NDOT - DISTRICT III
Remote ITS Control & Telemetry Solution

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Web Relay Agenda

- History and Background
- Research and Development
- 2016 Web Relay Design - Version 1
- 2017 Web Relay Design - Version 2
- Implementation - Use Cases
- Cost – Benefit
- Live Demo
- Future Features and Improvements

History and Background

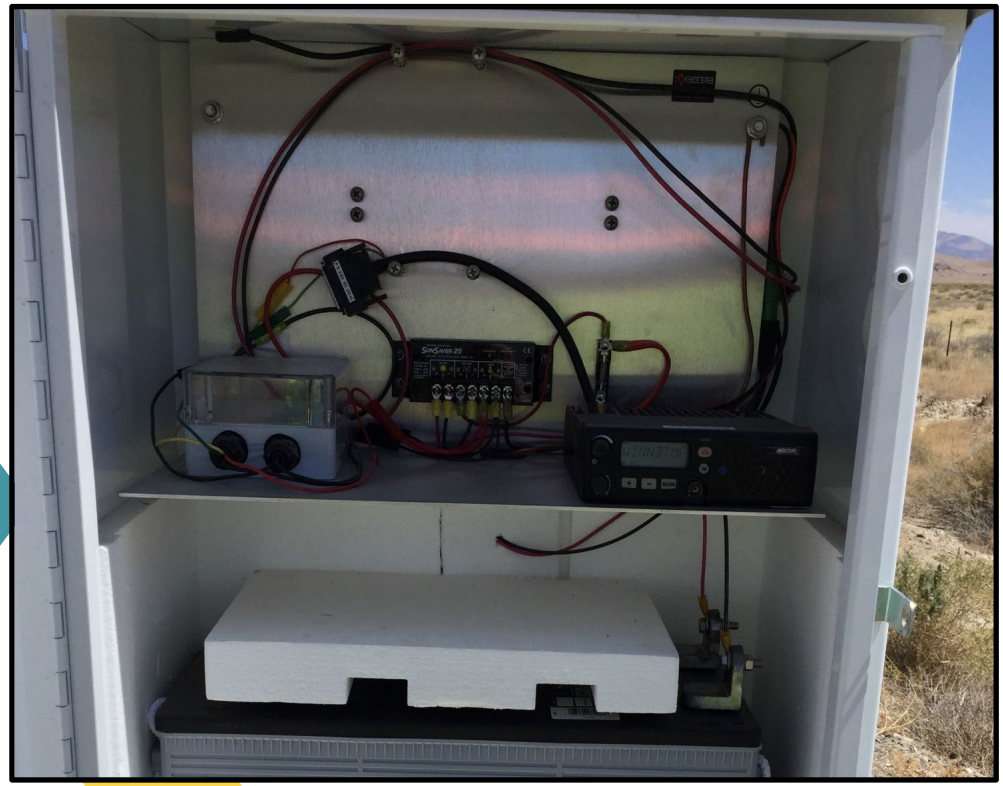


District III History

- 1990 – 2015: First sign activation through Nevada Shared Radio System (NSRS) using dual-tone multi-frequency (DTMF) signaling
- 2005 – 2009: Consultant design: Kimley Horn 386. Canceled due to the cost and complexity of building the system.
- 2012: DelCan NTCIP controller with Central Software – Canceled due to support and integration issues. Discontinued by the manufacturer. Only had 8 outputs.
- 2013: Consultant design and build using Arduino and Raspberry Pi. Canceled due to operating system and environmental issues.
- 2016 – present: Helix RCR11 box – Works well, but limited capability; one input/output. Still used for flashing beacons in Districts 1 and 2
- 2017 – present: Control by Web
  - X600 server - 2015
  - X320 (V1Controller) 2015
  - X410 (V2 AC site Controller) 2018
  - X400 (V2 AC and DC site controller) 2016

1990 - NSRS and DTMF Sign Activation

ITS cabinet with an 800MHz Radio and (DTMF) board – 1990 to 2015



1. 800 MHz LMR Radio
2. DTMF controller Box
3. 12VDC solar power system
4. Dual-tone multi-frequency (DTMF) signaling

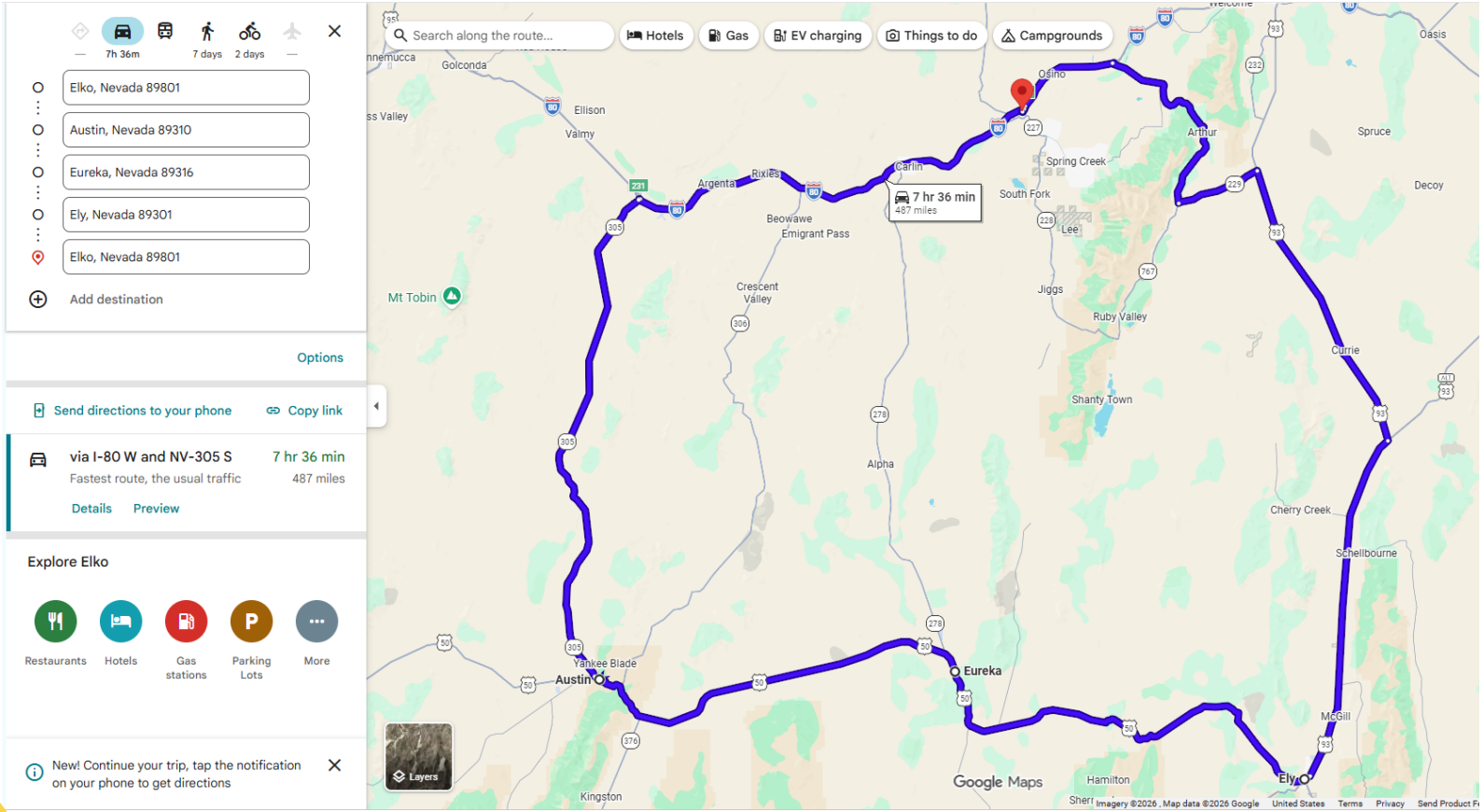
1990 - System Issues

- 800 MHz L3 Harris Maestro console had to be configured for paging tones to send out on a specific mountaintop and a specific talk group
- Activated with a four-digit DTMF tone with a # or * to designate the On/Off mode
- Weather would degrade audio & RF signal
- Radios had to be set to a specific speaker volume
- Radios would get logged out of the radio system and require a local manual reboot
- Duplicate logical IDs would log out the radio
- No ability to confirm site status remotely

1990 - Technology and Staff Issues

- No Site Telemetry, unable to confirm site status
- Multiple site visits required for maintenance and repairs - 2054 maintenance lane miles
- Employee time cost and overtime
- Fuel, equipment and repair cost
- More battery replacements required due to unmanaged battery systems

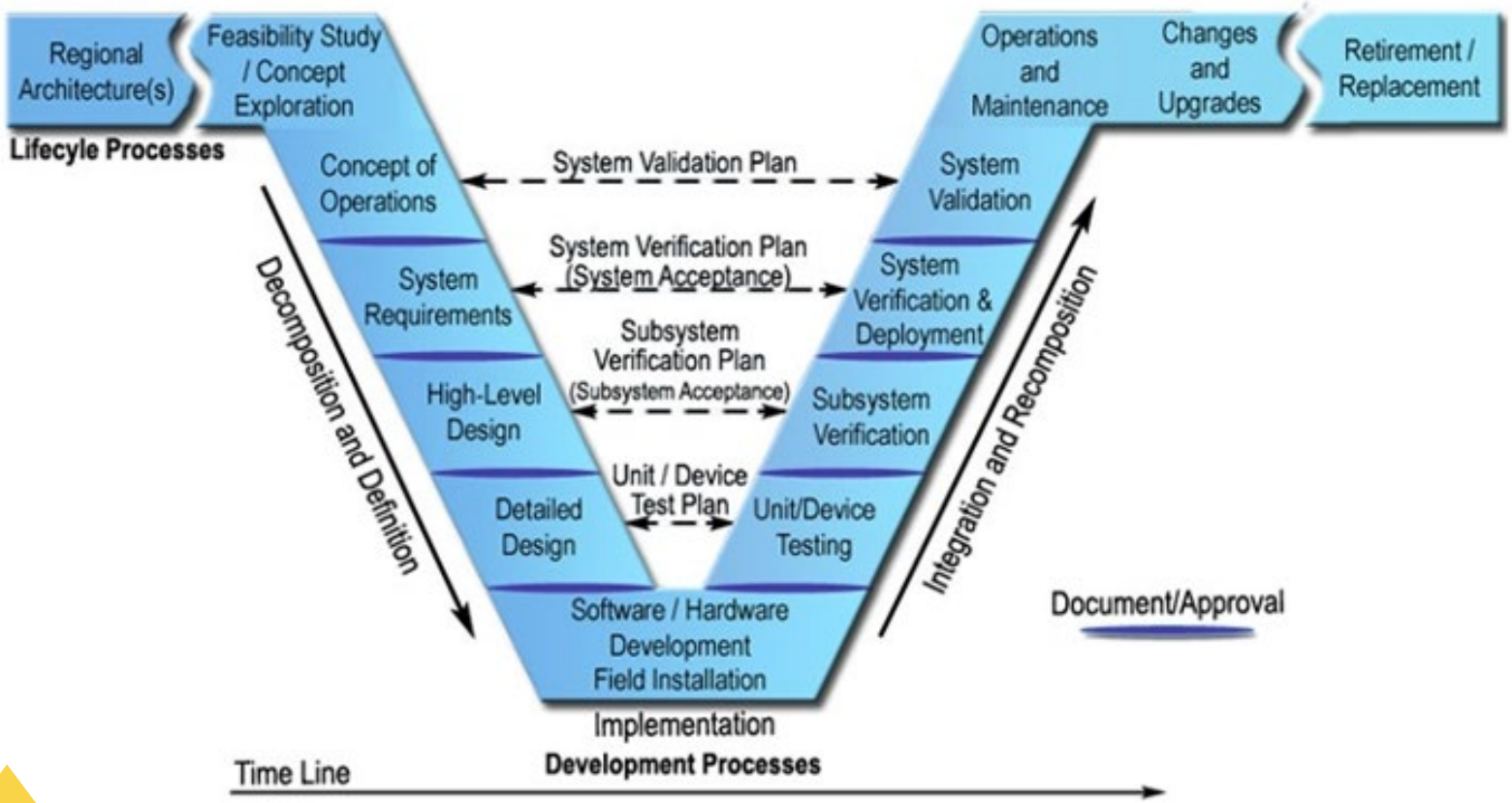
Travel 797 Lane Miles Every Two Weeks to Fix Sites



Research and Development



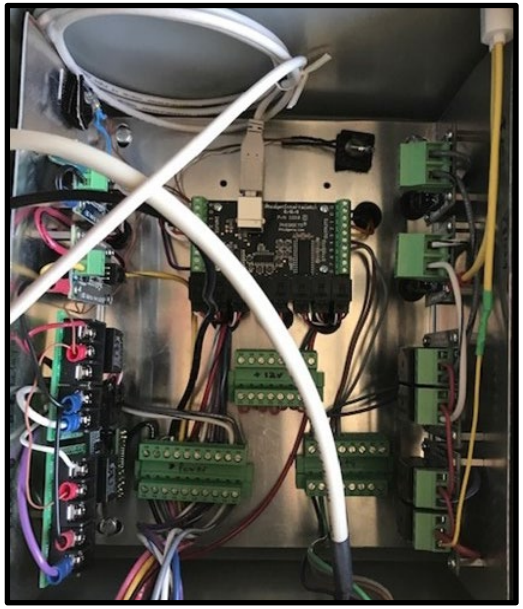
ITS Systems Engineering Considerations

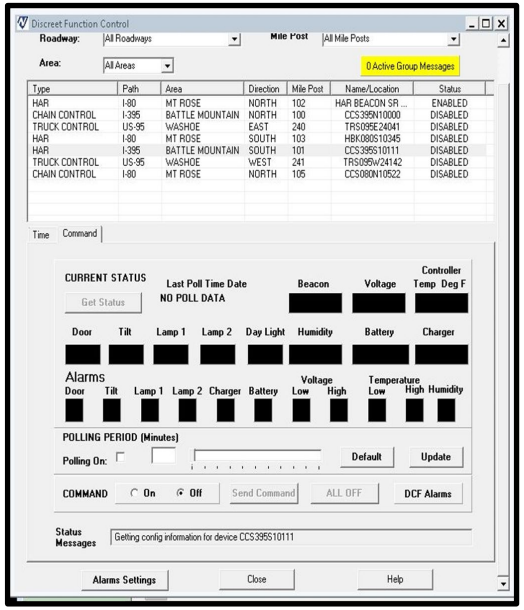


2005 - First Design - 368 Processor

- **Original Design – 2005**
- **Kimley Horn 386 processor and sensors**
- **Freeway Management Software (FMS)**







2005 Development - Hardware and Software Issues

- Did not work well with the Radio Data Interface (RDI) communication protocol used on the NSRS (Nevada Shared Radio System)
- Tied up talk channels on the transmission trunked radio system.
- Used proprietary machine language programming
- Difficulty integrating with the Freeway Management System (FMS)
- The 386 computer was not hardened for outdoor field cabinets
- Sensor accuracy issues
- No configuration backup
- No expansion or modification

2005 Development - System Issues

- Overly complex – design by committee
- Learning the system was difficult and required coding
- Troubleshooting was difficult and counterintuitive
- Parts and assembly were costly
- Limited vendor support and development
- Used Phidget sensors, which were in early development and had limited capability
- Changing sensors required vendor support for operating system changes
- This design was abandoned in 2009

2012 - Delcan - NTCIP Traffic Controller



- No feedback or telemetry
- Relay out only
- NTCIP predefined programming
- Only 8 I/O's
- Lack of customer support
- Item quickly became unavailable
- Expensive - $2,000.00 each
- Limited repair and warranty

2013 - Web search ARDUINO Microcontroller

- **Arduino - found through web research**
  - **NDOT consultant did a test pilot**
  - **Required coding to program**
  - **No remote updating**
  - **Not field hardneded**
  - **Operating system crashes required a periodic reboot**

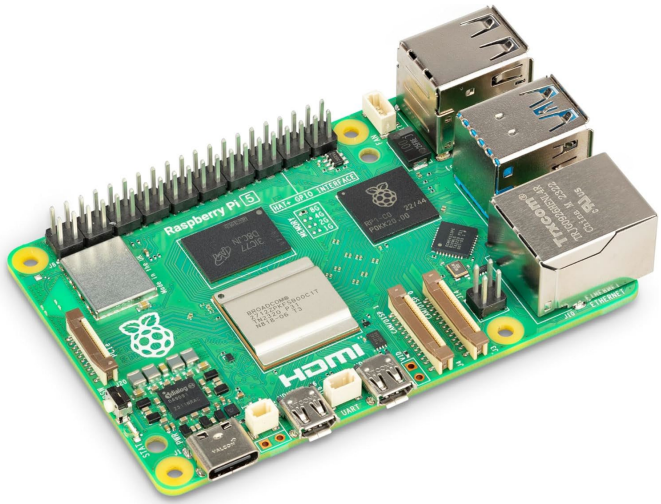


Arduino - https://www.arduino.cc/Home

NEVADA DOT

2013 - Web search Raspberry Pie Microcontroller

- **Raspberry Pie - Found through web research**
  - **Required coding to program**
  - **No remote updating**
  - **Not field hardened**
  - **No power indication**
  - **Operating system crashes required a periodic reboot**



https://www.raspberrypi.com/

2015 - Helix RCR01 Network Relay Controller



- **One input, one output**
- **Limited I/O telemetry**
- **5VDC power supply required – AC or DC converter needed at the site**
- **Communicates RDI protocol with the Freeway Management Center**
- **Still actively used in NDOT Districts 1 and 2**

2016 Web Relay Design Version 1



2015 - NDOT Field Technician System Design Requirements

- Off-the-shelf parts and sensors that are readily available
- Long-term support and security
- Field hardened and reliable
- Up-to-date network security protocols
- Easy to manage databases/server with device backups
- Straightforward installation and design
- Easy to configure field and server devices
- IP Ethernet-based communications
- Expandable and upgradable
- Cost-effective
- Ease of sensor integration
- Full site telemetry I/O capable

NEVADA DOT

2016 – Traffic Operations Center System Design Requirements

- Customizable Web Page
- Users touchscreen capable
- User friendly interface
- Real time sign feedback
- Minimal training required

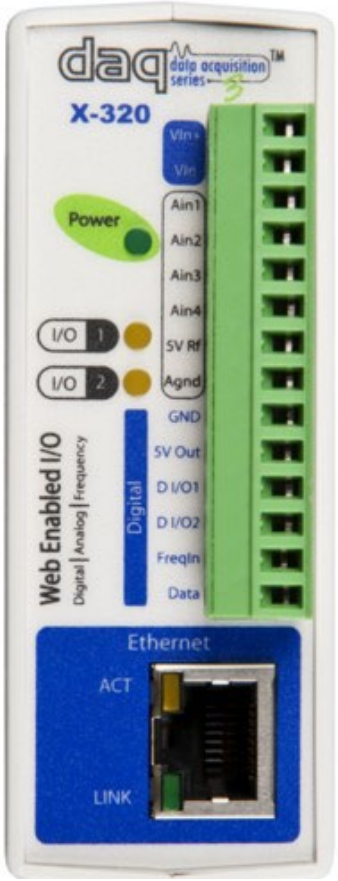
2016 Web Relay Version 1 & 2 X600 Server – Met Design Requirements



- 2015 Server Device
- Road Operations custom web page; touchscreen capable
- Built-in software – ready to program
- End user ease of access
- Long-term support
- Updated network security protocols
- Peer to Peer communications
- Easy to manage databases - Server configuration
- Ethernet-based
- Expandable & Upgradable
- Cost effective
- Availability – short lead times
- Custom webpage option
- Optional external server control

Control by Web –Field - Met Design Requirements

- There were no other devices that met the design requirements from the NDOT history
- Other solutions were using SCADA, serial communications, and 900 MHz radios
- X320 was found through web research
- The overall system was designed by NDOT using off-the-shelf components
- Built-in web GUI – No engineering or special programming is required
- No support expenses
- No company development expenses
- Parts are inexpensive and cost-effective
- 5 Year warranty
- Simple to configure & backup
- Expandable and scalable

