Open-Source Antenna Pattern Measurement System

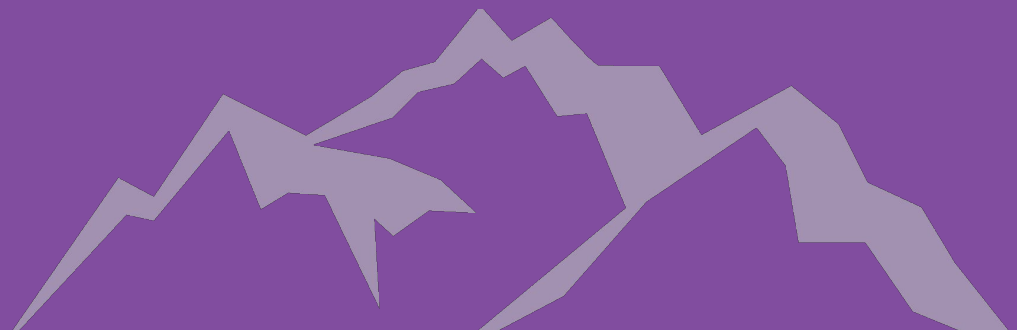
SDR-based Student Research and Development

1 | Background
Phase 1: 2018-2019
Phase 2: 2021-2022

2 | Application
3 Antennas Under Test

3 | Upgrades
Hardware
Software
Raspberry Pi

4 | Future Work
Upcoming
Summary

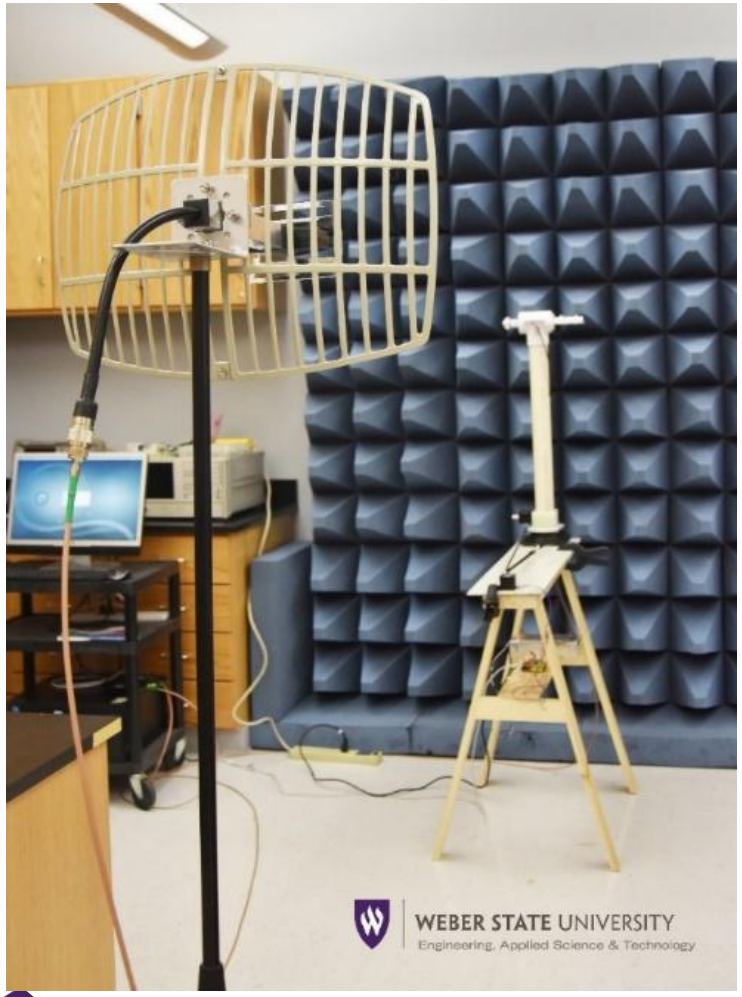


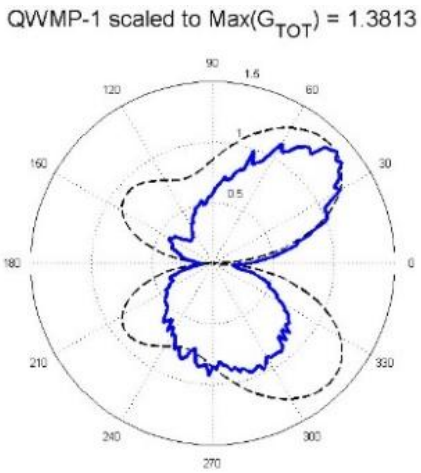
1 | Background : Objectives

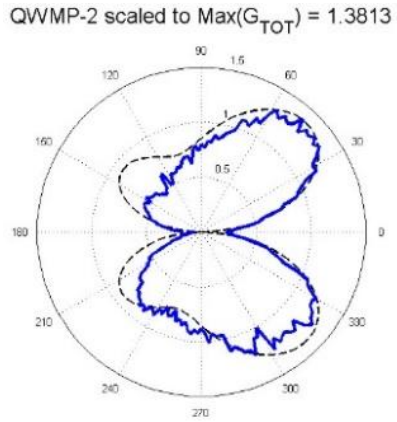
- A low-cost open source antenna pattern measurement system based upon an IEEE paper* was modified to incorporate:
  - Software-defined radios
  - Arduino microcontroller
  - Commercial hardware
  - Custom-made parts using 3-D printer technology
- The system is low-cost and accessible allowing future student projects to experiment with communication theory topics and hardware
- Outreach & loan/collaborates with other universities

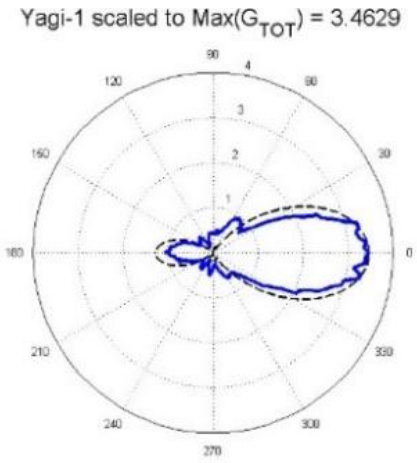
*Picco & Martin, “An Automated Antenna Measurement System Utilizing Wi-Fi Frequency” (IEEE A & P Magazine, Dec 2011)

