



## OUTDOOR SOLAR TRACKING SYSTEM



### DL SUN-TRACKER 4.0

#### **INTRODUCTION**

Fixed photovoltaic panels cannot capture sunlight when the sun is not at the optimal angle of incidence. However, solar tracking systems help the panels orient themselves toward the sun, thus increasing production by 10–25%. Because they capture sunlight throughout the day and in all seasons, the efficiency of solar panels increases significantly.

The **DL SUN-TRACKER 4.0** is an educational system designed to **automatically orient a solar panel** in the direction most favourable for sunlight throughout the day, maximizing the amount of solar energy captured. The goal is to keep the sun's rays perpendicular to the panel's surface to maximize energy absorption throughout the day and consequently increase its efficiency.

It's a trainer designed for technical institutes and universities. It's not just a solar tracker, but a complete laboratory that allows you to study the intersection of renewable energy, automation, and digital communication.

Its adjustable operation is based on a mechanical structure that changes the orientation of the solar panels.



# RENEWABLE ENERGIES



It uses:

- **Light sensors** to detect the sun's position by detecting the direction of the strongest light and sending signals to motors (**actuators**) to move the structure.
- **Actuators** (electric motors) to move the structure, and
- **Control algorithms** to maintain correct alignment.

There are two main categories based on the degrees of freedom of movement (both powered by electricity from the solar system):

- **Single-axis:** Rotates the panels along a single axis (usually east-west) to follow the sun's daily path.
- **Dual-axis:** Moves on two axes, adjusting both the horizontal orientation and the vertical tilt (height of the sun), as is the case with our system. It accounts for the sun's daily movement and seasonal changes, ensuring optimal panel positioning, thus allowing for maximum energy production throughout the day.

In conclusion, compared to fixed structures, solar trackers allow for a significant increase in yield – ranging from 15% to 30% in single-axis systems and up to 40% in dual-axis systems – ensuring better use of the installed surface area and a higher energy return.

They have reached advanced technological maturity: more robust components, accurate control algorithms, and reliable mechanical solutions reduce the risk of failure and simplify routine maintenance. Their widespread deployment also demonstrates their economic competitiveness and ability to integrate effectively into utility-scale systems.

Their adoption remains a key element in the design of modern solar systems, with tangible benefits in terms of both performance and the system's long life cycle.

## SYSTEM DESCRIPTION

### 4-DIMENSIONAL EDUCATIONAL PATH

The **DL SUN-TRACKER 4.0** educational trainer offers **four different control logics**, allowing teachers to structure lessons that cover different areas such as:

- 1) **Astronomical Algorithm (Real-Time Clock):** Students learn to plan movement based on geographic coordinates and time, studying the trigonometry of the solar position.
- 2) **Reactive Tracking (LDR Sensors):** Photometry study. The system actively responds to environmental stimuli through differential sensors, ideal for understanding closed-loop systems.
- 3) **Bluetooth Wireless Control:** Introduction to short-range communication. A dedicated app allows you to control axis movement servomotors, including the management of mobile communication protocols.
- 4) **Manual Control:** Direct management for calibration tests and understanding of axis kinematics.



## IoT LAB & TOTAL TRANSPARENCY WITH MQTT

The real heart of Industry 4.0 is data management, and the **DL SUN-TRACKER 4.0** uses the MQTT (**M**essage **Q**ueuing **T**elemetry **T**ransport) protocol, the IoT (Internet of Things) industry standard, to transmit in real time:

- **Electrical Telemetry:** Analysis of voltage (V), current (I) and power (P) generated by the panel.
- **Asset Data:** Precise angular feedback to verify the congruence between theoretical (optimal) and real position.



Thanks to these two points mentioned above, students can subscribe to tracker "**topics**" via brokers (like **Mosquitto**/one of the most popular open source **MQTT brokers**), visualize graphs on dashboards like **Node-RED**, allowing anyone to create applications that collect, transform and visualize their data, building flows that can automate their world, or on a **SCADA** interface.

