

Wellesley Amateur Radio Society

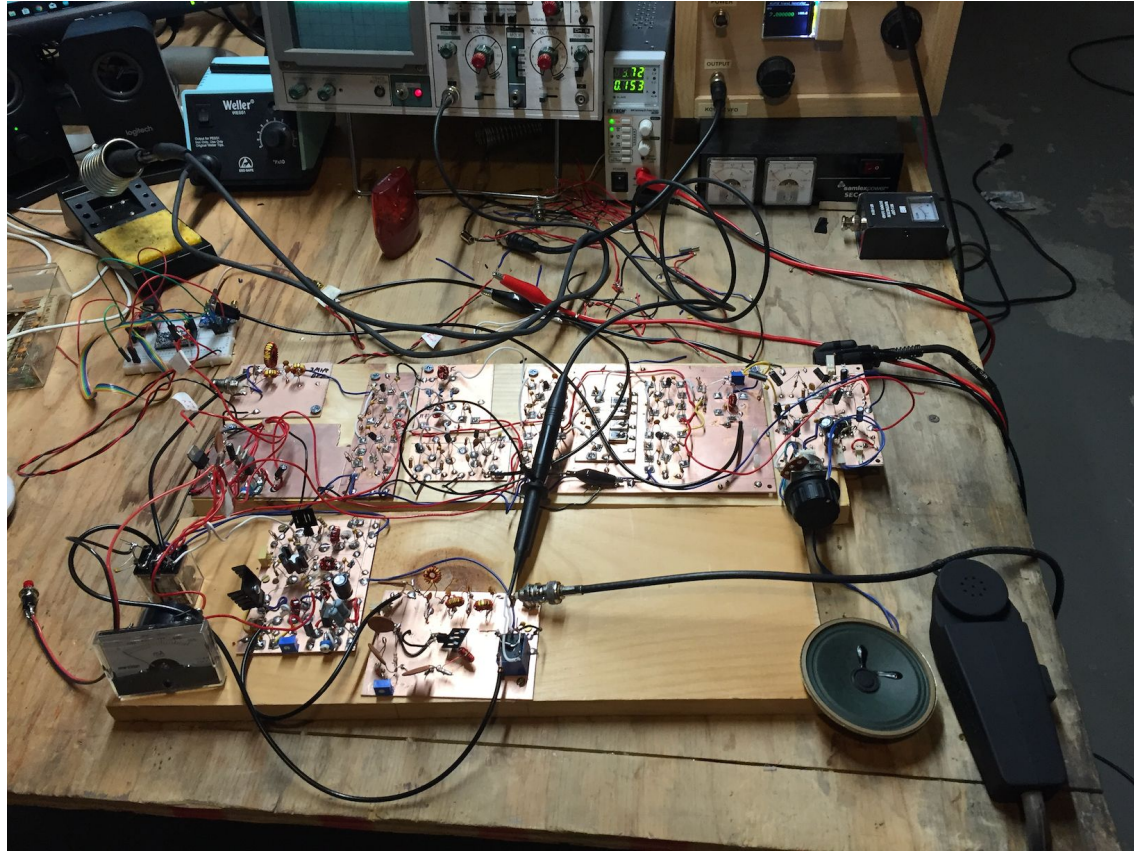
LoRa Birdhouse Mesh Network Project

HamXposition 2022

Bruce MacKinnon KC1FSZ



Homebrew HF Rig



Homebrew HF Rig



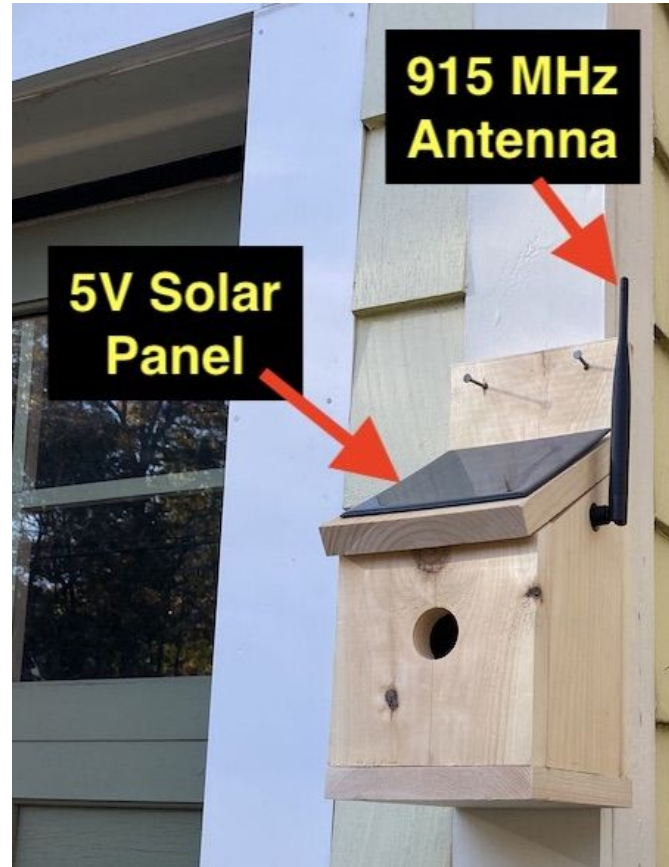
Project Goals



Project Overview



LoRa Mesh Birdhouse Station



LoRa Mesh Desktop Station



Why Birdhouses?



