

STARC ABL Software

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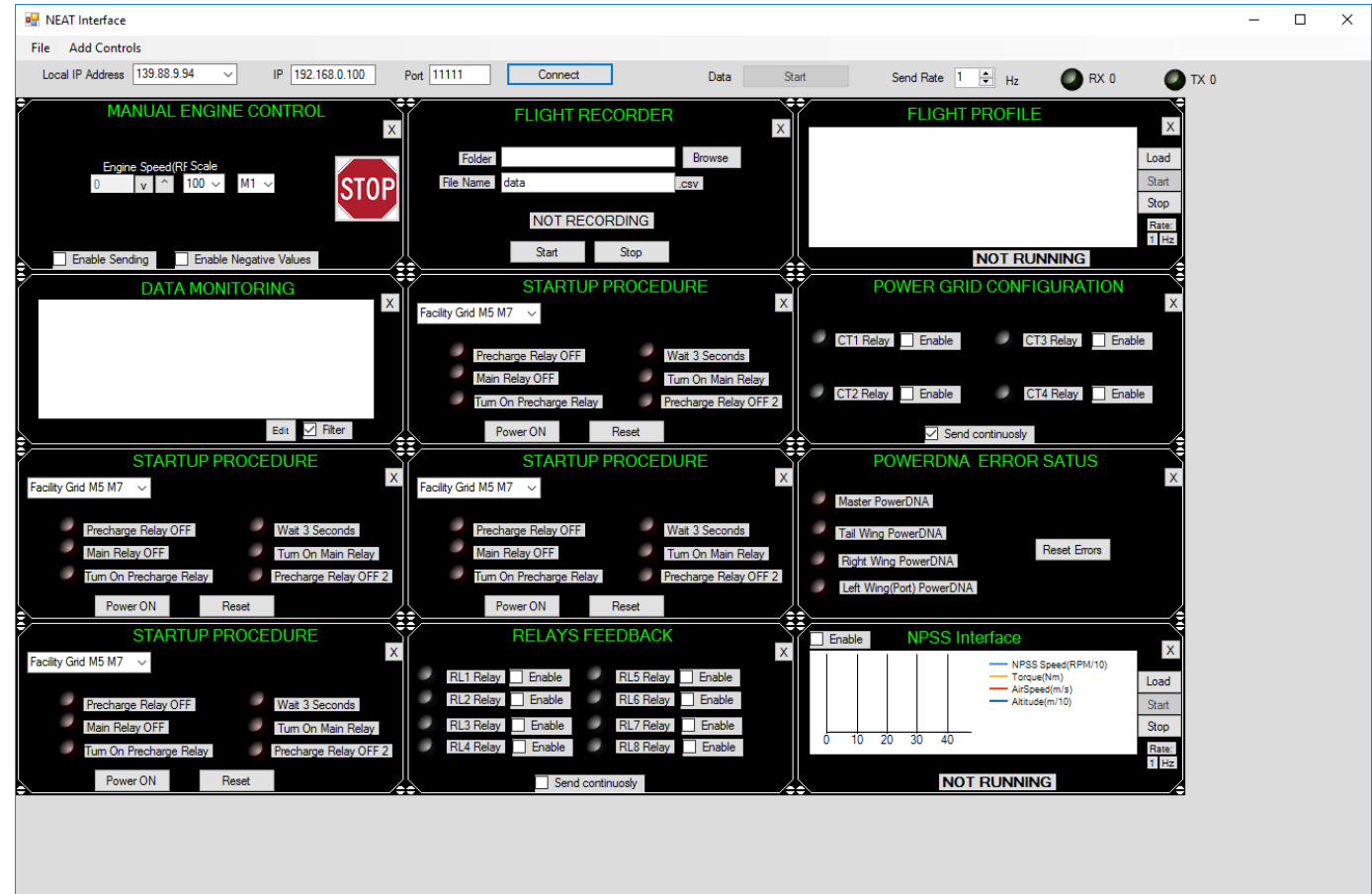
System architecture

- 8 250 KW Inverters
- 2 PCs
- 4 Embedded Linux Devices (PowerDNA)



