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Smart Windows for House Illumination

Sangeetha K [1], Malini A [2]

Associate Professor, Dept. of ECE, Krishnasamy College of Engineering and Technology, Cuddalore, Tamilnadu, India[1]

PG Student [EST], Dept. of EEE, Krishnasamy College of Engineering and Technology, Cuddalore, Tamilnadu, India [2]

ABSTRACT: In recent years, as a result of industrial development and population growth solar energy is increasingly being recognised as one of the main substitutes for fossil fuels due to its essentially non-polluting inexhaustible nature and is quite simple, the energy is produced directly by the sun. In this system a new concept of smart window whereby water cooled concentrator-PV cell units are incorporated inside the gap between two panes of a double glazed window. Fresnel lens is used as optical concentrators are coupled for the effective focusing of the sun light to the PV component. This approach is considered for concentrating solar systems, in which heat removal from the PV cells is possible for generating electricity and for producing hot water. This solar smart window maintains cooling in building, by blocking direct sunlight with consequent reduction in building energy cooling load thereby, increasing the thermal comfort in buildings while lowering space heating and cooling energy consumption and transmit diffuse sunlight to provide natural daylight. The Time based Tilted Single Axis Tracking Mechanism is used for tracking and is implemented using a microcontroller based system.

KEYWORDS: solar, PV cells, Fresnel lens.

I. INTRODUCTION

Energy crisis is any great bottleneck (or price rise) in the supply of energy resources to an economy. In popular literature though, it often refers to one of the energy sources used at a certain time and place, particularly those that supply national electricity grids or serve as fuel for vehicles. There has been an enormous increase in the global demand for energy in recent years as a result of industrial development and population growth. Solar energy is rapidly gaining notoriety as an important means of expanding renewable energy resources. Solar energy is increasingly being recognised as one of the main substitutes for fossil fuels due to its essentially non-polluting inexhaustible nature. Solar energy is quite simply the energy produced directly by the sun and collected elsewhere, normally the earth.

Solar energy is the ultimate source of energy from millions of years and it is renewable energy. This energy consists of radiant light and heat energy from the sun. Out of all energy emitted by sun only a small fraction of energy is absorbed by the earth. Just this tiny fraction of the sun's energy that hits the earth is enough to meet all our power needs. Using present solar techniques some of the solar energy reaching the earth is utilized for generating electricity etc. Even then the energy demand met by using solar energy is very less. Our project aims at converting solar power to electrical power using photovoltaic (PV) cells within smart windows. Photovoltaic cells generate electric current when subjected to sunlight. Our target is to extract maximum power out of a given solar panel throughout the day. The concentrated solar panel is formed by the focusing of sunlight to the solar cells using the Fresnel lens as optical concentrator.

A. PHOTOVOLTAICS

Photovoltaics (PV) is a method of converting solar energy into using semiconducting materials that exhibit the photovoltaic effect. The photovoltaic effect is the creation of voltage or electric current in a The operation of a photovoltaic (PV) cell material upon exposure to light. The photovoltaic effect refers to photons of light exciting electrons into a higher state of energy, allowing them to act as charge carriers for an electric current. A photovoltaic system employs solar panels composed of a number of solar cells to supply usable solar power. Solar cells produce direct current electricity from sun light which can be used to power equipment or to recharge a battery. Power

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generation from solar PV has long been seen as a clean sustainable energy technology which draws upon the planet's most plentiful and widely distributed renewable energy source the sun. The direct conversion of sunlight to electricity occurs without any moving parts or environmental emissions during operation.

Requires 3 basic attributes:

- The absorption of light, generating either electron-hole pairs or excitons.
- The separation of charge carriers of opposite types.
- The separate extraction of those carriers to an external circuit.

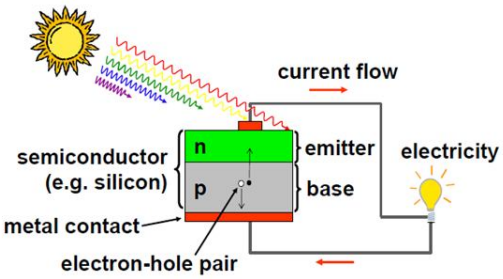

Fig .1 Photovoltaics operation

Photovoltaic power generation employs solar panels composed of a number of solar cells containing a photovoltaic material. Materials presently used for photovoltaics include monocrystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, and copper indium gallium selenide/sulfide. Copper solar cables connect modules (module cable), arrays (array cable), and sub-fields. Because of the growing demand for renewable energy sources, the manufacturing of solar cells and photovoltaic arrays has advanced considerably in recent years.

