INTRODUCTION

Solar energy is radiant light and heat from the Sun that is harnessed using a range of ever-evolving technologies such as solar heating, photovoltaic, solar thermal energy, solar architecture, molten salt power plants and artificial photosynthesis.

It is an important source of renewable energy and its technologies are broadly characterized as either passive solar or active solar depending on how they capture and distribute solar energy or convert it into solar power. Active solar techniques include the use of photovoltaic systems, concentrated solar power and solar water heating to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light-dispersing properties, and designing spaces that naturally circulate air.

HOW DO SOLAR PANELS WORK?

Solar energy works by capturing the sun’s energy and turning it into electricity for your home or business.

Our sun is a natural nuclear reactor. It releases tiny packets of energy called photons, which travel the 93 million miles from the sun to Earth in about 8.5 minutes. Every hour, enough photons impact our planet to generate enough solar energy to theoretically satisfy global energy needs for an entire year.

Currently photovoltaic power accounts for only five-tenths of one percent of the energy consumed in the United States. But solar technology is improving and the cost of going solar is dropping rapidly, so our ability to harness the sun's abundance of energy is on the rise.

A 2017 report from the International Energy Agency shows that solar has become the world's fastest-growing source of power – marking the first time that solar energy's growth has surpassed that of all other fuels. In the coming years, we will all be enjoying the benefits of solar-generated electricity in one way or another.

When photons hit a solar cell, they knock electrons loose from their atoms. If conductors are attached to the positive and negative sides of a cell, it forms an electrical circuit. When electrons flow through such a circuit, they generate electricity. Multiple cells make up a solar panel, and multiple panels (modules) can be wired together to form a solar array. The more panels you can deploy, the more energy you can expect to generate.

WHAT ARE SOLAR PANELS MADE OF?

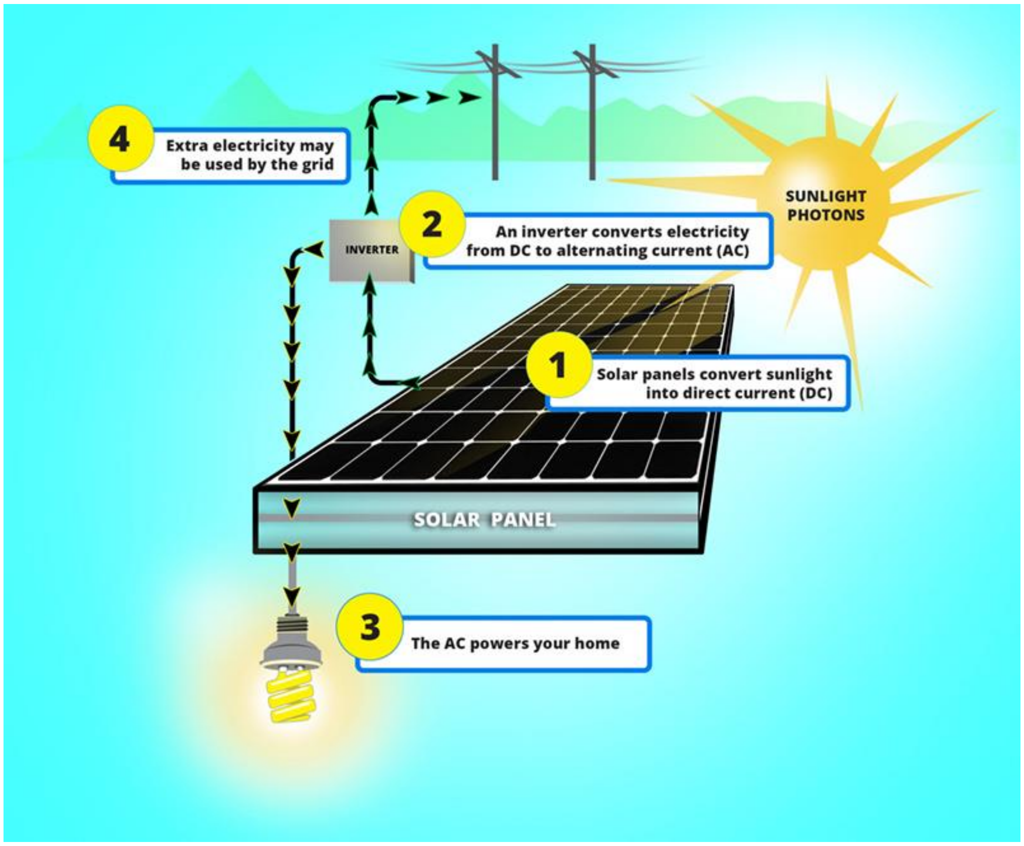
Photovoltaic (PV) solar panels are made up of many solar cells. Solar cells are made of silicon, like semiconductors. They are constructed with a positive layer and a negative layer, which together create an electric field, just like in a battery.

HOW DO SOLAR PANELS GENERATE ELECTRICITY?

PV solar panels generate direct current (DC) electricity. With DC electricity, electrons flow in one direction around a circuit. This example shows a battery powering a light bulb. The electrons move from the negative side of the battery, through the lamp, and return to the positive side of the battery.

With AC (alternating current) electricity, electrons are pushed and pulled, periodically reversing direction, much like the cylinder of a car’s engine. Generators create AC electricity when a coil of wire is spun next to a magnet. Many different energy sources can “turn the handle” of this generator, such as gas or diesel fuel, hydroelectricity, nuclear, coal, wind, or solar.

AC electricity was chosen for the U.S. electrical power grid, primarily because it is less expensive to transmit over long distances. However, solar panels create DC electricity. How do we get DC electricity into the AC grid? We use an inverter.



WHAT DOES SOLAR INVERTER DO?

A solar inverter takes the DC electricity from the solar array and uses that to create AC electricity. Inverters are like the brains of the system. Along with inverting DC to AC power, they also provide ground fault protection and system stats, including voltage and current on AC and DC circuits, energy production and maximum power point tracking.

Central inverters have dominated the solar industry since the beginning. The introduction of micro-inverters is one of the biggest technology shifts in the PV industry. Micro-inverters optimize for each individual solar panel, not for an entire solar system, as central inverters do. This enables every solar panel to perform at maximum potential. When a central inverter is used, having a problem on one solar panel (maybe it's in the shade or has gotten dirty) can drag down the performance of the entire solar array. Micro-inverters, such as the ones in Sun Power's Equinox home solar system, make this a non-issue. If one solar panel has an issue, the rest of the solar array still performs efficiently.

HOW DOES A SOLAR PANEL SYSTEM WORK?

Here's an example of how a home solar energy installation works. First, sunlight hits a solar panel on the roof. The panels convert the energy to DC current, which flows to an inverter. The inverter converts the electricity from DC to AC, which you can then use to power your home. It's beautifully simple and clean, and it's getting more efficient and affordable all the time.

However, what happens if you're not home to use the electricity your solar panels are generating every sunny day? And what happens at night when your solar system is not generating power in real time? Don't worry, you still benefit through a system called "net metering."

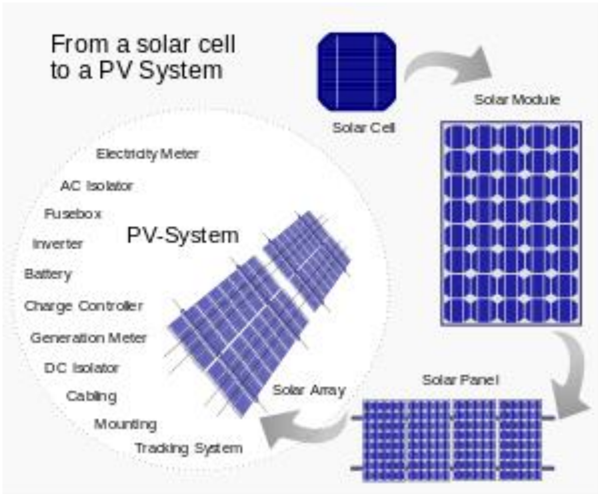
A typical grid-tied PV system, during peak daylight hours, frequently produces more energy than one customer needs, so that excess energy is fed back into the grid for use elsewhere. The customer gets credit for the excess energy produced, and can use that credit to draw from the conventional grid at night or on cloudy days. A net meter records the energy sent compared to the energy received from the grid.

SOLAR PANEL

Photovoltaic solar panels absorb sunlight as a source of energy to generate direct current electricity. A photovoltaic (PV) module is a packaged, connected assembly of photovoltaic solar cells available in different voltages and wattages. Photovoltaic modules constitute the photovoltaic array of a photovoltaic system that generates and supplies solar electricity in commercial and residential applications.

The most common application of solar energy collection outside agriculture is solar water heating systems.

THEORY AND CONSTRUCTION



From a solar cell to a PV system

Photovoltaic modules use light energy (photons) from the Sun to generate electricity through the photovoltaic effect. The majority of modules use wafer-based crystalline silicon cells or thin-film cells. The structural (load carrying) member of a module can either be the top layer or the back layer. Cells must also be protected from mechanical damage and moisture. Most modules are rigid, but semi-flexible ones based on thin-film cells are also available. The cells must be connected electrically in series, one to another.

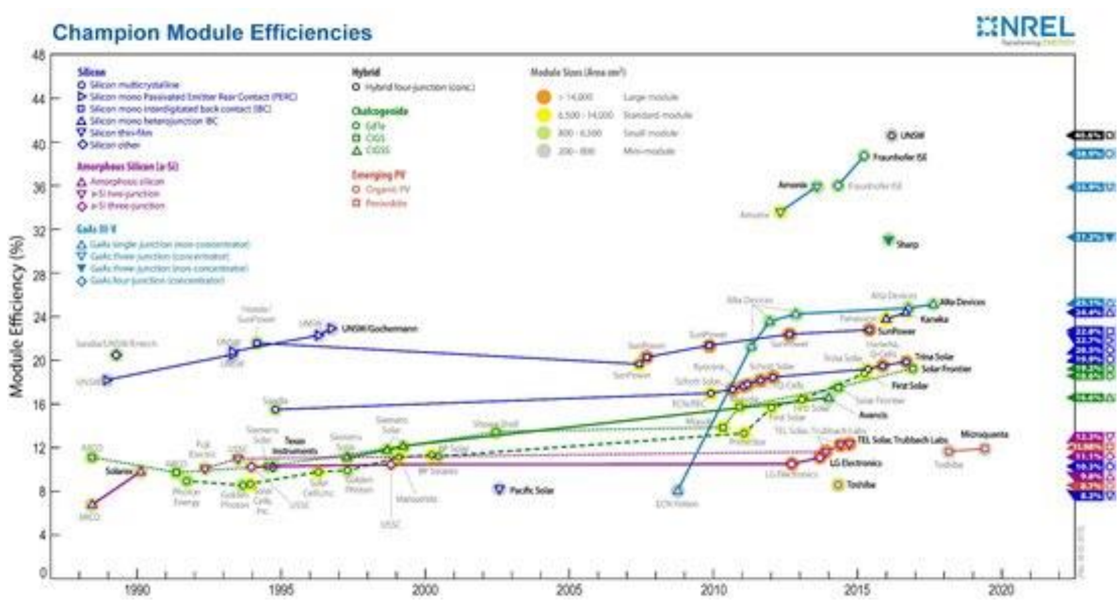
A PV junction box is attached to the back of the solar panel and it is its output interface. Externally, most of photovoltaic modules use MC4 connectors type to facilitate easy weatherproof connections to the rest of the system. Also, USB power interface can be used.

Module electrical connections are made in series to achieve a desired output voltage or in parallel to provide a desired current capability (amperes). The conducting wires that take the current off the modules may contain silver, copper or other non-magnetic conductive transition metals. Bypass diodes may be incorporated or used externally, in case of partial module shading, to maximize the output of module sections still illuminated.

Some special solar PV modules include concentrators in which light is focused by lenses or mirrors onto smaller cells. This enables the use of cells with a high cost per unit area (such as gallium arsenide) in a cost-effective way.

Solar panels also use metal frames consisting of racking components, brackets, reflector shapes, and troughs to better support the panel structure.[2]

EFFICIENCY



The above figure shows the reported timeline of champion solar module energy conversion efficiencies since 1988 (National Renewable Energy Laboratory)

Each module is rated by its DC output power under standard test conditions (STC), and typically ranges from 100 to 365 Watts (W). The efficiency of a module determines the area of a module given the same rated output – an 8% efficient 230 W module will have twice the area of a 16% efficient 230 W module. There are a few commercially available solar modules that exceed efficiency of 24%.

Depending on construction, photovoltaic modules can produce electricity from a range of frequencies of light, but usually cannot cover the entire solar range (specifically, ultraviolet, infrared and low or diffused light). Hence, much of the incident sunlight energy is wasted by solar modules, and they can give far higher efficiencies if illuminated with monochromatic light. Therefore, another design concept is to split the light into six to eight different wavelength ranges that will produce a different color of light, and direct the beams onto different cells tuned to those ranges. This has been projected to be capable of raising efficiency by 50%.

A single solar module can produce only a limited amount of power; most installations contain multiple modules. A photovoltaic system typically includes an array of photovoltaic modules, an inverter, a battery pack for storage, interconnection wiring, and optionally a solar tracking mechanism.

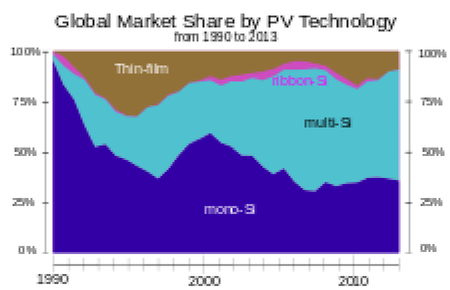
Currently, the best achieved sunlight conversion rate (solar module efficiency) is around 21.5% in new commercial products typically lower than the efficiencies of their cells in isolation. The most efficient mass-produced solar modules have power density values of up to 175 W/m^2 (16.22 W/ft^2).