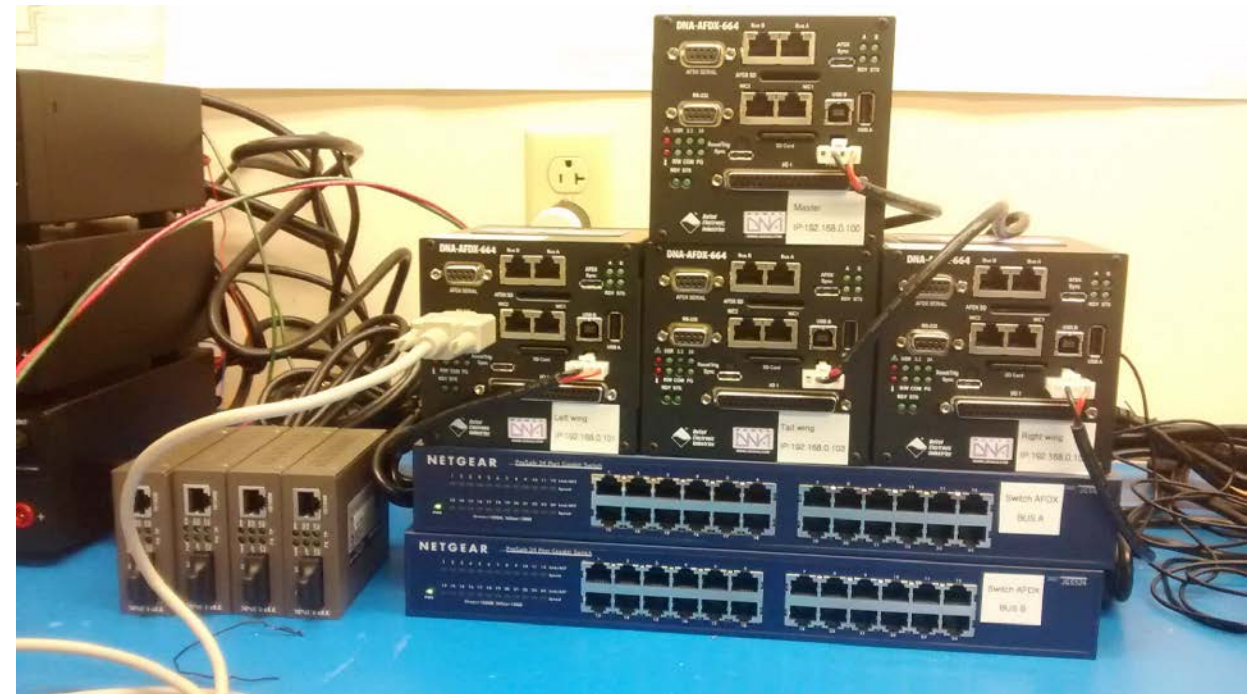
GUI (Graphical User Interface)

- Controls Motors
- Controls Relays
- Saves Data
- Shows Relay Feedback
- Displays Data
- Runs Flight Profiles
- Software written in C#



