Critical Design Review

LFEV-ESCM-2014

March 28, 2014

LFEV-Y2-2014

Continuation of Lafayette Formula Electric Vehicle-Energy Storage, Control, and Management (LFEV-ESCM) project for use in the Formula Hybrid Competition.

Website:
http://sites.lafayette.edu/ece492-sp14/

Roadmap

- Introduction
- 2014 Deliverables
- System Design
  - Pack Mechanical
  - AMS
  - PacMan
  - Charger
  - Motor/MCS
  - Software
- ATP
- Budget
- Schedule

ROADMAP

- Introduction
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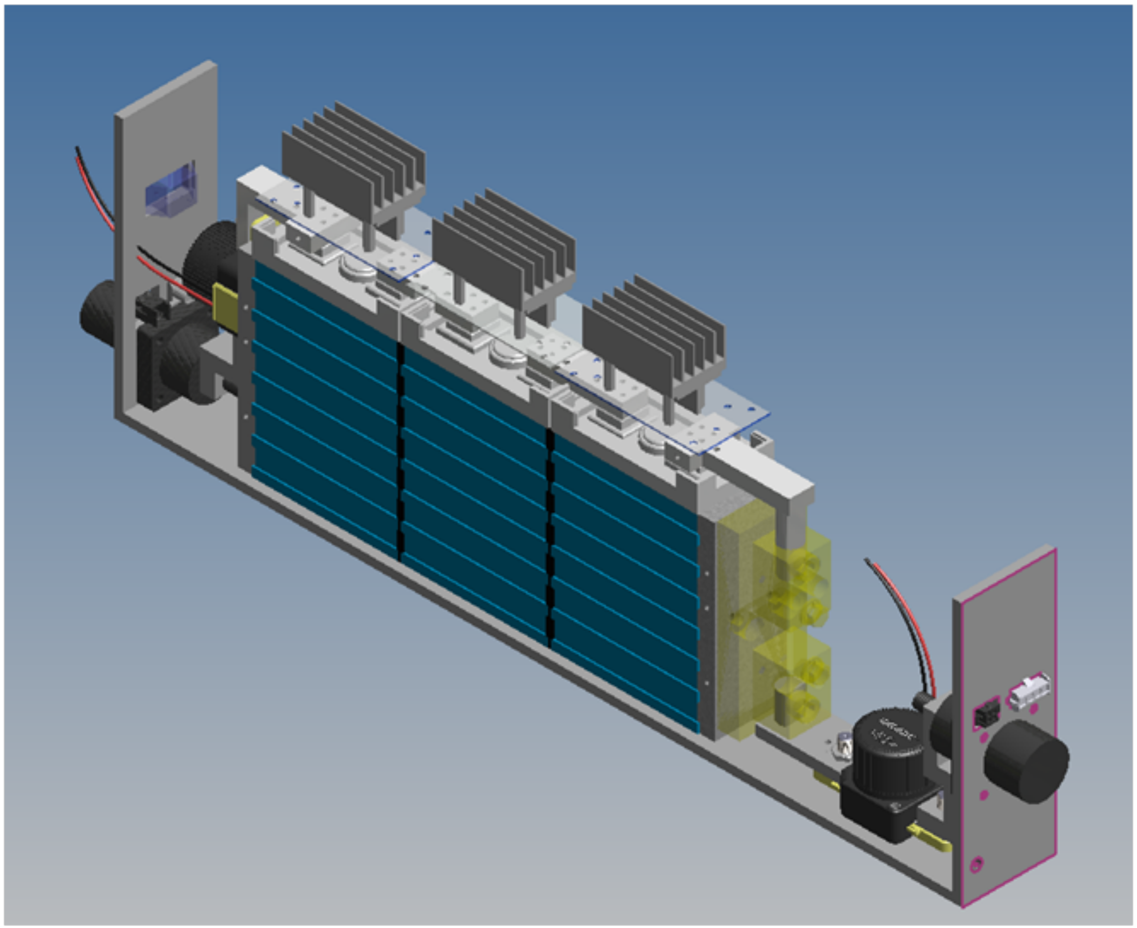
2013 Achievements

- 3-cell pack
  - Good for demo, not for competition
- OBPC-AMS
  - Voltage - some minor range issues
  - Temperature - questionable accuracy
  - Current - java.util.Random
  - PIC Firmware - SOLID!
- SCADA - currently inoperable
- Pit Station - not user-friendly
- GLV - plug-in power supply, not battery
- IMD/Safety Loop

2013 Pack



2013 Integrated System

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2014 Goals - Key Deliverables

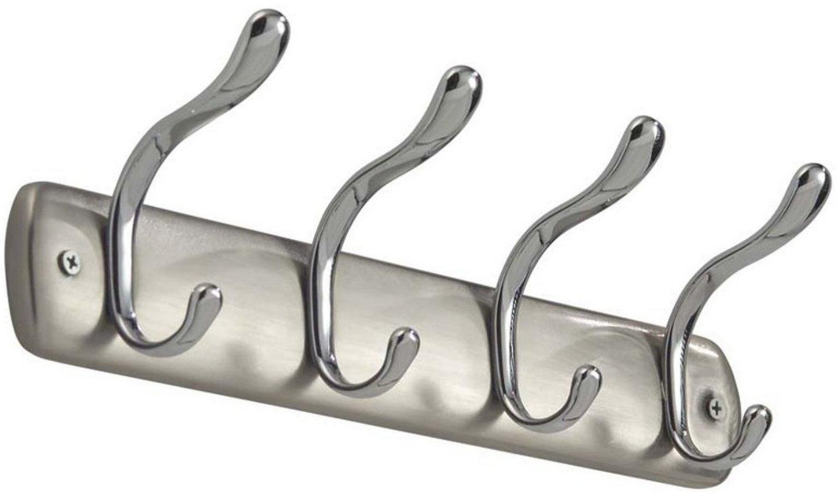
- AMS with improved sensor performance
- PacMan - Pack Manager
  - Monitor cell- and pack-level parameters
  - Display key parameters and status on-pack
  - Manage charging (Plug and Forget)
  - Meet Safety Loop requirements (EV3.6.7)
- One, 7-cell, competition-ready pack
  - Improved current path
  - Pack construction
- Pack Charger (part of Pit Station)
- Motor, MCS, & test stand

2014 Goals – Key Non-Deliverables

- Central VSCADA components
  - Driver Dashboard
  - Off-car data link
  - Pit Station data analysis
- 4 packs
  - Not enough budget or manpower for fab
- Other components (not originally included)
  - GLV system
  - Safety Loop

2014 Scope Considerations

- Aim for quality over quantity
- Object-Oriented Design - HW *and* SW
- Leave "hooks" for future teams



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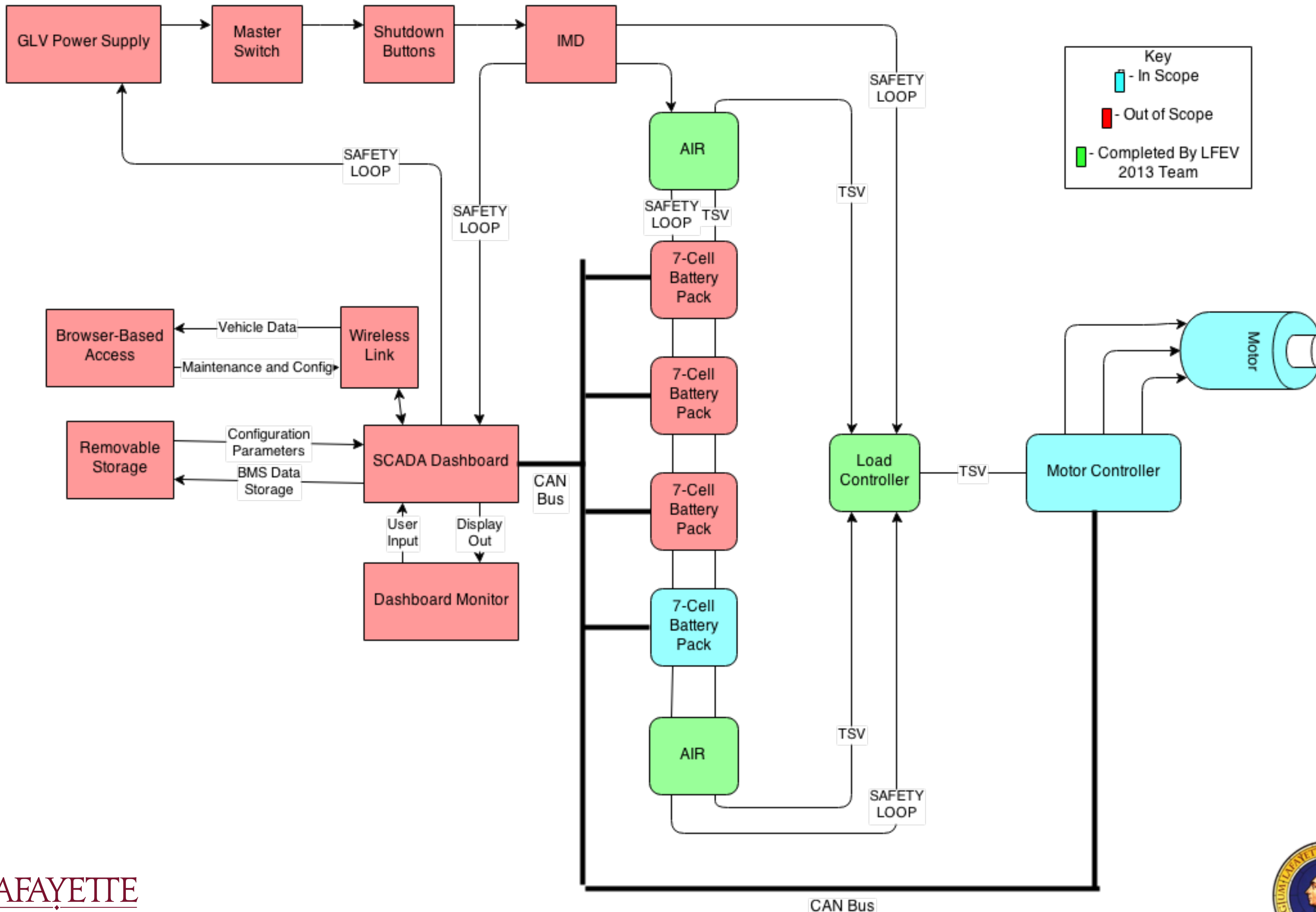
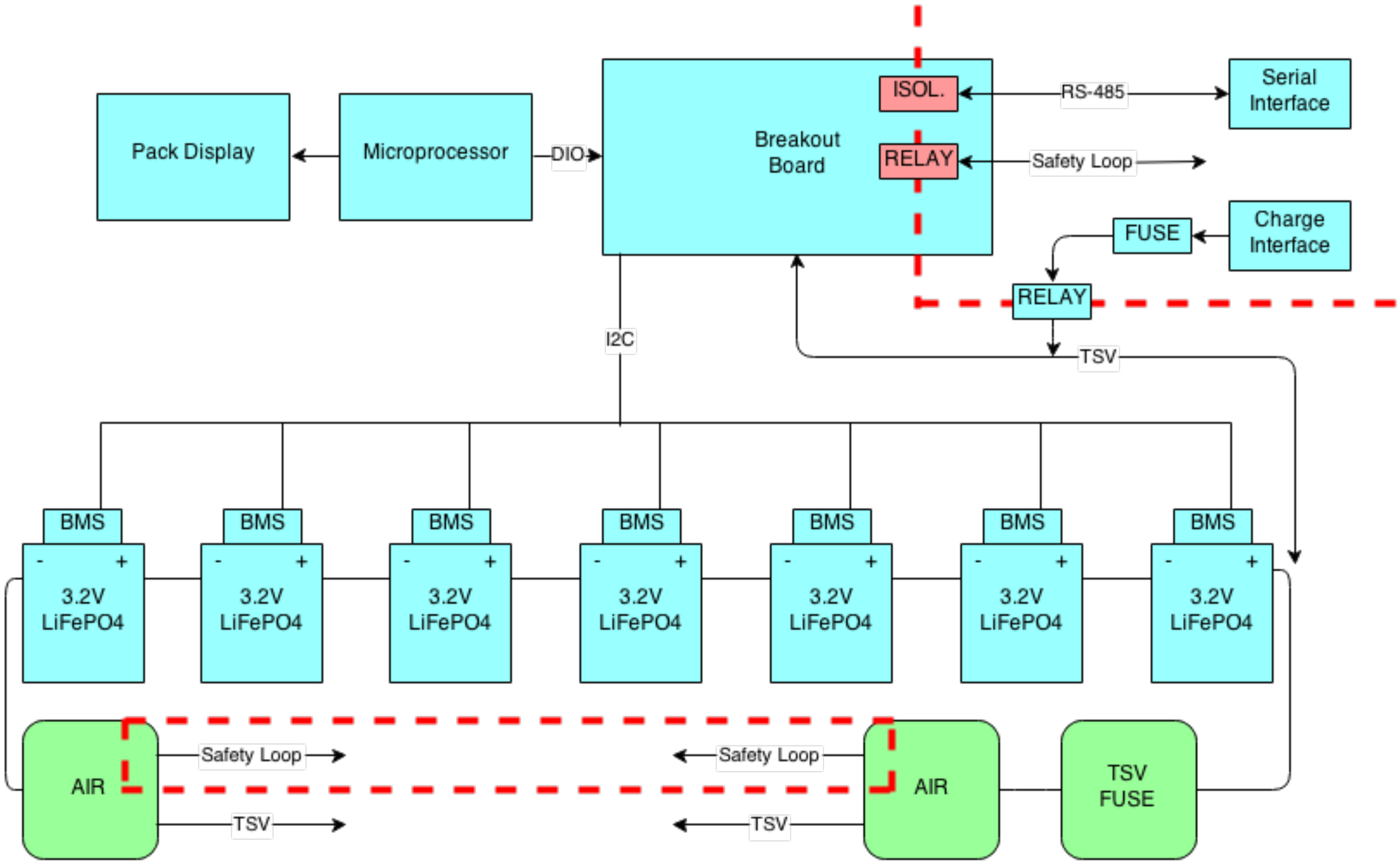
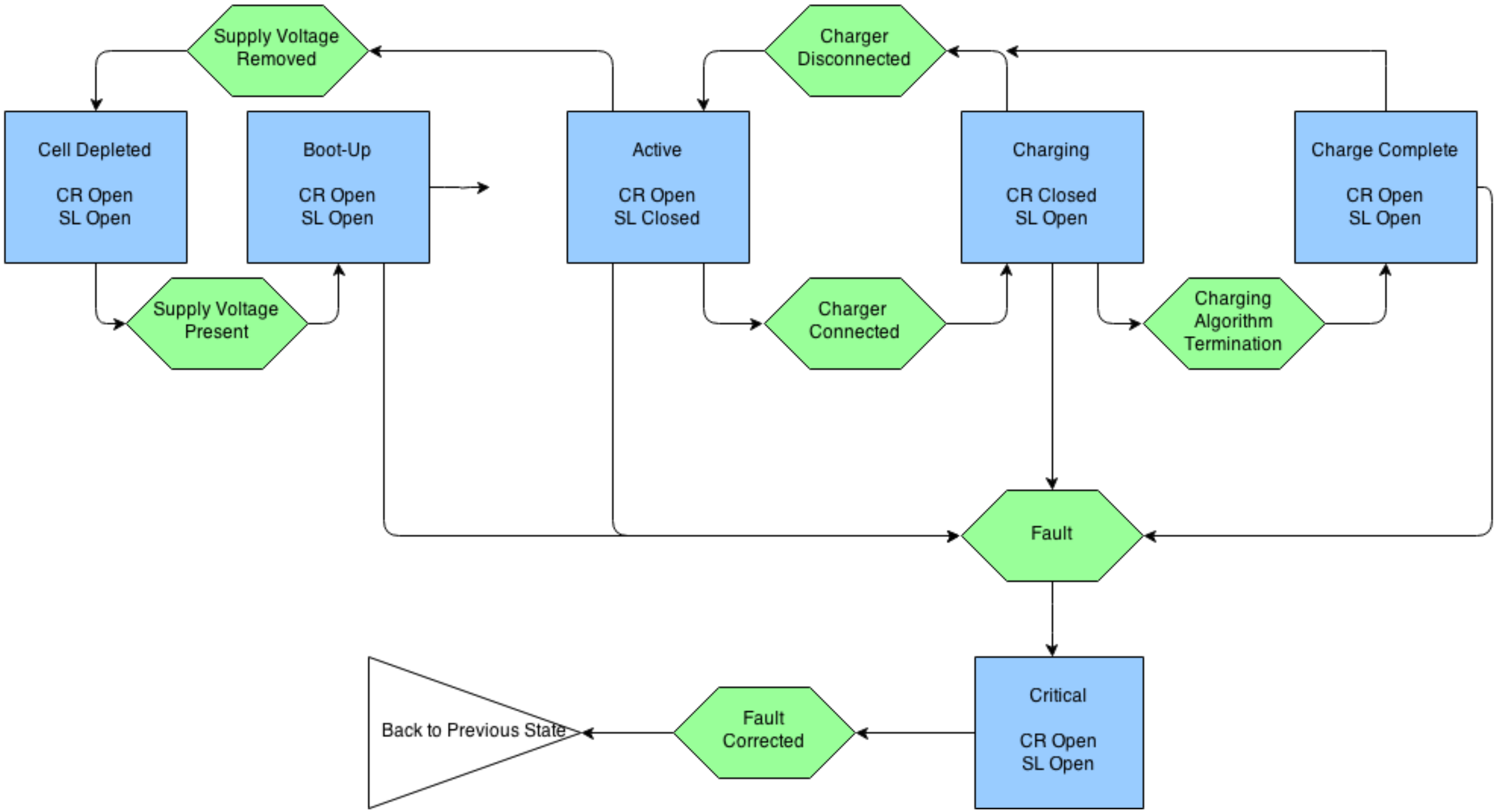
LFEV-ESCM System Block Diagram



Pack Block Diagram



TOP-LEVEL STATE DIAGRAM



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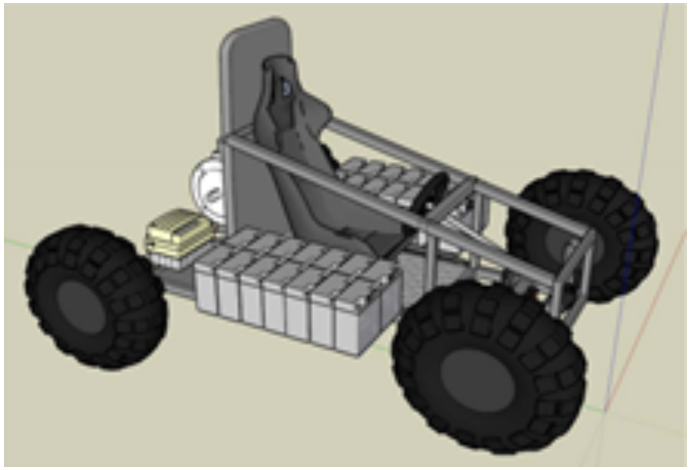
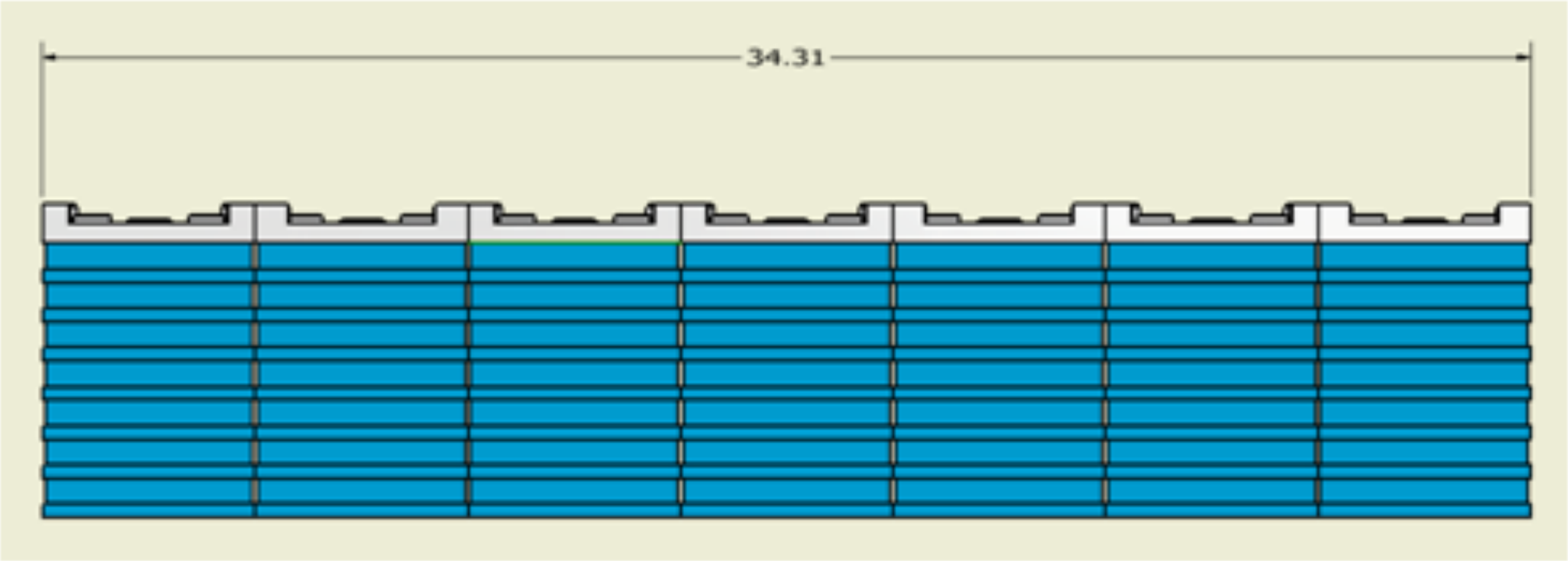
2013 Pack Layout

- Current Formula SAE design
  - Recycled into next year's EV
- 2013 pack design is too long
  - Pack length: >53"
  - 2014 SAE car 46" between wheels
- Under-driver mount raises COG





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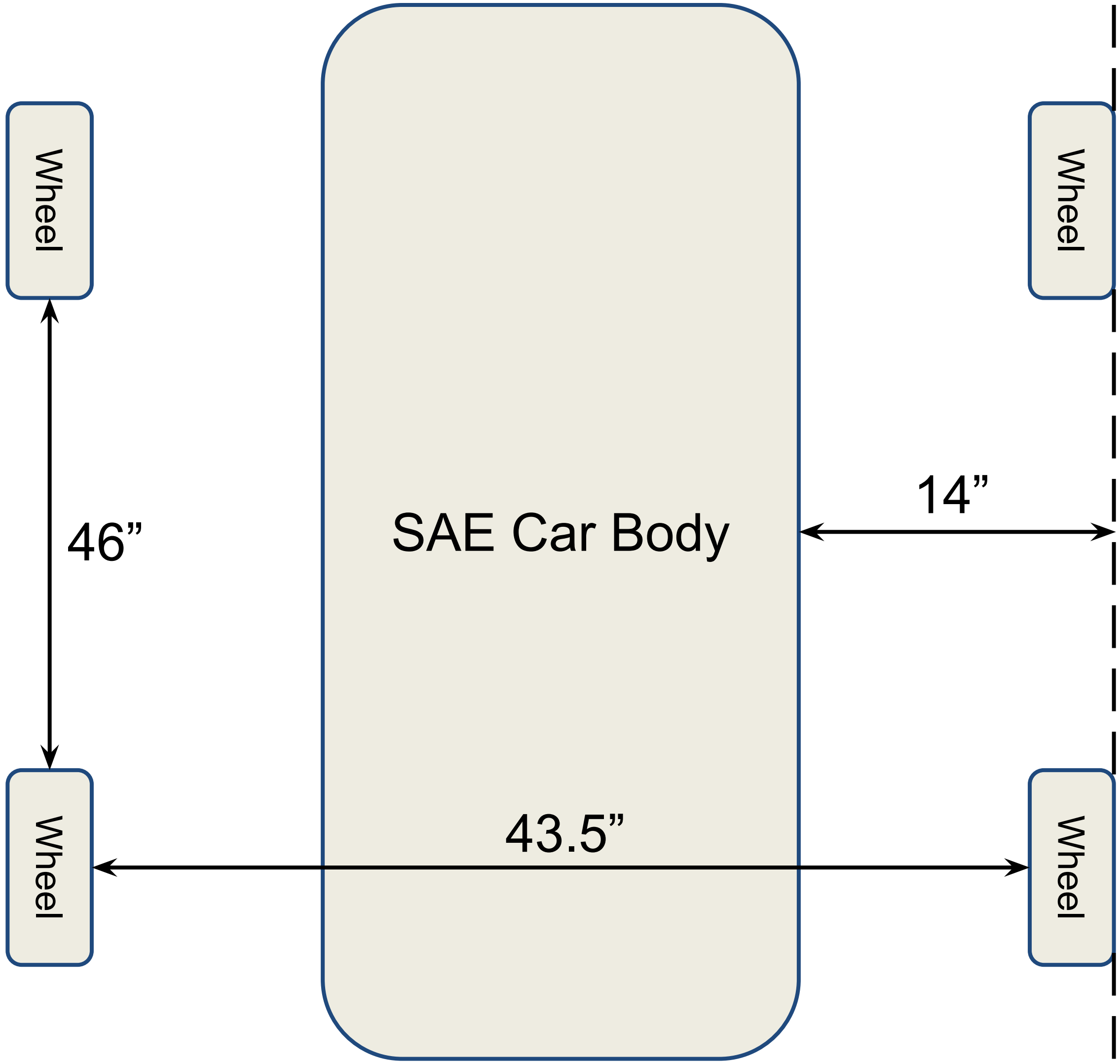
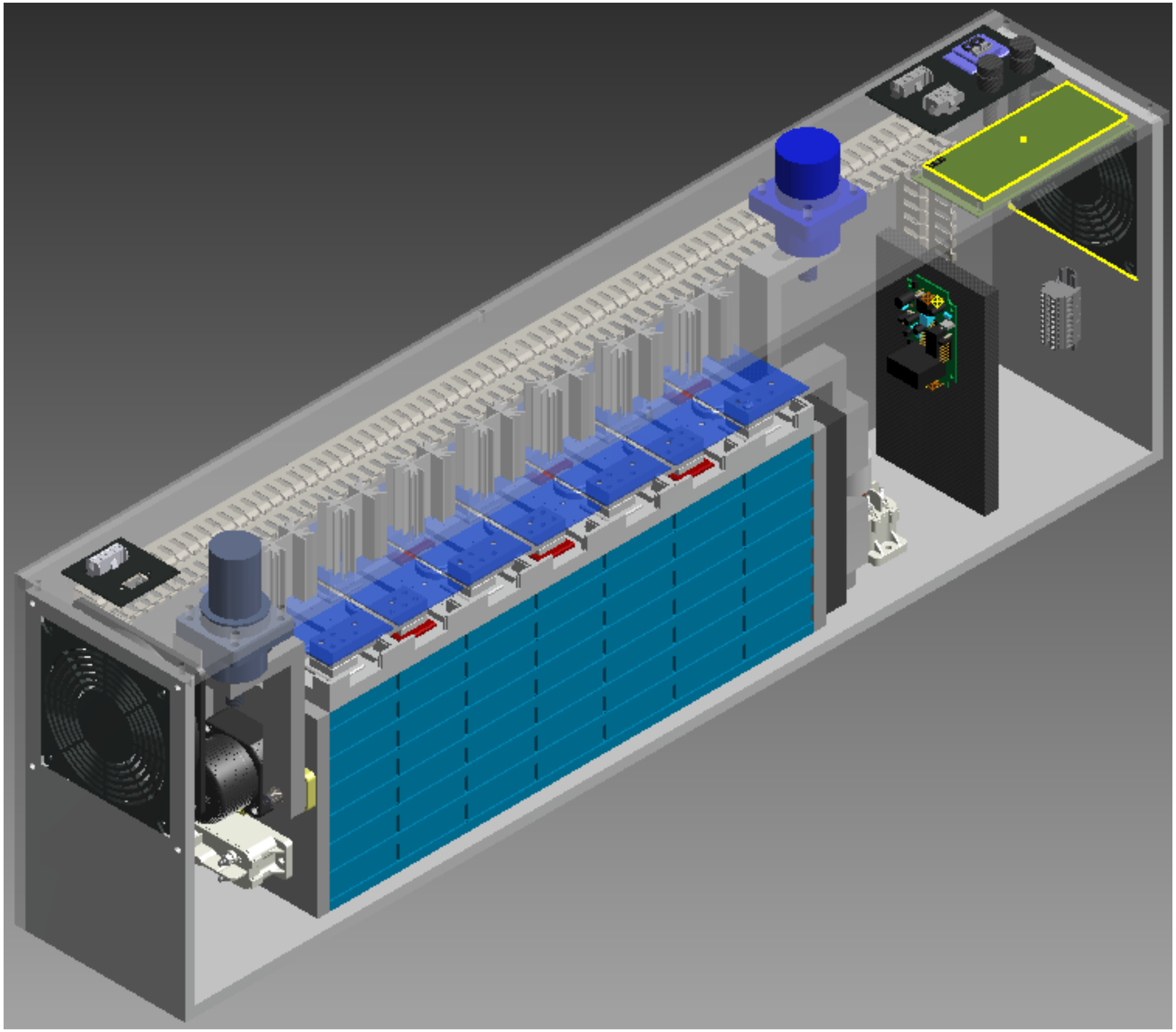
2014 SAE Car Dimensions (not to scale)



