A FLEXIBLE, AFFORDABLE, POWERFUL DIGITAL TRANSCEIVER FOR THE RASPBERRY PI

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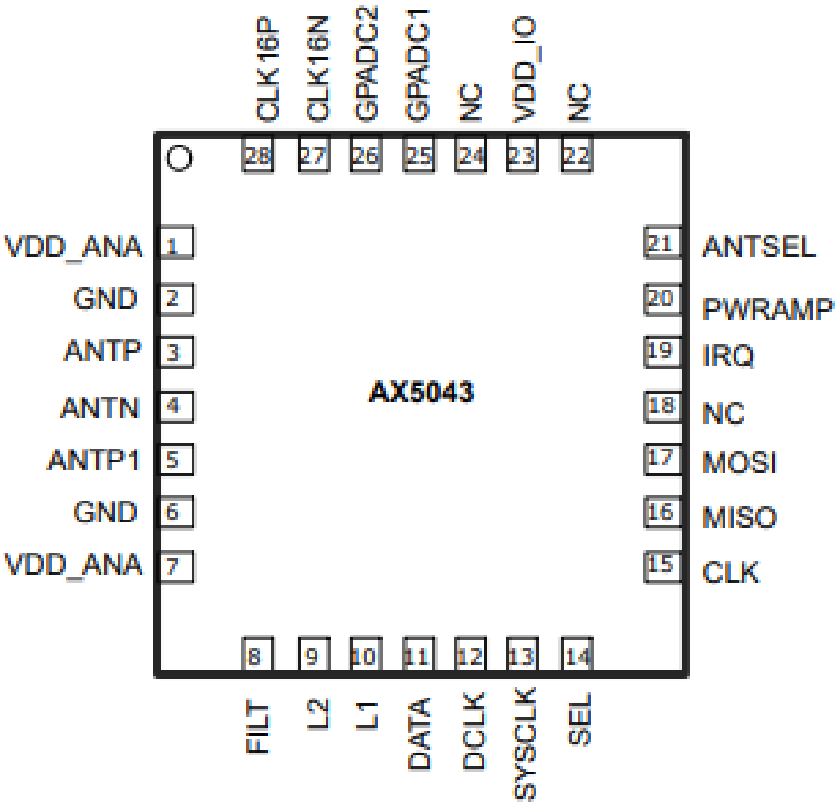
WHAT DO THE FOLLOWING HAVE IN COMMON?

- AMSAT
- Libre Space Foundation
- University of Louisiana
- Portland State University

ALL ARE USING THE AX5043 DIGITAL TRANSCEIVER IC

- AMSAT
  - Golf-TEE IHU, Golf-1 IHU, Satellite Simulator
- Libre Space Foundation
  - PocketQube Format Satellite Modules
- University of Louisiana
  - Satellite Beacon, Education Platform
- Portland State University
  - OreSat IHU Transceiver



WHAT IS THE ON SEMICONDUCTOR AX5043?

- A single chip, low-power digital transceiver
- Modulation and demodulation is performed on chip.
- For transmit, the host processor sends the data byte stream. The AX5043 adds optional FEC and modulates for transmission
- For reception, the AX5043 demodulates the signal, validates optional FEC then sends the resulting data to the host processor.

