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Solar Power Generation with Automatic Sun Tracking System

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ABSTRACT: Solar energy is the most abundant stream of energy. It is available directly as solar isolation and indirectly as wind energy. Solar energy has the sources of renewable energy. Its potential is 178 Billion MW, which is about 20,000 times the world's demand. Sun sends out energy in the form of electromagnetic radiation. In this project we use the solar energy for generation of electrical energy, by using the Solar cells. The solar cells receive the solar energy. The solar cells operate on the photo-electric energy by using solar cells principle. The energy from the photo voltaic cells is used to switch on the lights. At present solar electric power generation systems are having fixed solar panels whose efficiency of generation is less. The aim of the project is to introduce the SOLAR TRACKING to the existing fixed solar panels, thus we are maintaining the constant maximum power output. Thus by using this tracking system we can increase the conversion efficiency of the solar electric power generation. For this tracking purpose we use a sensor and the input from the sensor is given to the micro controller and according to the program the panel is fixed to the maximum intensity position. Here we are using PIC micro controller. The 16F877 is a low-power, high-performance CMOS 8-bit microcontroller with 4K bytes of Flash Programmable and Erasable Read Only Memory (PEROM). The opto-coupler used is to provide isolation between the micro controllers to the sensor circuits.

KEYWORDS: electromagnetic radiation, microcontroller, solar tracking, photo-electric effect, opto-coupler.

I.INTRODUCTION

Sun is the primary source of Energy. The earth receives 16 x 10^{18} units of energy from the sun annually, which is 20,000 times the requirement of mankind on the Earth. Some of the Solar Energy causes evaporation of water, leading to rains and creation of rivers etc. Some of it is utilized in photosynthesis which is essential for sustenance of life on earth. Man has tried from time immemorial to harness this infinite source of energy. But has been able to tap only a negligibly fraction of this energy till today. The broad categories of possible large scale applications of solar power are the heating and cooling of residential and commercial buildings, the chemical and Biological conversion of organic material to liquid solid and gaseous fuels, Conversion of solar energy to Electricity. In this paper we use the solar energy for the generation of electrical energy, by using solar cells. The solar cell receives the solar energy. The solar cells operate on the principle of photovoltaic effect, by using solar cells. Basically the cells are placed in an open and fixed manner. Drastic changes in energy conversion system are anticipated due to shortage of conventional fuels. Fuel deposit in the world will soon deplete by the end of 2030. Fossil fuel scarcity will be maximum. The main reasons for the above are due to increasing demand for electricity, rising population, rapid advance in technology. It is worthwhile to mention here that indiscriminate use of commercial energy has lead to serious environment problems like air and water pollutions. Man, when he is embarking on use of alternate sources of energy should bear in mind, his environment. The creation of new source of perennial environmentally acceptable, low cost electrical energy as a replacement for energy from rapidly depleting resources of fossil fuels is the fundamental need for the survival of mankind. Solar energy has the greatest potential of all the sources of renewable energy and it will be one of the most important source of energy especially when other sources in the country have depleted. Solar energy could supply all the present and future energy needs of the world on a connecting basis. This makes it one of the most promising of the nonconventional energy sources. Solar Energy can be a major source of power. Its potential is 178 billion MW which is about 20,000 times the worlds demand. The energy radiated by the sun on a bright sunny day is approximately 1kw/m^2. The problem associated with the use of solar energy is that its availability varies widely with time. The variations in availability occur daily, because of the day-night cycle and also seasonally because of Earth's orbit around the sun. In addition variations occur at a specific location because of local weather conditions. Consequently the energy collected

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with the sun is shining must be stored for use during periods when it is not available. Attempts have been made to make use of this energy in raising steam which may be used in driving the prime movers for the purpose of generation of electrical energy. However due to large space requirement and uncertainty of availability in constant rate this method becomes ineffective. Photovoltaic cell is an alternate device used for power generation which converts suns radiation directly into electrical power. Thus power generated can be stored and utilized.

II.ENVIRONMENTAL IMPACT OF SOLAR POWER

Air Pollution

This can be caused by chemical reactants used in storage or organic fluids for heat transport. The release of CO, SO_2, SO_3, hydrocarbon vapors and other toxic gases should be accounted, through their magnitude is not high. The fire hazard associated with overheated organic working fluids exists. Human tissues when exposed would be destroyed because of high energy flux densities.

Land Use

Solar plants require large land and the collection field produce shading not normally present over large areas. This may cause disturbance in local ecosystem.

Noise and Thermal Effect

The thermal effects of solar plants are minimal. Actually these systems eliminate local thermal pollution associated with fossil fuel combustion. Some reduction in local environmental heat budget or balance will occur if electricity produced is exported elsewhere. Solar systems do not add any new noise to that already existing in the present industrial or utility areas.

