



Interlocks Safety Systems DAQ in Controls

Beau Harrison

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Purpose

Transfer of ESH&Q Interlocks' Safety DAQ System to AD Controls as well as a redesign of the system.

Interlocks will assist with providing documentation, guidance, project management support, and final approval.

Interlocked personnel safety systems:

- Radiation
- Electrical
- Laser
- Oxygen deficiency
 - FIRUS and ACNET

Project Milestones

DAQ System Project Milestones

Review: Project Engineering Requirements

Existing Safety System DAQ System review and documentation

Technology solution evaluation and selection

Review: Solution proposal document

Redesign of the new Safety System DAQ System

Review: New Safety System DAQ design review

Beta testing validation

Review: Acceptance report

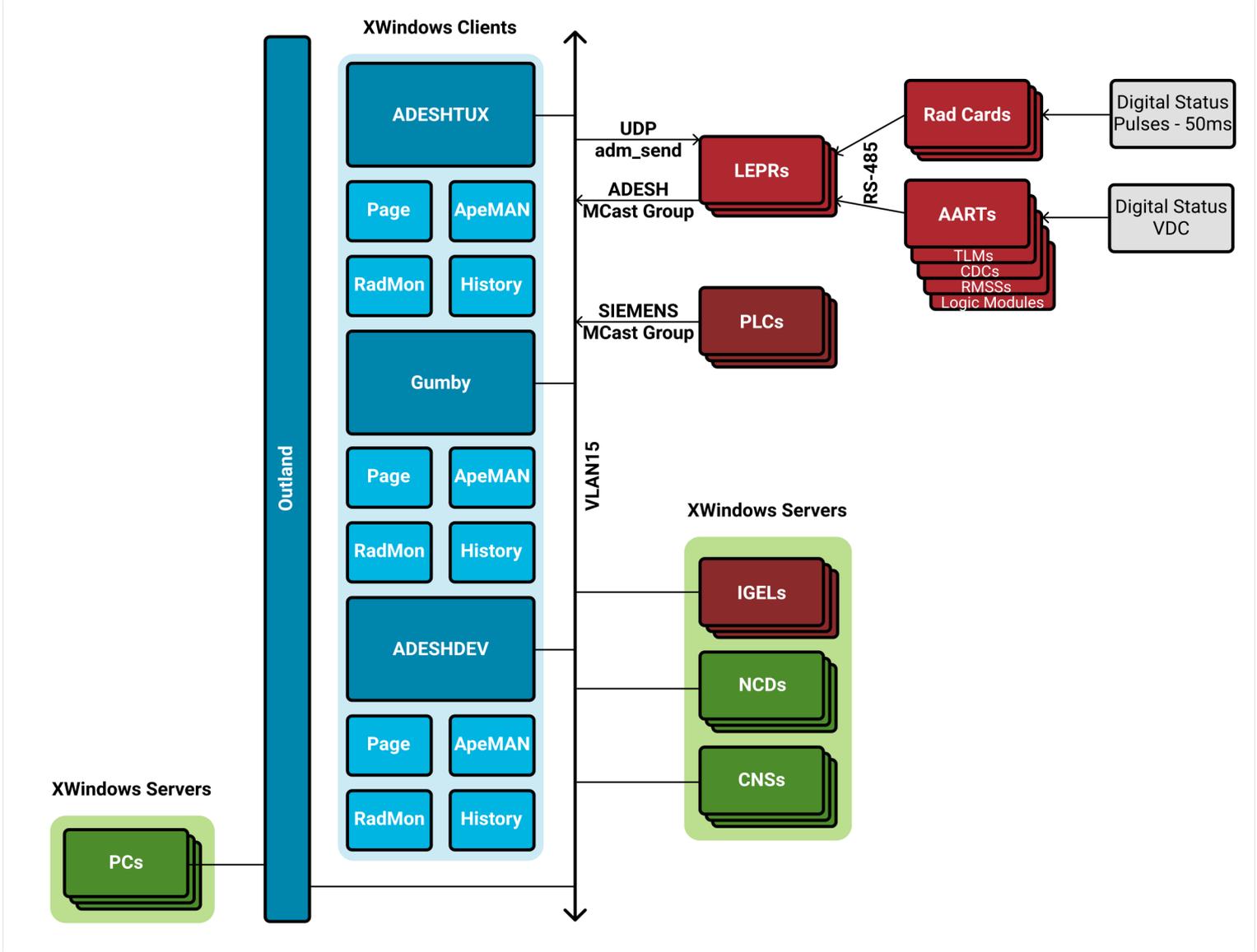
New Safety System DAQ System Commissioned

* This is a draft

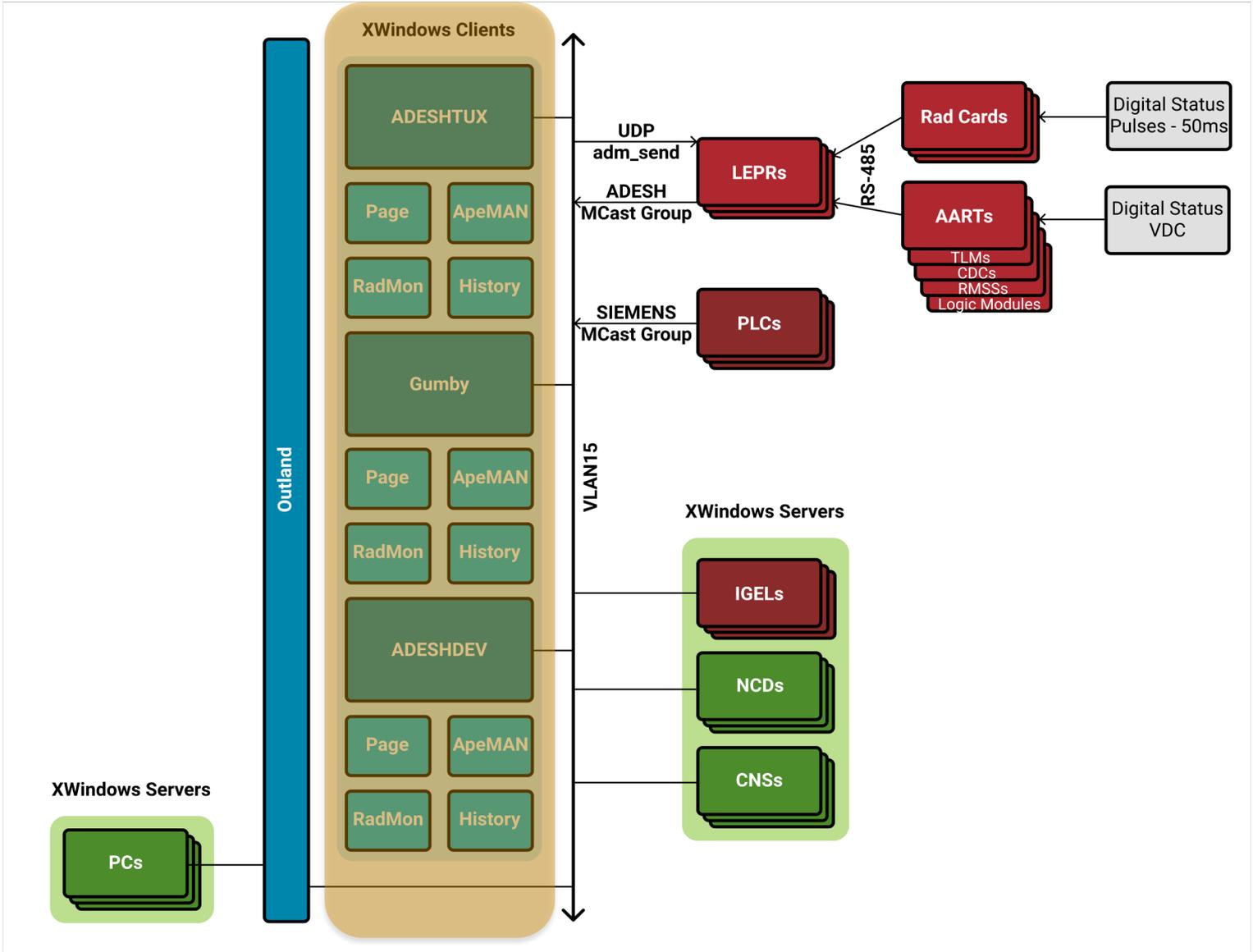
Definitions

- LEPR
 - Linux-based Ethernet Port Repeater
- AART
 - Addressable Asynchronous Receiver Transmitter
- DAQ
 - Data AcQuisition
- CDC
 - Critical Device Controller
- ESS
 - Electrical Safety System

Safety System Overview



Safety System Overview



Servers

Three SLF6 servers:

- ADESHTUX
 - Production
 - Rack mount in computer room
- Gumby
 - Backup
 - Rack mount in computer room
- ADESHDEV
 - Development and maintenance
 - Desktop in Interlocks office

For the most part, these are identical.