## ENVIRONMENTAL MONITORING

The **DL SUN-TRACKER 4.0** doesn't just track light; it monitors the surrounding environment to provide a comprehensive analytical picture. The integration of meteorological sensors allows students to study the variables that influence renewable energy production and analyse environmental data in real time.

All weather parameters are sampled by the microcontroller and sent via **MQTT** together with electrical data, such as:

- **Wind Speed (Anemometer):** Study structural safety. Students can program a "Safe Mode" function that automatically switches the tracker to a horizontal position if wind gusts exceed a set threshold.
- **Wind Direction:** Analysis of airflow and heat distribution around the modules.
- **Precipitation (Rain gauge):** Monitoring of rainfall intensity to study the "self-cleaning" effect of the panels or the reduction of irradiation.
- **Photovoltaic Cells Temperature (Temperature Sensor):** Essential for calculating the temperature coefficient of photovoltaic cells.



With this system the student will experiment with different methods to control a dual-axis outdoor solar tracking system and will increase the skills needed for HW design and SW programming.

The experimental teaching activities are the following:

- **Manual Control:** Management of the motorized system via analog interface (Joystick).
- **Remote Control:** Implementation of wireless control using Bluetooth protocol.
- **Time tracking:** Solar tracking based on a time system.
- **Adaptive Tracking:** Automatic tracking and aiming via irradiance sensors (LDR).
- **Energy Characterization:** Analysis of efficiency curves and electrical parameters of photovoltaic panels. Productivity comparison between fixed-orientation and tracking systems.
- **Environmental data collection.**

## TECHNICAL CHARACTERISTICS

### Photovoltaic (PV) Panels

- **Type:** Polycrystalline Silicon.
- **Total power:** Approximately 220 Wp (peak watts).
- **Configuration:** 2 panels to study the effects of series/parallel connections.
- **Construction:** Highly transmissive tempered glass, anodized aluminum frame, IP67 junction box.

### Dual-Axis Tracking Mounting System

- **Axes of Movement:**
  - ◆ **PAN (Azimut):** East-West inclination.
  - ◆ **TILT:** From 0° to 60° to adapt to the height of the sun in different seasons.
- **Actuators:** Linear motors or actuators.
- **Position feedback:** Tilt sensor.

### Electrical characteristics

- **Measurement Range:**
  - ◆  $V_{max}$ : 50Vdc.
  - ◆  $I_{max}$  continuous: 15A.
  - ◆  $I_{max}$  temporary: 20A.

### Power supply

- **V:** battery of 12Vdc/27Ah.
- $I_{rest}$ : 100mA.
- $I_{max}$ : 1A with 2 motors active at the same time.

Supplied with all necessary accessories (cables, SW) and a detailed practical manual.



# RENEWABLE ENERGIES



## OPTION FOR PHOTOVOLTAIC AND HYBRID SYSTEMS

The **DL SUN-TRACKER 4.0** system can be used with our systems belonging to the photovoltaic and hybrid renewable energy fields (as an alternative to the traditional photovoltaic panel), in particular with:

- **DL SOLAR-B**: Modular system for the study of solar energy.
- **DL SOLAR-D1**: Modular trainer for the study of solar energy with grid connection.
- **DL SOLAR-AT**: Advanced trainer for the study of photovoltaic solar energy.
- **DL SOLAR-GTS**: Modular system for the study of solar energy with grid connection and storage.
- **DL WP-SOLAR-D**: Solar pump trainer.
- **DL SUNWIND-OG**: Modular trainer for the study of solar/wind energy.
- **DL SUNWIND-GT**: Trainer for the study of solar/wind energy with grid connection.
- **DL SUNWIND-A2**: Advanced trainer for the study of solar/wind energy.
- **DL SGWD/DL SWGD-W/DL SGWD2.0/DL SGWD2.0-W**: SMART GRID.