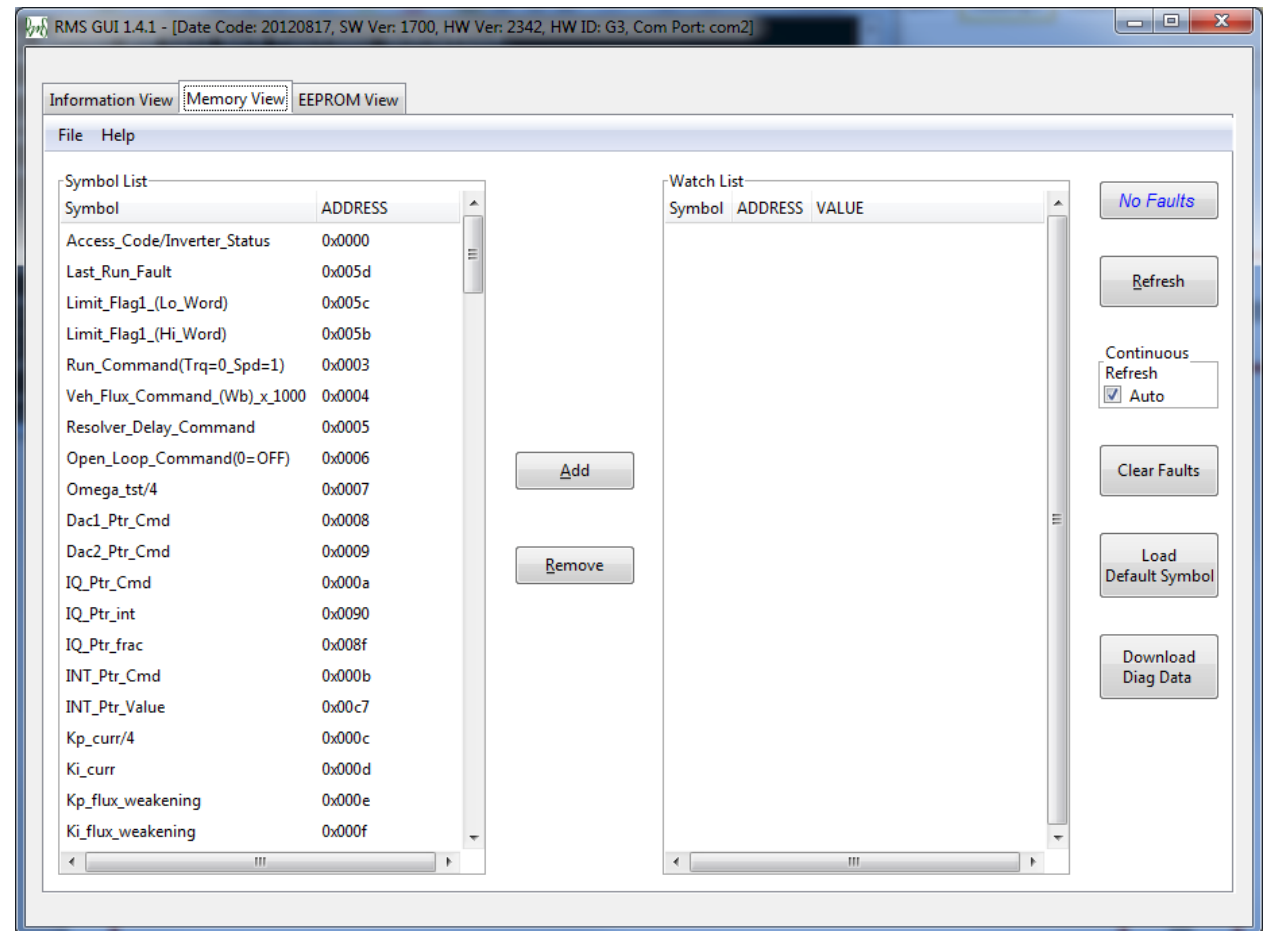
Embedded Linux Boxes

- Firmware written in C
- One for each wing (Starboard, Port and Tail)
- A Master that talks to all wing units
- Contains the ARINC664 and CANbus interfaces
- Allows access through SSH, SFTP



