AUTOMATIC POWER FLOW USING PHOTOVOLTAIC SOLAR PANEL

A Project report submitted in partial fulfilment
of the requirements for the degree of B. Tech in Electrical Engineering

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: Table of Contents:

Page no.

Acknowledgement…………………………………………….. 3

Certificate…………………………………………………. 4

Introduction……………………………………………… 5-13

Theory…………………………………………………… 14-22

IC Used………………………………………………… 23-29

Diode Used…………………………………………….. 30-36

Buck Chopper Circuit……………………………………… 37

Conclusion……………………………………………... 38

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Name and Signature of the Student

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Date:

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CERTIFICATE

To whom it may concern

This is to certify that the project work entitled (**Automatic Power Flow Using Photovoltaic Solar Panel)** is the bona fide work carried out by **(Souvik Nath(11701614053),Sourov Malakar(11701614051),Sougata Pal(11701614046),Mrinmoy Roy(11701614029))** , a student of B.Tech in the Dept. of Electrical Engineering, RCC Institute of Information Technology (RCCIIT), Canal South Road, Beliaghata, Kolkata-700015, affiliated to Maulana Abul Kalam Azad University of Technology (MAKAUT), West Bengal, India, during the academic year 2017-18, in partial fulfillment of the requirements for the degree of Bachelor of Technology in Electrical Engineering and that this project has not submitted previously for the award of any other degree, diploma and fellowship.

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Signature of the Guide

Name:

Designation

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Signature of the HOD

Name:

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Signature of the External Examiner

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Designation:

- ***INTRODUCTION***

Solar Panel **:-**

Photovoltaic solar panels absorb sunlights a source of energy to generate electricity.

A photovoltaic (PV) module is a packaged, connect assembly of typically 6x10 photovoltaic solar cells. Photovoltaic modules constitute the photovoltaic array of a photovoltaic system that generates and supplies solar electricity in commercial and residential applications.

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%.

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.

The most common application of solar panels is solar water heating systems.

The price of solar power has continued to fall so that in many countries it is cheaper than ordinary fossil fuel electricity from the grid (there is "grid parity").

Fig 1 Solar Panel

- ***Theory and Construction*** ***:-***

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. Externally, most of photovoltaic modules use MC4 connectors type to facilitate easy weatherproof connections to the rest of the system.

Module electrical connections are made in series to achieve a desired output voltage or in parallel to provide a desired current capability. 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.

- ***Efficiencies*** ***:-***

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%.

Scientists from Spectrolab, a subsidiary of Boeing, have reported development of multi-junction solar cells with an efficiency of more than 40%, a new world record for solar photovoltaic cells. The Spectrolab scientists also predict that concentrator solar cells could achieve efficiencies of more than 45% or even 50% in the future, with theoretical efficiencies being about 58% in cells with more than three junctions.

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[disputed – discuss] have power density values of up to 175 W/m2 (16.22 W/ft2).

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 aluminumnanocylinders 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 nanocylinders 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* :-**

Most solar modules are currently produced from crystalline silicon (c-Si) solar cells made of multi crystalline 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.

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 (GaAs) and other semiconductor materials. Another emerging PV technology using MJ-cells is concentrator photovoltaics (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 colourless fluoropolymer 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/m2, solar spectrum of AM 1.5 and module temperature at 25°C.

Electrical characteristics include nominal power (PMAX, measured in W), open circuit voltage (VOC), short circuit current (ISC, measured in amperes), maximum power voltage (VMPP), maximum power current (IMPP), peak power, (watt-peak, Wp), 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 VOC is the maximum voltage that the module can produce when not connected to an electrical circuit or system. VOC can be measured with a voltmeter directly on an illuminated module's terminals or on its disconnected cable.

The peak power rating, Wp, 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 water heater

The ability of solar modules to withstand damage by rain, hail, heavy snow load, and cycles of heat and cold varies by manufacturer, although most solar panels on the U.S. market are UL listed, meaning they have gone through testing to withstand hail. Many crystalline silicon module manufacturers offer a limited warranty that guarantees electrical production for 10 years at 90% of rated power output and 25 years at 80%. Installations intended to withstand extreme environments like large hail or heavy snow will require extra protection in the form of steep installations, sturdy framing and stronger glazing.

Potential induced degradation (also called PID) is a potential induced performance degradation in crystalline photovoltaic modules, caused by so-called stray currents. This effect may cause power loss of up to 30%.

The largest challenge for photovoltaic technology is said to be the purchase price per watt of electricity produced, new materials and manufacturing techniques continue to improve the price to power performance. The problem resides in the enormous activation energy that must be overcome for a photon to excite an electron for harvesting purposes. Advancements in photovoltaic technologies have brought about the process of "doping" the silicon substrate to lower the activation energy thereby making the panel more efficient in converting photons to retrievable electrons.

Chemicals such as Boron (p-type) are applied into the semiconductor crystal in order to create donor and acceptor energy levels substantially closer to the valence and conductor bands.[24] In doing so, the addition of Boron impurity allows the activation energy to decrease 20 fold from 1.12 eV to 0.05 eV. Since the potential difference (EB) is so low, the Boron is able to thermally ionize at room temperatures. This allows for free energy carriers in the conduction and valence bands thereby allowing greater conversion of photons to electrons.

