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Chapter 1

1.0 INTRODUCTION & BACKGROUND

Engineering for sustainability is an emerging theme for twenty-first century, and the need for more environmentally benign power system is a critical part of this new thrust. Renewable energy systems that take advantage of energy source that won't diminish over time and are independent of fluctuations in price and availability are playing an ever increasing role in modern power systems. Wind farms in the United States and Europe have become the fastest growing source of electric power; solar powered photovoltaic system has entered the marketplace; fuel cells that will generate the electricity without pollution are on the horizon. Moreover, the newest fossil fueled power plants approach twice the efficiency of coal burners that they are replacing while emitting only a tiny fraction of the pollution.

The continuously increasing electrical energy demands the significant rise of the oil price and the decrement of fossil fuel reserves, combined with the environmental pollution caused by the conventional thermal electric energy generating units has led to the worldwide concern on the development of alternative energy production methods.

There are compelling reasons to believe that the traditional system of large, central power stations connected to their customers by hundreds or thousands miles of transmission lines will likely be supplemented and eventually replaced with cleaner, smaller plants located closer to their loads. Not only do such distributed generation systems reduce transmission line losses and costs, but the potential to capture and utilize waste heat on site greatly increases their overall efficiency and economic advantages. Moreover, distributed generation system offer increased reliability and reduced threat of massive and widespread power failures of the sort.

It is an exciting time in electric power industry, worldwide. New technologies on both sides of the meter leading to structural changes in the way that power is provided and used, an emerging demand for electricity in the developing countries where two billion people now live without any access to power, and increased attention being paid to the environmental impacts of power production are all leading to the need for the new books, new courses, and a new generation of engineers who will find satisfying, productive careers in this newly transformed industry.

1.1 The village Electrification programme in India

Work on the electrification of all remote villages in the country begins as a distinct programme in financial year 2001-2002. MNES identified three major renewable energy technologies to accomplish this task: Photovoltaic's, small hydro power and biomass gasifier-based generation. The concept was to generate power and to distribute it within a village, or alternately install individual home system.

The photovoltaic route permits both options to be used, depending upon the size and topography of the village. The village can be electrified either through the individual, stand alone home systems or through the installation of power plant from where a line could be taken all over the villages to energize homes as well as street lights and other community installations.

Most remote villages are characterized by the following features:

- They are located in difficult areas such as forests, hills, deserts and islands.
- They are located 3-30 km away from the existing grid and in some cases even more.
- Transport and communication facilities are minimal.
- The income level and hence the paying capacity in many cases is likely to be low.
- Literacy levels and technical skills are poor.

Considering the above features, it appears that photovoltaic route may be the best possible option to electrify the bulk of villages from a technology point of view. Biomass and small hydropower could be lower cost options, but also require the resources to be available locally on a year round basis. Although no clear assessment has been made, it is likely that photovoltaic systems would be most appropriate choices for the electrification of 75-80 % of remote villages.

According to the data compiled up to February 2003, 491,186 villages are considered electrified leaving about 96,000 villages still to be electrified. It was also estimated that there were about 18,000 villages in difficult and remote areas which cannot be electrified by conventional grid extension. This figure is likely to go beyond 20,000 or more villages. Ministry of Non-conventional energy sources (MNES) also exclaims that approximately only about 43.5% of rural homes are connected to the conventional grid. It further states that nearly 77 million household in the country depend on kerosene for lighting. The census data also reveals that about 522,000 homes uses solar energy for lighting.

It is clear from the above that potential for the use of renewable energy sources, particularly solar energy is immense in India. In 2001 the Indian government decided to electrify all the remaining villages in time bound manner. The task of electrifying all the remote villages has been given to the MNES.

In other words these villages are to be electrified in a decentralized manner using renewable energy sources. Assuming about 20,000 villages fall in this category, there can be about one million household to be covered. In addition there are several thousands hamlets which are not classified as independent villages, but would still need to be electrified in a decentralized manner, as they are located in difficult areas.

Solar-powered lighting systems are already available in rural as well as urban areas. These include solar lanterns, solar home lighting systems, solar street lights, solar garden lights and solar power packs. All of them consist of four components: Solar photovoltaic module, rechargeable battery, solar charge controller and load. In the solar-powered lighting system, the solar charge controller plays an important role as the system's overall success depends mainly on it. It is considered as an indispensable link between the solar panel, battery and load.

The main components used in this project are as following:-

- Solar Photovoltaic system.
- Fuel cell.
- Dc-Dc converter.
- Charging controller.

Chapter 2

2.0 LITERATURE REVIEW

In India the demand for electricity has also been growing at an average rate of about 9% per year. Although the country's total power generating capacity is also increasing steadily exceeding the limit of 104, 000 MW, there are frequent shortages of power in several parts of the country. The per capita power consumption is also well below the global averages.

2.1 PHOTOVOLTAIC DEVELOPMENT IN INDIA

The photovoltaic programme in India is more than 25 years old as the writer [1] explains. It further expresses that the technology for the production of solar cells and modules for terrestrial use was developed in seventies and put into commercial use in eighties. There are 8 cell manufacturers and 14 module manufacturers in active production today in the country. The total production has been increasing steadily and has touched a figure of 22MW of cells and 23 MW of modules during the financial year 2002-2003. This places India in the fifth place in the matter of Pv production. The MNES has been implementing a country –wide programme of demonstration and utilization for over two decades now. A variety of system has been developed and deployed in the country for various applications. These include solar lanterns, home systems, street lights, pumping systems, small power activities such as water pumping and other economic activities. This may require an investment of upto Rs. 3 million ($60, 000) per village. On this basis, the remote village electrification programme in India is estimated to require an investment of about $1.20 billion. The PV systems commonly installed under the programme are as following:

- Five models of solar home systems with modules in three sizes: 18W, 37W and 74W.
- Street lights with a 74W module and 11W CFL, for night long operation.
- Power plants in the range of (1-25)kw of array capacity, with matching battery capacity and inverter.
- Stand alone PV-pumps where necessary.

The systems are generally procured by the state agencies and installed on a turn-key basis by established manufacturers who are selected through competitive bidding. They are required to adhere to the specifications laid down by the MNES and possess test certificates for the system issued by authorized test centers.

A total of 915 villages has been electrified past two years, out of which 878 villages has been electrified through photovoltaic technology. The following table (1) shows the state wise electrification during 2001-2003.

State	Villages Electrified	Under Progress
Arunachal Pradesh	10	63
Assam	36	03
Chhattisgarh	120	200

State	Villages Electrified	Under Progress
Gujarat	-	01
Jammu & Kashmir	57	-
Jharkhand	-	20
Madhya Pradesh	-	55
Manipur	-	137
Meghalaya	-	25
Mizoram	07	14
Nagaland	-	13
Tripura	11	18
Uttaranchal	80	209
Uttar Pradesh	-	14
West Bengal	594	321
Total	915	1114

Among the many projects taken up in India, two examples stand out because of their size or locational features. These are locations in Sunderban region of West-Bengal and the Laddakh region of Jammu & Kashmir. They are described below.

2.2.1 SUNDERBANS SOLAR PROJECTS

The sunderban is a large area about 100km south of Kolkata, crisscrossed by the rivers. There are a number of villages in the region, none having electricity. Sagar and moushuni are two prominent islands in the region, each having several villages. The West Bengal Renewable Energy Development Agency with support from MNES , installed a total of 10 PV power plants with an aggregate capacity of about 375 KWp. Eight plants in sagar are in the range of (25-28)KWp, while two in moushuni have capacities of 55KWp and 105KWp.

The plants were commissioned between 1996 and 2003. The cost of the plants has ranged between $6,000 to $8,000 per KW, with a downward trend over the years.

A 25KWp plant serves 100-200 households and provides power also to street lights and some other community installations. In a few villages power has been given to pumps which provide drinking water supply.

2.2.2 LADDAKH ELECTRIFICATION

The laddakh region is located near the eastern part of the state Jammu & Kashmir and is a region of high altitude and cold climate. Most habitations are located at a height of approximately between 3000 and 4000 meters. The region is cut off for about 6 months in a year. The two districts of Leh and Kargil depend upon diesel and some amount of hydro-power for electricity.

The MNES has been supporting the installation of solar PV systems in laddakh for over a decade now. In 2001, a special project was taken up in association with the state government to electrify the remaining unelectrified villages in the two districts. The project covered 57 villages and 27 hamlets. The ministry sanctioned 10,000 solar home systems and 6,000 solar lanterns under this special project, and provided 90% of the cost of the systems. Although the state government provided the balance 10%, an initial contribution was charged from all users to help build a revolving fund. Monthly contributions are also being obtained. The two companies that executed the project have trained local people in the maintenance tasks. The project has enabled the laddakh region to achieve 100% electrification.

Distributed Generation (DG) systems are potential solutions for efficient and economic integration of many ncs into existing power grid. Among various alternative power sources, fuel cells are strong candidates for DG applications. Suitable interfacing of such resources into DG network critically depends on design and performance of the power conversion stage. [2]

A methodology for the design optimization and the economic analysis of Pv grid connected systems (PVGCs) is presented. The purpose is to suggest, among a list of commercially available system devices, the optimal number and type of system devices and optimal values of pv module installation details, such that the total net economic benefit achieved during the system operational lifetime period is maximized. [3]

2.3 Statement of Problem

The main work till now is dependency on one non-conventional energy sources as the writer in [2] and [3] tries to integrate either fuel cell or Photovoltaic cell alone.

