بسم الله الرحمن الرحيم

AUTOMATED RAILWAY SIGNALING SYSTEM

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF BACHELOR OF SCIENCE IN TECHNICAL EDUCATION IN ELECTRICAL & ELECTRONICS ENGINEERING (SPECIALIZATION IN INSTRUMENTATION AND CONTROL)

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This study is dedicated to our teachers

Declaration

We do hereby declare that this thesis has not been submitted elsewhere for Obtaining any degree or diploma or certificate or for publication.

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AUTOMATIC RAILWAY CONTROL SYSTEM

ABSTRACT

The railroad industry’s own desire to maintain their ability to provide safe and secure transport of their customers hazardous materials, has introduced new challenges in rail security. Addressing these challenges is important, as railroads, and the efficient delivery of their cargo, play a vital role in the economy of the country.

The present project is designed to satisfy the security needs of the railways. This system provides the security in four ways: automatic gate opening/closing system at track crossing, signaling for the train driver, tracking the signals, and the track protection. The automatic gate opening/closing system is provided with the Reflection sensors placed at a distance of few kilometers on the both sides from the crossing road. These sensors give the train reaching and leaving status to the embedded controller at the gate to which they are connected. The controller operates (open/close) the gate as per the received signal from the Reflection sensors.

The train driver always observes the signals placed beside the track. These signals are controlled from the control room. The green light denotes that the track is free and red light denotes the track is busy or damaged. These signals are controlled based on the train position which is sensed by using the Reflection sensors placed along the track. The position of the train can be estimated by using the Reflection sensor placed along the track and is displayed on the control room to indicate the train position along the track.

The track protection is achieved by providing the closed loop along the track. If any crack or cut is occurred to the track simultaneously the same happens to the closed loop. This gives a signal to the controller at the control room. From control room we can give the red signal by knowing the position of the train through the Reflection sensors.

Contents

Chapter 1

Introduction

1.1 EMBEDDED SYSTEM:

An embedded system is a special-purpose system in which the computer is completely encapsulated by or dedicated to the device or system it controls. Unlike a general-purpose computer, such as a personal computer, an embedded system performs one or a few predefined tasks, usually with very specific requirements. Since the system is dedicated to specific tasks, design engineers can optimize it, reducing the size and cost of the product. Embedded systems are often mass-produced, benefiting from economies of scale.

Personal digital assistants (PDAs) or handheld computers are generally considered embedded devices because of the nature of their hardware design, even though they are more expandable in software terms. This line of definition continues to blur as devices expand. With the introduction of the OQO Model 2 with the Windows XP operating system and ports such as a USB port — both features usually belong to "general purpose computers", — the line of nomenclature blurs even more.

Physically, embedded systems ranges from portable devices such as digital watches and MP3 players, to large stationary installations like traffic lights, factory controllers, or the systems controlling nuclear power plants.

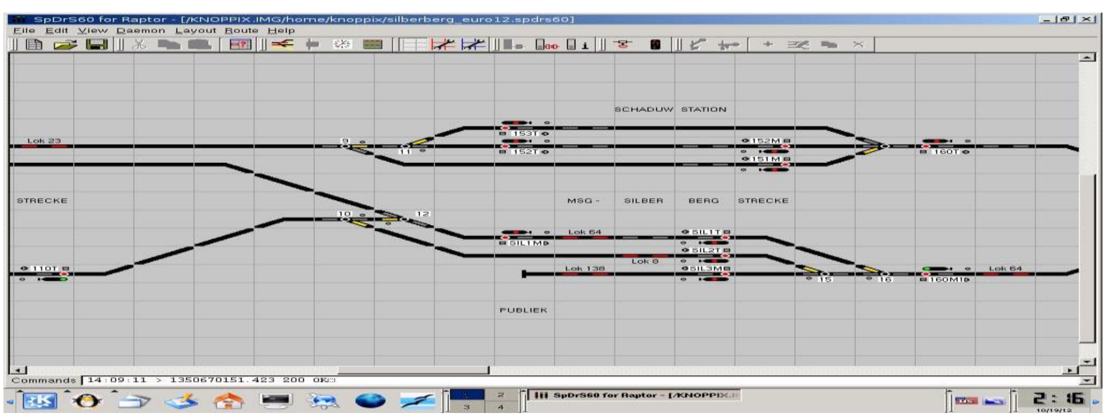


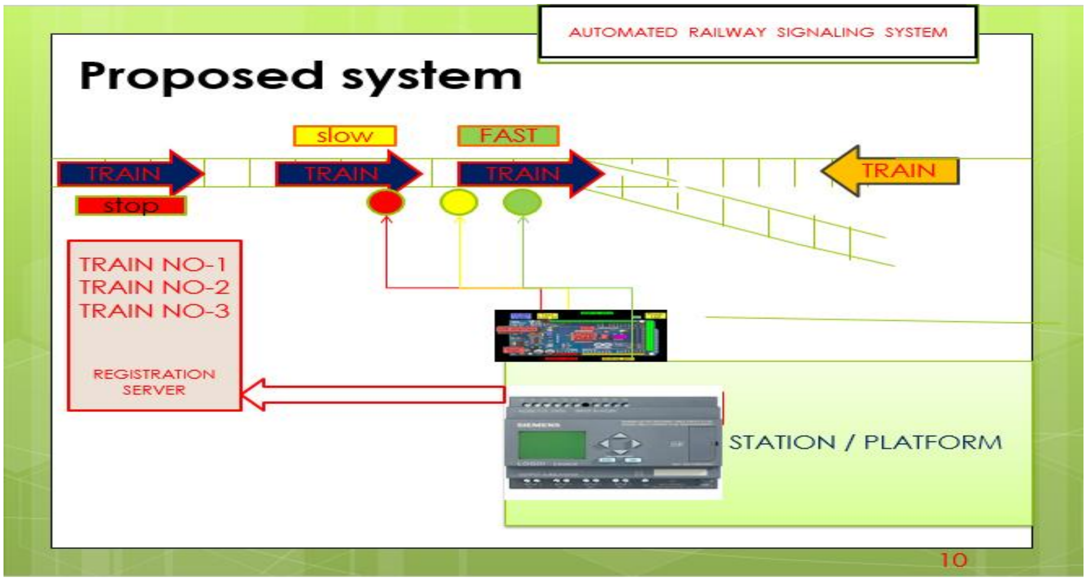
Figure 1.1: **Embedded control Systems in Bangladesh**

In terms of complexity embedded systems can range from very simple with a single microcontroller chip, to very complex with multiple units, peripherals and networks mounted inside a large chassis or enclosure.

Examples of Embedded Systems:

- Avionics, such as inertial guidance systems, flight control hardware/software and other integrated systems in aircraft and missiles
- Cellular telephones and telephone switches
- Engine controllers and antilock brake controllers for automobiles
- Home automation products, such as thermostats, air conditioners, sprinklers, and security monitoring systems
- Handheld calculators
- Handheld computers
- Household appliances, including microwave ovens, washing machines, television sets, DVD players and recorders
- Medical equipment
- Personal digital assistant
- Videogame consoles
- Computer peripherals such as routers and printers.

Industrial controllers for remote machine operation. Railway is a complex and fascinating research and development area in railways. The purpose of a signaling system is to facilitate the safe and efficient movement of trains on the railway. Two major worldwide markets in railways are Main Line Railways and Urban Rail Transportation Systems (Metro, LRT (Light Rail Transit), Tramway). This project investigates all aspects of railway signaling systems for İstanbul Urban Rail Systems to design and develop national signaling solutions. The initial target of the project is to build the research and development infrastructure (signaling literature and information infrastructure, railway signaling lab, development team, team processes and dynamics,) and to produce the first road map, some technical blue prints, requirements analysis and system architecture design documents, and railway signaling simulator programs.



Fixed Block Systems

Looking back over the past few decades, railway signaling technology has been based mainly on the so called "Conventional Fixed Block System" (ref1, ref2) principle. Traditional signaling systems are based on fixed blocks: the railway is divided into sections of track, which are separated by signals. A train is not allowed to enter a given track section (=block) before the preceding train has cleared it. This system has a number of disadvantages, one being its lack of flexibility: the block size is the same for all trains regardless of their speed and braking performance. Thus the big safety distances required by fast trains are imposed on slower trains as well. Obviously this reduces track capacity.

The fixed block technology inherently imposed a service limitation because of the need to reserve buffer block(s) for train separation. With increasing patronage, demand grew to achieve higher line capacities on existing rail infrastructures. In order to realize this requirement without major upgrades to the rolling stock and rail infrastructure, intelligent signaling and train control systems have become a crucial technology for the new age of rail systems and services.

The distance-to-go principle has therefore been developed on the "Fixed Block System," which provides flexible control of the buffer block(s) for train separation.

Further to that, the "Moving Block System", which also operates on the distance-to-go principle, has evolved. Moving block systems require less wayside equipment than fixed block systems. They provide considerable cost reductions for personnel and maintenance due to a strong reduction in way-side equipment.

Moving Block Systems (CBTC = Communications Based Train Control)

A moving block system (often called CBTC = Communications Based Train Control) does not require traditional fixed-block track circuits for determining train position. Instead, it relies on continuous two-way digital communication between each controlled train and a wayside control center. On a moving block equipped railway, the line is usually divided into areas or regions, each area under the control of a computer and each with its own radio transmission system. Each train transmits its identity, location, direction and speed to the area computer which makes the necessary calculations for safe train separation and transmits this to the following train. The radio link between each train and the area computer is continuous so the computer knows the location of all the trains in its area all the time. It transmits to each train the location of the train in front and gives it a braking curve to enable it to stop before it reaches that train. In effect, it is a dynamic distance-to-go system. As long as each train is travelling at the same speed as the one in front and they all have the same braking capabilities, they can, in theory, run as close together as a few meters (e.g. about 50 meters at 50 km/h). This, of course, would contradict the railways safety policies. Instead, one safety feature of fixed block signaling is usually retained - the requirement for a full speed braking distance between trains. This ensures that, if the radio link is lost, the latest data retained on board the following train will cause it to stop before it reaches the preceding train. What distinguishes moving block from fixed block is that it makes the block locations and lengths consistent with train location and speed, i.e. making them movable rather than fixed.

1.2 ABBREVIATIONS

SYMBOL	NAME
ACC	Accumulator
B	B register
PSW	Program status word
SP	Stack pointer
DPTR	Data pointer 2 bytes
DPL	Low byte
DPH	High byte
P0	Port0
P1	Port1
P2	Port2
P3	Port3
IP	Interrupt priority control
IE	Interrupt enable control
TMOD	Timer/counter mode control
TCON	Timer/counter control
T2CON	Timer/counter 2 control
T2MOD	Timer/counter mode2 control
TH0	Timer/counter 0high byte
TL0	Timer/counter 0 low byte
TH1	Timer/counter 1 high byte
TL1	Timer/counter 1 low byte
TH2	Timer/counter 2 high byte
TL2	Timer/counter 2 low byte
SCON	Serial control
SBUF	Serial data buffer
PCON	Power control

Chapter 2

BLOCK DIAGRAM & SCHEMATIC DIAGRAM

2.1BLOCK DIAGRAM:

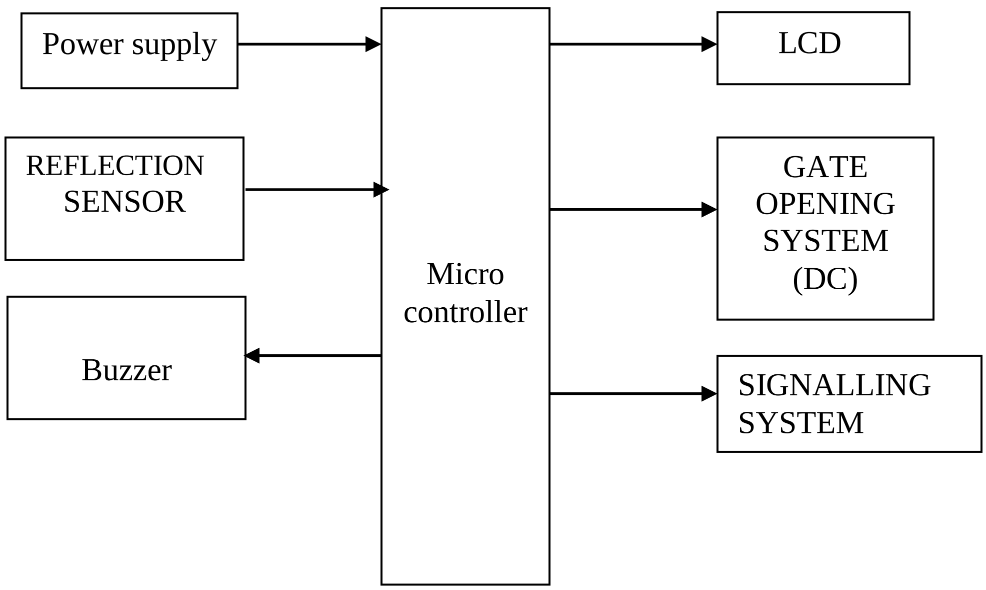


Figure 2.1: **Block diagram of control Systems.**

Block diagram explanation:

The objective of this project is to provide signaling system for the railways to enter and leave the track. The automatic gate opening/closing system is provided with the Reflection sensors placed at a distance of few kilometers on the both sides from the crossing road. These sensors give the train reaching and leaving status to the embedded controller at the gate to which they are connected. The controller operates (open/close) the gate as per the received signal from the Reflection sensors.

LCD will provide the status of the gate and also the faults of the track if any present when arrival of the rail.

The buzzer will be ON whenever the track is corrupted, and OFF when there is no problem with the track. The LEDs i.e. green light denotes that the track is free and red light denotes the track is busy or damaged.