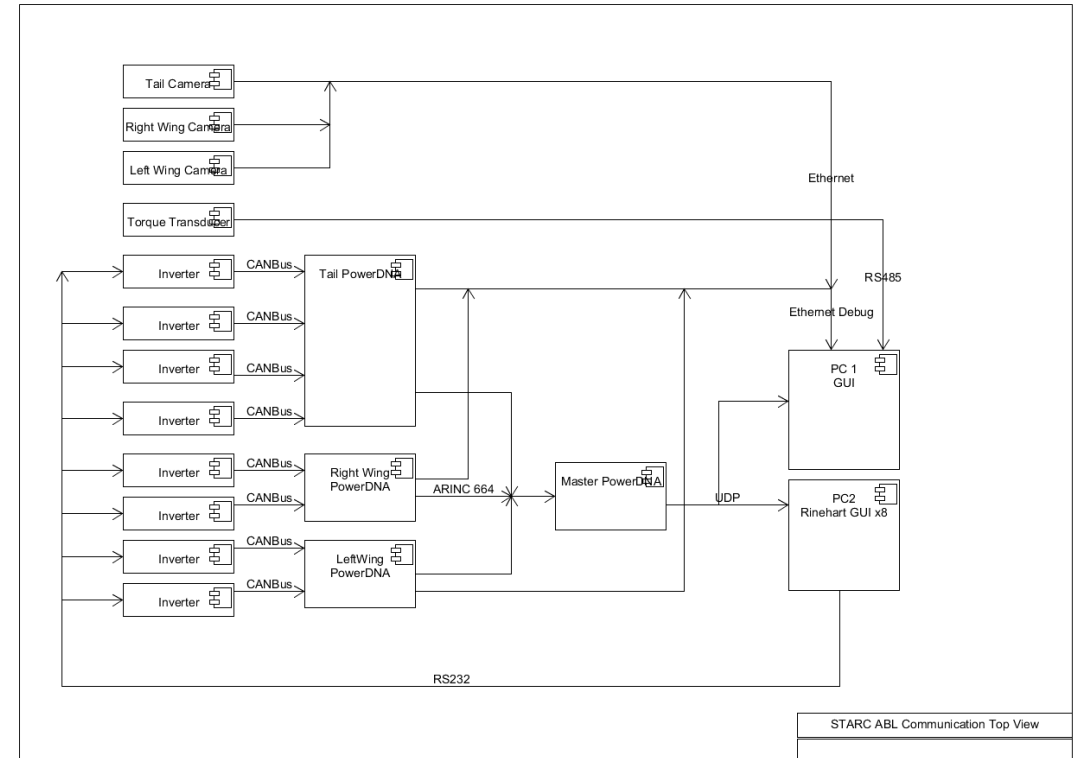
Inverter Setup and Feedback

- Rinehart GUI
- Allows changing the limits(speed/torque rate)
- Display the raw data



Communication

- Protocols
UDP, CANBus, ARINC664
- Over optical fiber
- Redundant for data and commands



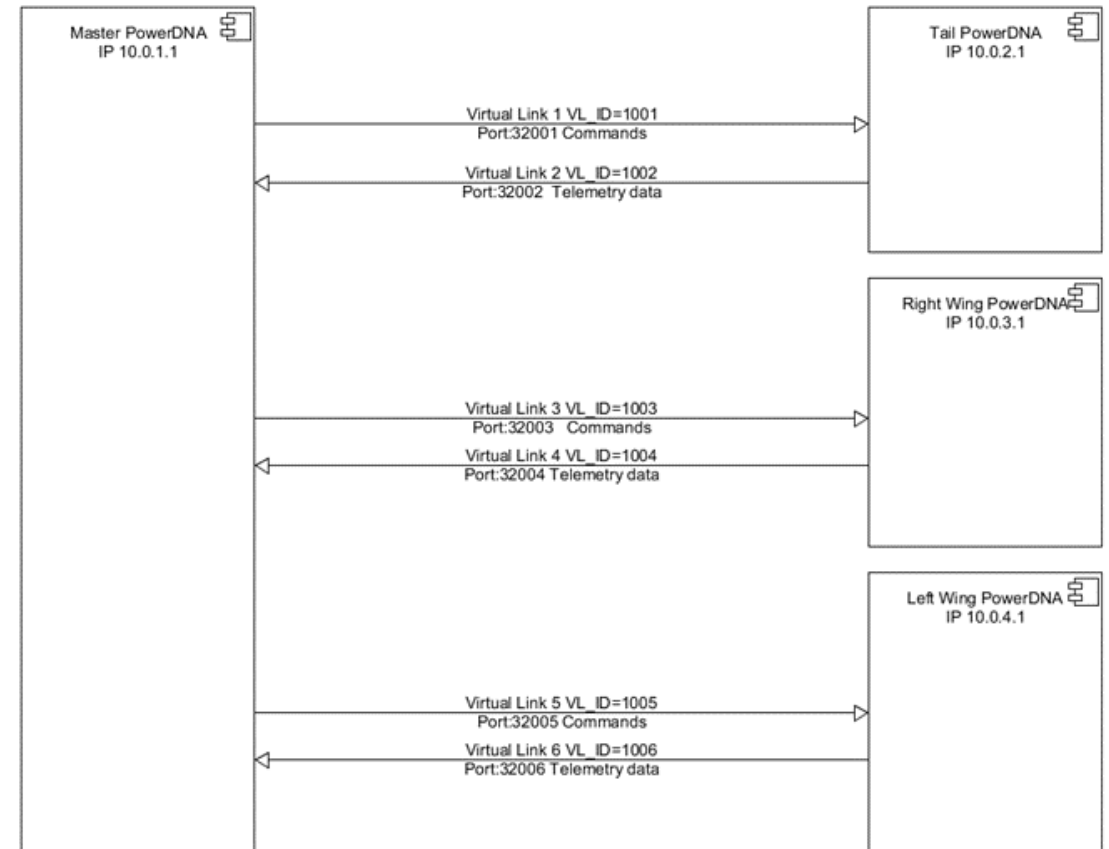
CANBus Communication (Controller Area Network)Communication