Servers - Functions

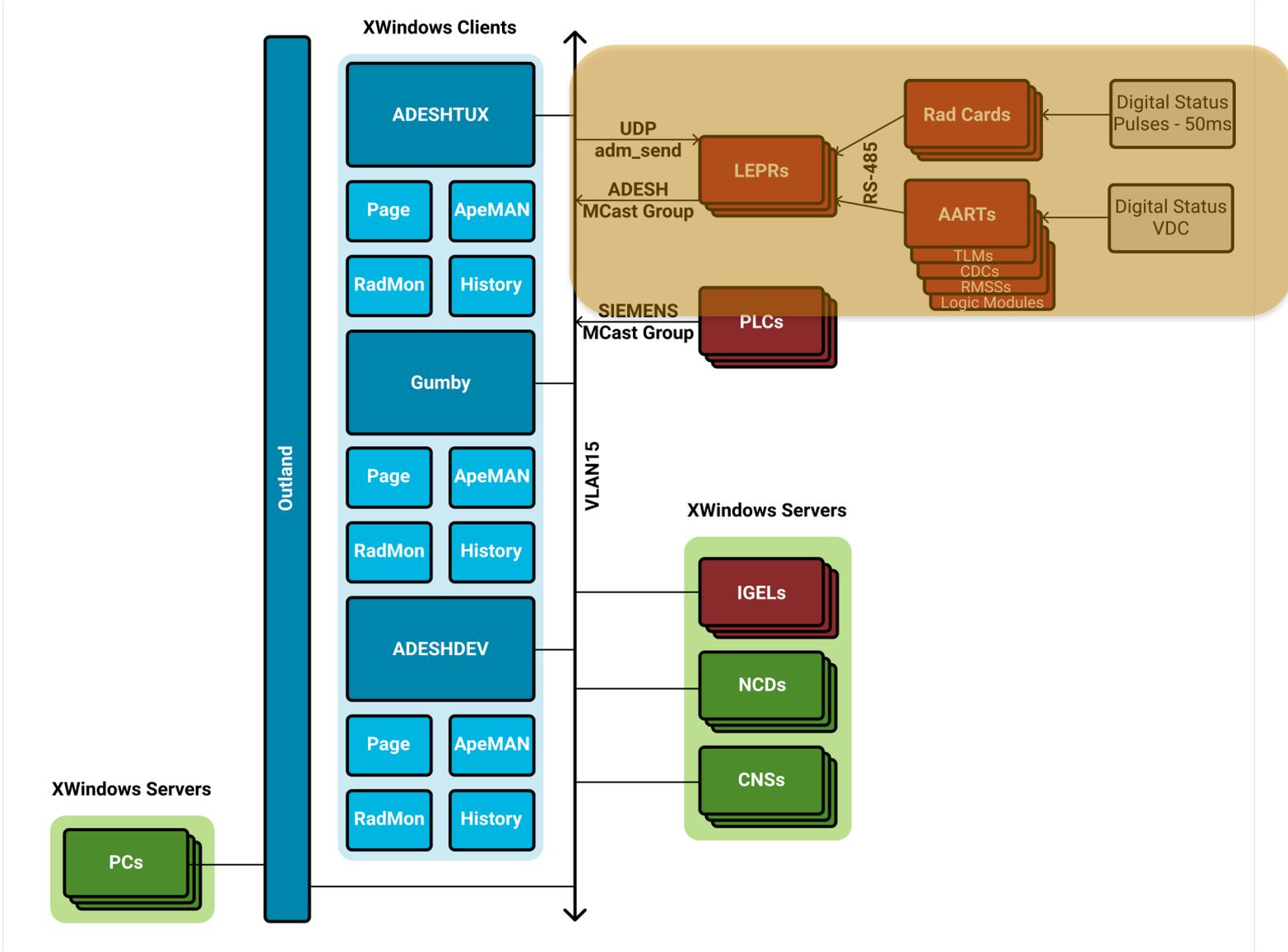
Functions:

- Host client applications, including announcements
- Multicast receiver
- Data-pooling
- “Databases”
- Diagnostics

Unique to ADESHDEV:

- Scripts for moving data between servers and LEPRs

Safety System Overview



LEPRs

Linux system on a board

- 18 deployed in the field
- One for testing AARTS in the Interlocks office
- Two test nodes in the Interlocks office

Functions:

- Convert serial to ethernet
- Data-pooling
- Multicast transmission
- Handle remote commands
- Diagnostics

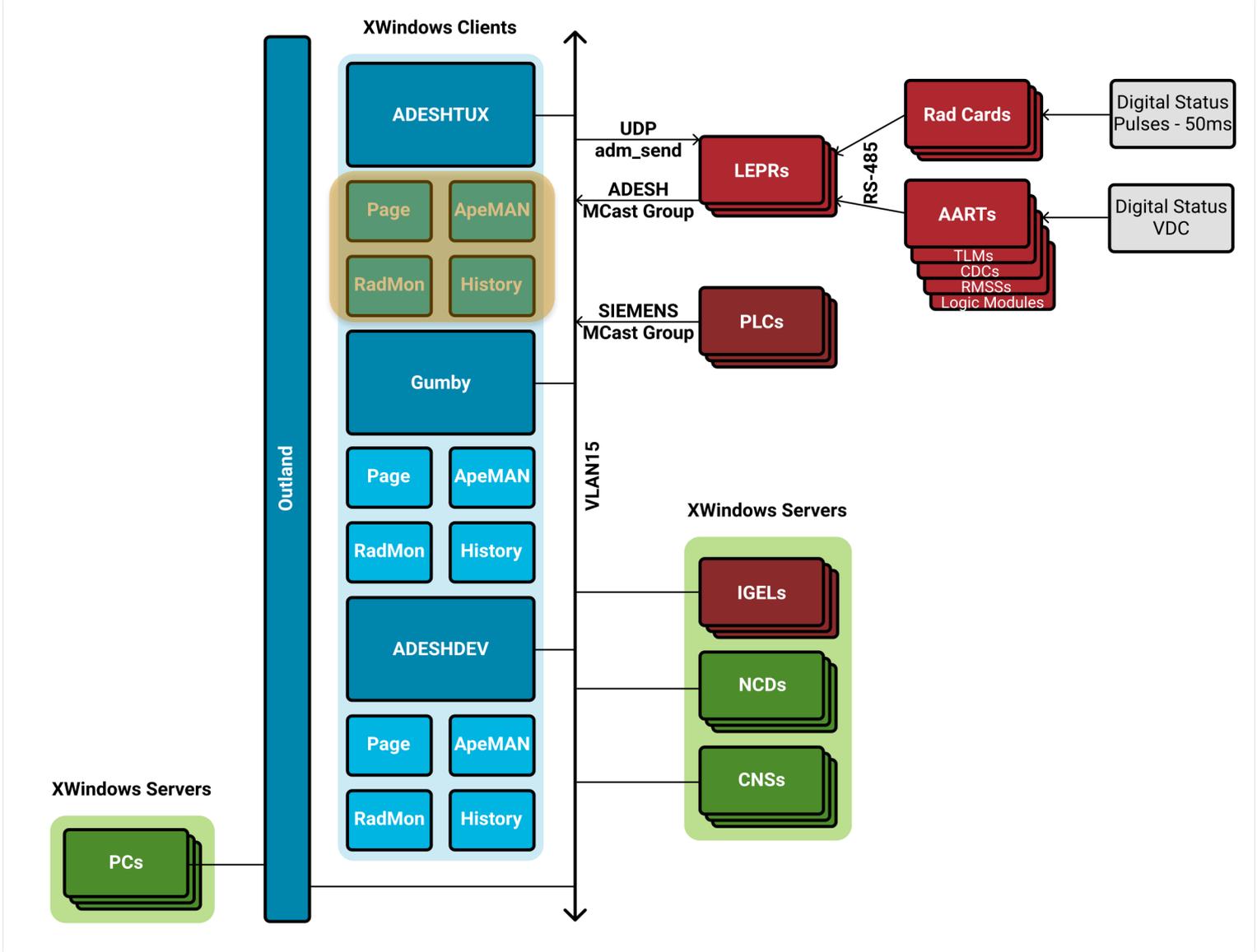
LEPRs Pictures - Front



LEPRs Pictures - Internals



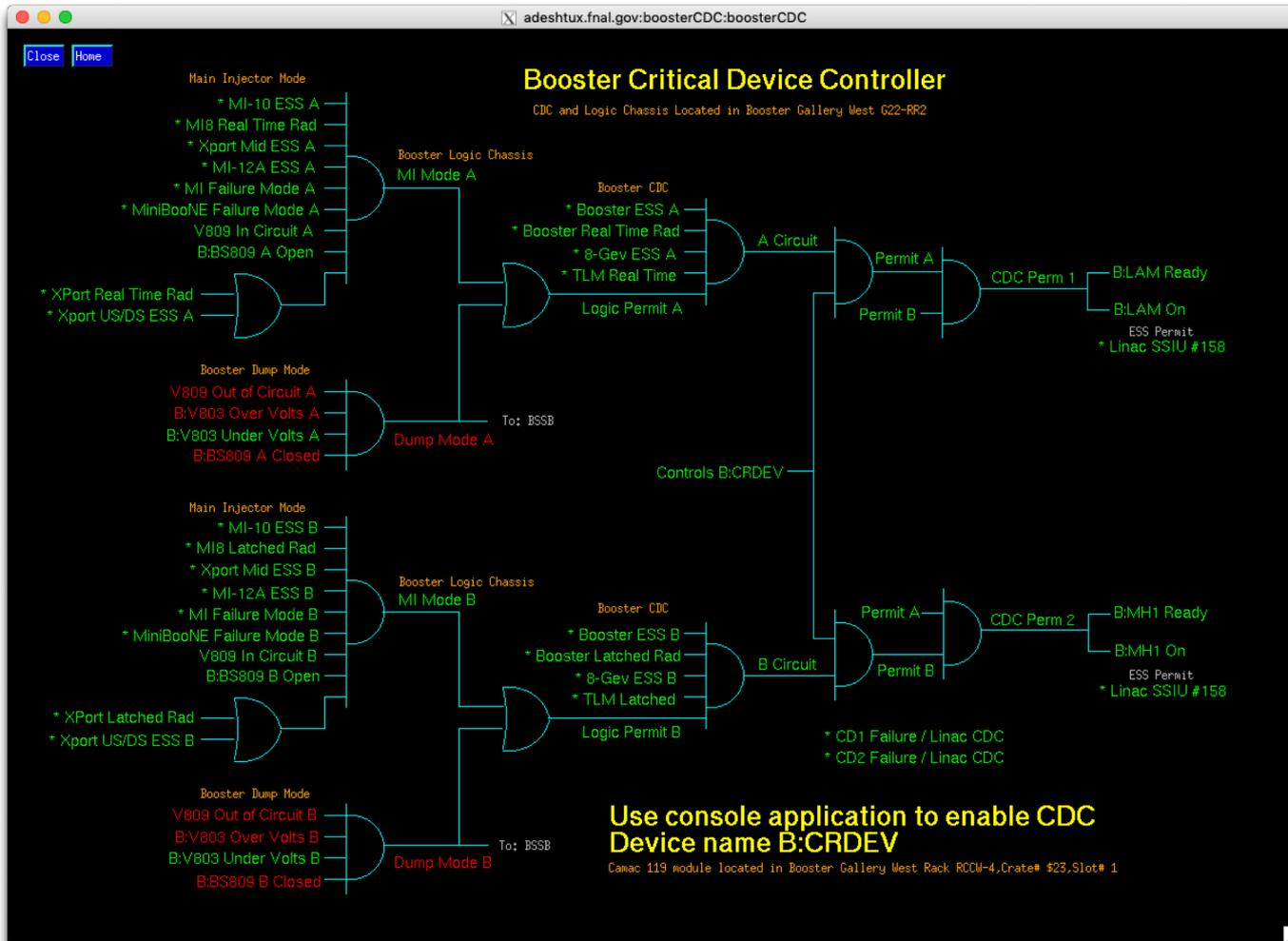
Safety System Overview



The screenshot shows a web browser window with the address bar displaying "page v17.6.29:adeshtux.fnal.gov:localhost:0". The main content is a grid of interlock page categories and their sub-items, organized into columns. The categories are: Linac, Main Injector, Tevatron, Meson, M-Center, Muon Campus, MuCool, Booster, Mini BooNE, Numi, Outlying Areas Diagnostics, and M-Test. Each category lists specific interlock pages such as Doors, Keys, ESS, CDC, Rad, and various beam lines or sectors.

