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# Weather box

May 7, 2022

KM5PO – KI5EMN

# Need to learn

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- Revisiting our previous best DX we got a surprise
  - Try to extend from 17 km to 20 km
  - Return to 17 km first
  - Signals weaker than before at 17 km
  - Wind gusts began to move dish
  - Signal dropped much lower
  - Signal could be acquired by aiming with use of rifle scope.
  - Heat shimmer noted sighting through scope. Temperature was 81 F at both locations
  - European post referring to red kit birds using thermal = increased path losses at 122 GHz
  - Signal dropped into noise.
  - **What are the conditions that caused this fail?**

# Red Kites

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- Dave G8KHU post in groupsio 122 GHz group
  - Short path test was successful
  - Longer path (3 km) should have provided 15 dB margin S/N but signals were much much weaker – barely audible on CW
  - Dave comments:
    - There was considerable heat shimmer and both of us noticed it felt humid so the increased path attenuation could be due to thermal boundaries / disturbances or local increased humidity – or something else entirely! We'll try this path again as it should go.
    - Sadly there were no Red Kites around as they give a very useful indication of thermals, when they don't have to flap for 20 minutes there's a lot of rising air around
- Thermals = problem at 122 GHz! WA5VJB confirmed!
- Red Kites are like our "Hawk" or "Eagle"



# Let's build the Weather box



- Barry Chambers G8AGN design
- Arduino sketch is available from Barry email: b.chambers@sheffield.ac.uk
- Upgraded sketch is available from Jim McMasters email: km5po@aol.com (we found a couple tweaks to make in the G8AGN code and documented the source to line up with the hardware build described in this presentation)
- Great write up here on 122 Ghz propagation and the Weatherbox
  - https://microwavers.org/scatterpoint/2020/Scatterpoint_2001.pdf
  - "In practice, the weather on any particular day will determine the actual values of all three variables barometric pressure, temperature and RH and so if accurate estimates of losses are to be established then they must all be measured at the time of making a contact if a later comparison between measured and predicted received S/N is to be made."

# Let's build the Weather box



- Gather the parts
  - Mega 2560 Arduino
  - LCD – GeeekPi 2004
  - Keypad – DEVMO 4x4 Matrix
  - Sensor – BME280
  - GPS – NEO-6M
  - SD card? – HiLetgo Micro SD TF card (use 32 GB card)
  - Internal battery  and recharge scheme
- Download the sketch to the Arduino
- Build the wiring harnesses
- Perform smoke test
- Prepare the enclosure
- Assemble all parts
- Learn stuff!

# Parts

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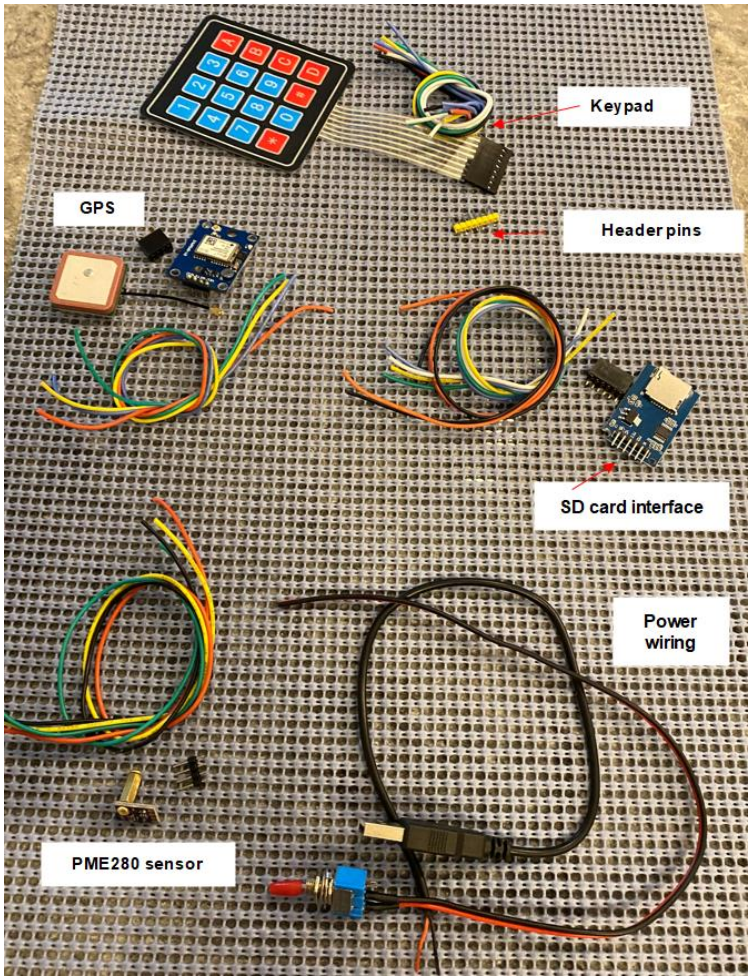