Packaging Study - Focus Group



Focus Group Question #1



Focus Group Question #1



1. Birds
2. Shelter
3. Cute



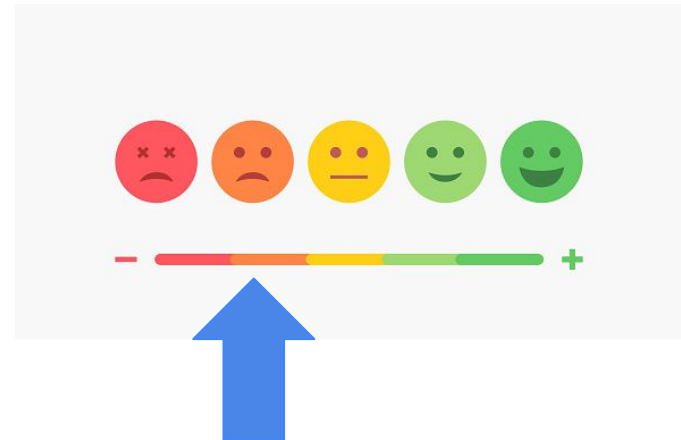
Focus Group Question #2



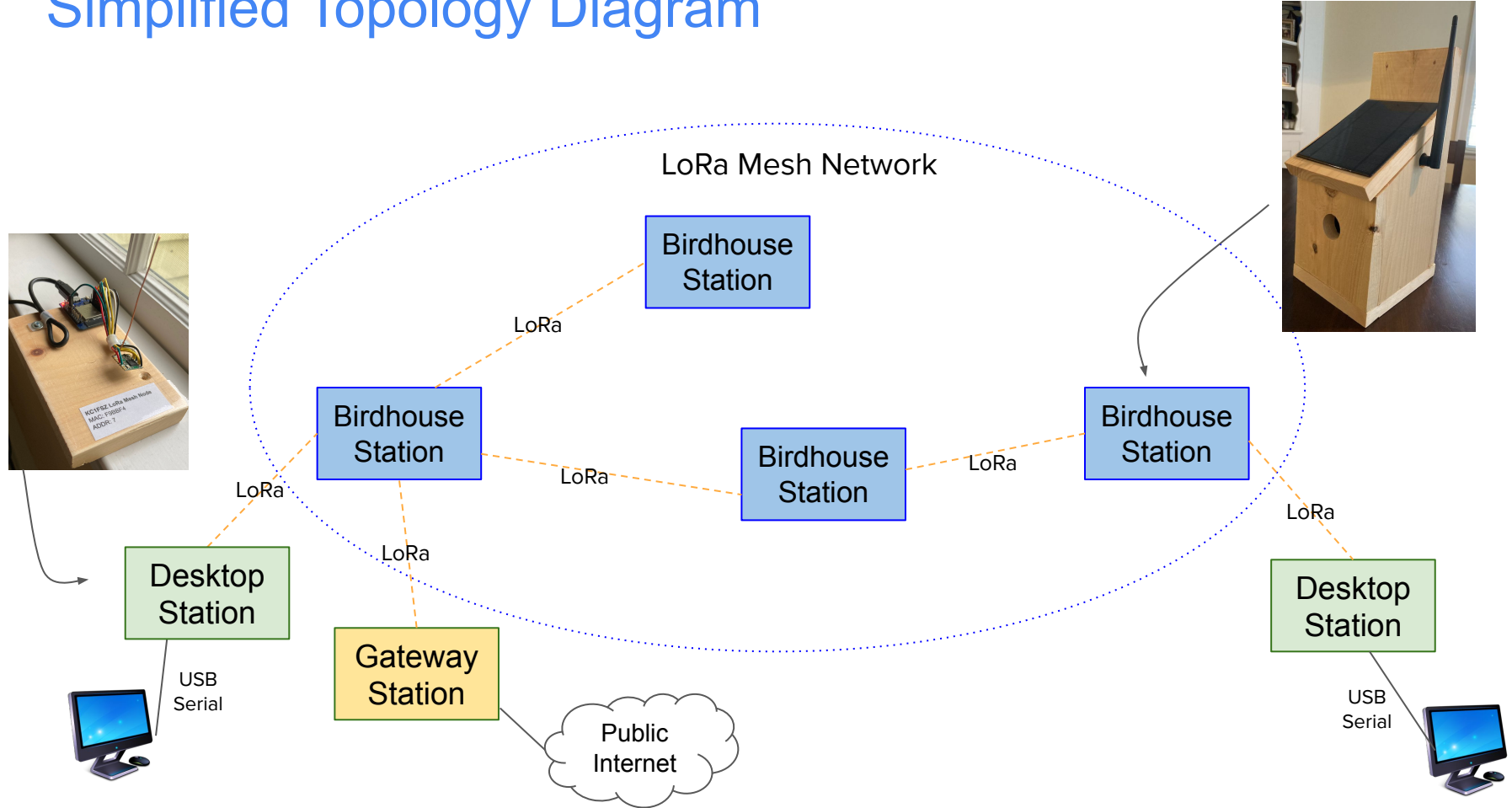
Focus Group Question #2