Linac	Main Injector	Tevatron	Meson	M-Center	Muon Campus
Doors	MI-8 Line	F-Sector	CDC	CDC	M1 CDC
Keys	Doors	Doors	F-Line	MC6	Pre-Target
ESS	Keys	Keys	Doors	Doors	Doors
CDC	ESS	ESS	Keys	Keys	Keys
Rad	MI-10 / MI-20-62	Transfer Hall	ESS	ESS	ESS
Laser	ESS	Doors	M01	MC7/MB7	Pre-Vault
NTF	Crash Loop	Keys	Doors	Doors	Doors
CDC	CDC	ESS	Keys	Keys	Keys
	Coasting Beam	A150/P150	ESS	ESS	M4A
MuCool	MI-10	Doors	M02	Neutrino	Vault
Doors	Doors	Keys	Doors	CDC	Keys
Keys	Keys	ESS	Keys	Rad	ESS
ESS	ESS	P150 CDC	ESS	G-Line	Transport MID
CDC	MI-20/62	Rad F-Sec	M03	Doors	Doors
Rad	Doors	Enc. B	Doors	Keys	Keys
Permits	Keys	Doors	Keys	ESS	ESS
201 MHz	ESS	Keys	ESS	N01	Rad
805 MHz	Rad	ESS	M04	Doors	Transport US-DS
Booster	MI-31 Stub	Switchyard	Doors	Keys	Doors
Doors	Doors	Doors	Keys	ESS	Keys
Keys	Keys	Keys	ESS	NM2	ESS
ESS	ESS	ESS	M05	Doors	Transport
CDC	Recycler	CDC	Doors	Keys	ESS
Rad	Coasting Beam		Keys	ESS	Delivery Ring
TLM			ESS	NM3	Doors
Mini BooNE	Numi	Outlying Areas Diagnostics	M-Test	Doors	Keys
CDC	CDC	Index	CDC	Keys	ESS
Rad	Rad	Aart Diag	Rad	ESS	Rad Monitors
MI-12A Line	MI-65	UPS Status	MT6 Sec 1	NM4	CDC
Doors	Doors	Audio System	Doors	Doors	Coasting Beam
Keys	Keys	Testing	Keys	Keys	Extraction
ESS	ESS	WebRelays	ESS	ESS	Doors
MI-12B Line	Minos	Proto Pages	MT6 Sec 2		Keys
Doors	Doors		Doors		ESS
Keys	Keys		Keys		CDC
ESS	ESS		ESS		

Index of interlock pages

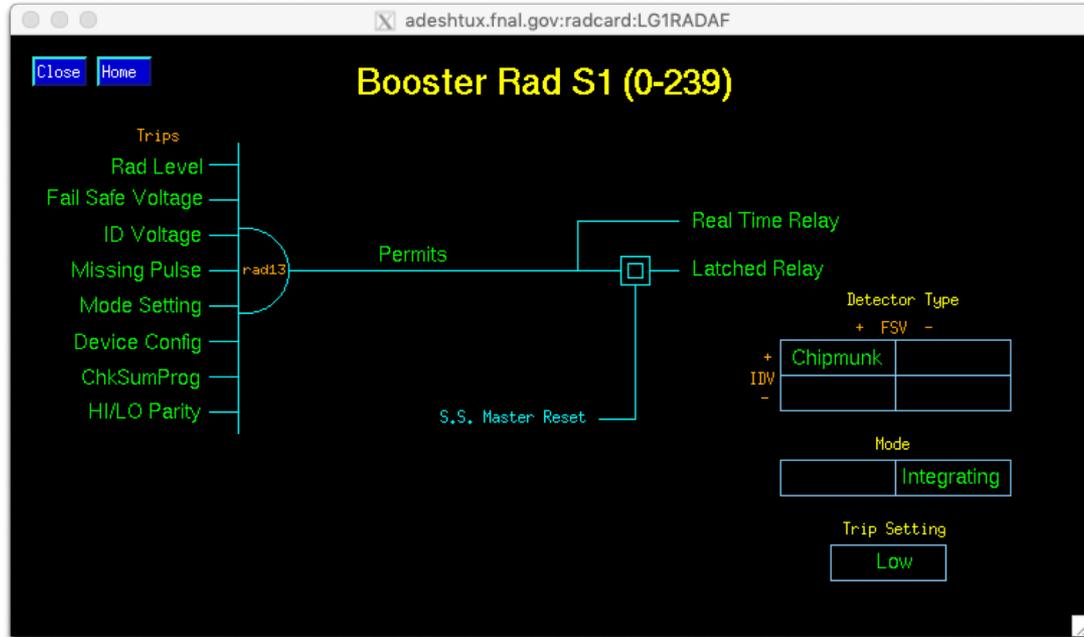


Logic tree from an array of inputs for enabling and disabling beam to enclosures.

Page – CDC Chassis



Page - RadCard

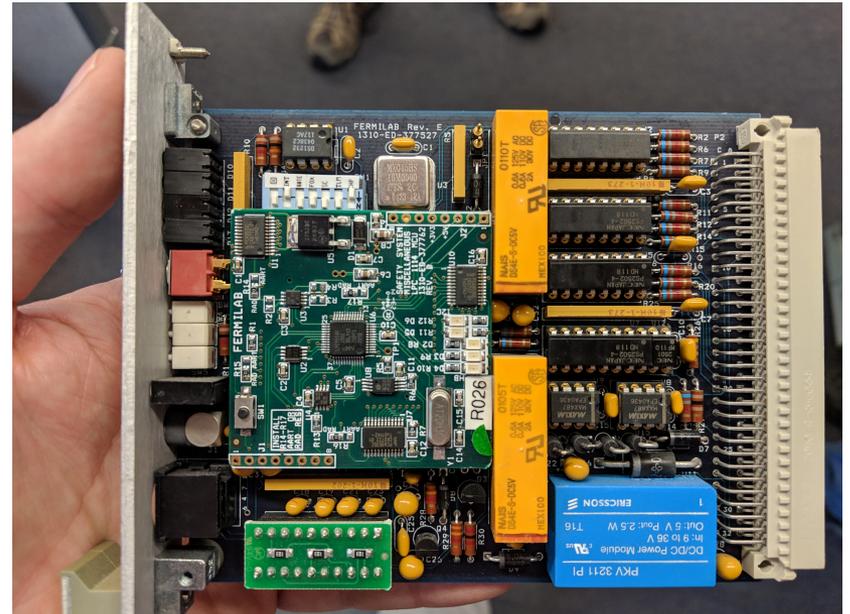


Logic tree from an array of inputs for toggling the central relays in the vault.

Page - RadCard



Page - RadCard



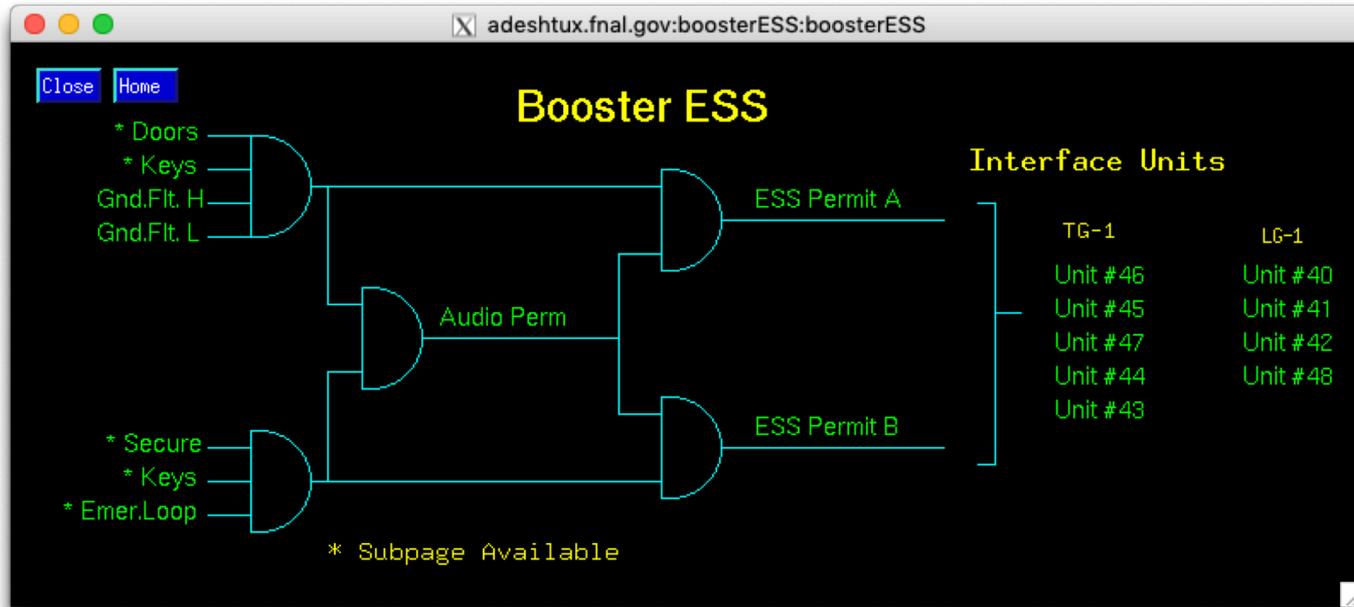
RadMon

The screenshot displays the RadMon v17.12.18 interface. The main window shows a table of radiation monitors with columns for Linac, BooTLM, MI-1040, MI-8, Delivery, Extraction, M-BooNE, MuCool, M-TestA, and M-TestB. Each monitor entry includes a B-Ch, Ty, Cnts, mR(nC), and Location. The table lists numerous monitors across various areas like HT3 Cryo Lab, Booster, and various extraction and test areas.

Below the table is a control panel with buttons for 'Prev', 'Next', and 'Reset'. The status bar shows '12/03/18 14:33:38 RD/ESH radmon@adeshtux.fnal.gov:localhost:0 - Online.' Below this is a detailed status window for monitor 'rad13' showing 'Current Radiation' (mRnT 0.6, LnCts: 4, TotCts: 3), 'Miss Fls', 'R/I Mode', 'Device', 'ChkSumPrng', and 'Hi/Lo AlB'. A flow diagram shows 'RadLoops' leading to 'Realtime Relay' and 'Latched Relay', which then connect to 'Realtime Loop' and 'Latched Loop' respectively.

A comprehensive list of radiation monitors deployed in the field.

