TEAM SPACE COAST UNMANNED AIRSPEW CHALLENGE

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OBJECTIVE

Design a system that:

1. Attaches to a DJI Phantom 4 without permanent modification
   - Remote activation using built in DJI functionality
2. Plays audio output via speaker system
3. Ability to incorporate Software Defined Radio
   - Radio transmission in FM frequency
   - GNURadio compatible
4. Drops one pound of pamphlets

SPACE COAST UNMANNED'S SOLUTION

- All in one solution allowing a single Phantom to perform all aspects the mission
  - Reduces fleet requirement from 3 simultaneous Phantoms to 1 Phantom
  - Significant cost savings to end user due to reduced fleet size and maintenance
- All Payloads to not interfere with the camera or avoidance sensors
- System can be separated into individual modules if desired
  - Would allow much more weight for audio speaker system

CONFIGURATIONS

- Saddles can be removed and replaced for four configurations:

1. FM Transmitter
2. FM Transmitter, Audio Speakers
3. FM Transmitter, Pamphlet Dropper
4. FM Transmitter, Audio Speakers, Pamphlet Dropper

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DESIGN APPROACH

- Implement mature open source technologies where possible to minimize risk
- Design and produce as many components as possible to reduce dependencies on outside resources
  - Reduces risk for future change
  - Reduces procurement costs
- Allows greater customizability to meet customer's future needs

3D DESIGN

Using 3d scanners to get accurate CAD data of the Phantom 4, Space Coast Unmanned designed integrated payload modules.