2.2 Schematic diagram:

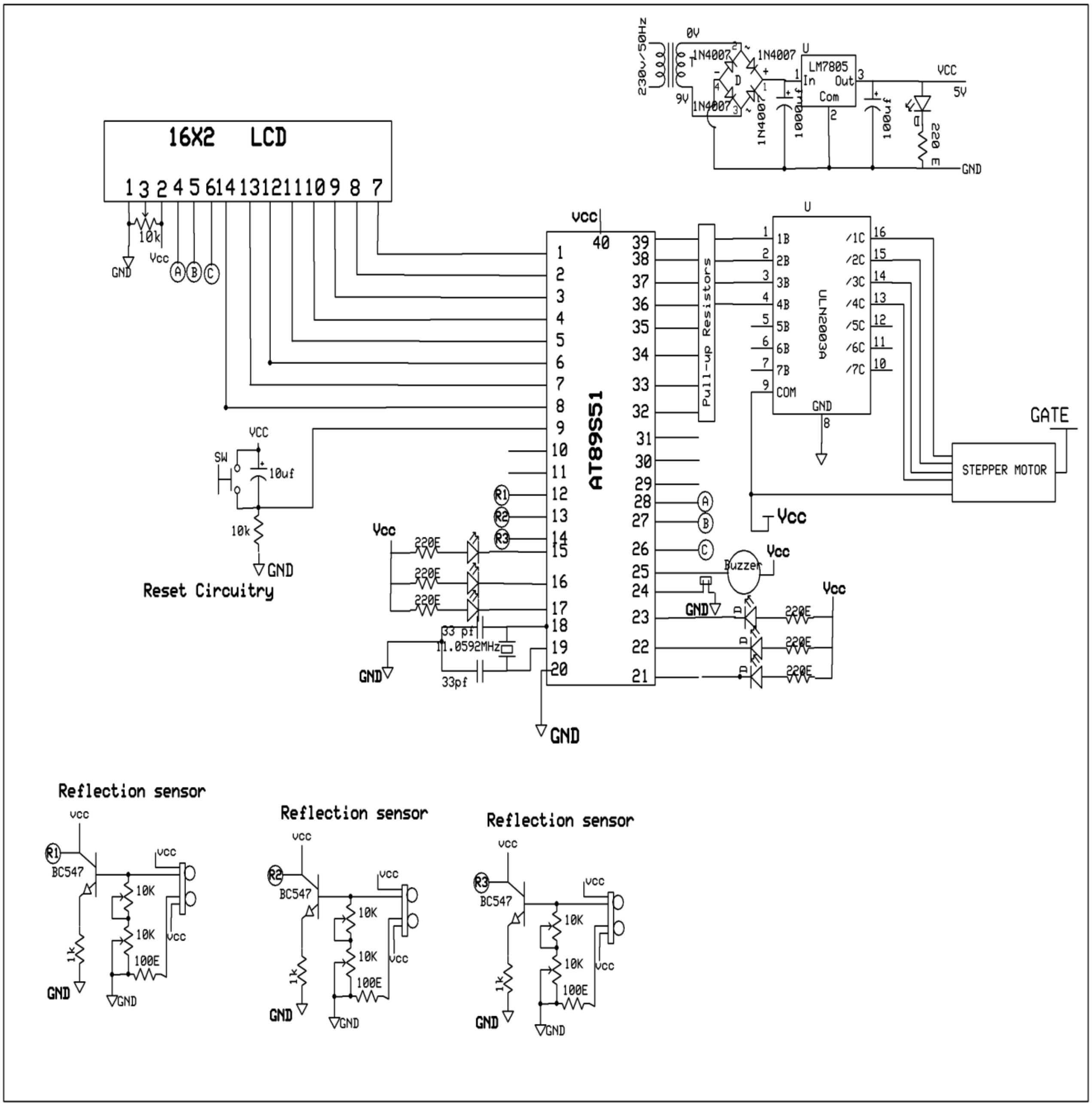


Figure 2.2: **Schematic diagram of control Systems.**

Schematic explanation:

Firstly, the required operating voltage for Microcontroller 89C51 is 5V. Hence the 5V D.C. power supply is needed by the same. This regulated 5V is generated by first stepping down the 230V to 9V by the step down transformer.

The step downed a.c. voltage is being rectified by the Bridge Rectifier. The diodes used are 1N4007. The rectified a.c voltage is now filtered using a 'C' filter. Now the rectified, filtered D.C. voltage is fed to the Voltage Regulator. This voltage regulator allows us to have a Regulated Voltage which is +5V.

The rectified; filtered and regulated voltage is again filtered for ripples using an electrolytic capacitor 100μF. Now the output from this section is fed to 40th pin of 89c51 microcontroller to supply operating voltage.

The microcontroller 89c51 with Pull up resistors at Port0 and crystal oscillator of 11.0592 MHz crystal in conjunction with couple of capacitors of is placed at 18th& 19th pins of 89c51 to make it work (execute) properly.

The reflection sensors are connected to using the transistor logics. The LEDs which will show the status of the track, either it is free or not.

The LCD data pins are connected to the port 1of the microcontroller. The control pins are connected to the p2.7 down to p2.5.

The reflection sensors are connected to the p3.2 top3.4as shown in the schematic.

The DC motor is connected to port 0 of microcontroller through the driver circuit which is known as the ULN driver.

Chapter 3

HARDWARE COMPONENTS

Hardware components:

- Micro Controller (Arduino)
- Buzzer
- LCD
- Gate opening system
- Signaling system
- Track Protection circuit
- IR Sensor

3.1 MICRO CONTROLLER (ARDUINO MEGA 2560)

A Micro controller consists of a powerful CPU tightly coupled with memory, various I/O interfaces such as serial port, parallel port timer or counter, interrupt controller, data acquisition interfaces-Analog to Digital converter, Digital to Analog converter, integrated on to a single silicon chip. If a system is developed with a microprocessor, the designer has to go for external memory such as RAM, ROM, EPROM and peripherals. But controller is provided all these facilities on a single chip. Development of a Micro controller reduces PCB size and cost of design. One of the major differences between a Microprocessor and a Micro controller is that a controller often deals with bits not bytes as in the real world application. Intel has introduced a family of Micro controllers called the MCS-51.

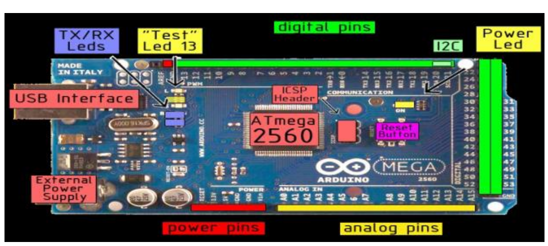


Figure 3.1: **MICRO CONTROLLER (ARDUINO MEGA 2560)**

Features:

• Compatible with MCS-51® Products

• 4K Bytes of In-System Programmable (ISP) Flash Memory

– Endurance: 1000 Write/Erase Cycles

• 4.0V to 5.5V Operating Range

• Fully Static Operation: 0 Hz to 33 MHz

• Three-level Program Memory Lock

• 128 x 8-bit Internal RAM

• 32 Programmable I/O Lines

• Two 16-bit Timer/Counters

• Six Interrupt Sources

• Full Duplex UART Serial Channel

• Low-power Idle and Power-down Modes

Description

The AT89S51 is a low-power, high-performance CMOS 8-bit microcontroller with 4K bytes of in-system programmable Flash memory. The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry- standard 80C51 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with in-system programmable Flash on a monolithic chip, the Atmel AT89S51 is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications.

Block diagram:

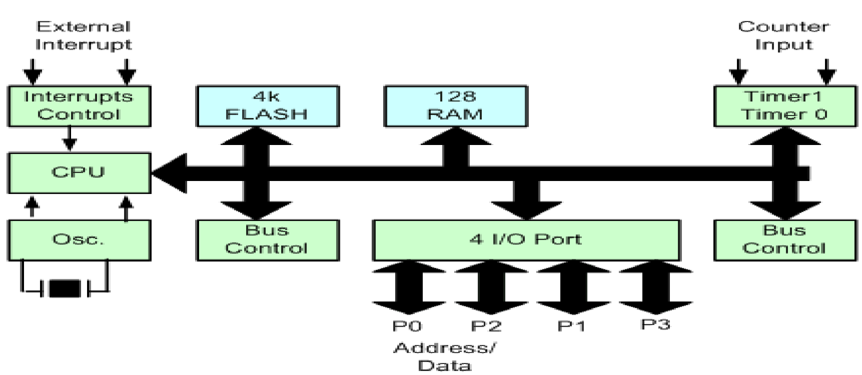


Figure 3.2:**Block diagram**

Pin diagram:

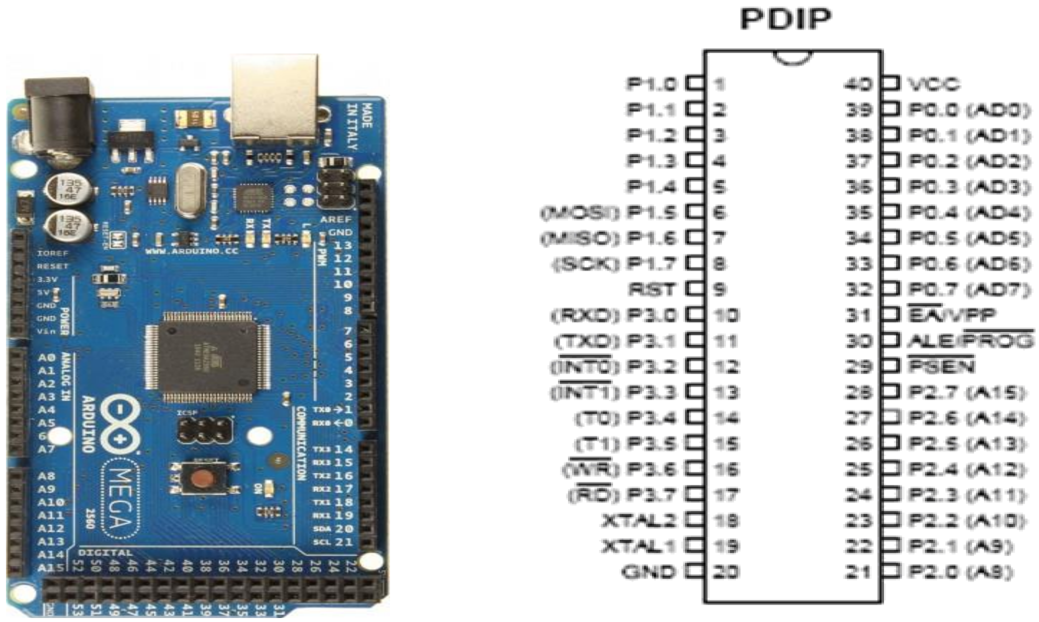


Figure 3.3: PIN DIAGRAM OF MICRO CONTROLLER

Pin Description

VCC - Supply voltage.

GND - Ground.

Port 0:

Port 0 is an 8-bit open drain bidirectional I/O port. As an output port, each pin can sink eight TTL inputs. When 1s are written to port 0 pins, the pins can be used as high-impedance inputs. Port 0 can also be configured to be the multiplexed low-order address/data bus during accesses to external program and data memory. In this mode, P0 has internal pull-ups. Port 0 also receives the code bytes during Flash programming and outputs the code bytes during program verification. External pull-ups are required during program verification.

Port 1:

Port 1 is an 8-bit bidirectional I/O port with internal pull-ups. The Port 1 output buffers can sink/source four TTL inputs. When 1s are written to Port 1 pins, they are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 1 pins that are externally being pulled low will source current (IIL) because of the internal pull-ups. Port 1 also receives the low-order address bytes during Flash programming and verification.

Port Pin	Alternate Functions
P1.5	MOSI (used for In-System Programming)
P1.6	MISO (used for In-System Programming)
P1.7	SCK (used for In-System Programming)

Port 2:

Port 2 is an 8-bit bidirectional I/O port with internal pull-ups. The Port 2 output buffers can sink/source four TTL inputs. When 1s are written to Port 2 pins, they are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 2 pins that are externally being pulled low will source current (IIL) because of the internal pull-ups. Port 2 also receives the high-order address bits and some control signals during Flash programming and verification.

Port 3:

Port 3 is an 8-bit bidirectional I/O port with internal pull-ups. The Port 3 output buffers can sink/source four TTL inputs. When 1s are written to Port 3 pins, they are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 3 pins that are externally being pulled low will source current (IIL) because of the pull-ups. Port 3 receives some control signals for Flash programming and verification. Port 3 also serves the functions of various special features of the AT89S51, as shown in the following table.

Port Pin	Alternate Functions
P3.0	RXD (serial input port)
P3.1	TXD (serial output port)
P3.2	$\overline{INT0}$ (external interrupt 0)
P3.3	$\overline{INT1}$ (external interrupt 1)
P3.4	T0 (timer 0 external input)
P3.5	T1 (timer 1 external input)
P3.6	$\overline{WR}$ (external data memory write strobe)
P3.7	$\overline{RD}$ (external data memory read strobe)

RST:

Reset input. A high on this pin for two machine cycles while the oscillator is running resets the device. This pin drives High for 98 oscillator periods after the Watchdog times out. The DISRTO bit in SFR AUXR (address 8EH) can be used to disable this feature. In the default state of bit DISRTO, the RESET HIGH out feature is enabled.

ALE/PROG:

Address Latch Enable (ALE) is an output pulse for latching the low byte of the address during accesses to external memory. This pin is also the program pulse input (PROG) during Flash programming. In normal operation, ALE is emitted at a constant rate of 1/6 the oscillator frequency and may be used for external timing or clocking purposes. Note, however, that one ALE pulse is skipped during each access to external data memory. If desired, ALE operation can be disabled by setting bit 0 of SFR location 8EH. With the bit set, ALE is active only during a MOVX or MOVC instruction. Otherwise, the pin is weakly pulled high. Setting the ALE-disable bit has no effect if the microcontroller is in external execution mode.

PSEN:

Program Store Enable (PSEN) is the read strobe to external program memory. When the AT89S51 is executing code from external program memory, PSEN is activated twice each machine cycle, except that two PSEN activations are skipped during each access to external data memory.

EA/VPP:

External Access Enable. EA must be strapped to GND in order to enable the device to fetch code from external program memory locations starting at 0000H up to FFFFH. Note, however, that if lock bit 1 is programmed, EA will be internally latched on reset. EA should be strapped to VCC for internal program executions. This pin also receives the 12-volt programming enable voltage (VPP) during Flash programming.

XTAL1:

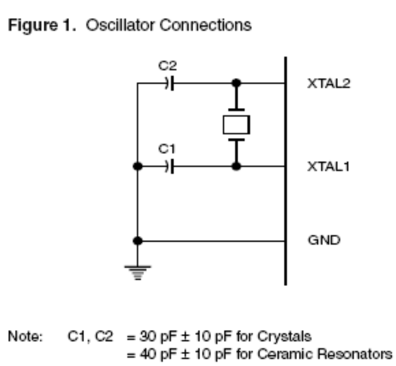
Input to the inverting oscillator amplifier and input to the internal clock operating circuit.

XTAL2:

Output from the inverting oscillator amplifier.

Oscillator Characteristics:

XTAL1 and XTAL2 are the input and output, respectively, of an inverting amplifier which can be configured for use as an on-chip oscillator, as shown in Figs 6.2.3. Either a quartz crystal or ceramic resonator may be used. To drive the device from an external clock source, XTAL2 should be left unconnected while XTAL1 is driven as shown in Figure 6.2.4.There are no requirements on the duty cycle of the external clock signal, since the input to the internal clocking circuitry is through a divide-by-two flip-flop, but minimum and maximum voltage high and low time specifications must be observed.



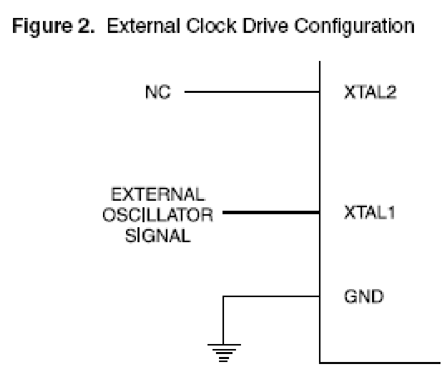


Figure 3.3: OSCILLATOR CONNECTIONS FIG 6.2.4 EXTERNAL CLOCK DRIVE CONFIGURATION

3.2 BUZZER

The "Piezoelectric sound components" introduced here in operate on an innovative principle utilizing natural oscillation of piezoelectric ceramics. These buzzers are offered in lightweight compact sizes from the smallest diameter of 12mm to large Piezo-electric sounders. Today, piezoelectric sound components are used in many ways such as home appliances, OA equipment, audio equipment telephones, etc. And they are applied widely, for example, in alarms, speakers, telephone ringers, receivers, transmitters, beep sounds, etc.

