Wireless Drone Charging Station

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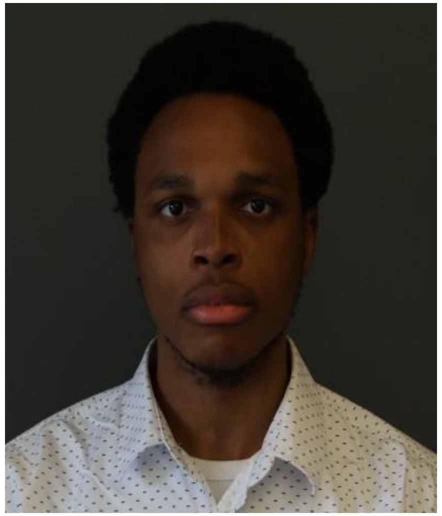

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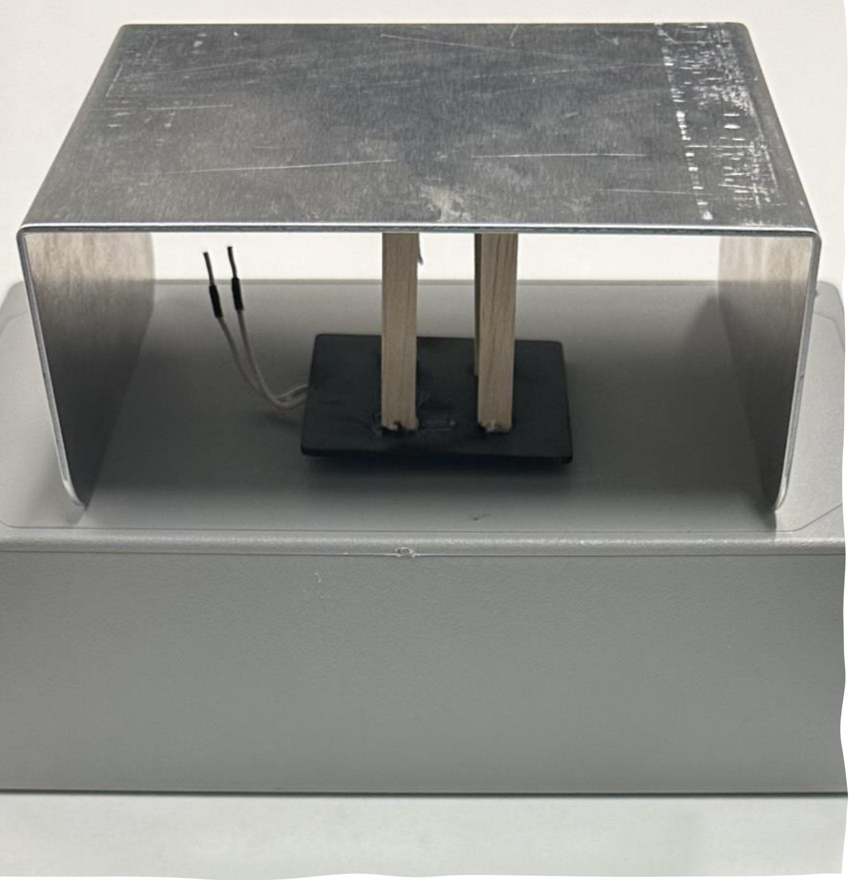
Why Wireless charging stations?

- Drone technology is becoming more vital for our modern society
- Improves productivity and precision for several applications.
- Key challenge – Operation time.
- Limited battery life
- Our Solution - Implement an automated drone charging system that extends the drone’s flight time without human intervention.

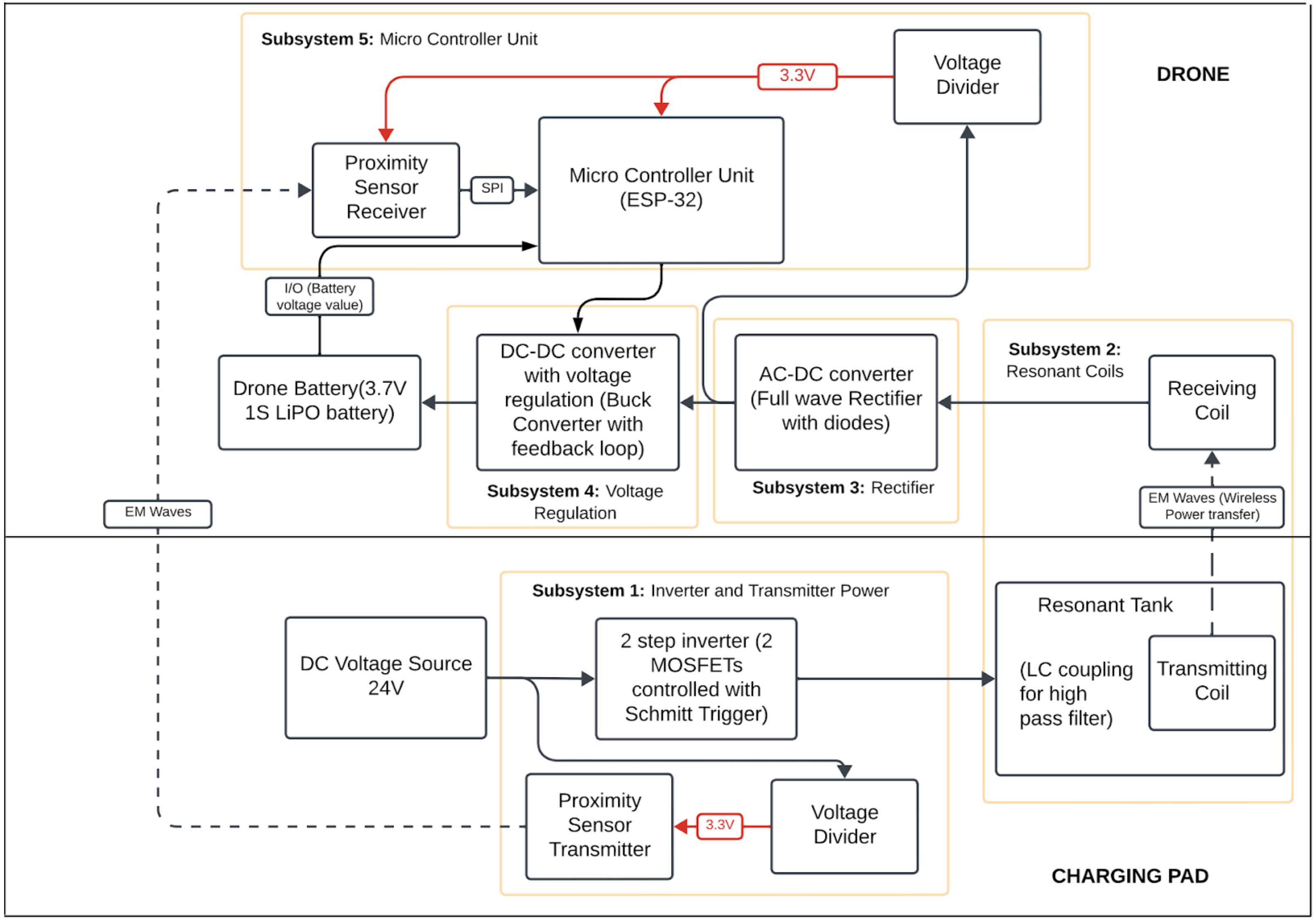


Project Description

- Supply 3.8V± 3% V DC to 1S LiPO battery, when supplied with 24V DC power from the power supply.
- Charge the drone to at least 90% of the maximum battery capacity without human interference with an efficiency of at least 50% only after the coils are within the set proximity of 5 cm.
- System should be able to operate up to a resonant frequency of 125kHz.
- System should operate within the 0.97dB range(Power produced by the resonant tank is between Pmax and 0.8*Pmax).