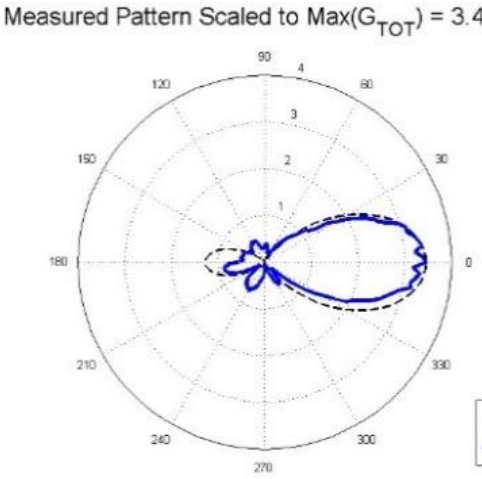
1 | Background : Utah NASA Space Grant I (2018-2019)











Figs 1. Version 1 in laboratory with normalized principal patterns of QWMP and Yagi prototypes

1 | Background : Coherent AM Detection

- Hack RF SDRs
- Clocks Tied Together
- New Mast Base
- Asymmetric Belts

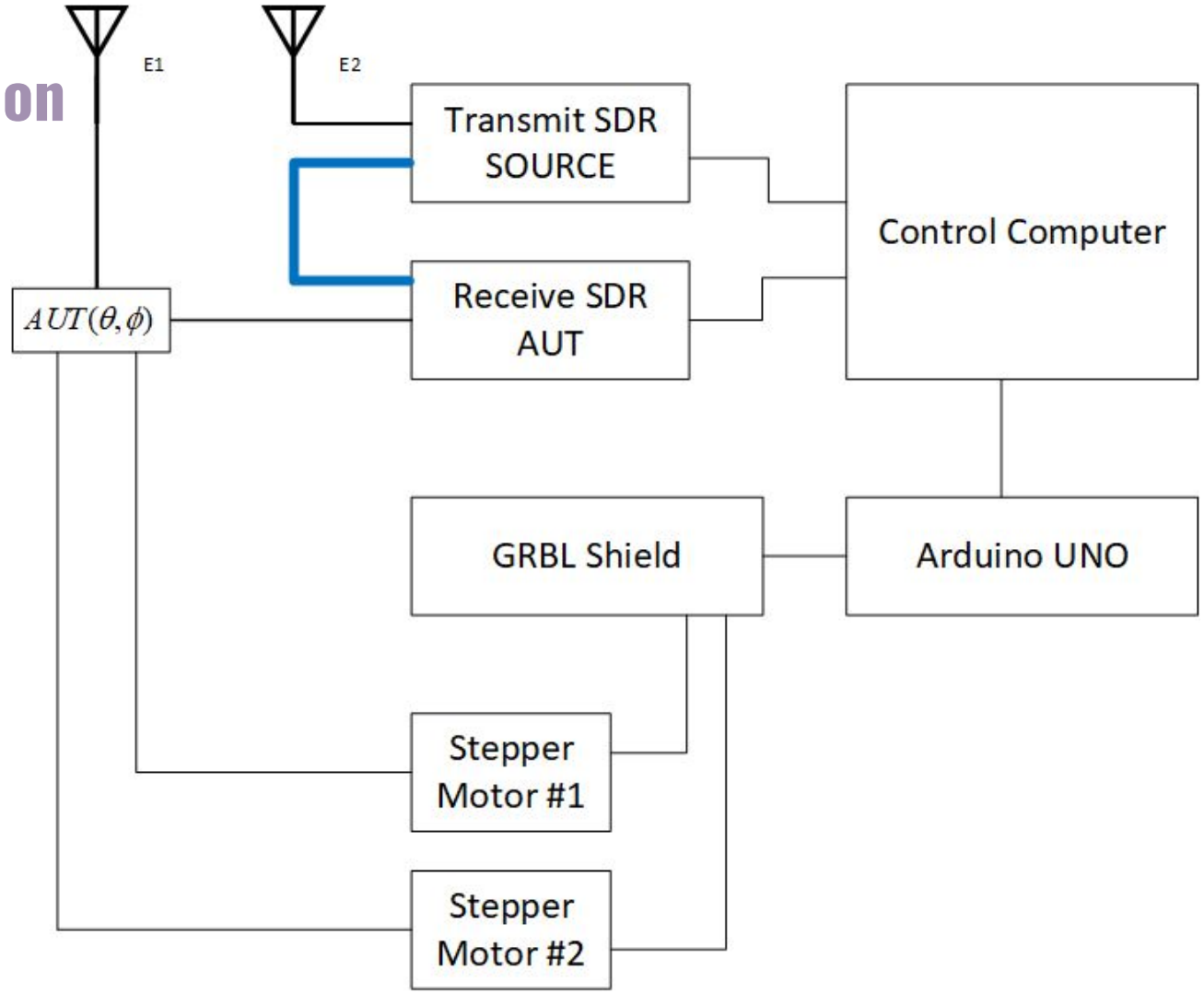


Fig. 2. Clock Synchronization between Tx and Rx software radios

