CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Electric vehicles offer superior energy efficiency while offering an enormous potential for reducing CO_2 emissions if the electricity is supplied from a renewable or nuclear source. However, they are presently neither range- nor cost-competitive compared to conventional vehicles, due to limited options for recharging, and expensive energy storage (batteries).

This project aims at extending the wireless power transfer to the charging of moving electric vehicles and static charging. The success of this program may prove to be a very significant step forward towards the possibility of unlimited range electric mobility. By extending the range of electric vehicles, this project will contribute to overcoming a critical limitation of existing electrical vehicles, by offering range at competitive costs.

1.2 OBJECTIVES

The objective of this project is to design and develop

1) An wireless power transmission through induction when the vehicle is in motion
2) Solar based wireless power transmission through induction when vehicle is at bus stop.

1.3 LITERATURE REVIEW

Inductive Power Transfer (IPT) technology is now widely regarded as an efficient and effective method for transferring power wirelessly from one system to another through inductive coupling and across an air-gap. It is possible to use Wireless Power Transfer for electric vehicles when the vehicle is in motion. Furthermore, it is proposed that the battery of electric vehicles can be charged wirelessly at the bus station.

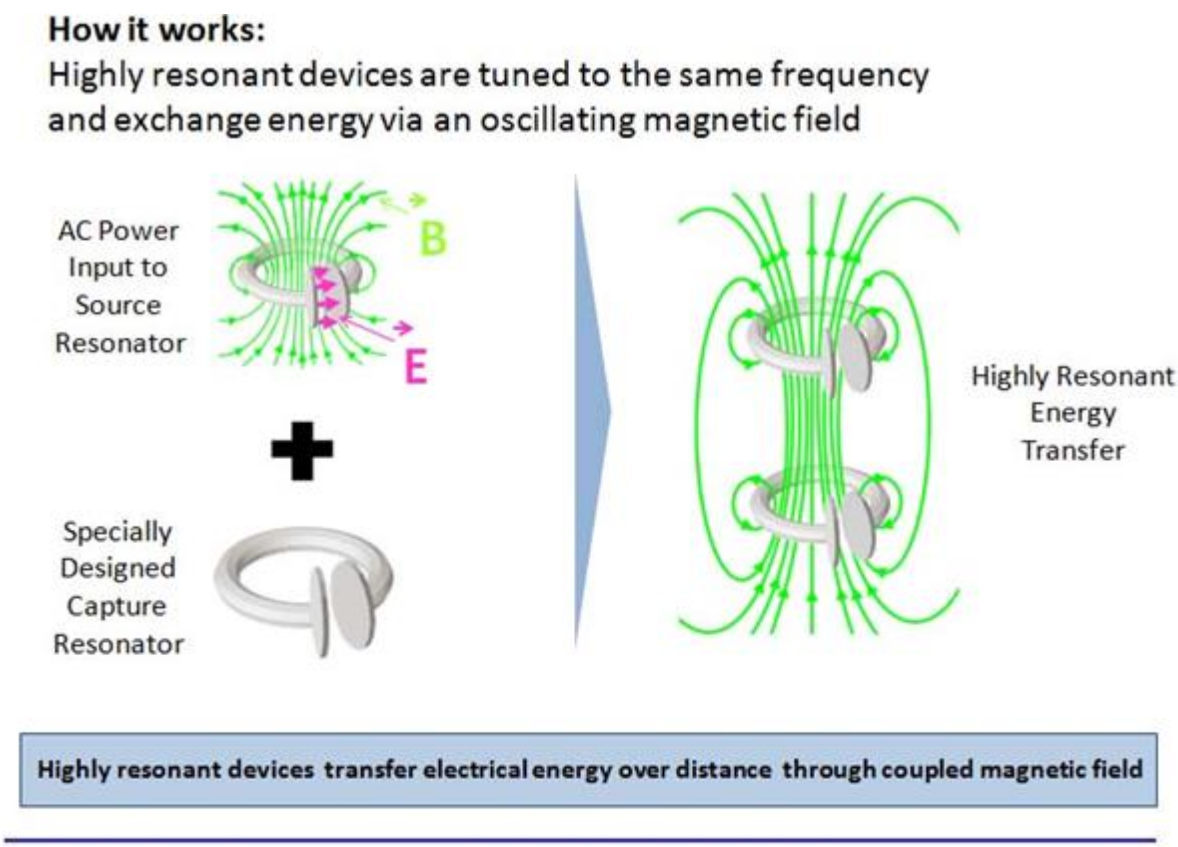


Figure 1: How Wireless Energy Works

"Resonance", a phenomenon that causes an object to vibrate when energy of a certain frequency is applied. Two resonant objects of the same frequency tend to couple very strongly." Resonance can be seen in musical instruments for example. "When you play a tune on one, then another instrument with the same acoustic resonance will pick up that tune, it will visibly vibrate,"

Instead of using acoustic vibrations, system exploits the resonance of electromagnetic waves.

Electromagnetic radiation includes radio waves, infrared and X-rays.

Typically, systems that use electromagnetic radiation, such as radio antennas, are not suitable for the efficient transfer of energy because they scatter energy in all directions, wasting large amounts of it into free space.

To overcome this problem, the team investigated a special class of "non-radiative" objects with so-called "long-lived resonances". When energy is applied to these objects it remains bound to them, rather than escaping to space. "Tails" of energy, which can be many meters long, flicker over the surface. If another resonant object is brought with the same frequency close enough to these tails then it turns out that the energy can tunnel from one object to another.

Hence, a simple copper antenna designed to have long-lived resonance could transfer energy to a laptop with its own antenna resonating at the same frequency. The computer would be truly wireless. Any energy not diverted into a gadget or appliance is simply reabsorbed. The systems that are described would be able to transfer energy over three to five metres. This would work in a room let's say but can be adapted to work in a factory. It could also be scaled down to the microscopic or nanoscopic world.

CHAPTER 2

METHODOLOGY

2.1 BLOCK DIAGRAM OF SYSTEM

2.1.1 Inductive Charging When Vehicle On Move

At first an ac source is taken and it is connected with the rectifier. Then the rectifier is connected to the oscillator. Oscillator transfers current to the transmitter coil. A magnetic field is then created between the transmitter coil and receiver coil. The magnetic field energy is transferred to the battery of a vehicle without using any wire.

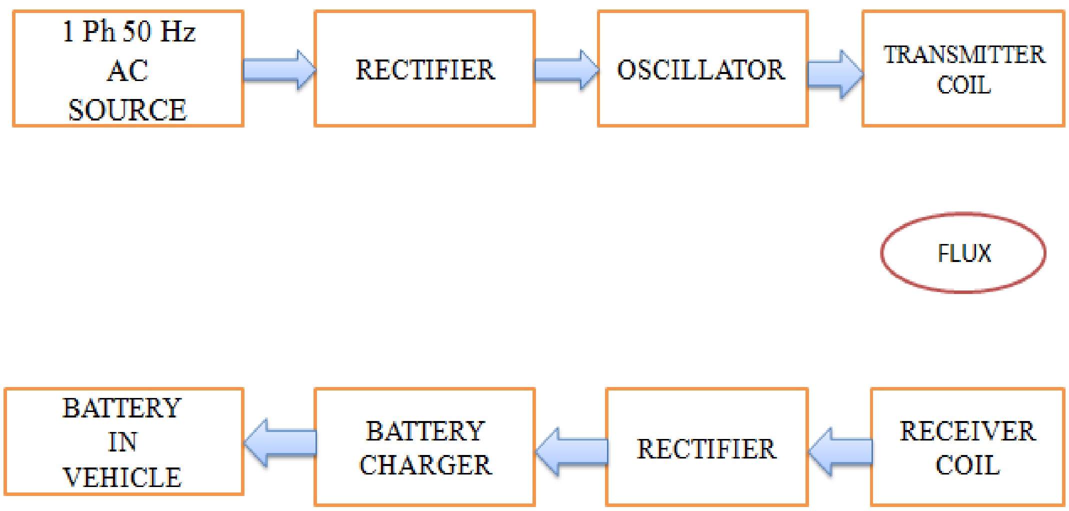


Figure 2: Inductive Charging When Vehicle On Move

2.1.2 Inductive Charging When Vehicle Is At Rest

At first solar panel receives solar power, this power is used to charge the 12 volt battery through battery charging circuit. Then the DC power of battery is transferred to the oscillator. Oscillator transfers current to the transmitter coil. A magnetic field is created between the transmitter coil and receiver coil. The magnetic field energy is transferred to the battery in a vehicle without using any wire.

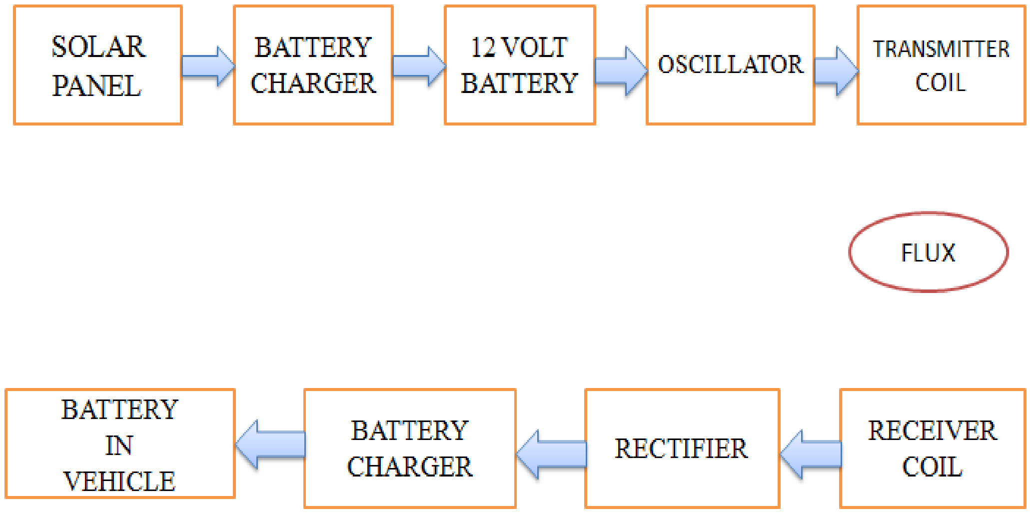


Figure 3: Inductive Charging When Vehicle Is At Rest

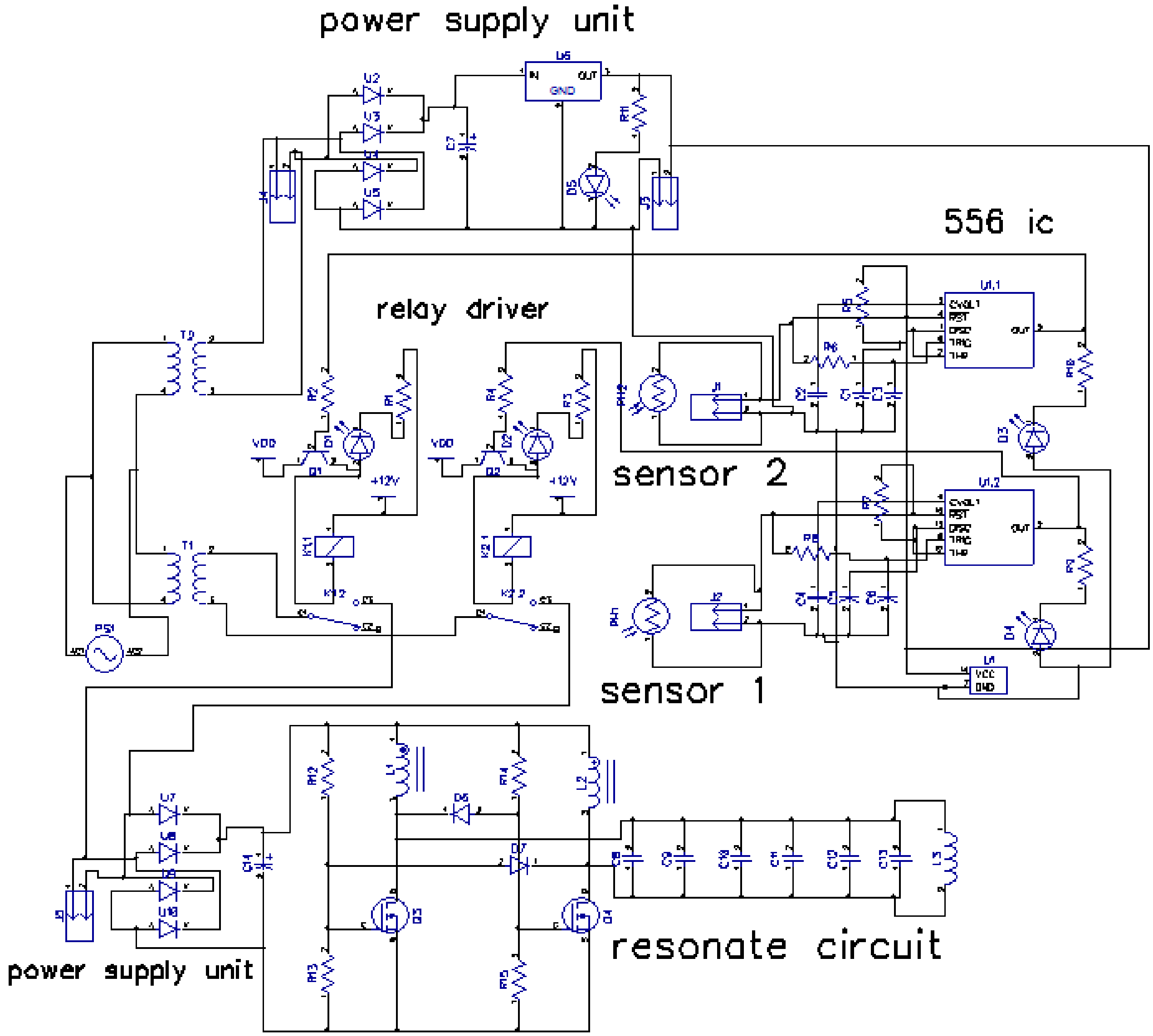


Figure 4: Circuit Diagram Of Wireless Power Transmission

CHAPTER 3

HARDWARE DISCRIPTION

3.1 AC SOURCE

A power supply is a device that supplies electric power to an electrical load. The term is most commonly applied to devices that convert one form of electrical energy to another, though it may also refer to devices that convert another form of energy (mechanical, chemical, solar) to electrical energy. A regulated power supply is one that controls the output voltage or current to a specific value; the controlled value is held nearly constant despite variations in either load current or the voltage supplied by the power supply’s energy source. Here a (220V-50Hz) ac source is used.