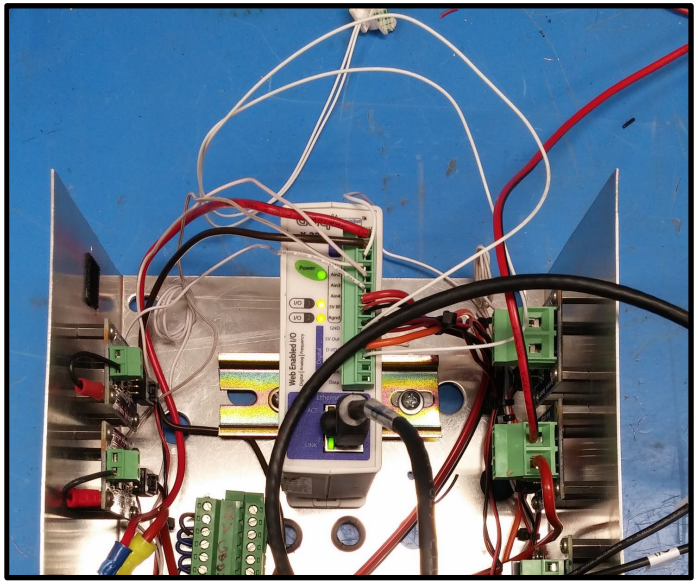


https://controlbyweb.com/

2016 Web Relay Version 1 – Bench Testing and Proof of Concept

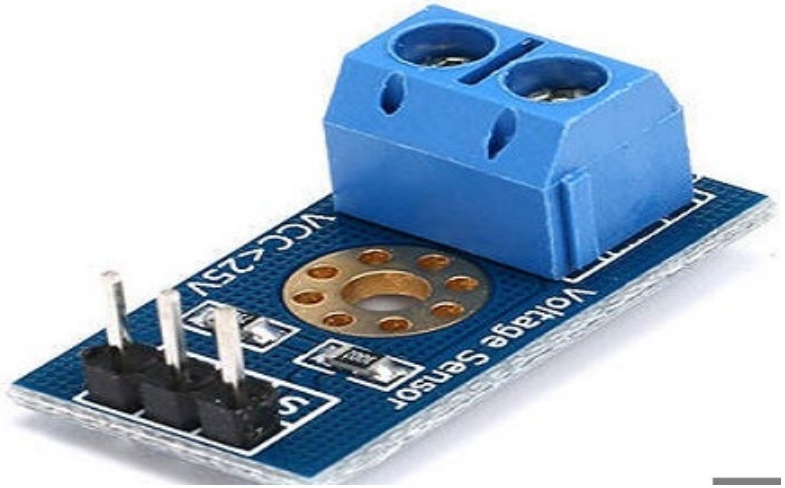


2016 Web Relay Version 1
Design and Bench Testing by NDOT Staff



- Initial cost: $500 for the controller and server
- Control by Web - Dual Web Relay Controller
- Reused sensors from the previous project
- Issues found during bench test:
  - Current sensing solution for beacon circuit
  - Voltage sensing
  - Not enough I/Os

2016 Version 1 Voltage Sensor Solution



[Phidgets Inc. - Products for USB Sensing and Control]

Abandoned due to precision and accuracy issues

2016 Version 1 Current Sensor Issues

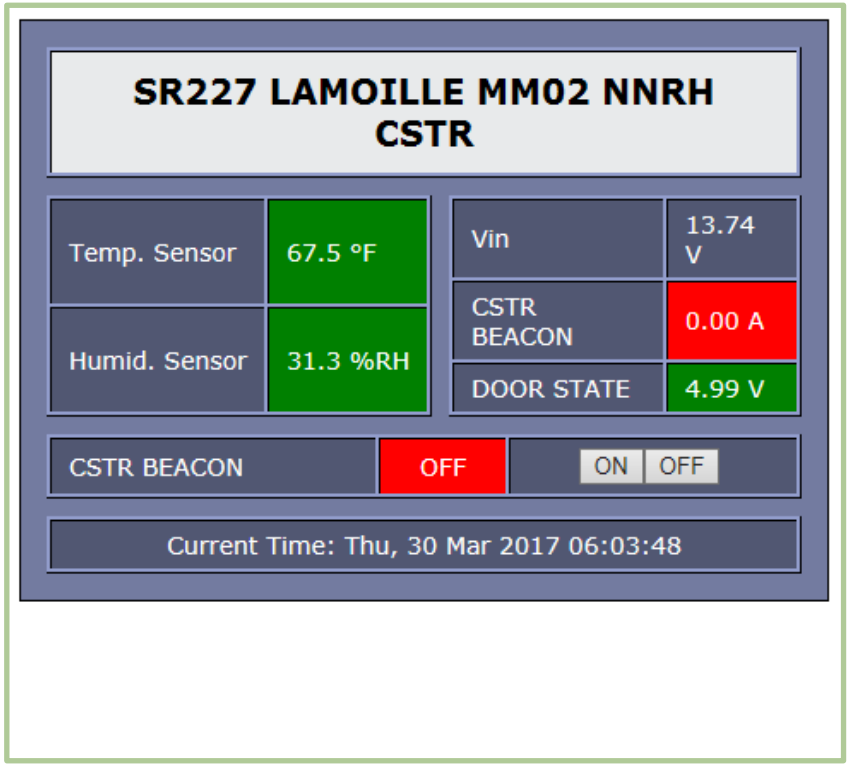


https://www.automationdirect.com/

Too many variables and accuracy issues to use version 1 sensor -

- **Momentary current surge due to beacon (Wig-Wag)**
- **Did not sense the Beacon properly**
- **AC current draw needed< .10 Amps**
- **DC current draw needed < 1.1 Amps**
- **How many windings of wire do I need?**
- **Different wire gauge sizes are in the field**
- **We tried three different Hall Effect Sensors**

2016 First Web Relay Version 1 Control page



Flashing beacon current sensing issues

1. **Momentary current draw**
2. **DC Voltage drop – wire size**
3. **Reusing the 2000 design sensors not granular or feasible to get accurate measurements**
4. **Limited I/O's – 2 inputs and 2 outputs**

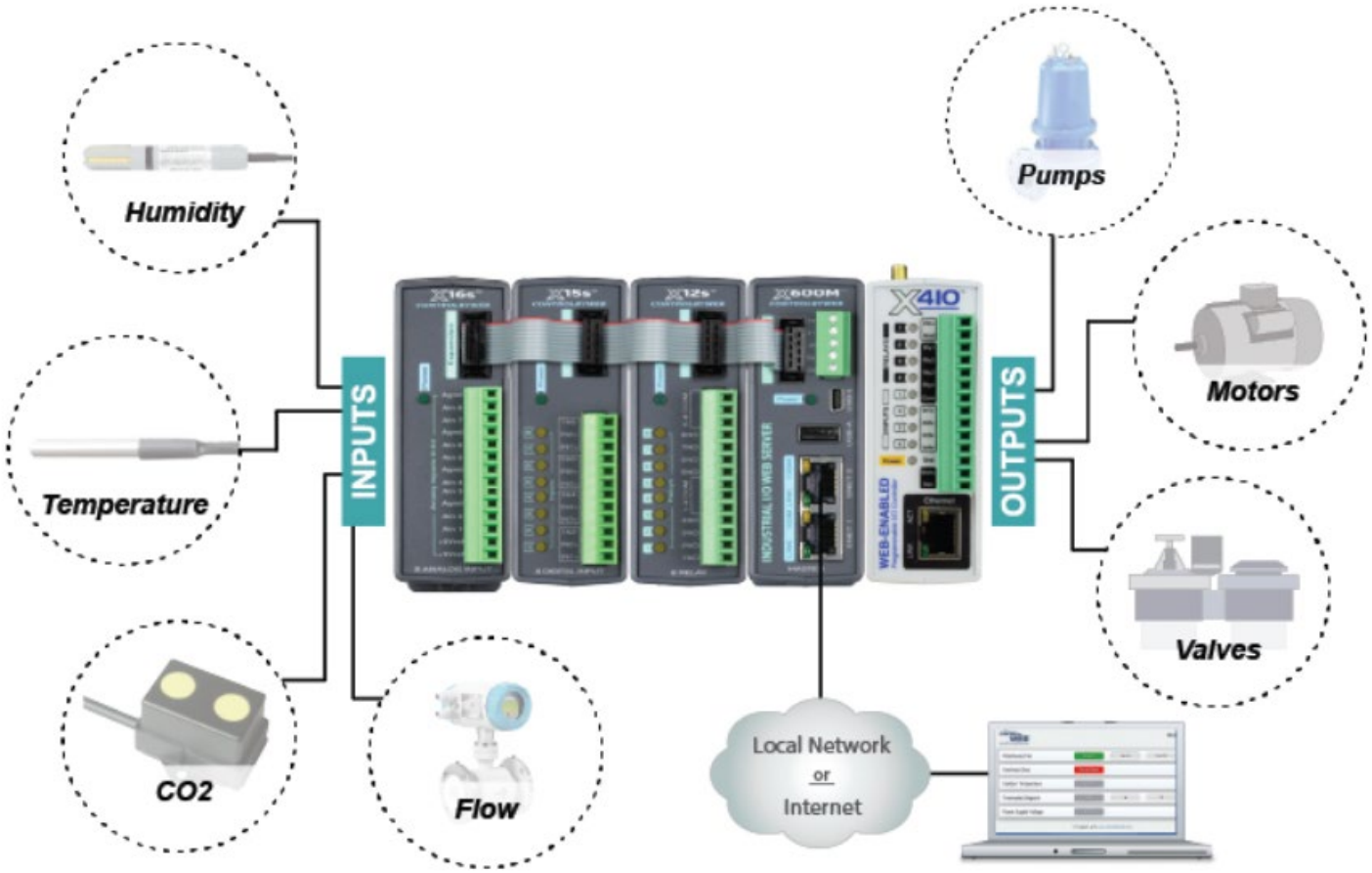
Version 1 - Voltage & Current Sensor Compatibility Further Research Needed

- Voltage sensor – had to be calibrated to distance and wire size
- Beacon current sensor – wig wag with alternating current load
- Abandoned due to lack of precision and accuracy

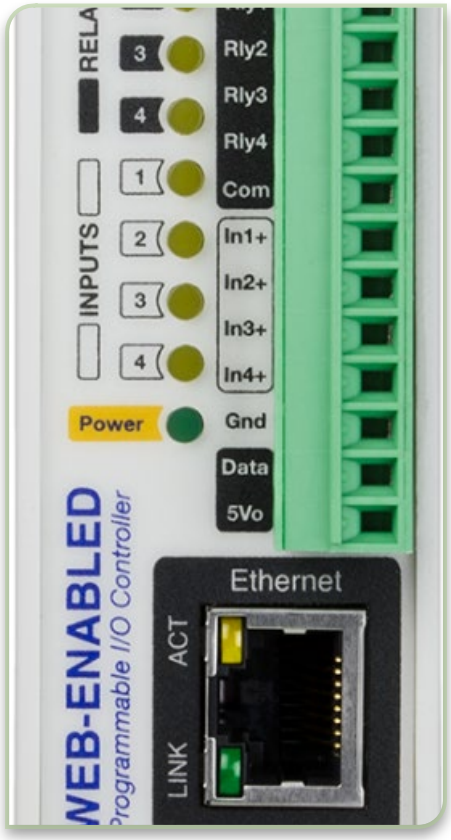
2017 Web Relay Design Version 2



Control By Web Product expands during the 2017 version 2 build process



2017 – Web Relay Version 2
AC Site Web Relay X410 Beacon Field Device



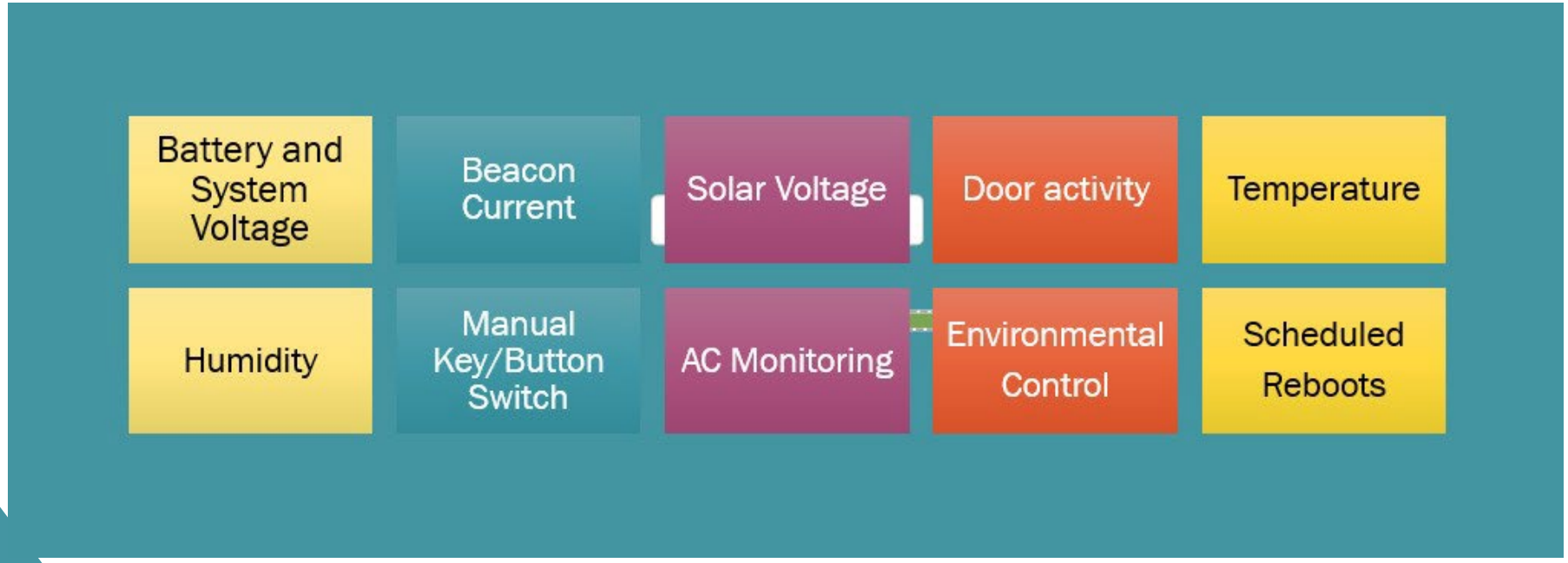
- X410 Web Relay controller
  - 4 relays, 4 inputs
  - Data sensor inputs
- <u>Software in the device – Ready to program and communicate to server</u>
- Supports updated security protocols
- Long-term vendor support
- Easy to program
- Field hardened
- Expandable and upgradable
- Inexpensive
- Ease of sensor integration
- Off the shelf controller
- POE powered

2017 Version 2 Web Relay
Solar Site Web Relay X400 / X17 / X22 Field Device

- Expandable and upgradable
- X400 Web Relay controller
  - X17 4 relays, 4 inputs
  - X22 8 analog I/O's
  - Data sensor inputs
- <u>Software in the device – ready to program</u>
- Easy to program and design
- Off-the-shelf parts - controller and Ssnsors
- POE powered



2017 - Final Beacon Sensors and Function List



2017 Version 2 Voltage Sensor Solution



https://www.automationdirect.com/

- **Successfully tested and validated**
- **Wide voltage range**
- **Measures both AC and DC voltage**
- **Requires a 250 Ohm resistor for analog inputs**
- **4ma-20ma standard analog setting**

2017 Web Relay Version 2
Phoenix Current Sensor Validated

- **Programmable from 0.01 to 5 amps**
- **AC and DC capable**
- **A configured program can be saved and reloaded**
- **DIP switch settings option for manual setup**
- **Lab setup to find the proper current setting and Phoenix programming**
- **Tested different DIP switch and Programming options**
- **Special 1/8” programming cord needed**
- **Phoenix Software Purchase needed**
- **A new version of this part is coming out soon.**



https://www.phoenixcontact.com/

Phoenix Current Range chart

Ideal exploitation of the measuring ranges

Measuring range MCR-S-1-5-...DCI	Span potentiometer: -25 %	Nominal range*: 0 %	Span potentiometer: + 25 %	DIP 1	DIP 2
1 A input: 0...0.2 A to 0...1.1 A	0...0.75 A	0...1.00 A	0... 1.10 A	OFF	OFF
	0...0.48 A	0...0.65 A	0... 0.81 A	OFF	ON
	0...0.30 A	0...0.40 A	0... 0.50 A	ON	OFF
	0...0.18 A	0...0.25 A	0... 0.31 A	ON	ON
5 A input: 0...0.94 A to 0...5.5 A	0...3.75 A	0...5.00 A	0... 5.50 A	OFF	OFF
	0...2.43 A	0...3.25 A	0... 4.06 A	OFF	ON
	0...1.50 A	0...2.00 A	0... 2.50 A	ON	OFF
	0...0.94 A	0...1.25 A	0... 1.56 A	ON	ON
10 A input: 0...4.87 A to 0...11 A	0...7.50 A	0...10.0 A	0... 11.00 A	OFF	OFF
	0...4.87 A	0 ... 6.5 A	0 ... 8.12 A	OFF	ON

Measuring range MCR-S-10-50-...DCI	Span potentiometer: -25 %	Nominal range*: 0 %	Span potentiometer: + 25 %	DIP 1	DIP 2
0...9.5 A to 0...55 A	0...37.5 A	0...50.0 A	0... 55.0 A	OFF	OFF
	0...24.4 A	0...32.5 A	0... 40.6 A	OFF	ON
	0...15.0 A	0...20.0 A	0... 25.0 A	ON	OFF
	0...9.38 A	0...12.5 A	0... 15.6 A	ON	ON

* The nominal range has been adjusted!

4.3.5. Configuring the analog output

		DIP 3	DIP 4	DIP 5	DIP 6
Output	0...20 mA	OFF	OFF	OFF	OFF
	20... 0 mA	OFF	OFF	OFF	**ON**
	4...20 mA	OFF	OFF	**ON**	OFF
	20... 4 mA	OFF	OFF	**ON**	**ON**
	0...10 V	OFF	**ON**	OFF	OFF
	10... 0 V	OFF	**ON**	OFF	**ON**
	0... 5 V	OFF	**ON**	**ON**	OFF
	5... 0 V	OFF	**ON**	**ON**	**ON**
	1... 5 V	**ON**	OFF	**ON**	OFF
	5... 1 V	**ON**	OFF	**ON**	**ON**
	-10... 10 V	**ON**	**ON**	OFF	OFF
	10...-10 V	**ON**	**ON**	OFF	**ON**
	-5... 5 V	**ON**	**ON**	**ON**	OFF
	5... -5 V	**ON**	**ON**	**ON**	**ON**

2026 New Phoenix current sensor replacement



- New manufacturer replacement
- **Not tested yet**
- ECM-UC-10A-UI-REL - current measuring transducer
- Phoenix - long-term support
- USB-C connection to software

2017 Version 2 Door Sensor Solution



- **12v-24v compatible**
- **Proximity sensor**
- **Robust and reliable**

https://www.automationdirect.com/



- **Standard ITS Cabinet Switch**
- **Fails over time - abandoned**

2017 Version 2 Temperature and Humidity Sensor Solution



https://controlbyweb.com/

Control By Web - X-DTHS-WMX

- **Designed to work with X series**
- **No Programming**
- **Dropdown selection in controller**

2017 Web Relay Version 2
Backup Manual Site Activation Solution

Local Site Beacon activation button – Momentary Push Button



Local Site Beacon activation switch – Manual Off / On



Allows for remote turn off of beacons when activated in manual mode

2017 Version 2 Web Relay Converter Added

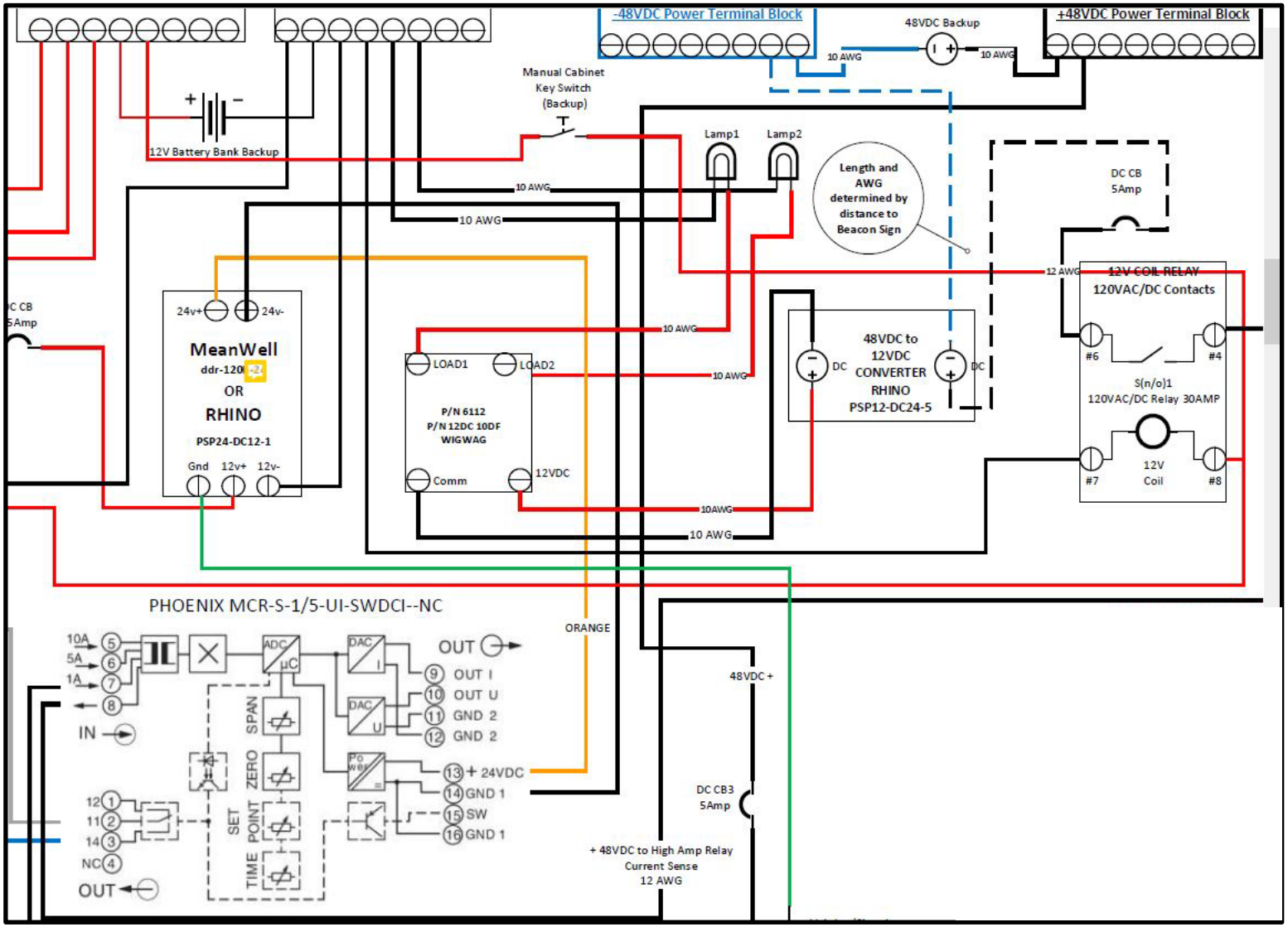


Added a 12v to <u>24v</u> DC 5 Amp converter

- **Power new Current sensor**
- **Power new Door Sensor**
- **Power new Voltage sensor**
- **Industrial power converter**
- **Provides redundancy**

