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SOLAR TRACKER WITH STEPPER MOTOR CONTROL

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ABSTRACT

The purpose of this project is to design and construct a solar tracker system that follows the sun direction for producing maximum out for solar powered applications. Achieving balance between power consumption and power production is a bigger challenge today. The best way to solve this imbalanced equation is to use solar energy as efficiently as possible. The problem in the usage of solar energy is with solar cell panel should be exposed maximum to the sun light. If the solar panel is fixed in a particular direction then the sun light intensity varies from morning to evening. Moving the solar cell panel in the direction of sun can increase the solar energy generated from the solar cell. This project consists of few sun light sensors and a motorized mechanism for rotating the panel in the direction of sun. Microcontroller based control system takes care of sensing sunlight and controlling the motorized mechanism. This system works continuously without any interruption. The main controlling device of the project is Microcontroller to which LDR's and stepper motor with panel setup to its shaft are interfaced. The Microcontroller gets input from LDR sensors regarding the direction of sun and controller process this information and controls the movement of solar panel attached to Stepper motor. The system also displays the voltage generated on LCD display unit. This achieves the goal of tracking sun. The Microcontroller is programmed using powerful Embedded C language.

KEYWORDS: Solar Cell, Stepper Motor, Microcontroller, Sun Light

The purpose of this project is to design and construct a solar tracker system that follows the sun direction for producing maximum out for solar powered applications. Achieving balance between power consumption and power production is a bigger challenge today. The best way to solve this imbalanced equation is to use solar energy as efficiently as possible. The problem in the usage of solar energy is with solar cell panel should be exposed maximum to the sun light. If the solar panel is fixed in a particular direction then the sun light intensity varies from morning to evening. Moving the solar cell panel in the direction of sun can increase the solar energy generated from the solar cell [AnkitAnuraj, 2014].

This project consists of few sun light sensors and a motorized mechanism for rotating the panel in the direction of sun. Microcontroller based control system takes care of sensing sunlight and controlling the motorized mechanism [Tsung-Yu Tsai, 2006]. This system works continuously without any interruption.

The main controlling device of the project is Microcontroller to which LDR's and stepper motor with panel setup to its shaft are interfaced. The Microcontroller gets input from LDR sensors regarding the direction of sun and controller process this information and controls the movement of solar panel attached to Stepper motor. The system also displays the voltage generated on LCD display unit. This achieves the goal of tracking sun. The Microcontroller is programmed using powerful Embedded C language.

The main objectives of the project are:

1. Tracking sun direction.
2. Automatic starting the system in the morning from start point.
3. Stepper motor controlled movement of solar panel.
4. Voltage measuring unit with display on LCD.
5. Voltage measuring unit with display on LCD.

EMBEDDED SYSTEMS

Embedded Systems

An embedded system is a computer system designed to perform one or a few dedicated functions often with real-time computing constraints. It is embedded as part of a complete device often including hardware and mechanical parts. By contrast, a general-purpose computer, such as a personal computer (PC), is designed to be flexible and to meet a wide range of end-user needs.

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Embedded systems control many devices in common use today.

Embedded systems are controlled by one or more main processing cores that are typically either microcontrollers or digital signal processors (DSP). The key characteristic, however, is being dedicated to handle a particular task, which may require very powerful processors. For example, air traffic control systems may usefully be viewed as embedded, even though they involve mainframe computers and dedicated regional and national networks between airports and radar sites. (Each radar probably includes one or more embedded systems of its own.) Since the embedded system is dedicated to specific tasks, design engineers can optimize it to reduce the size and cost of the product and increase the reliability and performance. Some embedded systems are mass-produced, benefiting from economies of scale. Physically embedded systems range from portable devices such as digital watches and MP3 players, to large stationary installations like traffic lights, factory controllers, or the systems controlling nuclear power plants. Complexity varies from low, with a single microcontroller chip, to very high with multiple units, peripherals and networks mounted inside a large chassis or enclosure.

