referred to as a **photoconductor**.

A photoresistor is made of a high resistance semiconductor. If light falling on the device is of high enough frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electron (and its hole partner) conduct electricity, thereby lowering resistance.

A photoelectric device can be either intrinsic or extrinsic. An intrinsic semiconductor has its own charge carriers and is not an efficient semiconductor, e.g. silicon. In intrinsic devices the only available electrons are in the valence band, and hence the photon must have enough energy to excite the electron across the entire band gap. Extrinsic devices have impurities, also called dopants, added whose ground state energy is closer to the conduction band; since the electrons do not have as far to jump, lower energy photons (i.e., longer wavelengths and lower frequencies) are sufficient to trigger the device. If a sample of silicon has some of its atoms replaced by phosphorus atoms (impurities), there will be extra electrons available for conduction. This is an example of an extrinsic semiconductor.

APPLICATIONS

Photoresistor come in many different types. Inexpensive cadmium sulfide cells can be found in many consumer items such as camera light meters, street lights, clock radios, alarms, and outdoor clocks.

They are also used in some dynamic compressors together with a small incandescent lamp or light emitting diode to control gain reduction.

Lead sulfide (PbS) and indium antimonide (InSb) LDRs (light dependent resistor) are used for the mid infrared spectral region. Ge:Cu photoconductors are among the best far-infrared detectors available, and are used for infrared astronomy and infrared spectroscopy.

1N4007

Diodes are used to convert AC into DC these are used as half wave rectifier or full wave rectifier. Three points must he kept in mind while using any type of diode.

1. Maximum forward current capacity
2. Maximum reverse voltage capacity
3. Maximum forward voltage capacity

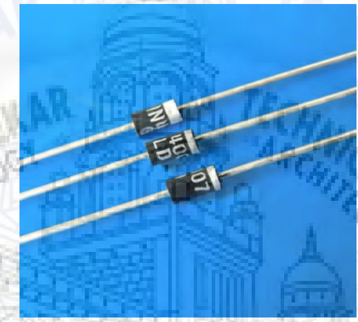


Fig: 1N4007 diodes

The number and voltage capacity of some of the important diodes available in the market are as follows:

- Diodes of number IN4001, IN4002, IN4003, IN4004, IN4005, IN4006 and IN4007 have maximum reverse bias voltage capacity of 50V and maximum forward current capacity of 1 Amp.
- Diode of same capacities can be used in place of one another. Besides this diode of more capacity can be used in place of diode of low capacity but diode of low capacity cannot be used in place of diode of high capacity. For example, in place of IN4002; IN4001 or IN4007 can be used but IN4001 or IN4002 cannot be used in place of IN4007.The diode BY125made by company BEL is equivalent of diode from IN4001 to IN4003. BY 126 is equivalent to diodes IN4004 to 4006 and BY 127 is equivalent to diode IN4007.

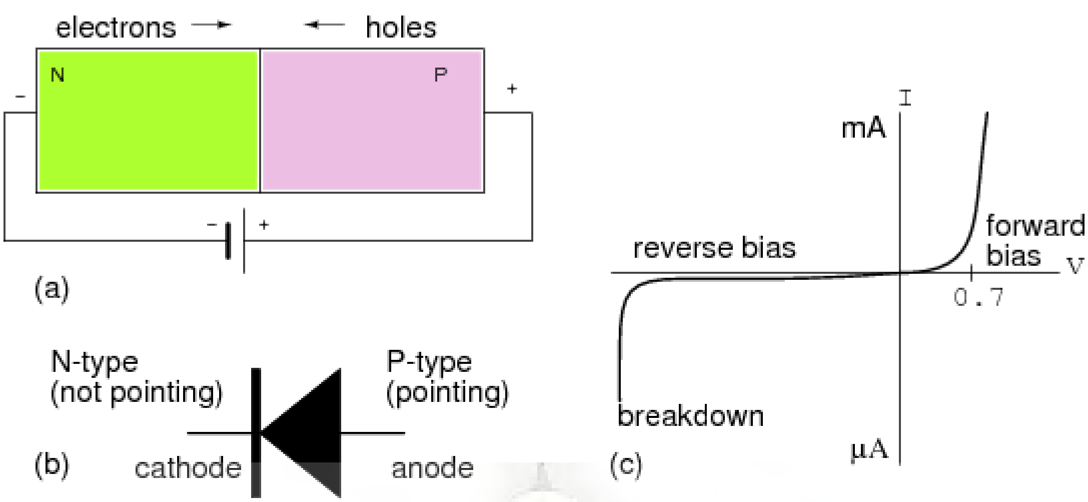


Fig:PN Junction diode

PN JUNCTION OPERATION

Now that you are familiar with P- and N-type materials, how these materials are joined together to form a diode, and the function of the diode, let us continue our discussion with the operation of the PN junction. But before we can understand how the PN junction works, we must first consider current flow in the materials that make up the junction and what happens initially within the junction when these two materials are joined together.

Current Flow in the N-Type Material

Conduction in the N-type semiconductor, or crystal, is similar to conduction in a copper wire. That is, with voltage applied across the material, electrons will move through the crystal just as current would flow in a copper wire. This is shown in figure 1-15. The positive potential of the battery will attract the free electrons in the crystal. These electrons will leave the crystal and flow into the positive terminal of the battery. As an electron leaves the crystal, an electron from the negative terminal of the battery will enter the crystal, thus completing the current path. Therefore, the majority current carriers in the N-type material (electrons) are repelled by the negative side of the battery and move through the crystal toward the positive side of the battery.

Current Flow in the P-Type Material

Current flow through the P-type material is illustrated. Conduction in the P material is by positive holes, instead of negative electrons. A hole moves from the positive terminal of the P material to the negative terminal. Electrons from the external circuit enter the negative terminal of the material and fill holes in the vicinity of this terminal. At the positive terminal, electrons are removed from the covalent bonds, thus creating new holes. This process continues as the steady stream of holes (hole current) moves toward the negative terminal

LED

A light-emitting diode (LED) is a semiconductor light source. LEDs are used as indicator lamps in many devices, and are increasingly used for lighting. When a light-emitting diode is forward biased (switched on), electrons are able to recombine with holes within the device, releasing energy in the form of photons. This effect is called electroluminescence and the color of the light (corresponding to the energy of the photon) is determined by the energy gap of the semiconductor. An LED is often small in area (less than 1 mm^2), and integrated optical components may be used to shape its radiation pattern. LEDs present many advantages over incandescent light sources including lower energy consumption, longer lifetime, improved robustness, smaller size, faster switching, and greater durability and reliability.

