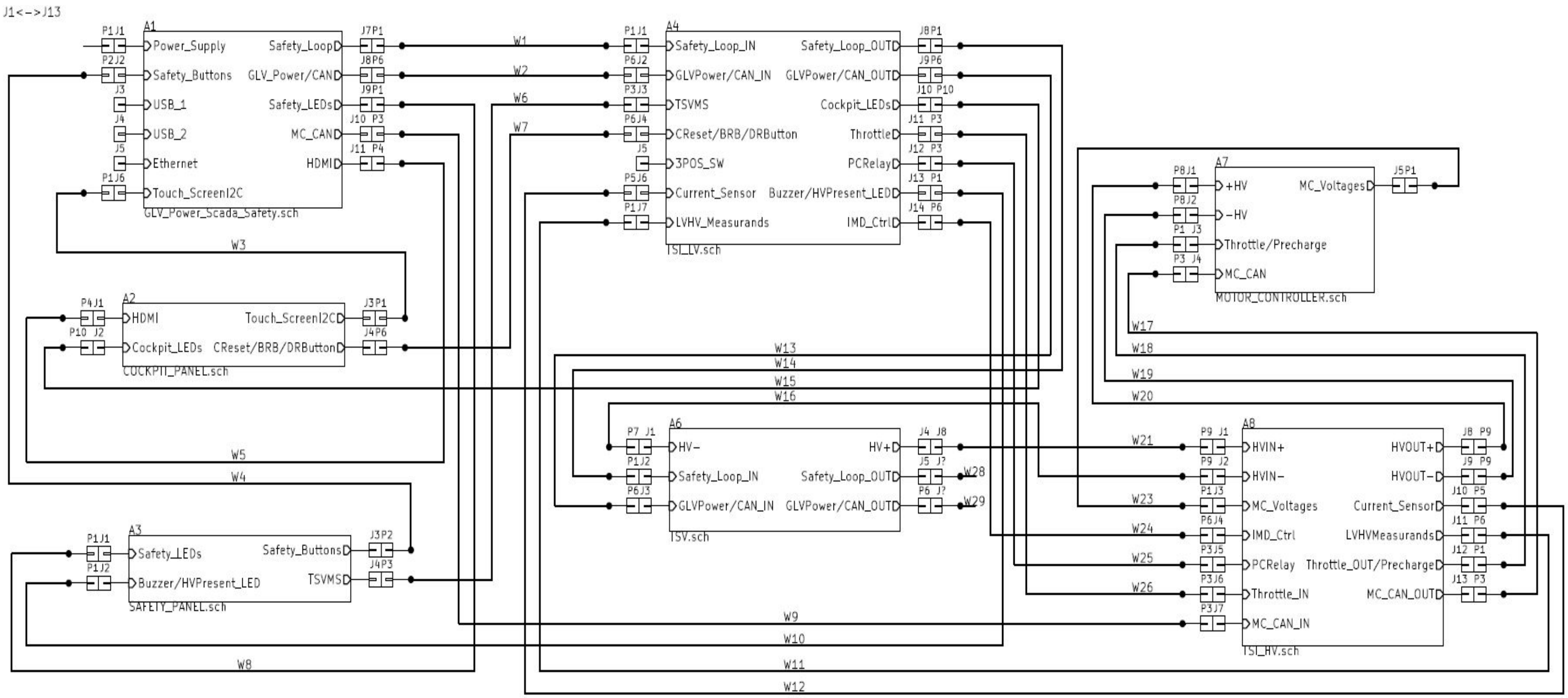
LFEV-Y4-2016

Lafayette Formula Electric Vehicle
Year 4

ECE 492 - Spring 2016

LAFAYETTE
ELECTRICAL & COMPUTER ENGINEERING

System Design - Top Level



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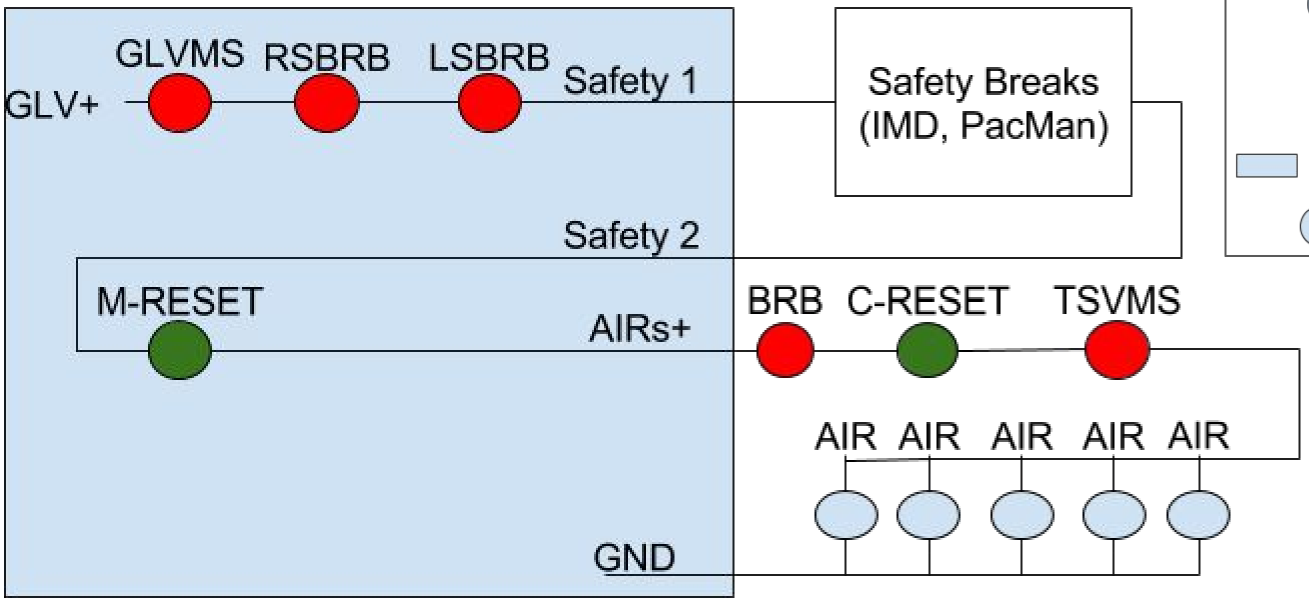
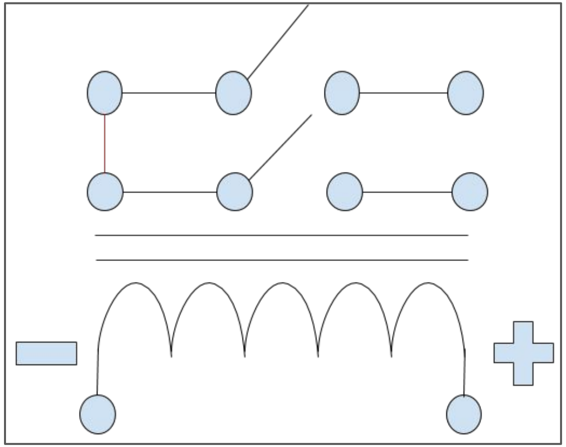
GLV - Grounded Low Voltage

System Design - GLV

- Grounded Low Voltage, or GLV, operates below +30V
- Powers all systems except for the motor controller and TSV
- Remains galvanically isolated from TSV
- Safety loop - a four-wire system that is used to ensure that the driver, Tractive System Interface (TSI), or SCADA are able to disable power to the system in the case of an emergency
- TSI-LV and TSI-HV - monitor the state of the isolation between GLV and TSV, and controls TSV by opening and closing AIRs
- Majority of CAN communication bus remains in GLV, and an isolator separates it from TSV

System Design - Safety Loop

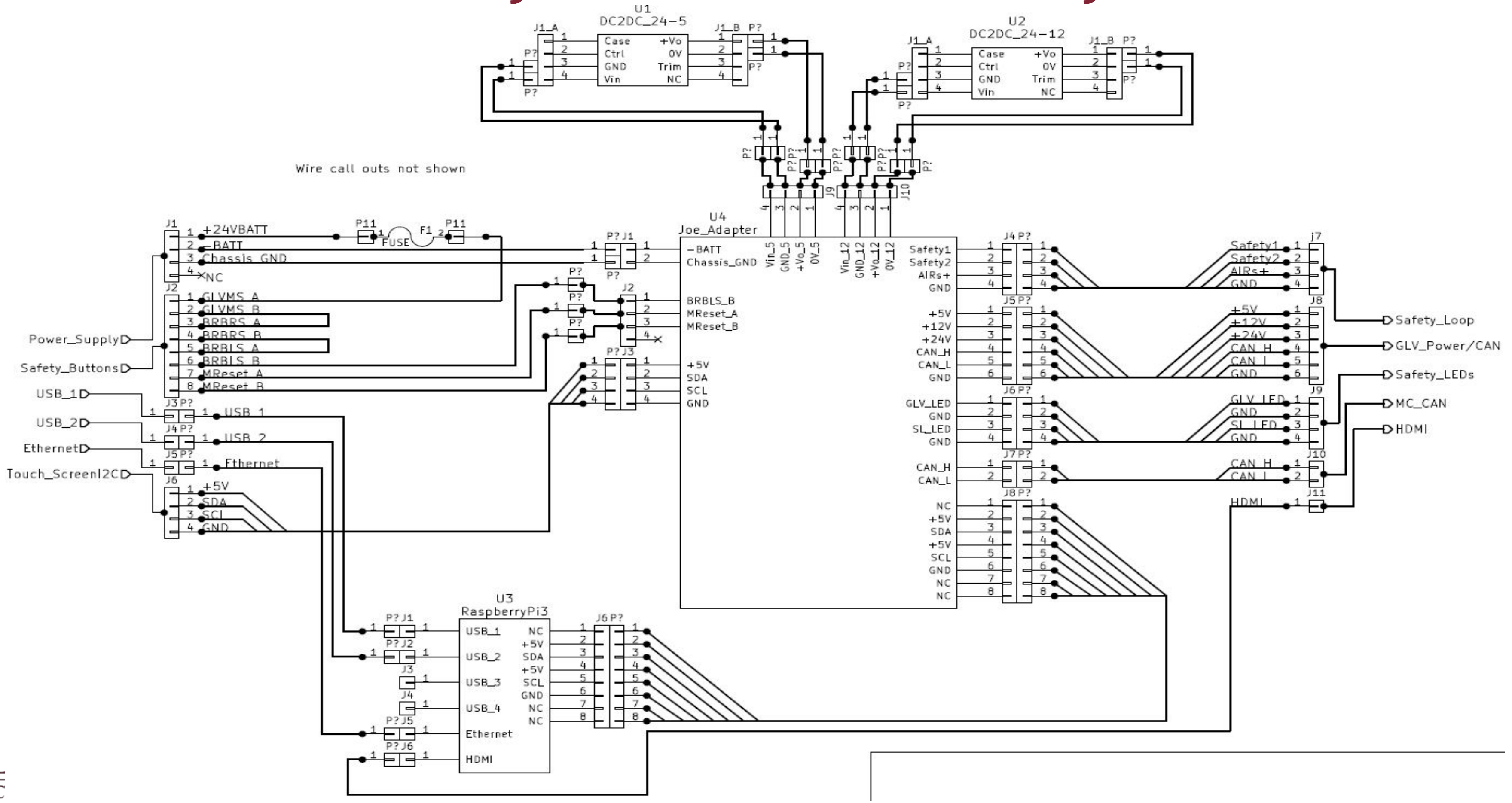




GLV Power/Safety/Scada Interface System

- The GLV system is intended to run off of a 24V+ battery that is independent of the TSV battery
- GLV distributes +5V, +12V, +24V, CAN_H and CAN_L, and the four wire safety loop
- Safety Loop Safety1, Safety2, AIRs+, and GND
- GLV interfaces with the scada computer (Raspberry Pi 3)
- 2x USB, 1x Ethernet, 1xHDMI, and I2C from the Raspberry Pi 7” touch screen and CAN

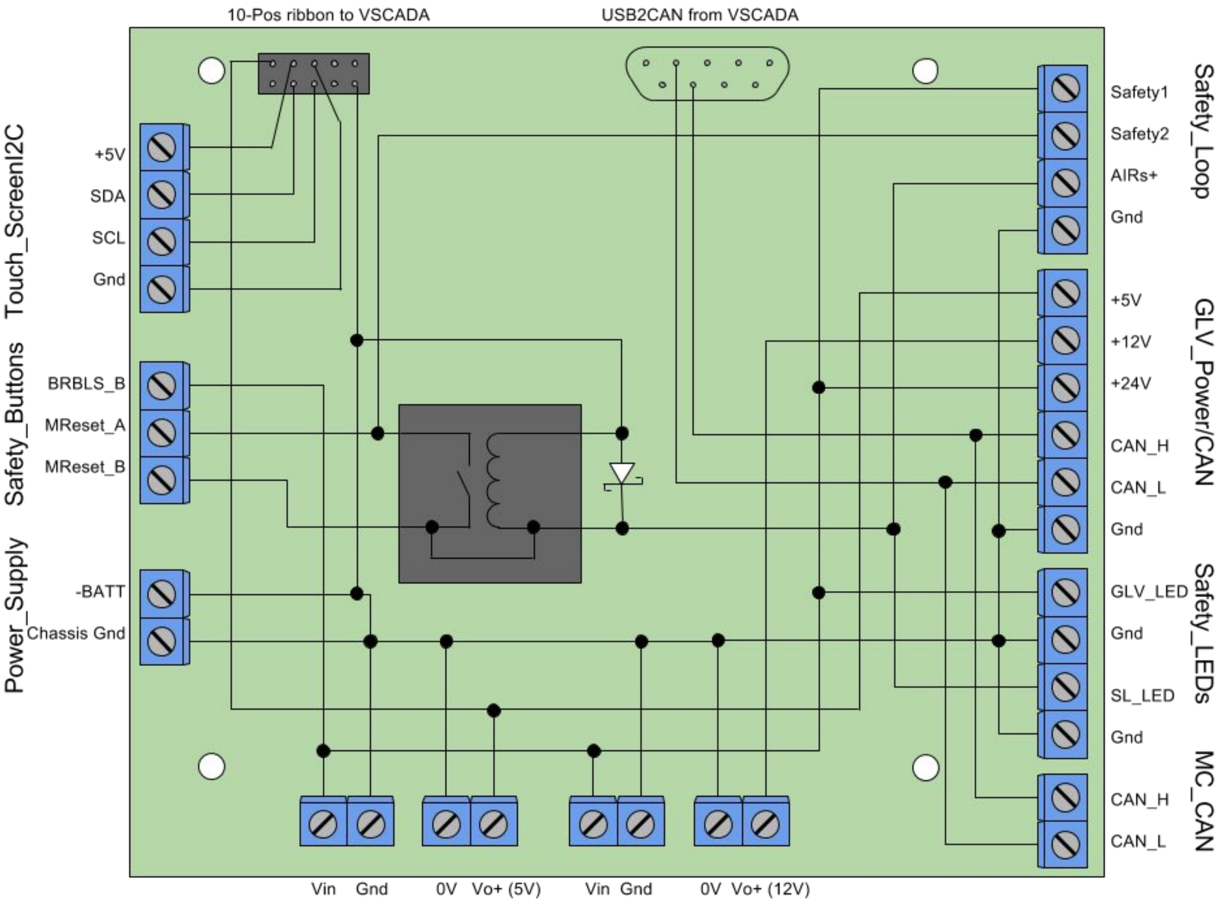
GLV Power/Safety/Scada Interface System Cont.



GLV Power/Safety/Scada Interface System Cont.

GLV_BoB (Joe_Adapter)

- Mounted below VSCADA Raspberry Pi
- 18 AWG wires connecting screw terminals to DT Connectors on outside of subsystem



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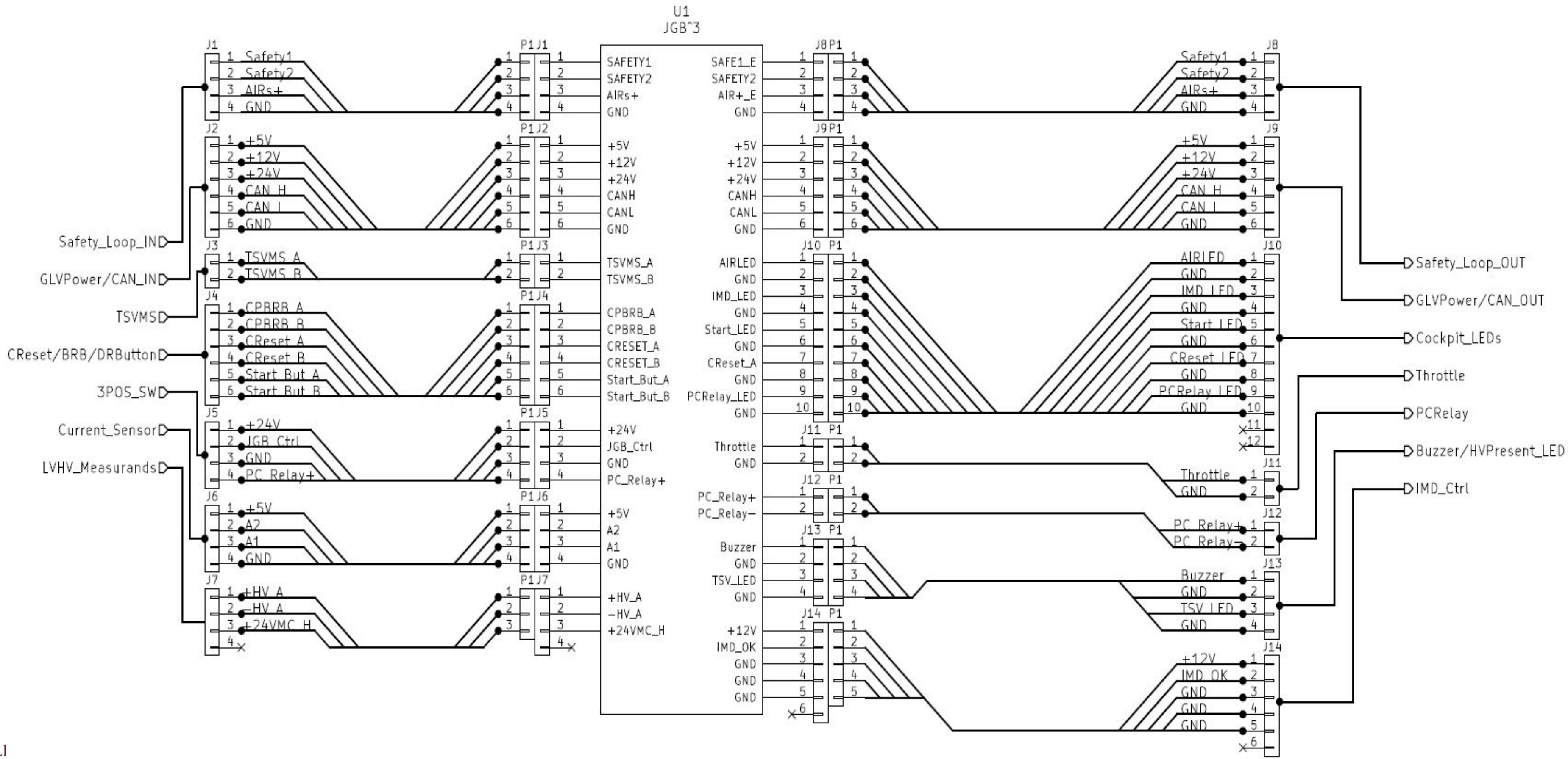
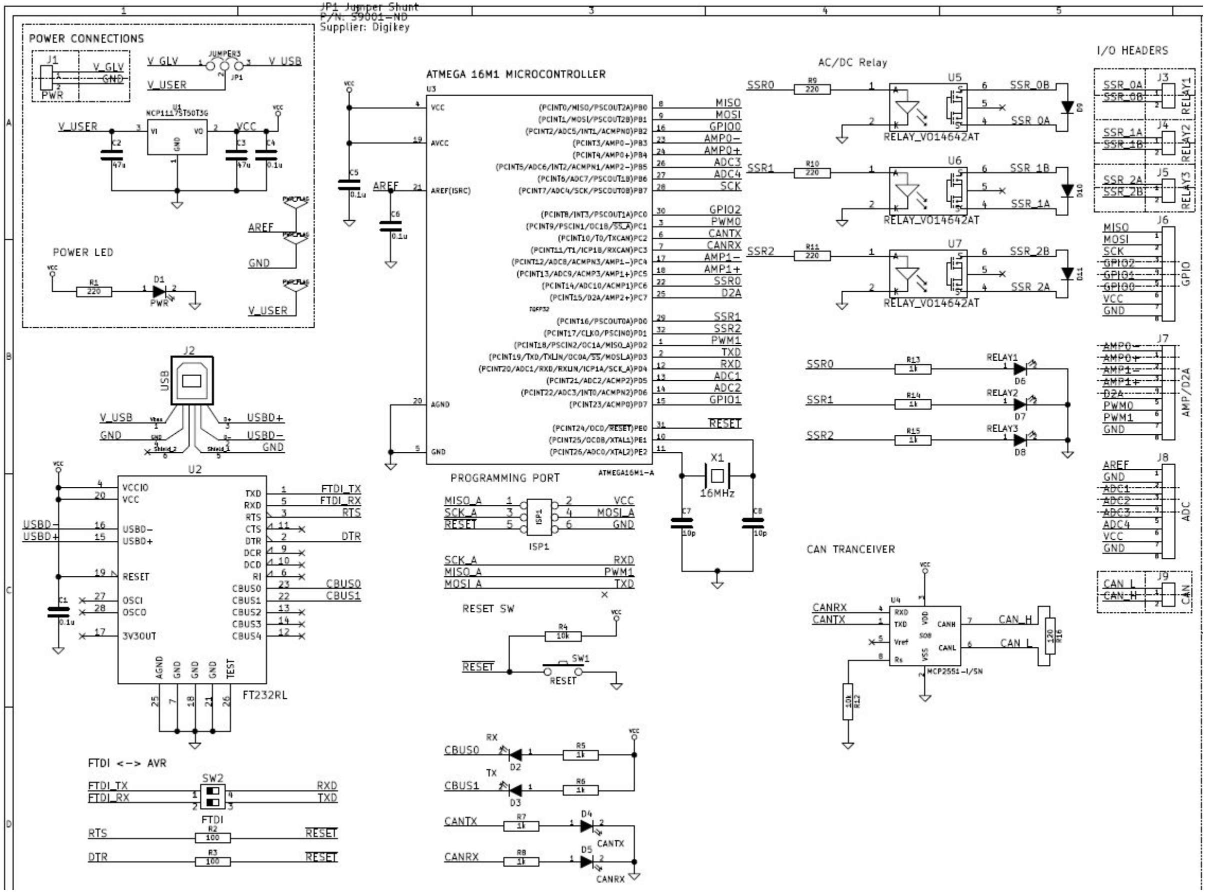
Tractive System Interface

- The traditional Tractive System Interface have been split into two sections TSI_LV and TSI_HV
- The TSI_LV contains a JGB^3, the JGB^3 is the “John Gehrig Board” with breakout board features added in addition to some glue logic
- The TSI_LV contains all of the decision logic for the TSI_HV
- The TSI_HV contains the HV voltage measuring point, the precharge relay, the current sensor, IMD, (Insulation monitoring device), the CAN bus isolator, and an Isolation board to isolate relevant signals living inside HV Land

