Blinky Lite

Blinky-Lite Platform

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11 October 2019

History and Motivation

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- In 2015, I was in charge of building Test Stand 1 for ESS. the goal of the test stand was to start testing klystrons and modulators while the ESS site was still under construction.
- Of course we needed a control system. I asked our controls group for help and the control group said “send us:
  - Your requirements,
  - Your WBS code
  - Your PBS….
- ...and we’ll get back to you”
- So I said “NEVER AGAIN WILL BE HELD AT THE MERCY OF THE CONTROLS GROUP! plus I want to have some fun”
- So we decided to build are own control system
  - How hard could it be?

History and Motivation

Blinky Lite

- We started with EPICS and since we didn’t have much money, we thought about using Raspberry Pi’s as IOCs.
- We were successful at doing this but we found EPICS was pretty cumbersome with a rather large footprint. We were also unhappy with the archiving tool that was available at that time.
- We attended the 2016 IOT conference in Lund, Sweden and became inspired to try to build a control system using wireless IoT technology.
- We were successful and built a system called ITSnet from scratch and we ran for 1.5 years while testing two klystrons and two modulators before the test stand was decommissioned and sent to the ESS site.

History and Motivation

Blinky Lite

- ITSnet was based on
  - Raspberry PI 3B as device message adapters
  - Arduinos or Adafruit Feathers as device controllers
  - MQTT as the communication system and protocol
  - Java 1.8 with GWT as the code base
  - Wireless communication (802, Bluetooth, and LoRa)
    - We even built a timing system using LoRa radios that had a precision of <2uS and a range of over 500 meters.
- Itsnet Drawbacks
  - No real central services such as archiving, security, and alarms
  - Loose definitions on device structure
  - GWT has unsupported
  - Small ecosystem in Java web tools
  - ...

History and Motivation

Blinky Lite

- In April 2018, I moved to MaxIV, a brand new 4th generation light source located outside Lund, Sweden
- MaxIV is a 3 GeV synchrotron light source
  - operating at an RF frequency of 100 MHz
  - with enough installed power for over 250 mA of beam current.
  - MaxIV is designed to operate in the long bunch mode (bunch lengths > 500 ps rms) using passive third harmonic Landau cavities.
- As of April 2018, it was not possible to operate in long bunch mode because of longitudinal instabilities.
  - MaxIV does possess a longitudinal bunch-by-bunch feedback system but the system was not effective in the long bunch mode.
  - It was surmised that the longitudinal instability was a dipole mode 0 coupled bunch mode instability but there were no diagnostics to definitively prove this assertion.

History and Motivation

- First, we needed to build a coupled bunch mode analyser diagnostic
- Then build narrow band but high gain coupled bunch feedback systems.
- These were big tasks:
  - However, to prove MaxIV's ground breaking approach of using muilti-bend achromats a success, it was crucial that this problem be solved quickly.
  - The beamlines were already several years behind schedule and the director was forced to resign
  - All controls efforts were (are) concentrated on the beam lines
  - MaxIV employs few technicians, electrical engineers laying-out and building their own electronics boards.
- For these reasons, the coupled bunch mode diagnostic system and the beam damping system were built using the Blinky-Lite platform

History and Motivation

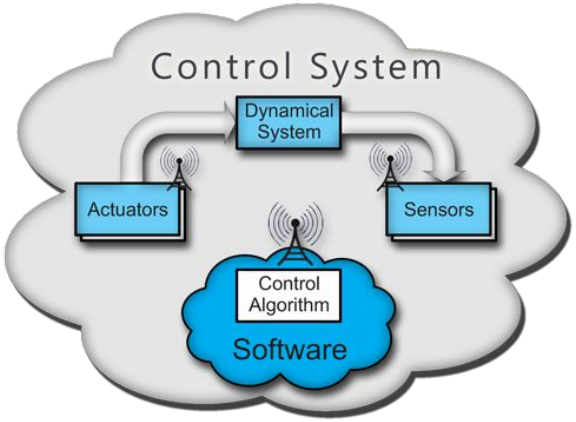
- In June 2018, coupled bunch mode analyzer commissioned and Mode 0 instability identified.
- In September 2018, Mode 0 damper commissioned
- In October 2018, long bunch operation at MaxIV was operational
- These were the strengths of the Blinky-Lite system
  - Time to delivery
  - Low Cost
  - Low resource load

Blinky-Lite

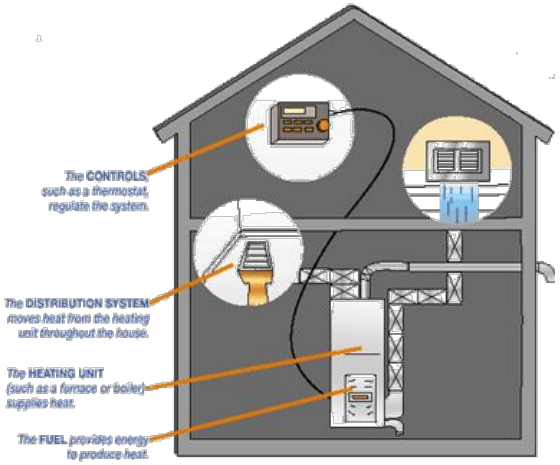
Controls for humans

A Control Platform Based on IoT Technology

Control systems are everywhere - from the the thermostat in your house to nuclear power plants. **Blinky-Lite** is flexible and powerful enough to control anything from a blinking LED to a particle accelerator.



- Example: Home Heating system
  - Sensor - Thermometer
  - Control algorithm - window comparator
  - Actuator - Relay that turns on/off Furnace
- Example: Nuclear Power Plant
  - Sensor - Neutron flux detector
  - Control algorithm - Computer, PLC,..
  - Actuator - Motor that moves in/out control rods



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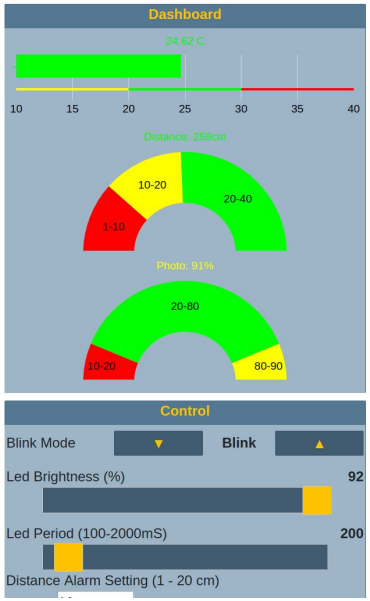
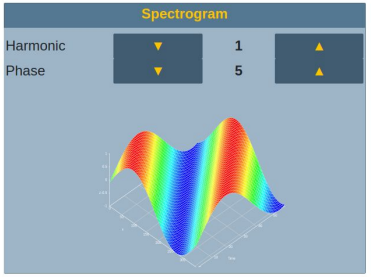
Blinky-Lite