- ***Maintenance*** **:-**

Solar panel conversion efficiency, typically in the 20% range, is reduced by dust, grime, pollen, and other particulates that accumulate on the solar panel. "A dirty solar panel can reduce its power capabilities by up to 30% in high dust/pollen or desert areas", says Seamus Curran, associate professor of physics at the University of Houston and director of the Institute for Nano Energy, which specializes in the design, engineering, and assembly of nanostructures.

Paying to have solar panels cleaned is often not a good investment; researchers found panels that had not been cleaned, or rained on, for 145 days during a summer drought in California, lost only 7.4% of their efficiency. Overall, for a typical residential solar system of 5 kW, washing panels halfway through the summer would translate into a mere $20 gain in electricity production until the summer drought ends—in about 2 ½ months. For larger commercial rooftop systems, the financial losses are bigger but still rarely enough to warrant the cost of washing the panels. On average, panels lost a little less than 0.05% of their overall efficiency per day.

- ***Recycling*** **:-**

Most parts of a solar module can be recycled including up to 95% of certain semiconductor materials or the glass as well as large amounts of ferrous and non-ferrous metals. Some private companies and non-profit organizations are currently engaged in take-back and recycling operations for end-of-life modules.

Recycling possibilities depend on the kind of technology used in the modules:

Silicon based modules: aluminium frames and junction boxes are dismantled manually at the beginning of the process. The module is then crushed in a mill and the different fractions are separated - glass, plastics and metals. It is possible to recover more than 80% of the incoming weight. This process can be performed by flat glass recyclers since morphology and composition of a PV module is similar to those flat glasses used in the building and automotive industry. The recovered glass for example is readily accepted by the glass foam and glass insulation industry.

Non-silicon based modules: they require specific recycling technologies such as the use of chemical baths in order to separate the different semiconductor materials. For cadmium telluride modules, the recycling process begins by crushing the module and subsequently separating the different fractions. This recycling process is designed to recover up to 90% of the glass and 95% of the semiconductor materials contained. Some commercial-scale recycling facilities have been created in recent years by private companies. For aluminium flat plate reflector: the trendiness of the reflectors has been brought up by fabricating them using a thin layer (around 0.016 mm to 0.024 mm) of Aluminium coating present inside the non-recycled plastic food packages.

Since 2010, there is an annual European conference bringing together manufacturers, recyclers and researchers to look at the future of PV module recycling.

- ***Mounting and Tracking*** ***:-***

Ground mounted photovoltaic system are usually large, utility-scale solar power plants. Their solar modules are held in place by racks or frames that are attached to ground based mounting supports. Ground based mounting supports include:

Pole mounts, which are driven directly into the ground or embedded in concrete.

Foundation mounts, such as concrete slabs or poured footings

Ballasted footing mounts, such as concrete or steel bases that use weight to secure the solar module system in position and do not require ground penetration. This type of mounting system is well suited for sites where excavation is not possible such as capped landfills and simplifies decommissioning or relocation of solar module systems.

Roof-mounted solar power systems consist of solar modules held in place by racks or frames attached to roof-based mounting supports. Roof-based mounting supports include:

Pole mounts, which are attached directly to the roof structure and may use additional rails for attaching the module racking or frames.

Ballasted footing mounts, such as concrete or steel bases that use weight to secure the panel system in position and do not require through penetration. This mounting method allows for decommissioning or relocation of solar panel systems with no adverse effect on the roof structure.

All wiring connecting adjacent solar modules to the energy harvesting equipment must be installed according to local electrical codes and should be run in a conduit appropriate for the climate conditions. 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.

- ***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-conductor the electricity wires, demand side management, etc. There are often limitations and costs related to these solutions.

Implication onto Electricity Bill Management and Energy Investment

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 systematically evaluation of options in operational improvement, energy efficiency, onsite generation and energy storage.

- ## ***THEORY***

How Do Solar Panels Work?

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.

