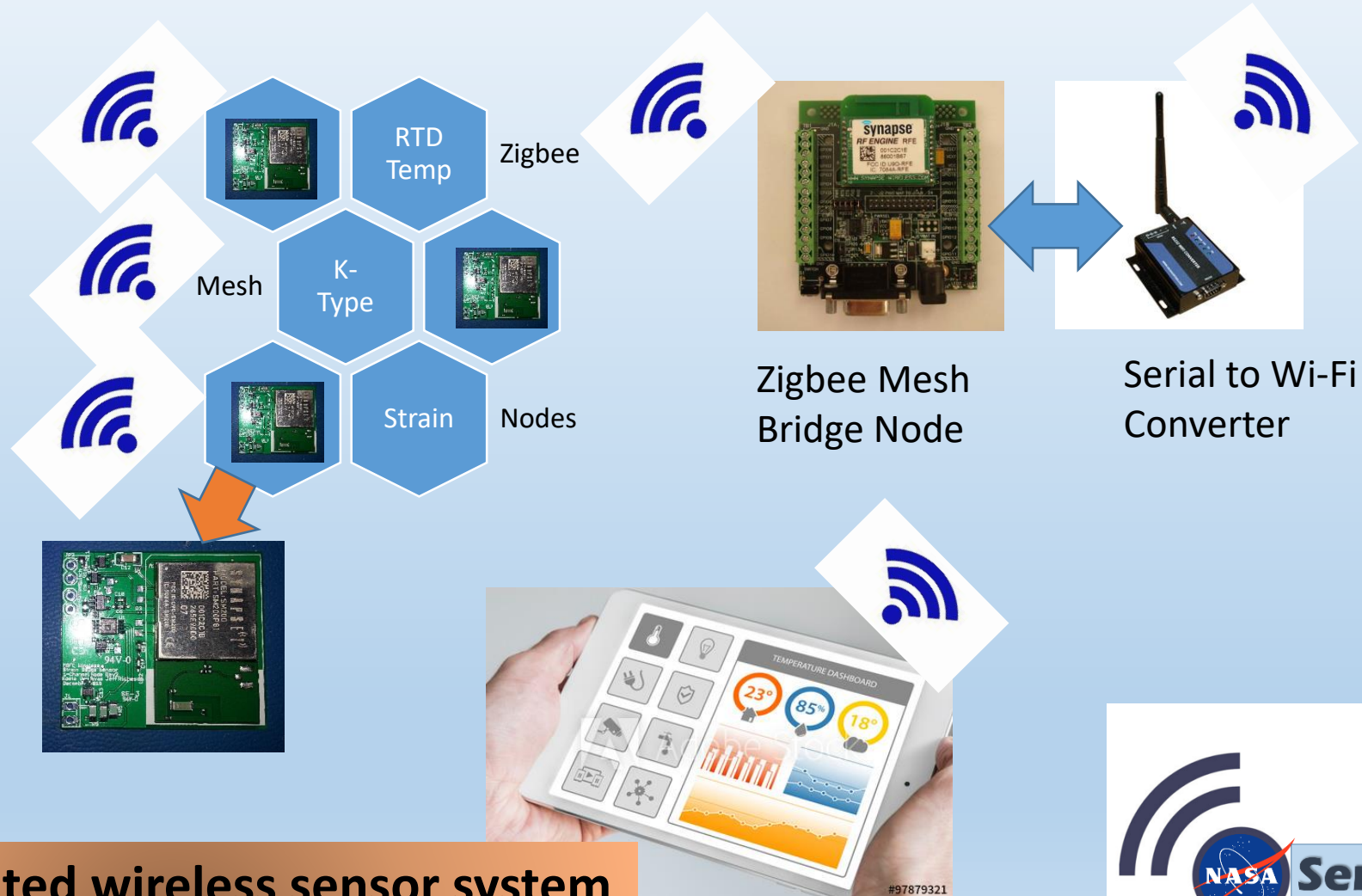


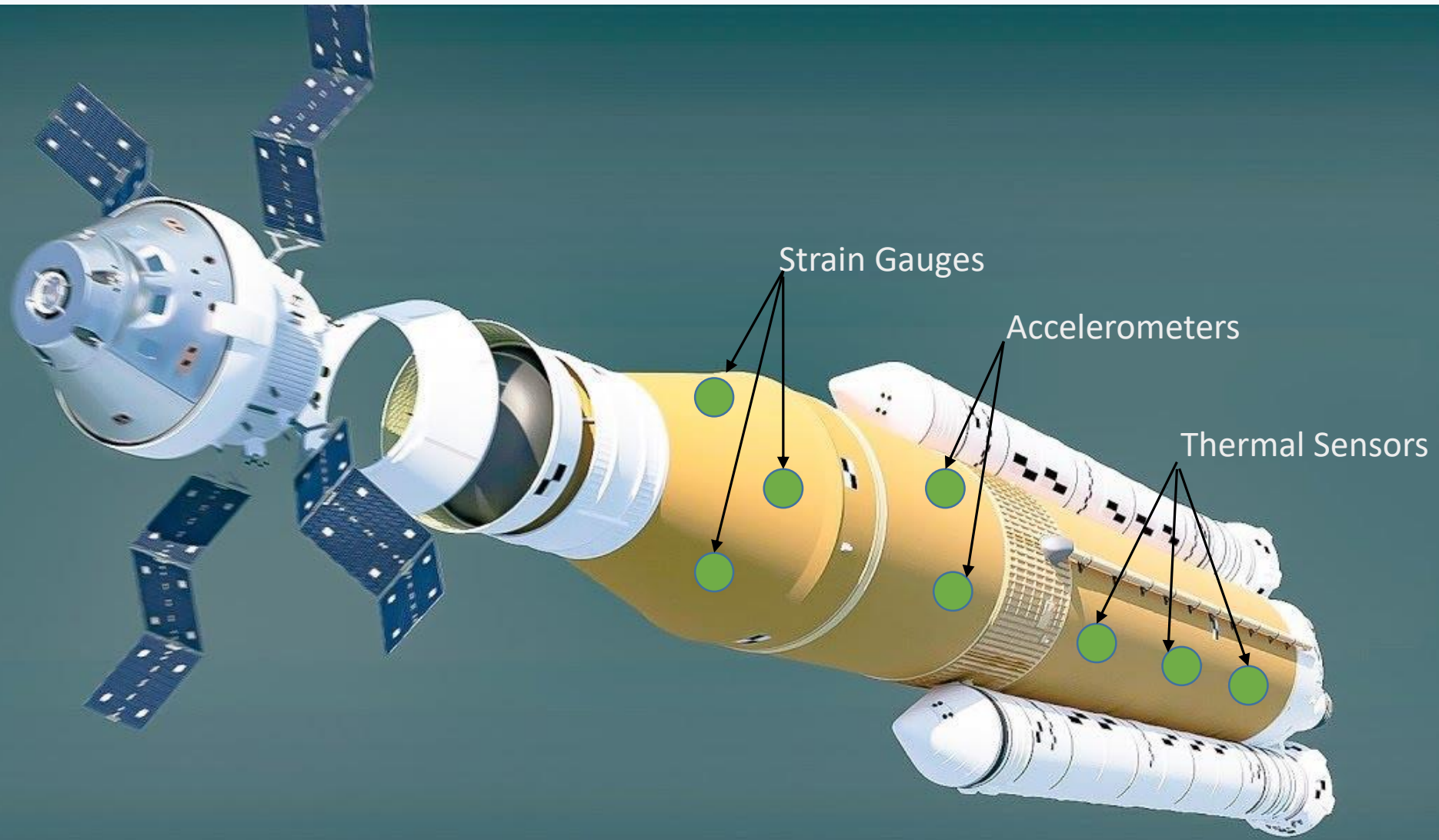
Sensor Nodes End to End Architecture



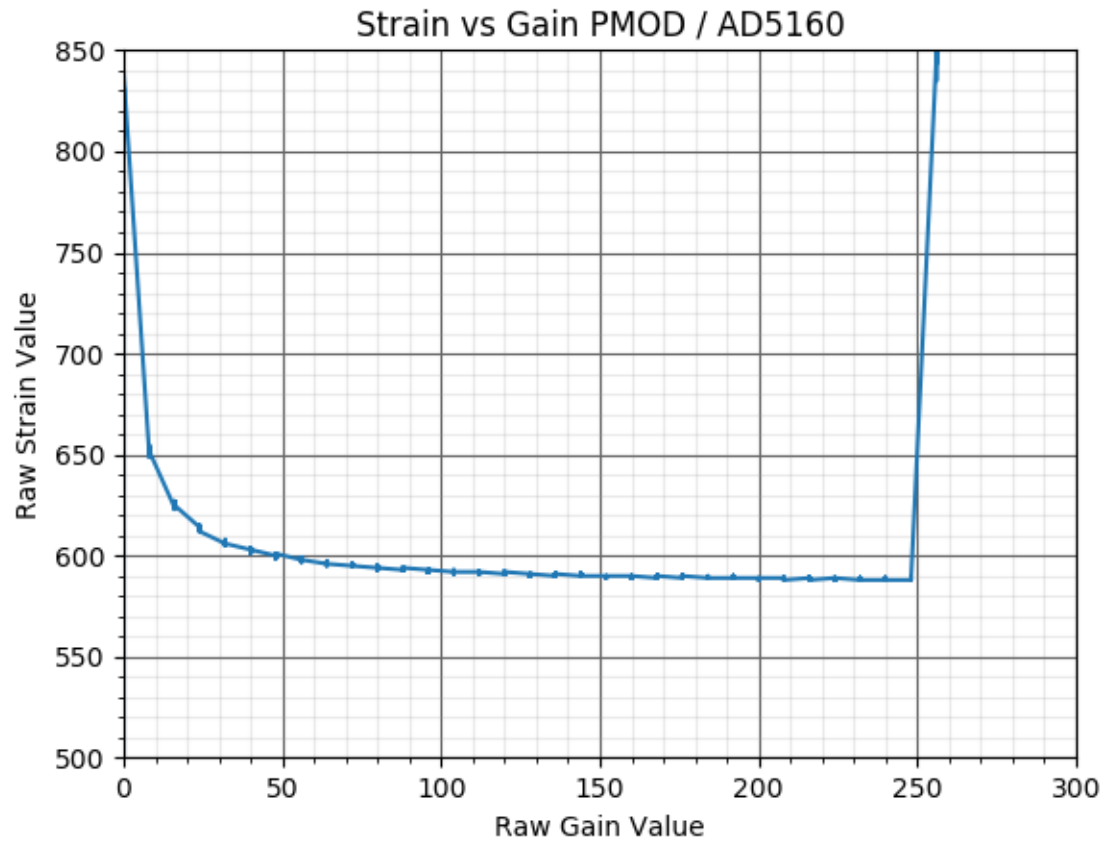
Fully integrated wireless sensor system

- Delay Tolerant

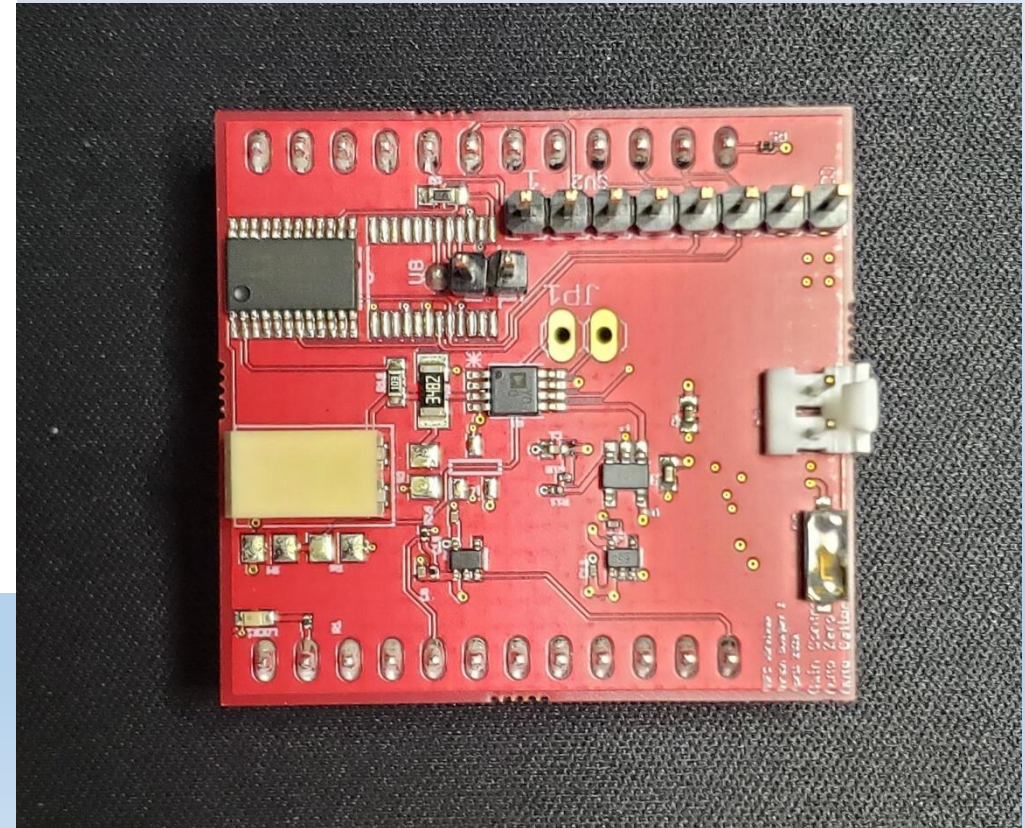




Digital Potentiometer Response