1 Background : Coherent AM Signal Simulation

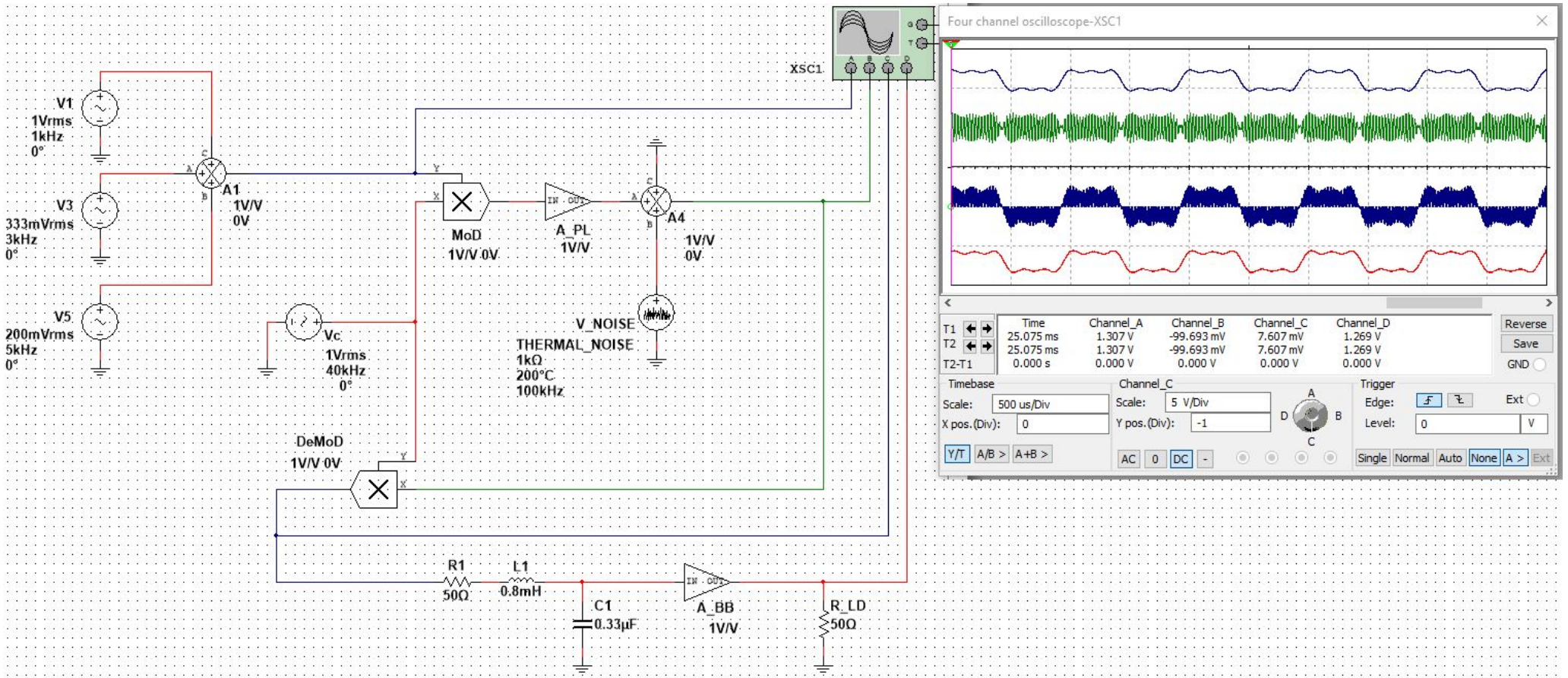
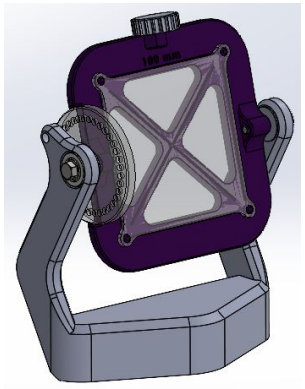
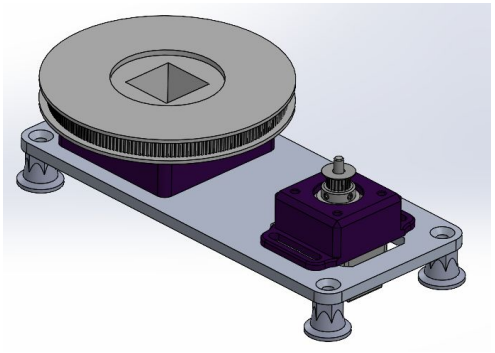
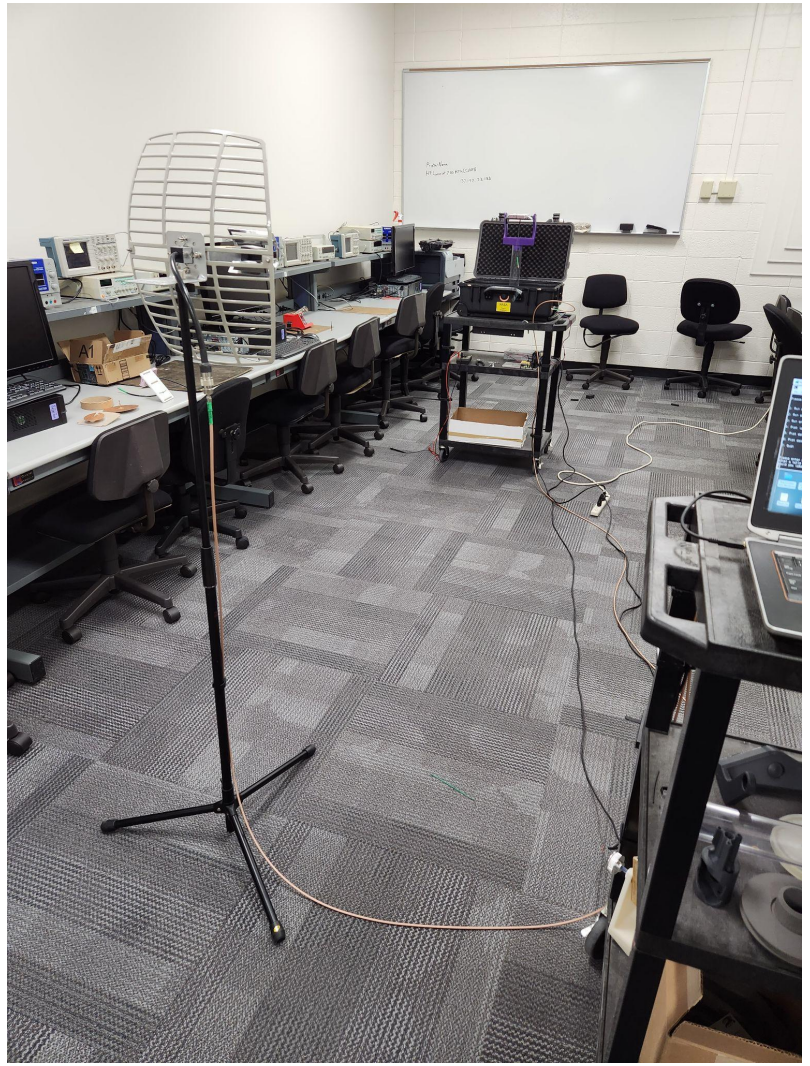


Fig. 3. Multisim illustration of Coherent AM signal MOD/DeMOD

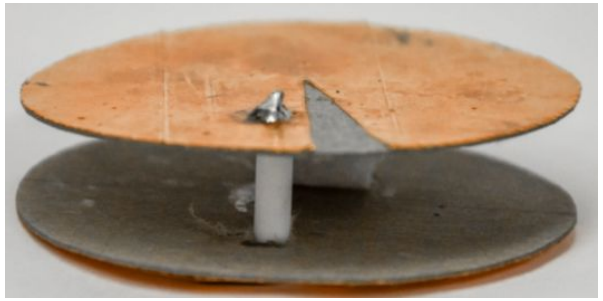
1| Background : Utah NASA Space Grant II (2021-2022)