2.4 Objective of dissertation

By observing closely the above work we came to know that they are individually integrating both fuel cell as well as photovoltaic cell. So in order to reduce the dependency on one non-conventional energy sources I tried to integrate both the fuel cell as well as photovoltaic cell such that maximum power is derived from photovoltaic cell and the rest of the demand is met by the fuel cell.

2.5 Organisation of dissertation

Chapter 1 deals with the introduction part as well as Village electrification programme in India.

Chapter 2 deals with the literature review, pv development in India, two case studies (Sunderban and laddakh electrification), statement of problem, objective, organization of dissertation.

Chapter 3 deals with the block-diagram, circuit description, working of model, description about dusk-to-dawn sensor and charge control.

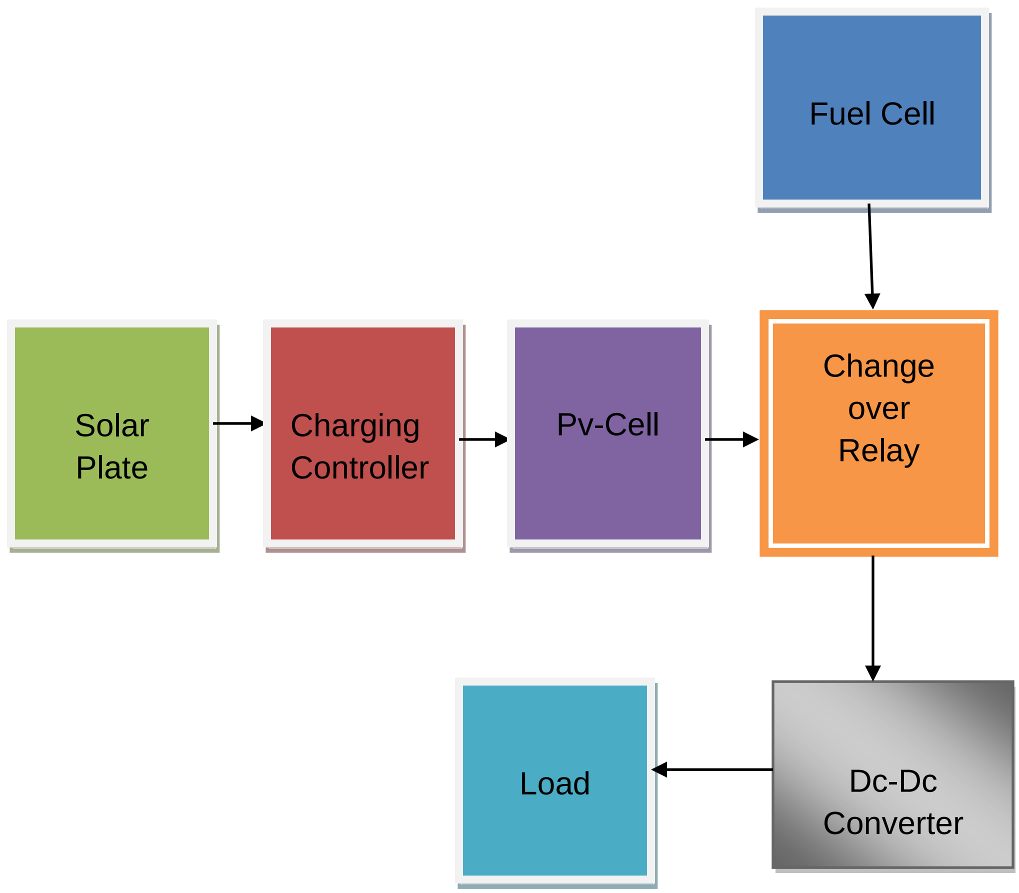
Chapter 4 deals with detailed explanation of components used here.

Chapter 5 deals with experimental results which is obtained in the month of May (2010).

Chapter 6 deals with Conclusion and future work.

Chapter 3

3.1 BLOCK DIAGRAM



3.2 Circuit Description

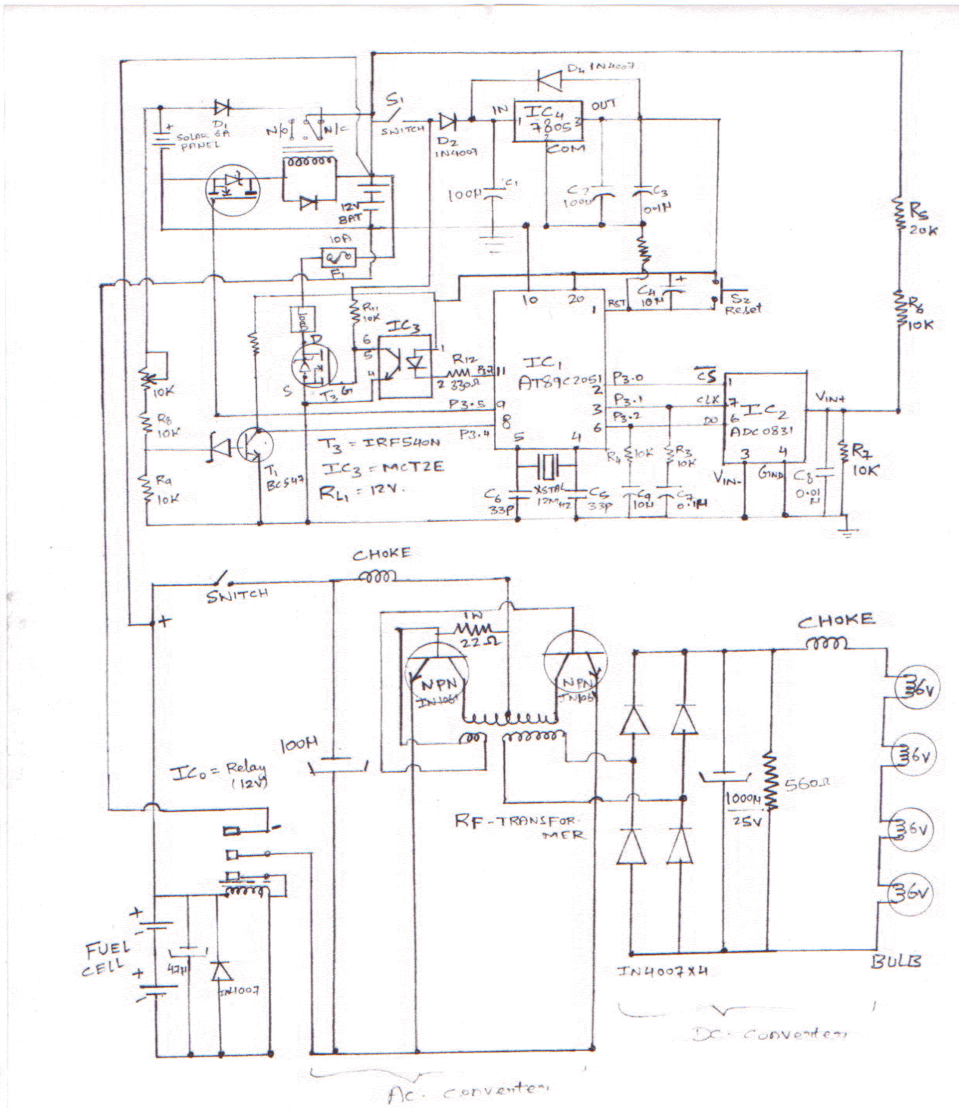


Fig. CIRCUIT DIAGRAM

3.3 Working

Once the power is on, the microcontroller reads the battery voltage with the help of the ADC. It monitors the input signal from the dusk-to-dawn sensor and activates the load or charging relay RL1 accordingly. As Vref of the ADC is connected to Vcc(5v), the input voltage to the ADC cannot exceed +5v. A potential divider is used at pin2 of the ADC (IC2) using resistors R5, R6 and R7 to scale down the voltage from 0V-2V to 0V-05V.

During charging the battery voltage is continuously monitored. When the voltage reaches 14.0V, the microcontroller interrupts the charging current by energising the relay, which is connected to mosfet BS170 (T2), and starts a 5-minute timer.

After five minutes, the relay reconnects the panel to the battery. This way the charging current is pulsed at the interval of five minutes and the cycle repeats until the panel voltage is present.

When the panel voltage falls below the zener diode (ZD1) voltage of the dusk-to-dawn sensor, the microcontroller senses this and activates the load by switching on MOSFET T3 via optocoupler IC3.

In this mode, the microcontroller monitors for low battery. When the battery voltage drops below 10 volts, the microcontroller turns off the load by switching off MOSFET T3. Normally, when the load is switched off, the battery voltage tends to rise back and the load oscillates between on and off states. To avoid this microcontroller employs a hysteresis control by entering into lock mode during low battery state and comes out of the lock mode when sensor receives the panel voltage.

Now once the battery is fully charged the output (12V) is taken through the battery to the Dc-Dc converter in which 12V dc is converted to Ac and is fed to the RF-transformer, where some additional winding is done in the transformer to increase the voltage upto 20V ac.

Now this 20V ac is converted to the 24V dc with the help of rectifier bridge circuit. Four Led (bulbs) each of 6V is connected in the output for display. During winter season or when the battery is not fully charged then in that case power is obtained through fuel cell for that a provision is made using change-over relay which is done manually, and hence feedback is not required.