DESIGN

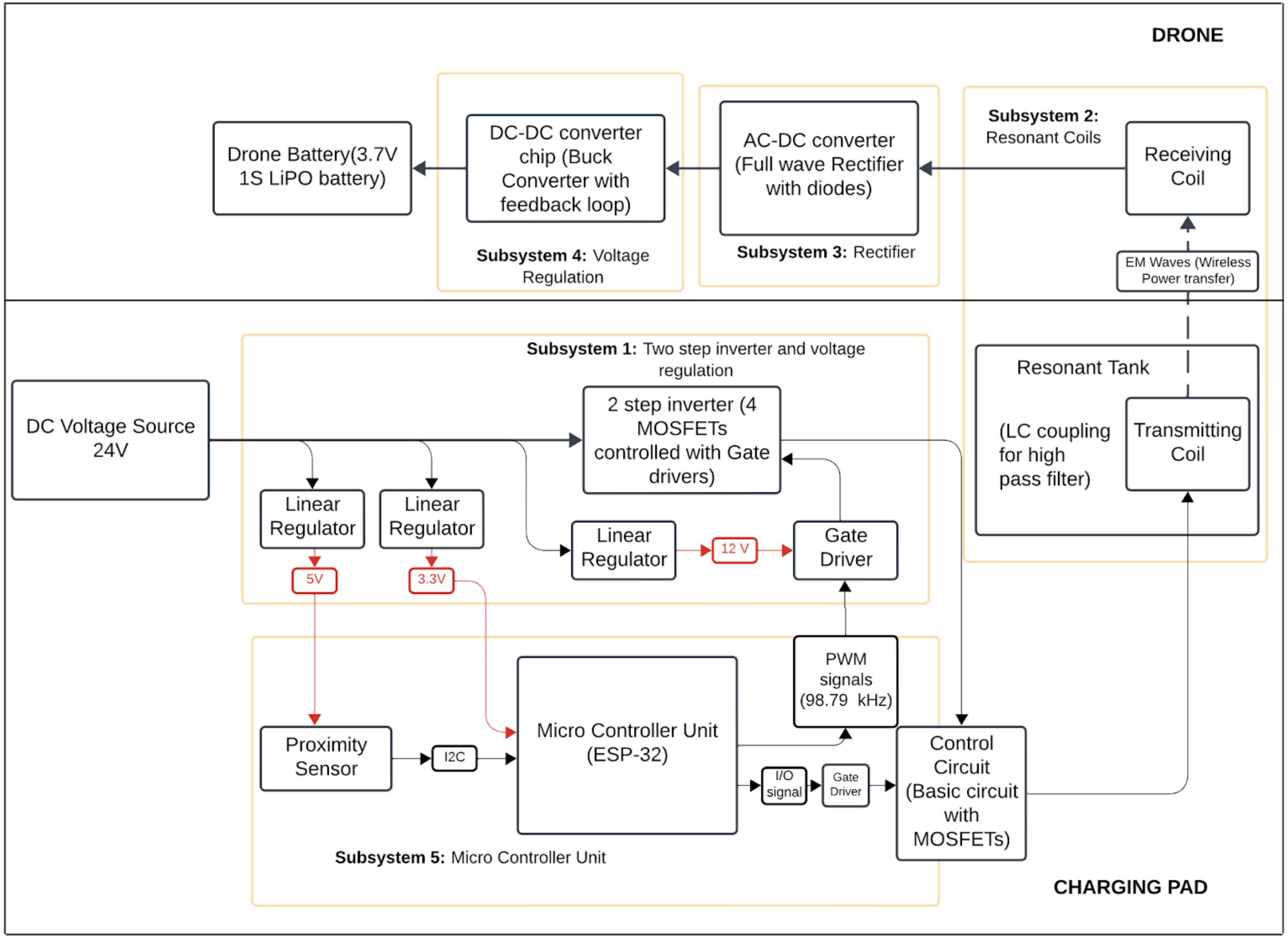
Initial Block Diagram



Issues with the initial design

- Unnecessary power losses due to the voltage dividers.
- The 2 MOSFET inverter would give a square wave going from 0V to 24V. This would mean that the drone would not receive power for half of the cycle.
- MCU unit needed on the transmitting side to control the power transmission.
- Output from the system not enough to charge the battery satisfactorily.