Research by Imperial College, London has shown that the efficiency of a solar panel can be improved by studding the light-receiving semiconductor surface with aluminum Nano cylinders similar to the ridges on Lego blocks. The scattered light then travels along a longer path in the semiconductor which means that more photons can be absorbed and converted into current. Although these Nano cylinders have been used previously (aluminum was preceded by gold and silver), the light scattering occurred in the near infrared region and visible light was absorbed strongly. Aluminum was found to have absorbed the ultraviolet part of the spectrum, while the visible and near infrared parts of the spectrum were found to be scattered by the aluminum surface. This, the research argued, could bring down the cost significantly and improve the efficiency as aluminum is more abundant and less costly than gold and silver. The research also noted that the increase in current makes thinner film solar panels technically feasible without "compromising power conversion efficiencies, thus reducing material consumption".

- Efficiencies of solar panel can be calculated by MPP (maximum power point) value of solar panels
- Solar inverters convert the DC power to AC power by performing MPPT process: solar inverter samples the output Power (I-V curve) from the solar cell and applies the proper resistance (load) to solar cells to obtain maximum power.
- MPP (Maximum power point) of the solar panel consists of MPP voltage (V mpp) and MPP current (I mpp): it is a capacity of the solar panel and the higher value can make higher MPP.

Micro-inverted solar panels are wired in parallel, which produces more output than normal panels which are wired in series with the output of the series determined by the lowest performing panel (this is known as the "Christmas light effect"). Micro-inverters work independently so each panel contributes its maximum possible output given the available sunlight.

TECHNOLOGY



Market-share of PV technologies since 1990

Most solar modules are currently produced from crystalline silicon (c-Si) solar cells made of multicrystalline and monocrystalline silicon. In 2013, crystalline silicon accounted for more than 90 percent of worldwide PV production, while the rest of the overall market is made up of thin-film technologies using cadmium telluride, CIGS and amorphous silicon[16]

Emerging, third generation solar technologies use advanced thin-film cells. They produce a relatively high-efficiency conversion for the low cost compared to other solar technologies. Also, high-cost, high-efficiency, and close-packed rectangular multi-junction (MJ) cells are preferably used in solar panels on spacecraft, as they offer the highest ratio of generated power per kilogram lifted into space. MJ-cells are compound semiconductors and made of gallium arsenide

(GA As) and other semiconductor materials. Another emerging PV technology using MJ-cells is concentrator photovoltaic (CPV).

THIN FILM

In rigid thin-film modules, the cell and the module are manufactured in the same production line. The cell is created on a glass substrate or superstrate, and the electrical connections are created in situ, a so-called "monolithic integration". The substrate or superstrate is laminated with an encapsulant to a front or back sheet, usually another sheet of glass. The main cell technologies in this category are CdTe, or a-Si, or a-Si+uc-Si tandem, or CIGS (or variant). Amorphous silicon has a sunlight conversion rate of 6–12%

Flexible thin film cells and modules are created on the same production line by depositing the photoactive layer and other necessary layers on a flexible substrate. If the substrate is an insulator (e.g. polyester or polyimide film) then monolithic integration can be used. If it is a conductor then another technique for electrical connection must be used. The cells are assembled into modules by laminating them to a transparent colorless fluoro polymer on the front side (typically ETFE or FEP) and a polymer suitable for bonding to the final substrate on the other side.

SMART SOLAR MODULES

Several companies have begun embedding electronics into PV modules. This enables performing maximum power point tracking (MPPT) for each module individually, and the measurement of performance data for monitoring and fault detection at module level. Some of these solutions make use of power optimizers, a DC-to-DC converter technology developed to maximize the power harvest from solar photovoltaic systems. As of about 2010, such electronics can also compensate for shading effects, wherein a shadow falling across a section of a module causes the electrical output of one or more strings of cells in the module to fall to zero, but not having the output of the entire module fall to zero.

PERFORMANCE AND DEGRADATION

Module performance is generally rated under standard test conditions (STC): irradiance of 1,000 W/m^2, solar spectrum of AM 1.5 and module temperature at 25°C.

Electrical characteristics include nominal power (P_{MAX}, measured in W), open circuit voltage (V_{OC}), short circuit current (I_{SC}, measured in amperes), maximum power voltage (V_{MPP}), maximum power current (I_{MPP}), peak power, (watt-peak, W_p), and module efficiency (%).

Nominal voltage refers to the voltage of the battery that the module is best suited to charge; this is a leftover term from the days when solar modules were only used to charge batteries. The actual voltage output of the module changes as lighting, temperature and load conditions change, so there is never one specific voltage at which the module operates. Nominal voltage allows users, at a glance, to make sure the module is compatible with a given system.

Open circuit voltage or V_{OC} is the maximum voltage that the module can produce when not connected to an electrical circuit or system. V_{OC} can be measured with a voltmeter directly on an illuminated module's terminals or on its disconnected cable.

The peak power rating, W_p, is the maximum output under standard test conditions (not the maximum possible output). Typical modules, which could measure approximately 1 m × 2 m or 3 ft. 3 in × 6 ft. 7 in, will be rated from as low as 75 W to as high as 350 W, depending on their efficiency. At the time of testing, the test modules are binned according to their test results, and a typical manufacturer might rate their modules in 5 W increments, and either rate them at +/- 3%, +/-5%, +3/-0% or +5/-0%.

Solar trackers increase the amount of energy produced per module at a cost of mechanical complexity and need for maintenance. They sense the direction of the Sun and tilt or rotate the modules as needed for maximum exposure to the light. Alternatively, fixed racks hold modules stationary as the sun moves across the sky. The fixed rack sets the angle at which the module is held. Tilt angles equivalent to an installation's latitude are common. Most of these fixed racks are set on poles above ground. Panels that face West or East may provide slightly lower energy, but evens out the supply, and may provide more power during peak demand.

APPLICATIONS

There are many practical applications for the use of solar panels or photovoltaic. It can first be used in agriculture as a power source for irrigation. In health care solar panels can be used to refrigerate medical supplies. It can also be used for infrastructure. PV modules are used in photovoltaic systems and include a large variety of electric devices:

- Photovoltaic power stations
- Rooftop solar PV systems
- Standalone PV systems
- Solar hybrid power systems
- Concentrated photovoltaic
- Solar planes
- Solar-pumped lasers
- Solar vehicles
- Solar panels on space crafts and space stations.

LIMITATIONS

➢ POLLUTION AND ENERGY IN PRODUCTION

Solar panel has been a well-known method of generating clean, emission free electricity. However, it produces only direct current electricity (DC), which is not what normal appliances use. Solar photovoltaic systems (solar PV systems) are often made of solar PV panels (modules) and inverter (changing DC to AC). Solar PV panels are mainly made of solar photovoltaic cells, which has no fundamental difference to the material for making computer chips. The process of producing solar PV cells (computer chips) is energy intensive and involves highly poisonous and environmental toxic chemicals. There are few solar PV manufacturing plants around the world producing PV modules with energy produced from PV. This measure greatly reduces the carbon footprint during the manufacturing process. Managing the chemicals used in the manufacturing process is subject to the factories' local laws and regulations.

➢ IMPACT ON ELECTRICITY NETWORK

With the increasing levels of rooftop photovoltaic systems, the energy flow becomes 2-way. When there is more local generation than consumption, electricity is exported to the grid. However, electricity network traditionally is not designed to deal with the 2- way energy transfer. Therefore, some technical issues may occur. For example in Queensland Australia, there have been more than 30% of households with rooftop PV by the end of 2017. The famous Californian 2020 duck curve appears very often for a lot of communities from 2015 onwards. An over-voltage issue may come out as the electricity flows from these PV households back to the network. There are solutions to manage the over voltage issue, such as regulating PV inverter power factor, new voltage and energy control equipment at electricity distributor level, re-conducting the electricity wires, demand side management, etc. There are often limitations and costs related to these solutions.

➢ IMPLICATION ONTO ELECTRICTIY BILL MANAGEMENT AND ENERGY CONSERVATION

There is no silver bullet in electricity or energy demand and bill management, because customers (sites) have different specific situations, e.g. different comfort/convenience needs, different electricity tariffs, or different usage patterns. Electricity tariff may have a few elements, such as daily access and metering charge, energy charge (based on kWh, MWh) or peak demand charge (e.g. a price for the highest 30min energy consumption in a month). PV is a promising option for reducing energy charge when electricity price is reasonably high and continuously increasing, such as in Australia and Germany. However for sites with peak demand charge in place, PV may be less attractive if peak demands mostly occur in the late afternoon to early evening, for example residential communities. Overall, energy investment is largely an economical decision and it is better to make investment decisions based on systematical evaluation of options in operational improvement, energy efficiency, onsite generation and energy storage.

EMBEDDED SYSTEMS

Embedded system is any electronic equipment built in intelligence and dedicated software. All embedded systems use either a microprocessor or a microcontroller. The application of these microcontrollers makes user-friendly cheaper solutions and enables to add features otherwise impossible to provide by other means.

Embedded device can be defined as any devices with a microprocessors or microcontroller embedded in it that has a relatively focused. The software for the embedded system is called firmware. The firmware in written in Assembly language for time or resource critical operation or using higher- level languages like C or Embedded C. The software will be simultaneously micro codes simulations for the largest processor. Since they are supported to perform only specific task, these programs are stored in Read Only Memories (ROMs). Moreover they may need no or minimal inputs from the user, hence the user interface like monitor, mouse & large keyboard etc., may be absent.

Embedded systems are also known as real time systems since they respond to an input or event and produce the result within the guaranteed time period. This time period can be a few micro seconds to days or months.

An embedded system can be explained as, one consisting of processor, associated peripherals and software used for specific purpose. Like any other computer system, an embedded system is a combination of hardware and software. The embedded system was developed in 1978. Literally embedded means entrenched or implanted.

Embedded system is thus a system having a microcontroller with relevant software and interfacing peripherals to perform a specified task. Real time concept can easily be implemented using an embedded system. Desktop computers are “general purpose computers” used for performing a variety of everyday tasks such as playing games, processing, accounting, scientific applications and others. In contrast, an embedded system performs a single well defined task.

CATEGORIES OF EMBEDDED SYSTEMS

The embedded system can be broadly classified in to the following categories. The categorization is based upon whether system has to work as an independent unit or it has to be networked, whether it has to perform real time operations or not and so on.

STAND ALONE EMBEDDED SYSTEMS

Stand-alone embedded system work in stand-alone mode, which is taking input and producing output. The input can be electrical signals from sensors or commands from a human being, such as pressing a button. The output can be electrical signals to drive another system or an LED or LCD display for conveying information to users. For stand-alone embedded system, the dead line to carry out a specific task may not be very strict. That is, the response time is not crucial. Examples for this category are air conditioner, toys, CD players etc.

REAL TIME EMBEDDED SYSTEMS

Some embedded systems are required to carry out specific task in a specified amount of time. Such embedded systems are called Real Time Embedded Systems. These are used to extensively in the field of process control, when time critical task have to be carried out. Such embedded systems RTOS for its functioning. The RTOS is the abbreviation for Real Time Operating System. The real time systems are broadly classified in to two types, viz.

(a) Hard Real time Embedded Systems

(b) Soft Real time Embedded System

NETWORK APPLIANCES

Some embedded systems are connected to a network, typically one based on a TCP/IP protocol (Transmission Control Protocol/Internet Protocol), such as in the Internet or accompanying intranet. These systems are of a new brand that has emerged in the recent years. They run the complete TCP/IP protocol stack and can communicate with other node on the network. Even a web server can be embedded in to the system. A typical example is the monitoring of equipment in manufacturing system.

ADVANTAGES OF THE EMBEDDED SYSTEMS

The advantages of an embedded system can be listed as follows

- Reliability
- Cost effectiveness
- Low power consumption
- Efficient use of memory
- Appropriate execution time
- High performance
- Slimmer and more compact
- Reduced design and developments

- **RELIABILITY**

Embedded systems can work without the need for the rebooting or resetting typical of many desktop systems. This calls for very reliable hardware and software. If for example the embedded system comes to a halt because of a hardware error, the system should reset itself without the need for human intervention.

- **COST EFFECTIVENESS**

In embedded systems, the designers will develop an application specific integrated circuit (ASIC) or an application specific microprocessor to reduce the hardware components and hence the cost. Typically developer first creates a prototype by writing the software for the general-purpose processor, and subsequently develops an ASIC to reduce the cost.

- **LOW POWER CONSUMPTION**

Batteries, rather than a main supply power in many embedded systems. In such cases the power consumption should be minimized to avoid draining the batteries. Hardware designers must address this issue- for example, by reducing the number of hardware components, or by designing the processor to revert to low power “sleep” mode when there is no perform.

- **EFFICIENT USE OF MEMORY**

Most embedded systems do not have secondary storage such as hard disk. The memory chips available on the embedded systems are only read only memory (ROM), to hold the program; and random access memory (RAM), to hold the data. Microcontrollers are DSPs come with on board memory. Such processors are used for small-embedded systems, as the cost generally is low and execution generally is fast.

- **APPROPRIATE EXECUTION TIME**

In real time embedded systems, certain tasks must be performed within a specified time. Consequently analyzing the tasks to meet such performance constraints is of considerable importance. So we are using special operating systems (RTOS), to run on the embedded systems. So performance analysis is needed to choose whether the embedded system is a hard real time or a soft real time system.

- **HIGH PERFORMANCE**

The integration of various ICs shortens the travelling route and time of data to be transmitted resulting in higher performance.

- **SLIMMER AND MORE COMPACT**

Housed in a single separate package, the chip is smaller in size and their fore occupies less space on the PCB. Hence products using embedded systems are slimmer and more compact.

- **REDUCED DESIGN AND DEVELOPMENTS**

The system on a chip provides all functionality required by the system. System designers need not worry about the basic function the system-right from the beginning of the basic phase, they can focus on the development features. As a result the time spends on research and development is reduced and this in turn reduces the time to market of their products.

EMBEDDED SYSTEMS DEVELOPMENTS

In the development of embedded system application the hardware and software must go hand in hand. The software created by the software engineers must be burnt in to or micro coded into the hardware or the microcontroller produced by VLSI engineers. The microcontroller and the software micro coded in it together from the system for the particular application.

The software program for real time system is written either in assembly or high level language such as C. The assembly language is used in the case of some critical applications. Nowadays high-level languages replaced most of the assembly language constructs.

EMBEDDED SYSTEM MARKETS

Embedded technology is present in almost every electronic device we use today. There is embedded software inside the cellular phone, automobiles and a thermostat in air conditioners, industrial control equipment and scientific and medical equipment, defense uses communication satellites etc. Embedded technology thus covers a broad range of products of which generalization is difficult.