3.2 TRANSFORMER

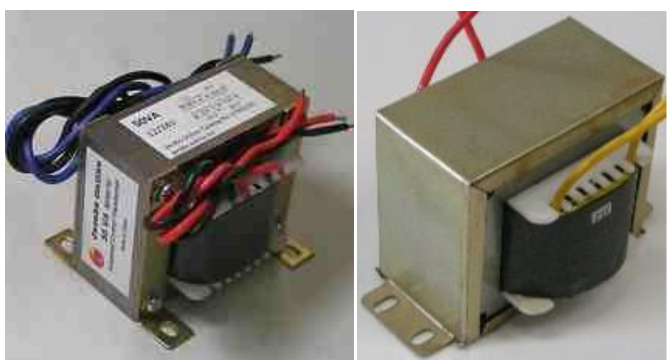


Figure 5: Transformer

A **transformer** is an electrical device that transfers energy between two or more circuits through electromagnetic induction.

A varying current in the transformer's primary winding creates a varying magnetic flux in the core and a varying magnetic field impinging on the secondary winding. This varying magnetic field at the secondary induces a varying electromotive force (EMF) or voltage in the secondary winding. Making use of Faraday's Law in conjunction with high magnetic permeability core properties, transformers can thus be designed to efficiently change AC voltages from one voltage level to another within power networks.

Transformers range in size from RF transformers less than a cubic centimetre in volume to units interconnecting the power grid weighing hundreds of tons. A wide range of transformer designs is encountered in electronic and electric power applications. Since the invention in 1885 of the first constant potential transformer, transformers have become essential for the AC transmission, distribution, and utilization of electrical energy

3.3 RECTIFIER

The function of the rectifier is to convert AC to DC current or voltage, Usually in the rectifier circuit full wave bridge rectifier is used.

3.3.1 Bridge Rectifiers

- There are several ways of connecting diodes to make a rectifier to convert AC to DC. The bridge rectifier is one of them and it is available in special packages containing the four diodes required. Bridge rectifiers are rated by their maximum current and maximum reverse voltage. They have four leads or terminals: the two DC outputs are labelled + and -, the two AC inputs are labelled ~.
- The diagram shows the operation of a bridge rectifier as it converts AC to DC. Notice how alternate pairs of diodes conduct.

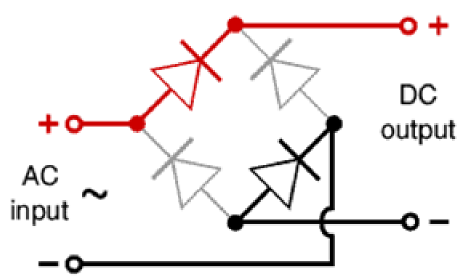


Figure 6: Bridge Rectifier

3.3.2 Parameters Of Full Wave Bridge Rectifier

Rectifier Efficiency : 81.2 %

Ripple factor : 0.48%

Output frequency : 2 F_{in}

Peak inverse voltage : 1 V_m

The output voltage across rectifier circuit is not a pure DC. It has some AC components known as Ripple.

3.3.3 Working Principle Of Full Wave Bridge Rectifier

AC input voltage is given to the primary winding of a step down transformer. This voltage across the secondary winding.

During positive half cycle of secondary voltage the end P of the secondary winding becomes positive and end Q is negative. This makes diodes DI & D3 forward biased while diodes D_2 D_4 reverse biased. Therefore only diodes DI and D3 conduct. These 2 diodes will be in series through the load $R_{L.}$

During negative half cycle of secondary voltage end P of the secondary winding becomes negative and end Q is positive. This makes diodes D2 & D4 forward biased while diodes D1 and D4 reverse biased. Therefore only diodes D2 and D4 conduct. These 2 diodes will be in series through the load $R_{L.}$The DC output obtained across load $R_{L.}$**.**

3.4 SWITCHING DIODE

The 1N4148 is usually listed under the heading of “small-signal diodes” or “switching” diodes. The 1N400x is usually listed under the heading of “rectifier” diodes. What is the difference between the two? The key difference is in their voltage and current handling capability. Look at the data sheet for each (on the course web site): the 1N4148 can handle currents of up to 300 mA and peak reverse voltages of 75V, and the 400x can handle up to 1A and voltages ranging from 60V (1N4001) to 1200V (1N4007). So the 4148 tends to be used in applications where the currents are small, for example in an audio amplifier circuit. The 400x, on the other hand, is designed for abuse and is a good choice in power-supply applications. There are lots of other diodes available on the market; this discussion is just intended to make you aware that diode selection involves a number of considerations beyond threshold voltage. Often packaging and availability are important considerations too.

On the subject of packaging, the parts we use in ECE2 are "wire-lead" parts designed for "through-hole" mounting, as opposed to "surface mount" parts which have tiny leads or sometimes no leads at all. A few popular diode packages are shown in Figure 1-3. Through-hole parts have wire leads that are design to poke through a PCB board. These are great for educational and important for some legacy circuits, but nowadays

3.5 THE OSCILLATOR CIRCUIT

An oscillator is a mechanical or electronic device that works on the principles of oscillation: a periodic fluctuation between two things based on changes in energy. Computers, clocks, watches, radios, and metal detectors are among the many devices that use oscillators. A clock pendulum is a simple type of mechanical oscillator. The most accurate timepiece in the world, the atomic clock, keeps time according to the oscillation within atoms. Electronic oscillators are used to generate signals in computers, wireless receivers and transmitters, and audio-frequency equipment, particularly music synthesizers.

An electronic oscillator is an electronic circuit that produces a repetitive electronic signal, often a sine wave or a square wave. They are widely used in many electronic devices. Common examples of signals generated by oscillators include signals broadcast by radio and television transmitters, clock signals that regulate computers and quartz clocks, and the sounds produced by electronic beepers and video games.

Oscillators are often characterized by the frequency of their output signal: an audio oscillator produces frequencies in the audio range, about 16 Hz to 20 kHz. An RF oscillator produces signals in the radio frequency (RF) range of about 100 kHz to 100 GHz. A low-frequency oscillator (LFO) is an electronic oscillator that generates a frequency below 20 Hz. This term is typically used in the field of audio synthesizers, to distinguish it from an audio frequency oscillator.

3.5.1 Working Principle Of A Simple Lc Oscillator

Energy needs to move back and forth from one form to another for an oscillator to work. We can make a very simple oscillator by connecting a capacitor and an inductor together. A capacitor stores energy in the form of an electrostatic field, while an inductor uses a magnetic field. Imagine the following circuit below:

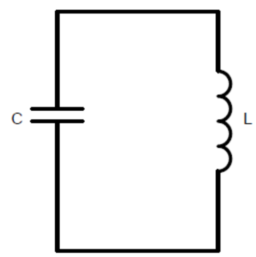


Figure 7: Simple LC Tank

If we charge up the capacitor with a battery and then insert the inductor into the circuit, the following will happen:

I. The capacitor will start to discharge through the inductor. As it does, the inductor will create a magnetic field.

II. Once the capacitor discharges, the inductor will try to keep the current in the circuit moving, so it will charge up the other plate of the capacitor.

III. Once the inductor's field collapses, the capacitor has been recharged (but with the opposite polarity), so it discharges again through the inductor.

This oscillation will continue until the circuit runs out of energy due to resistance in the wire. It will oscillate at a frequency that depends on the size of the inductor and the capacitor.

3.5.2 The Oscillator Circuit Of System

The prototype oscillator Circuit designed for the project is a modified Royer oscillator (Figure 6.2). This oscillator circuit is incredibly simple yet a very powerful design. Very high oscillating current can be achieved with this circuit depending on the semiconductor used. Here high current is necessary to increase the strength of the magnetic field. Although Insulated Gate Bipolar Transistors (IGBT) is recommended for this type of oscillator, but IGBTs have limitations in high frequencies. Thus, a HEXFET Power MOSFET was used for its properties. The HEXFET is ultra-low on resistance and has an operating temperature of 175°C. It has an advanced process technology and is very fast in switching.

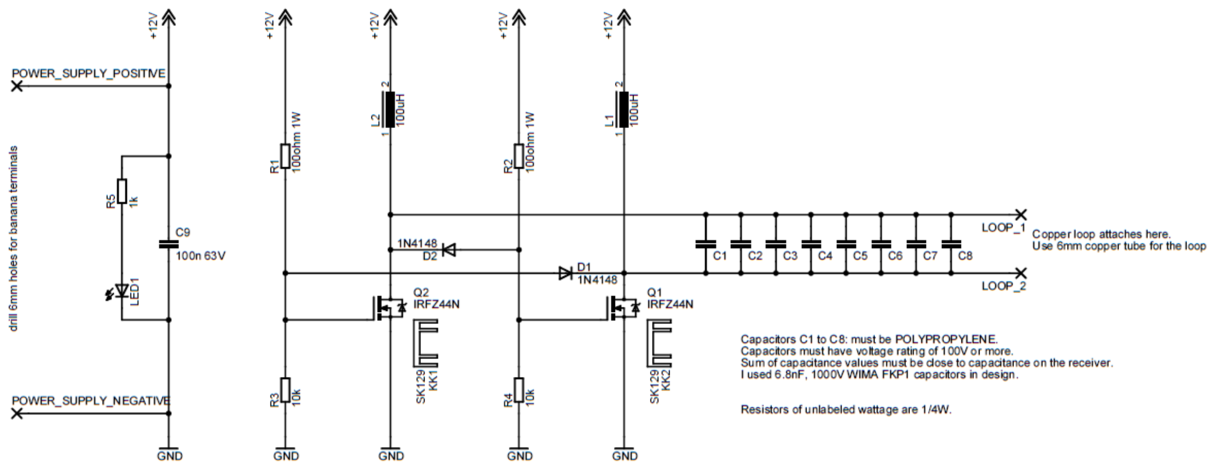


Figure 8: Oscillator Circuit

3.5.3 Operation Of The Oscillator Circuit For The System

The circuit consists of with two chokes labeled L1 and L2, two semiconductors (Here N-channel Enhancement power-MOSFETS) labeled Q1 and Q2, a resonating capacitor labeled C and an inductor (here the transmitter coil) labeled L. Cross-coupled feedback is provided via the diodes D1 and D2. R1, R3 and R2, R4 are the biasing network for MOSFETS Q1 and Q2.

When power is applied, DC current flows through the two sides of the coil and to the transistors' drain. At the same time the voltage appears on both gates and starts to turn the transistors on. One transistor is invariably a little faster than the other and will turn on more. The added current flowing in that side of the coil does two things. One, it takes away drive from the other transistor.

Two, the auto-transformer action impresses a positive voltage on the conducting transistor, turning it hard on. The current would continue to increase until the coil (transformer) saturates. The resonating capacitor C causes the voltage across the primary to first rise and then fall in a standard sine wave pattern.

Assuming that Q1 turned on first, the voltage at the drain of Q1's will be clamped to near ground while the voltage at Q2's drain rises to a peak and then falls as the tank formed by the capacitor and the coil primary oscillator through one half cycle.

The oscillator runs at the frequency determined by the inductance of the coil, the capacitor value and to a lesser extent, the load applied to the secondary (Source coil).

The operating frequency is the familiar formula for resonance,

F= $1/2 \times \pi \times \sqrt{(LC)}$………………………………………… **(1)**

3.6 BATTERY

Figure 9: Battery

An electric battery is a device consisting of one or more electrochemical cells that convert stored chemical energy into electrical energy. Each cell contains a positive terminal, or cathode, and a negative terminal, or anode. Electrolytes allow ions to move between the electrodes and terminals, which allows current to flow out of the battery to perform work.

Primary (single-use or "disposable") batteries are used once and discarded; the electrode materials are irreversibly changed during discharge. Common examples are the alkaline battery used for flashlights and a multitude of portable devices. Secondary(rechargeable batteries) can be discharged and recharged multiple times; the original composition of the electrodes can be restored by reverse current. Examples include the lead-acid batteries used in vehicles and lithium ion batteries used for portable electronics.

Batteries come in many shapes and sizes, from miniature cells used to power hearing aids and wristwatches to battery banks the size of rooms that provide standby power for telephone exchanges and computer data centers.

Batteries have much lower specific energy (energy per unit mass) than common fuels such as gasoline. This is somewhat offset by the higher efficiency of electric motors in producing mechanical work, compared to combustion engines.

3.6.1 Battery Charger

A **battery charger** or **recharger** is a device used to put energy into a secondary cell or rechargeable battery by forcing an electric currentt through it.

The charging protocol depends on the size and type of the battery being charged. Some battery types have high tolerance for overcharging and can be recharged by connection to a constant voltage source or a constant current source; simple chargers of this type require manual disconnection at the end of the charge cycle, or may have a timer to cut off charging current at a fixed time. Other battery types cannot withstand long high-rate over-charging; the charger may have temperature or voltage sensing circuits and a microprocessor controller to adjust the charging current, determine the state of chargee and cut off at the end of charge.