Final Block Diagram

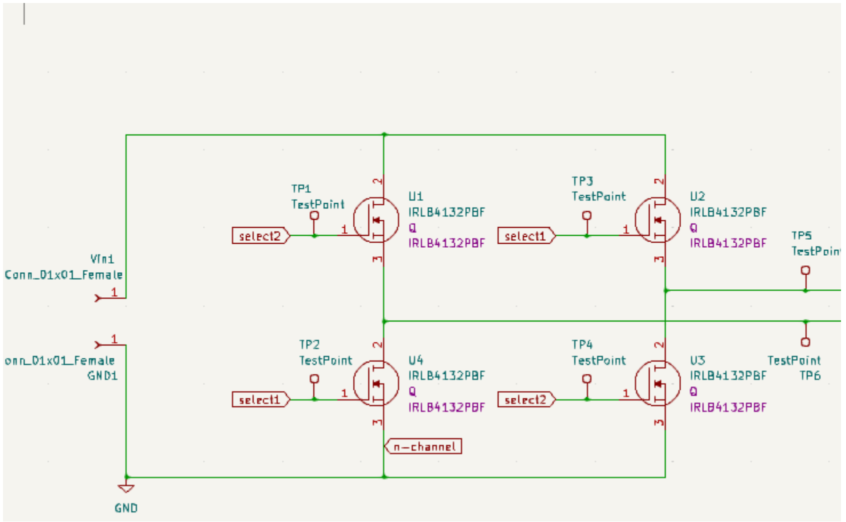


Changes made to the design

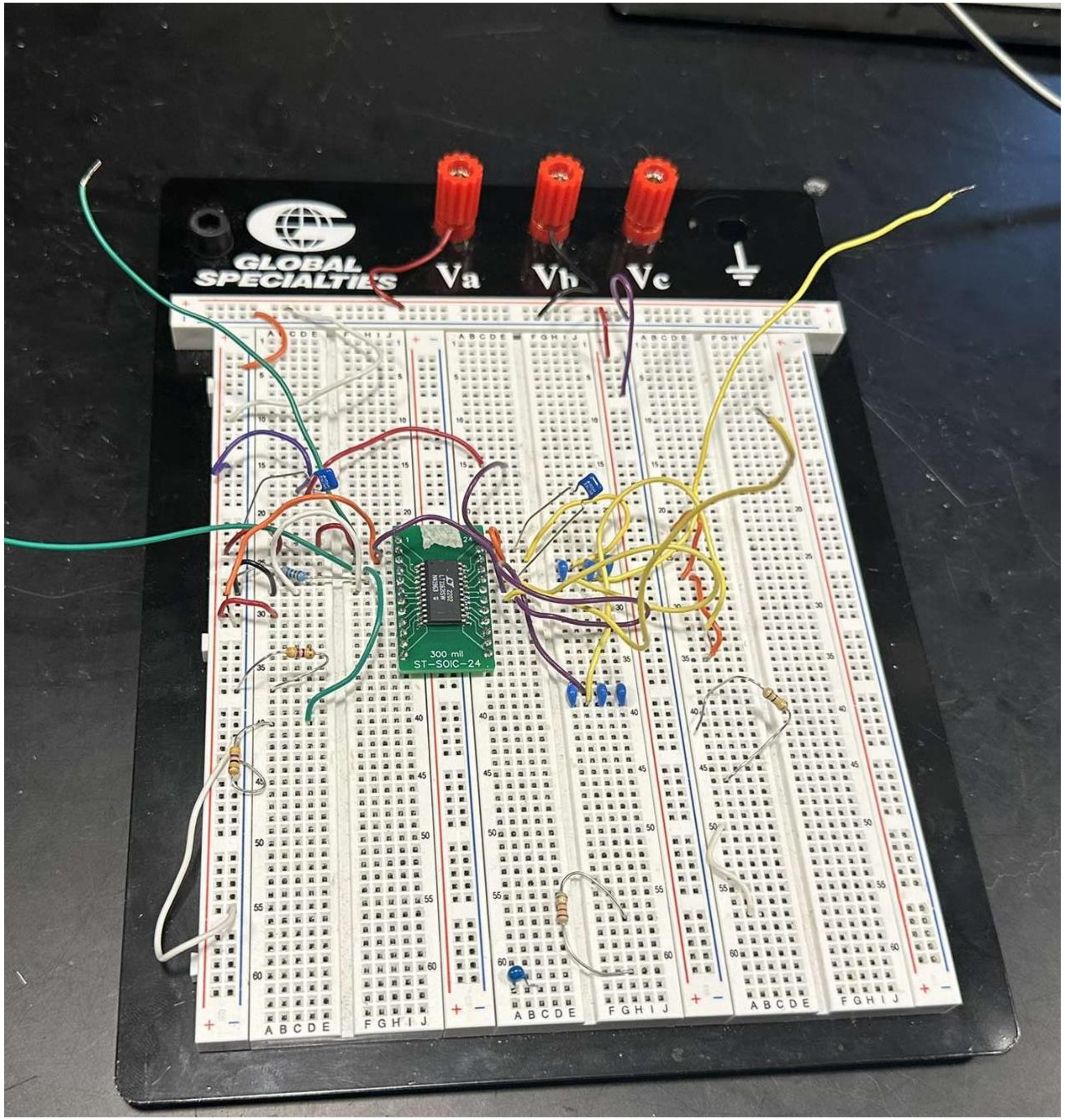
- Used linear regulators to limit power losses and maintain stable voltages.
- MCU shifted on the transmitting PCB and it controls the PWM.
- Used 4 MOSFETs with a gate driver to get a square wave from 24v to -24V always ensuring power to the circuit.
- Changed the output voltage to 3.8V to successfully charge the battery at all times

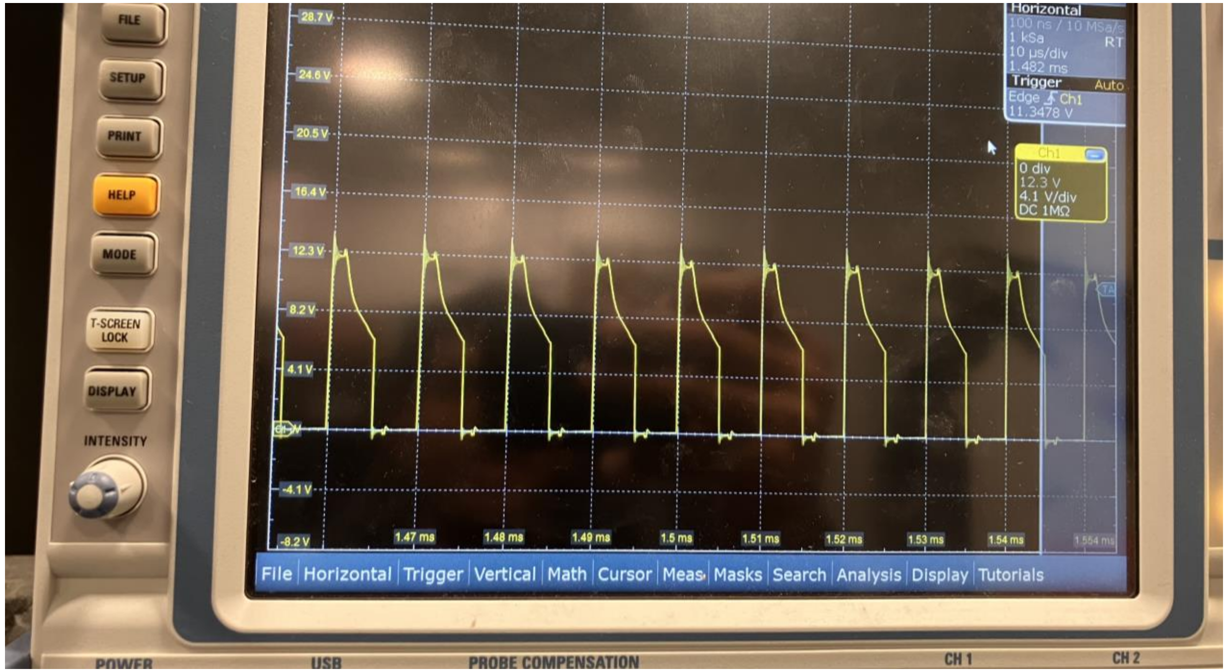
SUBSYSTEMS

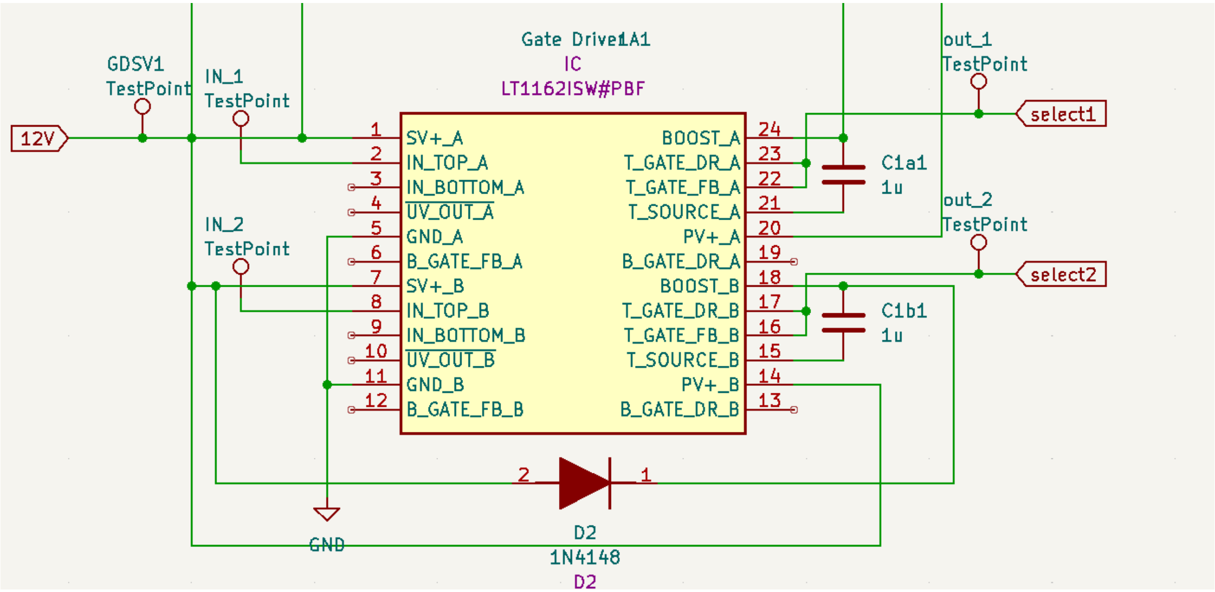
Subsystem 1: Two Step Inverter and Voltage Regulation