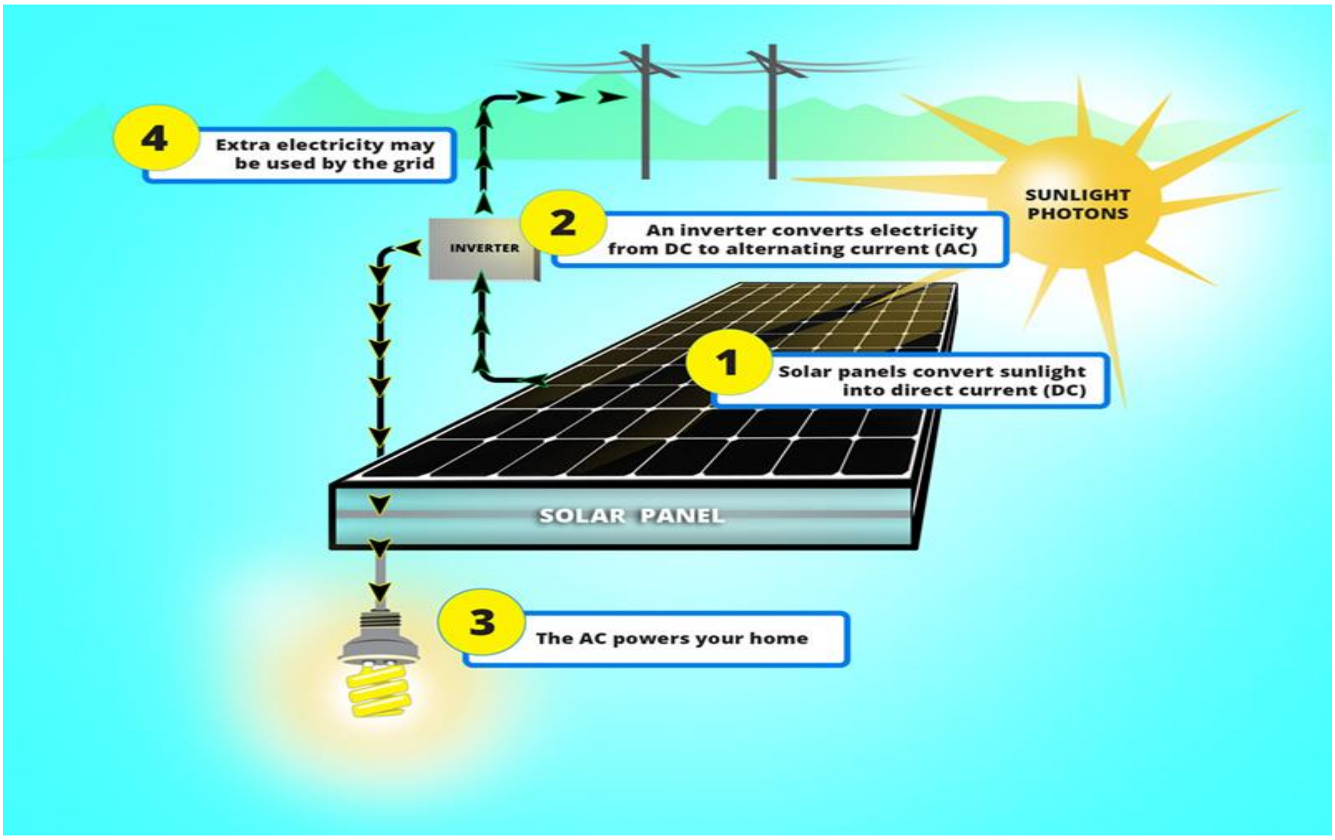


Fig 2 The Process Getting AC Power from DC Solar Power

What Does a 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 cloudyuuuuuuu days. A net meter records the energy sent compared to the energy received from the grid. Find out more about net metering here.

Buck Converter

A buck converter (step-down converter) is a DC-to-DC power converter which steps down voltage (while stepping up current) from its input (supply) to its output (load). It is a class of switched-mode power supply (SMPS) typically containing at least two semiconductors (a diode and a transistor, although modern buck converters frequently replace the diode with a second transistor used for synchronous rectification) and at least one energy storage element, a capacitor, inductor, or the two in combination. To reduce voltage ripple, filters made of capacitors (sometimes in combination with inductors) are normally added to such a converter's output (load-side filter) and input (supply-side filter). Switching converters (such as buck converters) provide much greater power efficiency as DC-to-DC converters than linear regulators, which are simpler circuits that lower voltages by dissipating power as heat, but do not step up output current.[2]

Buck converters can be highly efficient (often higher than 90%), making them useful for tasks such as converting a computer's main (bulk) supply voltage (often 12 V) down to lower voltages needed by USB, DRAM and the CPU (1.8 V or less).

Theory of Operation

The basic operation of the buck converter has the current in an inductor controlled by two switches (usually a transistor and a diode). In the idealised converter, all the components are considered to be perfect. Specifically, the switch and the diode have zero voltage drop when on and zero current flow when off, and the inductor has zero series resistance. Further, it is assumed that the input and output voltages do not change over the course of a cycle (this would imply the output capacitance as being infinite).

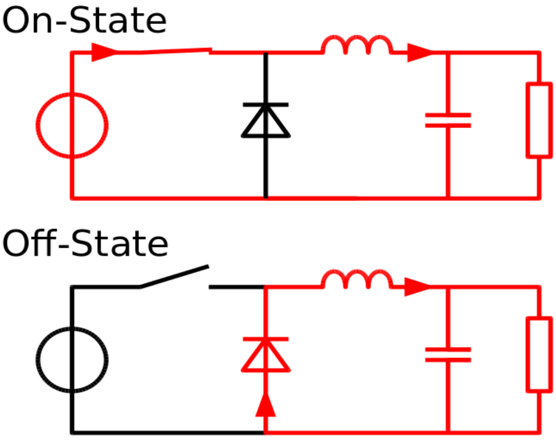


Fig 3 The two circuit configurations of a buck converter: on-state, when the switch is closed; and off-state, when the switch is open

