

Ac Hybrid Charge Controller

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Abstract

One of the primary needs for socio-economic development in any nation in the world is the provision of reliable electricity supply systems with lower carbon footprint levels. The purpose of this work is the development of a hybrid Power system that harnesses the renewable energy in sun and electricity to generate electricity. The working model can able to run on dual mode- solar and electricity. It can also be driven independently either by solar or electricity. The battery can be charge from solar panel (40W) or by power supply. The household single phase A.C. power supply of 230V is converted into 12V D.C. using step down transformer and rectifying circuit. The working model can achieve energy saving, low carbon emission, environmental protection for the upcoming future of human life.

Index Terms— Battery, charge controller hybrid, photovoltaic, cell, power, solar, AC mains.

I. Introduction

We all know that the world is facing a major threat of fast depletion of the fossil fuel reserves. Most of the present energy demand is met by fossil and nuclear power plants. A small part is met by renewable energy technologies such as the wind, solar, biomass, geothermal etc. There will soon be a time when we will face a severe fuel shortage. As per the law of conservation of energy, “Energy can neither be created, nor be destroyed, but it can only be converted from one form to another”. Most of the research now is about how to conserve the energy and how to utilize the energy in a better way. Research has also been into the development of reliable and robust systems to harness energy from non-conventional energy resources. Among them, the solar power sources have experienced a remarkably rapid growth in the past 10 years.

With high economic growth rates and over 17 percent of the world’s population, India is a significant consumer of energy resources. Despite the global financial crisis, India’s energy demand continues to rise. India consumes its maximum energy in Residential, commercial and agricultural purposes in comparison to China, Japan, and Russia. Kerala is one of the states in India that is blessed with renewable energy resources. Despite being a densely populated state with high consumption rate of energy, it lacks appropriate energy management policies and has started facing resource scarcity. We do still believe that setting up of small and reliable hybrid power generating units like this will effectively make

consumers independent in meeting their own power demands. This will in turn bring down the burden on the grid.

Solar energy is energy from the Sun. It is renewable, inexhaustible and environmental pollution free. Solar charged battery systems provide power supply for complete 24 hours a day irrespective of bad weather. By adopting the appropriate technology for the concerned geographical location, we can extract a large amount of power from solar radiations. More over solar energy is expected to be the most promising alternate source of energy. The global search and the rise in the cost of conventional fossil fuel is making supply-demand of electricity product almost impossible especially in some remote areas. Generators which are often used as an alternative to conventional power supply systems are known to be run only during certain hours of the day, and the cost of fueling them is increasingly becoming difficult if they are to be used for commercial purposes.

In addition, much of the world’s population lives in remote or rural areas, which are sparsely populated and geographically isolated. Due to the low demand, such regions are not connected to the grid. To develop such areas, an efficient as well as financially feasible method needs to be found to provide these areas with electricity. It has been suggested that renewable energy sources may be well-suited to this task. Renewable energy sources such as solar energy have been deemed clean, inexhaustible, unlimited, and environmental friendly. Such characteristics have

attracted the energy sector to use renewable energy sources on a larger scale.

However, all renewable energy sources have drawbacks. The one that is common to solar sources is their dependence on unpredictable factors such as weather and climatic conditions. This brings us to the hybrid power plant concept. A system that brings together two sources of energy is called a hybrid system. The concept of having hybrid power stations is not new, but has gained popularity in recent years. Hybrid energy stations have proven to be advantageous for decreasing the depletion rate of fossil fuels, as well as supplying energy to remote rural areas without harming the environment. Thus, a AC solar hybrid power system that takes advantage of solar energy. However, the difficulty brought

about by combining two different energy sources makes the hybrid system more difficult to analyze. For this reason, there is a rich literature dedicated to modeling and designing hybrid energy sources such as solar power plants. AC hybrid solar systems using battery banks and developed an optimal model for designing such systems.

There is a growing awareness that renewable energy such as photovoltaic system have an important role to play in order to save the situation. Hybrid power system consist of a combination of renewable energy source such solar and AC mains etc of charge batteries and provide power to meet the energy demand, considering the local geography and other details of the place of installation.