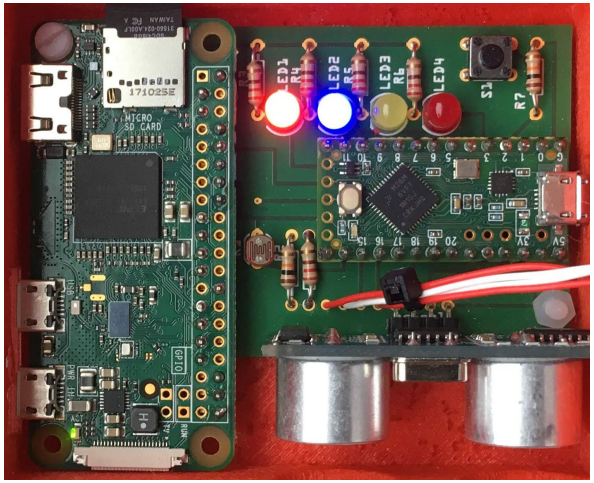
Controls for humans

An open source IoT Control Platform:

- **Extremely reliable and robust control**
  - Blinky-Lite is based on high performance but inexpensive IoT computing placed *close* to the devices to control.
- **Web Accessibility**
  - Blinky-Lite applications are web-based giving control from anywhere in the world.
- **Flexibility**
  - Blinky-Lite is 100% open source for easy customization
- **Easy to implement**
  - Blinky-Lite is designed for non-experts who have beginner knowledge in Javascript.







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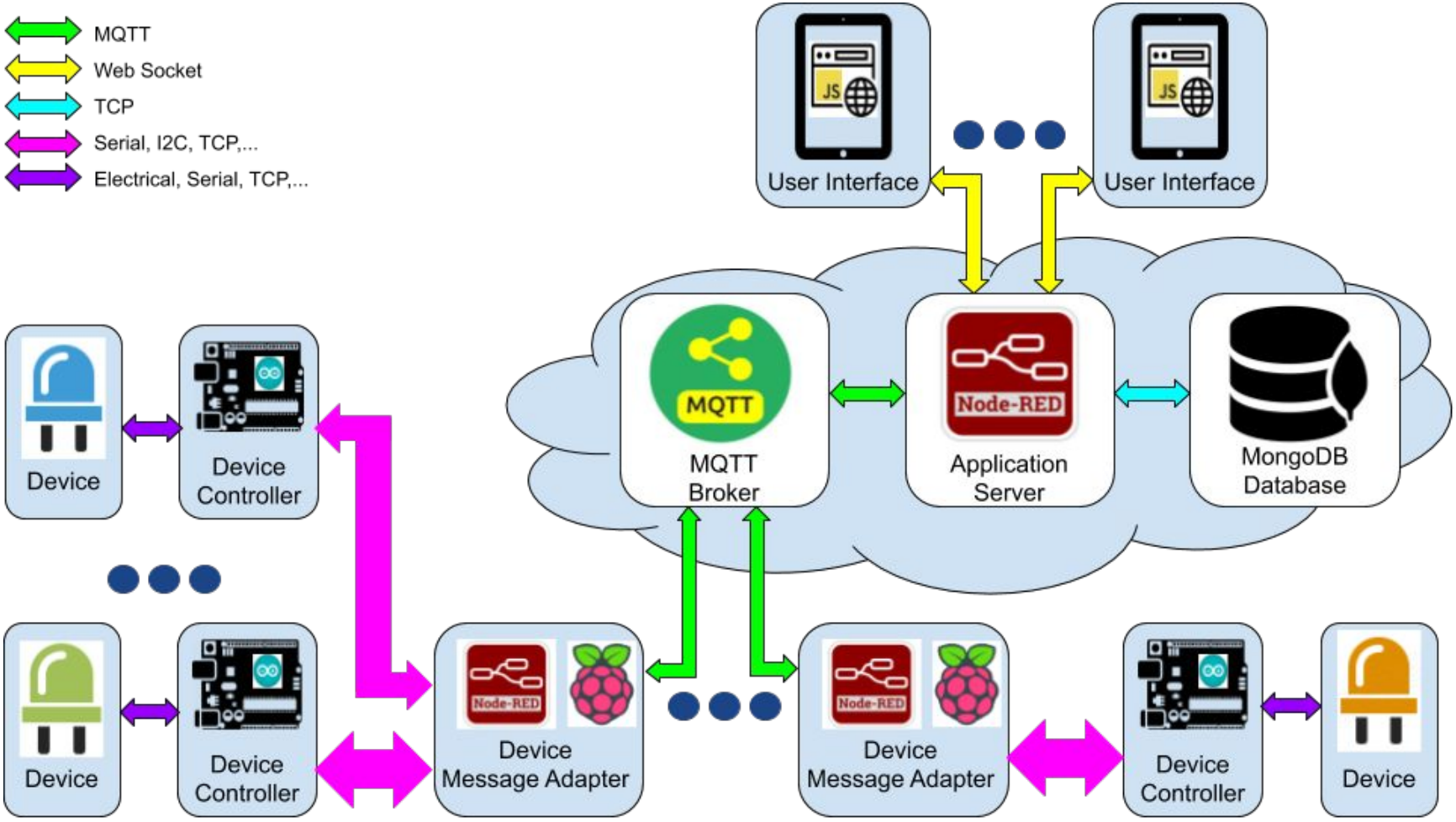
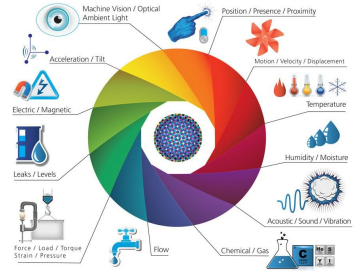
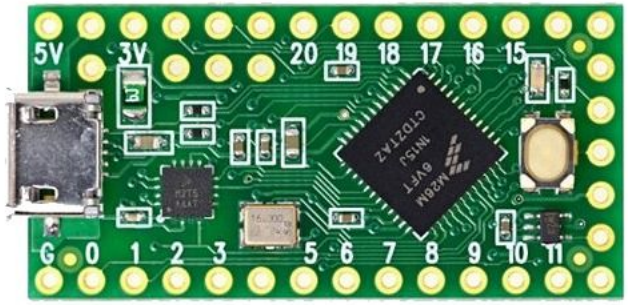
Blinky -Lite Architecture



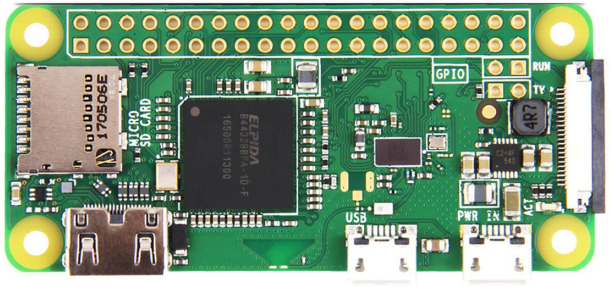
Blinky Lite Components

- Device
  - Plethora of IoT sensors and actuators
- Device Controller
  - Interfaces directly with device sensor and/or actuator through ADC, PWM, Digital I/O or DAC pins
  - Communicates (serially, I2C,...) to the Device Message Adapter (DMA)
  - Usually programmed using the Arduino IDE
- Device Message Adapter (DMA)
  - Communicates with a number of Device Controllers
  - Concentrates and scales device data
  - Translates data to and from the MQTT broker
  - Programmed in Node.js with the Node-RED programming environment