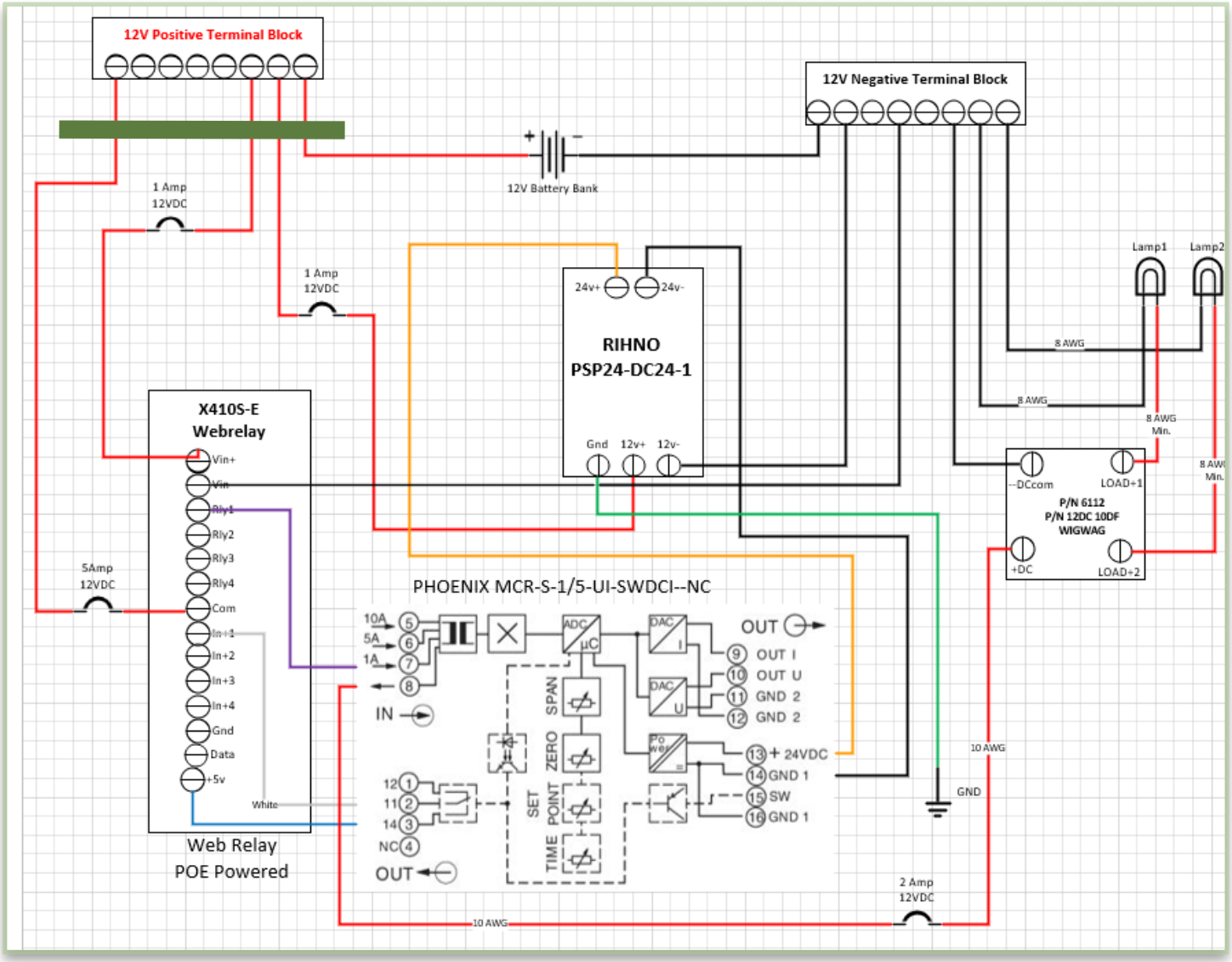
https://www.automationdirect.com/adc/home/home

2017 V2 NDOT Web Relay Schematics

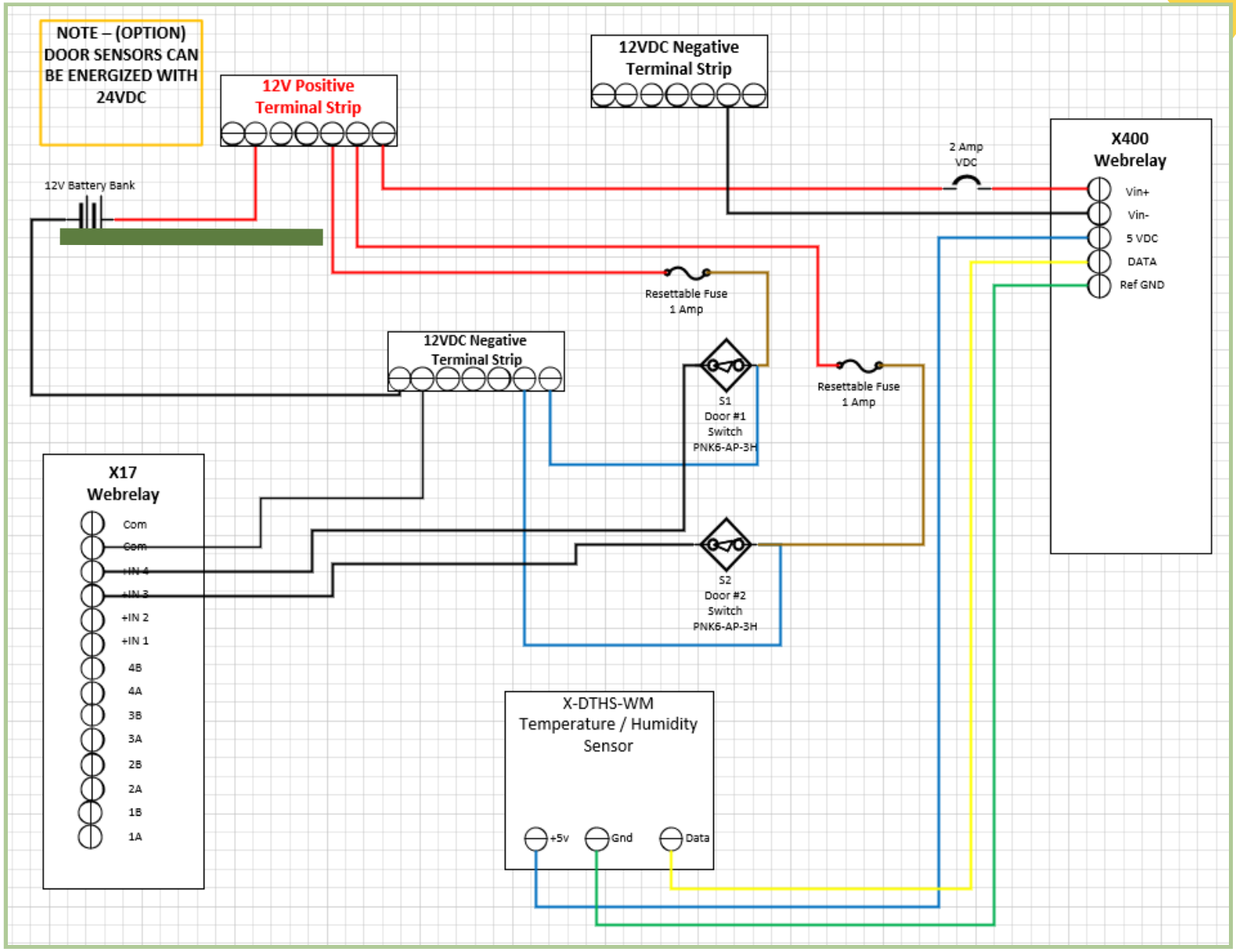


X410 Standard 12VDC Beacon Block Diagram

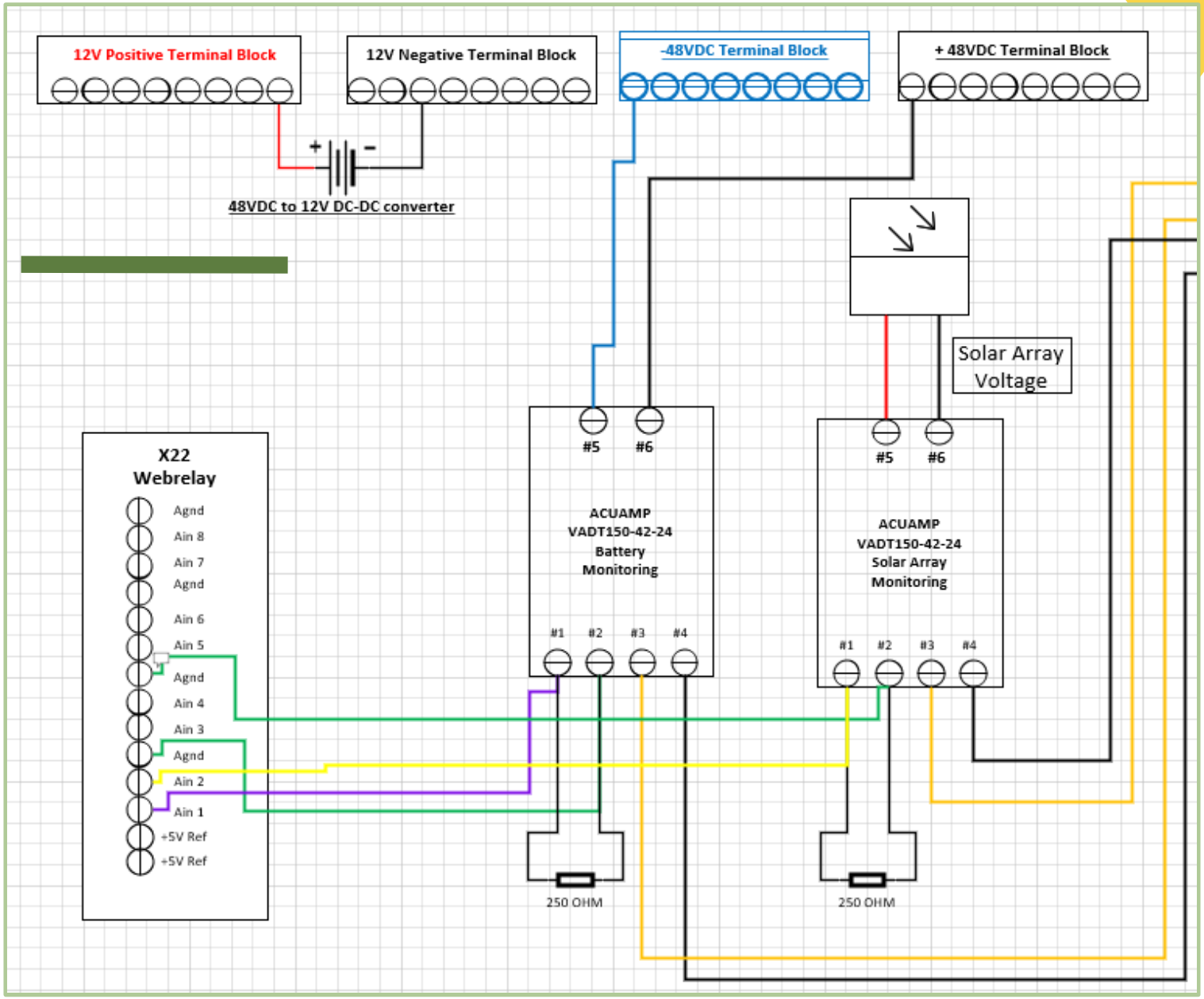
- **The main Beacon system operates on 12VDC**
- **NDOT has 12VDC, 24VDC, 48VDC, and 120VAC sites**



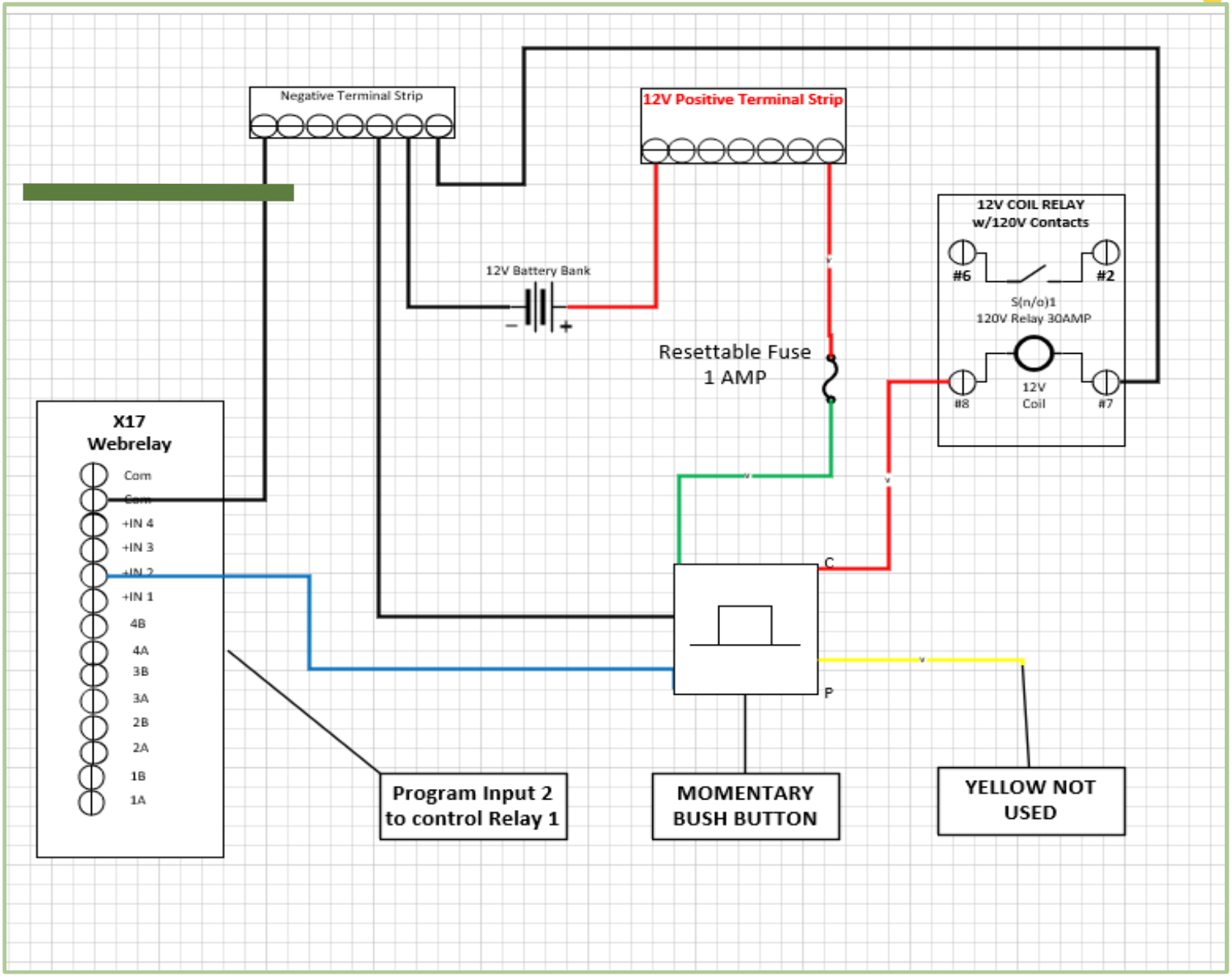
Temp / Humidity / Door Sensors Block Diagram