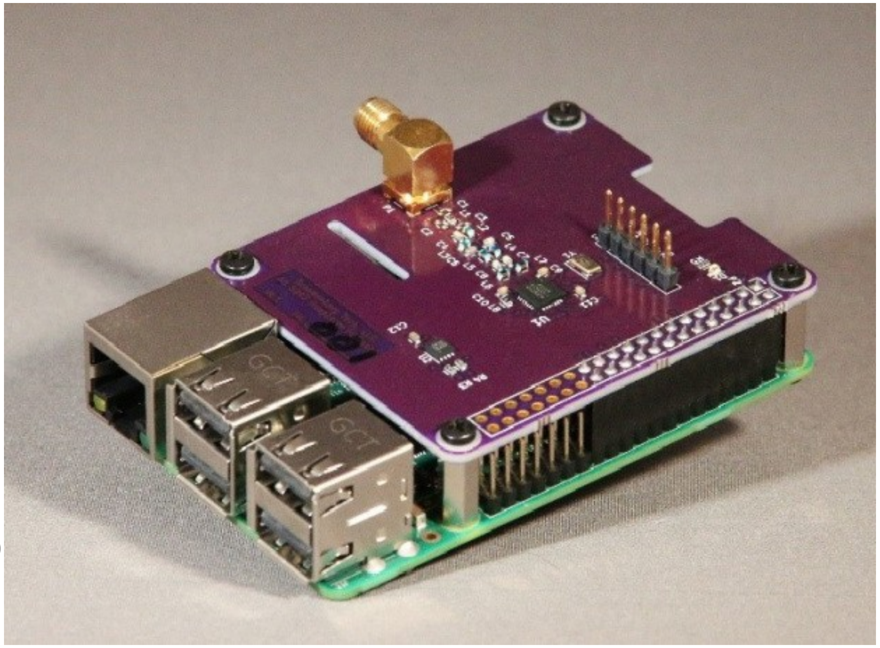
- What modulation standards?
  - FM
  - GMSK
  - ASK
  - GFSK
  - PSK
  - MSK
  - FSK
  - 4-FSK
  - AFSK

WHAT IS THE AX5043?

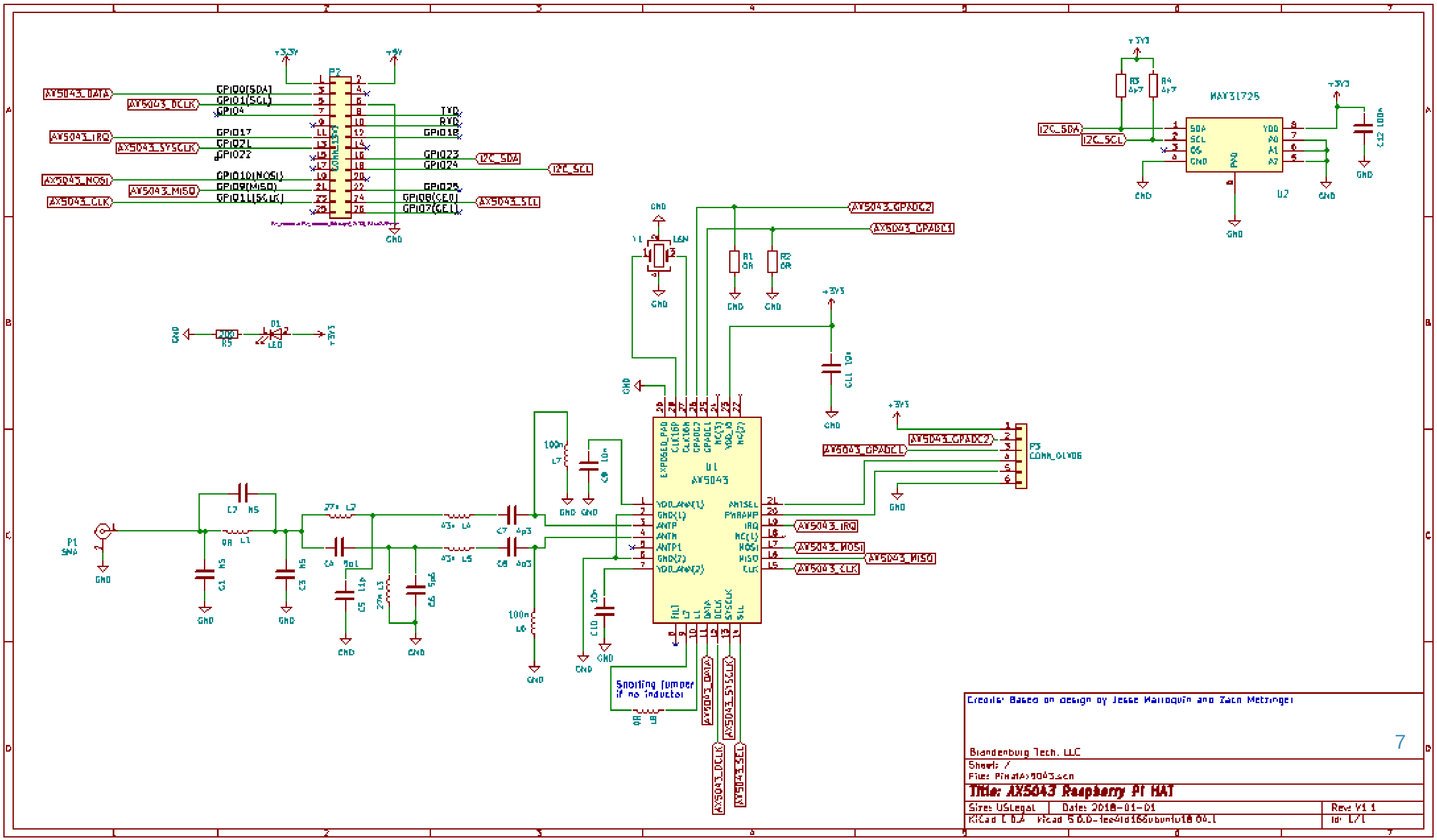
- What frequencies?
  - From 27 MHz to 1050 MHz
- What about output power?
  - 16 dBm (40 mW)
  - Of course, may add an external power amplifier
- What about sensitivity?
  - Example: -138 dBm @ 0.1 kbps, 868 MHz, FSK
  - Example: -108 dBm @ 125 kbps, 868 MHz, PSK
- What about chip power requirements?
  - 6.5 mA – 9.5 mA when receiving
  - 7.5 mA when transmitting at 0 dBm
  - 48 mA when transmitting at 16 dBm
  - 500 nA power-down mode with clock
  - 50 nA deep sleep current