Major Advantages of Solar Cells

1) Solar cells directly convert the solar radiation into electricity using photovoltaic effect without going through a thermal process.
2) Solar cells are reliable, modular, durable and generally maintenance free and therefore, suitable even in isolated and remote areas.
3) Solar cells are quiet, benign, and compatible with almost all environments, respond instantaneously with solar radiation and have an expected life time of 20 or more years.
4) Solar cells can be located at the place of use and hence no distribution network is required.

Major Disadvantages of Solar Cells

1) The conversion efficiency of solar cells is limited to 10 percent. Large areas of solar cell modular are required to generate sufficient useful power.
2) The present costs of solar cells are comparatively high, making them economically uncompetitive with other conventional power generation methods for terrestrial applications, particularly where the demand of power is very large.
3) Solar energy is intermittent and solar cells produce electricity when sun shines and in proportion to solar intensity. Hence, some kind of electric storage is required making the whole system more costly. However, in large installations, the electricity generated by solar cells can be fed directly into the electric grid system.

III.PRINCIPLE OF OPERATION OF SOLAR PHOTOVOLTAICS

The solar energy can be directly converted into electrical energy by means of photovoltaic effect, i.e. conversion of light into electricity. Generation of an electromotive force due to absorption of ionizing radiation is known as photovoltaic effect. The energy conversion devices which are used to convert sunlight to electricity by use of the photovoltaic effect are called solar cells. Photo voltaic energy conversion is one of the most popular nonconventional energy source. The photovoltaic cell offers an existing potential for capturing solar energy in a way that will provide clean, versatile, renewable energy. This simple device has no moving parts, negligible maintenance costs, produces no pollution and has a lifetime equal to that of a conventional fossil fuel. Photovoltaic cells capture solar energy and convert it directly to electrical current by separating electrons from their parent atoms and accelerating them across a one way electrostatic barrier formed by the function between two different types of semiconductor material. Semiconductors are materials which are neither conductors nor insulators. The photo voltaic effect can be observed in nature in a variety of materials but semiconductors has shown best performance. When photons from the sun are absorbed in a semiconductor they create for electrons with higher energies than the electrons which provide the

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boarding in the base crystal. Once these electrons are created, there must be an electric field to induce these higher energy electrons to flow out of the semiconductor to do useful work. The electric field in most solar cells is provided by a junction of materials which have different electrical properties. To understand more about the functioning and properties of semiconductors, let us briefly discuss. Semiconductors are classified into 1) Extrinsic semiconductor 2) Intrinsic semiconductor. Semiconductors in its purest form are called intrinsic and when impurities are added it is called extrinsic. Further extrinsic semiconductors are divided into p type and N type semiconductor.

P-Type Semiconductor When a small amount of pentavalent impurities (e.g. Gallium, Indium, Aluminum, and Boron) are added to intrinsic semiconductor, it is called as p type semiconductor. In p type semiconductor, when an electric potential is applied externally, the holes are directed towards the negative electrode. Hence current is produced.

Type Semiconductor When a small amount of pentavalent impurities (e.g. Antimony, Arsenic, Bismuth, and Phosphorus) are added to intrinsic semiconductors it is called N type semiconductor. When an external electrical field is applied the free electrons are directed towards positive electrode. Hence current is produced.

PN Junction Silicon Solar Cell A PN junction is formed from a piece of semiconductor by diffusing p type materials to one half side and N type materials to other half side. It consists of both types of semiconductor materials. The N type layer is situated towards the sunlight. As N type layer is thin, light can penetrate through it. The energy of the sunlight will create free electron in the N type material and holes in the p type material. This condition built up the voltage with in the crystal. Because the holes will travel to the positive region and the holes will travel to the negative region. This conduction ability is one of the main technical goals in fabricating solar cells.