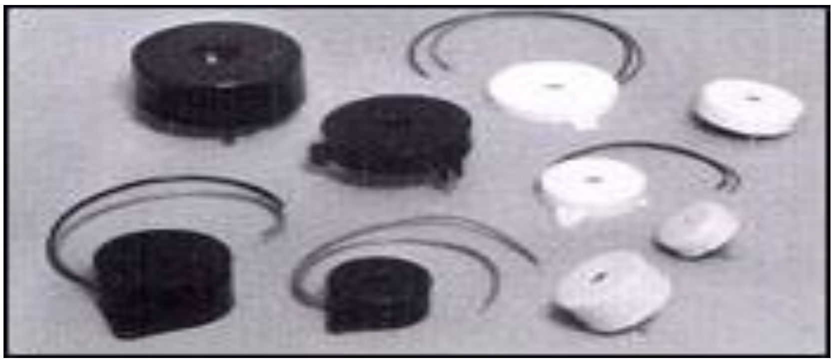
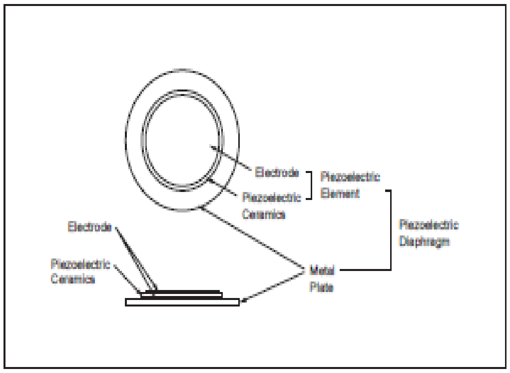


Figure 3.4: Types of Buzzers

Oscillating System:

Basically, the sound source of a piezoelectric sound component is a piezoelectric diaphragm. A piezoelectric diaphragm consists of a piezoelectric ceramic plate which has electrodes on both sides and a metal plate (brass or stainless steel, etc.).A piezoelectric ceramic plate is attached to metal plate with adhesives.

Fig. 2 shows the oscillating system of a piezoelectric diaphragm. Applying D.C. voltage between electrodes of piezoelectric diaphragm causes mechanical distortion due to the piezoelectric effect. For a misshaped piezoelectric element, the distortion of the piezoelectric element expands in a radial direction. And the piezoelectric diaphragm bends toward the direction shown in Fig.2 (a).



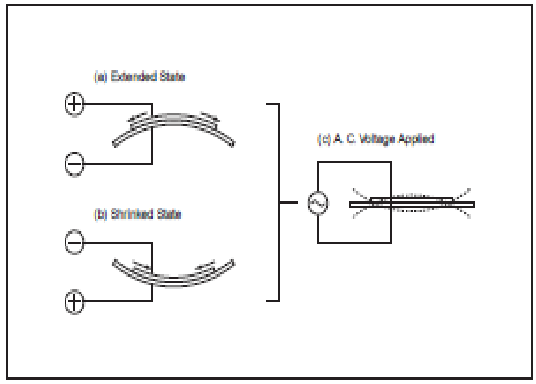


Figure 3.5: structure of piezoelectric diaphragmFigure3.5 (a):oscillating system

The metal plate bonded to the piezoelectric element does not expand. Conversely, when the piezoelectric element shrinks, the piezoelectric diaphragm bends in the direction shown in Fig.2 (b).Thus, when AC voltage is applied across electrodes, the bending shown in Fig.2 (a) and Fig.2 (b) is repeated as shown in Fig.2 (c), producing sound waves in the air.

DESIGN PROCEDURES:

In general, man's audible frequency range is about 20Hz to 20 kHz. Frequency ranges of 2 kHz to 4kHz are most easily heard. For this reason, most piezoelectric sound components are used in this frequency range, and the resonant frequency (f0) is generally selected in the same range too. As shown in Fig. 3, the resonant frequency depends on methods used to support the piezoelectric diaphragm. If piezoelectric diaphragms are of the same shape, their values will become smaller in the order of (a), (b) and (c).

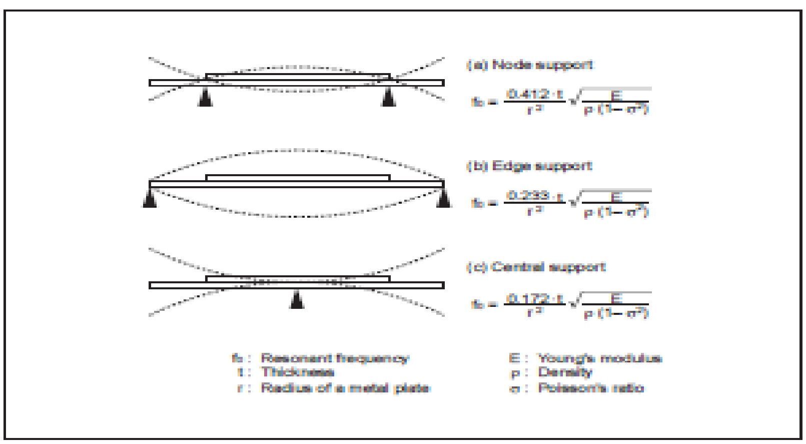


Figure 3.6: Supporting Method

In general, the piezoelectric diaphragm is installed in a cavity to produce high sound pressure. The resonant frequency (fcav) of the cavity in is obtained from Formula (1)(Helmholtz's Formula). Since the piezoelectric diaphragm and cavity have proper resonant frequencies,(f0) and (fcav) respectively, sound pressure in specific frequencies can be increased and a specific bandwidth can be provided by controlling both positions.

3.3 Power supply:

The power supplies are designed to convert high voltage AC mains electricity to a suitable low voltage supply for electronic circuits and other devices. A power supply can by broken down into a series of blocks, each of which performs a particular function. A d.c power supply which maintains the output voltage constant irrespective of a.c mains fluctuations or load variations is known as “Regulated D.C Power Supply”

For example a 5V regulated power supply system as shown below:

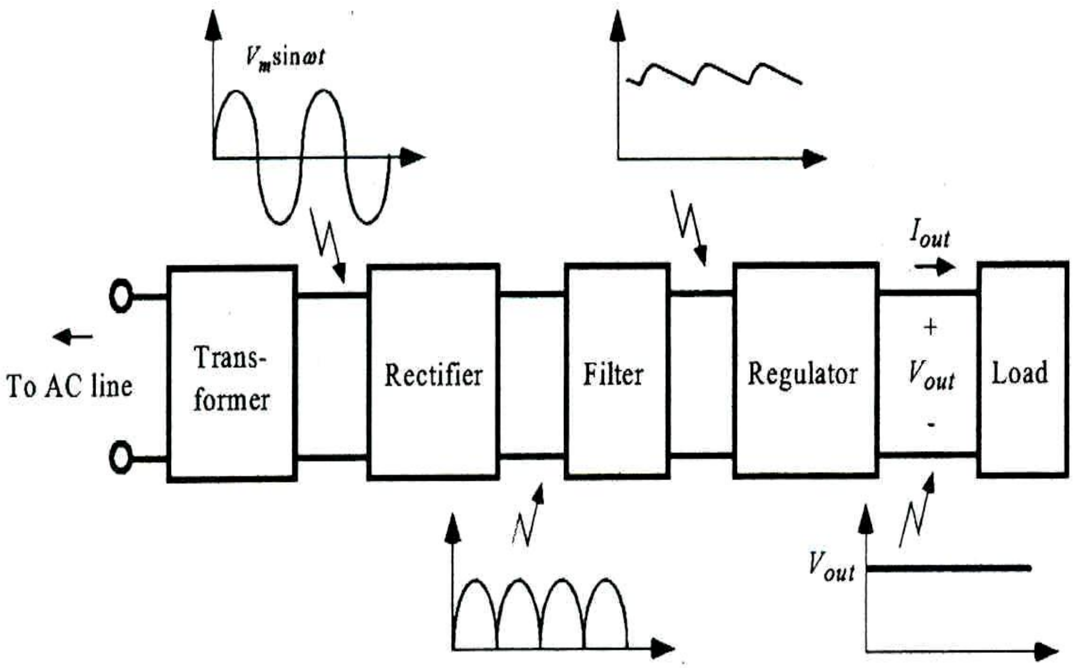


Figure 3.7: COMPONENTS OF TYPICAL LINEAR POWER SUPPLY

Transformer:

A transformer is an electrical device which is used to convert electrical power from one Electrical circuit to another without change in frequency. Transformers convert AC electricity from one voltage to another with little loss of power. Transformers work only with AC and this is one of the reasons why mains electricity is AC. Step-up transformers increase in output voltage, step-down transformers decrease in output voltage. Most power supplies use a step-down transformer to reduce the dangerously high mains voltage to a safer low voltage. 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 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.

Figure 3.8: Electrical Transformer

An Electrical Transformer

Turns ratio = $V_p / V_S = N_p / N_S$

Power Out= Power In

$V_S \times I_S = V_P \times I_P$

Vp = primary (input) voltage

Np = number of turns on primary coil

Ip = primary (input) current

RECTIFIER:

A circuit which is used to convert a.c to dc is known as RECTIFIER. The process of conversion a.c to d.c is called "rectification"

TYPES OF RECTIFIERS:

- Half wave Rectifier
- Full wave rectifier
    1. Centre tap full wave rectifier.
    2. Bridge type full bridge rectifier.

Comparison of rectifier circuits:

Parameter	Type of Rectifier		
	Half wave	**Full wave**	**Bridge**
Number of diodes	1	2	4
PIV of diodes	Vm	2Vm	Vm
D.C output voltage	Vm/ π	2Vm/ π	2Vm/ π
Vdc,at no-load	0.318Vm	0.636Vm	0.636Vm
Ripple factor	1.21	0.482	0.482
Ripple frequency	f	2f	2f
Rectification efficiency	0.406	0.812	0.812
Transformer Utilization Factor(TUF)	0.287	0.693	0.812
RMS voltage Vrms	Vm/2	Vm/√2	Vm/√2

Full-wave Rectifier:

From the above comparison we came to know that full wave bridge rectifier as more advantages than the other two rectifiers. So, in our project we are using full wave bridge rectifier circuit.

Bridge Rectifier:

A bridge rectifier makes use of four diodes in a bridge arrangement to achieve full-wave rectification. This is a widely used configuration, both with individual diodes wired as shown and with single component bridges where the diode bridge is wired internally.

A bridge rectifier makes use of four diodes in a bridge arrangement as shown in fig3.9(a) to achieve full-wave rectification. This is a widely used configuration, both with individual diodes wired as shown and with single component bridges where the diode bridge is wired internally.

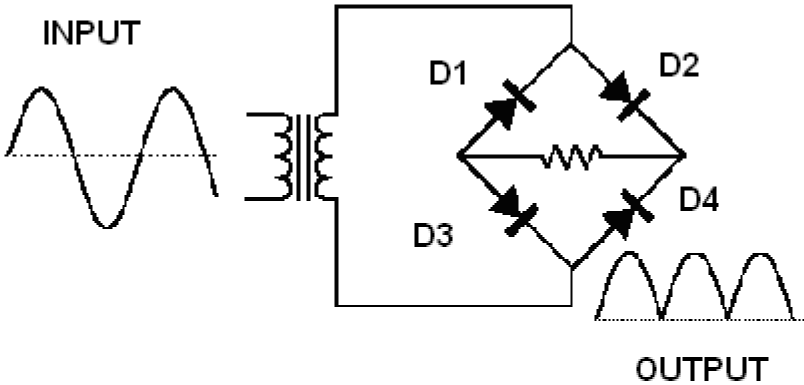


Figure 3.9(a)

Operation:

During positive half cycle of secondary, the diodes D2 and D3 are in forward biased while D1 and D4 are in reverse biased as shown in the fig(b). The current flow direction is shown in the fig3.9 (b) with dotted arrows.

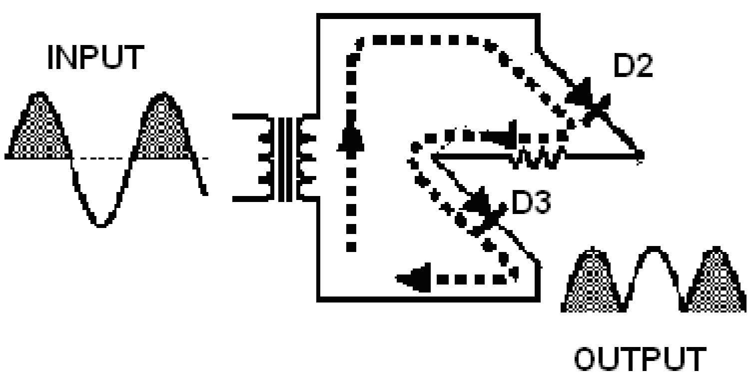


Figure 3.9(b)

During negative half cycle of secondary voltage, the diodes D1 and D4 are in forward biased while D2 and D3 are in reverse biased as shown in the fig 4.9 (c). The current flow direction is shown in the fig 4.9 (c) with dotted arrows.

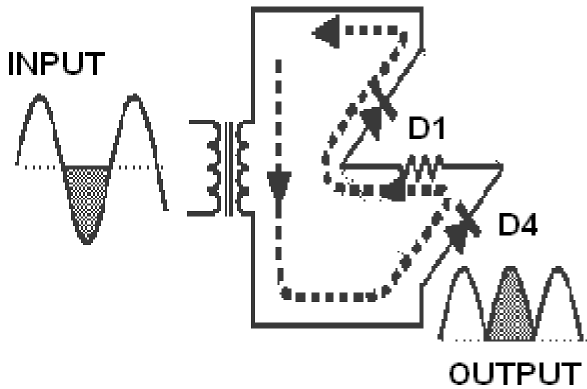


Figure 3.9(c)

Filter:

A Filter is a device which removes the a.c component of rectifier output but allows the d.c component to reach the load

Capacitor Filter:

We have seen that the ripple content in the rectified output of half wave rectifier is 121% or that of full-wave or bridge rectifier or bridge rectifier is 48% such high percentages of ripples is not acceptable for most of the applications. Ripples can be removed by one of the following methods of filtering.

(a) A capacitor, in parallel to the load, provides an easier by –pass for the ripples voltage though it due to low impedance. At ripple frequency and leave the d.c.to appears the load.

(b) An inductor, in series with the load, prevents the passage of the ripple current (due to high impedance at ripple frequency) while allowing the d.c (due to low resistance to d.c)

(c) Various combinations of capacitor and inductor, such as L-section filter π section filter, multiple section filter etc. which make use of both the properties mentioned in (a) and (b) above. Two cases of capacitor filter, one applied on half wave rectifier and another with full wave rectifier.