I WANT TO PLAY!!!

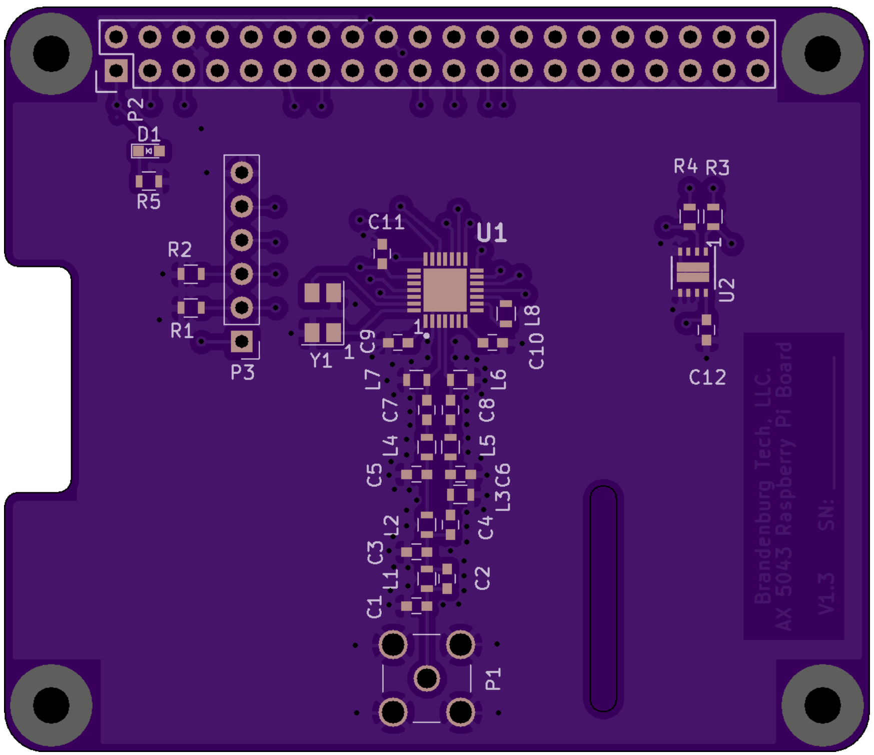
- I do what any of you might do… I create a custom board… for the Raspberry Pi
- Why the Raspberry Pi?
  - It's an affordable experimentation platform
  - It has the peripherals (SPI) to communicate with the AX5043