3.3.1 Dusk to dawn sensor

Normally during the daytime the load is disconnected from the battery and the battery is recharged with current from the solar panel. The microcontroller needs to know the presence of the solar panel voltage to decide whether the load is to be connected to or disconnected from the battery, or whether the battery should be in charging mode or discharging mode. A simple sensor circuit is built using a potential divider formed around resistors R8 and R9, zener diode ZD1 and transistor T1 for the presence of panel voltage.

3.3.2 Charge control

Relay RL1 connects the solar panel to the battery through diode D1. Under normal conditions, it allows the charging current from the panel to flow into the battery. When the battery is at full charge (14V), the charging current becomes pulsed. To keep the overall current consumption of the solar controller low, normally closed (N/C) contacts of the relay are used and the relay is normally in de-energized state.

Basically, there are two methods of controlling the charging current: Series regulation and parallel (shunt) regulation. In series regulation a series regulator is inserted between the solar panel and the battery. The series regulator wastes a lot of energy while charging the battery, as the control circuitry is always active and series regulator requires the input voltage to be 3-4 volts higher than the output voltage. The Current and voltage output of a solar panel is governed by the angle Of incidence of light, which keeps varying.

Parallel regulation is preferred in solar field. In parallel regulation, the control circuitry allows the charging current (even in mA) to flow into the battery and stop charging once the battery is fully charged. At this stage, the charging current is wasted by converting into heat (current is passed through low value, high wattage resistor); this part of the regulation dissipates a lot of heat. In this project, we have used parallel regulation technique but instead of wasting the charging current as heat, we have made it pulsed and applied to the battery to keep the battery topped-up.

Chapter 4

4.1 COMPONENTS EXPLANATION

4.1.1 Photovoltaic Technology

Solar photovoltaic (PV) systems convert solar energy directly into electrical energy. Basic conversion device used is known as solar Photovoltaic cell or a solar cell. A solar cell is basically an electrical current source, driven by a flux of radiation. Solar cell was first produced in 1954 and was rapidly developed to provide Power for space satellites based on semiconductor technology. Its terrestrial applications were considered seriously only after the oil Crisis of 1973, when a real need of alternative energy sources was felt globally for the first time.

Solar cell is the most expensive component in a solar PV system (about 60% of the total cost), though its cost is falling slowly. Commercial photocells may have efficiencies in the range of 10-20% and can produce electrical energy of 1-2 KWh per sq m per day in ordinary sunshine. A typical commercial cell of 100 sq cm area, thus produces a current of 2 A. It has a life span in excess of about 20 years. As a PV system has no moving parts it gives almost maintenance free service for long periods, and can be used unattended at inaccessible locations.

Major uses of photovoltaics have been in space satellites, remote radio communication booster stations and marine warning lights. These are also increasingly being used for lighting, water pumping and medical refrigeration in remote areas especially in developing countries. A typical photovoltaic-cell is shown below.

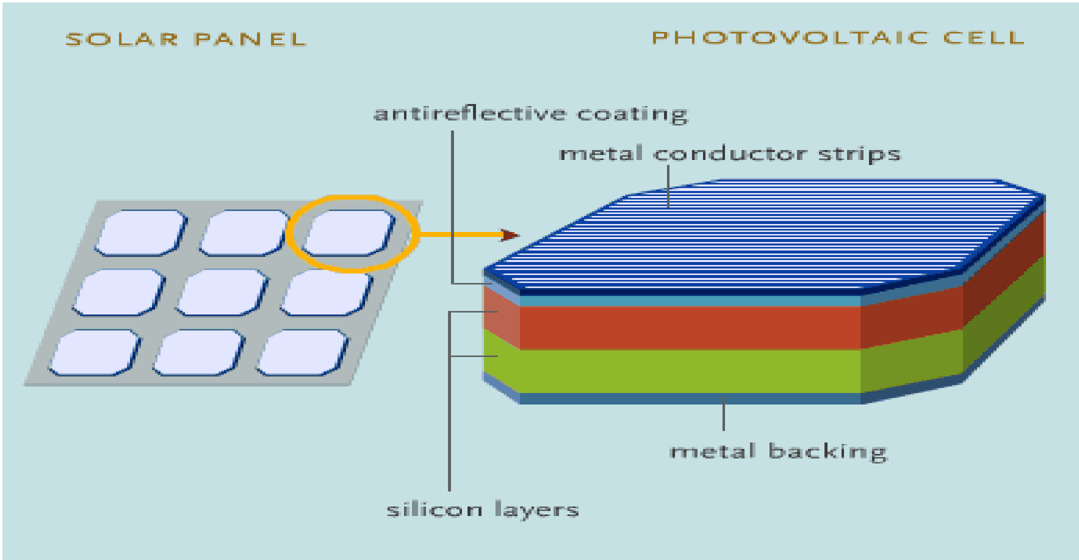


Fig 4.1 Photovoltaic-cell

4.1.2 Solar cell classification

Solar cell may be classified on the basis of:

- Thickness of active material.
- Type of junction structure.
- The type of active material used in its fabrication.

4.1.2(a) On the basis of thickness of active material

Depending on the thickness of the active material, they are classified as:

- Bulk material cell.
- Thin film cell.

In bulk material cells, base material (starting material in fabrication Process) is itself an active material. In thin film cells, a thin film (A fraction of a micron) deposition of active material is carried out on the back of support sheet, known as substrate.

4.1.2(b) On the basis of junction structure

On the basis of the type of junction structure they are classified as following:-

- Pn homojunction cell.
- Pn heterojunction cell.
- Pn multijunction cell.
- Metal-semiconductor schottky junction.
- P-i-n (P type- intrinsic-n type) semiconductor junction.

4.1.2(c) On the basis of type of active material

Depending on the type of material used for fabrication of junction, they are classified as following:-

- Single crystal silicon cell.
- Multicrystalline silicon cell.
- Amorphous silicon (A-si).
- Gallium arsenide cell (GaAS)
- Copper indium (gallium) diselenide cell (CIS).
- Cadmium telluride cell (CdTe)
- Organic Pv-cell.

At present, only single crystal, multicrystalline, and to some extent a Si cells are being produced commercially.

4.1.3 How solar cells work

A typical photovoltaic cell consists of semiconductor material (Usually silicon) having a P-n junction. Sunlight striking the cell raises the energy level of electron and frees them from their atomic shells. The electric field at the P-n junction drives the electron into the n region while the positive charges are driven to the p region.

A metal grid on the surface of the cell collects the electron while a metal back-plate collects the positive charges. In this project we will control the charging of photovoltaic-cell with the help of digital controller such that solar panel will receive the sun rays and the sunlight will be converted to the electricity. This electricity will be stored in a battery which will feed to the Dc-dc converter operating in parallel. When the sufficient amount of power is not available through the photovoltaic cell, then in that case the rest of the power demand is fulfilled by the use of fuel cell/battery.

4.2 Fuel cell

A fuel cell is an electrochemical energy conversion device that continuously converts chemical energy of a fuel directly into electrical energy. Continuous operation requires supply of fuel and oxidant and removal of water vapour, spent fuel, spent oxidant, inert residue and heat etc. Like a conventional primary cell it also has two electrodes and an electrolyte between them and produces dc power. It is also a static power Conversion device. However, active materials are supplied from outside unlike conventional cell where it is contained inside the cell.

Fuel is supplied at the negative electrode, also known as fuel electrode and oxidant is supplied at positive electrode, also known as Oxidant electrode. Main exhaust of a fuel cell, if pure hydrogen is used as fuel (and pure oxygen as oxidant), is water vapour, which is not pollutant. In case of hydrocarbon fuel, carbon dioxide is also produced. If air is used as oxidant, nitrogen (spent air) is also produced in the exhaust. No other pollutant such as particulate matter, NOx and SOx are produced. Some amount of heat is also produced, which can be easily dissipated in atmosphere or used locally for heating purpose. No cooling water is required, unlike conventional thermal power conversion devices where substantial quantity of cooling water is required.

4.2.1 Classification of fuel cells

Fuel cells can be classified in several ways which are as following.

4.2.1(a) Based on the type of electrolyte

- Phosphoric acid fuel cell (PAFC).Alkaline fuel cell (AFC).
- Polymer electrolytic membrane fuel cell (PEMFC).
- Molten carbonate fuel cell (MCFC).
- Solid oxide fuel cell (SOFC).

4.2.1(b) Based on the types of the fuel and oxidant

- Hydrogen (pure)-Oxygen (pure) fuel cell.
- Hydrogen rich gas-air fuel cell.
- Hydrogen peroxide fuel cell.
- Ammonia-air fuel cell.
- Synthesis gas-air fuel cell.
- Hydrocarbon (gas)-air fuel cell.
- Hydrocarbon (liquid)-air fuel cell.

4.2.1(c) Based on operating temperature

- Low temperature fuel cell (below 150 degree centigrade).
- Medium temperature fuel cell (150-250 degree centigrade).
- High temperature fuel cell (250-800 degree centigrade).
- Very high temperature fuel cell (800-1100 degree centigrade).

4.2.1(d) Based on application

- Fuel cell for space applications.
- Fuel cell for vehicle propulsion.
- Fuel cell for submarines.
- Fuel cell for defense applications.
- Fuel cell for commercial applications.