Types of LED'S

Light-emitting diodes are used in applications as diverse as replacements for aviation lighting, automotive lighting as well as in traffic signals. The compact size, the possibility of narrow bandwidth, switching speed, and extreme reliability of LEDs has allowed new text and video displays and sensors to be developed, while their high switching rates are also useful in advanced communications technology.

Electronic Symbol:

RESISTORS

A resistor is a two-terminal electronic component designed to oppose an electric current by producing a voltage drop between its terminals in proportion to the current, that is, in accordance with Ohm's law:

$$V = IR$$

Resistors are used as part of electrical networks and electronic circuits. They are extremely commonplace in most electronic equipment. Practical resistors can be made of various compounds and films, as well as resistance wire (wire made of a high-resistivity alloy, such as nickel/chrome).

The primary characteristics of resistors are their resistance and the power they can dissipate. Other characteristics include temperature coefficient, noise, and inductance. Less well-known is critical resistance, the value below which power dissipation limits the maximum permitted current flow, and above which the limit is applied voltage. Critical resistance depends upon the materials constituting the resistor as well as its physical dimensions; it's determined by design.

Resistors can be integrated into hybrid and printed circuits, as well as integrated circuits. Size, and position of leads (or terminals) are relevant to equipment designers; resistors must be physically large enough not to overheat when dissipating their power.

A resistor is a two-terminal passive electronic component which implements electrical resistance as a circuit element. When a voltage V is applied across the terminals of a resistor, a current I will flow through the resistor in direct proportion to that voltage. The reciprocal of the constant of proportionality is known as the resistance R, since, with a given voltage V, a larger value of R further "resists" the flow of current I as given by Ohm's law:

$$I = \frac{V}{R}$$

Resistors are common elements of electrical networks and electronic circuits and are ubiquitous in most electronic equipment. Practical resistors can be made of various compounds and films, as well as resistance wire (wire made of a high-resistivity alloy, such as nickel-chrome). Resistors are also implemented within integrated circuits, particularly analog devices, and can also be integrated into hybrid and printed circuits.

The electrical functionality of a resistor is specified by its resistance: common commercial resistors are manufactured over a range of more than 9 orders of magnitude. When specifying that resistance in an electronic design, the required precision of the resistance may require attention to the manufacturing tolerance of the chosen resistor, according to its specific application. The temperature coefficient of the resistance may also be of concern in some precision applications. Practical resistors are also specified as having a maximum power rating which must exceed the anticipated power dissipation of that resistor in a particular circuit: this is mainly of concern in power electronics applications. Resistors with higher power ratings are physically larger and may require heat sinking. In a high voltage circuit, attention must sometimes be paid to the rated maximum working voltage of the resistor.

The series inductance of a practical resistor causes its behavior to depart from ohms law; this specification can be important in some high-frequency applications for smaller values of resistance. In a low-noise amplifier or pre-amp the noise characteristics of a resistor may be an issue. The unwanted inductance, excess noise, and temperature coefficient are mainly dependent on the technology used in manufacturing the resistor. They are not normally specified individually for a particular family of resistors manufactured using a particular technology. A family of discrete resistors is also characterized according to its form factor, that is, the size of the device and position of its leads (or terminals) which is relevant in the practical manufacturing of circuits using them.

Units

The ohm (symbol: Ω) is the SI unit of electrical resistance, named after Georg Simon Ohm. An ohm is equivalent to a volt per ampere. Since resistors are specified and manufactured over a very large range of values, the derived units of milliohm (1 mΩ = 10^{-3} Ω), kilohm (1 kΩ = 10^{3} Ω), and megohm (1 MΩ = 10^{6} Ω) are also in common usage.

The reciprocal of resistance R is called conductance G = 1/R and is measured in Siemens (SI unit), sometimes referred to as a mho. Thus a Siemens is the reciprocal of an ohm: $S = \Omega^{-1}$. Although the concept of conductance is often used in circuit analysis, practical resistors are always specified in terms of their resistance (ohms) rather than conductance.

Theory of operation

Ohm's law

The behavior of an ideal resistor is dictated by the relationship specified in Ohm's law:

$$V = I \cdot R$$

Ohm's law states that the voltage (V) across a resistor is proportional to the current (I) passing through it, where the constant of proportionality is the resistance (R).

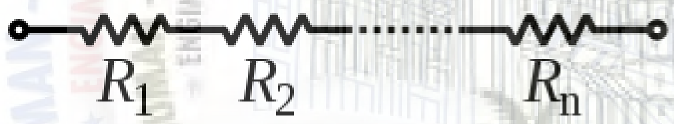
Equivalently, Ohm's law can be stated:

$$I = \frac{V}{R}$$

This formulation of Ohm's law states that, when a voltage (V) is present across a resistance (R), a current (I) will flow through the resistance. This is directly used in practical computations. For example, if a 300 ohm resistor is attached across the terminals of a 12 volt battery, then a current of 12 / 300 = 0.04 amperes (or 40 milliamperes) will flow through that resistor.

Series and parallel resistors

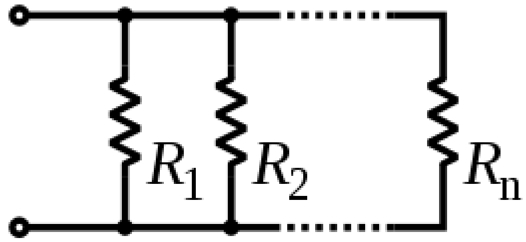
In a series configuration, the current through all of the resistors is the same, but the voltage across each resistor will be in proportion to its resistance. The potential difference (voltage) seen across the network is the sum of those voltages, thus the total resistance can be found as the sum of those resistances:



$$R_{eq} = R_1 + R_2 + \cdots + R_n$$

As a special case, the resistance of N resistors connected in series, each of the same resistance R, is given by NR.

Resistors in a parallel configuration are each subject to the same potential difference (voltage), however the currents through them add. The conductances of the resistors then add to determine the conductance of the network. Thus the equivalent resistance (R_{eq}) of the network can be computed:



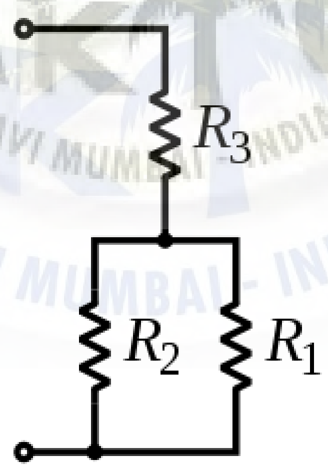
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}$$

The parallel equivalent resistance can be represented in equations by two vertical lines "||" (as in geometry) as a simplified notation. For the case of two resistors in parallel, this can be calculated using:

$$R_{eq} = R_1 \| R_2 = \frac{R_1 R_2}{R_1 + R_2}$$

As a special case, the resistance of N resistors connected in parallel, each of the same resistance R, is given by R/N.