Page - ESS



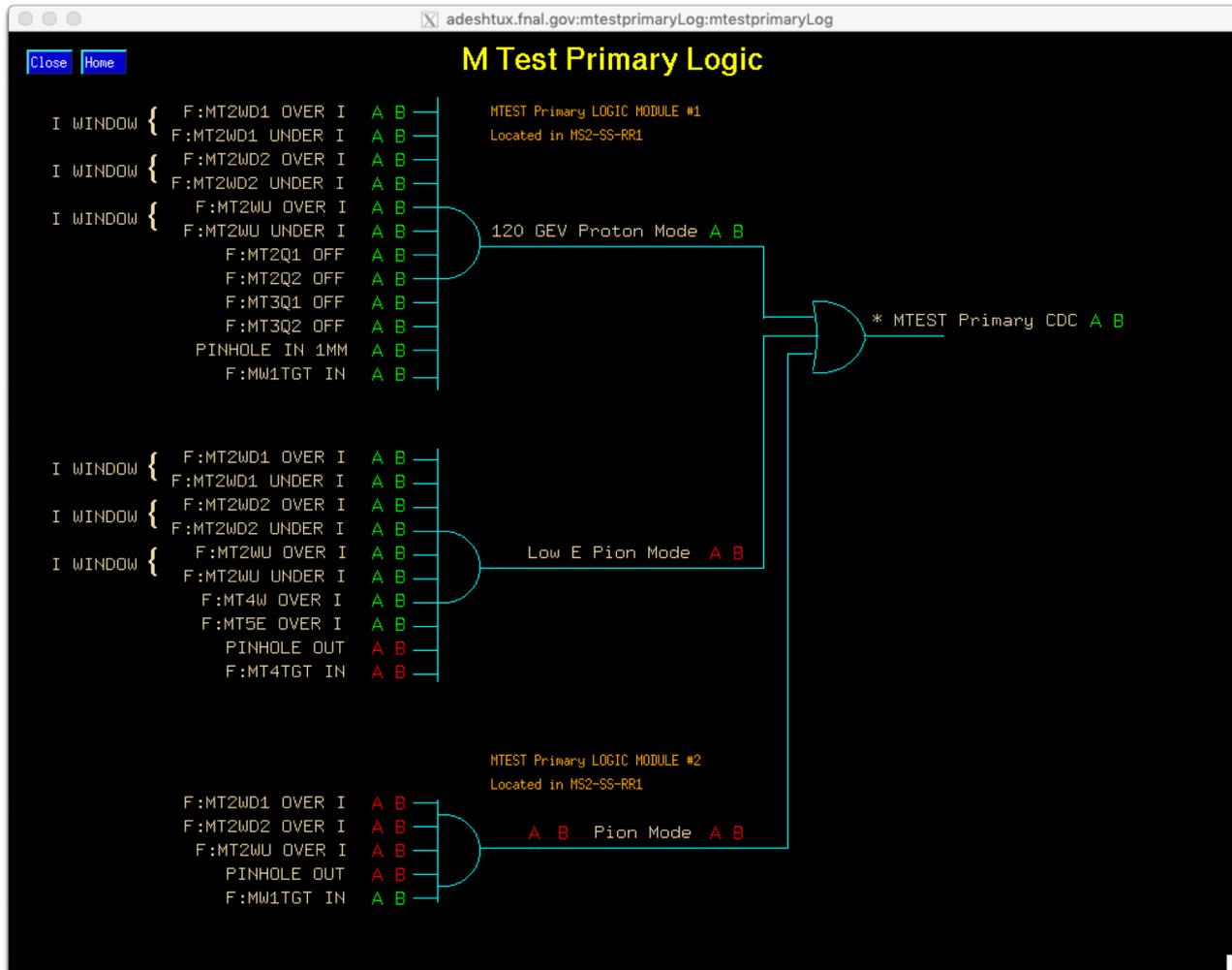
Logic tree from an array of inputs for enabling and disabling certain powered elements to enclosures.

Page - Keys



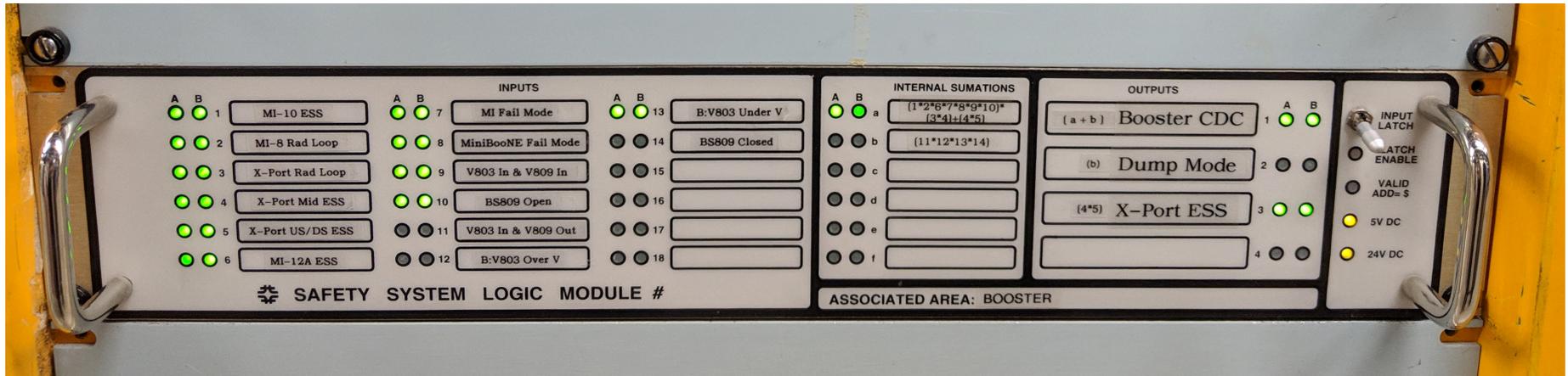
Keys from the MCR are summed into one bit in the ESS logic that is a part of the CDC logic.

Page - Logic

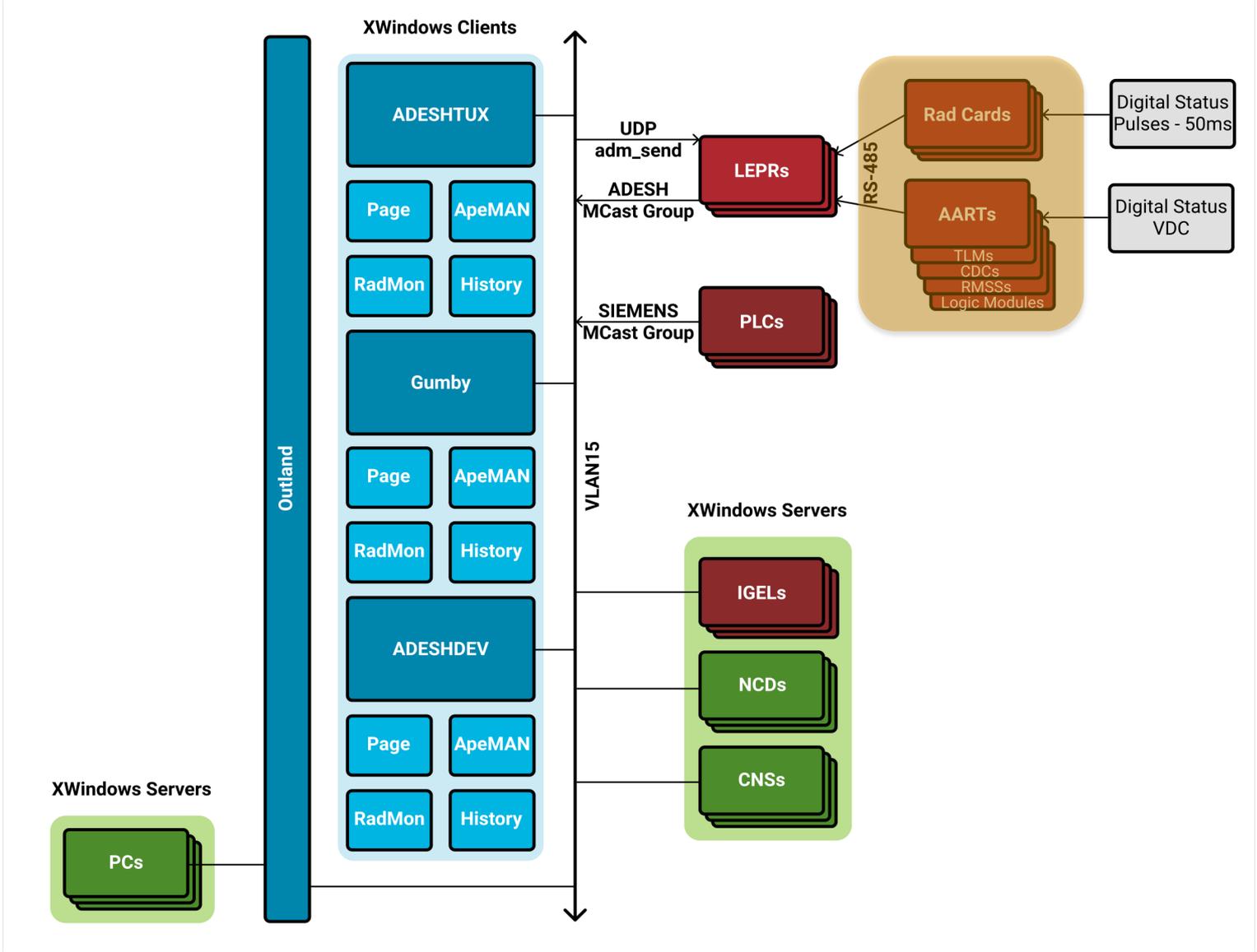


Logic tree of EPLD as an input into the CDC.