4.2.1(e) Based on chemical nature of electrolyte

- Acidic electrolyte type.
- Alkaline electrolyte type.
- Neutral electrolyte type.

4.2.2 Advantages

- It is quite in operation as it is static.
- It is less pollutant.
- Its conversion efficiency is more due-to direct single stage conversion.

Note: - Figure of fuel cell is shown below. In this project for the purpose of demonstration of model i had used battery instead of fuel cell because of unavailability of fuel cells.

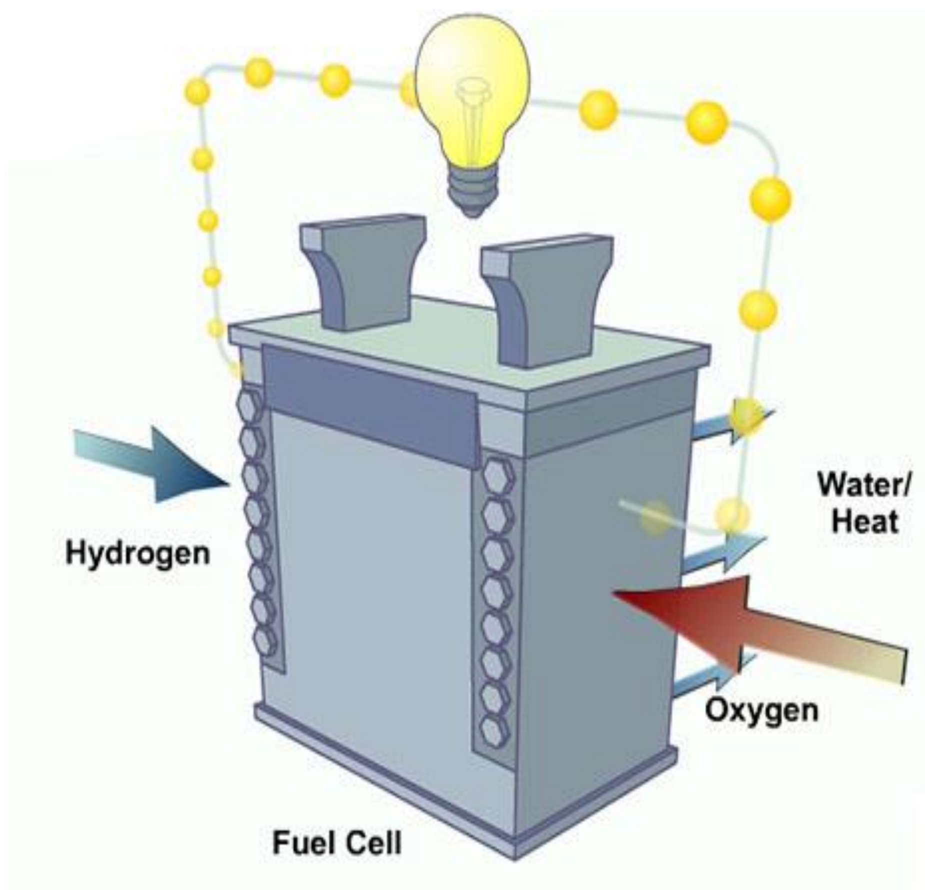


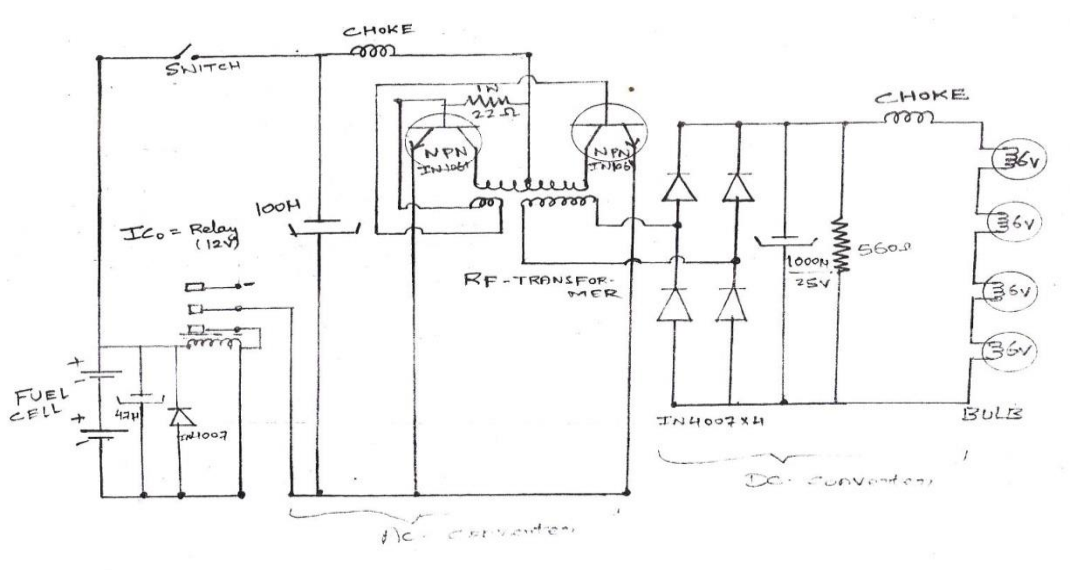
Fig 4.2 A typical fuel cell.

4.3 Dc-dc converter operating in parallel

Dc-dc converter operating in parallel offers the advantage of increasing the current as required by the output device. Besides that it has got the several other advantages which are described as below.

- One of the most important aspects is to improve the system reliability and operational redundancy by it.
- It can be covered over a wide power range.
- Cost of the development and existing systems can be extended easily.
- If the trigger equipments are synchronized and phase shifted the ripple contents of the output voltage and inductor current are reduced significantly.
- Reduction of the size of the magnetic devices. This leads to the lower stray inductances and therefore to lower switching losses.

Fig 4.3 Dc-dc converter



A dc-dc converter comprises of the following parts:-

- Inverter circuit.
- RF-transformer.
- Rectifier bridge circuit.

4.3.1 Inverter Circuit

A DC/AC inverter controlling system controls a DC/AC inverter so as to continuously output maximum AC power thereof, taking account of solar energy generated from a solar cell. In this inverter circuit, DC power is connected to a transformer through the centre tap of the primary winding. A switch is rapidly switched back and forth to allow current to flow back to the DC source following two alternate paths through one end of the primary winding and then the other. The alternation of the direction of current in the primary winding of the transformer produces alternating current (AC) in the secondary circuit.

4.3.2 RF-Transformer

RF transformers are used here for voltage step-up and for isolating dc from two circuits while maintaining ac continuity.

Essentially an RF transformer consists of two windings linked by a mutual magnetic field. When one winding, the primary has an ac voltage applied to it, a varying flux is developed; the amplitude of the flux is dependent on applied voltage and number of turns in the winding. Mutual flux linked to the secondary winding induces a voltage whose amplitude depends upon the number of turns in the secondary windings. Here by designing the number a turn in the primary as well as in secondary the step-up voltage is achieved. Mutual coupling is attained by the use of core of iron or ferromagnetic material having higher permeability than air. The output of RF-transformer is 20V ac.

4.3.3 Rectifier bridge circuit

With the help of Rectifier Bridge circuit 20V Ac voltage is converted into 24V dc. Capacitor is employed in conjunction with inductor to form LC-combination to separate the required signal from the unwanted ones. This LC-combination is also used for storing the energy in the magnetic form using the property that an electric current flowing through the coil produces a magnetic field, which in turn produces an electric current. In other words, coils offer a means of storing energy on the basis of inductivity (reactive magnetic flux). A simplified rectifier bridge circuit as well as general layout of a dc-dc converter is shown below.

A main problem of the parallel operating converters is to attain an accurate equalization of the module output currents. There are different solutions to this problem; all the approaches so far try to reach this goal with a minimum of technical complexities in order to keep the cost of module at a low level. In recent years the implementation of digital control concepts in switching power supply systems seems to be of growing interest. Here we have combined parallel operating Dc-dc converter with a digital control unit.