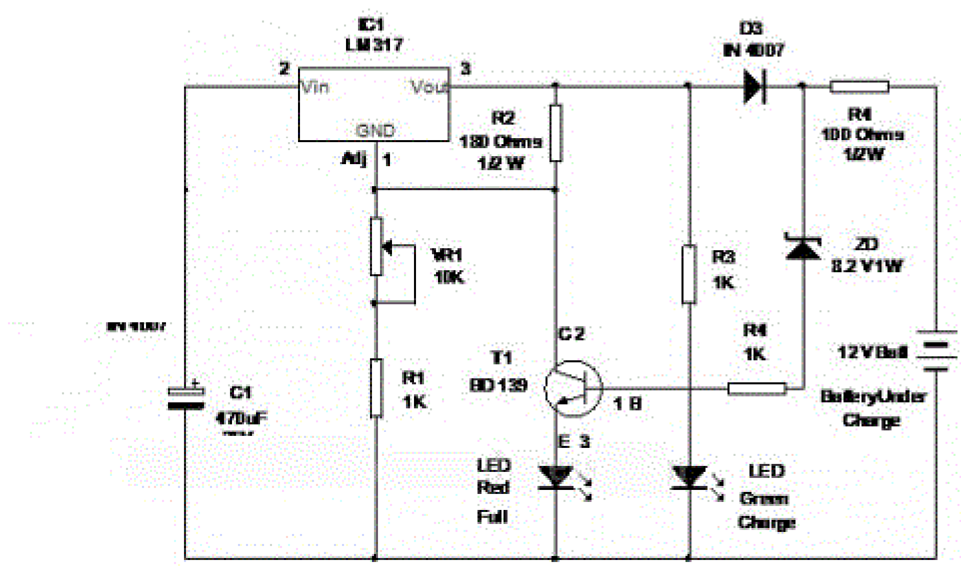


Figure 10: Battery Circuit

3.6.2 Battery Charger Circuit

Working of the circuit is too simple. The 15-0-15 – 1 Ampere step-down transformer with its rectifiers D1 ,D2 and smoothing capacitor C1 provides 15 Volt DC to the Three terminal variable voltage regulator IC LM317. It can handle up to 1.5 ampere current and can vary the output voltage from 1.2 volts to 37 volts. The output depends on the feedback from the output pin (pin 3) to the adjust pin (pin1) of LM 317. By adjusting VR1 it is easy to set the output voltage from 1.2 V to 15 V DC. The charging current depends on the values of R1 and R4 and around 300 milli amperes current is available for charging at 15 volt DC.

When the output is available from IC1, Green LED lights and current flows through diode D3 and resistor R4 to the battery provided the battery voltage is below 12 volts. Zener diode will not conduct in this state since the battery takes all the current for charging. When the terminal voltage of battery rises to 13.5 volts, the current flow to the battery ceases and Zener gets breakdown voltage and it conducts. The current from the Zener forward bias T1 so that all the output current from LM 317 will be drained through T1 to the ground as indicated by the Red LED. This stops the charging process. Charger remains in this state till the battery voltage drops below 12 volts (break down voltage of Zener). If this happens Zener turns off and T1 switched off allowing output current from LM317 to pass into the battery for charging again.

3.7 LDR

A photo resistor or light dependent resistor or cadmium sulfide (CdS) cell is a resistor whose resistance decreases with increasing incident light intensity. It can also be referenced as a photoconductor.

3.7.1 Photo Resistor

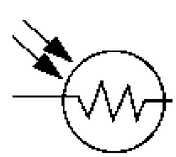


Figure 11: symbol of Photo Resistor

The symbol for a photo resistor

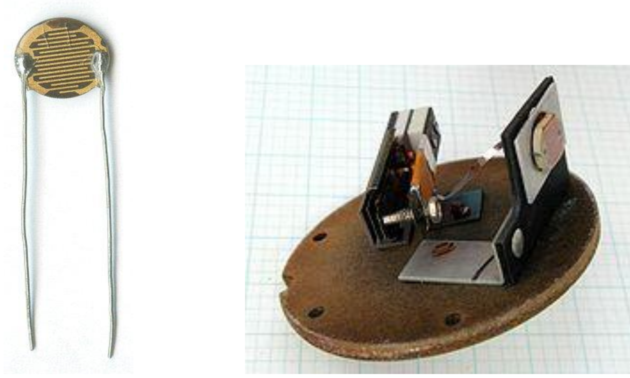


Figure 12: LDR

The internal components of a photoelectric control for a typical American streetlight:

The photo resistor is facing rightwards, and controls whether current flows through the heater which opens the main power contacts. At night, the heater cools, closing the power contacts, energizing the street light. The heater/bimetal mechanism provides a built-in time-delay.

A photo resistor or light dependent resistor or cadmium sulfide (CdS) cell is a resistor whose resistance decreases with increasing incident light intensity. It can also be referenced as a photoconductor.

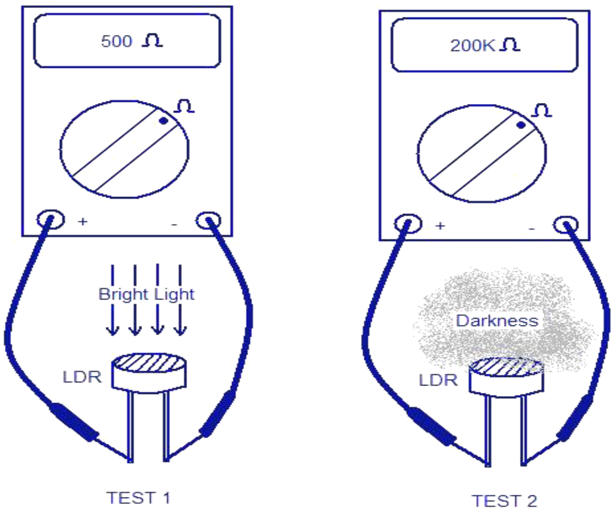


Figure 13:Diagram Of Testing Of LDR

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

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

3.7.2 Applications Of Photo Resistor:

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

- They are also used in some dynamic compressors together with a small incandescent lamp or light emitting diode to control gain reduction.Lead sulfide (PbS) and indium antimonide (InSb) LDR's (light dependent resistor) are used for the mid infrared spectral region.

- Ge:Cu photoconductors are among the best far-infrared detectors available, and are used for infrared astronomy and infrared spectroscopy.

3.8 LCD DISPLAY

LCD Background: One of the most common devices attached to a micro controller is an LCD display. Some of the most common LCD's connected to the many microcontrollers are 16x2 and 20x2 displays. This means 16 characters per line by 2 lines and 20 characters per line by 2 lines, respectively.

3.8.1 Basic 16x 2 Characters LCD

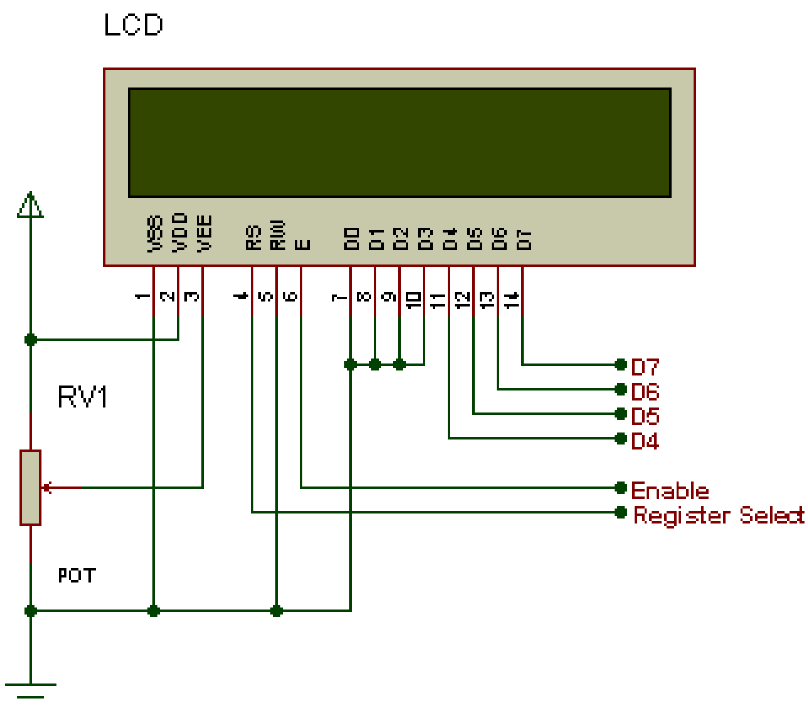


Figure 14: LCD Pin diagram

Pin description:

Pin No.	Name	Description
Pin no. 1	**VSS**	Power supply (GND)
Pin no. 2	**VCC**	Power supply (+5V)
Pin no. 3	**VEE**	Contrast adjust
Pin no. 4	**RS**	0 = Instruction input 1 = Data input
Pin no. 5	**R/W**	0 = Write to LCD module 1 = Read from LCD module
Pin no. 6	**EN**	Enable signal
Pin no. 7	**D0**	Data bus line 0 (LSB)
Pin no. 8	**D1**	Data bus line 1
Pin no. 9	**D2**	Data bus line 2
Pin no. 10	**D3**	Data bus line 3
Pin no. 11	**D4**	Data bus line 4
Pin no. 12	**D5**	Data bus line 5
Pin no. 13	**D6**	Data bus line 6
Pin no. 14	**D7**	Data bus line 7 (MSB)

Table 1: Pin Description Of LCD

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

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

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

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

The **RW** line is the "Read/Write" control line. When RW is low (0), the information on the data bus is being written to the LCD. When RW is high (1), the program is effectively querying (or reading) the LCD. Only one instruction ("Get LCD status") is a read command. All others are write commands--so RW will almost always be low.

Finally, the data bus consists of 4 or 8 lines (depending on the mode of operation selected by the user). In the case of an 8-bit data bus, the lines are referred to as DB0, DB1, DB2, DB3, DB4, DB5, DB6, and DB7.

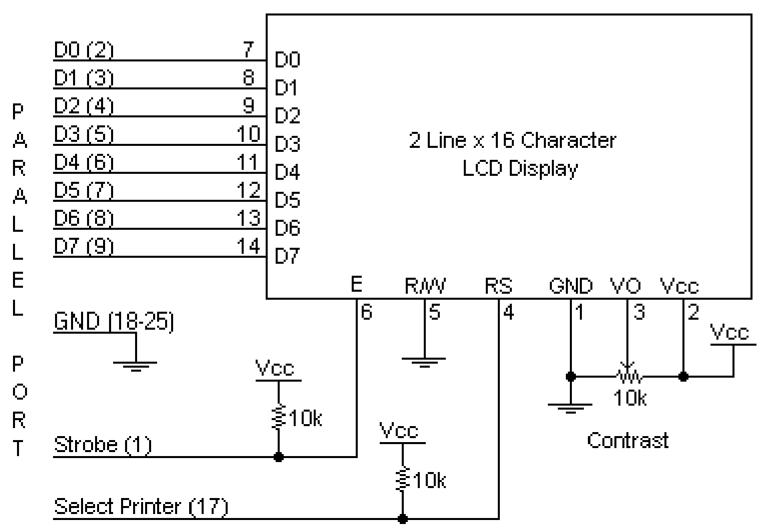


Figure 15: Schematic of LCD display

3.8.2 Circuit Description:

Above is the quite simple schematic. The LCD panel's Enable and Register Select is connected to the Control Port. The Control Port is an open collector / open drain output. While most Parallel Ports have internal pull-up resistors, there is a few which don't. Therefore by incorporating the two 10K external pull up resistors, the circuit is more portable for a wider range of computers, some of which may have no internal pull up resistors.

We make no effort to place the Data bus into reverse direction. Therefore we hard wire the R/W line of the LCD panel, into write mode. This will cause no bus conflicts on the data lines. As a result we cannot read back the LCD's internal Busy Flag which tells us if the LCD has accepted and finished processing the last instruction. This problem is overcome by inserting known delays into our program.

The 10k Potentiometer controls the contrast of the LCD panel. Nothing fancy here. As with all the examples, I've left the power supply out. We can use a bench power supply set to 5v or use an onboard +5 regulator. Remember a few de-coupling capacitors, especially if we have trouble with the circuit working properly.

SETB RW :

Handling the EN control line: As we mentioned above, the EN line is used to tell the LCD that we are ready for it to execute an instruction that we've prepared on the data bus and on the other control lines. Note that the EN line must be raised/ lowered before/after each instruction sent to the LCD regardless of whether that instruction is read or write text or instruction. In short, we must always manipulate EN when communicating with the LCD. EN is the LCD's way of knowing that we are talking to it. If we don't raise/lower EN, the LCD doesn't know we're talking to it on the other lines.

Thus, before we interact in any way with the LCD we will always bring the **EN** line low with the following instruction:

CLR EN: And once we've finished setting up our instruction with the other control lines and data bus lines, we'll always bring this line high:

SETB EN: The line must be left high for the amount of time required by the LCD as specified in its datasheet. This is normally on the order of about 250 nanoseconds, but checks the datasheet. In the case of a typical microcontroller running at 12 MHz, an instruction requires 1.08 microseconds to execute so the EN line can be brought low the very next instruction. However, faster microcontrollers (such as the DS89C420 which executes an instruction in 90 nanoseconds given an 11.0592 MHz crystal) will require a number of NOPs to create a delay while EN is held high. The number of NOPs that must be inserted depends on the microcontroller we are using and the crystal we have selected.

The instruction is executed by the LCD at the moment the EN line is brought low with a final CLR EN instruction.

