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Research Article

Design of Automotive Battery Charging System by Alternation of Alternator and Solar Panel

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ABSTRACT

The present project discusses the design and implementation of automotive charging system by alternation of solar panel and alternator in KIGALI-RWANDA. The project aim is to design the system which will prevent the problem of jump starting the vehicle especially ones with automatic transmission which is has the problem of not allowing the push starting.

Furthermore, apart from the charging system, this solar panel will continue to supply all vehicle electrical systems even if the battery of the vehicle is not present. This system serves as a clean source of energy and will not damage the environment since it uses renewable energy. For that purpose, the researcher used various methods and techniques of research such as documentation, primary and secondary data collection. This system is composed of different components such as: Alternator and solar panel as the source of electrical energy to charge the battery, the controller, the relay to alternate the current from both sources and the battery to store the electrical energy.

Keywords: Two circuits; Changing system; City of Kigali and vehicle

INTRODUCTION

By 1960, automotive alternators were standard equipment for most car brands. Prior to that, generators had been used in vehicles because rectification of AC current into DC current required mechanical means until the advent of heavy-duty silicon diodes.

The main component in the charging system is the ALTERNATOR. This is because all modern automobiles have a 12 volt, DC electrical system. A VOLTAGE REGULATOR regulates the charging voltage that the alternator produces, keeping it between 13.5 and 14.5 volts to protect the electrical components throughout the vehicle. Alternators are used in modern automobiles to charge the battery and to power the electrical system when its engine is running. Until the 1960s, automobiles used DC dynamo generators with commutators. With the availability of affordable silicon diode rectifiers, alternators were used instead. By 1960, automotive alternators were standard equipment for most car brands [1].

Alternators with bad diodes can cause battery drain. Now day's the vehicle charging system is done by using the electrical generator called alternator. This system is affected by a discharging of the battery while the vehicle is not moving and the engine is off. This problem of discharging affects the vehicles with automatic transmission because the jump starting is not used on these vehicles.

In the year 2019, the charging system by alternation of alternator and solar panel was proposed by bintunimana flavien from institut superieur des technologies(burkinafaso). This system is used to solve the problem of lack of vehicle electrical power during parking of the vehicle and engine off, specifically the starting of vehicle equipped with automatic transmission where it is very difficult to start these vehicles if no other battery available.

The purpose of this system is to maintain the optimum charging in the vehicle's battery, and to provide the main source of electrical energy while the engine is not running. If the charging system by alternator stopped working, the battery's charge would soon be depleted, so this system coupled directly the solar panel and the battery.

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Our research has benefits to different categories of people like: the manufacturer, individuals, societies and others researchers [2].

Benefits to manufacturers: the presents study will help us to improve our knowledge in automotive engineering career especially in creativity and innovation.

Benefits to society: this study has a social interest because it will provide a document to user as guide book for the owners of this system and the operating principle of our chosen project will be found in our report. We hope one who will read it carefully will lead him/her to create a job of installing the system for the purpose of getting money and other income.

Benefits to users: This study will help the people to get more information about our chosen research study and its advantages to them including saving energy.

The design of the system involves the integration of the hardware. The system also consists of two input sources supply which are solar energy and utility alternating current (AC) which is converted into DC by using the rectifiers(Diodes). The solar source is connected to the DC converter such that a smooth continuous DC power will supply the battery bank. The system continuously monitors the solar voltage, DC voltage, battery voltage, charging current and load current. PV system consists of solar panels, DC voltage converters, controllers, and batteries. DC voltage converters are used for matching the characteristics of the load with those of the solar panels. The use of the battery allows the photovoltaic system to behave as a real source to the feeder so that it may exhibit constant voltage levels corresponding to the different loads.