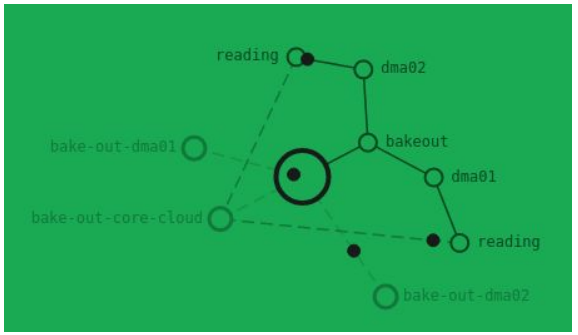
Teensy LC Device Controller

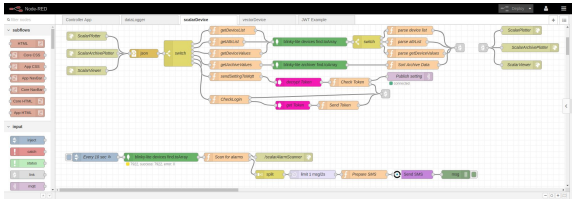


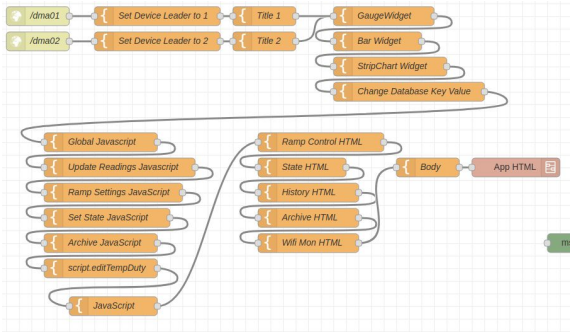
Raspberry Pi Zero DMA

Blinky Lite Components

- MQTT Broker
  - *Can be cloud based*
  - Receives and transmits messages to DMA's
  - Receives and transmits messages from to the WAS
- Web Application Server (WAS)
  - *Can be cloud based*
  - Collects and transmits data to DMAs and user applications
  - Archives data to MongoDB database
  - Serves user applications
  - Handles authentication
- MongoDB database
  - *Can be cloud based*
  - Archives data
  - Records are JSON documents
    - matches well with Node.js and Node-RED
    - Non-relational - easy to extend
- User Application
  - Web based for easy deployment
    - mobile first but not mobile only
  - Written in Javascript
  - Communicates to the Web Application server via web-sockets







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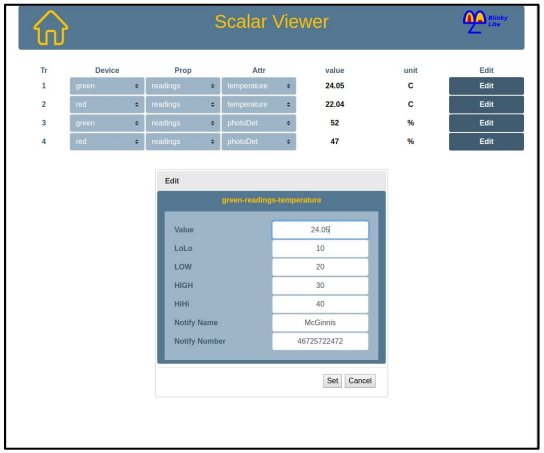
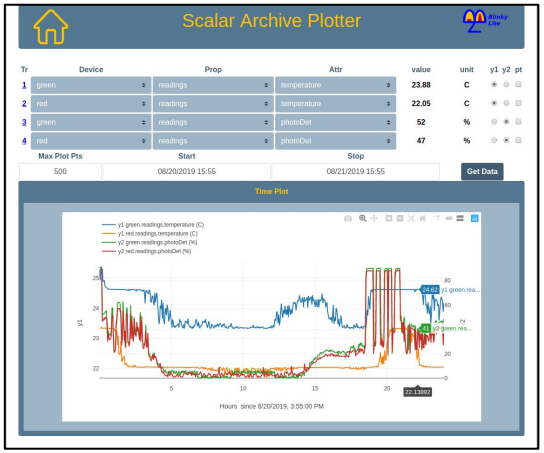
Features

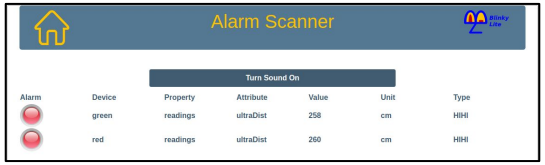
- Cloud capable - Cloud deployments give enhanced:
  - Accessibility and deployment capability,
  - Along with enhanced reliability and security (https:// and wss://),
- Layered authentication
  - JSON Web Tokens for client-server transactions
  - Authenticated MQTT broker for server-device transactions
- JSON Device configuration
  - Flexible data types (scalar, vector, text, images, blobs,...)
  - Human readable and configurable
- MQTT and Websocket communication
  - Publish-subscribe instead of polling protocols
- SMS Alarm notification
- Graphical Node-Red code environment
  - Re-usable code
  - Self documentation