1. Controller
2. Surveillance
3. Ham Radio



Simplified Topology Diagram



What Can The Network Do? (+/-s)



Mesh Networking Basics



Packet Format

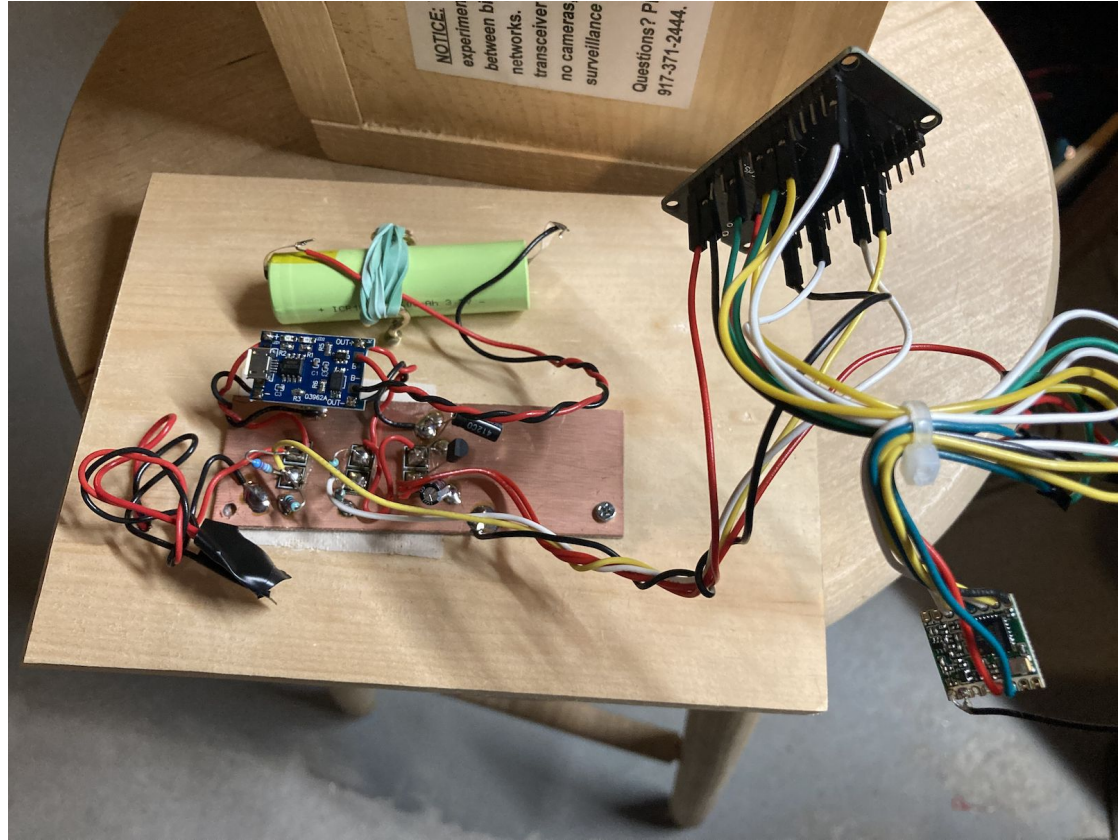
WARS Birdhouse Mesh Packet Header Format (V2)