IV.FUNCTIONAL BLOCK DIAGRAM

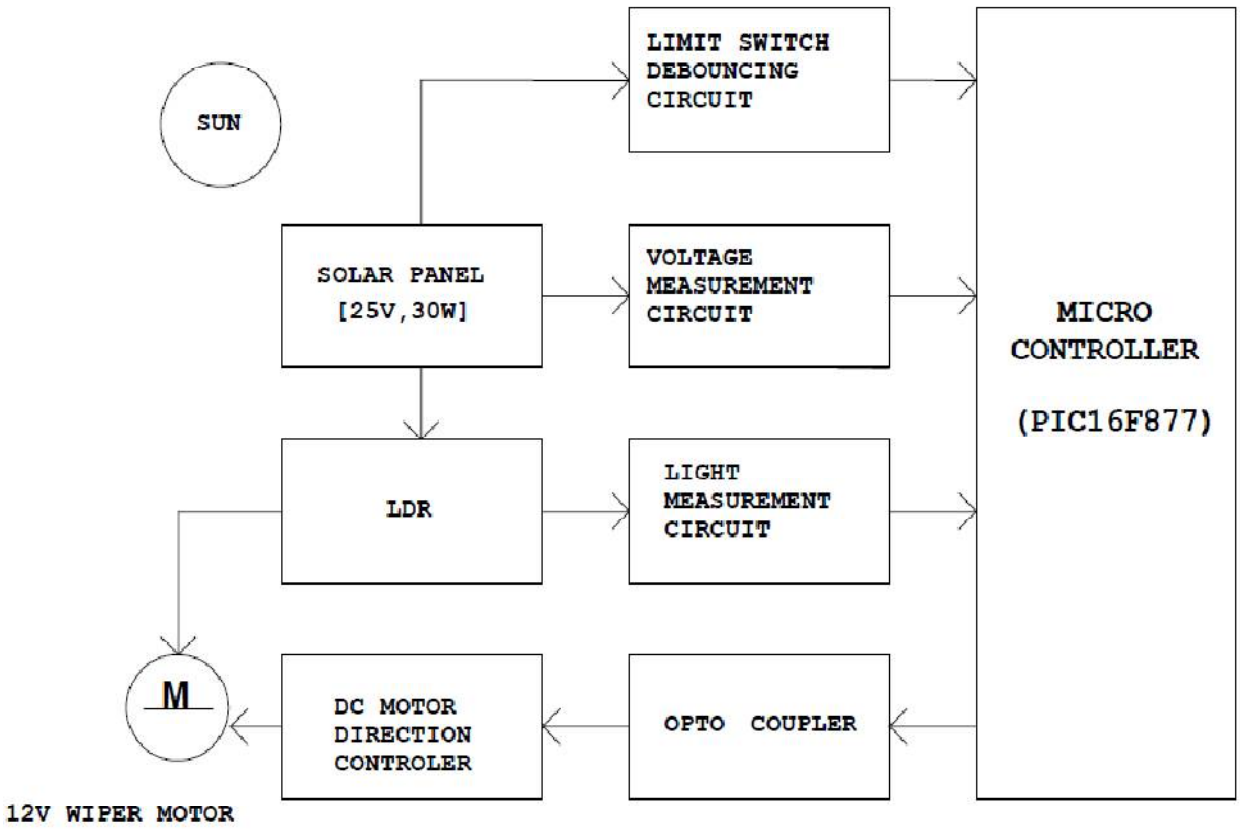

Fig.1 Functional block diagram

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MICROCONTROLLER CORE FEATURES:

- High performance RISC CPU
- Only 35 single word instructions to learn
- All single cycle instructions except for program Branches which are two cycle
- Operating speed: DC - 20 MHz clock input DC - 200 ns instruction cycle
- Up to 8K x 14 words of FLASH Program Memory, Up to 368 x 8 bytes of Data Memory (RAM) Up to 256 x 8 bytes of EEPROM Data Memory
- Pin out compatible to the PIC16C73B/74B/76/77
- Interrupt capability (up to 14 sources)
- Eight level deep hardware stack
- Direct, indirect and relative addressing modes
- Power-on Reset (POR)
- Power-up Timer (PWRT) and Oscillator Start-up Timer (OST)
- Watchdog Timer (WDT) with its own on-chip RC Oscillator for reliable operation
- Programmable code protection
- Power saving SLEEP mode
- Selectable oscillator options
- Low power, high speed CMOS FLASH/EEPROM Technology.
- Fully static design
- In-Circuit Serial Programming. (ICSP) via two pins
- Single 5V In-Circuit Serial Programming capability
- In-Circuit Debugging via two pins
- Processor read/write access to program memory
- Wide operating voltage range: 2.0V to 5.5V
- High Sink/Source Current: 25 mA
- Commercial, Industrial and Extended temperature ranges.
- Low-power consumption:

WORKING OF AUTOMATIC SUN TRACKING SYSTEM:

Basic Principle:

The basic functional blocks of this system are six sensors, and their operation depends upon the intensity of light falling on solar panel. All sensors (each with different functionality) send their output to microcontroller AT89c52. Then the microcontroller executes predefined task in its software. These sensors are being used with following names and functionality:

Sun Tracking Sensors (STS)

These two sensors are mounted in “V” shape (figure-6) exactly in the middle of the solar panel (figure-8). The automatic sun tracking is accomplished according to following 3-step diagram.

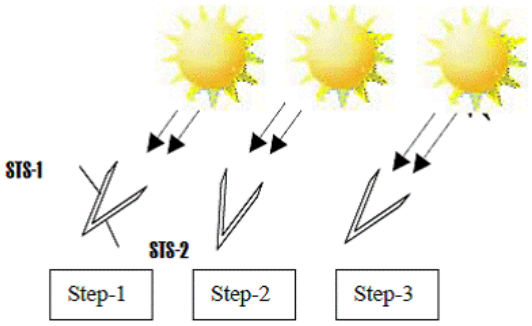

Fig.2 Basic Automatic Sun Tracking Operation

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• Step-1 shows that when the sun is in front of solar panel, both sensors i.e. STS-1 and STS-2 are getting same amount of light.