3D SCAN Phantom 4 UAV

FM Transmitter/Computer

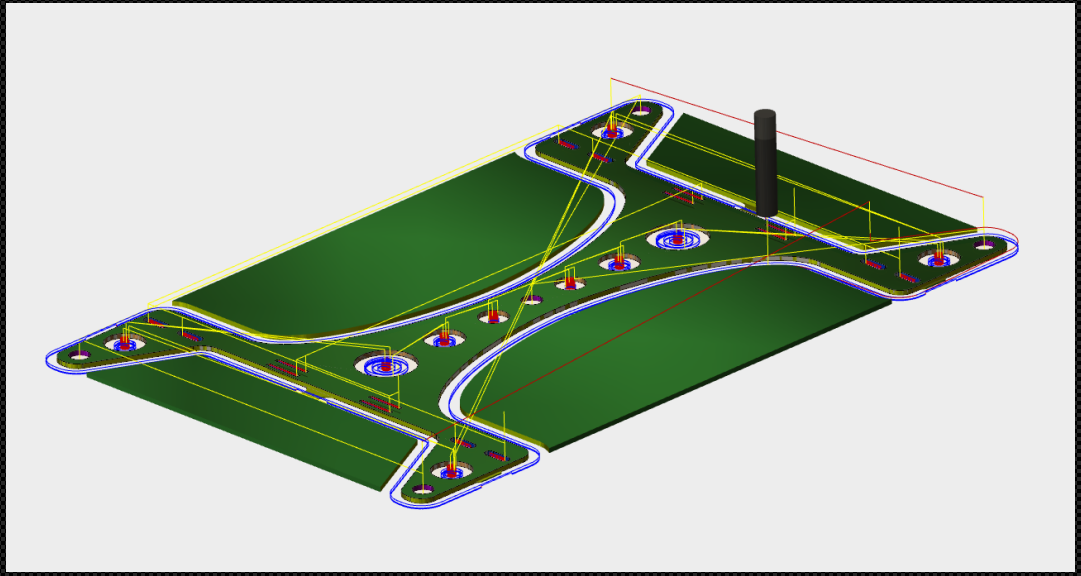
Leaflet Dropper

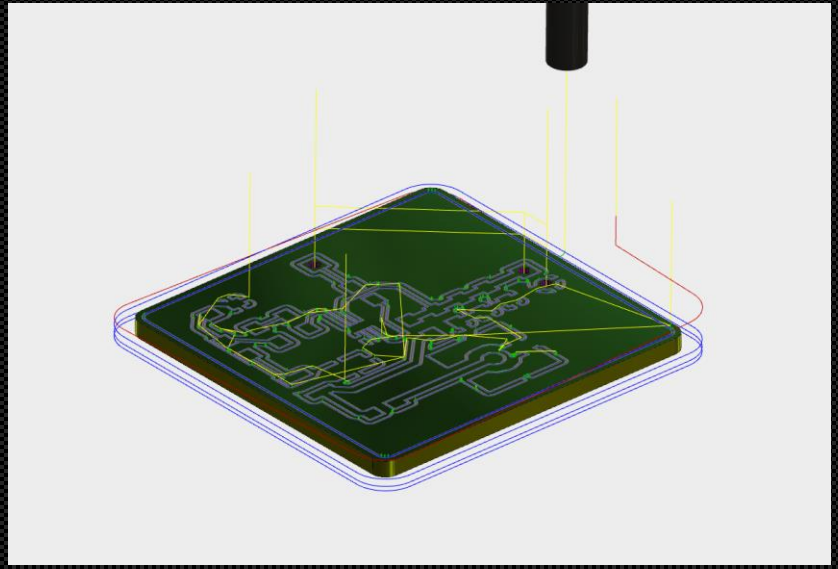
Loud Speaker

ALL IN ONE SOLUTION

MANUFACTURING

- All custom components were designed and manufactured by Space Coast Unmanned, saving time and cost.





ATTACHES WITHOUT PERMANENT MODIFICATION

- Light Sensor
  - Attaches in place of friction fit clear lens cap for forward LED using velcro
- Pamphlet Dropper/Speaker module
  - Attaches to right side of Phantom landing gear using Velcro
- Raspberry Pi/FM transmitter/Audio amplifier/Battery module
  - Attach to left side of Phantom landing gear using Velcro
- Landing gear standoff attaches to landing gear using Velcro
- <u>No permanent modifications required</u>

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CONTROL USING DJI FUNCTIONALITY

- A light sensor module was designed that simply replaces the clear lens cap on one of the forward lights
  - Simple design using only 3 passive components, highly reliable with minimal cost
- Attaches via Velcro for quick modification

AUDIO OUTPUT

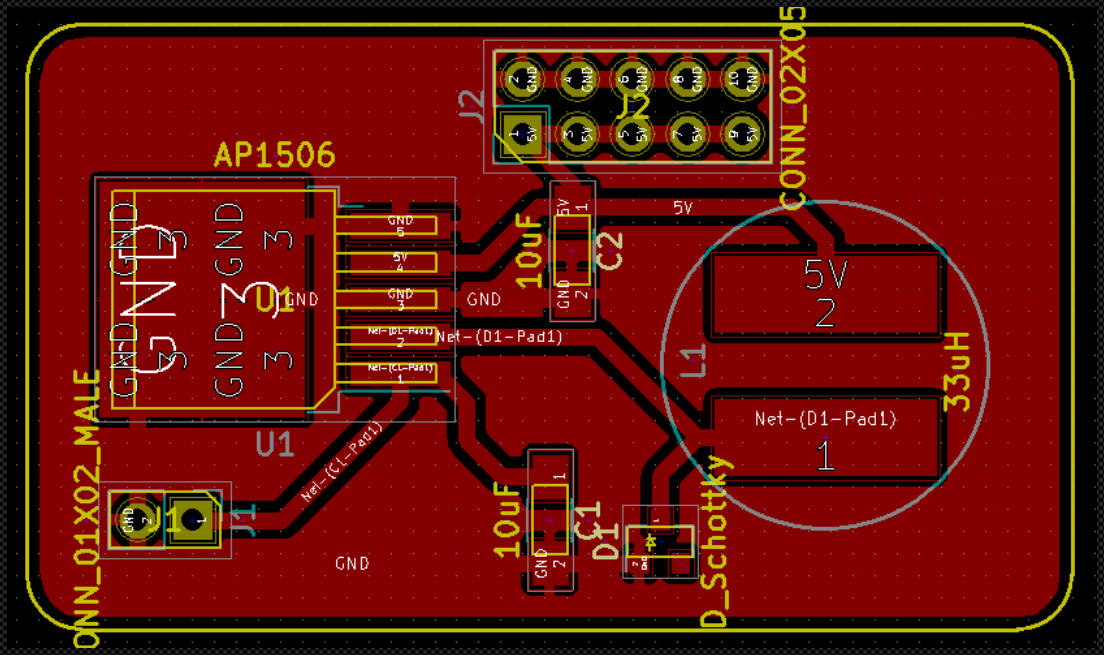
- Off the shelf audio amplifier from Adafruit was leveraged to minimize development time and risk
  - Uses Texas Instruments TPA2016D2 chip
  - Example code provided, along with schematics
  - Future versions can be made without purchasing unit from Adafruit for cost savings
- Class D operation is ~90% efficient, allowing longer battery life while maintaining higher output volume