Bytes	0	1	2	3	4	5	6	7
0-3	Version		Packet Type		Packet ID			
4-11	Source Call							
12-19	Final Destination Call							
20-27	Original Source Call							
28-35	Destination Address		Source Address			Final Destination Address		Original Source Address

Radio Stuff



V1 Prototype Hardware



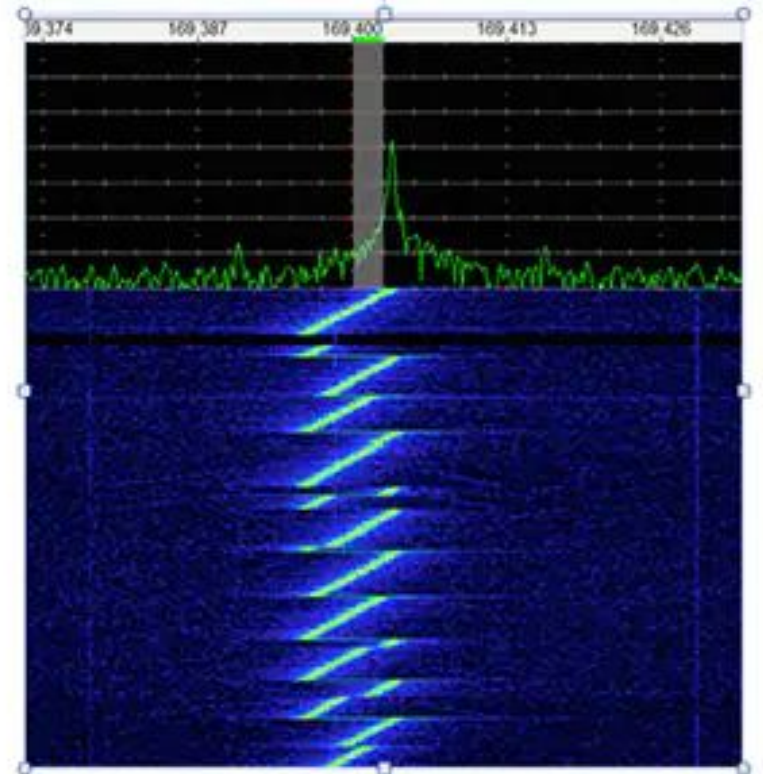
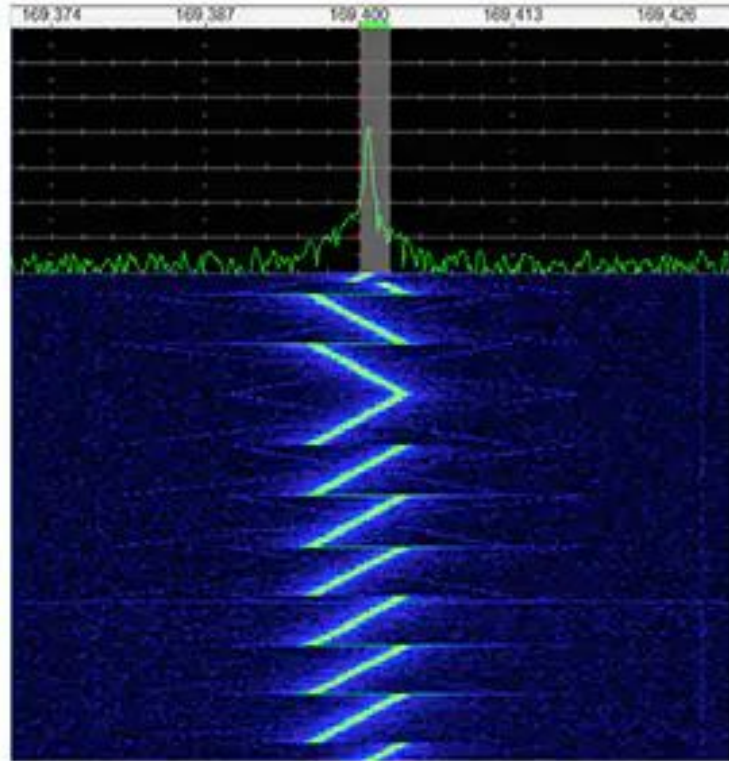
V2 Integrated PCB