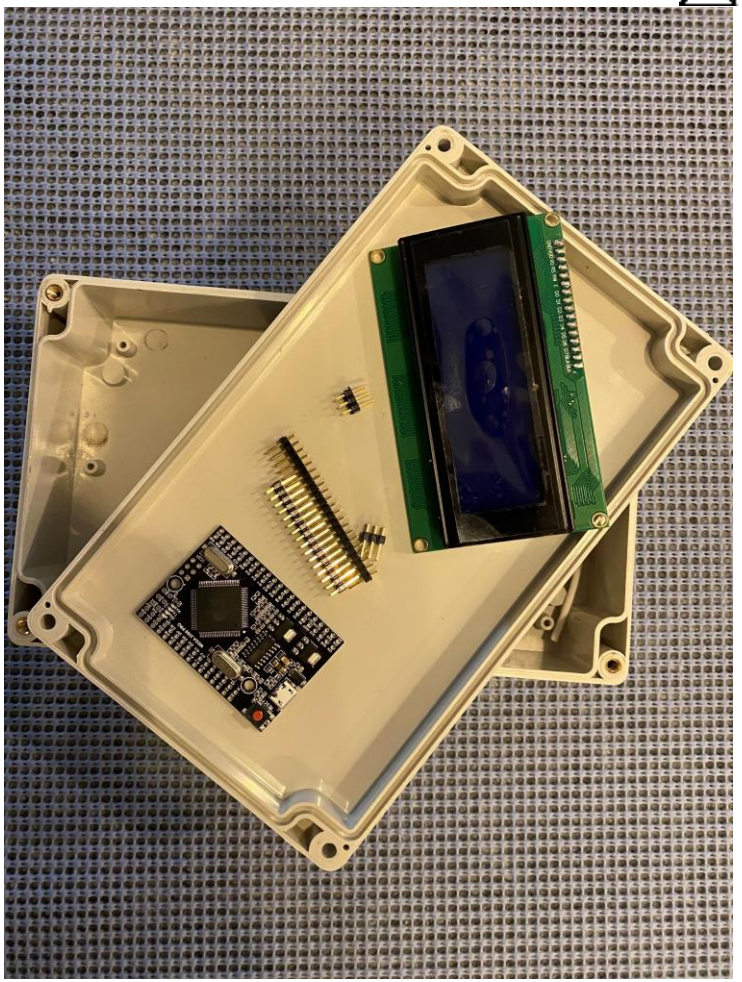

# Mega 2560 connections

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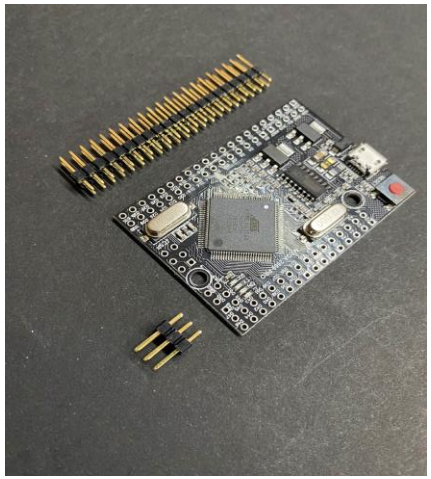
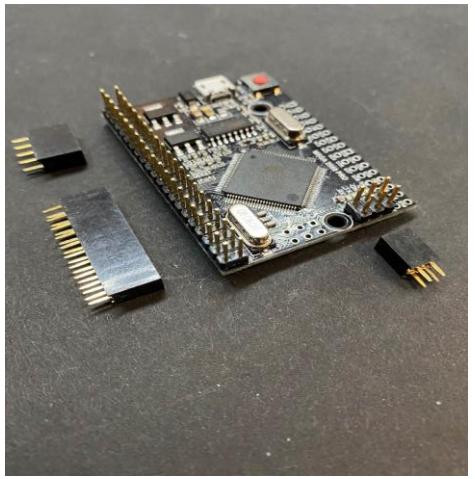


Pin headers shipped with Mega 2560

Additional connectors

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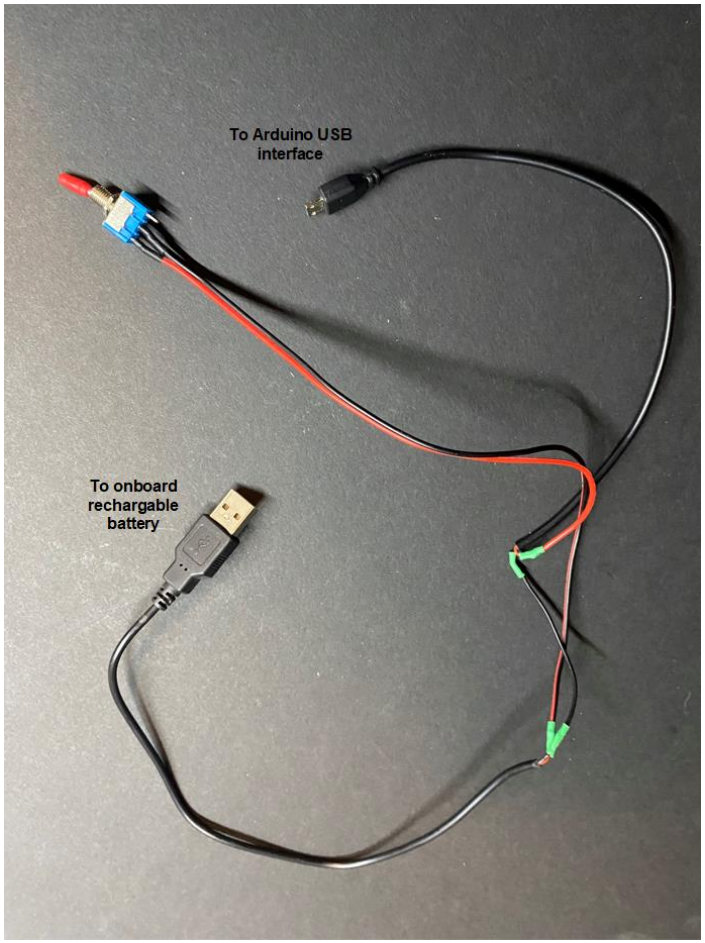
# Power




# Keypad & SD card

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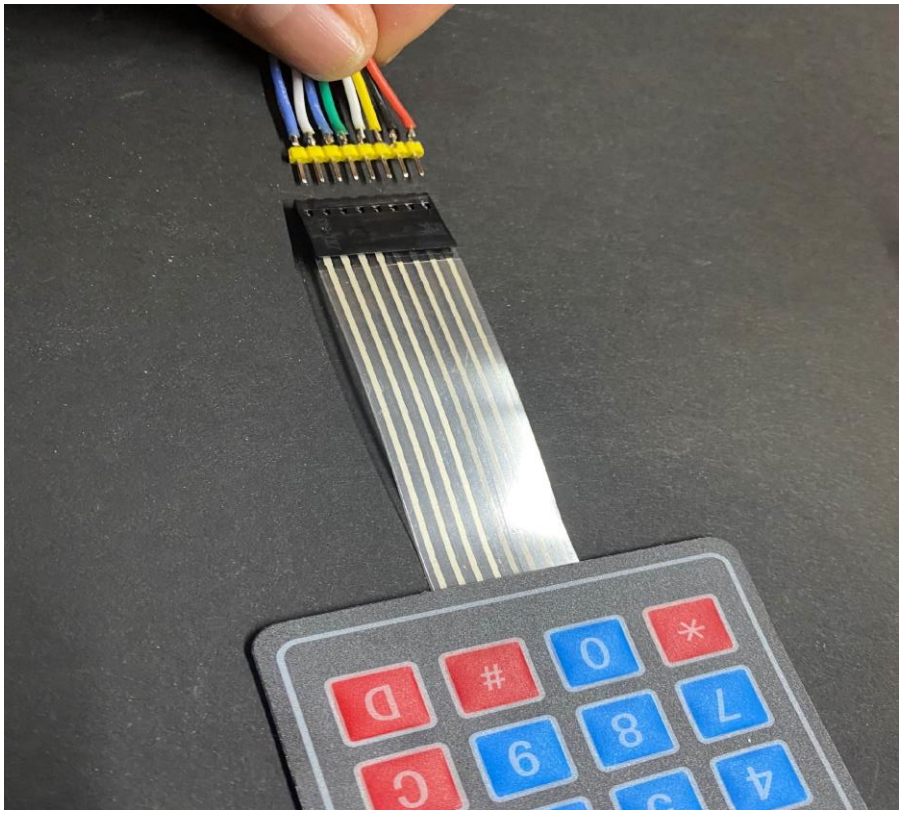