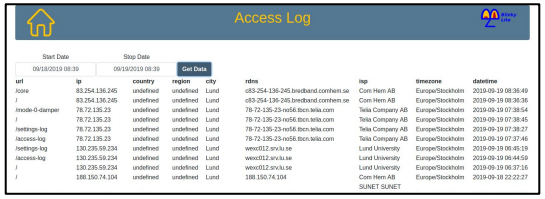
Features

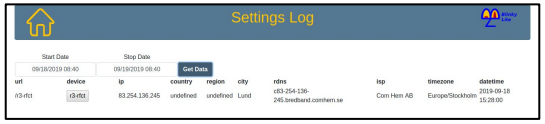
Eight web-based core applications

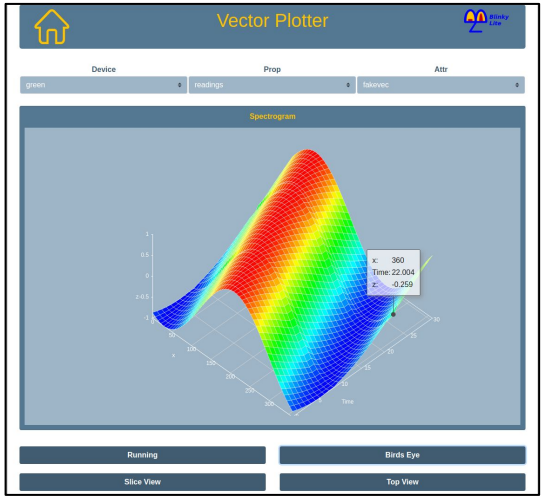


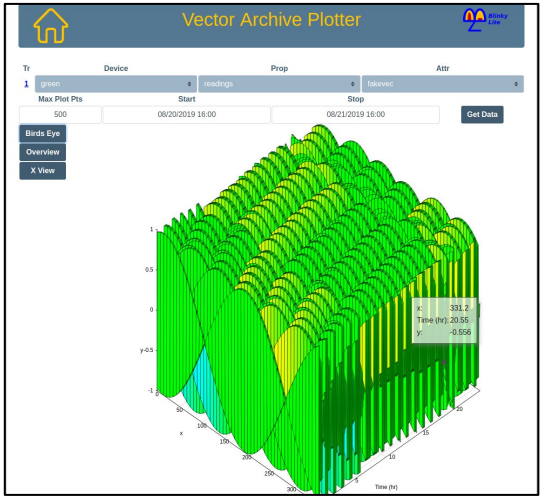












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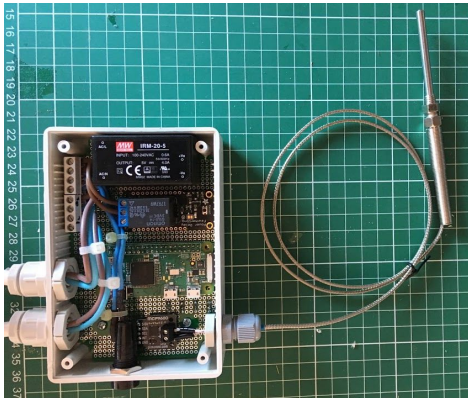
Blinky Lite Implementations

UHV Bake-out System

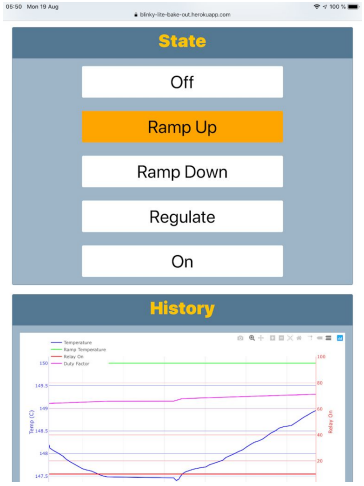


Blinky-Lite Bake-out System

Bake-out status

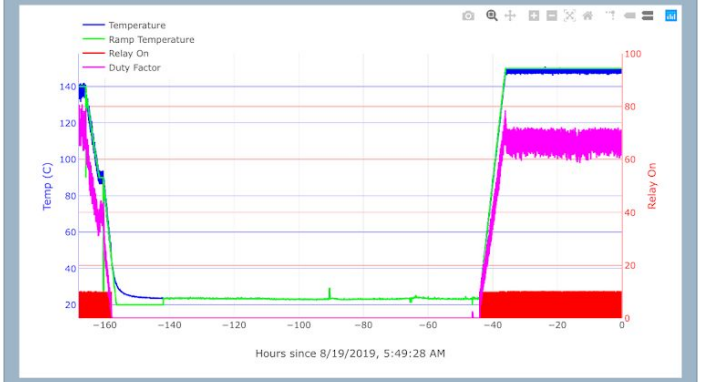
Parameter	Cntrl 1	Cntrl 2
Temp. (C)	149.58	149.22
Duty (%)	65.25	35.13
Relay	Off	Off
State	Ramp Up	Ramp Up
Target (C)	150	150
Link(dBm)	-51	-62
Heatbeat		

Blinky-Lite Core



Archive

2 | 4 | 8 | 24 | 72 | 168 Hours



Bake-out Controller 1

Ramp Control

Temperature (C)	149.51	Edit
Duty Factor (%)	67.92	Edit
Ramp Up (hrs)	8	
Ramp Down (hrs)	4	
Reg. Temp. (C)	150	
Reg. Window (C)	1	

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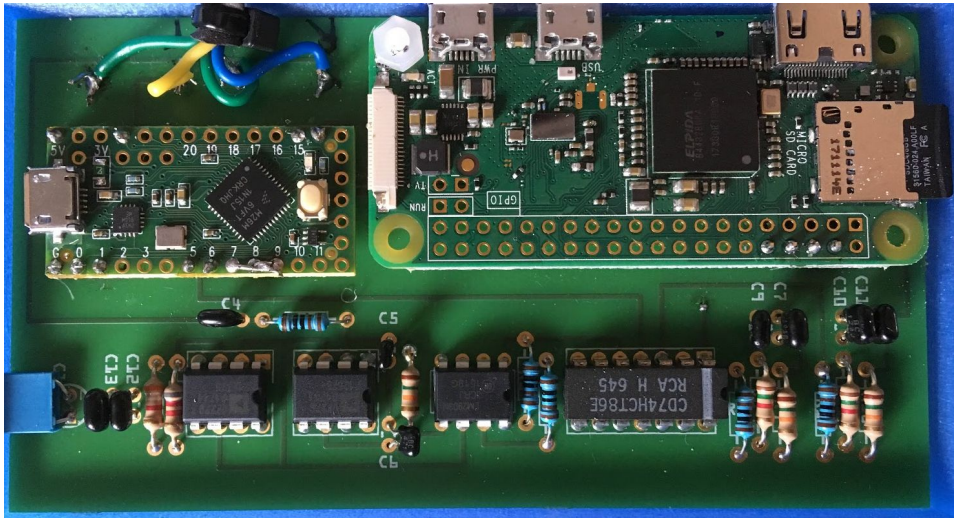
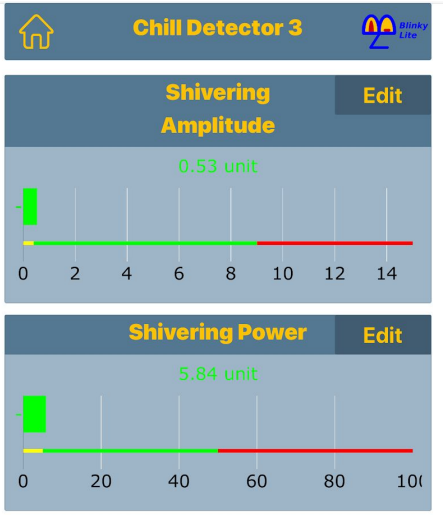
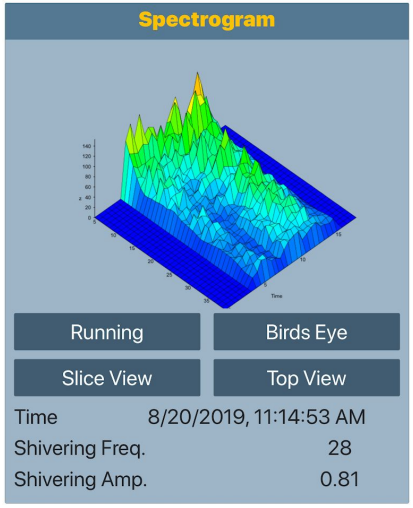
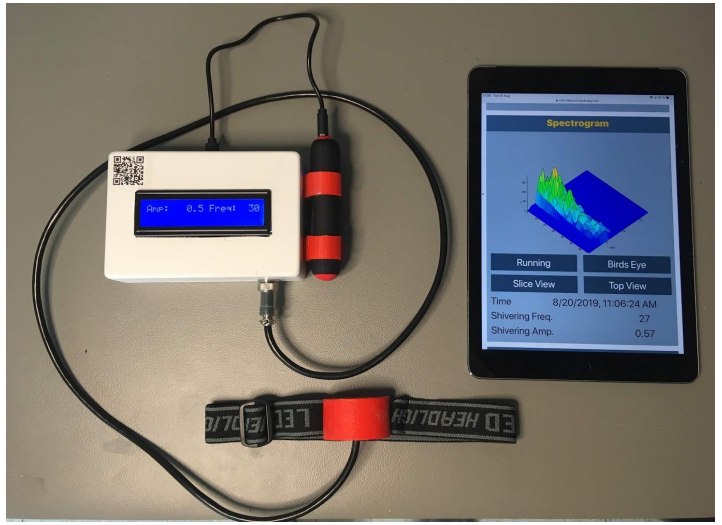
Blinky-Lite Implementations