In general, "embedded system" is not a strictly definable term, as most systems have some element of extensibility or programmability. For example, handheld computers share some elements with embedded systems such as the operating systems and microprocessors which power them, but they allow different applications to be loaded and peripherals to be connected. Moreover, even systems which don't expose programmability as a primary feature generally need to support software updates. On a continuum from "general purpose" to "embedded", large application systems will have subcomponents at most points even if the system as a whole is "designed to perform one or a few dedicated functions", and is thus appropriate to call "embedded". A modern example of embedded system is shown in fig: 2.1.

Solar Tracker with Stepper motor control

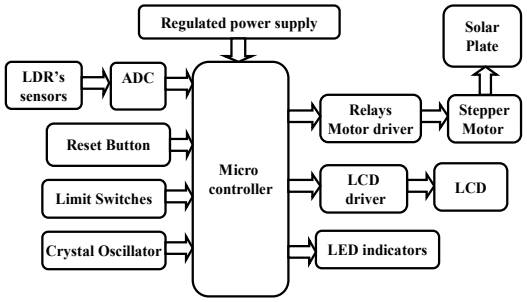

Figure 2.1: Block diagram of construction of Microcontroller based solar tracker using Stepper motor

The main blocks of this project are:

1. Micro controller (PIC16F72)
2. Reset button
3. Crystal oscillator
4. Regulated power supply (RPS)
5. LED indicators
6. Solar cell/plate
7. Stepper motor
8. Limit Switches
9. Relay

Micro Controller

A Microcontroller is a programmable digital processor with necessary peripherals. Both microcontrollers and microprocessors are complex sequential digital circuits meant to carry out job according to the program / instructions. Sometimes analog input/output interface makes a part of microcontroller circuit of mixed mode (both analog and digital nature).

1. A smaller computer
2. On-chip RAM, ROM, I/O ports...

Example: Motorola's 6811, Intel's 8051, Zilog's Z8 and PIC 16X

Reset

Reset is used for putting the microcontroller into a 'known' condition. That practically means that microcontroller can behave rather inaccurately under certain undesirable conditions. In order to continue its proper functioning it has to be reset, meaning all registers would be placed in a starting position. Reset is not only used when microcontroller doesn't behave the way we want it to, but can also be used when trying out a device as an interrupt in program execution, or to get a microcontroller ready when loading a program.

Crystal Oscillator

The crystal oscillator speed that can be connected to the PIC microcontroller range from DC to 20Mhz. Using the CCS C compiler normally 20Mhz oscillator will be used and the price is very cheap. The 20 MHz crystal oscillator should be connected with about 22pF capacitor. Please refer to my circuit schematic.

There are 5 input/output ports on PIC microcontroller namely port A, port B, port C, port D and port E. Each port has different function. Most of them can be used as I/O port.

Regulated Power Supply

Power supply is a supply of electrical power. A device or system that supplies electrical or other types of energy to an output load or group of loads is called a power supply unit or PSU. The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarely to others. A power supply may include a power distribution system as well as primary or secondary sources of energy such as

Conversion of one form of electrical power to another desired form and voltage, typically involving converting AC line voltage to a well-regulated lower-voltage DC for electronic devices. Low voltage, low power DC power supply units are commonly integrated with the devices they supply, such as computers and household electronics.

- Batteries.
- Chemical fuel cells and other forms of energy storage systems.
- Solar power.
- Generators or alternators.

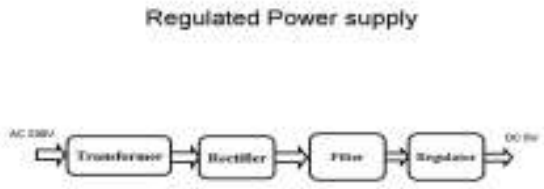

Figure 4.1K Regulated Power Supply

Rectification

The process of converting an alternating current to a pulsating direct current is called as rectification. For rectification purpose we use rectifiers.

Rectifiers

A rectifier is an electrical device that converts alternating current (AC) to direct current (DC), a process known as rectification. Rectifiers have many uses including as components of power supplies and as detectors of radio signals. Rectifiers may be made of solid-state diodes, vacuum tube diodes, mercury arc valves, and other components.A device that it can perform the opposite function (converting DC to AC) is known as an inverter.