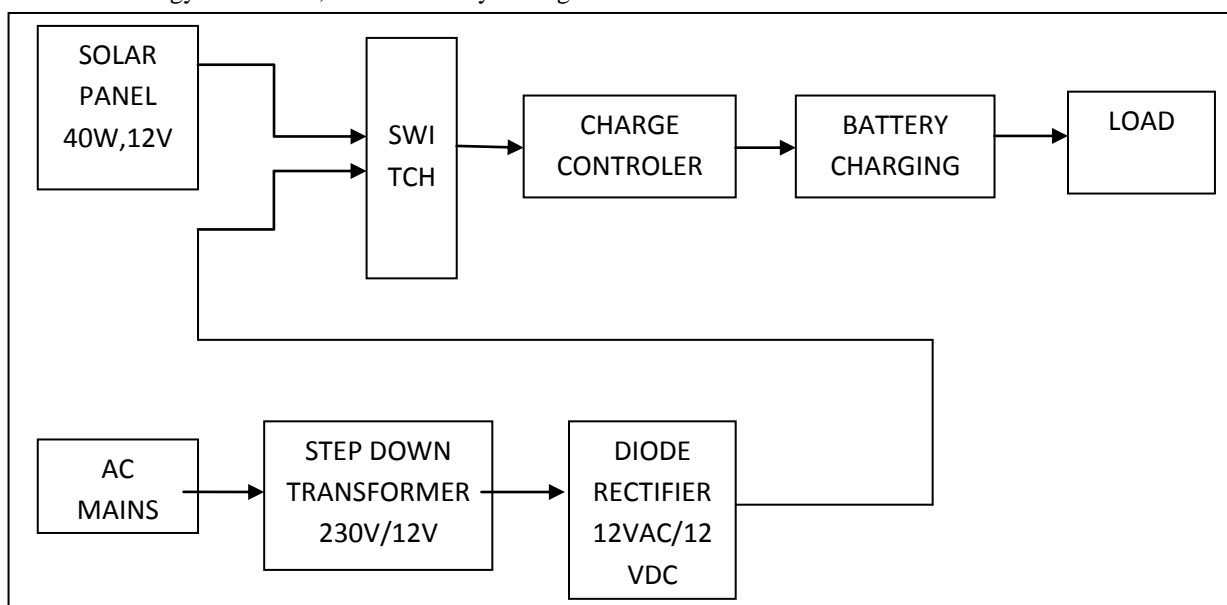


Fig 1.1 block diagram of AC hybrid charge controller

II. Solar power system

Solar energy is the energy produced by sun through the process of thermonuclear fusion. The process converts about 650 Mega tons of hydrogen to helium per second. The process creates heat and electromagnetic radiations (radiation is the process of heat transfer from source to the target directly). The heat remains in sun and is instrumental in maintaining the thermonuclear reaction. The electromagnetic radiation stream's out in all directions and some energy is lost by Scattering Absorption Cloud cover Reflection Climate The solar energy irradiation at the site is a major factor in selection of the implementation of the project. The solar cells which are also called as photovoltaic (PV) cells are p-n junction diodes with large areas and the junction positioned close to the top surface. The cell converts sun light into direct current electricity. Unlike the dynamic wind turbines, the PV installations is static, does not need strong tall towers,

produces no vibration or noise, and needs no cooling. Because much of the current PV technology uses crystalline semiconductor material similar to integrated circuit chips, the production costs have been high. The price of the cell has been coming down over the years. This high price is also compensated by the government by giving subsidies to the customers. This has helped in increasing the popularity of solar cells for small scale and large scale uses. Components of a Solar Power System. The following are the major components required to implement a solar powered system.

1. Collector unit (Photovoltaic cells)
2. Storage unit (battery bank)

The collector unit collects the radiations that falls on it and converts a fraction into the required form of energy (either electricity and heat or heat alone). The storage unit is connected to the system because of the variable nature of solar energy. At night and during the cloudy days, the energy extracted will be

comparatively small. The storage unit (battery bank) holds the excess energy produced during the period of maximum productivity and supplies the backup power whenever required.

III. Hybrid power system

As the sun does not shine for the entire day, using a single source will not be a suitable choice. A hybrid arrangement of combining the power harnessed from both the AC and the sun and stored in a battery can be a much more reliable and realistic power source. The load can still be powered using the stored energy in the batteries even when there is no sun. Hybrid systems are usually built for design of systems with lowest possible cost and also with maximum reliability.