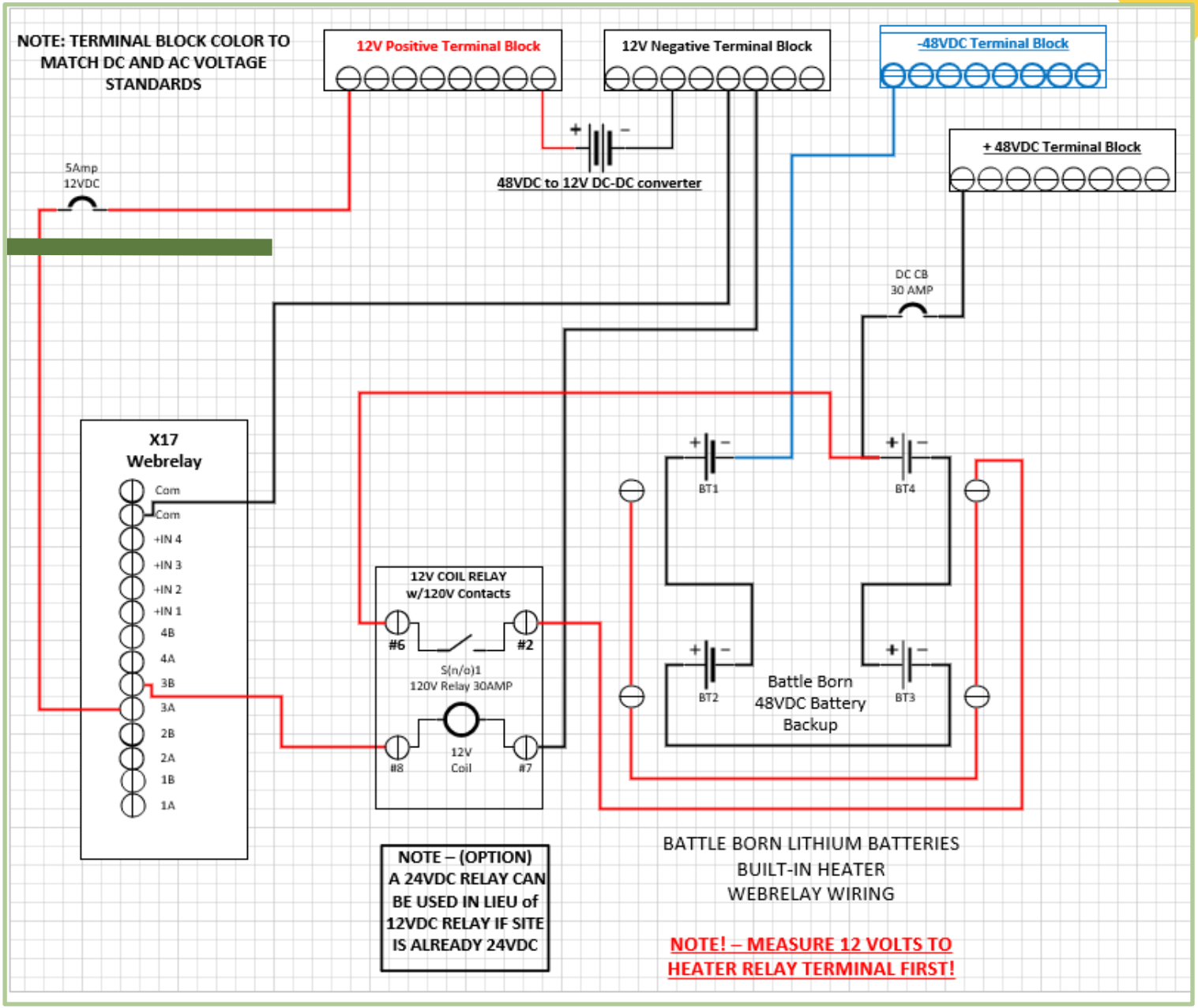
X22 Analog Sensor Block Diagram



Manual Push Button Block Diagram



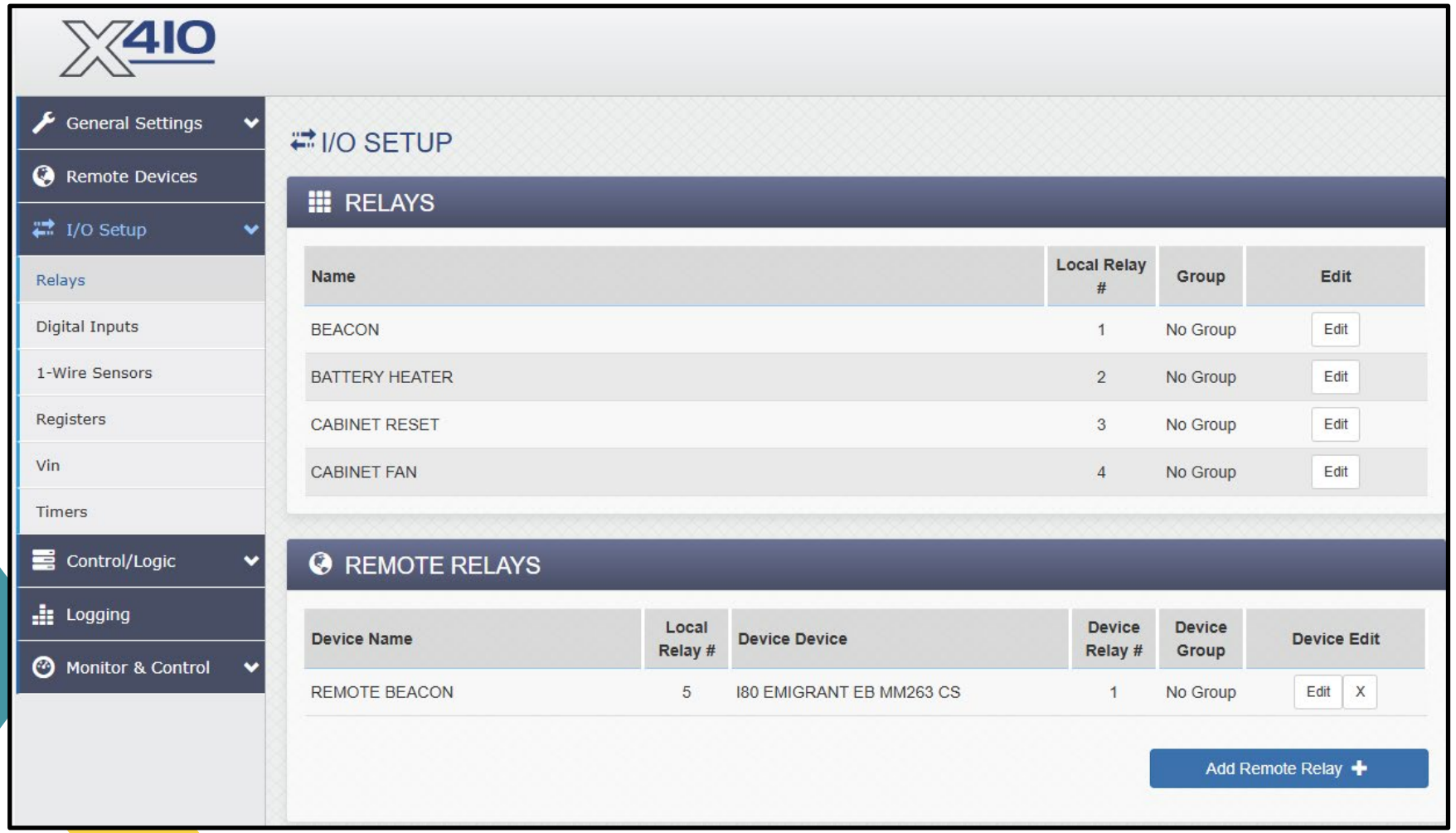
Lithium Battery Heaters Block Diagram



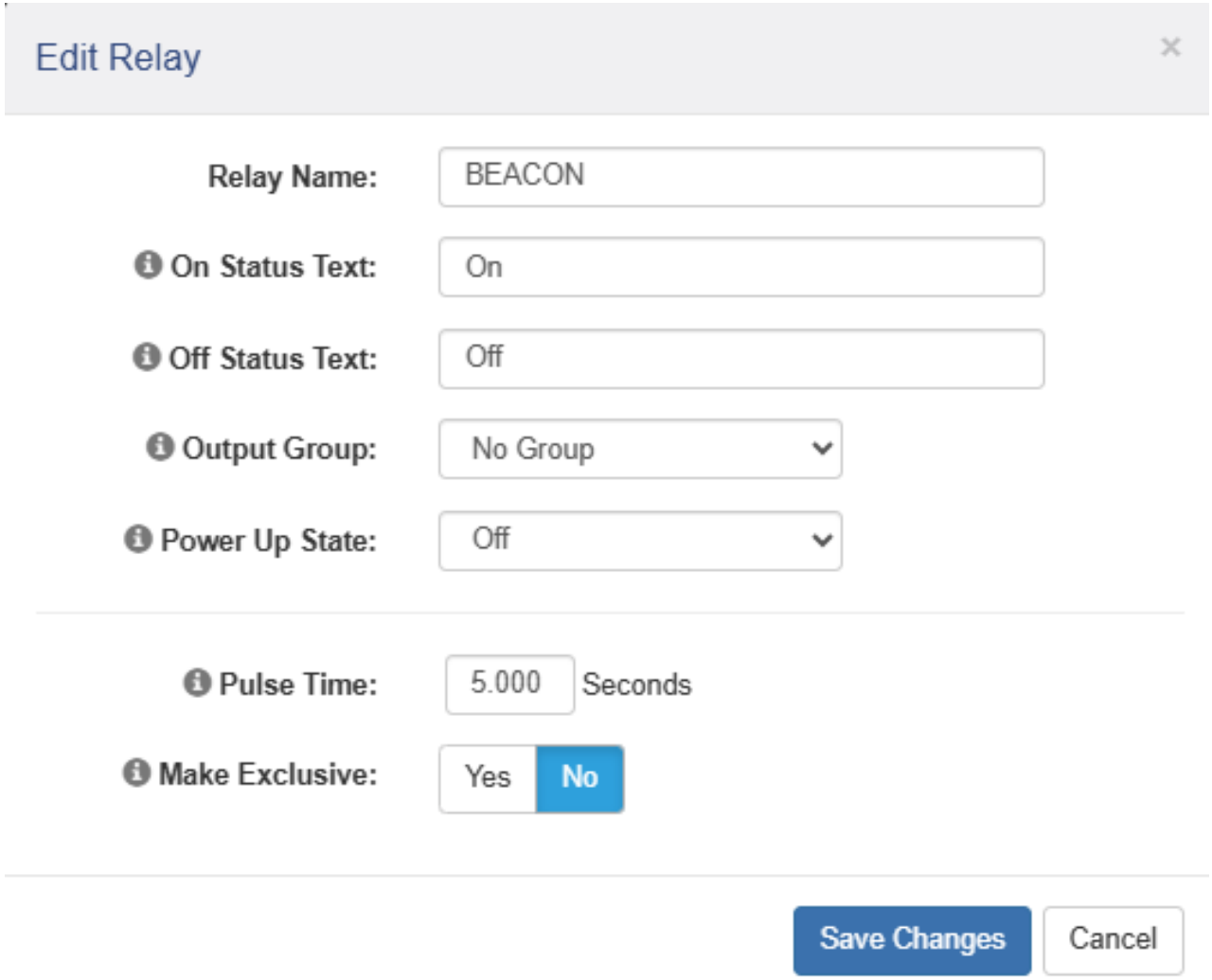
2017 Web Relay Version 2 - Field Device Programming Process

- **The Control by Web manual is well written on all products, including wiring detail and programming**
- **Free customer support was used for specific programming requirements and troubleshooting**
- **District 3 wanted to avoid coding and scripting as much as possible**

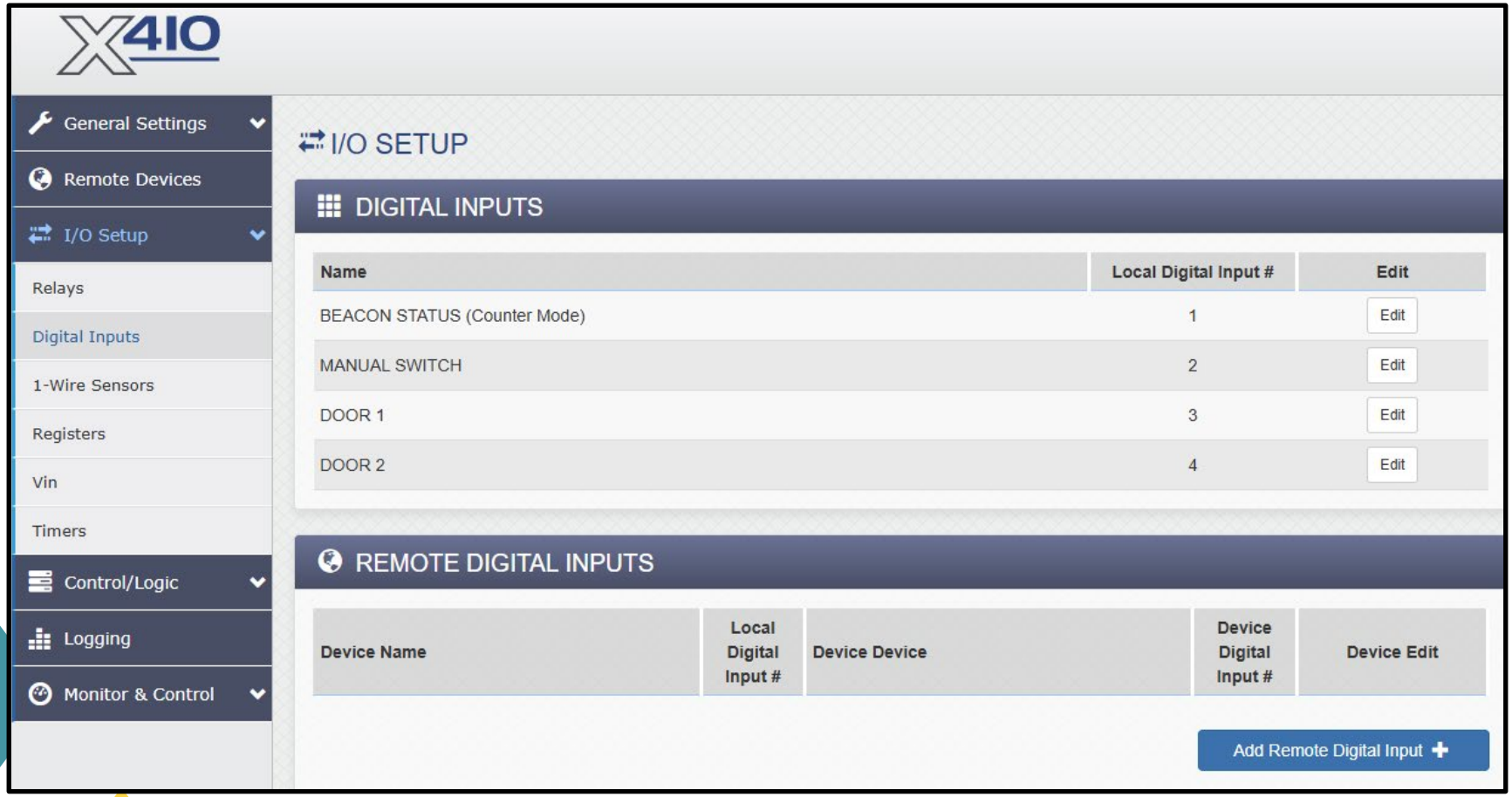
Field Device Relay Programming Process



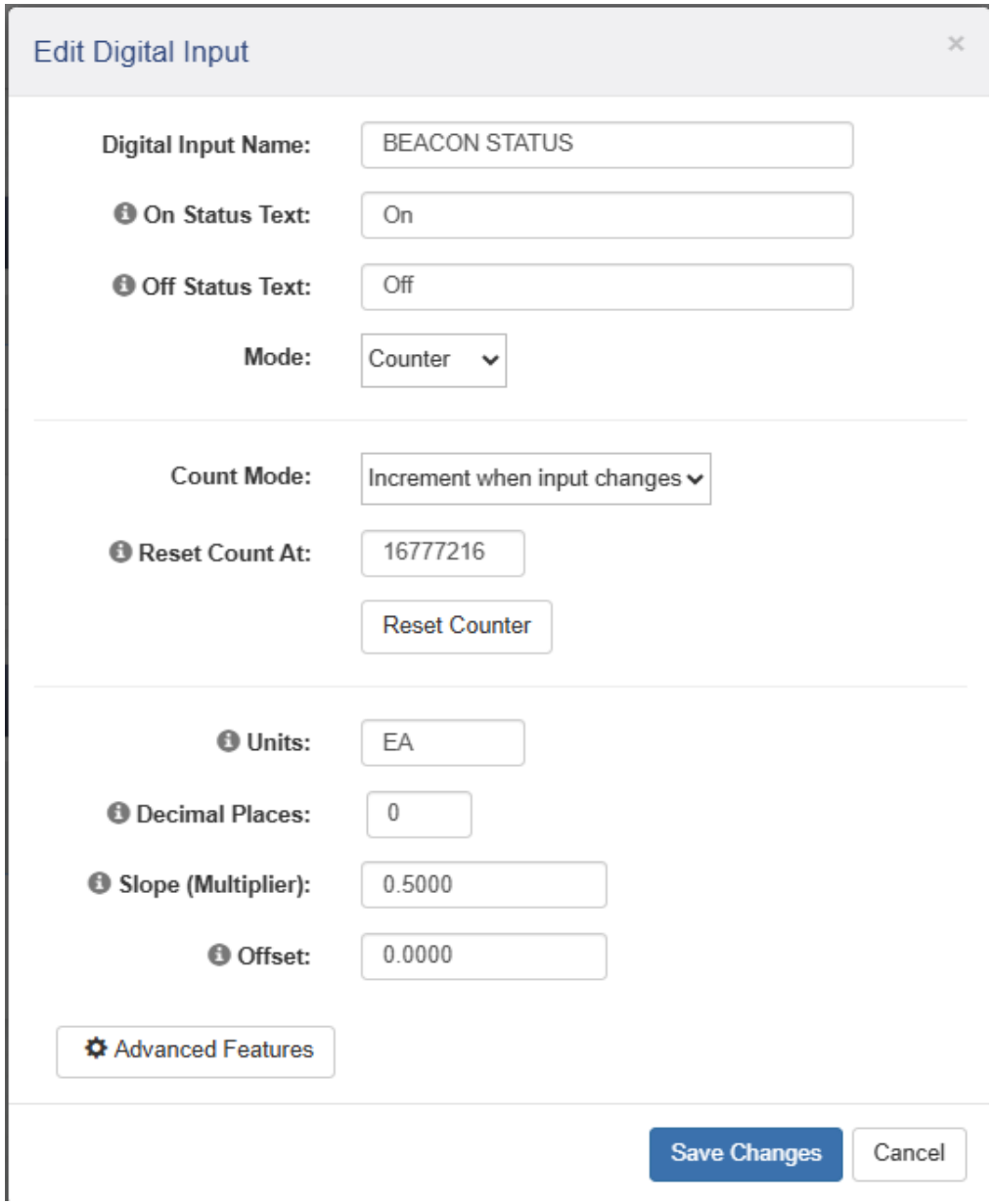
Field Device Relay Programming Detail



Field Device Input Programming process



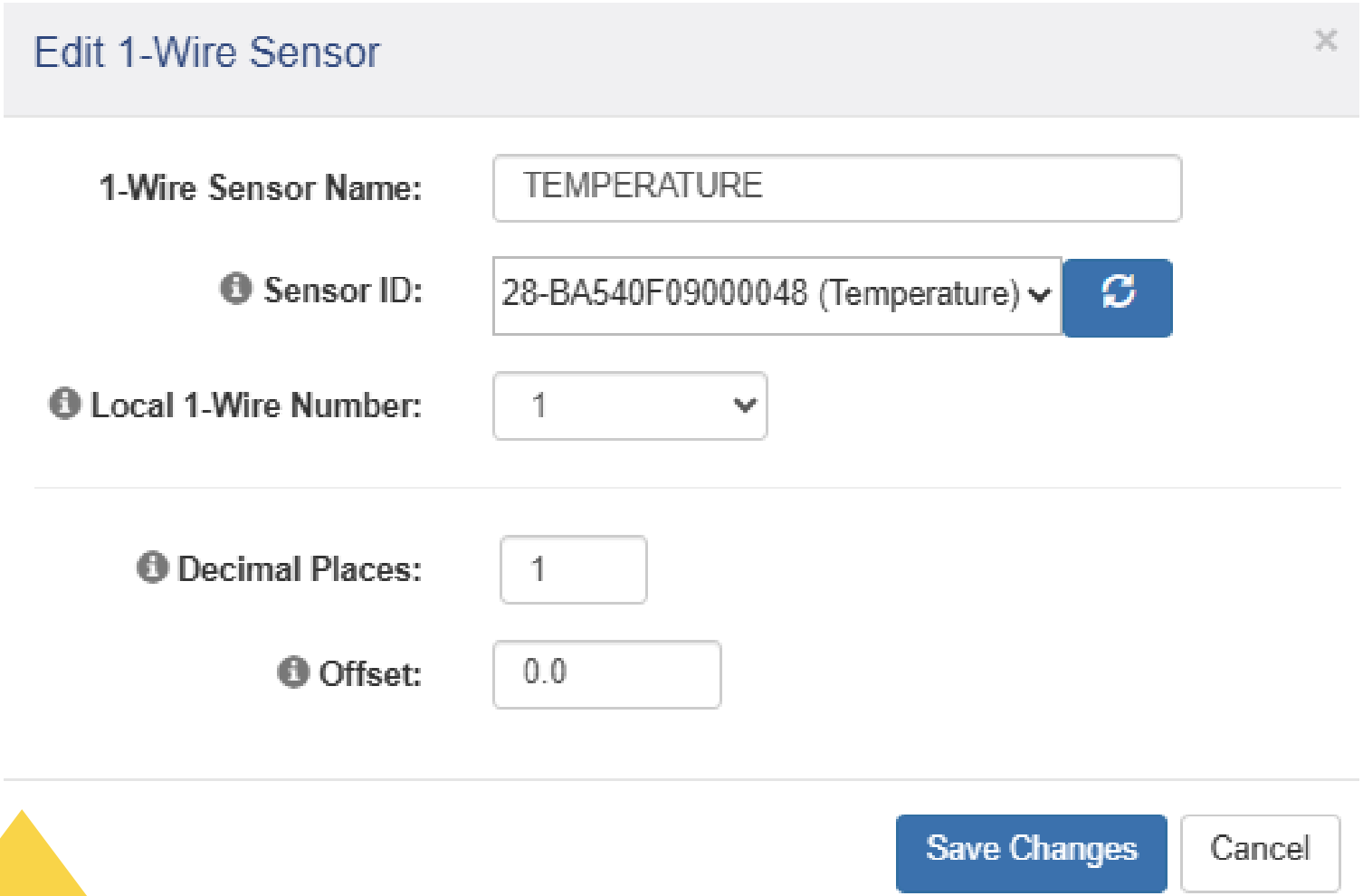
Field Device Input Programming Detail



Field Device Temp / Humidity Programming



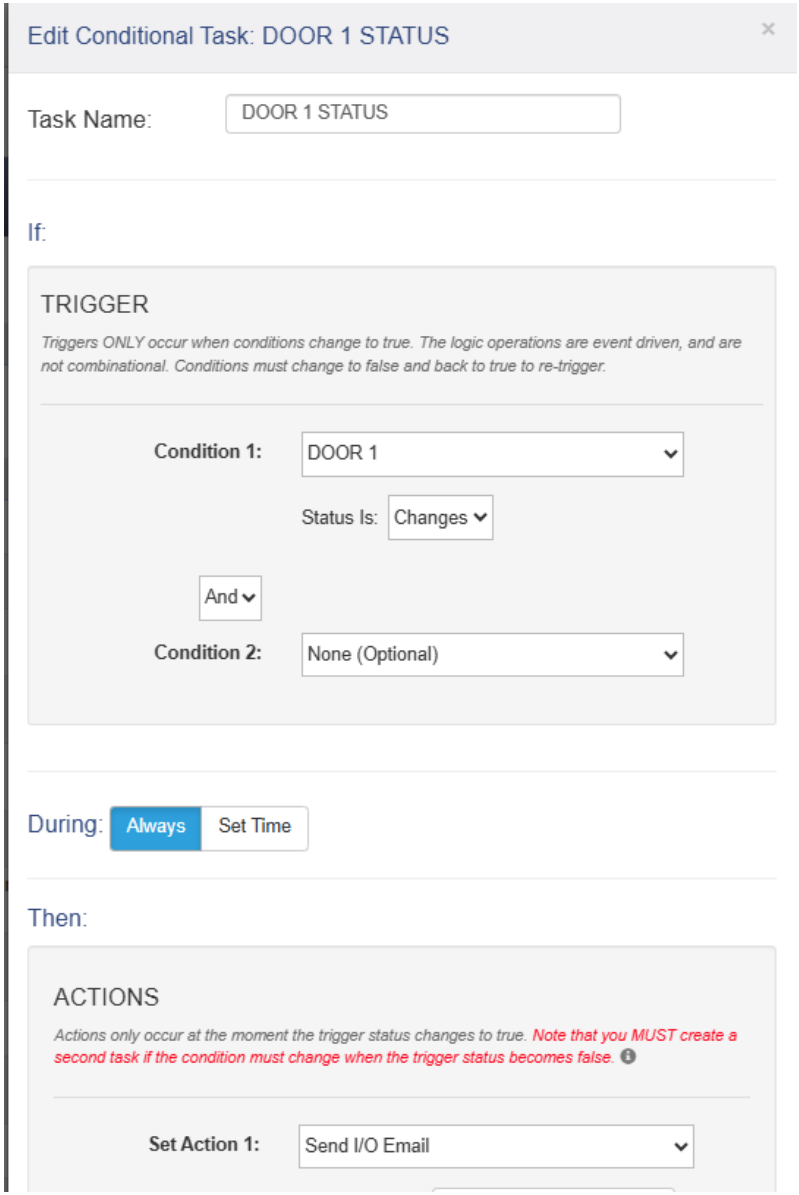
Field Device Temp / Humidity Programming Detail