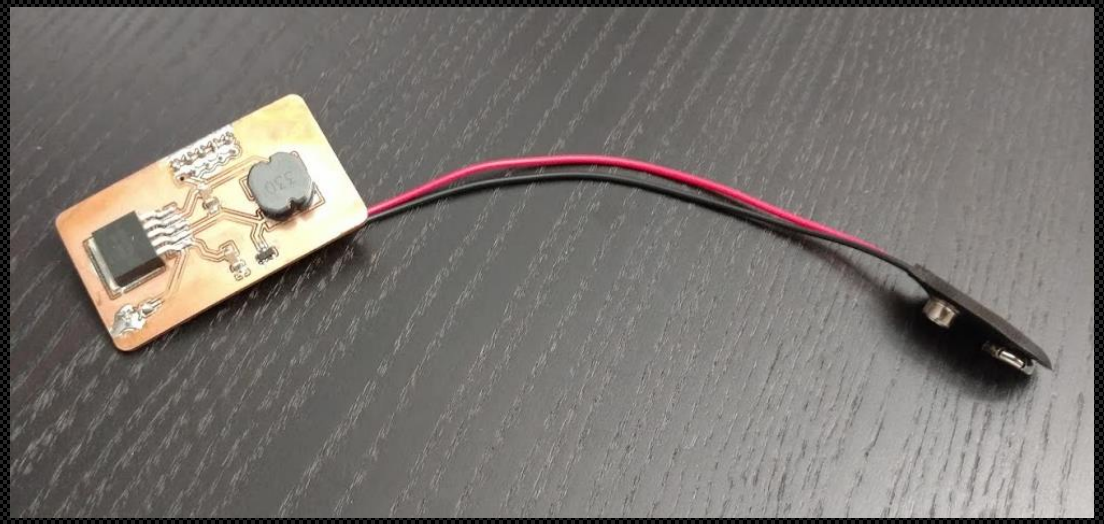
COMPUTING NODE

- Raspberry Pi was chosen for:
  - Processing power
  - Linux OS allows GNURadio compatibility
  - Small form factor
  - Low cost
  - Large pool of resources available online

POWER SUPPLY

- Using high efficiency AP1506 5V 3A DC-DC Switching power supply
  - ~85% efficiency at 9V input
- Module designed, built, and tested successfully