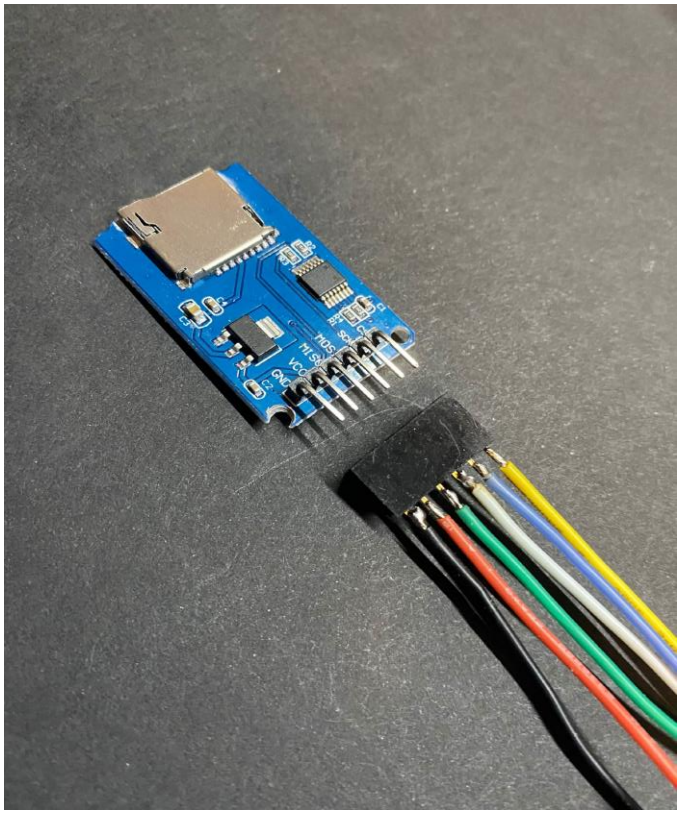

# Sensor & GPS

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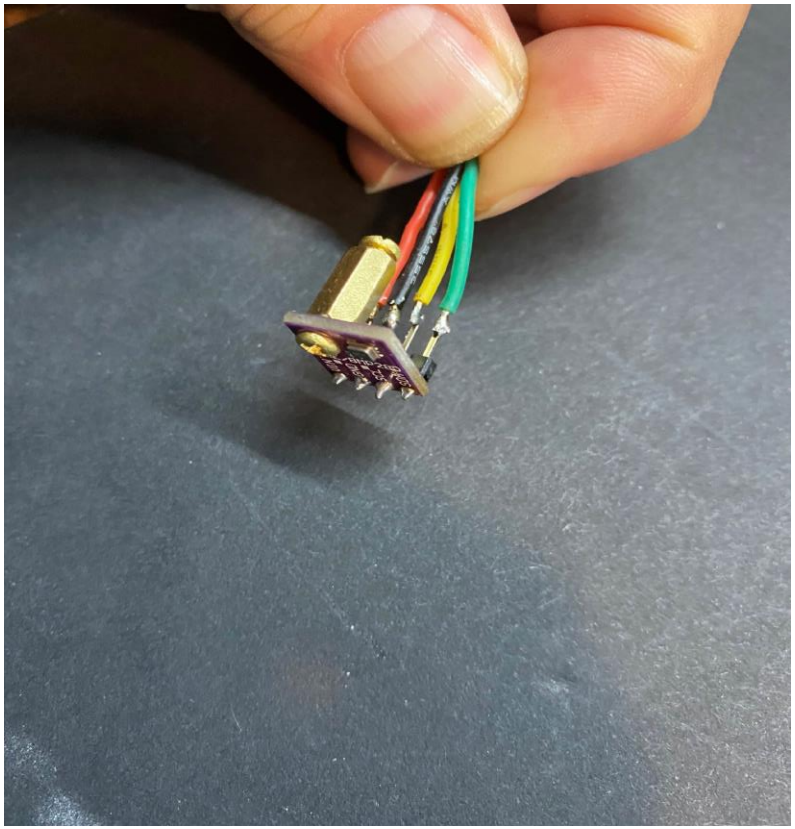