Page – Logic Chassis



Safety System Overview

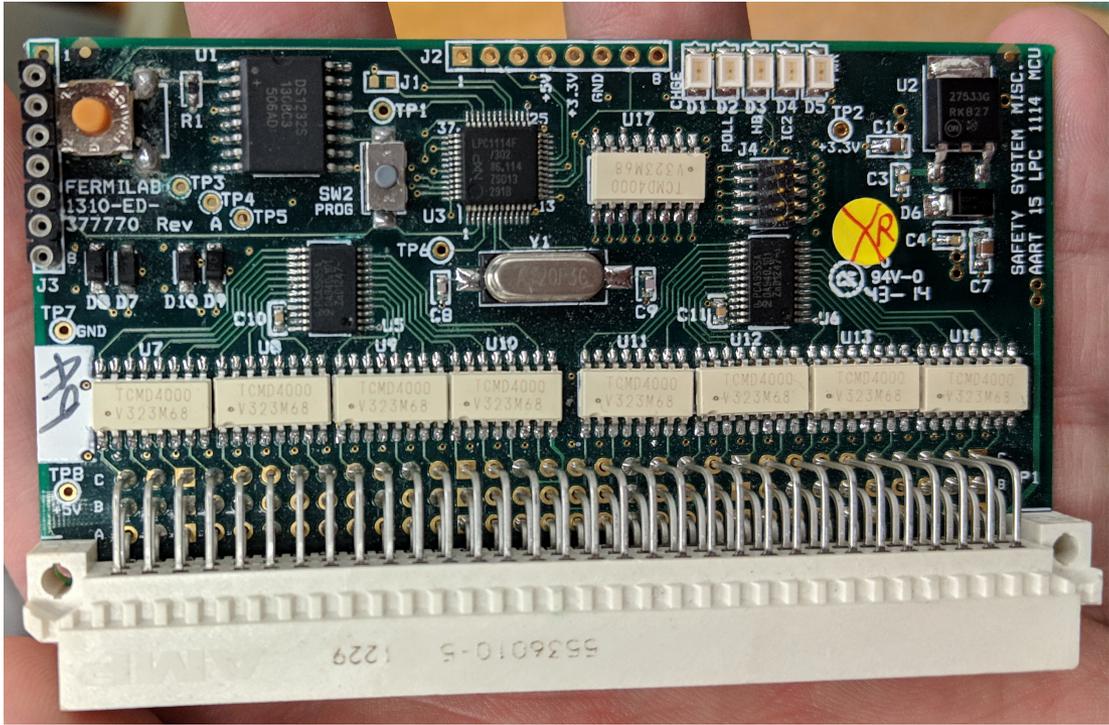


Page – AART Diagnostics

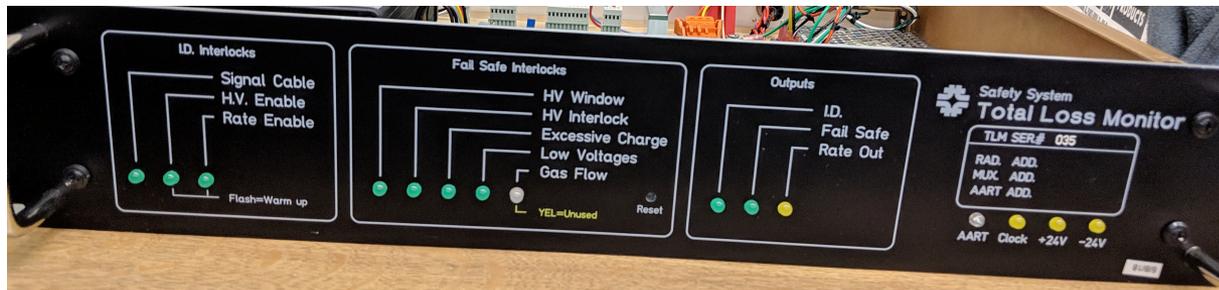
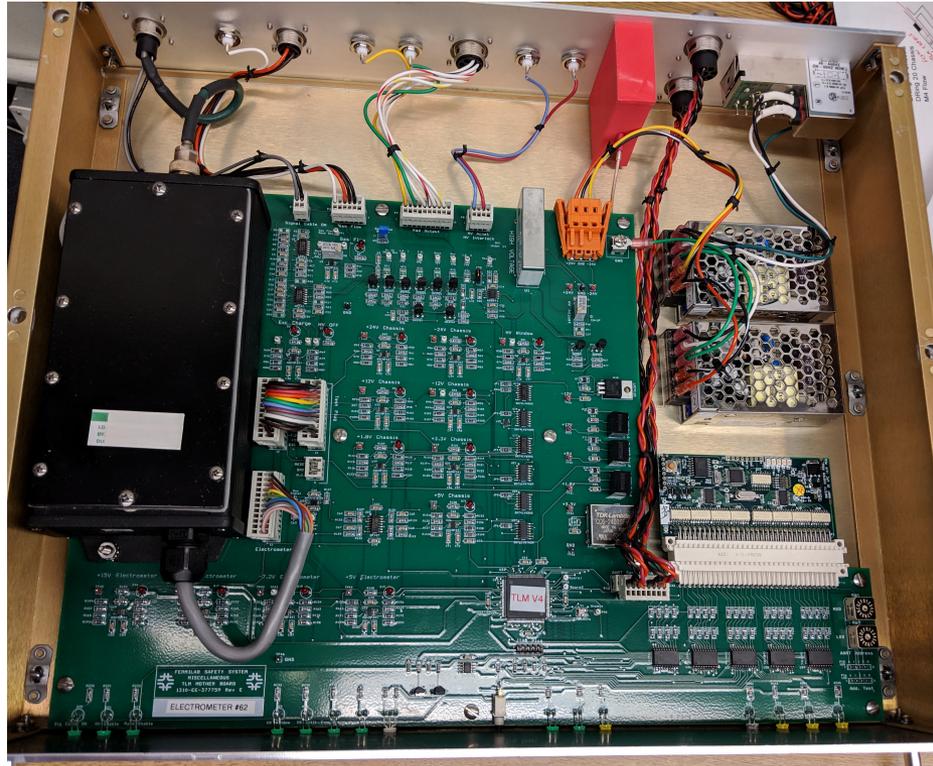
The screenshot displays the 'AART Diagnostics' application window. The title bar shows the URL 'adeshtux.fnal.gov:aartdiag:aartdiag'. The interface is organized into a grid of diagnostic panels, each representing a different system or component. Each panel has a title, a status indicator (e.g., '2', '14', '4'), and a list of diagnostic points with their current status (e.g., 'OK', 'Terminator').

- Vlt/Keys** (2): Lists components like ML0090, AUDIO_01, AUDIO_02, etc.
- Linac** (14): Lists components like R000B_21, R000B_22, R000B_23, etc.
- Booster** (4): Lists components like L019_31, L01RAD00, L01RAD01, etc.
- Booster** (20): Lists components like L019_41, L01RAD00, L01RAD01, etc.
- Main Inj** (9): Lists components like M001B00, M001B01, M001B02, etc.
- Main Inj** (12): Lists components like M002A00, M002A01, M002A02, etc.
- Main Inj** (36): Lists components like M002D00, M002D01, M002D02, etc.
- P-Bar** (6): Lists components like P001B00, P001B01, P001B02, etc.
- P-Bar** (8): Lists components like P001B03, P001B04, P001B05, etc.
- IARC** (15): Lists components like IARC0001, IARC0002, IARC0003, etc.
- F0-A1** (18): Lists components like F0_A1_01, F0_A1_02, F0_A1_03, etc.
- Meson** (34): Lists components like M001B00, M001B01, M001B02, etc.
- Meson** (22): Lists components like M002A00, M002A01, M002A02, etc.
- Neutrino** (32): Lists components like N001B00, N001B01, N001B02, etc.
- NNL** (30): Lists components like NNL_A001, NNL_A002, NNL_A003, etc.
- XGC-103** (24): Lists components like XGC103_01, XGC103_02, XGC103_03, etc.
- PLC's**: Lists components like PLC001, PLC002, PLC003, etc.
- AO/SHY** (26): Lists components like AO_SHY_01, AO_SHY_02, AO_SHY_03, etc.
- Spare** (1): Lists components like Spare001.
- IB1** (28): Lists components like IB1_001, IB1_002, IB1_003, etc.
- Test** (48): Lists components like Test001, Test002, Test003, etc.
- Test** (50): Lists components like Test004, Test005, Test006, etc.

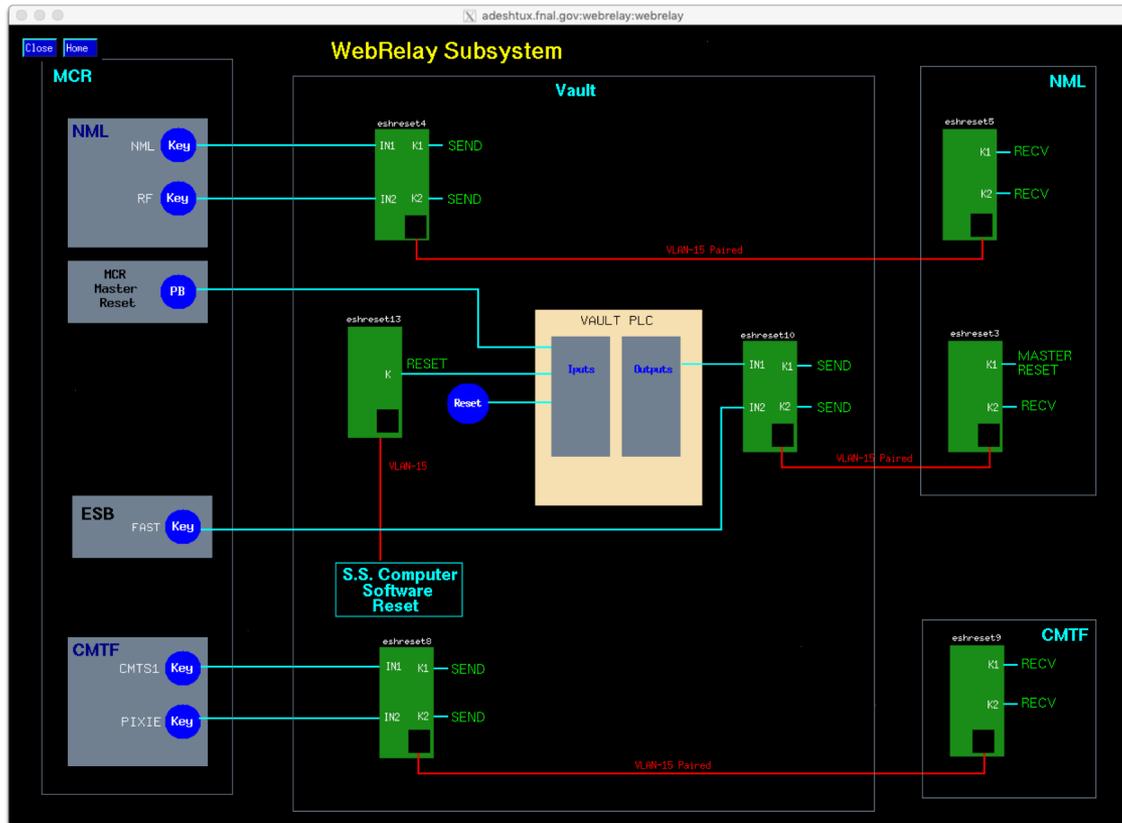
A comprehensive list of LEPRs and AARTs deployed in the field.