Filtering is performed by a large value electrolytic capacitor connected across the DC supply to act as a reservoir, supplying current to the output when the varying DC voltage from the rectifier is falling. The capacitor charges quickly near the peak of the varying DC, and then discharges as it supplies current to the output. Filtering significantly increases the average DC voltage to almost the peak value (1.4 × RMS value).

To calculate the value of capacitor(C),

$$C = \frac{1}{4}*\sqrt{3}*f*r*Rl$$

Where,

f = supply frequency,

r = ripple factor,

Rl = load resistance

Note: In our circuit we are using 1000µF. Hence large value of capacitor is placed to reduce ripples and to improve the DC component.

Regulator:

Voltage regulator ICs is available with fixed (typically 5, 12 and 15V) or variable output voltages. The maximum current they can pass also rates them. Negative voltage regulators are available, mainly for use in dual supplies. Most regulators include some automatic protection from excessive current ('overload protection') and overheating ('thermal protection'). Many of the fixed voltage regulator ICs have 3 leads and look like power transistors, such as the 7805 +5V 1A regulator shown on the right. The LM7805 is simple to use. You simply connect the positive lead of your unregulated DC power supply (anything from 9VDC to 24VDC) to the Input pin, connect the negative lead to the Common pin and then when you turn on the power, you get a 5 volt supply from the output pin.

Figure 3.10:A Three Terminal Voltage Regulator

78XX:

The Bay Linear LM78XX is integrated linear positive regulator with three terminals. The LM78XX offer several fixed output voltages making them useful in wide range of applications. When used as a zener diode/resistor combination replacement, the LM78XX usually results in an effective output impedance improvement of two orders of magnitude, lower quiescent current. The LM78XX is available in the TO-252, TO-220 & TO-263packages,

Features:

• Output Current of 1.5A
• Output Voltage Tolerance of 5%
• Internal thermal overload protection
• Internal Short-Circuit Limited
• No External Component
• Output Voltage 5.0V, 6V, 8V, 9V, 10V,12V, 15V, 18V, 24V
• Offer in plastic TO-252, TO-220 & TO-263
• Direct Replacement for LM78XX

3.4 LIGHT EMITING DIODES

It is a semiconductor diode having radioactive recombination. It requires a definite amount of energy to generate an electron-hole pair. The same energy is released when an electron recombines with a hole. This released energy may result in the emission of photon and such a recombination. Hear the amount of energy released when the electro reverts from the conduction band to the valence band appears in the form of radiation. Alternatively the released energy may result in a series of phonons causing lattice vibration. Finally the released energy may be transferred to another electron. The recombination radiation may be lie in the infra-red and visible light spectrum. In forward is peaked around the band gap energy and the phenomenon is called injection luminescence. I n a junction biased in the avalanche break down region, there results a spectrum of photons carrying much higher energies. Almost White light then gets emitted from micro-plasma breakdown region in silicon junction. Diodes having radioactive recombination are termed as Light Emitting Diode, abbreviated as LEDs. In gallium arsenide diode, recombination is predominantly a radiation recombination and the probability of this radioactive recombination far exceeds that in either germanium or silicon . Hence Ga As LED has much higher efficiency in terms of

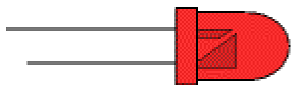
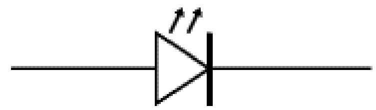
Photons emitted per carrier. The internal efficiency of Ga As LED may be very close to 100% but because of high index of refraction, only a small fraction of the internal radiation can usually come out of the device surface. In spite of this low efficiency of actually radiated light , these LEDs are efficiency used as light emitters in visual display units and in optically coupled circuits, The efficiency of light generation increases with the increase of injected current and with decreases in temperature. The light so generated is concentrated near the junction since most of the charge carriers are obtained within one diffusion length of the diode junction.

The following are the merits of LEDs over conventional incandescent and other types of lamps

1. Low working voltages and currents
2. Less power consumption
3. Very fast action
4. Emission of monochromatic light
5. small size and weight
6. No effect of mechanical vibrations
7. Extremely long life

Typical LED uses a forward voltage of about 2V and current of 5 to 10mA. GaAs LED produces infra-red light while red, green and orange lights are produced by gallium arsenide phosphide (GaAs) and gallium phosphide (Gap).

Light Emitting Diodes (LEDs)

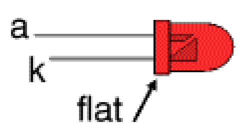
Example:  Circuit symbol: 

Function

LEDs emit light when an electric current passes through them.

Connecting and soldering

LEDs must be connected the correct way round, the diagram may be labelled a or + for anode and k or - for cathode (yes, it really is k, not c, for cathode!). The cathode is the short lead and there may be a slight flat on the body of round LEDs. If you can see inside the LED the cathode is the larger electrode (but this is not an official identification method).



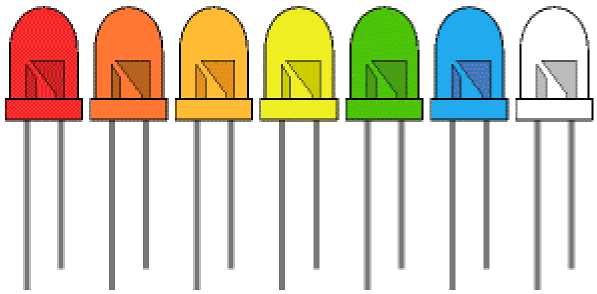
LEDs can be damaged by heat when soldering, but the risk is small unless you are very slow. No special precautions are needed for soldering most LEDs.

Testing an LED

Never connect an LED directly to a battery or power supply. It will be destroyed almost instantly because too much current will pass through and burn it out. LEDs must have a resistor in series to limit the current to a safe value, for quick testing purposes a $1k\Omega$ resistor is suitable for most LEDs if your supply voltage is 12V or less. Remember to connect the LED the correct way round!

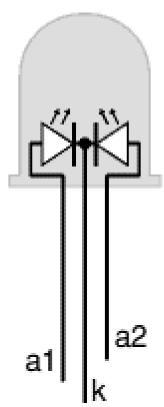
Colors of LEDs

LEDs are available in red, orange, amber, yellow, green, blue and white. Blue and white LEDs are much more expensive than the other colours.



The color of an LED is determined by the semiconductor material, not by the coloring of the 'package' (the plastic body). LEDs of all colors are available in uncolored packages which may be diffused (milky) or clear (often described as 'water clear'). The colored packages are also available as diffused (the standard (type) or transparent.

Tri-color LEDs



The most popular type of tri-color LED has a red and a green LED combined in one package with three leads. They are called tri-color because mixed red and green light appears to be yellow and this is produced when both the red and green LEDs are on.

The diagram shows the construction of a tri-color LED. Note the different lengths of the three leads. The center lead (k) is the common cathode for both LEDs, the outer leads (a1 and a2) are the anodes to the LEDs allowing each one to be lit separately, or both together to give the thirdcolor.

Bi-color LEDs

A bi- color LED has two LEDs wired in 'inverse parallel' (one forwards, one backwards) combined in one package with two leads. Only one of the LEDs can be lit at one time and they are less useful than the tri-color LEDs described above.

Sizes, Shapes and Viewing angles of LEDs

LEDs are available in a wide variety of sizes and shapes. The 'standard' LED has a round cross-section of 5mm diameter and this is probably the best type for general use, but 3mm round LEDs are also popular.

Round cross-section LEDs are frequently used and they are very easy to install on boxes by drilling a hole of the LED diameter, adding a spot of glue will help to hold the LED if necessary. LED clips are also available to secure LEDs in holes. Other cross-section shapes include square, rectangular and triangular.

As well as a variety of colors, sizes and shapes, LEDs also vary in their viewing angle. This tells you how much the beam of light spreads out. Standard LEDs have a viewing angle of 60° but others have a narrow beam of 30° or less. Rapid Electronics stock a wide selection of LEDs and their catalogue is a good guide to the range available.

Calculating an LED resistor value

An LED must have a resistor connected in series to limit the current through the LED, otherwise it will burn out almost instantly.

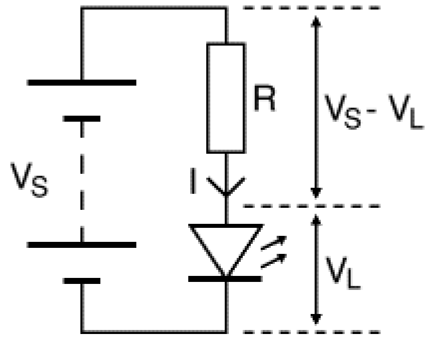


Figure 3.11:LED resistor equivalent ckt.

The resistor value, R is given by

$$\mathbf{R = (V_S - V_L) / I}$$

V_S = supply voltage

V_L = LED voltage (usually 2V, but 4V for blue and white LEDs)

I = LED current (e.g. 20mA), this must be less than the maximum permitted

If the calculated value is not available choose the nearest standard resistor value which is greater, so that the current will be a little less than you chose. In fact you may wish to choose a greater resistor value to reduce the current (to increase battery life for example) but this will make the LED less bright.

Working out the LED resistor formula using Ohm's law

Ohm's law says that the resistance of the resistor,

$$R = V/I,$$

Where:

V =voltage across the resistor (= VS - VL in this case)

I=the current through the resistor

So $R = (V_S - V_L) / I$

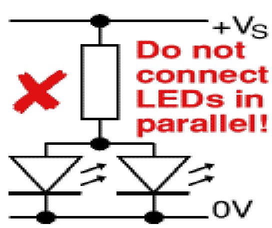
Connecting LEDs in series

If you wish to have several LEDs on at the same time it may be possible to connect them in series. This prolongs battery life by lighting several LEDs with the same current as just one LED.

All the LEDs connected in series pass the same current so it is best if they are all the same type. The power supply must have sufficient voltage to provide about 2V for each LED (4V for blue and white) plus at least another 2V for the resistor. To work out a value for the resistor you must add up all the LED voltages and use this for VL.

Avoid connecting LEDs in parallel

Connecting several LEDs in parallel with just one resistor shared between them is generally not a good idea. If the LEDs require slightly different voltages only the lowest voltage LED will light and it may be destroyed by the larger current flowing through it. Although identical LEDs can be successfully connected in parallel with one resistor this rarely offers any useful benefit because resistors are very cheap and the current used is the same as connecting the LEDs individually.



3.5 PHOTO SENSOR

This sensor consists of IR transmitter and receivers on a single plain.Where Infrared (IR) radiation is part of the electromagnetic spectrum, which includes radio waves, microwaves, visible light, and ultraviolet light, as well as gamma rays and X-rays.

The IR range falls between the visible portion of the spectrum and radio waves. IR wavelengths are usually expressed in microns, with the lR spectrum extending from 0.7 to 1000microns.

Using advanced optic systems and detectors, non-contact IR thermometers can focus on nearly any portion or portions of the0.7-14 micron band. Because every object (with the exception of a blackbody) emits an optimum amount of IR energy at a specific point along the IR band, each process may require unique sensor models with specific optics and detector types.

For example, a sensor with a narrow spectral range center data 3.43 microns is optimized for measuring the surface temperature of polyethylene and related materials. A sensor set up for 5 microns is used to measure glass surfaces. A micron sensor is used for metals and foils. The broader spectral ranges are used to measure lower temperature surfaces, such as paper, board, poly, and foil composites.

The intensity of an object's emitted IR energy increases or decreases in proportion to its temperature. It is the emitted energy, measured as the target's emissivity that indicates an object's temperature.

Emissivity is a term used to quantify the energy-emitting characteristics of different materials and surfaces. IR sensors have adjustable emissivity settings, usually from 0.1 to 1.0, which allow accurate temperature measurements of several surface types.

The emitted energy comes from an object and reaches the IR sensor through its optical system, which focuses the energy onto one or more photosensitive detectors. The detector then converts the IR energy into an electrical signal, which is in turn converted into a temperature value

Based on the sensor's calibration equation and the target's emissivity. This temperature value can be displayed on the sensor or, in the case of the smart sensor, converted to a digital output and displayed on a computer terminal.

IR remote controls use wavelengths between 850 - 950nm. At this short wavelength, the light is invisible to the human eye, but a domestic camcorder can actually view this portion of the electromagnetic spectrum. Viewed with a camcorder, an IR LED appears to change brightness.

All remote controls use an encoded series of pulses, of which there are thousands of combinations. The light output intensity varies with each remote control; remotes working at 4.5V dc generally will provide a stronger light output than a 3V dc control. Also, as the photodiode in this project has a peak light response at 850nm, it will receive a stronger signal from controls operating closer to this wavelength. The photodiode will actually respond to IR wavelengths from 400nm to 1100nm, so all remote controls should be compatible. A sensor is a type of transducer, or mechanism, which responds to a type of energy by producing another type of energy signal, usually electrical. They are either direct indicating (an electrical meter) or are paired with an indicator (perhaps indirectly through an analog to digital converter, a computer and a display) so that the value sensed is translated for human understanding. Types of sensors include electromagnetic, chemical, biological and acoustic. Aside from other applications, sensors are heavily used in medicine, industry& robotics.

In order to act as an effectual sensor, the following guidelines must be met:

- the sensor should be sensitive to the measured property
- the sensor should be insensitive to any other property
- the sensor should not influence the measured property

In theory, when the sensor is working perfectly, the output signal of a sensor is exactly proportional to the value of the property it is meant to measure. The gain is then defined as the ratio between output signal and measured property. For example, if a sensor measures temperature and has an actual voltage output, the gain is a constant with the unit.

When the sensor is not perfect, various deviations can occur, including gain error, long term drift, and noise. These and other deviations can be classified as systematic, or random, errors. Systematic deviations may be compensated for by means of some kind of calibration strategy. Noise is an example of a random error that can be reduced by signal processing, such as filtering, usually at the expense of the dynamic behavior of the sensor.

A sensor network is a computer network of spatially distributed devices using sensors to monitor conditions (such as temperature, sound, vibration, pressure, motion or pollutants) at a variety of locations. Usually the devices are small and inexpensive, allowing them to be produced and deployed in large numbers; this constrains their resources in terms of energy, memory, and computational speed and bandwidth. Each device is equipped with a radio transceiver, a small micro controller, and an energy source, most commonly a battery. The devices work off each other to deliver data to the computer which has been set up to monitor the information. Sensor networks involve three areas: sensing, communications, and computation (hardware, software, algorithms). They are applied in many areas, such as video surveillance, traffic monitoring, home monitoring and manufacturing.

PRINCIPE:

Transmitter and receiver are incorporated in a single housing. The modulated infrared light of the transmitter strikes the object to be detected and is reflected in a diffuse way. Part of the reflected light strikes the receiver and starts the switching operation. The two states – i.e. reflection received or no reflection – are used to determine the presence or absence of an object in the sensing range. This system safely detects all objects that have sufficient reflection. For objects with a very bad degree of reflection (matt black rough surfaces) the use of diffuse reflection sensors for short ranges or with background suppression is recommended.

