PROJECT ABSTRACT

DC Electronic Circuit Breaker with Fast Trip

Solid-state DC circuit breaker using MOSFET switching, Hall-effect current sensing and a comparator-based fast trip with adjustable threshold, delivered as a built-to-order student project with prototype, firmware, report, PPT and viva kit.

01. Title

DC Electronic Circuit Breaker with Fast Trip

02. Introduction / Background

DC distribution is common in student and prototype work: solar installations, battery banks, telecom supplies and EV auxiliary circuits all run on low-voltage DC. The protection most benches reach for is still the thermal-magnetic MCB, a device designed around AC mains behavior. In a DC circuit there is no natural current zero to quench an arc, and a thermal trip that takes seconds to react can let a shorted converter or a stalled motor destroy itself long before the contacts open. Fuses are faster but single-use and imprecise. An electronic DC breaker answers this with fully solid-state switching: power MOSFETs in the current path, a Hall-effect sensor watching current continuously, and a comparator stage that drops the gate drive the instant current exceeds a set threshold.

03. Problem Statement

Existing low-voltage DC protection for student projects is either too slow (thermal-magnetic breakers designed for AC), single-use (fuses), or contact-based (relay cutoffs that arc and wear). There is no compact, resettable, adjustable protector that demonstrates modern power-electronics protection concepts on the bench. This project fills that gap with a 12-24 V solid-state breaker whose trip threshold is adjustable, whose trip event is latched and displayed, and whose response is electronic rather than thermal.

04. Objectives

- Build a solid-state DC breaker for 12-24 V systems with MOSFET pass elements (IRF3205 class) and an isolated Hall-effect current sensor (ACS712-20A).
- Achieve a design target of under 100 microseconds from overcurrent to MOSFET turn-off via the LM393 comparator and TC4420 gate-driver trip path, with a buyer-run oscilloscope procedure to verify it.

- Provide an adjustable trip threshold (approximately 2-10 A) with live current, threshold and status on a 0.96-inch OLED display.
- Implement latch-off with manual reset plus inrush blanking for motor loads, and deliver the complete student kit: prototype, firmware, schematics, report, PPT and viva Q&A.

05. Proposed Methodology

Current is sensed continuously by the ACS712 Hall-effect sensor, keeping the measurement isolated from the power path. The sensor signal is filtered and compared against the potentiometer-set threshold by an LM393 comparator; on overcurrent the comparator disables the TC4420 gate driver, turning the MOSFET pass element off. An Arduino Nano supervises the system: it samples current for the OLED readout, latches the trip state, freezes the peak fault current for analysis, and manages manual reset or configurable auto-retry. A blanking window after switch-on ignores normal motor inrush. The PCB layout keeps the power loop tight to minimize stray inductance.

06. System Architecture / Working

The DC source feeds the load through the MOSFET pass element with the ACS712 in series. Under normal load the sensor voltage stays below the comparator reference and the gate driver holds the MOSFETs on. When current crosses the threshold the comparator flips, the gate driver pulls the MOSFET gates low, and the load is isolated. The controller latches the fault, lights the red LED and freezes the peak current on the OLED. The output stays off until the front-panel reset is pressed (or the auto-retry interval elapses). During normal operation the OLED continuously shows live current, the set threshold and status.

07. Hardware / Software Requirements

- Arduino Nano (ATmega328P) for monitoring, display and reset logic
- IRF3205-class N-channel power MOSFETs with heatsinks (series switching element)
- ACS712-20A Hall-effect current sensor; LM393 comparator; TC4420 gate driver
- 0.96-inch I2C OLED display; front-panel potentiometer, reset button, fault LED
- 12-24 V DC source and test load (bench supply / battery, user side)
- KiCad for schematic and PCB layout; Arduino IDE for firmware

08. Expected Outcomes

A working bench prototype that interrupts DC overloads and short circuits electronically, with an adjustable 2-10 A threshold and a visible trip indication. The design target of sub-100 microsecond trip response is derived from component propagation delays and is verified by the buyer with the included oscilloscope

procedure rather than claimed as a measured factory figure. The report documents gate-drive design, sensing design, thermal considerations and the buyer's own test results, giving genuine viva material on MOSFET switching and protection.

09. Applications

- Bench protection for solar, battery and DC-motor student experiments (prototype scope)
- Teaching demonstrator for power-electronics protection: gate driving, current sensing, comparator trip paths
- Reference design for adjustable electronic fusing in low-voltage DC systems
- Fault-injection test bed for studying DC short-circuit behavior safely

10. Future Scope

- High-side switching variant with charge-pump gate drive
- Higher voltage/current ratings with paralleled MOSFET stages
- Digital threshold setting via rotary encoder with EEPROM presets
- Trip-event logging to SD card or IoT dashboard for fault forensics
- Selective coordination between cascaded breaker modules