Concept

The conceptual model of the buck converter is best understood in terms of the relation between current and voltage of the inductor. Beginning with the switch open (off-state), the current in the circuit is zero. When the switch is first closed (on-state), the current will begin to increase, and the inductor will produce an opposing voltage across its terminals in response to the changing current. This voltage drop counteracts the voltage of the source and therefore reduces the net voltage across the load. Over time, the rate of change of current decreases, and the voltage across the inductor also then decreases, increasing the voltage at the load. During this time, the inductor stores energy in the form of a magnetic field. If the switch is opened while the current is still changing, then there will always be a voltage drop across the inductor, so the net voltage at the load will always be less than the input voltage source. When the switch is opened again (off-state), the voltage source will be removed from the circuit, and the current will decrease. The decreasing current will produce a voltage drop across the inductor (opposite to the drop at on-state), and now the inductor becomes a Current Source. The stored energy in the inductor's magnetic field supports the current flow through the load. This current, flowing while the input voltage source is disconnected, when concatenated with the current flowing during on-state, totals to current greater than the average input current (being zero during off-state). The "increase" in average current makes up for the reduction in voltage, and ideally preserves the power provided to the load. During the off-state, the inductor is discharging its stored energy into the rest of the circuit. If the switch is closed again before the inductor fully discharges (on-state), the voltage at the load will always be greater than zero.

Continuous Mode

A buck converter operates in continuous mode if the current through the inductor (I_L) never falls to zero during the commutation cycle. In this mode, the operating principle is described by the plots in:

When the switch pictured above is closed, the voltage across the inductor is $V_L= V_I-V_0$. The current through the inductor rises linearly (in approximation, so long as the voltage drop is almost constant). As the diode is reverse-biased by the voltage source V, no current flows through it;

When the switch is opened, the diode is forward biased. The voltage across the inductor is

$V_L= - V_0$ (neglecting diode drop). Current I_L decreases.

The energy stored in inductor L is

$$E = \frac{1}{2} L I_L{}^2$$

Therefore, it can be seen that the energy stored in L increases during on-time as I_L increases and then decreases during the off-state. L is used to transfer energy from the input to the output of the converter.

The rate of change of IL can be calculated from:

$$V_L = L \frac{dI_L}{dt}$$

With V_L equals to $V_i – V_0$ during the on-state and to $– V_0$ during the off-state. Therefore, the increase in current during the on-state is given by:

$$\Delta I_{Lon} = \int_0^{t_{on}} \frac{V_L}{L} dt = \frac{V_i - V_0}{L} t_{on}, t_{on} = DT$$

Where *D* is a scalar called the duty cycle with a value between 0 and 1.

Conversely, the decrease in current during the off-state is given by:

$$\Delta I_{Loff} = \int_{t_{on}}^{T = t_{on} + t_{off}} \frac{V_L}{L} dt = \frac{-V_0}{L} t_{off}, t_{off} = (1-D)T$$

If we assume that the converter operates in the steady state, the energy stored in each component at the end of a commutation cycle T is equal to that at the beginning of the cycle. That means that the current I_L is the same at t=0 and at t=T.

So we can write from the above equations:

$$\Delta I_{Lon} + \Delta I_{Loff} = 0$$

$$\frac{V_i - V_0}{L} t_{on} - \frac{-V_0}{L} t_{off} = 0$$

The above integrations can be done graphically. In ΔI_{Lon} is proportional to the area of the yellow surface, and ΔI_{Loff} to the area of the orange surface, as these surfaces are defined by the inductor voltage (red lines). As these surfaces are simple rectangles, their areas can be found easily: $(V_i - V_0)\ t_{on}$ for the yellow rectangle and $-V_0\ t_{off}$ for the orange one. For steady state operation, these areas must be equal.

As can be seen, t_{on} = DT and $t_{off} = (1-D)T$

This yields:

$$(V_i - V_0)\ DT - V_0(1-D)T = 0$$

$$DV_i - V_0 = 0$$

$$D = \frac{V_i}{V_0}$$

From this equation, it can be seen that the output voltage of the converter varies linearly with the duty cycle for a given input voltage. As the duty cycle *D* is equal to the ratio between t_{on} and the period T, it cannot be more than 1. Therefore, $V_0 \le V_i$ This is why this converter is referred to as step-down converter.

So, for example, stepping 12 V down to 3 V (output voltage equal to one quarter of the input voltage) would require a duty cycle of 25%, in our theoretically ideal circuit.

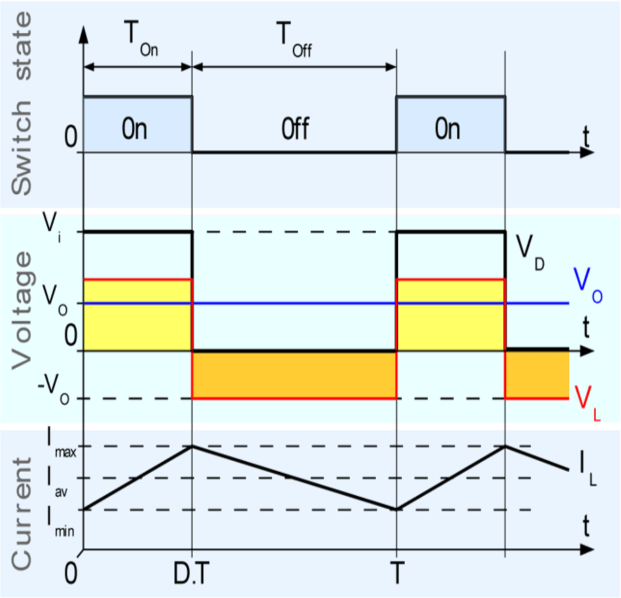


Fig 4 Evolution of the voltages and currents with time in an ideal buck converter operating in continuous mode.