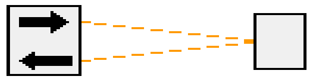


Figure 3.12:PHOTO TRANSMITTER

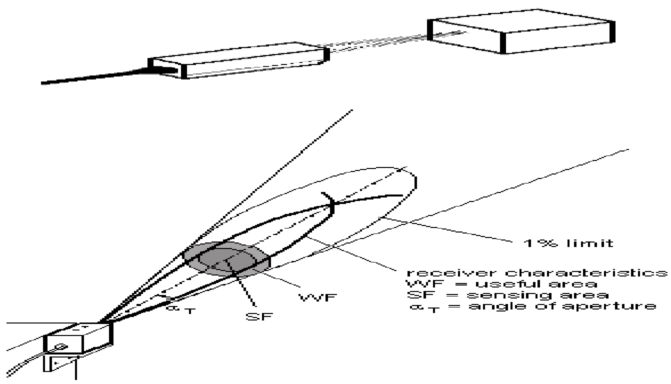


Figure 3.13:RECEIVER CHARACTERISTICS

Sensitivity setting - Diffuse reflection sensors

For diffuse reflection sensors with sensitivity setting the sensitivity should always be set to maximum independent of the required range in order to achieve the highest possible operational safety. Only in the case of interfering backgrounds (walls, machine parts) could it be necessary to reduce the range.

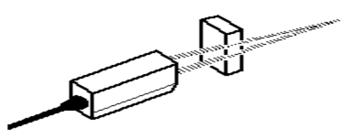


Figure 3.14:Diffuse reflection sensors for short ranges

Diffuse reflection sensors for short ranges

Short-range diffuse type sensors are diffuse reflection sensors which have been specifically designed for short ranges. Light and dark objects are almost equally detectable within the set sensing range. Short-range diffuse types have high excess gains which allow usage even under extreme environmental conditions (e.g. dust, mist etc.). Objects outside the range are not detected.

Diffuse reflection sensor with foreground suppression

Diffuse reflection sensors with foreground suppression are the preferred choice in the case of well reflecting backgrounds and less well reflecting objects. They are adjusted to the background (background serves as reflector). Reflections from the foreground are evaluated as an interruption of the light beam.

Diffuse reflection sensor with background suppression

Diffuse reflection sensors with background suppression limit the range to adjustable, geometrically defined areas. This makes it possible to optically suppress interfering elements (e.g. shining machine parts) behind the object to be sensed. Objects within the range are detected largely independent of their reflective characteristics (color, size, surface). Thus the effective range does not depend on the target objects, but only on the set range.

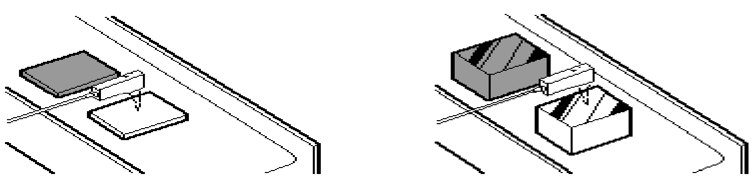


Figure 3.15:reflection sensor.

3.6 Liquid crystal display

Liquid crystal displays (LCDs) have materials, which combine the properties of both liquids and crystals. Rather than having a melting point, they have a temperature range within which the molecules are almost as mobile as they would be in a liquid, but are grouped together in an ordered form similar to a crystal. An LCD consists of two glass panels, with the liquid crystal material sand witched in between them. The inner surface of the glass plates are coated with transparent electrodes which define the character, symbols or patterns to be displayed polymeric layers are present in between the electrodes and the liquid crystal, which makes the liquid crystal molecules to maintain a defined orientation angle.

One each polarizers are pasted outside the two glass panels. These polarizers would rotate the light rays passing through them to a definite angle, in a particular direction. When the LCD is in the off state, light rays are rotated by the two polarizers and the liquid crystal, such that the light rays come out of the LCD without any orientation, and hence the LCD appears transparent. When sufficient voltage is applied to the electrodes, the liquid crystal molecules would be aligned in a specific direction. The light rays passing through the LCD would be rotated by the polarizers, which would result in activating/ highlighting the desired characters. The LCD's are lightweight with only a few millimeters thickness. Since the LCD's consume less power, they are compatible with low power electronic circuits, and can be powered for long durations. The LCD's don't generate light and so light is needed to read the display. By using backlighting, reading is possible in the dark. The LCD's have long life and a wide operating temperature range. Changing the display size or the layout size is relatively simple which makes the LCD's more customers friendly. The LCDs used exclusively in watches, calculators and measuring instruments are the simple seven-segment displays, having a limited amount of numeric data. The recent advances in technology have resulted in better legibility, more information displaying capability and a wider temperature range. These have resulted in the LCDs being extensively used in telecommunications and entertainment electronics. The LCDs have even started replacing the cathode ray tubes (CRTs) used for the display of text and graphics, and also in small TV applications.

This section describes the operation modes of LCD's then describe how to program and interface an LCD to 8051 using Assembly and C.

LCD operation

In recent years the LCD is finding widespread use replacing LEDs (seven-segment LEDs or other multi segment LEDs).This is due to the following reasons:

1. The declining prices of LCDs.

2. The ability to display numbers, characters and graphics. This is in contract to LEDs, which are limited to numbers and a few characters.

3. Incorporation of a refreshing controller into the LCD, there by relieving the CPU of the task of refreshing the LCD. In the contrast, the LED must be refreshed by the CPU to keep displaying the data.

4. Ease of programming for characters and graphics.

LCD pin description

The LCD discussed in this section has 14 pins. The function of each pins is given in table.

TABLE 1:Pin description for LCD:

Pin	symbol	I/O	Description
1	Vss	--	Ground
2	Vcc	--	+5V power supply
3	VEE	--	Power supply to control contrast
4	RS	I	RS=0 to select command register RS=1 to select data register
5	R/W	I	R/W=0 for write R/W=1 for read
6	E	I/O	Enable
7	DB0	I/O	The 8-bit data bus
8	DB1	I/O	The 8-bit data bus
9	DB2	I/O	The 8-bit data bus
10	DB3	I/O	The 8-bit data bus
11	DB4	I/O	The 8-bit data bus
12	DB5	I/O	The 8-bit data bus
13	DB6	I/O	The 8-bit data bus
14	DB7	I/O	The 8-bit data bus

TABLE 2: LCD Command Codes

Code(hex)	Command to LCD Instruction Register
1	Clear display screen
2	Return home
4	Decrement cursor
6	Increment cursor
5	Shift display right
7	Shift display left
8	Display off, cursor off
A	Display off, cursor on
C	Display on, cursor off
E	Display on, cursor on
F	Display on, cursor blinking
10	Shift cursor position to left
14	Shift cursor position to right
18	Shift the entire display to the left
1C	Shift the entire display to the right
80	Force cursor to beginning of 1st line
C0	Force cursor to beginning of 2nd line
38	2 lines and 5x7 matrix

Uses:

The LCDs used exclusively in watches, calculators and measuring instruments are the simple seven-segment displays, having a limited amount of numeric data. The recent advances in technology have resulted in better legibility, more information displaying capability and a wider temperature range. These have resulted in the LCDs being extensively used in telecommunications and entertainment electronics. The LCDs have even started replacing the cathode ray tubes (CRTs) used for the display of text and graphics, and also in small TV applications.

LCD INTERFACING

Sending commands and data to LCDs with a time delay:

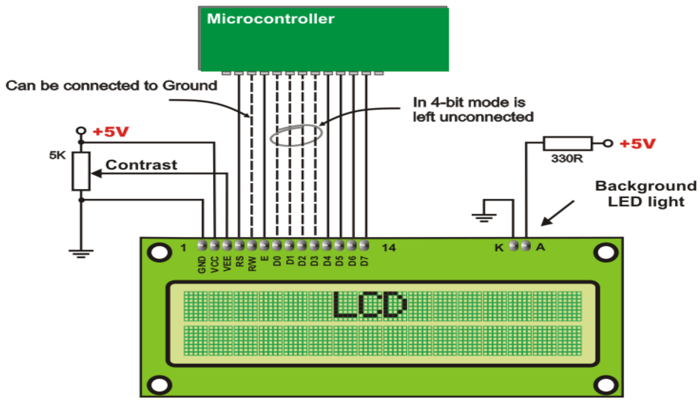


Figure 3.15:Interfacing of LCD to a micro controller.

To send any command from table 2 to the LCD, make pin RS=0.
for data, make RS=1.Then send a high –to-low pulse to the E pin to enable the internal latch of the LCD.

3.7 STEPPER MOTOR

Stepping motors can be used in simple open-loop control systems; these are generally adequate for systems that operate at low accelerations with static loads, but closed loop control may be essential for high accelerations, particularly if they involve variable loads. If a stepper in an open-loop control system is over torqued, all knowledge of rotor position is lost and the system must be reinitialized; servomotors are not subject to this problem.

Stepping motors are known in German as Schrittmotoren, in French as moteurs pas à pas, and in Spanish as motor PasoPaso. Stepper motor control may be based on open loop or closed loop models. We are primarily interested in open loop models, because this is where stepping motors excel, but we will treat closed loop models briefly because they are somewhat simpler. Figure 7.1 illustrates an extreme

Example:

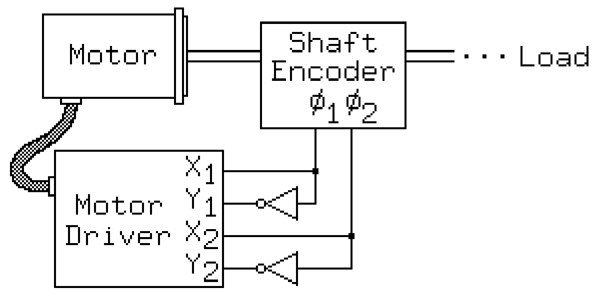


Figure 3.16:Stepper motor open loop model.

Rotary shaft encoders are typically rated in output pulses per channel per revolution; for this example to be useful, for a motor with n steps per revolution, the shaft encoder output must gives n/2 pulses per channel per revolution. If this is the case, the behavior of this system will depend on how the shaft encoder is rotated around the motor shaft relative to the motor. If the shaft encoder is rotated into a position where the output of the shaft encoder translates to a control vector that holds the motor shaft in its initial position, the motor shaft will not rotate of itself, and if the motor shaft is rotated by force, it will stay wherever it is left. We will refer to this position of the shaft encoder relative to the motor as the neutral position.

If the shaft encoder is rotated one step clockwise or counterclockwise from the neutral position, the control vector output by the shaft encoder will pull the rotor clockwise (or counterclockwise). As the rotor turns, the shaft encoder will change the control vector so that the rotor is always trying to maintain a position one step clockwise (or counterclockwise) from where it is at the moment. The torque produced by this method will fall off with rotor speed, but this control system will always produce the maximum torque the motor is able to deliver at any speed.

In effect, with this one-step displacement, we have constructed a brushless DC motor from a stepping motor and a collection of off-the-shelf parts. In practice, this is rarely done, but there are numerous applications of stepping motors in closed-loop control systems that are based on this model, usually with a microprocessor included in the feedback loop between the shaft encoder and the motor controller. In an open-loop control system, this feedback loop is broken, but at a high level, the basic principle remains quite similar, as illustrated in Figure 6.4.2

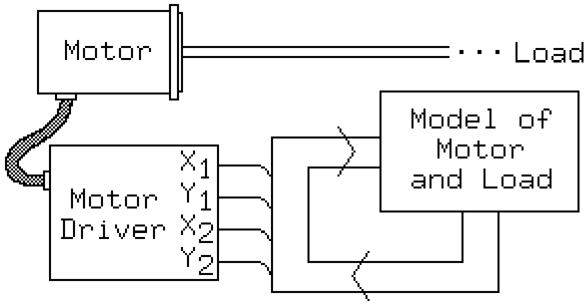


Figure 3.17:Stepper motor open loop model.

In Figure 6.4.2, we replace the shaft encoder from Figure 6.4.1 with a simulation model of the response of the motor and load to the control vector. At any instant, the actual position of the rotor is unknown! Nonetheless, we can use the simulation model to predict, based on an assumed rotor position and velocity, how the motor will respond to the control vector, and we can construct this model so that its output is the control vector generated by a simulated shaft encoder.

So long as the model is sufficiently accurate, the behavior of the motor controlled by this model will be the same as the behavior of the motor controlled by a closed loop system!

STEPPER MOTOR TYPES

Stepping motors come in two varieties, permanent magnet and variable. Lacking a label on the motor, We can generally tell the two apart by feel when no power is applied. Permanent magnet motors tend to "cog" as you twist the rotor with your fingers, while variable reluctance motors almost spin freely (although they may cog slightly because of residual magnetization in the rotor). We can also distinguish between the two varieties with an ohmmeter. Variable reluctance motors usually have three (sometimes four) windings, with a common return, while permanent magnet motors usually have two independent windings, with or without center taps. Center-tapped windings are used in uni-polar permanent magnet motors. Stepping motors come in a wide range of angular resolution. The coarsest motors typically turn 90 degrees per step, while high resolution permanent magnet motors are commonly able to handle 1.8 or even 0.72 degrees per step. With an appropriate controller, most permanent magnet and hybrid motors can be run in half-steps, and some controllers can handle smaller fractional steps or micro-steps. For both permanent magnet and variable reluctance stepping motors, if just one winding of the motor is energized, the rotor (under no load) will snap to a fixed angle and then hold that angle until the torque exceeds the holding torque of the motor, at which point, the rotor will turn, trying to hold at each successive equilibrium point.

Variable Reluctance Motors

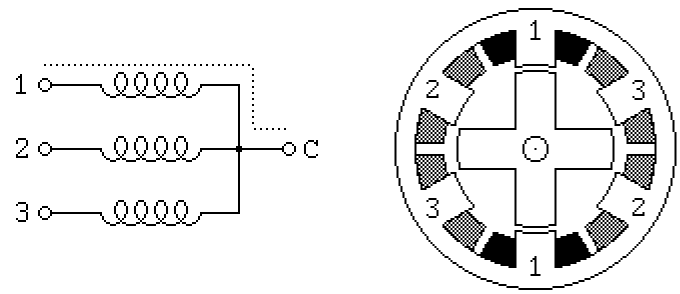


Figure 3.18:Variable Reluctance motors.

If motor has three windings, typically connected as shown in the schematic diagram in Figure 1.1, with one terminal common to all windings, it is most likely a variable reluctance stepping motor. In use, the common wire typically goes to the positive supply and the windings are energized in sequence.

The cross section shown in Figure 1.1 is of 30 degree per step variable reluctance motor. The rotor in this motor has 4 teeth and the stator has 6 poles, with each winding wrapped around two opposite poles. With winding number 1 energized, the rotor teeth marked X are attracted to this winding's poles. If the current through winding 1 is turned off and winding 2 is turned on, the rotor will rotate 30 degrees clockwise so that the poles marked Y line up with the poles marked 2. To rotate this motor continuously, we just apply power to the 3 windings in sequence. Assuming positive logic, where a 1 means turning on the current through a motor winding, the following control sequence will spin the motor illustrated in Figure 1.1 clockwise 24 steps or 2 revolutions:

```
    Winding 1 100100100100100100100100
    Winding 2 010010010010010010010010
    Winding 3 001001001001001001001001
  time --->
```

There are also variable reluctance stepping motors with 4 and 5 windings, requiring 5 or 6 wires. The principle for driving these motors is the same as that for the three winding variety, but it becomes important to work out the correct order to energize the windings to make the motor step nicely. The motor geometry illustrated in Figure 1.1, giving 30 degrees per step, uses the fewest number of rotor teeth and stator poles that performs satisfactorily. Using more motor poles and more rotor teeth allows construction of motors with smaller step angle. Toothed faces on each pole and a correspondingly finely toothed rotor allows for step angles as small as a few degrees.