Page – AART in TLM

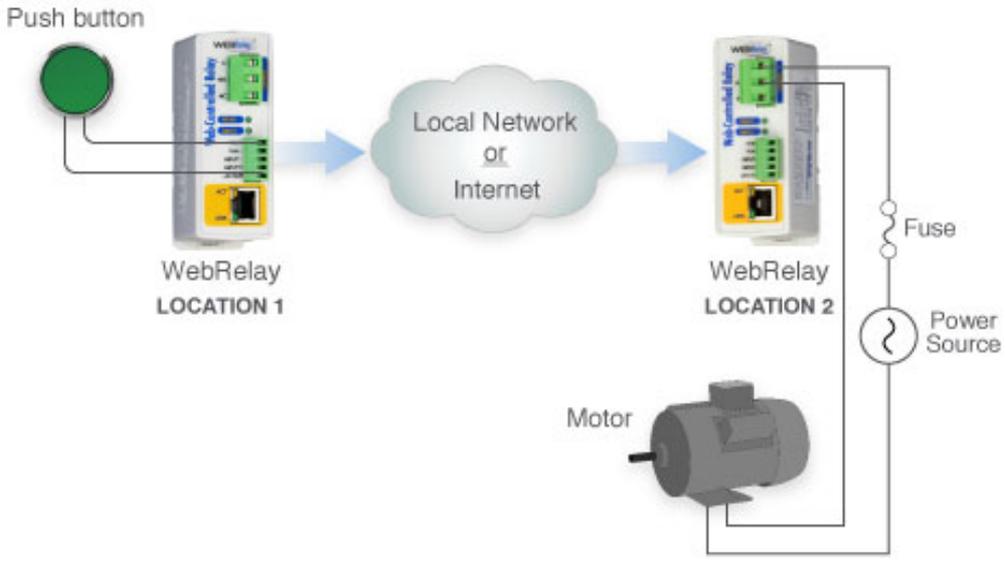


Page – WebRelay



WebRelays simplify sending signals to outlying areas.

Page – WebRelay



Page – Audio



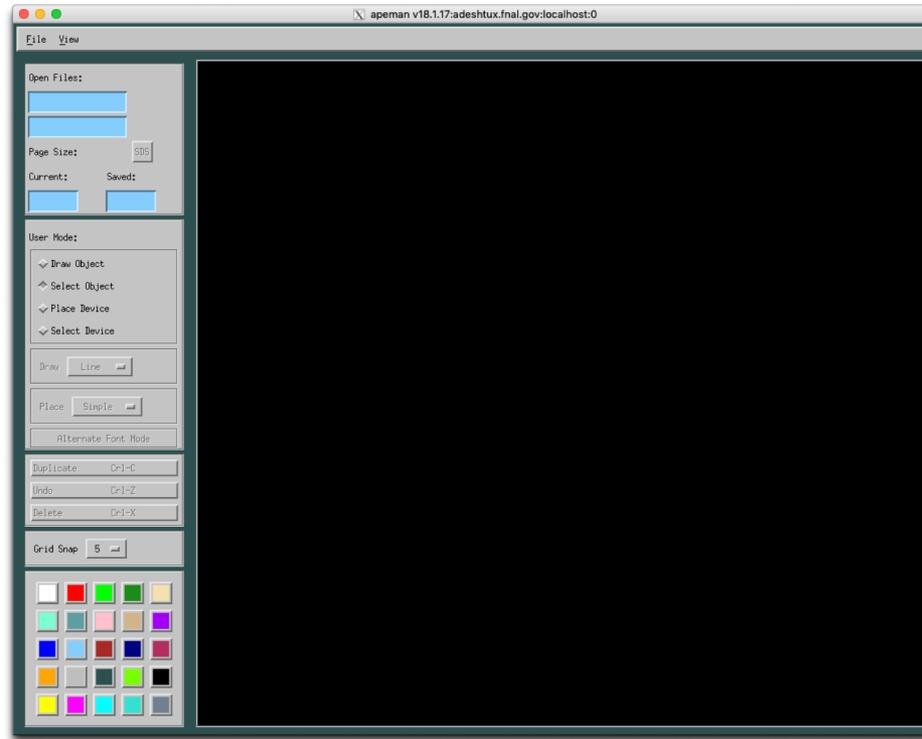
The screenshot shows a web browser window with the URL `adeshtux.fnal.gov:audio:audio`. The interface is divided into two main sections: **Caress Vault** and **Outlying Areas**. Each section contains a table with columns for **Audio Request**, **ESS**, and **Audio Permit**, and a list of **Speaker(s) Selected**.

Caress Vault			Speaker(s) Selected
Audio Request	ESS	Audio Permit	
Linac		Linac	Linac
Booster		Booster	Booster
8 Gev		8 Gev	8 Gev
MI 20-62		MI 20-62	MI 20-62
F-Sector		TeV F-Sector	F-Sector
TH-Sector		TeV TH-Sector	TH-Sector
B0/CDF		B0/CDF	TeV A-E
			B0 CDF
			Exp-1
Transport Mid.		Transport Mid	Transport Mid.
Pre-Target		Pre-Target	Pre-Target
Pre-Vault		Pre-Vault	Pre-Vault
Transport US/DS		Transport US/DS	Transport US/DS
Delivery Ring		Delivery Ring	Delivery Ring
Enclosure B		Enclosure B	Enclosure B
Enc. C,D,E		Enc. C,D,E	Enc. C,D,E
F-Manholes		F-Manholes	F-Manholes
			Exp-2
G2 Manhole		G2 Manhole	G-Manhole
			Muon Extraction
MC1		MC1	MC1
MI-10		MI-10	MI-10
MI-12A		MI-12A	MI-12A
MI-12B		MI-12B	MI-12B
MI-65		MI-65	MI-65
MINOS		MINOS	MINOS Hall
A150/P150		A150/P150	

Outlying Areas		
Audio Request	ESS	Audio Permit
MI-31 Stub		MI-31 Stub
Pelletron		Pelletron
M01		M01
M02		M02
M03		M03
M04		M04
M05		M05
MC6		MC6
MC7/MB7		MC7/MB7
MT6 Sec 1		MT6 Sec 1
MT6 Sec 2		MT6 Sec 2
NML		NML
ILC-HTC		ILC-HTC
HINS-CTC		HINS-CTC

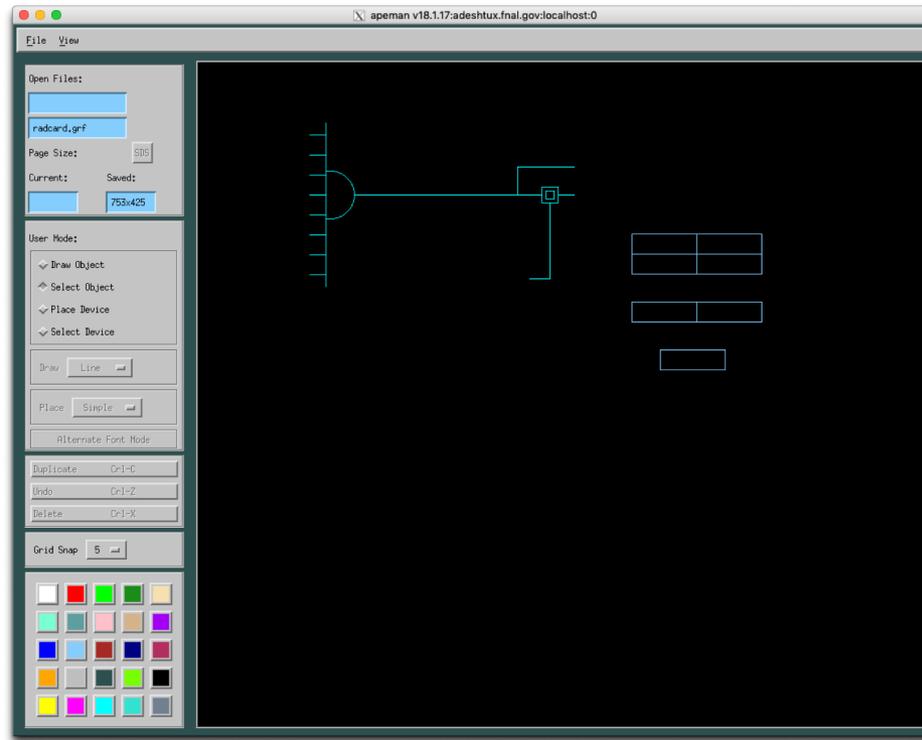
There is an audio system that allows the Safety System to communication with different areas. This is the audible whoop you here when an enclosure is secured.

APEMan



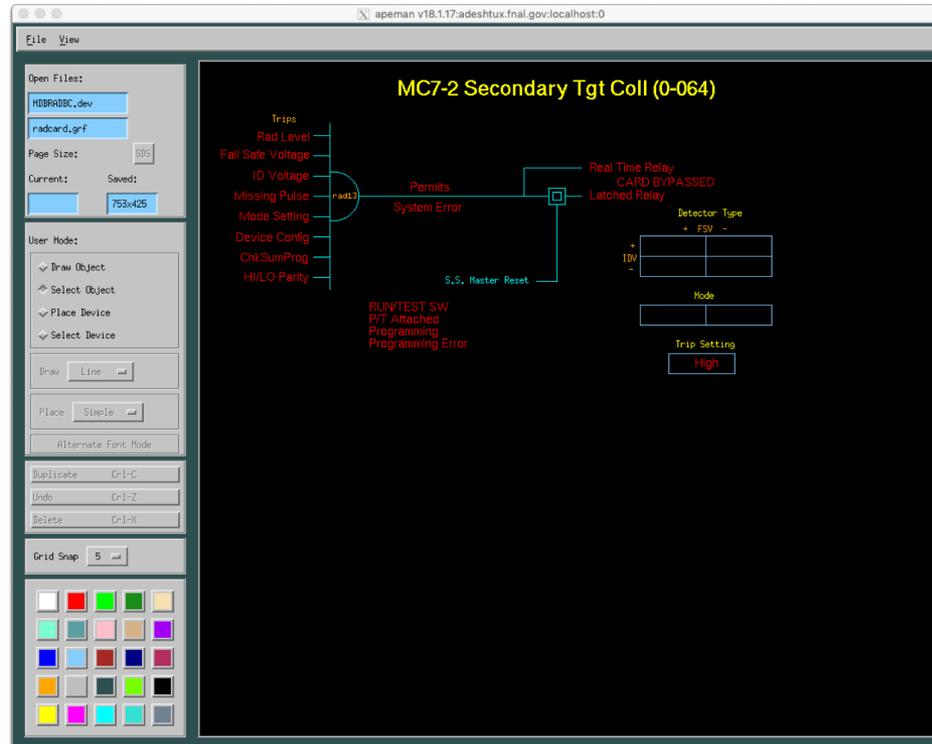
Advanced Page Editor and MANager in a GUI builder for the pages in Page.