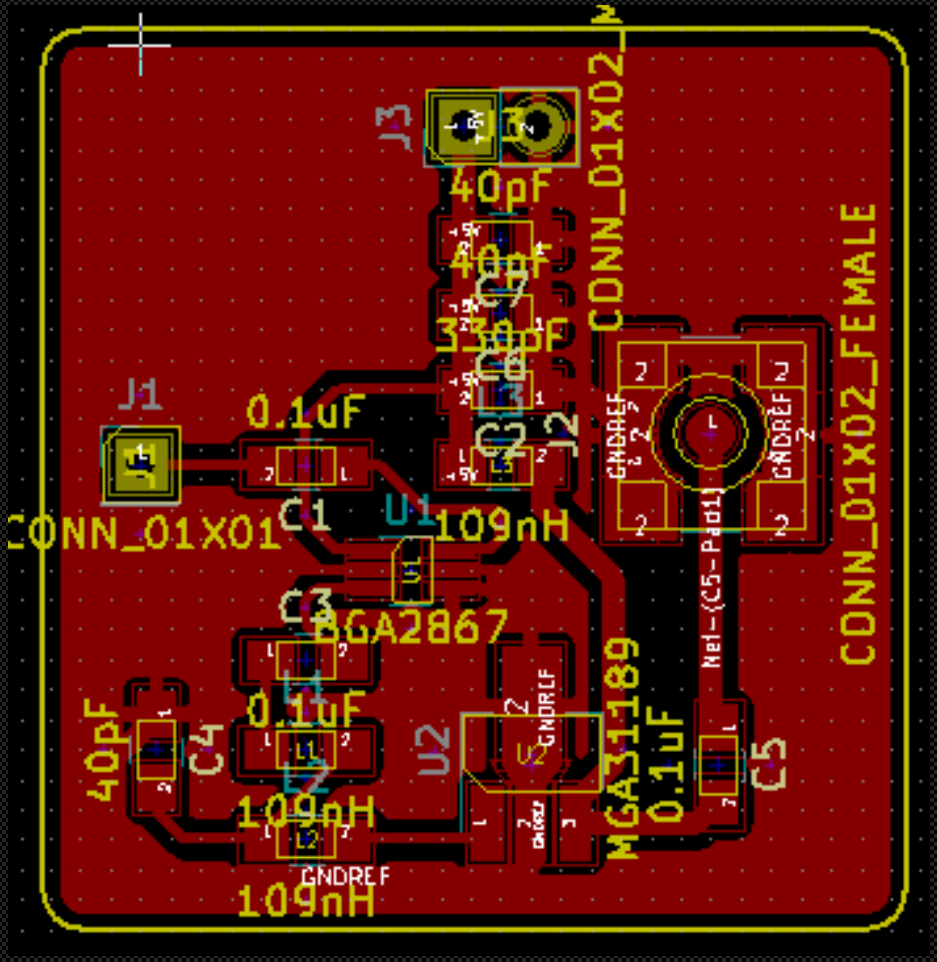


FM TRANSMITTER

- Off the shelf FM transmitter from Adafruit was leveraged to minimize development time and risk
  - Uses Silicon Labs SI4713 chip
  - Example code provided, along with schematics
  - Future versions can be made without purchasing unit from Adafruit for cost savings
- SI4713 does not meet Airspew challenge output power requirements
  - Requirement of 24dBm (250mW) exceeds FCC regulation maximum of 0.01µW
  - https://www.fcc.gov/media/radio/low-power-radio-general-information
  - https://apps.fcc.gov/edocs_public/attachmatch/DOC-297510A1.pdf
- Space Coast Unmanned has designed but not built a high power RF amplifier that will meet desired power output