- Used because of the Inverter
- CANBus is used mainly by auto industry
- 1 Mb/s
- Sends Telemetry
- Receives commands

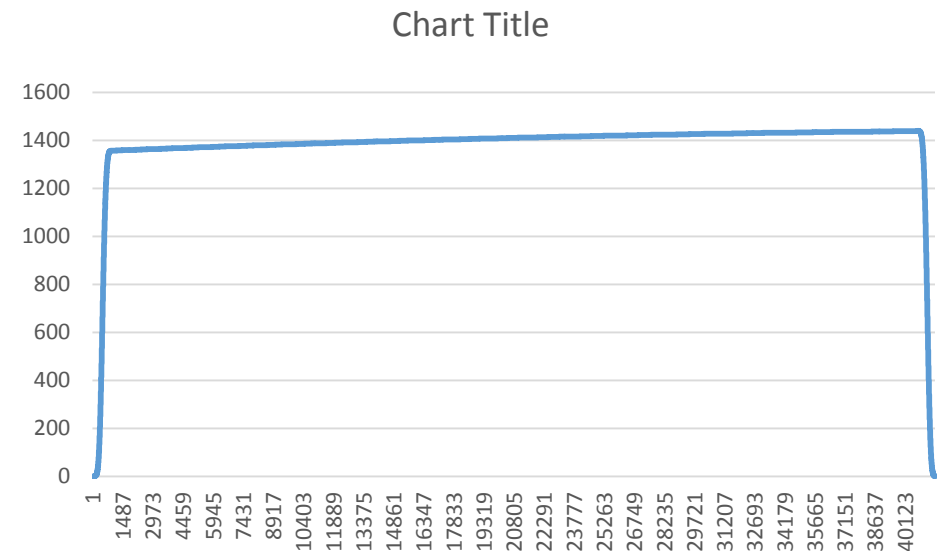
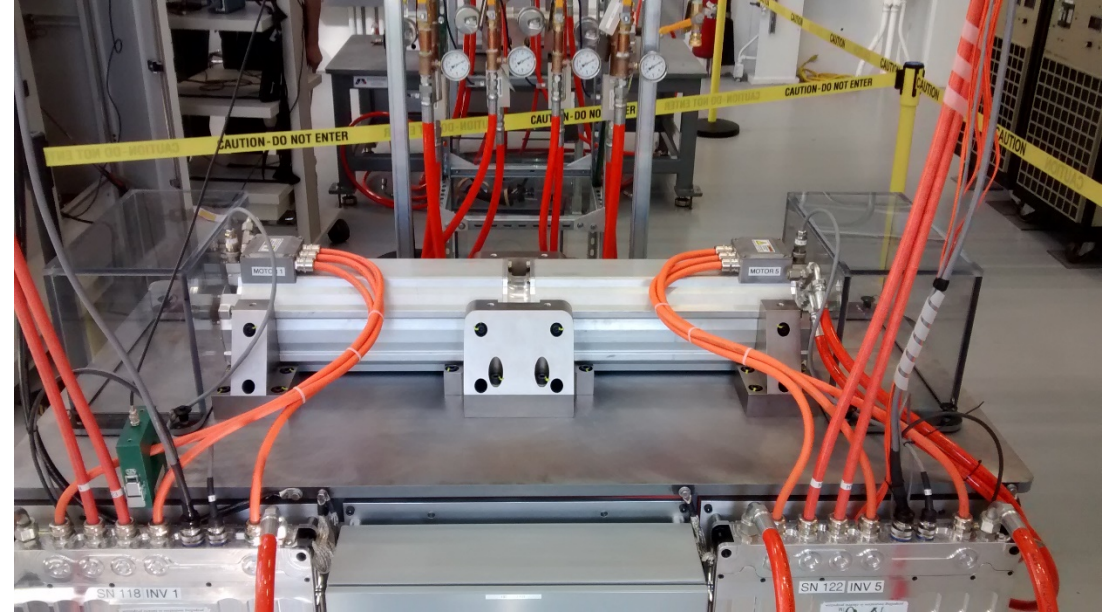
ARINC 664 Protocol