- Will allow for auto gain control
- Will allow for auto zero function.
- Will allow for auto calibration.
- Advanced strain gauge features.

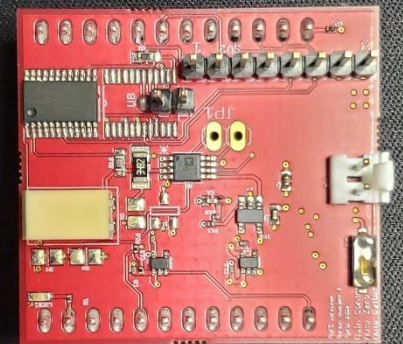
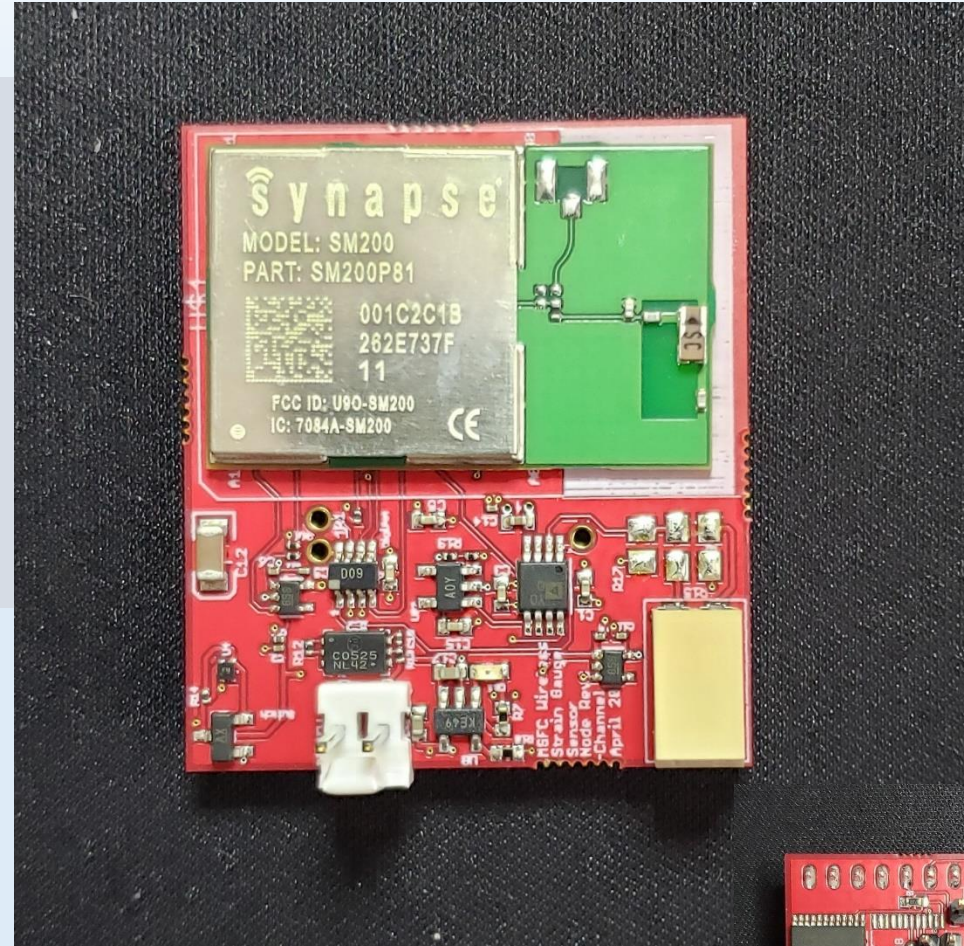


Strain Gauge

- Final board incorporating digital control circuits for Over