2014 Pack: 36" x 6"

2014 Pack Layout



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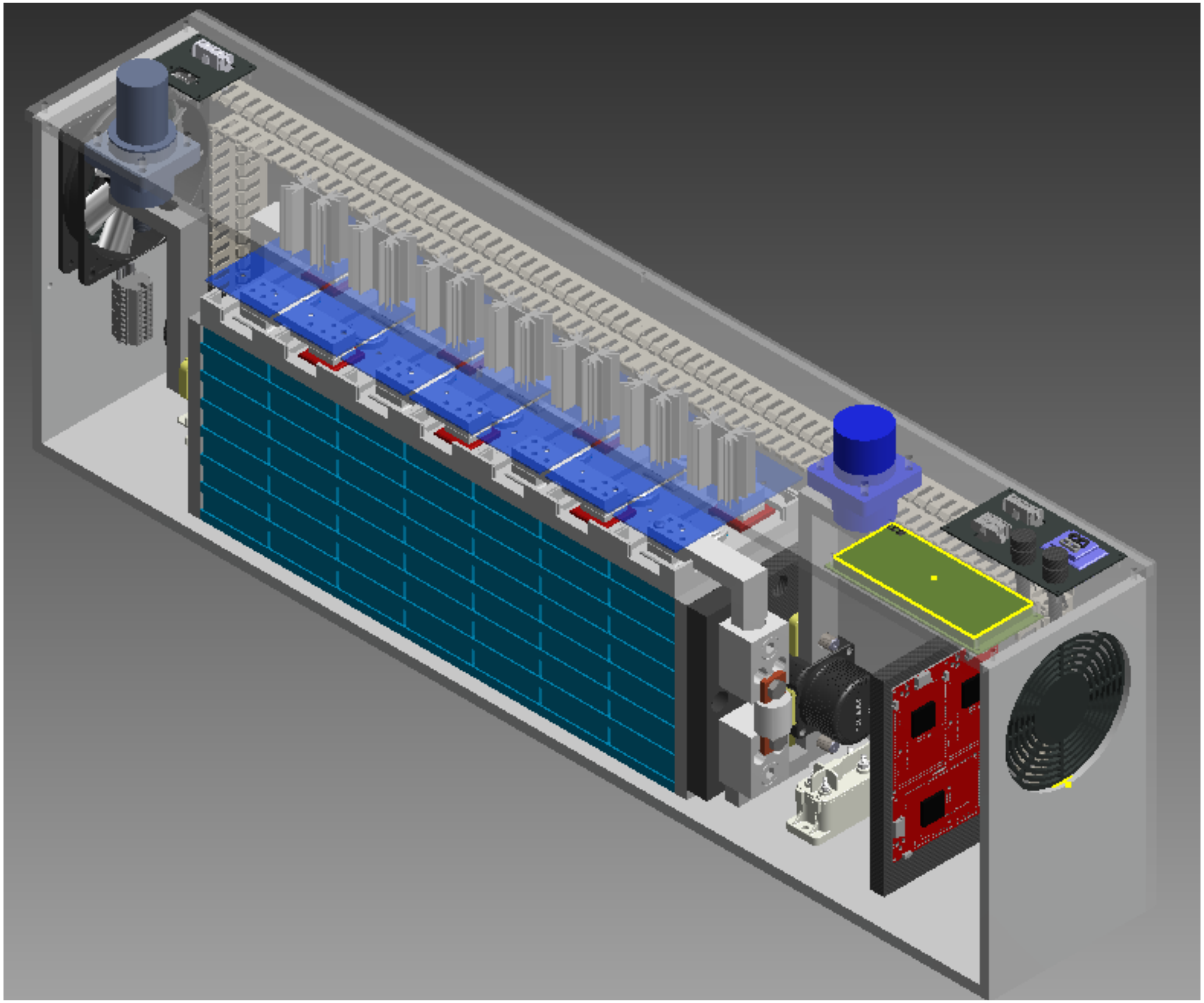
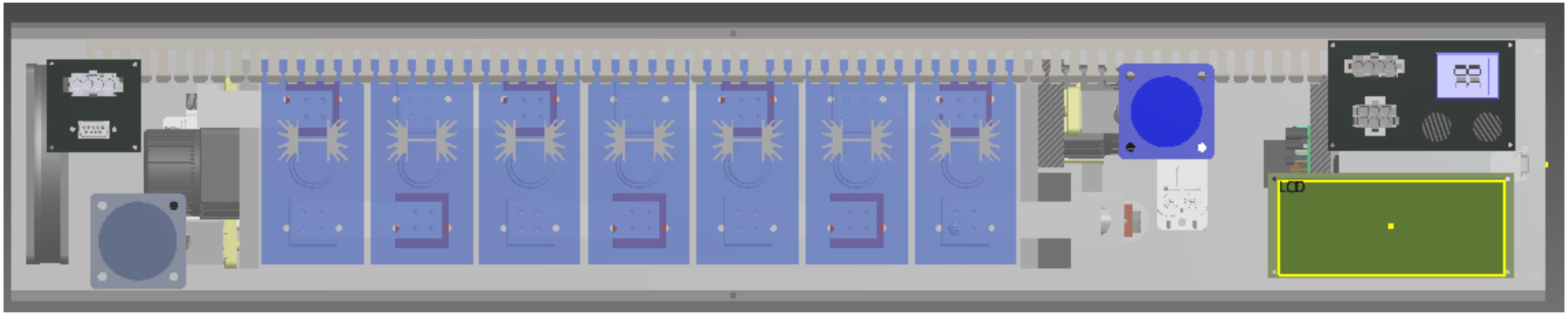
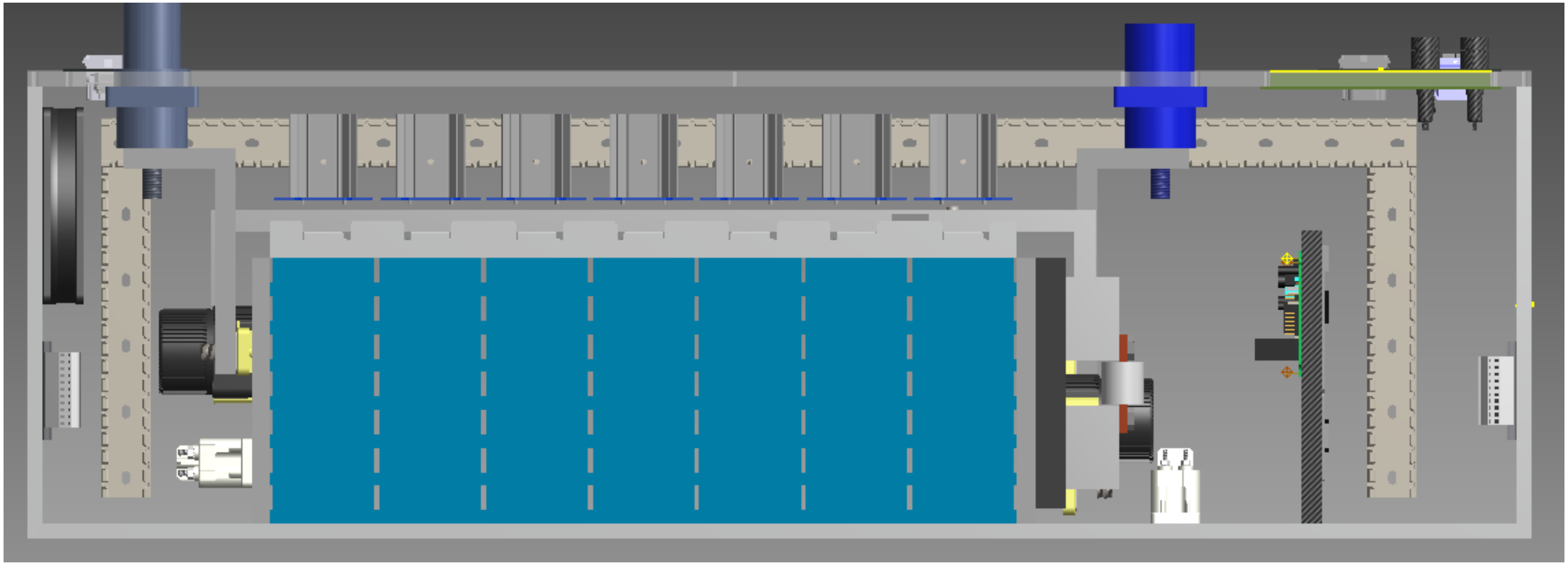
2014 Pack Layout



2014 Pack Layout

Top View





Front View

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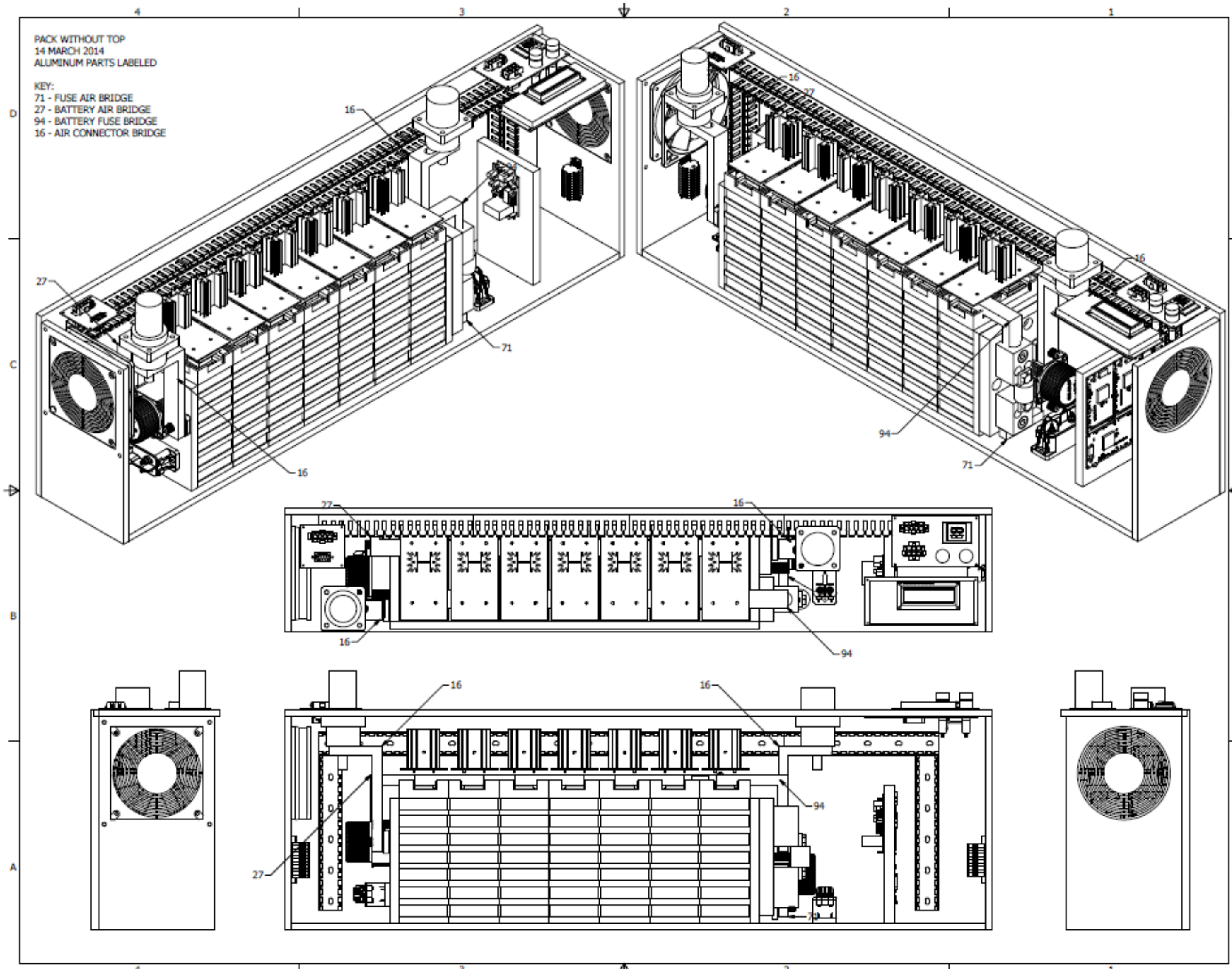
Pack


PACK WITHOUT TOP
14 MARCH 2014
ALUMINUM PARTS LABELED
KEY:
71 - FUSE AIR BRIDGE
27 - BATTERY AIR BRIDGE
94 - BATTERY FUSE BRIDGE
16 - AIR CONNECTOR BRIDGE

Assemblies Overview

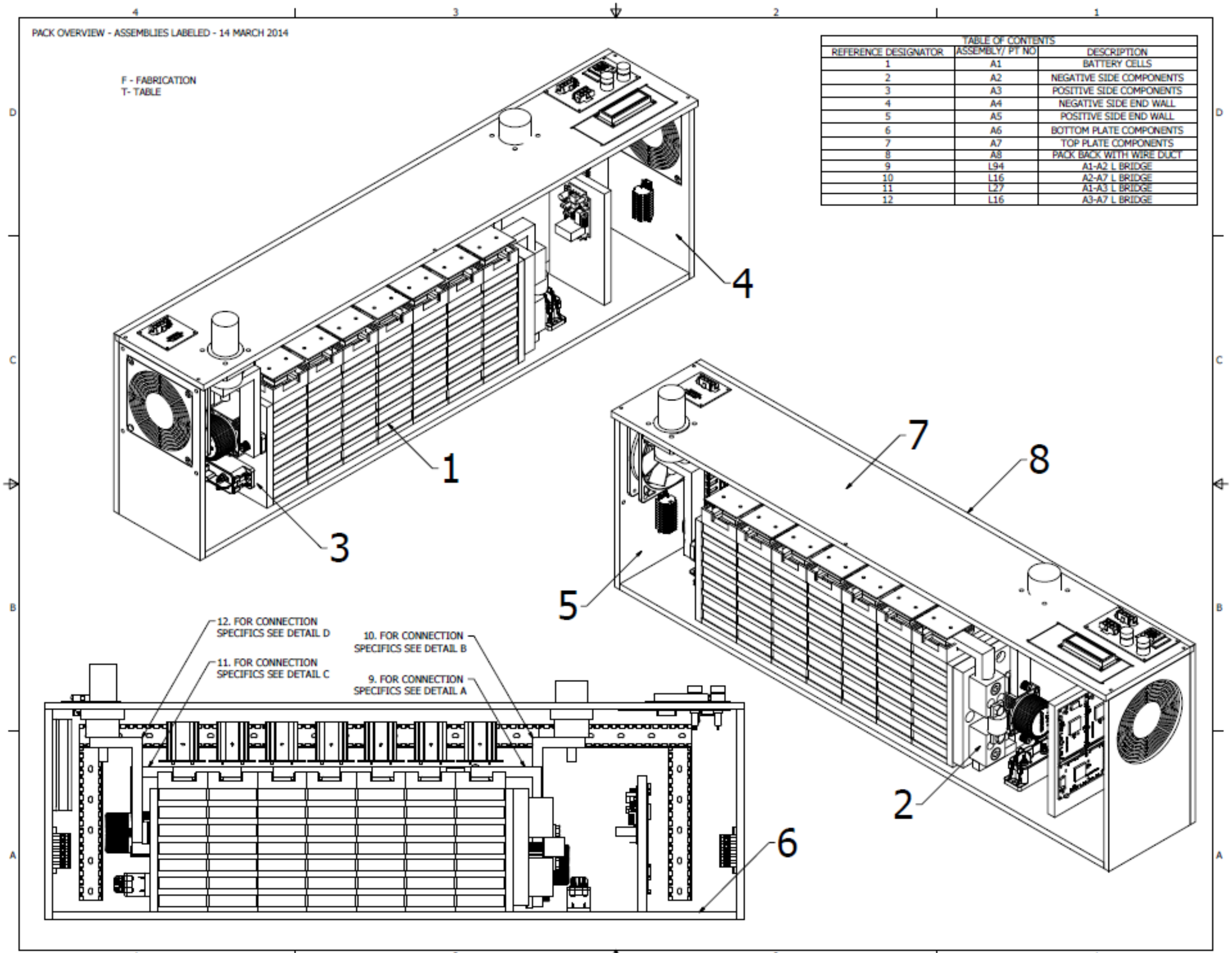
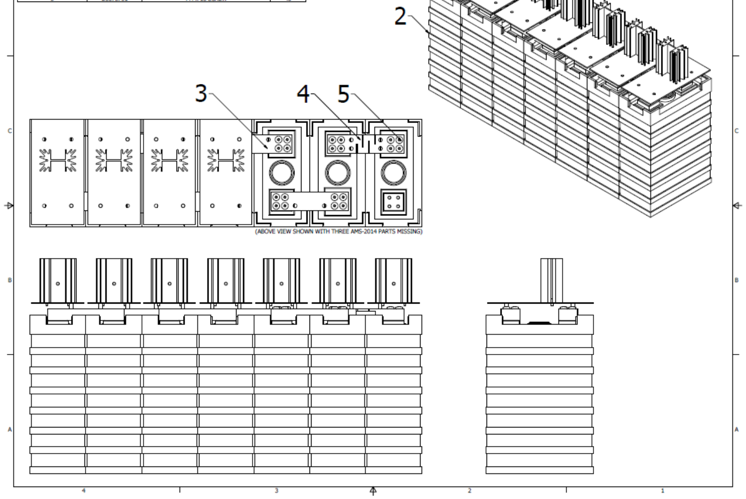


TABLE OF CONTENTS		
REFERENCE DESIGNATOR	ASSEMBLY/ PT NO	DESCRIPTION
1	A1	BATTERY CELLS
2	A2	NEGATIVE SIDE COMPONENTS
3	A3	POSITIVE SIDE COMPONENTS
4	A4	NEGATIVE SIDE END WALL
5	A5	POSITIVE SIDE END WALL
6	A6	BOTTOM PLATE COMPONENTS
7	A7	TOP PLATE COMPONENTS
8	A8	PACK BACK WITH WIRE DUCT
9	L94	A1-A2 L BRIDGE
10	L16	A2-A7 L BRIDGE
11	L27	A1-A3 L BRIDGE
12	L16	A3-A7 L BRIDGE

Assemblies 1-4

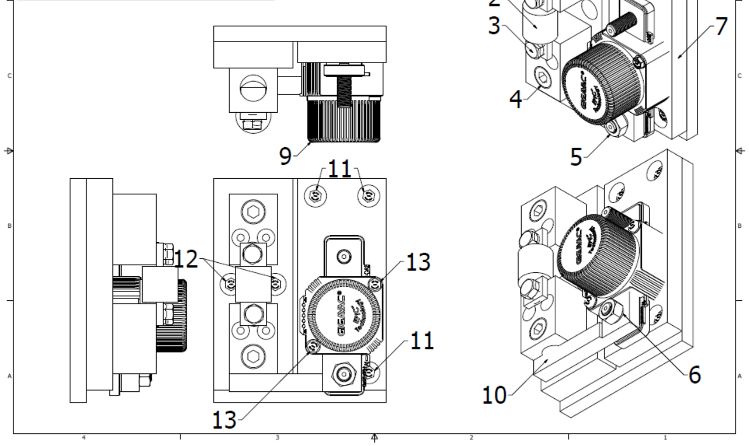
PACK OVERVIEW - ASSEMBLY 1
26 MARCH 2014

REFERENCE TABLE			
REFERENCE DESIGNATOR	ASSEMBLY/PART NO	DESCRIPTION	QUANTITY
1	AMS-2014	ACCUMULATOR MANAGEMENT SYSTEM BOARD	7
2	LFP-G60	BATTERY CELL	7
3	L49	BATTERY TERMINAL CONNECTORS	5
4	L50	BATTERMINAL U STRAP	1
5	D5875701	M4 x 18 SCREW	48



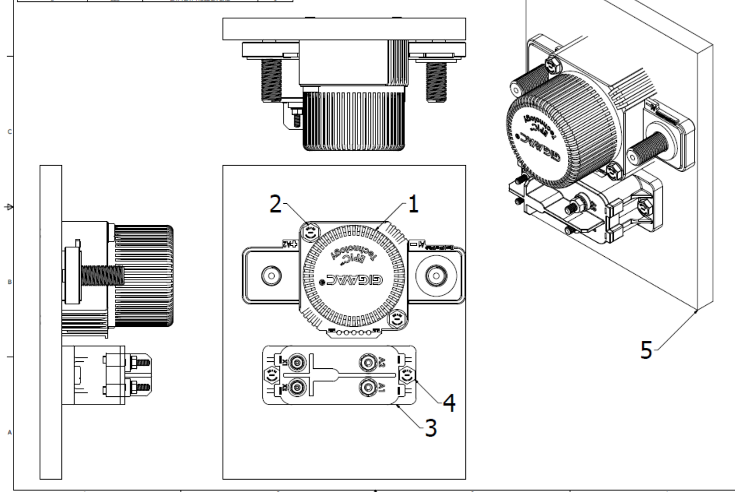
PACK OVERVIEW - ASSEMBLY 2
26 MARCH 2014

REFERENCE TABLE			
REFERENCE DESIGNATOR	ASSEMBLY/PART NO	DESCRIPTION	QUANTITY
1	G1878003	FUSE HOLDER	1
2	G3475534	FUSE	1
3		FUSE BOLT	2
4		FUSE CLAMP BOLT	1
5		FUSE AIR CONNECTOR BOLT	1
6		AIR SPLIT WASHER	1
7	L72	AIR SPACER	1
8	L23	BATTERY ENDS	1
9	GX14CB	AIR	1
10	L71	FUSE AIR CONNECTOR	1
11		AIR SPACER MOUNTING SCREWS	3
12		FUSE HOLDER MOUNTING SCREWS	2
13		AIR MOUNTING SCREWS	2



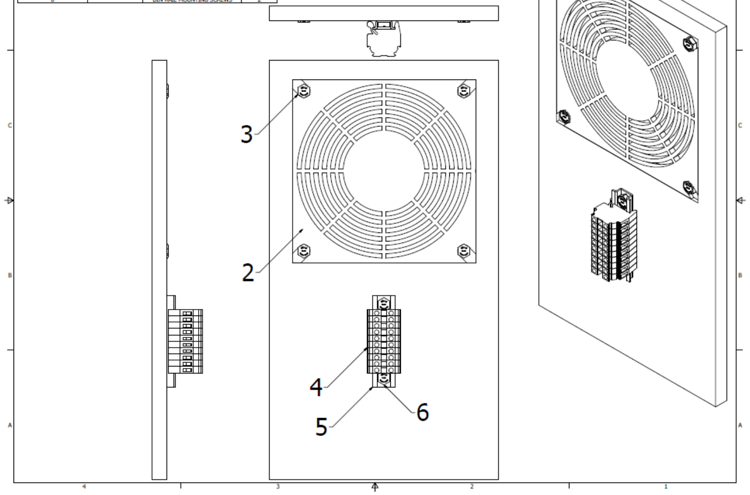
PACK OVERVIEW - ASSEMBLY 3
26 MARCH 2014

REFERENCE TABLE			
REFERENCE DESIGNATOR	ASSEMBLY/PART NO	DESCRIPTION	QUANTITY
1	GX14CB	AIR	1
2		AIR MOUNTING SCREWS	2
3	P105CDA	CHARGING RELAY	1
4		CHARGING RELAY MOUNTING SCREWS	2
5	L23	BATTERY HOLDER END	1

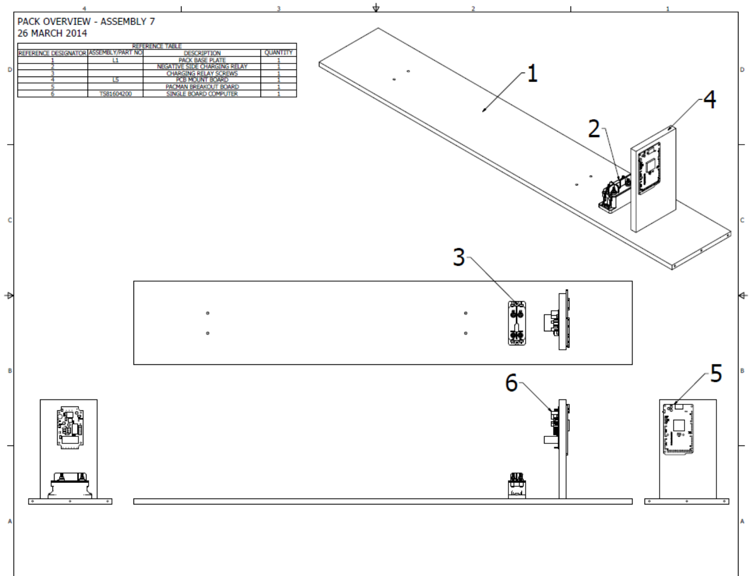


PACK OVERVIEW - ASSEMBLY 4
26 MARCH 2014

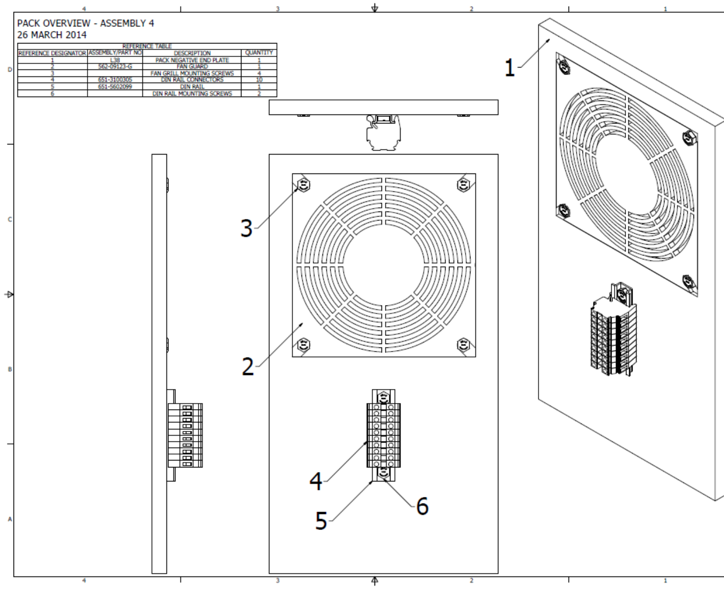
REFERENCE TABLE			
REFERENCE DESIGNATOR	ASSEMBLY/PART NO	DESCRIPTION	QUANTITY
1	L38	PACK NEGATIVE END PLATE	1
2	562-09123-G	FAN GUARD	1
3		FAN GRILL MOUNTING SCREWS	4
4	651-3100305	DIN RAIL CONNECTORS	10
5	651-5602099	DIN RAIL	1
6		DIN RAIL MOUNTING SCREWS	2



Assemblies 5-8



REFERENCE TABLE			
REFERENCE DESIGNATOR	ASSEMBLY/PART NO	DESCRIPTION	QUANTITY
1	L1	PACK BASE PLATE	1
2		NEGATIVE SIDE CHARGING RELAY	1
3		CHARGING RELAY SCREWS	1
4	L5	PCB MOUNT BOARD	1
5		PACMAN BREAKOUT BOARD	1
6	TS81604200	SINGLE BOARD COMPUTER	1