- Used by Airbus 380 ,Boeing 787
- Full duplex
- Redundant
- Deterministic
- Virtual links



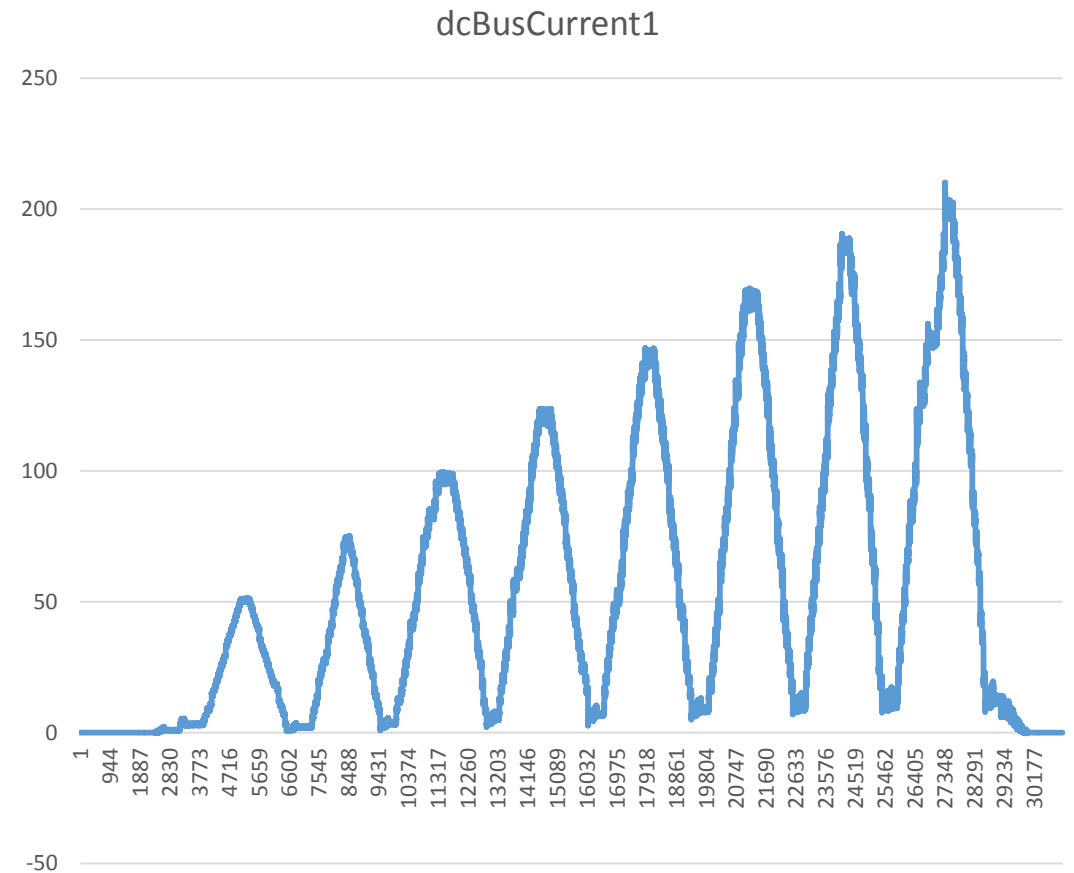
Motor Control

- Ability to use flight profiles
- (saved as excel files)
- Variable command control rate
(normally 50 Hz)
- Torque or Speed modes