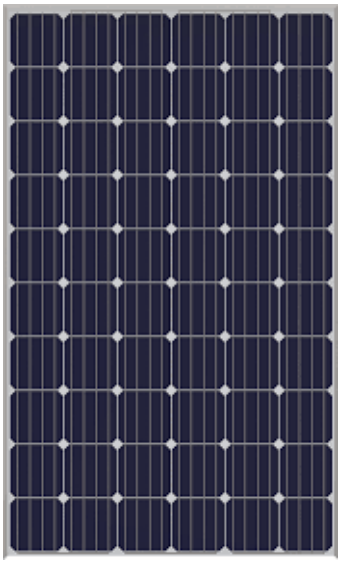
Comparison between charging system by solar panel and Charging by an Alternator

Solar energy might be one of the easiest ways for people to produce energy. Indeed, people usually have several large buildings whose roofs are directly under the sun, without being hindered by the shadows of the trees, turning them into an ideal place to settle a photovoltaic system. Therefore, the use of solar energy in general is becoming increasingly popular and the energy produced from this renewable source can be used either on the farm or in the local power grid, providing the people with an additional income [3-6].

This project of design the automotive battery charging system by alternating alternator and solar panel with description is reliable, economic, and compact. It causes no danger to the environment and It can be used in small or big vehicles. The photovoltaic have many advantages including they operate on freely available sunlight and therefore incur no fuel or electrical costs. They are also environmentally friendly, reliable and have a long working life. This system will charge the vehicle battery and supply all electrical consumers in the case of alternator and battery failure. There are two fundamental types of solar power systems are found and they are: Battery-Coupled and Direct-Coupled. These two fundamental types help us to determine the optimum system for a particular application, and they are explained briefly below.

Solar panel system

Photovoltaic cells are devices which collects the light and converts it into electricity. The cells are wired in series, sealed between sheets of glass or plastic, and supported inside a metal frame. These frames are called solar modules or panels. They are used to power a variety of applications ranging from calculators and wrist-watches to complete home systems and large power plants. PV cells are made of thin silicon wafers; a semi-conducting material similar to that used in computer chips. When sunlight is absorbed by these materials, the solar energy knocks electrons loose from their atoms, allowing the electrons to flow through the material to produce electricity. This process of converting light to electricity is called the "photovoltaic effect. Using photovoltaic to generate power or electricity is the best idea because it is found that it has many advantage such less expensive. It is good for rural areas. One of the good points is about how to increase the power of photovoltaic.
The solar panel that will be used has 12V for output with the power of 50 watts in order to achieve full sun exposure to the panels, adjust the panel at a tilt angle of 30 degrees will increase energy production.



How the voltage is generated

Solar-powered photovoltaic (PV) panels convert the sun's rays into electricity by exciting electrons in silicon cells using the photons of light from the sun. This electricity can then be used to supply renewable energy to your home or business.

A charge controller

Charger controller, charge regulator or battery regulator: limits the rate at which electric current is added to or drawn from electric batteries. It prevents overcharging and may protect against overvoltage, which can reduce battery performance or lifecycle, and may pose a safety risk. It may also prevent completely draining("deep discharging") a battery, or perform controlled discharges, depending on the battery technology, to protect battery life.

The terms "charge controller" or "charge regulator" may refer to either a stand-alone device, or to control circuitry integrated

within a battery pack, battery-powered device, or battery charger [7-10].

OPERATING PRINCIPLE OF A CHARGE CONTROLLER

Blocking Reverse Current: Solar 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. (Our term "battery" represents either a single battery or bank of batteries.) The potential loss is minor, but it is easy to prevent. Some types of wind and hydro generators also draw reverse current when they stop (most do not except under fault conditions).

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 older controllers, an electromagnetic coil opens and closes a mechanical switch (called a relay - you can hear it click on and off.) The relay switches off at night, to block reverse current. These controllers are sometimes referred to as call shunt controllers.

If you are using a solar panel array only to trickle-charge a battery (a very small array relative to the size of the battery), then you may not need a charge controller. This is a rare application.

An example is a tiny maintenance module that prevents battery discharge in a parked vehicle but will not support significant loads. You can install a simple diode in that case, to block reverse current. A diode used for this purpose is called a "blocking diode."

Preventing Overcharge: When a battery reaches full charge, it can no longer store incoming energy. If energy continues to be applied at the full rate, the battery voltage gets too high. Water separates into hydrogen and oxygen and bubbles out rapidly. (It looks like it's boiling so we sometimes call it that, although it's not actually hot.) There is excessive loss of water, and a chance that the gasses can ignite and cause a small explosion. The battery will also degrade rapidly and may possibly overheat. Excessive voltage can also stress your loads (lights, appliances, etc.) or cause your inverter to shut off.