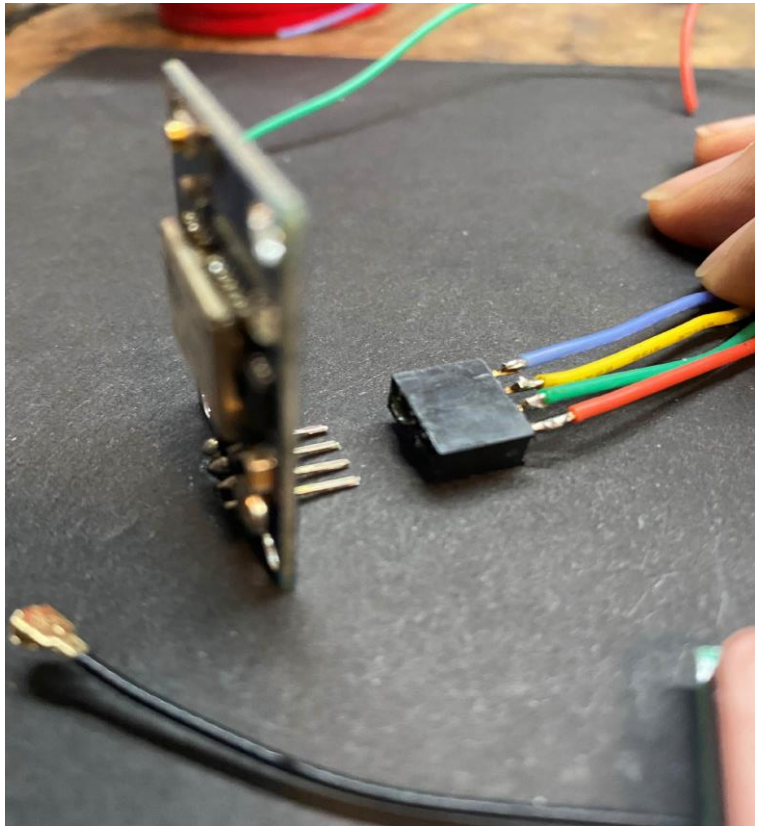

# Pin out guide

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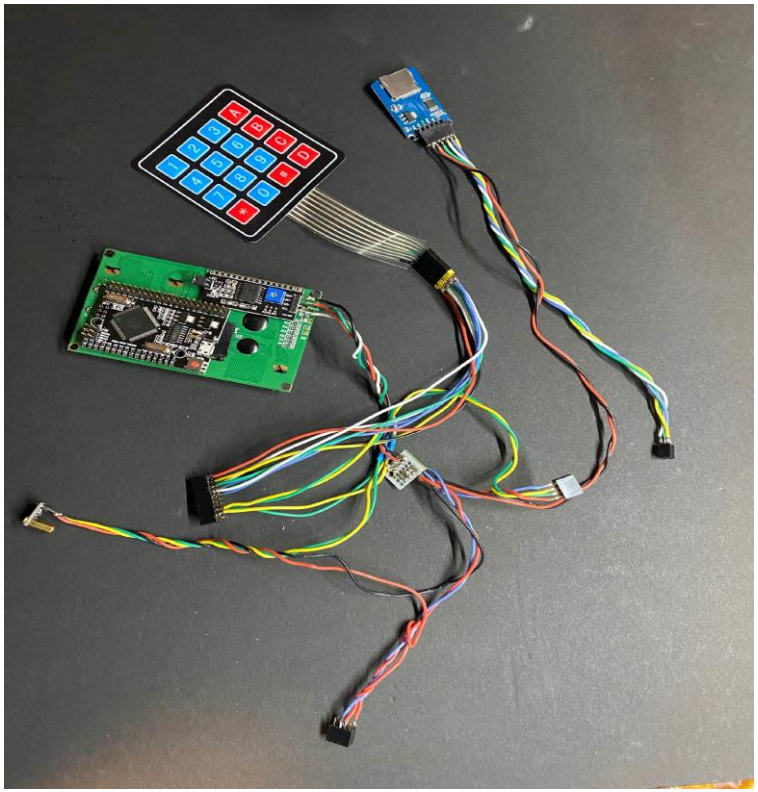
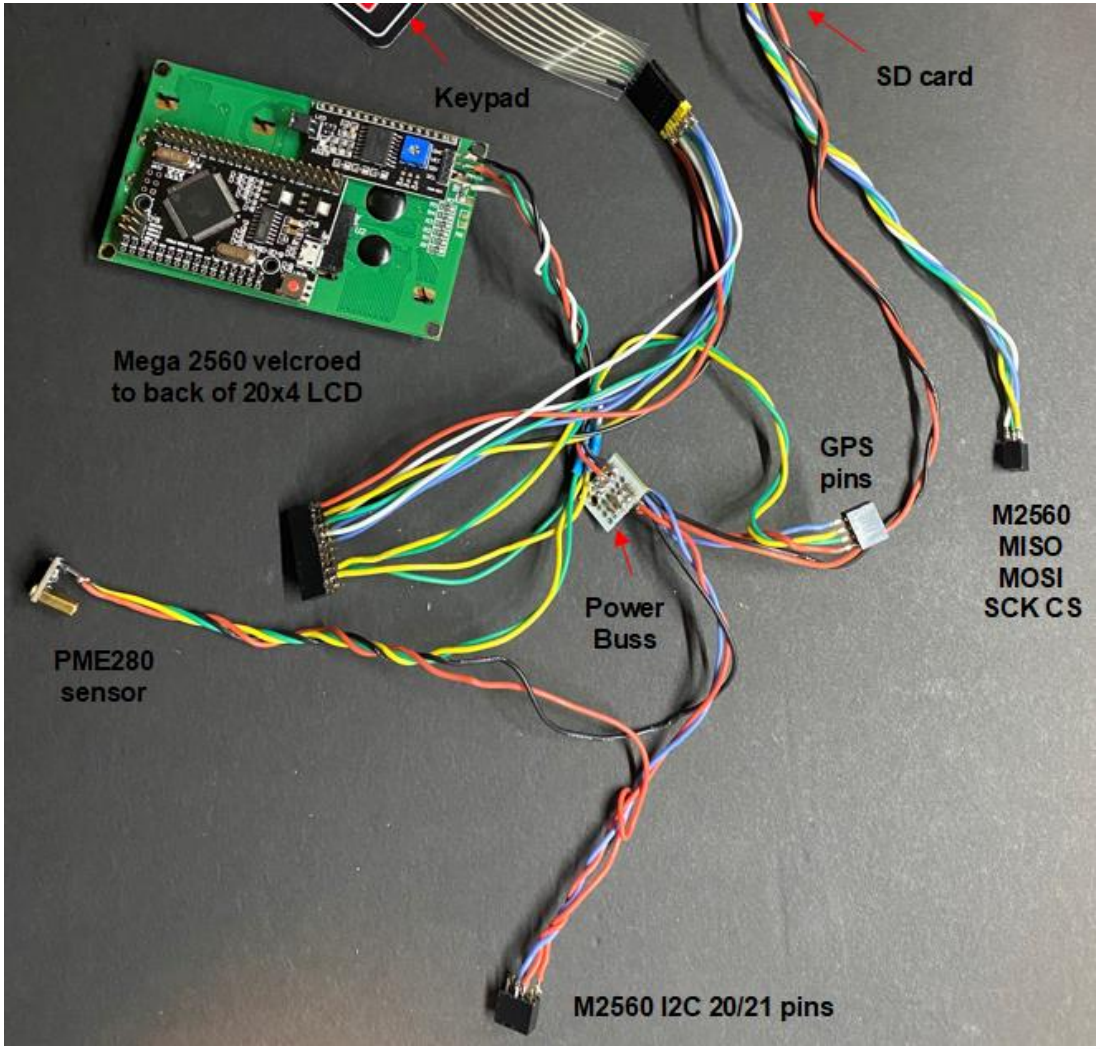
| Component | Pin Function | Connect to Mega2560 pin |
|---|---|---|
| GPS module | VCC | 5V |
| | GND | 0V |
| | TX | 19 |
| | RX | 18 |
| PME280 sensor default I2C address 0x76 | VIN | 3.3V |
| | GND | 0V |
| | SCL | 21 (SCL) |
| | SDA | 20 (SDA) |
| 20x4 LCD display default I2C address 0x27 | VCC | 5V |
| | GND | 0V |
| | SCL | 21 (SCL) |
| | SDA | 20 (SDA) |
| Keypad | LH lead or pin | 5 |
| | Intermediate leads or pins | 6, 7, 8, 9, 10, 11 |
| | RH lead or pin | 12 |
| SD card interface | GND | 0V |
| | VCC | 5V |
| | MISO | 50 |
| | MOSI | 51 |
| | SCK | 52 |
| | CS | 53 |



# Wiring


Keypad
SD card
Mega 2560 velcroed
to back of 20x4 LCD
GPS
pins
M2560
MISO
MOSI
SCK CS
Power
Buss
PME280
sensor
M2560 I2C 20/21 pins

# Enclosure

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# Enclosure

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Opening for PME280 sensor and standoff mounting hole

