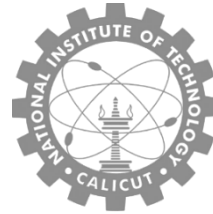




# ElectroQuad

## Problem Statement



### Objective:

Design and simulate an **adaptive battery charging circuit** that efficiently charges a **12V battery** while dynamically adjusting the charging current based on load conditions. The system should:

1. **Maintain a constant charging voltage of 12V** using a **linear or switching regulator**.
2. **Dynamically adjust the charging current** based on battery state and load variations (ranging from **0.5A to 2A**).
3. Include **overvoltage, overcurrent, and thermal protection mechanisms**.
4. Provide a **stable output with minimal ripple (<100mV peak-to-peak)**.

### Design Requirements & Constraints:

#### Input Conditions:

- **Input voltage: 15V to 30V DC** (to simulate real-world fluctuations).
- **Battery type: 12V rechargeable battery**.
- **Maximum charging current: 2A**.

#### Output Conditions:

- **Constant 12V output voltage** during charging.
- **Adaptive charging current: Varies between 0.5A - 2A** based on the load.
- **Load variations:** Simulate an **electronic device drawing different currents (e.g., 0.5A, 1A)**.

#### Circuit Features & Challenges:

##### 1. Voltage Regulation:

- Use a **linear (e.g., IC 7815 with modifications) or switching regulator (Buck-Boost, SEPIC, etc.)** to maintain **12V at output**.
- Design a **feedback control loop** to regulate the voltage dynamically.

##### 2. Adaptive Current Control:

- Implement a **current sensing mechanism** using **shunt resistors and op-amps**.
- Design a **PWM-based control strategy** for dynamic current adjustment.

- **Bonus challenge:** Design an **intelligent control system** (e.g., using an analog comparator or microcontroller-based logic) to switch charging modes.

### 3. Protection Mechanisms:

- **Overvoltage Protection:** Circuit should shut down or regulate if the voltage exceeds **13.5V**.
- **Overcurrent Protection:** Cut off charging if the current exceeds **2A**.
- **Thermal Management:** Include a **temperature sensing mechanism** to prevent overheating of regulators.

## Allowed Components:

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- **Regulators:** IC 7815 (modified for current control) OR Buck-Boost / SEPIC converter.
- **Resistors, capacitors, inductors** for filtering and feedback.
- **MOSFETs / BJTs** for switching control.
- **Operational amplifiers** (LM358, LM324) for current sensing & feedback.
- **Diodes, Zener diodes** for protection.
- **NTC/PTC thermistors** (if thermal protection is implemented).

\*\*\* Strict Rule: No pre-built battery charging ICs allowed participants must design their own regulation and control system.

## Submission Requirements:

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- **Circuit file** (.slx for MATLAB or .asc for LTspice).
- **Simulation results showing:**
  - **Voltage regulation** across different load conditions.
  - **Current variation** (0.5A, 1A, 2A) and dynamic response.
  - **Protection circuit response** (overvoltage, overcurrent, thermal control).
- **Short explanation** (max 500 words) detailing:
  - **Design methodology & component choices.**
  - **How adaptive current control** is implemented.
  - **Protection strategies** and their working principles.
  - **Efficiency improvements** and trade-offs