TEAM SPACE COAST UNMANNED AIRSPEW CHALLENGE

MATTHEW COLVIN, JAMES TOLSON

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

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
- 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

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
- No permanent modifications required

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

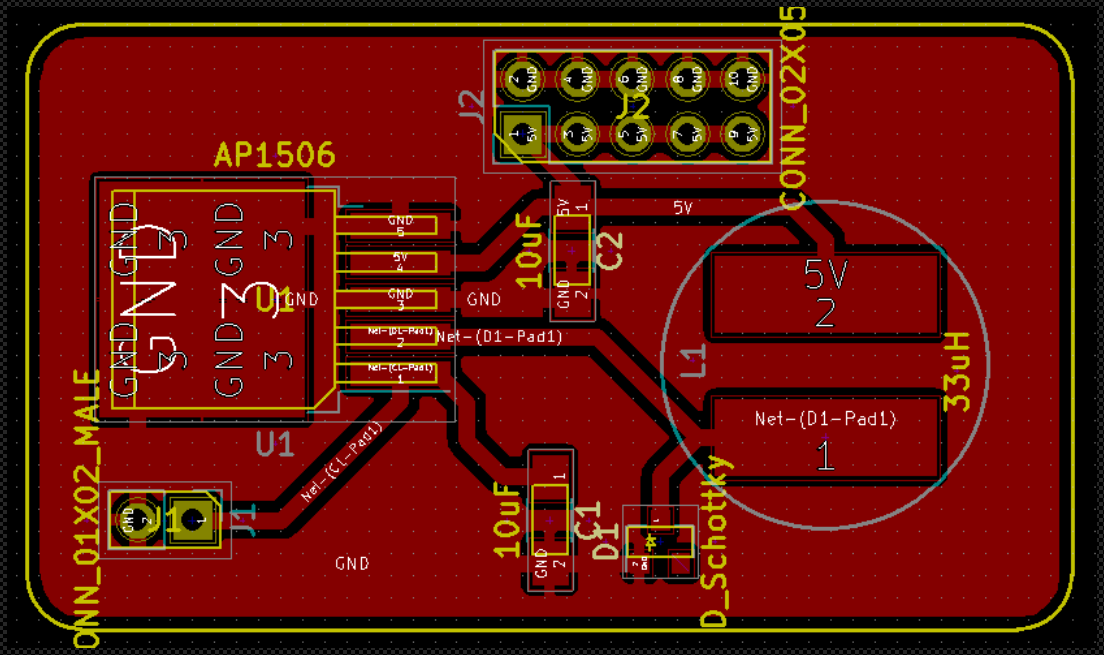
- Off the shelf audio amplifier from Adafruit was leveraged to minimize development time and risk
  - Uses Texas Instruments TPA2016D2 chip
  - Example code provided, along with schematics
  - Future versions can be made without purchasing unit from Adafruit for cost savings
- Class D operation is ~90%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