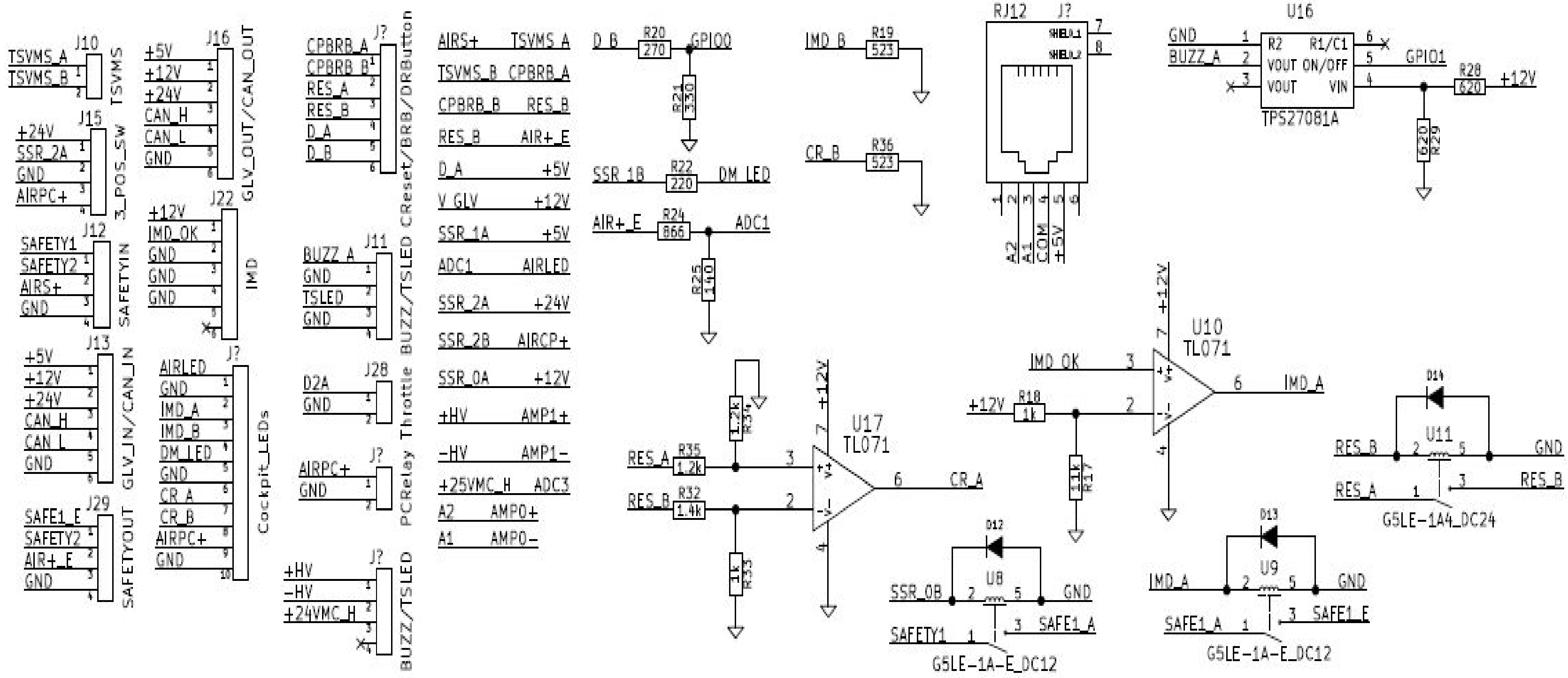
Low Voltage Tractive System Interface



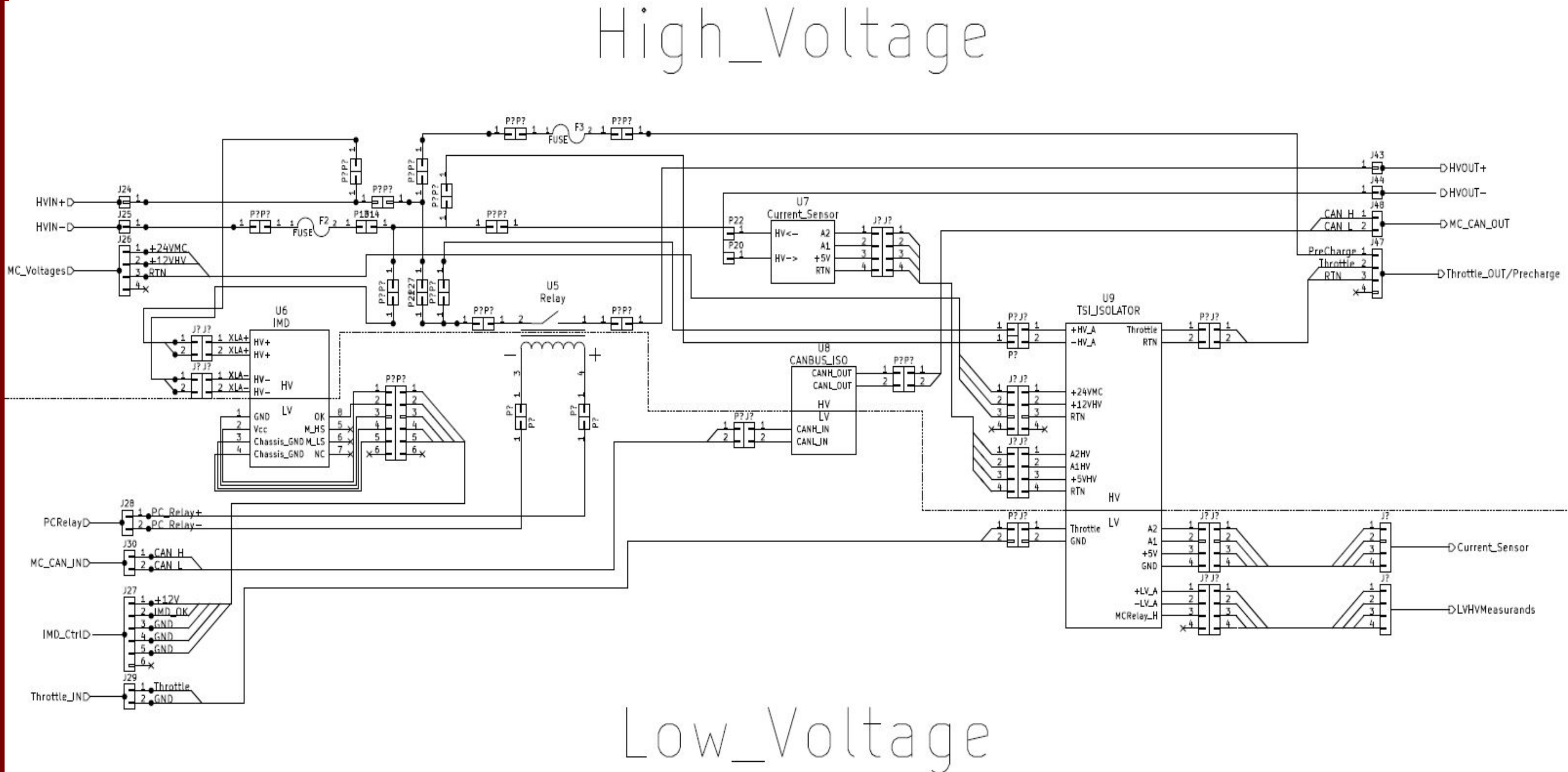
Low Voltage Tractive System Interface Cont.



Low Voltage Tractive System Interface Cont.

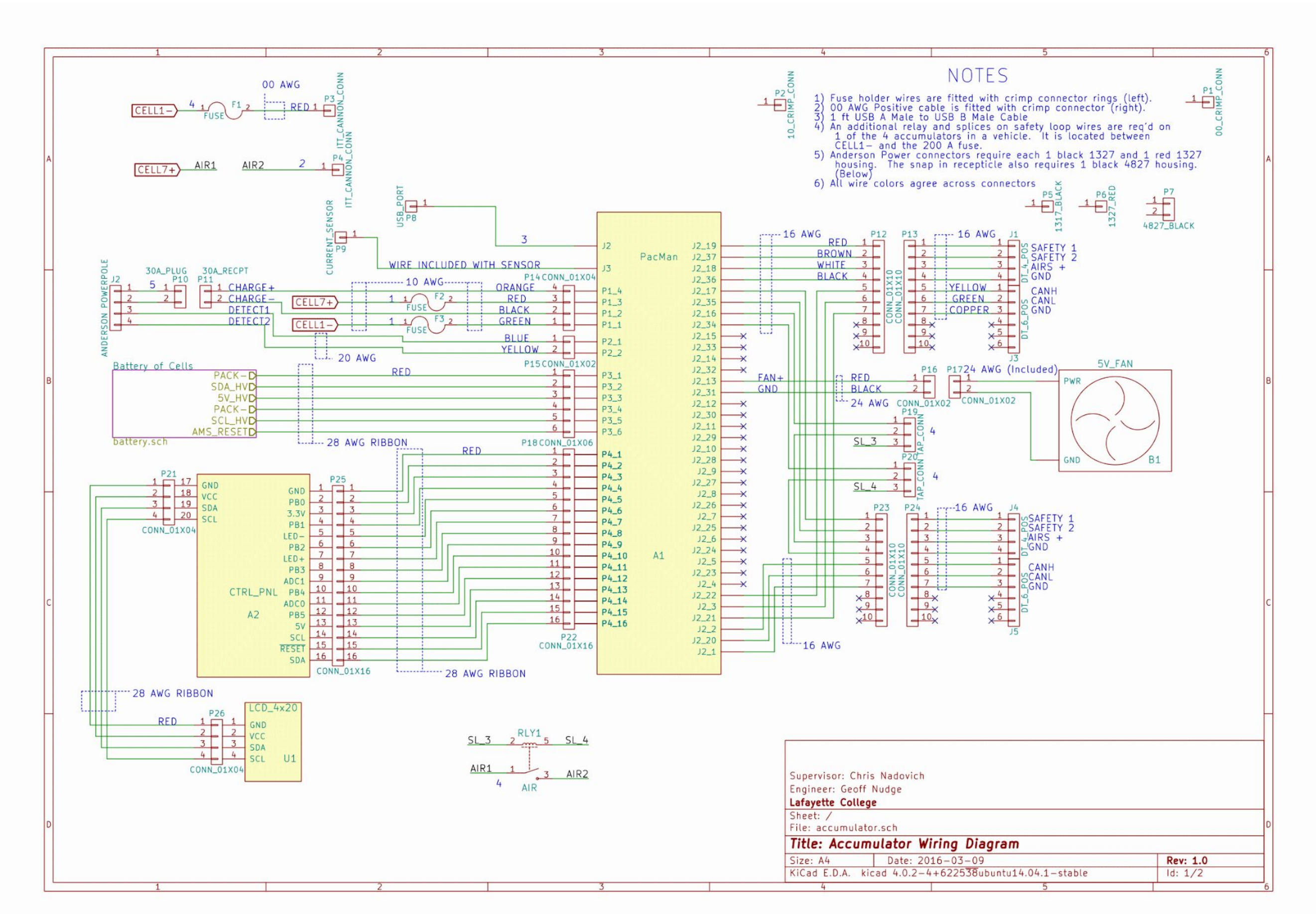


High Voltage Tractive System Interface



TSV - Tractive System Voltage

System Design – TSV – Accumulator



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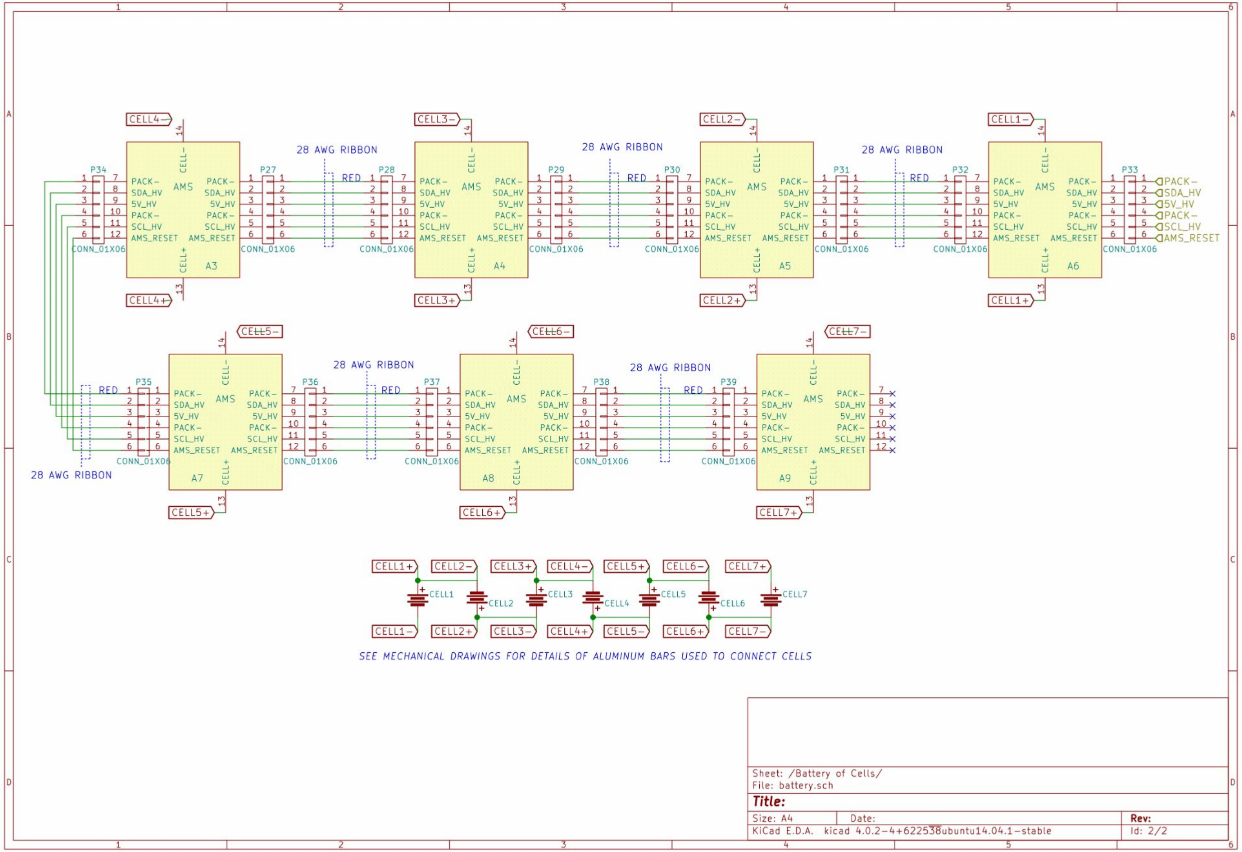
System Design - TSV - Accumulator

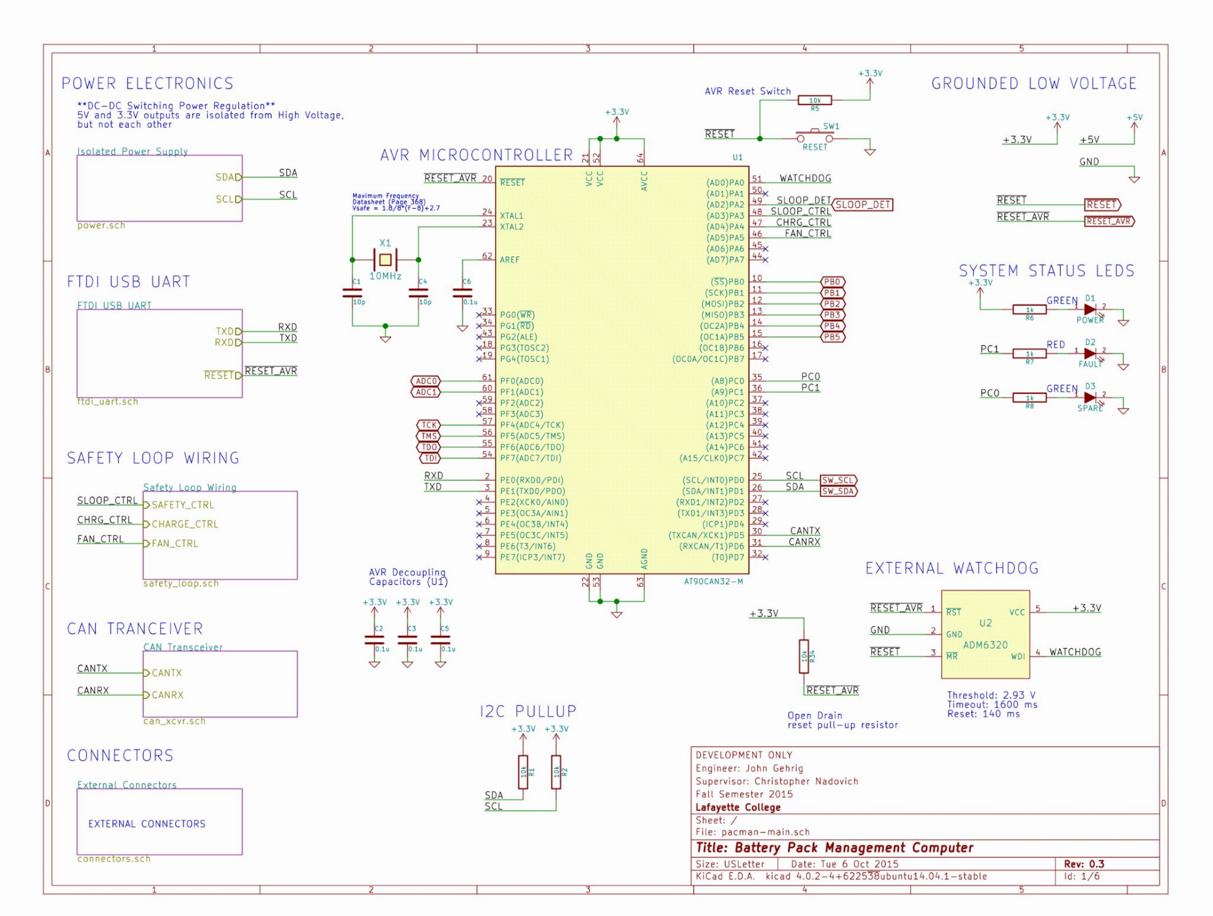


System Design – TSV – Accumulator

		Accumulator BOM						
Referenc	Value	Supplier	Supplier P/N	Manufacturer	Manufacturer P/N	Description	Unit Cost	Accessory
J1	DT_4_POS	wirecare.com	DT04-4P-L012	Deutsch	Same	DT - 4 Pin Receptacle Gray Flange	7.97	
A1	PacMan							
B1	5V_FAN	Digikey	603-1284-ND	Delta Electronics	AFB0605MB	FAN AXIAL 60X15MM BALL 5VDC WIRE	12.08	Fan Grate (x2)
J5	DT_6_POS	wirecare.com	DT04-6P-CL09	Deutsch	Same	DT - 6 Pin Receptacle Reduced Dia. Seals	25.72	
P8	USB_PORT	Digikey	1195-3481-ND	Harting	9454521901	CONN ADAPT USB A FMALE/FMALE 2.0	21.65	
P9	CURRENT_SENSOR	GMW Associates	BBM-01	Ametes	BBM-01	Bus Bar Module DC Current Sensor	40	
P22	CONN_01X16	Digikey	ED10502-ND	On Shore Technology Inc	101-166	CONN SOCKET IDC 16POS W/KEY GOLD	0.36	
F1	FUSE	Zoro	G3475534	MERSEN/FERRAZ SHAWMUT	A3T200	Fuse 200 Amp 300VAC/160DC V Fast Ser A3T	29.02	
P3	ITT_CANNON_CONN	Newark	44W4365	ITT Cannon	NPS-N-BL-T4	PANEL SOURCE NEUTRAL BLUE 400A (Female)	50.23	
P4	ITT_CANNON_CONN	Newark	44W4352	ITT Cannon	NLS-3-GY-S120-M40	LINE SOURCE LINE 3 GREY 400A (Male)	52.89	
F2	FUSE	Digikey	F5984-ND	Littlefuse Inc	FHAC0002LXN	FUSE HOLDER BLADE 30A IN LINE	4.79	25 A Fuse
F3	FUSE	Digikey	F5984-ND	Littlefuse Inc	FHAC0002LXN	FUSE HOLDER BLADE 30A IN LINE	4.79	25 A Fuse
P14	CONN_01X04	Digikey	556879-4-ND	TE Connectivity AMP Connector	556879-4	CONN HSG PLUG 4POS 11.18MM BLACK	4.83	
J2	ANDERSON POWERPOL	Mouser	879-1470G1	Anderson Power Products	1470G1	PP PAK 2-4P HSG SNAP-IN RECEPT	2.65	Retaining Pin: Mouser P/N 879-110G9
P12	CONN_01X10	Digikey	A111927-ND	TE Connectivity AMP Connector	1-1586018-0	CONN PLUG 10POS DUAL PANEL MT	0.27	Pin: Digikey P/N A100459TR-ND
P13	CONN_01X10	Digikey	A30594-ND	TE Connectivity AMP Connector	1-794954-0	CONN RECEPT 10POS FREE HANGING	0.27	Pin: Digikey P/N A99268TR-ND
P15	CONN_01X02	Digikey	WM2900-ND	Molex	50579402	CONN HOUSING 2POS .100 W/LATCH	0.26	
P18	CONN_01X06	Mouser	538-50-57-970	Molex	50-57-9706	6 pin connector	0.53	Pin: Mouser P/N 538-16-02-0096 Drawer: Mouser P/N 538-73838-0006
P16	CONN_01X02	Digikey	A30590-ND	TE Connectivity AMP Connector	794954-2	CONN RECEPT 2POS FREE HANGING	0.15	Pin: Digikey P/N A30638-ND
P23	CONN_01X10	Digikey	A111927-ND	TE Connectivity AMP Connector	1-1586018-0	CONN PLUG 10POS DUAL PANEL MT	0.27	Pin: Digikey P/N A100459TR-ND
P24	CONN_01X10	Digikey	A30594-ND	TE Connectivity AMP Connector	1-794954-0	CONN RECEPT 10POS FREE HANGING	0.27	Pin: Digikey P/N A99268TR-ND
P17	CONN_01X02	Digikey	A30654-ND	TE Connectivity AMP Connector	1586000-2	CONN PLUG 2POS FREE HANGING	0.12	Pin: Digikey P/N A30646-ND
A2	CTRL_PNL							
P25	CONN_01X16	Digikey	ED10502-ND	On Shore Technology Inc	101-166	CONN SOCKET IDC 16POS W/KEY GOLD	0.36	
U1	LCD_4x20	DFRobot	DFR0154	DFRobot	Same	I2C/TWI LCD2004 Module	23.55	
P2	10_CRIMP_CONN	Digikey	A27284CT-ND	TE Connectivity AMP Connector	2-36161-2	CONN RING 10-12 AWG #10 PIDG	0.5	
P1	00_CRIMP_CONN	Mouser	571-160001	TE Connectivity	160001	Terminals TERM SOLIS R 2/0 M10	3.92	
RLY1	AIR	Gigavac	GX14CB	Same	Same	AIR	UNK	
P19	TAP_CONN	Digikey	920074-07-ND	3M	558	CONN TAP 22-16 AWG RED	0.59	
P20	TAP_CONN	Digikey	920074-07-ND	3M	558	CONN TAP 22-16 AWG RED	0.59	
P21	CONN_01X04	Digikey	WM2902-ND	Molex	50579404	CONN HOUSING 4POS .100 W/LATCH	0.27	Pin: Digikey P/N WM2562-ND
P26	CONN_01X04	Digikey	WM2902-ND	Molex	50579404	CONN HOUSING 4POS .100 W/LATCH	0.27	Pin: Digikey P/N WM2562-ND
J4	DT_4_POS	wirecare.com	DT04-4P-L012	Deutsch	Same	DT - 4 Pin Receptacle Gray Flange	7.97	
J3	DT_6_POS	wirecare.com	DT04-6P-CL09	Deutsch	Same	DT - 6 Pin Receptacle Reduced Dia. Seals	25.72	
P10	30A_PLUG	Mouser	879-1460G1	Anderson Power Products	1460G1	PP PAK 2-4P HSG-PLUG W/LATCH	1.7	
P11	30A_RECPT	Mouser	879-1461G1	Anderson Power Products	1461G1	PP PAK 2-4P HSG-PLUG NO LATCH	1.54	
P5	1317_BLACK	Mouser	879-1327G6FP	Anderson Power Pruducts	1327G6FP	PP15/45 FINGERPROOF HOUSING ONLY, BLAC	0.85	Pin: Mouser P/N 879-261G2-LPBK
P6	1327_RED	Mouser	879-1327FP	Anderson Power Pruducts	1327FP	PP15/45 FINGERPROOF HOUSING ONLY, RED	0.79	Pin: Mouser P/N 879-261G2-LPBK
P7	4827_BLACK	Mouser	879-4827G6	Anderson Power Products	4827G6	PPMX 2-PIECE BLACK HOUSING ONLY	0.77	Pin: Mouser P/N 879-4802G3 and Mouser P/N 879-4803G3
A6	AMS							
A3	AMS							
A5	AMS							
A4	AMS							
A7	AMS							
A8	AMS							
A9	AMS							
CELL1	Cell	AA Portable Power Cor	LFP-G60	AA Portable Battery Corp	SAME	LiFePO4 Prismatic Module: 3.2V 60 Ah	102.3	
CELL2	Cell	AA Portable Power Cor	LFP-G60	AA Portable Battery Corp	SAME	LiFePO4 Prismatic Module: 3.2V 60 Ah	102.3	
CELL3	Cell	AA Portable Power Cor	LFP-G60	AA Portable Battery Corp	SAME	LiFePO4 Prismatic Module: 3.2V 60 Ah	102.3	
CELL4	Cell	AA Portable Power Cor	LFP-G60	AA Portable Battery Corp	SAME	LiFePO4 Prismatic Module: 3.2V 60 Ah	102.3	
CELL5	Cell	AA Portable Power Cor	LFP-G60	AA Portable Battery Corp	SAME	LiFePO4 Prismatic Module: 3.2V 60 Ah	102.3	
CELL7	Cell	AA Portable Power Cor	LFP-G60	AA Portable Battery Corp	SAME	LiFePO4 Prismatic Module: 3.2V 60 Ah	102.3	
P33	CONN_01X06	Mouser	538-50-57-970	Molex	50-57-9706	6 pin connector	0.47	Pin: Mouser P/N 538-16-02-0096 Drawer: Mouser P/N 538-73838-0006
P32	CONN_01X06	Mouser	538-50-57-970	Molex	50-57-9706	6 pin connector	0.47	Pin: Mouser P/N 538-16-02-0096 Drawer: Mouser P/N 538-73838-0006
P31	CONN_01X06	Mouser	538-50-57-970	Molex	50-57-9706	6 pin connector	0.47	Pin: Mouser P/N 538-16-02-0096 Drawer: Mouser P/N 538-73838-0006
P30	CONN_01X06	Mouser	538-50-57-970	Molex	50-57-9706	6 pin connector	0.47	Pin: Mouser P/N 538-16-02-0096 Drawer: Mouser P/N 538-73838-0006
P29	CONN_01X06	Mouser	538-50-57-970	Molex	50-57-9706	6 pin connector	0.47	Pin: Mouser P/N 538-16-02-0096 Drawer: Mouser P/N 538-73838-0006
P28	CONN_01X06	Mouser	538-50-57-970	Molex	50-57-9706	6 pin connector	0.47	Pin: Mouser P/N 538-16-02-0096 Drawer: Mouser P/N 538-73838-0006
P27	CONN_01X06	Mouser	538-50-57-970	Molex	50-57-9706	6 pin connector	0.47	Pin: Mouser P/N 538-16-02-0096 Drawer: Mouser P/N 538-73838-0006
P34	CONN_01X06	Mouser	538-50-57-970	Molex	50-57-9706	6 pin connector	0.47	Pin: Mouser P/N 538-16-02-0096 Drawer: Mouser P/N 538-73838-0006
P35	CONN_01X06	Mouser	538-50-57-970	Molex	50-57-9706	6 pin connector	0.47	Pin: Mouser P/N 538-16-02-0096 Drawer: Mouser P/N 538-73838-0006
P36	CONN_01X06	Mouser	538-50-57-970	Molex	50-57-9706	6 pin connector	0.47	Pin: Mouser P/N 538-16-02-0096 Drawer: Mouser P/N 538-73838-0006
P37	CONN_01X06	Mouser	538-50-57-970	Molex	50-57-9706	6 pin connector	0.47	Pin: Mouser P/N 538-16-02-0096 Drawer: Mouser P/N 538-73838-0006
P38	CONN_01X06	Mouser	538-50-57-970	Molex	50-57-9706	6 pin connector	0.47	Pin: Mouser P/N 538-16-02-0096 Drawer: Mouser P/N 538-73838-0006
P39	CONN_01X06	Mouser	538-50-57-970	Molex	50-57-9706	6 pin connector	0.47	Pin: Mouser P/N 538-16-02-0096 Drawer: Mouser P/N 538-73838-0006
CELL6	Cell	AA Portable Power Cor	LFP-G60	AA Portable Battery Corp	SAME	LiFePO4 Prismatic Module: 3.2V 60 Ah	102.3	