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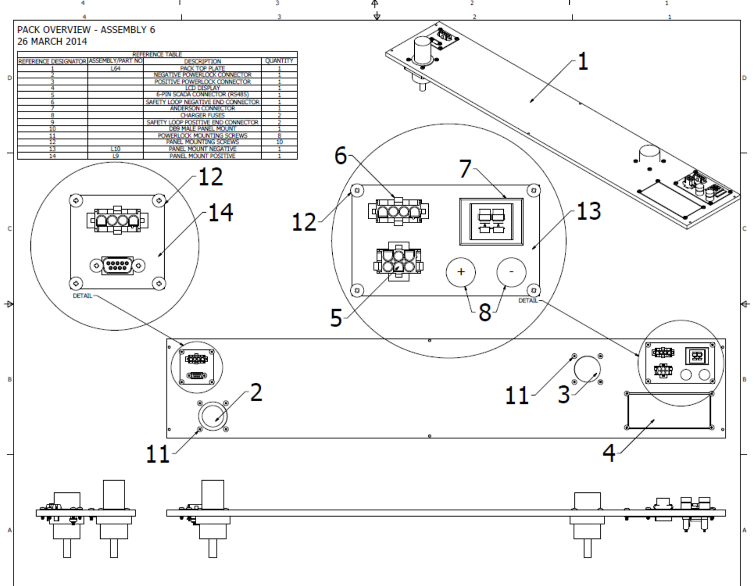
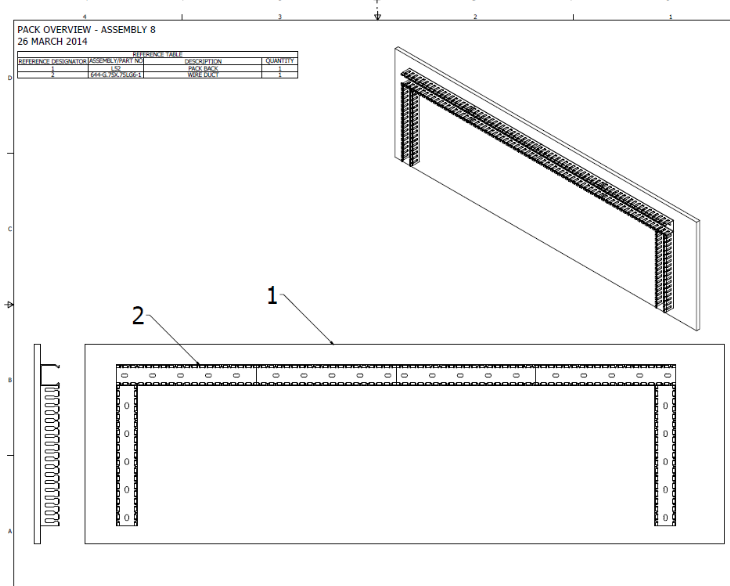


REFERENCE TABLE			
REFERENCE DESIGNATOR	ASSEMBLY/PART NO	DESCRIPTION	QUANTITY
1	L64	PACK TOP PLATE	1
2		NEGATIVE POWERLOCK CONNECTOR	1
3		POSITIVE POWERLOCK CONNECTOR	1
4		LCD DISPLAY	1
5		6-PIN SCADA CONNECTOR (RS485)	1
6		SAFETY LOOP NEGATIVE END CONNECTOR	1
7		ANDERSON CONNECTOR	1
8		CHARGER FUSES	2
9		SAFETY LOOP POSITIVE END CONNECTOR	2
10		DB9 MALE PANEL MOUNT	1
11		POWERLOCK MOUNTING SCREWS	8
12		PANEL MOUNTING SCREWS	10
13	L10	PANEL MOUNT NEGATIVE	1
14	L9	PANEL MOUNT POSITIVE	1



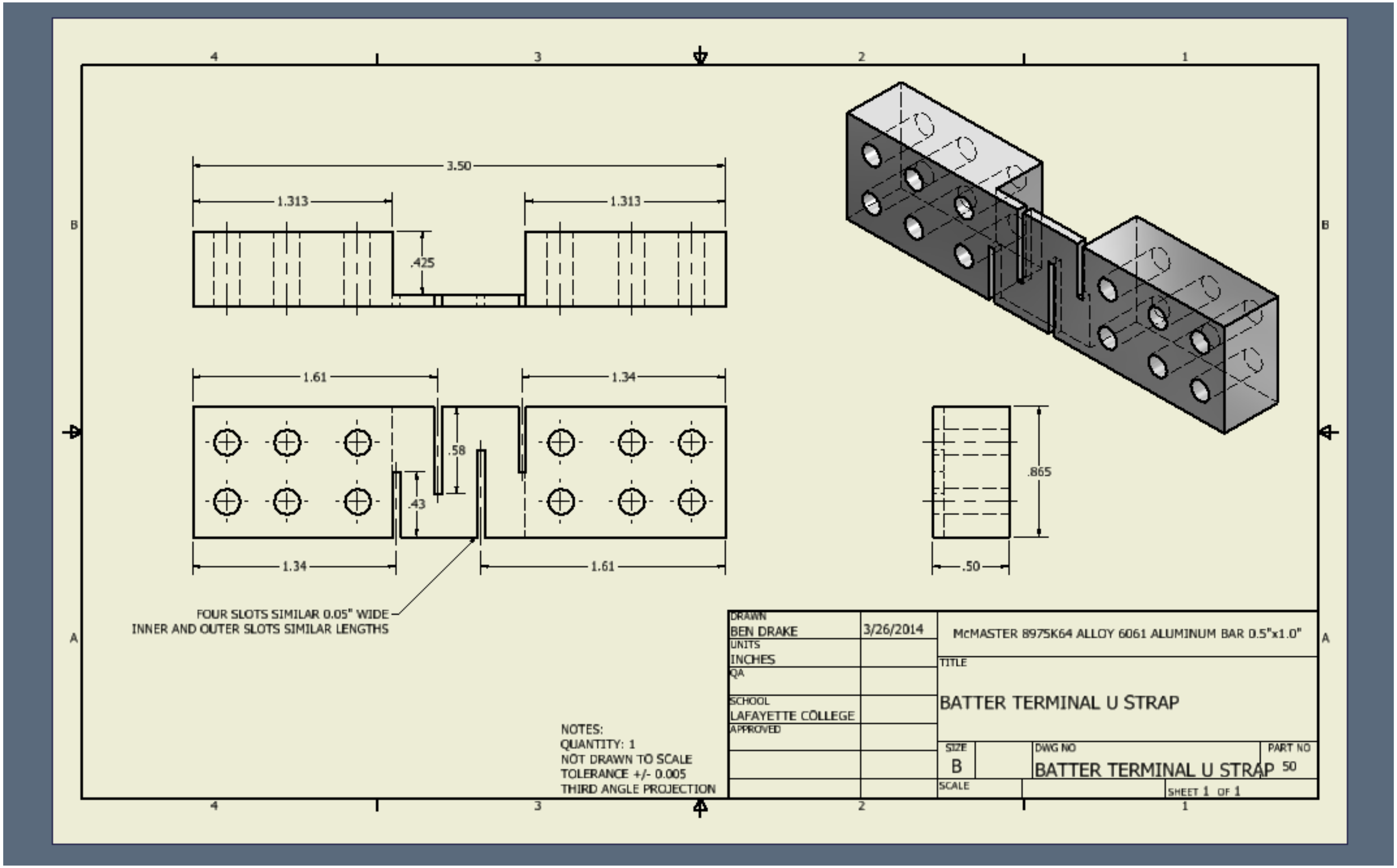
REFERENCE TABLE			
REFERENCE DESIGNATOR	ASSEMBLY/PART NO	DESCRIPTION	QUANTITY
1	L52	PACK BACK	1
2	644-G.75X.75LG6-1	WIRE DUCT	1

Pack Construction

Movies on website

http://sites.lafayette.edu/ece492-sp14/system-design/pack-mechanical/

Current Monitoring Shunt



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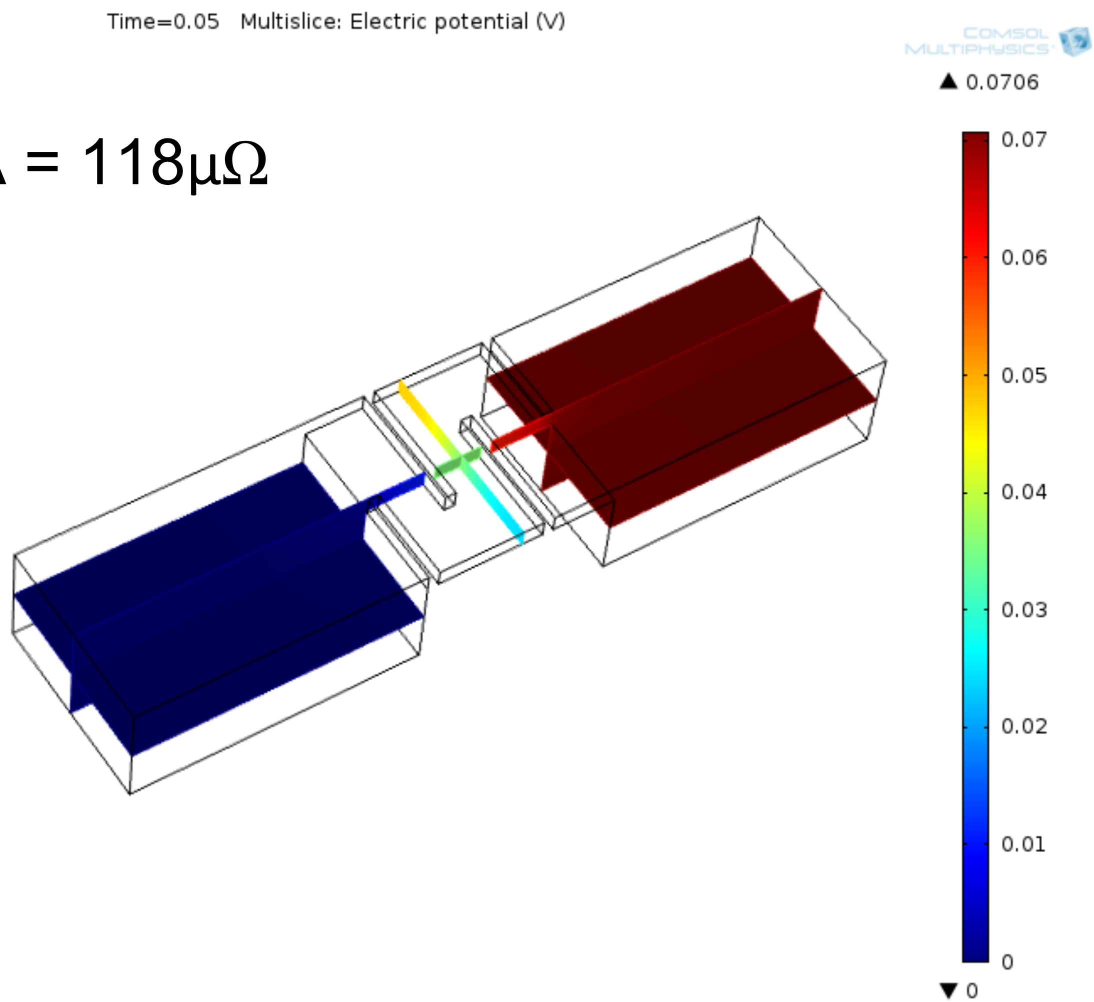
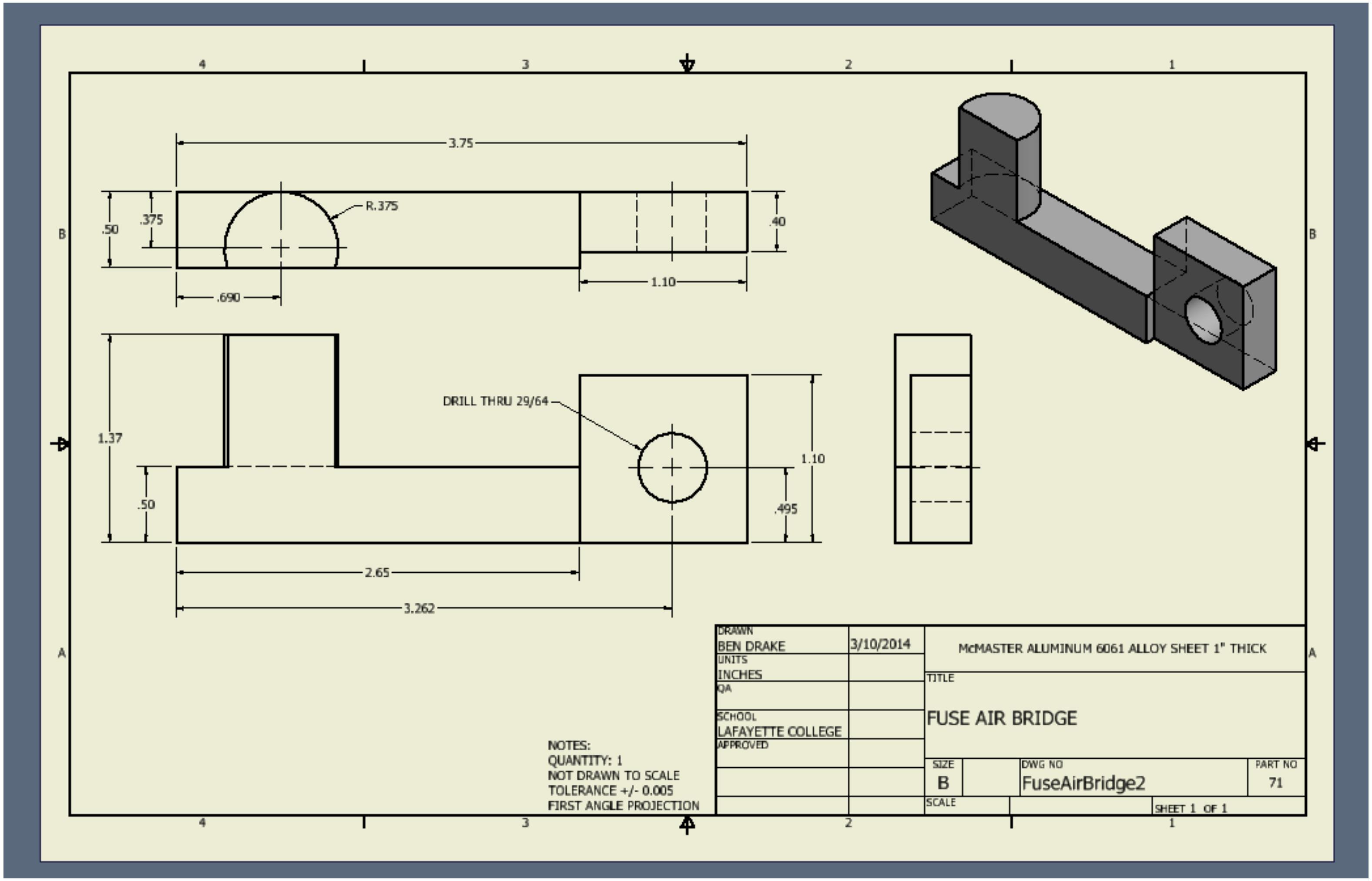
Current Monitoring Shunt

.0706V / 600A = 118μΩ



Fuse to AIR Bridge



2014 Improvements

- Reduced overall length of pack
- Added fan for cooling while charging
- Added wire duct to keep wires neat
- Added charging relays
- Added LCD to display pack information
- More robust SCADA connector
- Subassemblies for connectors
- Lower Resistance of Current Path
  - Reduce number of mating surfaces
    - 4 Bolted joints
    - 1 Press-fit joint

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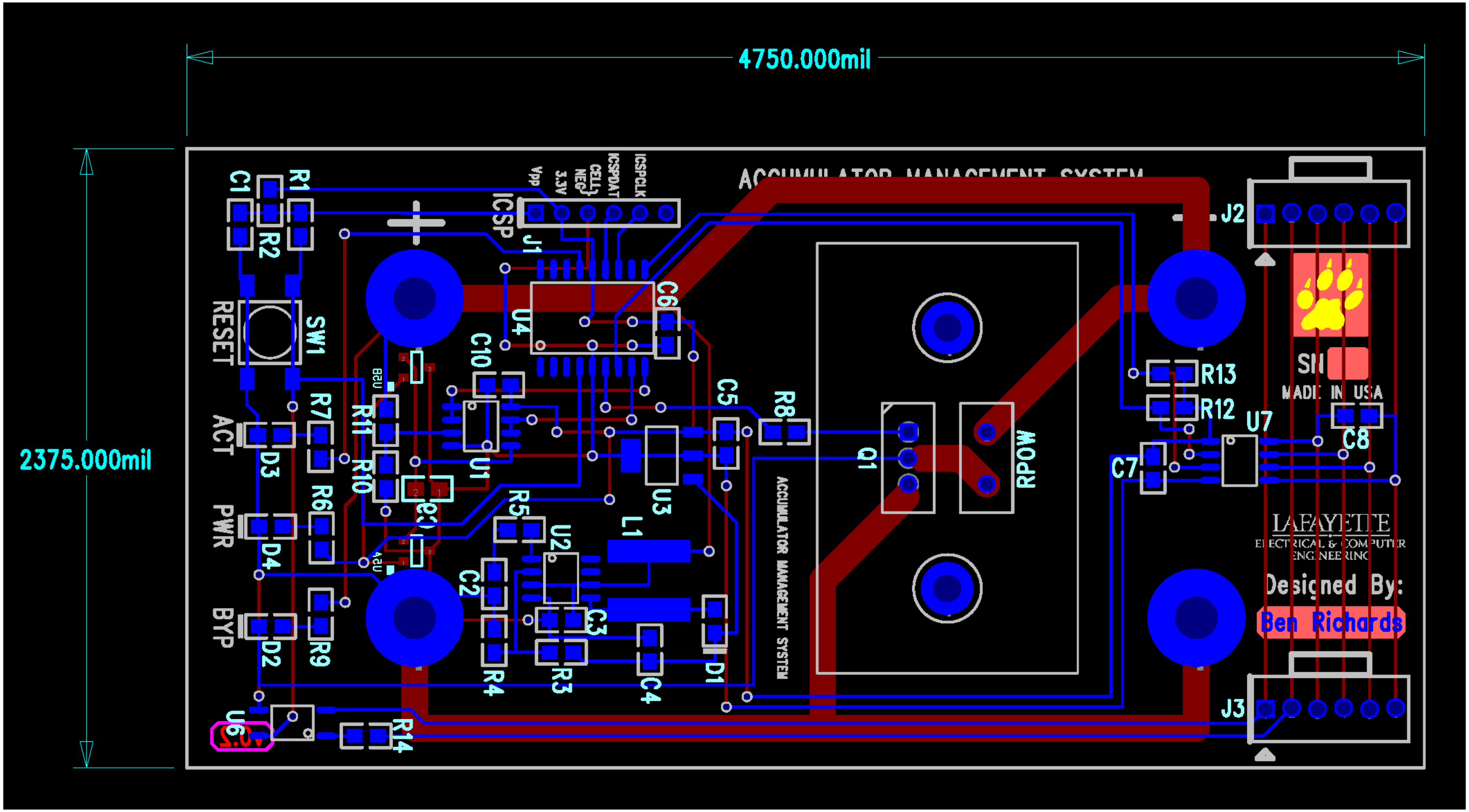
AMS - Function

- Monitor cell parameters
  - Voltage
  - Temperature
- Activate bypass circuit
  - Bypass timeout
- Communicate with PacMan via I2C

AMS - PADS PCB Layout



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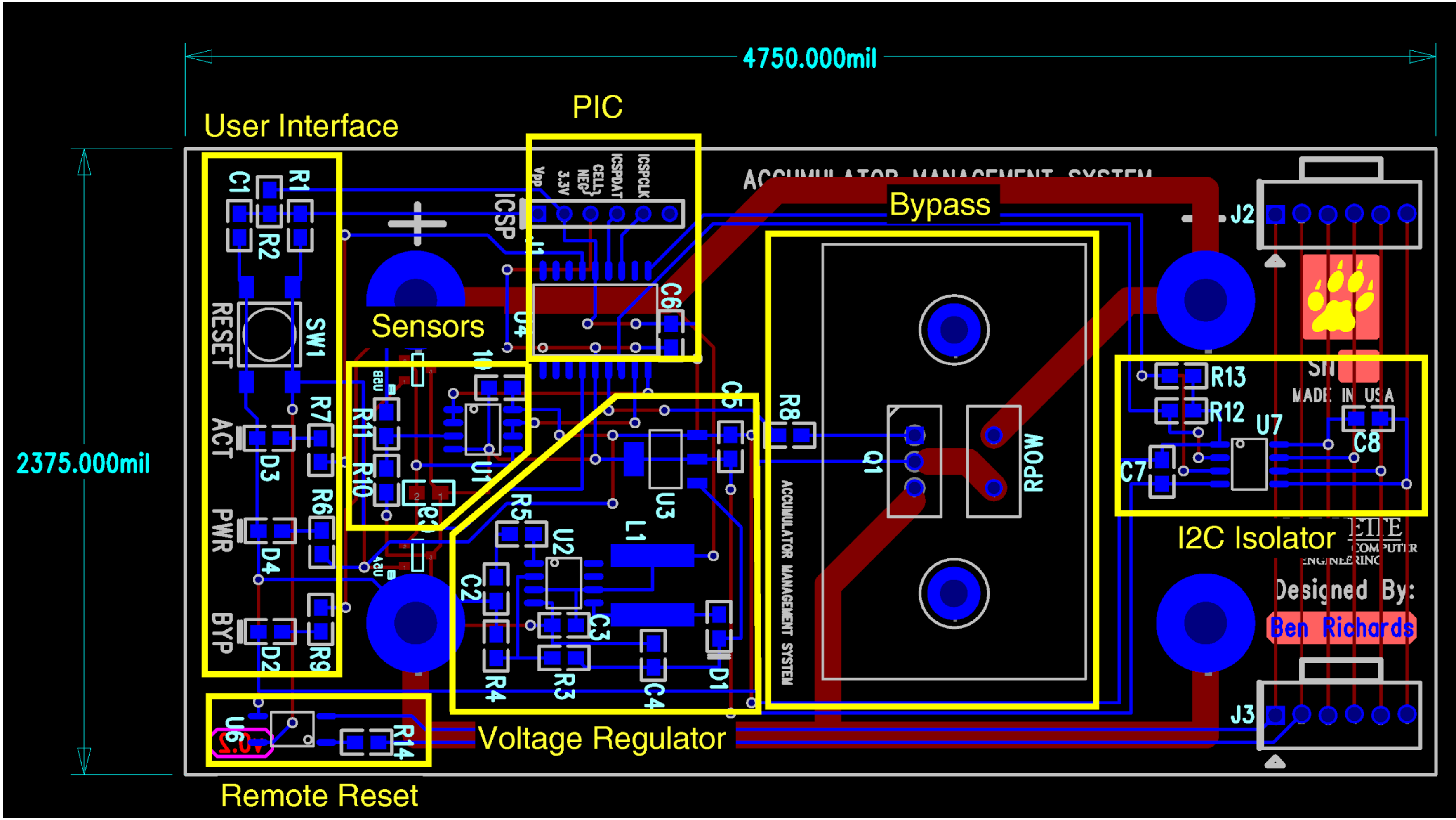

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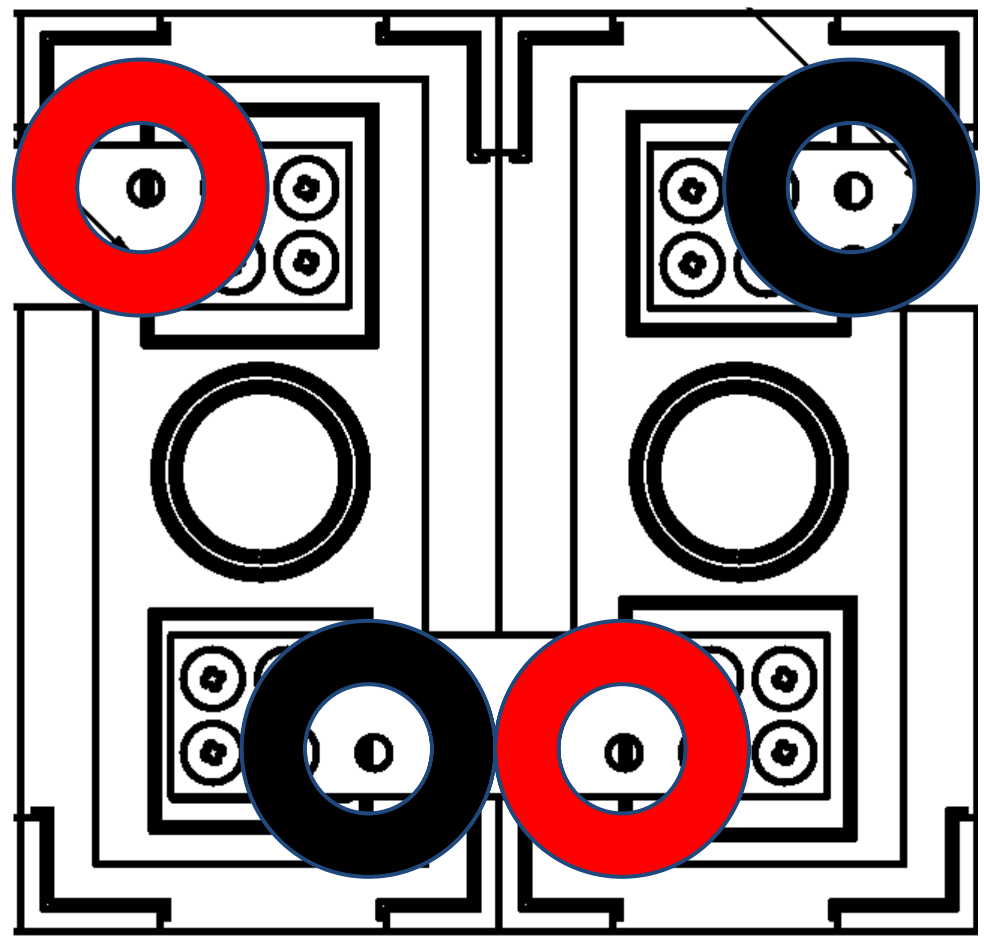
AMS - Key Improvements

- Two physical mounting configurations
- One-piece PCB-mount heatsink
- Simplified cell voltage measurement
- Added remote reset capability
- Current-sensing relocated to PacMan

AMS - Cell Mounting

- Boards face same direction
- + / - terminals alternate

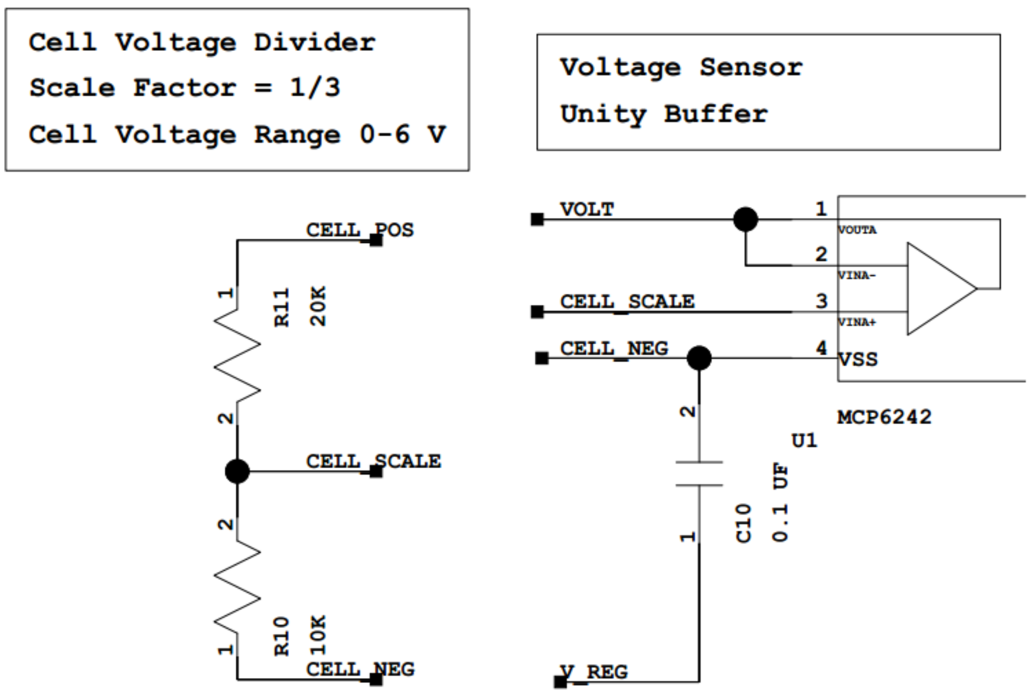


AMS - Bypass/Heatsink

- Bypass Circuit
  - Balance cells during charging
  - Constant 3A bypass when active
- Heatsink selection
  - One-piece, board-mount
  - Mounts both resistor and transistor
- Heatsink Performance
  - 3.5°C/W @ 100 LFPM
  - 10.2W Power Dissipation at 3.65V
  - 36°C Rise

AMS - Cell Voltage

- Maximum PIC A/D input: 2.048V
- Sense circuit:
  - 3:1 resistor divider into unity buffer
  - Allows 0-6V sense range