B. CONCEPT OF SOLAR RADIATION

The sun, at an estimated temperature of 5800 K, emits high amounts of energy in the form of radiation, which reaches the planets of the solar system. Sunlight has two components, the direct beam and diffuse beam. Direct radiation (also called beam radiation) is the solar radiation of the sun that power plant termed as solar thermoelectricity. Concentrating technologies exist in five common forms, namely parabolic trough has not been scattered (causes shadow). Direct beam carries about 90% of the solar energy, and the "diffuse sunlight" that carries the remainder. The diffuse portion is the blue sky on a clear day and increases as a proportion on cloudy days. The diffuse radiation is the sun radiation that has been scattered (complete radiation on cloudy days). Reflected radiation is the incident radiation (beam and diffuse) that has been reflected by the earth. The sum of beams, diffuse and reflected radiation is considered as the global radiation on a surface. As the majority of the energy is in the direct beam, maximizing collection requires the sun to be visible to the panels as long as possible.

II. DESIGN METHODOLOGY

The smart window design for building includes the combination of a thermal and PV component for concentrating solar systems, in which heat removal from the PV cells is possible for generating electricity and for producing hot water. A new concept of smart windows where by water cooled concentrator-PV cell units are incorporated inside the gap between two panes of a double glazed window is implemented. Fresnel lens concentrators are coupled to the PV cells for efficient focusing of the incident solar light. Existing systems have different types of double-skin facades employed in buildings to provide increased thermal comfort while lowering space heating and cooling energy consumption. Solar radiation is comprised of both long and short wave radiation, i.e., heat and light. When seeking to regulate the amount of solar radiation entering into a may pose a safety risk. It may also prevent completely draining ("deep discharging") a battery, or perform controlled discharges, depending on the battery building, the challenge is to achieve desired levels

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of daylight intensity without excess introduction of the concomitant heat. Excessive direct solar isolation in the interior space, workplace or home, can lead to discomfort due to high levels of glare when the sun is directly in the field of view or is secularly reflected from indoor surfaces.

BLOCK DIAGRAM

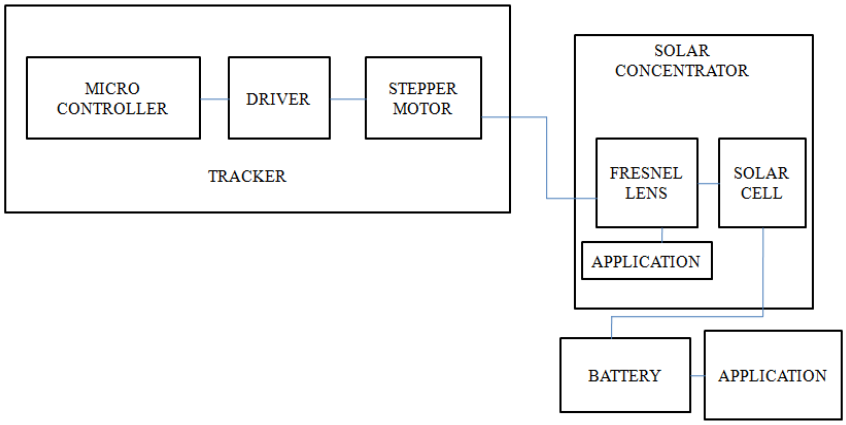

Fig.2 Block Diagram of Smart window

A.SOLAR CONCENTRATOR

The concentrator section consists of a Fresnel lens which efficiently focuses the incident solar radiation to the solar cell. The solar cell in turn produces electric energy and gets heated up, the heat from the lens and cell can be used for a domestic application i.e., producing hot water. The application within the window block consists of a copper tube that carries water, the focused solar radiation increases the temperature of water flowing inside the tube and hence hot water can be obtained from the outlet. The solar energy converted into electrical energy from the PV cell is stored in the battery and is used for any simple electrical appliance i.e., a simple incandescent light or fluorescent lamp or charging of a mobile phone and so on.