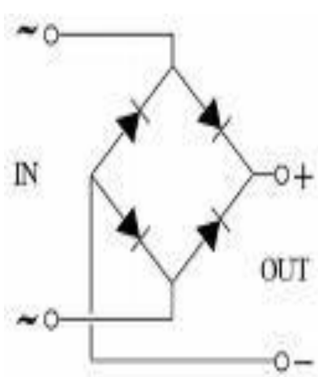
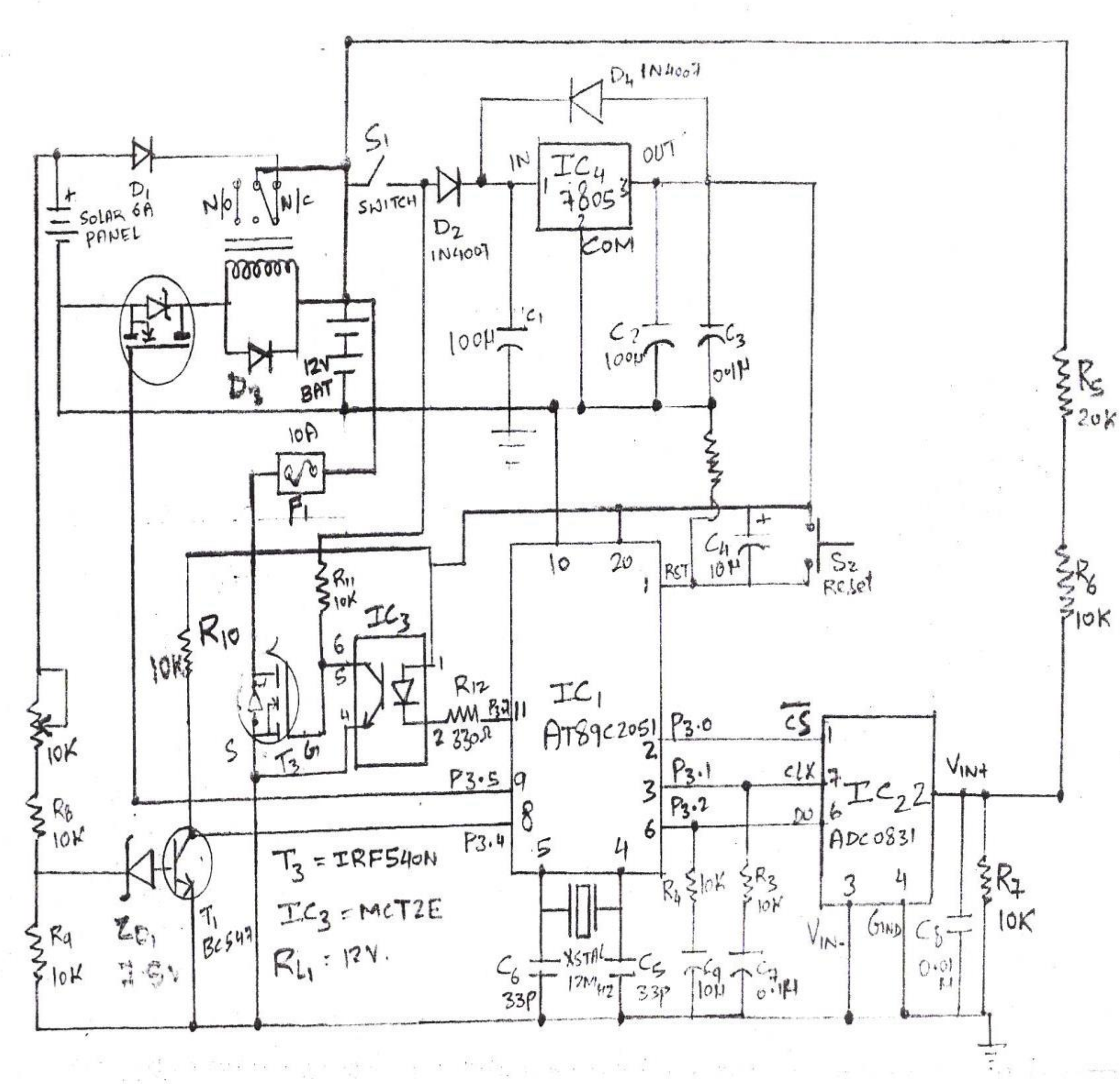


Fig 4.3(a) Bridge circuit **Fig 4.3(b) General layout of Dc-dc converter.**

4.4 Charging controller

The charging controller is used to control the charging of photovoltaic cell. The output of photovoltaic-cell is fed to Dc-dc converter which will be operating in parallel. Circuit diagram (4.4) of solar charge controller is shown below.



The circuit of the solar charge controller comprises of the following.

- Microcontroller AT89C2051.
- Serial analogue-to-digital converter ADC0831.
- Optocoupler MCT2E.
- Regulator Ic-7805.
- Mosfets IRF540N & BS170.
- Transistor BC547.
- Fuse of 10A Rating.
- Crystal oscillator.
- Few discrete components.

The charging controller offers the following advantages.

- Automatic dusk-to-dawn operation of the load.
- Parallel or shunt type regulation.
- Overcharge protection.

- Deep-discharge protection.
- Low battery lock.
- Charging current changes to pulsed at full charge.
- Low current consumption.
- Highly efficient design.
- Suitable for 10-40w solar panels for 10A load.

4.4.1 Microcontroller

Microcontroller AT89C2051 is the heart of the circuit. It is a low voltage , high performance, 8-bit microcontroller that features 2 KB of flash, 128 bytes of ram, 15 input/output(I/O) lines, two 16 bit timers/counters, a five vector two-level interrupt architecture, a full duplex serial port, a precision analogue comparator, on-chip oscillator and clock circuitry.

A 12MHZ crystal is used for providing the basic clock frequency. All I/O pins are reset to ‘1’ as soon as RST pin goes high. Holding RST pin high for two machine cycles, while the oscillator is running, resets the device.

The device is manufactured using Atmel’s high density non-volatile memory technology and is compatible with the industry standard MCS-51Tm instruction set and pinout. The Atmel AT89C2051 is a powerful microcomputer which provides a highly flexible and cost effective solution to many embedded control applications. The Block-diagram is as shown.

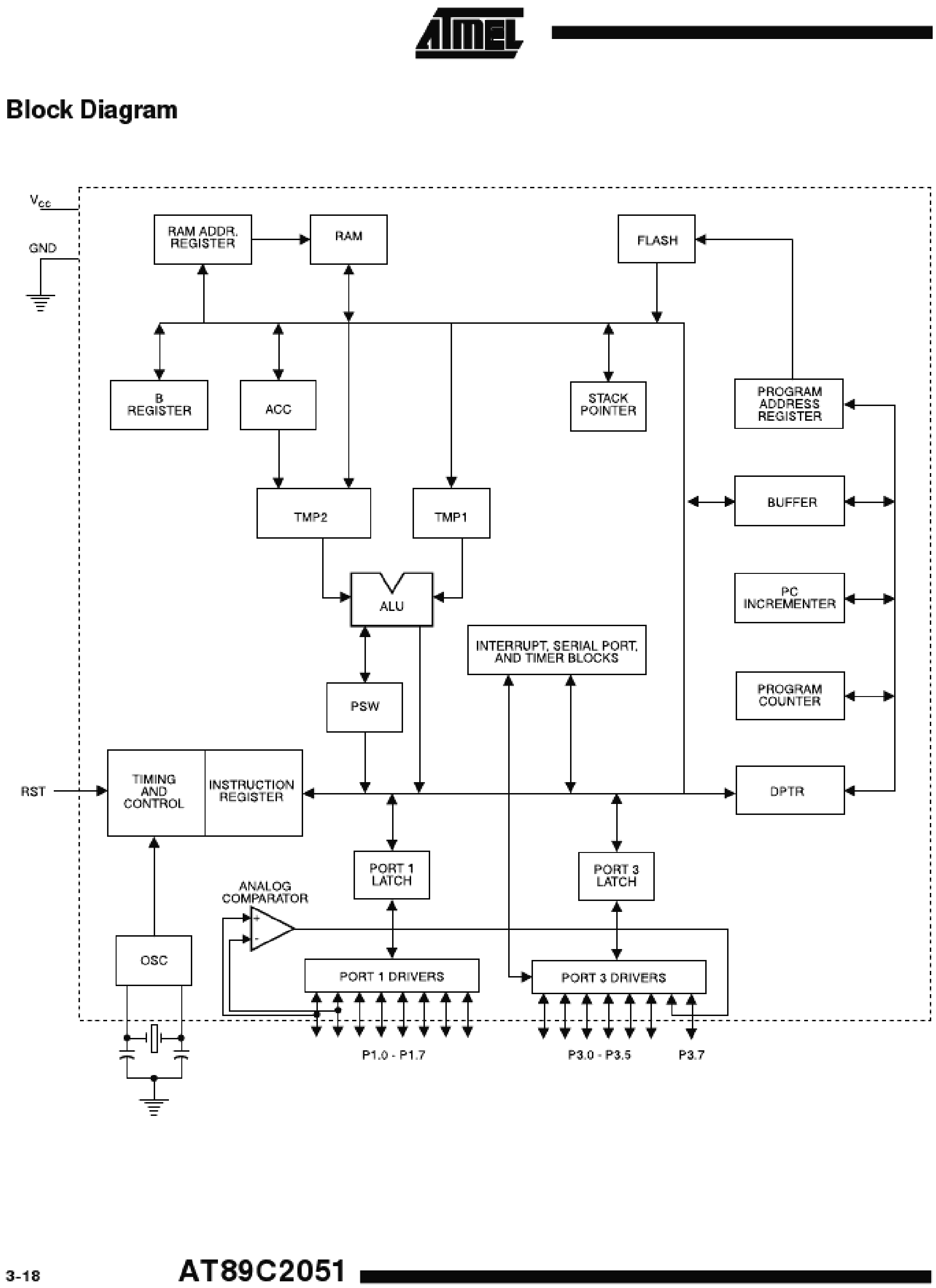


Fig 4.4.1 Block diagram of microcontroller.

4.4.1(a) 8051 Architecture

The 8051 is an 8-bit machine. Its memory is organized in bytes and practically all its instruction deal with byte quantities. It uses an accumulator as the primary register for the instruction results. Operands resides in one of the five memory spaces of the 8051.

The five memory spaces of 8051 are: Program memory, External data memory, internal data memory, special function registers and bit memory.

The program memory space contains all the instructions, immediate data and constants tables and strings. It is principally addressed by the 16-bit program counter (pc), but it can also be accessed by the few instructions using the 16-bit data pointer (Dptr). The maximum size of program memory space is 64k bytes.