3.8.3 Checking the busy status of the LCD:

As previously mentioned, it takes a certain amount of time for each instruction to be executed by the LCD. The delay varies depending on the frequency of the crystal attached to the oscillator input of the LCD as well as the instruction which is being executed.

While it is possible to write code that waits for a specific amount of time to allow the LCD to execute instructions, this method of "waiting" is not very flexible. If the crystal frequency is changed, the software will need to be modified. A more robust method of programming is to use the "Get LCD Status" command to determine whether the LCD is still busy executing the last instruction received.

The "Get LCD Status" command will return to us two tidbits of information; the information that is useful to us right now is found in DB7. In summary, when we issue the "Get LCD Status" command the LCD will immediately raise DB7 if it's still busy executing a command or lower DB7 to indicate that the LCD is no longer occupied. Thus our program can query the LCD until DB7 goes low, indicating the LCD is no longer busy. At that point we are free to continue and send the next command.

3.8.4 Applications:

- Medical equipment
- Electronic test equipment
- Industrial machinery Interface
- Serial terminal
- Advertising system
- EPOS
- Restaurant ordering systems
- Gaming box
- Security systems
- R&D Test units
- Climatizing units
- PLC Interface
- Simulators
- Environmental monitoring
- Lab development
- Student projects
- Home automation
- PC external display
- HMI operator interface.

3.9 MICRO CONTROLLER:

Figure 16: Microcontrollers

3.9.1 Introduction to Microcontrollers:

Circumstances that we find ourselves in today in the field of microcontrollers had their beginnings in the development of technology of integrated circuits. This development has made it possible to store hundreds of thousands of transistors into one chip. That was a prerequisite for production of microprocessors, and the first computers were made by adding external peripherals such as memory, input-output lines, timers and other. Further increasing of the volume of the package resulted in creation of integrated circuits. These integrated circuits contained both processor and peripherals. That is how the first chip containing a microcomputer, or what would later be known as a microcontroller came about.

Microprocessors and microcontrollers are widely used in embedded systems products. Microcontroller is a programmable device. A microcontroller has a CPU in addition to a fixed amount of RAM, ROM, I/O ports and a timer embedded all on a single chip. The fixed amount of on-chip ROM, RAM and number of I/O ports in microcontrollers makes them ideal for many applications in which cost and space are critical.

The AVR is a modified Harvard architecture 8-bit RISC single chip microcontroller which was developed by Atmel in 1996. The AVR was one of the first microcontroller families to use on-chip flash memory for program storage, as opposed to One-Time Programmable ROM, EPROM, or EEPROM used by other microcontrollers at the time.

3.9.2 Crystal Oscillator:

XTAL1 and XTAL2 are input and output, respectively, of an inverting amplifier which can be configured for use as an On-chip Oscillator, Either a quartz

Crystal or a ceramic resonator may be used. The CKOPT Fuse selects between two different Oscillator amplifier modes. When CKOPT is programmed, the Oscillator output will oscillate a full rail-to-rail swing on the output. This mode is suitable when operating in a very noisy environment or when the output from XTAL2 drives a second clock buffer. This mode has a wide frequency range. When CKOPT is unprogrammed, the Oscillator has a smaller output swing. This reduces power consumption considerably.

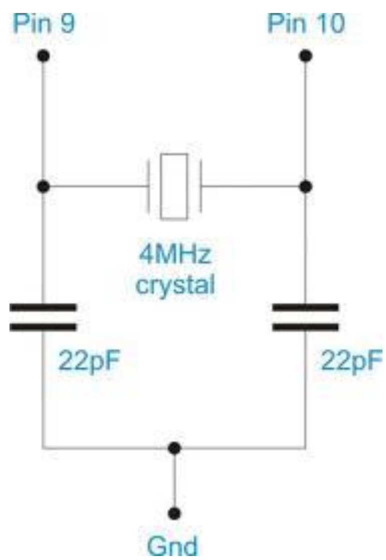


Figure 17: Crystal Oscillator Circuit

This mode has a limited frequency range and it cannot be used to drive other clock buffers. For resonators, the maximum frequency is 8 MHz with CKOPT unprogrammed and 16 MHz with CKOPT programmed. C1 and C2 should always be equal for both crystals and resonators. The optimal value of the capacitors depends on the crystal or resonator in use, the amount of stray capacitance, and the electromagnetic noise of the environment. For ceramic resonators, the capacitor values given by the manufacturer should be used. The Oscillator can operate in three different modes, each optimized for a specific frequency range. The operating mode is selected by the fuses CKSEL3..1

3.9.3 Architecture of AVR:

Memory: It has **8 Kb** of Flash program memory (10,000 Write/Erase cycles durability), **512 Bytes** of EEPROM (100,000 Write/Erase Cycles). **1Kbyte** Internal SRAM

I/O Ports: 23 I/ line can be obtained from three ports; namely Port B, Port C and Port D.

Interrupts: Two External Interrupt source, located at port D. 19 different interrupt vectors supporting 19 events generated by internal peripherals.

Timer/Counter: Three Internal Timers are available, two 8 bit, one 16 bit, offering various operating modes and supporting internal or external clocking.

SPI (Serial Peripheral interface): ATmega8 holds three communication devices integrated. One of them is Serial Peripheral Interface. Four pins are assigned to Atmega8 to implement this scheme of communication.

USART: One of the most powerful communication solutions is USART and ATmega8 supports both synchronous and asynchronous data transfer schemes. It has three pins assigned for that. In many projects, this module is extensively used for PC-Micro controller communication.

TWI (Two Wire Interface): Another communication device that is present in ATmega8 is Two Wire Interface. It allows designers to set up a commutation between two devices using just two wires along with a common ground connection, As the TWI output is made by means of open collector outputs, thus external pull up resistors are required to make the circuit.

Analog Comparator: A comparator module is integrated in the IC that provides comparison facility between two voltages connected to the two inputs of the Analog comparator via External pins attached to the micro controller.

Analog to Digital Converter: Inbuilt analog to digital converter can convert an analog input signal into digital data of **10bit** resolution. For most of the low end application, this much resolution is enough.

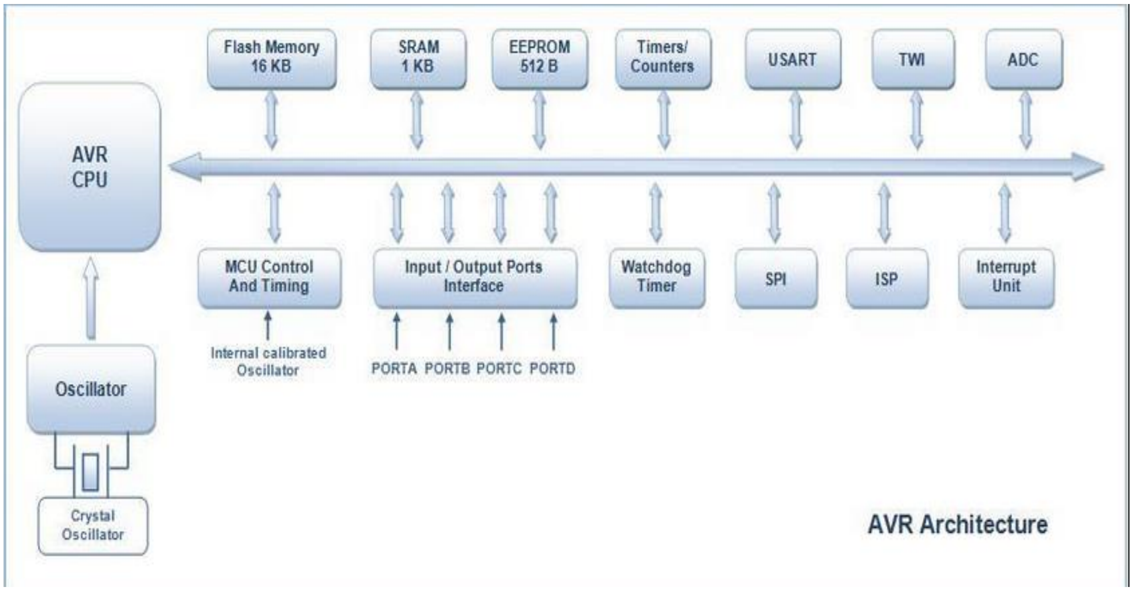


Figure 18: AVR Architecture

Microcontroller: Microcontroller can be termed as a single on chip computer which includes number of peripherals like RAM, EEPROM, Timers etc., required to perform some predefined task.

The computer on one hand is designed to perform all the general purpose tasks on a single machine like you can use a computer to run a software to perform calculations or you can use a computer to store some multimedia file or to access internet through the browser, whereas the microcontrollers are meant to perform only the specific tasks, for e.g., switching the AC off automatically when room temperature drops to a certain defined limit and again turning it ON when temperature rises above the defined limit.

There are number of popular families of microcontrollers which are used in different applications as per their capability and feasibility to perform the desired task, most common of these are 8051, **AVR** and PIC microcontrollers. In this article we will introduce you with **AVR** family of microcontrollers.

AVR was developed in the year 1996 by Atmel Corporation. The architecture of **AVR** was developed by Alf-Egil Bogen and Vegard Wollan. AVR derives its name from its developers and stands for **Alf-Egil Bogen Vegard Wollan RISC microcontroller**, also known as **A**dvanced **V**irtual **R**ISC. The AT90S8515 was the first microcontroller which was based on **AVR architecture** however the first microcontroller to hit the commercial market was AT90S1200 in the year 1997.

AVR microcontrollers are available in three categories:

1. **TinyAVR** – Less memory, small size, suitable only for simpler applications

2. **MegaAVR** – These are the most popular ones having good amount of memory (upto 256 KB), higher number of inbuilt peripherals and suitable for moderate to complex applications.

3. **XmegaAVR** – Used commercially for complex applications, which require large program memory and high speed.

3.9.4 Architecture Of AtMega328p

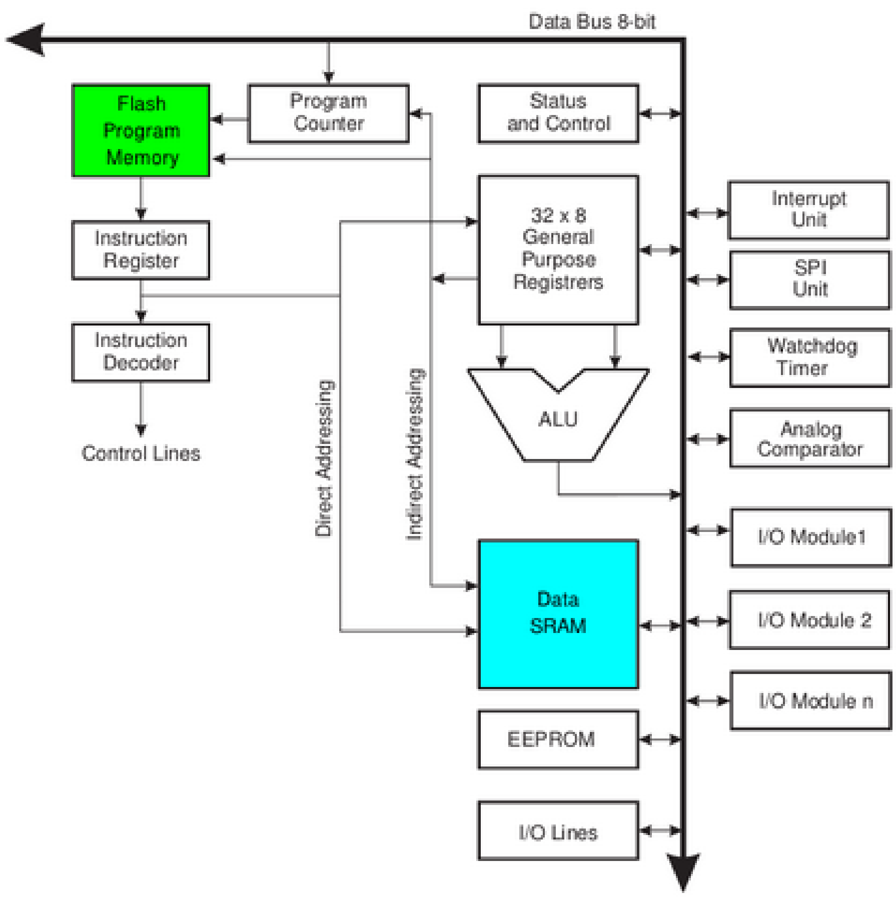


Figure 19: Architecture Of AtMega328p

Device architecture

Flash, EEPROM, and SRAM are all integrated onto a single chip, removing the need for external memory in most applications. Some devices have a parallel external bus option to allow adding additional data memory or memory-mapped devices. Almost all devices (except the smallest TinyAVR chips) have serial interfaces, which can be used to connect larger serial EEPROMs or flash chips.

Program memory

Program instructions are stored in non-volatile flash memory. Although the MCUs are 8-bit, each instruction takes one or two 16-bit words.

The size of the program memory is usually indicated in the naming of the device itself (e.g., the ATmega64x line has 64 kB of flash while the ATmega32x line has 32 kB).

There is no provision for off-chip program memory; all code executed by the AVR core must reside in the on-chip flash. However, this limitation does not apply to the AT94 FPSLIC AVR/FPGA chips.

Internal data memory

The data address space consists of the register file, I/O registers, and SRAM.

Internal registers

The AVRs have 32 single-byte registers and are classified as 8-bit RISC devices.

In most variants of the AVR architecture, the working registers are mapped in as the first 32 memory addresses (0000_{16}–$001F_{16}$) followed by the 64 I/O registers (0020_{16}–$005F_{16}$).

Actual SRAM starts after these register sections (address 0060_{16}). (Note that the I/O register space may be larger on some more extensive devices, in which case the memory mapped I/O registers will occupy a portion of the SRAM address space.)