BOM

System Design - TSV - PacMan



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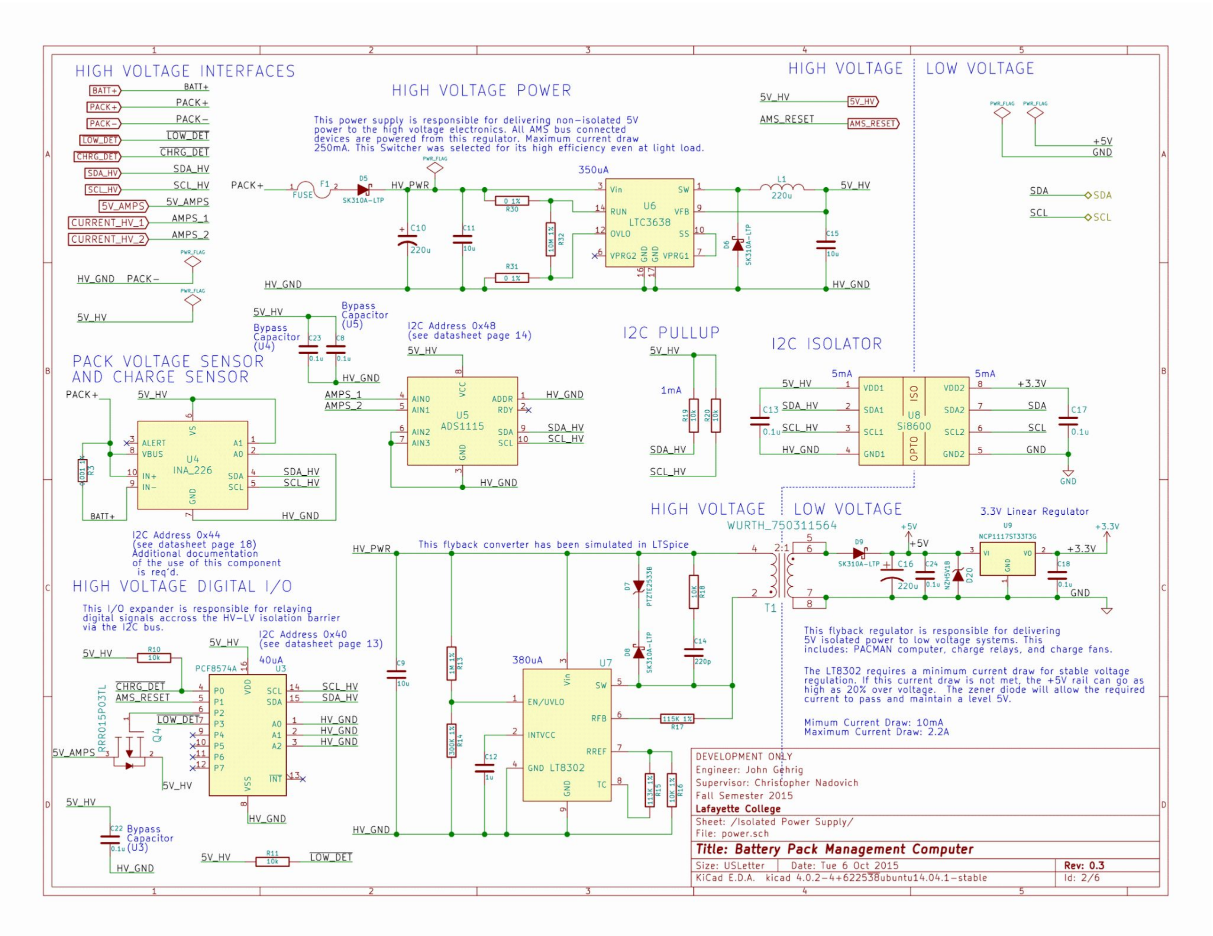
System Design – TSV – PacMan



[Layout](#)

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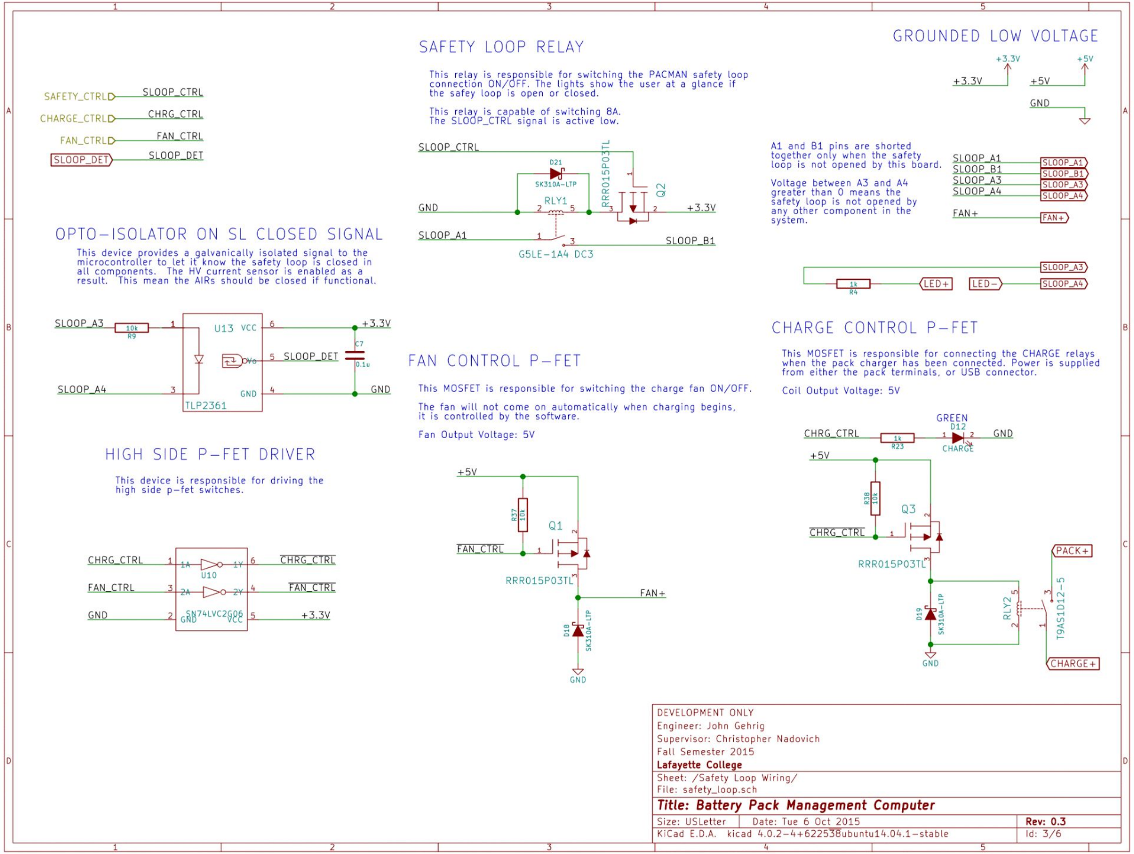
System Design - TSV - PacMan



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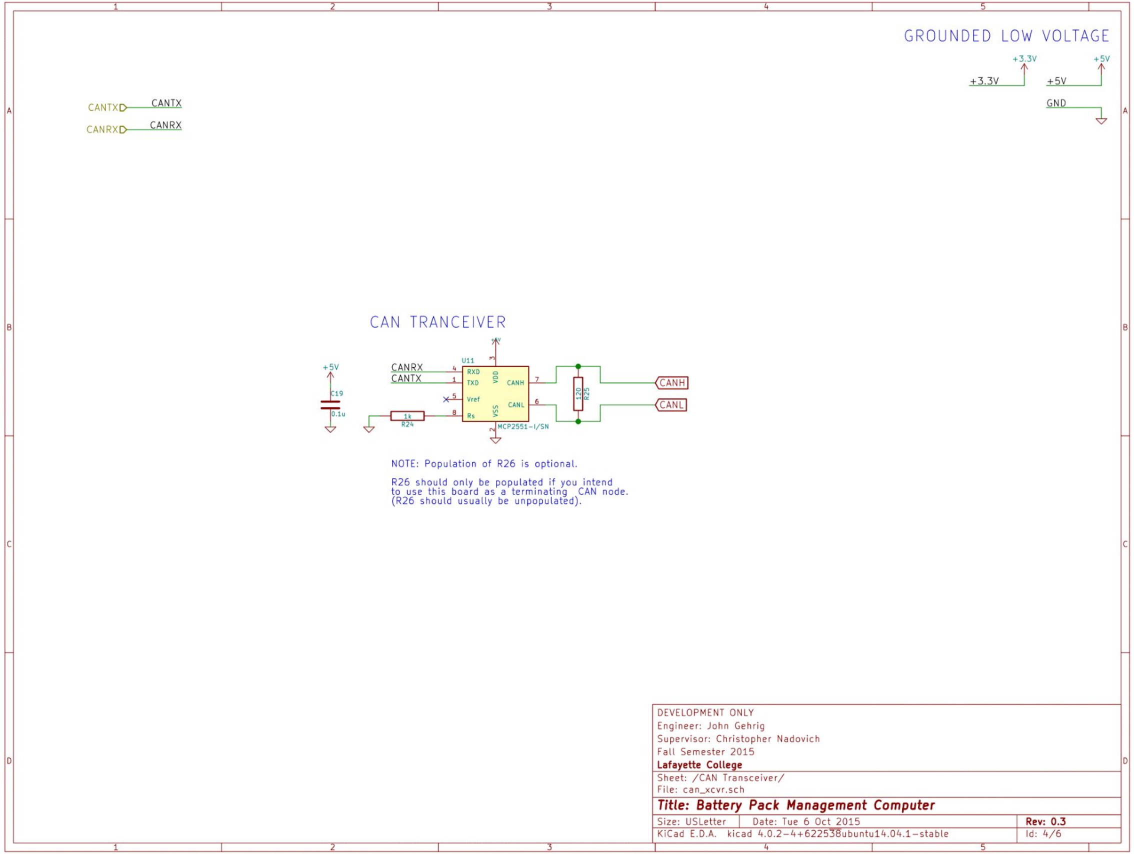
System Design - TSV - PacMan



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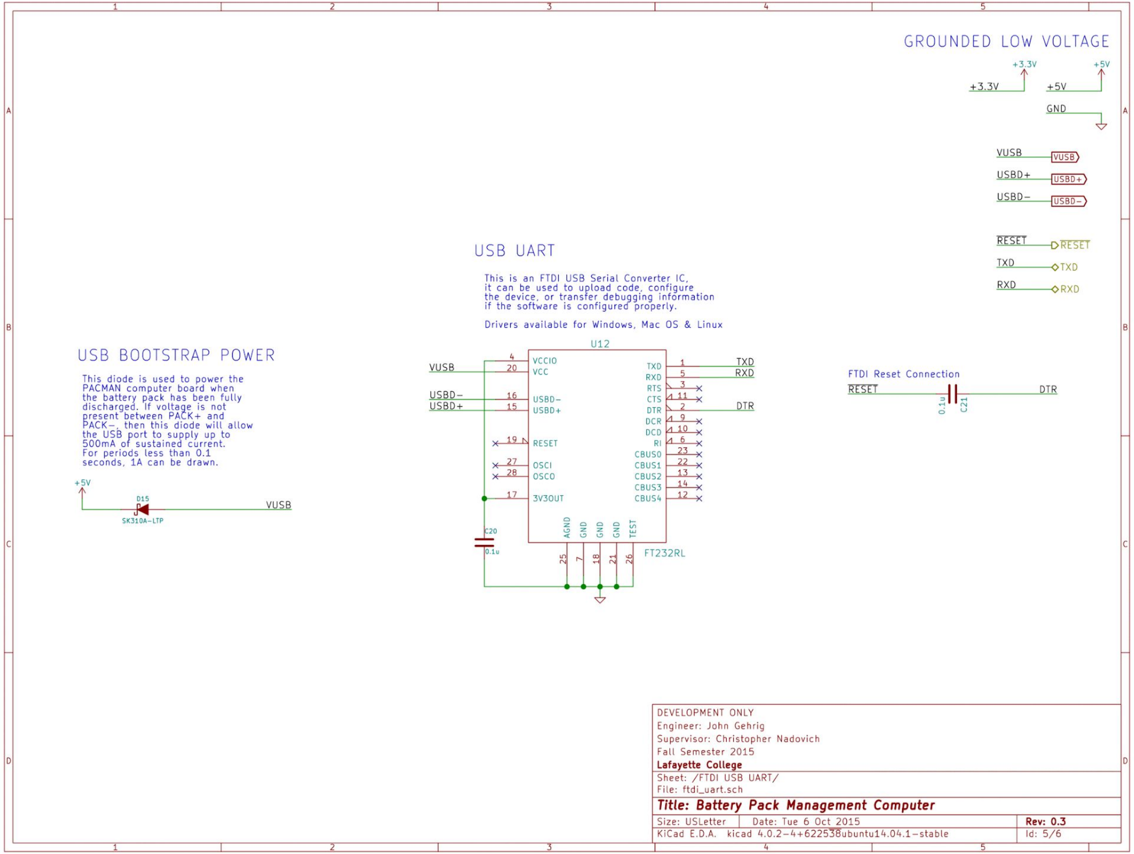
System Design – TSV – PacMan



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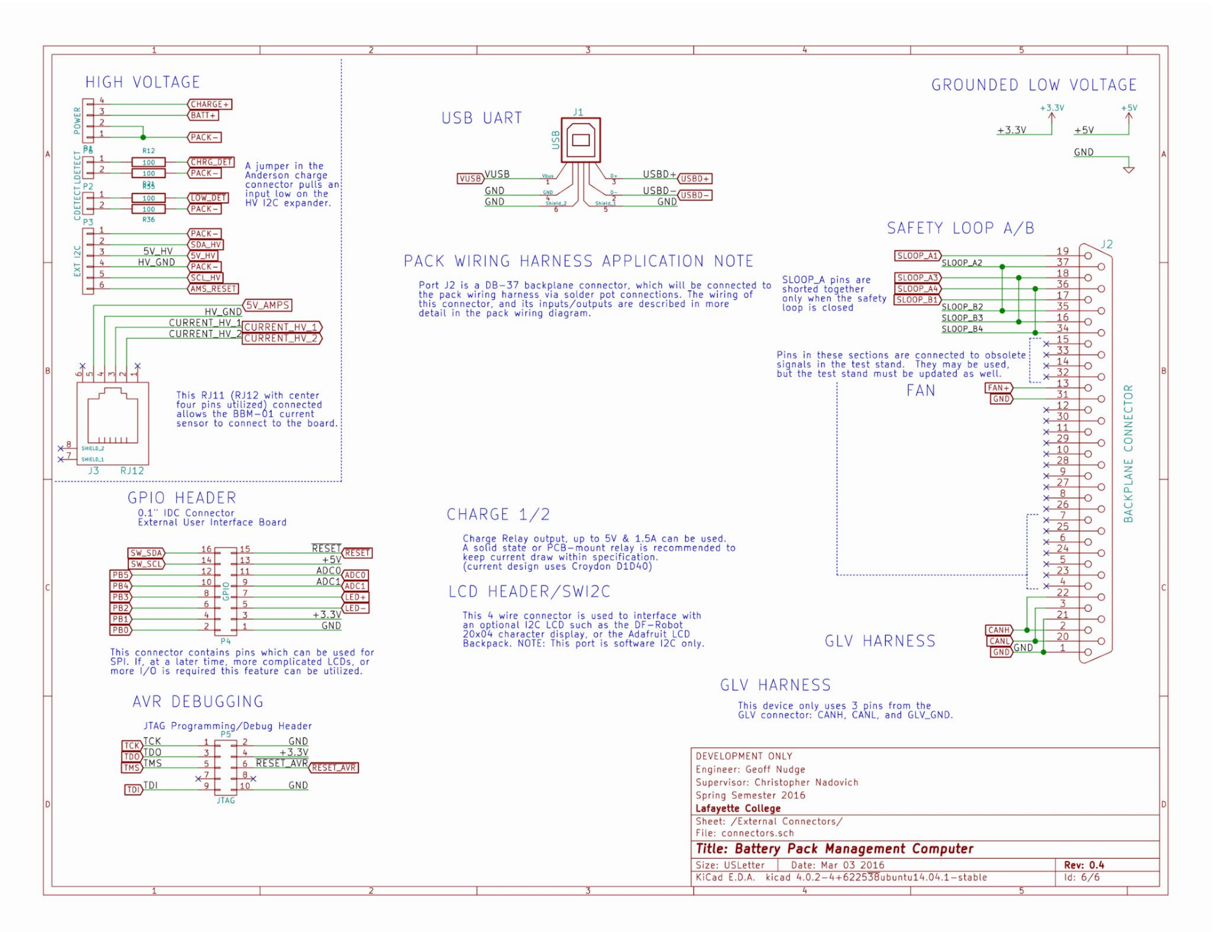
System Design – TSV – PacMan



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System Design – TSV – PacMan

			PacMan BOM				
Referenc	Value	Supplier	Supplier P/N	Manufacturer	Manufacturer P/N	Description	Unit Cost
C2	0.1u						
X1	10MHz	Digikey	887-1741-1-ND	TXC Corporation	7A-10.000MAAE-T	10MHz SMD Crystal	0.72
C1	10p						
C4	10p						
C6	0.1u						
SW1	RESET	Digikey	CKN9363CT-ND	C&K Components	1.14100.5030000	SWITCH PUSH SPST-NO 0.1A 42V	2.43
R5	10k						
C3	0.1u						
C5	0.1u						
R6	1k						
R7	1k						
D1	POWER					0603 LED (BLUE)	
D2	FAULT					0603 LED (RED)	
U1	AT90CAN128-M	Digikey	AT90CAN128-16AURCT-ND	Atmel	AT90CAN128-16AUR	IC MCU 8BIT 128KB FLASH 64TQFP	10.4
U2	ADM6320	Digikey	ADM6320CY29ARJZ-R7CT-N	Analog Devices	ADM6320CY29ARJZ-R	External Watchdog IC 2.9V 1600mS 140mS	1.52
R1	10k						
R2	10k						
R34	10k						
D3	SPARE					0603 LED (BLUE)	
R8	1k						
U9	NCP1117ST33T3G	Digikey	NCP1117ST33T3GOSCT-ND	ON Semiconductor	NCP1117ST33T3G	IC REG LDO 3.3V 1A SOT223	0.49
C16	220u	Digikey	493-6214-1-ND	Nichicon	UUR1C221MCL6GS	SMD 16volts 220uF 20% 85C 6.3X7.7	0.41
C18	0.1u						
U8	Si8600	Digikey	SI8600AC-B-ISR-ND	Silicon Labs	Si8600AC-B-IS	3.75kV Bidirect I2C Isolator 1.7MHz	2.96
C13	0.1u						
C17	0.1u						
U3	PCF8574A	Digikey	568-1074-1-ND	NXP Semiconductors	PCF8574AT3518	IC I/O EXPANDER I2C 8B 16SOIC	1.22
U6	LTC3638	Digikey	LTC3638EMSE#PBF-ND	Linear Technology	LTC3638EMSE#PBF	IC REG BUCK ADJ 0.25A 16MSOP	7.79
C11	10u	Digikey	490-1891-1-ND	Murata Electronics	GRM32DF51H106ZA01	CAP CER 10UF 50V Y5V 1210	0.61
L1	220u	Digikey	445-173047-1-ND	TDK Corporation	VLS6045EX-221M	FIXED IND 220UH 500MA 1.15 MOHM	0.52
D6	SK310A-LTP	Digikey	SK310A-LTPMSCT-ND	Micro Commercial Components (MMC)	SK310A-LTP	Schottky Diodes & Rectifiers DIODE SCHOTTKY 100V 3A DO214AC	0.57
C15	10u	Digikey	490-1891-1-ND	Murata Electronics	GRM32DF51H106ZA01	CAP CER 10UF 50V Y5V 1210	0.61
C9	10u	Digikey	490-1891-1-ND	Murata Electronics	GRM32DF51H106ZA01	CAP CER 10UF 50V Y5V 1210	0.61
C12	1u						
R20	10k						
R19	10k						
C8	0.1u						
R13	1M 1%						
R14	300K 1%						
R17	115K 1%						
R16	10K 1%						
C10	220u	Digikey	493-9426-1-ND	Nichion	UCW1H221MNL1GS	CAP ALUM 220UF 20% 50V SMD	0.79
D5	SK310A-LTP	Digikey	SK310A-LTPMSCT-ND	Micro Commercial Components (MMC)	SK310A-LTP	Schottky Diodes & Rectifiers DIODE SCHOTTKY 100V 3A DO214AC	0.57
T1	WURTH_750311564	Digikey	1297-1132-1-ND	Wurth Electronics	750313441	TRANS FLYBACK LT8302	4.55
R15	113K 1%						
D7	PTZTE2533B	Digikey	PTZTE2533BCT-ND	Rohm Semiconductor	PTZTE2533B	DIODE ZENER 35V 1W PMDS	0.45
C14	220p						
R18	10K						
D8	SK310A-LTP	Digikey	SK310A-LTPMSCT-ND	Micro Commercial Components (MMC)	SK310A-LTP	Schottky Diodes & Rectifiers DIODE SCHOTTKY 100V 3A DO214AC	0.57
D9	SK310A-LTP	Digikey	SK310A-LTPMSCT-ND	Micro Commercial Components (MMC)	SK310A-LTP	Schottky Diodes & Rectifiers DIODE SCHOTTKY 100V 3A DO214AC	0.57
U7	LT8302	Digikey	LT8302ES8E#PBF-ND	Linear Technology	LT8302ES8E#PBF	IC REG FLYBCK INV ISO 3.6A 8SOIC	7.41
R10	10k						
R30	0 1%						
R32	10M 1%						
R31	0 1%						
C22	0.1u						
C23	0.1u						
U5	ADS1115	Digikey	296-38849-1-ND	Texas Instruments	ADS1115IDGSR	IC ADC 16BIT 860SPS LP 10MSOP	5.65
C24	0.1u	Digikey	?				