Setup to Control Logic Functions - Conditional

Conditional Logic Tasks

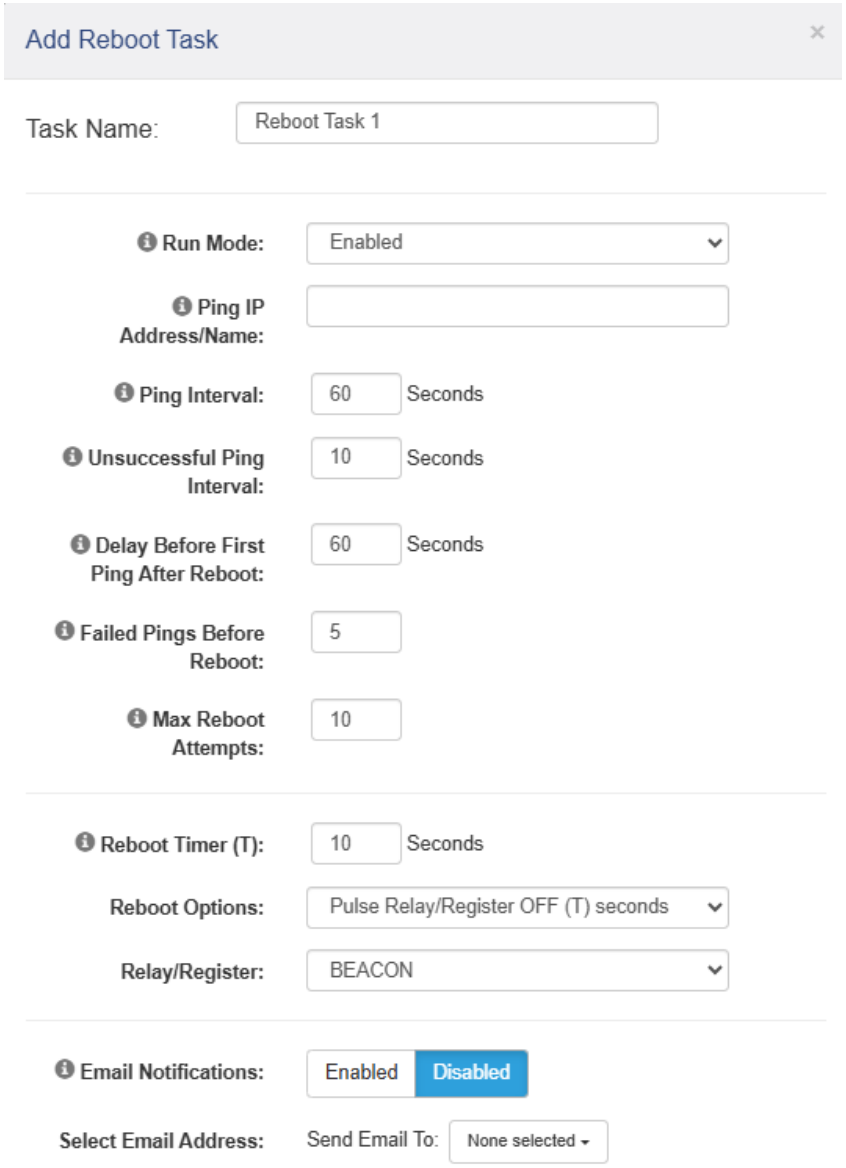
- **1 – 2 Conditions**
- **Up to 3 Actions**



Setup to Control Logic Functions - Reboot

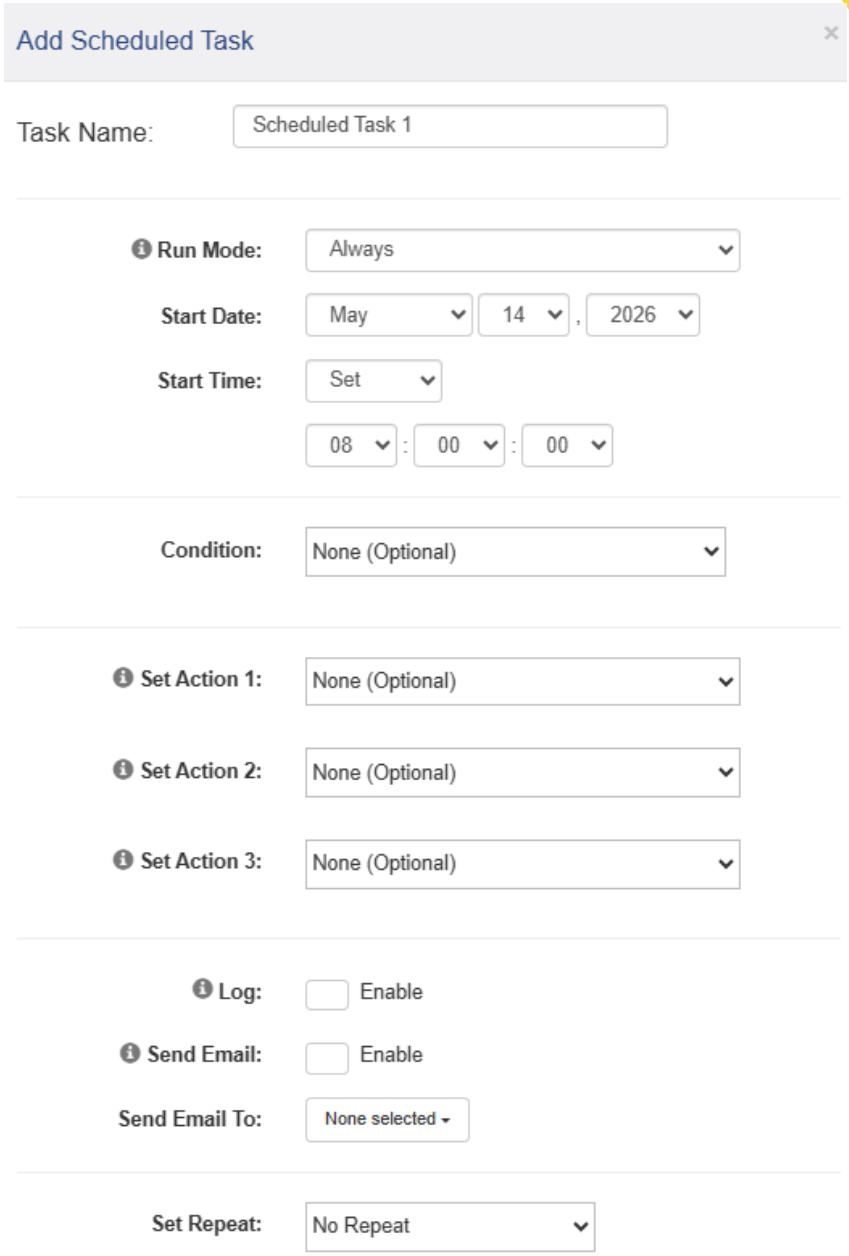
Reboot Task

Watchdog

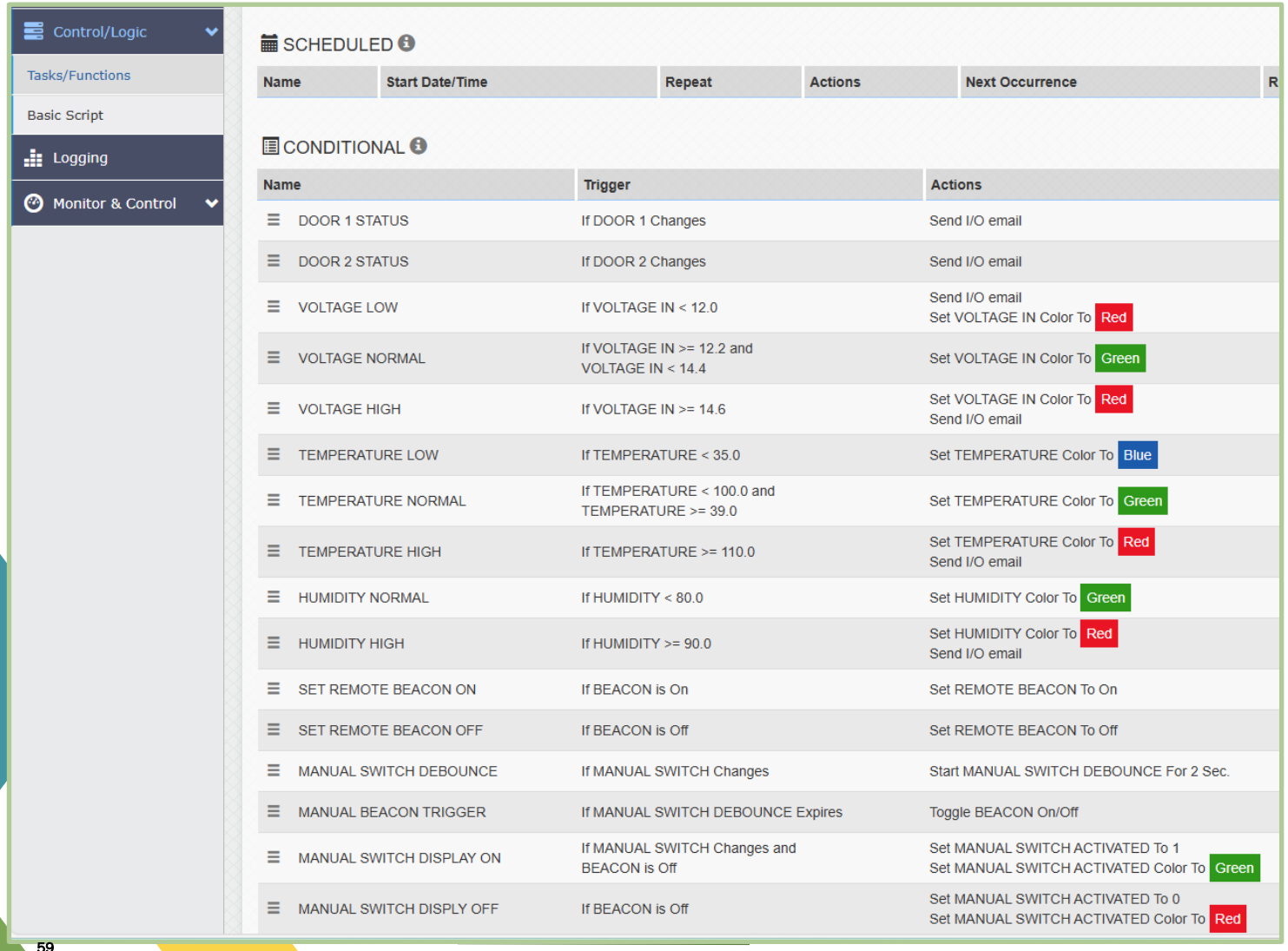


Setup to Control Logic Functions - Scheduled

Scheduled Task

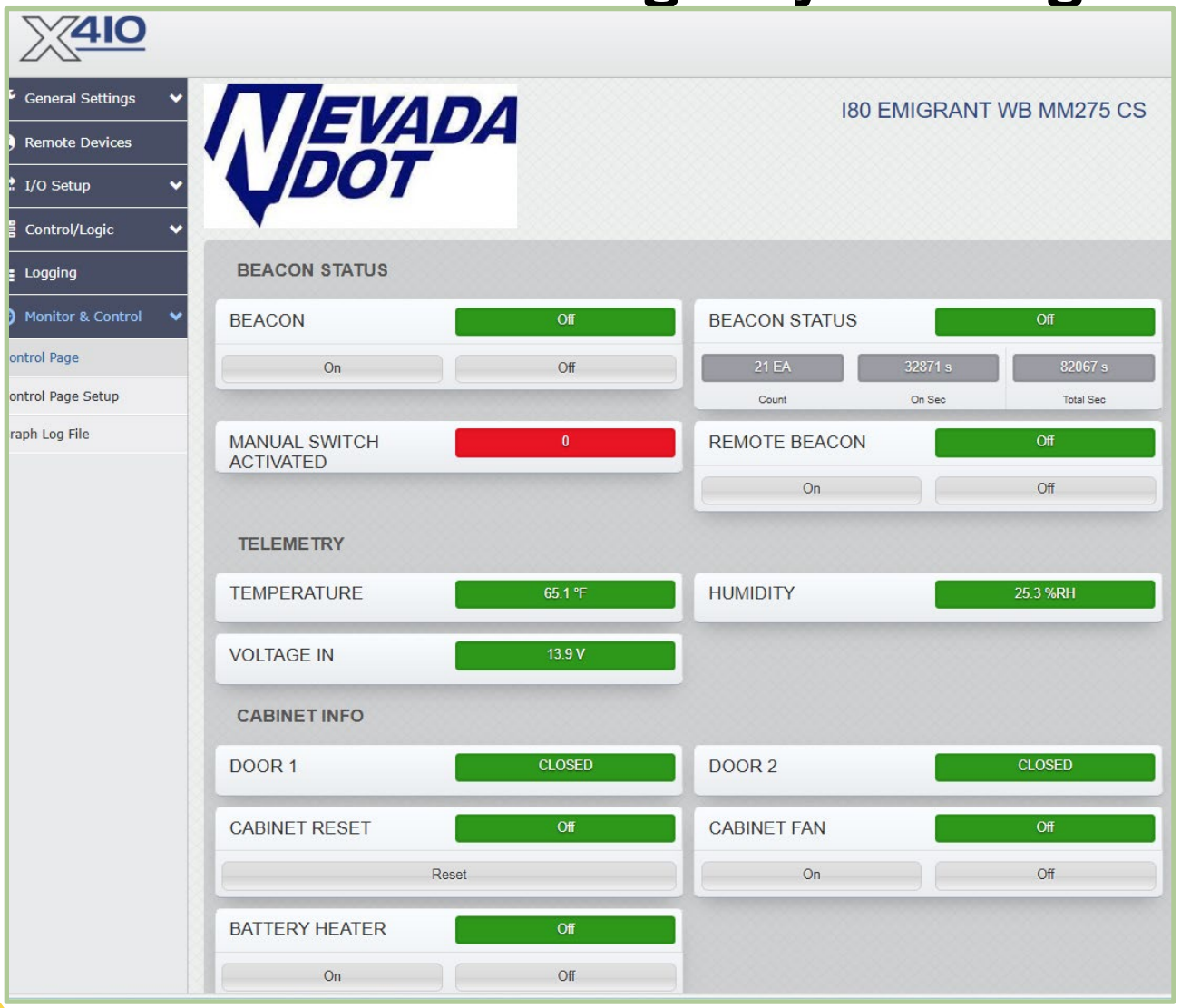


Field Device Logic / Control Programming



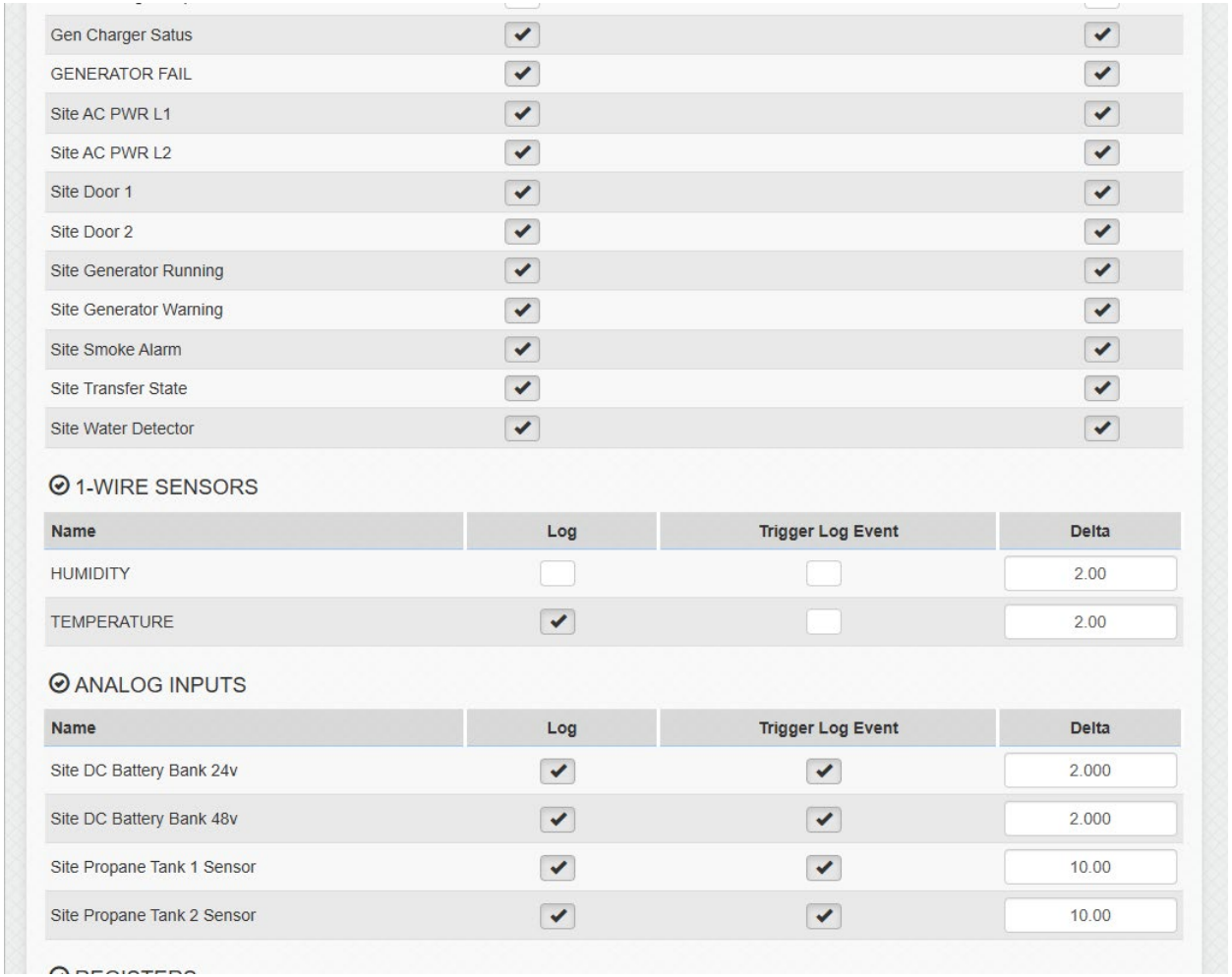
- **Automation**
- **Logic**
- **Conditional**
- **Scheduled**
- **Watchdog**
- **Scrips**

Field Device Control Page Layout Designer



Field Device Logging Report Setup Detail

Log files can be automated and sent to an email server



Gen Charger Satus	✓	✓
GENERATOR FAIL	✓	✓
Site AC PWR L1	✓	✓
Site AC PWR L2	✓	✓
Site Door 1	✓	✓
Site Door 2	✓	✓
Site Generator Running	✓	✓
Site Generator Warning	✓	✓
Site Smoke Alarm	✓	✓
Site Transfer State	✓	✓
Site Water Detector	✓	✓

1-WIRE SENSORS

Name	Log	Trigger Log Event	Delta
HUMIDITY			2.00
TEMPERATURE	✓		2.00

ANALOG INPUTS

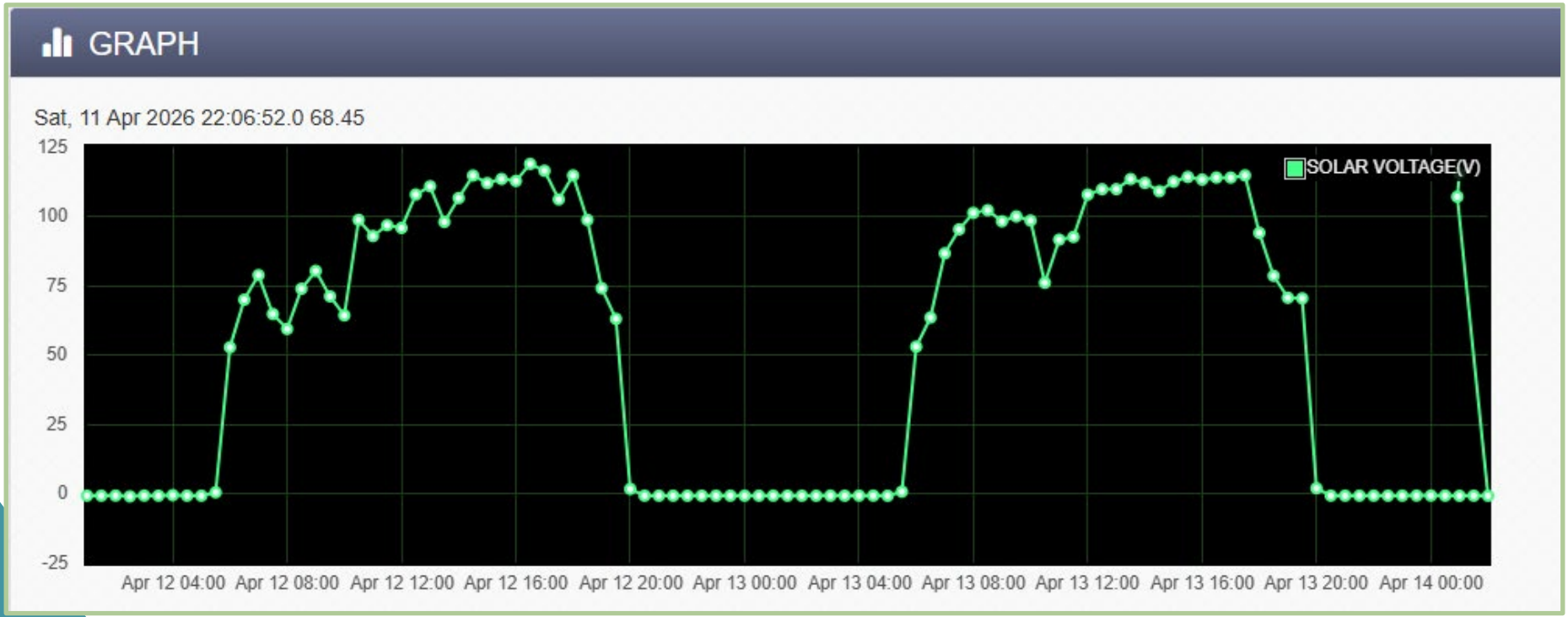
Name	Log	Trigger Log Event	Delta
Site DC Battery Bank 24v	✓	✓	2.000
Site DC Battery Bank 48v	✓	✓	2.000
Site Propane Tank 1 Sensor	✓	✓	10.00
Site Propane Tank 2 Sensor	✓	✓	10.00

Field Device Battery Graph History Detail



You can pick your sensor and graph the history

Field Device Solar Graph History Detail



You can pick your sensor and graph the history

Field Device Email Alarm Reporting Example

SITE-INFORMATION
Comm Site Door 1: CLOSED
Gen Site Door 2: CLOSED
Site Smoke Alarm: NORMAL
GEN BLDG SMOKE ALARM: NORMAL
HVAC Lockout: NORMAL
HVAC Lockout 2: NORMAL
Temperature: 72.26 F
Humidity: 11.81 %RH
Site Water Detector: DRY
Site AC Power: AC SITE PWR ON
BLDG Low TEMP: NORMAL
BLDG Hi TEMP: NORMAL
Network RM Surge Arrestor: NORMAL
Gen RM Surge Arrester: NORMAL
CO2 DETECTOR: NORMAL
SITE-DC-VOLTAGE
DC 48v Battery Bank Sensor 1: 52.901 V
DC 12v Battery Bank Sensor 2: 12.875 V
WebRelay Vin: 25.8 V
SITE-GENERATOR
GEN AUTO Switch: NORMAL
Site Generator State: NORMAL
Gen Oil Pressure: NORMAL
Site Generator Warn Fail: NORMAL
Gen Coolant Lvl: NORMAL
ATMS Emergency: ON COMM AC PWR
Gen E-Stop Over Crank: NORMAL
GEN ENGINE TEMP: ALERT
ATMS COMM AC: ON COMM AC PWR
GEN LOW CRANK V: NORMAL
HIGH ENGINE TEMP: ALERT

Time: 05/15/2026 08:08:01

No need to log into the device as the information is all here

Field device backup file is created for each type of field controller and site type



- Clear text configuration files can be saved, modified, and reused
- As long as -
  - The Sites are wired the same
  - Site Inputs and Outputs are wired consistently
- Devices can be reprogrammed remotely
- Update firmware can be updated remotely
- Server database files and field devices can be backed up manually

2017 NDOT AC Site X410 Beacon Field Installation



AC Site X410 Chain Sign Beacon System

2018 DC Site X400 Series Beacon Installation

Solar Site X400 Chain Sign Beacon System

- **Expanded - Voltage monitoring added for solar power systems**

X600 Server Configuration adding the field device



Devices | Configuration

Add device.

