
DAEmod-915 Transceiver

Distributed Amateur EFR32FG23 module for 915MHz

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Presentation Outline

- Overview
- Goals
- Specifications
- Progression
- Funding
- Future Work



Overview

Project Statement

- Within the market, there is a lack of 915MHz open-source and open-hardware modules for implementing digital radio modes in the 915 MHz ISM band.
- Create a highly configurable platform to make a positive impact in open initiatives and receive contributions from others.
- Select low cost and ubiquitous hardware to facilitate inexpensive modules.

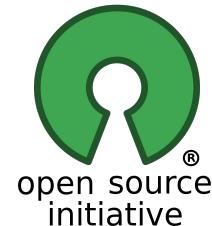
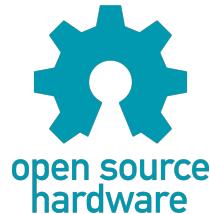


Table of LoRa WAN vs our Product

	LoRa	Our Product
Frequency	902-928 MHz	902-928 MHz
Data Rate	300 bit/s - 27 kbit/s	512 bit/s - 2 Mbit/s
Duty Cycle	Very Low	Up to 100%
Hand-Shake	Required Handshake	Optional Handshake
Broadcasting	Does not Support	Support
License	\$6000 Yearly	GPLv3



Device Specifications

Final Specifications of Transceiver module

Transceiver	EFR32FG23
Wide Operating Range	1.71 V to 3.8 V -40 °C to +125 °C
Antenna	SMA male 50 Ω
Power Max	13 dBm - 20mW
Frequencies	915 ISM band (902-928 MHz)

- Theoretical Range
 - 2dbi Antenna ideal range is 2.9km (1.80 Miles)
 - 5dbi Antenna ideal range is 15km (9.3 Miles)
- Baseline Current draw at 3.3V
 - Sleep draw is 26 µA
 - Full TX draw is 85.5mA
 - RX draw is 4mA