Introduction to LoRa™



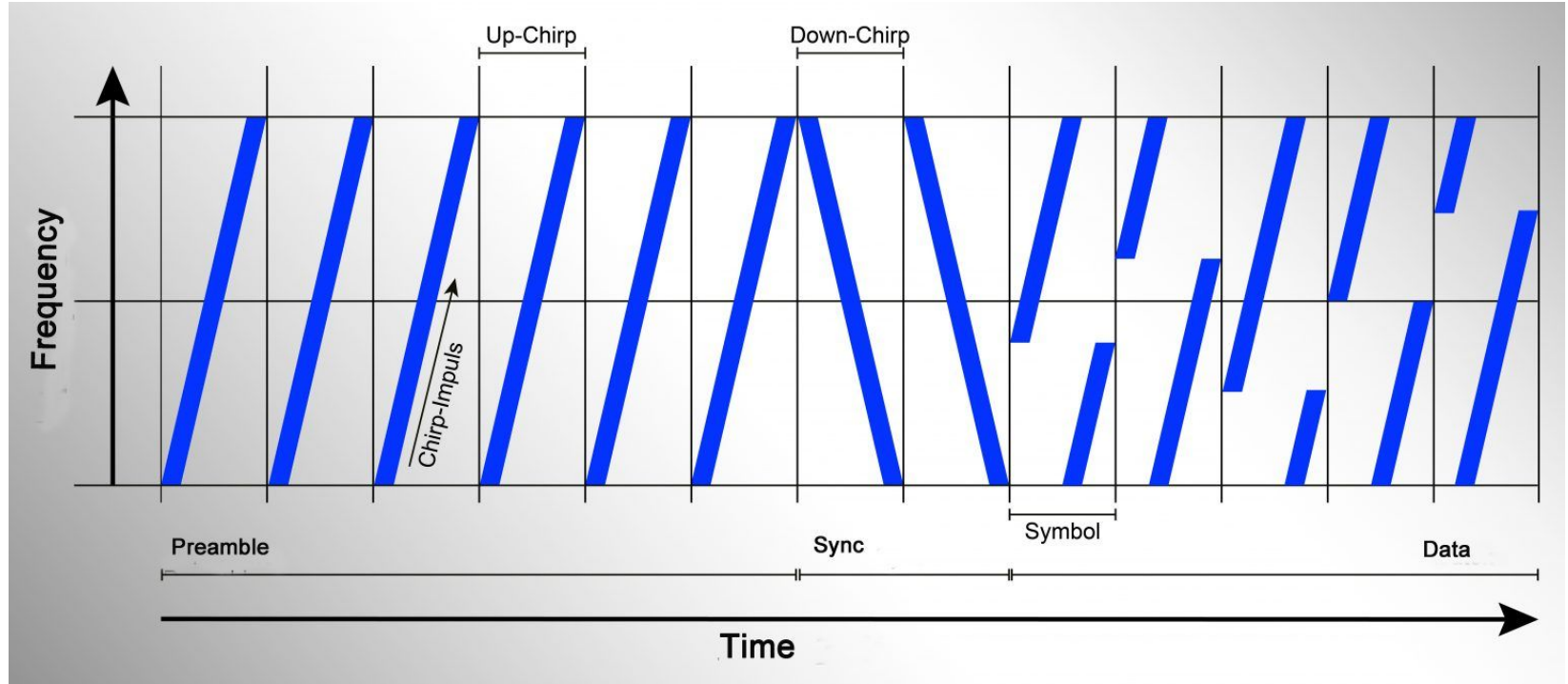
LoRa Waterfall



LoRa Modulation/Encoding Details

- Important Parameters
 - Modulation
 - Bandwidth (narrower = slower, more noise immunity)
 - Spreading Factor (higher = slower, more noise immunity, more power required)
 - Coding Rate (controls how much coding redundancy is in the message, data/FEC ratio)
- We are using:
 - 125 KHz
 - SF9
 - CR 4:5
 - Implies a data rate = 1,760 bits per second