A resistor network that is a combination of parallel and series connections can be broken up into smaller parts that are either one or the other. For instance,



$$R_{eq} = (R_1 \| R_2) + R_3 = \frac{R_1 R_2}{R_1 + R_2} + R_3$$

However, some complex networks of resistors cannot be resolved in this manner, requiring more sophisticated circuit analysis. For instance, consider a cube, each edge of which has been replaced by a resistor. What then is the resistance that would be measured between two opposite vertices? In the case of 12 equivalent resistors, it can be shown that the corner-to-corner resistance is $^5/_6$ of the individual resistance. More generally, the Y-Δ transform, or matrix methods can be used to solve such a problem. One practical application of these relationships is that a non-standard value of resistance can generally be synthesized by connecting a number of standard values in series and/or parallel. This can also be used to obtain a resistance with a higher power rating than that of the individual resistors used. In the special case of N identical resistors all connected in series or all connected in parallel, the power rating of the individual resistors is thereby multiplied by N.

Power dissipation

The power P dissipated by a resistor (or the equivalent resistance of a resistor network) is calculated as: $P = I^2 R = IV = \frac{V^2}{R}$

The first form is a restatement of Joule's first law. Using Ohm's law, the two other forms can be derived.

The total amount of heat energy released over a period of time can be determined from the integral of the power over that period of time:

$$W = \int_{t_1}^{t_2} v(t) i(t) \, dt.$$

Practical resistors are rated according to their maximum power dissipation. The vast majority of resistors used in electronic circuits absorb much less than a watt of electrical power and require no attention to their power rating. Such resistors in their discrete form, including most of the packages detailed below, are typically rated as 1/10, 1/8, or 1/4 watt.

Resistors required to dissipate substantial amounts of power, particularly used in power supplies, power conversion circuits, and power amplifiers, are generally referred to as power resistors; this designation is loosely applied to resistors with power ratings of 1 watt or greater. Power resistors are physically larger and tend not to use the preferred values, color codes, and external packages described below.

If the average power dissipated by a resistor is more than its power rating, damage to the resistor may occur, permanently altering its resistance; this is distinct from the reversible change in resistance due to its temperature coefficient when it warms. Excessive power dissipation may raise the temperature of the resistor to a point where it can burn the circuit board or adjacent components, or even cause a fire. There are flameproof resistors that fail (open circuit) before they overheat dangerously.

Note that the nominal power rating of a resistor is not the same as the power that it can safely dissipate in practical use. Air circulation and proximity to a circuit board, ambient temperature, and other factors can reduce acceptable dissipation significantly. Rated power dissipation may be given for an ambient temperature of 25 °C in free air. Inside an equipment case at 60 °C, rated dissipation will be significantly less; a resistor dissipating a bit less than the maximum figure given by the manufacturer may still be outside the safe operating area and may prematurely fail.

CAPACITORS

A capacitor or condenser is a passive electronic component consisting of a pair of conductors separated by a dielectric. When a voltage potential difference exists between the conductors, an electric field is present in the dielectric. This field stores energy and produces a mechanical force between the plates. The effect is greatest between wide, flat, parallel, narrowly separated conductors.

An ideal capacitor is characterized by a single constant value, capacitance, which is measured in farads. This is the ratio of the electric charge on each conductor to the potential difference between them. In practice, the dielectric between the plates passes a small amount of leakage current. The conductors and leads introduce an equivalent series resistance and the dielectric has an electric field strength limit resulting in a breakdown voltage.

The properties of capacitors in a circuit may determine the resonant frequency and quality factor of a resonant circuit, power dissipation and operating frequency in a digital logic circuit, energy capacity in a high-power system, and many other important aspects.

A capacitor (formerly known as condenser) is a device for storing electric charge. The forms of practical capacitors vary widely, but all contain at least two conductors separated by a non-conductor. Capacitors used as parts of electrical systems, for example, consist of metal foils separated by a layer of insulating film.

Capacitors are widely used in electronic circuits for blocking direct current while allowing alternating current to pass, in filter networks, for smoothing the output of power supplies, in the resonant circuits that tune radios to particular frequencies and for many other purposes.

A capacitor is a passive electronic component consisting of a pair of conductors separated by a dielectric (insulator). When there is a potential difference (voltage) across the conductors, a static electric field develops in the dielectric that stores energy and produces a mechanical force between the conductors. An ideal capacitor is characterized by a single constant value, capacitance, measured in farads. This is the ratio of the electric charge on each conductor to the potential difference between them.

The capacitance is greatest when there is a narrow separation between large areas of conductor, hence capacitor conductors are often called "plates", referring to an early means of construction. In practice the dielectric between the plates passes a small amount of leakage current and also has an electric field strength limit, resulting in a breakdown voltage, while the conductors and leads introduce an undesired inductance and resistance.

SOFTWARE REQUIREMENTS

What is MPLAB IDE?

MPLAB IDE is a software program that runs on a PC to develop applications for Microchip microcontrollers. It is called an Integrated Development Environment, or IDE, because it provides a single integrated environment to develop code for embedded microcontrollers.

Description of an Embedded System

An embedded system is typically a design making use of the power of a small microcontroller, like the Microchip PIC micro MCU or dsPIC Digital Signal Controller(DSCs). These microcontrollers combine a microprocessor unit (like the CPU in a desk- top PC) with some additional circuits called peripherals, plus some additional circuits on the same chip to make a small control module requiring few other external devices. This single device can then be embedded into other electronic and mechanical devices for low-cost digital control.

Components of a Microcontroller

The PIC micro MCU has program memory for the firmware, or coded instructions, to run a program. It also has file register memory for storage of variables that the program will need for computation or temporary storage. It also has a number of peripheral device circuits on the same chip. Some peripheral devices are called I/O ports. I/O ports are pins on the microcontroller that can be driven high or low to send signals, blink lights, drive speakers ñ just about anything that can be sent through a wire. Often these pins are bidirectional and can also be configured as inputs allowing the program to respond to an external switch, sensor or to communicate with some external device.