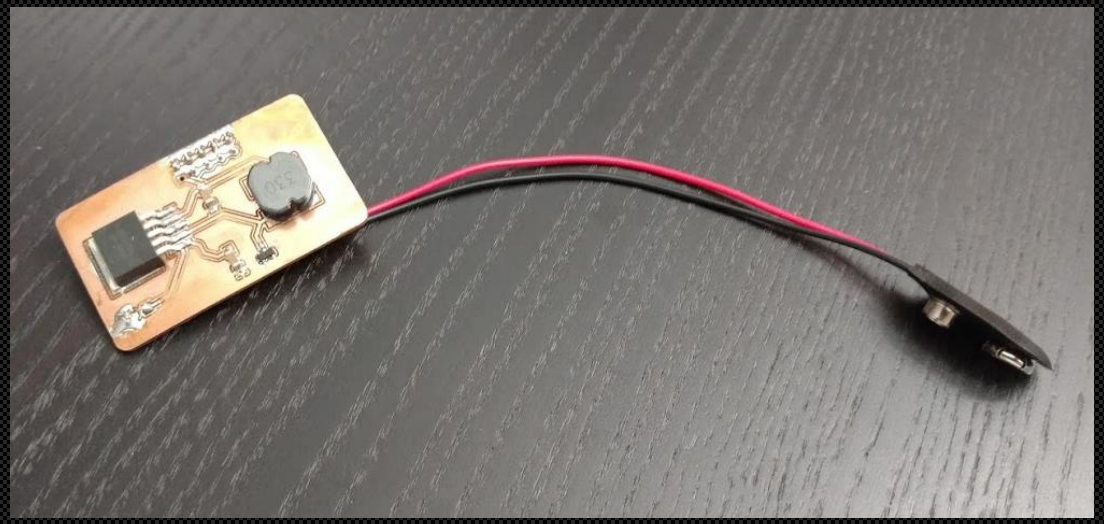
COMPUTING NODE

- 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



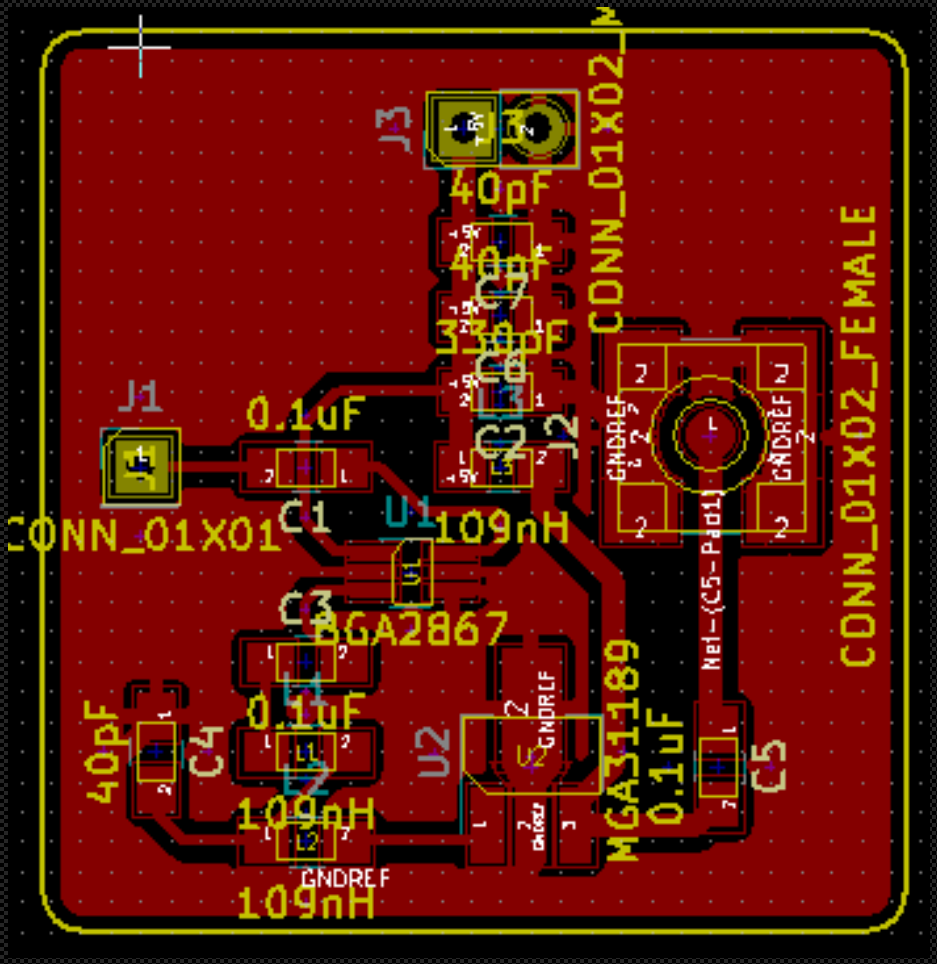


FM TRANSMITTER

- 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

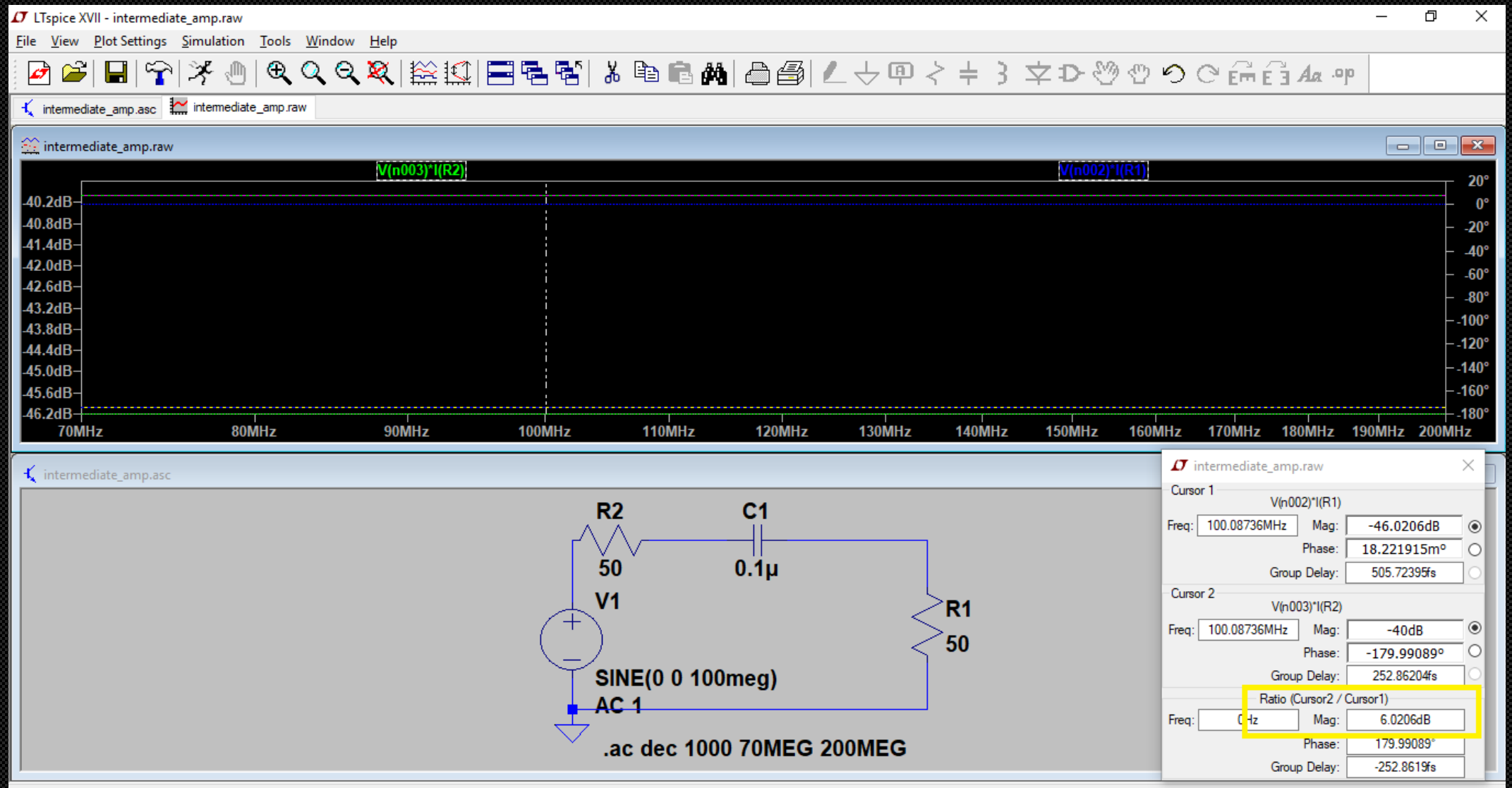
- A two stage amplifier was designed using SPICE simulation
  - Schematics available at Space Coast Unmanned's Github repository
- Accounting for losses, theoretical output is user adjustable between 14dbm and 41dbm
  - WARNING: Significant distortion will occur at output levels over 24dbm and damage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