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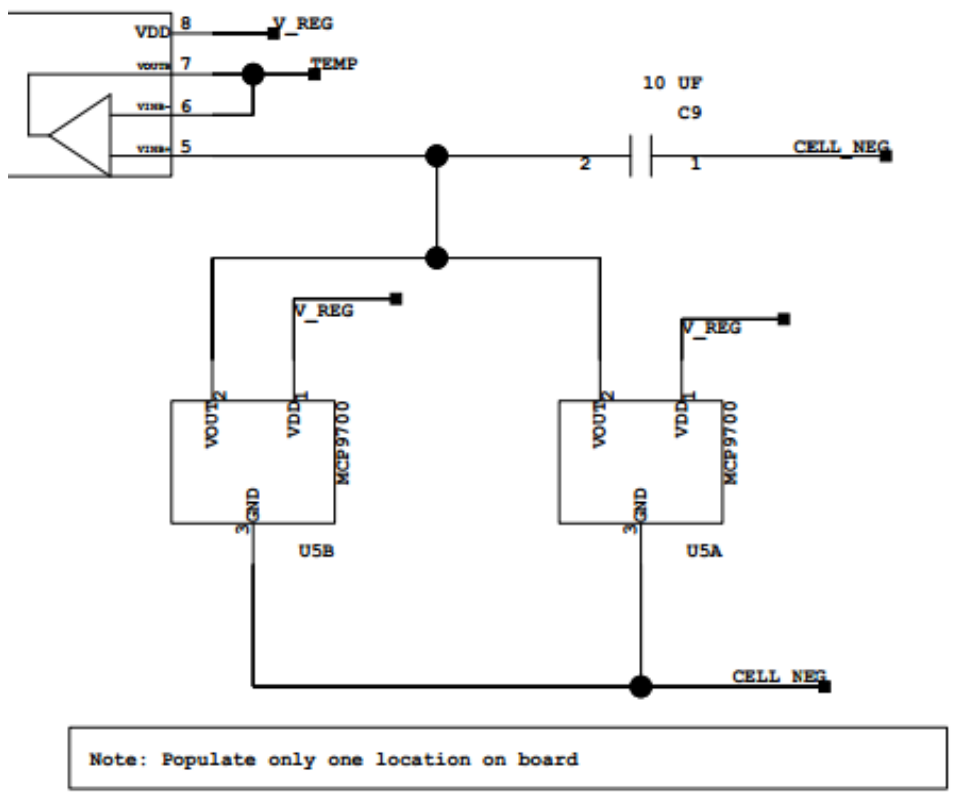
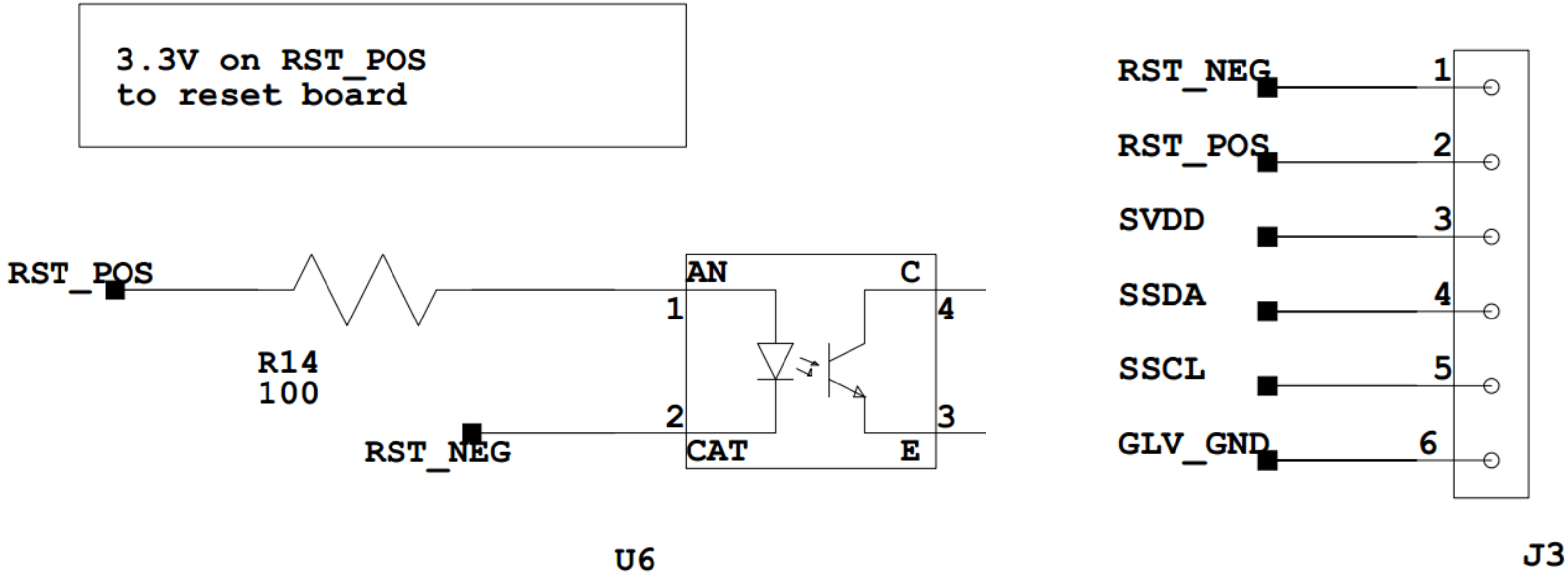
AMS - Temperature

- Added duplicate mounting pad
- MCP9700 output connects directly to PIC
- -50 to +150°C range (limited by PIC)



AMS - Remote Reset

- Reset action duplicated
  - PacMan can reset AMS boards if necessary
  - Optoisolator to address ground reference
  - Activated by 3.3V on pins 1 and 2 of J2/J3



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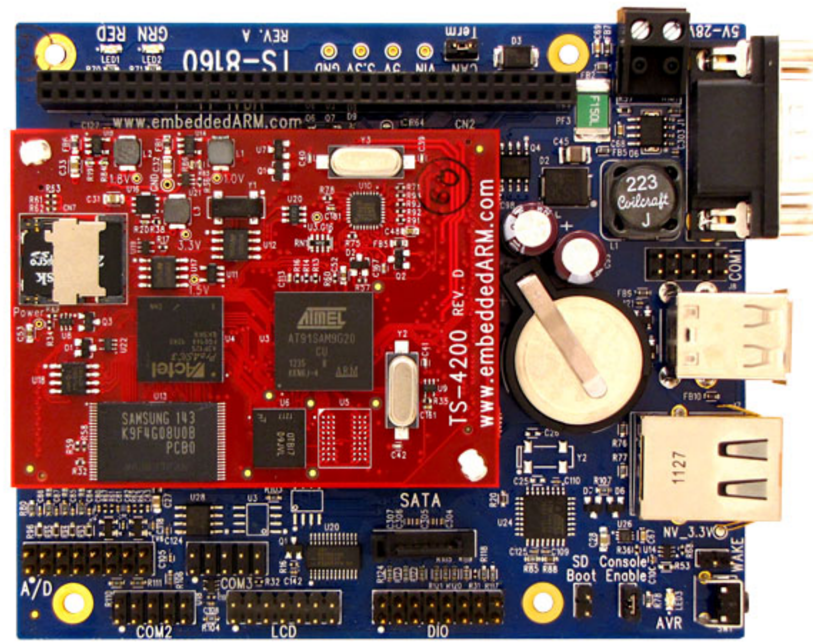
PACK MANAGER (PACMAN)

New in-pack component: PacMan

- Aggregate OBPC-AMS sensor data
- Monitor pack voltage, etc.
- Operate safety loop
- Display pack status and parameters
- Communicate with central SCADA
- Support pack charging

PacMan Controller Choice

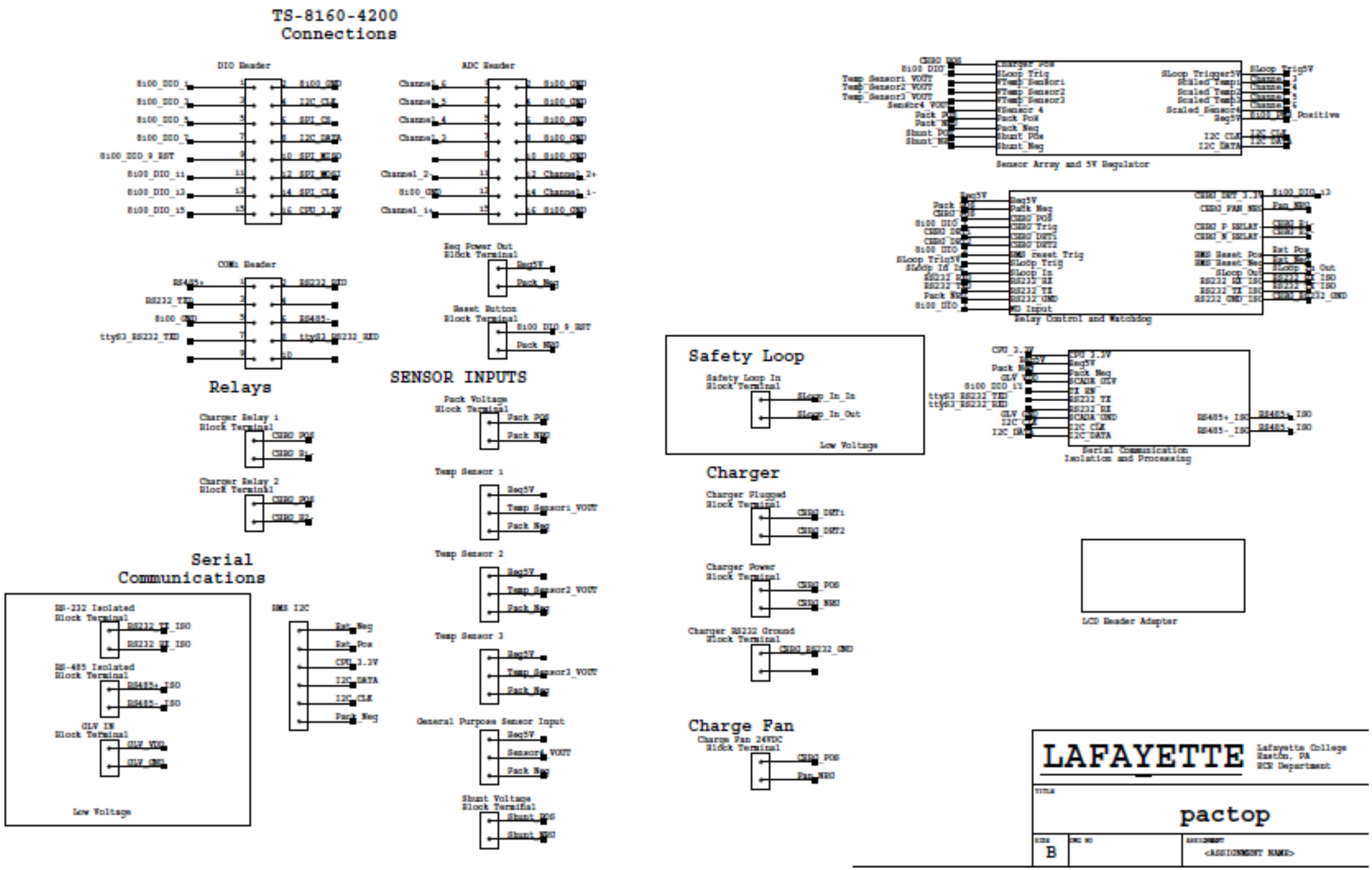
TS-8160-4200



Considerations:

- I/O capability (analog/digital) - 8 DIO, 6 ADC, LCD Header, COM Port
- Power Consumption - Around 0.7W
- Dev Environment - Debian Linux
- Communication - RS-232, I2C, RS-485

PacMan Breakout Board

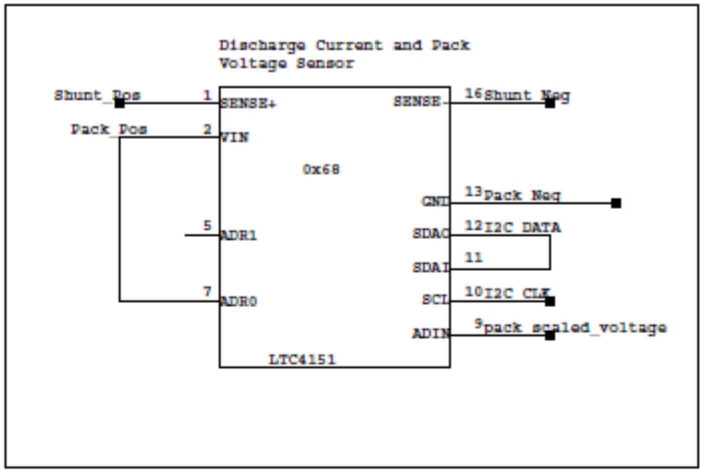


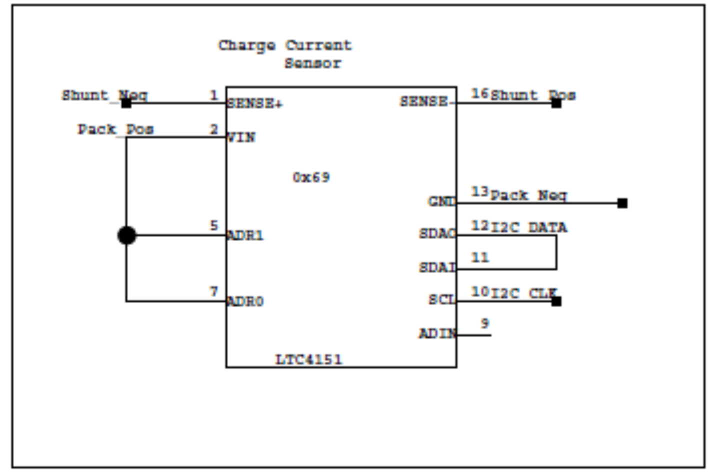
PacMan Breakout Board

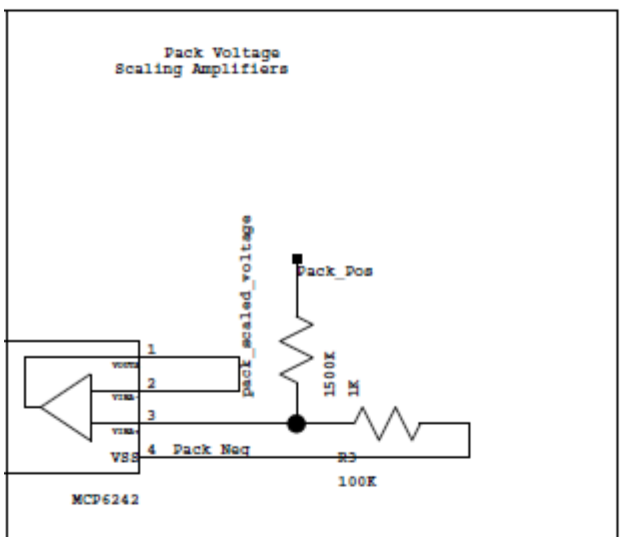
Main functions:

- Contains components for current measurement, fuse temperature measurement, and total battery voltage monitoring.
- Connect TS-8160-4200 to relays and AMS boards
- House external watchdog chip
- Provide Galvanic isolation for external communication ports

PacMan Breakout Board - Sensor Array







- 2 LTC4151 used for current sensing across shunt resistance
  - Discharge
  - Charge
- 1 of the LTC4151 used to measure total pack voltage
  - Scaled down by a factor of 16 for ADIN input (2.048V tolerance)
- 4 General Purpose Sensor inputs to TS-8160-4200 built-in ADCs

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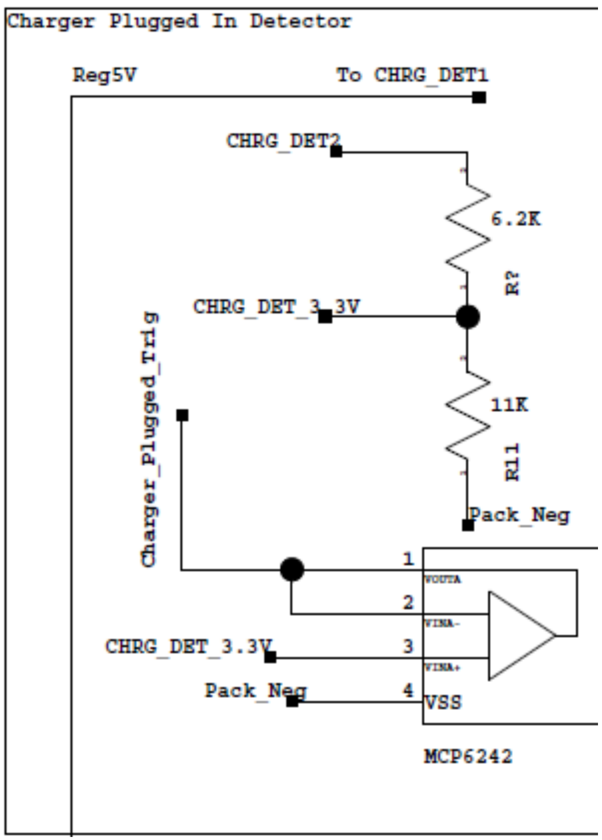
PacMan Breakout Board - Relay Control

- 3 Main Controls
  - Charging Relays
  - Charger Communication Relay
  - Safety Loop Relay

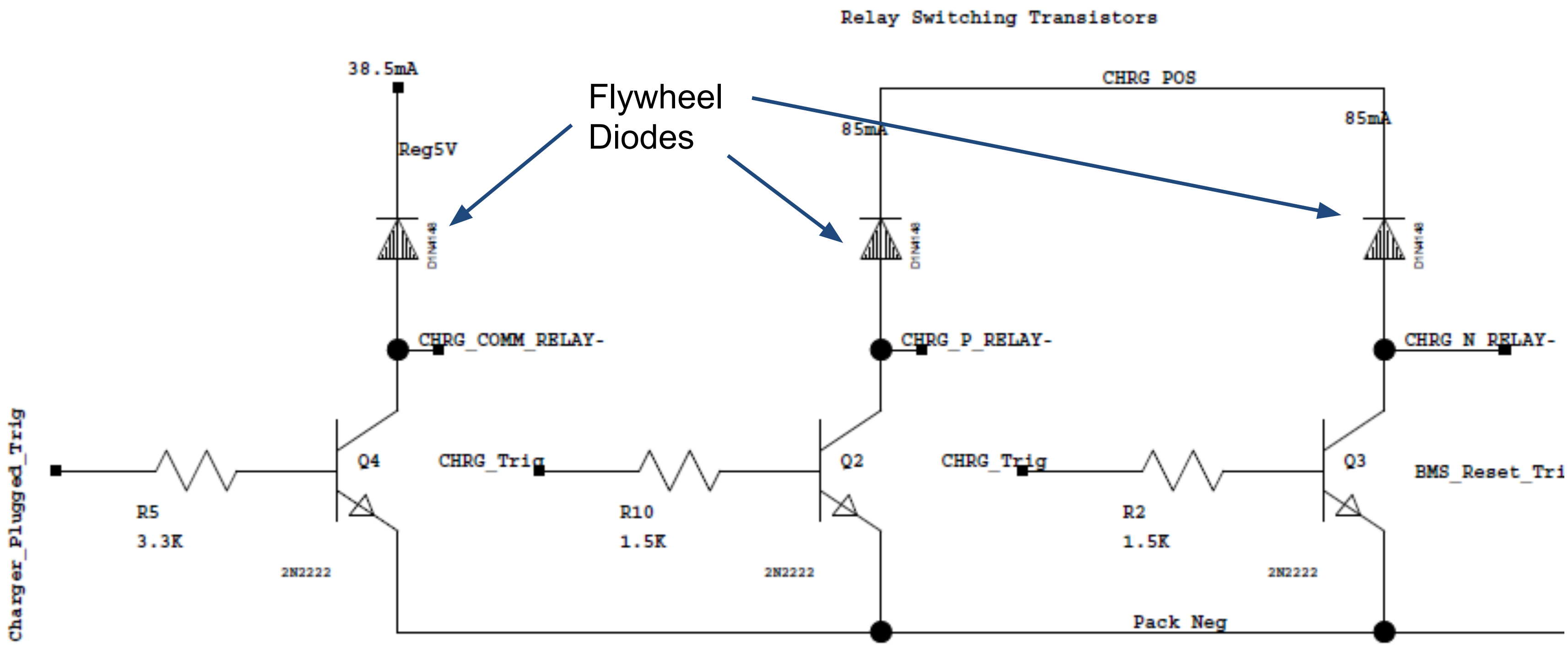
PacMan Breakout Board - Charger Interaction

- Charger Plugged in creates electrical connection between CHRG_DET1 and CHRG_DET2, pulling DIO pin 13 high
- TS-8160-4200 can determine when the charger is physically plugged in by polling this pin's input



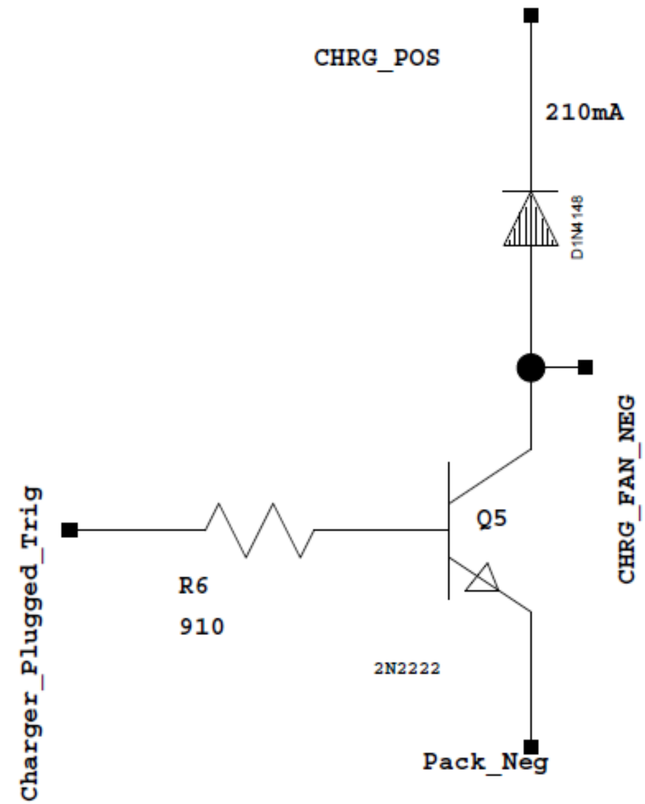
PacMan Breakout Board - Charger Interaction

- Charger Relays - Controlled by DIO Pin 1
- Communications Relay - Controlled by physical charger detection



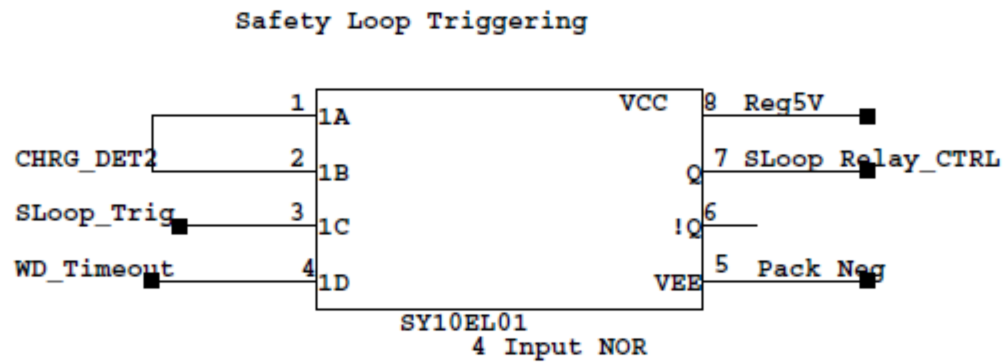
PacMan Breakout Board - Charger Interaction

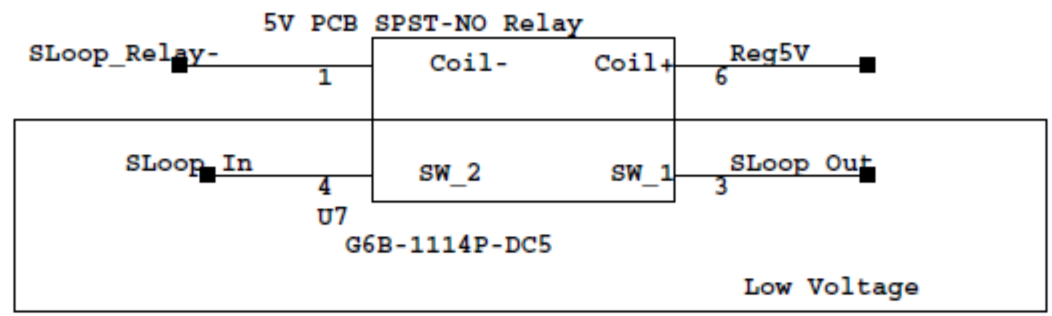
- Cooling Fan
  - Activated whenever charger plugged in
  - Ebm-papst 4414F
    - 24VDC 5W
    - 2900 RPM



PacMan Breakout Board - Safety Loop Relay

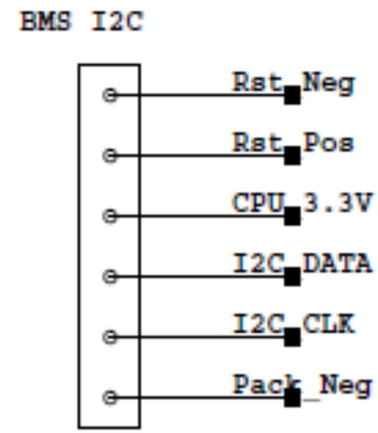
- Safety Loop can be opened in 3 ways by PM
  - DIO Pin 5
  - Watchdog Timeout
  - Charger Detection

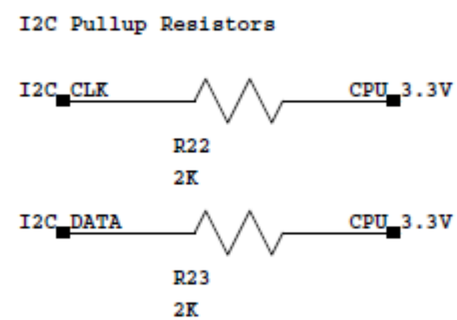


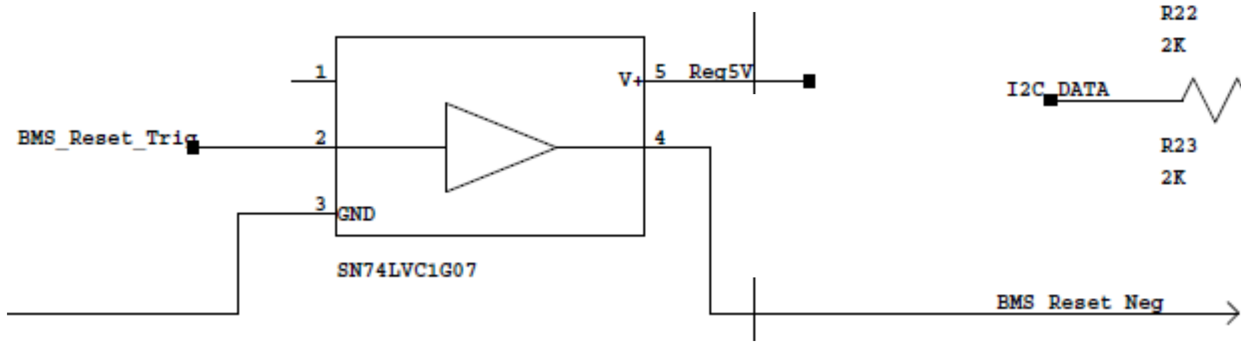


PacMan Breakout Board - AMS I2C

- I2C from AMS isolated, so pull-up resistors needed
- PM can reset AMS board hardware remotely by using DIO Pin 3







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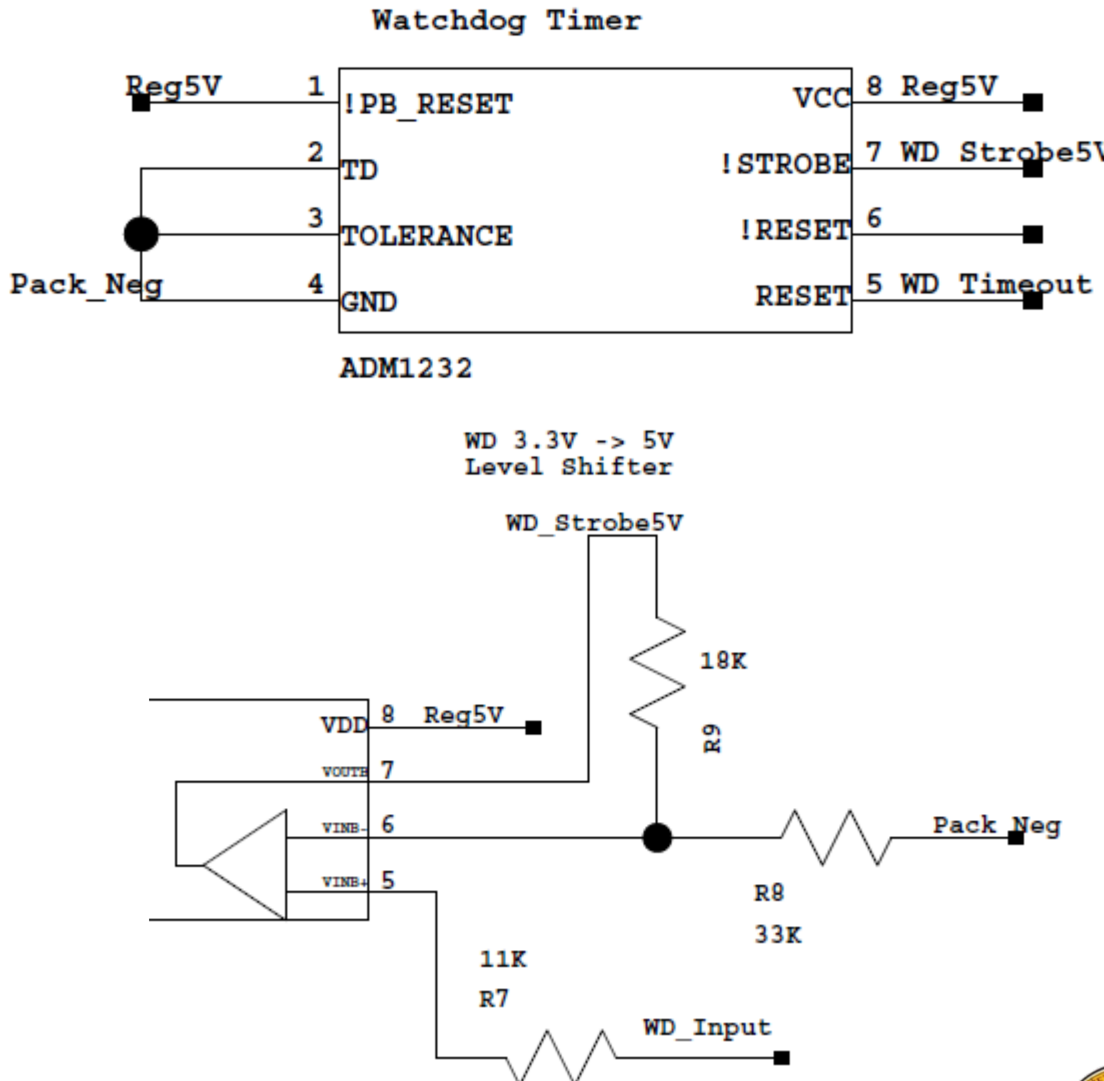
PacMan Breakout Board - Watchdog IC

