BASIC INDOOR SOLAR TRACKING SYSTEM

DL SUN-TRACKER 2.0

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 2.0** 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.

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

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.
- **Actuator**s (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.

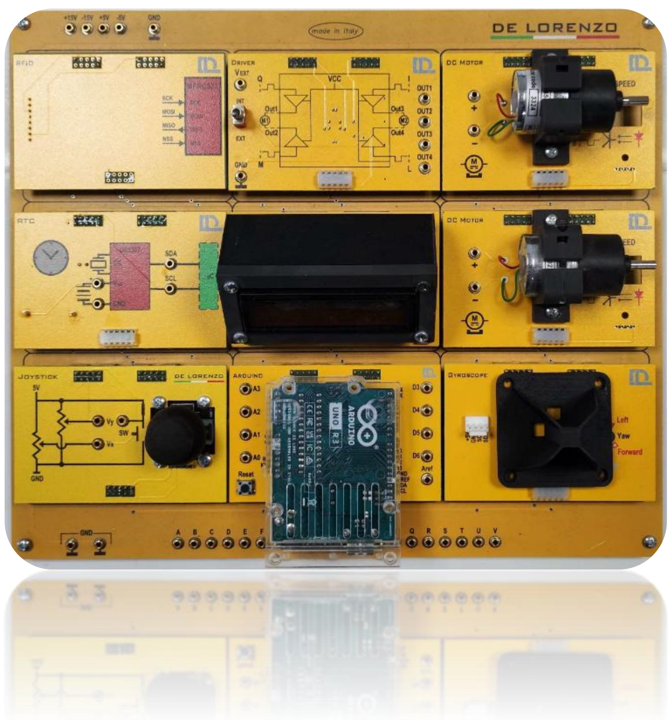
Their adoption remains a key element in the design of modern solar systems, with tangible benefits in terms of both performance and the system's long life cycle.

SYSTEM DESCRIPTION

The **DL SUN-TRACKER 2.0** training course is structured into **two complementary sections**, with the aim of providing students with the fundamental skills necessary to understand a solar tracking system.

First session

The first session consists of a training sheet that allows for a detailed analysis of the mechanical and electrical components integrated into a motorized tracking system. The aim of the sheet is to provide fundamental skills related to automatic control principles and solar tracking logic.



The board includes a kit of components that helps you study and understand the hardware features and control techniques used in a solar tracking system using an open-source microcontroller. The kit's boards include all the components, sensors, and actuators needed to develop a solar tracking system.
Through this simulator, students can learn how to make a solar tracking system react through a programmed microcontroller. Its design allows the components included in the kit to be connected, making them compatible with each other.

The circuit blocks that are mounted on the **basic development board** are as follows:

- Microcontroller board,
- Display board for monitoring,
- DC motor driver board,
- DC motor board + limit switches,
- RTC (**R**eal-**T**ime **C**lock) board,
- Joystick board,
- Bluetooth board,
- DAC (**D**igital to **A**nalog **C**onverter) board,
- LDR (**L**ight **D**ependent **R**esistor) board.

The kit also includes an external board with a multi-decade variable potentiometer.

Lessons and tools of the **OPEN SCADA-WEB** supervision software allow you to cover all the topics of interest related to the aforementioned cards, and the teaching experiences cover the following topics:

- Open-source µC programming.
- Electrical measurements of a 5W solar panel.
- Study of a DC motor driver.
- Control of a dual-axis motor using a joystick.
- Control of a dual-axis motor using Bluetooth.
- Control of a dual-axis motor using an LDR (**L**ight **D**ependent **R**esistor) irradiance sensor.
- Displaying Data on an LCD Display.

Second session

The second session consists of a dual-axis (tilt and rotation) indoor solar tracking system that provides an advanced teaching solution for the analysis of solar tracking models. The trainer allows for in-depth study of tracking dynamics and optimization of energy efficiency in experimental settings.

It is made up of two **5W** panels each, with the possibility of connecting them in series and parallel. With this system the student will experiment with different methods to control a dual-axis indoor solar tracking system and will increase the skills needed for HW design and SW programming.

The experimental teaching activities are the following:

- *Analog Manual Control*: Experimentation with assisted positioning of the photovoltaic module using a multi-axis joystick to understand the dynamics of mechanical movement.
- *Remote **PAN-TILT** Control via Bluetooth Protocol*: Wireless control of actuators via a dedicated application, aimed at studying point-to-point communication between mobile devices and the microcontroller.
- *Photometric Tracking (Solar Tracking)*: Implementation of automatic aiming algorithms based on brightness sensors. The system orients the panel towards the light source (natural or artificial) to maximize the energy efficiency index.
- *Optoelectronic Characterization and Analysis*: Analysis of the effects of light radiation on panel performance, with real-time monitoring of key electrical parameters (Voltage, Current, Power).
- *Supervision and Control via SCADA Software*: System integration with SCADA (**S**upervisory **C**ontrol **a**nd **D**ata **A**cquisition) software for archiving historical data and detailed analysis of the photovoltaic module's characteristic curves.

OPEN SCADA-WEB

The software integrated with this system is implemented with SCADA supervision which allows the end user to:

- *A didactic approach*: The program is structured with a didactic approach, which includes the theoretical and practical information necessary to complete the proposed exercises.
- *An open source code*: The license allows students to modify the projects provided with the system and customize them to display the parameters of interest.

- *A distance learning*: With the software you can remotely monitor your system from a local or remote PC using an Internet connection.

The SCADA software exchanges information with all the trainer's subsystems, displaying sensor data and status to monitor the system in real time. It also acts as a **C**omputer-**A**ided **I**nstruction (CAI) software that guides the student through their learning process.
Communication with the PC takes place via the Modbus RS485 protocol.

Power supply: single-phase from the network, 50/60 Hz.

Supplied with all necessary accessories (cables, software and a USB port protection key for the SCADA software) and with a detailed practical manual.