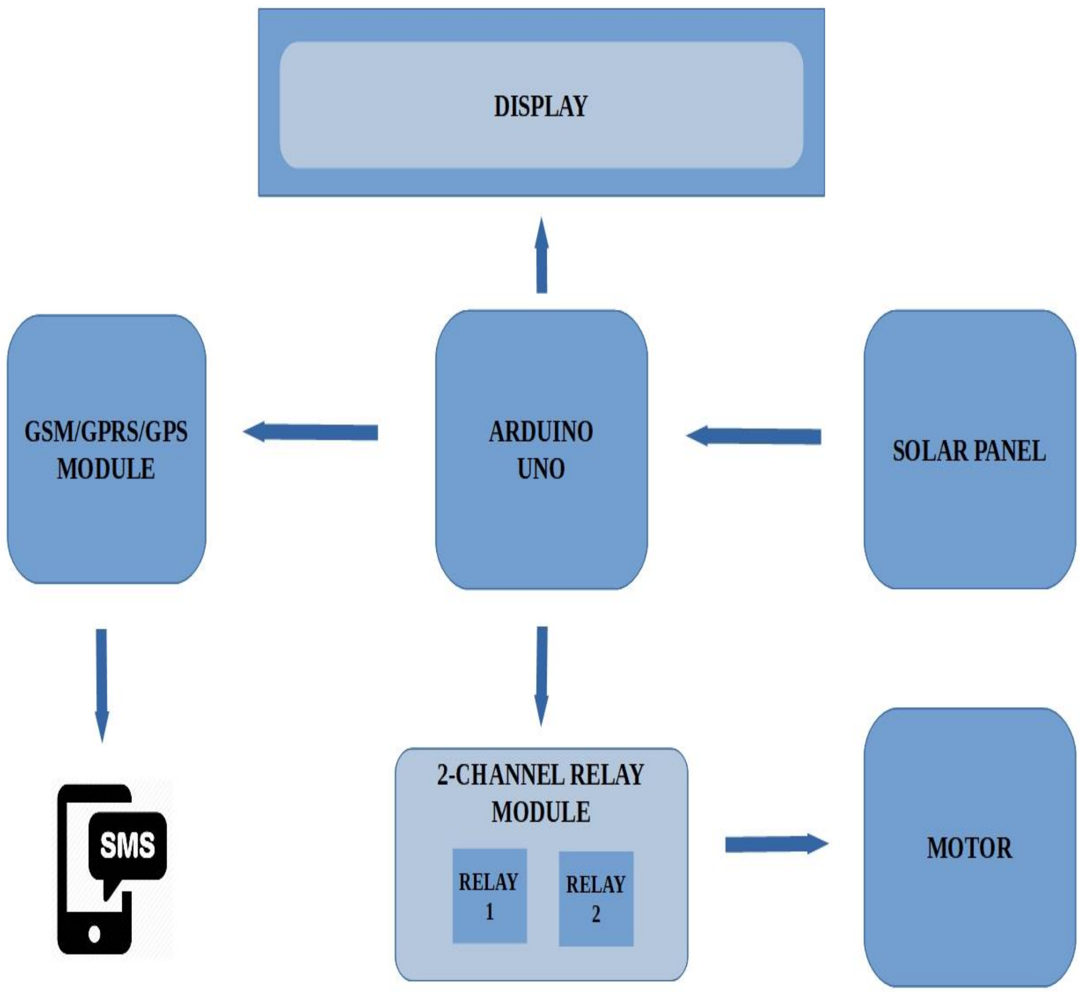
The embedded intelligence can be found in five broad markets. The first is consumer segments, which includes home appliances and entertainment equipment. The second is automotive segment- where a modern car has nearly 50 microcontrollers providing intelligence and control, like keyless entry, antilock breaking and airbags. The third is office automation, which includes PCs, keyboards, copiers and printers. The fourth market, telecommunications includes cellular phones, pagers and answering machines.

APPLICATIONS OF EMBEDDED SYSTEMS

In recent years, the applications of embedded systems are increased multi fold with advent of appliances that can be connected to networks, particularly the internet. Embedded systems are extensively used in control systems in the manufacturing industry, such as chemical plants, cement plants, semiconductor plants, missile development units, nuclear plants and so on. To understand the various applications of embedded systems, the applications are divided in to the following market segments, each of which is covered in the following sections:

- Consumer electronics
- Hand held computer Data communication
- Networked information appliances and Tele communications
- Wireless communications

BLOCK DIAGRAM



BLOCK DIAGRAM DESCRIPTION

The overall solar tracking system consists of a mechanism that enables the PV panels to follow or track the sun. The mechanical structure consists of one servo motor that drives the mechanism, LDR sensors for measuring light intensity, and a programmable microcontroller responsible for giving electric signals to the motors in accordance to the sun angle in order to achieve solar tracking (keeping the PV panel perpendicular to the sunlight). Based on the system requirement tilt angle is provided of 25° angle southwards. The feedback control system operation is based on servo mechanism principles and the controller is responsible for the solar tracker motion. The controller coding and servo mechanism is simulated in EAGLE. The simulation and development of a prototype of a single axis automatic solar tracking system using servo mechanism. The simulation for servo mechanism using EAGLE is described thereafter. This is followed by the description of the development of a proposed solar tracking system. The mechanism of the discussed system deals with the open loop tracking system in which sensors detect the higher light intensity. The motor actuates in the direction where sunlight is more. Such type of tracking mechanism is called servo mechanism and is also known as real-time tracking. It was resolved that real-time tracking would be necessary to follow the sun effectively so that no external data would be required in operation. The open-loop type is simpler and cheaper but it could not compensate for disturbances in the system and has low accuracy. On the other hand for the closed-loop tracking, the sun trackers usually sense the direct solar radiation falling on a photo-sensor as a feedback signal to ensure that the solar collector is tracking the sun all times and keep the solar collector at a right angle to the sun’s rays for getting maximum solar insolation. The closed-loop tracking mechanism can overcome the issues related to (cloudy, rainy) weather conditions using AC antenna motors, and power electronic control circuit to convert DC into AC. However, it causes more losses in the system. Since the PV module has nonlinear characteristics, it is necessary to model it for the design and simulation of PV system applications. Recently, a number of powerful component based electronics simulation software package have become popular in the design and development of power electronics applications. It is difficult to simulate and analyze in the generic modelling of the PV power system. To test the operation logic code there is one more software to simulate the servo mechanism, that is, EAGLE. Generally, most of the parameters are given in manufacturer's specifications but sometimes some parameters (such as ideality factor, series resistance, etc.) may not be given and may change due to ageing and other environmental factors. Hence, it is necessary to develop relations to find these parameters.

HARDWARE DESCRIPTION

1. LCD MODULE

The LCD module is a parallel interface sixteen pin module. The first three pins of LCD module are used for contrast adjusting. Here the first pin is connected to ground, second to the voltage supply and third to the variable resistor. The pins, seven to fourteen are data lines (D0 to D7). In this particular circuit the data lines D4 to D7 are used because the LCD driver available is 4 line data bus. 15^{th} pin is connected to the 5 volt supply. Pin 4, 5, 6 are control pins, R/W, RS and enable respectively. 16^{th} pin is connected to the ground through a transistor. The voltage from pic16f877a turn on the transistor and it in turn turns on the LCD backlight .Resistor R9 controls the voltage supplied to the transistor.

PINOUT

LCD modules may have a parallel or serial interface. The module discussed here has a 14-pin parallel interface. The pin out for this module is shown below.

PIN NO.	SYMBOL	FUNCTION
1	V_{ss}	Ground
2	V_{cc}	+5V

3	V_{EE}	Contrast
4	RS	H=Data, L=Instruction
5	R/W	H=Read, L=Write
6	E	Latch, H→L
7	DB0	LSB
8	DB1	
9	DB2	
10	DB3	
11	DB4	
12	DB5	
13	DB6	
14	DB7	MSB

- **Enable (E)** This line allows access to the display through R/W and RS lines. When this line is low, the LCD is disabled and ignores signals from R/W and RS. When (E) line is high, the LCD checks the state of the two control lines and responds accordingly.

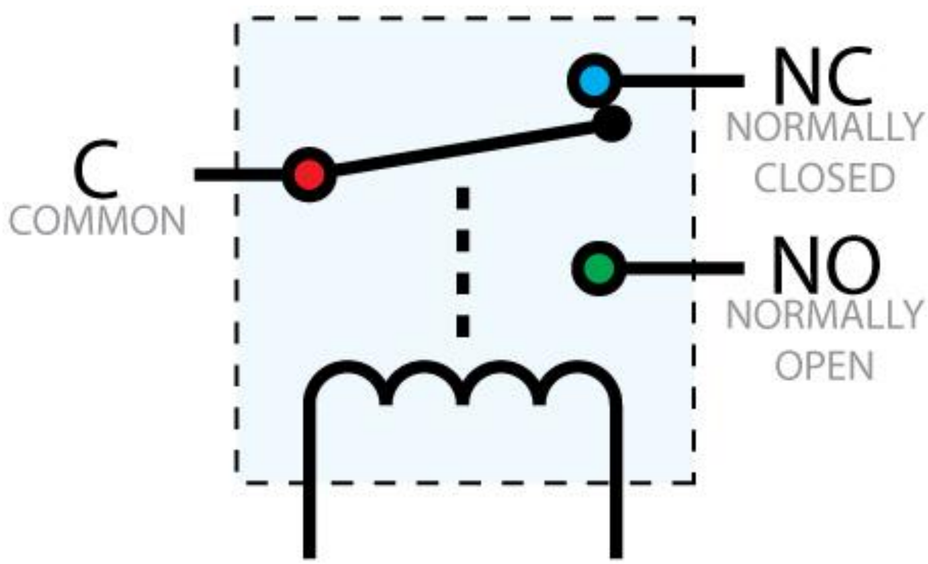
- ❖ **Read/Write (R/W)** This line determines the direction of data between the LCD and microcontroller. When it is low, data is written to the LCD. When it is high, data is read from the LCD.
- ❖ **Register select (RS)** with the help of this line, the LCD interprets the type of data on data lines. When it is low, an instruction is being written to the LCD. When it is high, a character is being written to the LCD.
- ❖ **Contrast:** A variable voltage applied to this pin controls the contrast. Use a potentiometer and adjust until you see the background.
- ❖ **DB0-DB7:** Apply the data or commands to these pins.

Reading data from the LCD is done in the same way, but control line R/W has to be high. When we send a high to the LCD, it will reset and wait for instructions. Typical instructions sent to LCD display after a reset are: turning on a display, turning on a cursor and writing characters from left to right. When the LCD is initialized, it is ready to continue receiving data or instructions. If it receives a character, it will write it on the display and move the cursor one space to the right. The Cursor marks the next location where a character will be written. When we want to write a string of characters, first we need to set up the starting address, and then send one character at a time. Characters that can be shown on the display are stored in data display (DD) RAM. The size of DDRAM is 80 bytes.

The LCD display also possesses 64 bytes of Character-Generator (CG) RAM. This memory is used for characters defined by the user. Data in CG RAM is represented as an 8-bit character bit-map. Each character takes up 8 bytes of CG RAM, so the total number of characters, which the user can define, is eight. In order to read in the character bit-map to the LCD display, we must first set the CG RAM address to starting point (usually 0), and then write data to the display.

2.RELAY(ELECTROMECHANICAL SWITCH)

A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits as amplifiers: they repeated the signal coming in from one circuit and re-transmitted it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations.



A type of relay that can handle the high power required to directly control an electric motor or other loads is called a contactor. Solid-state relays control power circuits with no moving parts, instead using a semiconductor device to perform switching. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to protect electrical circuits from overload or faults; in modern electric power systems these functions are performed by digital instruments still called "protective relays".

Magnetic latching relays require one pulse of coil power to move their contacts in one direction, and another, redirected pulse to move them back. Repeated pulses from the same input have no effect. Magnetic latching relays are useful in applications where interrupted power should not be able to transition the contacts.

Magnetic latching relays can have either single or dual coils. On a single coil device, the relay will operate in one direction when power is applied with one polarity, and will reset when the polarity is reversed. On a dual coil device, when polarized voltage is applied to the reset coil the contacts will transition. AC controlled magnetic latch relays have single coils that employ steering diodes to differentiate between operate and reset commands.

BASIC DESIGN AND OPERATION

A simple electromagnetic relay consists of a coil of wire wrapped around a soft iron core, an iron yoke which provides a low reluctance path for magnetic flux, a movable iron armature, and one or more sets of contacts (there are two contacts in the relay pictured). The armature is hinged to the yoke and mechanically linked to one or more sets of moving contacts. It is held in place by a spring so that when the relay is de-energized there is an air gap in the magnetic circuit. In this condition, one of the two sets of contacts in the relay pictured is closed, and the other set is open. Other relays may have more or fewer sets of contacts depending on their function. The relay in the picture also has a wire connecting the armature to the yoke. This ensures continuity of the circuit between the moving contacts on the armature, and the circuit track on the printed circuit board (PCB) via the yoke, which is soldered to the PCB.

When an electric current is passed through the coil it generates a magnetic field that activates the armature, and the consequent movement of the movable contact(s) either makes or breaks (depending upon construction) a connection with a fixed contact. If the set of contacts was closed when the relay was de-energized, then the movement opens the contacts and breaks the connection, and vice versa if the contacts were open. When the current to the coil is switched off, the armature is returned by a force, approximately half as strong as the magnetic force, to its relaxed position. Usually this force is provided by a spring, but gravity is also used commonly in industrial motor starters. Most relays are manufactured to operate quickly. In a low-voltage application this reduces noise; in a high voltage or current application it reduces arcing.

When the coil is energized with direct current, a diode is often placed across the coil to dissipate the energy from the collapsing magnetic field at deactivation, which would otherwise generate a voltage spike dangerous to semiconductor circuit components. Such diodes were not widely used before the application of transistors as relay drivers, but soon became ubiquitous as early germanium transistors were easily destroyed by this surge. Some automotive relays include a diode inside the relay case.

If the relay is driving a large, or especially a reactive load, there may be a similar problem of surge currents around the relay output contacts. In this case a snubber circuit (a capacitor and resistor in series) across the contacts may absorb the surge. Suitably rated capacitors and the associated resistor are sold as a single packaged component for this common place use.