- Watchdog Feed by DIO Pin 7
- 3.3->5V level shifter for DIO pin to watchdog input
- Upon timeout, SL opens



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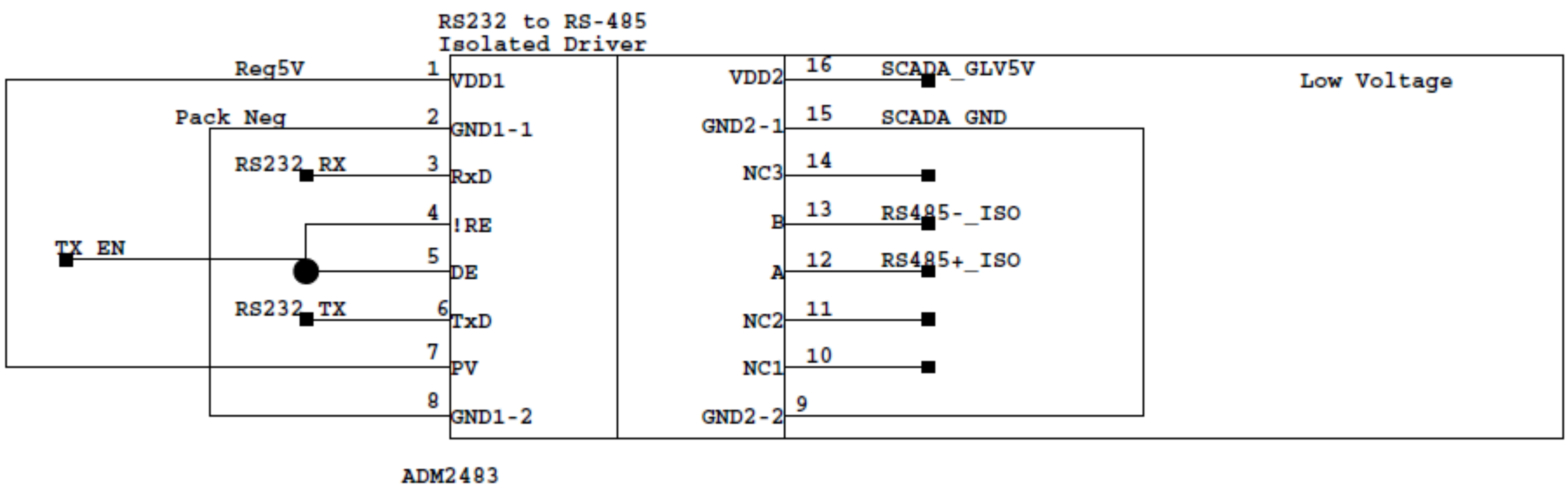
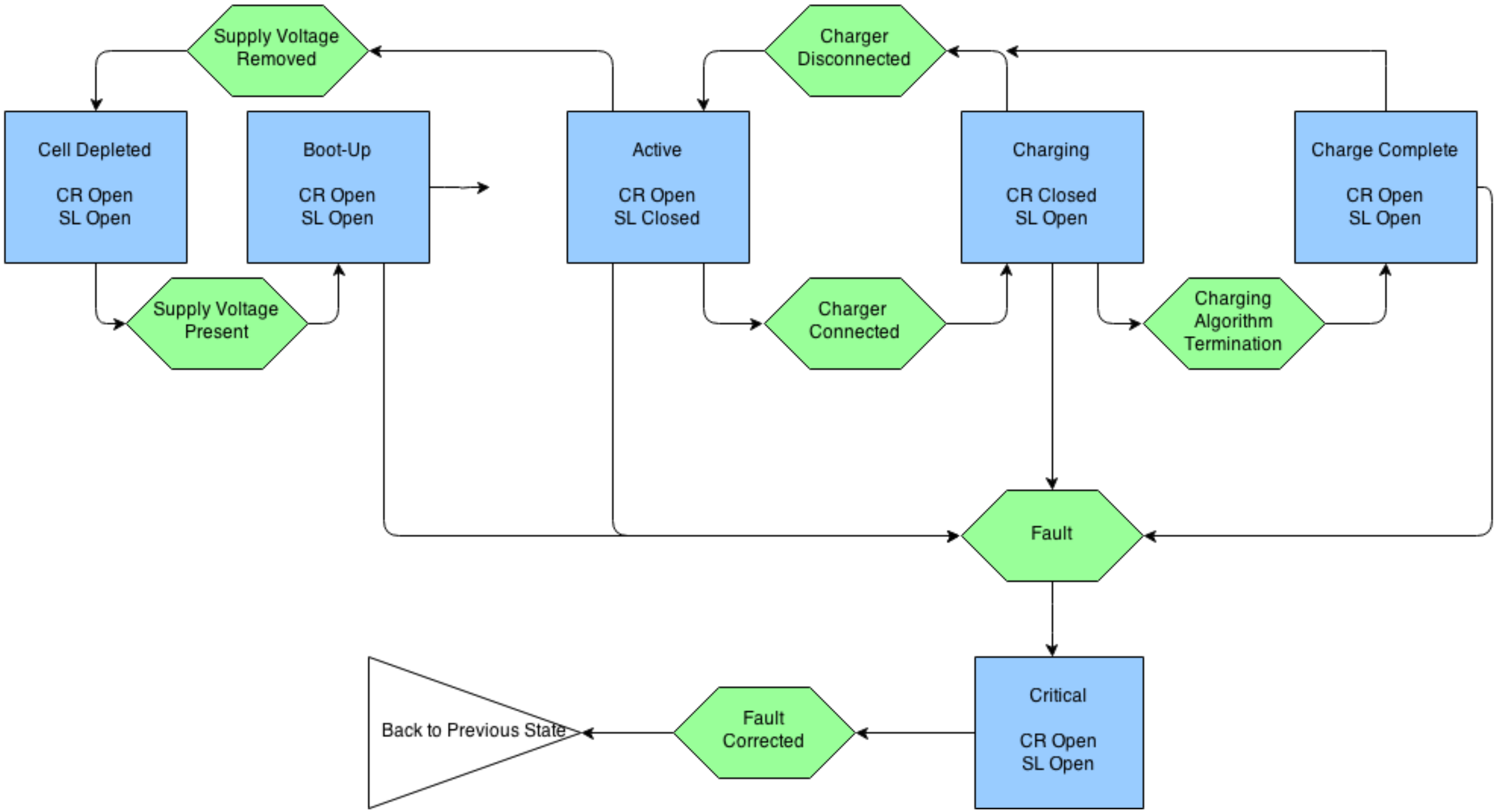
PacMan Breakout Board - Comm Isolation

- RS232 Port used on TS-8160-4200 side
- Feed into Isolated RS-485 driver
- Powered by GLV on isolated side
- TX_EN driven by DIO Pin 11



TOP-LEVEL STATE DIAGRAM



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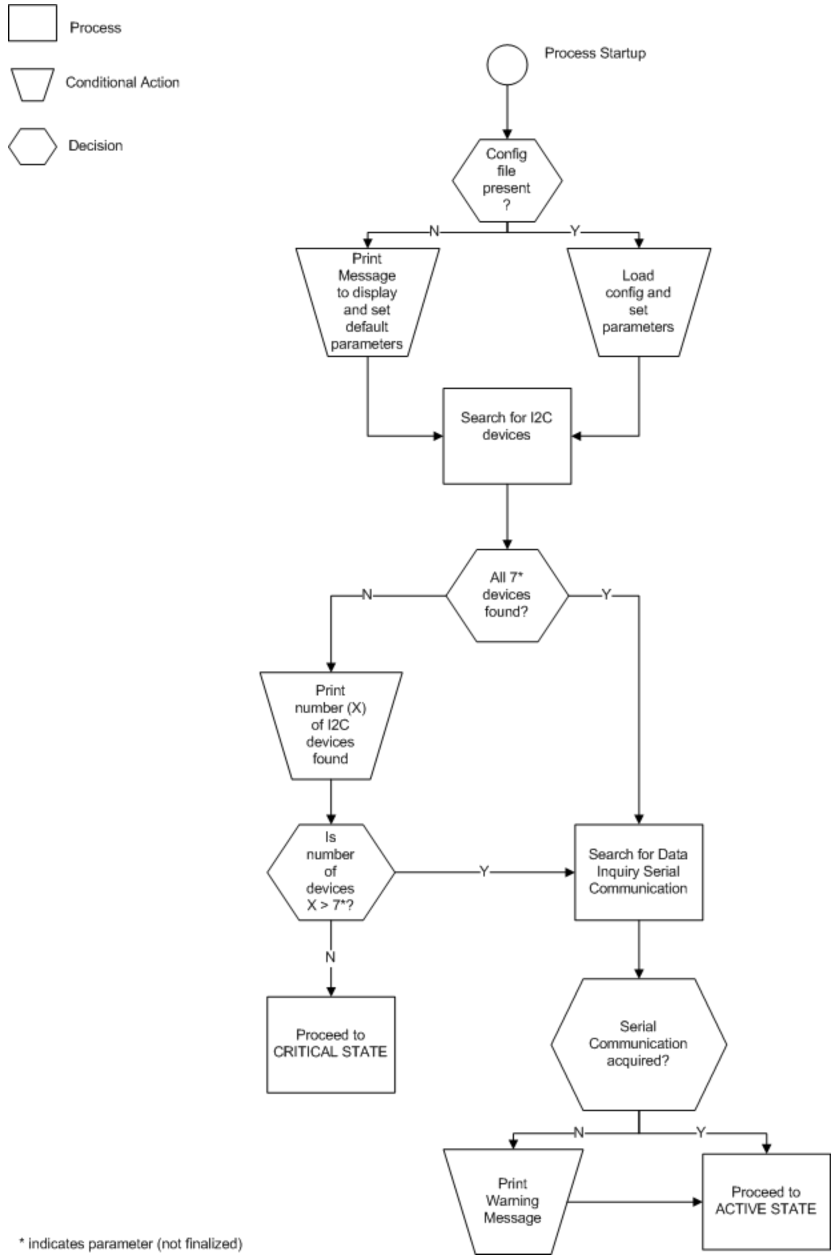
PacMan States -Boot-up



* indicates parameter (not finalized)

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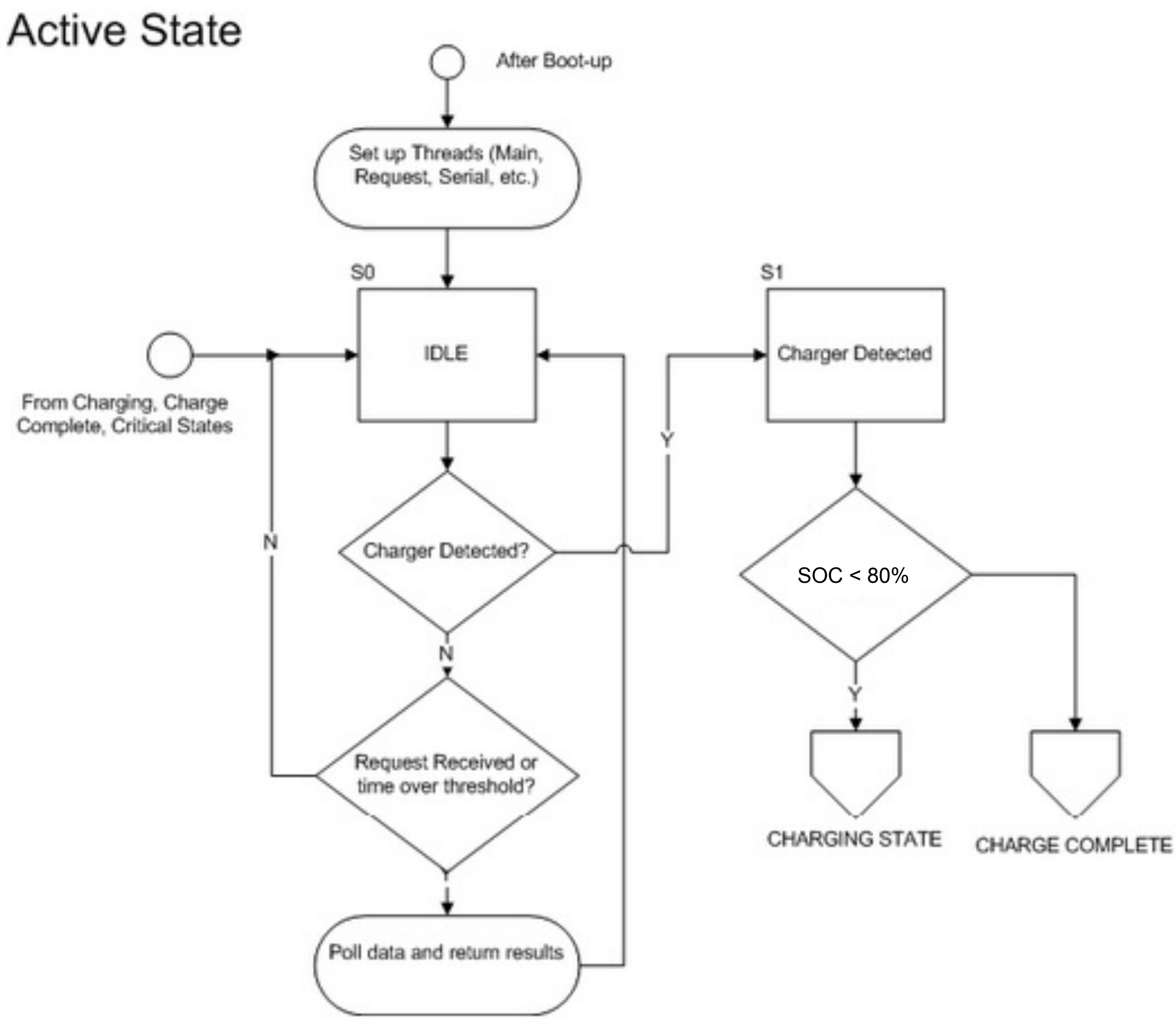
PacMan States - Active



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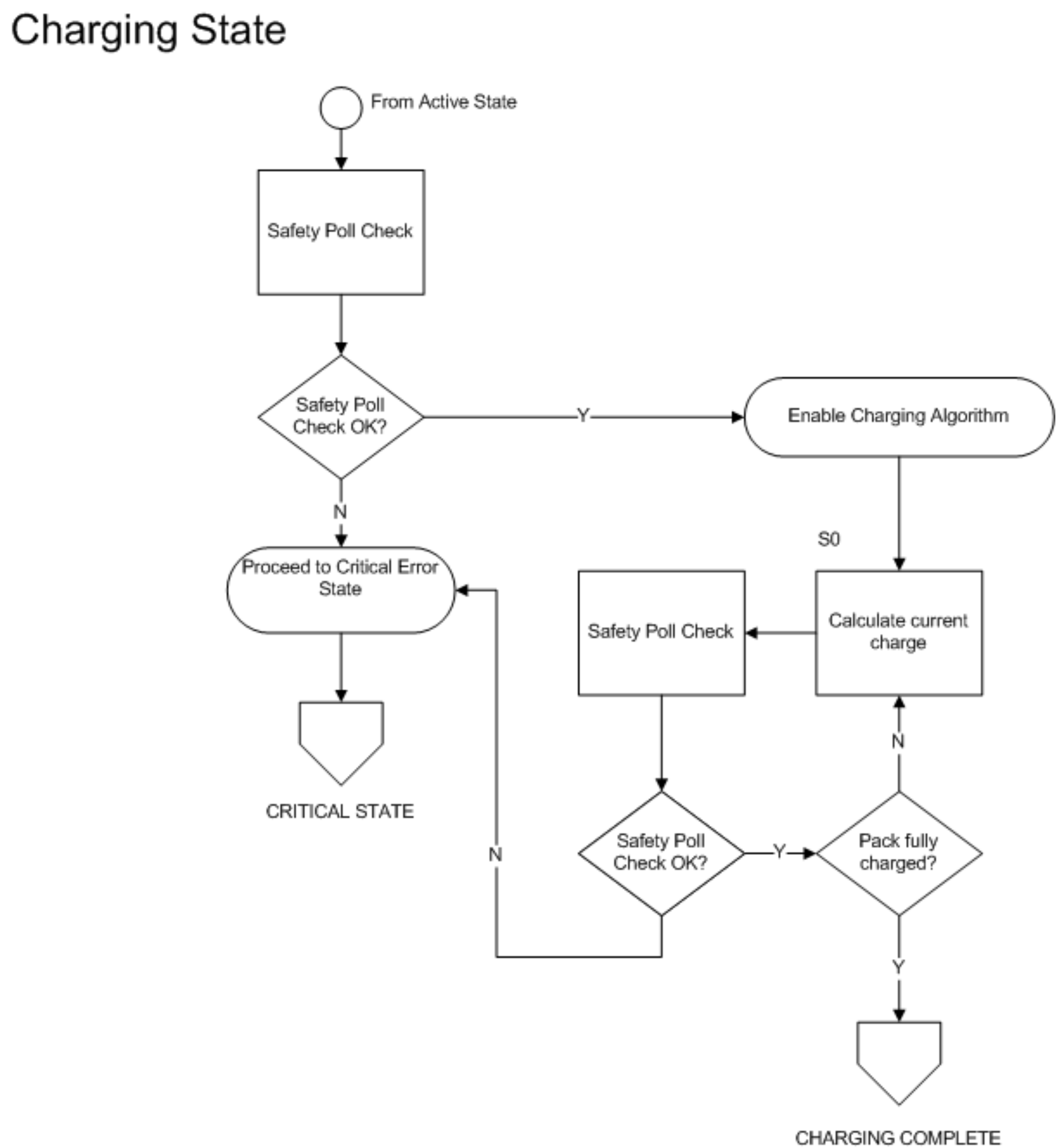
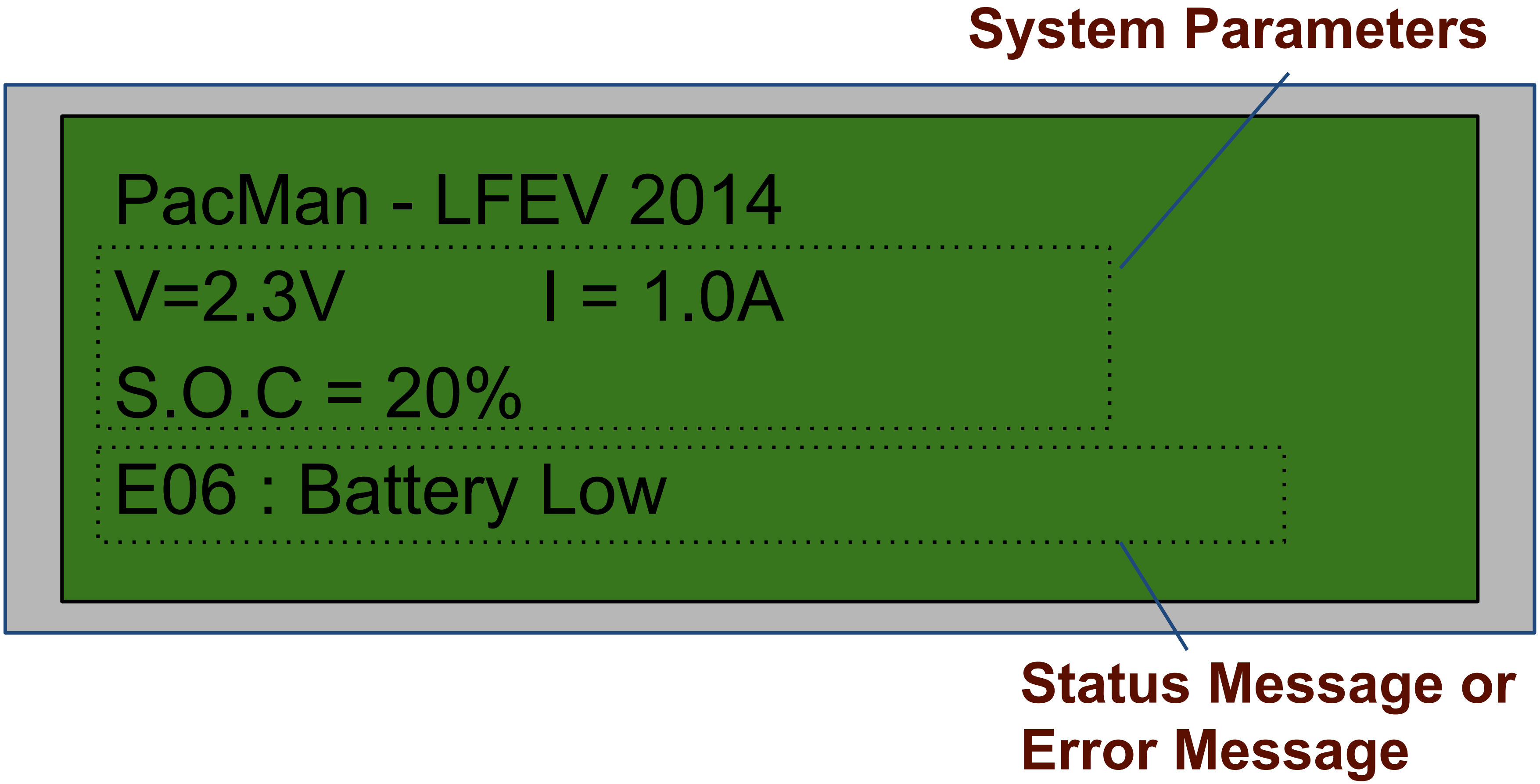
PacMan States - Charging



PacMan LCD Display



ROADMAP

- Introduction
- 2014 Deliverables
- System Design
  - Pack Mechanical
  - AMS
  - PacMan
  - **Charger**
  - Motor/MCS
  - Software
- ATP
- Budget
- Schedule

Charger

- "Smart Pack, Dumb Charger" model
    - Support Plug 'n Forget operation
    - No manual configuration
- Charge algorithm integrated into PacMan

Charger - TDK-Lambda GENH30-25

- Better not to build a "box"
  - Size
  - UL listing (EV8.2.11)
- 25A charge current
  - Manuf. recommended 0.3-0.8C charge current
  - 2.5 hours for full charge
- Programmable via serial link
  - Pack can adjust parameters
- Pigtail connection (Anderson PowerPole)
  - Combine signals into one cable/connector
  - Eliminate hassle of bolted terminals

Charging Algorithm

- Constant-current, voltage termination
- Li Cells Require Balancing
  - Dissipative balancing
  - Charging cycle only
- Activating bypass
  - delta-V threshold between cells
    - Absolute voltage depends on many things
    - Varies widely across cells
  - delta-derivative threshold per cell
    - Does not rely on absolute voltage
    - More consistent across cells

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MOTOR - HPEVS AC 5X 27.28

Weight: 85 lbs.

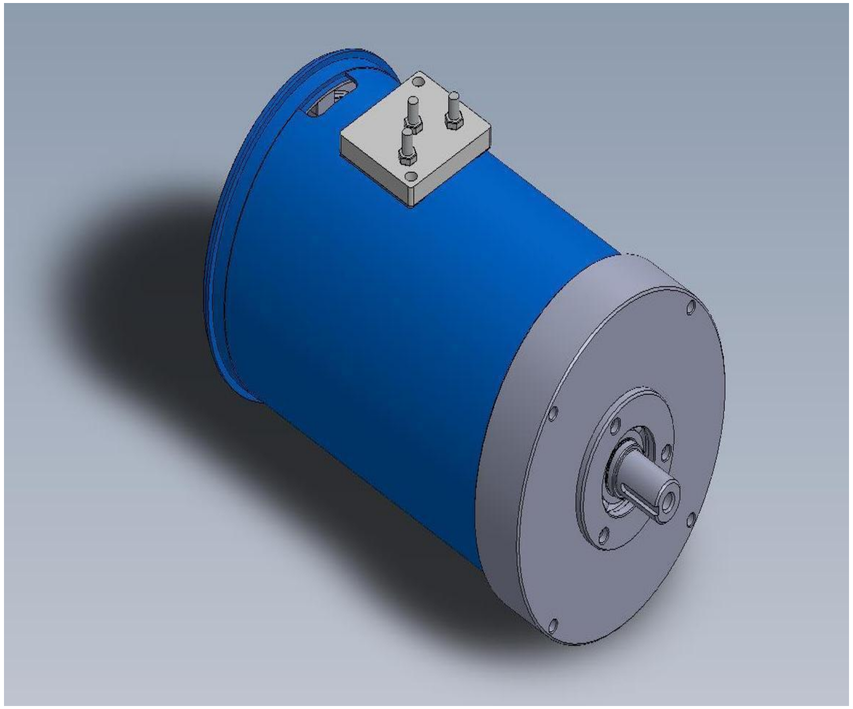
Horsepower: 71 hp

Torque: 120 ft.-lbs.