BOM

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System Design – TSV – PacMan

D20	NZH5V1B	Digikey	568-6370-1-ND	NXP Semiconductors	NZH5V1B	DIODE ZENER 5.1V 500MW SOD123F	0.2
U4	INA_226	Digikey	296-29034-1-ND	Texas Instruments	INA226AIDGSR		3.44
R3	0.001 1%	Digikey	CSNL1206FT1L00CT-ND	Stackpole Electronics	CSNL1206FT1L00	RES SMD 0.001 OHM 1% 1W 1206	0.65
F1	FUSE	Digikey	507-1077-1-ND	Bel Fuse Inc	C1Q 1	FUSE BOARD MOUNT 1A 125VAC 63VDC	0.31
Q4	RRR015P03TL	Digikey	RRR015P03TLCT-ND	Rohm Semiconductor	RRR015P03TL	MOSFET P-CH 30V 1.5A TSMT3	0.43
R11	10k						
D12	CHARGE					0603 LED (GREEN)	
R23	1k						
D18	SK310A-LTP	Digikey	SK310A-LTPMSCT-ND	Micro Commercial Components (MMC)	SK310A-LTP	Schottky Diodes & Rectifiers DIODE SCHOTTKY 100V 3A DO214AC	0.57
Q1	RRR015P03TL	Digikey	RRR015P03TLCT-ND	Rohm Semiconductor	RRR015P03TL	MOSFET P-CH 30V 1.5A TSMT3	0.43
D19	SK310A-LTP	Digikey	SK310A-LTPMSCT-ND	Micro Commercial Components (MMC)	SK310A-LTP	Schottky Diodes & Rectifiers DIODE SCHOTTKY 100V 3A DO214AC	0.57
R37	10k						
R38	10k						
RLY1	G5LE-1A4 DC3	Digikey	Z3697-ND	Omron	G5LE-1A4 DC3	RELAY GEN PURPOSE SPST 10A 3V	1.43
D21	SK310A-LTP	Digikey	SK310A-LTPMSCT-ND	Micro Commercial Components (MMC)	SK310A-LTP	Schottky Diodes & Rectifiers DIODE SCHOTTKY 100V 3A DO214AC	0.57
Q3	RRR015P03TL	Digikey	RRR015P03TLCT-ND	Rohm Semiconductor	RRR015P03TL	MOSFET P-CH 30V 1.5A TSMT3	0.43
Q2	RRR015P03TL	Digikey	RRR015P03TLCT-ND	Rohm Semiconductor	RRR015P03TL	MOSFET P-CH 30V 1.5A TSMT3	0.43
U10	SN74LVC2G06	Digikey	296-13493-1-ND	Texas Instruments	SN74LVC2G06DCKR	IC INVERTER DUAL 1INPUT SC706	0.54
R4	1k						
U13	TLP2361	Digikey	TLP2361(V4-TPLECT-ND	Toshiba Semiconductor and Storage	TLP2361(V4-TPL	OPTOISO 3.75KV PSH PULL SO6-5	1.14
C7	0.1u						
R9	10k						
RLY2	T9AS1D12-5	Digikey	PB1014-ND	TE Connectivity Potter & Brumfield Relay	T9AS1D12-5	RELAY GEN PURPOSE SPST 30A 5V	4.22
U11	MCP2551-I/SN	Digikey	MCP2551-I/SN-ND	Microchip	MCP2551-I/SN	CAN Interface IC	1.02
R25	120						
R24	1k						
C19	0.1u						
C20	0.1u						
U12	FT232RL	Digikey	768-1007-1-ND	FTDI	FT232RL-REEL	IC USB FS SERIAL UART 28-SSOP	4.5
C21	0.1u						
D15	SK310A-LTP	Digikey	SK310A-LTPMSCT-ND	Micro Commercial Components (MMC)	SK310A-LTP	Schottky Diodes & Rectifiers DIODE SCHOTTKY 100V 3A DO214AC	0.57
J1	USB	Digikey	A114945-ND	TE Connectivity	1734346-1	USB Connectors B Blk 4pos R/A SMT	1.36
P5	JTAG	Digikey	609-4054-ND	FCI	20021521-00010T1LF	Headers & Wire Housings 10P STRT 4WALL GLDFL	1.1
P3	EXT I2C	Digikey	WM1344-ND	Molex	15-91-2065	Headers & Wire Housings 2.54 WIRE/BOARD HDR Right Angle 6 CKT	4.2
P4	GPIO	Digikey	3M11931-ND	3M	30316-6002HB	Headers & Wire Housings 26P STRT 4WALL GLDFL	0.78
J2	BACKPLANE CONNECTO	Digikey	5237FE-ND	Norcomp Inc	171-037-213R011	D-Sub Connector Receptacle Female Sockets 37 Position Through Hole Sol	3.88
R35	100						
R36	100						
P2	CDETECT	Digikey	WM1340-ND	Molex	15-91-2025	Headers 2.54 WIRE/BOARD HDR Right Angle 2 CKT	2.61
J3	RJ12	Digikey	WM3789CT-ND	Molex LLC	855135002	CONN MOD JACK 6P6C VERT UNSHLD	1.16
P1	POWER	Digikey	A113982-ND	TE Connectivity AMP Connectors	556881-4	CONN RCPT 4POS 11.18MM PCB SLDR	8.66
R12	100						
R21	100						
P6	LDETECT	Digikey	WM1340-ND	Molex	15-91-2025	Headers 2.54 WIRE/BOARD HDR Right Angle 2 CKT	2.61

BOM

System Design – TSV – Control Panel

System Design – TSV – Control Panel

System Design - TSV - LCD Menu

```
ACTION         OUTPUT                 POSSIBLE OUTPUTS
Top Menu
           STATE:RDY   SOC: 78%  CHRG, CHRGD, LCO, FLT, DEAD, RDY, BOOT
           PACV:24.5 PACA:157.4
           SAFETY LOOP:CLOSED
           T> CHST               CHST, C1, C2, C3, C4, C5, C6, C7, CAL1, CAL2
Down
           STATE:RDY   SOC: 78%
           PACV:24.5 PACA:157.4
           SAFETY LOOP:CLOSED
           T> C1
Select
           STATE:OK              OK, BYP
           C1_V:3.4 C1_T:47.3

           T/C1> T               T, CAL
Down
           STATE:OK
           C1_V:3.4 C1_T:47.3

           T/C1> CAL
```

System Design - TSV - LCD Menu

```
ACTION          OUTPUT                      POSSIBLE OUTPUTS
Select
          VOFF:.002 TOFF:2.00
          VSLP:1.02 TSLP:0.99

          T/C1/CAL> V OFF      VOFF, VSLP, TOFF, TSLP, C1
Select
          VOFF:.002 TOFF:2.00
          VSLP:1.02 TSLP:0.99

          T/C1/CAL> VOFF
Select
          VOFF:.002 CURRENT
               .002 NEW
                123 DIGIT
          T/C1/CAL/VOFF> 1          1, 2, 3, CAL
Select and Up
          VOFF:.002 CURRENT
               .102 NEW        0, 1, 2, 3, 4, 5, 6, 7, 8, 9
                123 DIGIT
          T/C1/CAL/VOFF> OK?
```

System Design - TSV - LCD Menu

```
ACTION          OUTPUT                      POSSIBLE OUTPUTS
A Charge
History
Screen
           LAST DISCHRG%: 17
           LAST CHRG%:100
           CURRENT CHRG%: 78
           T/CHST> T                  T, DEL
CAL1
           VOFF:.021 AOFF:.205
           VSLP:0.97 ASLP:1.04
           KI:  2.54 KCC: 1.05
           T/CAL1> VOFF               VOFF, VSLP, AOFF, ASLP, CAL2, T
CAL2
           KSL1:.021 KSH1:.205
           KSL2:0.97 KSH2:1.04
           KSM :
           T/CAL1> KSL1               KSL1, KSL2, KSM, KSH1, KSH2, ASLP, CAL1, T
```

System Design - TSV - Charging and LCO

- Anderson Power connectors will facilitate distinguishing LCO from Charge connection
- Coulomb counting and a digital filter on sensed current will be used to determine state of charge
  - BBM-01
  - 1 mOhm current sensing resistor
- Cell bypass at 3.6 V, Complete at 3.9 V
- Complete Discharge at 2.9 V
- Initial Charge/Discharge cycle will initialize SOC algorithm

Cell Datasheet

VSCADA - Vehicle System Control and Data Acquisition

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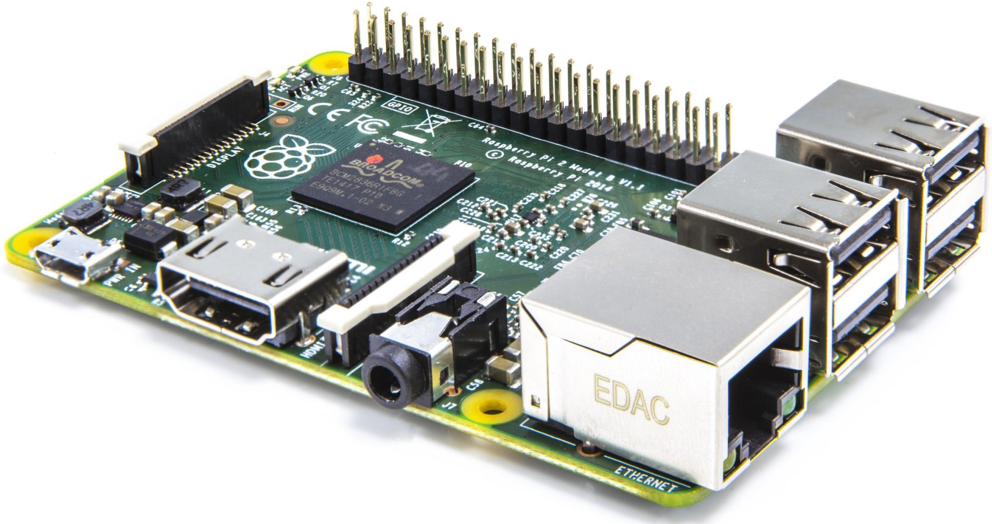
System Design - VSCADA - Overview

- VSCADA stands for Vehicle Supervisory Control And Data System.
- Collects data over CANbus network
- Calibrates data that needs calibration
- Outputs readouts to web service
  - Any computer on the network can view this
  - Dashboard is subsection of the web service
- VSCADA can also be controlled from web service
  - Dashboard uses a touchscreen
- VSCADA computer is Raspberry Pi 3
  - Logs will be stored to micro sd

System Design - VSCADA - Computer

SoC: Broadcom BCM2837
CPU: 4× ARM Cortex-A53, 1.2GHz
GPU: Broadcom VideoCore IV
RAM: 1GB LPDDR2 (900 MHz)
Networking: 10/100 Ethernet, 2.4GHz 802.11n wireless
Bluetooth: Bluetooth 4.1 Classic, Bluetooth Low Energy
Storage: microSD
GPIO: 40-pin header, populated
Ports: HDMI, 3.5mm analogue audio-video jack, 4× USB 2.0, Ethernet, Camera Serial Interface (CSI), Display Serial Interface (DSI)



System Design - VSCADA - The Process

- Previous VSCADA code exists but will be largely refactored in order to best accommodate the current requirements and the needs of future Lafayette teams.
- Goals
  - Maintainability
  - Extendability
  - Easy to read
  - Easy to Configure
  - Fast troubleshooting

System Design - VSCADA - Software Architecture

The software at it’s highest level is made up of three primary components.

1. A HTTP and WebSockets server.
2. A long term document-oriented logging system.
3. A system model

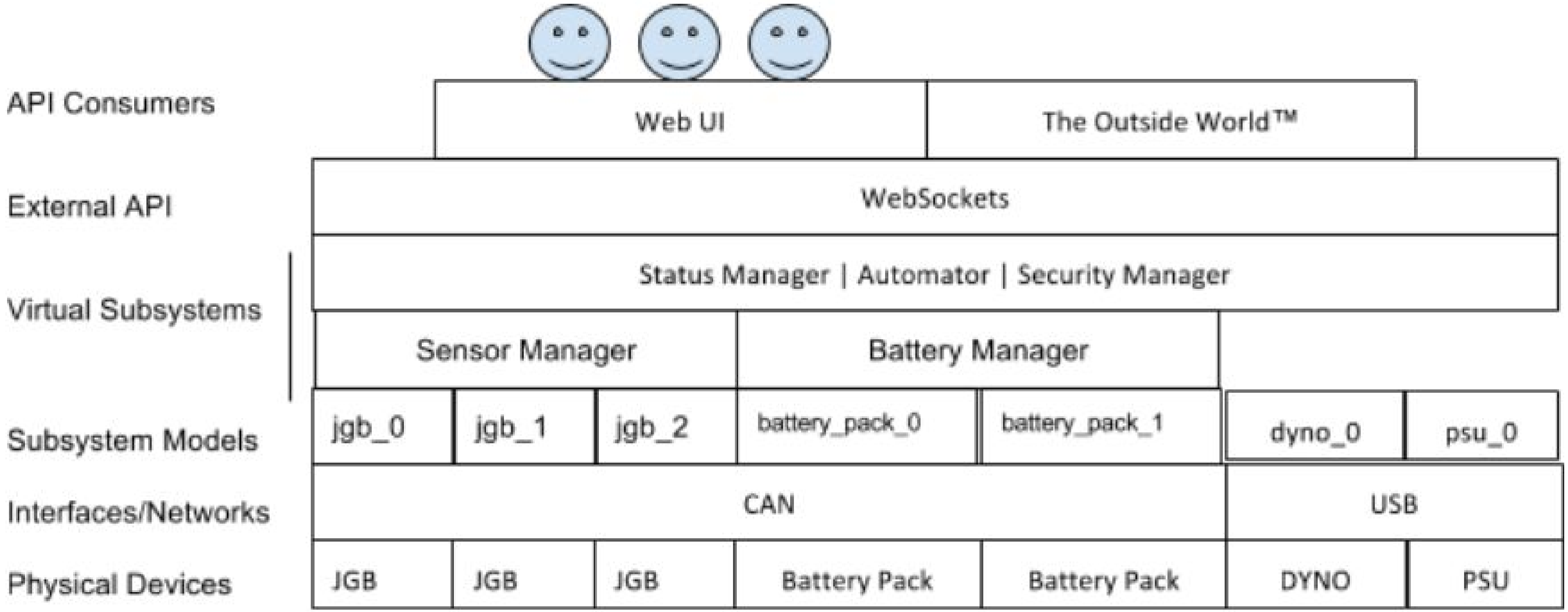
System Design - VSCADA - HTTP/WS Server

- Loaded immediately
- Serves a minimalistic web application
- Web app dumps the entire system state
- Will display any errors
  - Missing devices
  - Unknown devices
  - Files not found
  - Invalid configuration file
- State of system is transmitted as JSON over WebSockets

System Design - VSCADA - Document Logging

- VSCADA monitors the system model for changes in state--represented as dictionaries--and logs the changes as documents in a NoSQL database
- NoSQL database allows for simplicity of implementation and better data normalization

System Design - VSCADA - System Model



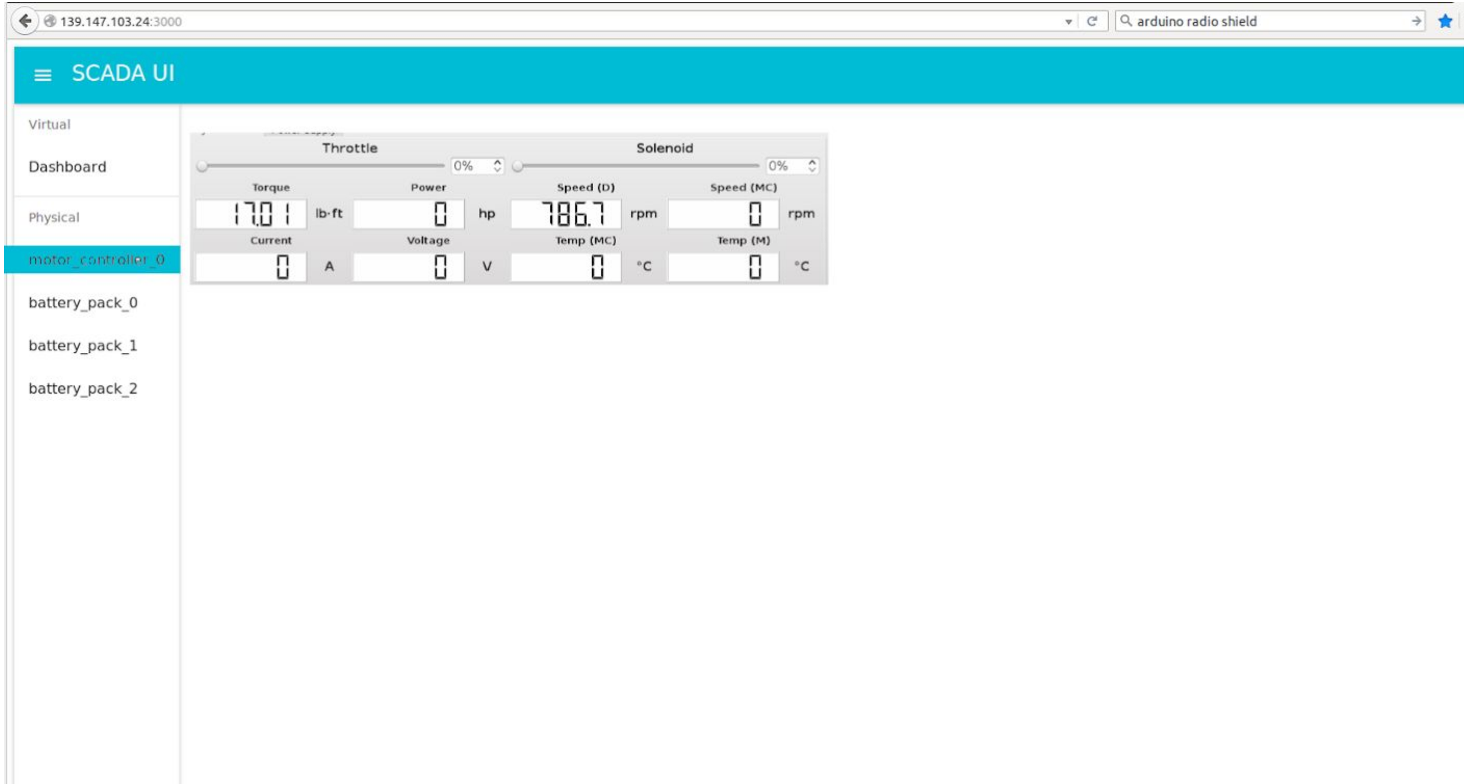
System Design - VSCADA - Configuration

```yaml
# system_topology.yml

physical:
 can0:
    "[0x601, 0x602]" : "MotorController"
    "[0x710, 0x711, 0x712]" : "BatteryPack"
    "[0x720, 0x721, 0x722]" : "BatteryPack"
    "[0x730, 0x731, 0x732]" : "BatteryPack"

 "/dev/usb": "Dyno"

virtual:
  - [RougeCANMonitor, can0]
  - [Heartbeat, can0]
```

System Design - VSCADA - Displays and GUIs

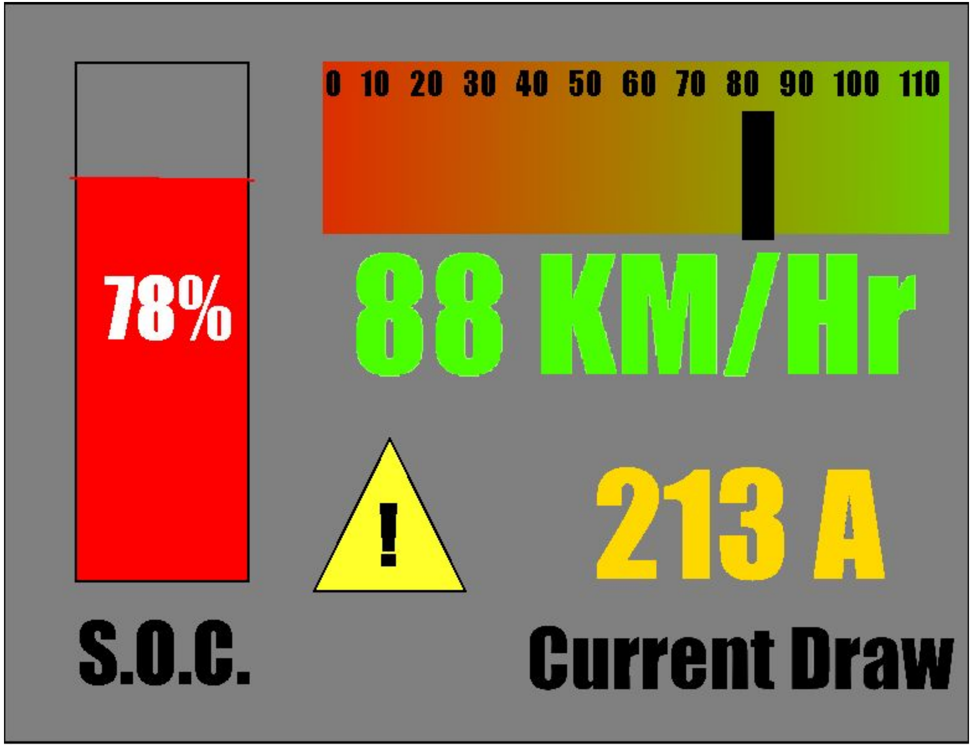
- All displays will be created by a scada-ui python program and can be accessed through a web browser using javascript
- The dashboard navigates to this page automatically but can also use the touchscreen for debugging
- The maintenance view of scada will have tabs representing modules and the ability to control modules on the web interface
- This will all be password protected to prevent unauthorized or accidental access to controls