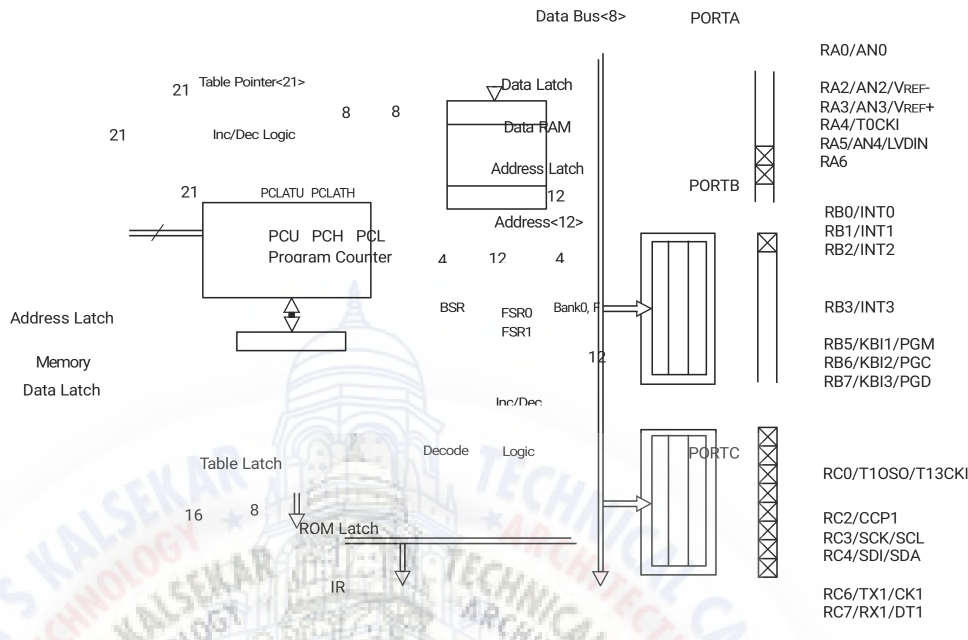


Fig 5.3: PIC MCU

In order to design such a system, it must be decided which peripherals are needed for an application. Analog-to-Digital Converters (ADCs) allow microcontrollers to connect to sensors and receive changing voltage levels. Serial communication peripherals allow you to stream communications over a few wires to another microcontroller, to a local network or to the internet. Peripherals on the PIC micro MCU called timers accurately measure signal events and generate and capture communications signals, pro- duce precise waveforms, even automatically reset the microcontroller if it gets hung or lost due to a power glitch or hardware malfunction. Other peripherals detect if the external power is dipping below dangerous levels so the microcontroller can store critical information and safely shut down before power is completely lost.

The peripherals and the amount of memory an application needs to run a program largely determines which PIC micro MCU to use. Other factors might include the power consumed by the microcontroller and its form factor, i.e., the size and characteristics of the physical package that must reside on the target design.

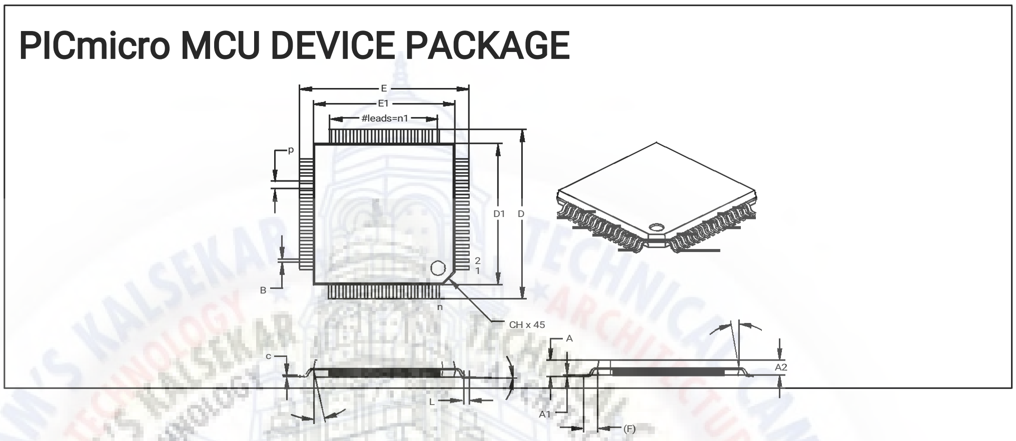


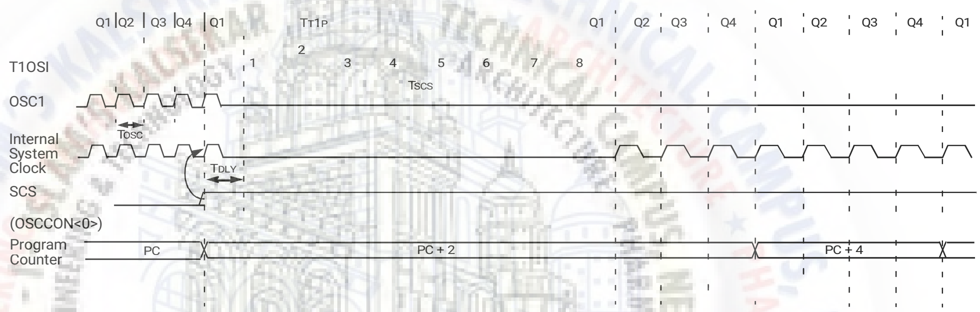
Fig 5.3.1:Implementing an Embedded System Design with MPLAB IDE

A development system for embedded controllers is a system of programs running on a desktop PC to help write, edit, debug and program code ñ the intelligence of embedded systems applications ñ into a microcontroller. MPLAB IDE runs on a PC and contains all the components needed to design and deploy embedded systems applications. The typical tasks for developing an embedded controller application are:

1. Create the high level design. From the features and performance desired, decide which PIC micro MCU or dsPIC DSC device is best suited to the application, then design the associated hardware circuitry. After determining which peripherals and pins control the hardware, write the firmware ñ the software that will control the hardware aspects of the embedded application. A language tool such as an assembler, which is directly translatable into machine code, or a compiler that allows a more natural language for creating programs, should be used to write and edit

code. Assemblers and compilers help make the code understandable, allowing function labels to identify code routines with variables that have names associated with their use, and with constructs that help organize the code in a maintainable structure.

PICmicro MCU DATA SHEET ñ TIMING



RRNCF	Rotate Right f (no carry)
Syntax:	[*label*] RRNCF f [,d [,a]
Operands:	0 ≤ f ≤ 255 d ∈ [0,1] a ∈ [0,1]
Operation:	(f<n>) → dest<n-1>, (f<0>) → dest<7>
Status Affected:	N, Z
Encoding:	0100 | 00da | ffff | ffff
Description:	The contents of register 'f' are rotated one bit to the right. If 'd' is '0', the result is placed in W. If 'd' is '1', the result is placed back in register 'f' (default). If 'a' is '0', the Access Bank will be selected, overriding the BSR value. If 'a' is '1', then the bank will be selected as per the BSR value (default). register f
Words:	1
Cycles:	1

Q Cycle Activity:

Q1	Q2	Q3	Q4
Decode	Read register 'f'	Process Data	Write to destination

Example 1: RRNCF REG, 1, 0

Before Instruction
REG = 1101 0111
After Instruction
REG = 1110 1011

Example 2: RRNCF REG, 0, 0

Before Instruction
W = ?
REG = 1101 0111
After Instruction
W = 1110 1011
REG = 1101 0111