Chill Detector









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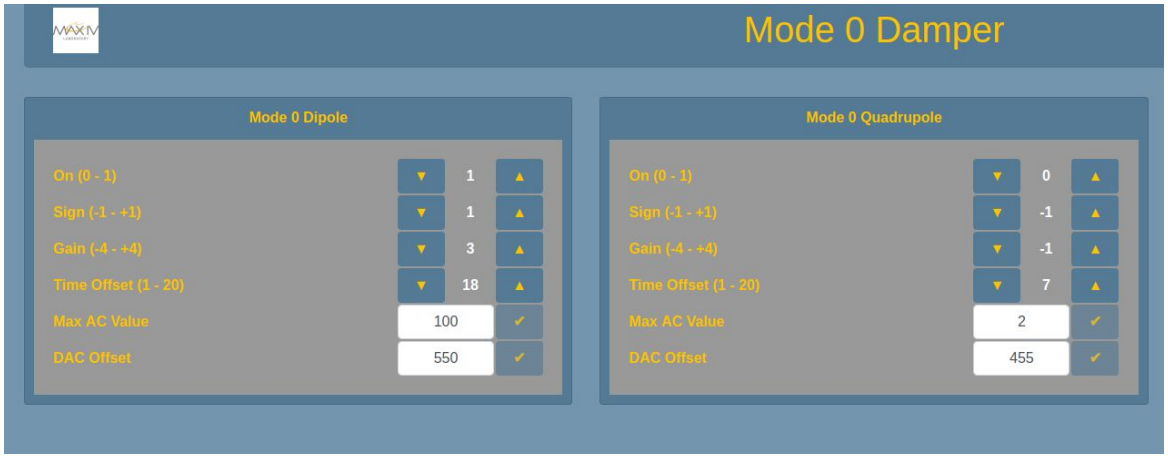
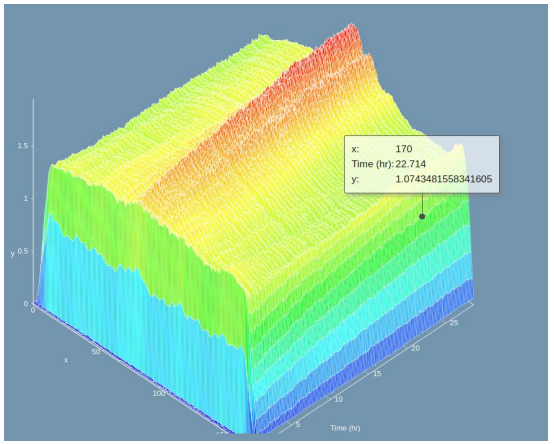
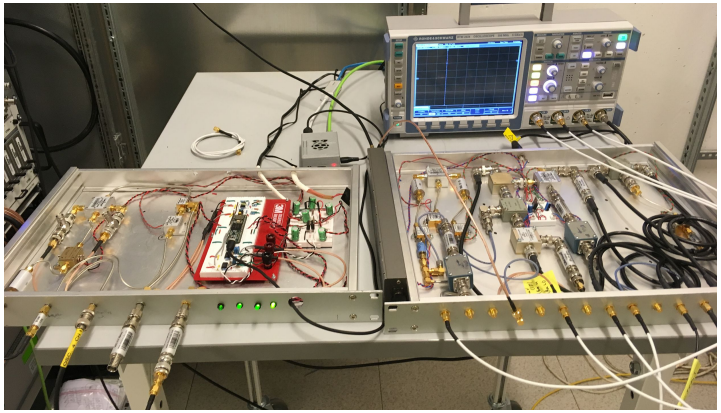
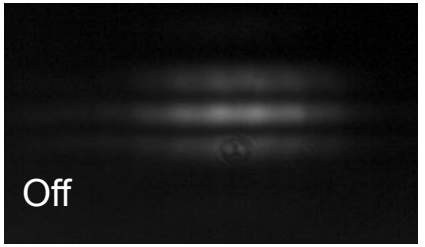
Blinky-Lite Implementations