Openings for power switch, recharge port and SD card interface slot

Mount SD card on scrape wood riser, trim front edge of SD card interface PCB

# Enclosure

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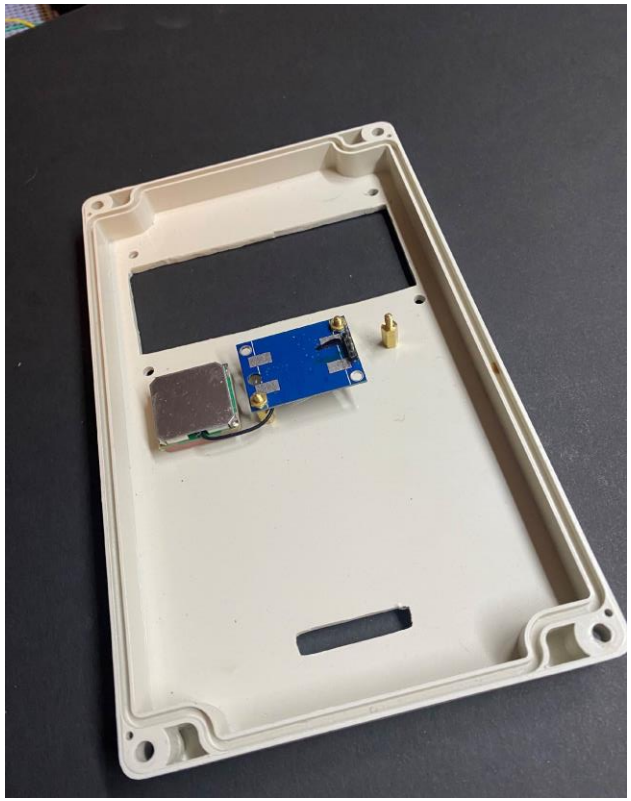
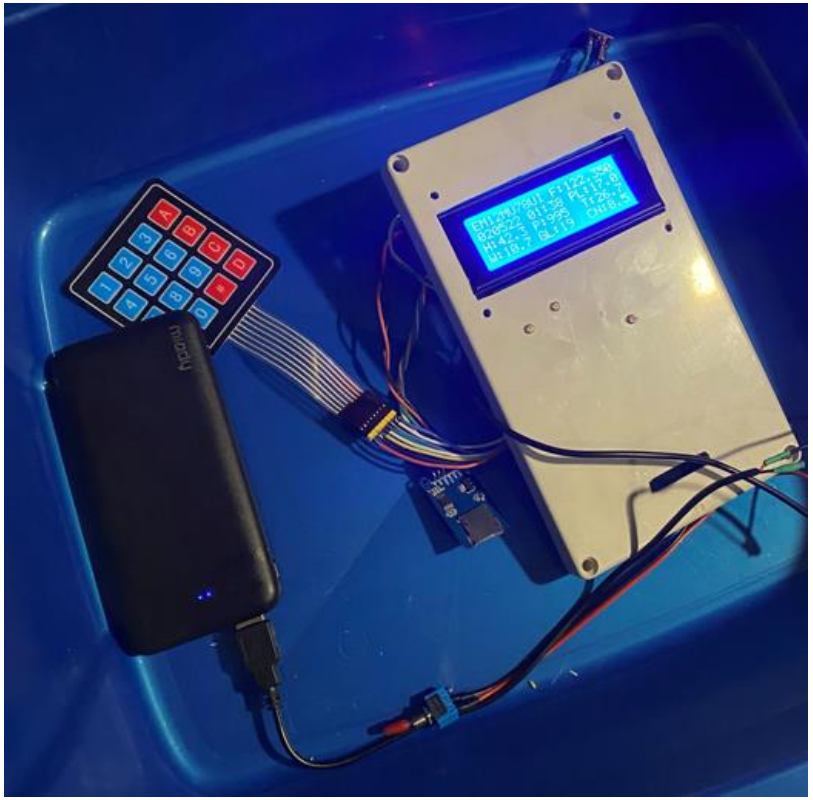


Mount GPS on standoffs, antenna with tape, add standoff for power buss.



Smoke test successful in plastic bucket on 3rd floor balcony

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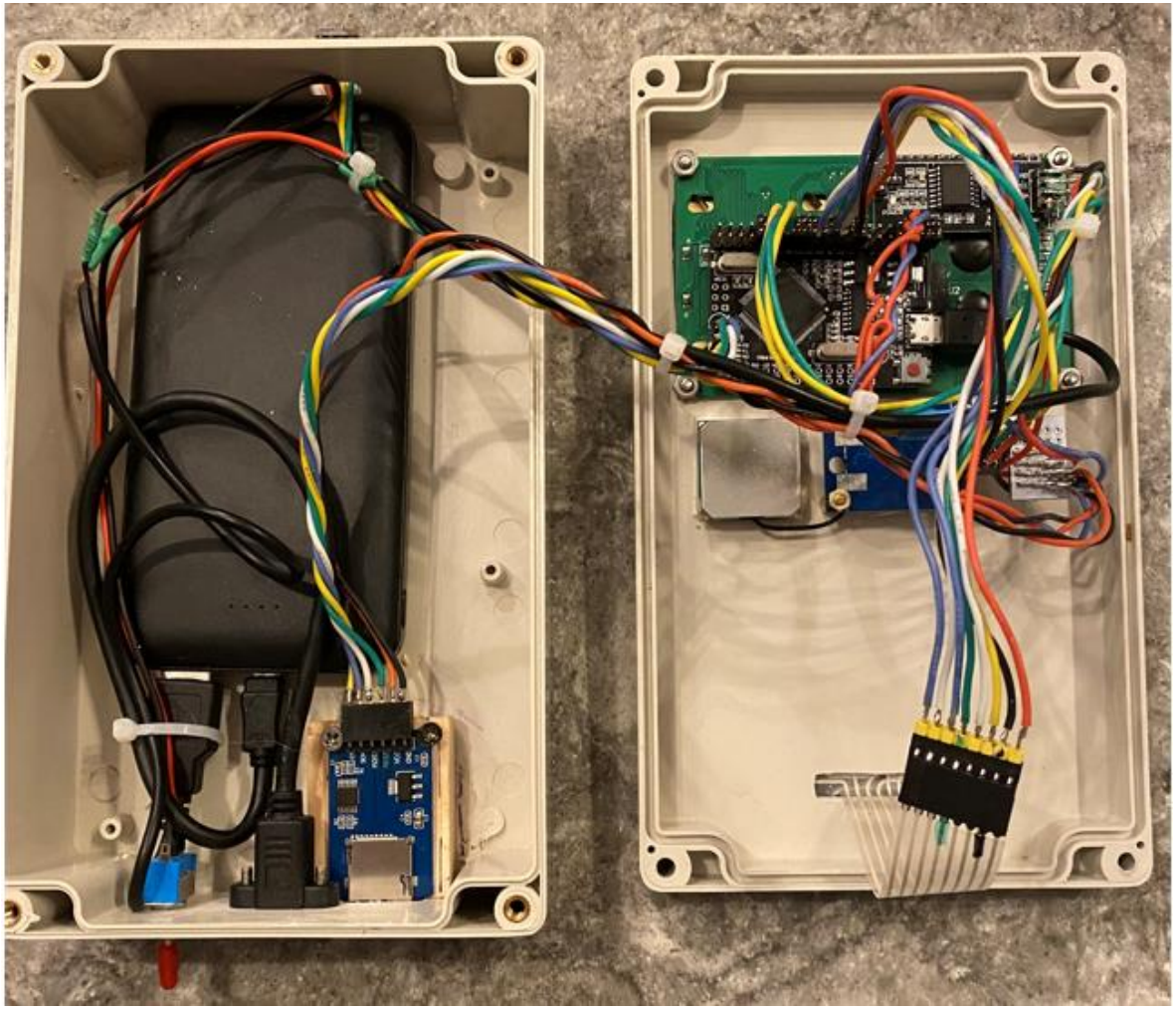
# Final assembly