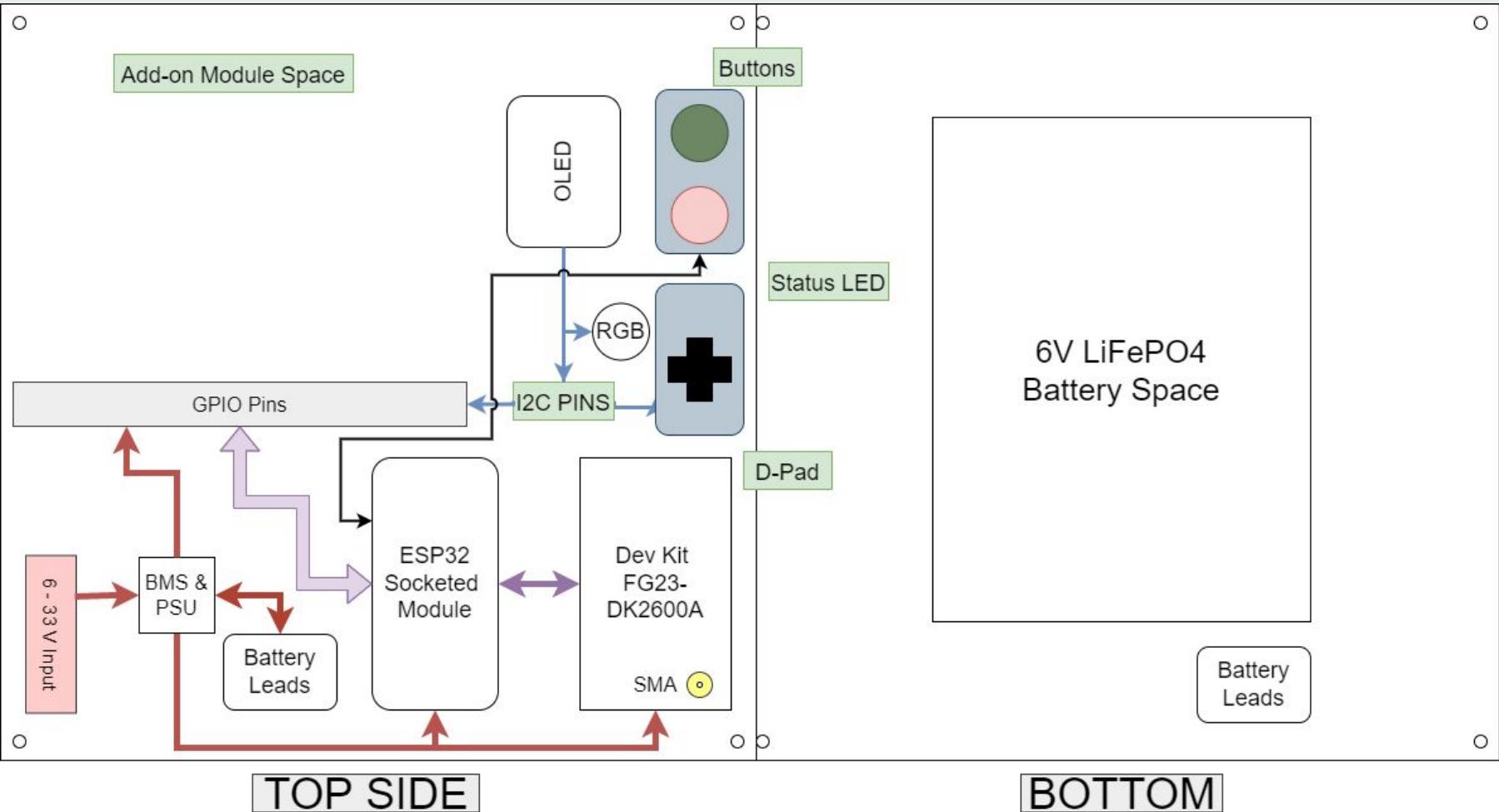
Final Specifications of Control module

Microcontroller	ESP 32
Communication I/O Protocols	SPI, I2C, WiFi, BT UART
Power Supply	6V → 5V → 3.3V
Testes Modules	Camera, Display, GPS, Battery, and Environment Sensor

- Baseline Current draw 3.3V
 - Sleep draw is .8mA
 - RF Tx off draw is 40mA
 - RF Tx on draw is 160mA
 - RF Tx off, WiFi/BT on draw 240mA
- External power budget 6V
 - 1A peak draw to peripheral devices