RF AMPLIFIER DESIGN

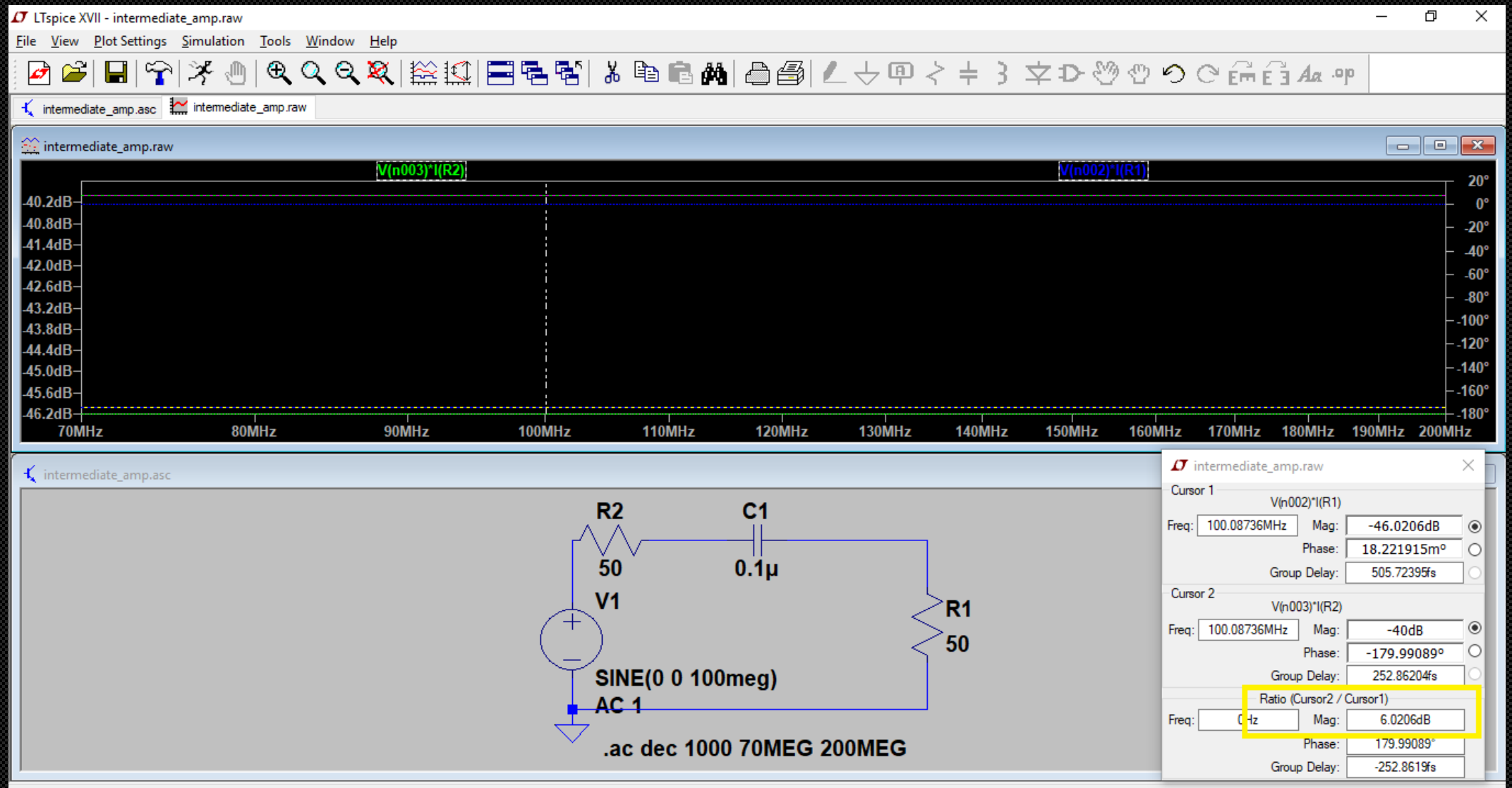
- A two stage amplifier was designed using SPICE simulation
  - Schematics available at Space Coast Unmanned's Github repository
- Accounting for losses, theoretical output is user adjustable between 14dbm and 41dbm
  - WARNING: Significant distortion will occur at output levels over 24dbm and damage is likely over 28dBm



RF AMPLIFIER STAGE 1

- Using BGA2867 small signal amplifier with internal 50ohm matching. Spice circuit and simulation shows roughly 6dB loss in coupling circuit
  - SI4713 max output of 115dBm is 8dbm
  - Gain of amplifier is 24dB, with 6dB loss max output of first stage is ~26dBm, but chip is only rated to 5dBm without significant distortion
  - Recommend not exceeding 94 dBµV setting in Si4713 Power parameter