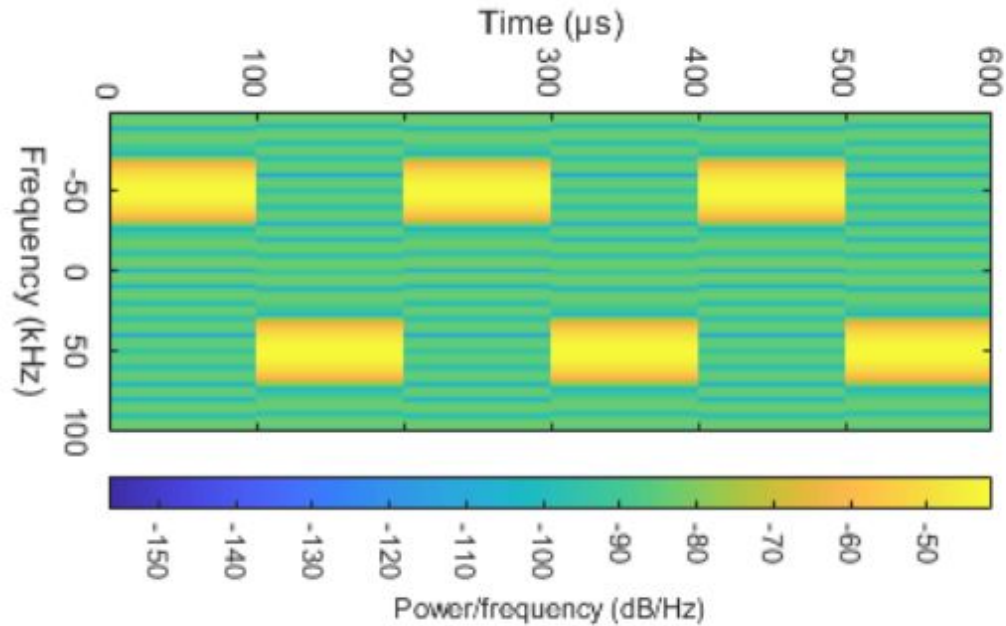
Chirp Modulation



FSK Symbols (this is not LoRa!)

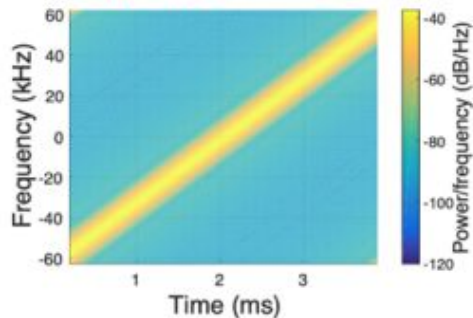
symbol='0'

symbol='1'

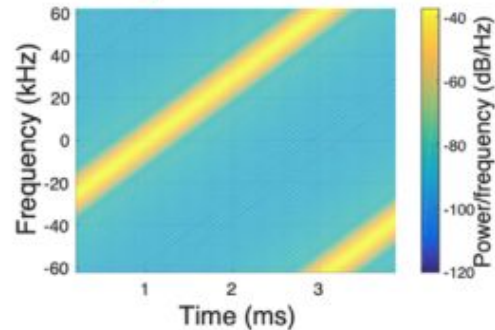


LoRa Chirp Symbols

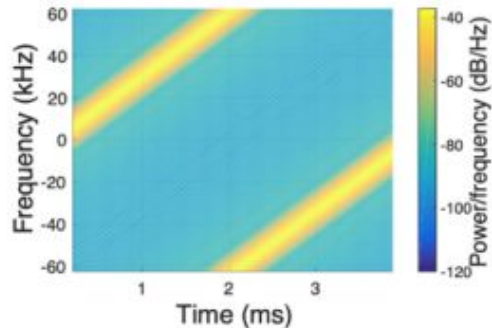
symbol = '0'



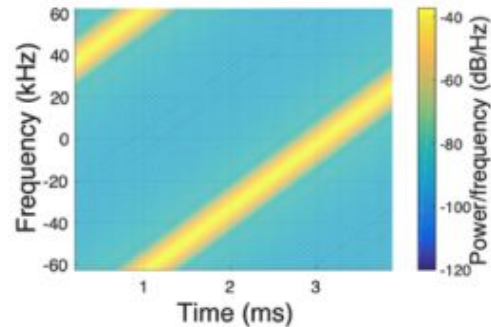
symbol = '1'



symbol = '2'



symbol = '3'



LoRa Reverse Engineering

Matt Knight, security researcher

Presented in 2016 at DEFCON and the JailBreak Security Summit

Used GNU Radio

A good paper was also written by grad students at EPFL (École polytechnique fédérale de Lausanne) in Switzerland. Swiss Federal Institute of Technology.

LoRa/SX1276 Physical Layer

(Very little structure, extremely versatile)



Hardware Details

(Champagne Capabilities at Beer Prices)



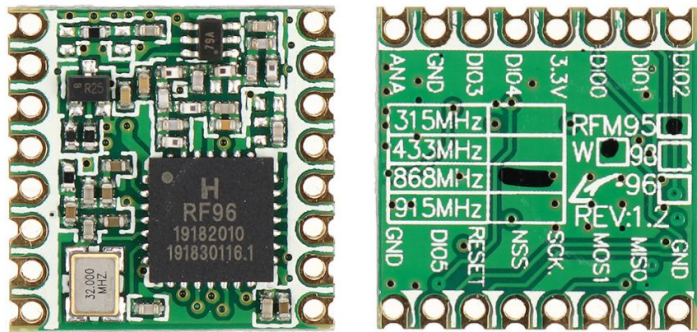
Semtech SX1276

- Semtech's first LoRa product
- QFN28 package (SMD)
- +20 dBm (100mW) power amplifier
- 3.3V part
- ~10 mA receive
- ~140 mA transmit
- SPI interface (Serial Peripheral Interface)
- More than 100 internal registers
- \$7 in 100 units on DigiKey **(Thank you municipal water systems!)**