Fig 5.3.2:PICmicro MCU DATA SHEET ñ INSTRUCTIONS

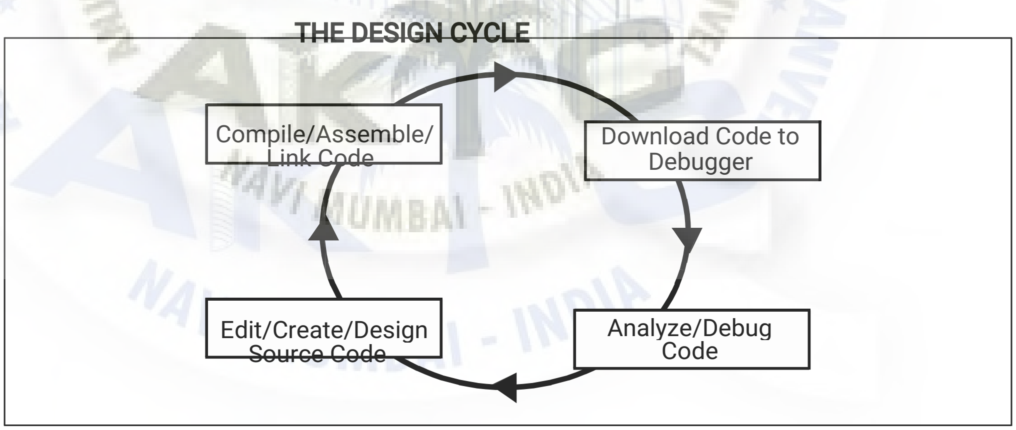
2. Compile, assemble and link the software using the assembler and/or compiler and linker to convert your code into ones and zeroes ñ machine code for the PIC micro MCUs. This machine code will eventually become the firmware (the code programmed into the microcontroller).

3.Test your code. Usually a complex program does not work exactly the way imagined, and bugs need to be removed from the design to get proper results. The debugger allows you to see the ones and zeroes execute, related to the source code you wrote, with the symbols and function names from your program. Debugging allows you to experiment with your code to see the value of variable sat various points in the program, and to do what if check, changing variable values and stepping through routines.

4. Burn the code into a microcontroller and verify that it executes correctly in the finished application. Of course, each of these steps can be quite complex. The important thing is to concentrate on the details of your own design, while relying upon MPLAB IDE and its components to get through each step without continuously encountering new learning curves.

THE DEVELOPMENT CYCLE

The process for writing an application is often described as a development cycle, since it is rare that all the steps from design to implementation can be done flawlessly the first time. More often code is written, tested and then modified in order to produce an application that performs correctly. The Integrated Development Environment allows the embedded systems design engineer to progress through this cycle without the distraction of switching among an array of tools. By using MPLAB IDE, all the functions are integrated, allowing the engineer to concentrate on completing the application without the interruption of separate tools and different modes of operation.

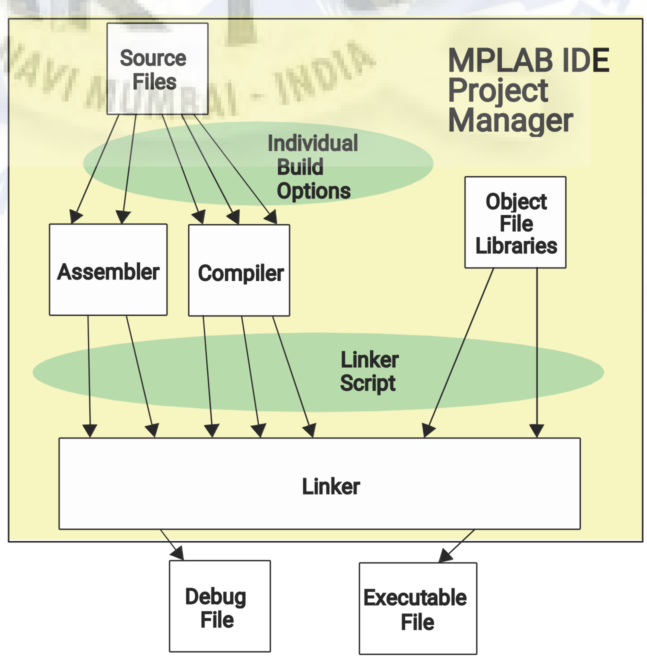


MPLAB IDE is a wrapper that coordinates all the tools from a single graphical user interface, usually automatically. For instance, once code is written, it can be converted to executable instructions and downloaded into a microcontroller to see how it works. In this process multiple tools are needed: an editor to write the code, a project manager to organize files and settings, a compiler or assembler to convert the source code to machine code and some sort of hardware or software that either connects to a target microcontroller or simulates the operation of a microcontroller.

PROJECT MANAGER

The project manager organizes the files to be edited and other associated files so they can be sent to the language tools for assembly or compilation, and ultimately to a linker. The linker has the task of placing the object code fragments from the assembler, compiler and libraries into the proper memory areas of the embedded controller, and ensure that the modules function with each other. This entire operation from assembly and compilation through the link process is called a project build.

Fig.5.5: MPLAB IDE PROJECT MANAGER



From the MPLAB IDE project manager, properties of the language tools can be invoked differently for each file, if desired, and a build process integrates all of the language tools operations.

The source files are text files that are written conforming to the rules of the assembler or compiler. The assembler and compiler convert them into intermediate modules of machine code and placeholders for references to functions and data storage. The linker resolves these placeholders and combines all the modules into a file of executable machine code. The linker also produces a debug file which allows MPLAB IDE to relate the executing machine codes back to the source files. A text editor is used to write the code. It is not a normal text editor, but an editor specifically designed for writing code for Microchip MCUs. It recognizes the constructs in the text and uses color coding to identify various elements, such as instruction mnemonics, C language constructs and comments. The editor supports operations commonly used in writing source code, such as finding matching braces in C, commenting and un-commenting out blocks of code, finding text in multiple files and adding special bookmarks. After the code is written, the editor works with the other tools to display code execution in the debugger. Breakpoints can be set in the editor, and the values of variables can be inspected by hovering the mouse pointer over the variable name. Names of variables can be dragged from source text windows and then dropped into a Watch window.