Device

Model Number:	X-400 (X-400 Web-Enabled I/O Controller)
*Name:	device59
*Description:	New Device
Serial Number:	00:0c:c8:
Address:	
Port:	80
Ethernet Comm. Type:	Direct (IP Address/Host Name)
Password:	
**Diagnostic Email Recipient:	Disabled

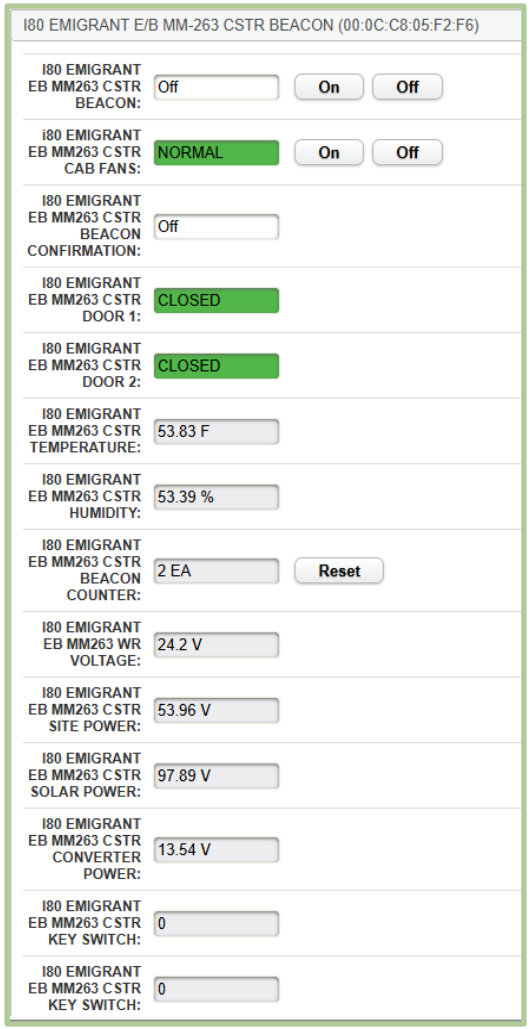
Add Cancel

Server Input / Output Database Configuration

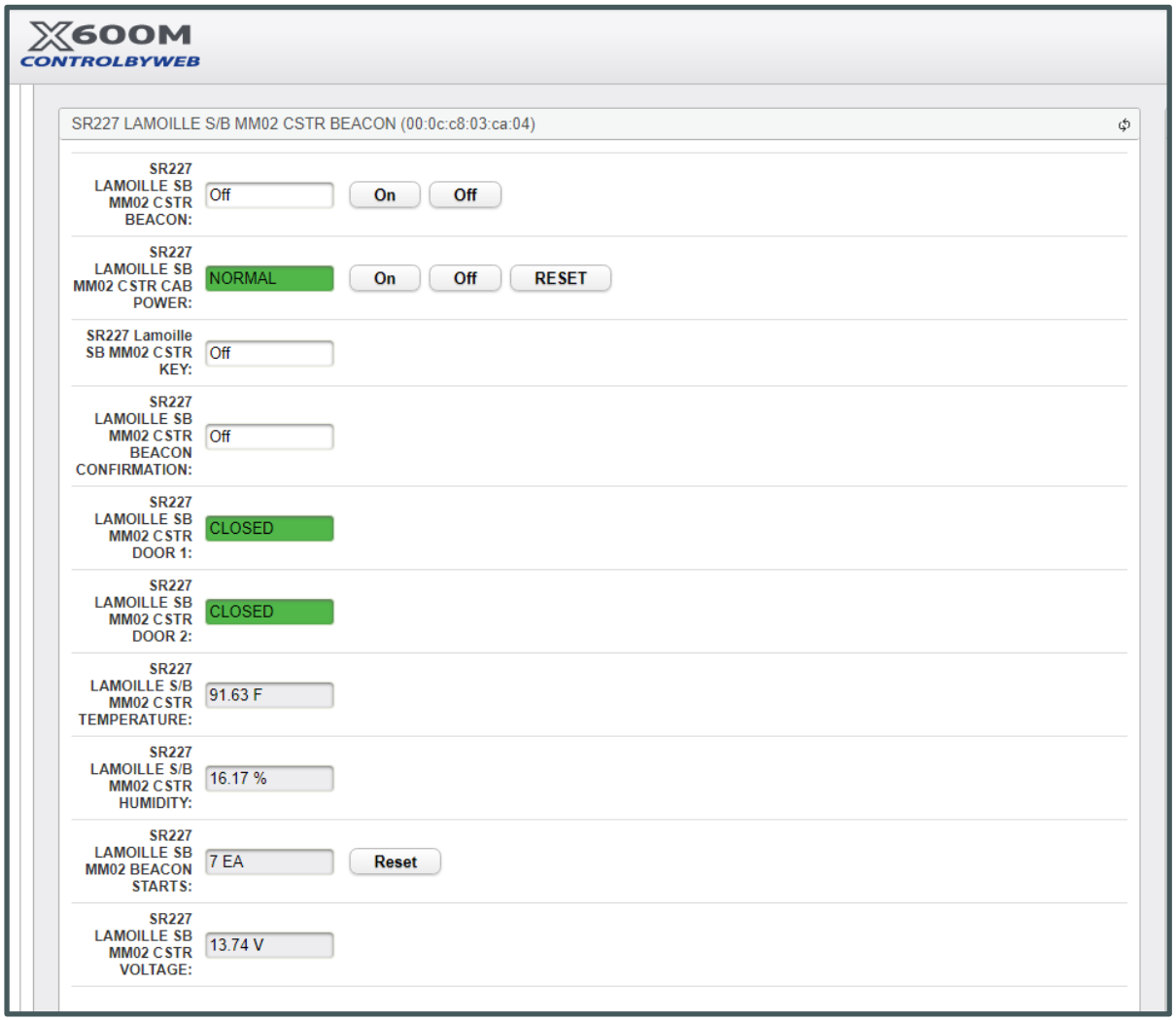
I/O Name	I/O Description	Device Name	Device Description	Device
i80bmWBm229CSrly	I80 BATTLE MTN WB MM229 CSTR BEACON	i80bmWBm229CSTR	I80 BATTLE MTN WB MM229 CSTR BEACON	1
i80bmWBm229CSpwr	I80 BATTLE MTN WB MM229 CSTR CAB POWER	i80bmWBm229CSTR	I80 BATTLE MTN WB MM229 CSTR BEACON	3
i80bmWBm229CSTRamp	I80 BATTLE MTN WB MM229 CSTR BEACON CONFIRMATION	i80bmWBm229CSTR	I80 BATTLE MTN WB MM229 CSTR BEACON	1
i80crgWBm158csAMP	I80 COSSGRAVE WB MM158 CSTR BEACON CONFIRMATION	i80crgWBm158CS	I80 COSSGRAVE WB MM158 CSTR BEACON	1
i80mbWBm229csDOOR1	I80 BATTLE MTN WB MM229 CSTR DOOR 1	i80bmWBm229CSTR	I80 BATTLE MTN WB MM229 CSTR BEACON	3
i80bmEBm234CSrly	I80 BATTLE MTN EB MM234 CSTR BEACON	i80bmEBm234CSTR	I80 BATTLE MTN EB MM234 CSTR BEACON	1
i80bmWBm229csDOOR2	I80 BATTLE MTN WB MM229 CSTR DOOR 2	i80bmWBm229CSTR	I80 BATTLE MTN WB MM229 CSTR BEACON	4

TECH Page Server Chain Sign Widget

- **Beacon Control**
- **Cabinet fan control**
- **Beacon confirmation**
- **Communication cabinet door 1**
- **Battery cabinet door 2**
- **Temperature**
- **Humidity**
- **Beacon counter**
- **Site power**
- **Device voltage**
- **Solar input**
- **Conver voltage**
- **Push button – local manual control**



District III Road Operations Server Page
Chain Sign widget display and control



Implementation - Use Cases

- Chain control sign beacons
- Solar site power telemetry
- Ice light beacons
- Web Boss– Whole site telemetry and control for communication buildings
- Railroad cossings beacons
- Queue warning systems
- Mountain top site telemetry



Expanding the System

- Charge/Discharge
- Solar DC current
- DC plant voltage
- Generator exercising, monitoring and notifications
- Temperature and humidity
- HVAC airflow
- Door status – open/closed
- Fuel Level – Propane and diesel
- Water detection
- Motion sensing

X400 Expandability
Input and Output Options



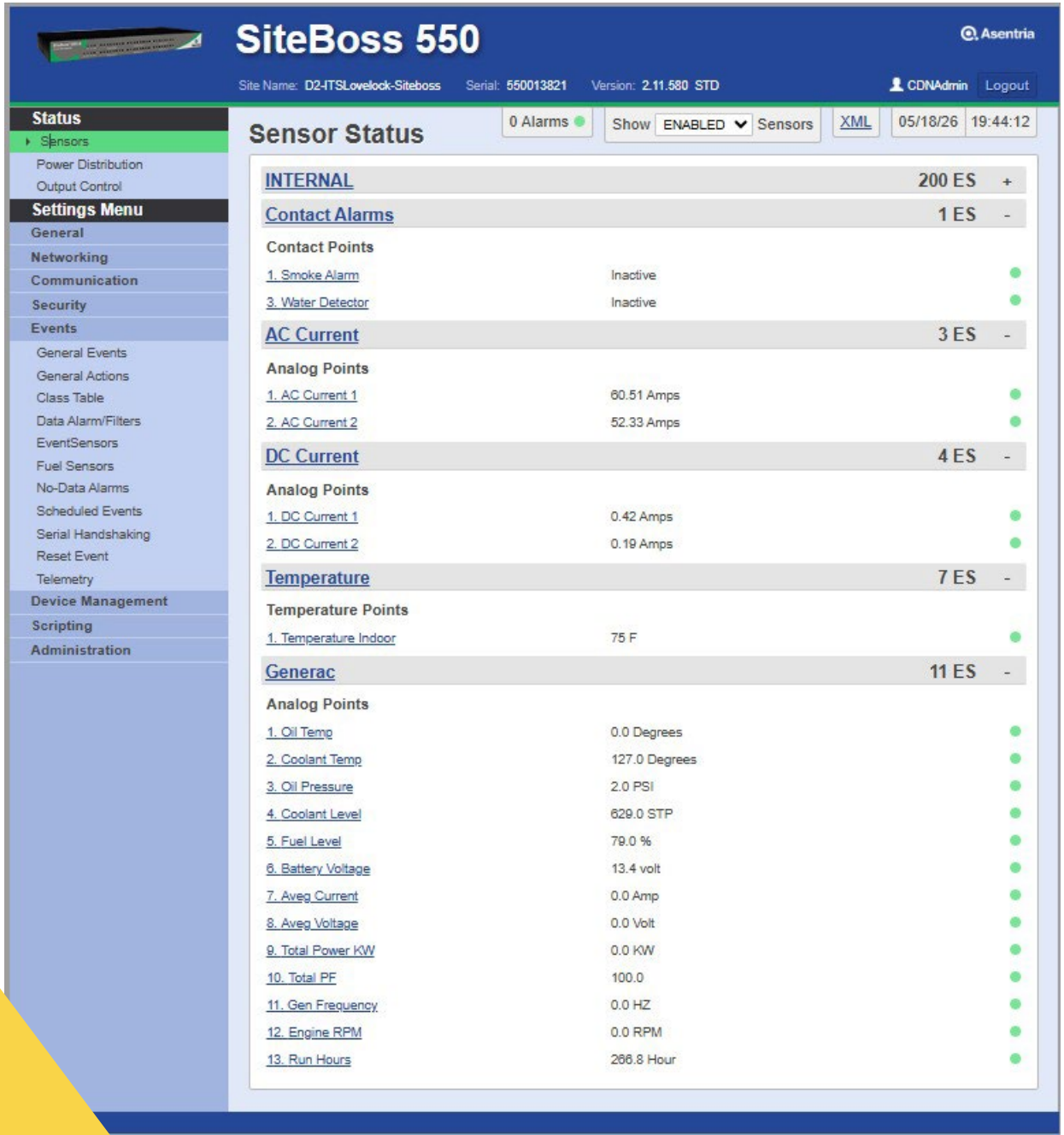
- **Supports up to 32 local expansion modules or remote Control By Web® devices through peer-to-peer communication**
- **Expandable, up to 64 I/O**
- **Relays, analog and digital inputs**
- **Up to 16 temperature sensors**
- **Cellular communications version available**
- **Peer-to-Peer communication (P2P) MQTT**

Aprista Site Boss – NDOT Legacy Monitoring Unit



- Still being used at multiple communication buildings
- Site Boss is being replaced with the Web Relay X19s
- Very difficult to program – requires coding
- Five times the cost of the Web Relay controllers
- Issues with sensor threshold reporting notifications
- Issues with site reporting on accurate values
- Limited vendor support