The high cost of solar PV cells makes it less competent for larger capacity designs. This is where the AC mains comes into the picture. Battery system is needed to store solar energy produced during the day time. During night time, the presence of solar is an added advantage, which increases the reliability of the system. In the monsoon seasons, the effect of sun is less at the site and thus it is applicable to use a AC hybrid solar system. In addition to the technical considerations, cost benefit is a factor that has to be incorporated into the process of optimizing a hybrid energy system. In general the solar AC hybrid system is more cost-effective and reliable.

IV. Methodology

A. Design

1) Solar panel

A solar cell, or photovoltaic cell, is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect. It is a form of photoelectric cell, defined as a device whose electrical characteristics, such as current, voltage, or resistance, vary when exposed to light. Solar cells are the building blocks of photovoltaic modules, otherwise known as solar panels.

Solar cells are described as being photovoltaic irrespective of whether the source is sunlight or an artificial light. They are used as a photo detector (for example infrared detectors), detecting light or other electromagnetic radiation near the visible range, or measuring light intensity.

The operation of a photovoltaic (PV) cell requires 3 basic attributes:

The absorption of light, generates electron-hole pairs.

The separation of charge carriers of opposite types.

Polycrystalline Panels (also known as multicrystalline)

Polycrystalline panels are made up from the silicon offcuts, moulded to form blocks and create a cell made up of several bits of pure crystal. Because

the individual crystals are not necessarily all perfectly aligned together and there are losses at the joints between them, they are not quite as efficient. However, this mis-alignment can help in some circumstances, because the cells work better from light at all angles, in low light, etc. The appearance is also different, the random crystal arrangement and the panels look a little bluer as they reflect some of the light.

Since they are cut into rectangular blocks, there is very little wasted space on the panel and it is difficult to see the little diamonds that are typical of mono or hybrid panels. Some people prefer this more uniform appearance, others like the diamonds.

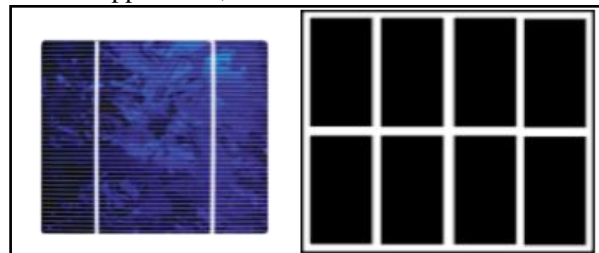


Fig 1.1 polycrystalline solar panel

2) MOSFET as a switch

The metal-oxide-semiconductor field-effect transistor (MOSFET, MOS-FET, or MOS FET) is a type of transistor used for amplifying or switching electronic signals.

Although the MOSFET is a four-terminal device with source (S), gate (G), drain (D), and body (B) terminals. The body (or substrate) of the MOSFET is often connected to the source terminal, making it a three-terminal device like other field-effect transistors. Because these two terminals are normally connected to each other (short-circuited) internally, only three terminals appear in electrical diagrams. The MOSFET is by far the most common transistor in both digital and analog circuits, though the bipolar junction transistor was at one time much more common. The main advantage of a MOSFET transistor over a regular transistor is that it requires very little current to turn on (less than 1mA), while delivering a much higher current to a load (10 to 50A or more). However, the MOSFET requires a higher gate voltage (3-4V) to turn on.

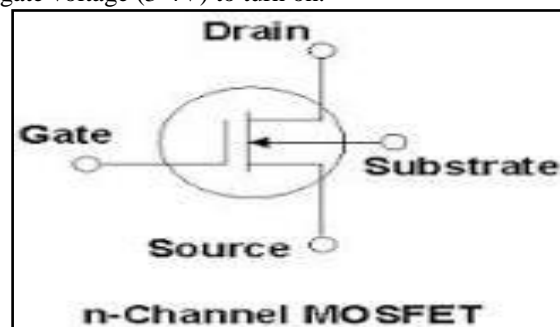


Fig 1.2 n-channel MOSFET

3) Charge controller

A charge controller is an essential part of nearly all power systems that charge batteries, whether the power source is PV, wind, hydro, fuel, AC mains or utility grid. Its purpose is to keep your batteries properly fed and safe for the long term.

