Automatic Solar Tracker

Bachelor of Science in Engineering and Computer Science

Prepared by Group 10

Chu Ha Linh	**V202100409**
Pham Anh Quan	**V202100574**
Tran Huy Hoang Anh	**V202100405**

COLLEGE OF ENGINEERING AND COMPUTER SCIENCE

VINUNIVERSITY

November 2024

I. Introduction

1. Background and motivation

The shortage of petroleum energy has become a globally rising concern, positioning solar energy as a promising alternative. Solar energy, categorized as renewable energy, is harnessed from natural sources that can replenish rapidly. Solar radiation, captured by photovoltaic panels, is converted into electrical energy, with the energy output depending on the duration of illumination and the incident energy. Traditionally, solar panels are installed outdoors and fixed to the ground in large open spaces. However, this fixed configuration limits the energy capture, as the sun's position changes continuously throughout the day. The panel's surface must be oriented directly toward the light source at a 90-degree angle, as this maximizes the incident radiant energy.

2. Project objectives and overview

In this project, we design a sun tracking system, one that can track the relative position of the sun to the panel and use this information to adjust its orientation, maintaining the optimal angle of illumination.

3. Scalability and applications

Our project utilizes components such as the Tiva C Series LaunchPad as the controller, light-dependent resistors, and servo motors, which are readily available and can be purchased on the market at affordable prices. The proposed solution is simple and cost-effective, compatible with various types and shapes of solar panels. It is scalable for application in larger systems, such as solar energy farms in China, Japan, or Vietnam.

II. System Description

An automatic solar tracker detects sunlight direction and adjusts the solar panel's position to maximize energy collection, enhancing efficiency. This system, built on the Tiva C Series LaunchPad, uses two Light Dependent Resistors (LDRs) to measure light intensity. The system also includes a servo motor that moves the panel to maintain optimal alignment with the sun.

1. System Architecture

The block diagram of the system is shown below:

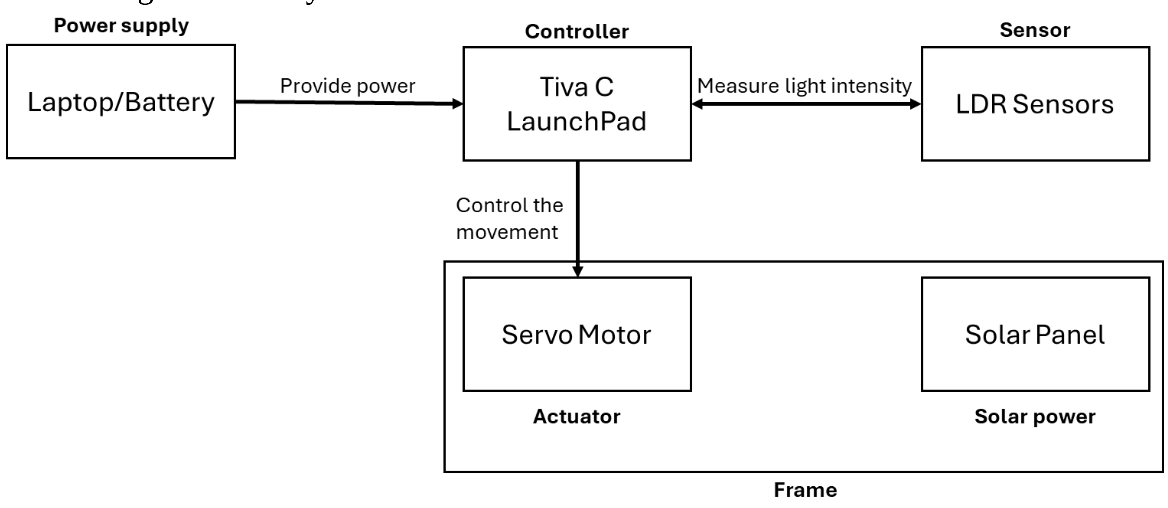

Figure 1: Block Diagram of the system.

The block diagram illustrates the architecture of the Automatic Solar Tracker System. At its core is the Tiva C Series LaunchPad, which serves as the central processing unit. The system is powered by either a laptop or a battery, providing the necessary energy to drive all components.

The LDR sensors are connected to the microcontroller and measure the intensity of sunlight from different directions. The sensor data is processed by the microcontroller to determine the optimal position for the solar panel. Based on this input, the LaunchPad controls a servo motor, which acts as an actuator to adjust the orientation of the solar panel.

The solar panel, mounted on the frame, which is connected to the actuator, aligns itself with the sun's position to maximize energy collection. The entire system is designed to ensure efficient solar tracking, enhancing energy output while minimizing power consumption.

2. Hardware components

- Tiva C Series LaunchPad: This microcontroller will handle sensor inputs, controlling the servo motor, and measuring the output from the solar panel.
- Light Dependent Resistors (LDRs): These sensors will detect sunlight intensity to determine the sun’s position. The LDRs will be placed to cover the horizontal movement of the sun across the sky.
- Servo Motor: The servo motor will adjust the solar panel’s position based on the signal from the microcontroller.
- Solar Panel: The solar panel will be mounted on the frame which has one rotational axis.
- Frame: The frame is equipped with a rotational axis that allows the actuator, controlled by the servo motor, to adjust the panel's orientation.
- Power Supply: The power supply for the system can be a laptop/ battery to supply power for the microcontroller board.