The Air (OTA) functions designed and on order. :
 - gain control
 - auto zero
 - Auto calibration

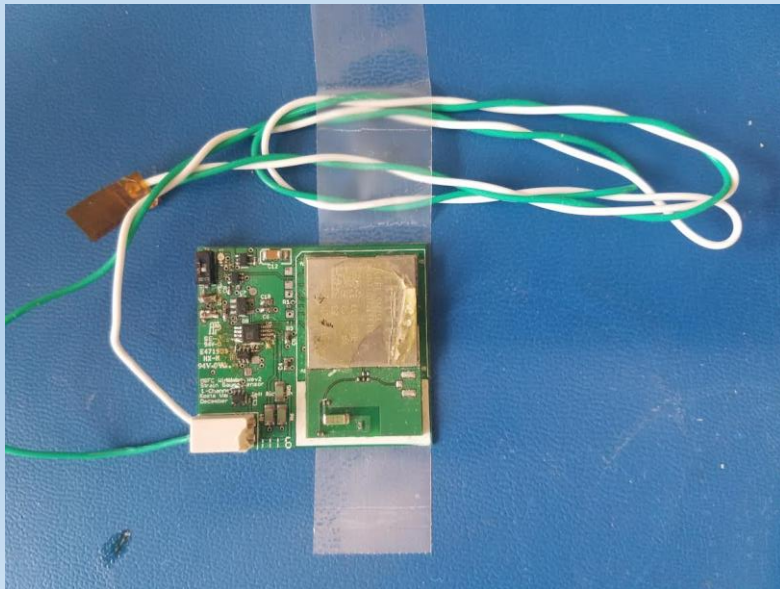
Next Steps:

- Calibrate strain measurement.
- Software to control the course and fine control of multiple digital potentiometers to implement above features.