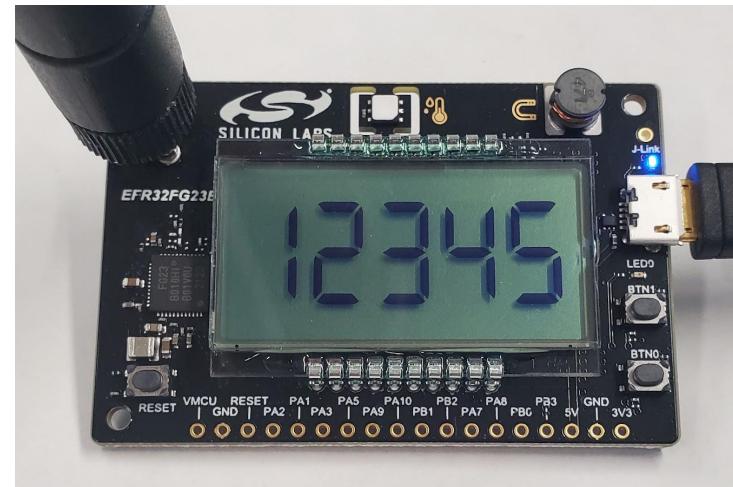


Block Diagram



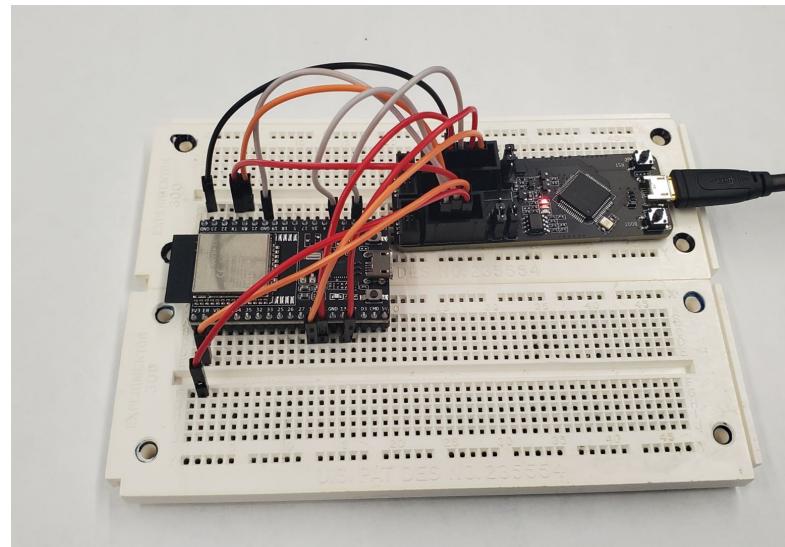
Transceiver module (Dev Kit FG23-DK2600A)

- Silicon Labs IC in dev kit will be used for the final custom PCB implementation
EFR32FG23A010f256GM48
- Low cost, new, and readily available at \$40
- Development environment in Simplicity Studio with detailed API documentation
- Selectable modulation schemes including:
FSK, ASK, GFSK, AFSK, GMSK, OOK,
OQPSK-DSSS