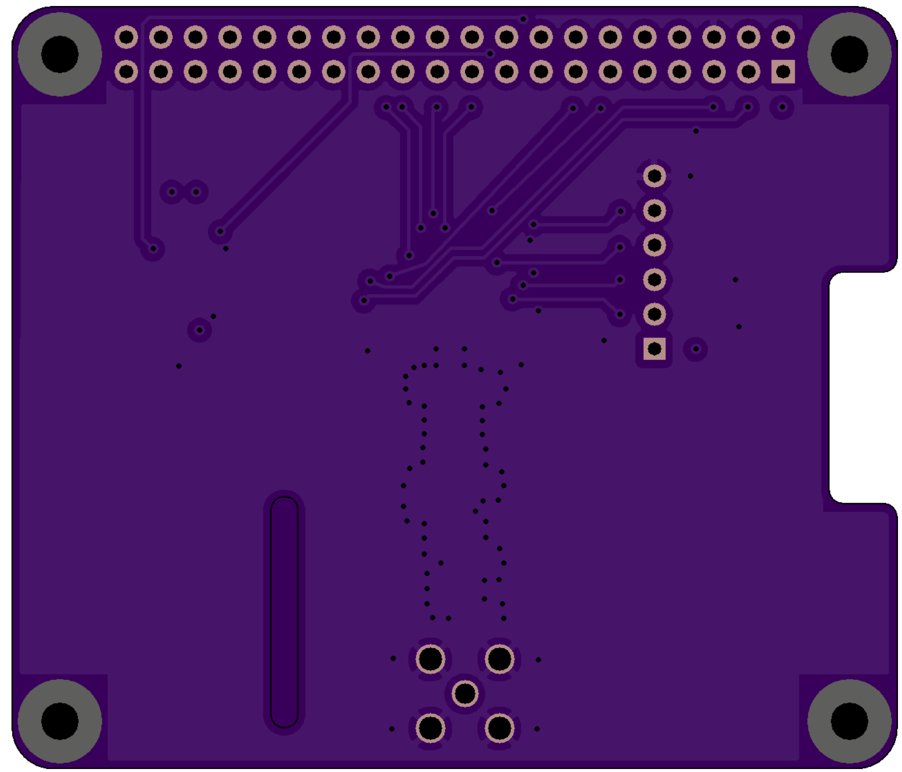


KICAD FOR THE SCHEMATIC AND LAYOUT



OSHPARK FOR BOARDS





HAND ASSEMBLED

DOES IT WORK?

- Yes!!!
- Developed several sample applications
  - A chat application at GFSK, 435.3 MHz, 4800 symbols/sec, HDLC encoding, CRC-16
  - APRS frames, AFSK, 435.3 MHz, X.25 frames
    - (I know FSK would typically be used at 435.3 MHz. Will talk about the matching network in a moment)

- Key Learning Opportunities:
  - The documentation is a “reference” not a “guide”.
  - AX-RadioLab application generates register values and sample code.
    - These register values are sometimes completely unexplained.
    - Generated code specific to On Semiconductor AX8052F100, including use of interrupts.

WHAT ABOUT HAM FREQUENCIES?

