AIN SHAMS UNIVERSITY, FACULTY OF ENGINEERING
Computer and Systems Engineering Department,

CSE271s: System Dynamics and Control Components (Fall, 2024)

Project (Solar Tracker)

Overview

- A solar tracker is a device that orients a payload toward the Sun. Payloads are usually solar panels, parabolic troughs, Fresnel reflectors, lenses, or the mirrors of a heliostat.
- For flat-panel photovoltaic systems, trackers are used to minimize the angle of incidence between the incoming sunlight and a photovoltaic panel, sometimes known as the cosine error. Reducing this angle increases the amount of energy produced from a fixed amount of installed power generating capacity.

Basic concept

- Sunlight has two components, the "direct beam" that 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 is a larger proportion of the total on cloudy days.
- As most of the energy is in the direct beam, maximizing collection requires the Sun to be visible to the panels for as long as possible. However, on cloudier days the ratio of direct vs. diffuse light can be as low as 60:40 or even lower.
- The energy contributed by the direct beam drops off with the cosine of the angle between the incoming light and the panel.

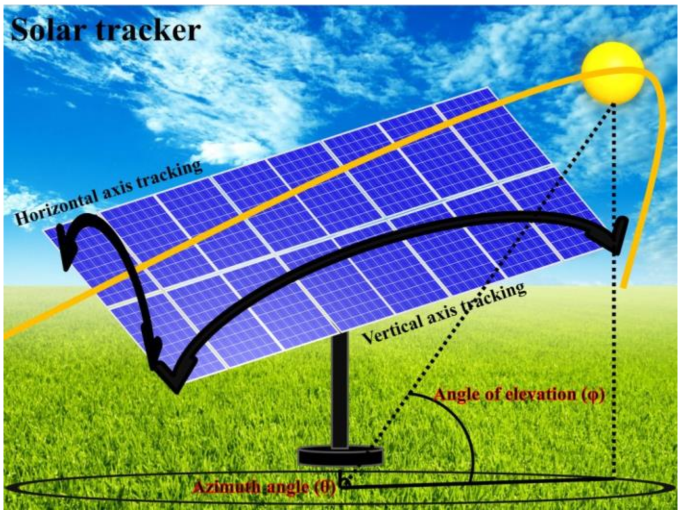
Direct power loss (%) due to misalignment (angle i) where Loss = $1 - \cos(i)$

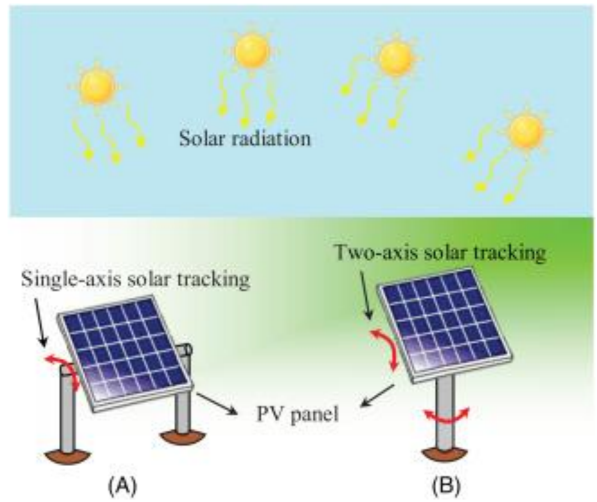
Angle i	Hours[a]	Loss
0°		0%
1°		0.015%
3°		0.14%
8°		1%
15°	1	3.4%
23.4°[b]		8.3%
30°	2	13.4%
45°	3	30%
60°	4	>50%[c]
75°	5	>75%[c]