The external data memory space contains all the variables, buffers and data structures that can’t fit on-chip. It is principally addressed by the 16-bit data pointer (Dptr), although the first two general purpose register (R0, R1) of the currently selected register bank can access a 256-byte bank of external data memory. The maximum size of external data memory space is 64K bytes.

The internal data memory space is functionally the most important data memory space. In it resides up to four banks of general purpose registers, the program stack, 128 bits of the 256 bit memory, and all the variables and data structures that are operated on directly by the program. The maximum size of internal data memory space is 256 bytes.

The special function register space contains all the on-chip peripheral I/O registers as well as particular registers that need program access. These registers include the stack pointer, the PSW and the accumulator. The maximum number of special function registers (SFRs) is 128.

The bit memory space is used for storing bit variables and flags. There are specific instructions in 8051 that operate only in the Bit-memory space. The maximum size of bit memory space is 256 bits. 128 of the bits overlaps with 16-bytes of the internal data memory space and 128 of the bits overlaps with 16 special function registers. Bits can only be accessed using the bit instructions and the direct addressing mode.

4.4.2 Serial ADC

The microcontroller monitors the battery voltage with the help of an analogue-to-digital converter. The ADC0831 is an 8-bit successive approximation analogue-to-digital converter with a serial I/O and very low conversion time of typically 32 micro-second. The differential analogue voltage input allows increase of the common mode rejection and offsetting of the analogue zero input voltage.

Fig 4.4.2 Analog to digital circuit.

4.4.3 OPTOCOUPLER (MCT2E)

Optocoupler consist of phototransistor and Led. It isolates the two circuit. When the LED is "off", the photoresistor resistance is high (R "off" - "dark" state). Depending on the component's specification, this can be in the region of 10's of Kilohms to Megaohms. A current is applied to the LED and it emits light. The optical coupling material guides the light optimally onto the photoresistor. The light falling on the photoresistor causes the resistance to reduce, after a period of time (usually ms) the photocell reaches its R"on" resistance. When the supply to the LED is removed and the LED stops emitting light, the photoresistor reacts to the removal of the light by starting to return to its "dark" state. It increases in resistance until (after a determined period of time) it reaches its R "off" resistance. The optocoupler circuit is shown in figure below. The left portion shown is LED while the right portion is phototransistor.

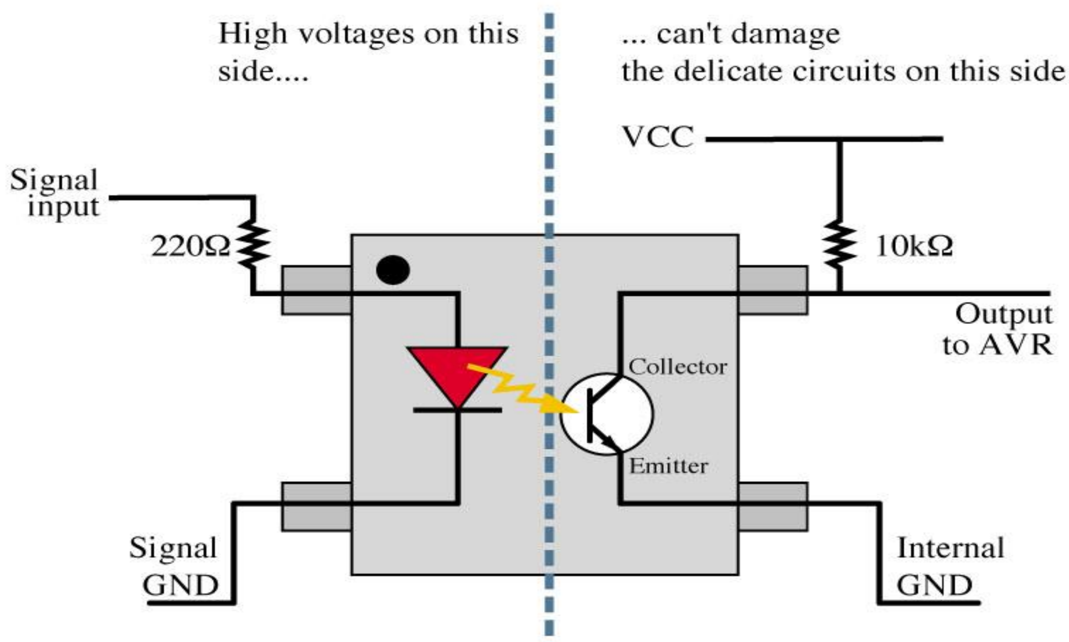


Fig 4.4.3 optocoupler circuit.

Modes of operation

There are two modes of operation viz

4.4.3(a) Analog Mode

In analog mode, the optocoupler performs the function of a "current controlled variable resistor". LEDs emit light directly proportional to the supply current and the photoresistor changes its resistance in proportion to the light level. This is a major benefit for audio designers who are using FETs or VCAs. When used in analog mode the photoresistor has considerably less distortion than a FET and is more cost effective than a VCA (voltage controlled amplifier).

4.4.3(b) Digital mode

When used in digital mode, the optocoupler is performing as a switch. Optocouplers have some unique properties in terms of switching or controlling audio signals and other audio components. Other electronic switching devices may perform better as switches but introduce adverse and unwanted distortion into the circuit.

4.4.4 REGULATOR IC (7805)

This ic provides the required 5v dc voltage to the microcontroller. There is built in protection for the regulator ic which shuts down the output when gets too hot.

This circuit can give +5V output at about 150 mA current, but it can be increased to 1A when good cooling is added to 7805 regulator chip. The circuit has over overload and thermal protection.

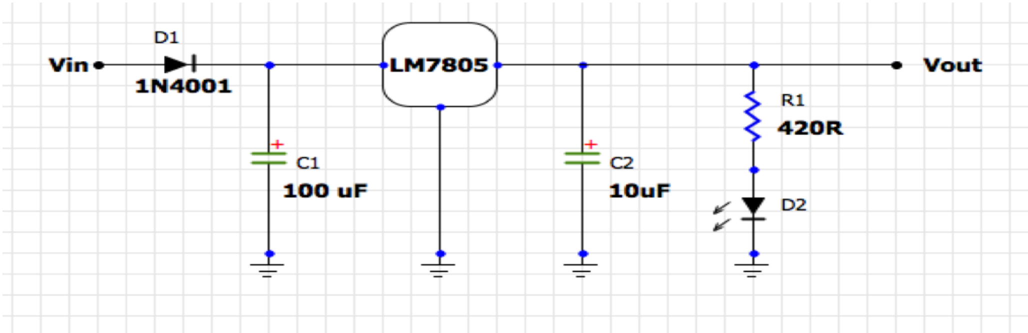


Fig 4.4.4(a) showing regulator IC (LM7805)

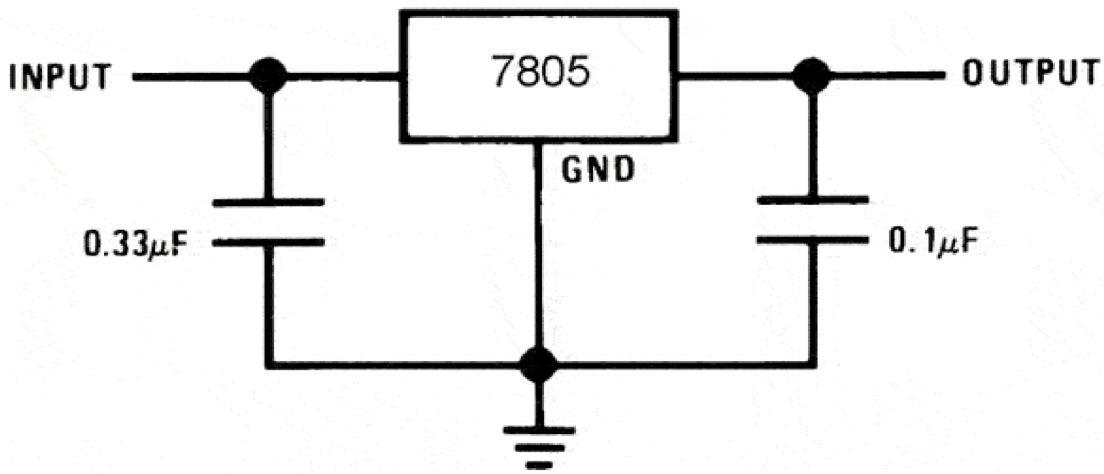
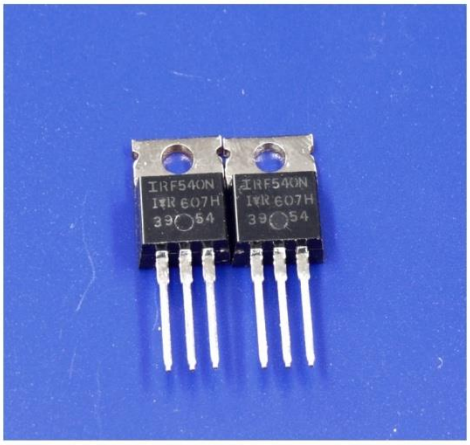


Fig 4.4.4(b) Ic-7805

4.4.5 MOSFET IRF-540N & BS170

A traditional metal–oxide–semiconductor (MOS) structure is obtained by growing a layer of silicon dioxide (SiO_2) on top of a silicon substrate and depositing a layer of metal or polycrystalline silicon (the latter is commonly used). As the silicon dioxide is a dielectric material, its structure is equivalent to a planar capacitor, with one of the electrodes replaced by a semiconductor.