Data collection

- Collect all inverter and motor telemetry
- Collected data is used to verify the simulation
- Saved as Excel csv format
- 50 samples/second



Software Unit Testing

- Using MinUnit Framework
 - The smallest testable part of an application
 - Unit testing finds problems early
- RUNNING rinehartTelemetryUpdate_can0xA6_inverter_unit_test UNIT TEST
 - RUNNING rinehartTelemetryUpdate_can0xA7_inverter_unit_test UNIT TEST
 - RUNNING rinehartTelemetryUpdate_can0xA8_inverter_unit_test UNIT TEST
 - RUNNING rinehartTelemetryUpdate_can0xA9_inverter_unit_test UNIT TEST
 - RUNNING rinehartTelemetryUpdate_can0xAA_inverter_unit_test UNIT TEST
 - RUNNING rinehartTelemetryUpdate_can0xAB_inverter_unit_test UNIT TEST
 - RUNNING rinehartTelemetryUpdate_can0xAC_inverter_unit_test UNIT TEST
 - RUNNING rinehartTelemetryUpdate_can0xAD_inverter_unit_test UNIT TEST
 - RUNNING rinehartTelemetryUpdate_can0xAE_inverter_unit_test UNIT TEST
 - RUNNING rinehartTelemetryUpdate_can0xAF_inverter_unit_test UNIT TEST
 - Software version 115 software major: 1 Software version 115 software minor: 15
ALL TESTS PASSED
 - Tests run: 41 .It took 0.066000 ms to finish the tests.
 - [centos@localhost Unit_tests_x86]\$

Code Statistics(lines of code)

- Firmware

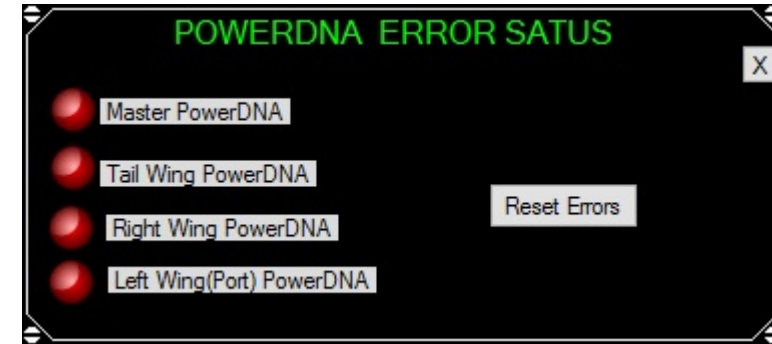
- -----
- | Language | files | blank | comment | code |
|----------------|-------|-------|---------|------|
| • C | 28 | 2192 | 1673 | 5885 |
| • C/C++ Header | 24 | 262 | 353 | 572 |
| • make | 8 | 70 | 0 | 191 |
| • XML | 8 | 1 | 0 | 114 |
| • YAML | 1 | 0 | 0 | 21 |
| • Bourne Shell | 1 | 3 | 3 | 3 |
| • ----- | | | | |
| • SUM: | 70 | 2528 | 2029 | 6786 |
| • ----- | | | | |

- GUI

- -----
- | Language | files | blank | comment | code |
|------------------|-------|-------|---------|-------|
| • XML | 25 | 193 | 0 | 25356 |
| • C# | 63 | 2716 | 2738 | 11204 |
| • HTML | 1 | 32 | 0 | 1811 |
| • MSBuild script | 3 | 0 | 21 | 779 |
| • ----- | | | | |
| • SUM: | 92 | 2941 | 2759 | 39150 |
| • ----- | | | | |

Error handling

- Communication Errors
- Inverter Errors
- Timeout Errors



Future Work

- Add computer control redundancy
- Add generator redundancy

Questions