# Final assembly

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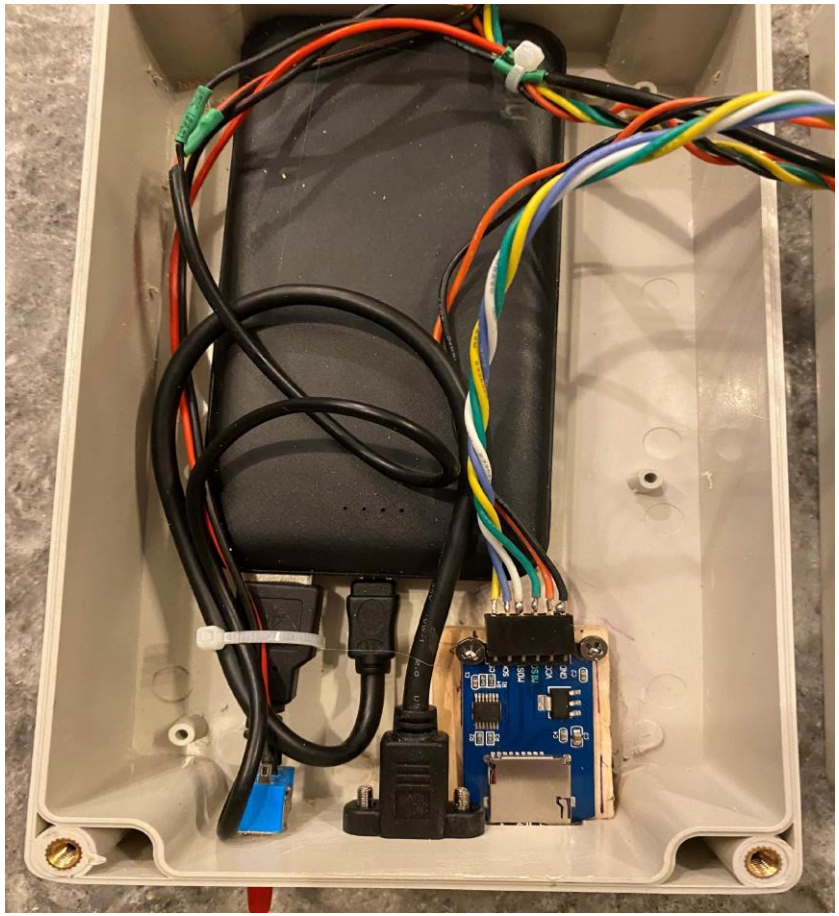
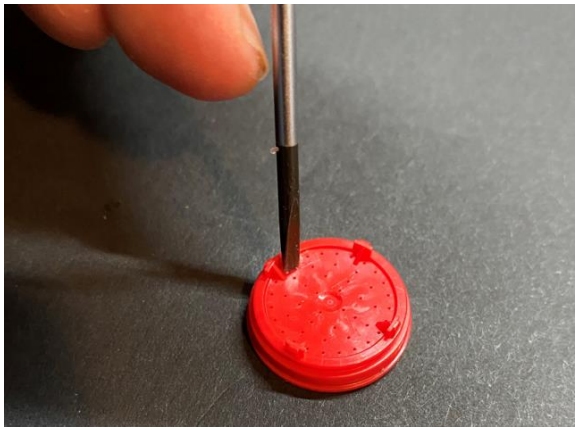
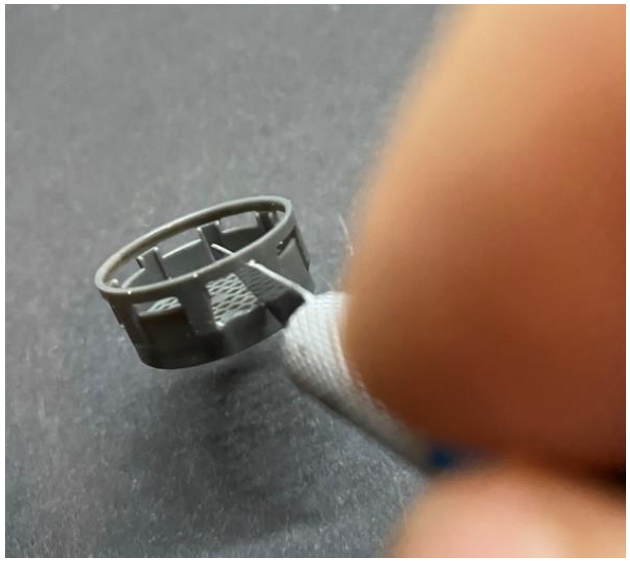
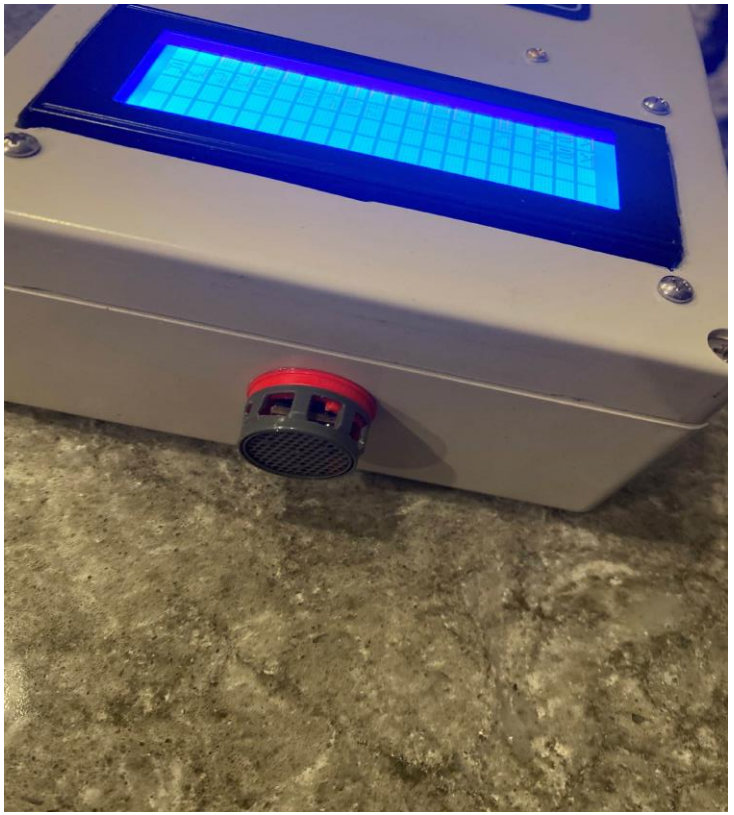