APEMan - Graphics



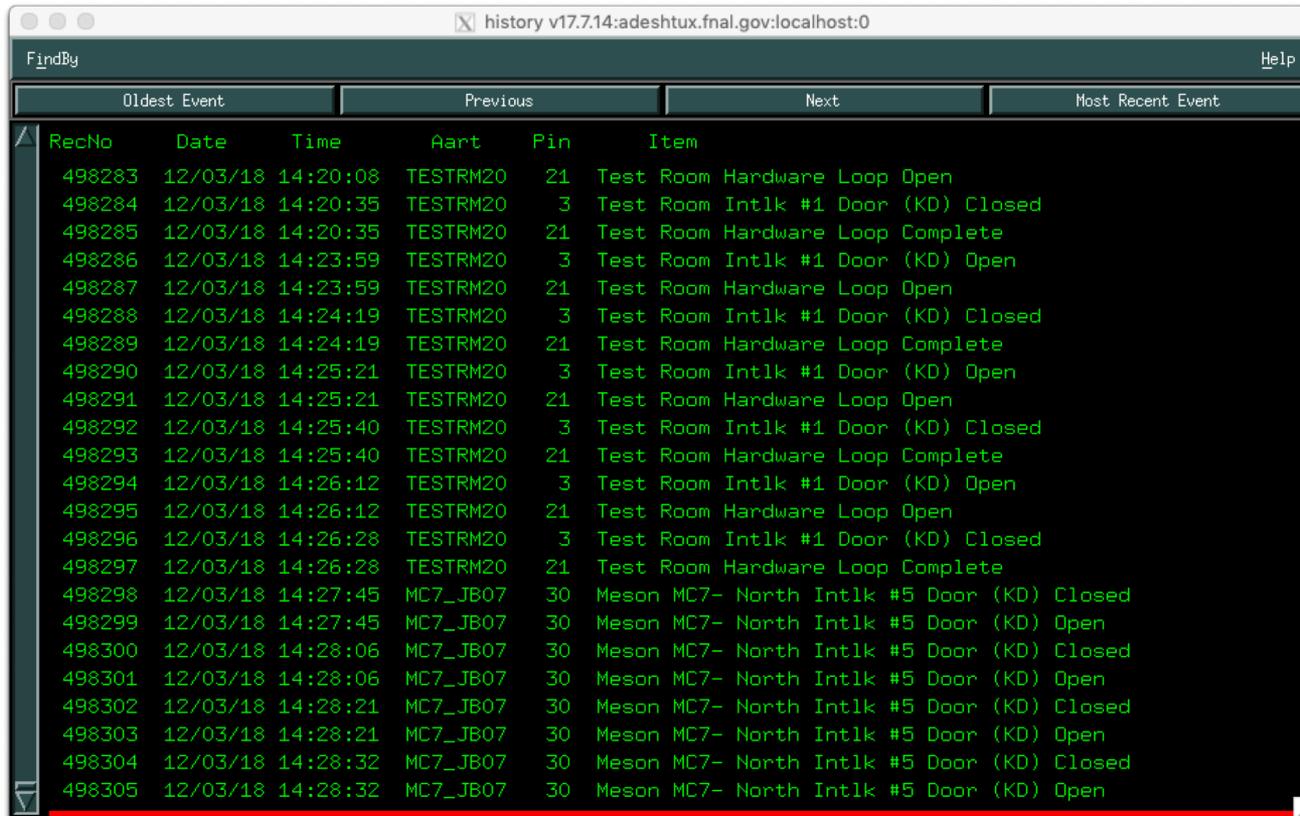
It uses a two file model. This is a .GRF file that has basic shape and color.

APEMan - Devices



This is a .DEV and .GRF file. The devices have a location, associated pin, fork (link), and color coding for status. Flat text is handled here too.

History



RecNo	Date	Time	Aart	Pin	Item
498283	12/03/18	14:20:08	TESTRM20	21	Test Room Hardware Loop Open
498284	12/03/18	14:20:35	TESTRM20	3	Test Room Intlk #1 Door (KD) Closed
498285	12/03/18	14:20:35	TESTRM20	21	Test Room Hardware Loop Complete
498286	12/03/18	14:23:59	TESTRM20	3	Test Room Intlk #1 Door (KD) Open
498287	12/03/18	14:23:59	TESTRM20	21	Test Room Hardware Loop Open
498288	12/03/18	14:24:19	TESTRM20	3	Test Room Intlk #1 Door (KD) Closed
498289	12/03/18	14:24:19	TESTRM20	21	Test Room Hardware Loop Complete
498290	12/03/18	14:25:21	TESTRM20	3	Test Room Intlk #1 Door (KD) Open
498291	12/03/18	14:25:21	TESTRM20	21	Test Room Hardware Loop Open
498292	12/03/18	14:25:40	TESTRM20	3	Test Room Intlk #1 Door (KD) Closed
498293	12/03/18	14:25:40	TESTRM20	21	Test Room Hardware Loop Complete
498294	12/03/18	14:26:12	TESTRM20	3	Test Room Intlk #1 Door (KD) Open
498295	12/03/18	14:26:12	TESTRM20	21	Test Room Hardware Loop Open
498296	12/03/18	14:26:28	TESTRM20	3	Test Room Intlk #1 Door (KD) Closed
498297	12/03/18	14:26:28	TESTRM20	21	Test Room Hardware Loop Complete
498298	12/03/18	14:27:45	MC7_JB07	30	Meson MC7- North Intlk #5 Door (KD) Closed
498299	12/03/18	14:27:45	MC7_JB07	30	Meson MC7- North Intlk #5 Door (KD) Open
498300	12/03/18	14:28:06	MC7_JB07	30	Meson MC7- North Intlk #5 Door (KD) Closed
498301	12/03/18	14:28:06	MC7_JB07	30	Meson MC7- North Intlk #5 Door (KD) Open
498302	12/03/18	14:28:21	MC7_JB07	30	Meson MC7- North Intlk #5 Door (KD) Closed
498303	12/03/18	14:28:21	MC7_JB07	30	Meson MC7- North Intlk #5 Door (KD) Open
498304	12/03/18	14:28:32	MC7_JB07	30	Meson MC7- North Intlk #5 Door (KD) Closed
498305	12/03/18	14:28:32	MC7_JB07	30	Meson MC7- North Intlk #5 Door (KD) Open

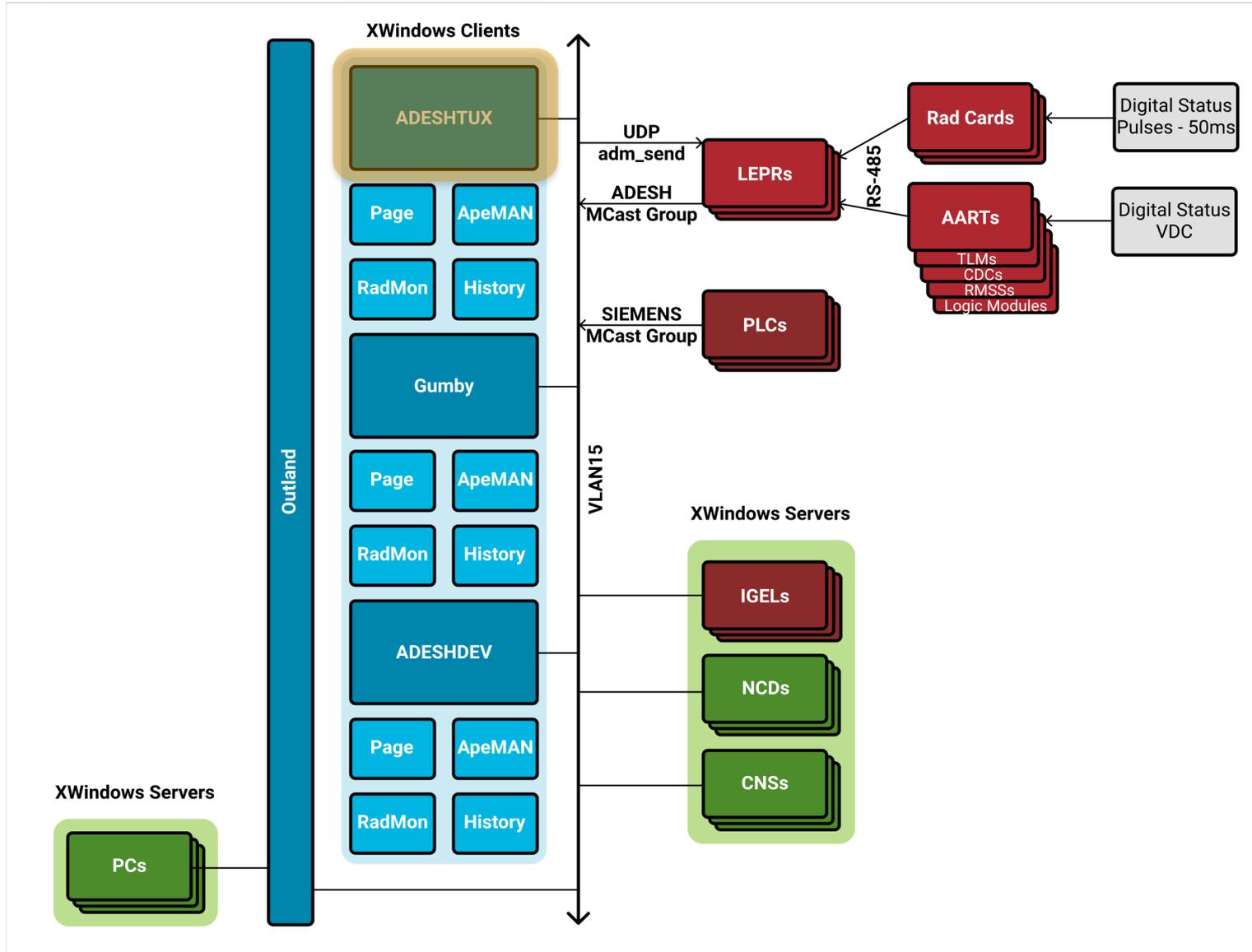
The history logger is a 1M line buffer of all pin state transitions.

Talk



The speech system is driven by a commercial product called Cepstral. It is a text to speech engine.

Safety System Overview



Databases

- Server generated
 - History log
 - Binary
 - Radiation log
 - Flat daily archive
- FileMaker Pro
 - AART config
 - AART pin config
 - PLC config
 - LEPR config
- Others
 - Talk config

Redmine

Greg wrote procedures for most common tasks. Those are now in Redmine.

