PROJECT ABSTRACT

MPPT Solar Charge Controller using Buck Converter

An Arduino-based maximum power point tracking charge controller running the perturb-and-observe algorithm on a buck converter stage, with 3-stage lead-acid charging, battery protection and LCD telemetry — delivered built-to-order with working prototype, firmware, wiring documentation, report, PPT and viva kit.

01. Title

MPPT Solar Charge Controller using Buck Converter

02. Introduction / Background

A photovoltaic panel delivers its rated power at only one voltage-current point — the maximum power point — which moves with irradiance and cell temperature. A panel tied directly to a battery is forced to operate at battery voltage, wasting a large share of the available energy. Maximum power point tracking solves this with a DC-DC converter whose duty cycle is continuously adjusted to hold the panel at its MPP while delivering the correct charging voltage. This project builds an MPPT controller from first principles: an Arduino measures panel voltage and current, runs the perturb-and-observe algorithm, drives a buck-converter MOSFET stage, and implements a full 3-stage lead-acid charging profile with battery protection.

03. Problem Statement

Students learn PV I-V characteristics in theory but rarely implement the tracking loop that makes panels useful: sensing panel power, deciding which way to move the converter operating point, and managing battery charging stages safely. The project addresses this with a complete bench MPPT controller where shading the panel visibly demonstrates the perturb-and-observe loop re-finding the maximum power point on the LCD telemetry.

04. Objectives

- Sense panel voltage and current and compute instantaneous panel power on an Arduino.
- Implement the perturb-and-observe MPPT algorithm driving a buck converter duty cycle.
- Provide 3-stage lead-acid charging: bulk (CC), absorption (CV) and float.

- Protect the battery with low-voltage load disconnect (with hysteresis) and reverse-current blocking.
- Display panel V/I/P, battery voltage, charging stage and duty cycle on an LCD.
- Deliver a buyer-run tuning procedure plus the complete student kit.

05. Proposed Methodology

The methodology has four stages. (1) Sensing: panel and battery voltage dividers plus Hall-effect current sensors feed the Arduino ADC. (2) Tracking: the P&O loop steps the buck PWM duty cycle, re-measures panel power, and keeps stepping toward increasing power with configurable step size and sampling interval. (3) Charging: battery voltage selects bulk/absorption/float stages with firmware-settable setpoints; the load output disconnects at low-voltage cut-off. (4) Verification: the buyer shades or re-angles the panel and observes the tracked power recover on the LCD, confirming tracking behavior.

06. System Architecture / Working

The power chain flows as: solar panel -> buck converter (MOSFET, inductor, Schottky diode, capacitors, gate driver) -> 12 V lead-acid battery, with the blocking stage preventing night-time reverse current. The control chain is: panel V/I sensors -> Arduino (P&O tracking, stage selection, protections) -> gate driver PWM, with battery voltage sensing closing the charging loop and a 16x2 LCD presenting all telemetry. A demo load connects through the low-voltage disconnect output.

07. Hardware / Software Requirements

- Hardware: Arduino Uno/Nano, buck power stage (MOSFET, inductor, Schottky diode, capacitors), gate driver, voltage dividers and Hall-effect current sensors, 16x2 LCD, 12 V lead-acid battery, small solar test panel.
- Software: Arduino IDE, C/C++ firmware (P&O loop, 3-stage charging, protections, LCD).
- Test: multimeter; sunlight or a high-power lamp as the panel source for indoor demo.

08. Expected Outcomes

A working MPPT controller that tracks the panel's peak-power point under changing light (design target ~90–95% converter efficiency at nominal load, verified by the buyer's own tests), charges a 12 V battery through a proper 3-stage profile, protects it with low-voltage disconnect, and shows the tracking behavior live on the LCD; plus firmware, docs, report, PPT and viva Q&A.

09. Applications

MPPT controllers are standard in rooftop solar, solar street lighting, solar water pumping and off-grid power systems. The bench build teaches the power-electronics and control fundamentals behind all of them.

10. Future Scope

Incremental-conductance tracking for comparison; synchronous buck rectification for higher efficiency; lithium-profile charging with a BMS; data logging of daily energy yield to SD card; and IoT telemetry of panel performance.