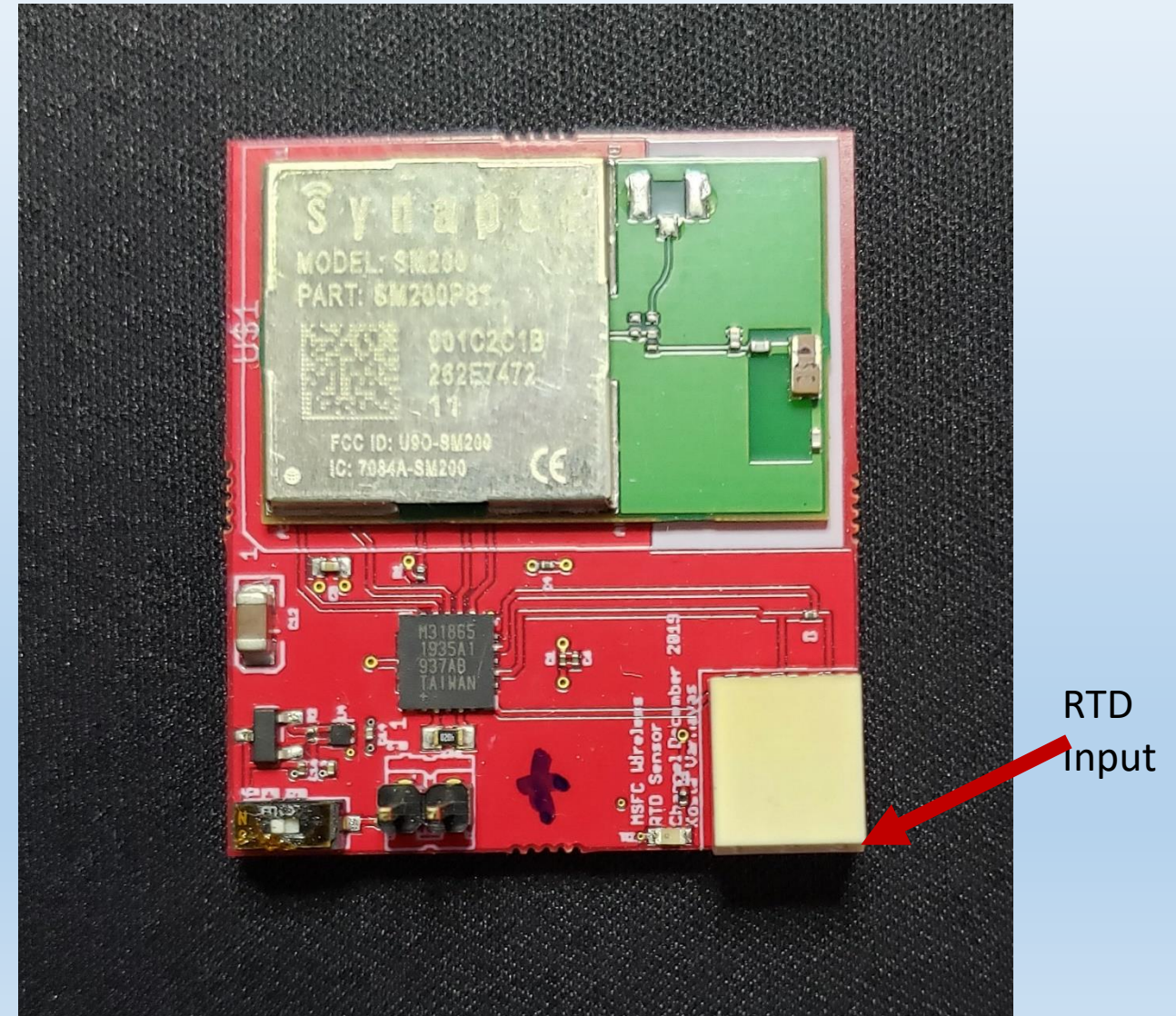
Strain Gauge Sensor Features



- 1 strain gauge
- Independent constant voltage regulator driving the excitation voltage, for very precise measurements.
- Power management hardware.
- Power management software.
- Op Amp has large and adjustable gain ranges.
- Gain control via software command and digital potentiometer.
- Digital potentiometer for auto calibration
- Digital potentiometer for auto zero.

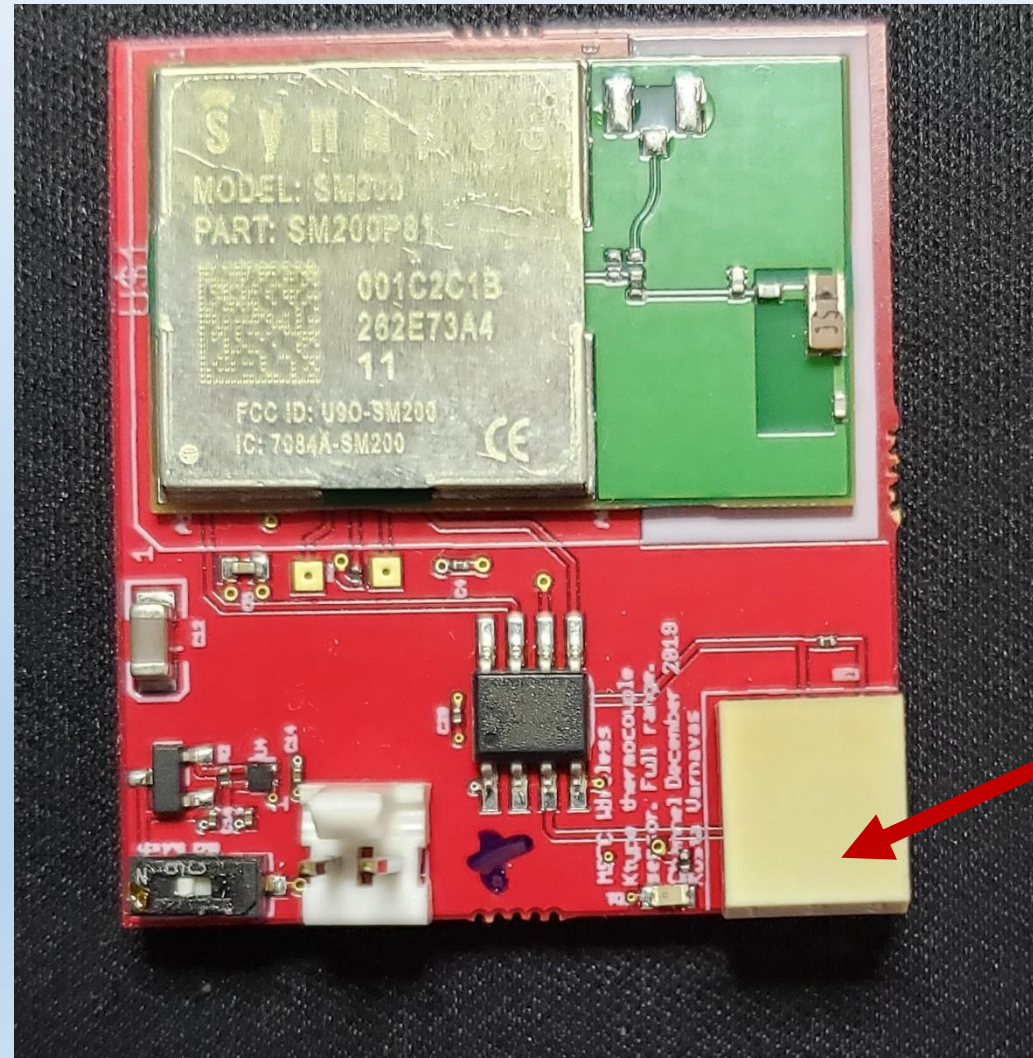
Resistive Thermal Device (RTD) Temperature Measurement