When only one diode is used to rectify AC (by blocking the negative or positive portion of the waveform), the difference between the term diode and the term rectifier is merely one of usage, i.e., the term rectifier describes a diode that is being used to convert AC to DC. Almost all rectifiers comprise a number of diodes in a specific arrangement for more efficiently converting AC to DC than is possible with only one diode. Before the development of silicon semiconductor rectifiers, vacuum tube diodes and copper (I) oxide or selenium rectifier stacks were used.

Filtration:

The process of converting a pulsating direct current to a pure direct current using filters is called as filtration.

Filters

Electronic filters are electronic circuits, which perform signal-processing functions, specifically to remove unwanted frequency components from the signal, to enhance wanted ones.

SOLAR CELL/PLATE

A solar cell or photovoltaic cell is a device that converts solar energy into electricity by the photovoltaic effect. Sometimes the term solar cell is reserved for devices intended specifically to capture energy from sunlight, while the term photovoltaic cell is used when the source is unspecified. Assemblies of cells are used to make solar panel, solar modules, or photovoltaic arrays. Photovoltaic is the field of technology and research related to the application of solar cells for solar energy. Solar cell efficiencies vary from 6% for amorphous silicon-based solar cells to 40.7% with multiple-junction research lab cells and 42.8% with multiple dies assembled into a hybrid package. Solar cell energy conversion efficiencies for commercially available multicrystalline Si solar cells are around 14-19%. Solar cells can also be applied to other electronics devices to make it self-power sustainable in the sun. There are solar cell phone chargers, solar bike light and solar camping lanterns that people can adopt for daily use

Equivalent circuit of a solar cell

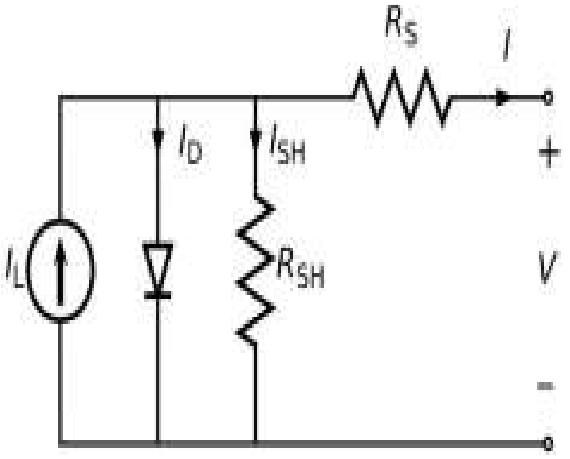

Figure 4.1: The equivalent circuit of a solar cell

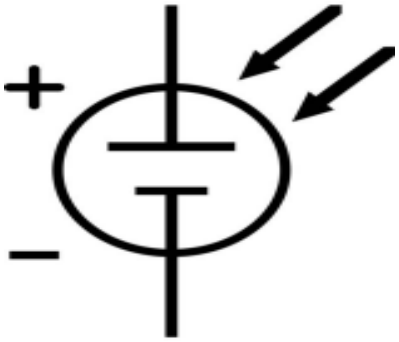

Figure 4.2: The schematic symbol of a solar cell

Working

Solar power systems employ photovoltaic cells to convert the radiant energy of sunlight directly into electrical energy. Photovoltaic solar cells are semiconductor devices which convert sunlight into electricity. Solar cells which utilize crystalline semiconductors, such as silicon, offer the advantages of high performance and reliability. Photovoltaic cells are silicon-base crystal wafers which produce a voltage between opposite surfaces when light strikes one of the surfaces, which surface has a current collecting grid thereon. The photons of the light are absorbed by photovoltaic cells and yield their energy to the valence electrons of the semiconductor and tear them from the bonds that maintain them joined to the cores of the atoms, promoting them to a superior energetic state called conduction band in which they can move easily through the semiconductor.

