Title
Wireless Drone Charging Station

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Abstract

Drone operation time is constrained by battery capacity and the need for manual recharging. This project developed an autonomous wireless charging station based on resonant inductive coupling. A two-stage inverter operating at 166.7 kHz drives the coupled coils, and the received power is rectified and buck-regulated to 8.4 V for the battery rail. This confirms end-to-end power transfer through the full chain; however, charging does not start when the battery is connected, indicating a load-dependent issue such as insufficient current delivery. Future work will characterize the system under load and implement appropriate charge control to enable reliable battery charging.

Objectives

- Design a high-frequency power stage to supply >20 Vpp at 100-200 kHz (no-load) to the resonant link.
- Design and tune TX/RX resonant coils and compensation networks to achieve >20 Vpp at the receiver (no load) at the target frequency.
- Design a converter that can safely and efficiently charge a 2S LiPo battery to ≥95%.

Materials and Methods

- Buck Converter+Linear Regulator: Steps down the supply voltages and regulates the battery charging rail.
- ESP32 MCU: Generates alternating signal for Gate Driver to convert voltage from DC to AC.
- Gate Driver IC+Full-Bridge MOSFET Stage: Amplifies and level-shifts MCU PWM to drive the full-bridge inverter at 166.7 kHz, converting DC to high-frequency AC for resonant coil excitation.
- Resonant TX/RX Coils + Compensation Network: Enables efficient magnetic coupling for wireless power transfer.
- STM32 MCU: Monitors battery voltages and controls buck converter for several protection.