If the coil is designed to be energized with alternating current (AC), some method is used to split the flux into two out-of-phase components which add together, increasing the minimum pull on the armature during the AC cycle. Typically this is done with a small copper "shading ring" crimped around a portion of the core that creates the delayed, out-of-phase component, which holds the contacts during the zero crossings of the control voltage.

TYPES

a. LATCHING RELAY

A latching relay (also called "impulse", "keep", or "stay" relays) maintains either contact position indefinitely without power applied to the coil. The advantage is that one coil consumes power only for an instant while the relay is being switched, and the relay contacts retain this setting across a power outage. A latching relay allows remote control of building lighting without the hum that may be produced from a continuously (AC) energized coil.

In one mechanism, two opposing coils with an over-center spring or permanent magnet hold the contacts in position after the coil is de-energized. A pulse to one coil turns the relay on and a pulse to the opposite coil turns the relay off. This type is widely used where control is from simple switches or single-ended outputs of a control system, and such relays are found in avionics and numerous industrial applications.

Another latching type has a remnant core that retains the contacts in the operated position by the remnant magnetism in the core. This type requires a current pulse of opposite polarity to release the contacts. A variation uses a permanent magnet that produces part of the force required to close the contact; the coil supplies sufficient force to move the contact open or closed by aiding or opposing the field of the permanent magnet. A polarity controlled relay needs changeover switches or an H bridge drive circuit to control it. The relay may be less expensive than other types, but this is partly offset by the increased costs in the external circuit.

In another type, a ratchet relay has a ratchet mechanism that holds the contacts closed after the coil is momentarily energized. A second impulse, in the same or a separate coil, releases the contacts. This type may be found in certain cars, for headlamp dipping and other functions where alternating operation on each switch actuation is needed.

A stepping relay is a specialized kind of multi-way latching relay designed for early automatic telephone exchanges. An earth leakage circuit breaker includes a specialized latching relay. Very early computers often stored bits in a magnetically latching relay, such as ferried or the later remerged in the 1ESS switch. Some early computers used ordinary relays as a kind of latch—they store bits in ordinary wire spring relays or reed relays by feeding an output wire back as an input, resulting in a feedback loop or sequential circuit. Such an electrically latching relay requires continuous power to maintain state, unlike magnetically latching relays or mechanically ratcheting relays.

In computer memories, latching relays and other relays were replaced by delay line memory, which in turn was replaced by a series of ever-faster and ever-smaller memory technologies.

b. REED RELAY

A reed relay is a reed switch enclosed in a solenoid. The switch has a set of contacts inside an evacuated or inert gas-filled glass tube which protects the contacts against atmospheric corrosion; the contacts are made of magnetic material that makes them move under the influence of the field of the enclosing solenoid or an external magnet.

Reed relays can switch faster than larger relays and require very little power from the control circuit. However, they have relatively low switching current and voltage ratings. Though rare, the reeds can become magnetized over time, which makes them stick 'on' even when no current is present; changing the orientation of the reeds with respect to the solenoid's magnetic field can resolve this problem.

Sealed contacts with mercury-wetted contacts have longer operating lives and less contact chatter than any other kind of relay.

c. MERCURY-WETTED RELAY

A mercury-wetted reed relay is a form of reed relay in which the contacts are wetted with mercury. Such relays are used to switch low-voltage signals (one volt or less) where the mercury reduces the contact resistance and associated voltage drop, for low-current signals where surface contamination may make for a poor contact, or for high-speed applications where the mercury eliminates contact bounce. Mercury wetted relays are position-sensitive and must be mounted vertically to work properly. Because of the toxicity and expense of liquid mercury, these relays are now rarely used.

The mercury-wetted relay has one particular advantage, in that the contact closure appears to be virtually instantaneous, as the mercury globules on each contact coalesce. The current rise time through the contacts is generally considered to be a few picoseconds, however in a practical circuit it will be limited by the inductance of the contacts and wiring. It was quite common, before the restrictions on the use of mercury, to use a mercury-wetted relay in the laboratory as a convenient means of generating fast rise time pulses, however although the rise time may be picoseconds, the exact timing of the event is, like all other types of relay, subject to considerable jitter, possibly milliseconds, due to mechanical imperfections.

The same coalescence process causes another effect, which is a nuisance in some applications. The contact resistance is not stable immediately after contact closure, and drifts, mostly downwards, for several seconds after closure, the change perhaps being 0.5 ohm.

d. MERCURY RELAY

A mercury relay is a relay that uses mercury as the switching element. They are used where contact erosion would be a problem for conventional relay contacts. Owing to environmental considerations about significant amount of mercury used and modern alternatives, they are now comparatively uncommon.

e. POLARIZED RELAY

A polarized relay places the armature between the poles of a permanent magnet to increase sensitivity. Polarized relays were used in middle 20th Century telephone exchanges to detect faint pulses and correct telegraphic distortion. The poles were on screws, so a technician could first adjust them for maximum sensitivity and then apply a bias spring to set the critical current that would operate the relay.

f. MACHINE TOOL RELAY

A machine tool relay is a type standardized for industrial control of machine tools, transfer machines, and other sequential control. They are characterized by a large number of contacts (sometimes extendable in the field) which are easily converted from normally open to normally closed status, easily replaceable coils, and a form factor that allows compactly installing many relays in a control panel. Although such relays once were the backbone of automation in such industries as automobile assembly, the programmable logic controller (PLC) mostly displaced the machine tool relay from sequential control applications.

A relay allows circuits to be switched by electrical equipment: for example, a timer circuit with a relay could switch power at a preset time. For many years relays were the standard method of controlling industrial electronic systems. A number of relays could be used together to carry out complex functions (relay logic). The principle of relay logic is based on relays which energize and de-energize associated contacts. Relay logic is the predecessor of ladder logic, which is commonly used in programmable logic controllers.

g. COAXIAL RELAY

Where radio transmitters and receivers share one antenna, often a coaxial relay is used as a TR (transmit-receive) relay, which switches the antenna from the receiver to the transmitter. This protects the receiver from the high power of the transmitter. Such relays are often used in transceivers which combine transmitter and receiver in one unit. The relay contacts are designed not to reflect any radio frequency power back toward the source, and to provide very high isolation between receiver and transmitter terminals. The characteristic impedance of the relay is matched to the transmission line impedance of the system, for example, 50 ohms.

h. TIME DELAY RELAY

Timing relays are arranged for an intentional delay in operating their contacts. A very short (a fraction of a second) delay would use a copper disk between the armature and moving blade assembly. Current flowing in the disk maintains magnetic field for a short time, lengthening release time. For a slightly longer (up to a minute) delay, a dashpot is used. A dashpot is a piston filled with fluid that is allowed to escape slowly; both air-filled and oil-filled dashpots are used. The time period can be varied by increasing or decreasing the flow rate. For longer time periods, a mechanical clockwork timer is installed. Relays may be arranged for a fixed timing period, or may be field adjustable, or remotely set from a control panel. Modern microprocessor-based timing relays provide precision timing over a great range.

Some relays are constructed with a kind of "shock absorber" mechanism attached to the armature which prevents immediate, full motion when the coil is either energized or de-energized. This addition gives the relay the property of time-delay actuation. Time-delay relays can be constructed to delay armature motion on coil energization, de-energization, or both.

3. DC MOTOR

A DC motor is electromechanical device that converts electrical energy into mechanical energy that can be used to do many useful works. DC motors comes in various ratings like 6V and 12V. It has two wires or pins. When connected with power supply the shaft rotates. We can reverse the direction of rotation by reversing the polarity of input.

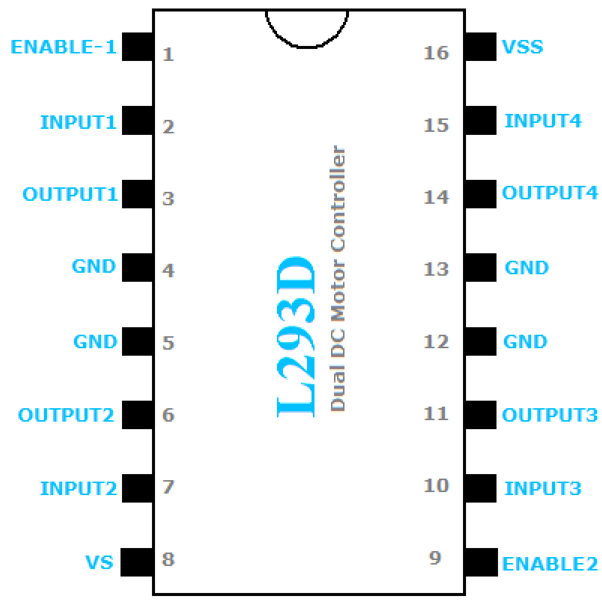
Here we uses 60RPM DC Motor with Gearbox. Different RPM available with standard size. It is very easy to use. For line tracking robotic application it is very excellent one.

FEATURES

- 60RPM, 12V, DC motors with Gearbox
- 12V DC Supply
- 6mm shaft diameter with threaded hole & screw
- 125gm weight
- same size motor available in various RPM
- 12kgcm torque
- No-load current = 60 Ma (Max), Load current = 250 mA (Max)

CONTROLLING DC MOTORS

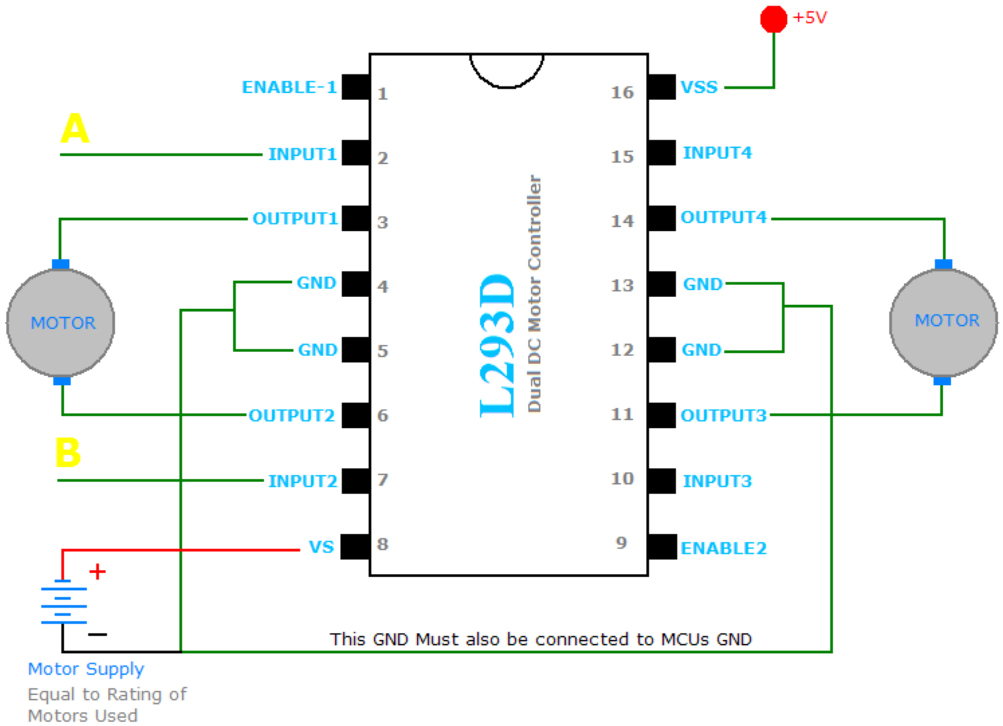
As the MCUs PORT are not powerful enough to drive DC motors directly so we need some kind of drivers. A very easy and safe is to use popular L293D chips. It is a 16 PIN chip. The pin configuration is as follows.



L293D DUAL H-BRIDGE MOTOR DRIVER

L293D is a dual H-Bridge motor driver, so with one IC we can interface two DC motors which can be controlled in both clockwise and counter clockwise direction and if you have motor with fix direction of motion the you can make use of all the four I/Os to connect up to four DC motors. L293D has output current of 600mA and peak output current of 1.2A per channel. Moreover for protection of circuit from back EMF output diodes are included within the IC. The output supply (VCC2) has a wide range from 4.5V to 36V, which has made L293D a best choice for dc motor driver.

A simple schematic for interfacing a DC motor using L293D is shown below.



	A	B
Stop	Low	Low
Clockwise	Low	High
Anti Clockwise	High	Low
Stop	High	High

We just need to set appropriate levels at two PINs of the microcontroller to control the motor. Since this chip controls two DC motors there are two more output pins (output3 and output4) and two more input pins(input3 and input4).

The INPUT3 and INPUT4 controls second motor in the same way as listed above for input A and B. There are also two ENABLE pins they must be high (+5v) for operation, if they are pulled low (GND) motors will stop.

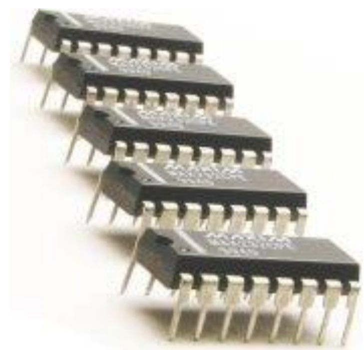
4. MAX 232 LEVEL CONVERTER

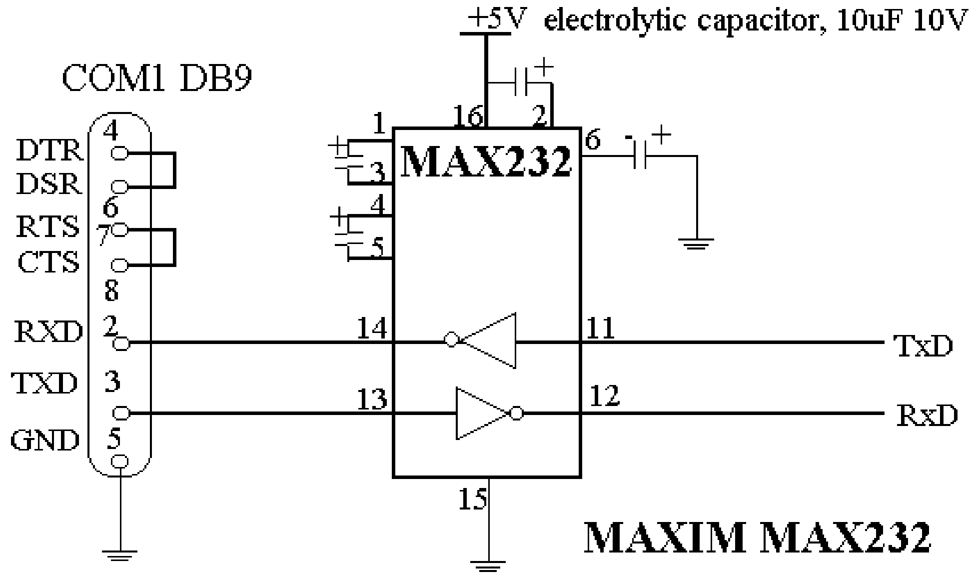
A standard serial interfacing for PC, RS232C, requires negative logic, i.e., logic '1' is -3V to -12V and logic '0' is +3V to +12V. To convert TTL logic, say, TxD and RxD pins of the uC chips, thus need a converter chip. A MAX232 chip has long been using in many uC boards. It provides 2-channel RS232C port and requires external 10uF capacitors. Carefully check the polarity of capacitor when soldering the board. A DS275, however, no need external capacitor and smaller. Either circuit can be used without any problems.