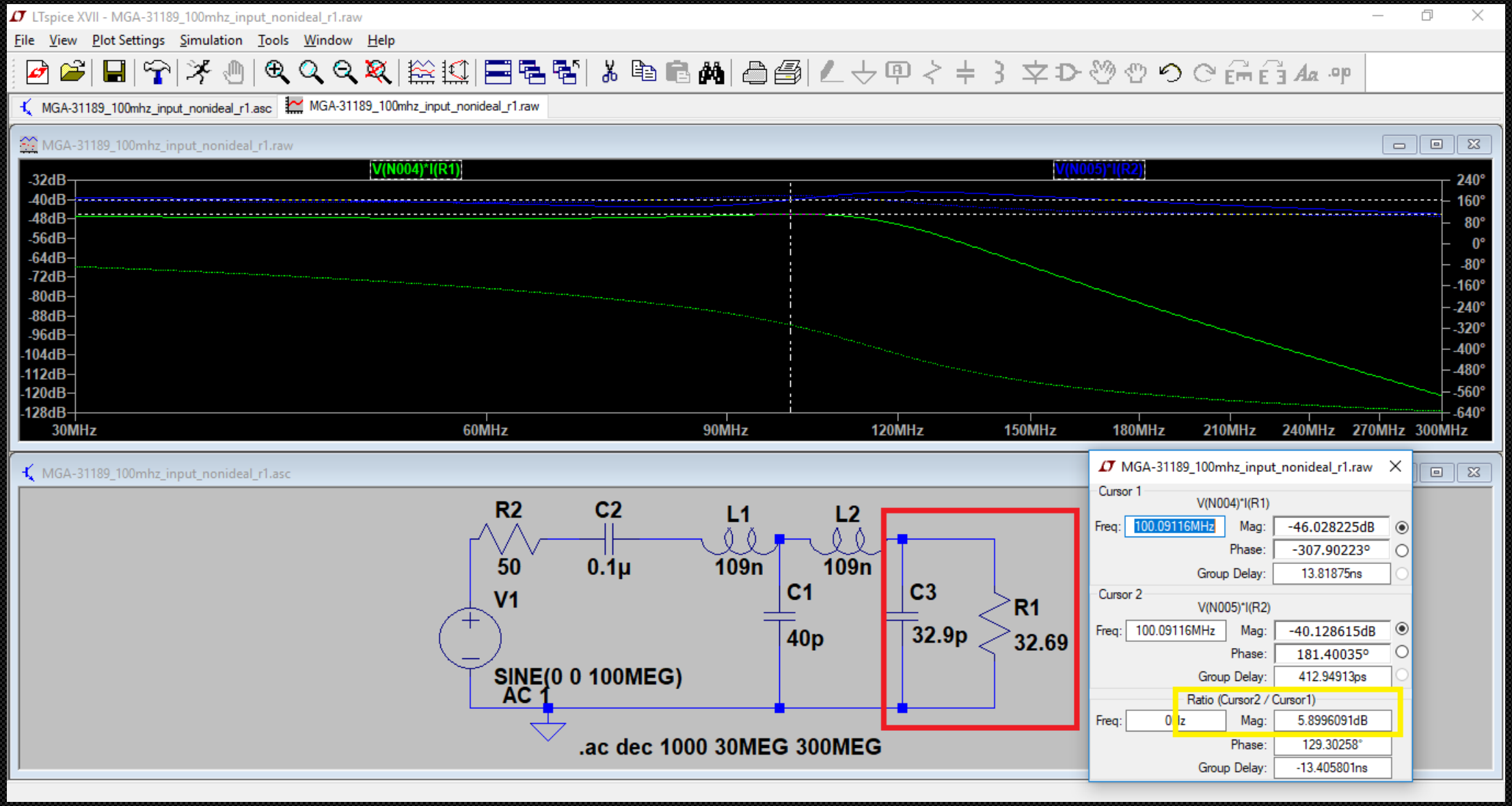
RF AMPLIFIER STAGE 1 SPICE SIMULATION



RF AMPLIFIER STAGE 2

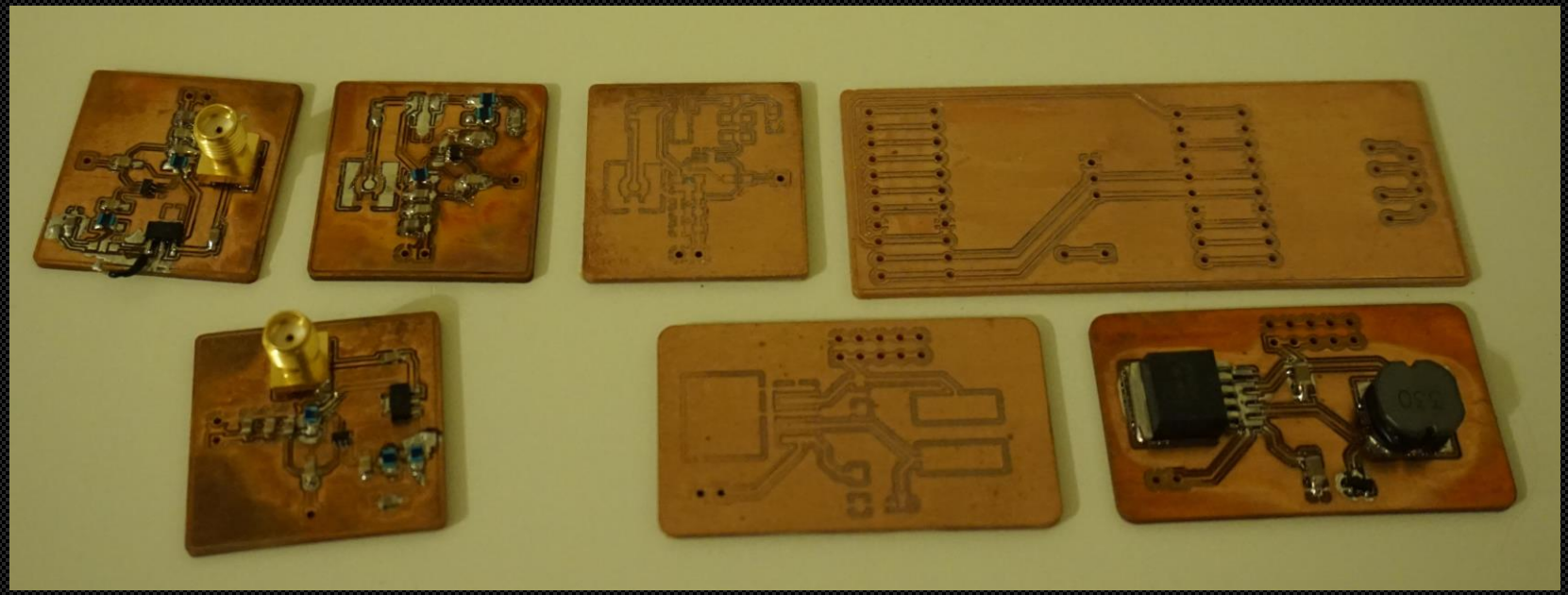
- Using MGA-31189 chip that is rated to 24dBm output without significant distortion
  - Component is not internally matched, and needs matching circuit
  - 21dB of gain, 5.8dB loss from matching circuit. Theoretical max output of total FM Transmitter is 41dBm (12.6W).
    - WARNING: This is a significant power level and will destroy components. It is not recommended to go higher than 26dBm output.