Diagrams/Figures/Experiments

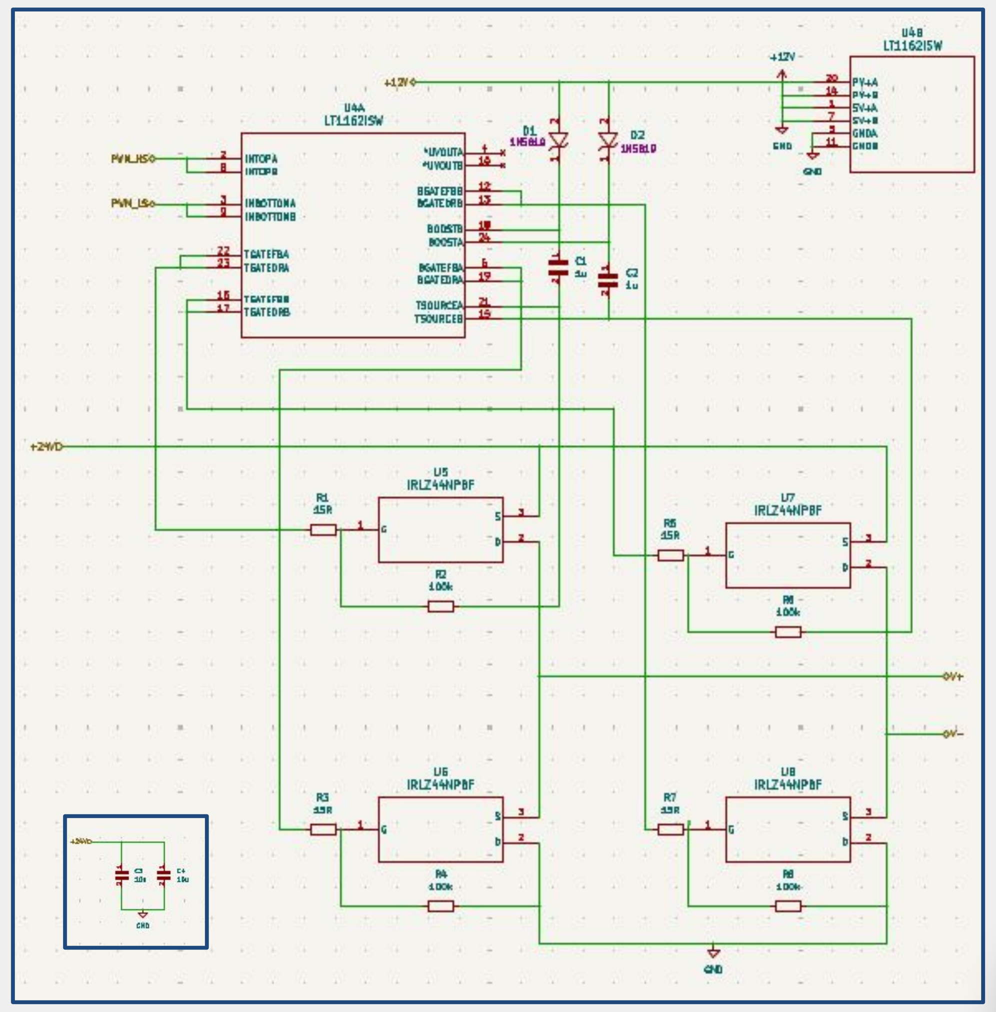


Figure 1: Schematic of the Gate Driver and 2-Step MOSFET Inverter Circuit

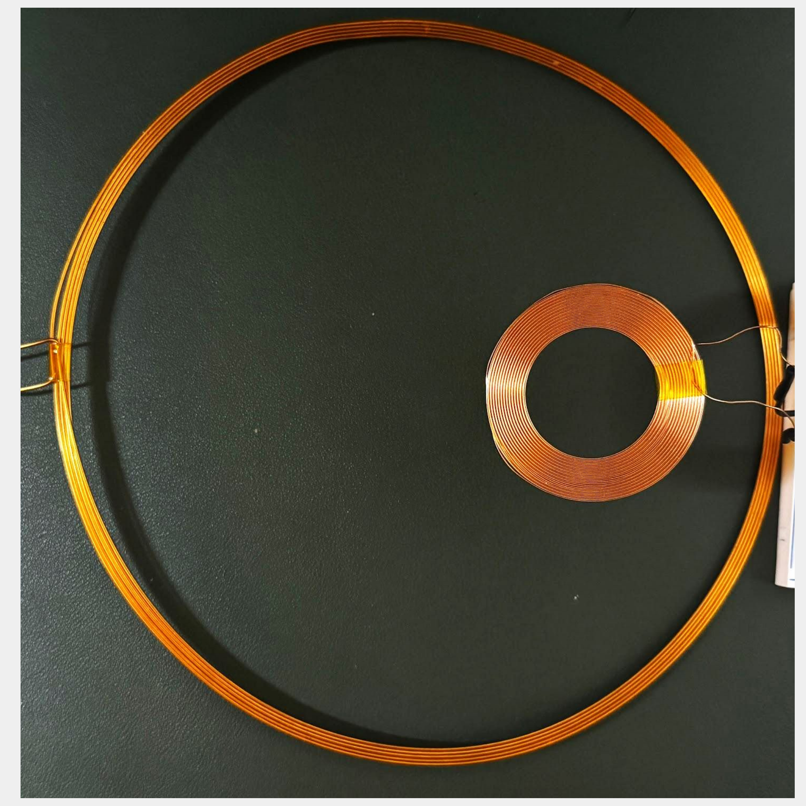