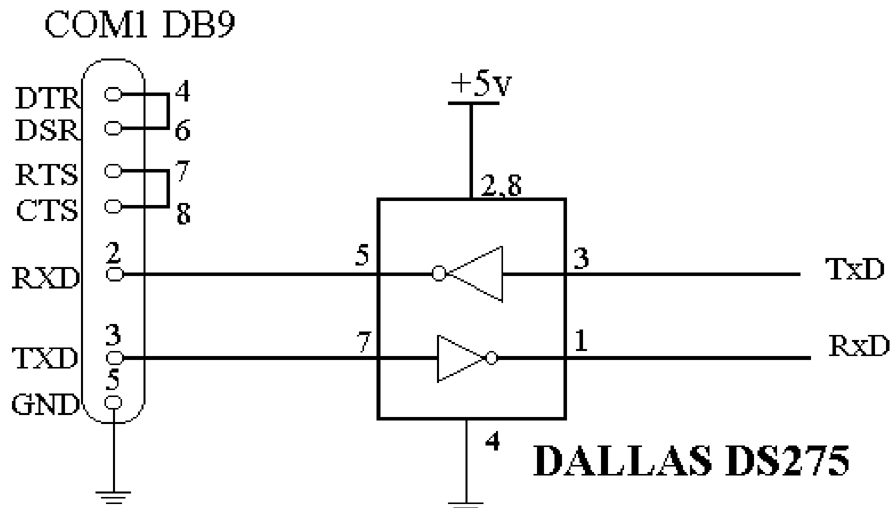
Serial RS-232 (V.24) communication works with voltages -15V to +15V for high and low. On the other hand, TTL logic operates between 0V and +5V. Modern low power consumption logic operates in the range of 0V and +3.3V or even lower.

Thus the RS-232 signal levels are far too high TTL electronics**,** and the negative RS-232 voltage for high can’t be handled at all by computer logic. To receive serial data from an RS-232 interface the voltage has to be reduced. Also the low and high voltage level has to be inverted.

RS-232	**TTL**	**Logic**
-15V … -3V	+2V … +5V	High
+3V … +15V	0V … +0.8V	Low







MAX232:

This module is primary of interest for people building their own electronics with an RS-232 interface. Serial RS-232 communication works with voltages (-15V ... -3V for high) and +3V ... +15V for low) which are not compatible with normal computer logic voltages. On the other hand, classic TTL computer logic operates between 0V ... +5V (roughly 0V ... +0.8V for *low*, +2V ... +5V for *high*). Modern low-power logic operates in the range of 0V ... +3.3V or even lower.

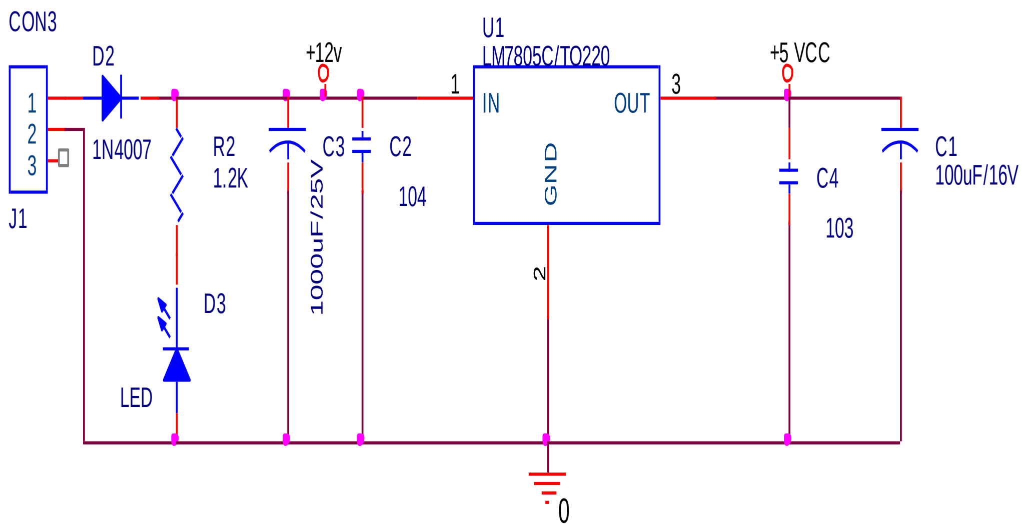
So, the maximum RS-232 signal levels are far too high for computer logic electronics, and the negative RS-232 voltage for high can't be grokked at all by computer logic. Therefore, to receive serial data from an RS-232 interface the voltage has to be reduced, and the low and high voltage level inverted. In the other direction (sending data from some logic over RS-232) the low logic voltage has to be "bumped up", and a negative voltage has to be generated, too.

RS-232		TTL		Logic
-15V ... -3V	<->	+2V ... +5V	<->	high
+3V ... +15V	<->	0V ... +0.8V	<->	low

All this can be done with conventional analog electronics, e.g. a particular power supply and a couple of transistors or the once popular 1488 (transmitter) and 1489 (receiver) ICs. However, since more than a decade it has become standard in amateur electronics to do the necessary signal level conversion with an integrated circuit (IC) from the MAX232 family (typically a MAX232A or some clone). In fact, it is hard to find some RS-232 circuitry in amateur electronics without a MAX232A or some clone.

The MAX232 from Maxim was the first IC which in one package contains the necessary drivers (two) and receivers (also two), to adapt the RS-232 signal voltage levels to TTL logic. It became popular, because it just needs one voltage (+5V) and generates the necessary RS-232 voltage levels (approx. -10V and +10V) internally. This greatly simplified the design of circuitry. Circuitry designers no longer need to design and build a power supply with three voltages (e.g. -12V, +5V, and +12V), but could just provide one +5V power supply, e.g. with the help of a simple 78x05 voltage converter.

5. POWER SUPPLY



The above figure shows the power supply circuit. Input is given through DC adaptor. Diode IN4007 is to avoid the polarity inversion when plugging. LED is for displaying the status. Capacitive filters are used to eliminate ripples. 1000uF capacitor is electrolytic and 0.1uF is disc capacitor. The capacitor filter should be rated at a minimum of 1000uF for each amp of current drawn and at least twice the input voltage. The 0.1uF capacitor eliminates any high frequency pulses that could otherwise interfere with the operation of the regulator.

Voltage regulators are very robust. They can withstand over-current draw due to short circuits and also over-heating. In both cases the regulator will shut down before damage occurs. The only way to destroy a regulator is to apply reverse voltage to its input. Reverse polarity destroys the regulator almost instantly. To avoid this possibility you should always use diode protection of the power supply. This is especially important when using nine volt battery supplies as it is common for people to 'test' the battery by connecting it one way and then the other. Even this short 'test' could destroy the regulator if a protection diode is not used. Generally a 1N4004, 1 amp power diode is connected in series with the power supply. If the supply is connected the wrong way around, the regulator will be protected from damage.

The LM78XX series of three terminal regulators is available with several fixed output voltages making them useful in a wide range of applications. One of these is local on card regulation, eliminating the distribution problems associated with single point regulation. The voltages available allow these regulators to be used in logic systems, instrumentation, HiFi, and other solid state electronic equipment. Although designed primarily as fixed voltage regulators these devices can be used with external components to obtain adjustable voltages and currents. The LM78XX series is available in an aluminum TO-3 package which will allow over 1.0A load current if adequate heat sinking is provided. Current limiting is included to limit the peak output current to a safe value. Safe area protection for the output transistor is provided to limit internal power dissipation.

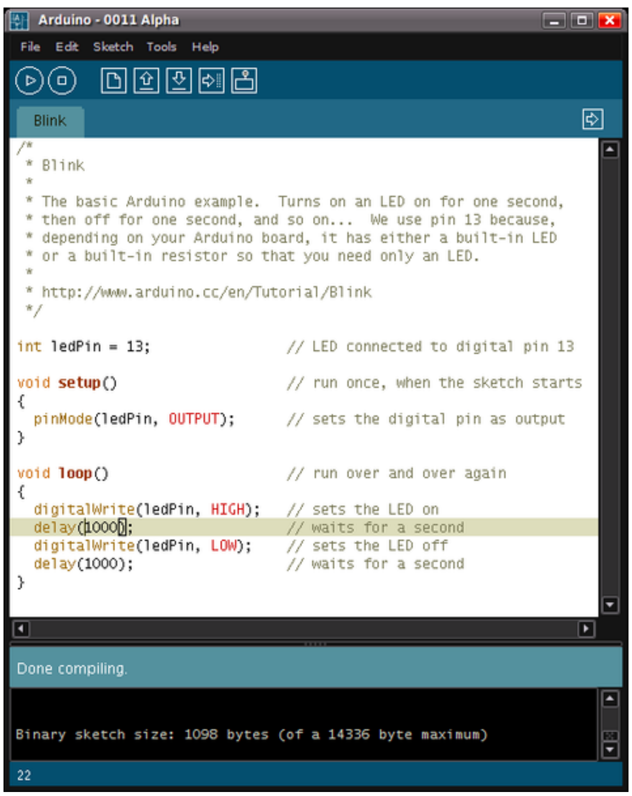
If internal power dissipation becomes too high for the heat sinking provided, the thermal shutdown circuit takes over preventing the IC from overheating. Considerable effort was expanded to make the LM78XX series of regulators easy to use and minimize the number of external components. It is not necessary to bypass the output, although this does improve transient response. Input bypassing is needed only if the regulator is located far from the filter capacitor of the power supply.

- Output current in excess of 1A
- Internal thermal overload protection
- No external components required
- Output transistor safe area protection
- Internal short circuit current limit
- Available in the aluminum TO-3 package

SOFTWARE DESCRIPTION

ARDUINO

Arduino is an open-source single-board microcontroller, descendant of the open-source Wiring platform, designed to make the process of using electronics in multidisciplinary projects more accessible. The hardware consists of a simple open hardware design for the Arduino board with an Atmel AVR processor and on-board input/output support. The software consists of a standard programming language compiler and the boot loader that runs on the board.



WHAT IS ARDUINO?

Arduino is a tool for making computers that can sense and control more of the physical world than your desktop computer. It's an open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the board.

Arduino can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs. Arduino projects can be stand-alone, or they can be communicate with software running on your computer (e.g. Flash, Processing, and MaxMSP.) The boards can be assembled by hand or purchased preassembled; the open-source IDE can be downloaded for free.

The Arduino programming language is an implementation of Wiring, a similar physical computing platform, which is based on the Processing multimedia programming environment.

WHY ARDUINO?

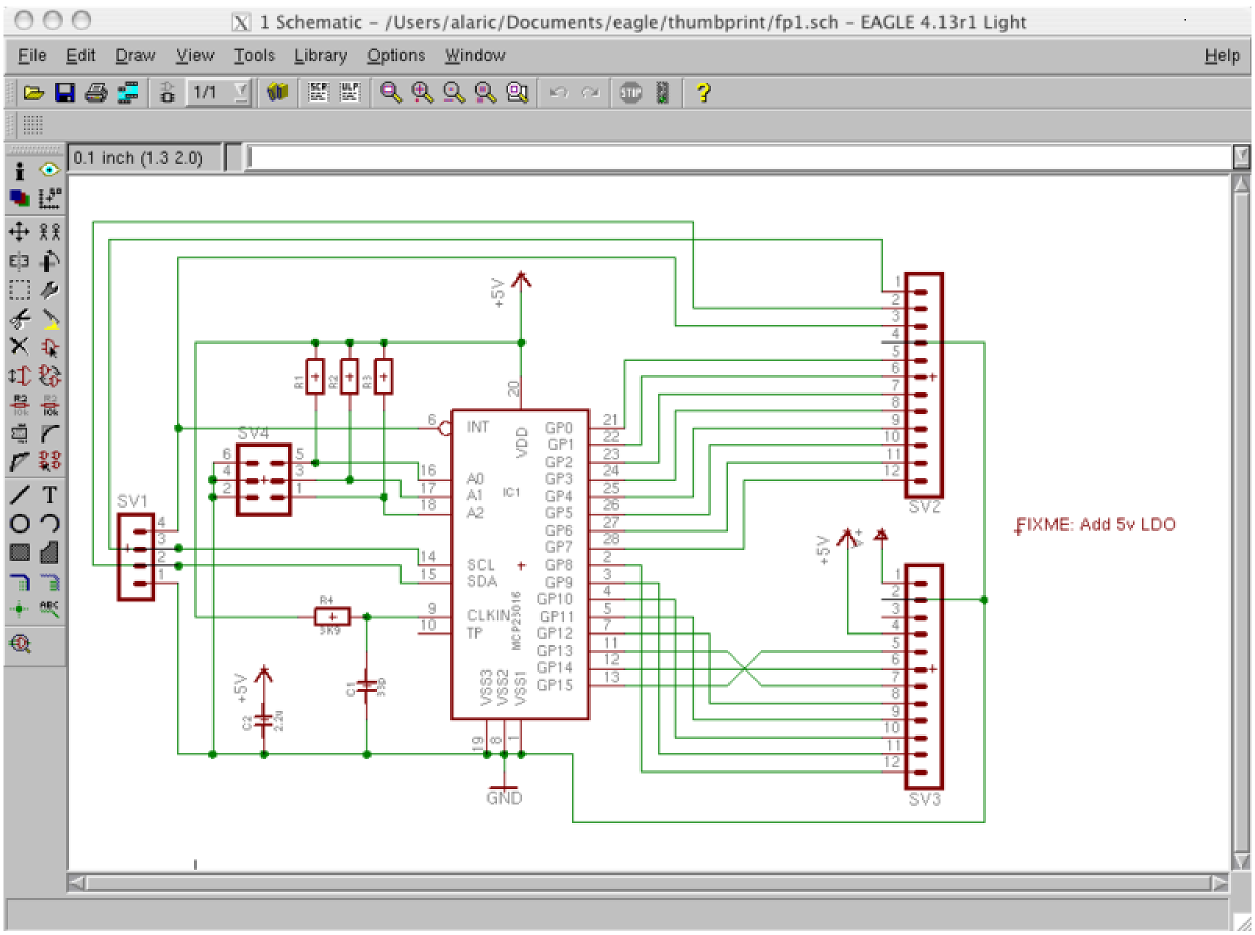
There are many other microcontrollers and microcontroller platforms available for physical computing. Parallax Basic Stamp, Net media's BX-24, Phi gets, MIT's Handy board, and many others offer similar functionality. All of these tools take the messy details of microcontroller programming and wrap it up in an easy-to-use package. Arduino also simplifies the process of working with microcontrollers, but it offers some advantage for teachers, students, and interested amateurs over other systems:

- Inexpensive - Arduino boards are relatively inexpensive compared to other microcontroller platforms. The least expensive version of the Arduino module can be assembled by hand, and even the pre-assembled Arduino modules cost less than $50
- Cross-platform - The Arduino software runs on Windows, Macintosh OSX, and Linux operating systems. Most microcontroller systems are limited to Windows.
- Simple, clear programming environment - The Arduino programming environment is easy-to-use for beginners, yet flexible enough for advanced users to take advantage of as well. For teachers, it's conveniently based on the Processing programming environment, so students learning to program in that environment will be familiar with the look and feel of Arduino
- Open source and extensible software- The Arduino software and is published as open source tools, available for extension by experienced programmers. The language can be expanded through C++ libraries, and people wanting to understand the technical details can make the leap from Arduino to the AVR C programming language on which it's based. Similarly, you can add AVR-C code directly into your Arduino programs if you want to.

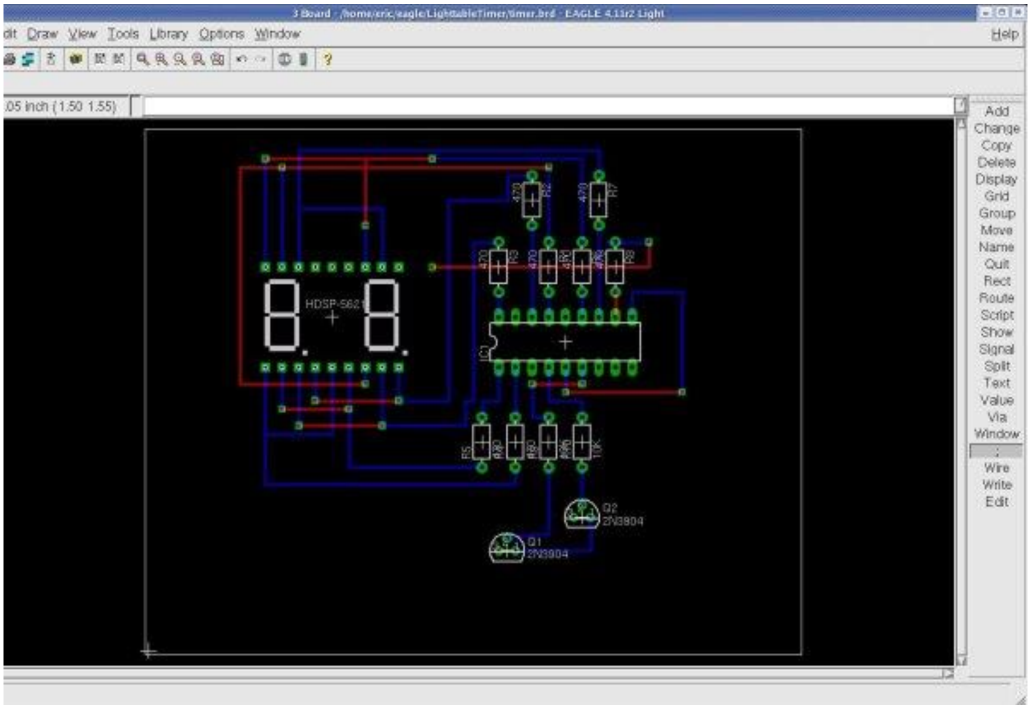
Arduino hardware is programmed using a Wiring-based language (syntax and libraries), similar to C++ with some simplifications and modifications, and a Processing-based integrated development environment.

Current versions can be purchased pre-assembled; hardware design information is available for those who would like to assemble an Arduino by hand. Additionally, variations of the Italian-made Arduino—with varying levels of compatibility—have been released by third parties; some of them are programmed using the Arduino software.

CAD SOFTWARE – EAGLE



EAGLE (Easily Applicable Graphical Layout Editor) is a proprietary ECAD program produced by Cad Soft in Germany (American marketing division: Cad Soft USA). It is very commonly used by private electronics enthusiasts, because there is a free limited version for non-profit use and it is available in English and German. Cad Soft has released versions for Microsoft Windows, Linux, and Mac OS X.



EAGLE contains a schematic editor, for designing circuit diagrams and a PCB layout editor, which allows back annotation to the schematic.

EAGLE includes a basic but functional auto router, or alternatively manual routing can be performed.

PCBs designed in EAGLE are accepted by a large amount of PCB fabrication houses without the need to export.

EAGLE is very popular with hobbyists because both a basic free edition (with a lower feature set) and a low cost non-profit edition are available.

Schematic capture or schematic entry is a step in the design cycle of electronic design automation (EDA) at which the electronic diagram, or electronic schematic of the designed electronic circuit is created by a designer.

This is done interactively with the help of a schematic capture tool also known as schematic editor.

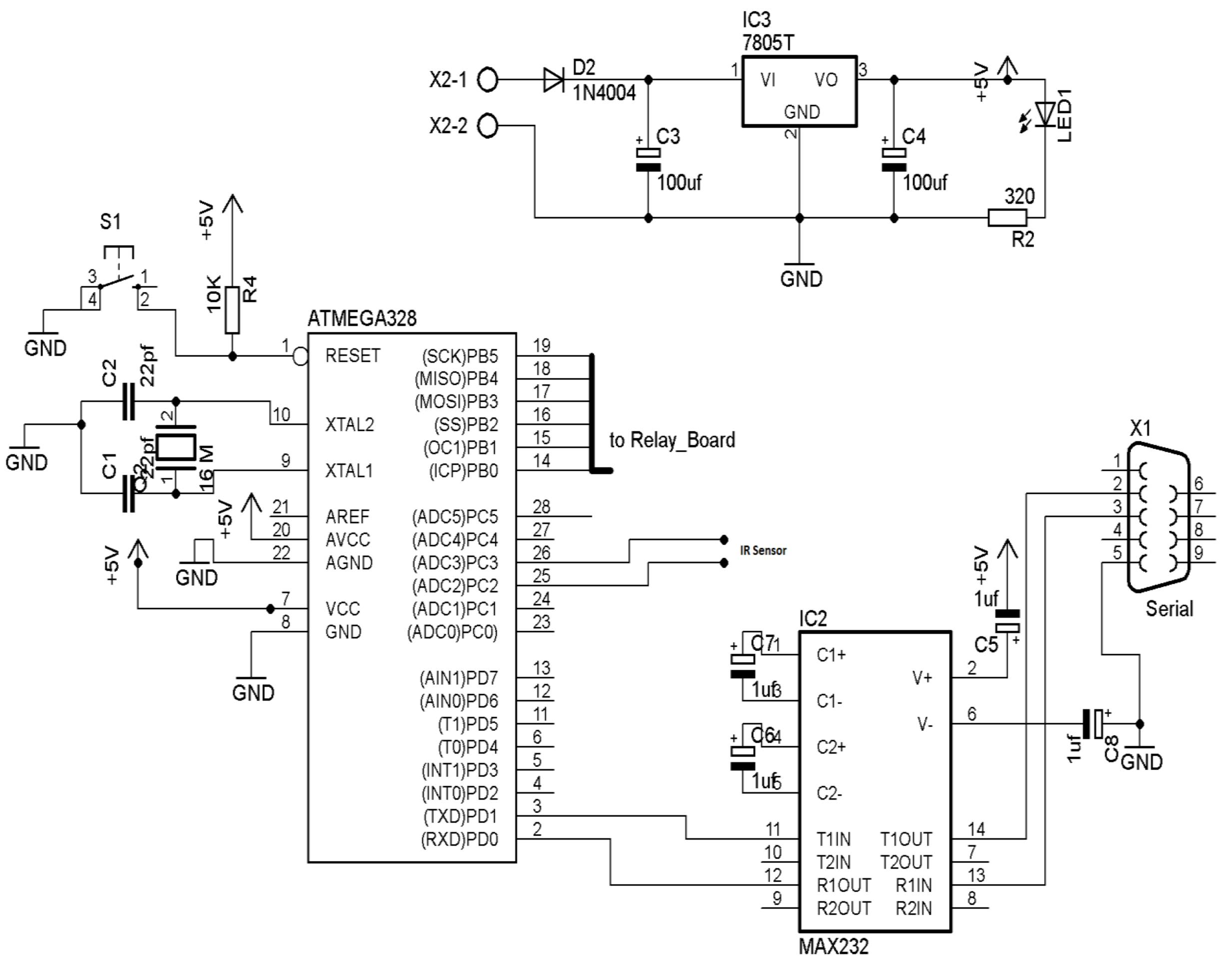
The circuit design is the very first step of actual design of an electronic circuit. Typically sketches are drawn on paper, and then entered into a computer using a schematic editor. Therefore schematic entry is said to be a front-end operation of several others in the design flow.

Despite the complexity of modern components – huge ball grid arrays and tiny passive components – schematic capture is easier today than it has been for many years. CAD software is easier to use and is available in full-featured expensive packages, very capable mid-range packages that sometimes have free versions and completely free versions that are either open source or directly linked to a printed circuit board fabrication company.

In past years, schematic diagrams with largely discrete components were fairly readable however with the newer high pin-count parts and with the almost universal use of standard letter-sized paper, schematics have become less so. Many times, there will be a single large part on a page with nothing but pin reference keys to connect it to other pages.

Readability levels can be enhanced by using buses and super buses, related pins can be connected into a common bus and routed to other pages. Buses don't need to be just the traditional address or data bus directly linked pins. A bus grouping can also be used for related uses, such as all analog input or all communications related pin functions.

CIRCUIT DIAGRAM



WORKING

Development of the tracking system was carried out through the following two major steps which were as follows:

1. Mechanical structure design
2. Control system design

1. **Mechanical structure**: The structure of the prototype was prepared using CAD Solid Works 2013 to check the free movement of panel in east–west direction. Realization was accomplished at the workshop of renewable energy engineering department. Figure 2 shows the design prepared for tracking system.

2. **Control system**: This can be understood in two parts. First one works with active components which controls the system automation. The second one is to prepare circuit using passive components for charge controller, voltage regulation, and connections of all components. The active components required are as follows:

a. **Light-dependent resistor (LDR)**: It is the light-depending resisters that have a particular property that they can detect lightning intensity in which they have been stored. The cell resistance falls with increasing light intensity. The sensitivity of a photo detector is the relationship between the light falling on the device and the resulting output signal. In the case of a photocell, one is dealing with the relationship between the incident light and the corresponding resistance of the cell.

b. **Microcontroller**: The microcontroller is the brain of the tracker, and it controls the tracking system. Basically, it receives input from the sensors, specifying the position of the sun and in response, it sends signal to the motors that are connected to the solar panel to move to the panel to the position of the sun in which optimum solar rays could be received. The microcontroller is made up of software and hardware components. The software component is basically the computer programs that decode the input signals and sends out appropriate signal in response to the inputs to control the tracking system. It is connected to the sensors and motors. The hardware executes the command. It requires 5 V DC.

c. **Servo motor**: Servomotors are handy and practical in today' s robotic and mechatronic systems as they provide a high level of accuracy, are simple to wire up, and relatively simple to control. They are also more applicable for certain applications than standard DC motors as they are position controlled rather than rotation controlled. A good application for servomotors is a sun tracking system for solar panels. The system requires a fairly high positional accuracy therefore, servomotors are ideal for the job. The motor used here requires 4.8 V and an operating speed of 0.18 sec/60° at no load.

d. **Battery**: The tracker needs a power source to keep it running due to the irregularity of the power received from the solar panel. A 6 V and 4.5 Amp rechargeable battery is used; the battery as it is connected to the tracking system is also connected to the output of the solar panel to keep it charging.

PCB FABRICATION

Printed Circuit Broad (PCB) is a mechanical assembly consisting of layers of fiberglass sheet laminated with etched copper patterns. It is used to mount electronic parts in a rigid manner suitable for packaging.

The type of integrated circuit components used in the fabrication process has an important role in the design of PCB. The conductor width, spacing between the signal conductors etc. are calculated to give optimum wave impedance of the conductor's lines. Optimum wave impedance gives minimum delay or rising and trailing edge of the pulse in digital circuit.

i. ART WORK GENERATION

The generation of PCB artwork should be considered as the first step of the PCB manufacturing process. The artwork is generated at 1:1:1 or 4:1 scale according to the accuracy needed. Ink drawing on a transparent drawing paper or cut up and strip method are the methods used for the art work generation.

ii. ROUTING

Presently artwork generation is not used for the PCB fabrication. Instead there are many types of software available for the routing of PCBs. Mainly used software’s are CAD SOFTWARE EAGLE, ORCAD, TRAXMAKER, EASYPCB, PORTAL etc. Here we make use of CAD SOFT EAGLE.

1. Manual. Traces are placed manually as done in the traditional method where you change the path of the trace every time you click the mouse.

2. Follow-me. This highly interactive method combines the power of an auto router with the control and flexibility of manual routing.