Unipolar Motors

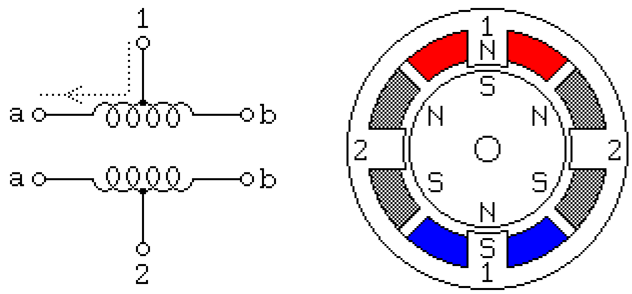


Figure 3.19:Unipolar motor.

The motor cross section shown in Figure 1.2 is of a 30 degree per step permanent magnet or hybrid motor -- the difference between these two motor types is not relevant at this level of abstraction. Motor winding number 1 is distributed between the top and bottom stator pole, while motor winding number 2 is distributed between the left and right motor poles. The rotor is a permanent magnet with 6 poles, 3 south and 3 north, arranged around its circumference.

For higher angular resolutions, the rotor must have proportionally more poles. The 30 degree per step motor in the figure is one of the most common permanent magnet motor designs, although 15 and 7.5 degree per step motors are widely available. Permanent magnet motors with resolutions as good as 1.8 degrees per step are made, and hybrid motors are routinely built with 3.6 and 1.8 degrees per step, with resolutions as fine as 0.72 degrees per step available.

As shown in the figure, the current flowing from the center tap of winding 1 to terminal a causes the top stator pole to be a north pole while the bottom stator pole is a south pole. This attracts the rotor into the position shown. If the power to winding 1 is removed and winding 2 is energized, the rotor will turn 30 degrees, or one step.

To rotate the motor continuously, we just apply power to the two windings in sequence. Assuming positive logic, where a 1 means turning on the current through a motor winding, the following two control sequences will spin the motor illustrated in Figure 1.2 clockwise 24 steps or 4 revolutions:

Winding 1a 1000100010001000100010001

Winding 1b 0010001000100010001000100

Winding 2a 0100010001000100010001000

Winding 2b 0001000100010001000100010

time --->

Winding 1a 1100110011001100110011001

Winding 1b 0011001100110011001100110

Winding 2a 0110011001100110011001100

Winding 2b 1001100110011001100110011

time --->

Note that the two halves of each winding are never energized at the same time. Both sequences shown above will rotate a permanent magnet one step at a time. The top sequence only powers one winding at a time, as illustrated in the figure above; thus, it uses less power. The bottom sequence involves powering two windings at a time and generally produces a torque about 1.4 times greater than the top sequence while using twice as much power.

The step positions produced by the two sequences above are not the same; as a result, combining the two sequences allows half stepping, with the motor stopping alternately at the positions indicated by one or the other sequence. The combined sequence is as follows:

Winding 1a 11000001110000011100000111

Winding 1b 00011100000111000001110000

Winding 2a 01110000011100000111000001

Winding 2b 00000111000001110000011100 time --->

Bipolar Motors

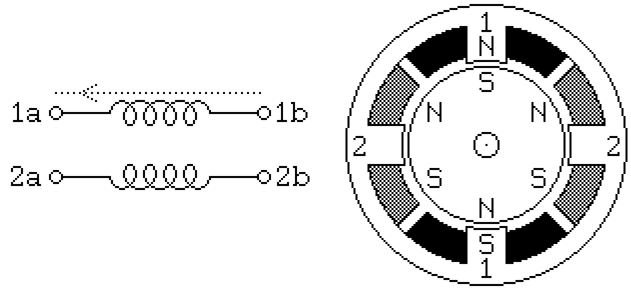


Figure 3.20:Bipolar motor.

Bipolar permanent magnet and hybrid motors are constructed with exactly the same mechanism as is used on unipolar motors, but the two windings are wired more simply, with no center taps. Thus, the motor itself is simpler but the drive circuitry needed to reverse the polarity of each pair of motor poles is more complex. The schematic in Figure 1.3 shows how such a motor is wired, while the motor cross section shown here is exactly the same as the cross section shown in Figure 1.2.

Briefly, an H-bridge allows the polarity of the power applied to each end of each winding to be controlled independently. The control sequences for single stepping such a motor are shown below, using + and - symbols to indicate the polarity of the power applied to each motor terminal:

Terminal 1a +---+---+---+--- ++--++--++--++--

Terminal 1b --+---+---+---+- --++--++--++--++

Terminal 2a -+---+---+---+-- -++--++--++--++-

Terminal 2b ---+---+---+---+ +--++--++--++--+

time --->

Note that these sequences are identical to those for a unipolar permanent magnet motor, at an abstract level, and that above the level of the H-bridge power switching electronics, the control systems for the two types of motor can be identical.

Note that many full H-bridge driver chips have one control input to enable the output and another to control the direction. Given two such bridge chips, one per winding, the following control sequences will spin the motor identically to the control sequences given above:

Enable 1 1010101010101010 1111111111111111

Direction 1 1x0x1x0x1x0x1x0x 1100110011001100

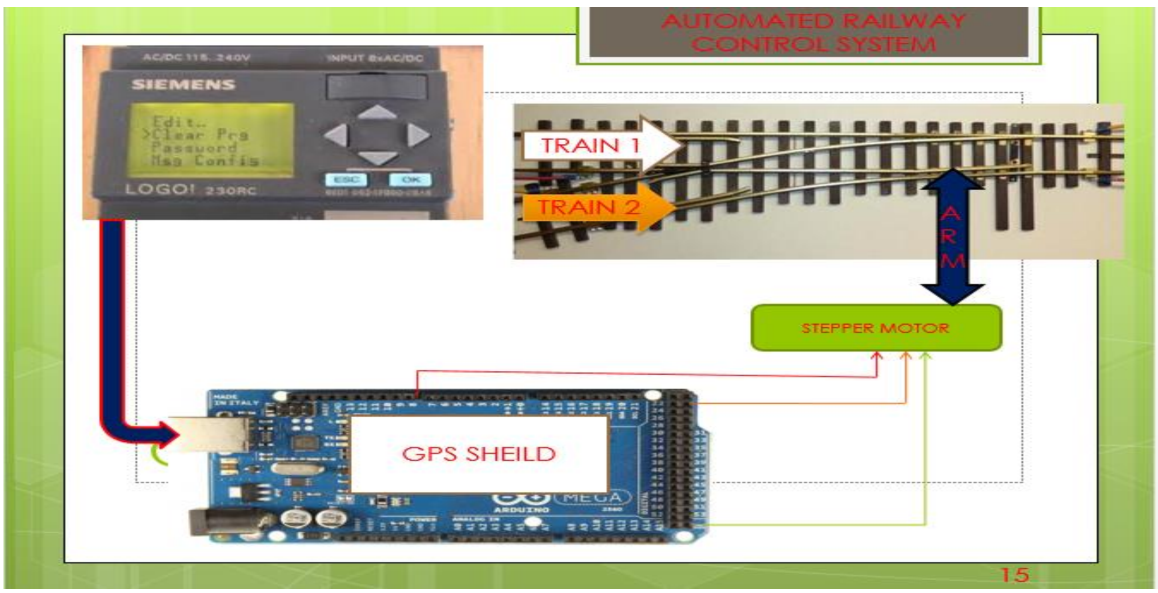
Enable 2 0101010101010101 1111111111111111

Direction 2 x1x0x1x0x1x0x1x0 0110011001100110

time --->

To distinguish a bipolar permanent magnet motor from other 4 wire motors, measure the resistances between the different terminals. It is worth noting that some permanent magnet stepping motors have 4 independent windings, organized as two sets of two. Within each set, if the two windings are wired in series, the result can be used as a high voltage bipolar motor. If they are wired in parallel, the result can be used as a low voltage bipolar motor. If they are wired in series with a center tap, the result can be used as a low voltage uni polar motor.

STEPPER MOTOR CONTROL CIRCUITS



This section of the stepper motor deals with the basic final stage drive circuitry for stepping motors. This circuitry is centered on a single issue, switching the current in each motor winding on and off, and controlling its direction. The circuitry discussed in this section is connected directly to the motor windings and the motor power supply, and this circuitry is controlled by a digital system that determines when the switches are turned on or off. This section covers the most elementary control circuitry for each class of motor. All of these circuits assume that the motor power supply provides a drive voltage no greater than the motor's rated voltage, and this significantly limits motor performance. The next section, on current limited drive circuitry, covers practical high-performance drive circuits.

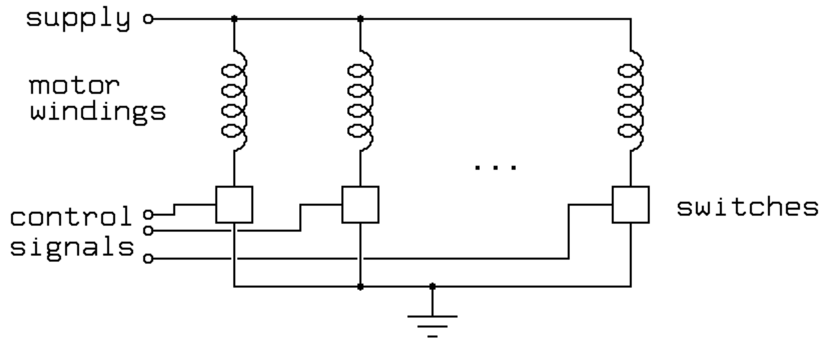


Figure 3.21:Boxes Used for representing switches.

In Figure 3.1, boxes are used to represent switches; a control unit, not shown, is responsible for providing the control signals to open and close the switches at the appropriate

Times in order to spin the motors. In many cases, the control unit will be a computer or programmable interface controller, with software directly generating the outputs needed to control the switches, but in other cases, additional control circuitry is introduced, sometimes gratuitously! Motor windings, solenoids and similar devices are all inductive loads. As such, the current through the motor winding cannot be turned on or off instantaneously without involving infinite voltages! When the switch controlling a motor winding is closed, allowing current to flow, the result of this is a slow rise in current. When the switch controlling a motor winding is opened, the result of this is a voltage spike that can seriously damage the switch unless care is taken to deal with it appropriately. There are two basic ways of dealing with this voltage spike. One is to bridge the motor winding with a diode, and the other is to bridge the motor winding with a capacitor. Figure 3.2 illustrates both approaches:

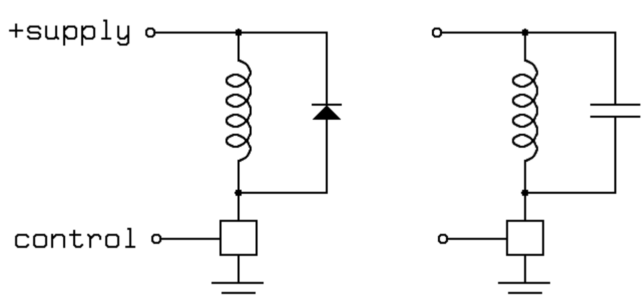


Figure 3.22:Bridge motor winding with a diode capacitor.

The diode shown in Figure must be able to conduct the full current through the motor winding, but it will only conduct briefly each time the switch is turned off, as the current through the winding decays. If relatively slow diodes such as the common 1N400X family are used together with a fast switch, it may be necessary to add a small capacitor in parallel with the diode. The capacitor shown in Figure 3.2 poses more complex design problems! When the switch is closed, the capacitor will discharge through the switch to ground, and the switch must be able to handle this brief spike of discharge current. A resistor in series with the capacitor or in series with the power supply will limit this current. When the switch is opened, the stored energy in the motor winding will charge the capacitor up to a voltage significantly above the supply voltage, and the switch must be able to tolerate this voltage. To solve for the size of the capacitor, we equate the two formulas for the stored energy in a resonant circuit:

$$P = C V^2 / 2$$

$$P = L I^2 / 2$$

Where:

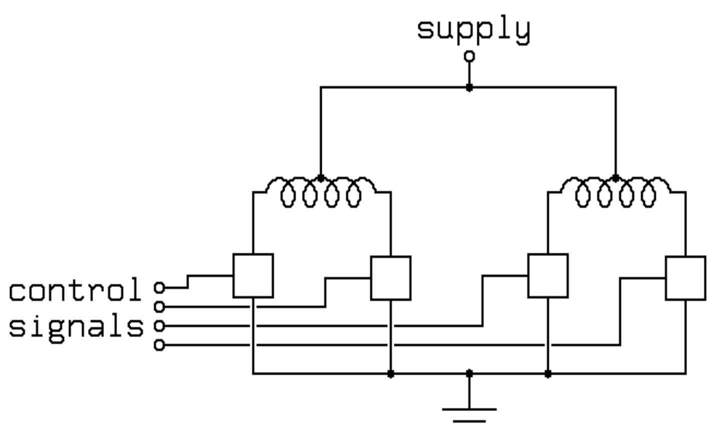


Figure 3.23:Boxes used to represent switches.

In Figure as in previous Figure boxes are used to represent switches; a control unit, not shown, is responsible for providing the control signals to open and close the switches at the appropriate times in order to spin the motors. The control unit is commonly a computer or programmable interface controller, with software directly generating the outputs needed to control the switches. As with drive circuitry for variable reluctance motors, we must deal with the inductive kick produced when each of these switches is turned off. Again, we may shunt the inductive kick using diodes, but now, 4 diodes are required, as shown in Figure 3.4:

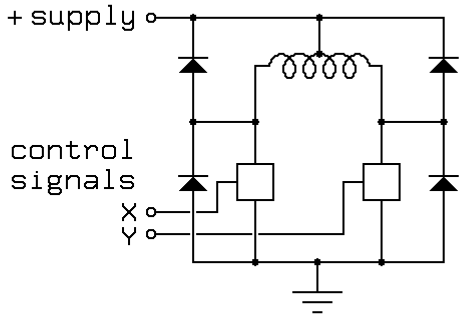


Figure 3.24: Drive circuitry of stepper motor.

The extra diodes are required because the motor winding is not two independent inductors, it is a single center-tapped inductor with the center tap at a fixed voltage. This acts as an autotransformer! When one end of the motor winding is pulled down, the other end will fly up, and visa versa. When a switch opens, the inductive kickback will drive that end of the motor winding to the positive supply, where it is clamped by the diode.