3. Software

- Programming: We will use Code Composer Studio (CCS) to build and debug the code of this project. The programming language for this project is C.
- Algorithm: First, the panel is placed parallel to the ground. When the system is on, if the light reaching both LDR sensors is equal, then the servo will not move. When a difference in light intensity is found, the servo motor will move to the side with higher light exposure until both sensors detect the same intensity.

4. Project Specification

4.1.Functional requirements

ID	Scope	User Requirement	Functional Requirement
FR1	Microcontroller	The controller can process sensor data, estimate the relative position of the light source, and move the solar panel to the sun’s position.	The Tiva C Launchpad can record data and perform real-time processing to calculate the direction of the light source and execute algorithms to drive the motor for solar tracking.
FR2	Sensor	The system can detect sunlight direction and intensity accurately.	The system uses LDR to measure light intensity.
FR3	Frame	The frame is stable and durable, supporting the whole system. It should be able to rotate the panel according to the light source.	The frame can support the solar panel and motor. It must also allow the panel to rotate for optimal sun tracking.

FR4	Power	The system can operate efficiently.	The control algorithm consumes minimal resources and power, allowing the system to operate for a long time without interruption.

Table 1: Functional Requirements.

4.2.Non-functional requirements

ID	Requirement	Description	Scope	Detail
NF1	Performance	Ensure the system operates correctly and meets real-time requirements.	Entire system	• The system must accurately detect sunlight intensity using the LDRs. • The solar panel must continuously adjust its orientation to maintain optimal alignment with the sun throughout the day. • The servo motor must adjust the panel position within 2 seconds of receiving control signals. • The microcontroller must process input data from the LDRs and generate appropriate control signals for the servo motor. • The frame must securely hold the solar panel and actuator, allowing rotational movement.
NF2.1	Reliability	**Availability:** System availability percentage	Entire system	• In use: 90%.
NF2.2		**MTBF: Mean Time Between Failures:** Average time between system failures	Entire system	• MTBF > 2 months
NF2.3		**Accuracy:** Required accuracy of the system output data	Entire system	• The system must align the solar panel within $\pm 10^{o}$ of the sun's position.
NF2.4		**MTTR: Mean Time To Repair**	Entire system	• Less than 2 days.
NF3	Maintainability	Facilitate easy maintenance.	Entire system	• Use clean code practice. • Maintenance time: < 4 hours/month.

Table 2: Non-functional requirements.

III. Development Timeline and Milestones

1. <u>Project Timeline</u>

Phase	Start date	End date	Task	Deliverable	Predecessor
Brainstorm ideas and proposal	11/15/24	11/27/24	- Explore practical issues - Propose feasible ideas	Project proposal	NA

			- Consult with professor and TA to finalize goals and scope.		
Technical preparation	11/28/24	11/30/24	- Review documentation - Examine source code	Summary of the reference materials	Project proposal
Setup workspace	11/30/24	12/01/24	- Set up a collaborative workspace for the team - Structure documents and code repository.	Github repository	Technical preparation
Procurement	11/30/24	12/04/24	Purchase necessary equipment: motors, solar panels, and light resistors.	Equipment	Technical preparation
Code development	12/04/24	12/10/24	Develop code blocks to control each device.	Code blocks	Equipment
Progress update	12/10/24	12/12/24	- Update progress - Receive feedback from TA and professor.	Presentation & report	Code blocks
Assembly	12/12/24	12/18/24	- Continue developing the code - Integrate the code blocks - Assemble the entire solar panel system.	Code & prototype	Code blocks & equipment
Progress update	12/18/24	12/19/24	- Update progress - Receive feedback from TA and professor.	Presentation & report	Code & prototype
Finalization	12/19/24	12/25/24	- Debug and optimize the code - Calibrate the design - Finalize the product.	Final product	Code & prototype
Live Demonstration	12/25/24	12/25/24	Live demonstration in front of the class.	Demonstration	Code & prototype
Final Video	12/25/24	12/28/24	Record a video of the entire system.	Demonstration video	The whole system
Final report	12/20/24	12/31/24	Write the final report	Final report	Final product

Table 3: Project Timeline.

IV. Work Distribution Plan

Team Member	Role	Contribution
Chu Ha Linh	Installation and Measurement Engineer	- Perform assembly and measurement on the equipment. - Assist with code development. - Assist with testing and calibration.
Pham Anh Quan	Test Engineer	- Test and verify the functionality of the product. - 3D drawing the frame. - Assist with code development.

Tran Huy Hoang Anh	Code Developer	-Develop code blocks, structure the project repository, and manage version control. - Assist with measurement and testing.

Table 4: Work Distribution Plan.

V. Bill of Materials

ID	Item Name	Quantity	Unit Price	Total Price	Link	Note
0	Tiva TM4C123G LaunchPad	1	---	---	---	Currently available
1	Light Dependent Resistor	2	0.0739	7.39	Amazon	Sold in a pack of 100
2	Servo Motor SG90	1	2.33	6.99	Amazon	Sold in a pack of 3
3	Solar Panel	1	5.2	15.59	Amazon	Sold in a pack of 5

Table 5: Bill of Materials of the system.

Note: The currency used is US dollars.

VI. References

Thai, M. T. (2024, November 7). *ELEC4020 Embedded Systems: Lecture Part 9 - Introduction to the course project* [Lecture slides]. VinUniversity. https://vinuni.instructure.com/courses/2312/files/464723?module_item_id=108858