DEVICE PROGRAMMING

After the application has been debugged and is running in the development environment, it needs to be tested on its own. A device can be programmed with the in-circuit debugger or a device programmer. MPLAB IDE can be set to the programmer function, and the part can be burned. The target application can now be observed in its nearly final state. Engineering prototype programmers allow quick prototypes to be made and evaluated. Some applications can be programmed after the device is soldered on the target PC board. Using In-Circuit Serial Programmingô (ICSPô) programming capability, the firmware can be programmed into the application at the time of manufacture, allowing updated revisions to be programmed into an embedded application later in its life cycle. Devices that support in-circuit debugging can even be plugged back into the MPLAB ICD 2 after manufacturing for quality tests and development of next generation firmware.

COMPONENTS OF MPLAB IDE

The MPLAB IDE has both built-in components and plug-in modules to configure the system for a variety of software and hardware tools.

MPLAB IDE Built-In Components

The built-in components consist of:

Project Manager:

The project manager provides integration and communication between the IDE and the language tools.

ï **Editor**

The editor is a full-featured programmer's text editor that also serves as a window into the debugger.

ï **Assembler/Linker and Language Tools**

The assembler can be used stand-alone to assemble a single file, or can be used with the linker to build a project from separate source files, libraries and recompiled objects. The linker is responsible for positioning the compiled code into memory areas of the target microcontroller.

ï **Debugger**

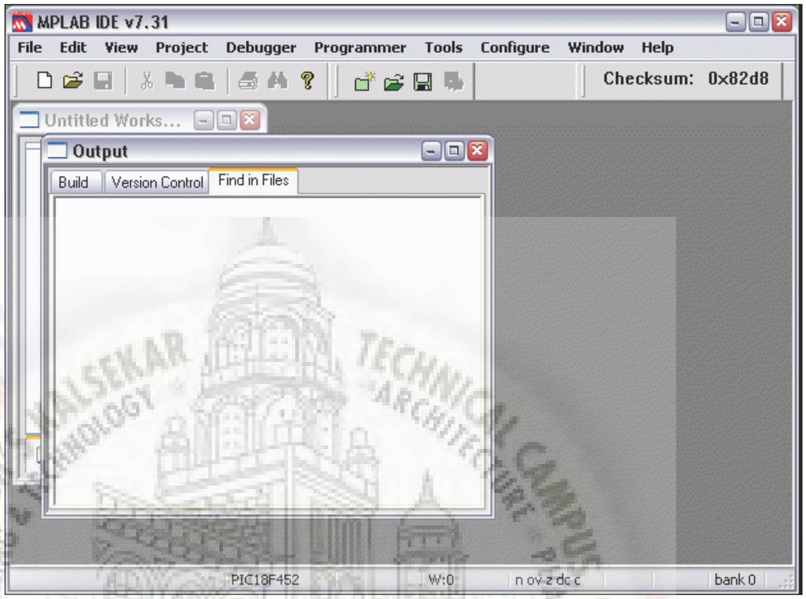
The Microchip debugger allows breakpoints, single stepping, watch windows and all the features of a modern debugger for the MPLAB IDE. It works in conjunction with the editor to reference information from the target being debugged back to the source code.

ï **Execution Engines**

There are software simulators in MPLAB IDE for all PIC micro MCU and dsPIC DSC devices. These simulators use the PC to simulate the instructions and some peripheral functions of the PIC micro MCU and dsPIC DSC devices. Optional in-circuit emulators and in-circuit debuggers are also available to test code as it runs in the applications hardware.

After installation or select Start>Programs>Microchip>MPLAB IDE vx.xx>MPLAB IDE. A screen will display the MPLAB IDE logo followed by the MPLAB IDE desktop.

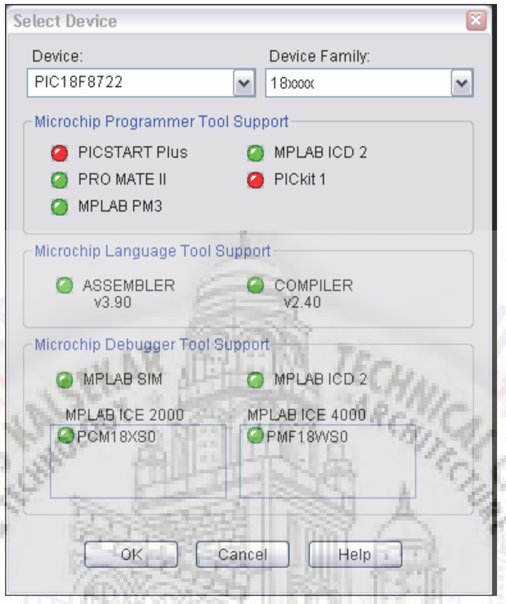
MPLAB IDE DESKTOP



SELECTING THE DEVICE

To show menu selections in this document, the menu item from the top row in MPLAB IDE will be shown after the menu name like this MenuName>MenuItem. To choose the Select Device entry in the Configure menu, it would be written as Configure>Select Device. Choose Configure>Select Device. In the Device dialog, select the PIC18F8722 from the list if itís not already selected.

SELECT DEVICE DIALOG



The lights indicate which MPLAB IDE components support this device.

ï A green light indicates full support.

ï A yellow light indicates preliminary support for an upcoming part by the particular MPLAB IDE tool component. Components with a yellow light instead of a green light are often intended for early adopters of new parts who need quick support and understand that some operations or functions may not be available.

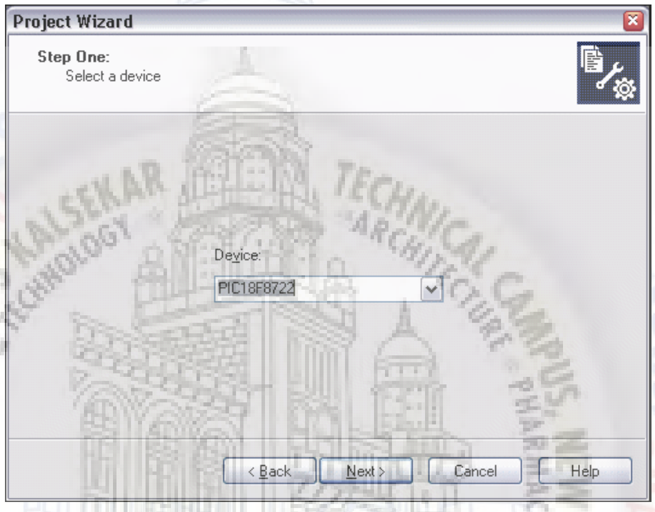
ï A red light indicates no support for this device. Support may be forthcoming or inappropriate for the tool, e.g., dsPIC DSC devices cannot be supported on MPLAB ICE 2000.

CREATING THE PROJECT

The next step is to create a project using the Project Wizard. A project is the way the files are organized to be compiled and assembled. We will use a single assembly file for this project and a linker script. Choose Project>Project Wizard. From the Welcome dialog, click on Next> to advance. The next dialog (Step One) allows you to select the device, which we have already done. Make sure that it says PIC18F8722.