Discontinuous Mode

In some cases, the amount of energy required by the load is too small. In this case, the current through the inductor falls to zero during part of the period. The only difference in the principle described above is that the inductor is completely discharged at the end of the commutation cycle This has, however, some effect on the previous equations.

The inductor current falling below zero results in the discharging of the output capacitor during each cycle and therefore higher switching losses. A different control technique known as Pulse-frequency modulation can be used to minimize these losses.

We still consider that the converter operates in steady state. Therefore, the energy in the inductor is the same at the beginning and at the end of the cycle (in the case of discontinuous mode, it is zero). This means that the average value of the inductor voltage (V_L) is zero; i.e., that the area of the yellow and orange rectangles in figure 5 are the same. This yields:

$$V_i - V_0 DT - V_0 \partial t = 0$$

So the value of δ is:

$$\partial = \frac{V_i - V_0}{V_0} D$$

The output current delivered to the load (I_0) is constant, as we consider that the output capacitor is large enough to maintain a constant voltage across its terminals during a commutation cycle. This implies that the current flowing through the capacitor has a zero average value. Therefore, we have

$$\overline{I_L} = I_0$$

Where $\overline{I_L}$ is the average value of the inductor current. As can be seen in figure 5, the inductor current waveform has a triangular shape. Therefore, the average value of IL can be sorted out geometrically as follow:

$$\overline{I_L} = (\frac{1}{2} I_{Lmax} DT + \frac{1}{2} I_{Lmax} \partial t) \frac{1}{T}$$

$$= \frac{I_{Lmax}(D + \partial)}{2}$$

= I0

The inductor current is zero at the beginning and rises during ton up to ILmax. That means that ILmax is equal to:

$$I_{Lmax} = \frac{V_i - V_0}{L} DT$$

Substituting the value of ILmax in the previous equation leads to:

$$I_0 = \frac{(V_i - V_0) DT (D + \partial)}{2L}$$

And substituting δ by the expression given above yields:

$$I_0 = \frac{(V_i - V_0) D T \left(D + \frac{V_i - V_0}{V_0} D\right)}{2L}$$

This expression can be rewritten as:

$$V_0 = V_i \frac{1}{\frac{2 L I_0}{D^2 V_i T} + 1}$$

It can be seen that the output voltage of a buck converter operating in discontinuous mode is much more complicated than its counterpart of the continuous mode. Furthermore, the output voltage is now a function not only of the input voltage (Vi) and the duty cycle D, but also of the inductor value (L), the commutation period (T) and the output current (Io).

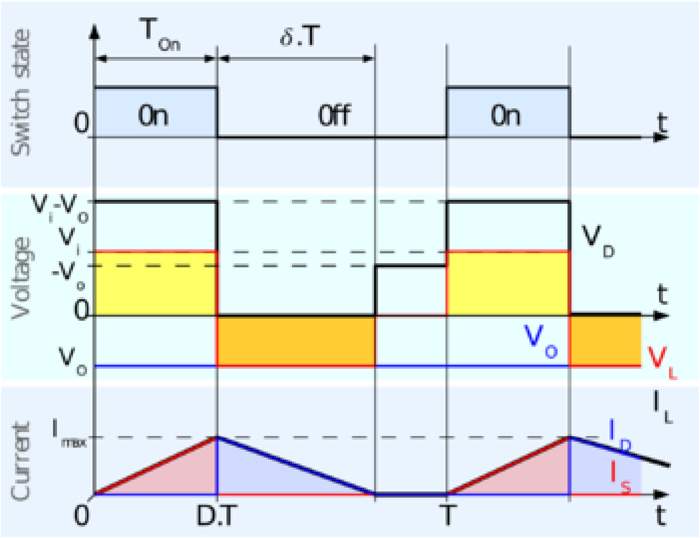


Fig 5 Evolution of the voltages and currents with time in an ideal buck converter operating in discontinuous mode