Voltage: 72-108 V

Current: 550-650 A

Max RPM: 6500 rpm



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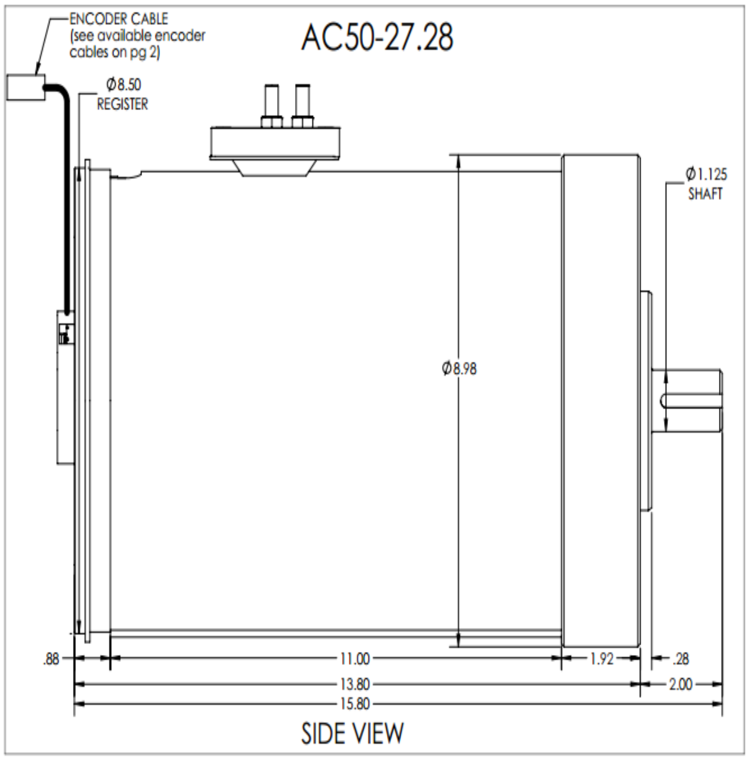
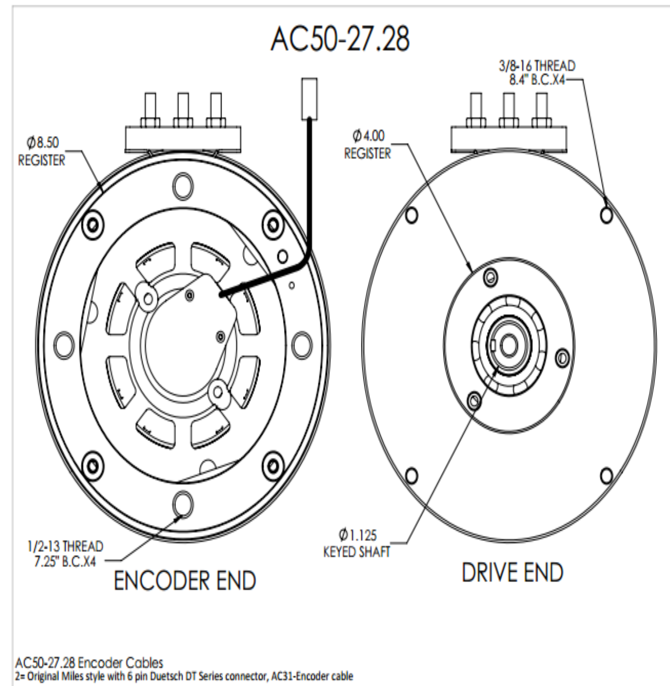
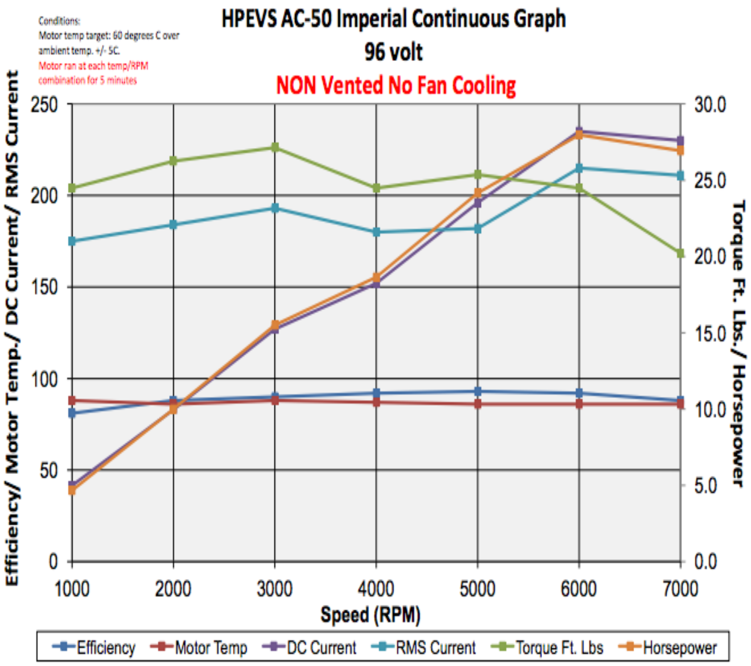
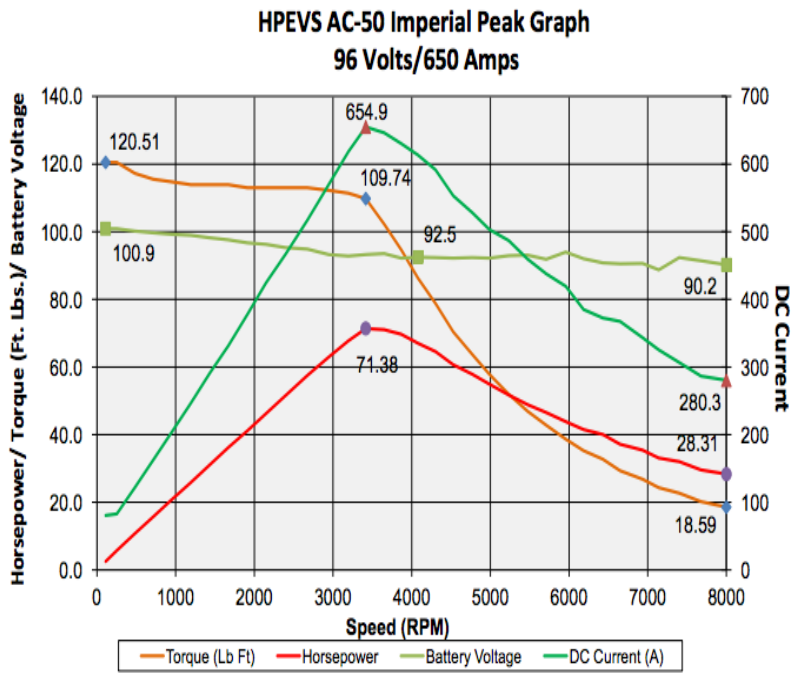
Motor Mechanical Drawings





Motor Power Graphs





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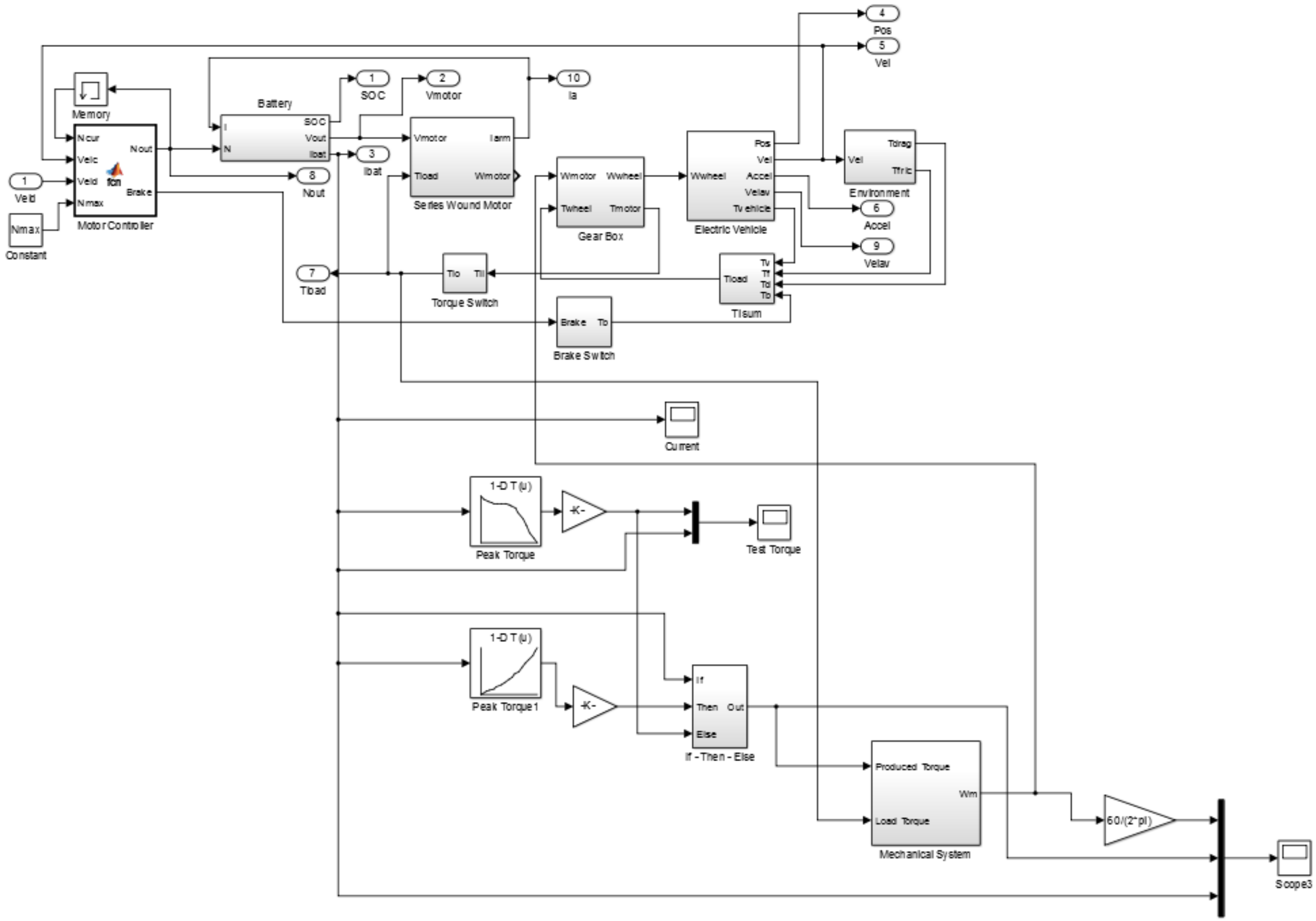
Motor Simulation

- Motor model designed in Simulink.
- Simulation derived from Kevin Schmid's model during the 2013 project.
- Adapted for use with HPEVS AC-50 Induction motor.
- Used lookup tables along with graphs from manufacturer to derive motor behavior

SIMULINK DIAGRAM



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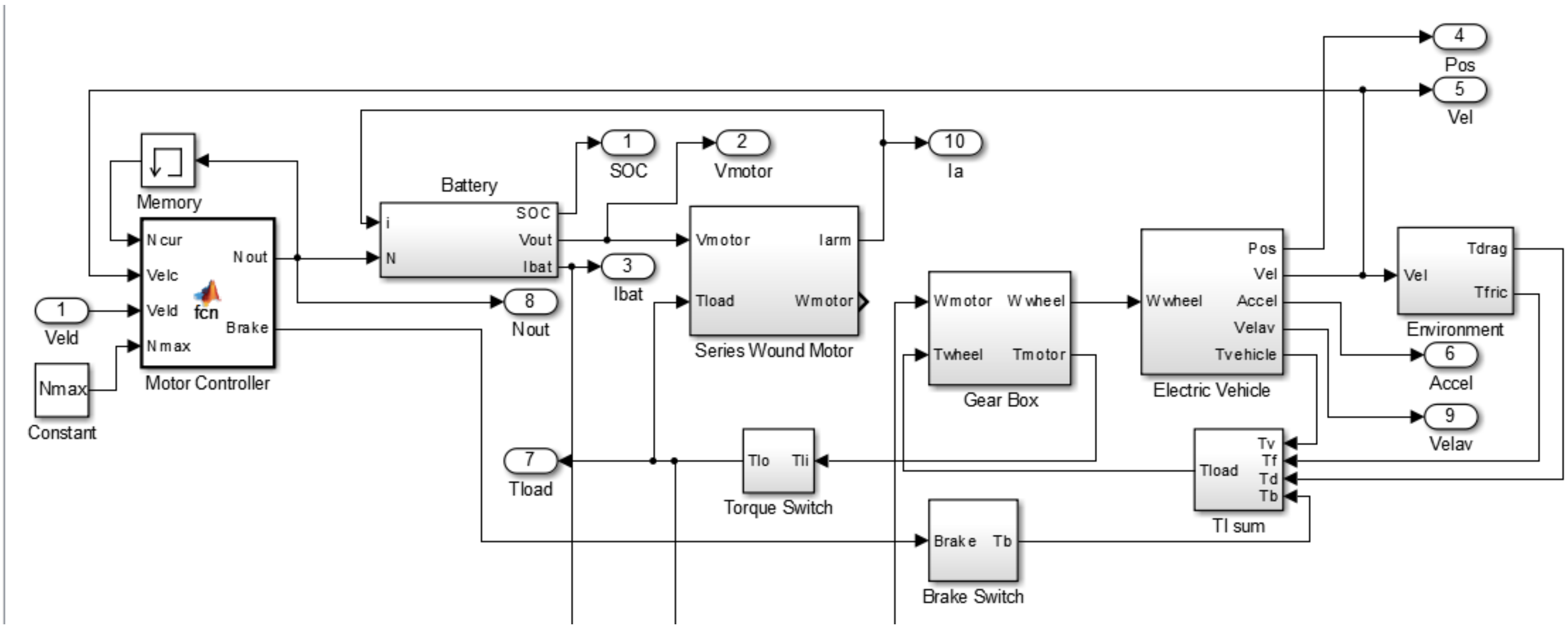
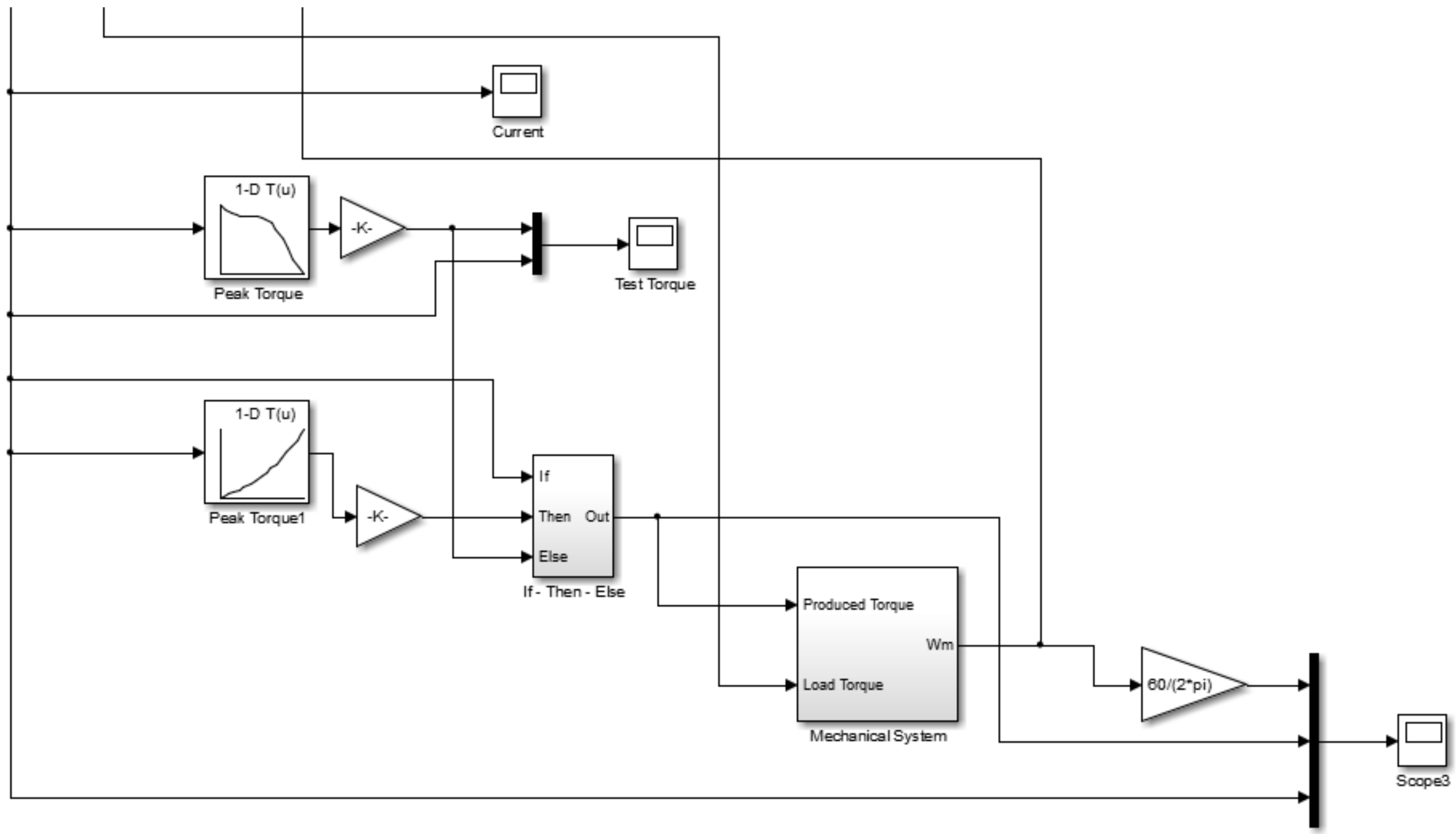
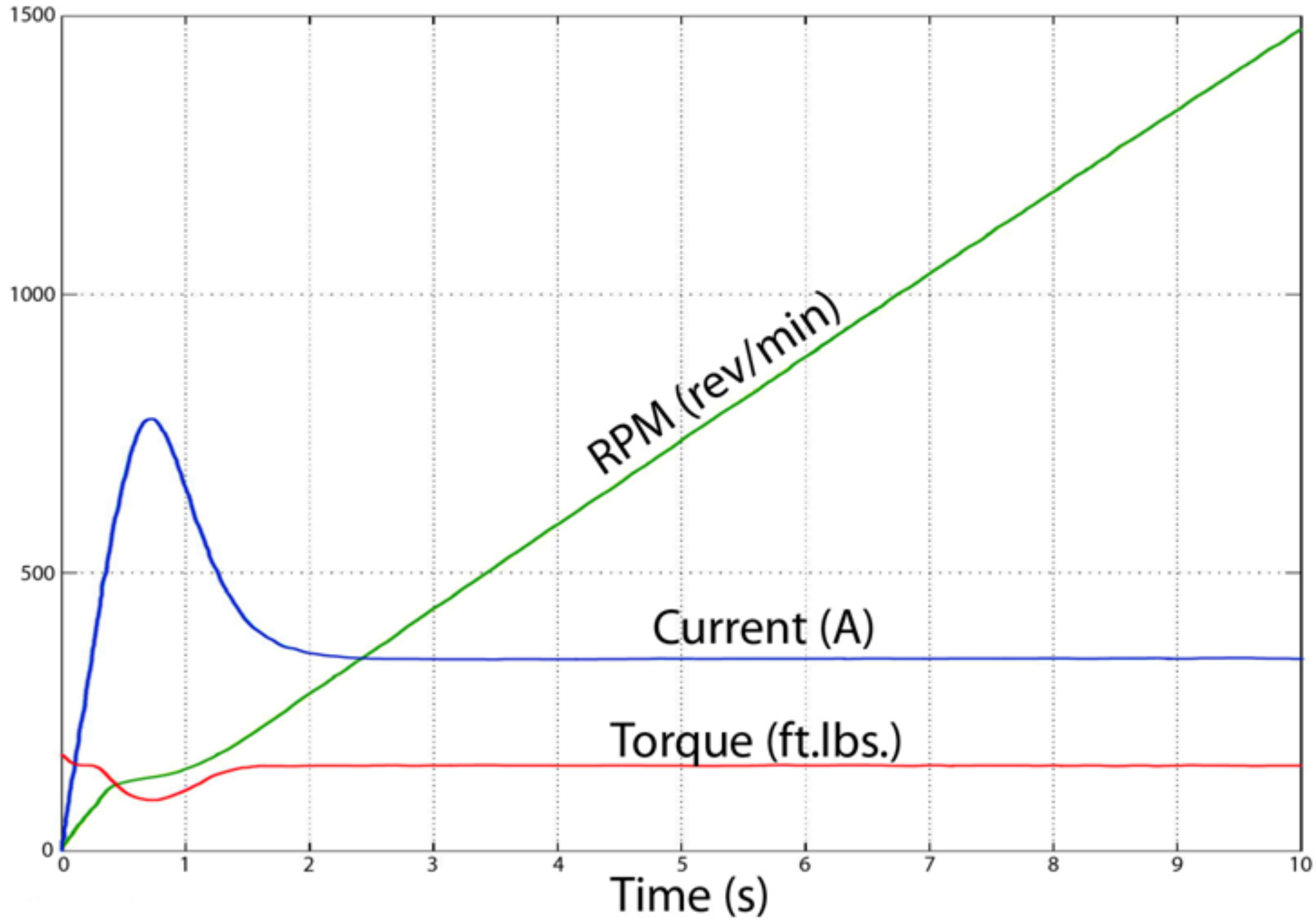
Simulink Diagram



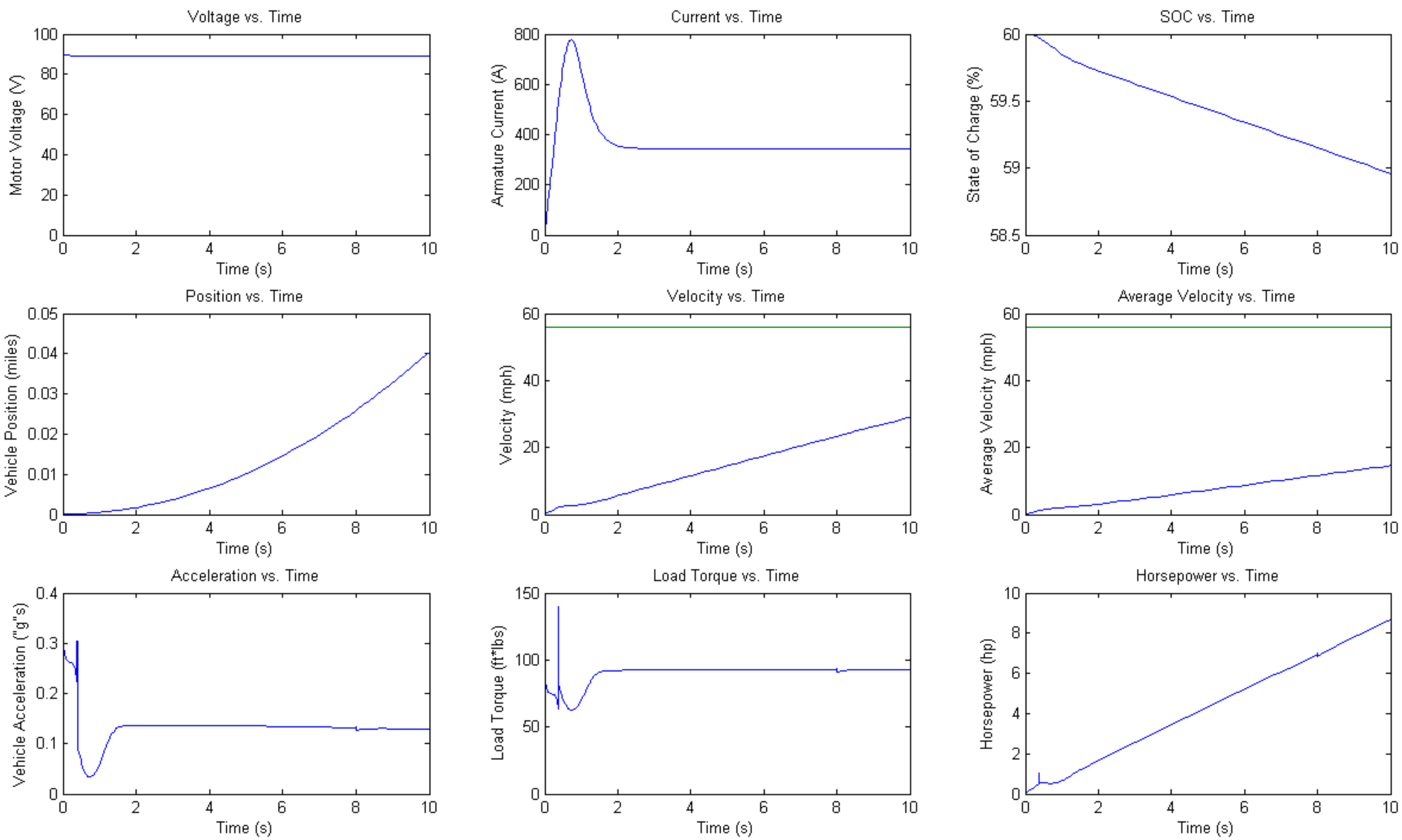
Simulink Diagram



Simulation Graphs



SIMULATION GRAPHS



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Motor Controller - Curtis 1238R

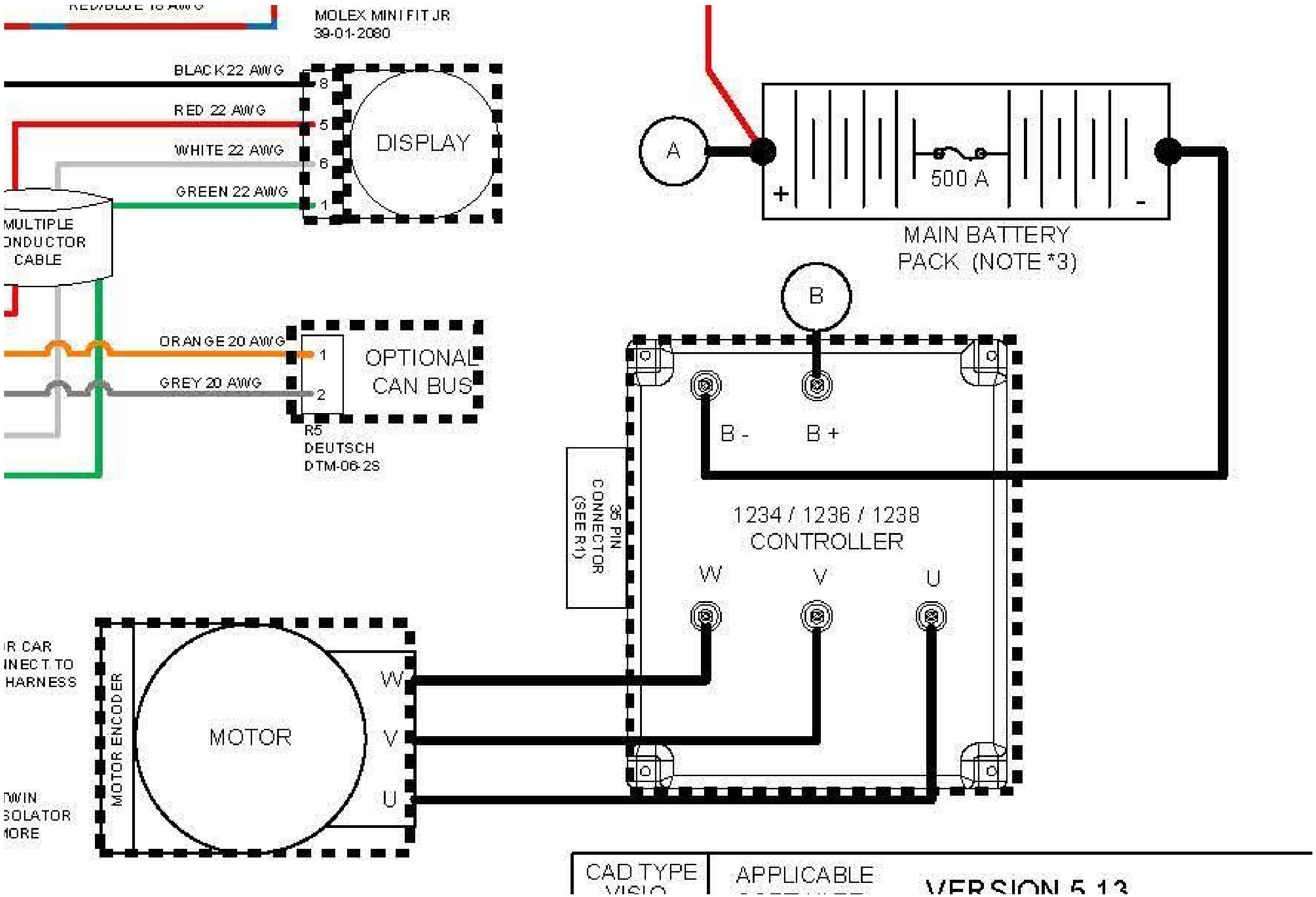
Max Power Rating (2 min): 73.6 kVA_{RMS}

Voltage: 72-96 V

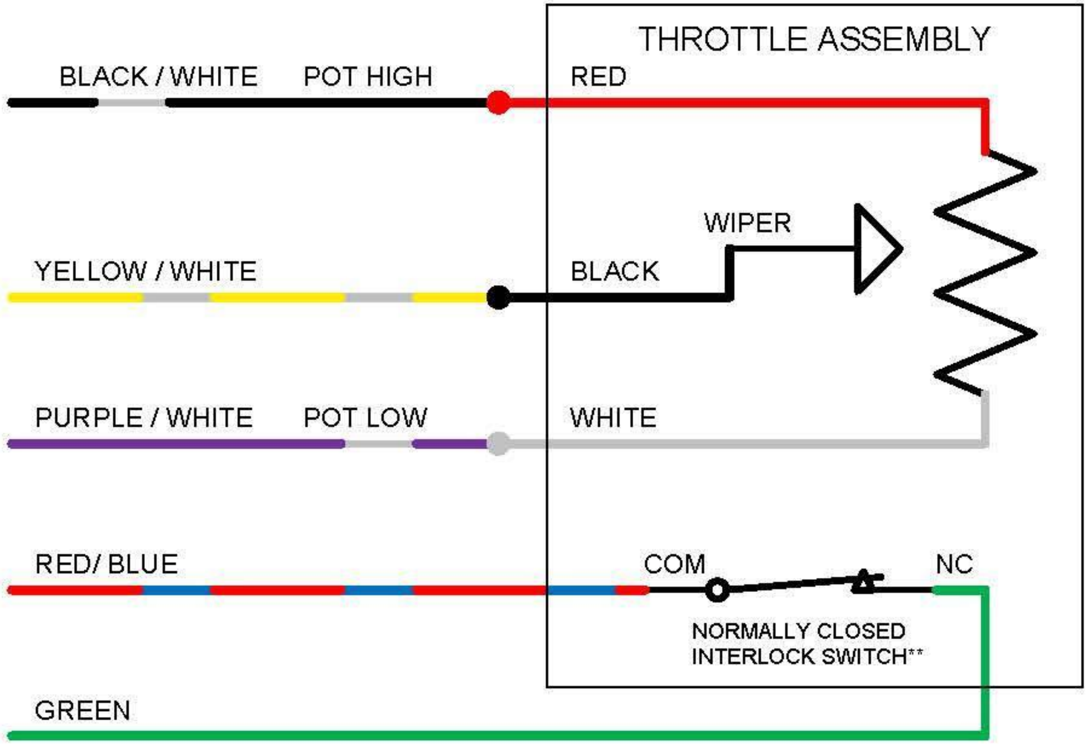
Max Current: 650 A_{RMS}

Torque: 115 ft. lbs.