3. Auto Router. This fully automated method will auto route an entire trace by clicking on a rats net line

Then using a laser printer solution prints the routed diagram. Laser printer is very affordable, fast and good quality. The printer used must have at least 600dpi resolution for all but the simplest PCB swill require only 300DPI resolution. It is very important that the printer produces the good solid black with no toner pinholes.

When using tracing paper or drafting film, always use manual paper feed, and set the straightest possible paper output path, to keep the artwork as flat as possible and minimize jamming. The printed diagram is then converted into film by using vertically mounted cameras.

iii. SCREEN-PRINTING

Screen-printing is arguably the most versatile of all printing process. It can be used to print on a wide variety of substrates, including paper, paper board, plastics, glass, metals, posters, labels, decals, signage, and all types of textiles and electronic circuit boards. The advantage of screenwriting over other print processes is that the press can print on substrates of any shape, thickness and size.

A significant characteristic of screen-printing is that a greater thickness of the ink can be applied to the substrate than is possible with other printing techniques. This allows for some very interesting effects that are not possible using other printing methods. Because of the simplicity of the application process, a wider range of inks and dyes are available for use in screen-printing than for use in any other printing process.

iv. SCREEN PRINTING PROCESS OVERVIEW

Screen-printing consists of three elements: the screen which is the image carrier, the squeegee; and ink. The screen-printing process uses a porous mesh stretched tightly over a frame made of wood or metal. Proper tension is essential to accurate color registration. The mesh is made of porous fabric or stainless steel mesh. A stencil is produced on the screen either manually or photo chemically. The stencil defines the image to be printed in other printing technologies this would be referred to as the image plate.

Screen printing ink is applied to the substrate by placing the screen over the material. Ink with a paint-like consistency is placed on to the top of the screen. Ink is then forced through the fine mesh openings using a squeegee that is drawn across the screen, applying pressure thereby forcing the ink through the open areas where no stencil is applied, thus forming an image on the printing substrate. The diameter of the threads and the thread count of the mesh will determine how much ink is deposited onto the substrates.

v. ETCHING

In all subtractive PCB process, etching is one of the most important steps. The final copper pattern is formed by selective removal of all unwanted copper, which is not protected by an etch resist. There are two basic ways that you can remove unwanted copper from copper-clad substrates to form electronic circuits: mechanical etching and chemical milling (etching).

- **MECHANICAL ETCHING**

It involves the use of a precise numerically controlled multi-axis machine tool and a special milling cutter to remove a narrow strip of copper from the boundary of each pad and trace. The removal of this copper electrically isolates the circuit element from the rest of the foil.

- **CHEMICAL ETCHING**

It relies on the action of any one of a family of corrosive liquids to dissolve away-unwanted copper in order to define the desired circuit pattern. But in practice, factors like under-etching and overhang compliance the etching process.

- **UNDER ETCHING**

During etching process etching must progress vertically. But in practice etching takes place in the sideways which attacks the pattern below the etch resist. Under etching can be minimized by keeping the etching, time as short as possible and by pressurized perpendicular discharge of the etched towards the surface to be etched.

vi. **RINSING**

After etching is over, the ferric chloride contaminated surface is cleaned. A simple spray water rinse is a dip in a 5% oxalic acid solution to remove the iron and copper salts.

vii. **PLATING**

Plating of metal can be accomplished on a copper pattern by three methods:

1) Immersion plating

2) Electrolysis plating

3) Electroplating

1) **IMMERSION PLATING**

It is the deposition of metallic coating on a substrate, by chemical replacement, from a solution of a salt of the coating metal. Advantages of immersion plating are simplicity, minor capital expenses and increase in deposits. Tin and its alloys and gold are the two most commonly used coating metals.

CIRCUIT FABRICATION AND SOLDERING DETAIL

SOLDERING TECHNIQUES

Soldering is an important skill for electrical technician. Good soldering is important for proper operation of equipment.

Solder is an alloy of tin and lead. The solder that is most used is 60/40 solder. This means that it is made from 60%tin and 40% lead. Solder melts at a temperature of about 400 degree Fahrenheit. For solder to adhere to join, the parts must to enough to melt the solder. Rosin flux is contained inside the solder. It is called rosin-core solder.
A good mechanical joint must be made when soldering. Heat is then applied until the material rare hot. When they are hot, solder is applied to the joint. The heat of the metal parts is used to melt the solder. Only a small amount of heat should be used sparingly. The joint should appear smooth and thin. If it does not, it could be a "cold" solder joint. This is called a “cold joint". Care should be taken not to damage PCB when soldering

parts on to them. Small, low wattage irons should be used with PCB and semiconductor devices

NEED OF FLUX

Flux is needed for achieving desired clean lines of the surface. Most metals tend to form compounds with atmospheric oxygen, which leads a coating of oxide even at room temperature, react chemically with oxides and disperse the reaction products. Fluxes are applied before and during soldering.

SOLDERING TOOLS

To facilitate soldering work, various tools are necessary. The most essential tools in the soldering practice are:

SOLDERING IRON

A soldering should supply sufficient heat to melt solder by heat transfer, when the iron tip is applied to the connection to the soldered. There are two general classes of soldering irons.

a) Soldering pencils: Soldering pencils are lightweight soldering tools, which can generate as little as 10W or as much as SOW. 25W is well suited for light duty works such as soldering on PCBs.

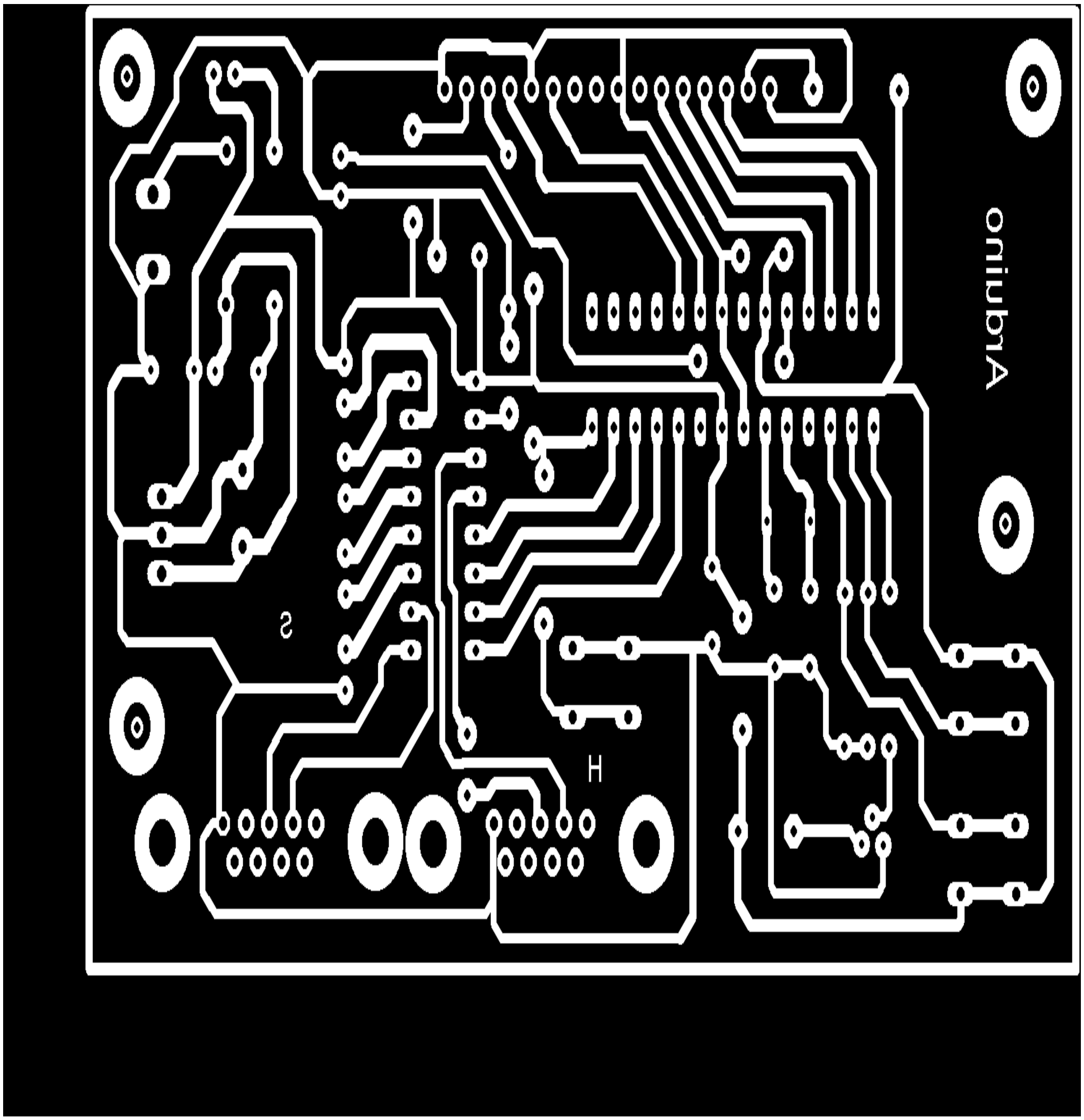
b) Soldering gun: A gun is heavier and generates more heat than the average pencils. Soldering of heavy-duty conductors requires the use of a gun because it can generate enough heat to quickly being a heavy metal joint at the proper soldering temperature. These soldering tools are called gun-soldering station.

STRIPPERS AND BENDING TOOLS

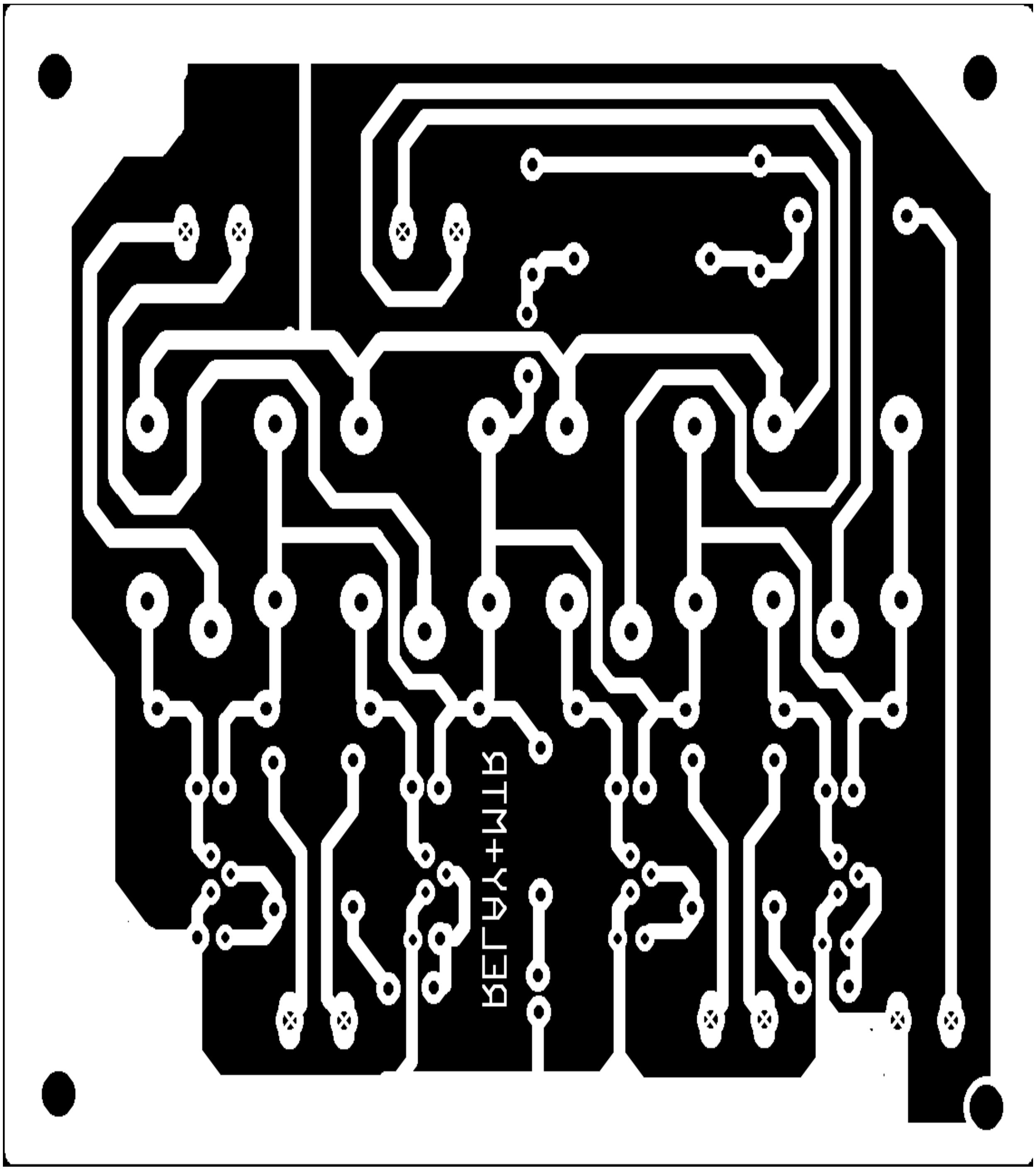
Strippers are used to remove insulation from the wire. Bending tools are those having smooth bending surface so that they do not cause any damage to the component.

The figure above shows the practical design of automatic solar tracking system.