The opposite end will fly downward, and if it was not floating at the supply voltage at the time, it will fall below ground, reversing the voltage across the switch at that end. Some switches are immune to such reversals, but others can be seriously damaged. A capacitor may also be used to limit the kickback voltage, as shown in Figure 6.4.10:

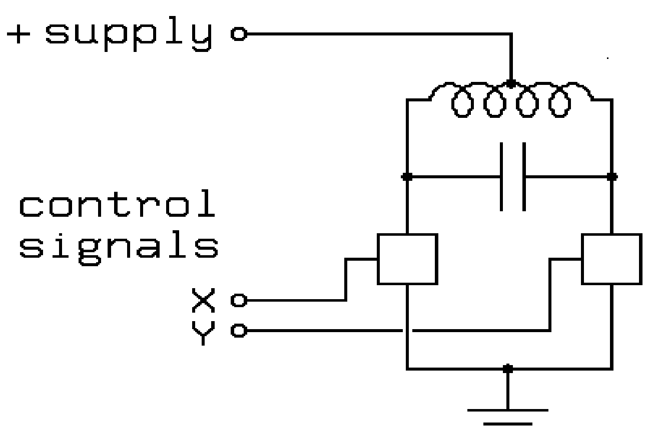


Figure 3.25:Capacitor used to limit the kickback voltage.

The rules for sizing the capacitor shown in Figure 3.5 are the same as the rules for sizing the capacitor shown in Figure 3.2, but the effect of resonance is quite different! With a permanent magnet motor, if the capacitor is driven at or near the resonant frequency, the torque will increase to as much as twice the low-speed torque! The resulting torque versus speed curve may be quite complex, as illustrated in

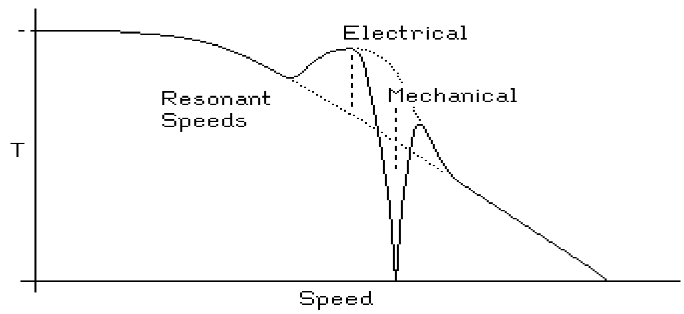


Figure 3.26:Torque speed Characteristics.

Figure 3.6 shows a peak in the available torque at the electrical resonant frequency, and a valley at the mechanical resonant frequency. If the electrical resonant frequency is placed appropriately above what would have been the cutoff speed for the motor using a diode-based driver, the effect can be a considerable increase in the effective cutoff speed. The mechanical resonant frequency depends on the torque, so if the mechanical resonant frequency is anywhere near the electrical resonance, it will be shifted by the electrical resonance! Furthermore, the width of the mechanical resonance depends on the local slope of the torque versus speed curve; if the torque drops with speed, the mechanical resonance will be sharper, while if the torque climbs with speed, it will be broader or even split into multiple resonant frequencies.

Fast decay mode or coasting mode, all switches open. Any current flowing through the motor winding will be working against the full supply voltage, plus two diode drops, so current will decay quickly. This mode provides little or no dynamic braking effect on the motor rotor, so the rotor will coast freely if all motor windings are powered in this mode. Figure 3.11 illustrates the current flow immediately after switching from forward running mode to fast decay mode.

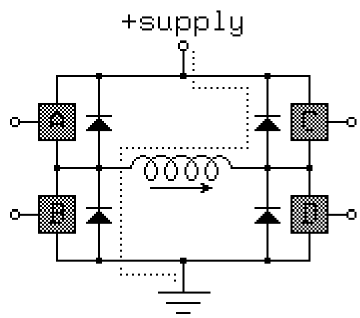


Figure 3.27:DriveCkt of Stepper Motor.

Slow decay modes or dynamic braking modes.

In these modes, current may re circulate through the motor winding with minimum resistance. As a result, if current is flowing in a motor winding when one of these modes is entered, the current will decay slowly, and if the motor rotor is turning, it will induce a current that will act as a brake on the rotor. Figure 3.12 illustrates one of the many useful slow-decay modes, with switch D closed; if the motor winding has recently been in forward running mode, the state of switch B may be either open or closed:

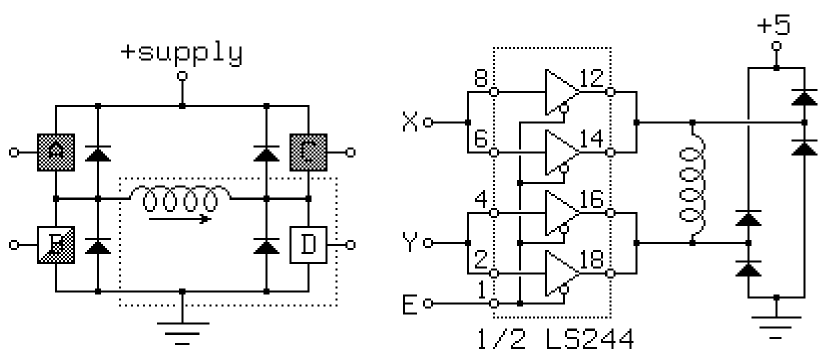


Figure 3.28:Slow Decay Modes.

This circuit is effective for driving motors with up to about 50 ohms per winding at voltages up to about 4.5 volts using a 5 volt supply. Each tri-state buffer in the LS244 can sink about twice the current it can source, and the internal resistance of the buffers is sufficient, when sourcing current, to evenly divide the current between the drivers that are run in parallel. This motor drive allows for all of the useful states achieved by the driver in Figure 3.13, but these states are not encoded as efficiently:

XYE	Mode
--1	Fast decay
000	Slower decay
010	**Forward**
100	**Reverse**
110	Slow decay

Tab 3.1: Stepper Motor Types and their Modes

The second dynamic braking mode, XYE=110, provides a slightly weaker braking effect than the first because of the fact that the LS244 drivers can sink more current than they can source.

Description of ULN2003

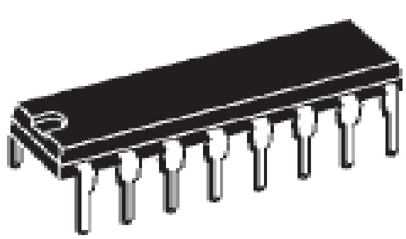
The ULN2003 is high voltage, high current Darlington arrays each containing seven open collectors Darlington pairs with common emitters. Each channel rated at 500mAand can withstand peak currents of 600mA.Suppressiondiodesare included for inductive load driving and the inputs are pinned opposite the outputs to simplify board layout.

The four versions interface to all common logic families:

ULN2001A	General Purpose, DTL, TTL, PMOS, CMOS
ULN2002A	14-25V PMOS
ULN2003A	5V TTL, CMOS
ULN2004A	6–15V CMOS, PMOS

Tab 3.2: types of ULN series and their voltages

These versatile devices are useful for driving a wide range of loads including solenoids, relays DC motors, LED displays filament lamps, thermal print heads and high power buffers.



DIP16

Figure 3.29:DIP 16.

PIN CONNECTION

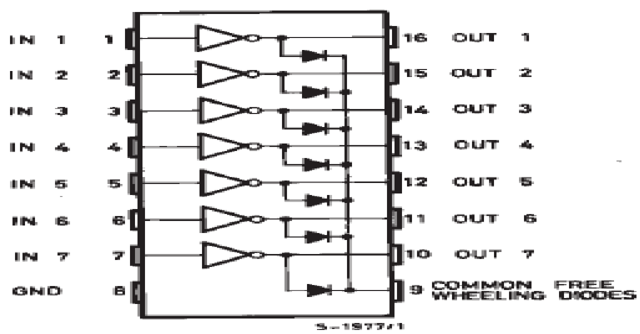


Figure 3.30:Pin connection of ULN 2003.

SCHEMATIC DIAGRAM

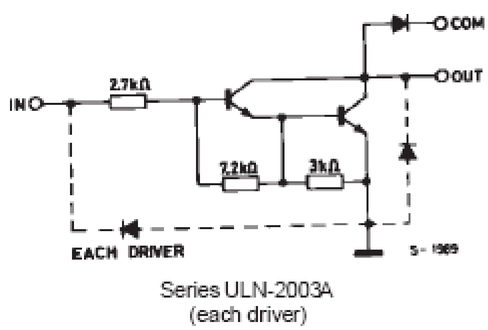


Figure 3.31:Schematic Diagram of ULN 2003.

CIRCUIT DESCRIPTION:

In this project we required operating voltage for Microcontroller 89C51 is 5V. Hence the 5V D.C. power supply is needed for the IC's. This regulated 5V is generated by stepping down the voltage from 230V to 18V now the step downed a.c voltage is being rectified by the Bridge Rectifier using 1N4007 diodes. The rectified a.c voltage is now filtered using a 'C' filter. Now the rectified, filtered D.C. voltage is fed to the Voltage Regulator. This voltage regulator provides/allows us to have a Regulated constant Voltage which is of +5V. The rectified; filtered and regulated voltage is again filtered for ripples using an electrolytic capacitor 100μF. Now the output from this section is fed to 40th pin of 89C51 microcontroller to supply operating voltage. The microcontroller 89C51 with Pull up resistors at Port0 and crystal oscillator of 11.0592 MHz crystal in conjunction with couple of 30-33pf capacitors is placed at 18th& 19th pins of 89C51 to make it work (execute) properly. The automatic gate opening/closing system is provided with the Reflection sensors placed at a distance of few kilometers on the both sides from the crossing road. These sensors give the train reaching and leaving status to the embedded controller at the gate to which they are connected. The controller operates (open/close) the gate as per the received signal from the Reflection sensors.

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_o	Output Voltage	50	V
V_{in}	Input Voltage (for ULN2002A/D - 2003A/D - 2004A/D)	30	V
I_c	Continuous Collector Current	500	mA
I_b	Continuous Base Current	25	mA
T_{amb}	Operating Ambient Temperature Range	– 20 to 85	°C
T_{stg}	Storage Temperature Range	– 55 to 150	°C
T_j	Junction Temperature	150	°C

Tab 3.3: Absolute max ratings of ULN 2003

THERMAL DATA

Symbol	Parameter		DIP16	SO16	Unit
$R_{th\ j\text{-}amb}$	Thermal Resistance Junction-ambient	Max.	70	100	°C/W

Tab 3.4: Thermal Data of ULN 2003

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit	Fig.
I_{CEX}	Output Leakage Current	V_{CE} = 50V T_{amb} = 70°C, V_{CE} = 50V T_{amb} = 70°C for ULN2002A V_{CE} = 50V, V_I = 6V for ULN2004A V_{CE} = 50V, V_I = 1V			50 100 500 500	µA µA µA µA	1a 1a 1b 1b
$V_{CE(sat)}$	Collector-emitter Saturation Voltage	I_C = 100mA, I_B = 250µA I_C = 200 mA, I_B = 350µA I_C = 350mA, I_B = 500µA		0.9 1.1 1.3	1.1 1.3 1.6	V V V	2 2 2
$I_{I(on)}$	Input Current	for ULN2002A, V_I = 17V for ULN2003A, V_I = 3.85V for ULN2004A, V_I = 5V V_I = 12V		0.82 0.93 0.35 1	1.25 1.35 0.5 1.45	mA mA mA mA	3 3 3 3
$I_{I(off)}$	Input Current	T_{amb} = 70°C, I_C = 500µA	50	65		µA	4
$V_{I(on)}$	Input Voltage	V_{CE} = 2V for ULN2002A I_C = 300mA for ULN2003A I_C = 200mA I_C = 250mA I_C = 300mA for ULN2004A I_C = 125mA I_C = 200mA I_C = 275mA I_C = 350mA			 13 2.4 2.7 3 5 6 7 8	V	5
h_{FE}	DC Forward Current Gain	for ULN2001A V_{CE} = 2V, I_C = 350mA	1000				2
C_I	Input Capacitance			15	25	pF	
t_{PLH}	Turn-on Delay Time	0.5 V_I to 0.5 V_o		0.25	1	µs	
t_{PHL}	Turn-off Delay Time	0.5 V_I to 0.5 V_o		0.25	1	µs	
I_R	Clamp Diode Leakage Current	V_R = 50V T_{amb} = 70°C, V_R = 50V			50 100	µA µA	6 6
V_F	Clamp Diode Forward Voltage	I_F = 350mA		1.7	2	V	7

Tab 3.5: Electrical Characteristics of ULN 2003

The train driver always observes the signals placed beside the track. These signals are controlled from the control room. The green light denotes that the track is free and red light denotes the track is busy or damaged. These signals are controlled based on the train position which is sensed by using the Reflection sensors placed along the track. The position of the train can be estimated by using the Reflection sensor placed along the track and is displayed on the control room to indicate the train position along the track.

.

The track protection is achieved by providing the closed loop along the track. If any crack or cut is occurred to the track simultaneously the same happens to the closed loop. This gives a signal to the controller at the control room. From control room we can give the red signal by knowing the position of the train through the Reflection sensors.

Chapter 4

Software

Software components

- Keil u-Vision
- Embedded 'C'
- Express PCB
- PLC

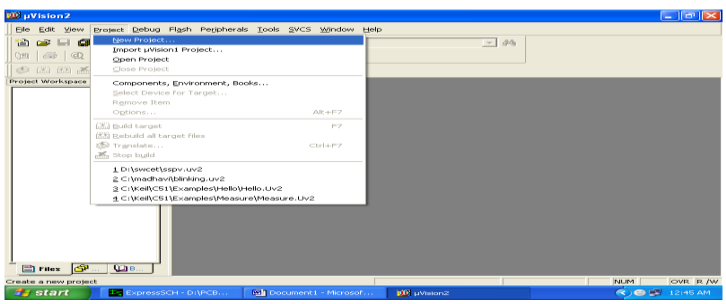
Keil u-Vision

Click on the Keil u Vision Icon on Desktop

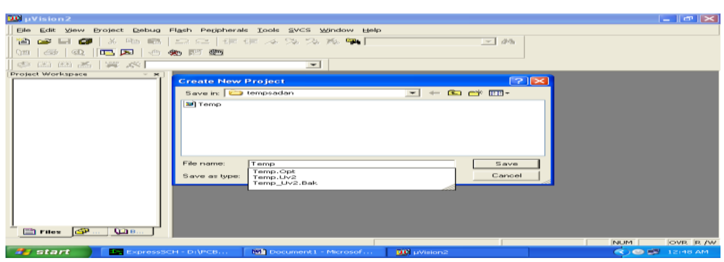
The following fig will appear

Click on the Project menu from the title bar

Then Click on New Project



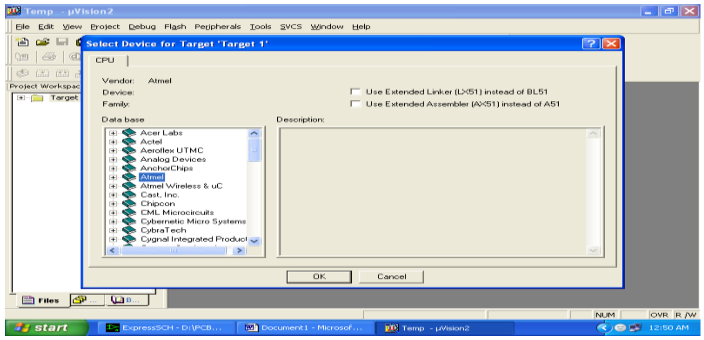
Save the Project by typing suitable project name with no extension in u r own folder sited in either C:\ or D:\



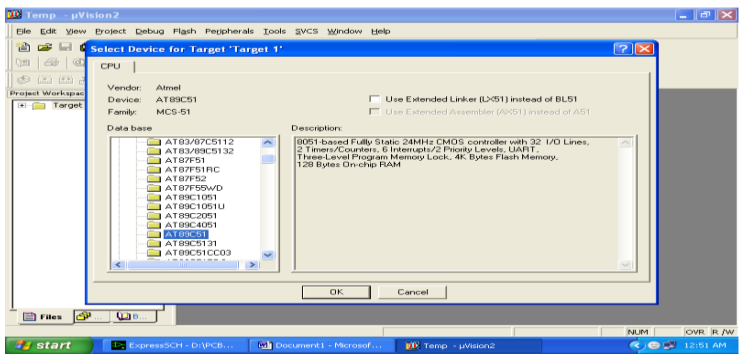
Then Click on Save button above.