The basic functions of a controller are quite simple. Charge controllers block reverse current and prevent battery overcharge. Some controllers also prevent battery over discharge, protect from electrical overload, and/or display battery status and the flow of power. Let's examine each function individually.

a) Blocking reverse current

Photovoltaic panels work by pumping current through your battery in one direction. At night, the panels may pass a bit of current in the reverse direction, causing a slight discharge from the battery. The potential loss is minor, but it is easy to prevent. In most controllers, charge current passes through a semiconductor (a transistor) which acts like a valve to control the current. It is called a "semiconductor" because it passes current only in one direction. It prevents reverse current without any extra effort or cost. In some controllers, an electromagnetic coil opens and closes a mechanical switch. This is called a relay. The relay switches off at night, to block reverse current.

You can install a simple diode in that case, to block reverse current. A diode used for this purpose is called a "blocking diode."

b) Preventing overcharge

Preventing overcharge is simply a matter of reducing the flow of energy to the battery when the battery reaches a specific voltage. When the voltage drops due to lower sun intensity or an increase in electrical usage, the controller again allows the maximum possible charge. This is called "voltage regulating." It is the most essential function of all charge controllers. The controller "looks at" the voltage, and regulates the battery charging in response.

Some controllers regulate the flow of energy to the battery by switching the current fully on or fully off. This is called "on/off control."

4) Boost Converter

The DC input to a boost converter can be from many sources as well as batteries, such as rectified AC from the mains supply, or DC from solar panels, fuel cells, dynamos and DC generators. The boost converter is different to the [Buck Converter](#) in that it's output voltage is equal to, or greater than its input voltage. However it is important to remember that, as power $(P) = \text{voltage } (V) \times \text{current } (I)$, if the output

voltage is increased, the available output current must decrease.

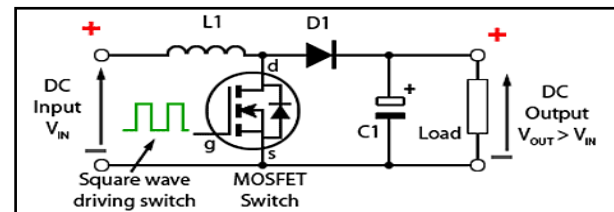


Fig. 3.2.1 Basic Boost Converter Circuit

Fig. 3.2.1 illustrates the basic circuit of a Boost converter. However, in this example the switching transistor is a [power MOSFET](#), both [Bipolar power transistors](#) and MOSFETs are used in power switching, the choice being determined by the current, voltage, switching speed and cost considerations. The rest of the components are the same as those used in the buck converter illustrated in [Fig. 3.1.2](#), except that their positions have been rearranged.

Boost converter Operation

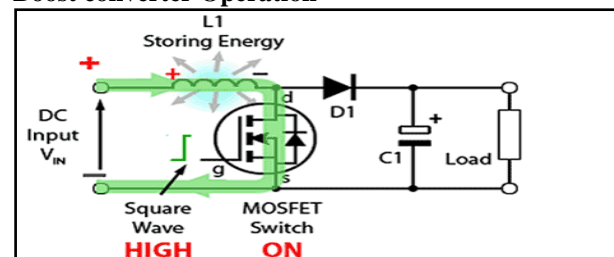


Fig. 3.2.2 Boost Converter Operation at Switch On

Fig 3.2.2 illustrates the circuit action during the initial high period of the high frequency square wave applied to the MOSFET gate at start up. During this time MOSFET conducts, placing a short circuit from the right hand side of L1 to the negative input supply terminal. Therefore a current flows between the positive and negative supply terminals through L1, which [stores energy](#) in its [magnetic field](#). There is virtually no current flowing in the remainder of the circuit as the combination of D1, C1 and the load represent a much higher impedance than the path directly through the heavily conducting MOSFET.

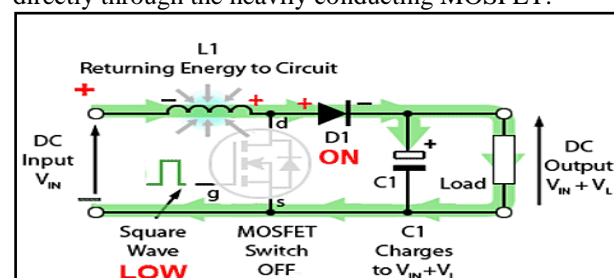


Fig. 3.2.3 Current Path with MOSFET Off

Fig. 3.2.3 shows the current path during the low period of the switching square wave cycle. As the

MOSFET is rapidly turned off the sudden drop in current causes L1 to produce a back e.m.f. in the opposite polarity to the voltage across L1 during the on period, to keep current flowing. This results in two voltages, the supply voltage V_{IN} and the back e.m.f. (V_L) across L1 in series with each other. This higher voltage ($V_{IN} + V_L$), now that there is no current path through the MOSFET, forward biases D1. The resulting current through D1 charges up C1 to $V_{IN} + V_L$ minus the small forward voltage drop across D1, and also supplies the load.