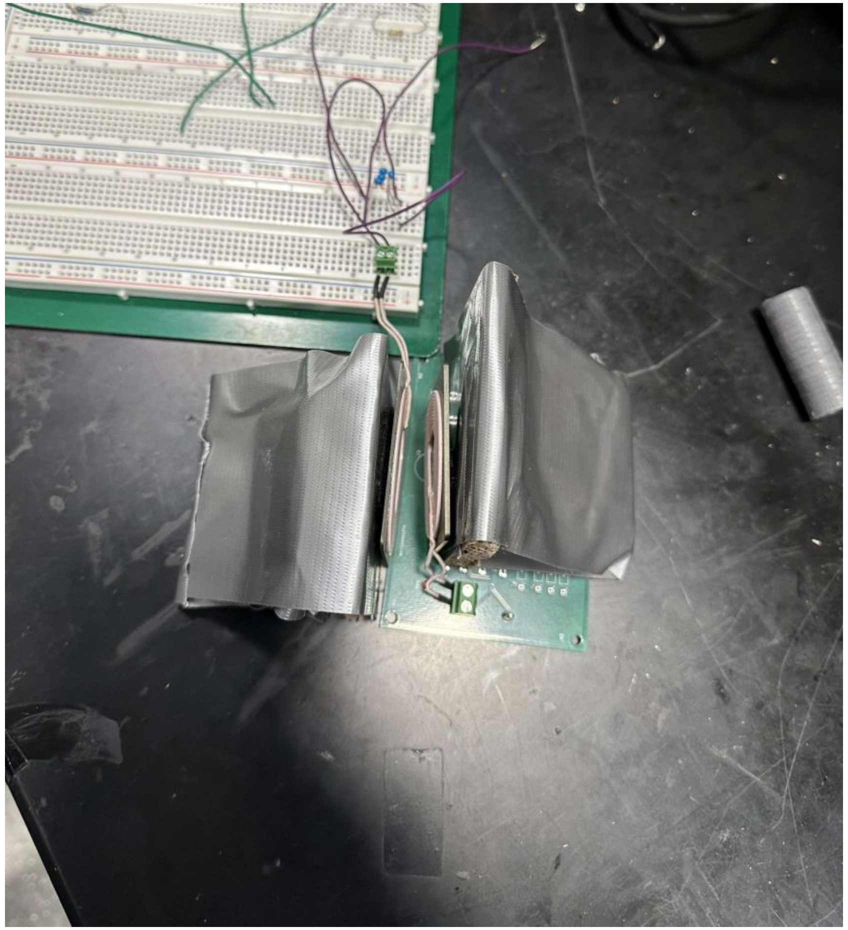
Requirements	Verification
The output of the circuit is a square wave with voltages -24V and 24V	Input 24V DC and use an oscilloscope to check the waveform of the output
The voltage supplied by the linear regulators match the specified value	Input 24V DC and check the output of the linear regulators with the help of an oscilloscope
All four MOSFETs in the full bridge inverter are driven at the correct switching frequency of 100 kHz .	This would be tested using the test points for select 1 and select 2 to make sure they are receiving the signal and that the signal is of a correct frequency. This is verifiable using an oscilloscope.
Gate driver works properly and amplifies the input signals	This would be tested using an oscilloscope and checking the input and output waveforms.


GLOBAL SPECIALTIES
Va
Vb
Vc
300 mil
ST-SOIC-24

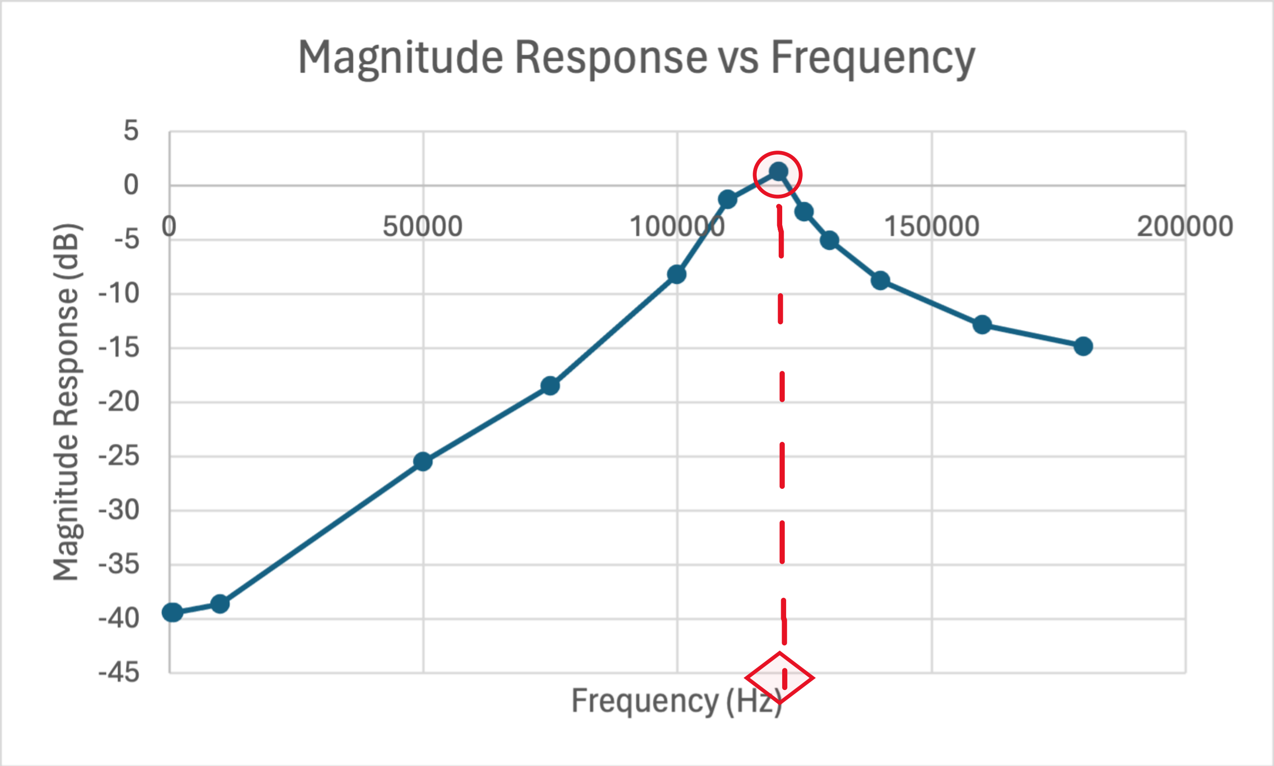

FILE
SETUP
PRINT
HELP
MODE
T-SCREEN LOCK
DISPLAY
INTENSITY
Horizontal
Trigger
Ch1
File
Horizontal
Trigger
Vertical
Math
Cursor
Meas
Masks
Search
Analysis
Display
Tutorials
POWER
USB
PROBE COMPENSATION
CH 1
CH 2