Even though there are separate addressing schemes and optimized opcodes for register file and I/O register access, all can still be addressed and manipulated as if they were in SRAM.

In the XMEGA variant, the working register file is not mapped into the data address space; as such, it is not possible to treat any of the XMEGA's working registers as though they were SRAM. Instead, the I/O registers are mapped into the data address space starting at the very beginning of the address space. Additionally, the amount of data address space dedicated to I/O registers has grown substantially to 4096 bytes (0000_{16}–$0FFF_{16}$). As with previous generations, however, the fast I/O manipulation instructions can only reach the first 64 I/O register locations (the first 32 locations for bitwise instructions). Following the I/O registers, the XMEGA series sets aside a 4096 byte range of the data address space which can be used optionally for mapping the internal EEPROM to the data address space (1000_{16}–$1FFF_{16}$). The actual SRAM is located after these ranges, starting at 2000_{16}.

EEPROM

Almost all AVR microcontrollers have internal EEPROM for semi-permanent data storage. Like flash memory, EEPROM can maintain its contents when electrical power is removed.

In most variants of the AVR architecture, this internal EEPROM memory is not mapped into the MCU's addressable memory space. It can only be accessed the same way an external peripheral device is, using special pointer registers and read/write instructions which makes EEPROM access much slower than other internal RAM.

However, some devices in the SecureAVR (AT90SC) family use a special EEPROM mapping to the data or program memory depending on the configuration. The XMEGA family also allows the EEPROM to be mapped into the data address space.

Since the number of writes to EEPROM is not unlimited — Atmel specifies 100,000 write cycles in their datasheets — a well designed EEPROM write routine should compare the contents of an EEPROM address with desired contents and only perform an actual write if the contents need to be changed.

Note that erase and write can be performed separately in many cases, byte-by-byte, which may also help prolong life when bits only need to be set to all 1s (erase) or selectively cleared to 0s (write).

Program execution

Atmel's AVRs have a two stage, single level pipeline design. This means the next machine instruction is fetched as the current one is executing. Most instructions take just one or two clock cycles, making AVRs relatively fast among eight-bit microcontrollers.

The AVR processors were designed with the efficient execution of compiled C code in mind and have several built-in pointers for the task.

MCU speed

The AVR line can normally support clock speeds from 0 to 20 MHz, with some devices reaching 32 MHz. Lower powered operation usually requires a reduced clock speed. All recent (Tiny, Mega, and Xmega, but not 90S) AVRs feature an on-chip oscillator, removing the need for external clocks or resonator circuitry. Some AVRs also have a system clock prescaler that can divide down the system clock by up to 1024. This prescaler can be reconfigured by software during run-time, allowing the clock speed to be optimized.

Since all operations (excluding literals) on registers R0 - R31 are single cycle, the AVR can achieve up to 1 MIPS per MHz, i.e. an 8 MHz processor can achieve up to 8 MIPS. Loads and stores to/from memory take two cycles, branching takes two cycles. Branches in the latest "3-byte PC" parts such as ATmega2560 are one cycle slower than on previous devices

Features:

• High-performance, Low-power Atmel®AVR® 8-bit Microcontroller

• Advanced RISC Architecture

– 130 Powerful Instructions – Most Single-clock Cycle Execution

– 32 × 8 General Purpose Working Registers

– Fully Static Operation

– Up to 16MIPS Throughput at 16MHz

– On-chip 2-cycle Multiplier

• High Endurance Non-volatile Memory segments

– 8Kbytes of In-System Self-programmable Flash program memory

– 512Bytes EEPROM

– 1Kbyte Internal SRAM

– Write/Erase Cycles: 10,000 Flash/100,000 EEPROM

– Data retention: 20 years at 85°C/100 years at 25°C(1)

– Optional Boot Code Section with Independent Lock Bits

In-System Programming by On-chip Boot Program

True Read-While-Write Operation

– Programming Lock for Software Security

• Peripheral Features

– Two 8-bit Timer/Counters with Separate Prescaler, one Compare Mode

– One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture

Mode

– Real Time Counter with Separate Oscillator

– Three PWM Channels

– 8-channel ADC in TQFP and QFN/MLF package

Eight Channels 10-bit Accuracy

– 6-channel ADC in PDIP package

Six Channels 10-bit Accuracy

– Byte-oriented Two-wire Serial Interface

– Programmable Serial USART

– Master/Slave SPI Serial Interface

– Programmable Watchdog Timer with Separate On-chip Oscillator

– On-chip Analog Comparator

• Special Microcontroller Features

– Power-on Reset and Programmable Brown-out Detection

– Internal Calibrated RC Oscillator

– External and Internal Interrupt Sources

– Five Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, and

Standby

• I/O and Packages

– 23 Programmable I/O Lines

– 28-lead PDIP, 32-lead TQFP, and 32-pad QFN/MLF

• Operating Voltages

– 2.7V - 5.5V (ATmega8L)

– 4.5V - 5.5V (ATmega8)

• Speed Grades

– 0 - 8MHz (ATmega8L)

– 0 - 16MHz (ATmega8)

• Power Consumption at 4Mhz, 3V, 25oC

– Active: 3.6mA

– Idle Mode: 1.0mA

– Power-down Mode: 0.5µA

Brown-out Detector:

If the Brown-out Detector is not needed in the application, this module should be turned off. If the Brown-out Detector is enabled by the BODEN Fuse, it will be enabled in all sleep modes, and hence, always consume power. In the deeper sleep modes, this will contribute significantly to the total current consumption. Refer to “Brown-out Detection” on page 38 for details on how to configure the Brown-out Detector.

Internal Voltage Reference the Internal Voltage Reference will be enabled when needed by the Brown-out Detector, the Analog Comparator or the ADC. If these modules are disabled as described in the sections above, the internal voltage reference will be disabled and it will not be consuming power. When turned on again, the user must allow the reference to start up before the output is used. If the reference is kept on in sleep mode, the output can be used immediately. Refer to “Internal Voltage Reference” on page 40 for details on the start-up time. Watchdog Timer If the Watchdog Timer is not needed in the application, this module should be turned off.

If the Watchdog Timer is enabled, it will be enabled in all sleep modes, and hence, always consume power. In the deeper sleep modes, this will contribute significantly to the total current consumption. Refer to “Watchdog Timer” on page 41 for details on how to configure the Watchdog Timer. Port Pins When entering a sleep mode, all port pins should be configured to use minimum power.

The most important thing is then to ensure that no pins drive resistive loads. In sleep modes where the both the I/O clock (clkI/O) and the ADC clock (clkADC) are stopped, the input buffers of the device will be disabled. This ensures that no power is consumed by the input logic when not needed. In some cases, the input logic is needed for detecting wake-up conditions, and it will then be enabled. Refer to the section “Digital Input Enable and Sleep Modes” on page 53 for details on which pins are enabled. If the input buffer is enabled and the input signal is left floating or have an analog signal level close to VCC/2, the input buffer will use excessive power.

Power-on Reset:

A Power-on Reset (POR) pulse is generated by an On-chip detection circuit. The detection level is defined in Table 15. The POR is activated whenever VCC is below the detection level. The POR circuit can be used to trigger the Start-up Reset, as well as to detect a failure in supply voltage.

A Power-on Reset (POR) circuit ensures that the device is reset from Power-on. Reaching the Power-on Reset threshold voltage invokes the delay counter, which determines how long the device is kept in RESET after VCC rise. The RESET signal is activated again, without any delay, when VCC decreases below the detection level.

External Reset:

An External Reset is generated by a low level on the RESET pin. Reset pulses longer than the minimum pulse width (see Table 15) will generate a reset, even if the clock is not running. Shorter pulses are not guaranteed to generate a reset. When the applied signal reaches the Reset Threshold Voltage – VRST on its positive edge, the delay counter starts the MCU after the time-out period tTOUT has expired.

3.9.3 Pin diagram:

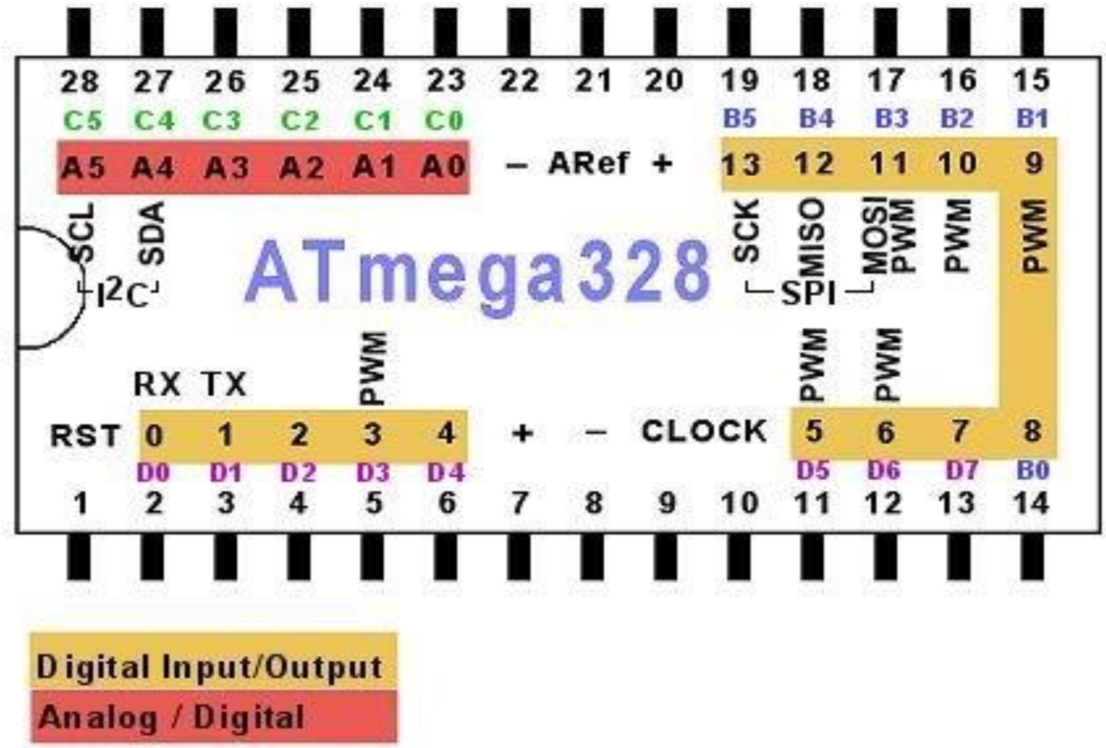


Figure 20: IC ATmega328

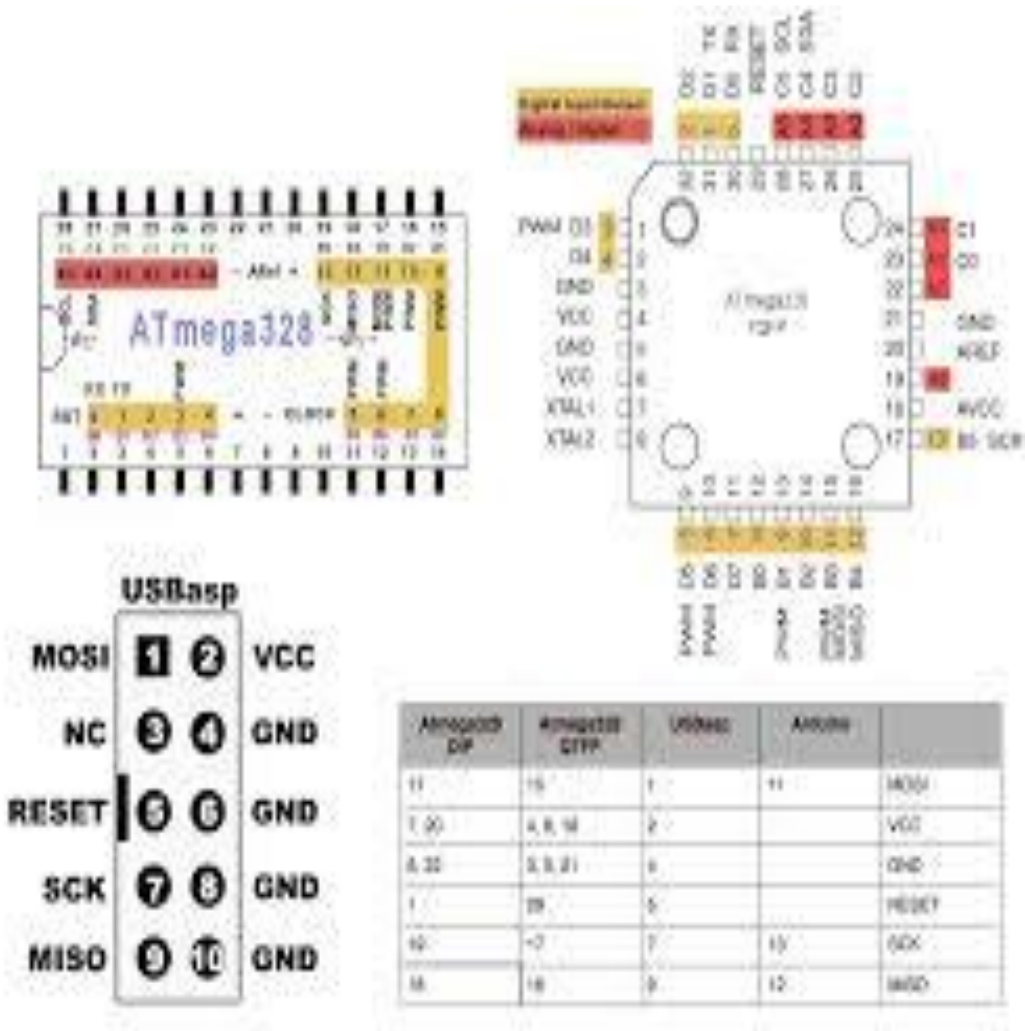


Figure 21: PIN Diagram OF ATmega328

VCC

Digital supply voltage magnitude of the voltage range between 4.5 to 5.5 V for the ATmega8 and 2.7 to 5.5 V for ATmega8L

GND

Ground Zero reference digital voltage supply.