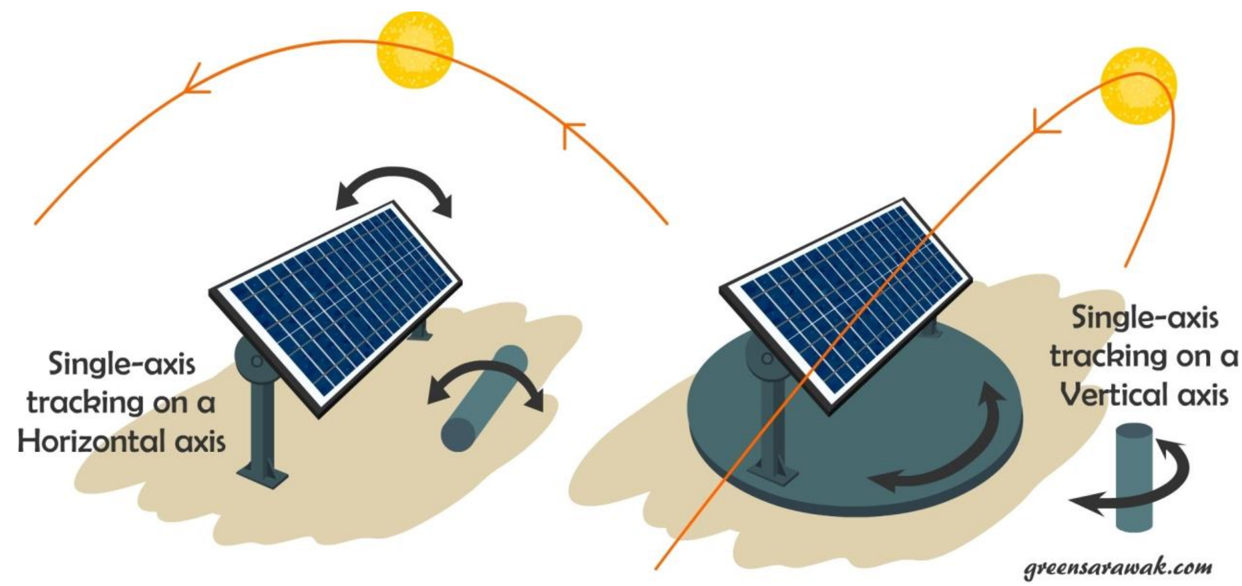
Disadvantages

- Trackers add cost and maintenance to the system – if they add 25% to the cost, and improve the output by 25%, the same performance can be obtained by making the system 25% larger, eliminating the additional maintenance.
- Tracking was very cost effective in the past when photovoltaic modules were expensive compared to today. Because they were expensive, it was important to use tracking to minimize the number of panels used in a system with a given power output. But as panels get cheaper, the cost effectiveness of tracking vs using a greater number of panels decreases. However, in off-grid installations where batteries store power for overnight use, a tracking system reduces the hours that stored energy is used thus requiring less battery capacity. As the batteries themselves are expensive (either traditional lead acid stationary cells or newer lithium-ion batteries), their cost needs to be included in the cost analysis.

Degree of freedom







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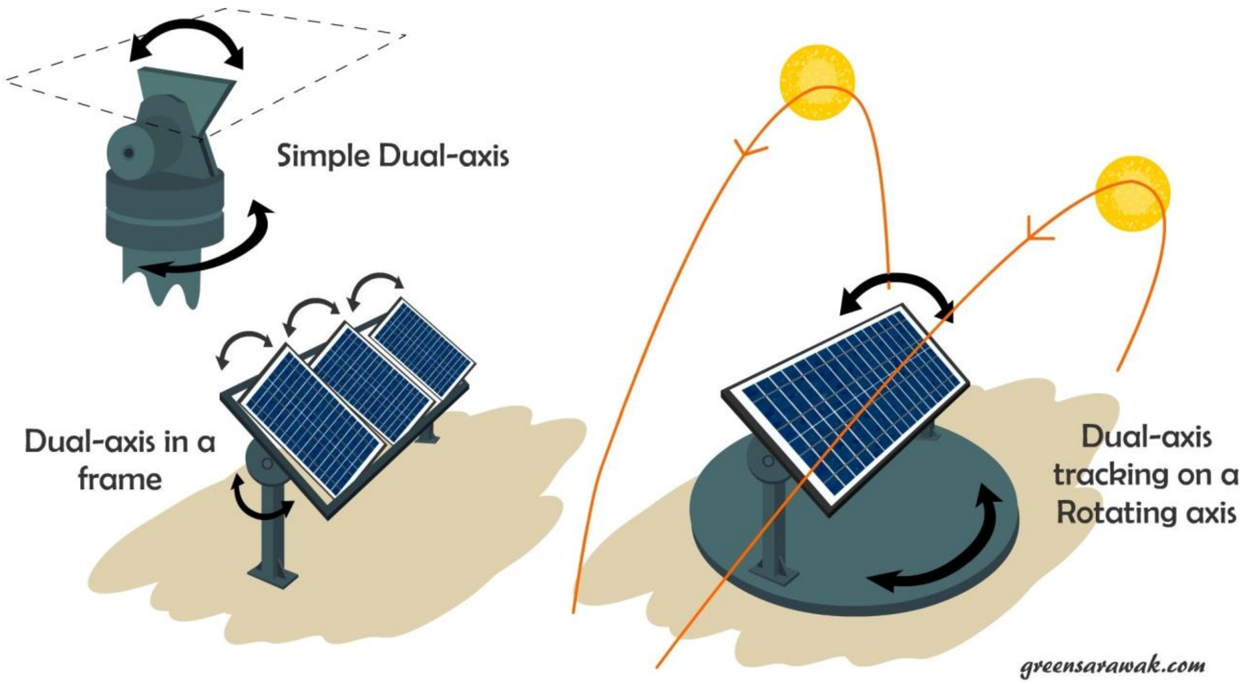

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Project requirements and specifications

Developing a Single-axis Solar Tracking Using a DC Motor

1. **Sunlight Detection:**
   Two Light-Dependent Resistors (LDRs) are used to detect the horizontal direction of sunlight (left/right).

2. **Signal Conditioning Circuit:**
   A suitable signal-conditioning circuit must be implemented to adjust the LDR outputs, generating two signals (0–5 V) representing the light intensity detected by each LDR.

   - **Note:** The signal-conditioning circuit should include potentiometers to adjust sensitivity according to ambient light conditions.

3. **Motor Control Circuit:**
   A control circuit must be designed to manage the motor's enable and direction functions:

   - An **H-bridge** can be used to control the motor's direction.
   - A **555 Timer IC** can generate a PWM signal to control the motor speed (select one fixed speed setting).
   - The motor's speed (duty cycle) should be controlled based on the difference in light intensity detected by the LDRs.

4. **Noise Mitigation:**
   A comparator with hysteresis should be employed to prevent noise interference when there is minimal or zero difference in light intensity between the LDRs.

5. **Mathematical Models and Simulation:**
   Mathematical models and simulations should demonstrate how a variable-duty-cycle pulse controls the DC motor. MATLAB simulations should be included to illustrate the system's functionality.