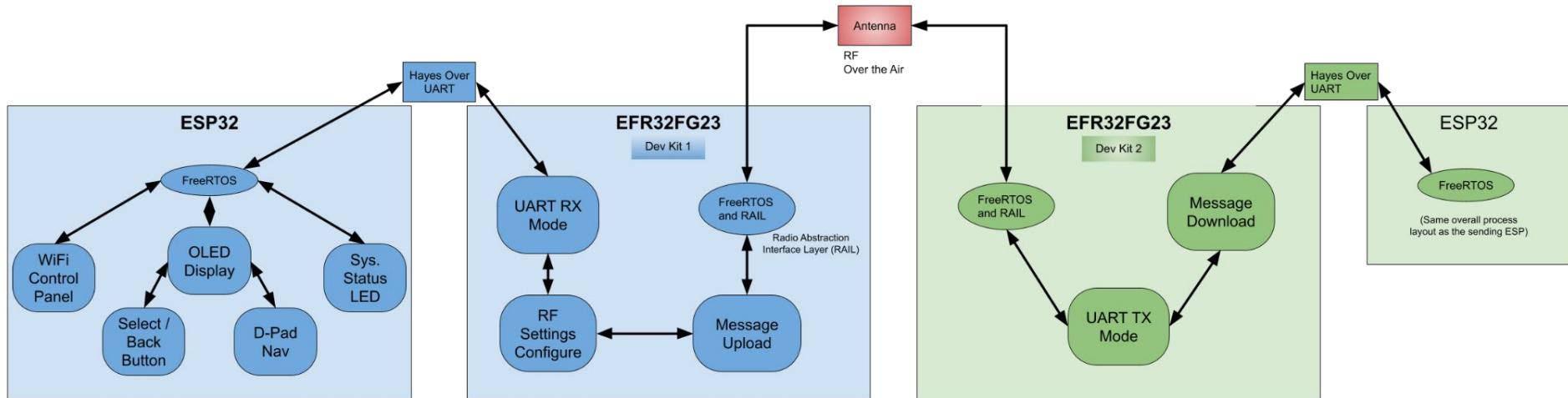


ESP32 module

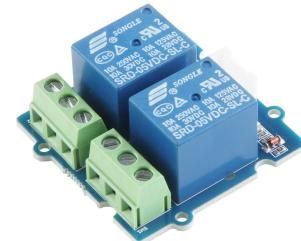
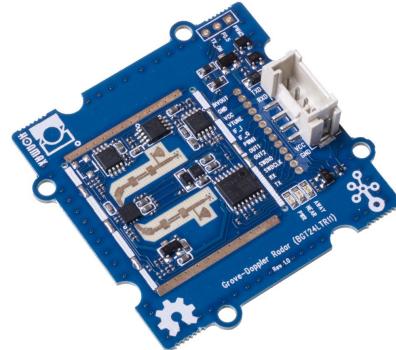
- Listen on local WiFi server with options to send and print received data.
- Xtensa dual-core 32-bit LX6 microprocessor, up to 240 MHz, 4MB SPI Flash
- Development environment in VSCode using PlatformIO and Espressif 32.
- ESP-PROG for live debugging.
- Creating set of control signals over UART using a form of the ESP AT Command Set.



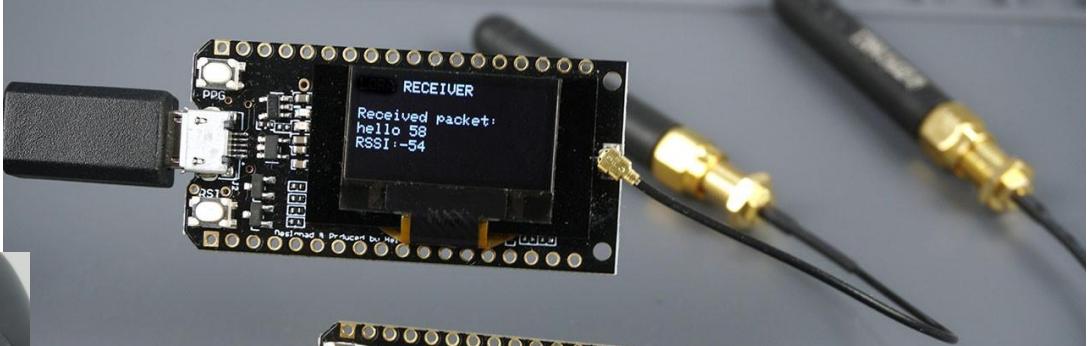
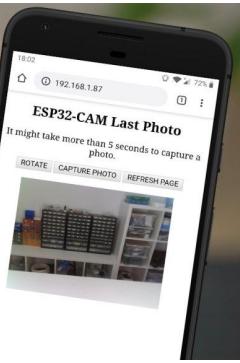
Software Design



Potential Modular Accessory



Potential Applications





Timeline

Fall Semester Schedule

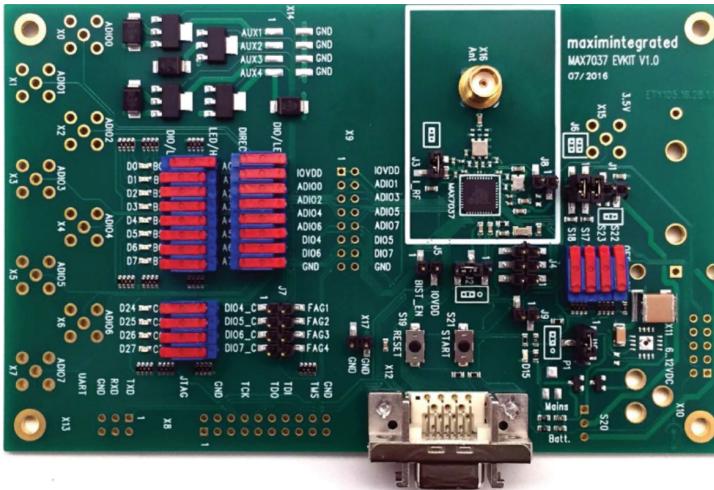
PROJECT	first Monday of each month	September 2021			October 2021			November 2021			December 2021		
		September 1	September 8	September 15	September 22	September 29	October 6	October 13	October 20	October 27	November 3	November 10	Finals
PHASE ONE	Project Brainstorming												
<i>Project Conception and Initiation</i>			Project Initiation										Winter Break
PHASE TWO				Statement / Whitepaper Draft									
<i>Project Definition, Planning, and Presentation</i>					Statement / Whitepaper Final			Repository Set Up	Project Proposal Practice				Finals
									Project Presentation Practice				Winter Break
										Final Project Report			