Charge controller

A charge 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 lifespan, and 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 recharger.

Battery

An electric battery is a device consisting of one or more electrochemical cells that convert stored chemical energy into electrical energy. Each cell contains a positive terminal, or cathode, and a negative terminal, or anode. Electrolytes allow ions to move between the electrodes and terminals, which allows current to flow out of the battery to perform work.

Inverter

Inverter is an electronic device or circuitry that changes direct current (DC) to alternating current (AC). The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry. The inverter does not produce any power; the power is provided by the DC source.

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Smart window

Smart window is designed by a Fresnel (pronounced fray-NEL) lens replaces the curved surface of a conventional optical lens with a series of concentric grooves. These contours act as individual refracting surfaces, bending parallel light rays to a common focal length (Figure 1). As a result, a Fresnel lens, while physically narrow in profile, is capable of focusing light similar to a conventional optical lens but has several advantages over its thicker counterpart.

Solar panel

A solar cell, or photovoltaic cell, is an electrical device that converts the energy of radiation onto a glass tube containing a fluid (also called a receiver, absorber or collector) running the length of the trough, positioned at the focal point of the reflectors. It consists of a linear parabolic reflector that concentrates light onto a receiver positioned along the reflector's focal line. The receiver is a tube positioned light directly into electricity by the photovoltaic effect.
The operation of a photovoltaic (PV) cell requires 3 basic attributes:

- The absorption of light, generating either electron-hole pairs or excitations.
- The separation of charge carriers of opposite types.
- The separate extraction of those carriers to an external circuit.

B.CONCENTRATED SOLAR POWER TECHNOLOGY

CSP is used to produce electricity (sometimes called solar thermoelectricity, usually generated through steam). Concentrated-solar technology systems use mirrors or lenses with tracking systems to focus a large area of sunlight onto a small area. The concentrated light is then used as heat or as a heat source for a conventional power plant (solar thermoelectricity). The solar concentrators used in CSP systems can often also be used to provide industrial process heating or cooling, such as in solar air-conditioning.

Different types of concentrators produce different peak temperatures and correspondingly varying thermodynamic efficiencies, due to differences in the way that they track the sun and focus light. New innovations in CSP technology are leading systems to become more and more cost-effective.

C.PARABOLIC TROUGH

A parabolic trough use a curved, mirrored trough which reflects the direct solar directly above the middle of the parabolic mirror and filled with a working fluid. A fluid (also called heat transfer fluid) passes through the receiver and becomes very hot. Common fluids are synthetic oil, molten salt and pressurized steam. The fluid containing the heat is transported to a heat engine where about a third of the heat is converted to electricity. The reflector follows the sun during the daylight hours by tracking along a single axis. A working fluid (e.g. molten salt) is heated to 150–350 °C (423–623 K (302–662 °F)) as it flows through the receiver and is then used as a heat source for a power generation system. Trough systems are the most developed CSP technology.

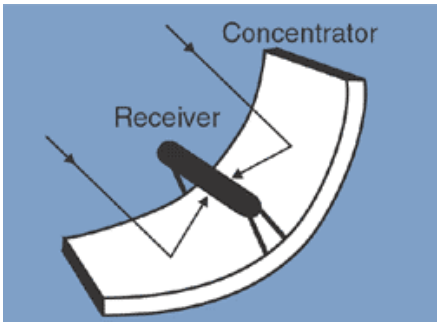

Fig .3 A parabolic trough schematic

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D.FRESNEL LENS

A Fresnel lens is a flat approximation of a curved lens, which consists of discrete concentric prism elements patterned on a superstrate, either monolithically or fashioned out of separate layer of material, and it is usually used as a cost-effective lightweight alternative to a corresponding conventional curved lens [8]. Compared to ellipsoidal concentrator, large size commercial Fresnel lenses made of polymethy lmetakrylat (PMMA) or silicone on glass (SOG) materials are reduced the cost of parabolic mirrors.