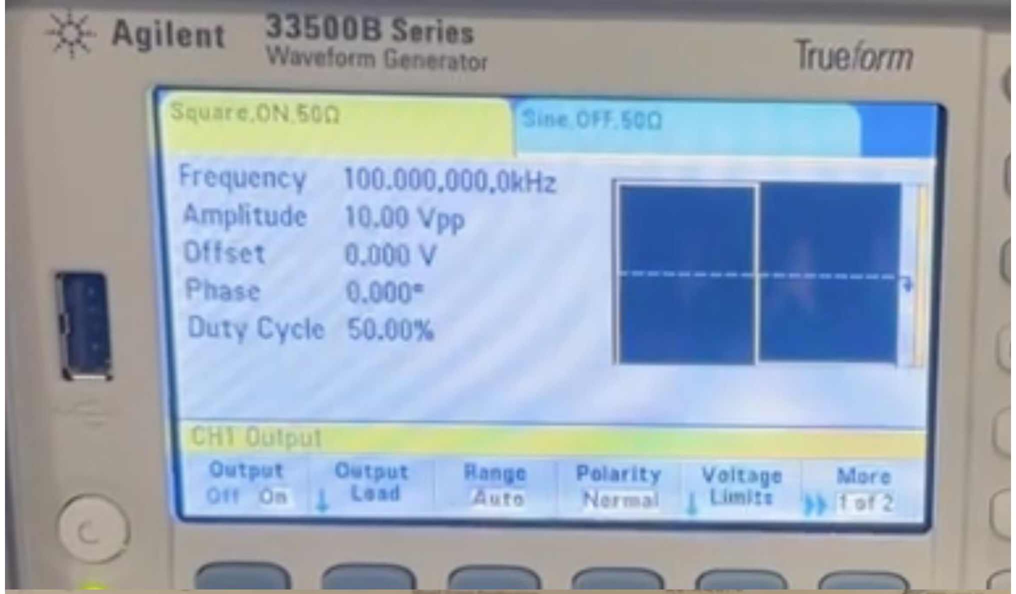

Gate Drive1A1
IC
LT1162ISW#PBF
GDSV1
TestPoint
IN_1
TestPoint
IN_2
TestPoint
12V
SV+_A
IN_TOP_A
IN_BOTTOM_A
UV_OUT_A
GND_A
B_GATE_FB_A
SV+_B
IN_TOP_B
IN_BOTTOM_B
UV_OUT_B
GND_B
B_GATE_FB_B
BOOST_A
T_GATE_DR_A
T_GATE_FB_A
T_SOURCE_A
PV+_A
B_GATE_DR_A
BOOST_B
T_GATE_DR_B
T_GATE_FB_B
T_SOURCE_B
PV+_B
B_GATE_DR_B
out_1
TestPoint
select1
C1a1
1u
out_2
TestPoint
select2
C1b1
1u
GND
D2
1N4148
D2

