Automation Control for Solar Trackers
Lower Total Cost to Design, Develop, and Deliver\textsuperscript{SM} Solutions from Rockwell Automation

**Advantages**

- **High Precision Sun Tracking Algorithm** – Implementing the NREL Solar Position Algorithm for Solar Radiation Applications Technical Report in the Allen-Bradley\textsuperscript{®} MicroLogix\textsuperscript{™} platform allows the derived angles to be applied in solutions using hydraulic or electrical positioning methods.

- **High Quality, Industrial Hardened Components** – Controllers built to industry standards (UL, IEC, CE, etc.) help lower installation and maintenance costs over black box controllers for harsh industrial applications.

- **Off-the-Shelf (OTS) Components** – Globally available OTS components, supported by a network of industry specialists, help reduce time to market for the OEM and meet end user goals for global support.

- **Product Life Cycle** – With over 100 years as a global provider of industrial automation power, control and information solutions, Rockwell Automation helps solar farm users with the support longevity they need. In addition, Rockwell Automation is committed to helping products achieve longer life cycles.

- **Supply Chain Solutions** – As a trusted supply chain partner, Rockwell Automation offers a global manufacturing and distribution network including panel design and fabrication capabilities worldwide.

- **Secure Remote Access/Monitoring** – OEMs and end users can adjust trackers, diagnose problems and monitor operations remotely, reducing operation and maintenance costs.

- **Fast, Efficient Data Communications** – Large solar field deployments can use open EtherNet/IP networks to achieve high speed, large data transfers (coordinated moves for multiple trackers) from a main control system to the individual trackers.

- **Faster Development/Troubleshooting** – Pre-programmed and tested positioning algorithm logic; Human Machine Interface (HMI) faceplates provide detailed networking diagnostics, drive operating parameters and status.

**Overview**

Solar trackers are devices used to orient photovoltaic panels and concentrating solar reflectors or lenses toward the sun. Since the sun’s position in the sky changes with the seasons and the time of day, trackers are used to align the collection system to maximize energy production.

Several factors must be considered when determining the use of trackers. Some of these include: the solar technology being used, the amount of direct solar irradiation, feed-in tariffs in the region where the system is deployed, and the cost to install and maintain the trackers.

Concentrated applications like concentrated photovoltaic panels (CPV) or concentrated solar power (CSP) require a high degree of accuracy to ensure the sunlight is directed precisely at the focal point of the reflector or lens. Non-concentrating applications do not require tracking, but using a tracker can improve the total power produced by the system. Photovoltaic systems using high efficiency panels with trackers can be very effective.

There are many types of solar trackers, of varying costs, sophistication, and performance. The two basic categories of trackers are single axis and dual axis.
Single axis solar trackers can either have a horizontal or a vertical axis. The horizontal type is used in tropical regions where the sun gets very high at noon, but the days are short. The vertical type is used in high latitudes where the sun does not get very high, but summer days can be very long. In concentrated solar power applications, single axis trackers are used with parabolic and linear Fresnel mirror designs.

**Challenge**

OEMs are challenged to balance two often opposing goals – maximizing yield and reducing complexity. As the complexity of the tracking system is reduced so too is the expected yield. However, with a less complex tracker fewer technical problems will occur.

Trackers require an accurate positioning algorithm in order to properly position the solar collection devices. Many trackers rely on mathematical equations to calculate the desired position in order to follow the sun. Machine builders can reduce their risk and deploy their solution more quickly by utilizing a proven algorithm like the one published by NREL (NREL Solar Position Algorithm for Solar Radiation Applications Technical Report revised January 2008).

Operators of solar trackers are looking for low maintenance, high quality, long lasting components that are available anywhere in the world. With off-the-shelf (OTS) components built to globally accepted standards, machine builders can offer end users rugged and reliable solutions that are competitively priced.

For solar field installations with a large number of deployed solar trackers, especially concentrated solar power applications, tracker positioning and monitoring requires fast, reliable data communications. Ethernet networking technology is required to move the required data easily between the tracker controllers, main energy center controllers and the HMI. Machine builders can offer a scalable solution using an open networking standard, like EtherNet/IP, to provide reliable high speed communications.

For machine builders who want to increase their scope of supply and potential revenue, an information-enabled platform could be provided to end users. End users are increasingly looking for more accessible data to identify trends, diagnose problems, and improve operations. Capabilities that can enhance machine builder value include offering secure remote access and alerting operations and maintenance of pending issues via automatically generated emails.