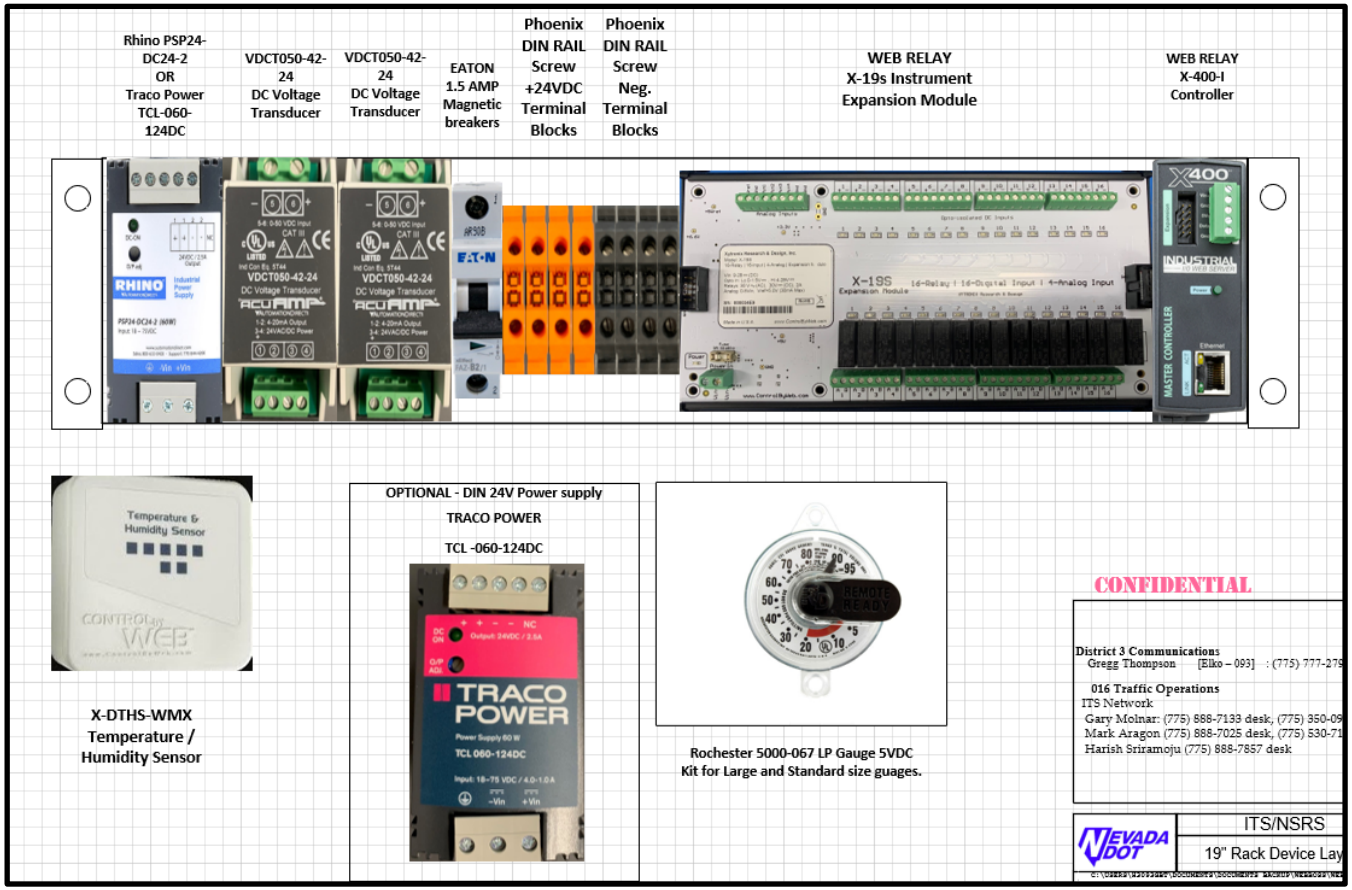
Aprista Site Boss – Web Page



X400 /x19 – Web Boss Layout

- **Web Relay X400 with a X19s Industrial Expansion Module**

- **16 relays**
- **16-digital inputs**
- **4-analog Inputs**



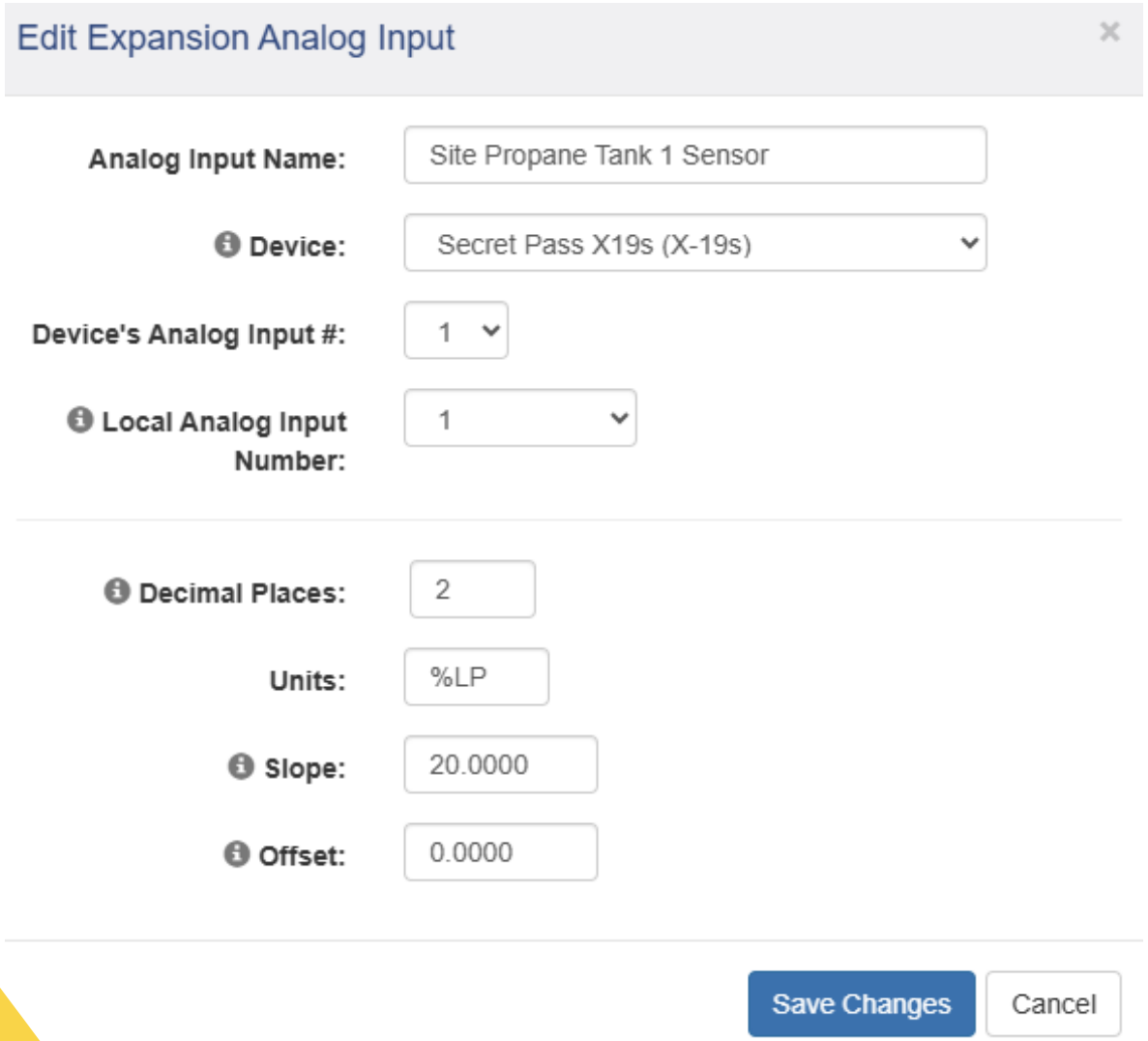
WEBOSS X400 Installation with X19



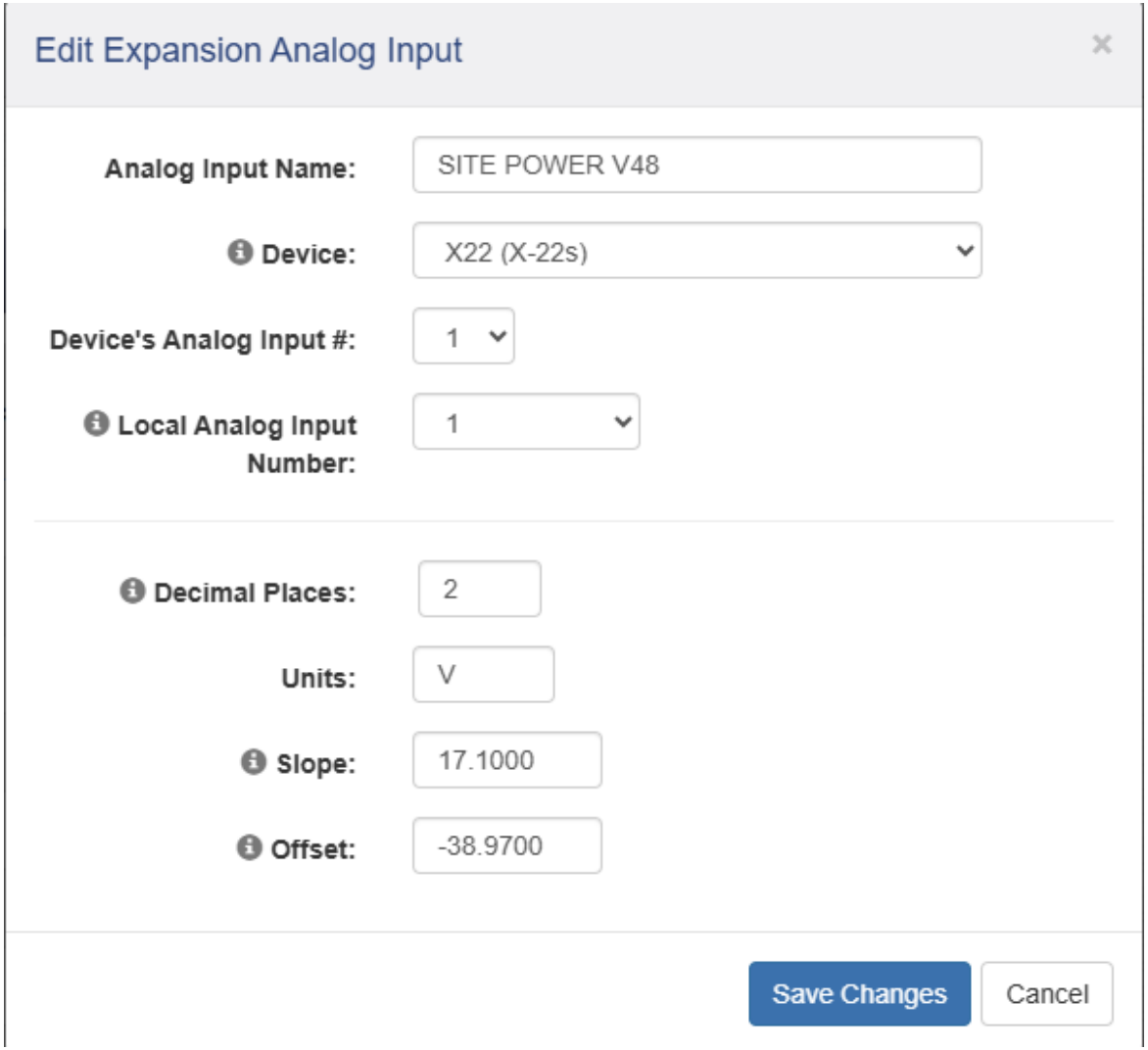
Web Boss X400 Device Web Page



Web Boss – Propane Analogue sensor setup



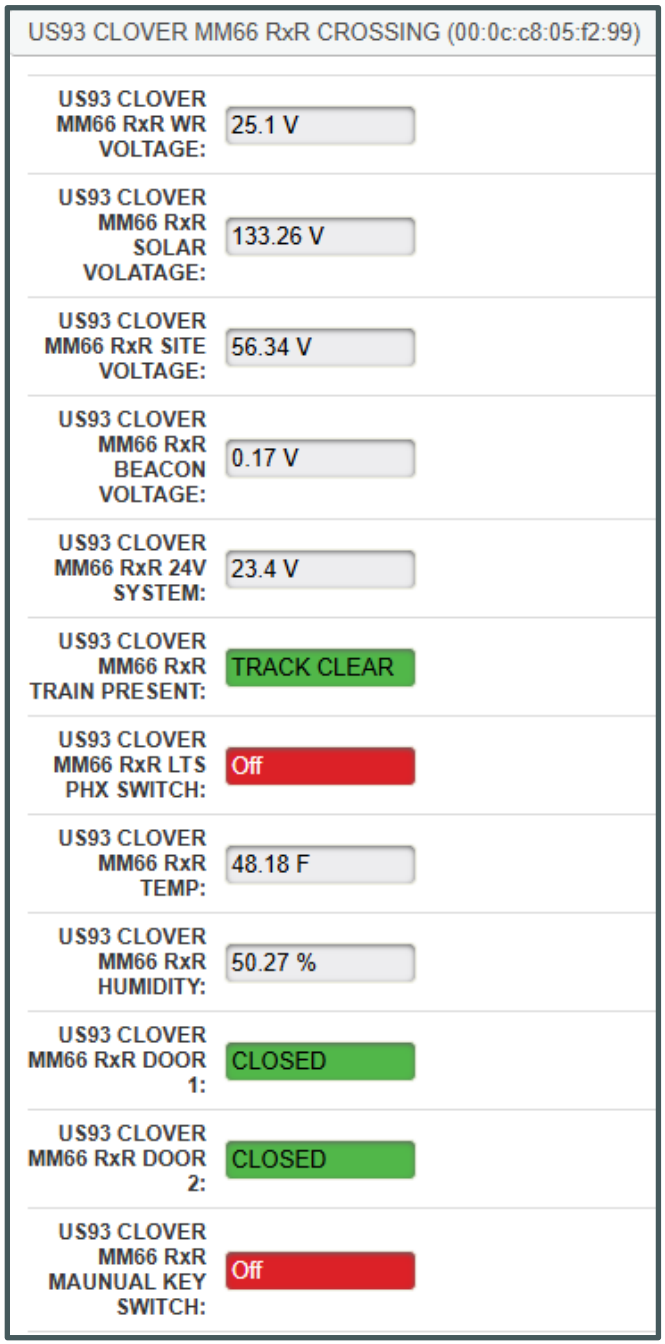
Web Boss – 48 Volt battery Bank Voltage sensor settings



X400 Web Relay for Railroad Application







Railroad Preempt Flashing Beacon Control Page

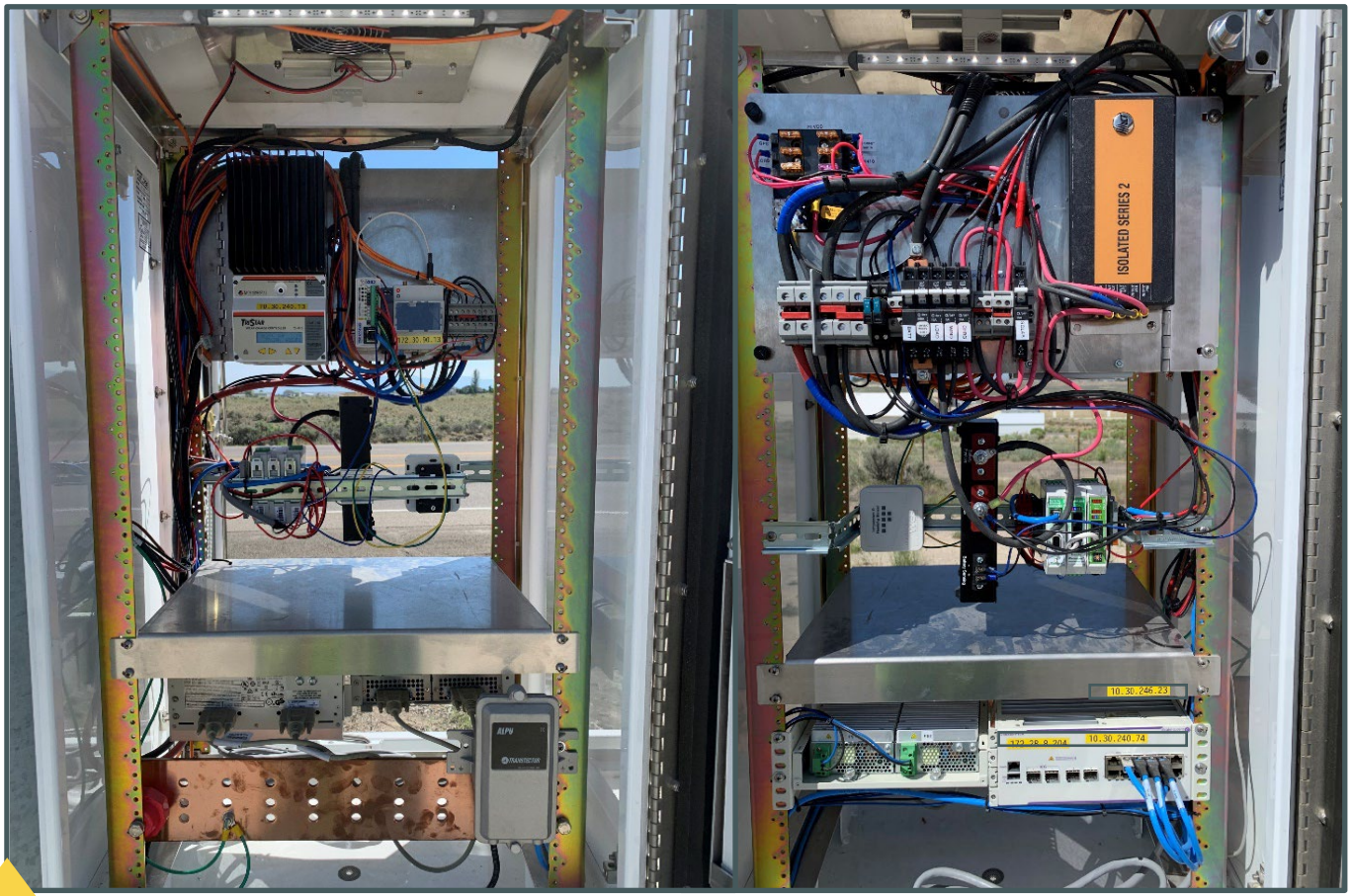
Extensive system alerting setup

Queue Warning System

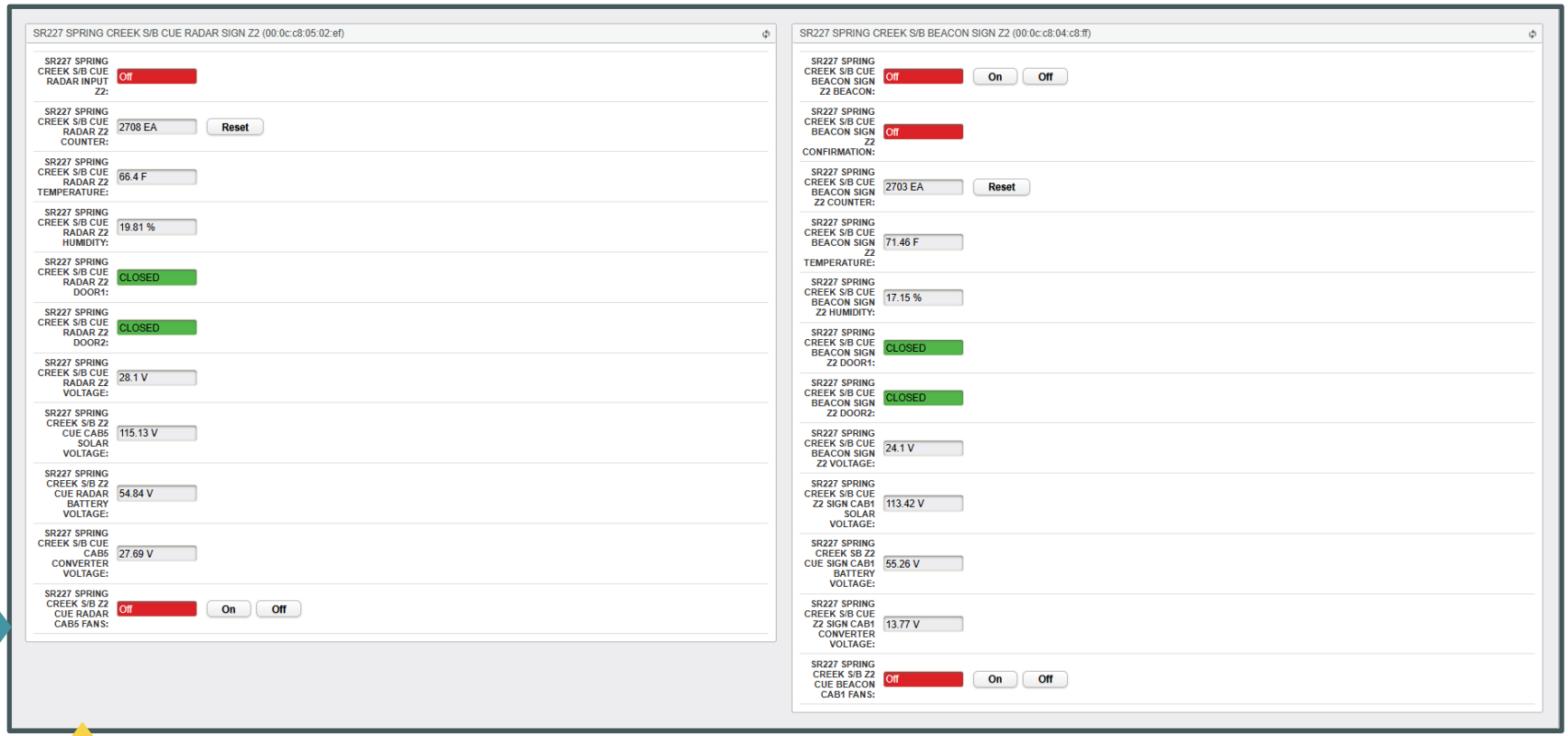
- **Radar controlled**
- **4 separate sites fully automated**
- **Traffic is measured and activated based on traffic thresholds programmed**
- **Site captures daily Queues**
- **Extensive system alerting setup**



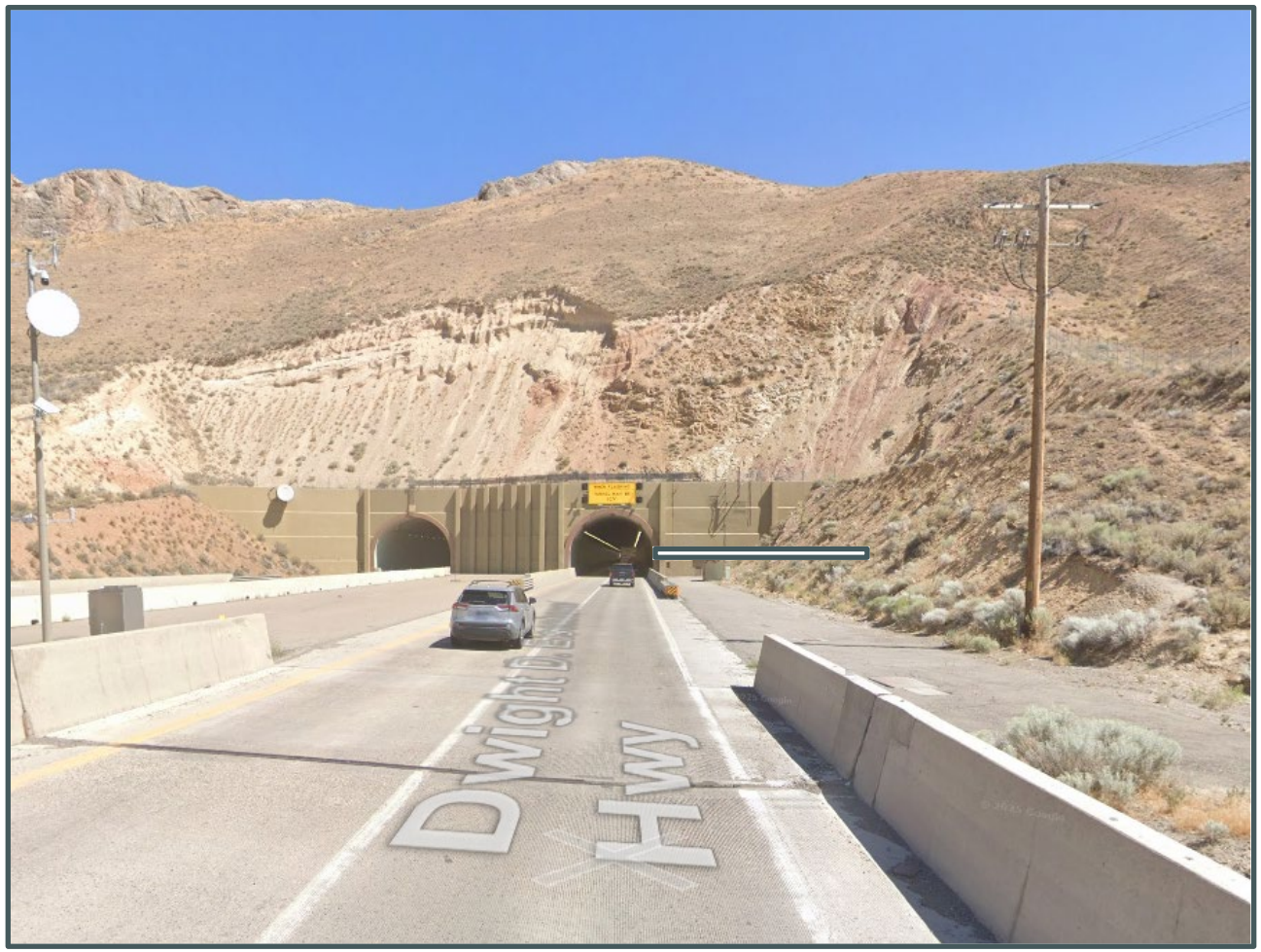
X400 Queue Warning Installation



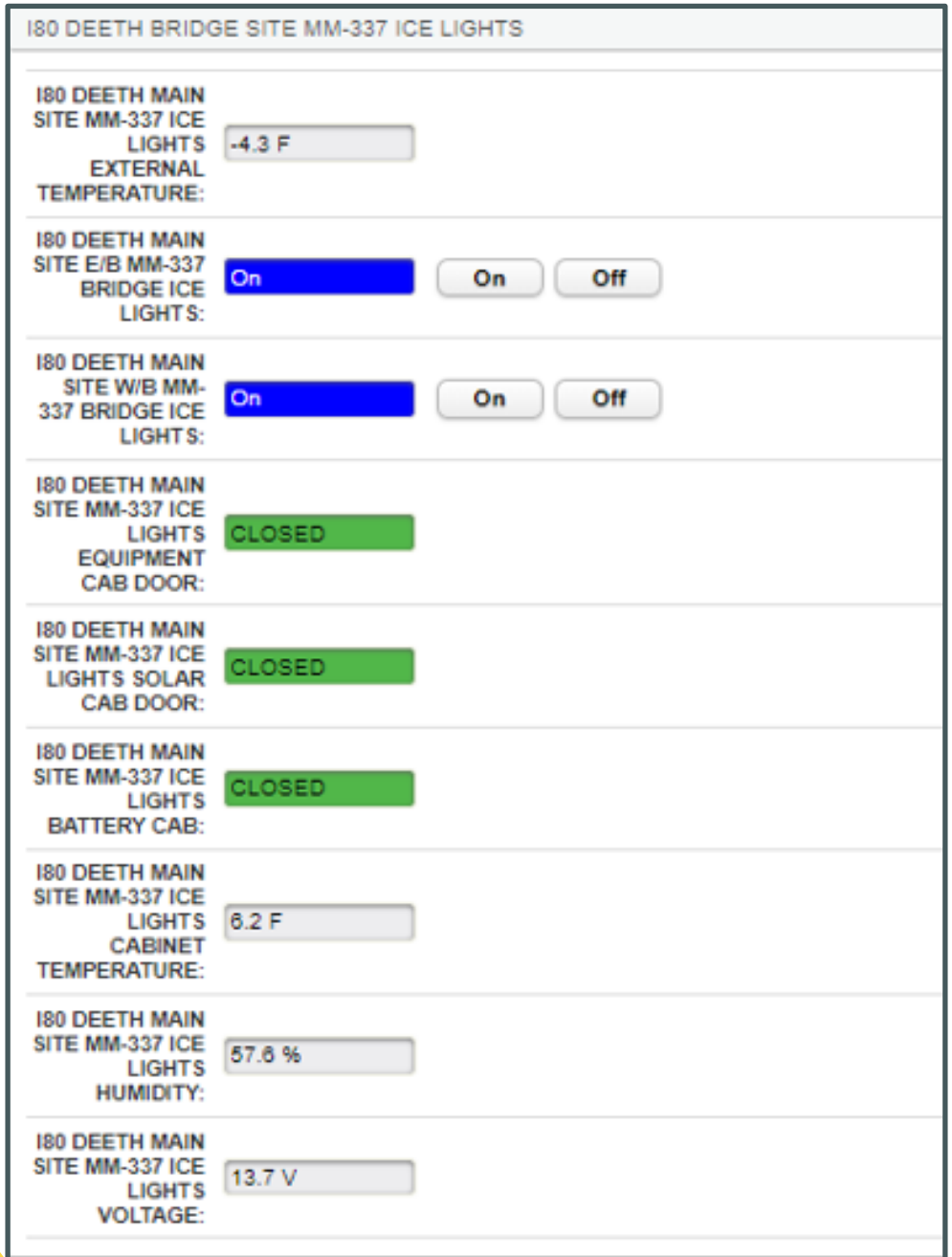
X600 District III Server Display
SR227 Queue Warning System web page