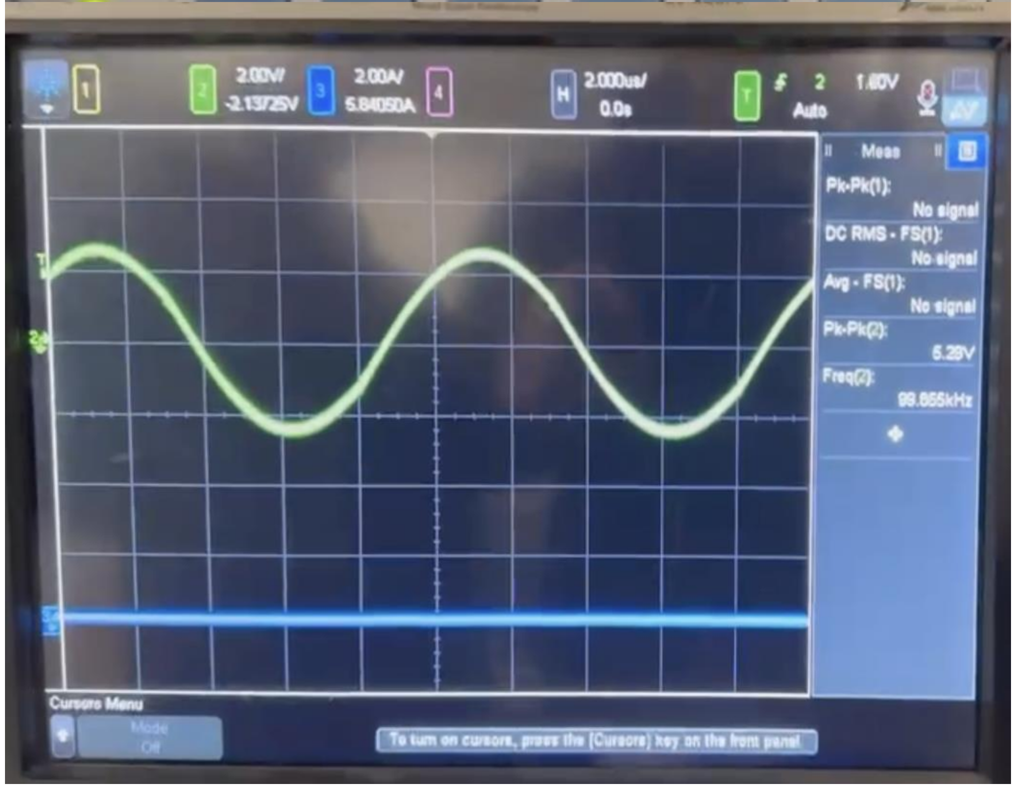
Subsystem 2: Wireless Power Transfer



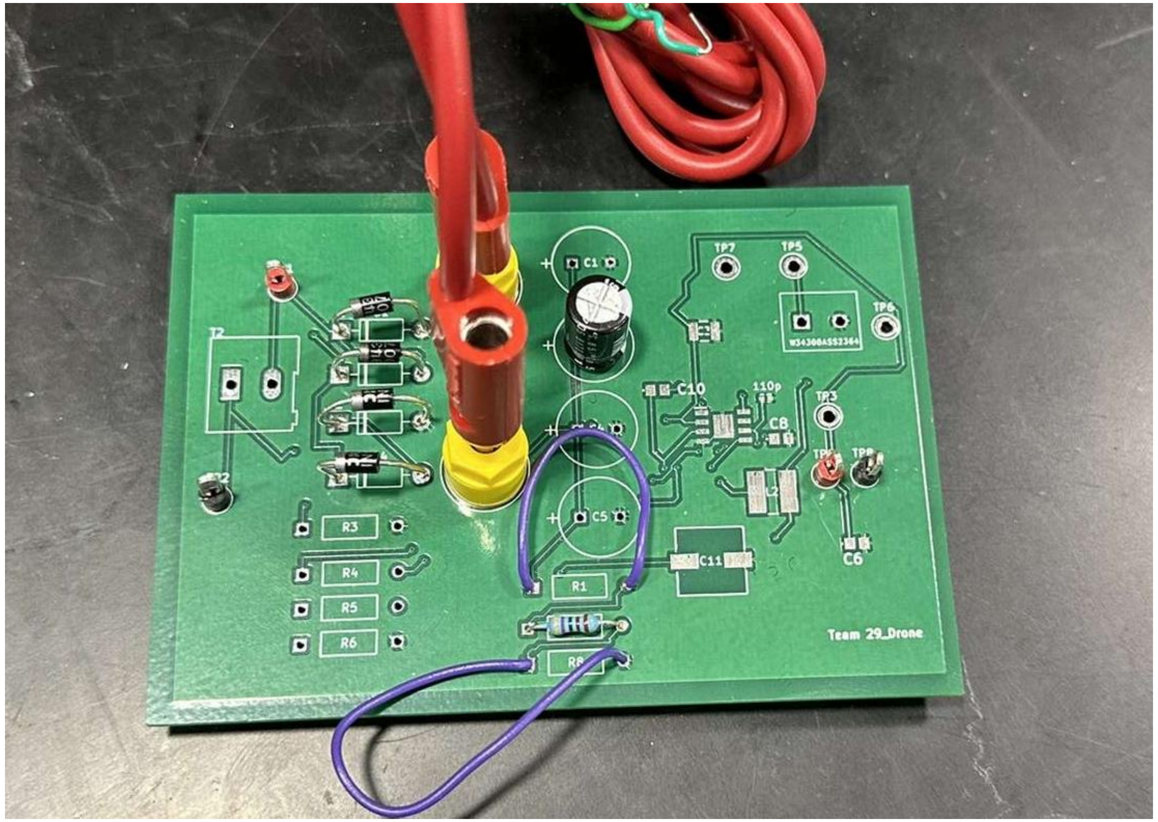
Requirements	Verification
The efficiency of the wireless power transmission should be more than 50%	Given an input AC, the input power on the transmission side and output power on the receiving side will be measured with the help of watt meters. The output power should be greater than 50% of the input power.
System should operate within the 0.97dB range(Power produced by the resonant tank is between Pmax and 0.8*Pmax).	We will check this by using a network analyzer. A network analyzer can determine the frequency response of the transmitting coil, ensuring it operates within the desired frequency range for efficient power transfer.
The distance between the coils should be less than 5cm	Checked physically with the help of a tape measure/ruler.


Magnitude Response vs Frequency
Magnitude Response (dB)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
0
50000
100000
150000
200000
Frequency (Hz)

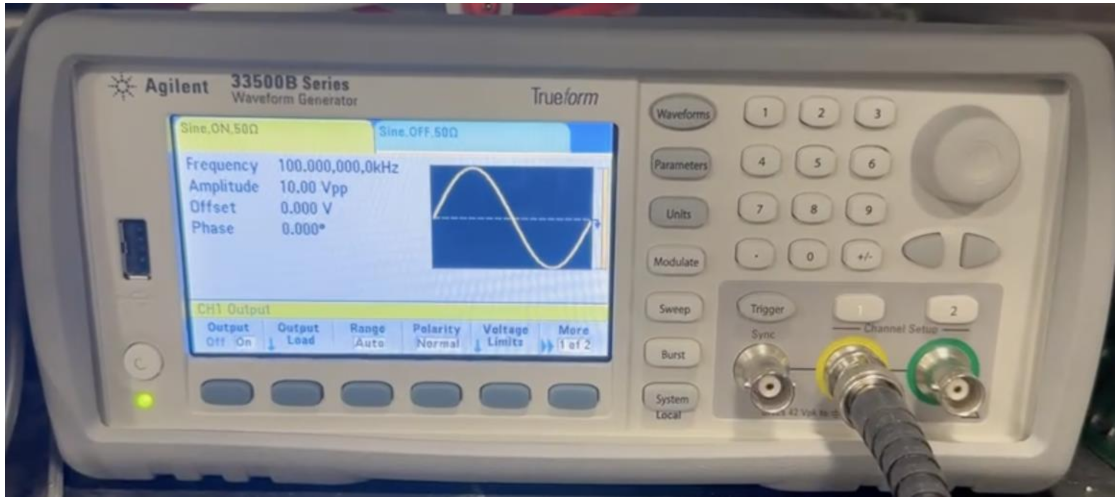

Agilent
33500B Series
Waveform Generator
Trueform
Square,ON,50Ω
Sine,OFF,50Ω
Frequency 100.000,000,0kHz
Amplitude 10.00 Vpp
Offset 0.000 V
Phase 0.000°
Duty Cycle 50.00%
CH1 Output
Output Off On
Output Load
Range Auto
Polarity Normal
Voltage Limits
More 1 of 2


2.00V/
2.00A/
2.000us/
0.0s
Auto
1.60V
Meas
Pk-Pk(1):
No signal
DC RMS - FS(1):
No signal
Avg - FS(1):
No signal
Pk-Pk(2):
5.28V
Freq(2):
99.665kHz
Cursors Menu

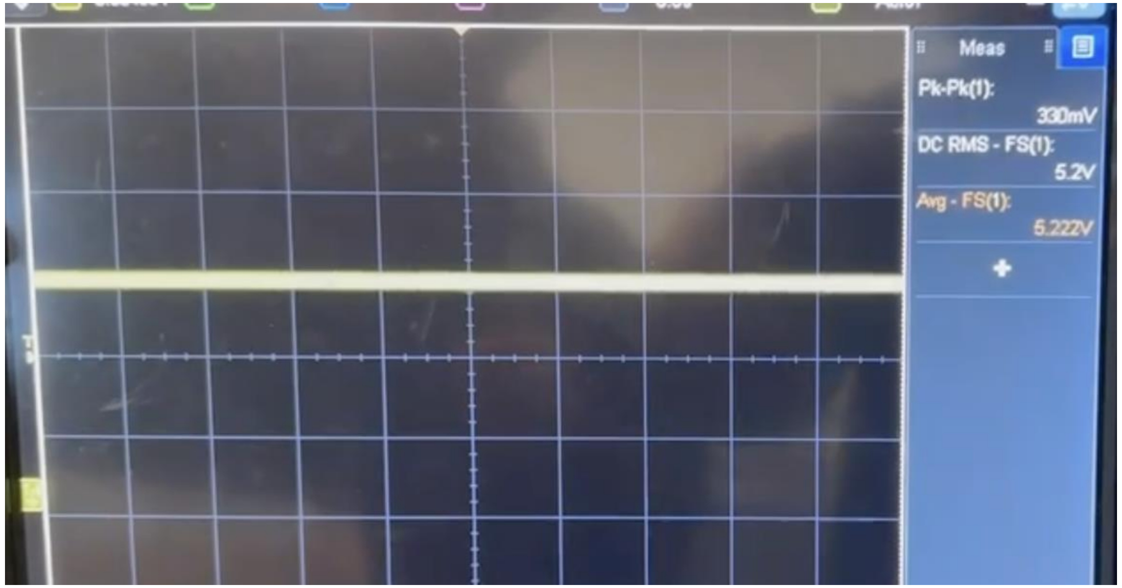
Subsystem 3: Full Bridge Rectifier



Requirements	Verification
The full bridge rectifier must be able to convert AC voltage from the WPF system to 10 ± 3% V DC.	We will use the variac, wattmeter, and oscilloscope in the lab to confirm this AC-DC conversion.