**Solution**

Rockwell Automation offers several solutions to help energy providers generate the most solar power from their system. One solution is focused on solar trackers. A control architecture based on an Allen-Bradley MicroLogix controller helps position the solar panels, mirrors, or lenses into the sun in order to capture the sun's energy.

Dual axis solar trackers have both a horizontal and a vertical axis allowing them to track the sun's apparent motion virtually anywhere in the world. In concentrated solar power applications, dual axis trackers are required when mirrors are used to direct the sun's energy. In power tower applications they are extremely important due to the angle errors resulting from longer distances between the mirror and the central receiver. Another CSP application requiring dual axis trackers is the Stirling engine.

Many traditional solar PV applications employ two axis trackers to position the solar panels perpendicular to the sun's rays. This maximizes the total power output by keeping the panels in direct sunlight for the maximum number of hours per day.
The MicroLogix controller can be equipped with a positioning algorithm to mathematically solve the optimum tracker position for any time of the day. The positioning algorithm deployed in the controller is based on the NREL Solar Position Algorithm for Solar Radiation Applications Technical Report revised January 2008. The algorithm can be used to calculate the solar zenith and azimuth angle with uncertainties equal to +/- 0.0003° in the period from year 2000 to 6000. Actual positioning accuracy will depend on mechanics of the chosen solution.

The outputs of the algorithm calculation are two angles – the zenith angle (used to determine the vertical tilt or elevation) and the azimuth angle (used to determine the horizontal rotation). Depending on the type of tracker being used (single or dual axis), one or both of these angles are then used to position the solar collection device.

The position loop can be closed in the controller or in the drive if the axis is so equipped. If the controller is used, the embedded High Speed Counter (HSC) instruction and corresponding inputs on the MicroLogix controller are utilized. Utilizing a drive that accepts an external encoder would allow the position loop to be managed within the drive.

Since concentrated solar applications require more precise positioning to provide maximum and constant power generation, drives with positioning capabilities are often used. Some models in the Allen-Bradley PowerFlex® family of drives offer positioning features that can be coupled with an appropriate gearbox reduction ratio to manage and hold position.

If drives are used, there are a few control capabilities that must be considered. To save energy, the drives are powered down at night or during long periods of inactivity. During shutdown periods, the position must be maintained or the tracker must go through a homing cycle before beginning the new day’s operation. A motor brake could be used if a homing cycle is not permitted. At the end of each day, the tracker will need to return to the starting or sunrise position.

In non-concentrating applications, linear actuators offer an alternative method to control a single axis solar tracker or the elevation in a dual axis solar tracker. Positioning the panel within a few degrees is often acceptable so there are less move intervals over the course of the day.

Automatic emailing from the tracker controller to operators or maintenance personnel can alert them of tracker problems. Maintenance costs can be reduced by being able to remotely adjust the tracker and to monitor tracker operation and status.

When many trackers are installed and managed in a solar field, a central controller is often required to coordinate the trackers and monitor them. An alternative to running the positioning algorithm in each tracker controller would be to use this central controller to execute the mathematical calculations and communicate the desired position coordinates to the respective trackers.

Using an Allen-Bradley ControlLogix® or CompactLogix™ programmable automation controller (PAC) opens the door to the capabilities of the Rockwell Automation Integrated Architecture™. Integrated Architecture brings together a powerful multi-disciplined control engine, seamless networking, a scalable visualization platform and the information technologies needed to help you lower the Total Cost to Design, Develop and Deliver® a solution.

The central controller can also act as a data concentrator to collect important operating conditions from each tracker contained within the field. Monitoring module orientation, motor status, controller status, and energy production are all possible. Data collected from the MicroLogix controllers can be displayed in a SCADA system like FactoryTalk® View SE. Alarms and status information from each tracker can be displayed in a central location or accessed remotely.

Rockwell Automation components can help make it possible to construct and control reliable solar trackers that are of high precision and quality. With over 100 years as a global provider of industrial automation power, control and information solutions, Rockwell Automation helps solar farm users with the support longevity they need. In addition, Rockwell Automation is committed to helping products achieve longer life cycles and more well defined migration paths.

Working with Rockwell Automation you can lower your Total Cost to Design, Develop, and Deliver™ a machine. This total cost approach solution accounts for all costs of delivering a machine or system to market over a given period of time. It is a final result of the purchase and build costs plus all aspects in the future use and maintenance of the machine components considered.
Solar Trackers: Typical Architecture:

Rockwell Automation solutions deliver improved production capabilities and reduced total cost of ownership by providing unparalleled functionality, flexibility and scalability. Machine builders can respond more quickly to customer or market demands, reduce maintenance costs and downtime and easily gain access to actionable plant and production information for improved management and decision-making.

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