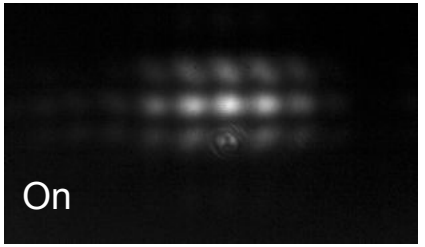
MaxIV Mode 0 Beam Stabilizer





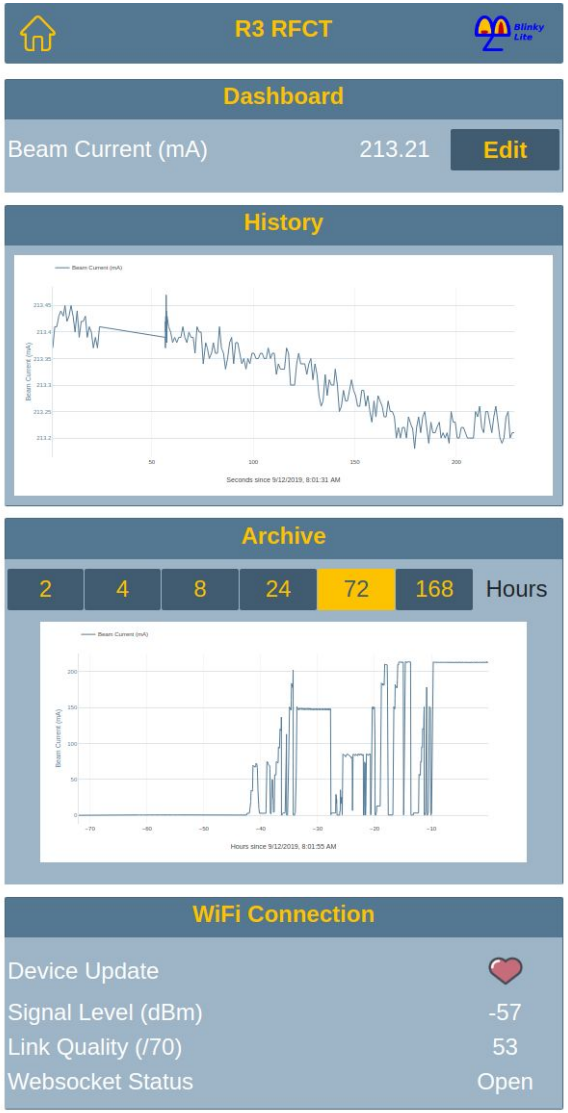


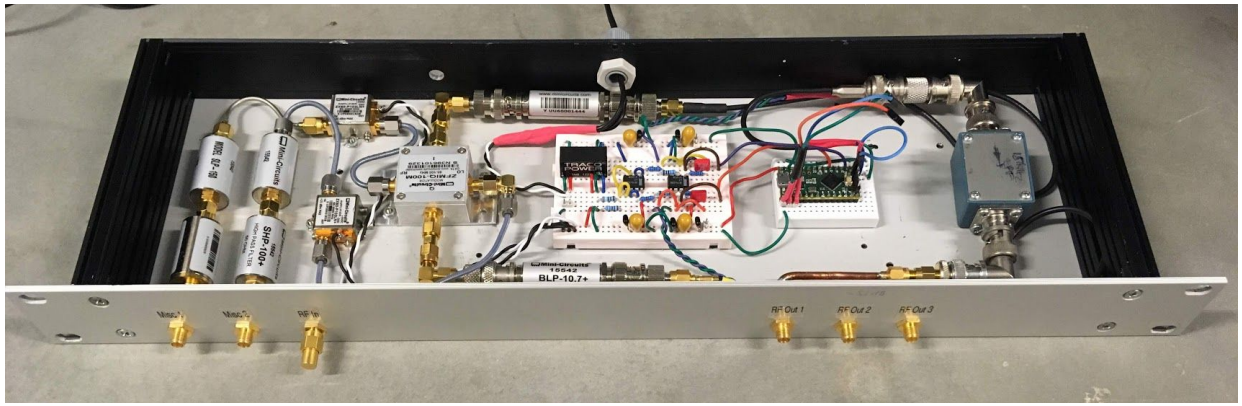


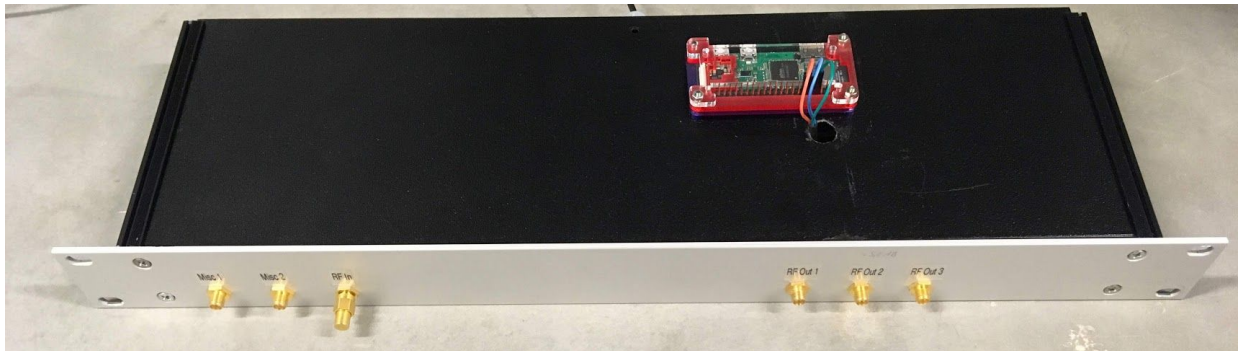


Blinky-Lite Implementations

MaxIV RF Current Transformer (RFCT)







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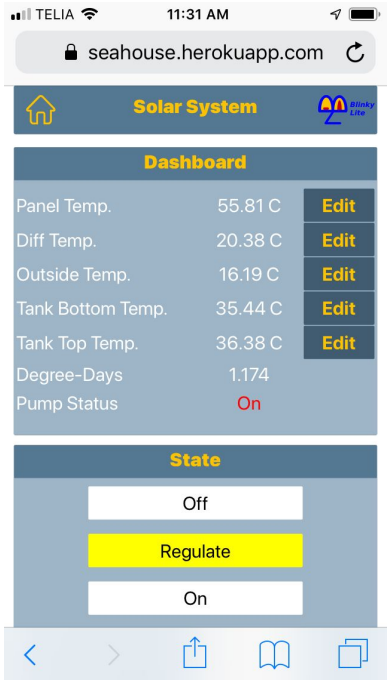
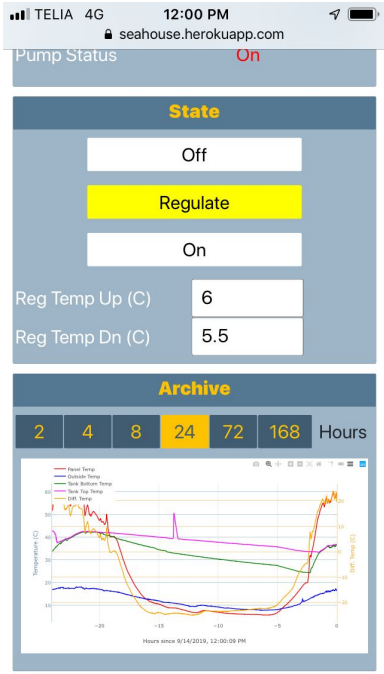
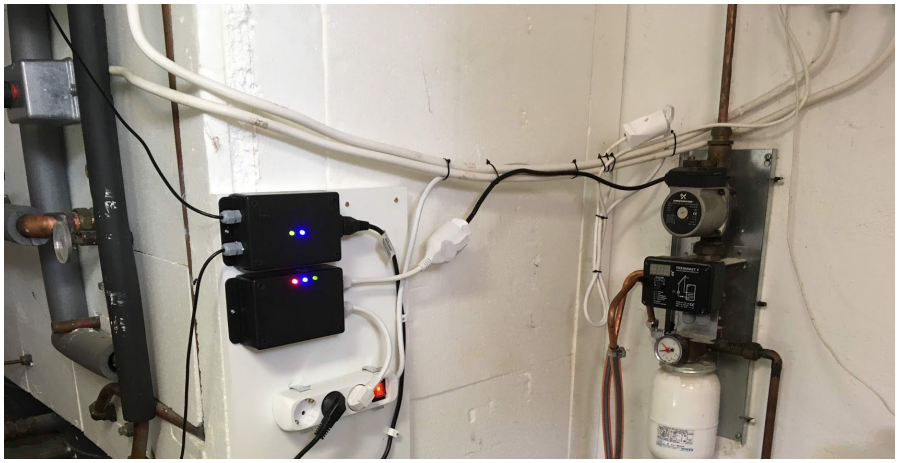
Blinky-Lite Implementations