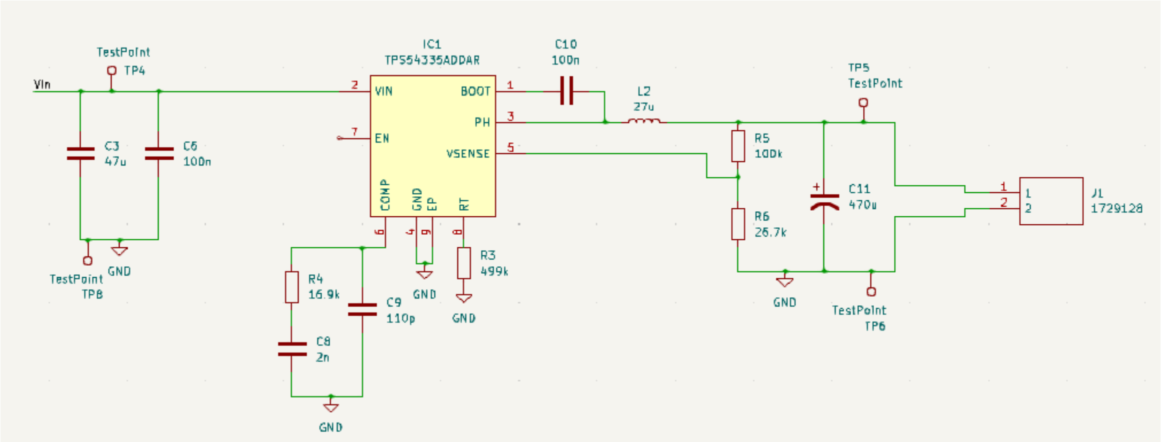


INPUT

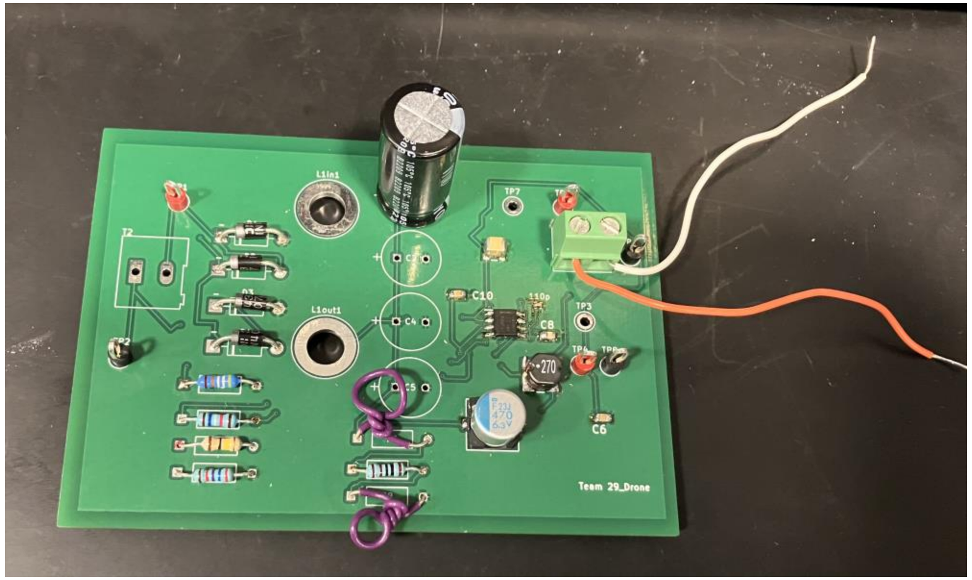


OUTPUT

Subsystem 4: Synchronous Buck Converter



Requirement	**Verification**
The TI buck converter should be able to convert 10 ± 3% V DC to regulated 3.8 ± 3% V DC.	This DC-DC conversion would be confirmed using a testbench DC power supply and oscilloscope.
Maximum output current of 2A	This would be confirmed using current probes.
Successful dynamic regulation of output voltage.	We will use the testbench DC power supply to send low input voltages into the converter chip to verify that the chip is able to control the duty ratio in order to maintain output voltage.