- What about Ham frequencies?
- AX 5043 data sheet has reference design to match the IC to a 50 Ohm antenna
  - 169 MHz
  - 433 MHz
  - 470 MHz
  - 868 / 915 MHz

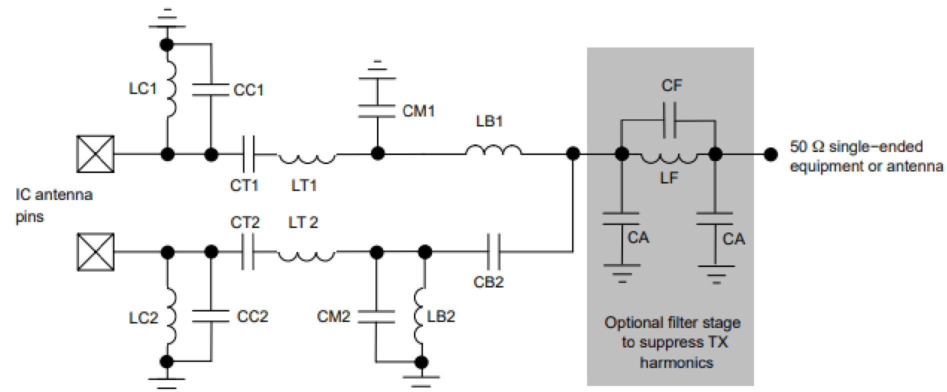
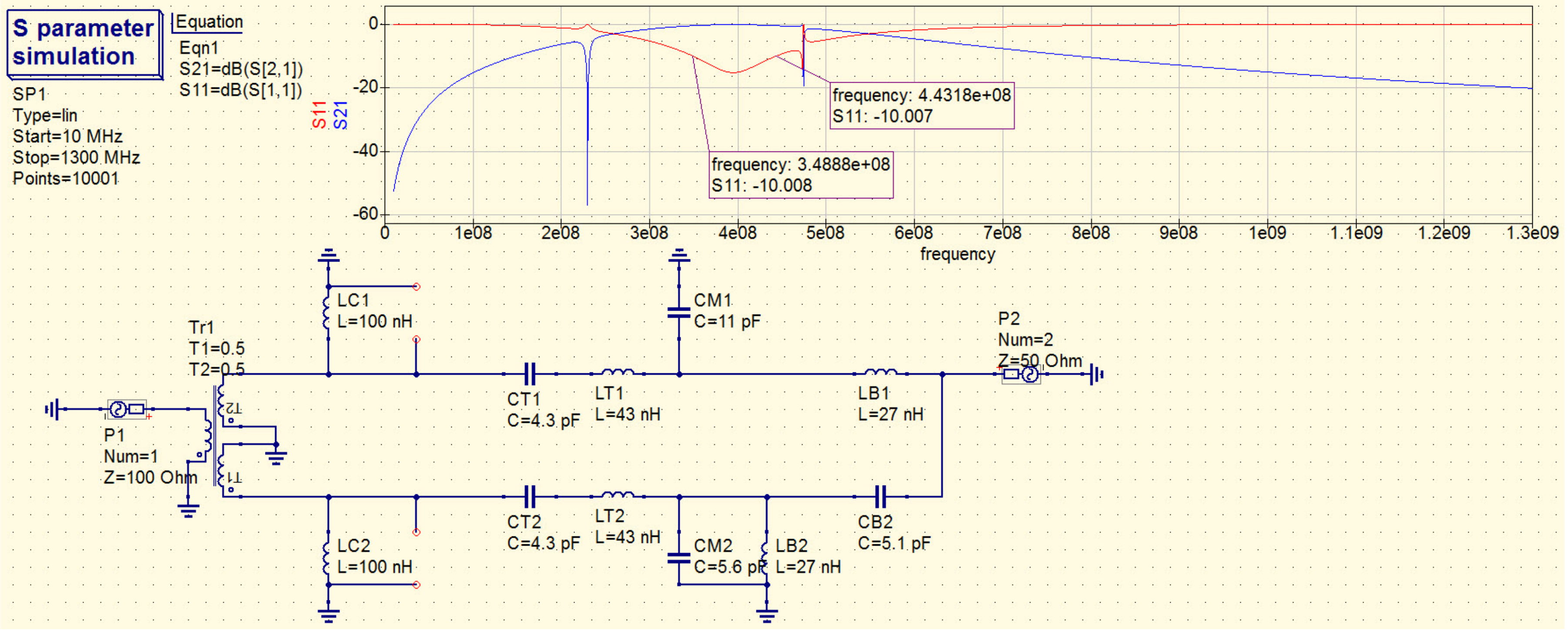