Figure 2: Resonant Coils for Power Transfer

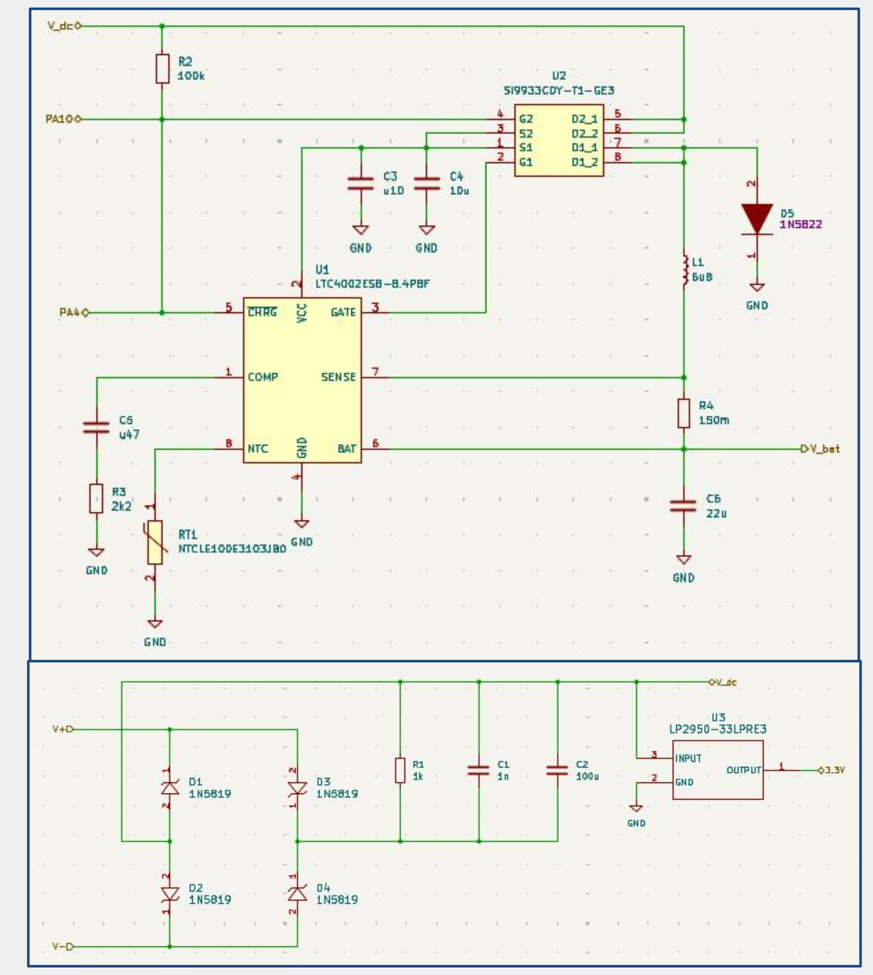
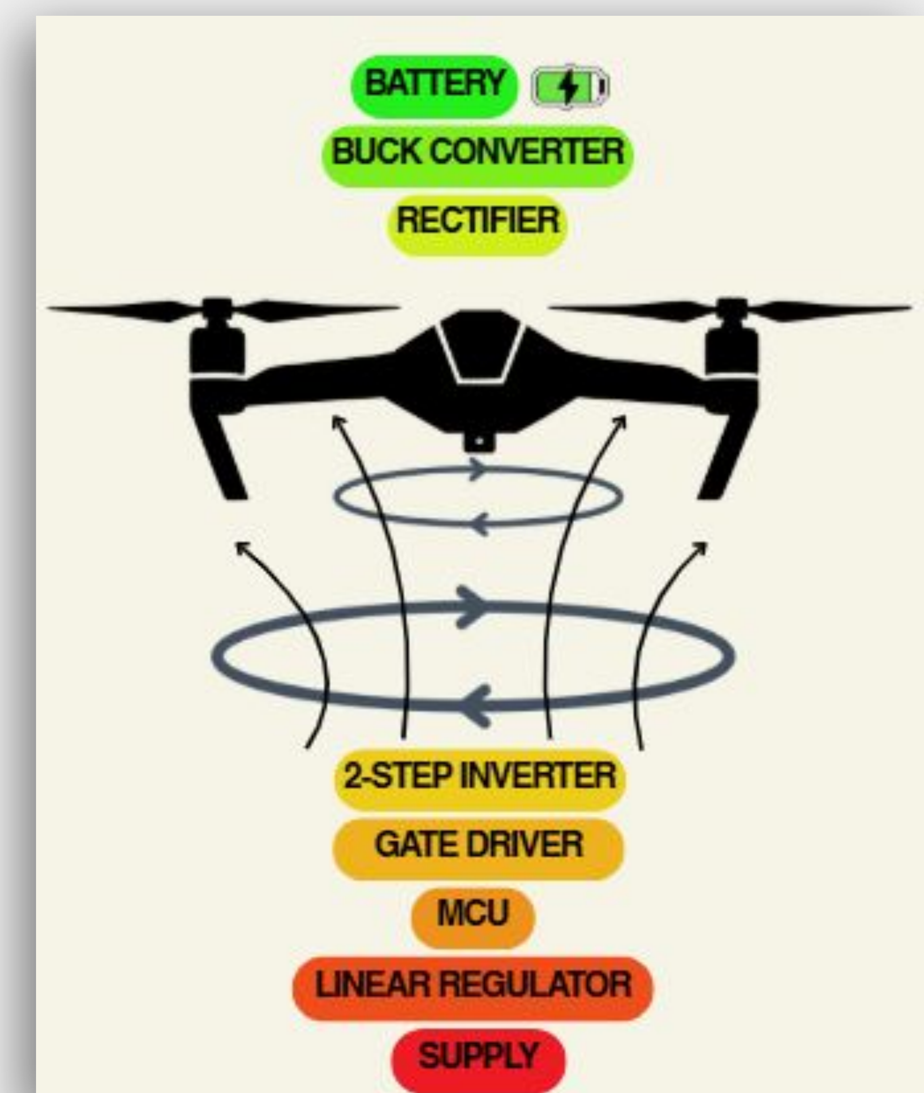


Figure 3: Schematics of the Buck Converter (Top) and the Full-Bridge Rectifier (Bottom)