Original Spring Semester Schedule

first Monday of each month	January 2022	February 2022	March 2022	April 2022	May 2022
Project Launch and Starting Prototype	Winter Break	Assemble Parts			
			Prototype Programming		
		Test Dev Board			
		Basic Component Testing			
		Design Layout			
			PCB Design and Procurement		
				Assemble parts on PCB	
				Program MAX 7037	
				RF Chip Testing	
				Program ESP	
Project Refinement and Assembly	Winter Break			Program Accessories	
				Verify Specifications	
				Presentation Practice	
				Rough Draft Report	
				Presentation	
				Report	
				Paper in QST	
				ARDC Report for Additional Funding	
					Graduation
Project Sendoff	Winter Break				

Current Spring Semester Schedule

Part Discontinuation



Initial B.O.M.

QTY	Vendor	Vendor Part	ITEM DESCRIPTION	UNIT PRICE	TOTAL
1	Digikey	MAX7037EVKIT915#-ND	Eval Board Max7037	\$254.99	\$254.99
10	Digikey	MAX7037EGL+-ND	MAX7037 Chips	\$5.96	\$59.62
2	Digikey	343-ANT-916-CW-RCL-SMA-ND	SMA 900Mhz Hi Gain (Small) Antenna	\$8.68	\$17.36
2	Digikey	2151-RST-W1B6-10808-22M-FY-001-ND	SMA 900Mhz Low Gain (Small) Antenna	\$4.64	\$9.28
2	Digikey	1597-104020250-ND	OLED Display 1.12 (SH1107) v3.0 128x128 resolution	\$12.50	\$25.00
1	Digikey	1597-103020272-ND	I2C HUB (6 PORT)	\$1.70	\$1.70
1	Digikey	1597-1092-ND	4PIN MALE JUMPERS 5PACK	\$3.20	\$3.20
1	Digikey	1597-109020022-ND	GPS module for GPS / Beidou / Glonass / Galileo / QZSS / SBAS	\$13.10	\$13.10
2	Digikey	1597-1674-ND	Switch Human Interface 5WAY	\$4.90	\$9.80
2	Digikey	1597-104020169-ND	RGB LED	\$4.40	\$8.80
2	Digikey	1597-111020103-ND	Switch Human Interface Large Dual Button	\$2.40	\$4.80
1	Digikey	223-1785-ND	MS8607 SENSOR FOR GROVE SYSTEM	\$16.09	\$16.09
2	Digikey	1597-1687-ND	ESP32-CAM 2MP WIFI+BT AI-THINKER	\$10.00	\$20.00
2	Digikey	1965-ESP32-DEVKITC-32E-ND	ESP32-WROOM-32E series Transceiver Evaluation Board	\$10.00	\$20.00
1	Amazon	SMA Female Base	SMA Female Jack Connector 10-Count	\$7.89	\$7.89
1	Amazon	B07BBPX8B8	UART Cable	\$10.99	\$10.99