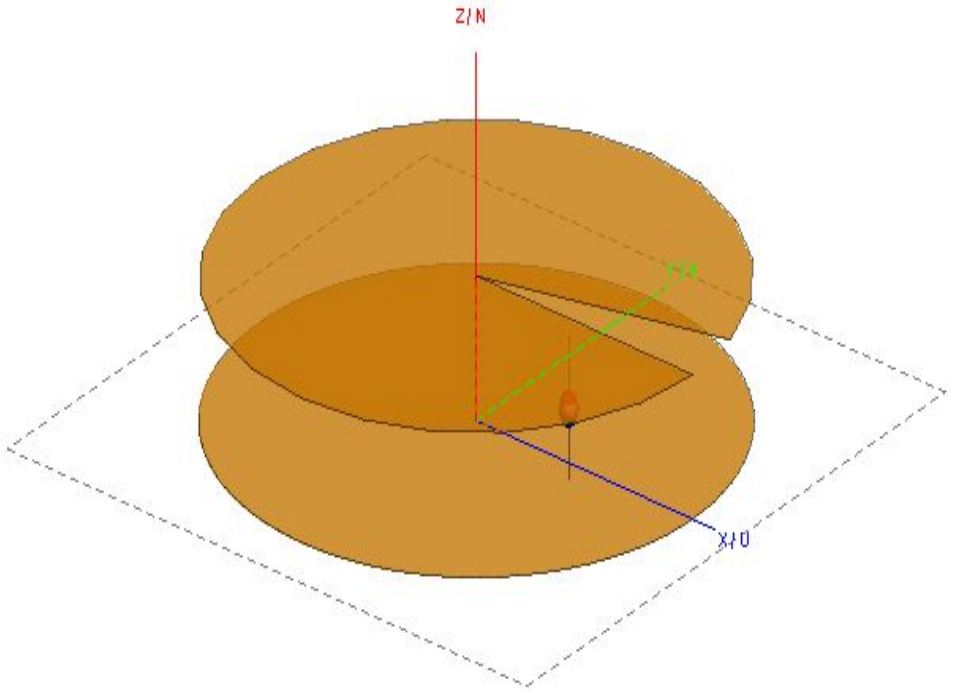


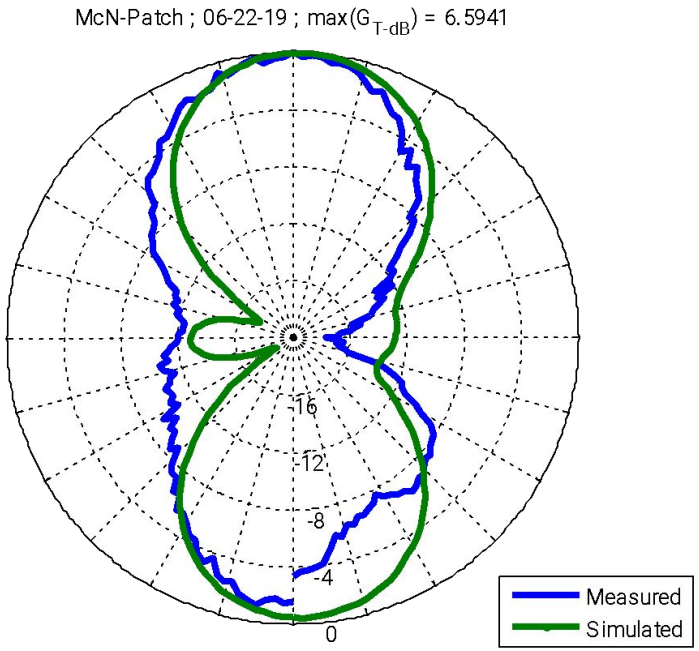




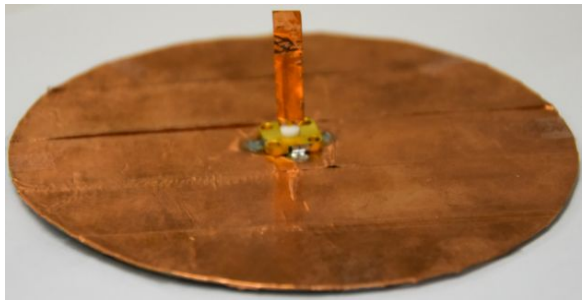
2| Application : Circular Microstrip Patch