III. HARDWARE DESCRIPTION

A.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. This solar panel produce direct-current (DC) electricity.

Fig .4 solar cell

B.CHARGE CONTROLLER

A charge 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 lifespan, 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 recharger.

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.

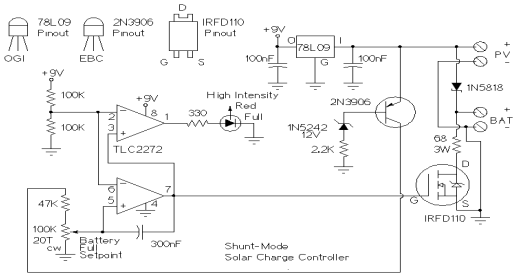

Fig.5 Circuit of charge controller

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Simple charge controllers stop charging a battery when they exceed a set high voltage level, and re-enable charging when battery voltage drops back below that level. Pulse width modulation (PWM) and maximum power point tracker (MPPT) technologies are more electronically sophisticated, adjusting charging rates depending on the battery's level, to allow charging closer to its maximum capacity. Charge controller circuits are used for rechargeable electronic devices such as cell phones, laptop computers, portable audio players, and uninterruptible power supplies, as well as for larger battery systems found in electric vehicles and orbiting space satellites.

C.BATTERY

An electric battery is a device consisting of one or more electrochemical cells that convert stored chemical energy into electrical energy. Each cell contains a positive terminal, or cathode, and a negative terminal, or anode. Electrolytes allow ions to move between the electrodes and terminals, which allows current to flow out of the battery to perform work.

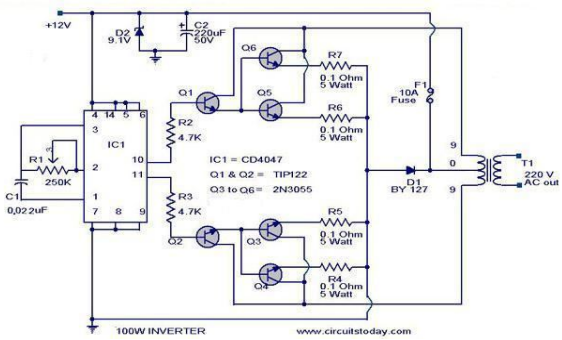

Fig.6 Circuit of inverter

The switch in the simple inverter described above, when not coupled to an output transformer, produces a square voltage waveform due to its simple off and on nature as opposed to the sinusoidal waveform that is the usual waveform of an AC power supply.

Since the electrical appliance used in the buildings use alternating current, the inverter is used for the conversion of produced DC current into AC. The appliance acquires the A.C supply from the inverter.

IV. RESULTS AND DISCUSSION

The smart window module, with Fresnel lens as optical concentrators are coupled for the effective focusing of the sun light to the PV component. The generated electricity is used for the simple electrical appliance i.e., a simple incandescent light or fluorescent lamp. The domestic application involves the production of hot water.

Fig.7 Hardware implementation

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V. CONCLUSION

A modelling and optimization method from a new point of view is proposed. More factors should be taken into considerations in the future modelling and optimization, such as the sensitivity range of the controlling system which determines when the solar tracker should operate to generate more power or stay still to save energy. In this project energy will consume by placing smart window near to the panel and show the power measurements comparing with other panels energy management.

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BIOGRAPHY

Sangeetha.K has received his B.E. (ECE) in the year 1999 from Periyar Maniamai College of Technology for Women , Bharathidasan University, Tamil Nadu, And she received M.Tech. (Communication System) in the year 2005 from National institute of Technology, Tiruchirappalli, Autonomous, Tamil Nadu. At present she is pursuing HOD/ECE in Krishnasamy College of Engineering and Technology, Cuddalore, Tamil Nadu, affliated to Anna University, Chennai.

Malini.A has received her B.E. (ECE) in the year 2011 from Dr.PAUL'S College of Engineering and Technology Villupuram, Tamil Nadu, affliated to Anna University, Chennai. At present she is pursuing M.E. (Embedded System Technologies) in Krishnasamy College of Engineering and Technology, Cuddalore, Tamil Nadu, affliated to Anna University, Chennai. Her research interest lies in the areas of Embedded System.