SUBTOTAL	\$482.62
SHIPPING	\$12.00
TOTAL	\$494.62

QTY	Vendor	Vendor Part Num.	ITEM DESCRIPTION	UNIT PRICE	TOTAL
10	Mouser	634-FG23-DK2600A	FG23-DK2600A Development Boards - Wireless FG23	\$39.00	\$390.00
20	Mouser	658-CR-2032/HSN	Coin Cell Battery 3V 220mAH	\$0.93	\$18.56
5	Digikey	343-ANT-916-CW-RCL-SMA-ND	SMA 900Mhz Hi Gain (Small) Antenna	\$8.68	\$43.40
5	Digikey	2151-RST-W1B6-10808-22M-FY-001-ND	SMA 900Mhz Low Gain (Small) Antenna	\$4.64	\$23.20
2	Digikey	505-EVAL-CN0522-EBZ-ND	900MHZ TX AMP TEMP SHUTDOWN	\$41.25	\$82.50
2	Digikey	744-1442-ND	FILTER SAW 915MHZ INLINE	\$36.72	\$73.44
20	Digikey	2057-PH1-18-UA-ND	CONN HEADER VERT 18POS 2.54MM	\$0.25	\$4.96
1	Digikey	PETG1752BLACK	IC3D PETG 1.75MM 2LB BLACK FILAM	\$33.99	\$33.99
2	Digikey	1528-2185-ND	JUMPER WIRE M TO M VARIOUS	\$4.95	\$9.90
1	Digikey	1528-1956-ND	JUMPER WIRE F TO F 8" 28AWG	\$6.95	\$6.95
2	Digikey	1597-1085-ND	GROVE 4PIN CABLES 5PACK 5CM	\$2.10	\$4.20
5	Digikey	1597-1082-ND	GROVE 2MM 4PIN VERT CONN 10PCS	\$1.70	\$8.50
1	Digikey	3M9921-ND	RF EMI SHIELDING TAPE 18'X2"	\$52.70	\$52.70
2	Digikey	GSPB-103M-ND	BREADBOARD ASSEMBLY 9.06X6.89"	\$43.73	\$87.46
2	Digikey	315-NC191SNL15-ND	SMOOTH FLOW LEAD-FREE SOLDER PAs	\$12.95	\$25.90
1	Digikey	SMD2SWLF.0158OZ-ND	LF SOLDER WIRE 99.3/0.7 TIN/COPP	\$39.19	\$39.19
2	Digikey	ACX2460-ND	CBL ASSY SMA RG174 19.69"	\$16.91	\$33.82
2	Digikey	ACX1636-ND	CBL ASSY SMA JACK-PLUG RG316 12"	\$24.55	\$49.10
2	Digikey	ACX1647-ND	CBL ASSY SMA JACK-PLUG RG58 6"	\$22.25	\$44.50
8	Digikey	1597-104020250-ND	OLED Display 1.12 (SH1107) v3.0 128x128 resolution	\$12.50	\$100.00
2	Digikey	1597-109020022-ND	GPS module for GPS / Beidou / Glonass / Galileo / QZSS / SBAS	\$13.10	\$26.20
2	Digikey	3217-SDCIT2/8GB-ND	Memory Card microSD™ 8GB Class 10, UHS-I, U3, V30, A1 TLC	\$12.00	\$24.00
10	Digikey	LTC4162IUFDFFS#PBF-ND	IC BAT LIFEPO4/LI-ION 1-9C 28QFN	\$6.79	\$67.90
5	Bioenno Power	BLF-0603W	6V, 3Ah LFP Battery (PVC, BLF-0603W)	\$24.99	\$124.95
1	Powerwerx	WP15-10	15 Amp Red/Black Anderson Powerpole Connectors	\$13.99	\$13.99
1	Powerwerx	Wire-RB-12-25	25ft Red/Black Bonded Zip Cord Easy ID Low Voltage Cable	\$24.09	\$24.09
1	PCBWay		10 Prototype Motherboards	\$450.00	\$450.00
				SHIPPING / HANDLING	\$75.00
				TOTAL	\$1,938.40

System Modularity



Function testing

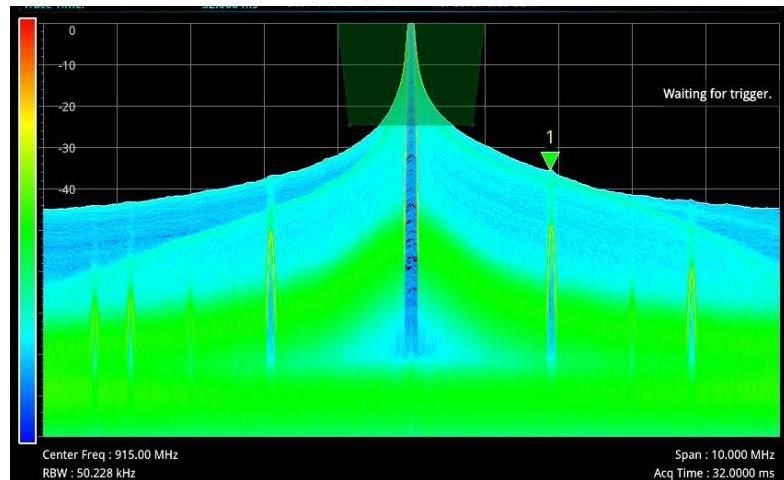
- Component level testing
 - Software stability
 - Proper hardware installation
- Digital Radio
 - Successful Tx/Rx modulation
 - Compliance with regulations
- Module Testing
 - Operates as intended
 - Communication between systems