- RTDs have higher accuracy and repeatability than thermocouples in industrial applications below 600 °C.
https://en.wikipedia.org/wiki/Resistance_thermometer
- Sensor input is 100 ohm PT100 RTDs
- 3 wire RTDs for wire length compensation.
- 15-Bit ADC Resolution Converter.
- Total Accuracy Over All Operating Conditions: 0.5C (0.05% of Full Scale) max
- Detects Shorts to GND or VCC.
- Detects Open RTD input.



K-Type Thermocouple Temperature Measurement

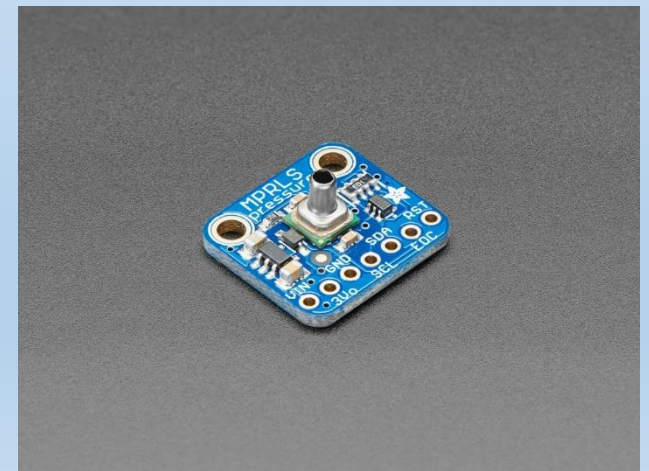
- Thermocouple Types: K, J, N, T, S, R, and E-Types supported by simple drop in part number change.
 - Type K
 - Typical temperature range: -200 to 1260 degC
 - Type E
 - Typical temperature range: -200 to 870 degC
 - Better temperature accuracy over Type K.
- 14-Bit, 0.25°C Resolution Converter.
- Automatically compensates for cold junction temperatures and linearizes the results.
- Detects Thermocouple Shorts to GND or VCC.
- Detects Open Thermocouple.



K-Type
Input

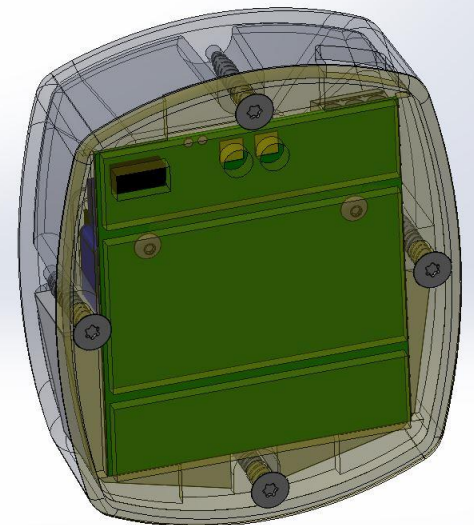
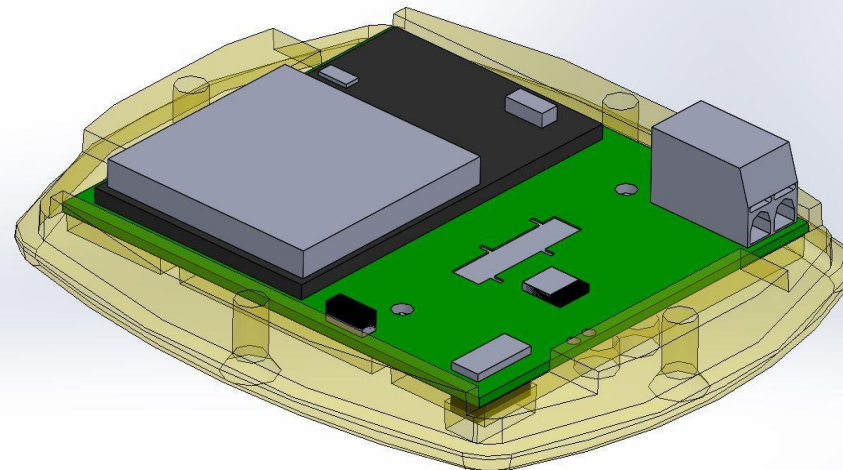
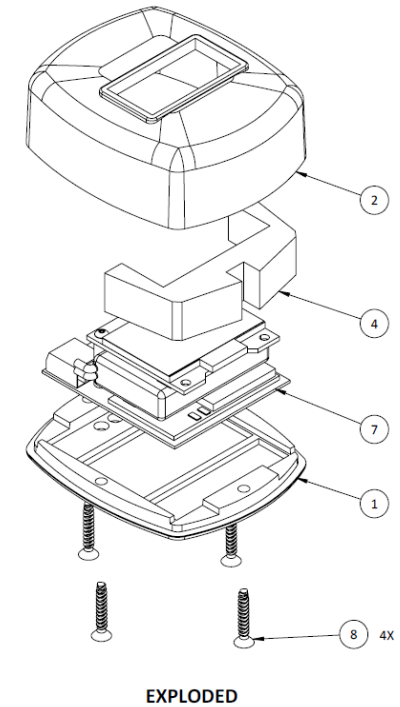
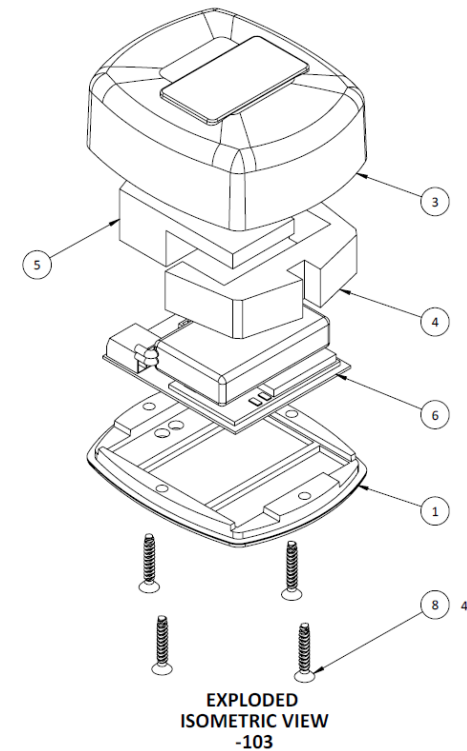
Pressure Measurements

