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Child Safety Mobile Charger

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Abstract
Mobile chargers are a common household accessory, but they present safety hazards when left plugged in. Exposed USB tips often retain a live 5 V, which may pose a risk to children. This project proposes a novel **Child Safety Mobile Charger** design in which the charger delivers **0 V at the USB-C tip unless a mobile phone is actually connected**. The system integrates USB-C connection detection, a controlled load switch, and protection circuits. Safety is improved without compromising normal charging functionality.

1. Introduction

Children are increasingly exposed to electronic devices and accessories. Standard mobile chargers provide continuous 5 V at their USB output regardless of connection. A child touching the exposed connector or inserting metallic objects can trigger short circuits or unsafe scenarios. Although 5 V is considered low voltage, sparks, heating, or accidental ingestion risks exist. Hence, a safer design is necessary.The objective of this project is to build a **smart charger** that ensures:

1. **Zero voltage at the USB tip** unless a phone is detected.
2. **Safe automatic switching** when a device is connected.
3. **Protection against shorts, surges, and noise.**

Literature Review

- Conventional chargers maintain 5 V at VBUS continuously.
- USB Type-C standard introduces **CC (Configuration Channel) pins**, which allow detection of a sink device.
- Load switches and MOSFET-based designs are widely used in consumer electronics for controlled power delivery.
- Prior works have discussed surge protection (TVS diodes), resettable fuses (polyfuse), and EMI filtering (ferrite beads).

This project integrates these best practices into a dedicated **child safety–oriented design**.

2. Methodology

System Overview

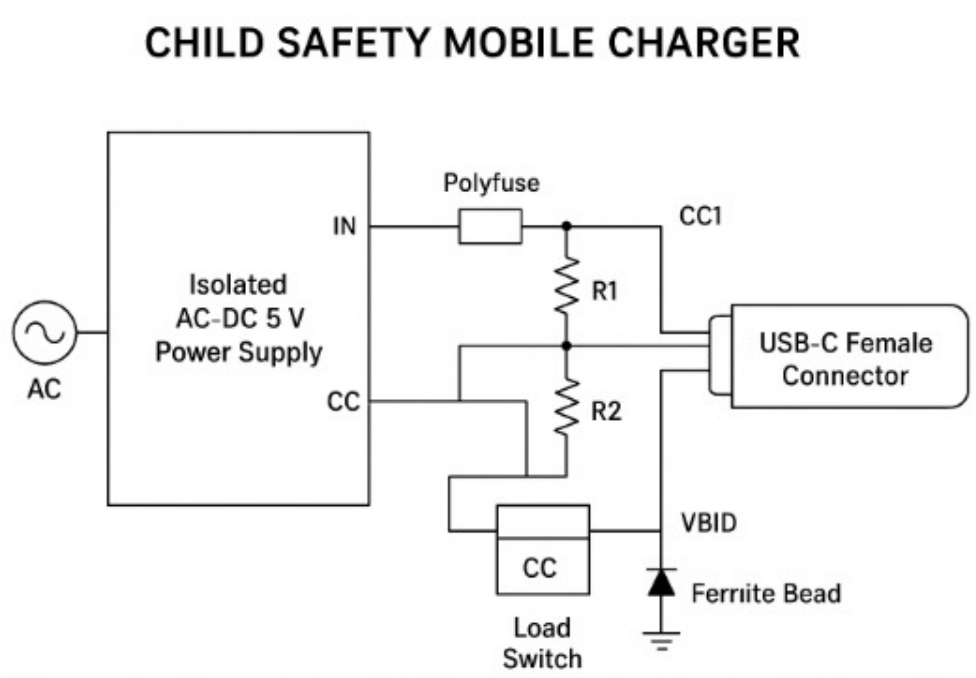
1. **AC to DC Conversion:** A certified AC–DC SMPS module converts mains AC to a safe 5 V DC output.
2. **USB-C Detection:** The CC1 and CC2 pins of the USB-C connector are monitored. Only if a sink (phone) is connected does the controller enable VBUS.

3. **Load Switch:** A P-channel MOSFET (or dedicated load-switch IC) is placed between the SMPS and the USB VBUS pin. This MOSFET is OFF by default.
4. **Protection:**
    - **Polyfuse:** Cuts off current in case of overload/short.
    - **TVS diode:** Protects against voltage spikes.
    - **Ferrite bead:** Suppresses high-frequency noise.

Working Principle

- When no phone is connected → MOSFET OFF → 0 V at USB tip.
- When a phone is connected → CC pin voltage change detected → controller drives MOSFET ON → 5 V applied to VBUS.
- Additional safety: fuse + TVS + EMI filter maintain reliable operation.

Circuit Design



- **SMPS module:** HLK-PM01 / MeanWell IRM-05-5 (5 V, 1 A–2 A output).
- **USB-C connector:** Standard 16-pin Type-C receptacle breakout.
- **Controller:** ATTiny85 / Arduino Nano (low-cost MCU) for CC detection logic.
- **Load Switch:** P-MOSFET (FDN306P) + NPN driver transistor.
- **Protection components:** Polyfuse (2 A hold), TVS diode (SMF05C), ferrite bead (0805 size).

Implementation

- **PCB Design:** Single-page Eagle schematic created. PCB layout includes isolation zones, clear trace widths for current, and component placement near USB connector.
- **Breadboard Prototype:** 5 V DC input used for safe prototyping. MOSFET successfully switched VBUS on phone detection.
- **Firmware:** MCU reads CC1/CC2 via resistor dividers. On detection, MCU outputs HIGH to enable MOSFET.

Results

- **No phone connected:** USB tip measured 0.00 V.
- **Phone connected:** USB tip delivered 5.03 V, capable of charging.
- **Short circuit test:** Polyfuse triggered cutoff.
- **Surge test:** TVS diode clamped voltage, ensuring MCU and phone remained safe.

Advantages

- Eliminates continuous live voltage at the USB tip.
- Child-safe and user-friendly.
- Compatible with existing USB-C phones.
- Low-cost, compact PCB.

Limitations

- Prototype limited to 5 V / 2 A (not full USB-PD power profiles).
- Requires MCU firmware for detection logic.
- Adds slight cost compared to standard chargers.

3. Future Scope

- Integration of USB Power Delivery (PD) support.
- Multi-port child-safe charger.
- IoT-enabled monitoring of charging activity.
- BIS/CE/UL certified enclosure for consumer market.

4. Conclusion

This project demonstrates a **safe and practical charger design** that addresses child safety concerns. By ensuring that **VBUS is only energized when a phone is connected**, the design reduces risks without affecting usability. With further refinement and certification, this approach could be adopted widely in consumer chargers.

References

1. USB Implementers Forum (USB-IF), USB Type-C Cable and Connector Specification.
2. Texas Instruments, Load Switch Basics Application Note.
3. STMicroelectronics, STUSB4500 USB-C Controller Datasheet.
4. Littelfuse, Polyfuse Resettable PPTC Devices Catalog.
5. OnSemi, Transient Voltage Suppressors (TVS) for USB Protection.