# Sensor guard



2 part plastic faucet filter. Knock out center and open side vents





Epoxy over PME280 sensor

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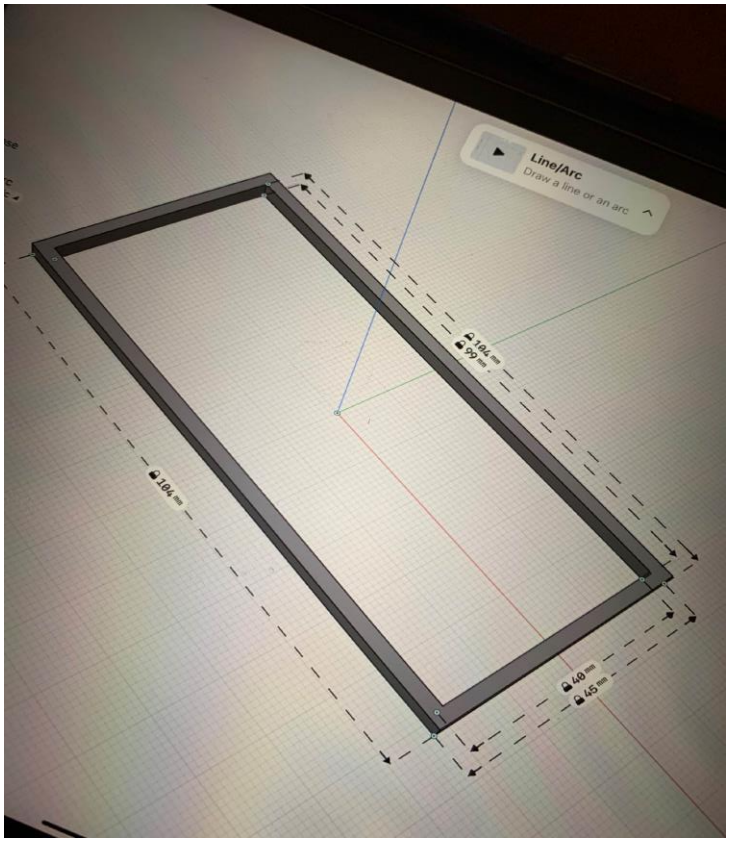
# Bezel


KI5EMN 3D printed bezel

# Inputs and outputs

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- Inputs (system and path parameters):
  - Frequency in GHz
  - Path length in km
  - Transmit power in mW
  - Transmit antenna gain in dB
  - Receive antenna gain in dB
  - Receive noise figure in dB
  - Receive bandwidth in kHz
- Outputs
  - 10-digit Maidenhead locator of your position
  - GPS clock date & UTC time
  - Atmospheric relative humidity (%)
  - Barometric pressure (mb)
  - Temperature (C)
  - Calculated water content of the atmosphere (gm/m3)
  - Additional attenuation (dB) due to presence of water vapour and atmospheric gases along the path
  - Estimated received carrier to noise ratio (dB)
  - Calcs for last 2 outputs are based on attenuation model given in ITU-676-12 report and are valid for any frequency between 1 and 1000 GHz

# Additional features

- SD card logging
  - How often to write log record is prompted

| EM12MU78UH 250422 | | | | | | | |
|---|---|---|---|---|---|---|---|
| 122.350 17.0 0.50 40 20 12 2.4 | | | | | | | |
| | | | | | | | |
| Time | Bar press | Temp | Rel Hum | H20 | GL | path loss | C/N dB |
| 21:31 | 1008.1 | 22.4 | 37.4 | 7.5 | 14.0 | 172.8 | 12.7 |
| 21:32 | 1008.1 | 22.6 | 36.7 | 7.4 | 13.8 | 172.6 | 12.8 |
| 21:33 | 1008.5 | 22.0 | 37.2 | 7.3 | 13.7 | 172.5 | 12.9 |
| 21:34 | 1008.2 | 22.2 | 37.0 | 7.3 | 13.7 | 172.5 | 12.9 |
| 21:35 | 1008.1 | 22.4 | 35.8 | 7.1 | 13.5 | 172.3 | 13.2 |
| 21:36 | 1008.3 | 22.5 | 35.8 | 7.2 | 13.5 | 172.3 | 13.1 |
| 14 hours later: | | | | | | | |
| 11:03 | 1013.6 | 14.1 | 57.6 | 7.0 | 14.8 | 173.6 | 11.9 |
| 11:04 | 1013.6 | 14.0 | 56.7 | 6.8 | 14.5 | 173.3 | 12.1 |
| 11:05 | 1013.7 | 13.9 | 58.5 | 7.0 | 14.8 | 173.7 | 11.8 |
| 11:06 | 1013.8 | 13.9 | 58.3 | 7.0 | 14.8 | 173.6 | 11.8 |

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# Additional features

- Storage of up to 10 system and path settings
  - Once save and recalled you can tweak any input
  - Set up your two station parms and vary the distance
  - Set up your two station parms and vary the frequency


122 GHz – C/N=2.7 dB


134 GHz – C/N= .08 dB

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# Additional features

- Use same parms and vary frequency


10 GHz – C/N=47 dB


24 GHz – C/N=35 dB


48 GHz – C/N=29 dB


78 GHz – C/N=21 dB

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# Twins - almost

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# Next steps

- Gather usage information during tests
  - Get experience before next cold season
  - Review on line propagation studies at higher mw freq.
- Improve design with touchscreen TWB
  - Smaller packaging not much higher cost
  - More intuitive use
- Prototype a remote controlled environment collections unit
  - No screen or SD card interface
  - Add cell phone card, control via text (similar to KI5EMN remote controlled high powered LED)
  - Possibly post up data to a web service allowing for automated integration of data from multiple remote sensors across the path

# KI5EMN touchscreen prototype

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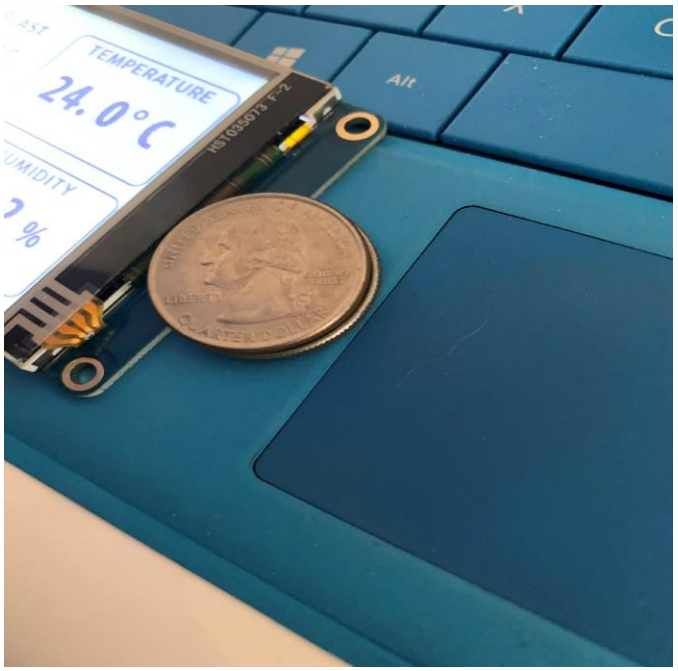