- Analog high pressure sensors.
 - Tecsisi 75PSI
- Honeywell MPRLS pressure sensors.
 - 30PSI max



Enclosures

- Custom enclosures are necessary for these custom sensor boards.
- All boards are created with charging pads, switch location , and sensor input in the same location.
- This allows all sensor modules to fit in same enclosure.
- Worked with local company to create enclosure designs.
- Worked with local company to manufacture

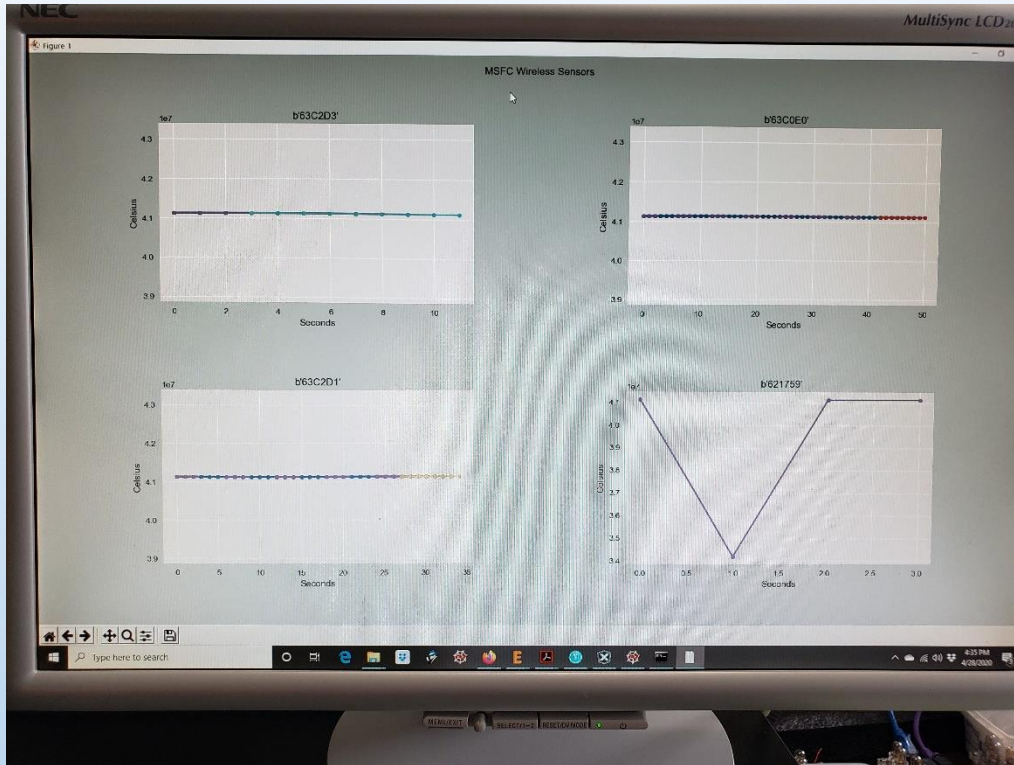


Software. Lots of Software

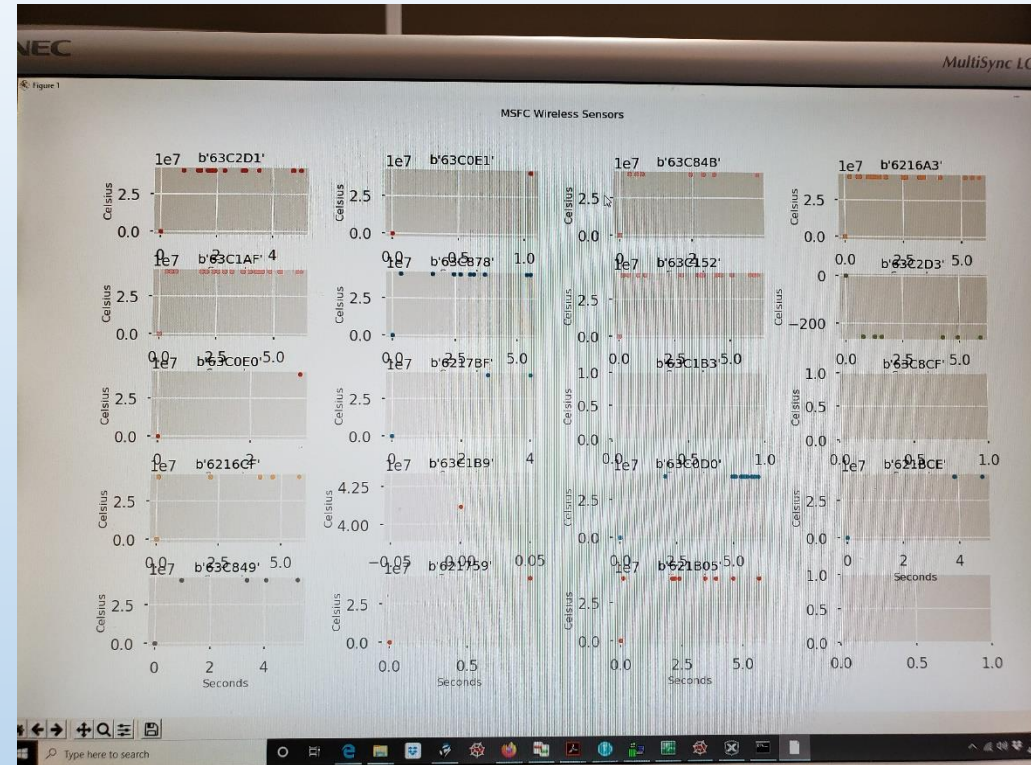
Wireless Nodes

- Specific python code for each sensor node to perform unique control requirements for each node.
 - Designed and coded communication protocol for each sensor to take commands and send data back to main control and display application.
 - Software functions to preserve battery life such as
 - Power on/ off circuits
 - Sleep mode controls.
 - Start / stop data collection