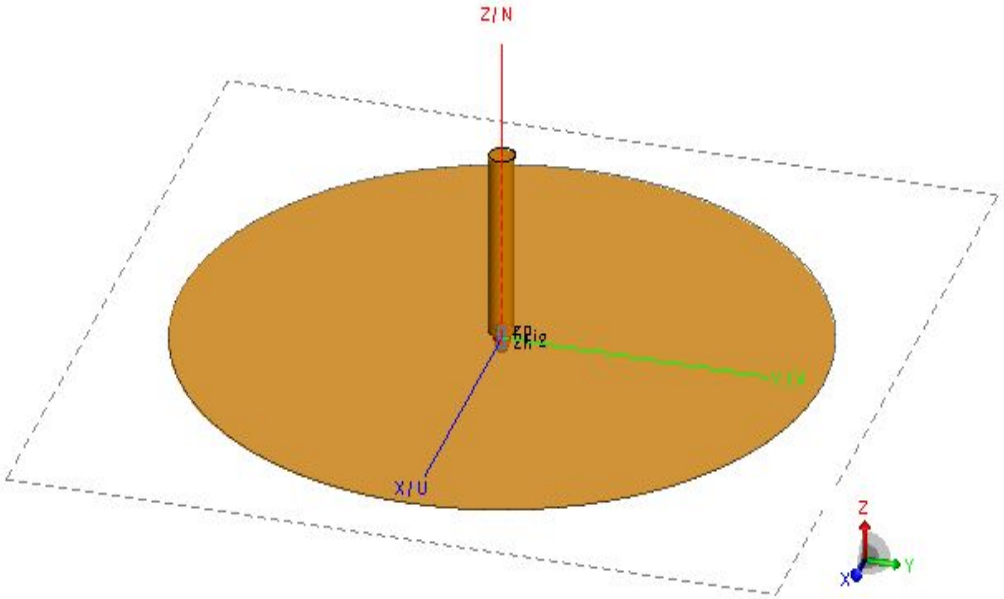


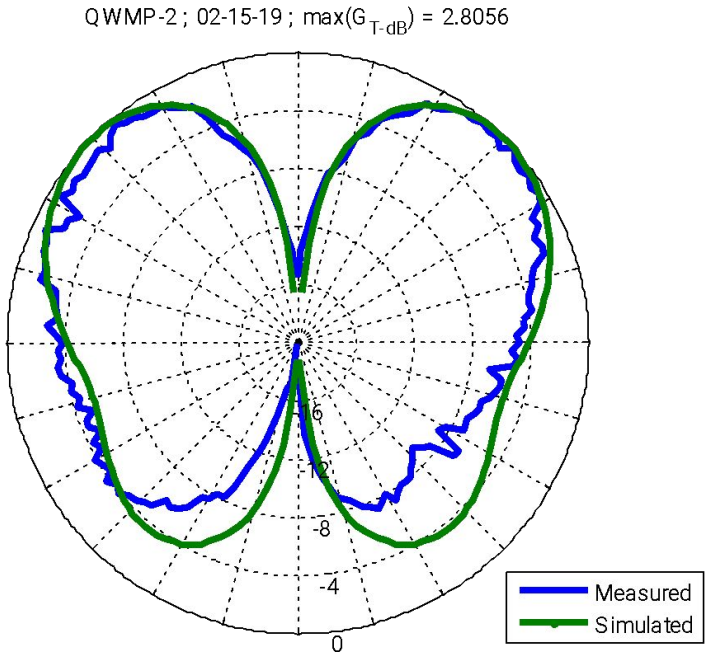




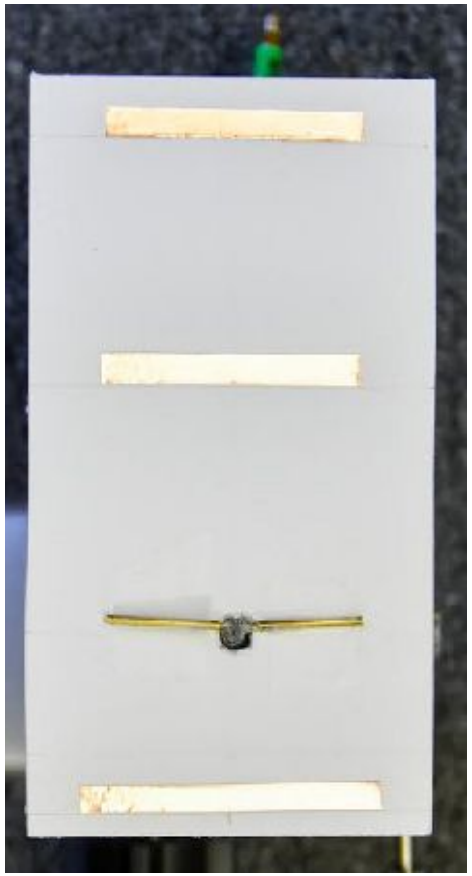
2| Application : Quarter-Wave Monopole

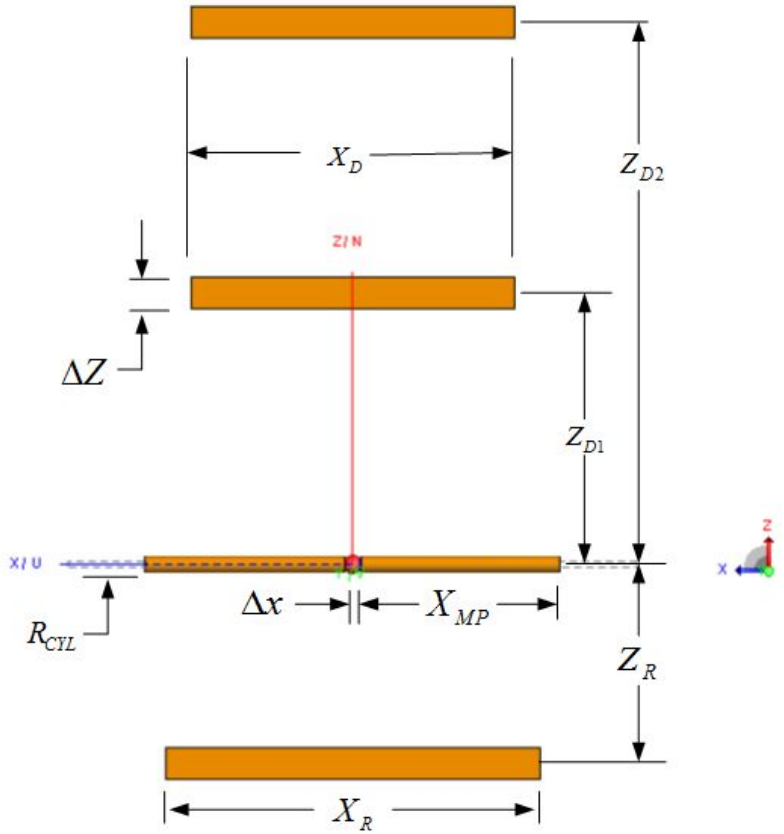


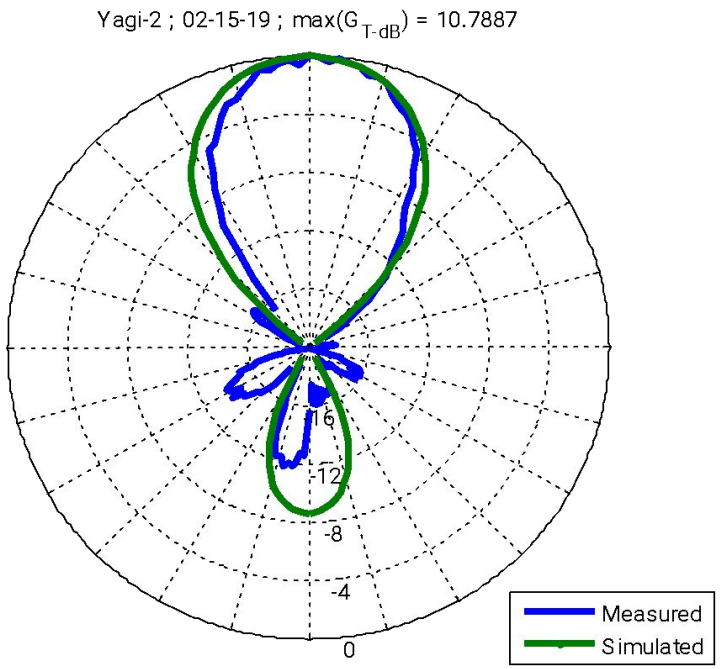




2| Application : Yagi-Uda Prototype



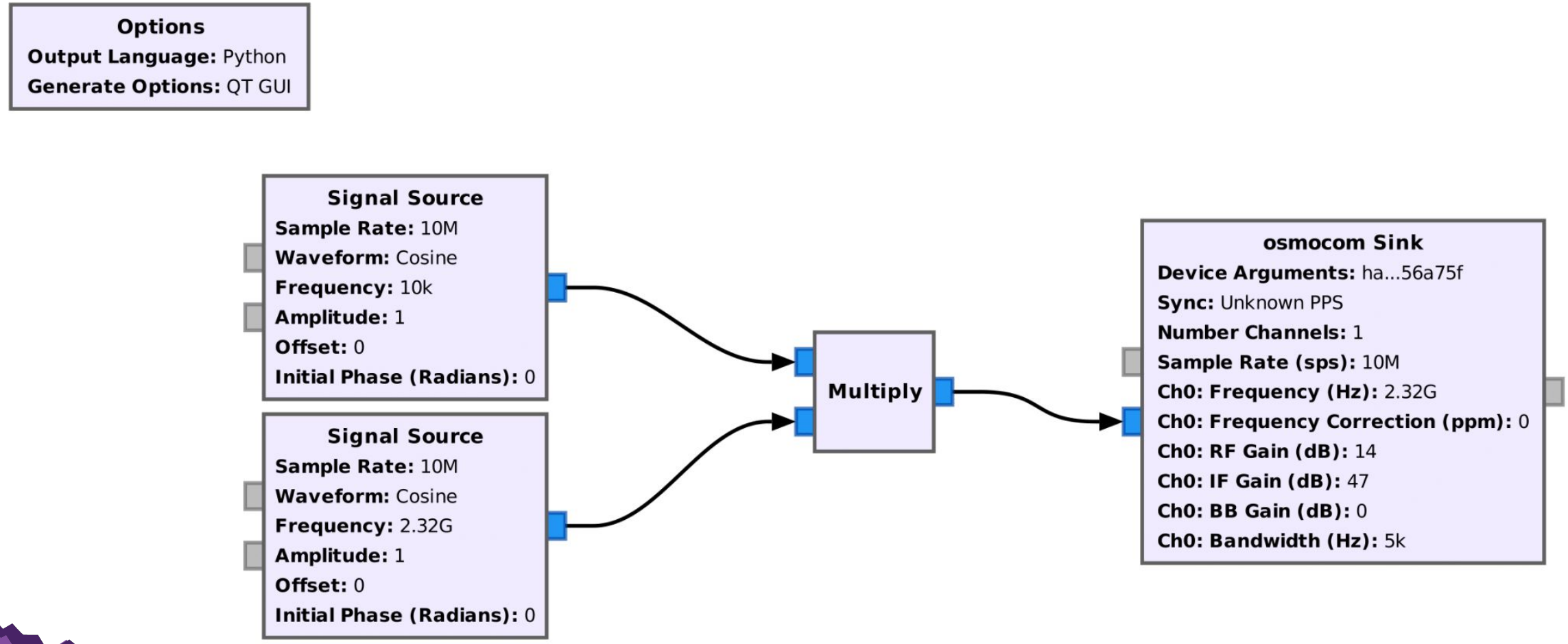