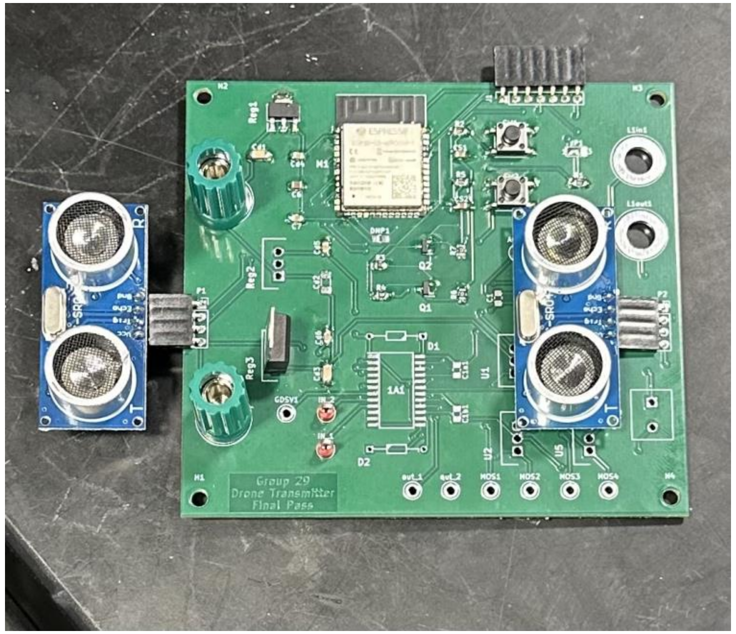


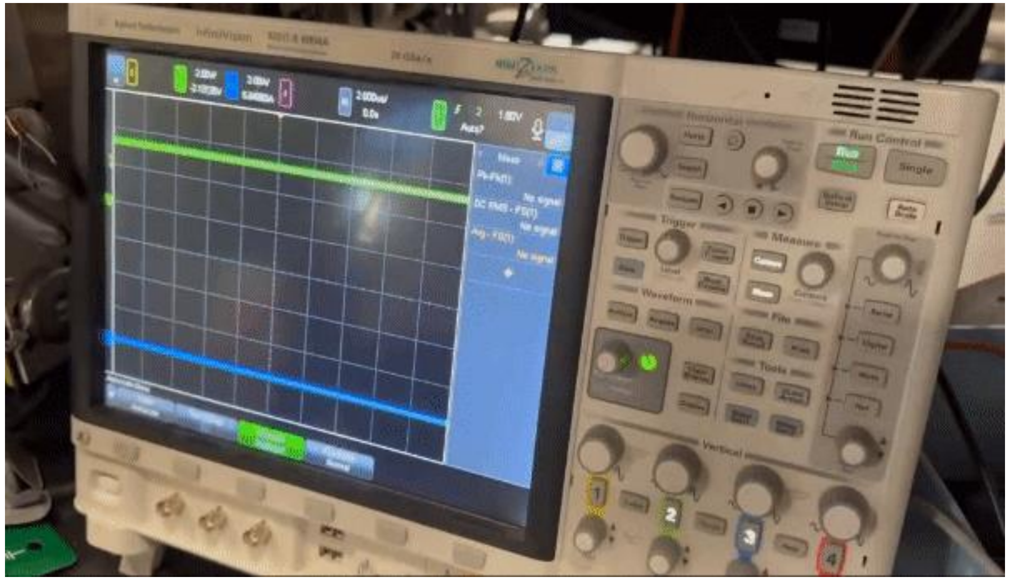
INPUT

OUTPUT

Subsystem 5: Microcontroller Unit

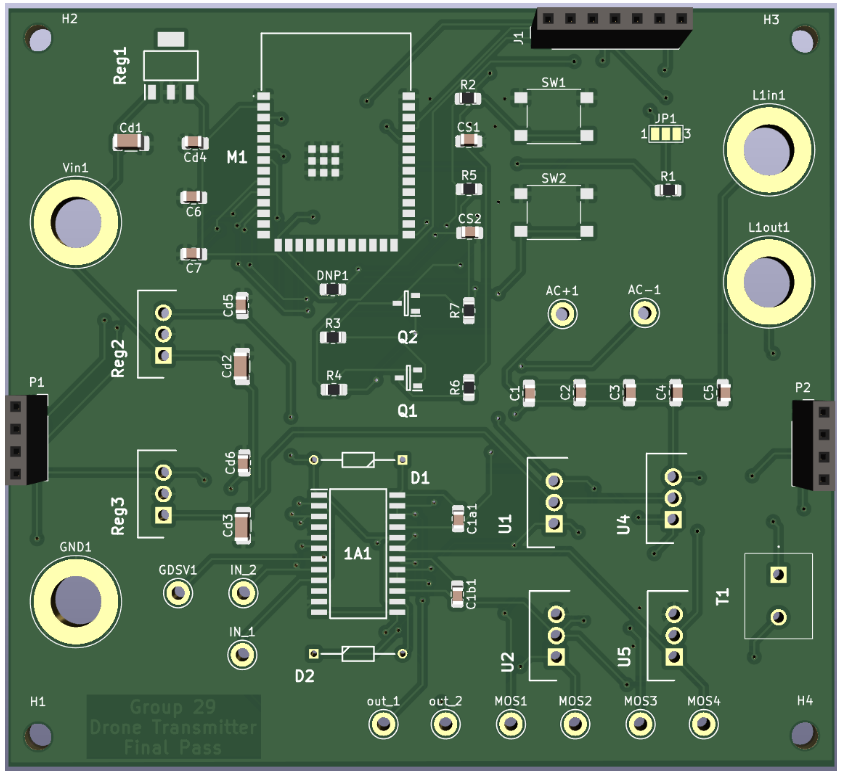
Requirement	Verification
Successful communication between proximity sensor and ESP32 microcontroller.	Confirmation that the proximity sensor distance data is being read through the use of serial printing onto the monitor.
Successful communication with the gate driver and the PWM(98.794kHz) signal is 98.794kHz.	Validated via serial printing onto the monitor.
Successful control of the transmitting circuit with I/O signal. Allow charging only when the drone is detected	Confirmed by observing the output of the MCU and the control circuit via an oscilloscope.



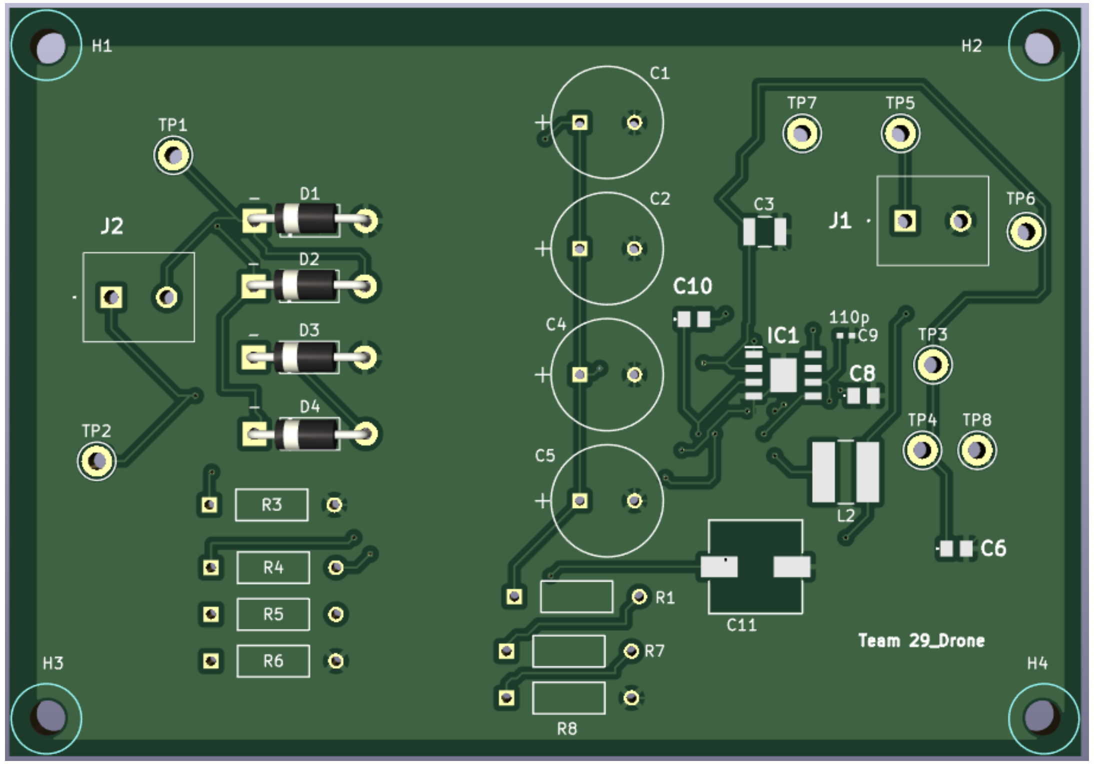


```
PWM Active
Distance1 (cm): 3.01
Distance2 (cm): 3.59
PWM Active
Distance1 (cm): 2.86
Distance2 (cm): 2.94
PWM Active
Distance1 (cm): 3.37
Distance2 (cm): 2.62
PWM Active
Distance1 (cm): 2.70
Distance2 (cm): 4.56
PWM Active
Distance1 (cm): 18.24
Distance2 (cm): 16.20
Distance1 (cm): 17.19
Distance2 (cm): 16.83
Distance1 (cm): 16.41
Distance2 (cm): 15.56
Distance1 (cm): 16.59
Distance2 (cm): 16.51
Distance1 (cm): 16.86
Distance2 (cm): 15.88
```

Final PCB



Transmitting PCB Final Design



Receiving PCB Final Design

CONCLUSION

Successes and Failures

Successes

- ✓ Wireless power transfer
- ✓ Full bridge rectifier
- ✓ Buck converter with voltage regulation
- ✓ Microcontroller

Failures

- Gate driver high side circuitry
- Triggering the MOSFETs to get a square wave a 2-step square wave.

Things we would differently

- Calculate the values of the capacitors and resistors needed without relying on the numbers in the datasheet
- Have a backup for driving the MOSFETs and not relying on a single IC.
- Not relying too much on the simulations and verify all the simulations on the breadboard.

Future Development

- Going forward we would like to fix the issue with the gate driver and get the whole system to work.
- We would also like to integrate an automatic landing feature that would allow the drone to land on the charging pad whenever it comes in close vicinity(within 2-3m)
- The main objective was to allow seamless charging of drones without human intervention and we would like to do that.

Final Thoughts

- This project was a great experience for all of us.
- We gained valuable insights into the entire process of designing and building a product from scratch.
- One of the most important lessons we learned was the significance of continuous testing and updating the design as we progressed.
- We would like to thank our TAs, Matthew and Jason and all rest of the course of staff throughout the semester.

THANK YOU