Typically, a plurality of solar cells are assembled and interconnected so as to form a physically-integrated module, and then a number of such modules are assembled together to form a solar panel. Several solar panels may be connected together to form a larger array. The individual photovoltaic cells in a module may be connected in series or parallel, typically by an internal wiring arrangement and similarly two or more modules in a panel may be connected in series or parallel, depending upon the voltage output desired. Solar cells are usually interconnected into series strips by electrically interconnecting a collector pad on the grid to the opposite surface of the adjacent cell in the strip. Photovoltaic cells are manufactured in a variety of configurations, but generally comprise a layered structure on a substrate. There are many different types of converging solar cell modules in which

sunlight is converged by means of a lens system so that the total area of expensive solar cells can be reduced in order to reduce the cost of electric power generating systems using these solar cells. In order to most efficiently use the electrical power generated by a photovoltaic cell or photovoltaic array, it is desirable to maximize the power generated by the photovoltaic cell or photovoltaic array, despite varying weather conditions. Various sun tracking systems have been used to enhance the power generating efficiency of the converging solar cell module.

STEPPER MOTOR

A stepper motor is an electro-mechanical device which converts electrical pulses into discrete mechanical movements. The shaft or spindle of a stepper motor rotates in discrete step increments when electrical command pulses are applied to it in the proper sequence. The motors rotation has several direct relationships to these applied input pulses. The sequence of the applied pulses is directly related to the direction of motor shafts rotation. The speed of the motor shafts rotation is directly related to the frequency of the input pulses and the length of rotation is directly related to the number of input pulses applied.

Figure 5.1: Stepper Motor Physical View

Stepper motor is a device which is used to convert the electrical pulses into mechanical motion. Motion of the stepper motor will be step by step in the nature. The interfacing of the stepper motor to the micro controller is showed below.

Figure 5.2: Stepper Motor physical view

Advantages of Stepper Motor:

1. The rotation angle of the motor is proportional to the input pulse.
2. The motor has full torque at standstill (if the windings are energized)
3. Precise positioning and repeatability of movement since good stepper motors have an accuracy of 3 – 5% of a step and this error is non cumulative from one step to the next.
4. Excellent response to starting/stopping/reversing.
5. Very reliable since there are no contact brushes in the motor. Therefore the life of the motor is simply dependant on the life of the bearing.
6. The motors response to digital input pulses provides open-loop control, making the motor simpler and l less costly to control.
7. It is possible to achieve very low speed synchronous rotation with a load that is directly coupled to the shaft.
8. A wide range of rotational speeds can be realized as the speed is proportional to the frequency of the input pulses.

DISADVANTAGES OF STEPPER MOTOR:

1. Resonances can occur if not properly controlled.
2. Not easy to operate at extremely high speeds.

ADVANTAGES DISADVANTAGES

Advantages

1. Conservation of Non Renewable energy sources.
2. Voltage measuring display on LCD.
3. Maximum output can be obtained.
4. Efficient and low cost design.
5. Low power consumption.

Disadvantages

1. Periodic Monitoring and Maintenance is required.
2. A drastic environmental change cannot be tolerated by the equipment.

Applications

1. This energy can be utilized for simple house hold appliances.
2. This energy can be stored and utilized as backup power supply mainly in industries.

RESULTS

Result

The project "Microcontroller based Automatic Solar Tracker using Stepper motor" was designed to construct a solar tracker system that follows the sun direction for producing maximum out for solar powered applications.

Conclusion

Integrating features of all the hardware components used have been developed in it. Presence of every module has been reasoned out and placed carefully, thus contributing to the best working of the unit. Secondly, using highly advanced IC's with the help of growing technology, the project has been successfully implemented. Thus the project has been successfully designed and tested.

Future Scope

Our project "Microcontroller based Automatic Solar Tracker using Stepper motor" is mainly intended to design and construct a solar tracker system that follows the sun direction for producing maximum out for solar powered applications.

This project consists of few sun light sensors and a motorized mechanism for rotating the panel in the direction of sun. Microcontroller based control system takes care of sensing sunlight and controlling the motorized mechanism. This system works continuously without any interruption.

The main controlling device of the project is Microcontroller to which LDR's and stepper motor with panel setup to its shaft are interfaced. The Microcontroller gets input from LDR sensors regarding the direction of sun and controller process this information and controls the movement of solar panel attached to Stepper motor with driver relays. The system also displays the voltage generated on LCD display unit. This achieves the goal of tracking sun. The Microcontroller is programmed using powerful Embedded C language. This project can be extended in a way such that the output from the solar plate is increased. This can be done by increasing the dimensions of the solar plate.

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