- ***IC Used***

1. *MC34063A*

1.1 PIN DIAGRAM

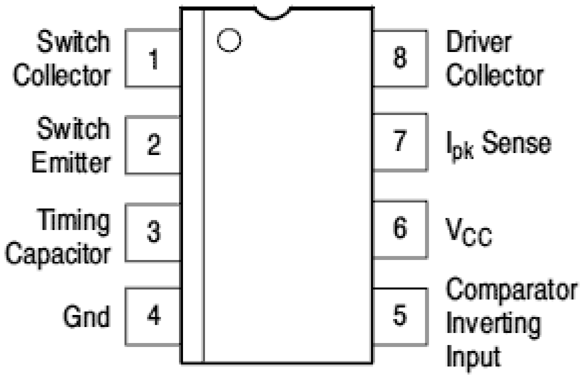


Fig 5 Pin Diagram

1.2 Funtional diagram

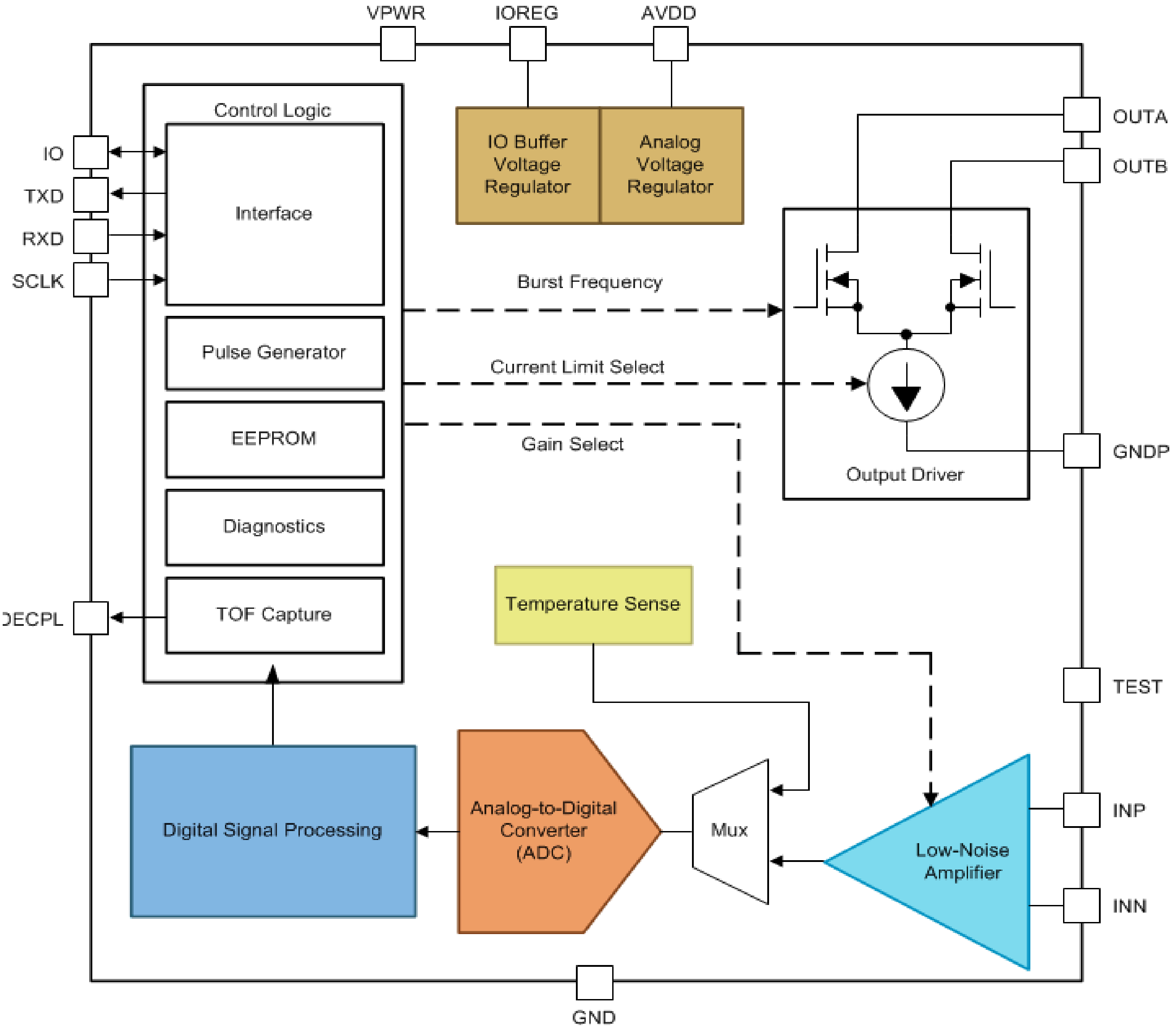


Fig 6 Funtional Diagram

MC34063A ***Details***

MC34063A

Industrial Standard, Universal DC/DC Converter

- ***FEATURES***

- 3V to 30V Input Voltage Operation.
- Internal 1.6A Peak Current Switch.
- Internal ±1.8% Reference.
- Low Quiescent Current at 1.6mA.
- Frequency Operation from 100Hz to 100KHz.
- Current Limiting.

- ***APPLICATIONS***

- Saver for Cellular phones
- DC-DC Converter Module

MC34063A

- ***ELECTRICAL CHARACTERISTICS (VCC= 5V, TA=25□C, unless otherwise specified.)***

PARAMETER	***TEST CONDITIONS***	***SYMBOL***	***MIN.***	***TYP.***	***MAX.***	***UNIT***
OSCILLATOR						
Charging Current	5.0V□VCC□30V	ICHG	10	25	40	□A
Discharge Current	5.0V□VCC□30V	IDISCHG	100	150	200	□A
Voltage Swing	PIN 3	VOSC		0.6		V
Discharge to Charge Current Ratio	VIPK(SENSE) =VCC	IDISCHG/ ICHG		6.0		
Current Limit Sense Voltage	ICHG=IDISCHG	VIPK(SENSE)	250	300	350	mV
Output Switch						
Saturation Voltage, Darlington Connection	ISW=1.0A; VC(DRIVER)=VC(SWITCH)	VCE(SAT)		1.0	1.3	V