Figure 10. Structure of the Differential Antenna Interface for TX/RX Operation to 50 Ω Single−ended Equipment or Antenna

Table 29. TYPICAL COMPONENT VALUES

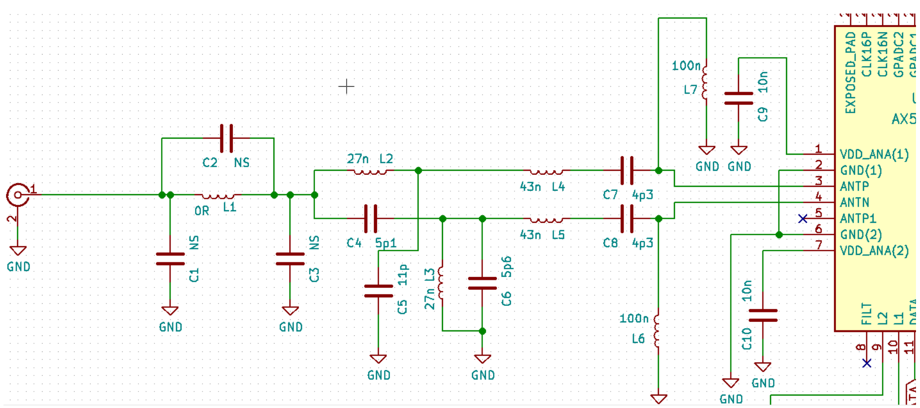
Frequency Band	LC1,2 [nH]	CC1,2 [pF]	CT1,2 [pF]	LT1,2 [nH]	CM1 [pF]	CM2 [pF]	LB1,2 [nH]	CB2 [pF]	CF [pF] optional	LF [nH] optional	CA [pF] optional
868 / 915 MHz	18	nc	2.7	18	6.2	3.6	12	2.7	nc	0 Ω	nc
433 MHz	100	nc	4.3	43	11	5.6	27	5.1	nc	0 Ω	nc
470 MHz	100	nc	3.9	33	4.7	nc	22	4.7	nc	0 Ω	nc
169 MHz	150	10	10	120	12	nc	68	12	6.8	30	27

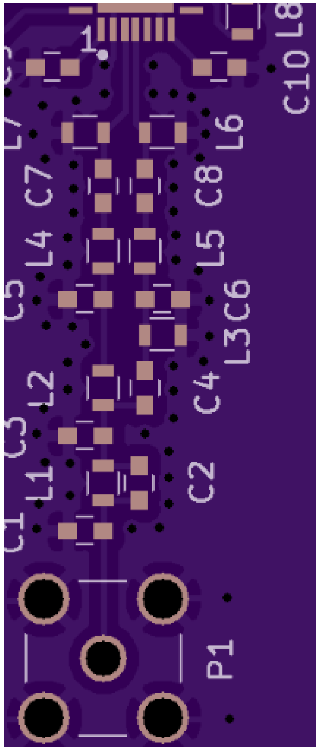
QUITE UNIVERSAL CIRCUIT SIMULATOR (QUCS)



MATCHING NETWORK

- The most interesting part of the schematic is the matching network
  - I populated my boards for 433 MHz
  - Simply populate with different components for other bands





WHAT NEXT?

- Adding a power amplifier
- AMSAT Golf-TEE IHU using NXP Semiconductor MMZ09312BT1
  - 400 – 1000 MHz
  - ~31.7 dB power gain (@ 900 MHz)
- Planning an onboard GPS for beaconing
- Planning a transverter for higher frequencies

DO YOU WANT ONE?

Questions / Answers

CREDITS

- Zach Metzinger (N0ZGO), Jesse Marroquin (K5JXM), Bill Reed (NX5R), and Jordan Trewitt (KF5COQ)
  - Design of the Hercules LaunchPad BoosterPack featuring the AX5043
- AMSAT
  - Supporting this platform as the basis for the Golf-TEE IHU