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INNOVATIVE MOTORLESS SOLAR TRACKING SYSTEM USING SHAPE MEMORY ALLOY

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Abstract-
This paper presents the design and fabrication of a prototype model of a novel solar tracker that exploits the unique properties of shape memory alloy for its actuator. As against the conventional solar trackers, the proposed tracker does not use a motor for changing the position of the PV cell. The shape memory alloy is in the form of a spring and is used for actuating. SMA spring moves the solar panel to track the Sun during day time and back to its original position at the end of the day. The proposed structure of the tracker not only increases the efficiency but also proves to be compact, light weight and robust.
Key Words: Shape memory alloy, Tracking, maximum Energy, Solar PV panels, automated etc.

1. Introduction

The world today is adopting sustainable energy sources that are clean and renewable by replacing fossil fuel-based sources. The energy industry has been exploring alternate eco-friendly energy sources considering various factors like environmental impact and rising cost of fossil fuel prices. The solar energy continues to be one of the most promising renewable energy sources due to its easy accessibility, abundance, low cost and environment friendly nature. SMAs have been used in a variety of applications such as solar overheating protection, self tracking, self cleaning solar systems. In addition to generating electric power using PV cells, solar energy is also being used for direct heating as in air and water heating applications.

The efficiency of solar PV cells and direct solar heating devices can be improved by means of solar tracking mechanisms. Such a mechanism would enhance the photoelectric conversion efficiency by adjusting the position of the panels in response to changing direct Sun angle. This paper presents an innovative solar tracking mechanism that uses a thermomechanical actuator made of SMA spring instead of a motor which makes it more efficient.

The SMA is a smart metal alloy that exhibits a unique behavior called shape memory effect. It has a special thermo-mechanical property which allows it to regain its original predefined shape when subject to specific temperatures.. An SMA has two main phases, Martensite and Austenite. Martensite is the phase in which the alloy is at low temperature with a low yield strength. Austenite is the phase in which the alloy is at a higher temperature with a higher yield strength to enable regaining of its original shape due to heating. The temperature at which the SMA transforms its shape depends basically on its chemical composition. The Nickel-Titanium based alloy, known as NiTiNOL is most popular due to low operating temperature, good thermo-mechanical properties, high reversibility and durability .

2. Literature review

From the above research work, we can conclude that although too much research has been done to develop an efficient sun tracking mechanism, all the papers focus on ion use of sun tracking sensors and motors. Although effective, such systems are expensive to use and require maintenance. This

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results in less efficiency of the solar energy generated as some of it is used to drive the sun tracking mechanism which uses high power DC motors to rotate the solar panel. In addition, the conventional approach required light-based activation using the intensity of light incident on the solar panel, which can be ineffective if the environment is cloudy, so the tracker does not work effectively. Also, the cost of deploying the current system and the maintenance considered, there must be an alternative solution for effective monitoring of solar PV panels.

3. Methodology

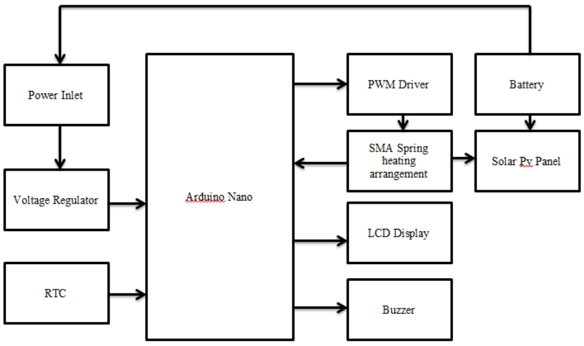

Fig1. Block diagram

A simple way to implement the project is described in this chapter.

1. Literature review: A brief literature review of the study will be conducted on the relevant topic. A number of domestic and international journal articles are reviewed to define the problem.
2. Development of Nitinol Shape Memory Alloy: Using memory alloy springs to make linear motion actuators that operate at different speeds to track the sun during the day
3. RTC and Microcontroller Interface: Actuator activation and linear motion settings rely on time feedback. The RTC module is used to keep track of the time. At this stage, the RTC module is connected to the microcontroller and the SMA springs are activated according to the time stamps of the RTC module to achieve accurate sun tracking.
4. Development of Controller-Enabled Solar Tracking System: In this step, the control signals for the SMA actuators are devised. SMA actuators heat up to varying degrees over time. A system for heating the SMA spring is developed at this stage using a PWM driver connected to a microcontroller.
5. LCD screen and microcontroller interface: shows how and when to connect the LCD screen with the microcontroller.
6. Development and programming of hardware: In this stage, the hardware of the project is designed and the launch is planned.
7. Testing and Optimization: Once the test setup is ready, the reliability of the setup is tested and optimized.