• In step-2, after some time as the earth rotates the solar panel gets repositioned with respect to sun and STS-1 obtains less amount of light. At this point the LDR i.e. STS-1 sends signal to the microcontroller (figure 3). Then the controller1 rotates motor, resulting the rotation of solar panel towards the sun.

• Finally step-3 shows the reorientation of solar panel. The process continues until the end of day.

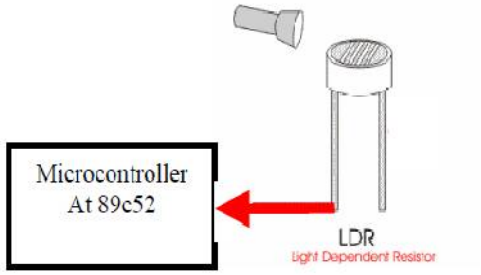

Fig.3 Interface of LDR with Microcontroller

Night Time Fault Detector (NTFD)

In routine work of the system if a general fault2 occurs during nighttime then the next morning it would not work. So at the next sunrise, this sensor detects whether the solar panel is ready for tracking or not. As shown in figure-8, the NTFD is mounted in east of the solar panel so in normal conditions it does not work because it gets lesser intense light (predefined) as compared to the middle sensors i.e. STS-1 and STS-2, but as the fault arises, it starts working.

Day Time Fault Detector (DTFD)

Except some special conditions e.g. cloudy weather etc, the ASTS is supposed to track the sun the whole day. If the panel stops rotation then DTFD detects this type of fault. The mounting strategy of this sensor is same as that of NTFD except that it is mounted in the west.

Night and Cloud Detection

In a cloudy day light intensity is less than a normal day. Similarly during night, light intensity is far less than a cloudy day. So the night and cloud sensors work on this principle to detect the event. To sense a smaller change in light intensity cloud sensor is more sensitive than the Night sensor. In case of Night event, the microcontroller stops all operations of the system and repositions the solar panel towards east to track the sun for next morning.

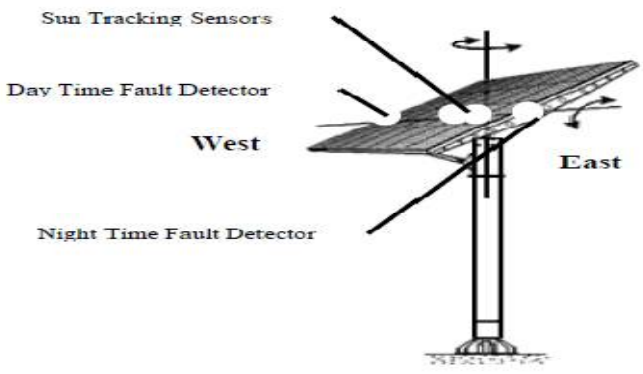

Fig.4 Sensor mounting assembly on solar panel

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V.RESULT AND DISCUSSION

In Fig.5, V-I characteristic of Photo voltaic cell is shown. In this characteristic it is shown that PV cell will generates the maximum power when voltages and currents corresponds to the maximum power. This condition can be achieved if we track the maximum solar radiation all the time. But this condition is not possible all the time in a day because of the movement of earth around the sun. Now with the use of automatic tracking system we can track the maximum radiation all the time and maximum power can be generated throughout the day.

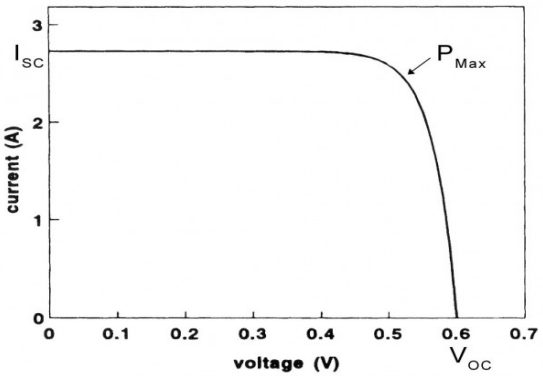

Fig.5V-I characteristic of Photo voltaic cell

VI.CONCLUSION

With the use of automatic sun tracking system the solar panel works on maximum power point and generates maximum power hence the efficiency of the system improves. Although automatic sun tracking system is a prototype towards a real system, but still its software and hardware can be used to drive a real and very huge solar panel. A small portable battery can drive its control circuitry. Therefore by just replacing the sensing instrument, its algorithm and control system can be used in RADAR and moveable Dish Antennas.

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