System Design - VSCADA - Displays and GUIs

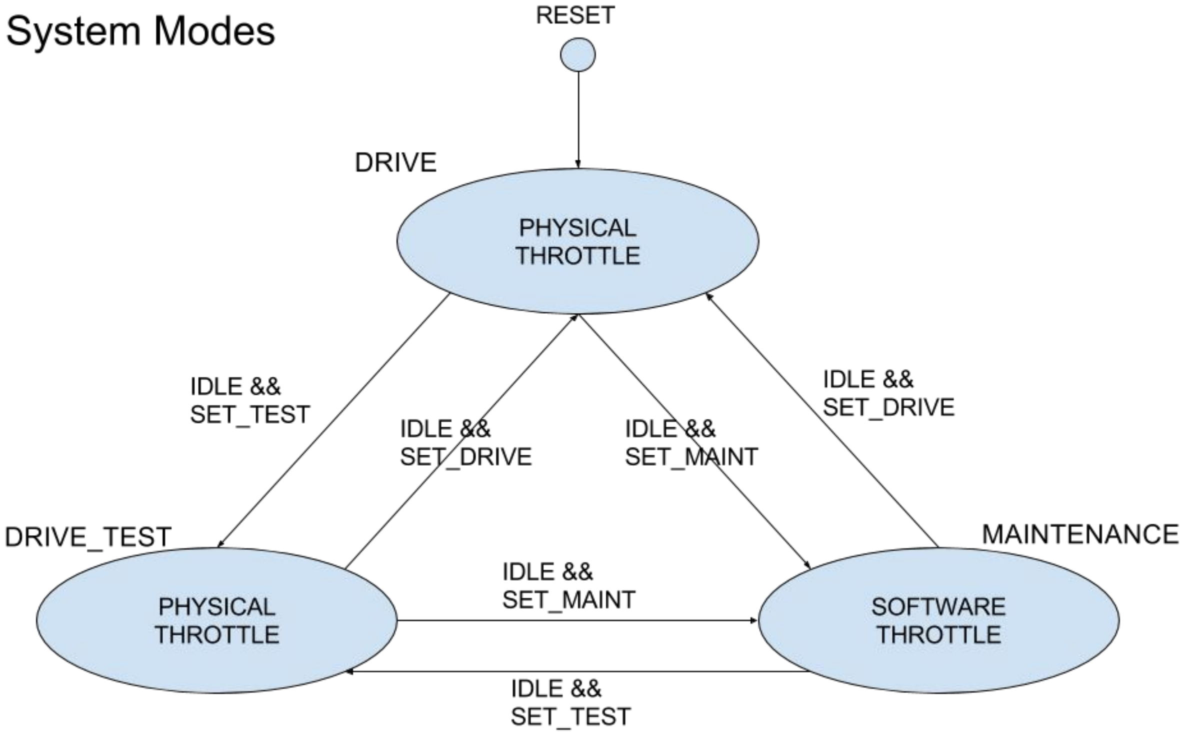


System Design – VSCADA – Displays and GUIs

System Design - VSCADA - Displays and GUIs



Analysis of System States



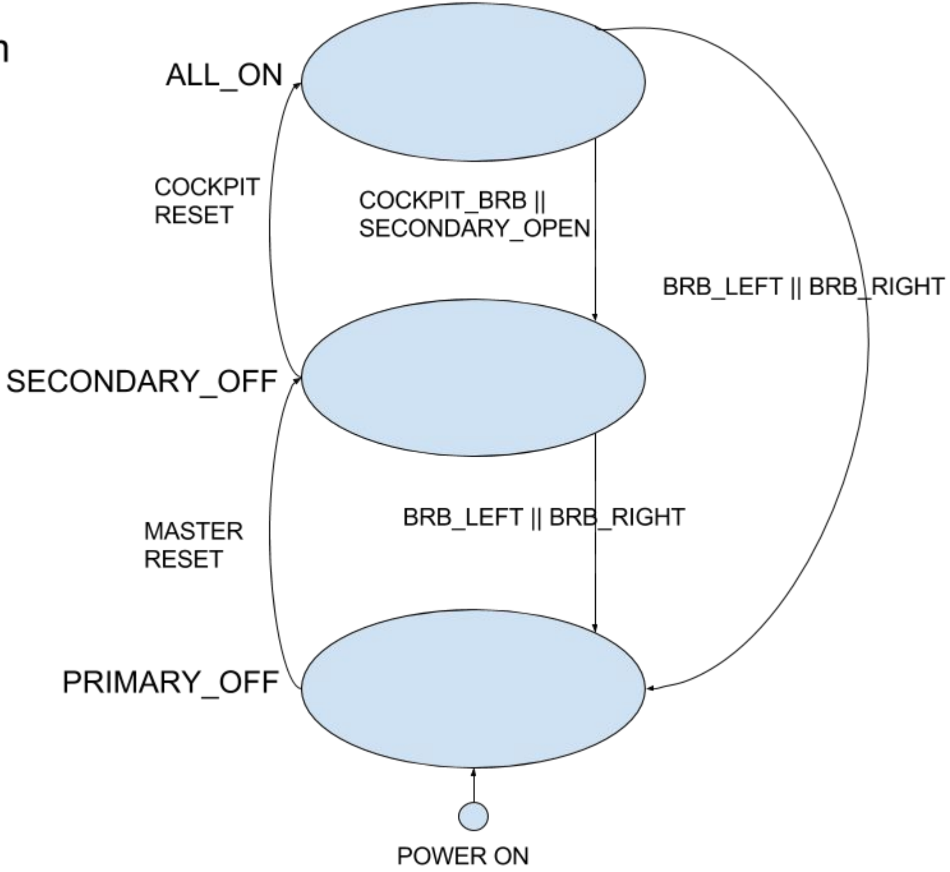
DRIVE_TEST and MAINTENANCE states do not require a closed safety loop for operation.
Transitions to MAINTENANCE require a password to be entered.
A working, closed safety loop is required to provide power to the motor controller in DRIVE.
These states are set and stored by the Raspberry Pi 3.
IDLE is TRUE when no TSV current is flowing in TSI or PacMan, and motor RPM is 0.

Analysis of System States

Safety Loop
State Diagram

In ALL_ON, the START button requests transition of the system into DRIVE mode.

PRIMARY_RESET will only cause transition if all BRBs are closed.



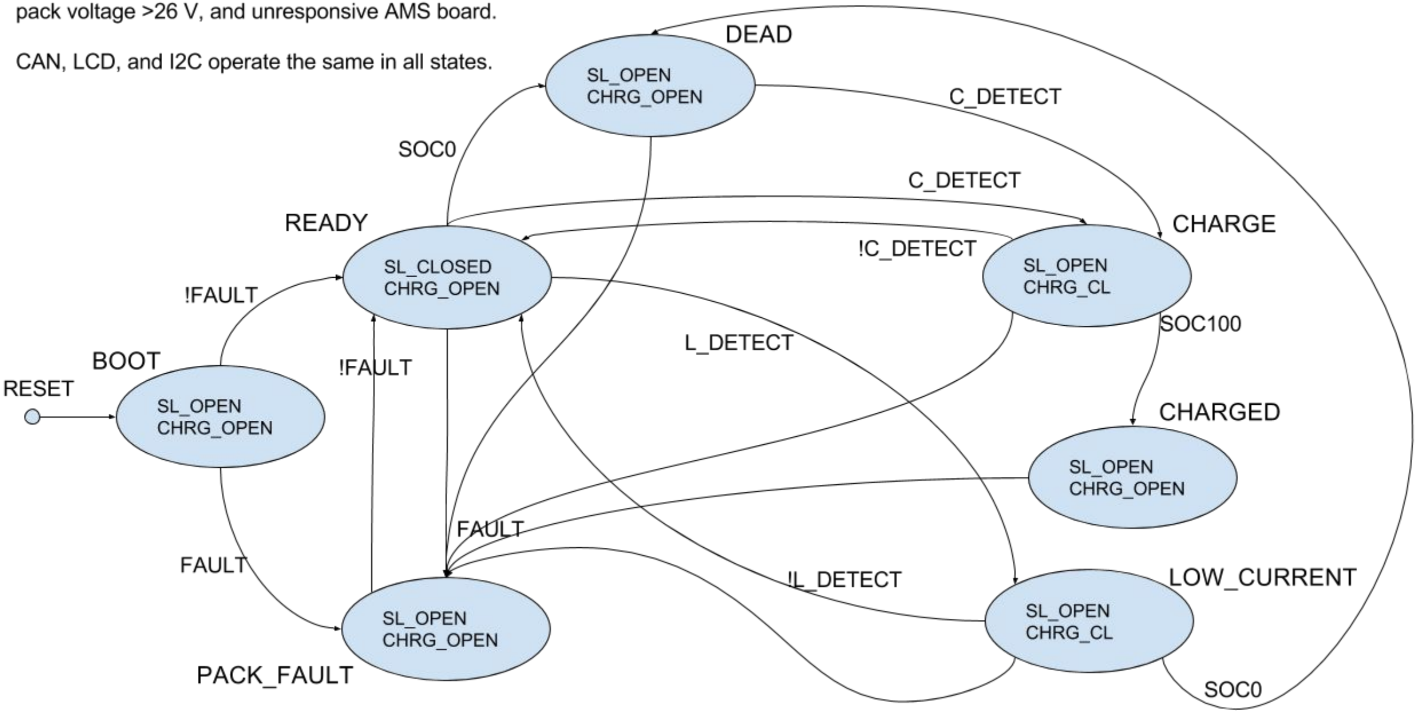
Analysis of System States

Transitions to LOW_CURRENT, CHARGE and CHARGED are locked when system is in DRIVE or DRIVE_TEST.

FAULT includes cell temp >60 C, cell voltage >4 V or <2.5 V, pack voltage >26 V, and unresponsive AMS board.

CAN, LCD, and I2C operate the same in all states.

PacMan State Diagram



Analysis of System States

Transitions to LOW_CURRENT, CHARGE and CHARGED are locked when system is in DRIVE or DRIVE_TEST.

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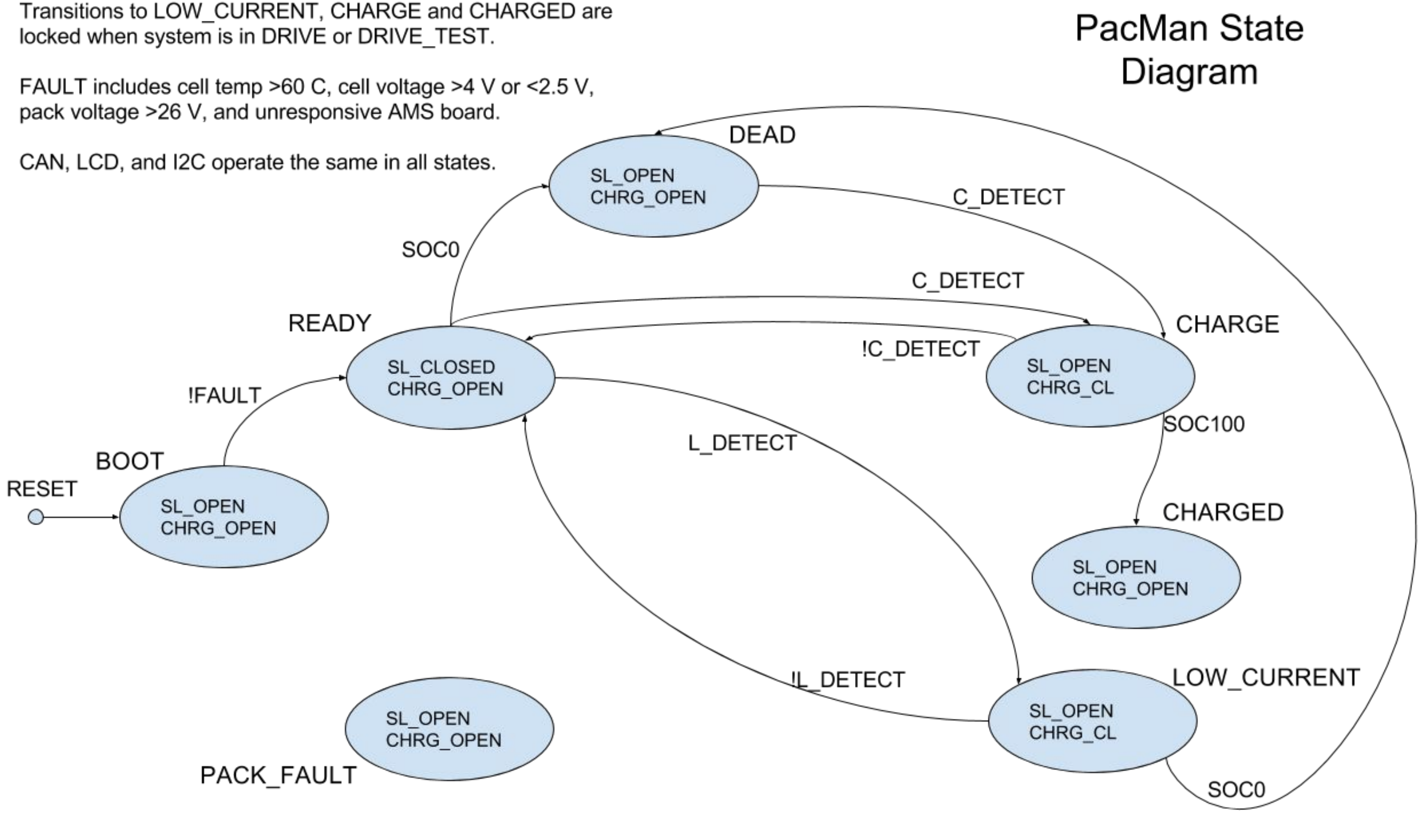
CAN, LCD, and I2C operate the same in all states.



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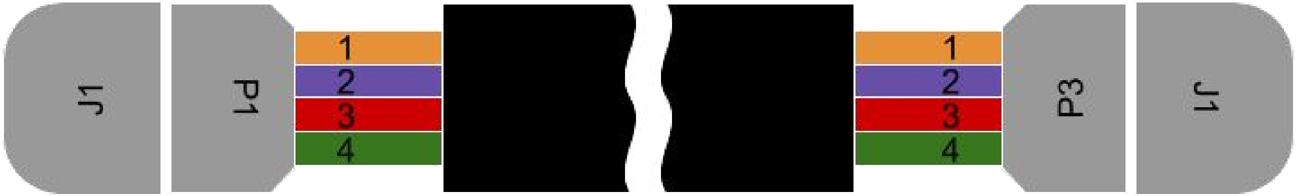
Interface Control Specifications – Example

Interface	Manufacturer	Manufacturer PN	Description	Color
J1	Deutsch DT Connectors	DT04-4P-L012-Assy	4-Way Receptacle Assembly, Flange Mount	Gray
P1	Deutsch DT Connectors	DT06-4S-Assy	4-Way Plug Assembly	Gray
P3	Deutsch DT Connectors	DT06-4S-Assy	4-Way Plug Assembly	Gray
J1	Deutsch DT Connectors	DT04-4P-L012-Assy	4-Way Receptacle Assembly, Flange Mount	Gray



Wire	Description	Guage (AWG)	Length (ft)	Color
1	Safety1	18		Orange
2	Safety2	18		Purple
3	AIRs+	18		Red
4	GND	18		Green

ICD

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Analysis of Communication Links - CANBus

- CANbus is a vehicle bus standard designed to allow microcontrollers and devices to communicate with each other in applications without a host computer.
- Very easy to add a device to the CANnetwork
- Devices on CAN
  - JGB
  - Motor Controller Measurements
  - PACMAN
  - SCADA

Analysis of Communication Links - USB Communication

- When CAN is not an option, we receive data over USB devices
- Huffbox sends data about oil and coolant and receives control information for the physical load on the dyno
- SCADA communicates with the dyno, reading its output and sending the Huffbox commands to adjust the load

Analysis of Communication Links - Laf Network

- Local internet connection used for accessing the web interface
- Any device on the same network as VSCADA has access to the information on the network
- Devices utilizing the Network
  - SCADA's computer will host a webserver that will be able to be accessed remotely to act as the GUI.
  - The network will also allow a remote ssh to the SCADA computer for maintenance
  - Any cell-phone or PC on the network will link up and be able to utilize the benefits of this network.
  - The dashboard will access the GUI across the localhost.

Comm Link Demo

Following this demonstration we invite you down to the lab to demonstrate the motor controller, a JGB, and VSCADA talking over CANbus. You can also see the current VSCADA UI.

Pack Alterations - MECH-E's

Based on ECE changes:

- Bottom Plate
- Fan Mounting Plates
- Top Panel Cutouts (positive and negative)
- Deleted slot for current sensor
- Changed AIRS bridge to accommodate new sensor
- User interface connectors

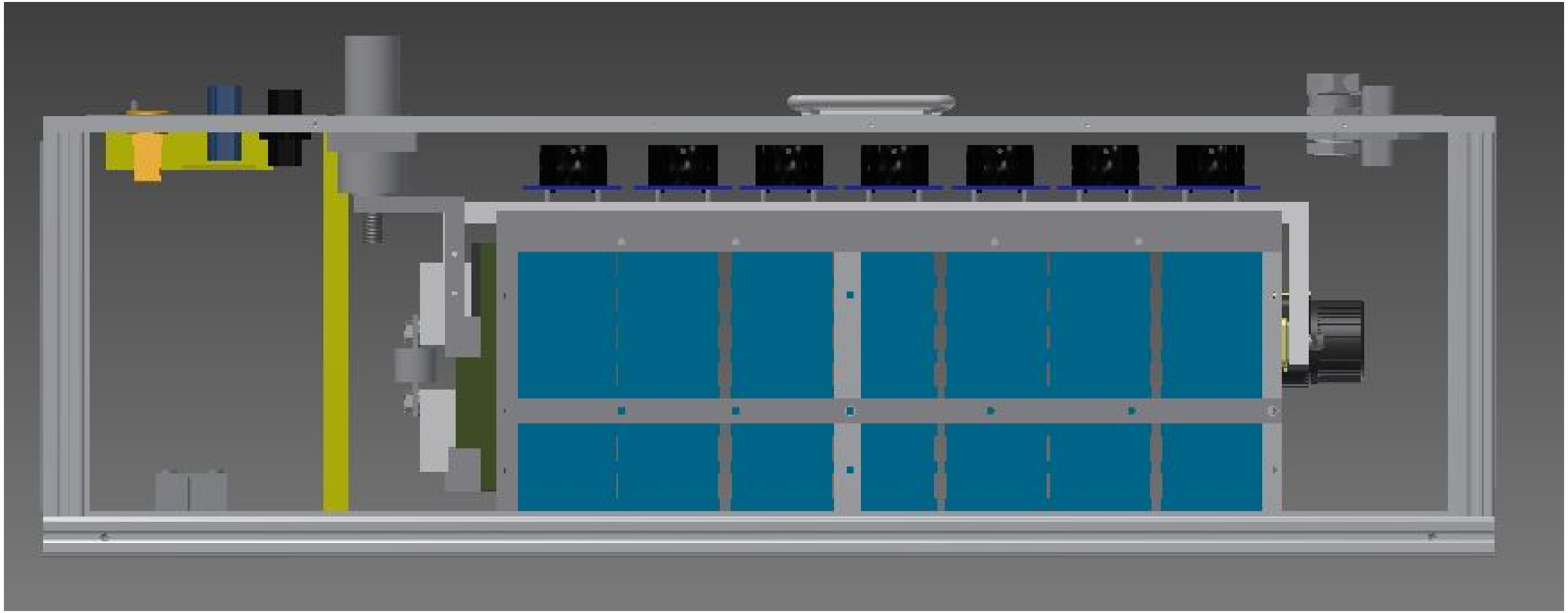
Based on ME changes:

- Wiring Path
- Heatsinks

Complete Drawings

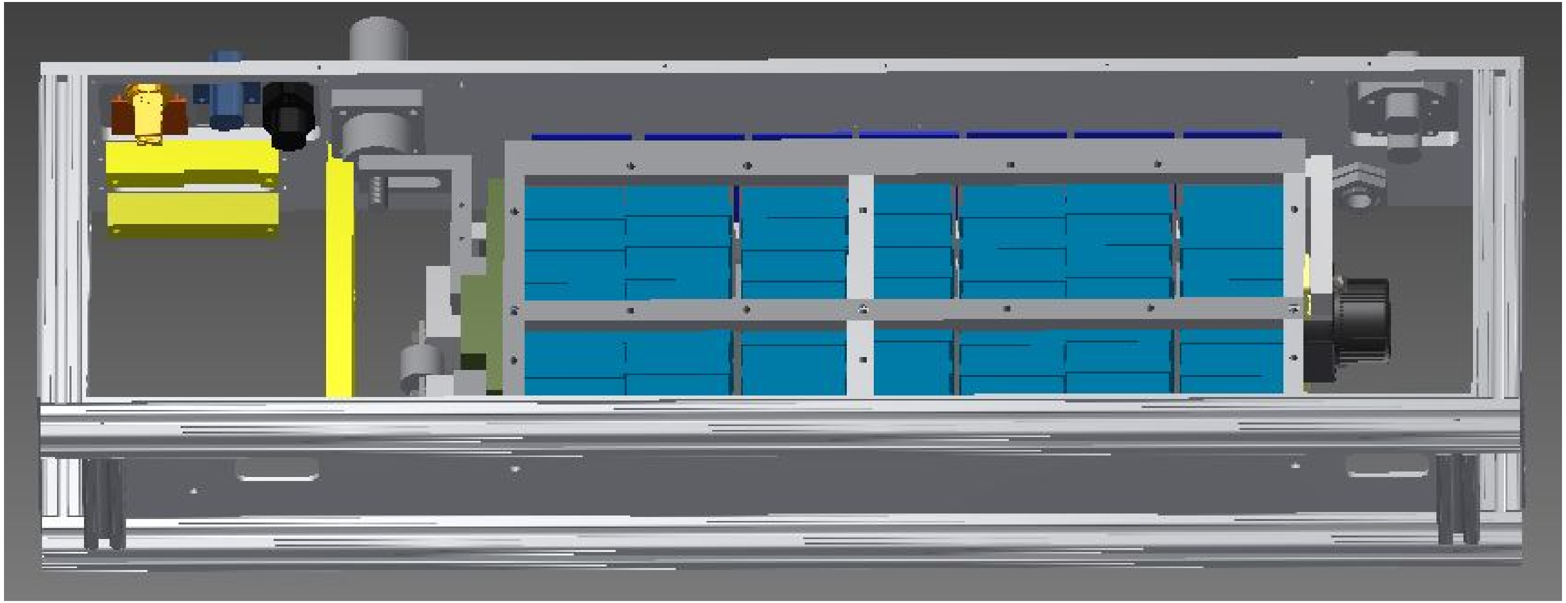
“Build to Print” Specs - MECH-E’s

Battery Pack CAD Model



“Build to Print” Specs - MECH-E’s

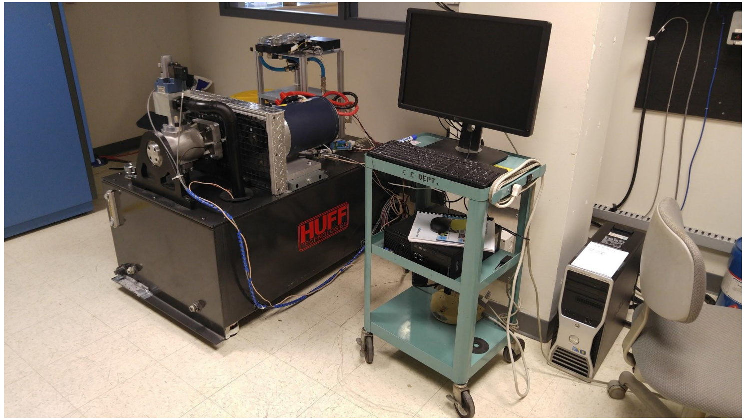
Battery Pack CAD Model

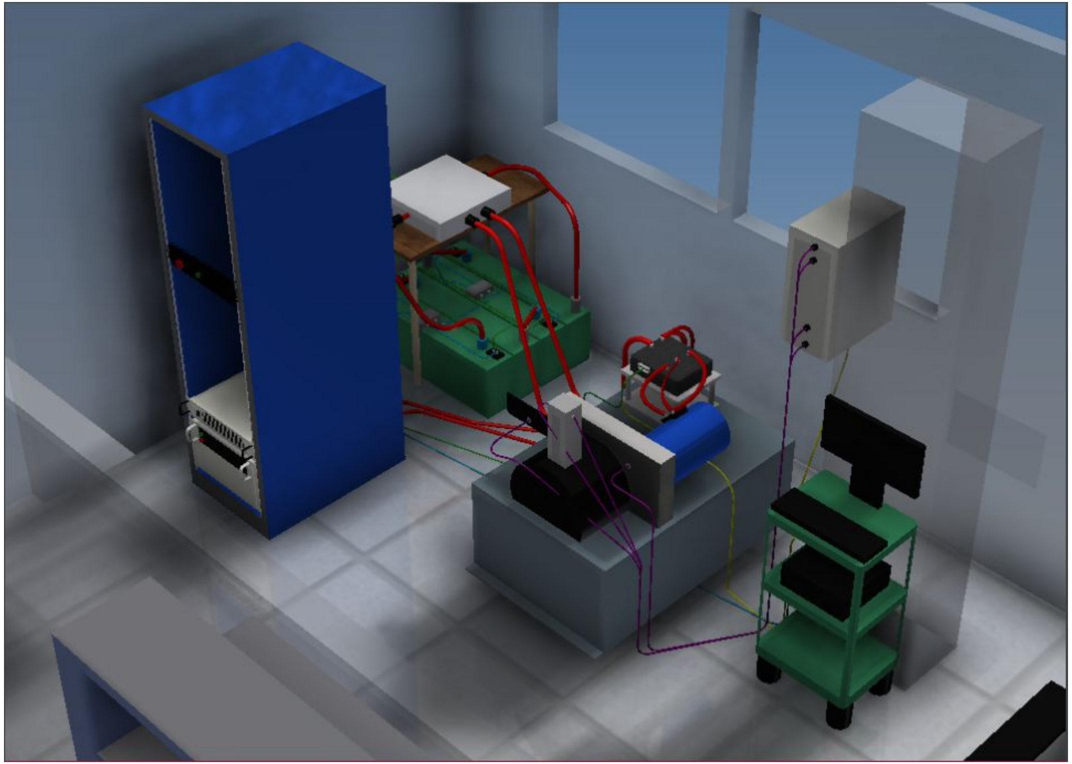


MCM – Motor Characterization and Modeling

Current Motor , Controller, Dynamometer Setup

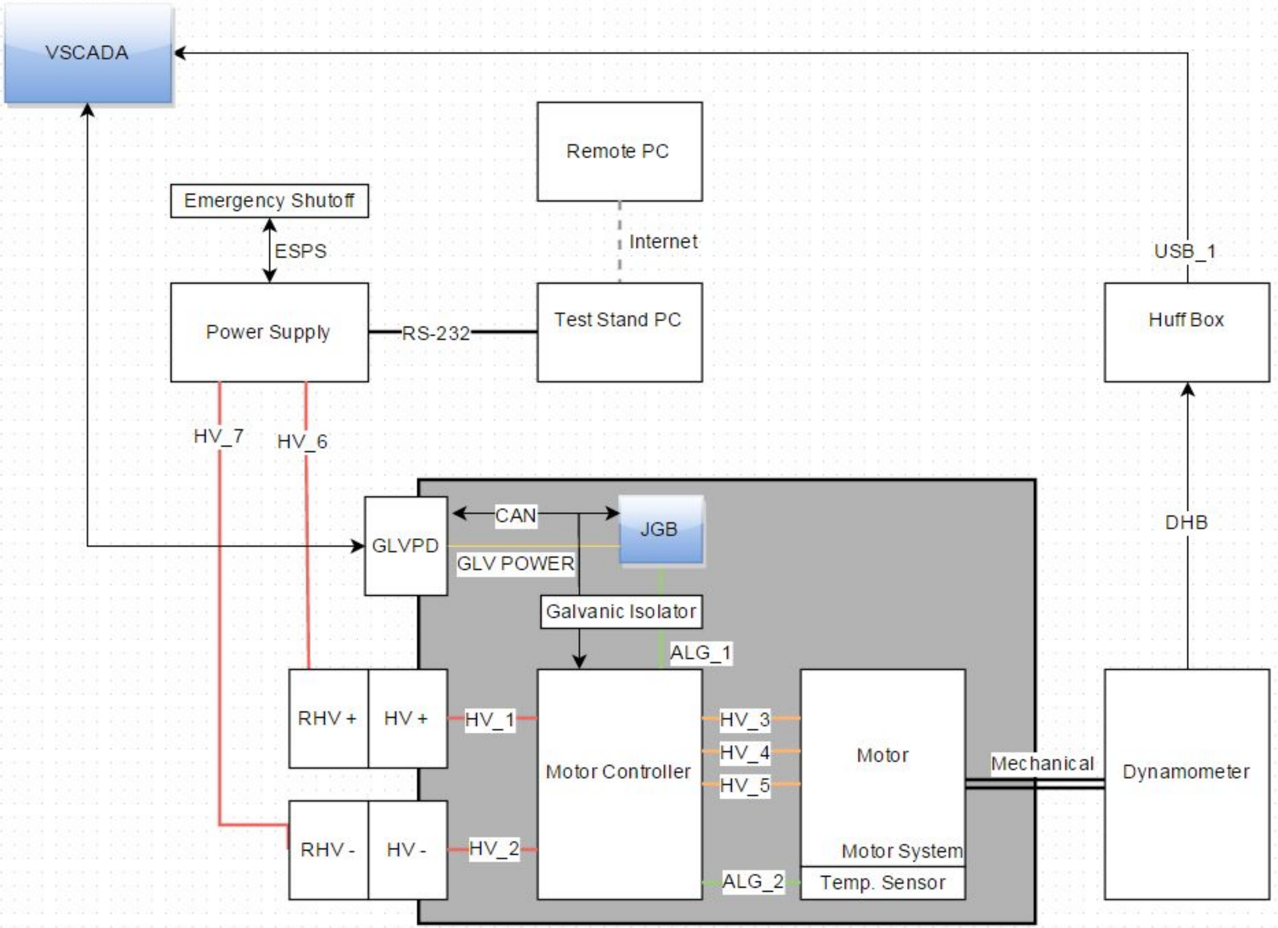
- Setup in AEC401:
  - HPEVS AC 50-27.28 Motor
  - Huff HTH-100 Dyno system
  - Curtis 1238R-7601 motor controller
  - Rack-mounted PC with last year’s VSCADA software





Credit: Spring 2015 ECE 492 design team CDR presentation

MCM System Overview



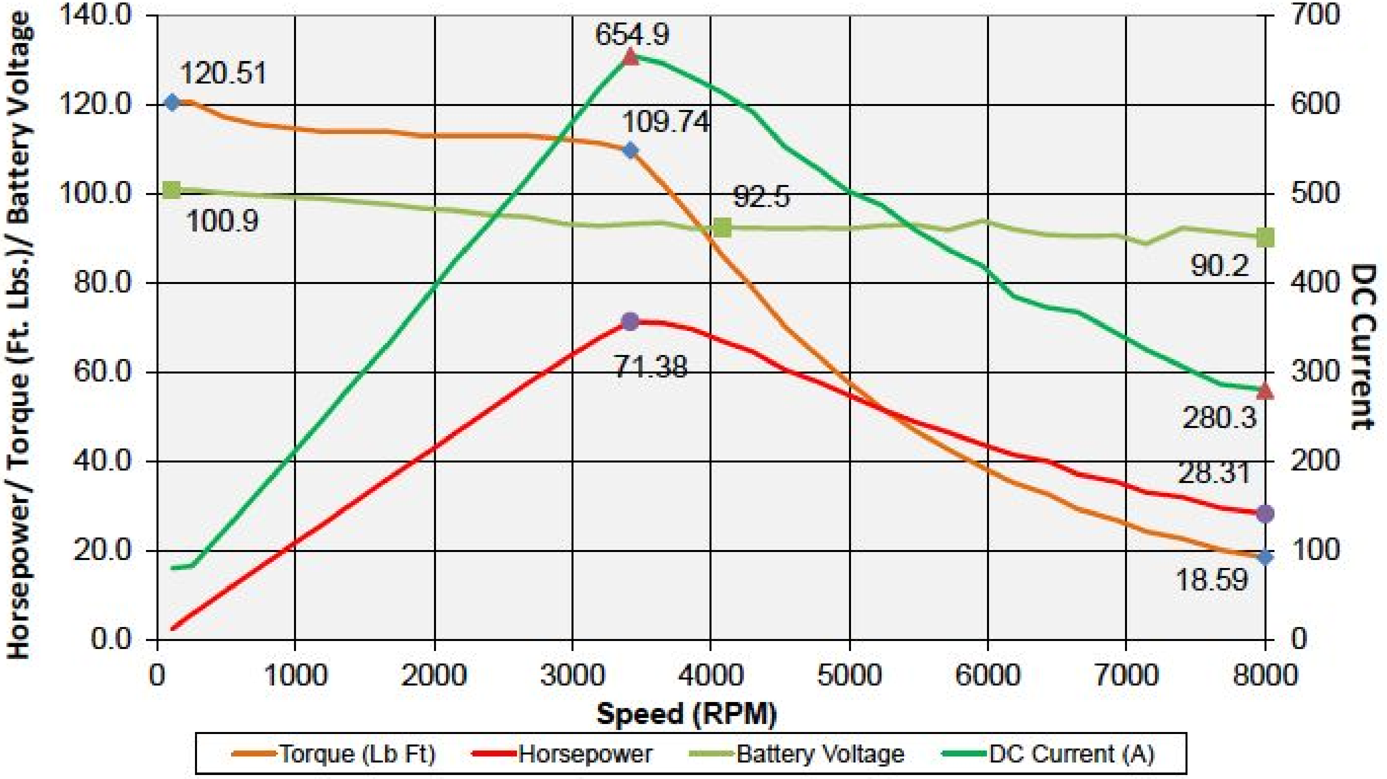
MCM Purpose

- Static Characterization:
  - Measuring torque and RPM
    - Ranges of measurement related to fully integrated car, but constrained to current test setup
  - Determining values of static parameters
    - To be used in modeling
- Dynamic Characterization:
  - Transient response of current test setup (torque, current, voltage, RPM)
- Efficiency and Cooling:
  - Input vs. output power
  - Graph comparison between “cold” and “hot” starting temperatures
- Mathematical and Simulink Modeling
  - Using parameters calculated during static/dynamic characterization

Hypothesis

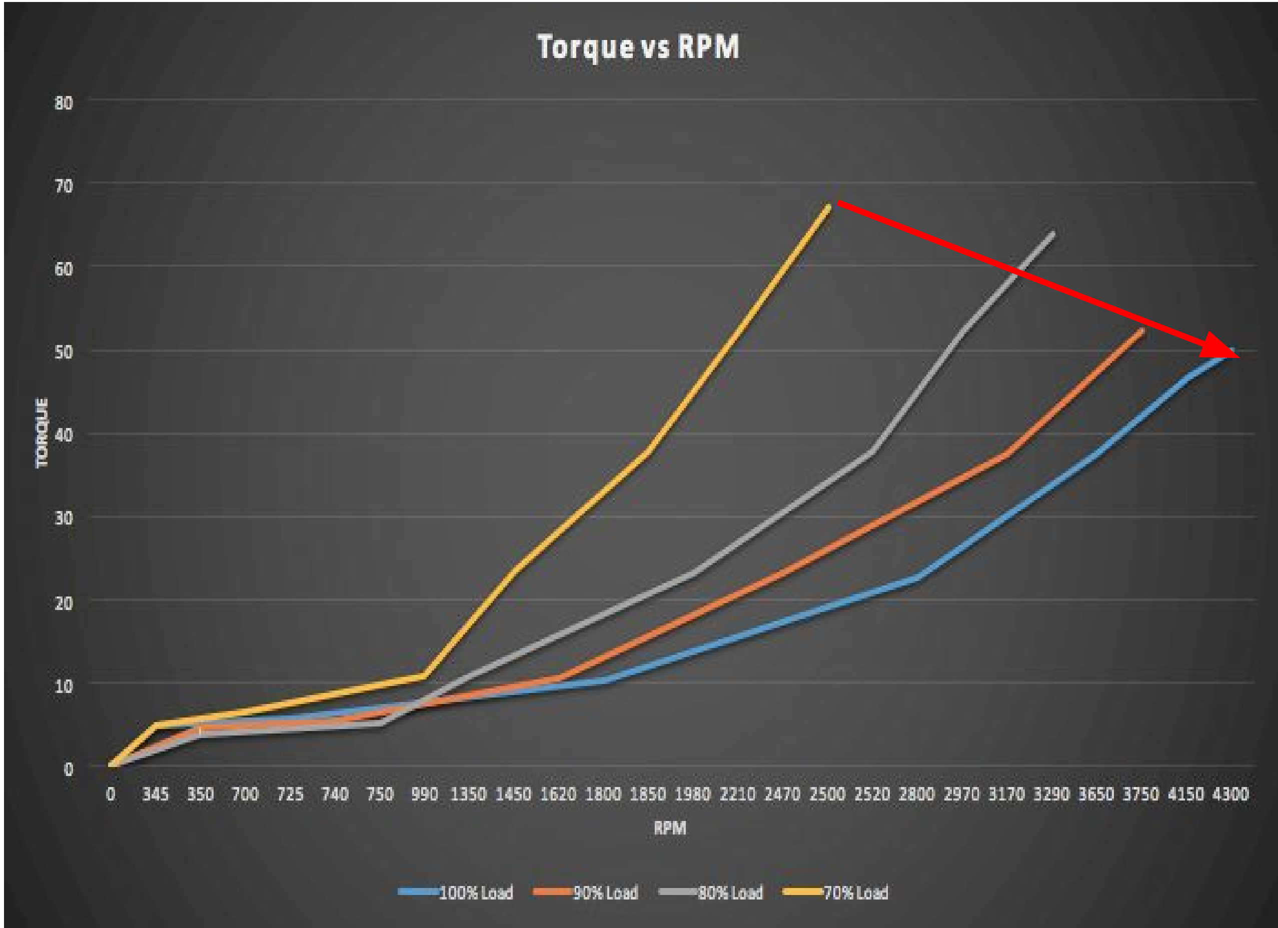
The Curtis Controller and AC-motor can be modeled as a DC motor with a single input and output.

HPEVS AC-50 Imperial Peak Graph
96 Volts/650 Amps



Does our hypothesis hold water?

- Shunt motors are basically constant speed motors
- Speed increases as load on the motor decreases



Dynamic Characterization

- Transient response data must be collected
  - Measurement hardware with slow response time cannot be used, oscilloscopes instead
- Dynamic constants to be calculated:
  - Armature Inductance L_a (current vs. time transient response)
  - Inertia J (speed vs. time transient response)
- Relevant electrical equation:

$$v_a(t) = L_a \frac{\mathrm{d}\, i_a}{\mathrm{d}t} + R_a\, i_a + e.$$

(where e is the back EMF of the motor)

- Relevant mechanical equation:

$$T_M - T_L = J \frac{\mathrm{d}\,\omega}{\mathrm{d}t} + F\,\omega.$$

(where F is the viscous friction coefficient of the motor)

Static Characterization

- Steady state response data must be collected
  - Measurement hardware currently implemented can be used using old VSCADA software
- Static constants to be calculated:
  - Torque constant K_T (torque per unit armature current)
  - Back EMF constant *e*
- Relevant electrical equation:

$$v_a(t) = L_a \cancel{\frac{\mathrm{d}i_a}{\mathrm{d}t}} + R_a i_a + e.$$

- Relevant mechanical equation:

$$T_M - T_L = J\cancel{\frac{\mathrm{d}\omega}{\mathrm{d}t}} + F\,\omega.$$

(where F is the viscous friction coefficient of the motor)

Efficiency

Throttle	Load	RPM	Torque(lb-ft)	Current (PS)	Voltage	Power(Watts	Motor Power (HP)	Motor Power (Watt	Efficiency	Torque(ft-lb) Correcte
5%	100	0	0	0	89.6	0	0			0
10%	100	345	2.5	2.5	89.6	224	0.164223153	122.461205	55%	5
15%	100	725	2.9	6	89.6	537.6	0.400323686	298.521372	56%	5.8
20%	100	1800	5.2	21.3	89.6	1908.48	1.782178218	1328.97029	70%	10.4
25%	100	2800	11.4	63.6	89.6	5698.56	6.077684692	4532.12947	80%	22.8
30%	100	3650	18.8	128.4	89.6	11504.64	13.06549886	9742.94249	85%	37.6
33%	100	4150	23.3	176.5	89.6	15814.4	18.41108149	13729.1434	87%	46.6
35%	100	4300	25	197	89.6	17651.2	20.46839299	15263.2806	86%	50
5%	90	0	0	0	89.6	0	0			0
10%	90	350	2.4	2.5	89.6	224	0.159939071	119.266565	53%	4.8
15%	90	740	2.7	5.9	89.6	528.64	0.380426504	283.684044	54%	5.4
20%	90	1620	5.3	19.5	89.6	1747.2	1.634805788	1219.07467	70%	10.6
25%	90	2470	11.6	56.3	89.6	5044.48	5.455445545	4068.12574	81%	23.2
30%	90	3170	18.8	112	89.6	10035.2	11.34729627	8461.67882	84%	37.6
35%	90	3750	26.1	178.9	89.6	16029.44	18.63575781	13896.684	87%	52.2
5%	80	0	0	0	89.6	0	0			0
10%	80	350	2	2.5	89.6	224	0.133282559	99.3888042	44%	4
15%	80	750	2.6	5.7	89.6	510.72	0.371287129	276.868811	54%	5.2
20%	80	1350	5.5	16.6	89.6	1487.36	1.413747144	1054.23124	71%	11
25%	80	1980	11.6	46	89.6	4121.6	4.373191165	3261.08865	79%	23.2
30%	80	2520	18.9	89.3	89.6	8001.28	9.068545316	6762.41424	85%	37.8
35%	80	2970	26.2	143.2	89.6	12830.72	14.81607007	11048.3434	86%	52.4
39%	80	3290	31.9	192	89.6	17203.2	19.98305407	14901.3634	87%	63.8
5%	70				89.6	0	0			0
10%	70	345	2.5	2.5	89.6	224	0.164223153	122.4612053	55%	5
15%	70	700	3.3	6.4	89.6	573.44	0.439832445	327.9830541	57%	6.6
20%	70	990	5.4	12.9	89.6	1155.84	1.017897944	759.0464966	66%	10.8
25%	70	1450	11.7	34.5	89.6	3091.2	3.23019802	2408.758663	78%	23.4
30%	70	1850	18.9	67	89.6	6003.2	6.657463823	4964.470773	83%	37.[illegible]
35%	70	2210	26.2	108.5	89.6	9721.6	11.02475248	8221.157921	85%	52.4
40%	70	2500	33.6	155.5	89.6	13932.8	15.99390708	11926.65651	86%	67.2

Efficiency
55%
56%
70%
80%
85%
87%
86%
53%
54%
70%
81%
84%
87%
44%
54%
71%
79%
85%
86%
87%

Modeling and Simulation

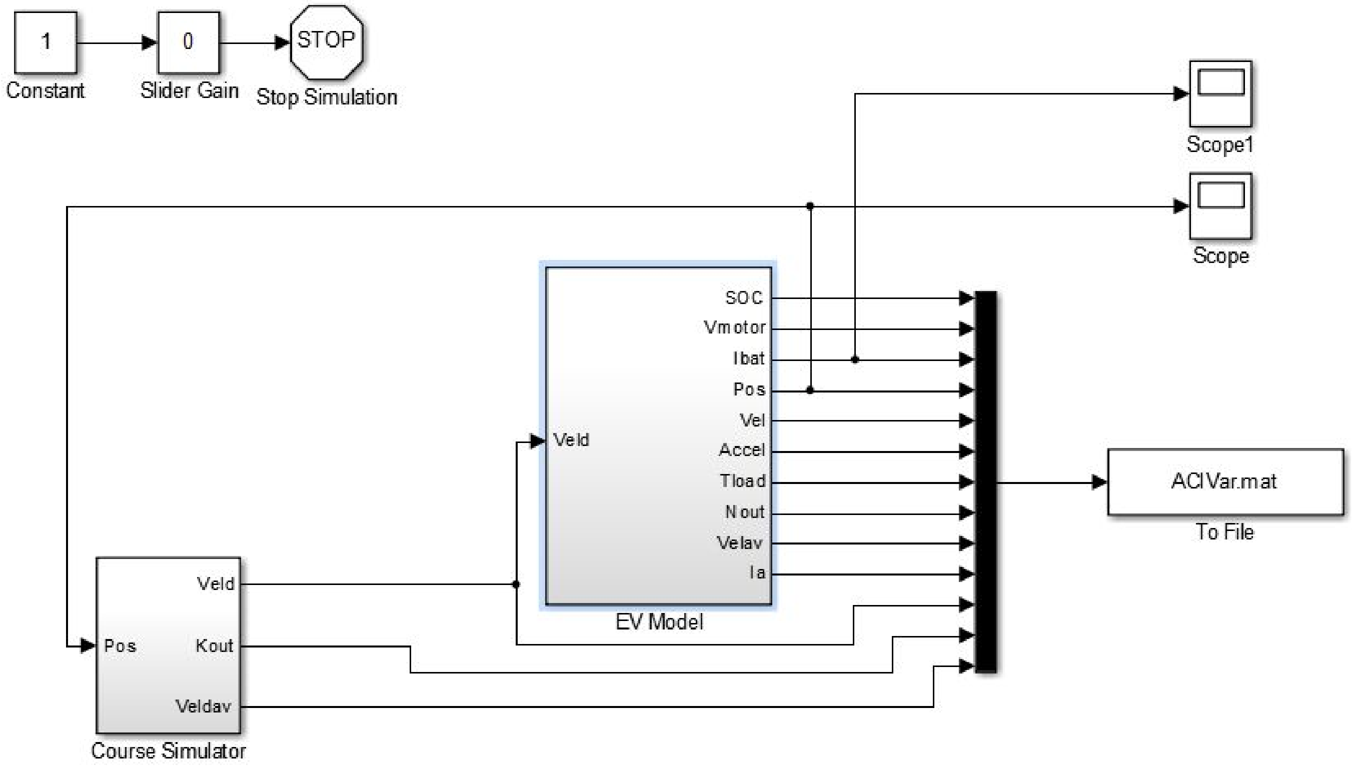
- Mathematical and Simulink models can be taken from SPR 2013 ECE 492 design team materials
  - Created using estimated and generic parameters for motor characteristics
  - Suitably simulates fully integrated car including factors:
    - Mass
    - Frictional losses
    - Gear ratios
  - Simulations from 2013 prove that given the correct parameters model will accurately depict fully integrated behavior of the car

Current Simulink Model

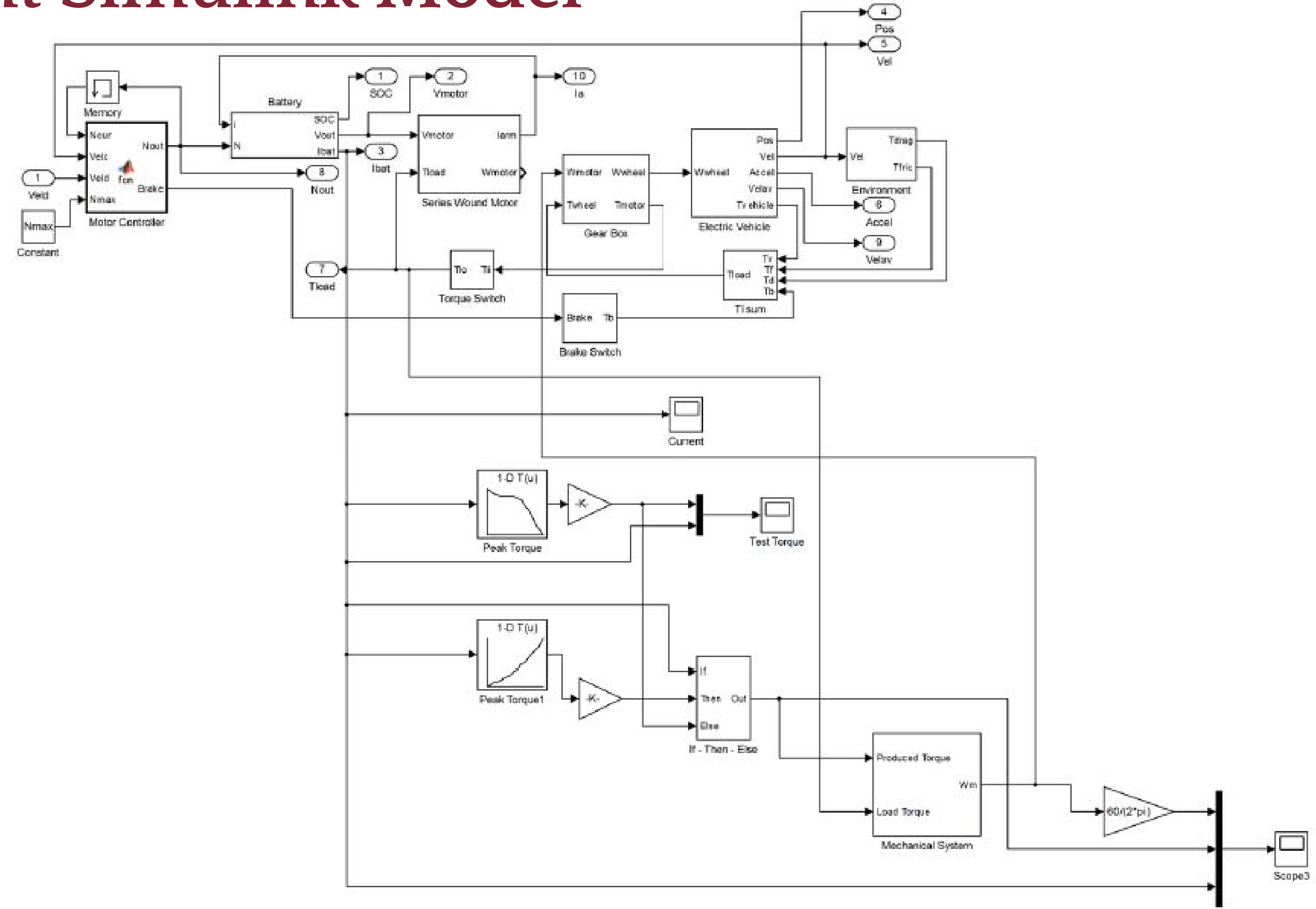
```
Kg = 3;            %(Wm/Wl) Initial Gear Ratio

Kswitch_t = 0;     %Setting Kswitch_t to 0 sets load torque to dynamic
                   %torque dependent upon vehicle state. Setting Kswitch
                   %to zero sets load torque equal to constant Ktorque.

Kswitch_m = 0;     %Setting Kswitch_m to 0 dictates the motor equations
                   %are based on PM DC motor equations. The armature
                   %inductance and resistance are La+Lf and Ra+Rf. Laf
                   %is not an inductance but the torque constant. When
                   %Kswitch_m is 1, the motor operates as a series wound
                   %where the individual inductances and resistances are
                   %given and the torque is proportional to the square of
                   %the current.

Ktorque = 20;      %(N*m) Constant Torque to feed into motor

%Model Calculations
Mv = Mf + 4*Mw + 2*Ma + Mgm + Mga;    %(kg) Total Mass of Vehicle

%(Kg*m^2) Load Moment of Inertia
Jl = 1/2*4*Mw*rt^2 + 1/2*2*Ma*ra^2 + 1/2*Mga*rga^2 + Mv*rt^2;
```

```
%*******************************************************
%The following parameters need to be obtained from the
%motor maufacturer or online power curves.
Ra = .0125;         %(Ohm) Internal Armature Resistance
Rf = .0125;         %(Ohm) Internal Field Resistance
La = .03;           %(H) Armature Inductance
Lf = .03;           %(H) Field Inductance
Laf = .00107;       %(H) Torque/Back EMF Constant
Jm = 1.75;          %(Kg*m^2) Moment of Inertia of the Motor
Bm = .008;          %(N*m/(rad/s)) Motor Viscous Damper
%*******************************************************


Bl = .005;          %(N*m/(rad/s)) Load Viscous Damper

Eg = 1;             %()Efficiency of the Gear Ratio
Et = 1;             %()Efficiency of the Transformer

rt = .254;          %(m) Radius of the tire
ra = .04;           %(m) Radius of the axle
rgm = .1;           %(m) Radius of the gear on the motor
rga = .1;           %(m) Radius of the gear on the axle

Mf = 350;           %(kg) Mass of car
Mw = 15;            %(kg) Mass of wheel
Ma = 10;            %(kg) Mass of axle
Mgm = 2;            %(kg) Mass of motor gear
Mga = 2;            %(kg) Mass of axle gear

ro = 1.2;           %(kg/m^3) Density of air
A = 1.5;            %(m^2) Cross-sectional area of the car
Cd = .35;           %() Drag coefficient
g = 9.81;           %(m/s^2) Acceleration of Gravity
Us = .20;           %() Static Coefficient of Friction
Bb = 1.25;          %("g"s) Brake acceleration
```