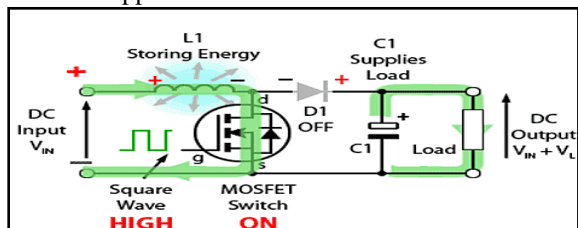


Fig. 3.2.4 Current Path with MOSFET On

Fig.3.2.4 shows the circuit action during MOSFET on periods after the initial start up. Each time the MOSFET conducts, the cathode of D1 is more positive than its anode, due to the charge on C1. D1 is therefore turned off so the output of the circuit is isolated from the input, however the load continues to be supplied with $V_{IN} + V_L$ from the charge on C1. Although the charge C1 drains away through the load during this period, C1 is recharged each time the MOSFET switches off, so maintaining an almost steady output voltage across the load.

B. Hardware Implimentation



Fig hardware implimentation of model

1) Solar charging

The output of the solar panel is fed to the charge controller. The charge controller then regulates the

voltage and current to suit the requirements of the battery to charge and its output is fed directly to the battery.

2) AC mains charging

During sunless condition, the battery is charged from household supply of 230V by converting it into 12V with the help of step- down transformer and with the help of rectifier circuit 12V a.c. supply is converted into 12V d.c. supply to charge the battery.

3) Charge controller

Charge controller is used to select the mode of charging. When the solar energy is available, it will charge the battery using solar panel and when solar energy is not available, it will charge through AC mains. Charge controller regulates the current from the main energy source and auxiliary energy source and fed the power into the battery.



Fig charge controller used in this model

Components	Specifications
Solar panel	40W, 12V
AC mains	230V
Battery	12V, 8A-hr
Step down transformer	12V, 5A

TABLE 1 .System components and specifications

V. Conclusion

In this paper the working model for solar hybrid charge controller has been presented. The aim of this project is to improve air quality in big cities, through the reduction in carbon dioxide emissions and by using renewable sources of energy (solar energy) we can reduce the world dependence on fossil fuel.. The hybrid system designed to charge a battery has been implemented utilizing both solar PV and AC supply suited to an Indian scenario. It can be inferred from the above that the hybrid charging system is much suited for those areas where both grid supply is insufficient and solar irradiation is available in abundance. The efficiency of batteries used also increase considering the methodology chosen for charging.

References

- [1] Eric Yep. (2011, March). india's Widening Energy Deficit [Online]. Available: <http://blogs.wsj.com/indiarealtime/2011/03/09/indias-widening-energy-deficit>
- [2] Ministry of Power, Government of India. (2013, June 30). Power Sector at a Glance "ALL iNDiA" [Online]. Available: http://www.powermin.nic.in/indian_electricity_scenario/introduction.htm
- [3] S. Chakrabarti et al., "Energy Statistics 2013," Central Statistics Office, Government of India, Mar. 2013.
- [4] A. S. Bakshi et al., "Load Generation Balance Report 2013-14," Central Electricity Authority, Ministry of Power, Government of India, May 2013.
- [5] Central Electricity Authority, Government of India. (2013, June) Executive Summary Report-June 2013 [Online]. Available: http://www.cea.nic.in/reports/monthly/executive_rep/jun13.pdf
- [6] Energy Department, Government of Tamil Nadu, India. (2012). Tamil Nadu Solar Energy Policy 2012 [Online]. Available: http://www.teda.in/pdf/tamilnadu_solar_energy_policy_2012.pdf
- [7] Koutroulis, E. and Kalaitzakis, K. , "Novel battery charging regulation system for photovoltaic applications," Electric Power Applications, TEE Proceedings -, vol. 51, no.2, pp.191,197, Mar 2004
- [8] Hisham Mahmood, Dennis Michaelson and Jin Jiang: "Control Strategy for a Standalone PV/Battery Hybrid System", 38th Annual Conference of the IEEE Industrial Electronics Society (IECON2012), Montreal, PQ, 25