IRF 540 Genuine International Rectifier Part

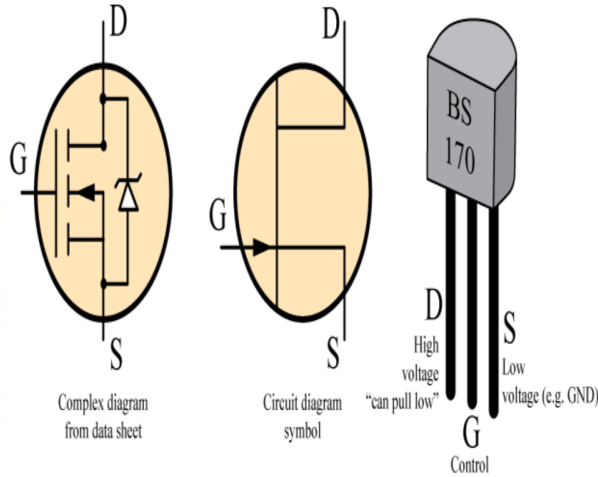


Fig 4.4.5(a) MOSFET IRF540N **Fig 4.4.5(b) MOSFET BS170**

4.4.6 TRANSISTOR BC547

The transistor is the key active component in practically all modern electronics, and is considered by many to be one of the greatest inventions of the twentieth century. The essential usefulness of a transistor comes from its ability to use a small signal applied between one pair of its terminals to control a much larger signal at another pair of terminals. This property is called gain. A transistor can control its output in proportion to the input signal, that is, it can act as an amplifier.

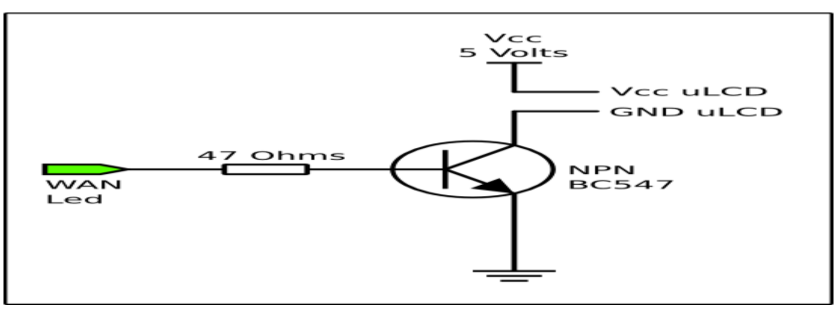


Fig 4.4.6 Transistor

4.4.7 Fuse

Fuse of 10A rating are used.

4.4.8 Crystal Oscillator

It provides the necessary 12MHz clock frequency to the microcontroller.

Fig 4.4.8 Crystal Oscillator

4.4.9 Relay

A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism, but other operating principles are also used. Relays find applications where it is necessary to control a circuit by a low-power signal, or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits, repeating the signal coming in from one circuit and re-transmitting it to another. Relays found extensive use in telephone exchanges and early computers to perform logical operations. A type of relay that can handle the high power required to directly drive an electric motor is called a contactor. Solid-state relays control power circuits with no moving parts, instead using a semiconductor device triggered by light 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 "protection relays".

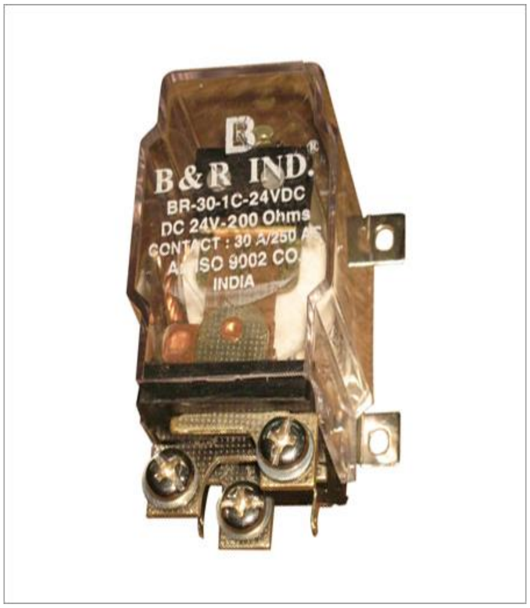


Fig 4.4.9 (a) Electromagnetic Relay **Fig 4.4.9 (b) Changeover Relay**

4.4.10 Solar panel

The solar panel used here is meant to charge a 12V battery and the wattage can range from 10 to 40 watts. The peak unloaded voltage output of the solar panel will be around 19 volts. The solar panel used here is of 10W.

4.4.11 Rechargeable Battery

The solar energy is converted into electrical energy and stored in a 12V lead-acid battery. The ampere-hour capacity of battery is 5.5Ah.

Chapter 5

RESULTS

As the photovoltaic cell discharges during load operation, the table (2) given below shows the variation of load voltage with the battery voltage, while table (3) given below shows the variation of charging current (solar panel current) with load current (current from battery).

Sr. No	Battery Voltage	Load Voltage
1.	11.0V	21.8V
2.	10.8V	21.1V
3.	10.3V	19.2V

Table-2

Sr. No	Charging Current	Load Current
1.	0.39A	0.43A
2.	0.38A	0.42A
3.	0.36A	0.40A

Table-3

Dusk-to-dawn sensor helps in disconnecting the load from battery during daytime and reconnecting the load to battery during night and hence the operational redundancy is reduced.

Chapter 6

CONCLUSION

Solar PV has proved to be an excellent technology for bringing the benefits of electricity to the regions that lived in darkness all along. Hence use of programmable Microcontroller makes the charging task much simpler and flexible. Also parallel or shunt type regulation allows current even in mA to charge the battery. Lastly, dependency on any particular Non-conventional energy sources at a time is eliminated since more than one Non-conventional energy sources can be combined. It also has environmental benefits as the systems don’t cause any harmful emission unlike conventional source of energy generation.

SUGGESTION FOR FUTURE WORK

Village power

By the utilization of this proposed model, it can be used to meet low energy demands of many small, isolated and generally unapproachable villages in most developed countries as well as in developing countries like in India. Two approaches can be used.

(a) Individual integrated (pv-fuel) system for every household.

(b) A centralized integrated (pv-fuel) plant to meet combined load demand of the village.

I have worked on combination of fuel cell and photovoltaic cell, similarly other Non-conventional energy sources (wind turbines, small hydro etc.) can be combined effectively and hence maximum utilization of Renewable energy sources can be achieved.

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- www.wikepidea.com

APPENDIX

Software

The source program for the project is written in Assembly language and assembled using Metalink's ASM51 assembler which is freely on the internet for download. The hex file 'solar.hex' is to be burnt into the microcontroller.