Current Simulink Model



Current Simulink Model

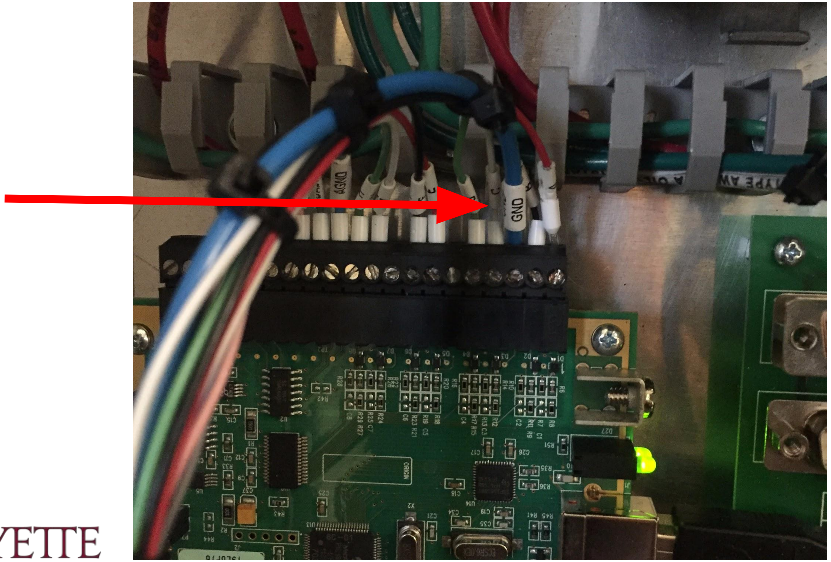


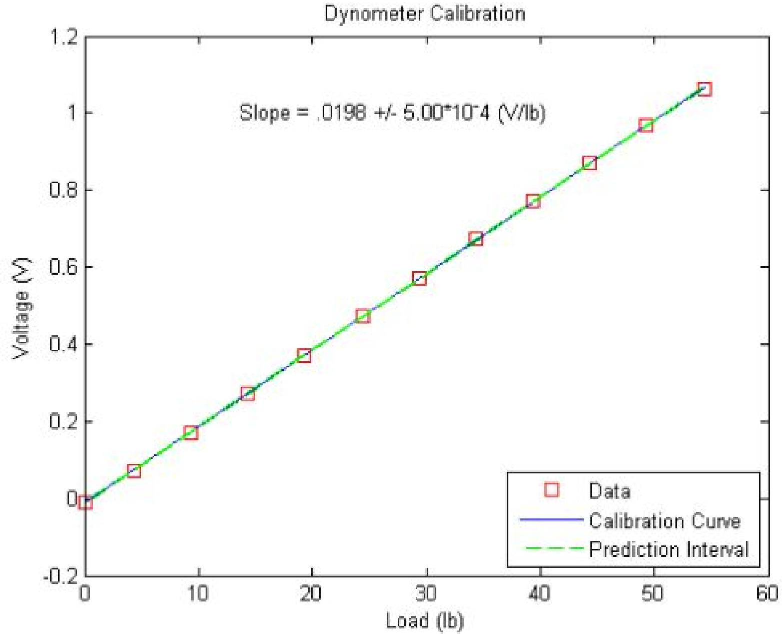
But first: Calibration!

- Important that all measurements using Huff system are tested to generate calibration factors and ensure accurate data
- Can take place in parallel with data collection / analysis
  - Measurements can be retroactively adjusted by calibration factor to create sets of accurate measurement data
- Measurements to be calibrated in the motor + dyno system:
  - Motor torque
  - Motor RPM

Torque calibration progress

- Weights of known mass are hung from torque bar which is attached to load cell
  - Used weight step interval of 5 lbs
- Voltage going into Huff box corresponding to load measured
  - Accurate values of torque calculated from known mass and bar length, compared to current VSCADA readout (torque readout previously incorrect)





Further Calibration Procedures

- Calibrating RPM
  - Similar procedure to torque- compare calculation based on voltage multimeter readout from Huffbox to data readout from DAQ software
  - Test equipment - stroboscope used as calibration standard
  - Analysis - error calculations based on comparisons of measured and read data
- Calibrating system temperature
  - Test equipment - IR temperature sensor

Safety Plan

A safety plan is generated (current plan here) for any subsystem operating with potential differences greater than 30V. It includes:

Analysis confirming any parts operating with greater than 30V are appropriately chosen.

A process for properly closing the subsystem prior to operation.

A list of precautions that are followed to ensure the safety of participants.

ECE Director of laboratories, or an alternate designated by him, reviews and accepts all electrical safety plans before any such assembly is closed or tested. The Director or alternate will sign a label that is placed on the assembly. The label includes the following:

Approved Assembly:___________________________

File Name of Safety Plan: _______________________

Approval Signature:________________ Date:______

Approval Expires(Date, if Applicable): _____________

ATP

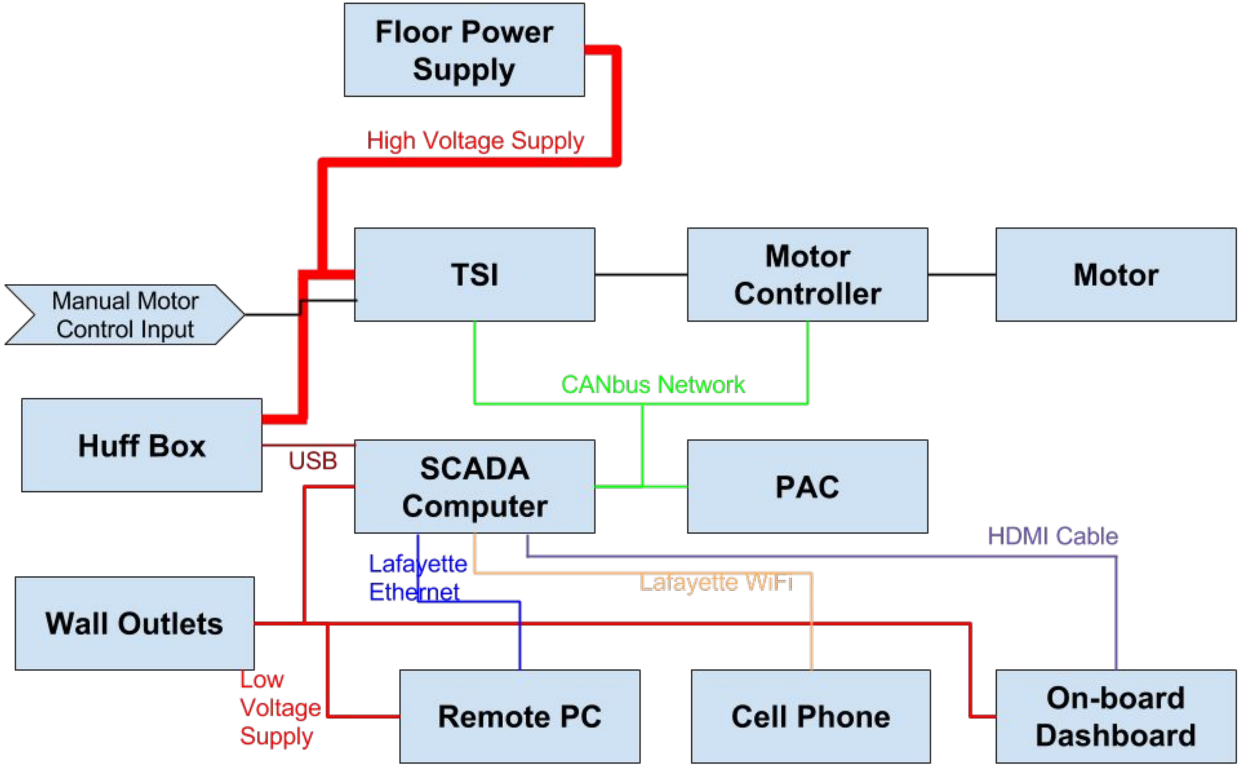
A plan with 22 items has been developed (available here).

QA tests will be performed by team members as subsystems are ready.

Acceptance Tests will be performed with faculty present after QA tests are passed.

The document also details what documents will be delivered and satisfactory documentation practices.

ATP - Item 1 - CAN Bus and 24 hr Reliability



ATP - Item 1 - CAN Bus and 24 hr Reliability

Description:
VSCADA talks to PAC-MAN and the TSI JGB, reading/setting values and displaying calibrated output data using automated script functionality on the VSCADA. The system is also able to run 24 hours straight without failure.

Successful Test:
Integrated system functions as expected and we receive similar results to that of individual QA tests and compare these results to a Calibration and Accuracy Analysis.

VSCADA values match values read on pack display, navigated to through on pack controls. The throttle is set to the values we have planned at the proper time and in the proper sequence

ATP - Item 1 - CAN Bus and 24 hr Reliability

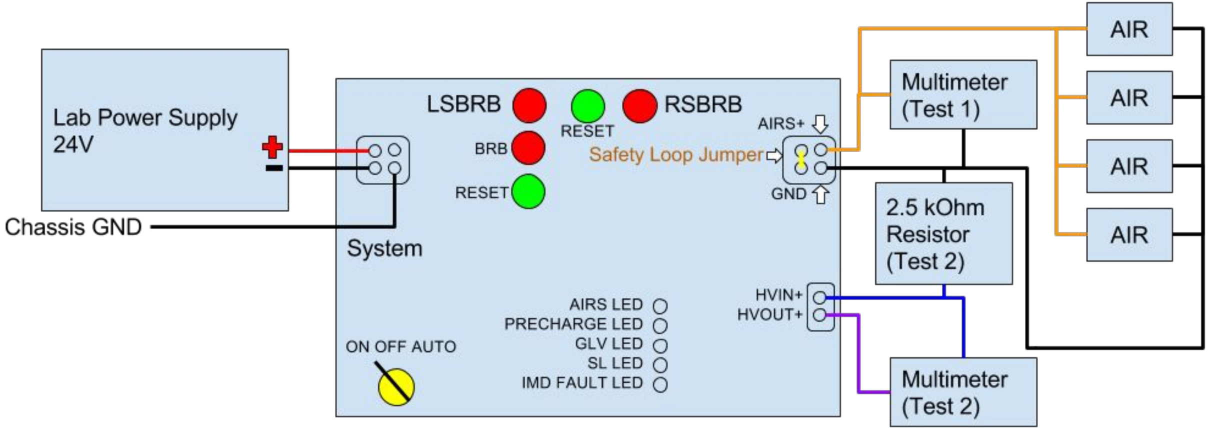
Successful Test:

Throttle responds to VSCADA control matching those of QAR002f1

Data viewed in the logs and graphs is representative of what is observed and backed up by QAR002m QA tests

System is able to operate 24 hours straight without failure and with no human intervention

ATP - Item 2 - Safety Loop Demonstration

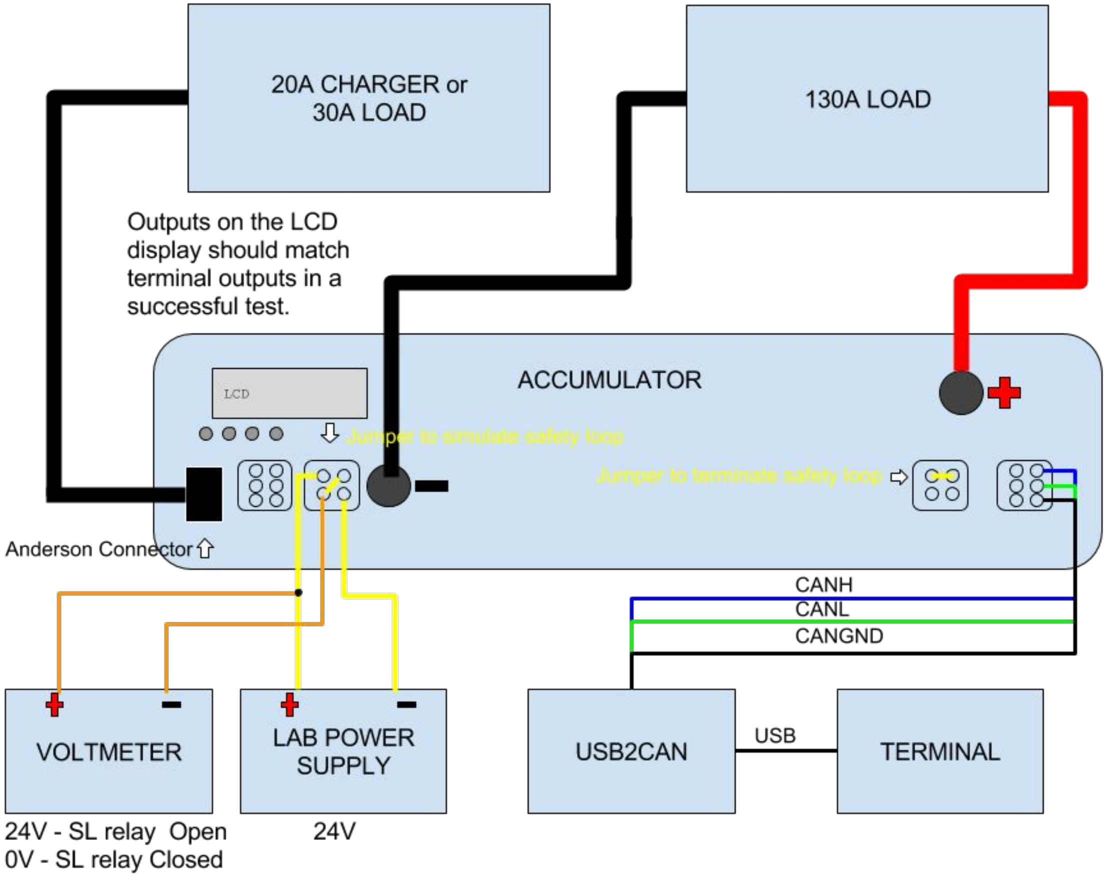


ATP - Item 2 - Safety Loop Demonstration

Successful Test:

The GLV light turns on when power is supplied through the master switches, the safety loop light must remain off once GLV power is first enabled and only turn on once all faults are cleared and the reset button is pressed, and the safety loop light turns off on a system fault. Additionally, the VSCADA system is able to monitor and log the status of the safety loop

ATP - Item 5 - Charging and Discharging



ATP - Item 5 - Charging and Discharging

Description:

Fully charge and discharge an accumulator on 20A port and Discharge an accumulator though AIRs while connected to a safety loop.

Successful Test:

PAC reads fully charged when it is fully charged and reads empty when empty.

PAC charges fully from multiple starting states of charge.

PAC discharges without issue with varying load.

PAC opens SL while charging.

The PAC discharges successfully without component failure, software lock ups, or unexpected human intervention.

ATP - Item 6

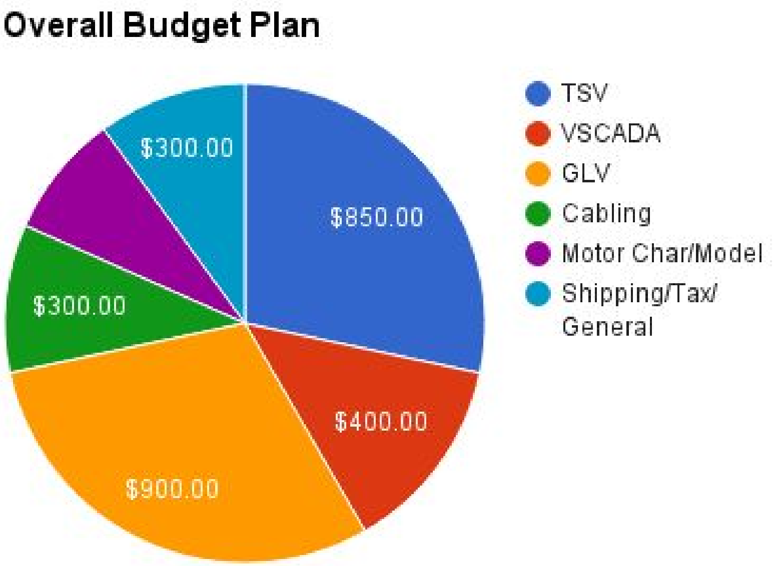
Description:

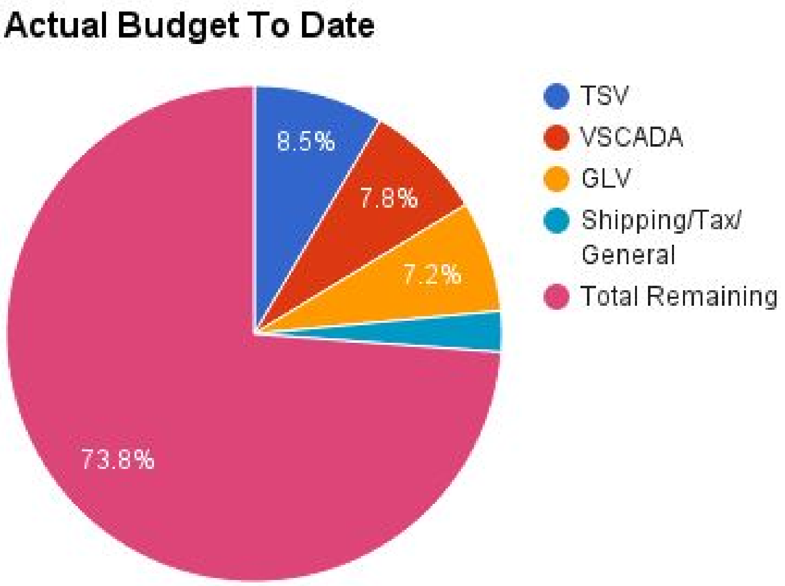
Motor spun with dynamometer close to FDD to demonstrate working capability of the system for specific RPM and torque measurements and show that the system has been correctly modeled.

Successful Test:

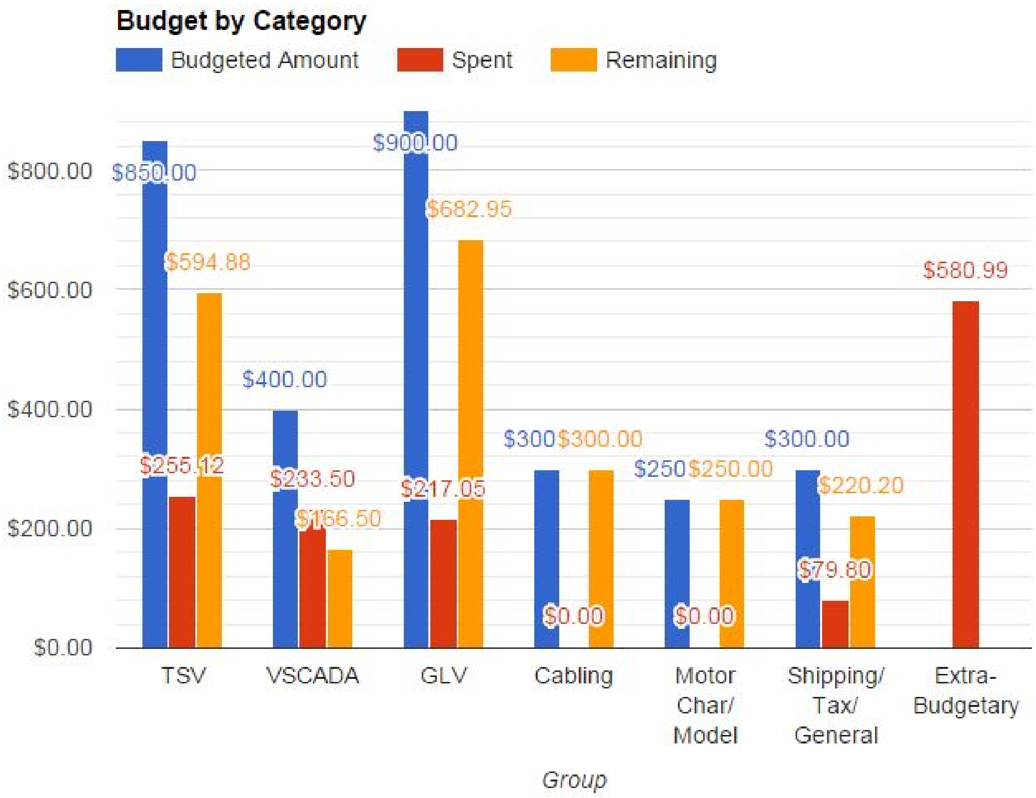
Motor in dynamometer setup is successfully spun using old VSCADA software for controlling throttle and load. Data collected using VSCADA software agrees with results of mathematical / Simulink model within specified standard uncertainty specified in Calibration & Accuracy document D011.

Cost Analysis and Detailed Budget





Cost Analysis and Detailed Budget



Note: The "Extra-Budgetary" column is being used for items we purchase for the project but are not required under the Statement of Work. Thus far, this has only been used for the TSV pack materials for 4 additional accumulator packs. Accounting for this, we have spend $1,366.46 total on the project, $785.47 of which has come from our own budget.