 - Designed and coded Time Division Multiple Access (TDMA) protocol for each node to get around collisions and data drop outs.
- User application software to control downstream nodes, and display sensor nodes data.
 - Performs node discovery to determine number of nodes, node names(addresses) and sensor types.
 - Based on number of nodes, create an array of charts, to display data real time.
 - All data sent to CSV file and SQLite database files for storage and future analysis.

Data Display and Analysis

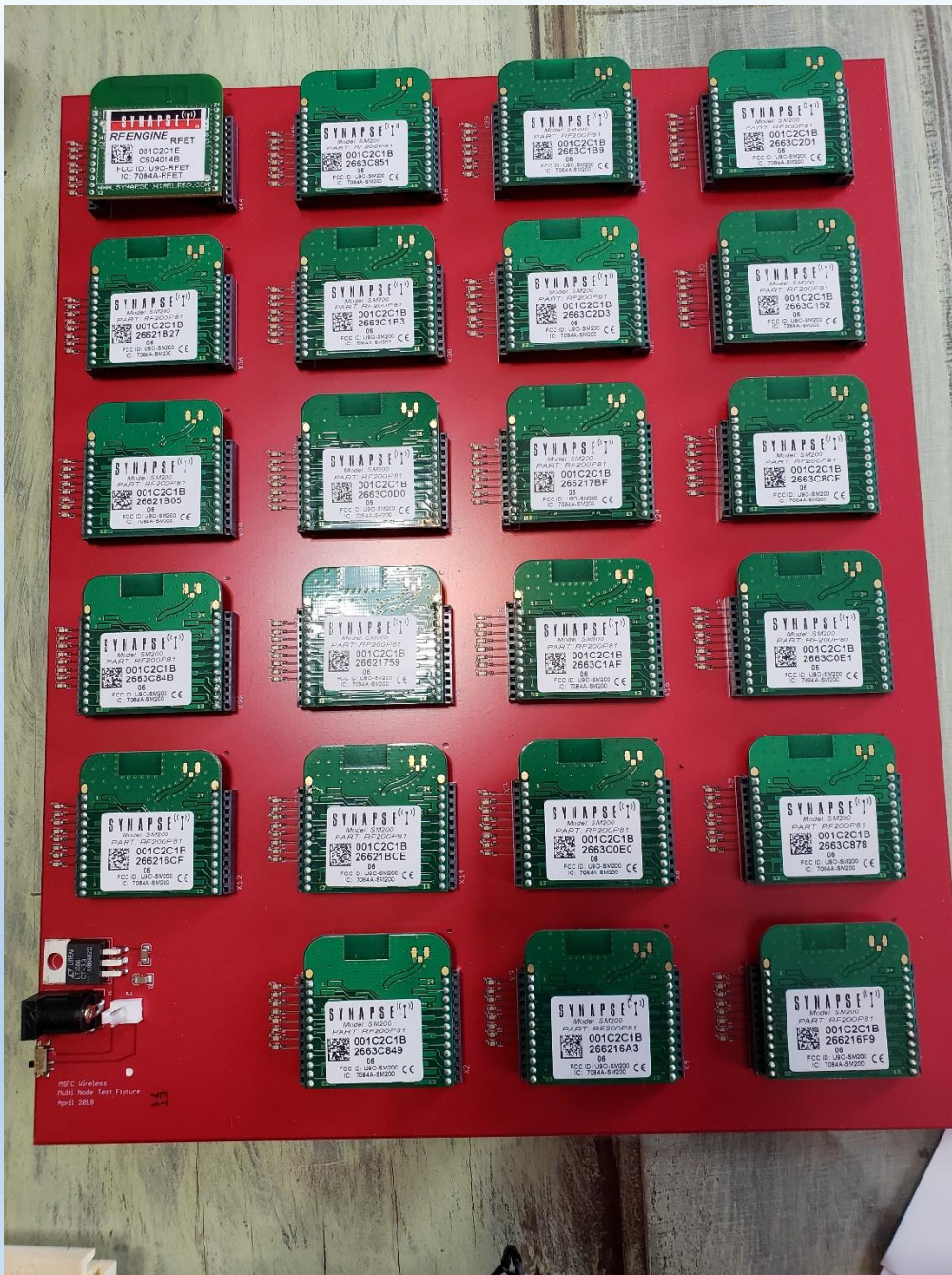


- Dynamic chart setup and display based on Nodes discovered.
- Raw data stored in CSV and SQLite data base formats for additional post processing.
- Cloud access being investigated.
- Enhanced Graphical User Interface (GUI) for added display features and control options.



The screenshot shows a Notepad window titled 'TestLog.log - Notepad' containing a log file with sensor data. The log entries are as follows:

Timestamp	Device	Channel	Value	Unit
12/04/2013 02:27:44 PM	5d1328	strain gauge 2	reported 1023	microstrains (me)
12/04/2013 02:27:44 PM	5d1328	strain gauge 3	reported 1023	microstrains (me)
12/04/2013 02:27:45 PM	5d1328	strain gauge 1	reported 1018	microstrains (me)
12/04/2013 02:27:45 PM	5d1328	strain gauge 2	reported 886	microstrains (me)
12/04/2013 02:27:45 PM	5d1328	strain gauge 3	reported 1023	microstrains (me)
12/04/2013 02:27:46 PM	5d1328	strain gauge 1	reported 1015	microstrains (me)
12/04/2013 02:27:46 PM	5d1328	strain gauge 2	reported 882	microstrains (me)
12/04/2013 02:27:46 PM	5d1328	strain gauge 3	reported 1023	microstrains (me)
12/04/2013 02:27:47 PM	5d1328	strain gauge 1	reported 1016	microstrains (me)
12/04/2013 02:27:47 PM	5d1328	strain gauge 2	reported 882	microstrains (me)
12/04/2013 02:27:47 PM	5d1328	strain gauge 3	reported 1023	microstrains (me)
12/04/2013 02:27:48 PM	5d1328	strain gauge 1	reported 1015	microstrains (me)
12/04/2013 02:27:48 PM	5d1328	strain gauge 2	reported 882	microstrains (me)
12/04/2013 02:27:48 PM	5d1328	strain gauge 3	reported 1023	microstrains (me)
12/04/2013 02:27:49 PM	5d1328	strain gauge 1	reported 1014	microstrains (me)
12/04/2013 02:27:49 PM	5d1328	strain gauge 2	reported 882	microstrains (me)
12/04/2013 02:27:49 PM	5d1328	strain gauge 3	reported 1023	microstrains (me)
12/04/2013 02:27:50 PM	5d1328	strain gauge 1	reported 1016	microstrains (me)
12/04/2013 02:27:50 PM	5d1328	strain gauge 2	reported 882	microstrains (me)
12/04/2013 02:27:50 PM	5d1328	strain gauge 3	reported 1023	microstrains (me)
12/04/2013 02:27:51 PM	5d1328	strain gauge 1	reported 1010	microstrains (me)
12/04/2013 02:27:51 PM	5d1328	strain gauge 2	reported 886	microstrains (me)
12/04/2013 02:27:52 PM	5d1328	strain gauge 3	reported 1023	microstrains (me)
12/04/2013 02:27:52 PM	5d1328	strain gauge 1	reported 1015	microstrains (me)
12/04/2013 02:27:52 PM	5d1328	strain gauge 2	reported 882	microstrains (me)
12/04/2013 02:27:53 PM	5d1328	strain gauge 3	reported 1023	microstrains (me)
12/04/2013 02:27:53 PM	5d1328	strain gauge 1	reported 1015	microstrains (me)
12/04/2013 02:27:53 PM	5d1328	strain gauge 2	reported 881	microstrains (me)
12/04/2013 02:27:54 PM	5d1328	strain gauge 3	reported 1023	microstrains (me)
12/04/2013 02:27:54 PM	5d1328	strain gauge 1	reported 1015	microstrains (me)
12/04/2013 02:27:55 PM	5d1328	strain gauge 2	reported 882	microstrains (me)
12/04/2013 02:27:55 PM	5d1328	strain gauge 3	reported 1023	microstrains (me)
12/04/2013 02:27:55 PM	5d1328	strain gauge 1	reported 1015	microstrains (me)
12/04/2013 02:27:56 PM	5d1328	strain gauge 2	reported 881	microstrains (me)
12/04/2013 02:27:56 PM	5d1328	strain gauge 3	reported 1023	microstrains (me)
12/04/2013 02:27:56 PM	5d1328	strain gauge 1	reported 1015	microstrains (me)
12/04/2013 02:27:57 PM	5d1328	strain gauge 2	reported 882	microstrains (me)
12/04/2013 02:27:57 PM	5d1328	strain gauge 3	reported 1023	microstrains (me)
12/04/2013 02:27:58 PM	5d1328	strain gauge 1	reported 1014	microstrains (me)



- Large mesh network board for testing Time Division Multiple Access (TDMA) algorithms to help data throughput and limit collisions and data loss for large networks.

Real Structures Lab Test Article Testing

- Instrument 20 + next generation wireless strain gauges , next to standardly used strain gauges on actual test article.
- Connect that network of sensors through Wi-Fi bridge node so control and data flow can be monitored from remote control room.
- Monitor for data throughput, dropouts, and collisions.
- Comparisons between wireless sensor measurements to standard measurements.
- Previous comparison tests have shown wireless sensors track standard sensors very well .



Current and Next Generation RF Modules

➤ The Synapse RF200 Modules, contain a complete A/D, Microcontroller ,802.15.4 radio and Mesh Protocol Software Stack.

➤ Capable of uploading new software into each module over the network.

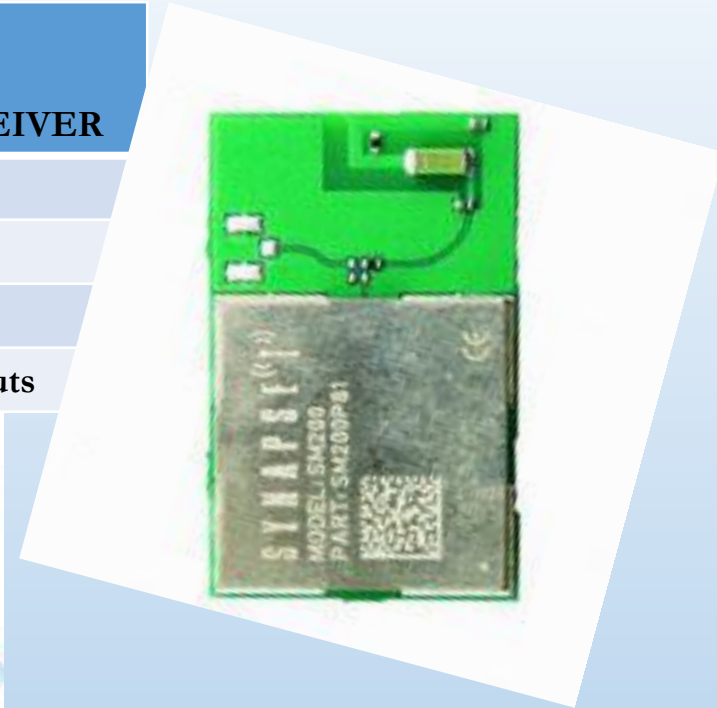
RF200P81 / SM200
Synapse 2.4 GHZ IEEE
802.15.4/ZIGBEE® RF TRANSCEIVER

RX: 22.5 mA (@ 3.3 V)

TX: 22.5 mA (@ 3.3 V)

33.86mm x 33.86mm

20 GPIO and up to 7 A/D inputs



The nRF52840 has:

- 12-bit 200 ksps AD
- 1 MB Flash, 256 KB RAM
- UART, SPI, TWI, PDM, I2S, QSPI
- Hardware security 128-bit AES CCM, ECB, AAR

Current draw at different RF power levels.

Radio current
consumption DC/DC at
3 V

14.8 mA at +8 dBm TX
power,
9.6 mA at +4 dBm TX
power,
4.8 mA at 0 dBm TX
power,
4.6 mA in RX at 1 Mbps
5.2 mA in RX at 2 Mbps