PORTB (PB7.. PB0)

PORTB is a port I / O two-way (bidirectional) 8-bit with internal pull-up resistor can be selected. This port output buffers have symmetrical characteristics when used as a source or sink. When used as an input, the pull-pin low externally will emit a current if the pull-up resistor is activated it. PORTB pins will be in the condition of the tri-state when RESET is active, although the clock is not running.

PORTC (PC5.. PC0)

PORTC is a port I / O two-way (bidirectional) 7-bit with internal pull-up resistor can be selected. This port output buffers have symmetrical characteristics when used as a source or sink. When used as an input, the pull-pin low externally will emit a current if the pull-up resistor is activated it. PORTC pins will be in the condition of the tri-state when RESET is active, although the clock is not running.

PC6/RESET

If RSTDISBL Fuse programmed, PC6 then serves as a pin I / O but with different characteristics. PC0 to PC5 If Fuse RSTDISBL not programmed, then serves as input Reset PC6. LOW signal on this pin with a minimum width of 1.5 microseconds will bring the microcontroller into reset condition, although the clock is not running.

PORTD (PD7.. PD0)

PORTD is a port I / O two-way (bidirectional) 8-bit with internal pull-up resistor can be selected. This port output buffers have symmetrical characteristics when used as a source or sink. When used as an input, the pull-pin low externally will emit a current if the pull-up resistor is activated it. PORTD pins will be in the condition of the tri-state when RESET is active, although the clock is not running.

RESET

Reset input pin. LOW signal on this pin with a minimum width of 1.5 microseconds will bring the microcontroller into reset condition, although the clock is not running. Signal with a width of less than 1.5 microseconds does not guarantee a Reset condition.

AVCC

AVCC is the supply voltage pin for the ADC, PC3 .. PC0, and ADC7..ADC6. This pin should be connected to VCC, even if the ADC is not used. If the ADC is used, AVCC should be connected to VCC through a low-pass filter to reduce noise.

Aref

Analog Reference pin for the ADC.

ADC7 .. ADC6

ADC analog input there is only on ATmega8 with TQFP and QFP packages / MLF.

PORTS

Term "port" refers to a group of pins on a microcontroller which can be accessed simultaneously, or on which we can set the desired combination of zeros and ones, or read from them an existing status. Physically, port is a register inside a microcontroller which is connected by wires to the pins of a microcontroller. Ports represent physical connection of Central Processing Unit with an outside world. Microcontroller uses them

The Atmega8 has 23 I/O ports which are organized into 3 groups:

- Port B (PB0 to PB7)
- Port C (PC0 to PC6)
- Port D (PD0 to PD7)

We will use mainly 3 registers known as **DDRX, PORTX** & **PINX**. We have total four PORTs on my ATmega16. They are **PORTA, PORTB, PORTC** and **PORTD**. They are multifunctional pins. Each of the pins in each port (total 32) can be treated as input or output pin.

3.9.5 Applications

AVR microcontroller perfectly fits many uses, from automotive industries and controlling home appliances to industrial instruments, remote sensors, electrical door locks and safety devices. It is also ideal for smart cards as well as for battery supplied devices because of its low consumption.

EEPROM memory makes it easier to apply microcontrollers to devices where permanent storage of various parameters is needed (codes for transmitters, motor speed, receiver frequencies, etc.). Low cost, low consumption, easy handling and flexibility make ATmega8 applicable even in areas where microcontrollers had not previously been considered (example: timer functions, interface replacement in larger systems, coprocessor applications, etc.).

In System Programmability of this chip (along with using only two pins in data transfer) makes possible the flexibility of a product, after assembling and testing have been completed. This capability can be used to create assembly-line production, to store calibration data available only after final testing, or it can be used to improve programs on finished products.

3.10 SOLAR PANEL

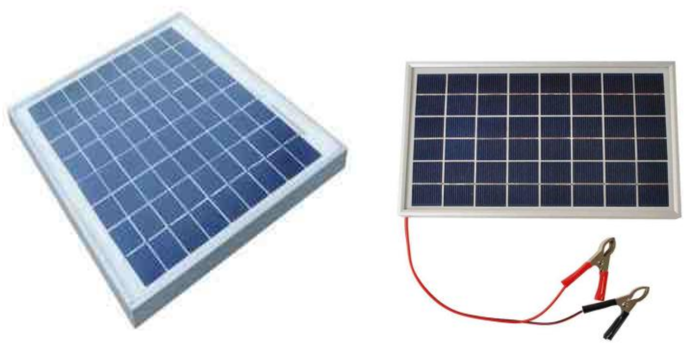


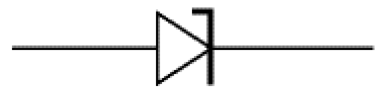
Figure 22: Solar Panel

Solar panel refers either to a photovoltaic (PV) module, a solar hot water panel, or to a set of solar photovoltaic modules electrically connected and mounted on a supporting structure. A PV module is a packaged, connected assembly of solar cells. Solar panels can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications. Each module is rated by its DC output power under standard test conditions, and typically ranges from 100 to 320 watts. The efficiency of a module determines the area of a module given the same rated output – an 8% efficient 230 watt module will have twice the area of a 16% efficient 230 watt module. There are a few solar panels available that are exceeding 19% efficiency. A single solar module can produce only a limited amount of power; most installations contain multiple modules. A photovoltaic system typically includes a panel or an array of solar modules, an inverter, and sometimes a battery and/or solar tracker and interconnection wiring.

The price of solar polar, together with batteries for storage, has continued to fall so that in many countries it is cheaper than ordinary fossil fuel electricity from the grid (there is "grid parity"). For example in 2015, an average home in Europe or the US could use around 3000kWh in electricity each year. Twelve 280 Watt solar panels (each generating 250 kWh annually) would generate at least 3000 kWh each year, even in a cloudy country like the UK

3.11 ZENER DIODE

Example: 

Circuit symbol: 

a = anode, k = cathode

Figure 23: Zener Diode

Zener diodes are used to maintain a fixed voltage. They are designed to 'breakdown' in a reliable and non-destructive way so that they can be used **in reverse** to maintain a fixed voltage across their terminals. The diagram shows how they are connected, with a resistor in series to limit the current.

Zener diodes can be distinguished from ordinary diodes by their code and breakdown voltage which are printed on them. Zener diode codes begin BZX... or BZY... Their breakdown voltage is printed with V in place of a decimal point, so 4V7 means 4.7V for example.

Zener diodes are rated by their breakdown voltage and maximum power:

A Zener diode is a type of diode that permits current not only in the forward direction like a normal diode, but also in the reverse direction if the voltage is larger than the breakdown voltage known as "Zener knee voltage" or "Zener voltage". The device was named after Clarence Zener, who discovered this electrical property.

A conventional solid-state diode will not allow significant current if it is reverse-biased below its reverse breakdown voltage. When the reverse bias breakdown voltage is exceeded, a conventional diode is subject to high current due to avalanche breakdown. Unless this current is limited by circuitry, the diode will be permanently damaged due to overheating. In case of large forward bias (current in the direction of the arrow), the diode exhibits a voltage drop due to its junction built-in voltage and internal resistance. The amount of the voltage drop depends on the semiconductor material and the doping concentrations.

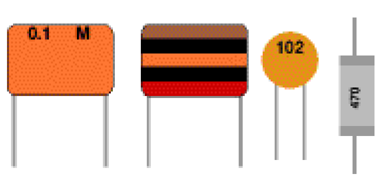
A Zener diode exhibits almost the same properties, except the device is specially designed so as to have a greatly reduced breakdown voltage, the so-called Zener voltage. By contrast with the conventional device, a reverse-biased Zener diode will exhibit a controlled breakdown and allow the current to keep the voltage across the Zener diode close to the Zener breakdown voltage

3.12 FILTER

The Filter is used to remove the pulsated AC. A filter circuit uses capacitor and inductor. The function of the capacitor is to block the DC voltage and bypass the AC voltage. The function of the inductor is to block the AC voltage and bypass the DC voltage.

Capacitors store electric charge. They are used with resistors in timing circuits because it takes time for a capacitor to fill with charge. They are used to smooth varying DC supplies by acting as a reservoir of charge. They are also used in filter circuits because capacitors easily pass AC (changing) signals but they block DC (constant) signals.

3.12.1 UNPOLARISED CAPACITORS (SMALL VALUES, UP TO 1μF)

Examples: 

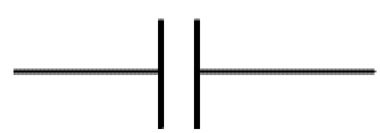
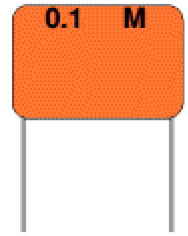
Circuit symbol: 

Figure 24: Unpolarised Capacitors

Small value capacitors are unpolarised and may be connected either way round. They are not damaged by heat when soldering, except for one unusual type (polystyrene). They have high voltage ratings of at least 50V, usually 250V or so. It can be difficult to find the values of these small capacitors because there are many types of them and several different labelling systems!



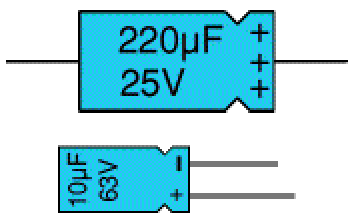
Many small value capacitors have their value printed but without a multiplier, so you need to use experience to work out what the multiplier should be!

For example **0.1** means 0.1μF = 100nF.

Sometimes the multiplier is used in place of the decimal point:

For example: **4n7** means 4.7nF.

3.12.2 POLARISED CAPACITORS (LARGE VALUES, 1μF +)

Examples: 

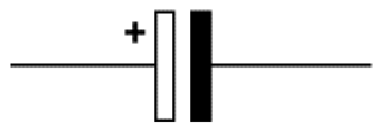
Circuit symbol: 

Figure 25: Polarised Capacitor

Electrolytic Capacitors

Electrolytic capacitors are polarized and they must be connected the correct way round, at least one of their leads will be marked + or -. They are not damaged by heat when soldering.

There are two designs of electrolytic capacitors; **axial** where the leads are attached to each end (220μF in picture) and **radial** where both leads are at the same end (10μF in picture). Radial capacitors tend to be a little smaller and they stand upright on the circuit board.

It is easy to find the value of electrolytic capacitors because they are clearly printed with their capacitance and voltage rating. The voltage rating can be quite low (6V for example) and it should always be checked when selecting an electrolytic capacitor. If the project parts list does not specify a voltage, choose a capacitor with a rating which is greater than the project's power supply voltage. 25V is a sensible minimum for most battery circuits.

3.13 INDUCTOR

Figure 26: Inductor

An inductor is a passive electronic component that storesenergy in the form of a magnetic field. In its simplest form, an inductor consistsof a wire loop or coil. The inductance is directly proportional to the number ofturns in the coil. Inductance also depends on the radius of the coil and on the type of material around which the coil is wound.

For a given coil radius and number of turns, air coresresult in the least inductance. Materials such as wood, glass, and plastic - known as dielectric materials - are essentially the same as air for the purposes of inductor winding. Ferromagnetic substances such as iron, laminated iron, and powdered iron increase the inductance obtainable with a coil having a given number of turns. In some cases, this increase is on the order of thousands of times. The shape of the core is also significant. Toroidal (donut-shaped) cores provide more inductance, for a given core material and number of turns, than solenoidal (rod-shaped) cores.

The standard unit of inductance is the henry, abbreviated. This is a large unit. More common units are the microhenry, abbreviated μH (1 μH =10^{-6}H) and the millihenry, abbreviated mH (1 mH =10^{-3} H). Occasionally, the nanohenry (nH) is used (1 nH = 10^{-9} H).

It is difficult to fabricate inductors onto integrated circuit (IC) chips. Fortunately, resistors can be substituted for inductors in most microcircuit applications. In some cases, inductance can be simulated by simple electronic circuits using transistors, resistors, and capacitors fabricated onto ICchips.

Inductors are used with capacitors in various wireless communications applications. An inductor connected in series or parallel with a capacitor can provide discrimination against unwanted signals. Large inductors are used in the power supplies of electronic equipment of all types, including computers and their peripherals. In these systems, the inductors help to smooth out the rectified utility AC, providing pure, battery-like DC.

3.13.1 NUMBER OF WIRE WRAPS, OR "TURNS" IN THE COIL:

All other factors being equal, a greater number of turns of wire in the coil results in greater inductance; fewer turns of wire in the coil results in less inductance.

Explanation: More turns of wire means that the coil will generate a greater amount of magnetic field force (measured in amp-turns!), for a given amount of coil current.

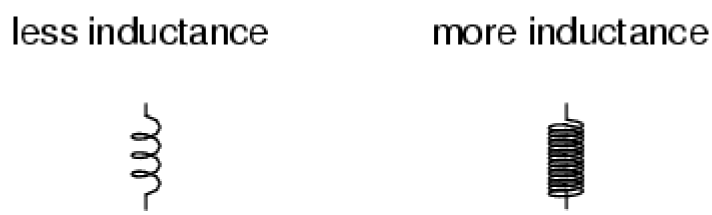


Figure 27: No. Of Turn Of Inductor

3.13.2 COIL AREA

All other factors being equal, greater coil area (as measured looking lengthwise through the coil, at the cross-section of the core) results in greater inductance; less coil area results in less inductance.