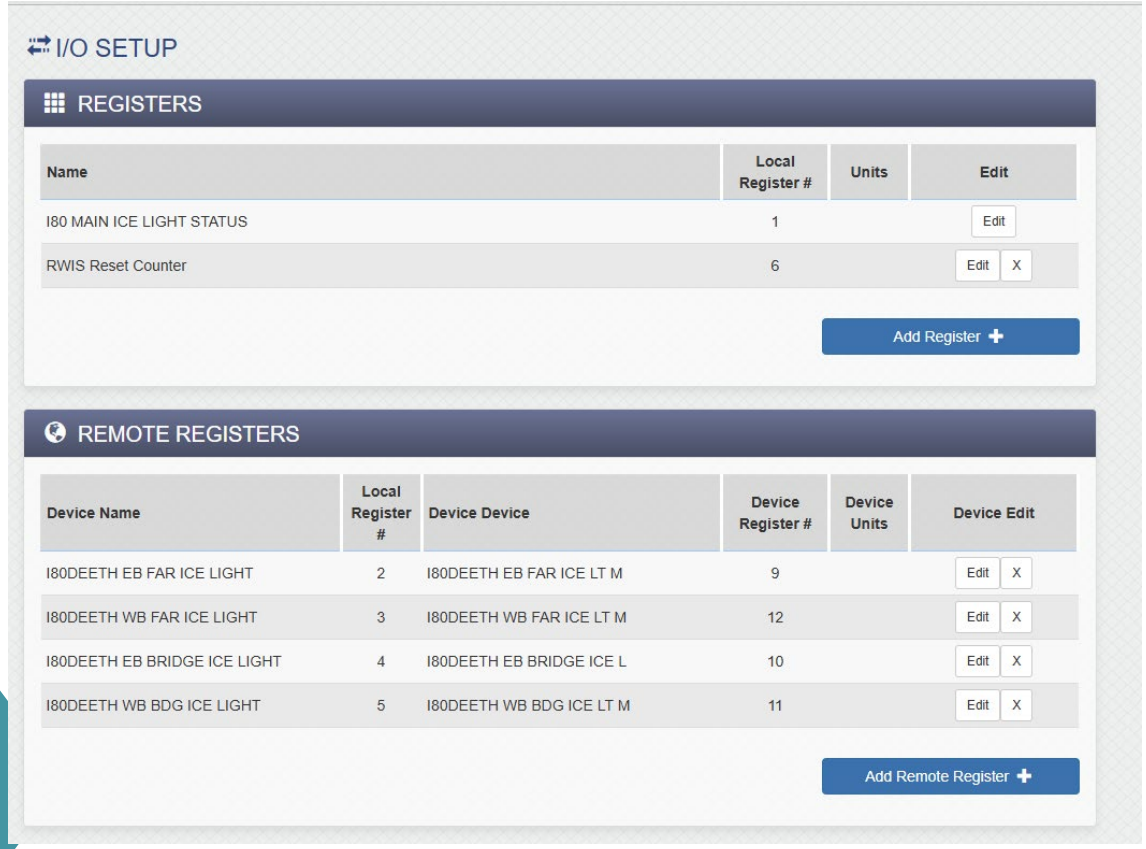
Carlin Tunnel Automated Ice Lights



X600 - Ice Light Control



Ice Light Control – 6 Inputs – 4 Relay activation



Programming registers require control flow coding to status check the temperature status on 6 sensors and a weather station

Goal:
If one of the 6 temperature sensors is below 32 degrees, make sure all 4 beacon sites activate

Cost - Benefit



Web Relay per-site base cost with installation

- **Thousands of hours per year saved in travel and employees' time**
- **Savings on Vehicle fuel and maintenance**
- **Proactive vs reactive – Single trips**
- **Remote battery telemetry – Save battery cost**
- **Remote resetting of end devices**
- **Network watchdog resetting**

X600 Web Server - $589.99 – No labor

X400 Chain control Sign - $3,400.00

X19 WEBBOSS - $2,400.00

X400 Railroad – $2,600.00

X400 Ice Light – $1,600.00

X400 Queue Warning – $2,300.00

District III Lane Miles

DISTRICT 3	
EL	717.154
EU	194.276
HU	343.521
LA	262.019
NY	77.734
PE	48.135
WP	411.177
Total	2054.016
DISTRICT I	1965.190
DISTRICT II	1416.334
DISTRICT III	2054.016
GRAND TOTAL	**5435.540**

PLUS 33 MOUNTAINTOP RADIO SITES

NDOT Annual Cost Savings

2013 - 27 Beacon Sites-

- **2013 - 8-12 Sites Visited each week**
- **2013 - 5000 miles driven per month**
- **Wear on NDOT fleet**
- **<u>Repeat repair trips</u>**

2026 - 57 Beacon Sites

- **2025 – 0-1 Sites visited each week**
- **2025 – 1600 Miles driven per month**

2005 - $82,000 cost in Time / Travel

2013 - $144,000 Cost in Time / Travel

2018 - $87,000 Cost in Time / Travel

2025 - $33,904 Cost in Time and Travel

50% more Web Relay sites since 2005

District III Sites Totals

- 58 Chain Signs
- 8 ICE Light Sites
- 6 Queue Warning Sites
- 4 Railroad Warning Lights
- 2 Road Closed Signs
- 2 NHP Check Station Sites
- 6 Fiber Hut Sites
- 25 Radio Sites

System Benefits

- Improved site security
- Easy to manage and deploy
- Availability and low cost of system components
- Long-term technical support
- Updated network security protocols
- Programmable scheduler and watchdog
- Automated I/O tasks
- Unlimited expandability
- Compatible with many sensor types
- Excellent customer support
- Vendor support for custom configurations

Technician Benefits

- Repairs can be completed proactively before failure
- 70% reduction in time and travel due to reduced field repairs
- Field devices can be modified, updated and rebooted remotely
- Real-time status of all I/O Systems
- Site history logs
- Solar tracking and power usage reports/graphs
- Backup and restore configurations

Traffic Operations Benefits

- Remote site activation/control
- Intuitive - easy to learn and use
- Traffic and system real-time information
- Beacon status confirmation
- Touch screen capable

NDOT reason to continue with Control By Web



1. The engineering department is quick to respond to support
2. The system is built out and would require a full reboot to change out
3. Easy to train employees
4. Cost for equipment is still low
5. Sensors are readily available
6. Reliable – only two X410 and two X400 failures over 10 years
7. 5 year warranty included

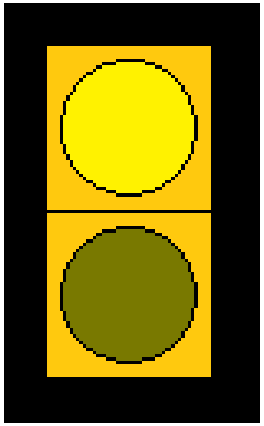
NEVADA DOT

Summary of Issues on Using this System

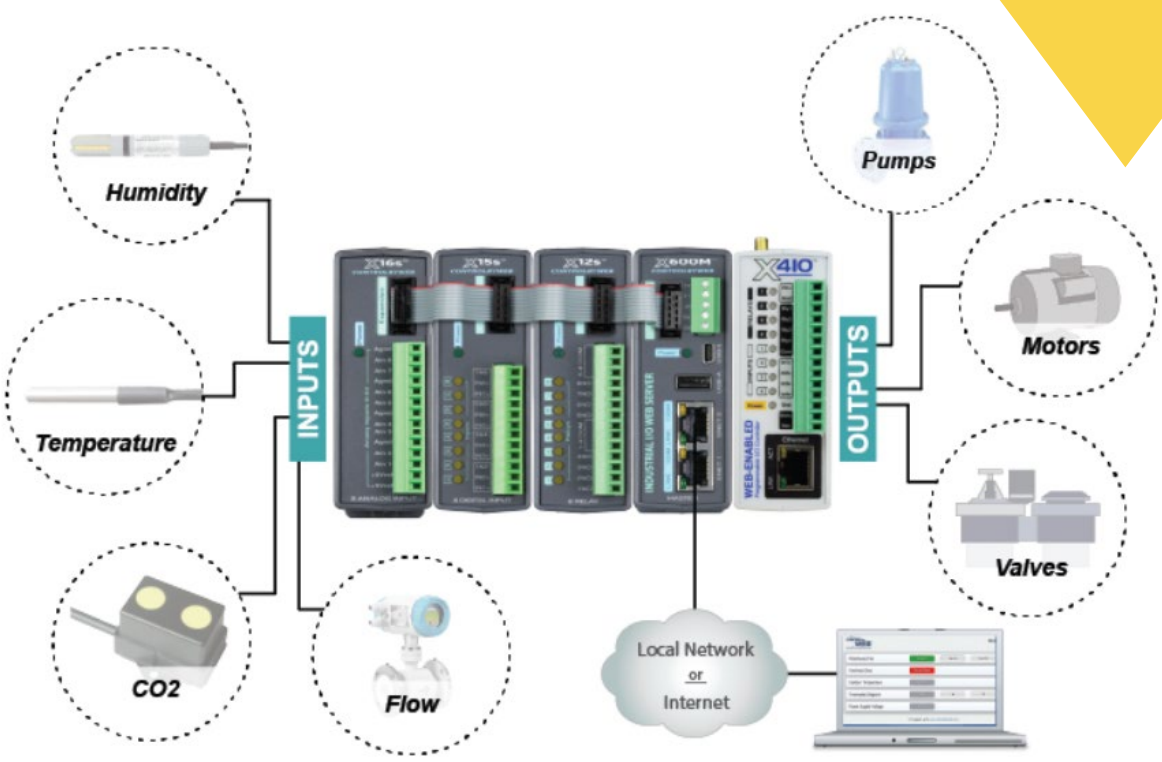
- MQTT – Port 443 security communication to the server – this needs to be implemented for improved security
- Advanced password control – fixed username, cannot be changed
- Some firmware releases may induce an improper relay state condition – currently, no issues
- Contractors do not want to spend the time wiring the system components – need to train or create a user manual
- Multiple inputs and multiple sites - same relay state issue - programming round robin – scripting involved
- Recent firmware on the X400 has reset to factory with unexpected high voltage
- Users want to stay with the web page control. Some users want to integrate with Freeway Software
- Each field device with must updated individually
- Server backups are manual

Phoenix MCR current sensor

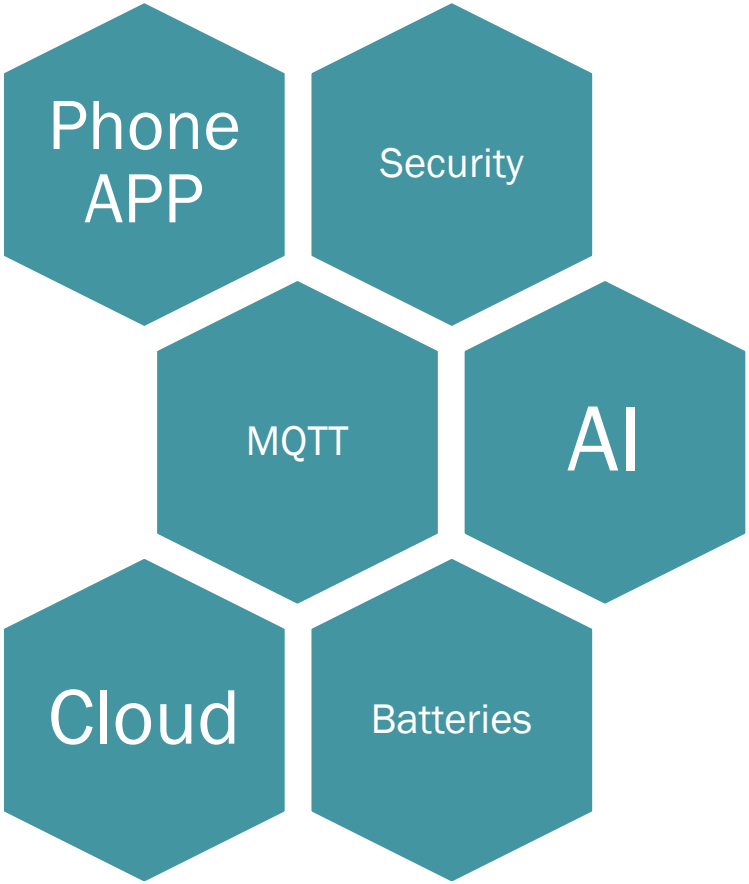
LIVE DEMO



Web Relay System Live Demo



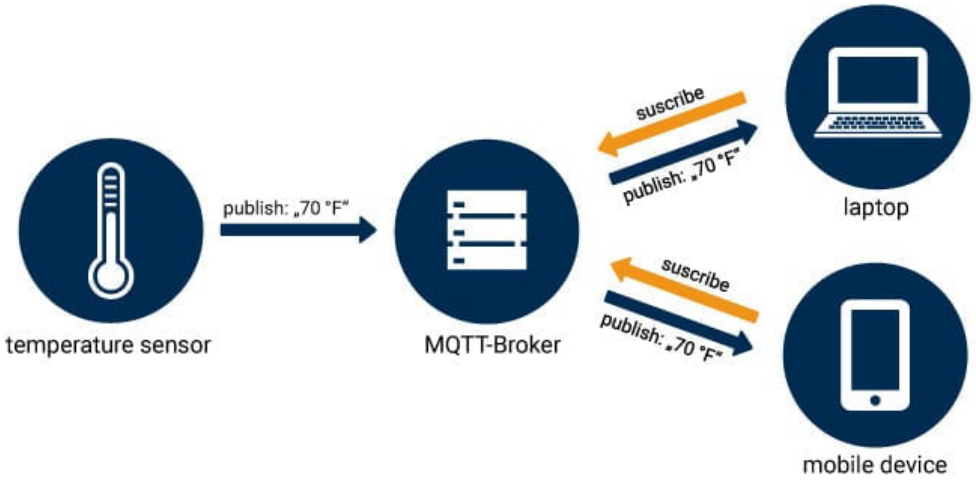
Future Features and Improvements



Control By Web Servers Protocols

- **MIB – NTCIP**
- **Modbus**
- **Remote server**
- **XML**

NDOT is Investigating the MQTT Protocol



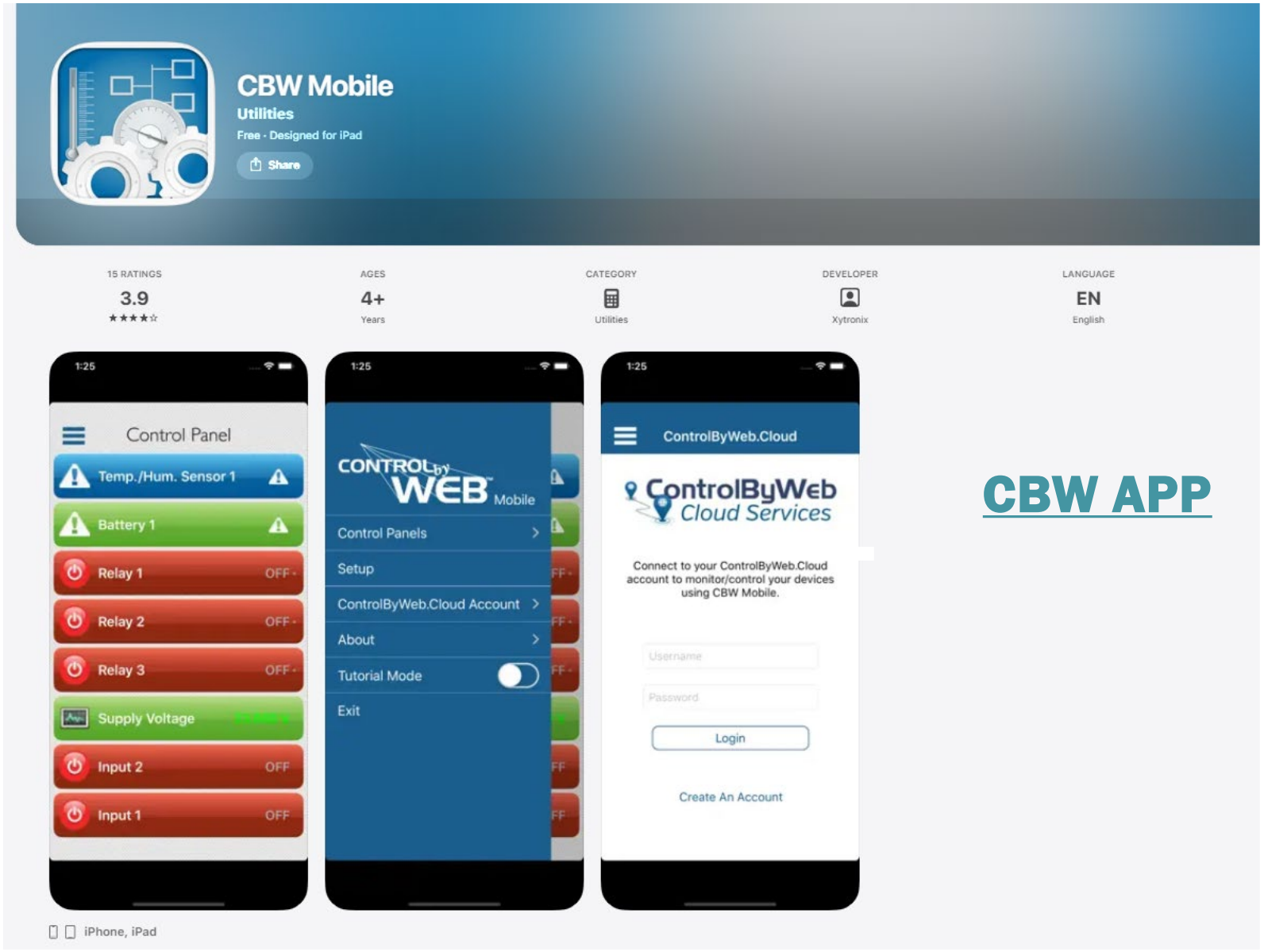
X400 SIM card remote standalone control option

NDOT will continue a wired ITS network for security.

NDOT has not used these options -

- **Failover Ethernet network through cell service – (option)**
- **Cloud Service (option)**
- **Phone control (option)**




CBW Mobile
Utilities
Free · Designed for iPad
Share
15 RATINGS
3.9
★★★★☆
AGES
4+
Years
CATEGORY
Utilities
DEVELOPER
Xytronix
LANGUAGE
EN
English
1:25
Control Panel
Temp./Hum. Sensor 1
Battery 1
Relay 1 OFF
Relay 2 OFF
Relay 3 OFF
Supply Voltage
Input 2 OFF
Input 1 OFF
CONTROL by WEB Mobile
Control Panels
Setup
ControlByWeb.Cloud Account
About
Tutorial Mode
Exit
ControlByWeb.Cloud
ControlByWeb Cloud Services
Connect to your ControlByWeb.Cloud account to monitor/control your devices using CBW Mobile.
Username
Password
Login
Create An Account
iPhone, iPad

CBW APP

Thank you

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