Working principle

The figure below shows the working principle of the project of solar tracking using shape memory alloy for the purpose of understanding memory alloy for the purpose of understanding.

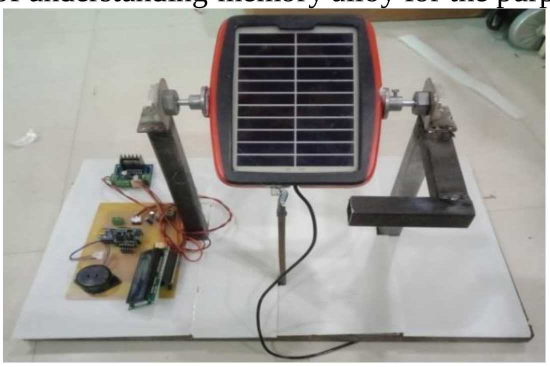

Fig2 Solar tracking model.

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The working principle of the development of the nitinol spring sun tracking mechanism shown by the illustrative diagram above. The assembly consists of a reciprocating linear actuator made using a nitinol spring, one end of which is clamped to the frame, while the other end is clamped to solar panel, as shown in the figure. As shown in the illustrative diagram, the system consists of a SMA spring arrangement that is used to track or move the position of the solar panel as shown. The SMA spring is activated using a signal received from the microcontroller depending on the time of day. A heater that is connected to the SMA spring arrangement will heat the spring with variable temperatures throughout the day depending on the time value recorded by the RTC. The control signal is generated by the microcontroller which is the arduino nano and is used to drive the SMA spring using a PWM controller connected to the Arduino. This helps in achieving motorless tracking of the solar panel using shape memory alloy.

Components

Hardware used

1) Arduino Nano
2) SMA Springs
3) RTC module
4) Ceramic Heater capsule
5) Solar PV panel-(5 Watt)
6) LM7805 Voltage Regulator
7) Battery
8) LCD display
9) Buzzer

Software used

1) Arduino IDE
2) Easy EDA

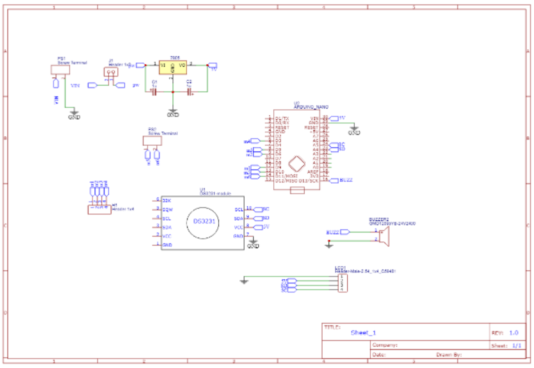

Fig3. Schematic diagram

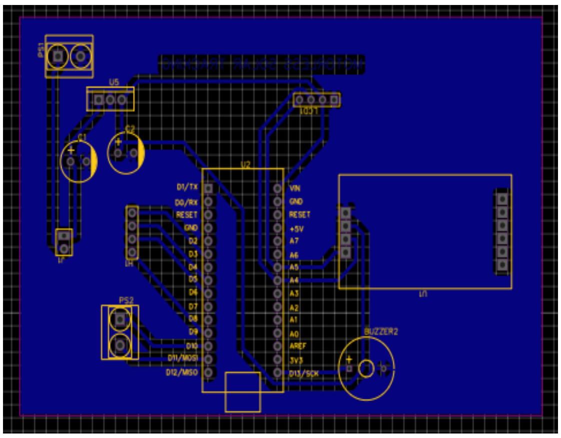

Fig4. PCB design

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3. Conclusion

The proposed system deals with the development of an innovative motorless solar tracking system for maximum energy utilization. From the proposed system, it can be expected that the proposed system can help in utilizing the maximum energy from the sun by properly orienting the PV panels in the direction of the sun. The tracking system is innovative in this project and is based on shape memory alloy rather than motorized tracking. This makes the system more cost-effective and easy to set up and use. Thus, the proposed project is expected to provide a cost-effective and maintenance-free setup for tracking the sun, making maximum use of the energy from the solar panels. From this project, we can expect that the tracking mechanism implemented in the solar panel can improve the efficiency of the solar panel. This can help us achieve the maximum efficiency of the solar PV cell or any solar flat panel collectors used

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