Explanation: Greater coil area presents less opposition to the formation of magnetic field flux, for a given amount of field force (amp-turns).

Figure 28: Bared On The Coil Area

3.13.3 COIL LENGTH

All other factors being equal, the longer the coil's length, the less inductance; the shorter the coil's length, the greater the inductance.

Explanation: A longer path for the magnetic field flux to take results in more opposition to the formation of that flux for any given amount of field force (amp-turns).

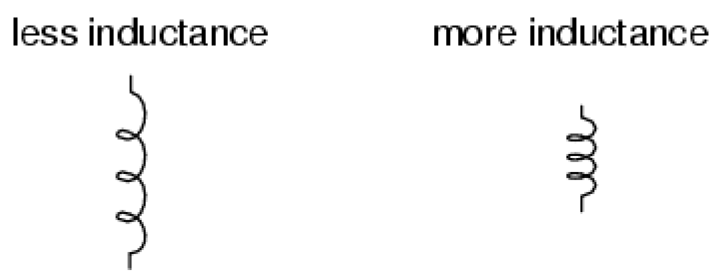


Figure 29: Based On The Coil Length

3.13.4 CORE MATERIAL

All other factors being equal, the greater the magnetic permeability of the core which the coil is wrapped around, the greater the inductance; the less the permeability of the core, the less the inductance.

Explanation: A core material with greater magnetic permeability results in greater magnetic field flux for any given amount of field force (amp-turns).

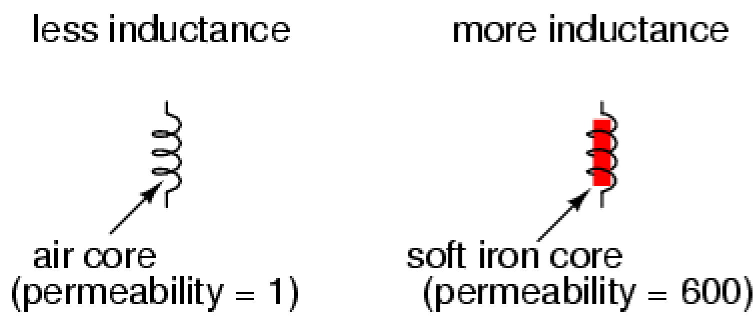
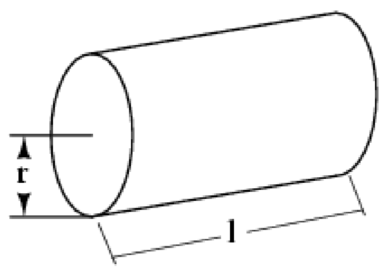


Figure 30: Based On The Coil Material

An approximation of inductance for any coil of wire can be found with this formula:

$$L = \frac{N^2 \mu A}{l}$$

$$\mu = \mu_r \mu_0$$



Where,

L = Inductance of coil in Henrys

N = Number of turns in wire coil (straight wire = 1)

μ = Permeability of core material (absolute, not relative)

μ_r = Relative permeability, dimensionless (μ_0=1 for air)

μ_0 = 1.26×10^{-6} T-m/At permeability of free space

A = Area of coil in square meters = πr^2

l = Average length of coil in meters

It must be understood that this formula yields *approximate* figures only. One reason for this is the fact that permeability changes as the field intensity varies (remember the nonlinear "B/H" curves for different materials). Obviously, if permeability (μ) in the equation is unstable, then the inductance (L) will also be unstable to some degree as the current through the coil changes in magnitude. If the hysteresis of the core material is significant, this will also have strange effects on the inductance of the coil. Inductor designers try to minimize these effects by designing the core in such a way that its flux density never approaches saturation levels, and so the inductor operates in a more linear portion of the B/H curve.

3.14 MOSFET (METAL-OXIDE SEMICONDUCTOR FIELD-EFFECT TRANSISTOR)

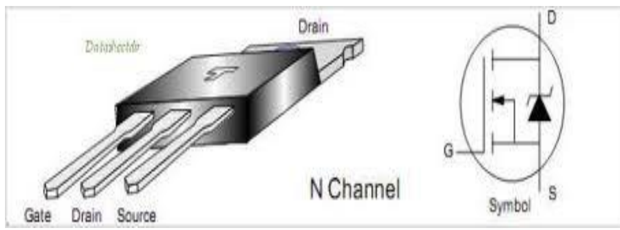


Figure 31: MOSFET

MOSFET (metal-oxide semiconductor field-effect transistor, pronounced MAWS-feht) is a special type of field-effect transistor (FET) that works by electronically varying the width of a channel along which charge carriers (electron s or hole s) flow. The wider the channel, the better the device conducts. The charge carriers enter the channel at the *source*, and exit via the *drain*. The width of the channel is controlled by the voltage on an electrode called the *gate*, which is located physically between the source and the drain and is insulated from the channel by an extremely thin layer of metal oxide.

There are two ways in which a MOSFET can function. The first is known as *depletion mode*. When there is no voltage on the gate, the channel exhibits its maximum conductance. As the voltage on the gate increases (either positively or negatively, depending on whether the channel is made of P-type or N-type semiconductor material), the channel conductivity decreases. The second way in which a MOSFET can operate is called *enhancement mode*. When there is no voltage on the gate, there is in effect no channel, and the device does not conduct. A channel is produced by the application of a voltage to the gate. The greater the gate voltage, the better the device conducts.

The MOSFET has certain advantages over the conventional junction FET, or JFET. Because the gate is insulated electrically from the channel, no current flows between the gate and the channel, no matter what the gate voltage (as long as it does not become so great that it causes physical breakdown of the metallic oxide layer). Thus, the MOSFET has practically infinite impedance. This makes MOSFETs useful for power amplifiers. The devices are also well suited to high-speed switching applications. Some integrated circuits (IC s) contain tiny MOSFETs and are used in computers.

Because the oxide layer is so thin, the MOSFET is susceptible to permanent damage by electrostatic charges. Even a small electrostatic buildup can destroy a MOSFET permanently. In weak-signal radio-frequency (RF) work, MOSFET devices do not generally perform as well as other types of FET.

3.15 RESISTORS

In many electronic circuit applications the resistance forms the basic part of the circuit. The reason for inserting the resistance is to reduce current or to produce the desired voltage drop. These components which offer value of resistance are known as resistors. Resistors may have fixed value i.e., whose value cannot be changed and are known as fixed resistors. Such of those resistors whose value can be changed or varied are known as variable resistors.

There are two types of resistors available. They are:

- Carbon resistors.
- Wire wound resistors.

Carbon resistors are used when the power dissipation is less than 2W because they are smaller and cost less. Wire wound resistors are used where the power dissipation is more than 5W. In electronic equipments carbon resistors are widely used because of their smaller size.

ALL RESISTORS HAVE THREE MAIN CHARACTERISTICS:

- Its resistance R in ohms (from 1 ohm to many mega ohms).
- Power rating (from several 10 W to 0.1 W).
- Tolerance (in percentage).

3.15.1 RESISTOR COLOUR CODING

The carbon resistors are small in size and are colour coded to indicate their resistance value in ohms. Different colors are used to indicate the numeric values. The dark colours represent lower values and the lighter colours represent the higher values. The color code has been standardized by the electronic industries association.

The color bands are printed at one end of the resistors and are read from the left to right. The first colour band closed to the edge indicates the first digit in the value of resistance .The second band gives the second digit. The third band gives the number of zero's after two digits. The resulting number is the resistance in ohms.

3.16 LIGHT EMITTING DIODES (LED's)

In a PN junction electrons cross from 'n' side and combine with holes on the 'p' side. Free electrons are in the conduction band of energy level while holes are in the valance band. Thus electrons are at a higher energy level than holes. During the recombination some of the energy is given up in the form of heat and light. If the semiconductor material is translucent the light will be emitted and the junction becomes a light source. Such a diode is called light emitting diode or LED.

The material used is gallium arsenide or gallium phosphate. The construction is as shown in figure 1. An 'n' type layer is grown upon a substrate and the 'p' junction is created by diffusion. Since the carrier recombination occur in the 'p' region. It must be kept upper most of the surface of the device. The metal film anode connections are so designed a gold film is applied at the bottom of to reflect as much light as possible and to provide cathode connection.

Gallium arsenide emits infrared i.e., invisible light. Gallium arsenide phosphate emits red or yellow light and gallium phosphate provides red or green emission. The symbol of L.E.D. is shown in the below figure.

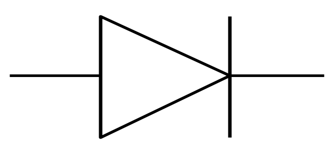


Figure 32: LED

There are also L.E.D capable of emitting any one of two. They are built with two light emitting junctions one of which has the spectral response peak in one region (say red) of the spectrum.

And other region (say green) of the spectrum which color-emitted will depends on the relative magnitude of the currents following through the junctions. The best performance of all is shown by the LED's incorporating here to junctions.

3.17 TRANSISTOR

The transistor an entirely new type of electronic device is capable of achieving amplification of weak signals in a fashion comparable and often superior to that realized by vacuum tubes. Transistors are far smaller than vacuum tube, have no filaments and hence need no heating power and may be operates in any position. They are mechanically strong, hence practically unlimited life and can do some jobs better than vacuum tubes.

3.17.1 TRANSISTOR CONSTRUCTION

A transistor consists of two pn junction formed by sand witching either p-type or n-type semiconductor between a pair of opposite type. Accordingly, there are two types of transistors namely:

1. n-p-n transistor
2. p-n-p transistor

An n-p-n is composed of two n-type semiconductors separated a by thin section of p-type. However, a p-n-p is formed by two p-section separated by a thin section of n-type.

These are two pn junctions. Therefore, a transistor may be regarded as a combination of two diodes connected back to back.

1) There are 3 terminals, taken from each type of semiconductor.
2) The middle section is very thin layer. This is the most important factor in the functioning of a transistor.

Origin of the name "transistor ": When new devices are invented, scientists often try to device a name that will appropriately describe the device. A transistor has two pn junctions. As the discussed later one junction is forward biased and the other is reversed biased. The forward biased junction has low resistance path whereas the reverse biased junction has low resistance path whereas the reverse biased junction has a high resistance path. The weak signal is introduced in the low resistance circuit and output is taken from the high resistance circuit. Therefore, a transistor transfers a signal from a low resistance to high resistance. The prefix 'tans' means the signal transfer property of the device while 'istor' classifies it as a solid element in the same general family with resistors.

3.17.2 NAMING THE TRANSISTOR TERMINALS:

A transistor (pnp or npn) has three sections of doped semiconductors. The section on one side is the emitter and the section on the opposite side is the collector. The middle section is called the base and forms two junctions between the emitter and collector.

1) Emitter: - The section on one side that supplies charge carriers (electrons or holes) is called the emitter. The emitter is always forward biased w.r.t base so that it can supply a large number of majority carriers.
2) Collector: - The section on the other side that collects the charge is called the collector. The collector is always reversing biased. Its function is to remove charges from its junction with the base.
3) Base: - The middle section, which forms to pn junctions between the emitter and collector, is called bas. The base emitter junction is forward biased, allowing low resistance for the emitter circuit. The base-collector junction is reversed biased and provides high resistance in the collector circuit.

3.17.3 CHARCTERISTICS OF TRANSISTORS

Whenever we have to decide about the applications of a transistor certain question arises. Some of these are – how much amplification get from it? What is the highest frequency upto which it can be used? How much power output could we get from it? And what should be the values of different components used in the circuits? The answers to these entire questions lie in the electrical properties of the transistor. These properties depend on the size, manufacturing techniques and materials used in the manufacturer of transistor and are known as characteristics. Transistor manufacturers give these characteristics in the data sheets published by them.

(a) Current gain factor ‘alpha’ (α)

(b) Current gain factor ‘beta’ (β)

(c) Input resistance (Rin)

(d) Output resistance (Rout)

(e) Cut-off frequency (F α and F β)

(f) Leakage current (I ‘co)

h) Maximum collector voltage (V_{ceo})

i) Maximum emitter current (IC Max)

j) Maximum Power dissipation (P max)

CHAPTER 4

DESIGN AND IMPLEMENTATION

4.1 PRINTED CIRCUIT BOARD (PCB)

The semiconductor technology of integrated circuit is a driving force behind systems development. However the PCB is an essential part of an overall system, since equipment is built by connecting active devices together in to manageable cost- effective blocks.

The PCB is an interconnection system, which is multilevel, highly conductive, consistently reproducible, and has a low medium dielectric constant. These attributes have made the PCB the standard, almost universal method of the re-construction for practically all-electric system.

The provides mechanical support as well as functional electrical inter-connection for the components, and some thermal management.

4.1.1 TYPES OF PCB'S

In order to fully appreciate the design requirement for pcb's a basic knowledge of the method of manufacturers is essential perquistes pcb's can be divided into 3 basic categories:

1. Single sided.
2. Double sided.
3. Multi layered

Pcb's form the very basis for the construction of every electronic project. The fabrication of a pcb basically consists of 4 steps:

1. Preparing PCB pattern.
2. Transferring the pattern on to the pcb.
3. Developing the pcb.
4. Finishing i.e drilling, cutting, smoothening, tinning ect.

4.1.2 PATTERN DESIGINING

This is the primary step in fabrication a PCB. In this step, all inter-connection between the components in the circuits are converted into pcb tracks of appropriate shapes and sizes. Several factors have to be considered while desigining the pattern. These include the position of the components and diameter of holes, the appropriate area that each component would occupy the type of end terminals thickness of tracks , full space utilization, max miniaturization, and prevention of overcrowding of components.