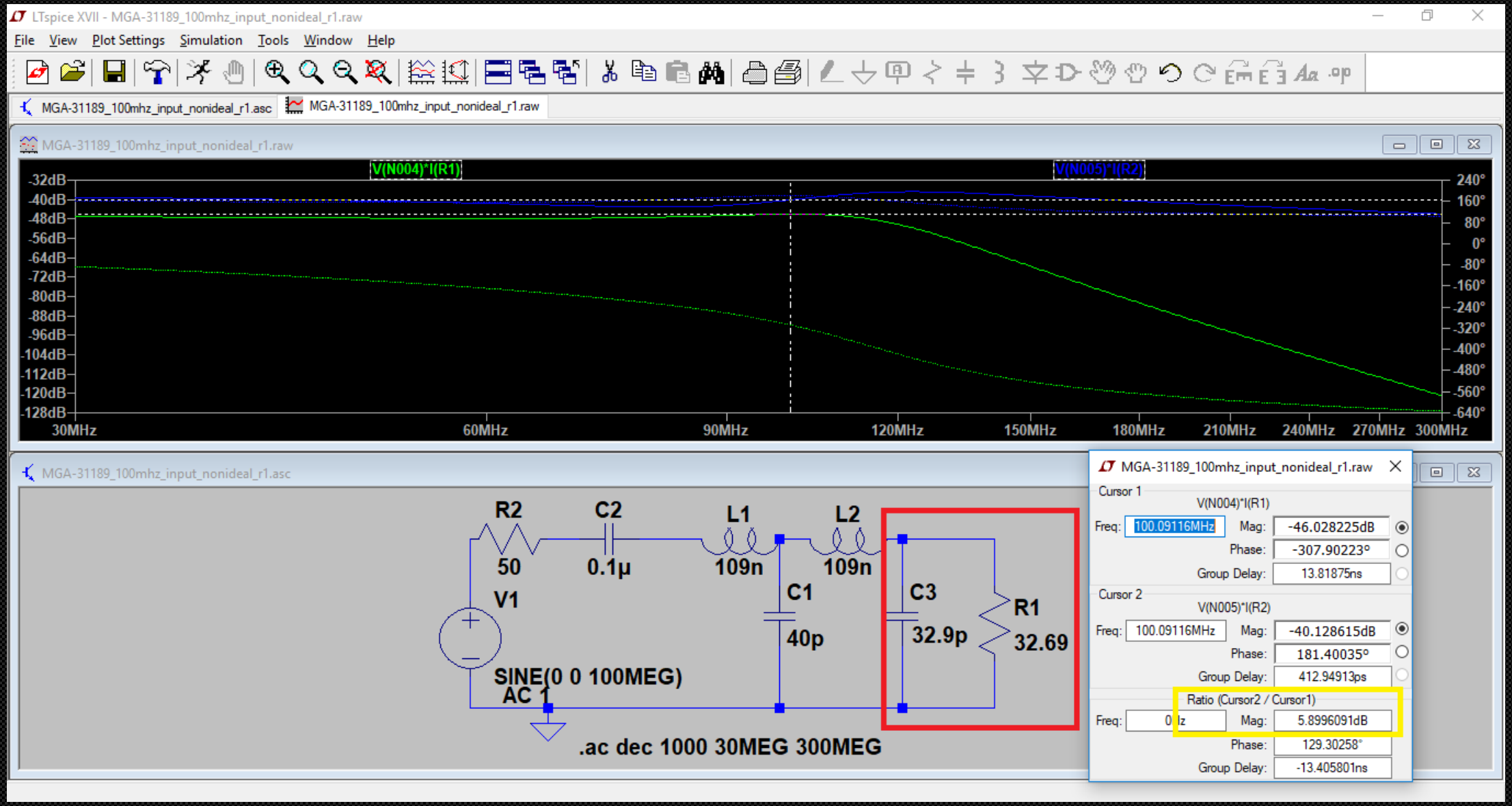
RF AMPLIFIER STAGE 1 SPICE SIMULATION



RF AMPLIFIER STAGE 2

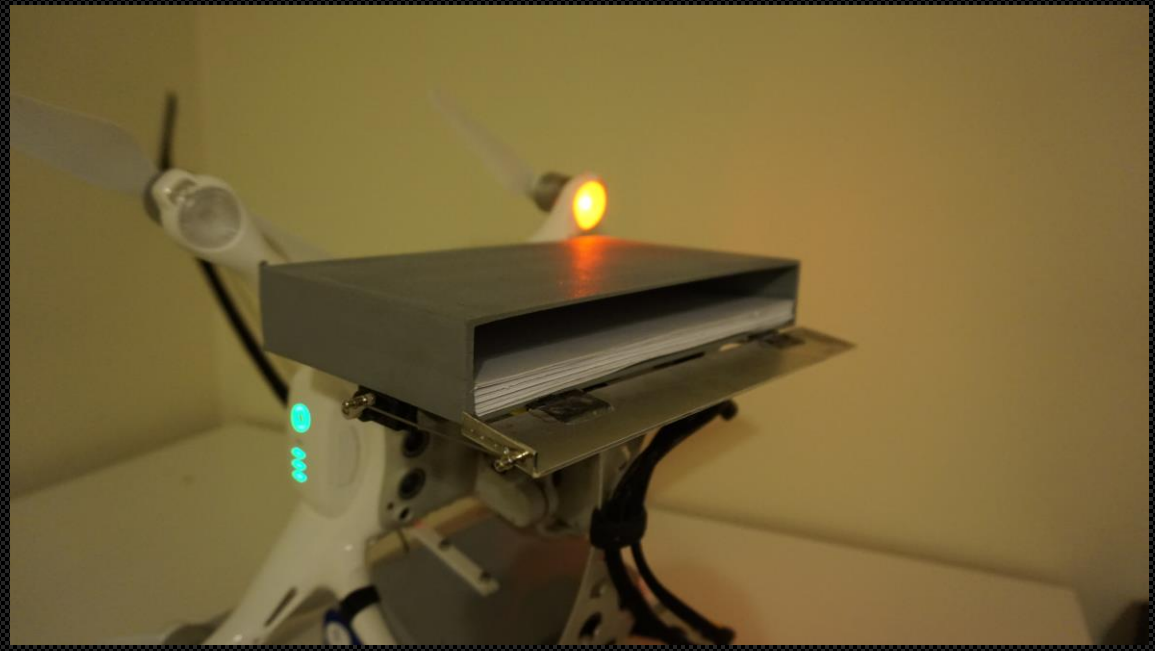
- Using MGA-31189 chip that is rated to 24dBm output without significant distortion
  - Component is not internally matched, and needs matching circuit
  - 21dB of gain, 5.8dB loss from matching circuit. Theoretical max output of total FM Transmitter is 41dBm (12.6W).
    - WARNING: This is a significant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

RF AMPLIFIER STAGE 2 SPICE SIMULATION



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



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
  - ✓ Radio transmission in FM frequency
  - ✓ GNURadio compatible
- ✓ Drops one pound of pamphlets