Select the component for u r project. i.e. Atmel……

Click on the + Symbol beside of Atmel

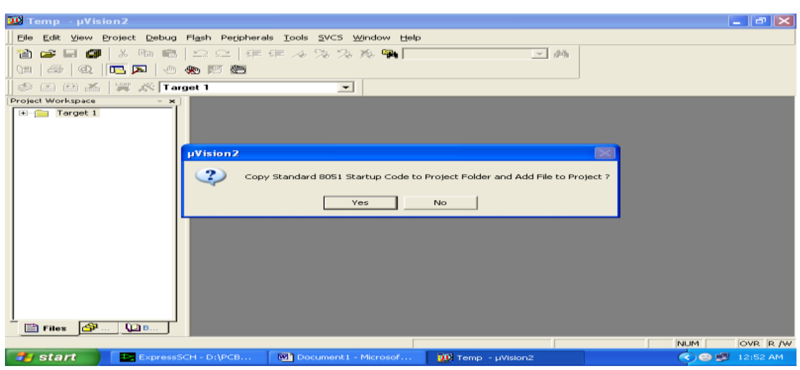


Select AT89C51 as shown below



Then Click on “OK”

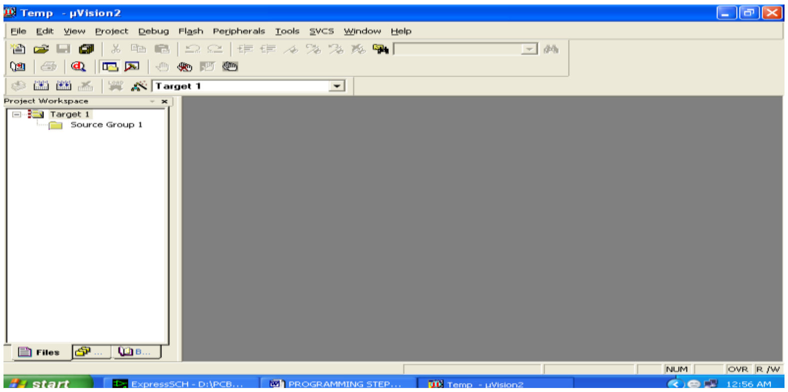
The Following fig will appear



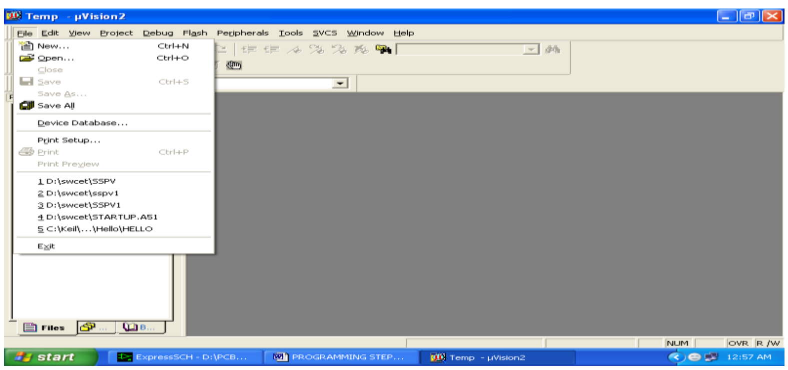
Then Click either YES or NO………mostly “NO”

Now your project is ready to USE

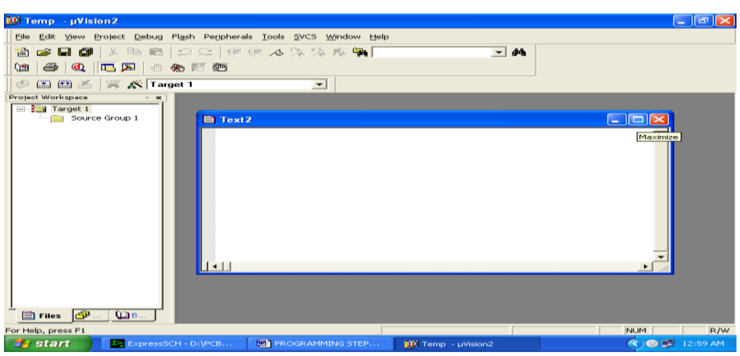
Now double click on the Target1, you would get another option "Source group 1" as shown in next page.



Click on the file option from menu bar and select "new"

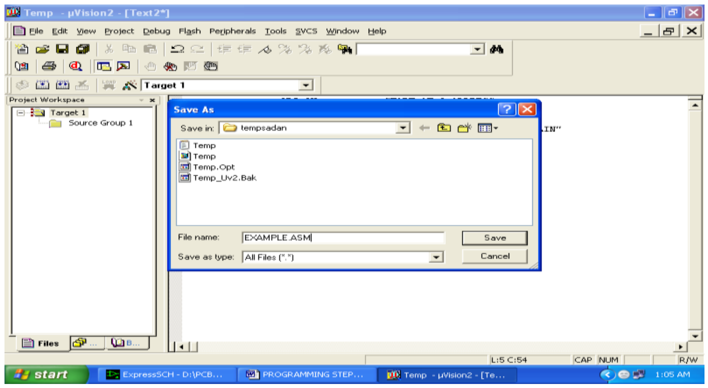


The next screen will be as shown in next page, and just maximize it by double clicking on its blue boarder.

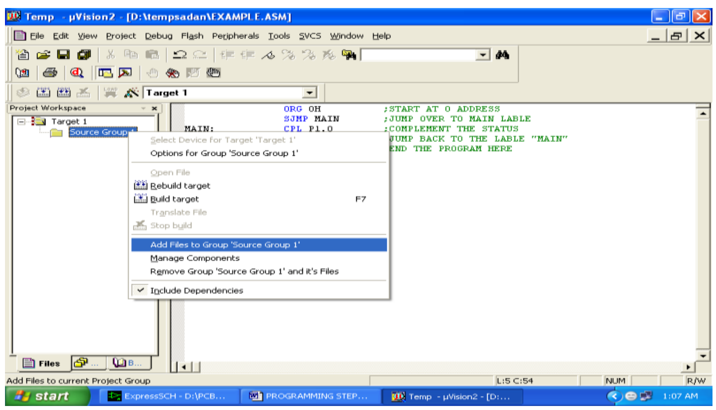


Now start writing program in either in “C” or “ASM”

For a program written in Assembly, then save it with extension “.asm” and for “C” based program save it with extension “ .C”



Now right click on Source group 1 and click on “Add files to Group Source”

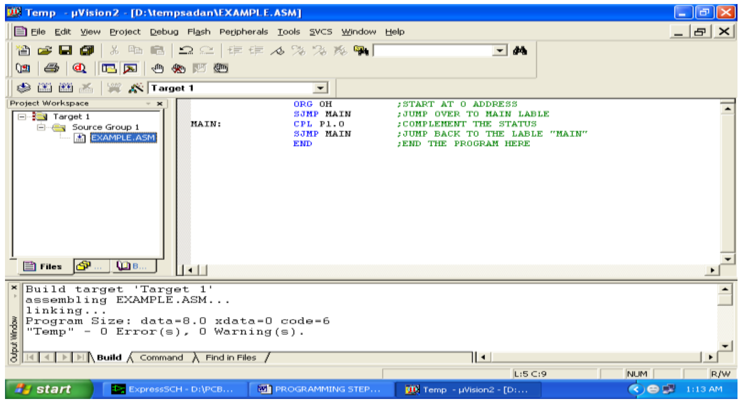


Now you will get another window, on which by default “C” files will appear.

Now select as per your file extension given while saving the file

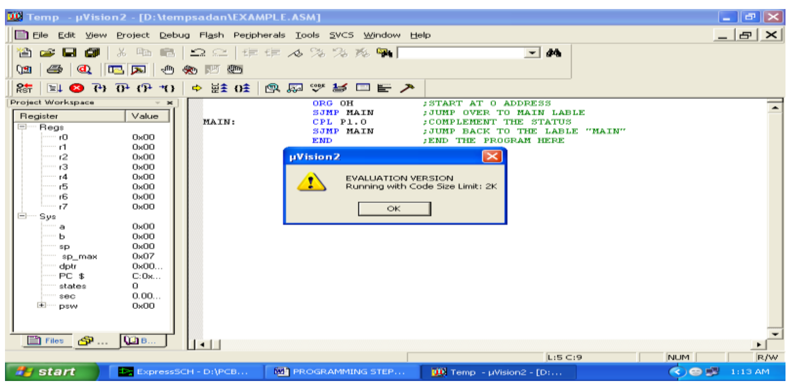
Click only one time on option “ADD”

Now Press function key F7 to compile. Any error will appear if so happen.



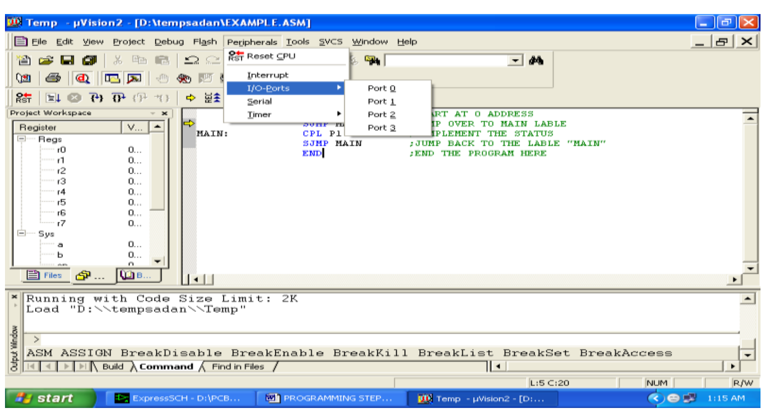
If the file contains no error, then press Control+F5 simultaneously.

The new window is as follows

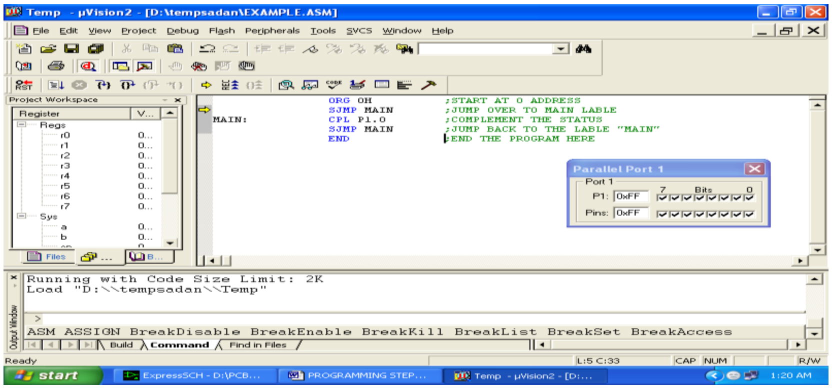


Then Click "OK"

Now Click on the Peripherals from menu bar, and check your required port as shown in fig below

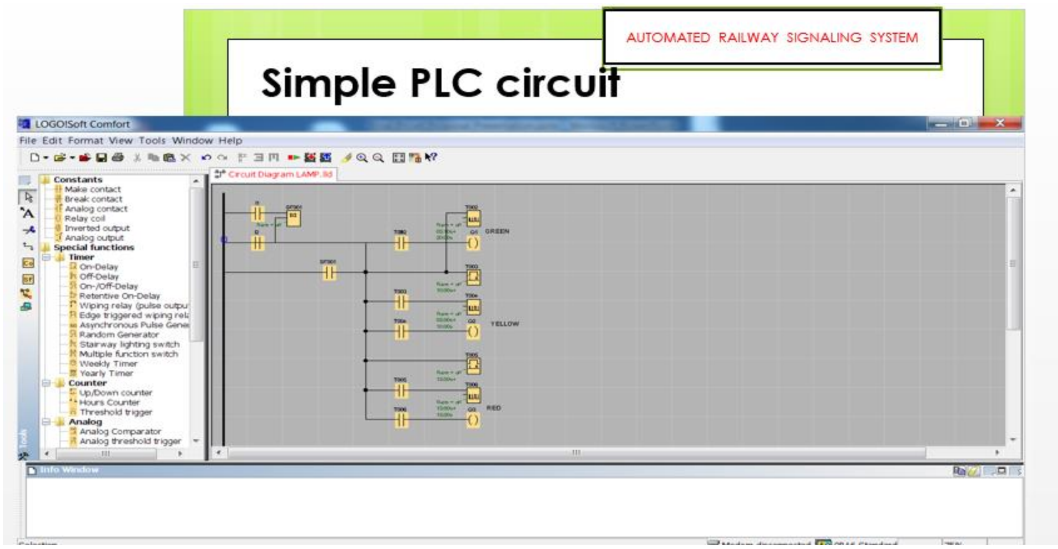


Drag the port a side and click in the program file.



Now keep Pressing function key “F11” slowly and observe.

You are running your program successfully



CONCLUTION

The project "**AUTOMATIC RAILWAY SIGNALLING SYSTEM**" has been successfully designed and tested.

It has been developed by integrating features of all the hardware components used. Presence of every module has been reasoned out and placed carefully thus contributing to the best working of the unit.

Secondly, using highly advanced IC's and with the help of growing technology the project has been successfully implemented.

The future signaling and train control system will very likely be a radio-based moving block system using a secure wireless data communication network to continuously track train location, speed and running direction. The subsystem would be required to utilize proven communication technologies to ensure data security and allow for interoperability with other systems. The system must also deliver robust performance under an adverse environment of high radio traffic and electromagnetic noises. It is also essential that the future system offers a low lifecycle cost and is able to overlay on any existing systems to facilitate system replacement.

Finally we conclude that "**AUTOMATIC RAILWAY SIGNALLING SYSTEM**" is an emerging field and there is a huge scope for research and development.

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3. Jump up to:*a b* Rolt, L. T. C (1966). *Red for Danger*. Newton Abott, Devon, United Kingdom: David & Charles Ltd.
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5. http://www.kpsec.freeuk.com/projects/signal.htm.
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