Motor and Controller Wiring Diagram

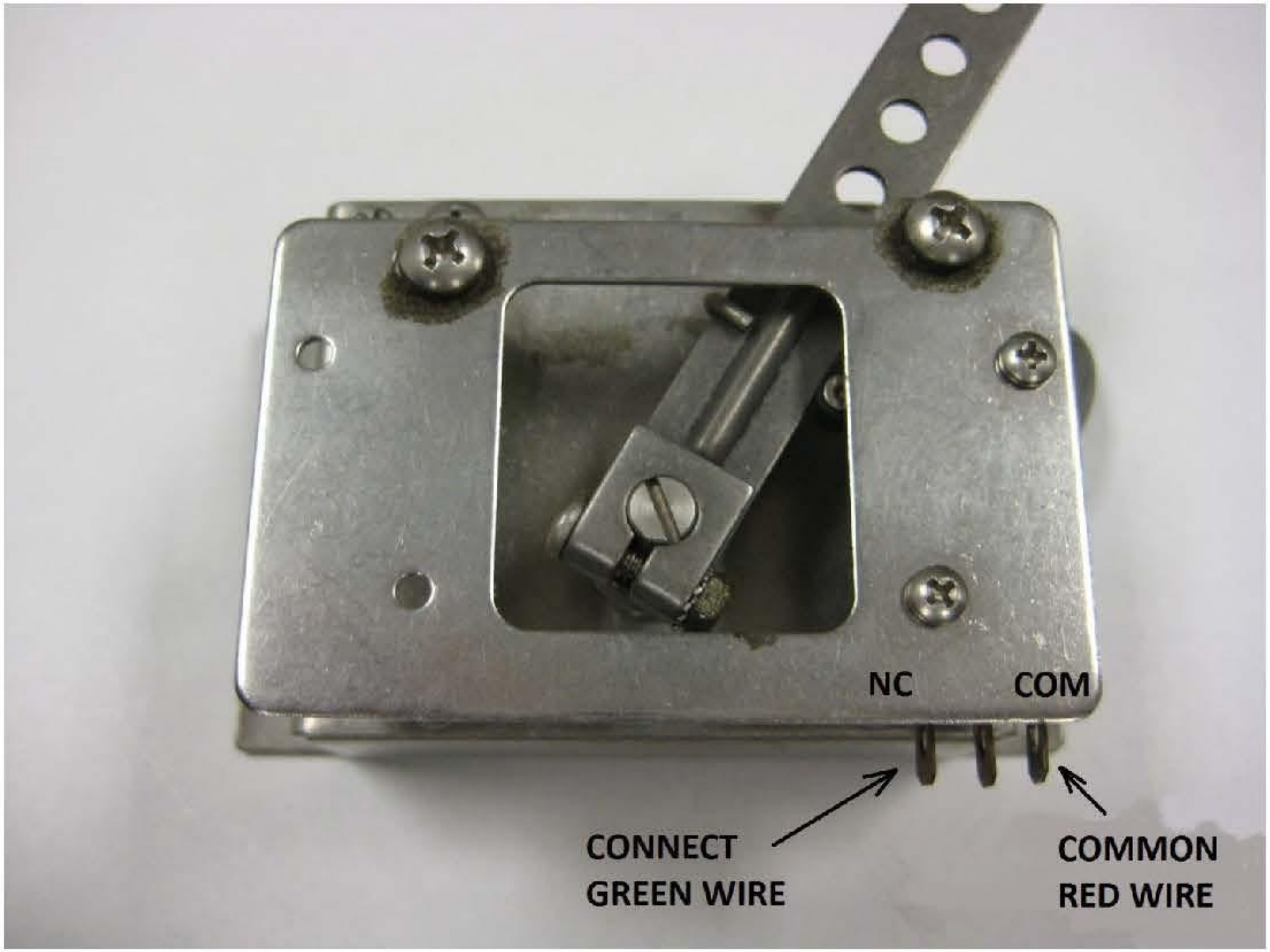


Throttle Wiring Diagram



CURTIS PB8 THROTTLE ASSEMBLY

Throttle



DYNAMOMETER - HUFF HTH-100

Power: 120 VAC @ 10 A (standard wall outlet)

Torque Capacity: 150 ft. lbs.

Max RPM: 11250 rpm

Water Use: Self Contained

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Power Supply – Magna Power TSD100-250/208

- DC programmable power supply
- Output: 0-100 Vdc; 0-250 Adc; 25kW
- Digital front panel for ease of use
- Can use outlet already installed in room 401
- Provides necessary ranges to operate motor at realistic power

Test Stand & Testing Plan

MCS and Test Stand Test Plan:

MCS and Test Stand Verification - This test will verify correct operation of motor while connected to a dynamometer on a test bench. It will verify the motor, motor controller and dynamometer are all functional.

Preconditions:
- Motor and dynamometer are each securely mounted to test bench. Motor and dynamometer are connected (if test requires dynamometer).
- Motor is connected to motor controller, which is plugged into a power supply.
- Area is prepared for safe operation of motor - all loose items are out of 15 safety area.
- Expected results from test are read aloud including maximum expectations for RPacMan and Torque so everyone knows when safe conditions have been exceeded.

Test Procedure:
- Turn on power supply to motor controller.
- Set-up any necessary configuration parameters on motor controller.
- Apply acceleration signal to motor and observe motor turning.
- Read data from display of dynamometer for more details.
- Turn off power supply and unhook from motor controller.

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Estimated Cost

HPEVS AC 50 Motor Kit w/ Curtis 1238R Controller = $4,150

Huff HTH-100 Dynamometer = $9,975

TSD100-250/208 PSU = $15,115

Total = $29,240

Budget Request: $35,000

Other possible costs:

- Water pump for extensive testing
- Dedicated 120VAC main circuit
- Pipes for dynamometer
- Installation / Maintenance costs

Where it will go / Who is responsible

- Room 401 has existing 208 Vdc 3-phase outlet required for power supply.
- Dynamometer is self-contained and does not require external cooling.
- Can be stored in Room 401 when not in use. No student access.
- The ECE department has agreed to take responsibility for the assembly.

Why We Need It

- Proper pack testing requires realistic load (i.e. the proposed motor)
- To further along the LFEV progress must be made. Purchasing the motor is a large milestone
- Next year's team has a lot of work to do. Purchasing the motor assures they will have time to test it and design the car around it.
- This project proposes many obstacles towards its completion. We'd like to eliminate this one.

Why We Can't Wait

- Time is of the essence. As soon as the pack is ready, it needs to be tested under realistic load.
- Last year's team picked out a motor and controller. If we don't make the purchase this semester, next year's team will have to waste valuable time doing work that has already been done.
- The LFEV would like to compete in 2015. This motor has to be purchased now if that will become a reality.

Why It's In Our Scope

- Both the motor and controller are electrical components. Knowledge about both of those things are gained in ECE classes.
- Testing the motor requires an electrical input which can be best provided within the ECE department.
- As much as possible should be studied about the motor before integration with the chassis, especially the electrical parameters.

What we're asking for

$35,000 to cover the full cost of:

- Motor and Controller
- Test stand and dynamometer
- Power Supply
- Parts required for assembly and upkeep
- Potential Installation costs
- PC dedicated to test stand (data acquisition)

Roadmap

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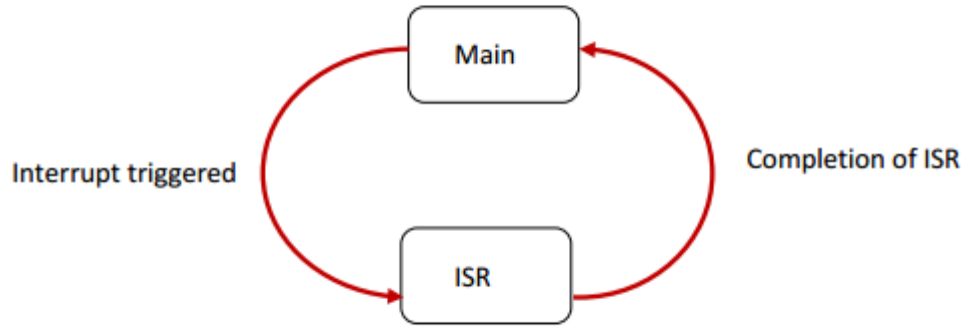
Issues with 2013 AMS design

1) AMS goes down once about every 5 messages

2) AMS returns corrupted data

3) AMS randomly sets its board address or bypass without being told to

AMS Firmware Design



Two noticed issues :-

1) AMS does not ask the master to wait after every I2C message.

2) Concurrent use of shared resources (or Read/Write Problems)

Suggested Solutions

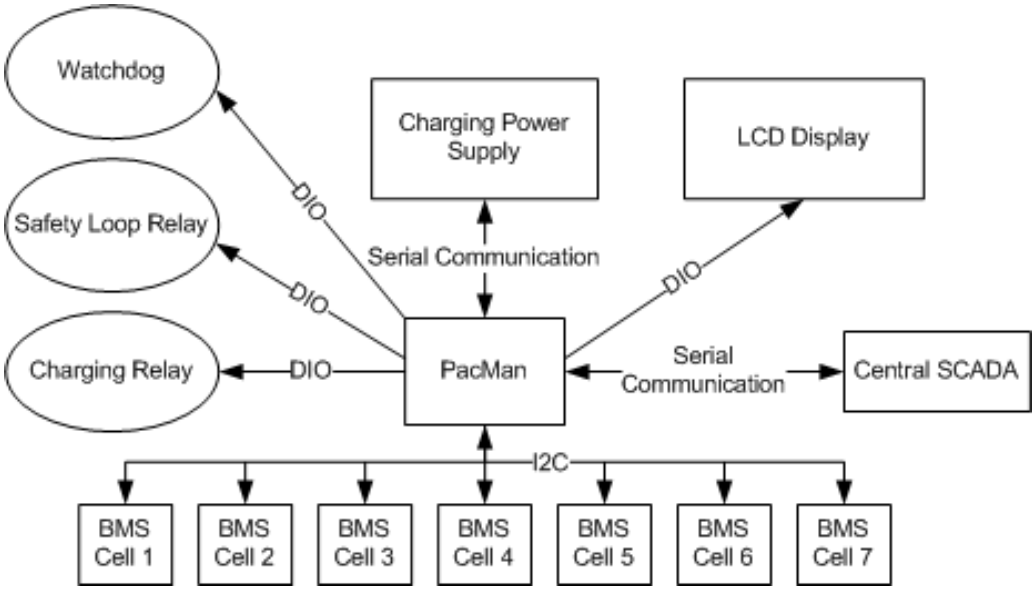
- AMS or the slave holds the clock line, preventing the master to transmit additional bytes until the slave finishes processing the request

- Read/Write problems are prevented by making sure shared data cannot be read and written at the same time

Software Design

Environment

- single-board computer
- Debian Linux Kernel
- Programming Language C



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Software Design

Functions of the software

The PacMan Program has 4 main functions. They are:-

1) Poll the data from Accumulator Management System (AMS)
2) Relay data gathered from AMS to Central System Control and Data Acquisition (SCADA)
3) Oversee charging the battery pack using cell balancing algorithm
4) Check if system parameters are within safe range

Goals

The key goals of the design are to:-

1) be as self-sufficient as possible with little human interaction
2) recover automatically from errors if certain conditions are fulfilled
3) perform multiple functions as the same time.

Use Cases

1 Boot-up and configuration

1.1 - Auto-bootup PM program

1.2 - Auto-configure system parameters, alarms, shut down rules and safety rules from config file

1.3 - Set alarms, shut down rules and configuration parameters

1.4 - Check for safety and follow safety rules

2 Active State

2.1 - Auto-detects devices

2.2 - Poll data from AMS boards through I2C

2.3 - Relay data to the Central SCADA

2.4 - Display battery pack information via LCD display

2.5 - Log events, faults and exceptions

3. Charging State

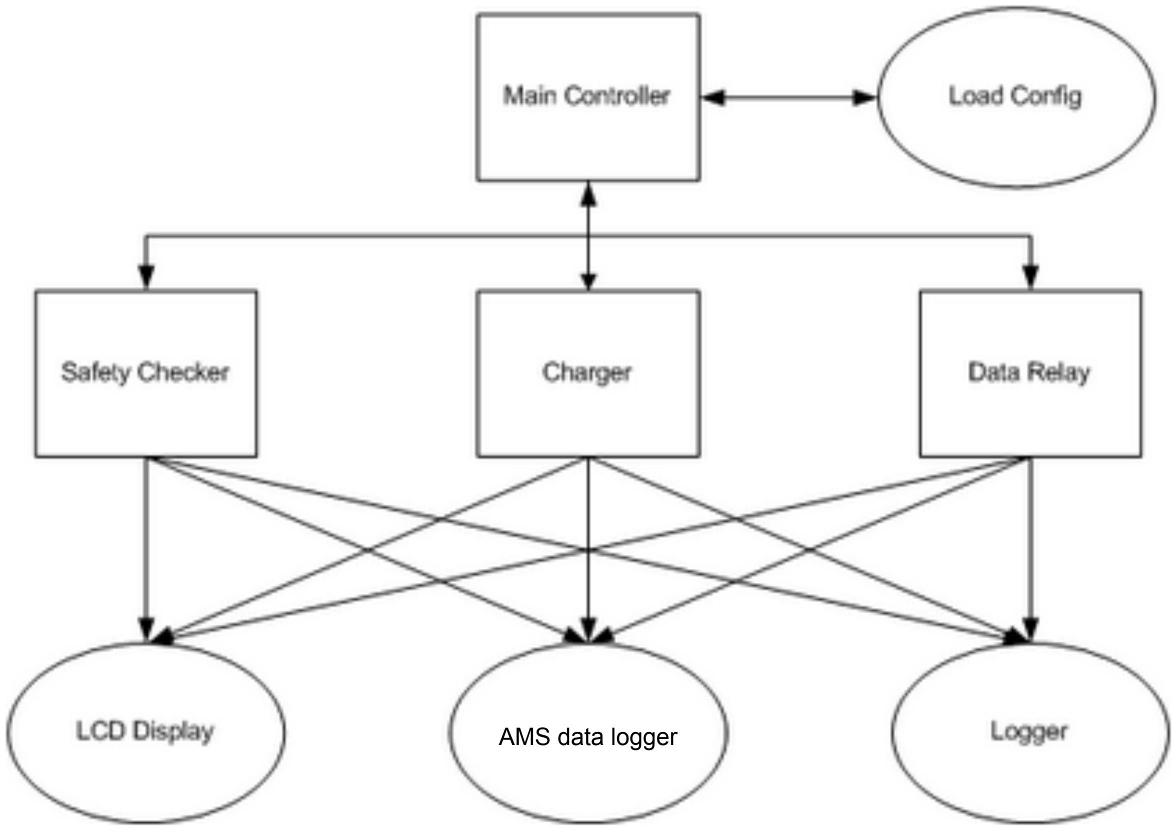
3.1 - Enter charging state automatically

3.2 - Charge the battery pack by balancing individual cell charge levels

3.3 - Display charging information via LCD display

3.4 - Log charging information

Multi-threaded , Object-Oriented Design



Threads

Main Controller

Safety Checker

Charger

Data Relay

Interfaces/Functions

AMS Data Poller

Logger

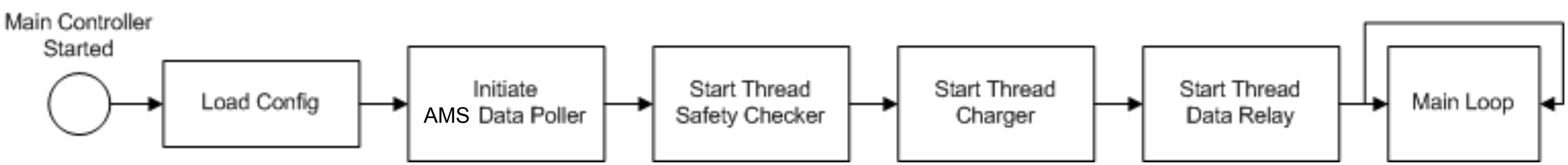
LCD display

Main Controller

- Setup program

- Start the threads

- Manage the threads



Config file

- Important System Parameters

 # I2C board addresses

 # Usage : AMSAddresses n1 n2 n3 n4 n5....

 # n1, n2 , n3,... etc are board addresses. If more cells are connected, their board addresses

 # should be separated by space

AMSAddresses 01 02 03 04 05 06 07

- Shutdown Rules

 # Shutdown if system values are in unsafe condition

 # Usage: ShutdownSafety n

 # n is either true or false

ShutdownSafety false

- Safety Rules

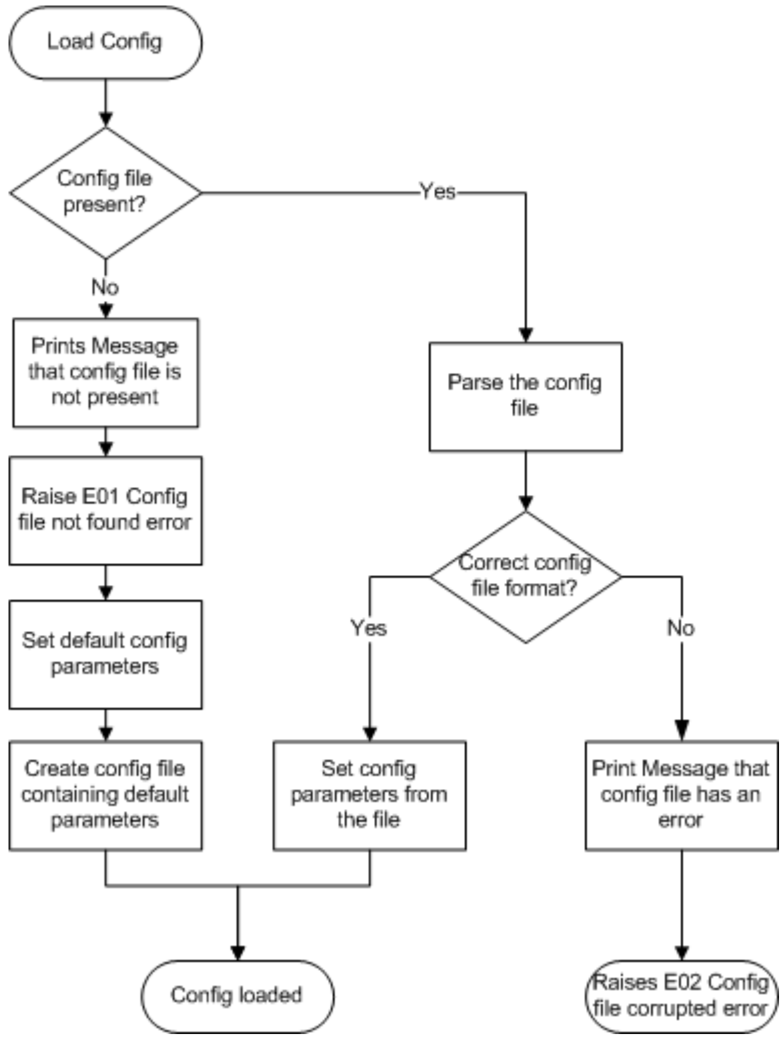
 # Temperature Upper Limit

 # Usage : UpperTempLimit n

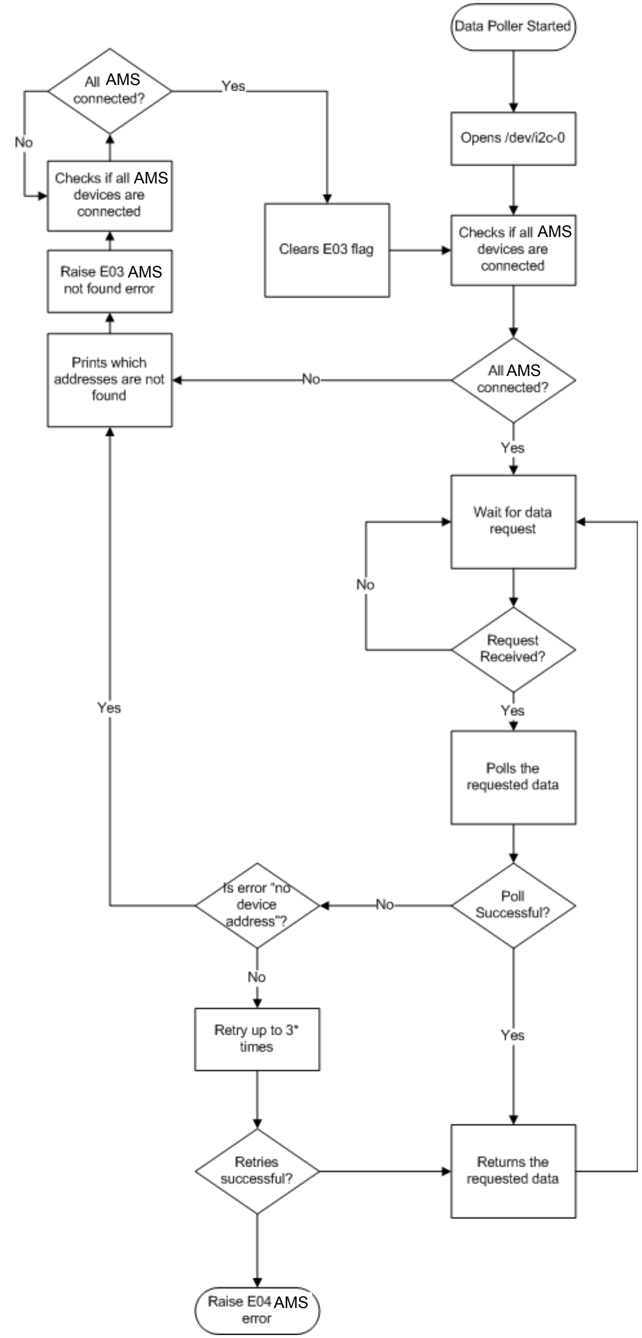
 # n is the value in degree C

UpperTempLimit 65

Loading Config



AMS Data Poller

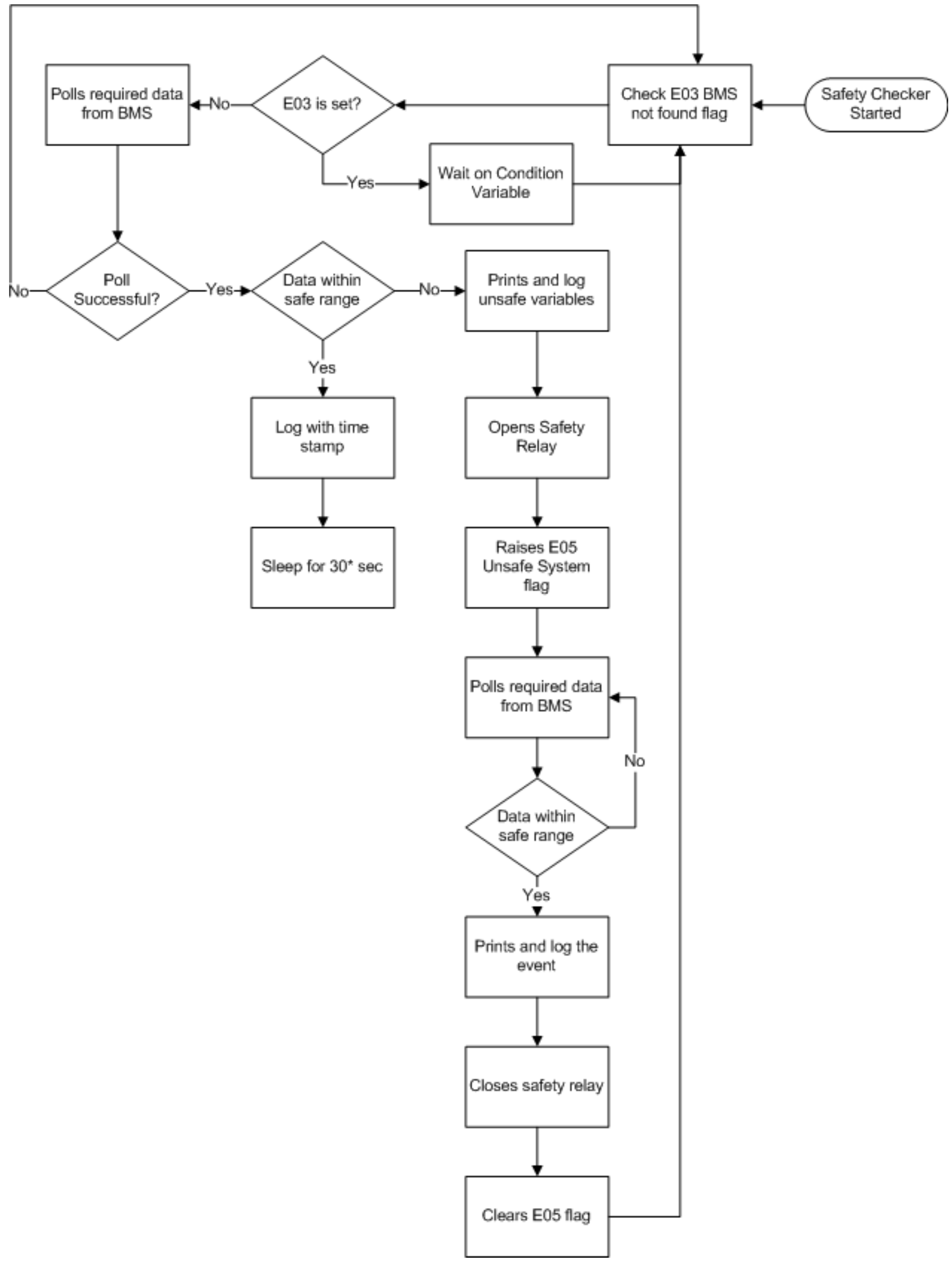


I2C Commands for AMS

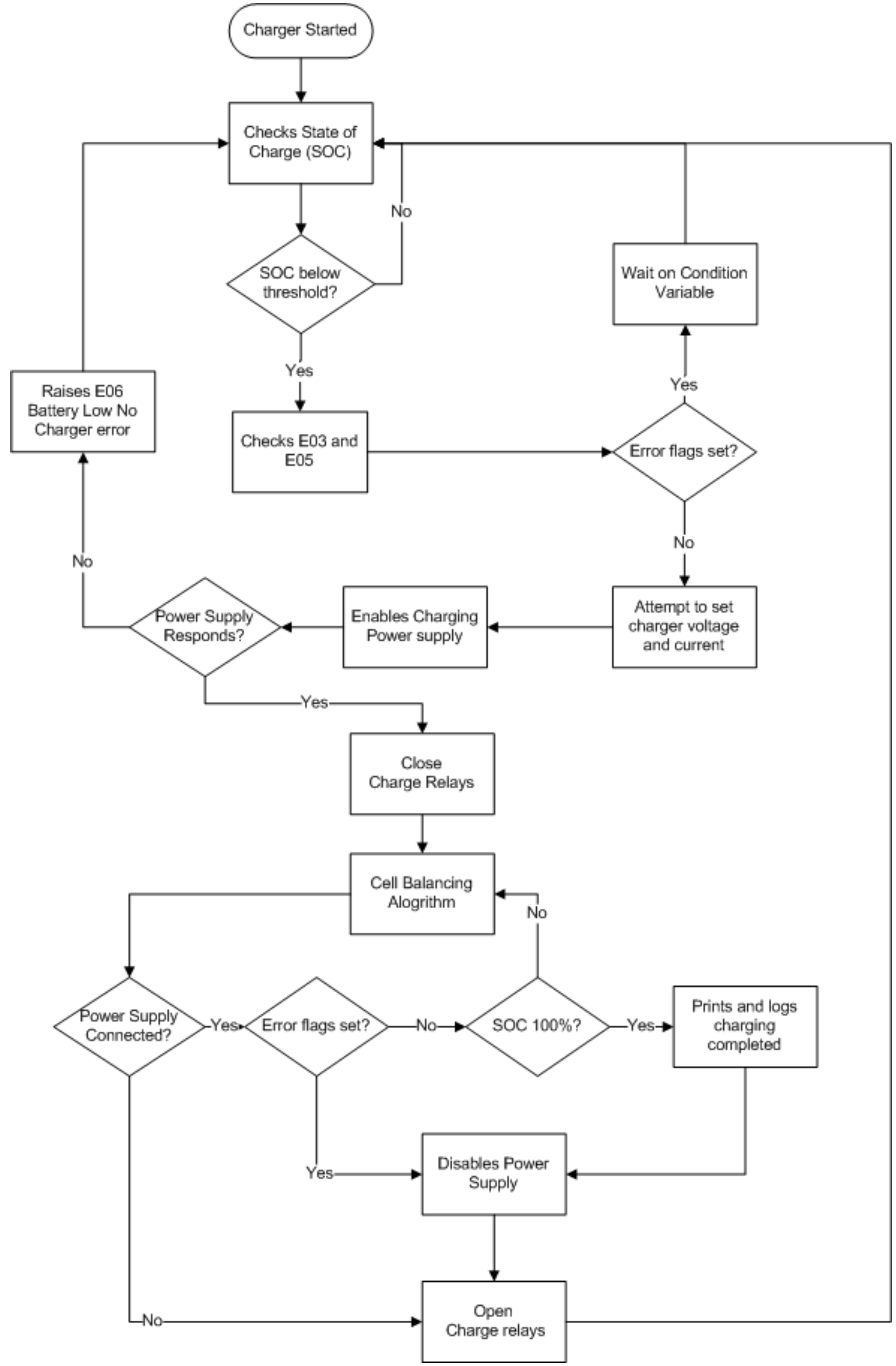
Command #	Description	#Bytes Returned
0x 10	Gets the cell voltage	2
0x 11	Gets the cell temperature	2
0x 12	Gets the pack charging current	2
0x 13	Gets the pack discharging current	2
0x 14	Gets the bypass resistor switch state	2
0x 15	Gets the slave/board address	2
0x 16	Gets the software version	2
0x 17	Gets 0x0042(test command)	2
0x 18	Gets the bypass time in minutes	2
0x 19	Gets charging coulomb count as well as the number of times the charging current was summed	8*
0x 1A	Gets discharging coulomb count, as well as the number of times the discharging current was summed	8*
0x 1B	Gets cell voltage and temperature	4
0x1C	Gets the voltage, temperature and charging current of the cell	6
0x 1D	Gets the voltage, temperature and discharging current of the cell	6
0x 1E	Gets the time elapsed since the bypass switch has been set	6**
0x00	Sets the bypass switch state	n/a
0x 01	Sets the board address	n/a
0x 02	Sets the bypass time in minutes	n/a
0x 03	Calls the function to test the watchdog timer	n/a

Designed by 2013 Team.

