

P.H.A.S.E.R.

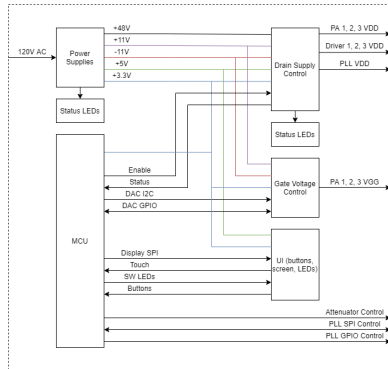
Portable Highly Adaptive Sterilization Electromagnetic Ray
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Objective

- Determine the feasibility of using microwave electromagnetic radiation to kill bacteria and other microorganisms on surfaces
- Develop a controllable device that sterilizes surfaces using microwave radiation

Control Hardware



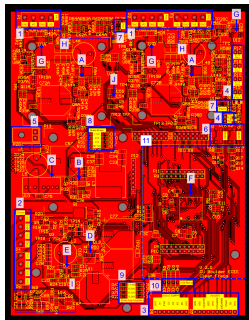
System-level overview of PCB

Board Interfaces

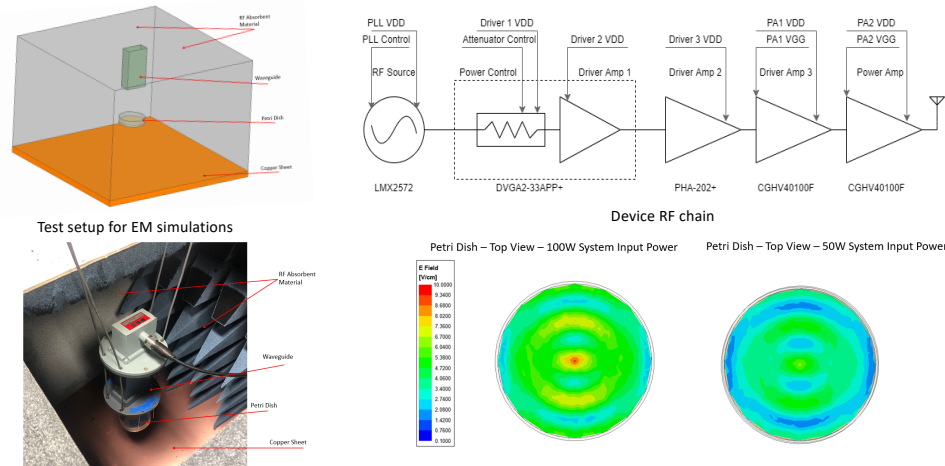
- PA VDD, VGG connectors
- Driver, PLL VGG connectors
- RF control connectors
- Fan connectors
- 48V power connector
- User buttons
- PA status LEDs
- Board power LEDs
- Driver status LEDs
- Software status LEDs
- Display

Board Circuits

- +28V Supply
- +11V Supply
- +5V Supply
- +3.3V Supply
- 11V Supply
- Microcontroller
- PA VDD current monitor
- PA VDD monitor
- Driver VDD monitor
- PA VGG DAC



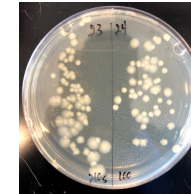
Microwave Sterilization Experiments



Experimental setup in high power RF lab

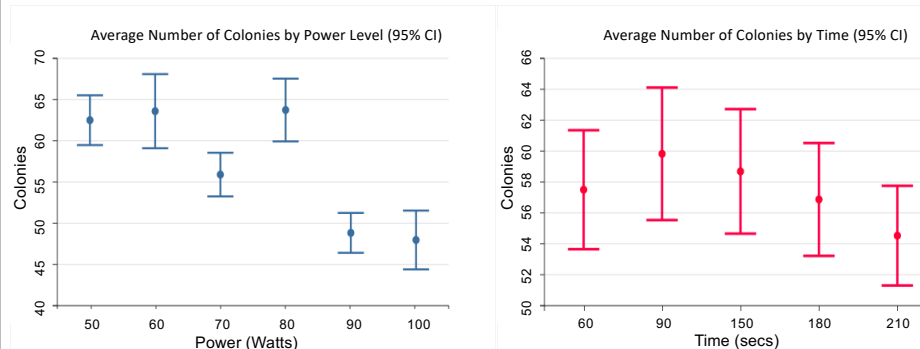
Experiment Procedure

- Inoculated 10mL of (TSB + antibiotics) liquid media with 100μL of overnight stock of E. Coli
- Placed in shaking incubator at 37°C for 1-3 hours until optical density at 600nm is between 0.3 and 0.7
- Diluted bacteria media to 10⁻⁶ power with PBS for plating onto a total of 180 petri dishes
- Transported bacteria plates immediately to high power RF lab for testing
- Tested with six power levels (50-100W at 10-watt increments) over five-time intervals (60, 90, 150, 180, and 210s) with a 2.45 GHz continuous wave over the course of the entire experiment
- After a single power level was tested for all the times, petri dishes were transported back to the Hernandez lab for overnight incubation.
- 17-24hrs later the colonies were counted on the petri dishes and recorded along with control dishes



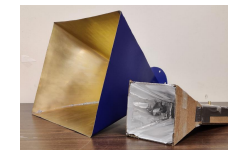
Sample of petri dish with E. Coli colonies after irradiation

Results

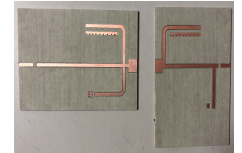


Prototype Hardware

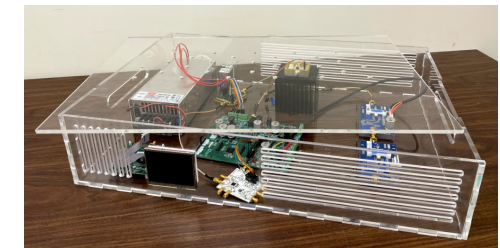
PHASER is designed to be adaptable to various applications. Users can connect different antennas and solid-state amplifiers to operate at various frequencies and output powers. The device enclosure includes extra space for additional hardware and cooling fans.



Horn antennas



RF power amplifier layout



System Enclosure

Conclusions

Power tests showed a statistically significant difference between higher power levels (90 and 100W) and lower power levels (50-80W), $F = 18.448$, $p = 0.000$, $\alpha = 0.05$.

Time tests showed no statistically significant data but suggest an overall trend that longer times will eliminate more colonies, $F = 1.142$, $p = 0.3386$, $\alpha = 0.05$.

The next steps of this project are to test more frequencies, modulations, directive beaming with antennas, and the impact that thermal effects induced.

Acknowledgments

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