If it does not, select the PIC18F8722 from the drop down menu. Click Next>.

PROJECT WIZARD ñ SELECT DEVICE



SETTING UP LANGUAGE TOOLS

Step Two of the Project Wizard sets up the language tools that are used with this project. Select Microchip MPASM Toolsuite in the Active Toolsuite list box. Then MPASM and MPLINK should be visible in the Toolsuite Contents box. Click on each one to see its location. If MPLAB IDE was installed into the default directory, the MPASM assembler executable will be:

C:\Program Files\Microchip\MPASM Suite\mpasmwin.exe

the MPLINK linker executable will be:

C:\Program Files\Microchip\MPASM Suite\mplink.exe and the MPLIB librarian executable will be:

C:\Program Files\Microchip\MPASM Suite\mplib.exe

If these do not show up correctly, use the browse button to set them to the proper files in the MPLAB IDE subfolders.

BUILDING THE PROJECT

From the Project menu, we can assemble and link the current files. They donít have any of our code in them yet, but this ensures that the project is set up correctly.

To build the project, select either:

ï Project>Build All

ï Right click on the project name in the project window and select Build All

ï Click the Build All icon on the Project toolbar. Hover the mouse over icons to see pop-up text of what they represent.

The Output window shows the result of the build process. There should be no errors on any step. The warnings listed in Figure will not interfere with the operation of the tutorial pro- gram. They are merely identifying a directive that has been deprecated, i.e., is being discontinued in favor of another. To turn off the display of warnings, do the following:

ï Select Project>Build Options>Project and click on the MPASM Assembler tab.

ï Select ìOutputî from the ìCategoriesî drop-down list.

ï Select ìErrors onlyî from the ìDiagnostic levelî drop-down list.

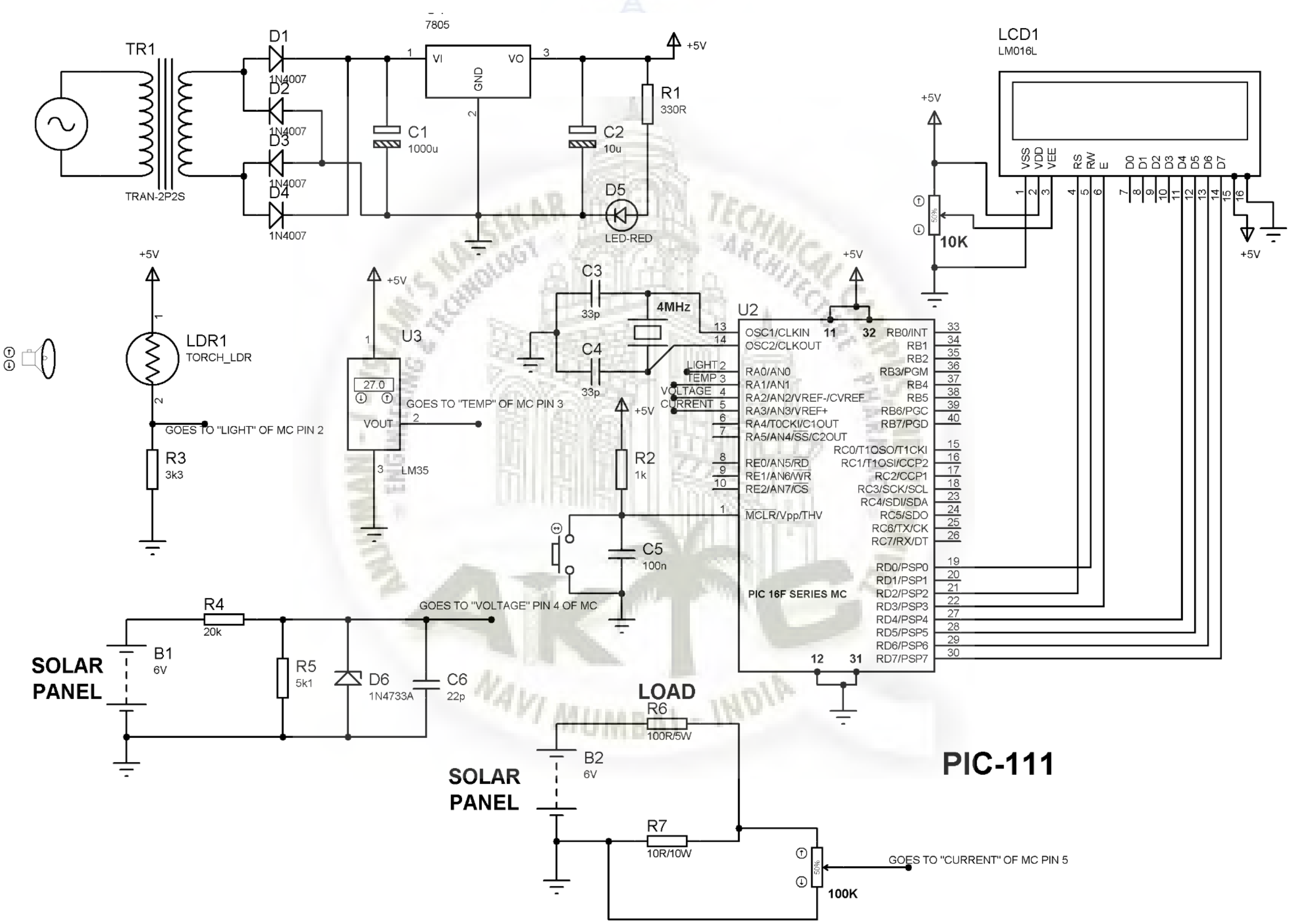
ï Click OK.

EMBEDDED C

Use of embedded processors in passenger cars, mobile phones, medical equipment, aerospace systems and defense systems is widespread, and even everyday domestic appliances such as dish washers, televisions, washing machines and video recorders now include at least one such device.

Because most embedded projects have severe cost constraints, they tend to use low-cost processors. These popular chips have very limited resources available most such devices have around limited amount of RAM, and the available processor power is around many times less than that of a desktop processor. As a result, developing embedded software presents significant new challenges, even for experienced desktop programmers. If you have some programming experience - in C, C++ or Java - then this book and its accompanying CD will help make your move to the embedded world as quick and painless as possible.

.SCHEMATIC DIAGRAM



DESCRIPTION

POWERSUPPLY

The circuit uses standard power supply comprising of a step-down transformer from 230v to 12v and 4 diodes forming a Bridge Rectifier that delivers pulsating dc which is then filtered by an electrolytic capacitor of about 470microf to 100microF. The filtered dc being unregulated IC LM7805 is used to get 5v constant at its pin no 3 irrespective of input dc varying from 9v to 14v. The input dc shall be varying in the event of input ac at 230volts section varies in the ratio of v1/v2=n1/n2.