- Nextion 3.5” 480x320 display

# KI5EMN touchscreen prototype

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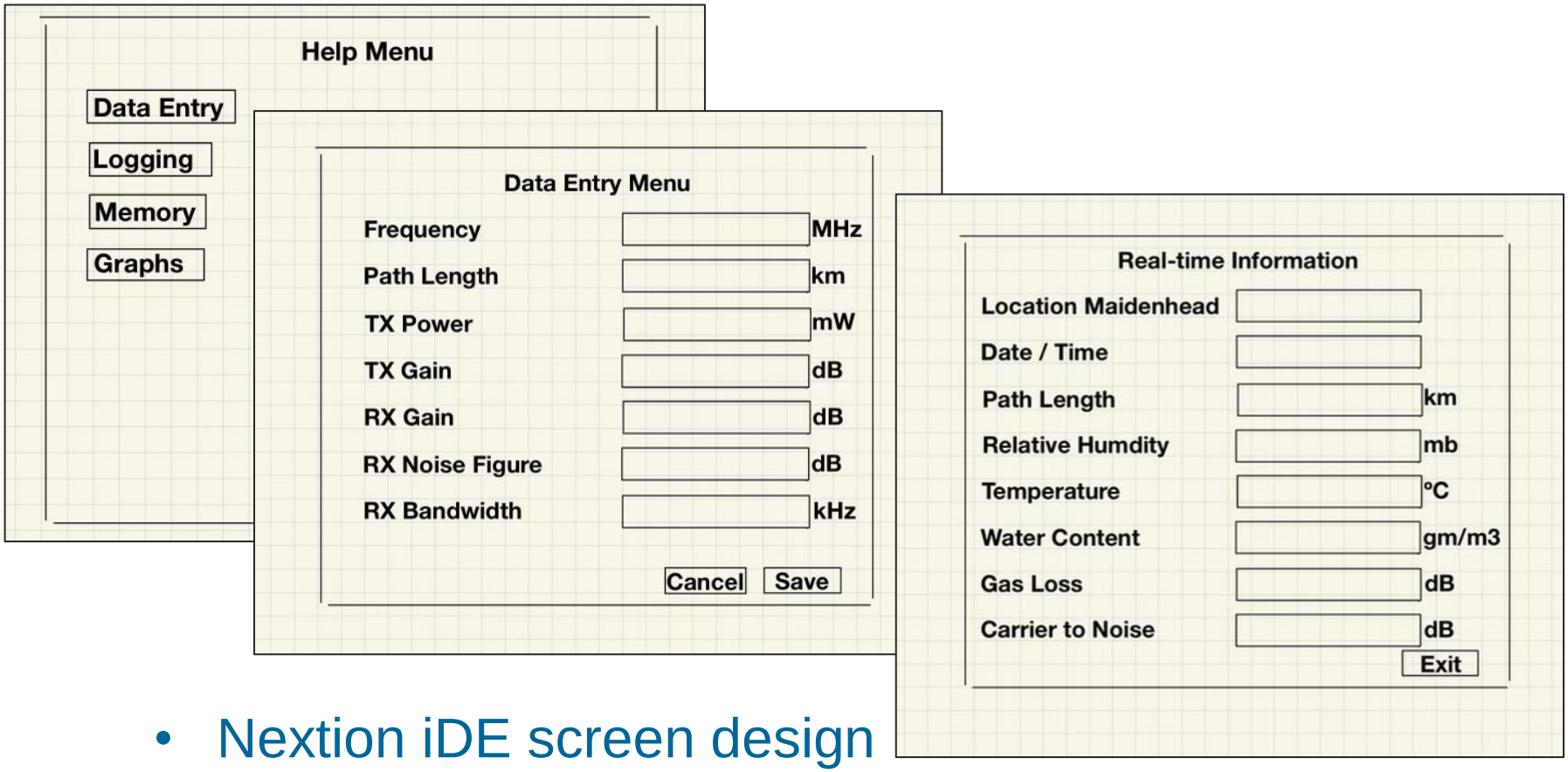


- Nextion iDE screen design

# KI5EMN touchscreen prototype

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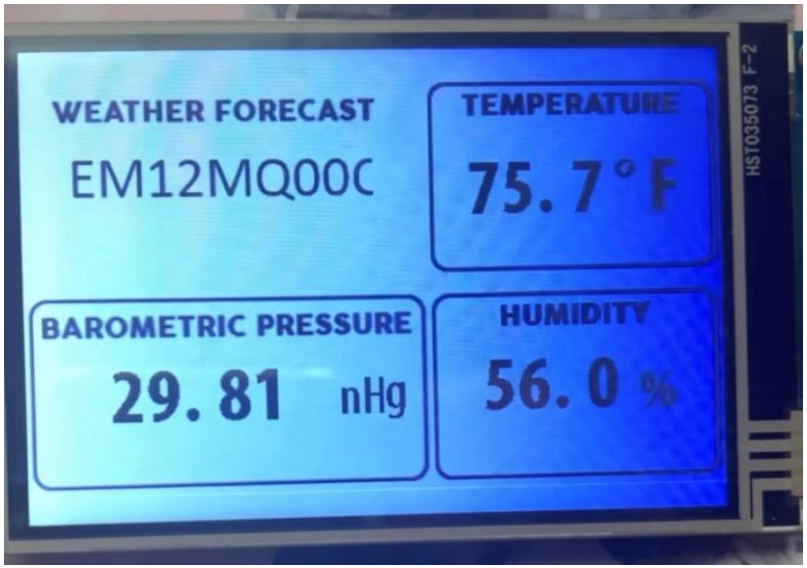


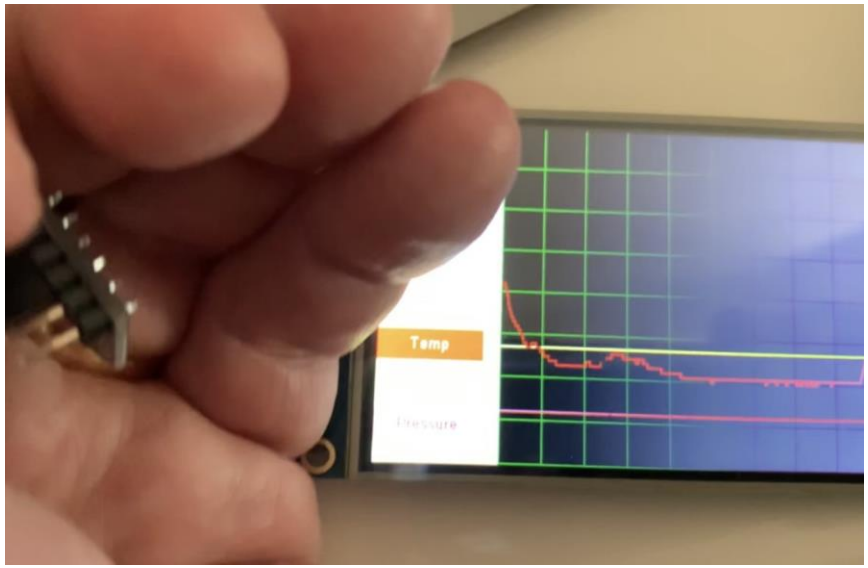


- Sensor interface tests
- Sensor data graphing

# Additional resources



- Mega pro CH340G Atmega2560
  - DIM==0G-00005641==MEGA-PRO-CH340GATmega2560.pdf (robotdyn.com)
- DD1US WeatherBox build
  - WeatherBox by G8AGN (dd1us.de)
- Barry Chambers G8AGN original WeatherBox documentation and 122 GHz propagation discussion
  - https://microwavers.org/scatterpoint/2020/Scatterpoint_2001.pdf
- On-line propagation path web page (demoed in previous presentations) VK5ZD
  - Path Loss Calculator (vk5microwave.net)

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# Questions?