- <https://cdcvs.fnal.gov/redmine/projects/ad-esh-department-interlocks-group>

Redmine

Projects:

- [APEMan](#)
 - [Pages](#)
- [Addressable asynchronous receiver-transmitter](#)
- [Data Pool](#)
- [Dialog Program](#)
- [History](#)
- [Linux Ethernet Port Repeater](#)
- [Net](#)
- [Page](#)
- [RadMon](#)
- [Radiation Monitor Interface](#)
- [Shared](#)
- [Talk](#)
- [Web relay](#)

Issues with the current implementation

- Downtime due to updates
- Lack of versioning for everything
- Limited data validation
- Weak data relationships
- Server failover is not automatic
- Fragile manual update processes
- Duplication of effort for the backup system
- Duplication of code
- User access to servers required
- Lacking documentation of compiling embedded software

Roadmap

Details are reserved for another conversation but here are my initial ideas:

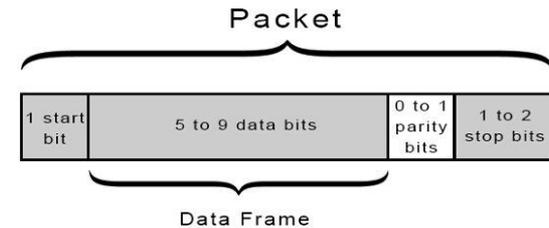
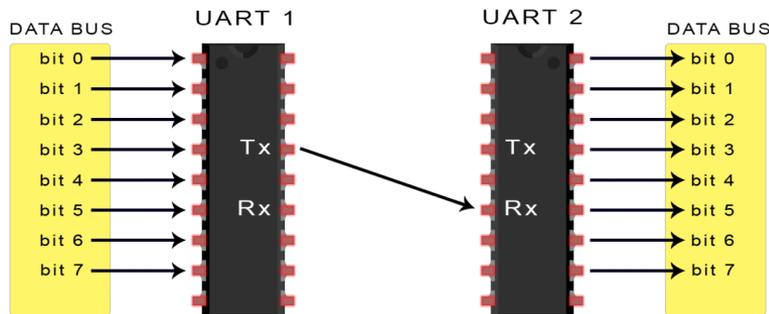
- **Container System**
 - Docker
 - Simplify development and deployment
 - Automate failure behavior
 - Maintain single image
- **Git/Redmine**
 - Revisioning and versioning
- **Code Refactoring**
 - Remove code duplication
 - Rust language
 - Safe embedded language
 - Opportunity to better understand
- **WYSIWYG Builder**
 - GrapesJS
 - Alternative to APEMan
 - Web app builder
- **Web Apps**
 - Alternative to XWindows applications
 - Isolates users from servers
 - Interface to automated procedures
- **Database**
 - Data validation
 - No downtime for updates
 - Strong data relationships
 - MariaDB or SQLite

Thank you

Questions?

UART

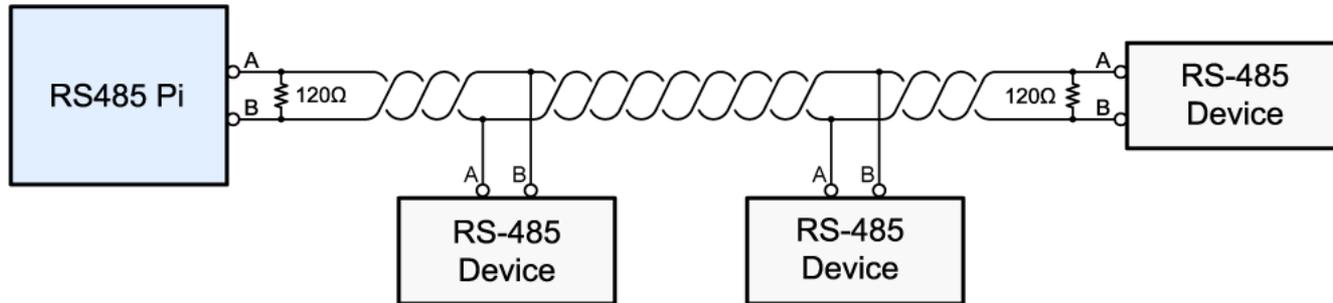
Universal Asynchronous Receiver/Transmitter



- Convert serial to parallel communication
- Can buffer incoming data in a FIFO pattern
- Baud rate dependent

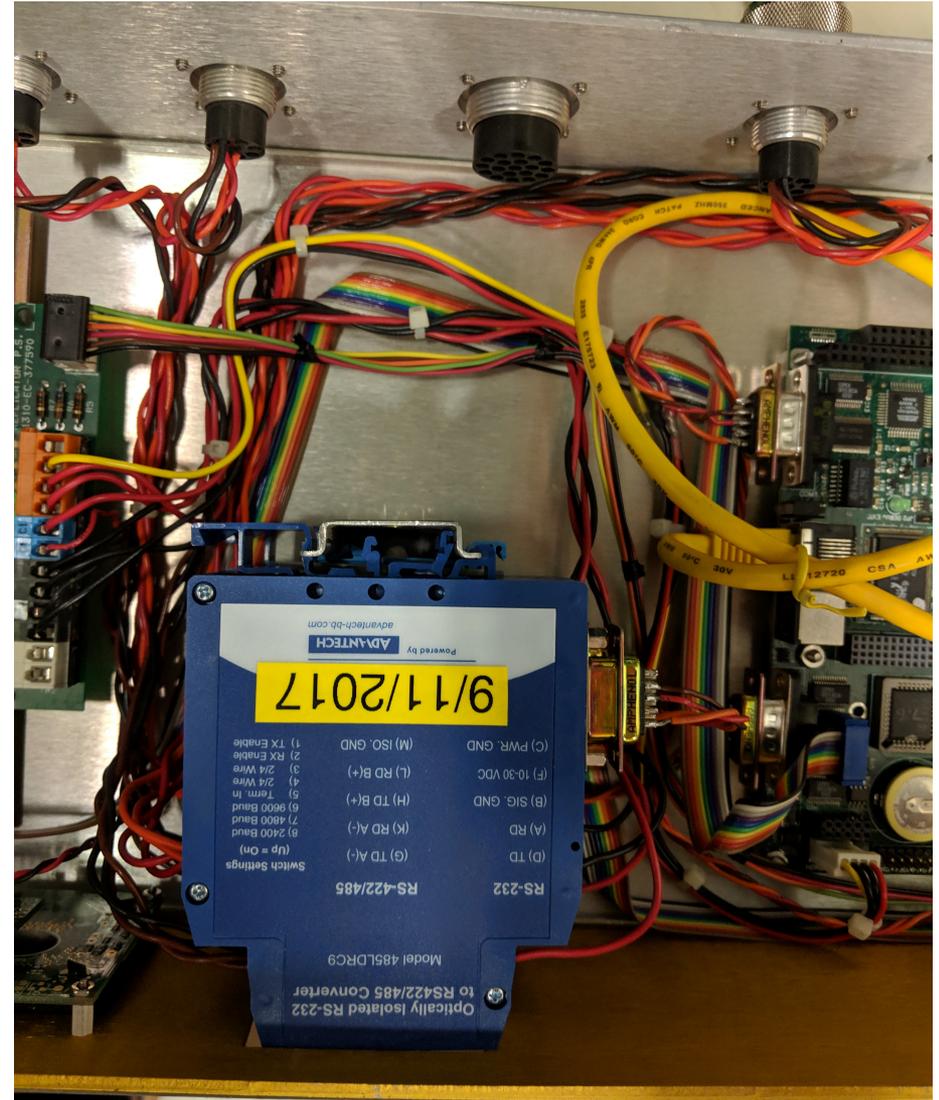
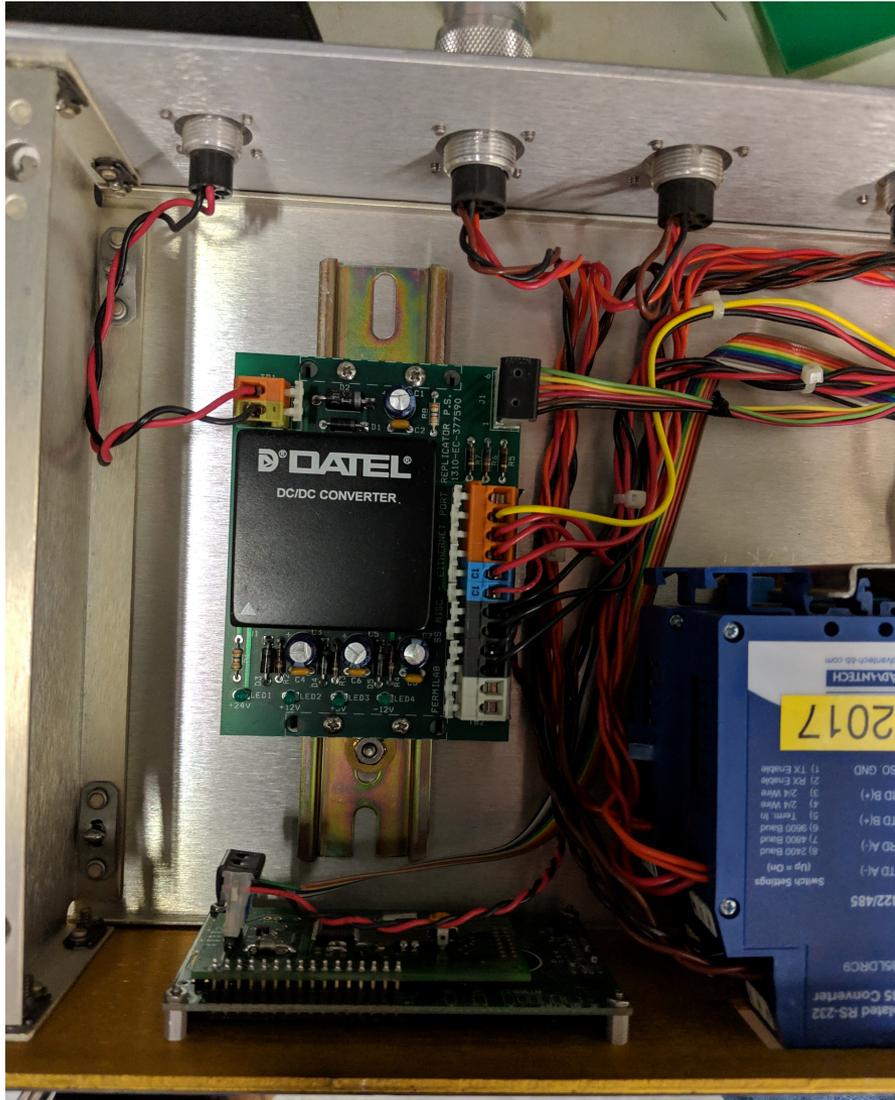
RS-485

Serial communication standard



- Allows for multiple devices on the same network
- Can be used over long distances, 1200m
- Twisted pair is resistant to environmental noise
- Bit rates of up to 35mbps

LEPR Close Ups



LEPR Close Ups