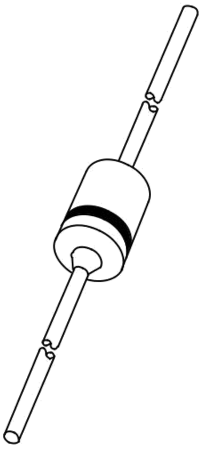
Saturation 0Voltage	ISW=1.0A; IC(DRIVER)=50 mA0 (Forced □□20)	VCE (SAT)		0.4	0.7	V
DC Current Gain	ISW=1.0A; VCE=5.0V	hFE	35	120		
Collector Off-State Current	VCE=30V	IC(OFF)		10		nA
Comparator						
Threshold Voltage	TA=25□C	VFB	1.227	1.25	1.273	V
Threshold Voltage	0□C□TA□70□C		1.21		1.29	
Threshold Voltage Line Regulation	3.0V□VCC□30V	REGLINE		0.1	0.3	mV/V
Input Bias Current	VIN=0V	IIB		0.4	1	□A

Supply current	VIPK(SENSE)=VCC VPIN 5>VFB 5.0V□VCC□30V CT=0.001□F, PIN 2=GND Remaining pins open	ICC	1.6 3	mA

- ***Diode Used***

1N5819

DATA SHEET
1N5817; 1N5818; 1N5819 Schottky barrier diodes



1N5819 (Schottky barrier diodes)

FEATURES

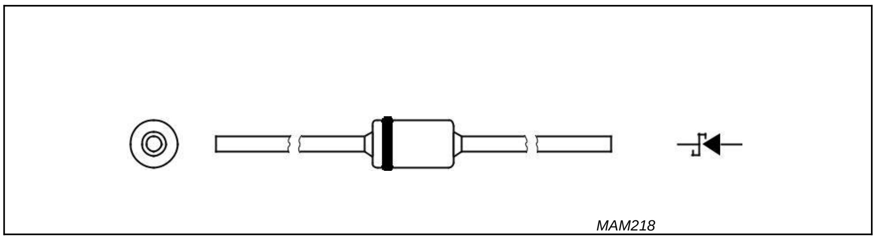
- Low switching losses
- Fast recovery time
- Guard ring protected
- Hermetically sealed leaded glass package.

APPLICATIONS

- Low power, switched-mode power supplies
- Rectifying
- Polarity protection.

DESCRIPTION

The 1N5819 types are Schottky barrier diodes fabricated in planar technology, and encapsulated in SOD81 hermetically sealed glass packages incorporating Implotec technology.



1N5819 (Schottky barrier diodes)

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
VR	continuous reverse voltage				
	1N5819		-	40	V
VRSM	non-repetitive peak reverse voltage				
	1N5819		-	48	V
VRRM	repetitive peak reverse voltage				
	1N5819		-	40	V
VRWM	crest working reverse voltage				

	1N5819		-	40	V
IF(AV)	average forward current	Tamb = 55 °C; Rth j-a = 100 K/W; note 1; VR(equiv) = 0.2 V; note 2	-	1	A
IFSM	non-repetitive peak forward current	t = 8.3 ms half sine wave; JEDEC method; Tj = Tj max prior to surge: VR = 0	-	25	A
Tstg	storage temperature		-65	+175	°C
Tj	junction temperature		-	125	°C

Notes

- Refer to SOD81 standard mounting conditions.
- For Schottky barrier diodes thermal run-away has to be considered, as in some applications, the reverse power losses PR are a significant part of the total power losses. Nomograms for determination of the reverse power losses PR and IF(AV) rating will be available on request.

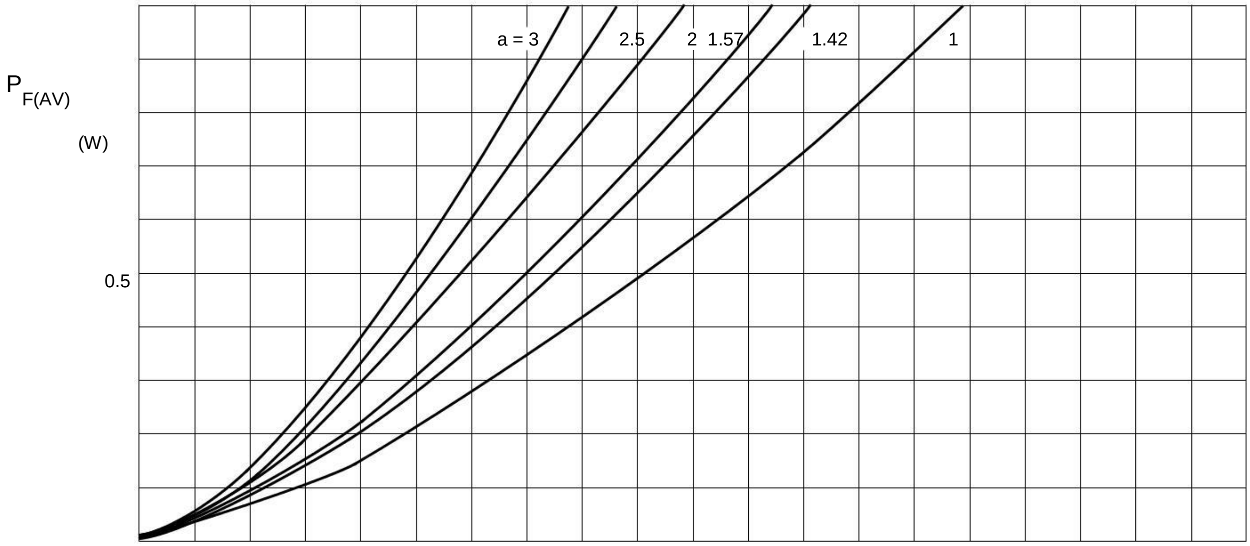
1N5819 (Schottky barrier diodes)