Program

SOLAR.ASM

```
LIST P=PIC AT89C2051

INIT

DYI EQU P3.4; SOLAR PANEL VOLTAGE SENSOR

CHG_RL EQU P3.5; CHARGING CONTROL RELAY

LD_RL EQU P3.7; LOAD CONTROL RELAY

DSEG

ORG 0020H

VAL1: DS 1

VAL2: DS 1

VAL3: DS1ADC_VAL: DS 1

BUF: DS 1

CNT1: DS 1

CNT2: DS 1

IMG: DS 1
```

```
FLAGS: DS 1

OCF BIT FLAGS.0; OVER CHARGE FLAG

LBF BIT FLAGS.1; LOW BATT FLAG

CSEG

ORG 0000H

JMP MAIN

ORG 000BH; Timer Interrupt 0

JMP COUNTDOWN

MAIN: MOV SP, #50H

MOV P3, #0FFH

MOV P1, #0FFH

CLR CHG_RL

CLR LD_RL

LCALL PWR_DELAY

LCALL INIT

SETB CLK

SETB DO

SETB CS

SETB DYI

MOV VAL1, #00H
```

```
MOV VAL2, #00H

MOV VAL3, #00H

MOV FLAGS, #00H

LOADCHAR: MOV BUF, #40H

LCALL CMD

MOV DPTR, #RCHAR

REP: CLR A

MOVC A, @A+DPTR

JZ SCREEN1

MOV BUF, A

LCALL DAT

INC DPTR

SJMP REP

MOVC A, @A+dptr

JZ OVER

MOV BUF, A

LCALL DAT

INC DPTR

SUMP HERE1

OVER: LCALL ONE_SEC_DELAY
```

```
LCALL CLEAR

MOV BUF, #0C0H

LCALL CMD

HERE2: CLR A

MOVC A, @A+DPTR

JZ CONVERT

MOV BUF, A

LCALL DAT

INC DPTR

SJMP HERE2

CONVERT: LCALL DELAY

CLR CS; INITIATE CONVERSION

SETB CLK

CLR CLK; FIRST CLOCK

SETB CLK

CLR CLK; SECOND CLOCK

MOV A, #00H; CLEAR A

MOV R5, #08H; 8 CLOCK PULSES

AGAIN: MOV C, DO

RLC A
```

```
SETB CLK

CLR CLK

DJNZ R5, AGAIN

SETB CS

MOV ADC_VAL, A

MOV B, #79D

MUL AB; PRODUCT IN AB

MOV R1, B; HIGH BYTE IN B

MOVR2, A; LOW BYTE IN A

LCALL HEX2BCD

MOV VAL1, R7

MOV VAL2, R6

MOV VAL3, R5

CHECK: JNB LBF, CHECK2; SEE IF ANY FLAGS ARE SET, i.e. LOW BATT
FLAG OR BATT FULL FLAG

JB DYI, CONVERT

CHECK2: JNB OCF, PROCEED

JB DYI, NIGHT

SJMP CONVERT

PROCEED: JB DYI, NIGHT
```

```
CLR LD_RL; OFF LOAD

CLR LBF; CLEAR LOW BATT FLAG

MOV A, VAL2; CHECK IF BATT IS FULL

XRL A, #04H

JZ FULLCHG

CLR CHG_RL; CONNECT BATT. TO PANEL

MOV IMG, #00H

LJMP CONVERT

FULLCHG: SETB OCF; SET OVERCHARGE FLAG

SETB CHG_RL; DISCONNECT BATT. FROM PANEL

MOV TH0, #03CH; START 5 MIN TIMER HERE

MOV TL0, #0B0H; DISCONNECT BATTERY FROM PANEL

MOV CNT1, #200D

MOV CNT2, #30D

SETB ET0

SETB TR0

SET EA

L JMP CONVERT

NIGHT: CHG_RL; RECONNECT BATT. TO PANEL

CLR TR0; STOP TIMER0 IN CASE IT IS RUNNING
```

```
CLR OCF; CLEAR OVER CHARGE FLAG

SETB LD_RL; CONNECT LOAD TO BATT.

MOV A, VAL1

XRL A, #00H

JZ LOWBATL JMP CONVERT

LOWBAT: SETB LBF

CLR LD_RL; DISCONNECT LOAD FROM BATT.

LJMP CONVERT

LCALL CMD

MOV A, VAL1

ORL A, #30H

MOV BUF, A

LCALL DAT

MOV A, VAL2

ORL A, # 30H

MOV BUF, A

LCALL DAT

MOV BUF, #30H

LCALL DAT

MOV A, VAL3
```

```
ORL A, #30H

MOV BUF, A

LCALL DAT

RET

HERE3: CLR A

MOVC A, @A+DPTR

MOV BUF, A

LCALL DAT

INC DPTR

SJMP HERE3

LCALL DAT

BACK:   RET

;************************************

; TIMER0 ISR (5 MIN TIMER)

;************************************

COUNTDOWN: CLR TR0

MOV TH0, #03CH

MOV TL0, #0B0H

SETB TR0

DJNZ CNT1, BACK2
```

```
MOV CNT1, #200D

DJNZ CNT2, BACK2

CLR TR0; OFF 5 MIN TIMER

CLR ET0

CLR OCF; CLEAR OVER CHARGE FLAG

CLR CHG_RL; RE-CONNECT BATT. TO PANEL

BACK2: RET1

Hex2BCD: MOV R3, #00D

MOV R4, #00D

MOV R5, #00D

MOV R6, #00D

MOV R7, #00D

ACALL H2B

RET

H2B: MOV B, #10D

MOV A, B

DIV AB

MOV R3, B;

MOV B, #10; R7, R6, R5, R4, R3

DIV AB
```

```
MOV R4, B

MOV R5, A

CJNE R1, #00H, HIGH_BYTE; CHECK FOR HIGH BYTE

SJMP ENDD

HIGH_BYTE: MOV A, #6

ADD A, R3

MOV B, #10

DIV AB

MOV R3, B

ADD A, #5

ADD A, R4

MOV B, #10

DIV AB

MOV R4, B

ADD A, #2

ADD A, R5

MOV B, #10

DIV AB

MOV R5, B

CJNE R6, #00D, ADD_IT
```

```
SJMP CONTINUE
ADD_IT:  ADD A, R6
CONTINUE: MOV R6, A
DJNZ R1, HIGH_BYTE
MOV B, #10D
MOV A, R6
DIV AB
MOV R6, B
MOV R7, A
ENDD: RET
ONE_SEC_DELAY: MOV R0, #10D; ONE SECOND DELAY ROUTINE
RZ3: MOV R1, #100D
RZ1: MO R2, #250D
RZ2: NOP
     NOP
     DJNZ R2, RZ2
     DJNNZ R1, RZ1
     DJNZ R0, RZ3
RETMOV R4, #100D
H2: MOV R3, #250D
```

```
H1: DJNZ R3, H1

DJNZ R4, H2

RET

*********END**********
```

CURRICULUM VITAE

Name: **MANNAWAR HUSSAIN** E-mail: dearmannawar@gmail.com

Department of Electrical Engineering

NIT Patna, India

OBJECTIVE:

To have a challenging and progressive career with an organization where the combination of my knowledge and zeal will help me to contribute in achieving the organization's goal and also developing me as an individual.

AFFILIATION:

Affiliate Member of **Institute of Engineering Designers (iED), UK.** Membership number is 33426.

EXPERIENCE:

Mosanada UGL (PROJECTS):-

- Leading a team of Engineers for the integration engineering team, tasked with supporting the service delivery process to the MOCS client. Primary responsibility includes project management, processes development & improvement and team leadership.
- Create **WBS** (work breakdown structure) for team, estimating activity duration and estimating activity resources, compressing schedules as required during the project. Recognizing and involving as much stakeholders and attending meetings during project.
- Led a team of engineers for **Thermal scanning** of all Electrical panels at all (13) **Minsitry of Culture and sports (MOCS)** venues in Qatar.
- Co-ordinate and supervise the erection of different types of electrical equipment Such us 33KV/11KV transformers, etc. Implementation of the Erection activities with the client, supervise the erection activities HT/LT panel erections, Control panels, etc.
- **Supervising** and **managing** all contractors and their work on site, maintaining and monitoring **quality** of the work performed by contractors as per the design.
- Review contractor bids; assign personnel to specific phases and elements of the project.
- Prepare progress reports, proposals and presentations throughout the project.

- Co-ordinate and supervise the erection of different types of electrical equipment Distribution boards (MSB, EMSB, LDB, PDB, UPS DB, and GENSET). To inspect Support systems for cable ladder, tray, Trunking, conduits etc.
- Coordination with vendors for specific jobs like LT-Switch Gear including MCCB/MCB/ELCB/RCCB. Project coordination, supervision and monitoring site construction progres.
- For any project or improvement work, prepare scope of work, liaise with the contractors for cost, submit recommendation to client and manage the project at site for closure.
- Inspection of the field installations and testing of all equipment done by the contractors.
- Check periodically for potential areas for energy saving opportunities.
- In Charge of the day-to-day activities of the expansion of electrical services which included Man, Material and Machine Management.
- Responsible for implementation on various types of improvement works.
  Able to work independently and under pressure.

Educational Qualifications:

- Completed **M.Tech(Power system)** in Electrical Engineering from **NIT PATNA**, **INDIA** with an aggregate of **8.04** CGPA in 2010.
- Completed **B.E** in **Electrical Engineering** from **Yeshwantrao Chavan College of Engineering, Nagpur, INDIA** in 2008.
- Completed **SSC** from M.G.college(B.I.E.C), **INDIA** in 2003.
- Completed **HSC** from K V Patna(C.B.S.E), **INDIA** in 2001.

PROJECT INFORMATION:

M.Tech Project Title: -Digital control of Non-conventional energy sources fed Dc-Dc

Converter operating in parallel.

B.Tech Project Title: - Microcontroller based prototype on-load tap changer.

TRAINING PROGRAM:

- Completed all 40 hours of **PMP** training to appear for **PMI** exam. Have complete knowledge and hands on experience of handling project team and their best co-ordination in the work.
- Industrial Training at **NTPC-Dadri**.
- Vocational Training in **Indian Railway** of Traction Distribution system.
- Completed Engineering Student Training Program on **PLC & AUTOMATION**.

MANAGEMENT & TECHNICAL SKILLS

- Experience of working in British & European standards.
- Willing to be on a call out rota for emergency callouts.
- Strong decision-making skills and the ability to prioritize and plan effectively.
- Methodical approach to all tasks.
- Knowledge of Building Services.

COMPUTER KNOWLEDGE & IT PROFICIENCY

- Strong Knowledge of IT applications and expert in MS Office Package.
- Working Knowledge and Proficient in C Language.
- Basics of mathematical modeling and computing skills in Matlab.

PERSONAL ATTRIBUTES

- Excellent Communication, Presentation, Negotiation and Inter-personal skills.
- Team player, desire & ability to learn, absorb & widen my knowledge.
- Ability to think clearly, logically & analytically.
- Ability to adapt to different culture, working environment, and build rapport with team & individual.
- Motivated by target, set goals, & efficient Planner.

PERSONAL PROFILE:

DATE OF BIRTH:	**10.04.1986**
SEX:	**MALE**
MARITAL STATUS:	**MARRIED**
NATIONALITY:	**INDIAN**
LANGUAGE KNOWN:	**ENGLISH, HINDI & URDU**

DECLARATION:

I consider myself familiar with Electrical Engineering aspects. I am also confident of my ability to work in a team. I hereby declare that the information furnished above is true to the best of my knowledge.

Date: December 6, 2019 Sincerely Yours

Place: Doha　　　　　　　　Mannawar Hussain