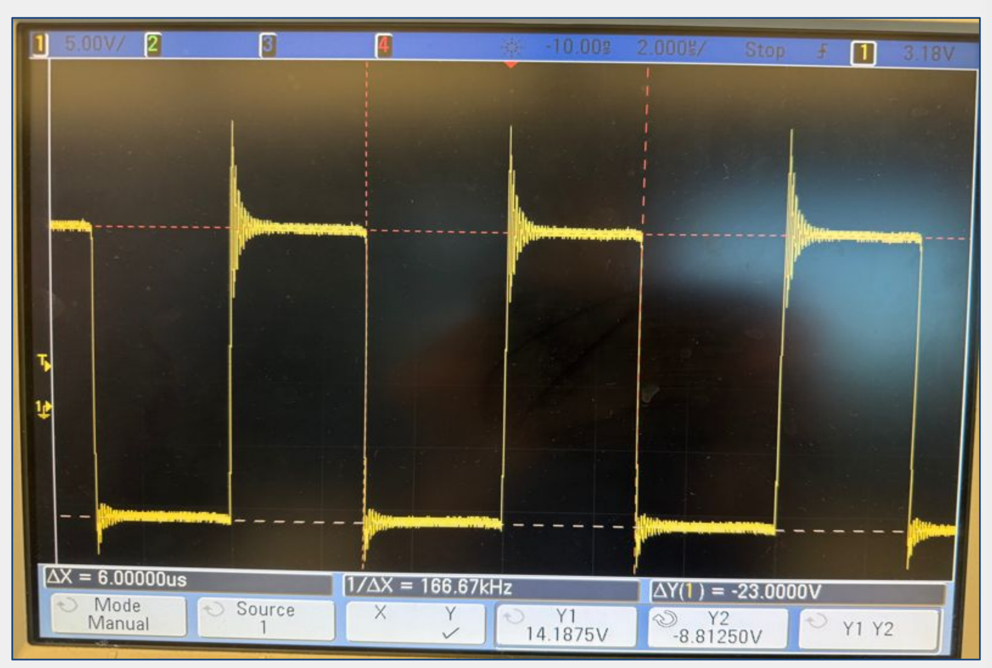


Figure 4: 2-Step MOSFET Inverter Output Waveforms

Figure 5: Transmitter and Receiver Coil Output Waveforms

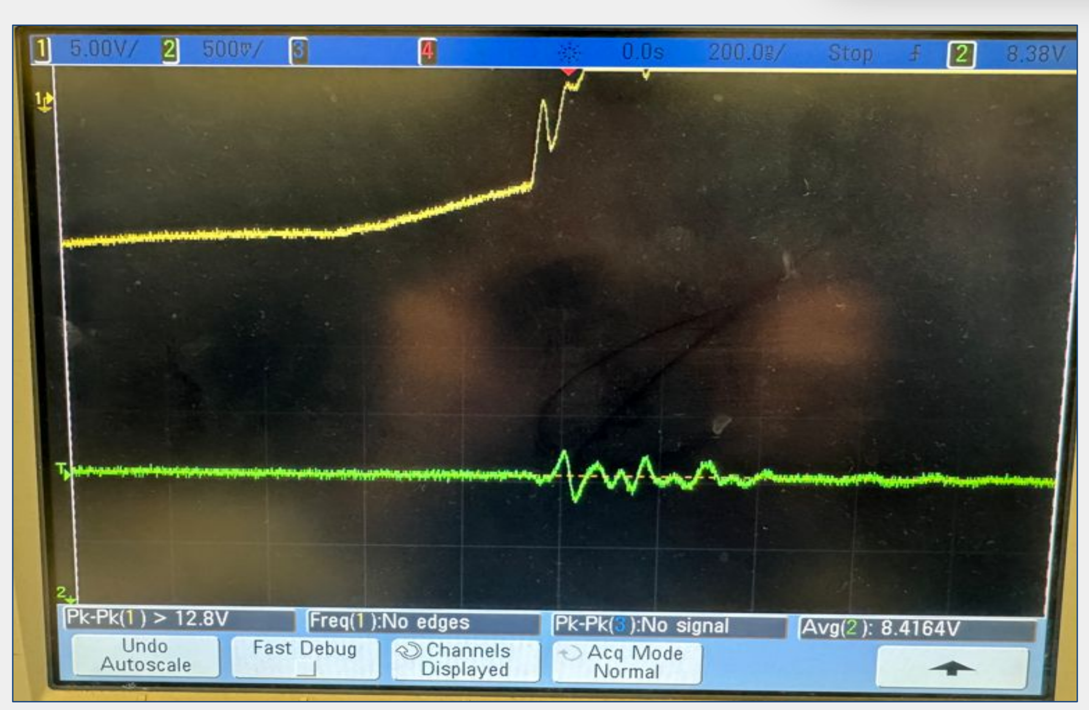


Figure 6: Regulated 8.4 V Battery-Rail Output

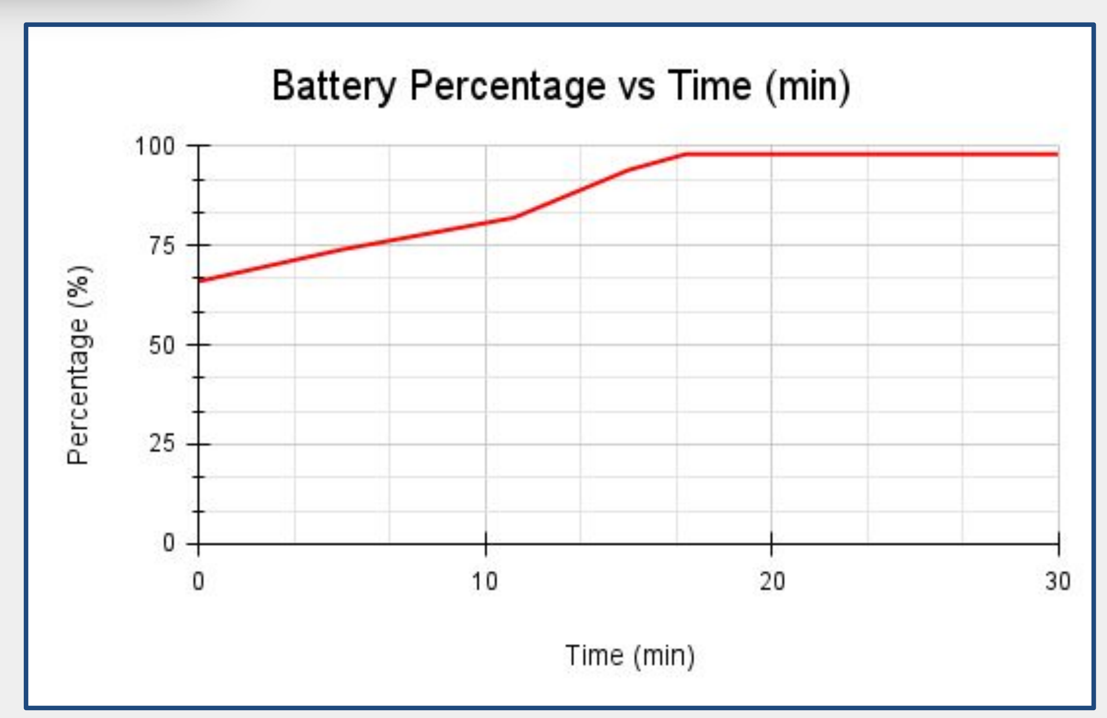


Figure 7: Battery Percentage vs Time (min)

Results

- 2-Step MOSFET Inverter: 23 Vpp at 166.67 kHz with +24V DC input
- Transmitter Coil: 15.662 Vpp at 167.19 kHz
- Receiver Coil: 25.652 Vpp at 167.11 kHz
- Rectifier + Buck: 8.4 V DC to the battery charging rail
- Battery Charge:
  - Given 10V DC input to buck converter:
    - 66% to 98% in 17 minutes at a steady current of ~0.5A
    - Decrease in charge rate at >98%
  - Given integration with the rest of the system (gate driver, coils, full-bridge rectifier, and buck converter):
    - Significant decrease in charging efficiency with a current of ~0.06 A (3.68% efficiency)

Additional Information

- QI Standard: Using resonant inductive coils of relatively close spacing and frequencies between 105-205 kHz.

References

[1] Inland ESP32 Core Board (Black and Eco-friendly) - Micro Center(https://community.microcenter.com/kb/articles/652-inland-esp32-core-board-black-and-eco-friendly?_gl=1*ahq0if*_gcl_au*MTM0NzUzOTQ4LjE3NzE5OTE5NTA.*_ga*ODU1MDYzNzMwLjE3NjQwMzAzMjY.*_ga_CSBPEX4VCV*czE3NzIxNTIzMjEkbzExJGcxJHQxNzcyMTUyMzYyJGoxOSRsMCRoMTc4MzYxMTQwMQ..)
[2] ESP32 PWM Library(https://github.com/khoih-prog/ESP32_PWM)