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." Others reduce the current gradually. This is called "pulse width modulation" (PWM). Both methods work well when set properly for your type of battery.

Control Set Points vs. Temperature: The ideal voltage set points for charge control vary with a battery's temperature. Some controllers have a feature called "temperature compensation." When the controller senses a low battery temperature, it will raise the set points. Otherwise when the battery is cold, it will reduce the charge too soon. If your batteries are exposed to temperature swings greater than about 30° F (17° C), compensation is essential.

Some controllers have a temperature sensor built in. Such a controller must be mounted in a place where the temperature is close to that of the batteries. Better controllers have a remote temperature probe, on a small cable. The probe should be attached directly to a battery in order to report its temperature to the controller.

An alternative to automatic temperature compensation is to manually adjust the set points (if possible) according to the seasons. It may be sufficient to do this only twice a year, in spring and fall.

Control Set Points vs. Battery Type: The ideal set points for charge controlling depend on the design of the battery. The vast majority of renewable energy systems use deep-cycle lead-acid batteries of either the flooded type or the sealed type. Flooded batteries are filled with liquid. These are the standard, economical deep cycle batteries.

Sealed batteries use saturated pads between the plates. They are also called"valve-regulated" or "absorbed glass mat," or simply "maintenance-free." They need to be regulated to a slightly lower voltage than flooded batteries or they will dry out and be ruined. Some controllers have a means to select the type of battery. Never use a controller that is not intended for your type of battery.

Automotive alternator: An automotive charging system is made up of three major components: the battery, the voltage regulator and an alternator. The alternator works with the battery to generate power for the electrical components of a vehicle, like the interior and exterior lights, and the instrument panel. An alternator gets its name from the term alternating current (AC).

Alternators are typically found near the front of the engine and are driven by the crankshaft, which converts the pistons' up-and-down movement into circular movement. Some early model vehicles used a separate drive belt from the crankshaft pulley to the alternator pulley, but most cars today have a serpentine belt, or one belt that drives all components that rely on crankshaft power. Most alternators are mounted using brackets that bolt to a specific point on the engine

Operating principle of an alternator: The battery is charged by an alternator on modern cars, or by a dynamo on earlier ones. Both are types of generator, and are driven by a belt from the engine.

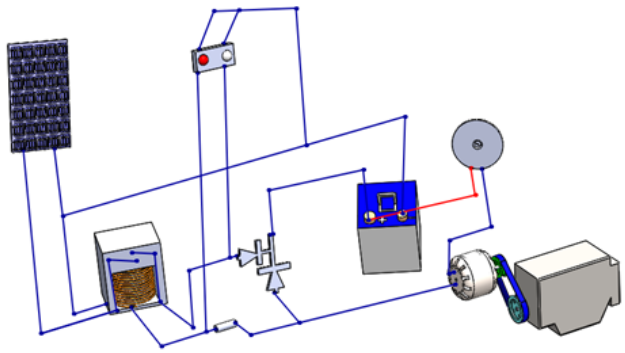
The alternator consists of a stator - a stationary set of wire coil windings, inside which a rotor revolves.The rotor is an electromagnet supplied with a small amount of electricity through carbon or copper-carbon brushes (contacts) touching two revolving metal slip rings on its shaft. The rotation of the electromagnet inside the stator coils generates much more

electricity inside these coils. The electricity is alternating current - its direction of flow changes back and forth every time the rotor turns. It has to be rectified - turned into a one-way flow, or direct current. A dynamo gives direct current but is less efficient, particularly at low engine speeds, and weighs more than an alternator. A warning light on the dashboard glows when the battery is not being adequately charged, - for example, when the engine stops. There may also be an ammeter to show how much electricity is being generated, or a battery-condition indicator showing the battery's state of charge. Moving a magnet past a closed loop of wire makes an electric current flow in the wire. Imagine a loop of wire with a magnet inside it. The north pole of the magnet passes the top of the loop as the south pole passes the bottom of it. Both passes make current flow in one direction round the loop. The poles move away, and current stops flowing until the south pole reaches the top and the north pole the bottom. This makes current flow again, but in the opposite direction.