Cost Analysis and Detailed Budget

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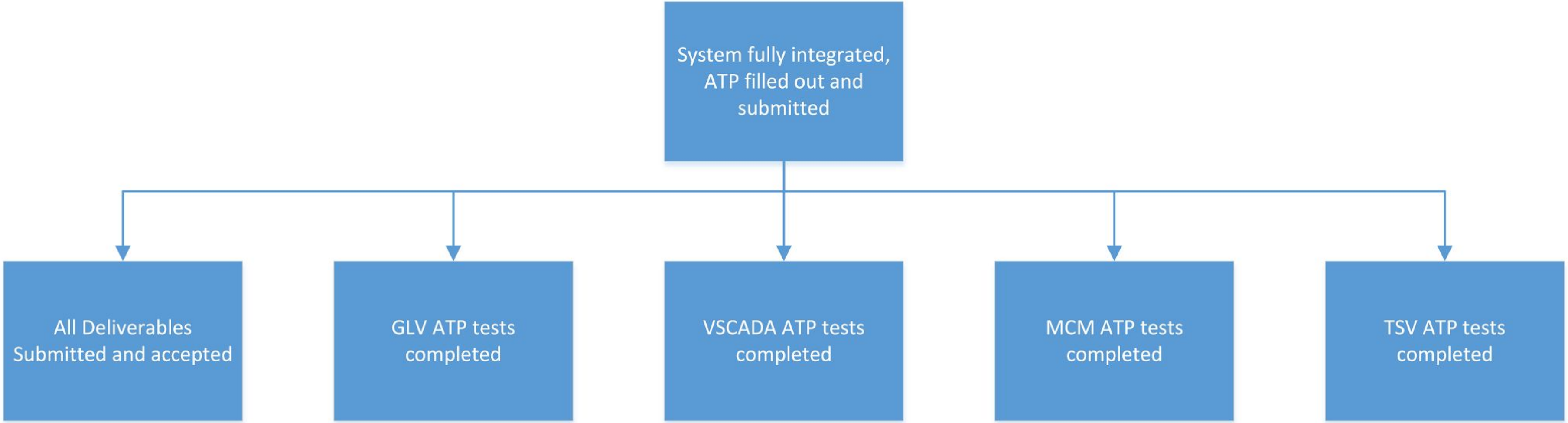
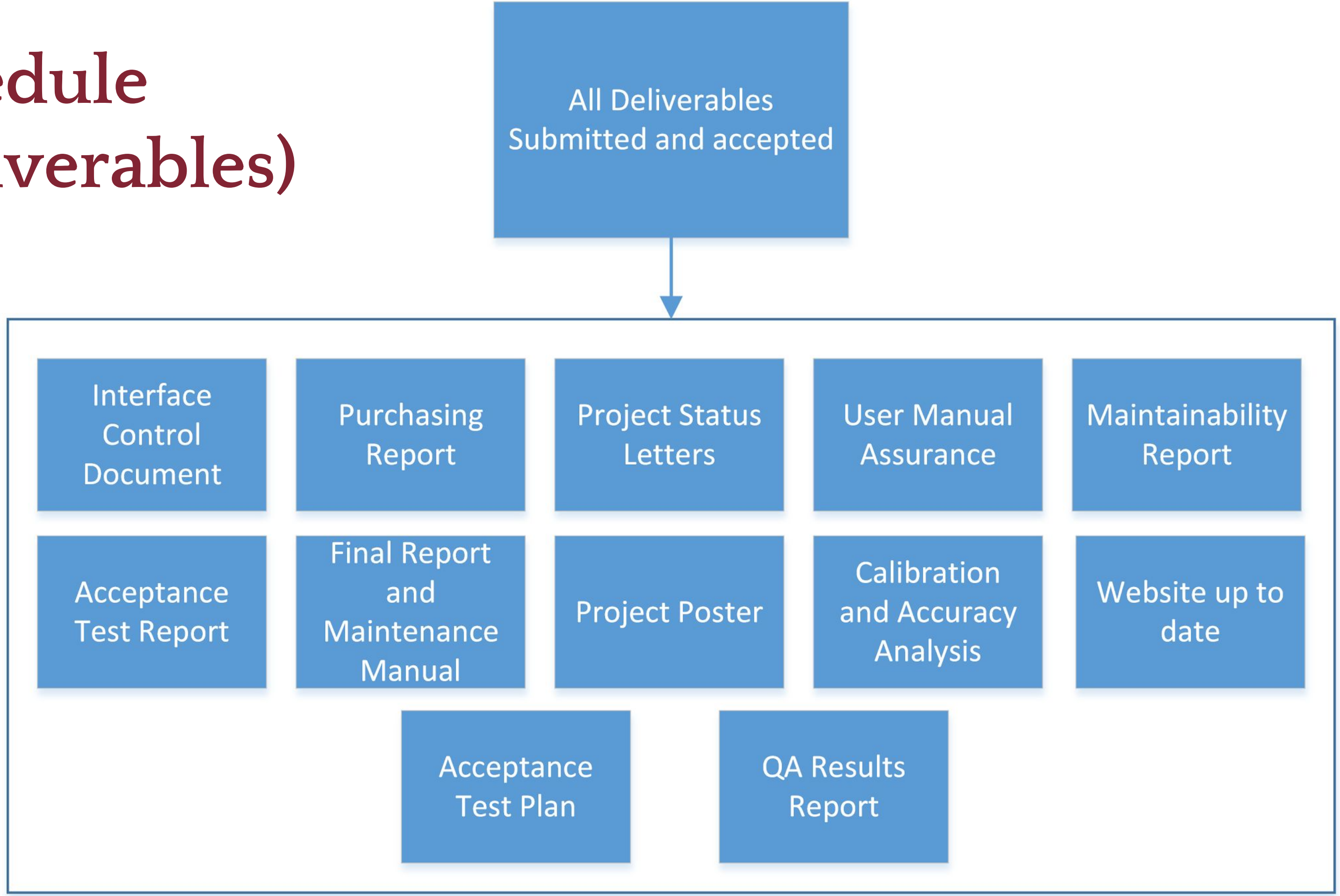
Schedule Hierarchy



Schedule (Deliverables)



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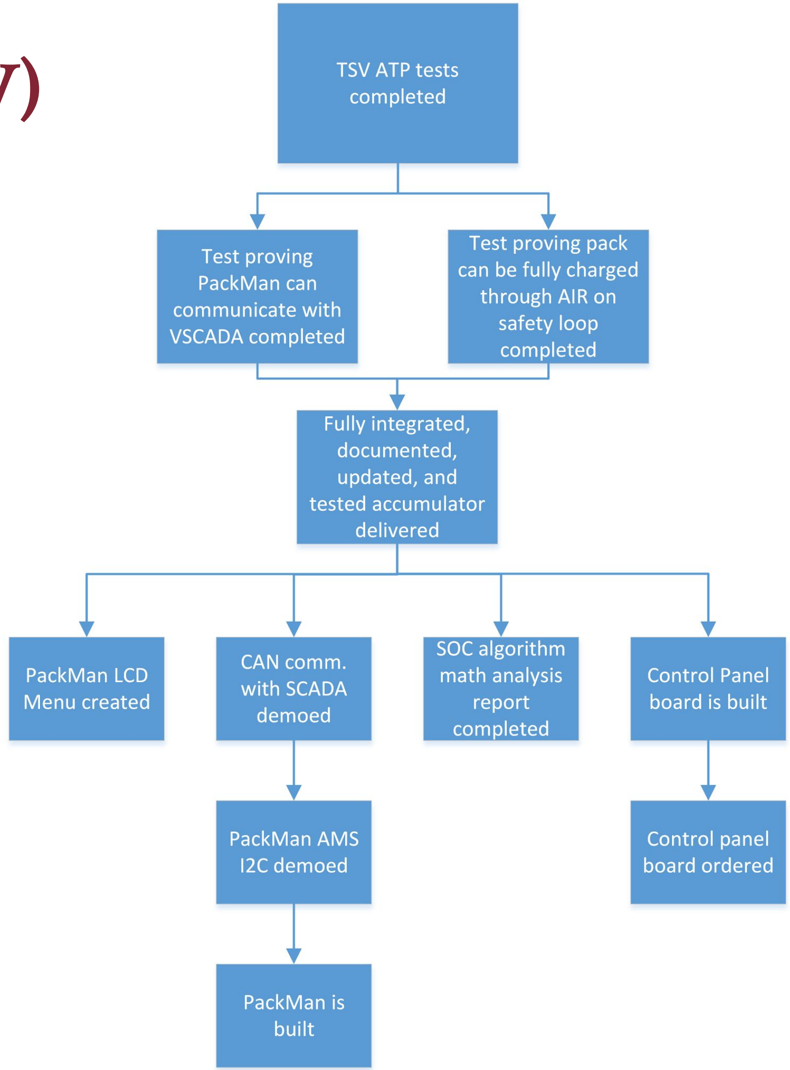
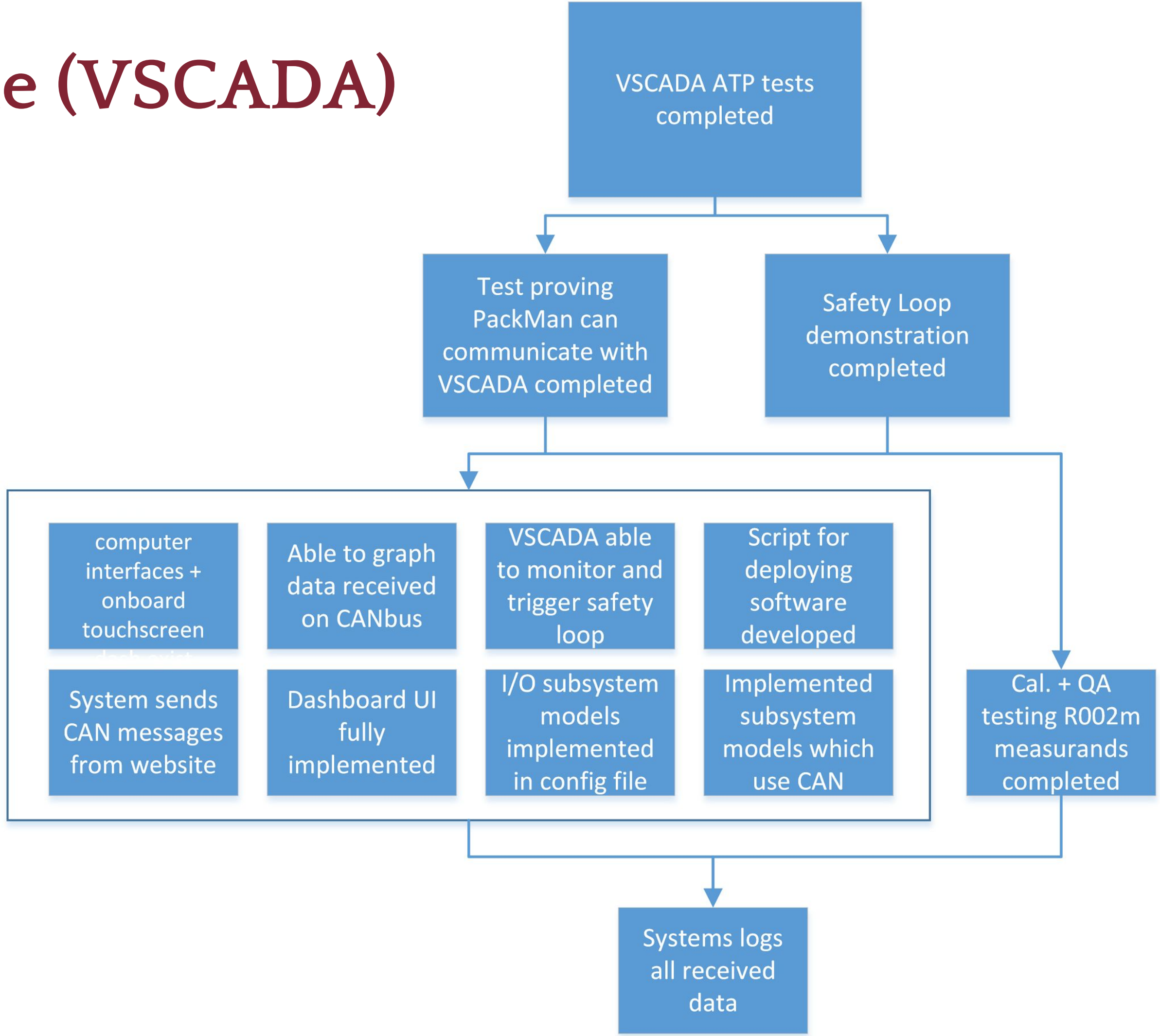
Schedule (TSV)



Schedule (TSV)

ID	Task Name	Start	Finish	Duration
1	State of charge alogrithm mathematical analysis report completed (Geoff)	3/17/2016	4/22/2016	37d
2	Control panel board ordered (Jae)	3/17/2016	3/25/2016	9d
3	Control panel board built (Jae)	3/26/2016	4/1/2016	7d
4	PackMan is built (Geoff)	3/17/2016	3/25/2016	9d
5	PackMan AMS I2C demoed (Geoff)	3/26/2016	4/1/2016	7d
6	PackMan LCD Menu created (Geoff)	4/2/2016	4/8/2016	7d
7	CAN communication with SCADA demoed (Geoff)	4/9/2016	4/15/2016	7d
8	Accumulator completely assembled (Geoff)	4/23/2016	4/29/2016	7d
9	All R001 QA tests completed (Geoff)	4/30/2016	5/6/2016	7d
10	Final ATP testing completed (Geoff)	5/7/2016	5/11/2016	5d

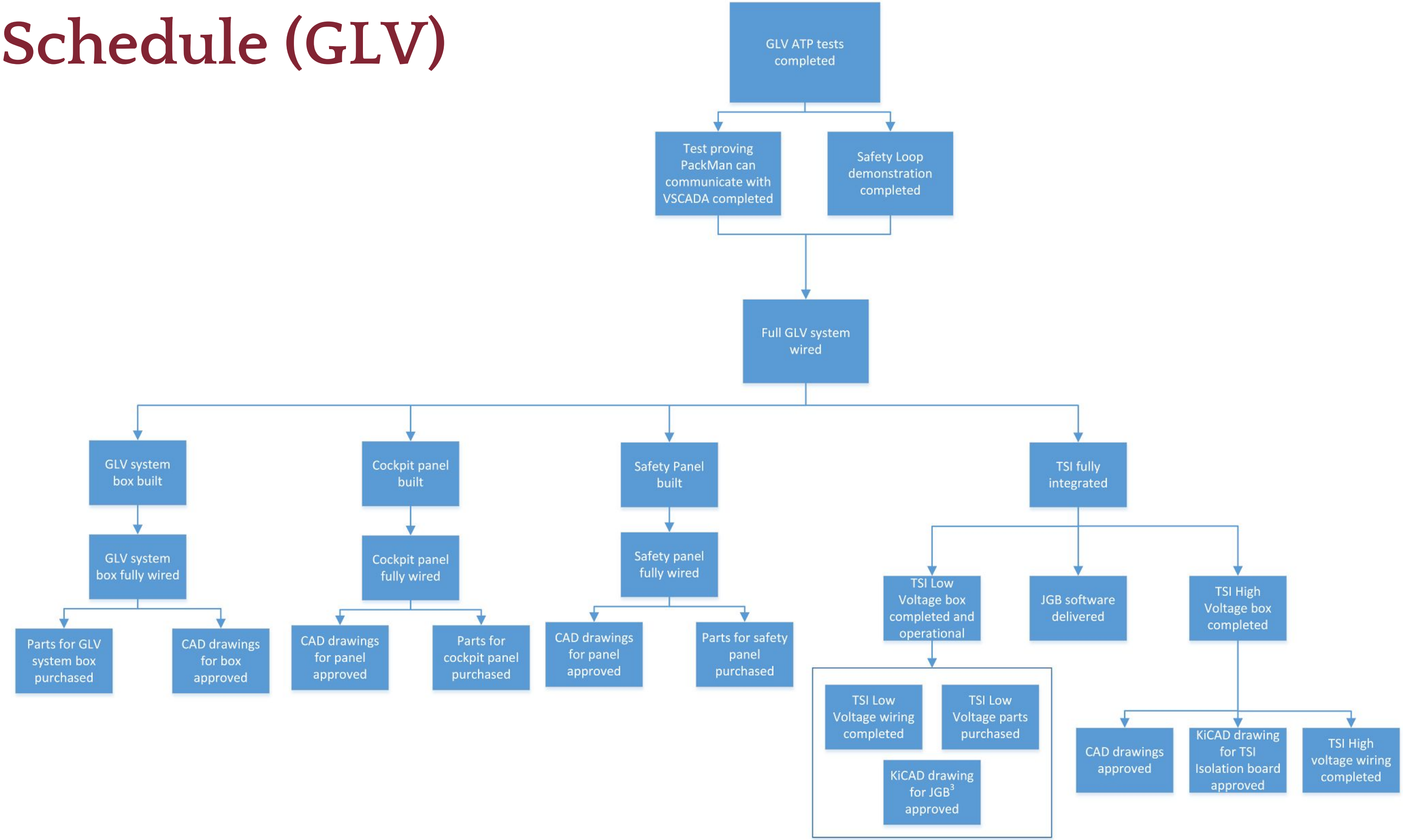
Schedule (VSCADA)



Schedule (VSCADA)

ID	Task Name	Start	Finish	Duration
1	System logs all received data (Nick)	3/17/2016	4/1/2016	16d
2	System able to send CAN messages from website (Brendon)	3/17/2016	4/1/2016	16d
3	Onboard computer interfaces + onboard touch-screen dashboard exist (Nick)	3/17/2016	4/1/2016	16d
4	Data received from CANbus can be graphed (Nick)	3/17/2016	4/8/2016	23d
5	Dashboard UI fully implemented (Brendon)	3/17/2016	4/8/2016	23d
6	Implemented subsystem models which use CAN (Brendon)	3/17/2016	4/20/2016	35d
7	Script for deploying software delivered (Nick)	3/17/2016	4/20/2016	35d
8	All I/O subsystem models implemented in a configuration file (Brendon)	3/17/2016	4/20/2016	35d
9	VSCADA able to monitor and trigger safety loop (Nick)	3/17/2016	4/20/2016	35d
10	Calibration and QA testing R002m measurands completed (all)	4/2/2016	4/20/2016	19d
11	Integration with other groups / ATP testing completed (Brendon)	4/21/2016	5/6/2016	16d
12	Tutorial and documentation for future groups completed (Nick)	4/21/2016	5/7/2016	17d

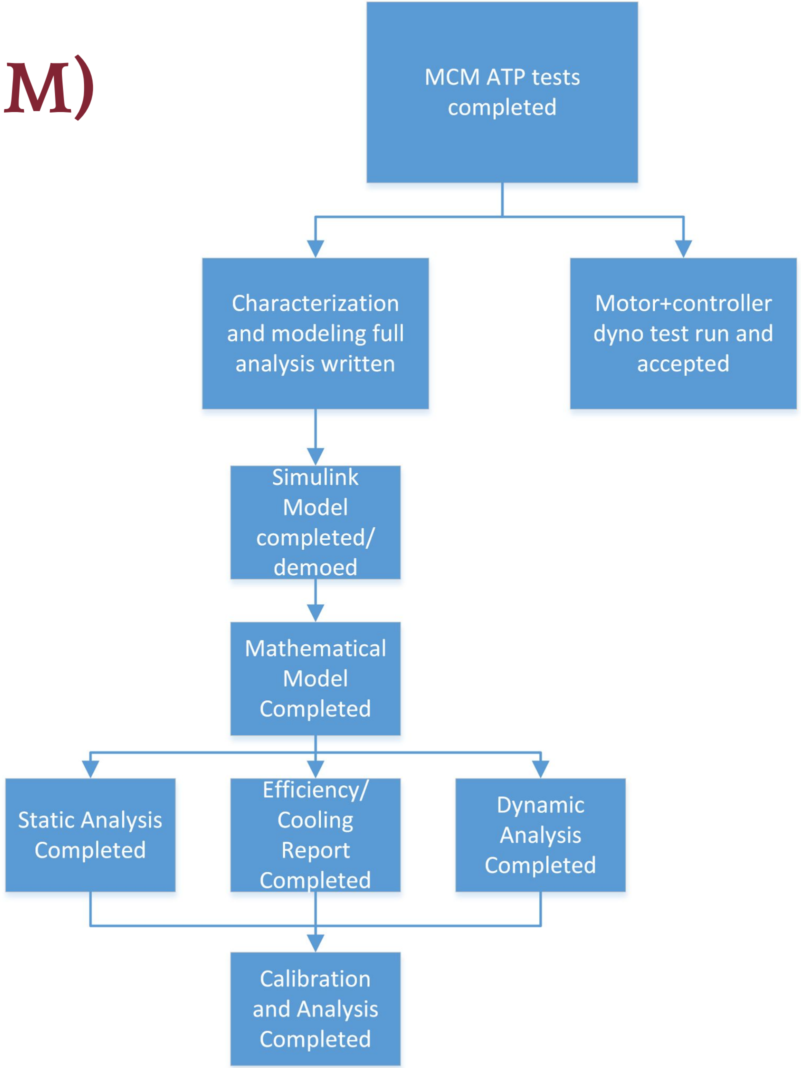
Schedule (GLV)



Schedule (GLV)

ID	Task Name	Start	Finish	Duration
1	JGB software delivered (Brandon)	3/17/2016	4/22/2016	37d
2	TSI-LV parts purchased (Joe)	3/17/2016	4/1/2016	16d
3	KiCAD drawing for JGB3 approved (Tim)	3/17/2016	4/1/2016	16d
4	TSI-LV wiring completed (Tim)	4/9/2016	4/21/2016	13d
5	TSI-LV box fully integrated and completed (Tim)	4/22/2016	4/22/2016	1d
6	KiCAD drawing for TSI Isolation board approved (Tim)	3/17/2016	4/1/2016	16d
7	CAD drawings approved for TSI-HV (Joe)	3/28/2016	4/15/2016	19d
8	TSI-HV wiring completed (Joe)	4/16/2016	4/21/2016	6d
9	TSI-HV box fully integrated and completed (Joe)	4/22/2016	4/22/2016	1d
10	TSI fully integrated (Tim)	4/23/2016	4/28/2016	6d
11	Parts for safety panel purchased (Joe)	3/17/2016	4/1/2016	16d
12	CAD drawings for safety panel approved (Tim)	3/17/2016	4/1/2016	16d
13	Safety panel fully wired (Brandon)	4/2/2016	4/7/2016	6d
14	Safety panel built (Brandon)	4/8/2016	4/8/2016	1d
15	Parts for cockpit panel purchased (Tim)	3/26/2016	4/8/2016	14d
16	CAD drawings for cockpit panel approved (Tim)	3/26/2016	4/8/2016	14d
17	Cockpit panel fully wired (Brandon)	4/9/2016	4/14/2016	6d
18	Cockpit panel built (Brandon)	4/15/2016	4/15/2016	1d
19	CAD drawings for GLV system box approved (Tim)	4/2/2016	4/15/2016	14d
20	Parts for GLV system box purchased (Tim)	4/2/2016	4/15/2016	14d
21	GLV system box fully wired (Joe)	4/16/2016	4/21/2016	6d
22	GLV system box built (Joe)	4/22/2016	4/22/2016	1d
23	Full GLV system wired/integrated (all)	4/29/2016	4/29/2016	1d
24	Safety loop demonstration completed and ATP filled out (Brandon)	4/30/2016	5/6/2016	7d
25	Test proving PackMan can communicate with VSCADA completed and ATP filled out (Brendon & Geoff)	5/7/2016	5/11/2016	5d

Schedule (MCM)



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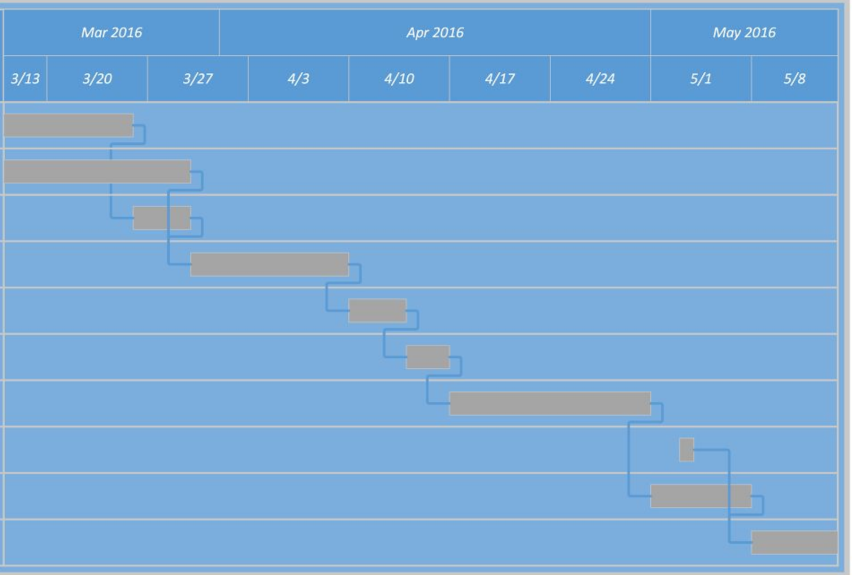
Schedule (MCM)

ID	Task Name	Start	Finish	Duration
1	Static Analysis complete, report portion completed (Armen)	3/17/2016	3/25/2016	9d
2	Calibration analysis report completed, calibration factors added (Armen	3/17/2016	3/29/2016	13d
3	Data collected, dynamic characterization (Dan)	3/26/2016	3/29/2016	4d
4	Dynamic analysis completed, report portion completed (Dan)	3/30/2016	4/9/2016	11d
5	Data collected, cooling (Armen)	4/10/2016	4/13/2016	4d
6	Efficiency / cooling analysis completed, report portion completed (Armen)	4/14/2016	4/16/2016	3d
7	Mathematical physics model completed, report portion completed (Dan)	4/17/2016	4/30/2016	14d
8	Motor, controller, dyno test completed, ATP portion filled out (Armen)	5/3/2016	5/3/2016	1d
9	Simulink model completed, able to be demoed (Dan)	5/1/2016	5/7/2016	7d
10	Final report completed, ATP for group fully filled out (Dan)	5/8/2016	5/13/2016	6d



Presentation Index