Solar Thermal Heating System







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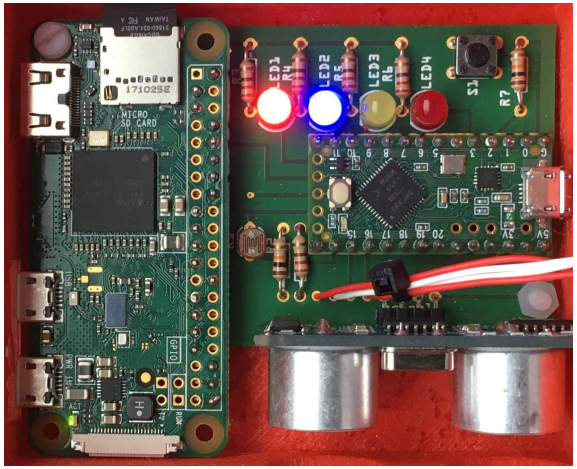
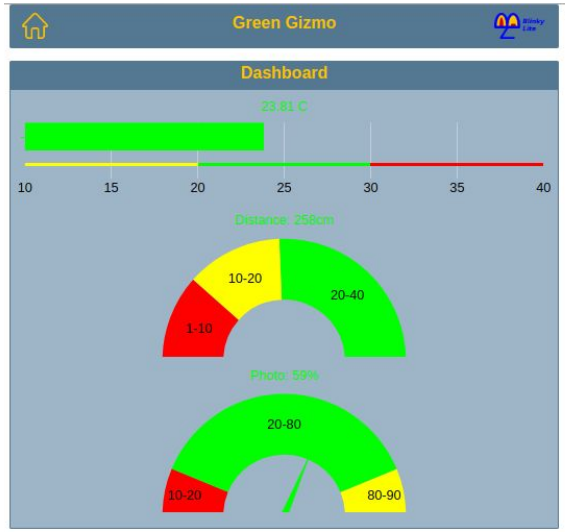
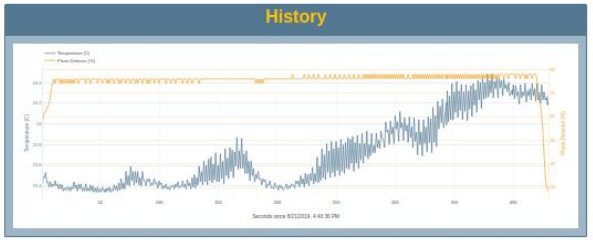
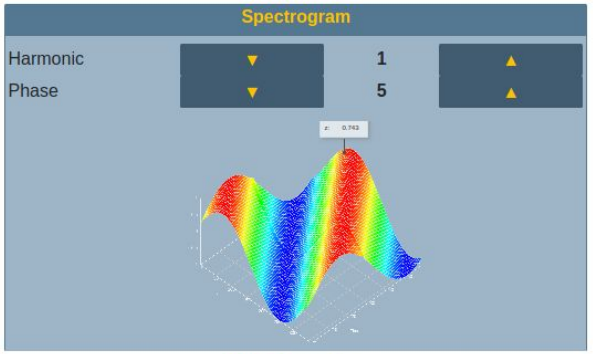
Blinky-Lite Implementations

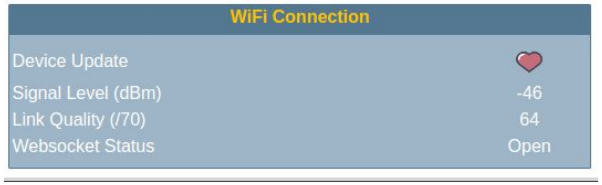
Demonstration Circuit

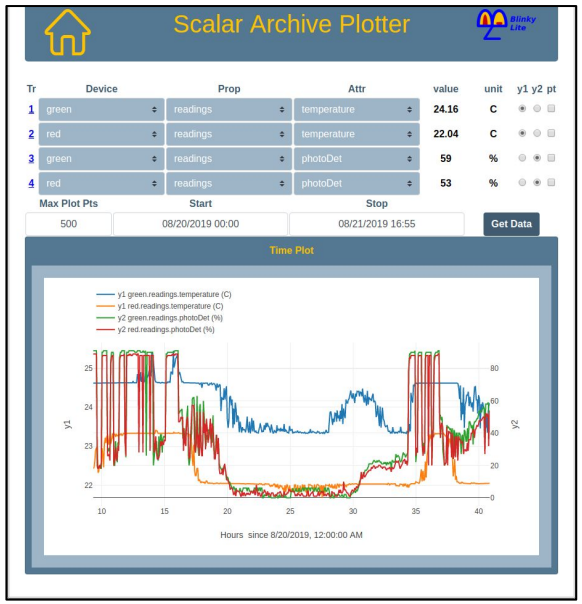












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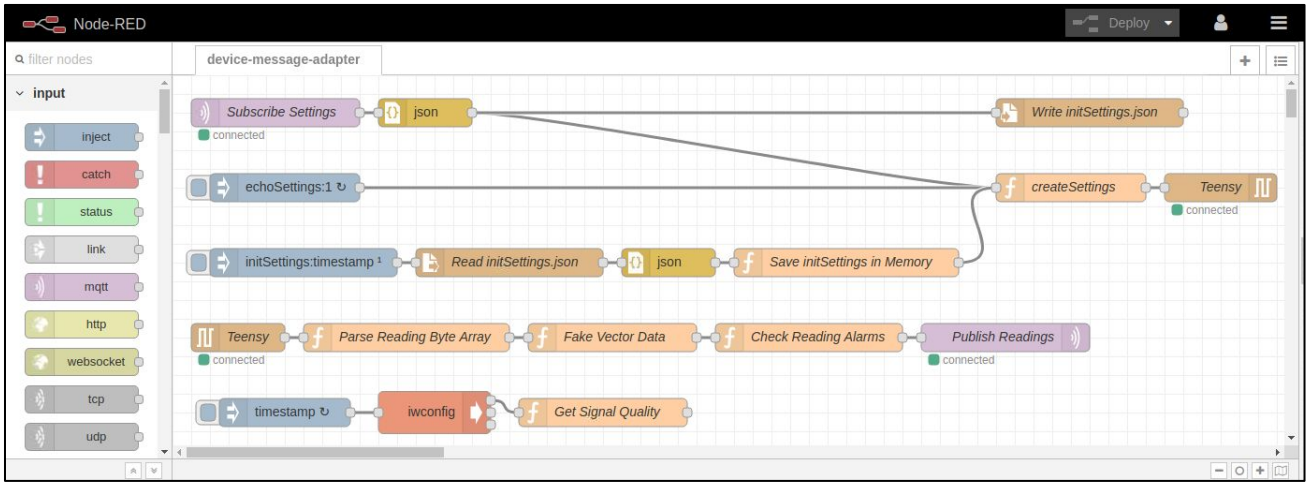
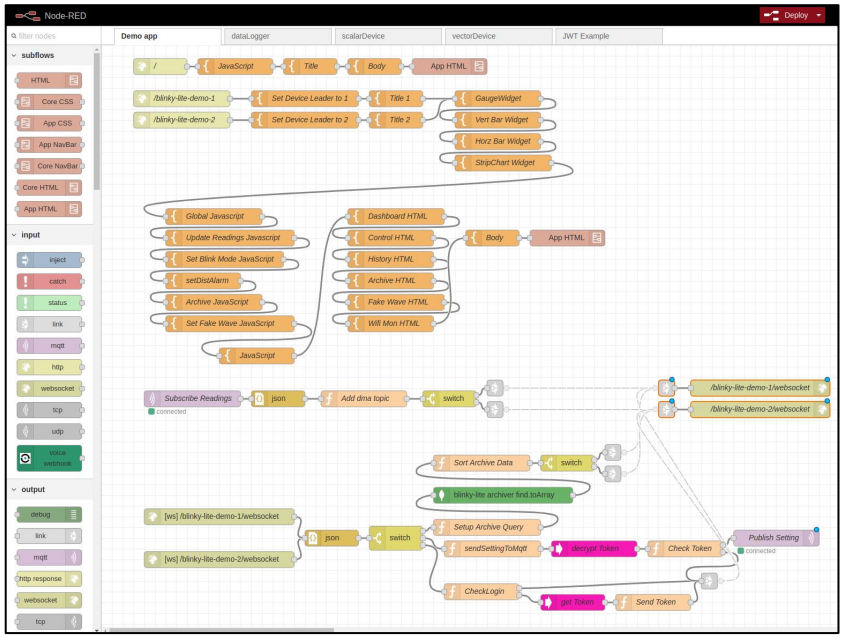
Blinky-Lite Implementations