RF AMPLIFIER STAGE 2 SPICE SIMULATION



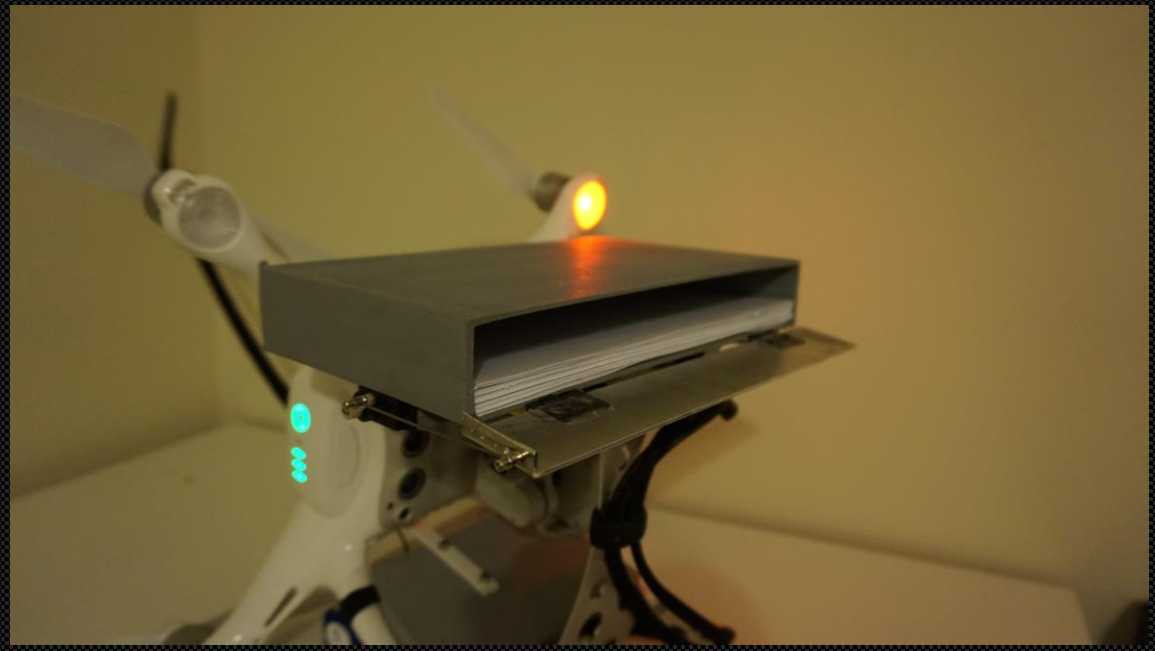
RF AMPLIFIER FABRICATION

- Several boards were fabricated, populated, and soldered
- Due to extremely small tolerances, we were unable to produce an electrically correct completed assembly



PAMPHLET DROPPER

- Tested to 1 pound pamphlet capacity
- Single servo control
- Releases all pamphlets at once in accordance with clarification provided during Q&A session
- Attaches using Velcro for non-permanent mounting
- Does not interfere with side, forward, aft and even the downward facing sensors



COST

- The development of all the components for the three modules keeps the cost to a minimum.
- Purpose built components ensure the end product is highly efficient at the lowest cost possible.

SPACE COAST UNMANNED'S SOLUTION

Offers a system that:

- ✓ Attaches to a DJI Phantom 4 without permanent modification
  - ✓ Remote activation using built in DJI functionality
- ✓ Plays audio output via speaker system
- ✓ Can easily incorporate Software Defined Radio
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- ✓ Drops one pound of pamphlets

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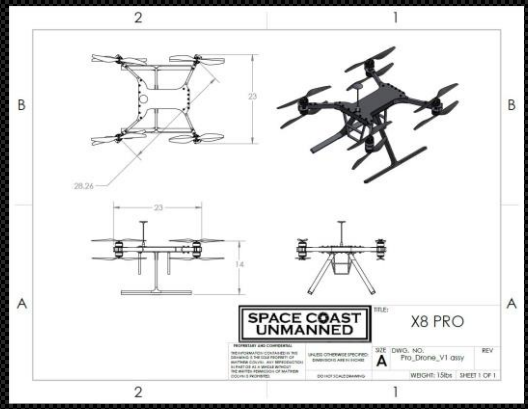
FUTURE IMPROVEMENTS

- SWAP(Size, Weight and Power): Space Coast Unmanned would do further research and development to lower the weight of modules.
- Audio Volume: develop a speaker module that produce louder sound.
- Space Coast Unmanned would like to discuss developing a purpose built UAV platform that can utilize all three payloads in an integrated package with higher endurance and greater control functionality.



RESOURCES

- This presentation, along with the User Manual and circuit schematics can be found at our Github repository:
- https://github.com/Space-Coast-Unmanned/AirSpew