ELECTRICAL CHARACTERISTICS

Tamb = 25 °C; unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
VF	forward voltage	see Fig.2				
	1N5819	IF = 0.1 A	-	-	340	mV
		IF = 1 A	-	-	600	mV
		IF = 3 A	-	-	900	mV
IR	reverse current	VR = VRRMmax; note 1	-	-	1	mA
		VR = VRRMmax; Tj = 100 °C	-	-	10	mA
Cd	diode capacitance	VR = 4 V; f = 1 MHz				
	1N5819		-	50	-	pF

1N5819 (Schottky barrier diodes)



1N5819. Maximum values steady state forward power dissipation as a function of the average forward current; a = IF(RMS)/IF(AV).

BUCK CHOPPER CIRCUIT USING MC34063A

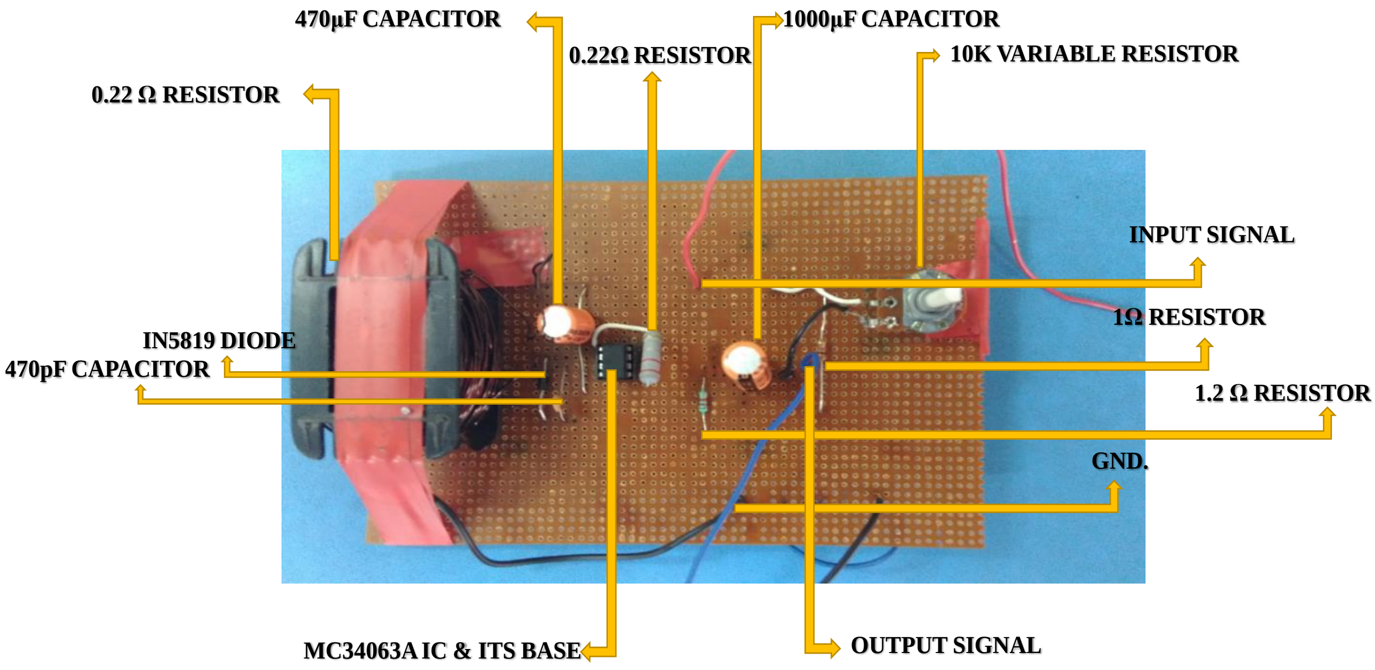


Fig 7 Buck Chopper Circuit Diagram

Conclusion

Therefore in this project we have successfully developed Buck Chopper Circuit. Solar power is an immense source of directly useable energy and ultimately creates other energy resources: biomass, wind, hydropower and wave energy.

Most of the Earth's surface receives sufficient solar energy to permit low-grade heating of water and buildings, although there are large variations with latitude and season. At low latitudes, simple mirror devices can concentrate solar energy sufficiently for cooking and even for driving steam turbines.

The energy of light shifts electrons in some semiconducting materials. This photovoltaic effect is capable of large-scale electricity generation. However, the present low efficiency of solar PV cells demands very large areas to supply electricity demands.