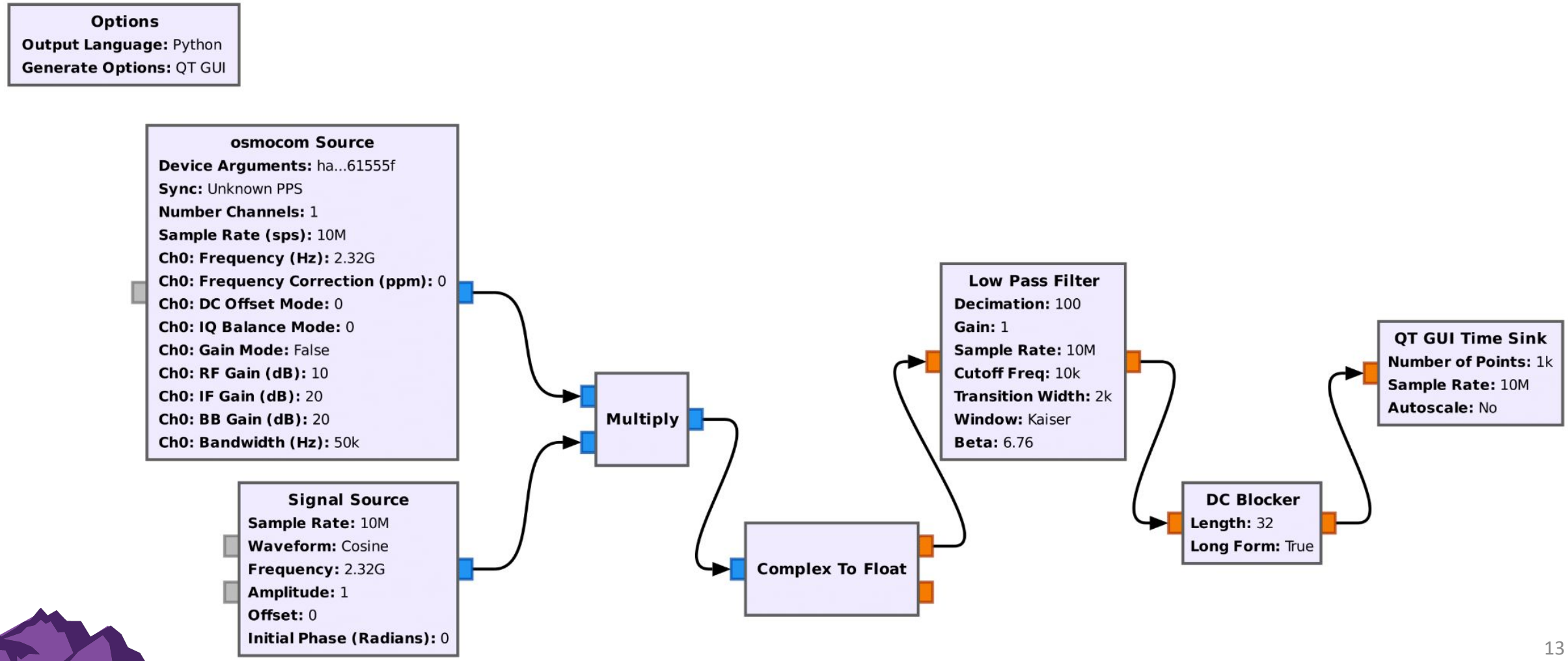
3| Upgrades : Software

- Python:
  - Python 3.6.5 -> Python 3.9
- GNU Radio:
  - 3.7.13.4 -> 3.9.2.0
- Linux:
  - 4.19 -> Debian Bullseye
  - 2018 Release -> 2022 Release
- Raspberry Pi Compatible:
  - Debian Bullseye -> Raspbian
- Motor Controls
  - GRBL Configurations 1.1f