Quantitative Testing

- RF Power of Carrier
- Carrier Frequency Deviation
- Spurious emission of harmonics
- Bandwidth of -20dbm

Results

- Power of Carrier 6.716 dbm
- Carrier at 914.988 Mhz (.0013% Deviation)
- 20dbm bandwidth .188 Mhz
- 6 harmonics more than 40dbm lower than carrier

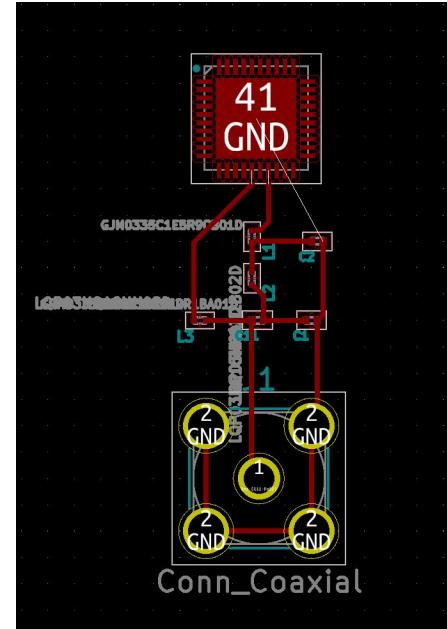


PCB

- 4 layer
- Thickness 1.6mm
- FR-4
- TG 140-150
- 1oz copper

PCB Layers

1. Power
2. Signal
3. Signal
4. Ground plane





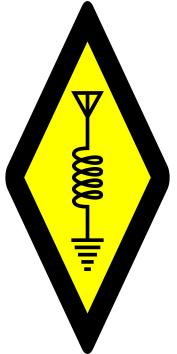
Additional Considerations

Funding

Three rounds of funding

1. ECE Department
2. ARDC R&D
3. ARDC Production





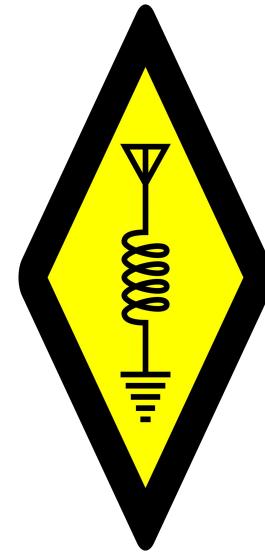
Project Near Future

- Receive ARDC Funded Parts
- Complete the proof-of-concept socketed prototype board
- Publish in QST and spread awareness of completed prototypes



Project Long Future

- Community Experimentation
- PCB development creating the non-socketed board
- Request ARDC Funding for Production Run



Conclusion

In Summary

- Adhere to open source software and hardware design philosophy allowing entire community to contribute.
- Inexpensive hardware for experimentation and future development of DAEmod platform at a low cost.
- Differentiate from LoRa via higher duty cycle and with extensibility in mind.
- Provide plenty of opportunities for educational development and learning experiences in digital communications technology.



Any Questions?



References

- https://www.espressif.com/sites/default/files/documentation/esp32_datasheet_en.pdf
- <https://docs.espressif.com/projects/esp-idf/en/latest/esp32/>
- <https://datasheets.maximintegrated.com/en/ds/MAX7037.pdf>
- https://lora-alliance.org/resource_hub/lorawan-104-specification-package/
- <https://www.silabs.com/wireless>
- https://github.com/SiliconLabs/application_examples
- <https://docs.platformio.org/en/latest/what-is-platformio.html>
- <https://www.ampr.org>