PCB LAYOUT



MOTOR CIRCUIT PCB LAYOUT



SOFTWARE PROGRAM

```
#include <SoftwareSerial.h>
SoftwareSerial debug (3, 2); // RX, TX
#include <LiquidCrystal.h>
const int rs = 8, en = 14, d4 = 12, d5 = 11, d6 = 10, d7 = 9;
LiquidCrystal lcd(rs, en, d4, d5, d6, d7);


int L_level;
int R_level;
int S_level;
int count;
void setup()
{
  debug.begin(9600);
  Serial.begin(9600);
  lcd.begin(16, 2);
  delay(100);
  lcd.print("  SOLAR  ");
```

```
  lcd.print(" TRACKER ");
  delay(1500);
  Serial.println("AT");
  delay(700);
  Serial.println("ATE1");
  delay(700);
  Serial.println("AT+CMGF=1");


  delay(700);
}


void loop()
{
  L_level = AnalogRead(0);
  R_level = AnalogRead(1);
  S_level = AnalogRead(2);
  if(L_level<100);
  {
    rotate_panel_L();
    send_msg="Panel Rotated Left";
```

```
  SerialsendSMS(send_msg);
}
else if(R_level<100);
{
  rotate_panel_R();
  send_msg="Panel Rotated Right";
  SerialsendSMS(send_msg);
}
else if(S_level<100);
{
  rotate_panel_S();
  send_msg="Panel Rotated Straight";
  SerialsendSMS(send_msg);
}
get_battery_V();
lcd.print(battery_V);

count=count+1;
delay(100);
if(count>=200)
```

```
  {
    clean_panel();
    count=0;
  }
}

void SerialsendSMS(char *number1)

{
  Serial.flush();
  delay(500);
  Serial.println("AT+CMGF=1");
  delay(1500);
  Serial.print("AT+CMGS=");
  Serial.print((char)34);
  Serial.print(number1);
  Serial.println((char)34);
  delay(500);
  Serial.print(send_msg);
  delay(2500);
```

```
  Serial.print((char)26);
  delay(3000);
}


/* Function for reading the analog pins for current transformer output */
int AnalogRead(int readPin)


{
  int temp_V;
  temp_V = analogRead(readPin);
  delay(150);
  return temp_V;
}


void upload_data(char *data)
{
  Serial.println("AT+SAPBR=3,1,\"Contype\",\"GPRS\"\r");
  Verify.println(get_response(5000));
  Serial.println("AT+SAPBR=3,1,\"APN\",\"www\"\r");
  Verify.println(get_response(5000));
```

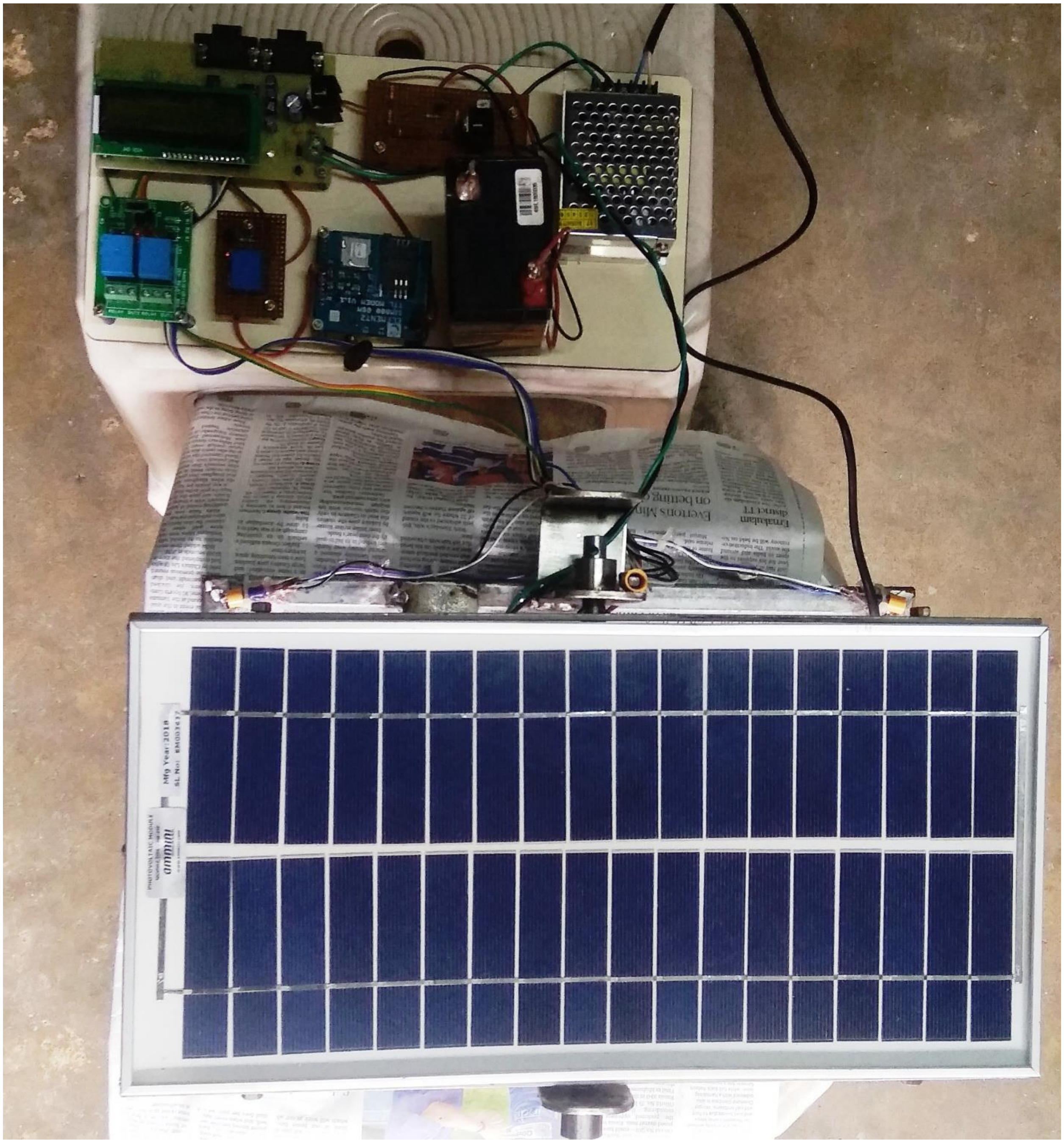
```
  Serial.println("AT+SAPBR=1,1\r");
  Verify.println(get_response(5000));
  Serial.println("AT+HTTPINIT\r");
  Verify.println(get_response(5000));

Serial.print("AT+HTTPPARA=\"URL\",\"serverSOLAR.000webhostapp.com/Project10/index.php?data=");
  delay(5000);
  Serial.print(data);
  Serial.println("\"\r");
  Serial.println("AT+HTTPACTION=0\r");
  Verify.println(get_response(15000));
  Serial.println("AT+HTTPTERM");
  Verify.println(get_response(500));
}

void clean_panel()

{
  digitalWrite(PUMP,HIGH);
  for(int k=0;k<5;k++)
```

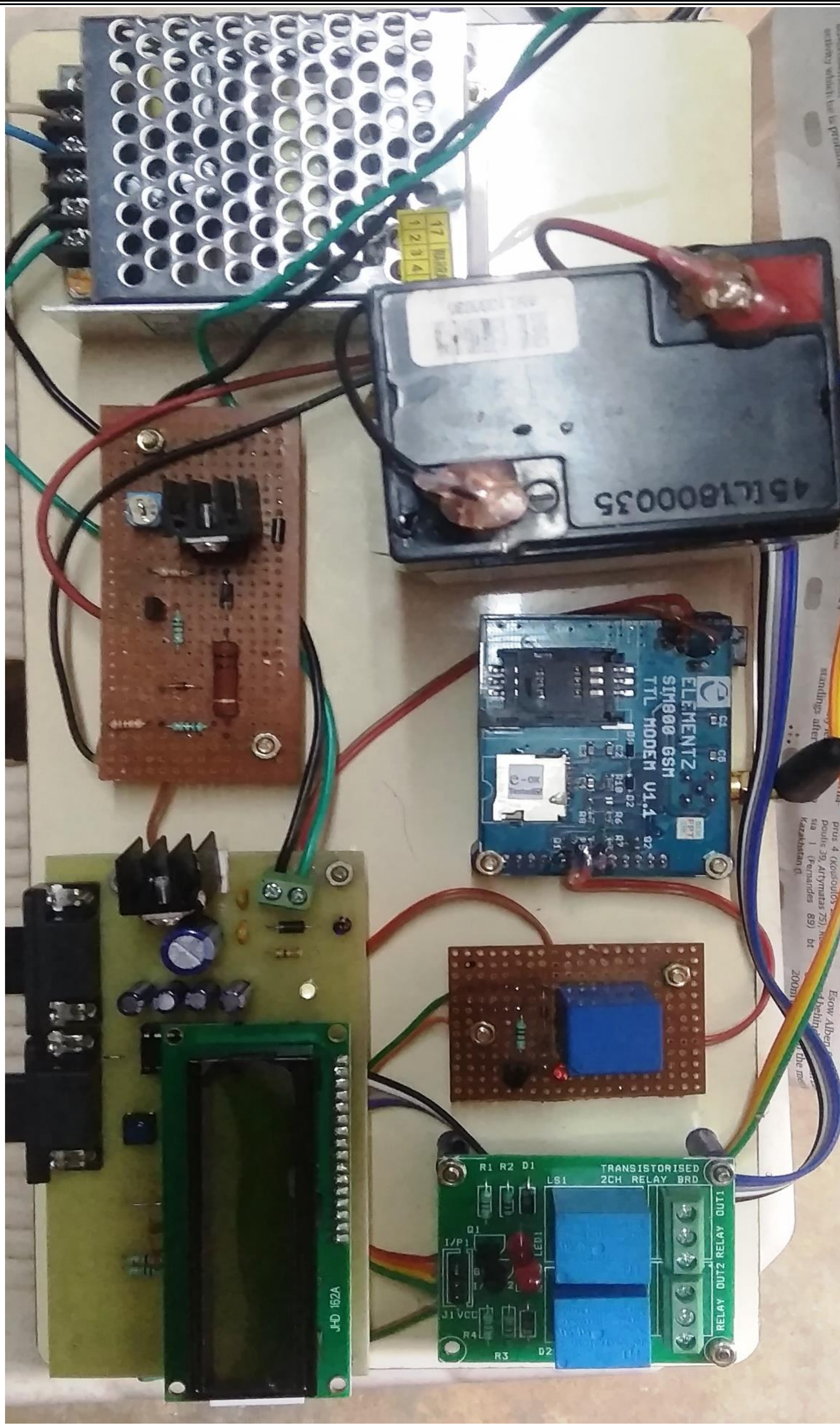
```
  {
    delay(1000);
  }
  digitalWrite(PUMP,LOW);
}

void rotate_panel_L()
{
  if(L_limit)
  {
    while(!L_limit)
    {
      digitalWrite(M1,LOW);
      digitalWrite(M2,HIGH);
    }
  }
  delay(10);
  digitalWrite(M1,LOW);
  digitalWrite(M2,LOW);
}
```

```
void rotate_panel_R()
{
  if(R_limit)
  {
    while(!R_limit)
    {
      digitalWrite(M1,HIGH);
      digitalWrite(M2,LOW);
    }
  }

  delay(10);
  digitalWrite(M1,LOW);
  digitalWrite(M2,LOW);
}

void rotate_panel_S()
{
  if(L_limit)
```

```
  {
      digitalWrite(M1,HIGH);
      digitalWrite(M2,LOW);
      delay(1500);
      digitalWrite(M1,LOW);
      digitalWrite(M2,LOW);
  }

  else if(R_limit)
  {
      digitalWrite(M1,LOW);
      digitalWrite(M2,HIGH);
      delay(1500);
      digitalWrite(M1,LOW);
      digitalWrite(M2,LOW);
  }
}
```

FINAL PRODUCT IMAGE




ELEMENTZ
SIM800 GSM
TTL MODEM V1.1
TRANSISTORISED
2CH RELAY BRD
JHD 162A

ADVANTAGES

- Trackers generate more electricity than their stationary counterparts due to increased direct exposure to solar rays. This increase can be as much as 10 to 25% depending on the geographic location of the tracking system.
- There are many different kinds of solar trackers, such as single-axis and dual-axis trackers, all of which can be the perfect fit for a unique jobsite. Installation size, local weather, degree of latitude and electrical requirements are all important considerations that can influence the type of solar tracker best suited for a specific solar installation.
- Solar trackers generate more electricity in roughly the same amount of space needed for fixed-tilt systems, making them ideal for optimizing land usage.
- In certain states, some utilities offer Time of Use (TOU) rate plans for solar power, which means the utility will purchase the power generated during the peak time of the day at a higher rate. In this case, it is beneficial to generate a greater amount of electricity during these peak times of the day. Using a tracking system helps maximize the energy gains during these peak time periods.
- Advancements in technology and reliability in electronics and mechanics have drastically reduced long-term maintenance concerns for tracking systems.

DISADVANTAGES

- Solar trackers are slightly more expensive than their stationary counterparts, due to the more complex technology and moving parts necessary for their operation. This is usually around a $0.08 – $0.10/W increase depending on the size and location of the project.
- Even with the advancements in reliability, there is generally more maintenance required than a traditional fixed rack, though the quality of the solar tracker can play a role in how much and how often this maintenance is needed.
- Trackers are a more complex system than fixed racking. This means that typically more site preparation is needed, including additional trenching for wiring and some additional grading.
- Single-axis tracker projects also require an additional focus on company stability and bankability. When it comes to getting projects financed, these systems are more complex and thus are seen as a higher risk from a financier's viewpoint.
- Solar trackers are generally designed for climates with little to no snow making them a more viable solution in warmer climates. Fixed racking accommodates harsher environmental conditions more easily than tracking systems.
- Fixed tracking systems offer more field adjustability than single-axis tracking systems. Fixed systems can generally accommodate up to 20% slopes in the E/W direction while tracking systems typically offer less of a slope accommodation usually around 10% in the N/S direction.

APPLICATIONS

1. This system software and hardware can be used to drive a real and very huge solar panel.
2. The computer and System Control Unit would have a wireless communication with the mechanical structure of solar panel.
3. To make emergency control better more powerful microcontrollers e.g. PIC 16F877A would be used.
4. For domestic backup power systems.
5. For power generations at remote places where power lines are not accessible.
6. It may be used in water treatment technologies and solar heating.
7. It can be used in solar street lighting system.

A model of solar tracker is shown above

CONCLUSION

In the proposed design and operation of the solar tracker system, the sun was not constantly tracked based on the irradiation. This helps to prevent unnecessary energy to be consumed by the devices and the system stops moving when the night falls. Simulation result shows that the codes generated for servo controlling are working accordingly. The developed system was also tested for performance evaluation. The designed that system which ensures 25 to 30% of more energy conversion than the existing static solar module system. Although ASTS is a prototype towards a real system, but still its software and hardware can be used to drive a real and very huge solar panel. A small portable battery can drive its control circuitry. Therefore by just replacing the sensing instrument, its algorithm and control system can be used in RADAR and moveable dish antennas.

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