HopeRF RFM95W Module

- Chinese (Shenzhen) IoT manufacturer
- Integrates Semtech SX1276 with crystal oscillator and power conditioning
- Castellated/through-hole package for ease of mounting
- 3.3V supply
- Approximately \$10



Commodity Antennas

- Turns out that cheap 900 MHz antennas are widely available (**Thank You LoRaWAN and Helium Network!!**)
- Most likely colinears: +3dBi



ESP32

Developed by Espressif Systems, Shanghai

32-bit, dual-core, 240 MHz, fully integrated WIFI/BLE

SMD package

Cost ~\$2.00 in 100 units on Digikey (**Thank you mass-market IoT!**)



ESP32-WROOM Module

ESP32 + flash memory + support components + WIFI/BLE antennas

Fully integrated module (SOIC)

Castellated pads (SMD)

About .5 MB RAM, 1 MB of Flash ROM

+3.3V supply

Cost: ~\$3.50 **(Thank you IoT market!)**



ESP32 D1 Mini Module

WROOM module + voltage regulator + USB interface + LEDs

Convenient through-hole package

Cost: ~\$7.00 (**Thank you maker mass-market!**)

One of many similar development modules

Power is a problem

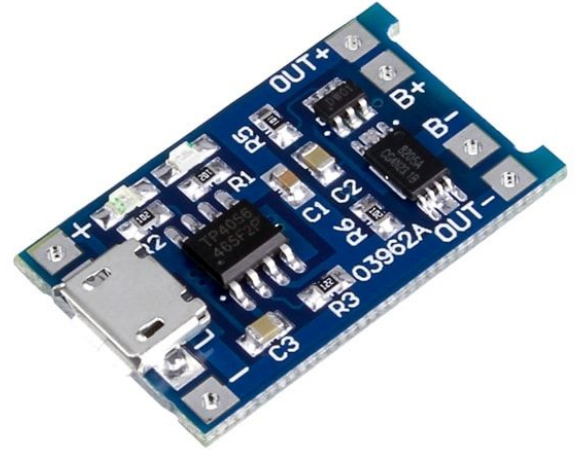
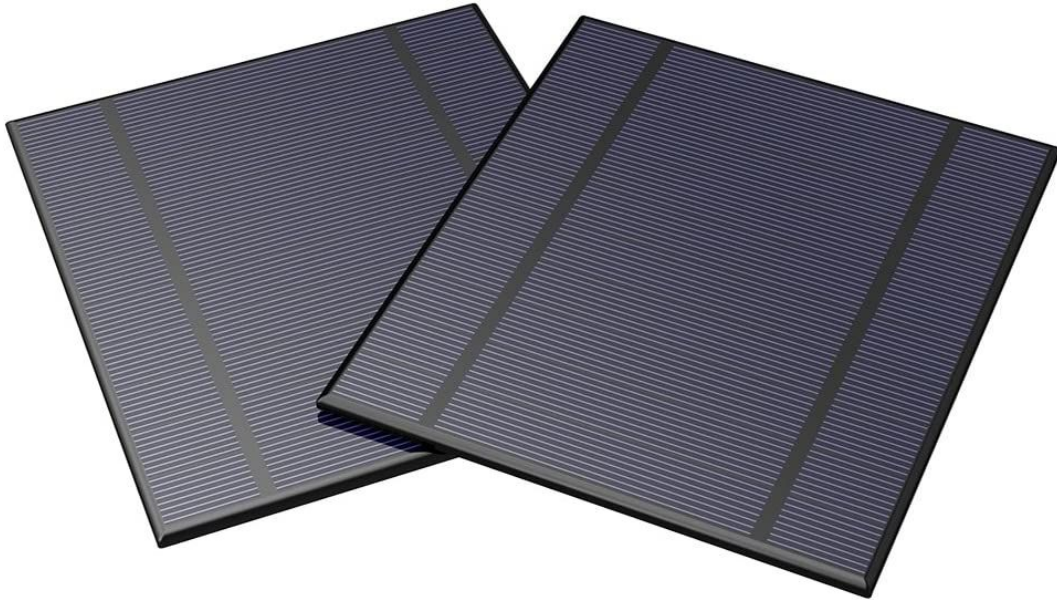
- Full default: ~240mA
- WIFI/BLE disabled: ~120mA
- Clock reduced, LEDs removed, LDO reg: ~40mA
- Deep sleep: ~8mA



Solar Panel and Charge Controller

2.5W, 4V solar panel, \$6.50 each

TP4056 Li-Ion charge controller, \$0.75 (Thank you cheap walkway lights @HD!)