Demonstration Circuit Node-RED Code



Device Message Adapter



User application

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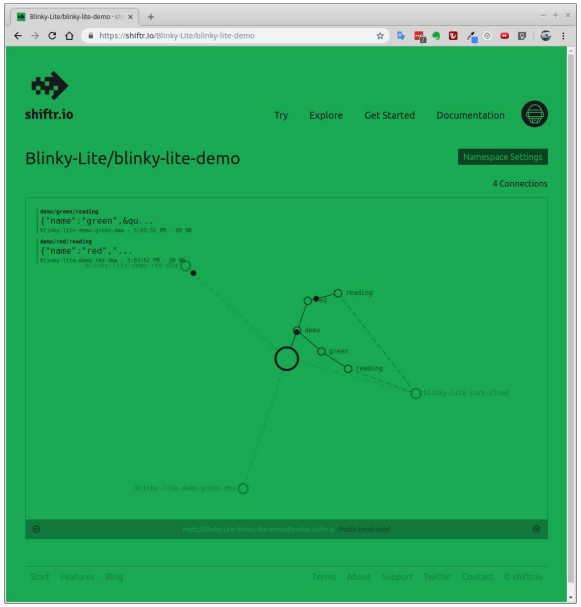
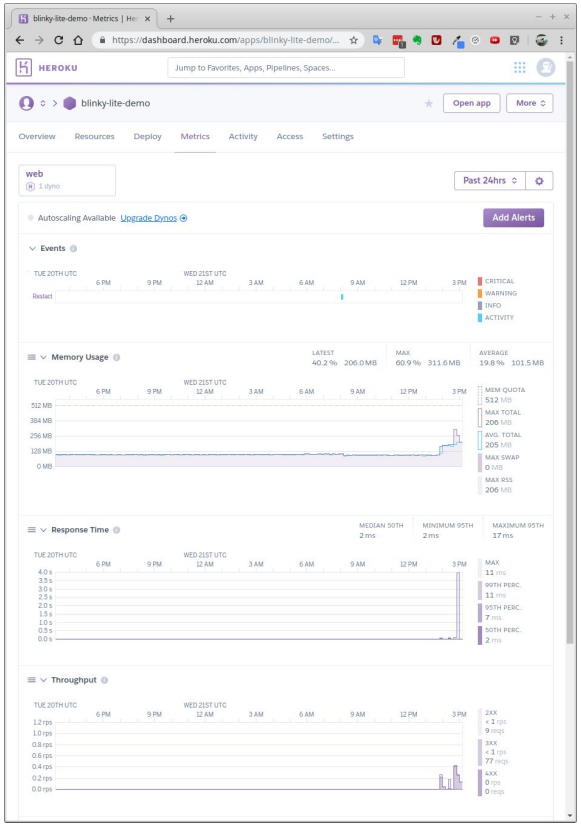
Blinky-Lite Implementations

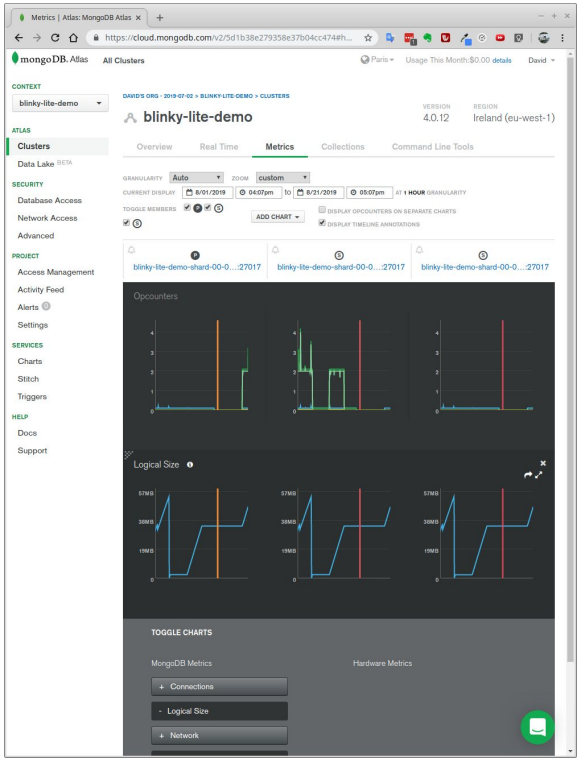
Demonstration Circuit Cloud Services



MQTT Broker at
https://shiftr.io/Blinky-Lite/blinky-lite-demo



Application server at
https://dashboard.heroku.com/apps



Database server at
https://cloud.mongodb.com

www.blinky-lite.io

Blinky-Lite Resources

- Web site (needs upgrade)
  - https://www.blinky-lite.io/
- Demo Project Web Application
  - https://blinky-lite-demo.herokuapp.com/
- Code Base and Demo Project Code
  - Device Controller - https://github.com/Blinky-Lite/blinky-lite-demo-device-controller
  - Device Message Adapter - https://github.com/Blinky-Lite/blinky-lite-demo-device-message-adapter
  - Core and User Interface - https://github.com/Blinky-Lite/blinky-lite-demo-user-interface