Pads of suitable dimension would be used for various components, the complete pattern should be mad on a thick sheet of paper with reverse carbon placed underneath. After the complete pattern has been designed, the holes of appropriate diameter should be made to mount pcb on the chassis. Now a mirror of the complete pattern is obtained on the reverse of the sheet.

4.1.3 TRANSFERING THE PATTERN

Two types of pc boards laminates are in use nowdays these are:

1) Phenolic board and
2) Glass epoxy board.

For the general use, the phenolic board, which is much cheaper than epoxy board, may used.

The copper side of the pcb thoroughly cleaned with the help of alcoholic spirit or petrol, and must be made completely free from dust and other contaminates. Commercially available sprays may be used for the purpose.

4.1.4 PAPER PREPARATION

I discard pages heavily printed, preferring pages with normal-size text on white background. Although ink usually does not transfer on the PCB, heavy print of headlines sometimes accumulate so much ink that some gets on copper.

Cut the paper to a size suitable for your printer. Try to get straight, clean cuts, as jagged borders and paper dust are more prone to clog printer mechanism. An office cutter is ideal, but also a blade-cutter and a steady hand work well.

Be careful to remove all staples, bindings, gadget glue or similar stuff, as they can damage printer's drum and mechanisms.

4.1.5 PRINTER SETUP

Figure 33: Image Of Printer Setup

Laser printers are not designed for handling thin, cheap paper, so we must help them feeding the sheets manually instead of using the paper tray. Selecting a straight paper path minimizes the chances of clogging. This is usually achieved setting the printer as if it were printing on envelopes.

You want to put as much toner on paper as possible, so disable "toner economy modes" and set printer properties to the maximum contrast and blackness possible. You want to print your PCB to exact size, so disable any form of scaling/resizing (e.g. "fit to page"). If your printer driver allows, set it to "center to page" as it helps to get the right position using a non-standard size sheet.

4.1.6 PRINTING

Disclaimer: your laser printer is not designed to handle this kind of paper. Feeding your printer with paper other than special laser printer paper could damage it and potentially voids the warranty. So you are warned: do it at your own risk.

Print your PCB layout as usual, except you must setup the printer as described above and you must print a mirrored layout.

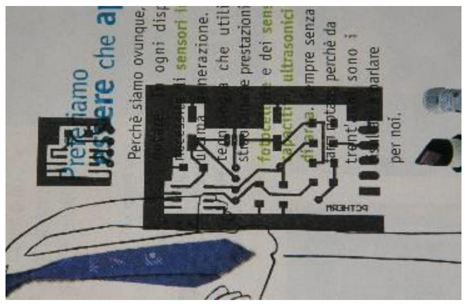


Figure 34: Image Of Printing

This is my PC thermometer circuit printed on IEN magazine paper. Notice that it is a mirror image of the circuit (the word PCTHERM is reversed). Placing some text helps recognizing when the layout is mirrored. Text will read straight again once the image is transferred on copper. If you look it very closely, you can see that toner is not opaque enough to 100% cover the words underneath, but this won’t affect etching.

4.1.7 PREPARING FOR TRANSFER

Figure 35: Image Of Transfer Of Print

To make paper alignment easy, cut excess paper around one corner (leave a small margin though). Leave plenty of paper on the other sides to fix the paper to the desk. As the board is larger than the final PCB, there is large margin for easy placement of paper on copper. Turn the iron to its maximum heat (COTTON position) and turn off steam, if present. While the iron warms up, position the materials on the table. Don't work on an ironing board as its soft surface makes it difficult to apply pressure and keep the PCB in place. Protect table surface with flat, heat-resistant material (e.g. old magazines) and place the board on top, copper face up. Lock the board in place with double-adhesive tape. Position the PCB printout over the copper surface, toner down, and align paper and board corners. Lock the paper with scotch tape along one side only. This way, you can flip the paper in and out instantly. IRON IT!

Flip out the paper, and preheat copper surface placing the iron on top of it for 30 seconds. Remove the iron, flip back paper into its previous position over the copper. It is essential that paper does not slip from its position. You can also cover with a second sheet of blank paper to distribute pressure more evenly. Keep moving the iron, while pressing down as evenly as you can, for about one minute. Remove the iron and let the board to cool down.

4.1.8 PEELING

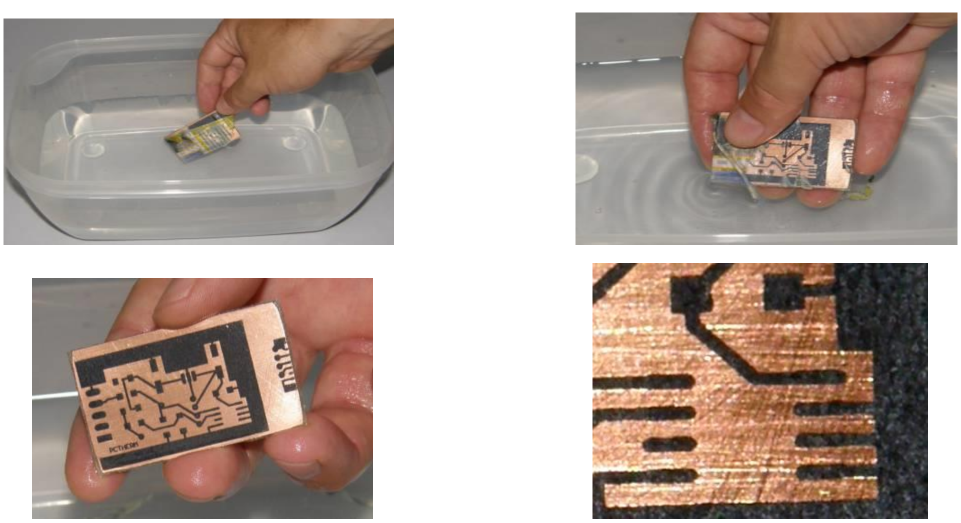


Figure 36: Image Of Peeling

This is the fun part. When the board is cool enough to touch, trim excess paper and immerge in water. Let it soak for 1 minute, or until paper softens.

Cheap paper softens almost immediately, turning into a pulp that is easy to remove rubbing with your thumb. Keep rubbing until all paper dissolves (usually less than 1 minute). Don't be afraid to scratch toner, if it has transferred correctly it forms a very strong bond with copper.

The board with all paper removed. It is OK if some microscopic paper fibres remain on the toner (but remove any fibre from copper), giving it a silky feeling. It is normal that these fibres turn a little white when dry.

Magnified view of the tracks, these are 1206 pads and SO8 SMT pads, connected by 20 mils tracks. Some white fibres show up on the black toner surface.

4.1.9 ETCHING

Figure 37: Image Of Etching

There are many alternatives for etching liquids, and you can use the one that suits your taste. I use ferric chloride (the brown stuff): it's cheap, can be reused many times, and doesn't require heating. Actually, moderate heating can speed up etching, but I find it reasonably fast also at room temperature (10…15 minutes).

The down side of this stuff is that it's incredibly messy. It permanently stains everything it gets in contact with: not only clothes or skin (never wear your best clothes when working with it!), but also furniture, floor tiles, tools, everything. It is concentrated enough to corrode any metal – including your chrome-plated sink accessories. Even vapours are highly corrosive: don't forget the container open or it will turn any tool or metallic shelf nearby into rust.

For etching, I place the container on the floor (some scrap cardboard or newspaper to protect the floor from drops). I fit the board on the hanger, and submerge the PCB. Stir occasionally by waving the hanger.

First impression may be that nothing happens, but in less than 10 minutes some copper is removed, making first tracks to appear. From now on, stir continuously and check often, as the process completes rather quickly. You don't want to overdo it, otherwise thinner tracks start being eroded sideways. As a rule of thumb, stop 30 seconds after you don't see any copper leftovers over large areas.

Rinse the board with plenty, plenty, plenty of water.

I store the etching solution in the same plastic box used for etching. When the job is done I just put the hermetic lid on. To further minimize risks of leakage, I put the container inside the bigger one I use for rinsing, put the second lid, and store it in a safe place.

Disclaimer: These are dangerous chemicals. Always read the labels that come with the solution, handle it wearing protective gloves and goggles, keep windows open, don't inhale the fumes.

4.1.10 FINISHING TOUCHES

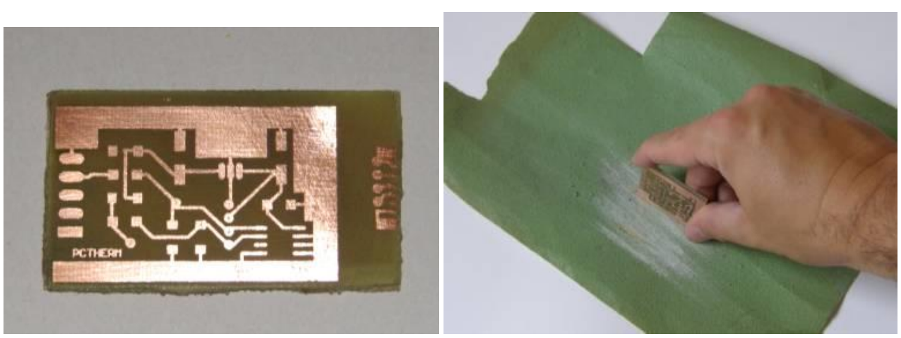


Figure 38: Image Of Finishing Touches

A few drops of thinner (nail polish remover works well) on a pinch of cotton wool will remove completely the toner, bringing back the copper surface. Rinse carefully and dry with a clean cloth or kitchen paper.Trim to final size and refine edges with sandpaper.

4.2 SOLDERING PROCESS

Soldering is a process in which molten solder is applied over the joint so that an electrical connection is made perfectly.

Solder: It’s an alloy of 40% lead and 60% tin, which is suitable for soldering in electrical field. This alloy can easily be melted by touching the hot bit of solder iron. The soldering duration depends upon the thickness of component i.e. more the thickness more will be the soldering time. The alloy, which is used in electrical field, is usually in the form of wire that is flux cored.

Flux: Flux or soldering paste is prepared with resin mixed with suitable diluted acid. The function of paste is to clean the surface of the joint and to make molten solder to flow over the entire surface of the joint.

Fluxing the PCB assembly removes oxide from component leads and circuit traces, which are important in achieving an acceptable, solder joint. The flux also reduces the surface tension of the solder deposited on the board as it passes to the solder wave.

Soldering: Before soldering is made the component leads and wires are cleaned by means of paper or pen knife. If wire component leads are blackened by oxidation and if the component leads are hot cleaned, soldering will not be perfect. After cleaning the component little flux is applied and soldering is made.

Points to be considered for making good solder:

1. Use right type of soldering iron.
2. Keep the hot tip of soldering iron on the mettle so that excess heat is dissipated.
3. Make sure that the connection to be soldered is cleaned.

4. Use just enough solder to cover the leads and the copper coil area of connection to be soldered.
5. Use efficient heat. Check the connections.

CHAPTER 5

SOFTWARE DESIGN

```
#include "LiquidCrystal.h"

LiquidCrystal lcd(2, 3, 4, 5, 6, 7);

float voltage = 0.0;

float temp=0.0;

int analog_value;

void setup()

{

        void setup()

        {

                Serial.begin(9600);

                lcd.begin(16, 2);           // set up the LCD's number of columns and rows:

                lcd.print(" WIRELESS POWER");    // Print a message to the LCD.

                lcd.setCursor(0,1);

                lcd.print( "  TRANSMISSION");    // Print a message to the LCD.

               delay(2000);

                lcd.clear();

                lcd.print("PROJECT SUBMITED");    // Print a message to the LCD.

               lcd.setCursor(0,1);

               lcd.print("      BY");

               delay(2000);

               lcd.clear();
```

```
lcd.print("     AKASH.M   ");     // Print a message to the LCD.
 lcd.setCursor(0,1);
lcd.print("    ASHITHA.S   ");     // Print a message to the LCD.
delay(2000);
 lcd.clear();
 lcd.print("     SPURTI.S ");     // Print a message to the LCD.
 lcd.setCursor(0,1);
 lcd.print("     VISHAL ");     // Print a message to the LCD.
delay(2000);
 lcd.clear();
lcd.print("UNDER GUIDENC BY");     // Print a message to the LCD.
 lcd.setCursor(0,1);
 lcd.print(" KAVITA.KADLI ");     // Print a message to the LCD.
 delay(2000);
 lcd.clear();
lcd.print("   CAR BATTERY ");
}
 lcd.begin(16, 2);
 lcd.setCursor (0,0);
 lcd.print(" Arduino based ");
lcd.setCursor(0,1);
 lcd.print("Digitalmeter");
delay(2000);
```

```
}
void loop()
{
     analog_value = analogRead(A0);
    temp = (analog_value * 5.0) / 1024.0;
     voltage = temp/(0.0909);
    if (voltage < 0.1)
    {
         voltage=0.0;
     }
     lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Voltage
     lcd.print(voltage);
     lcd.setCursor(13,1);
    lcd.print("V
    delay(30);
}
```

CHAPTER 6

APPLICATIONS

6.1 APPLICATIONS

- Automatic wireless charging for existing electric vehicle classes: golf carts, industrial vehicles.
- Automatic wireless charging for future hybrid and all-electric passenger and commercial vehicles, at home, in parking garages, at fleet depots, and at remote kiosks.
- Direct wireless power interconnections to replace costly vehicle wiring harnesses and slip rings.

6.2 ADVANTAGES

- Creating more demand for low cost and high efficiency transportation system.
- Use of electric vehicles becomes more convenient because there is no need for separate charging facilities.
- The wirelessly charged electric vehicles are eco friendly and pollution free.

6.3 DISADVANTAGES

- This type of vehicles can be used where there is an underground power transmission system.

CHAPTER 7

RESULTS