3| Upgrades : GNU: Transmitter Model

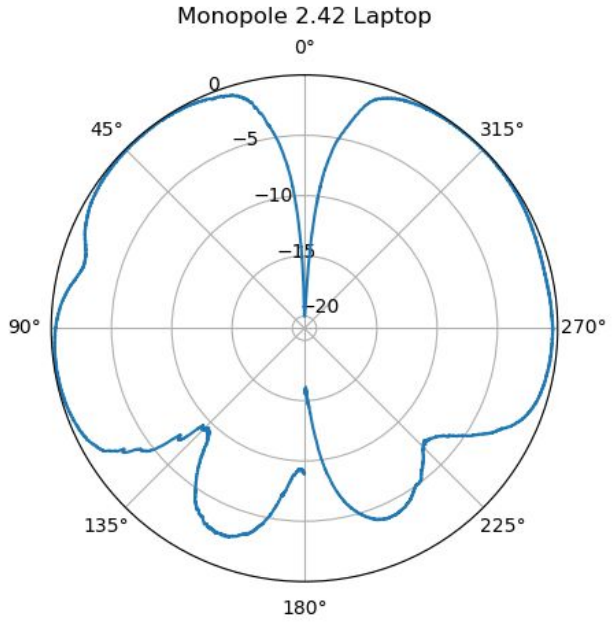


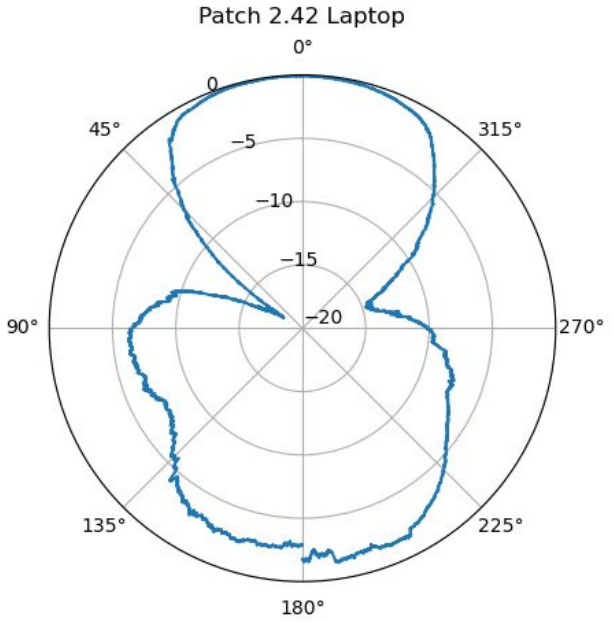
3| Upgrades GNU: Receiver Model



3| Upgrades : Updated Software

- Old Software -> Newest Software
- 64 bit OS and 32 bit
- Multiple Back-ups



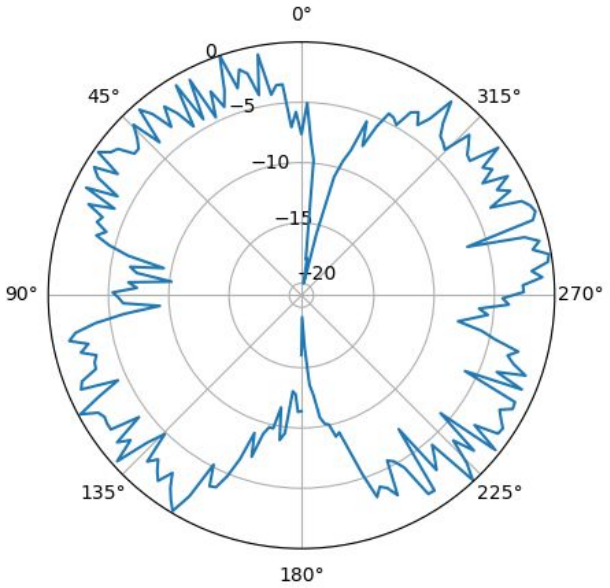


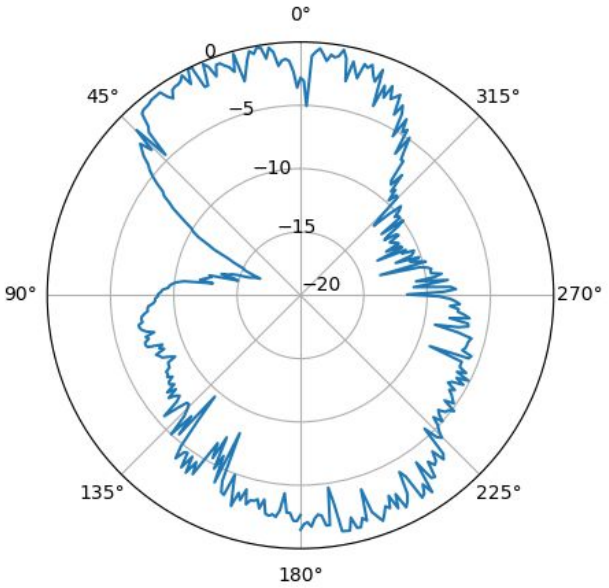
3| Upgrades : Raspberry Pi Integration

- Portable
  - Smaller Battery Packs
- Easily Replicable
  - One Time Setup
  - Micro SD Card
  - No OS installation needed
- Sufficient USB Ports
- Attachable Screens

3| Upgrades : First Attempt, Raspberry Pi 3

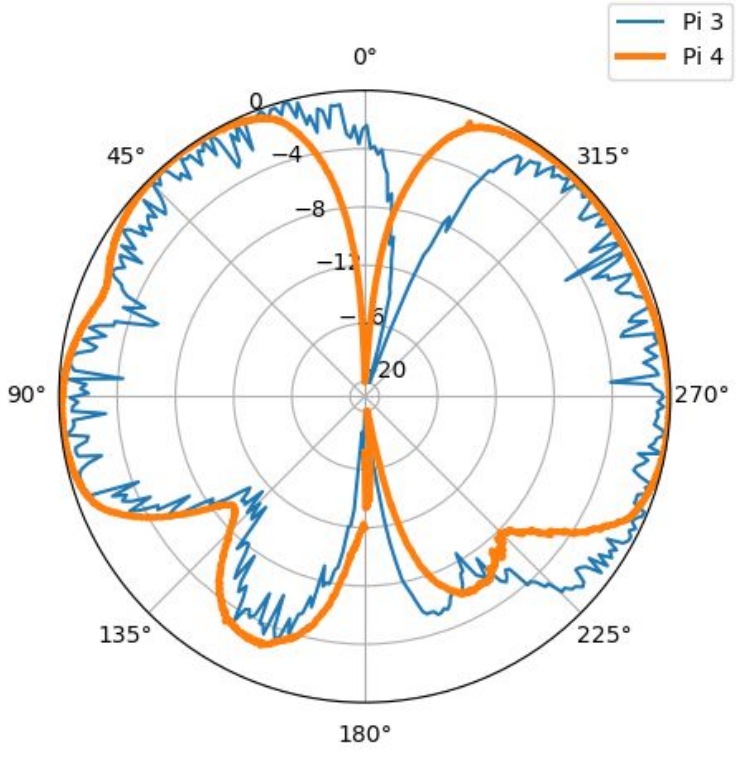
- Very Noisy
- Memory Errors
  - IDE independent
  - “DRI2 Failed to authenticate”