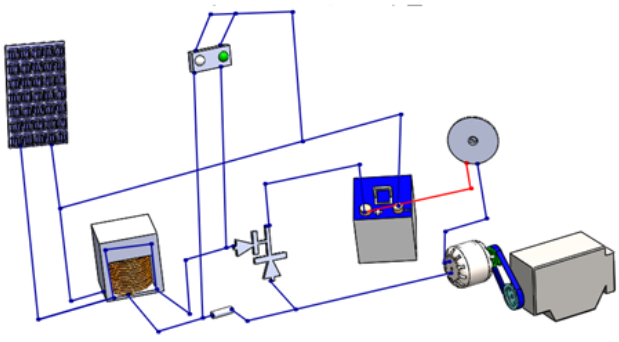
COMPONENTS OF THE SYSTEM

The construction of the whole system

A system when alternator is charging (Engine running)



A system when solar panel is charging (Engine is stationary)



OPERATING PRINCIPLE OF THE SYSTEM

When the ignition key is in on position, the current from the battery flows to the alternator to pre-excite it. If the engine is cranking, the alternator produces the voltage to charge the battery through the diode, at the same time the current from alternator flows to command solenoid of the relay to break its contacts, in that time the current from solar panel will be cut off. When the engine is stopped, the current from alternator will be cut off also. And then the magnetic field in the relay will disappear and then the relay contacts meet. In that time the current produced by the solar panel will flow to charge the battery through the charge controller and the diode because the rely contacts are met.

The dashboard light will indicate if the battery is being charged either by the alternator or the solar panel.

Charging system parameters

No	Parameters	Values
1	Battery	12 volts,70 A
2	Alternator	13-14 volts
3	Charging controller	12 volts
4	Cables	Single wire
5	Diodes	Ordinary
6	Solar panel	17 volts
7	Relays	Break relay
8	Ignition switch/ Driving switch	3 positions

METHODOLOGY

Design approach: This project shows its design in the form of electrical circuit. The circuit is made by using a circuit mechanical engineering software called solidworks (electrical).

Study Population: This design was made by different main parts including: one solar panel, one charge, one relay, one alternator and one battery with 12 volts. In the case of vehicle starting system with 24 volts, the 12 voltssolar panel and 24 volts' battery will be used.

Determination of the Sample size: The alternator to be used is 14 volts and solar panel with 12 volts and 40 watts

Data Collection: Collection of data was done through internet, documentation skills and vehicle manuals. **The principle method of data collection was administration of the self-made questionnaire alongside interviews and observation. The research proceeds firstly to the student, technicians, garage leaders who will give truth news about the teaching of** charging system**, secondly to the teacher who teaches this course and the technician who carry out the repair and maintenance of this system.**

Data collection instruments: The data was collected by using photographic instruments, videos and writings.

Pre-study: The system was tested (prototype testing) at the end of design, before designing the system, we tried our best to search the operation of the existing one and then we search for the

disadvantages of the existing system which lead us to achieve the problem statement. And the after finding the problem statement, we see how you are going to design your system (developing your idea).

Procedure of Data Collection: The data was corrected from garage (auto workshop) and from electrical supply system, we have identified the different parts to be used during the design.

Design: The system is designed so that the battery must be charge by two sources of electrical energy in sequencing manner, it means that the must be charged by the alternator when the engine is running and then by the solar panel when the engine stops.

Data Analysis: After combining a variety of statistical and machine learning techniques to understand the demand pattern of electric vehicle charging, we have integrated renewable energy to charging-intensive power grids as much as possible.

Measurements of variables (quantitative studies): In this design, the measurement variables are voltage, resistance, electrical current and electrical power.

Software used: During the design of this system, there is a software used which is called Solidworks, it is the software used in mechanical engineering which is very helpful one. It is used to design the mechanical parts and electrical ones. It is useful during design because it simulates the system.

Conclusion: Basing on what was studied; this essay shows the mechanical engineering works. Because we deal with designing of an automobile, with how to keep battery energy to avoid the problem battery discharging resulting in lack of engine starting and the load of jump starting by using external starter battery, the system solved all those kind of problems.

This system would be needed for all kinds of automobile industries and we hope all users in the automobile field will be happy with the system after allowing them to use it. The system is safe, economic and is comfortable with all kinds of cars, trucks and other types of vehicles.

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