Safety Checker



Charger



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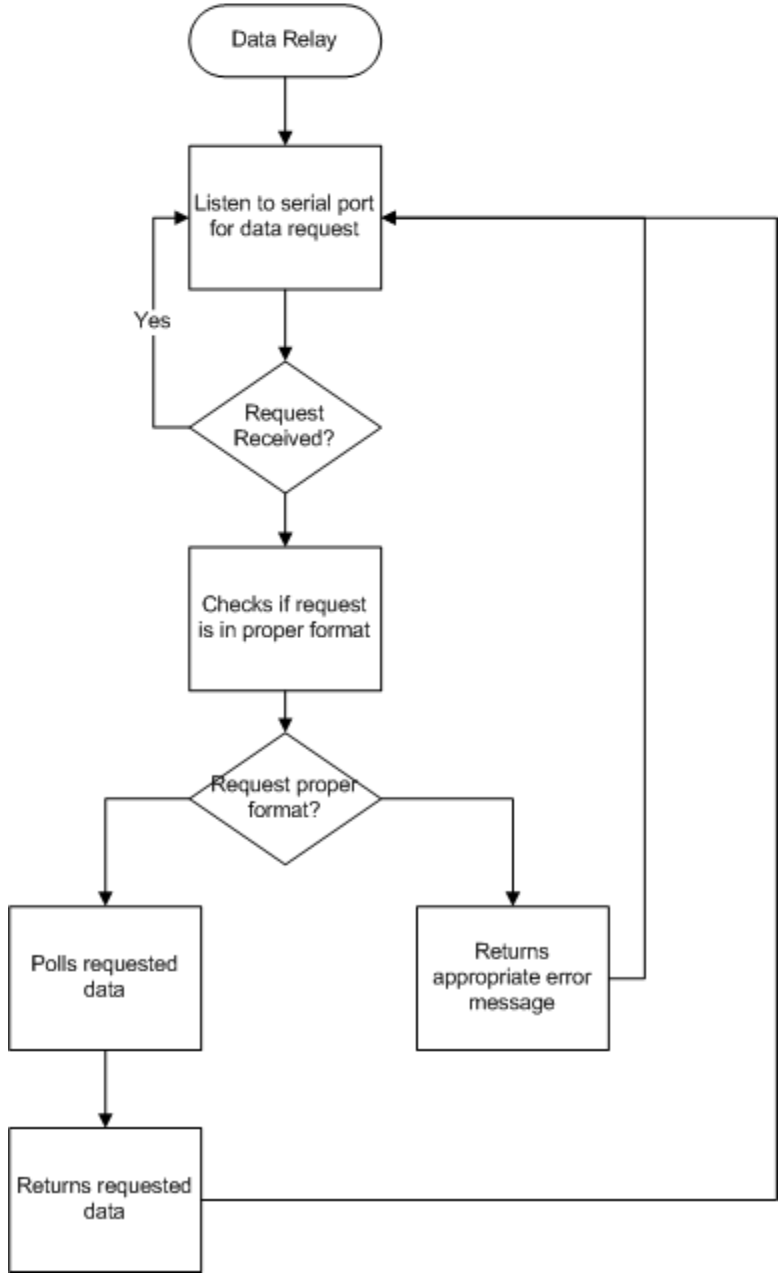
Data Relay



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Data Relay Communication Protocol

- Serial Communication
  8 bit, one start bit and one stop bit, with no parity bit

- End of message by End Of Transmission (ASCII 4)

- Acknowledgement “OK” or error message required for every write

Format
Pack number + Command + Argument(s)

Example
(Central SCADA) : 1 V? 1
(PM Board) : 1 OK
(PM Board) : 1 2.305(will be in hex)
(Central SCADA) : 1 OK

Command List

Command	Description
V? n	Gets the cell voltage of ‘n’ cell. If ‘n’ is omitted, all cell voltages will be returned in the order of increasing cell numbers.
T? n	Gets the cell temperature of ‘n’ cell. If ‘n’ is omitted, all cell temperatures will be returned in the order of increasing cell numbers.
XT? n	Gets the temperature from external sensor ‘n’. If ‘n’ is omitted all external sensor readings will be returned in order of increasing sensor numbers
C?	Gets the current in the discharge path of the battery pack
BPSS? n	Gets the bypass resistor switch state of ‘n’ cell. If ‘n’ is omitted, all bypass resistor switch states will be returned in the order of increasing cell numbers.
ADDR?	Gets the PM board address.
CELLCNT?	List the addresses of I2C devices connected to it.
TEST?	Returns ‘42’. (Test Command)
BPST? n	Gets the bypass time in minutes of ‘n’ cell. If ‘n’ is omitted, all times will be returned in the order of increasing cell numbers.
SAFETY?	Gets the current state of the safety loop relay on the pack manager
SOC?	Gets the current state of charge of the battery pack

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Error Message List

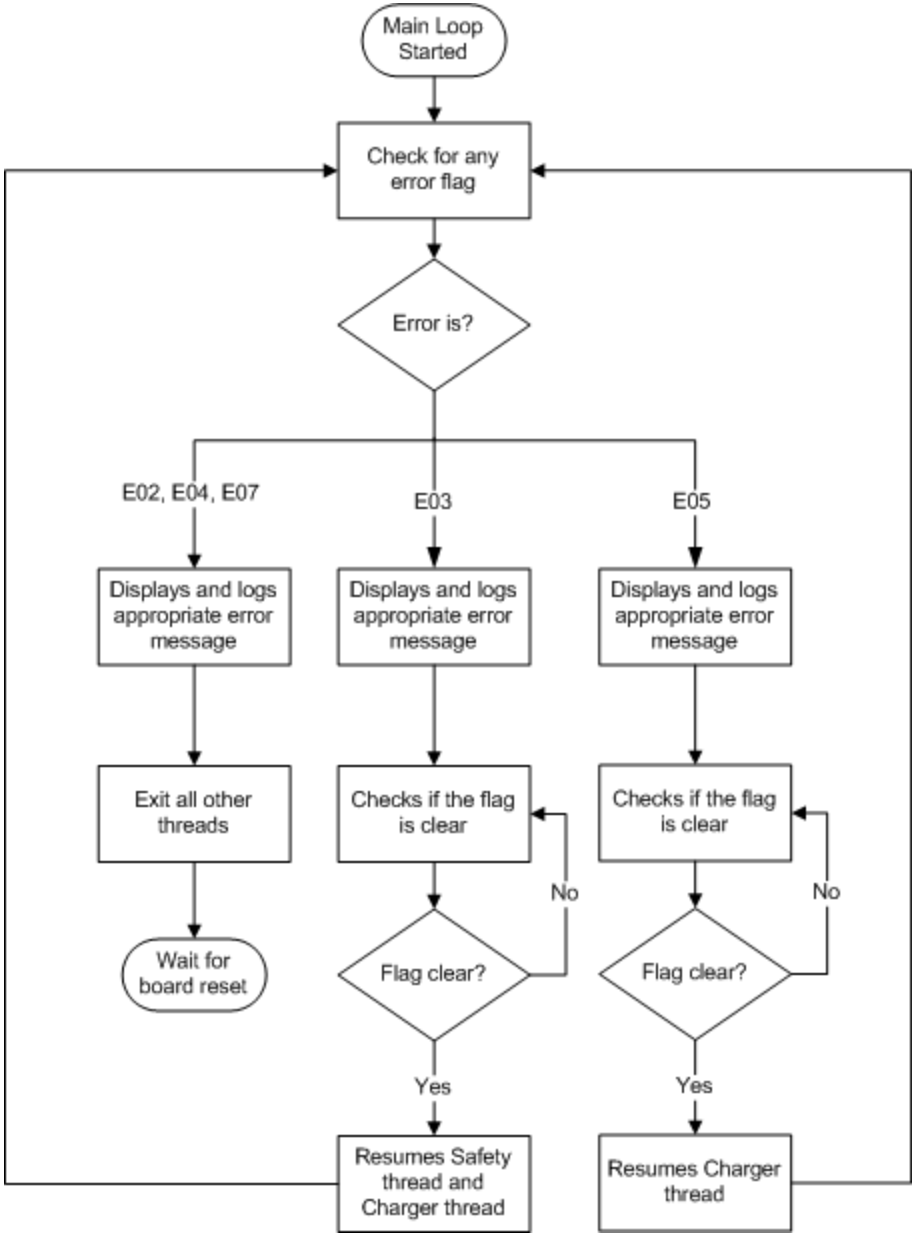
Unless the board needs to be reset, PM board will return error messages thus allowing CENTRAL SCADA to know the state of the system.

Error	Description
EBADFRMT	The format of the message is wrong or unknown. Usually happens when the message has missing spaces.
EBADCMD	The command is illegal or unknown.
EBADARG	The argument is in a bad format or missing.
ENOCELL	The specified cell is not connected or found. Checks with CELLCNT? command.
EERROR	This should not happen. This error message is returned when an unexpected error occurs within the PM board. This is the default error message if the none of the errors fits in the above categories. Checks the log file of PM board for more information.

Error Handling

Error Code	Safety	Charger	DataRelay
E01 : Config file not found			
E02 : Config file corrupted	✓	✓	✓
E03 : AMS not found	✓	✓	
E04 : AMS error	✓	✓	✓
E05 : Unsafe System		✓	
E06 : Battery Low and no charger			
E07 : Unexpected error	✓	✓	✓

Error Handling



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Acceptance Test Plan Methods

- Verifies Requirements are met through Inspection, Analysis, or Testing
- 9 Specific Tests in ATP
  - Battery Pack Display and Safety Qualification
  - Low Current Discharge Test
  - Charge Cycle Test
  - Drop-Out Charge Test
  - High Current Discharge Test
  - RS-485 Communication with Off-Board Systems
  - MCS and Test Stand Verification
  - Reliability Test
  - Maintainability Test

ATP - Test Descriptions

- T000 - Battery Pack Display and Safety Qualification: Verifies safety loop can be opened by PM. Shows PM can display battery pack information to the user
- T001 - Low Current Discharge Test: Verifies the battery pack can safely discharge at a low rate
- T002 - Charge Cycle Test: Verifies the battery pack can be charged using the plug and forget charge algorithm.

ATP - Test Descriptions

- T003 - Drop-Out Charge Test: Verifies the battery pack can be charged even when the battery voltage is too low to operate the PM
- T004 - High current discharge: Verifies the battery pack can safely discharge at the maximum rate (200A)
- T005 - RS-485 Communication with Off-Board Systems: Ensures PM can maintain RS-485 communications with external systems (Central SCADA).

ATP - Test Descriptions

- T006 - MCS and Test Stand Verification: Tests the motor, motor controller, and dynamometer together as a complete unit
- T007 - Reliability Test: Ensures our system can run successfully through its various states over a 24-hour period
- T008 - Maintainability Test: Demonstrates our system can be repaired in the event of both minor (blown fuse) and major failure.

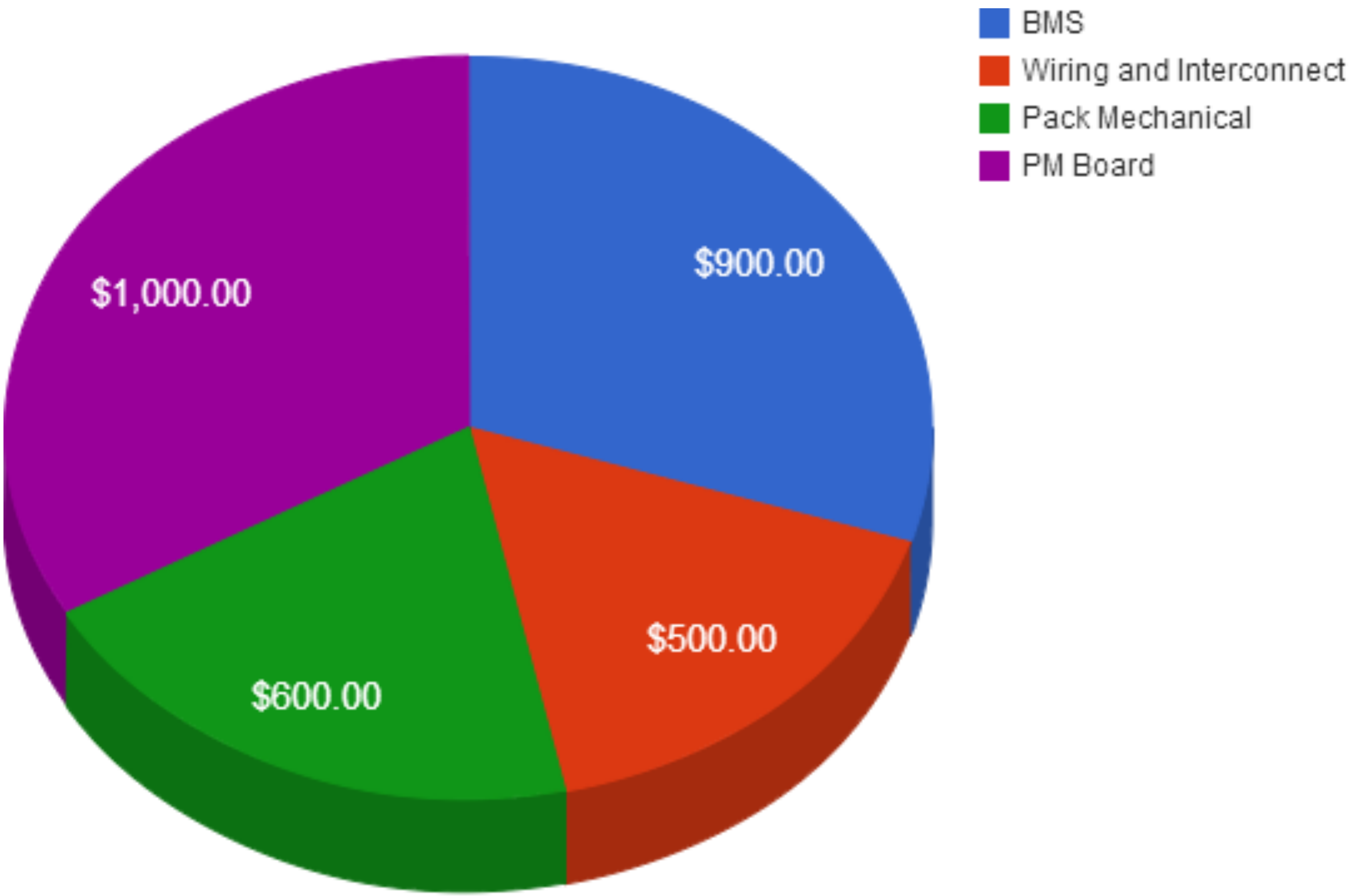
ROADMAP

- Introduction
- 2014 Deliverables
- System Design
  - Pack Mechanical
  - AMS
  - PacMan
  - Charger
  - Motor/MCS
  - Software
- ATP
- **Budget**
- Schedule

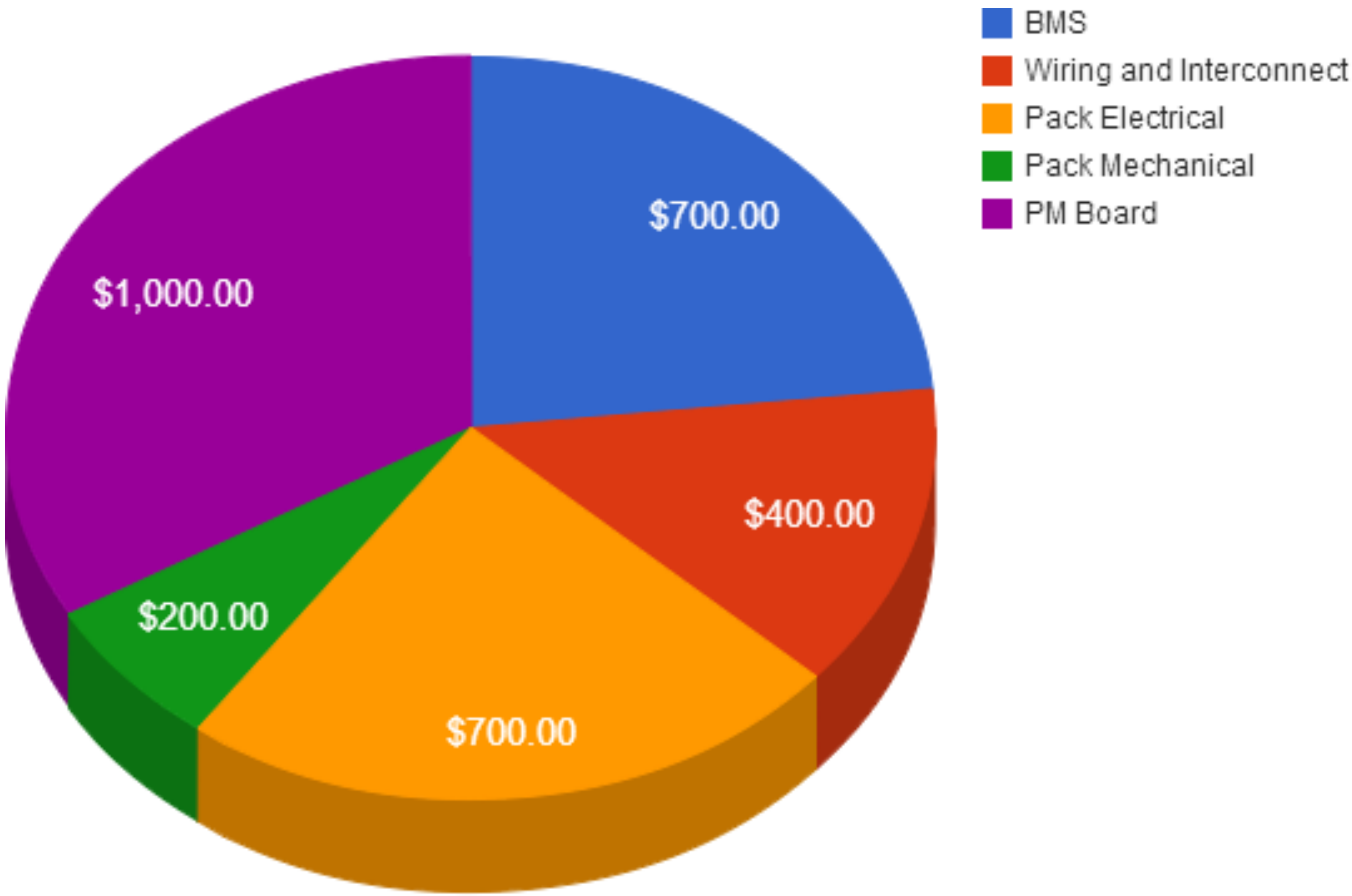
Budget

Budget	AMS	Wiring and Interconnect	Pack Electrical	Pack Mechanical	PM Board	Total
Total Spent	$210.50	$131.76	$633.94	$532.89	$813.43	**$2,322.52**
Original	$900.00	$500.00	X	$600.00	$1,000.00	**$3,000.00**
Revised	$700.00	$400.00	$700.00	$200.00	$1,000.00	**$3,000.00**
Remaining	$489.50	$268.24	$66.06	**-$332.89**	$186.57	**$677.48**

Original Budget



Revised Budget



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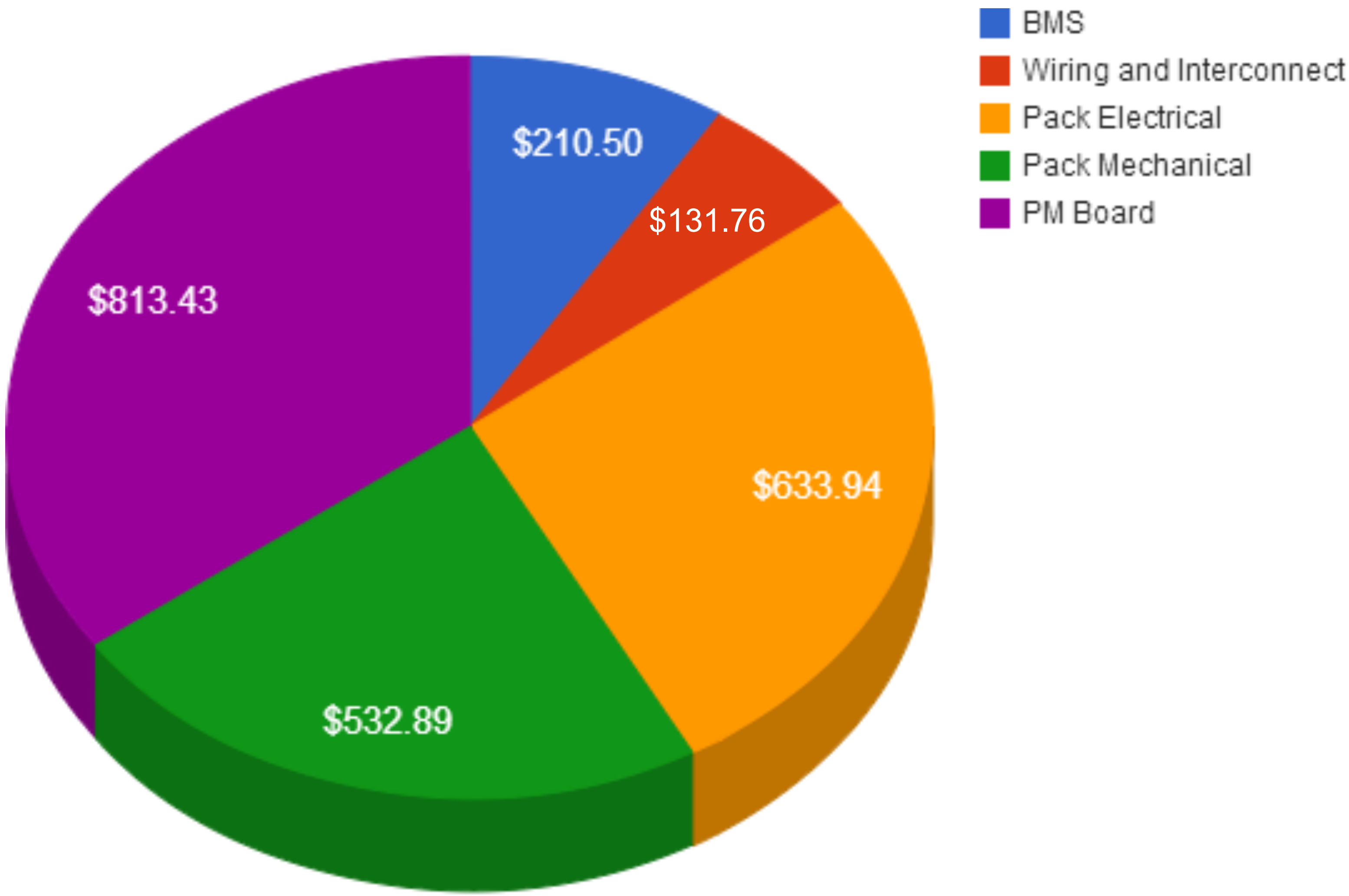
Total Spent



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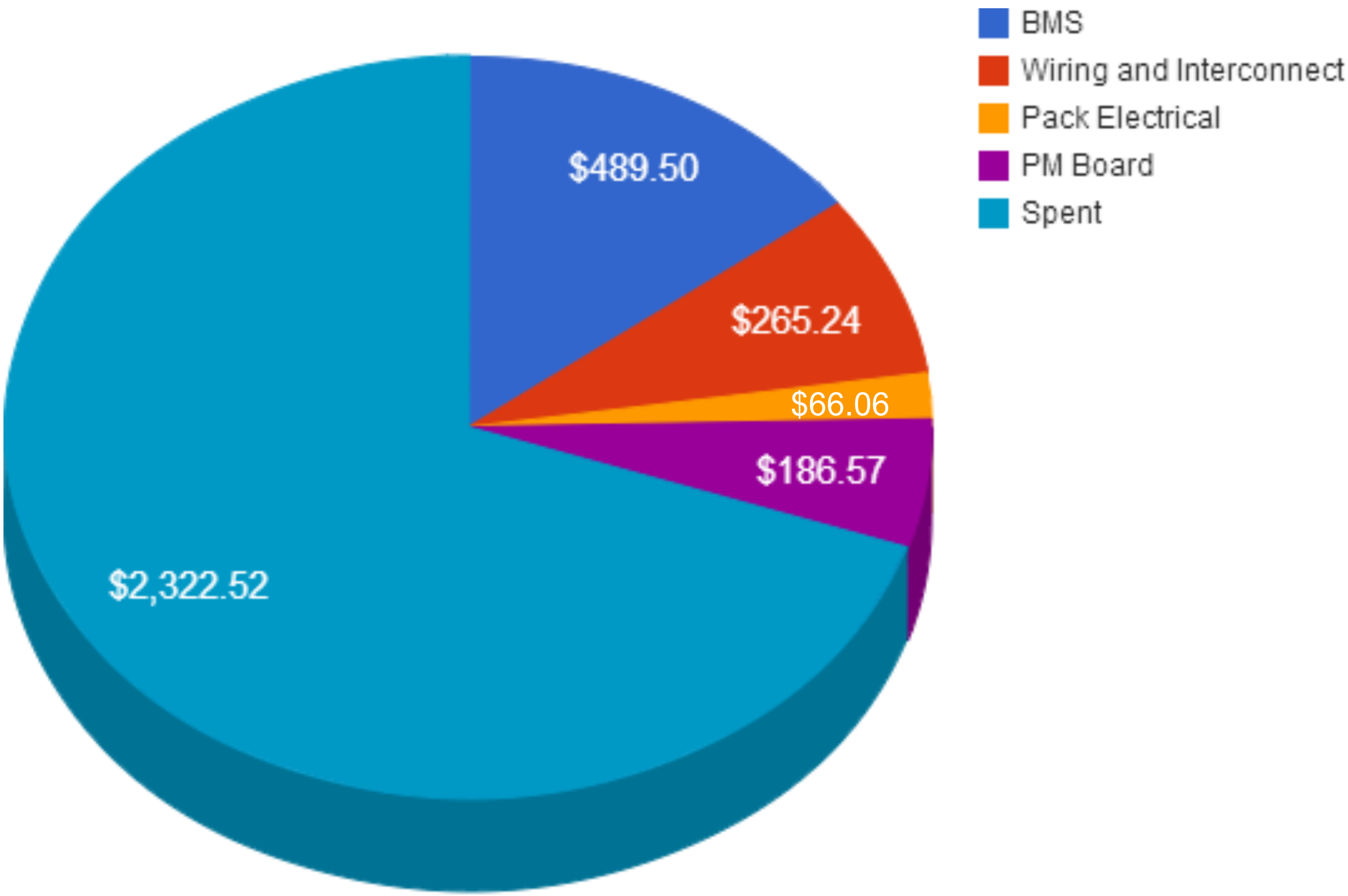
Remaining Budget



ROADMAP

- Introduction
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- **Schedule**

Schedule for April

April 2014

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
		1	2	3	4	5
Manufacturing Mechanical Parts and PCB Prototyping						
6	7	8	9	10	11	12
Software Programming						Software Completed
13	14	15	16	17	18	19
Quality Assurance and System Integration						
20	21	22	23	24	25	26
Acceptance Test Plan						
27	28	29	30	1	2	
Final Presentation					SDD	

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Wrap-up

Thank you for attending!

We appreciate your feedback.

Questions?