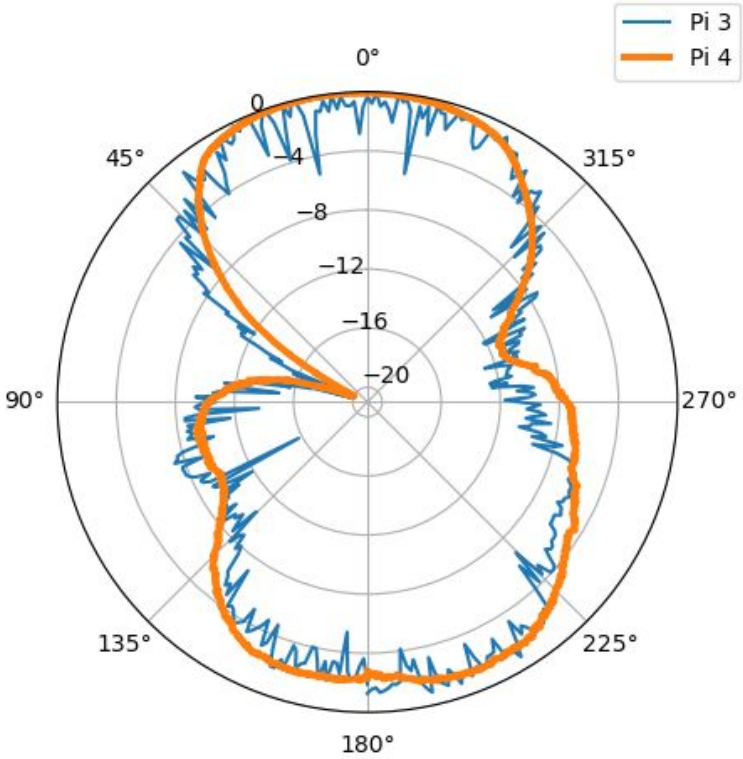




3| Upgrades : Pi 3 Vs Pi 4

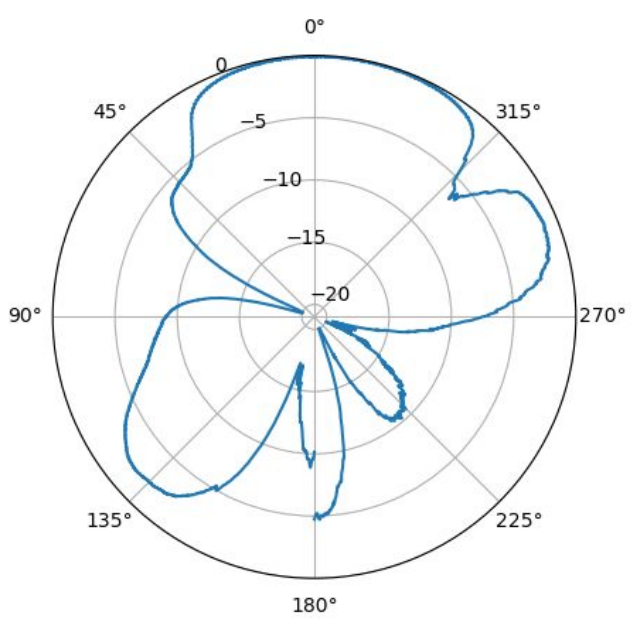
- Consistent Physical Setup
  - Antenna
  - Location
  - Distance
- Consistent Software Setup
  - SD card
  - SDR's
  - Motor Controllers

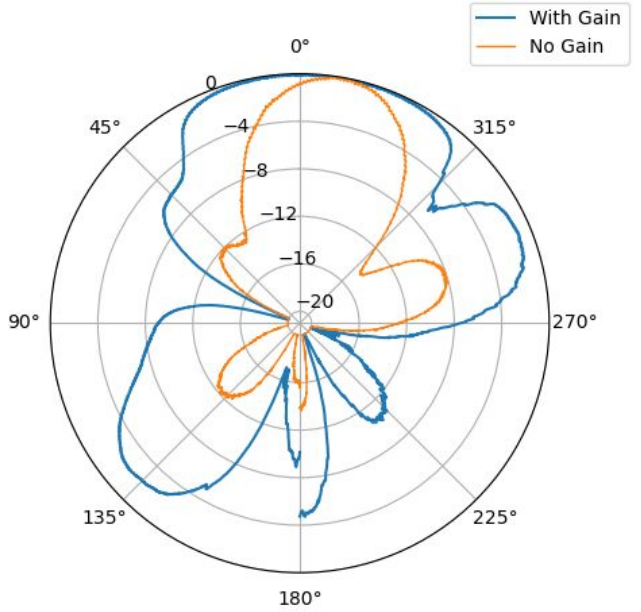




3| Upgrades : Directional Antennas

- Normalized Around Maximum Gain
- Clipping Data
- Physical Distance
- Transmitter Gain:
  - RF Gain: 14 -> 0
  - IF Gain: 47 -> 0





4| Future Work : Potential Projects

- 3-D Pattern Software
- Mechanical Improvements
- Sensors/Error Checking
- Modulation Methods
- Coding/Decoding to Reduce Multipath
- Narrow/Broad-Band Noise Interference Mitigation
- Professional vs Outreach Versions

4| Future Work : Summary

- Open Source - Student Maintained
  - Linux
  - GNU Radio Companion
  - Python
  - Arduino
- Updated Software
- Updated Hardware
- Back Up Motor Controllers
- Measurements in Multiple Locations

4| Acknowledgements

- **Utah NASA Space Grant Consortium**
- Moog Industries
- Weber State
  - Dan Newton
  - Taylor Hansen
  - Ren Fisher
  - Christian Hearn
  - Justin Knighton

Questions?