Battery

18650 Li-Ion battery

~3.7V, ~2,600 mAh

Widely used, commoditized, ~\$6.00 (Thank you E-Cigarettes Smokers!!)



Forest Products

Douglas Fir

Inexpensive, biodegradable, and fully renewable, through good forest management.

(Thank you Mother Nature!)



Power Management



Snow Birds



Software Notes



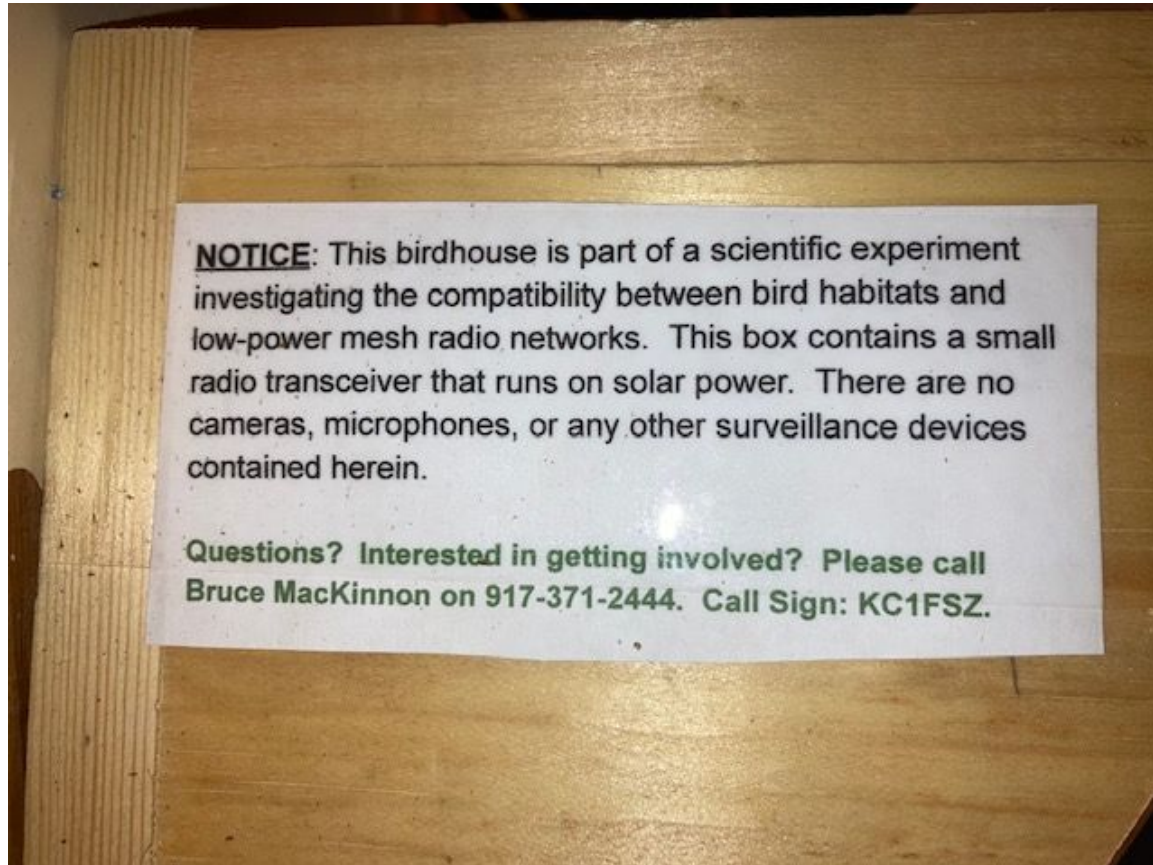
Future Directions



14' Tower - Height Matters!



Thank You For Your Interest!



NOTICE: This birdhouse is part of a scientific experiment investigating the compatibility between bird habitats and low-power mesh radio networks. This box contains a small radio transceiver that runs on solar power. There are no cameras, microphones, or any other surveillance devices contained herein.

Questions? Interested in getting involved? Please call Bruce MacKinnon on 917-371-2444. Call Sign: KC1FSZ.