The regulated 5volts dc is further filtered by a small electrolytic capacitor of 10 micro f for any noise so generated by the circuit. One LED is connected of this 5v point in series with a resistor of 330ohms to the ground i.e. negative voltage to indicate 5v power supply availability. The 5v dc is at 12v point is used for other applications as on when required.

OPERATION

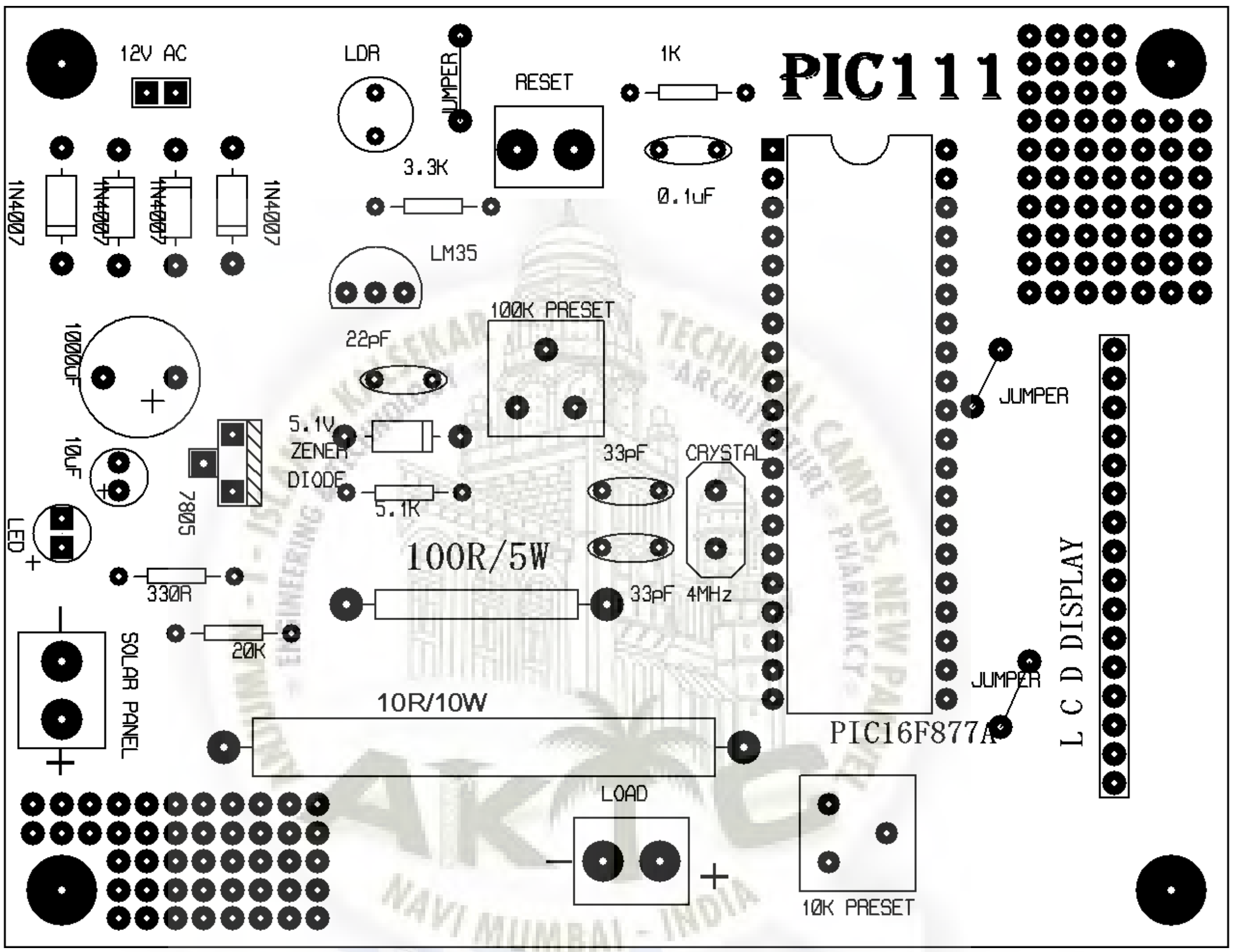
CONNECTIONS

The output of the power supply which is 5v is connected to 11 and 32 pins of micro controller and GND is connected to its 12 and 31 pins. Pin 2 of controller is connected to pin 2 of LDR sensor, Pin 3 of controller is connected to pin 2 of LM35 temperature sensor, Pin 4 of controller is connected to voltage sensing ckt & Pin 5 of controller is connected to current sensing ckt.

WORKING

The Voltage from the solar panel is fed to the MC pin no 4 through a potential divider comprising of R4 & R5. Zener diode D6 is used to protect the input to the microcontroller exceeding 5V. a 100ohm, 5W resistor R6 is used as load in series with another resistor R7 of 10ohm, 10W. a variable resistor 100K is used for setting/ calibrating the current parameters. The voltage drop across the resistor R7 is proportional to the load current which is fed to pin 5 of MC in a small portion by the variable resistor. Light input is sensed by LDR1 in combination with resistor R3 the common point of which is fed to MC pin 2. A temperature sensor LM35 (U3) delivers the output in analog voltage proportional to the heat on its surface being connected to pin 3 of MC. Thus, four analog varying voltage parameters are fed to the internal ADC of the MC out of total availablibiliy of 8 channels. A LCD is used to display all the output parameters such as light intensity, temperature, voltage and current of solar panel. The unit can be used either from the power supply comprising of TR1, D1-D4, C1, 7805, C2 R1 & D5 or can be directly fed from 6V source of the solar panel.

LAYOUT DIAGRAM



CONCLUSION

In this Project we tried to measure parameters of solar panels such as Voltage, current, power, temperature and intensity of light using PIC16F877A microcontroller.
Digital display can be used to display values of these parameters. PIC microcontroller can be used to measure analog values of these sensed parameters and analog to digital to converter which is in built in PIC microcontroller can be used to measure values of these parameters.
There are many ways to sense voltage. But in this proposed work we can easily measure voltage of solar panel using voltage divider. Two capacitors are connect parallel to voltage measurement resistor to avoid voltage fluctuation and avoid harmonics to go into ADC of PIC microcontroller
Here we have used differential amplifier to amplify voltage appearing across shunt resistor, because current value may be too high and too low in different timings.

BIBLIOGRAPHY

TEXT BOOKS REFERED:

1. PIC16F877A Data Sheets.

WEBSITES

- www.atmel.com
- www.beyondlogic.org
- www.wikipedia.org
- www.howstuffworks.com
- www.alldatasheets.com