Maintenance Manual: TSV Accumulator

LFEV-Y4-2016

Calibration

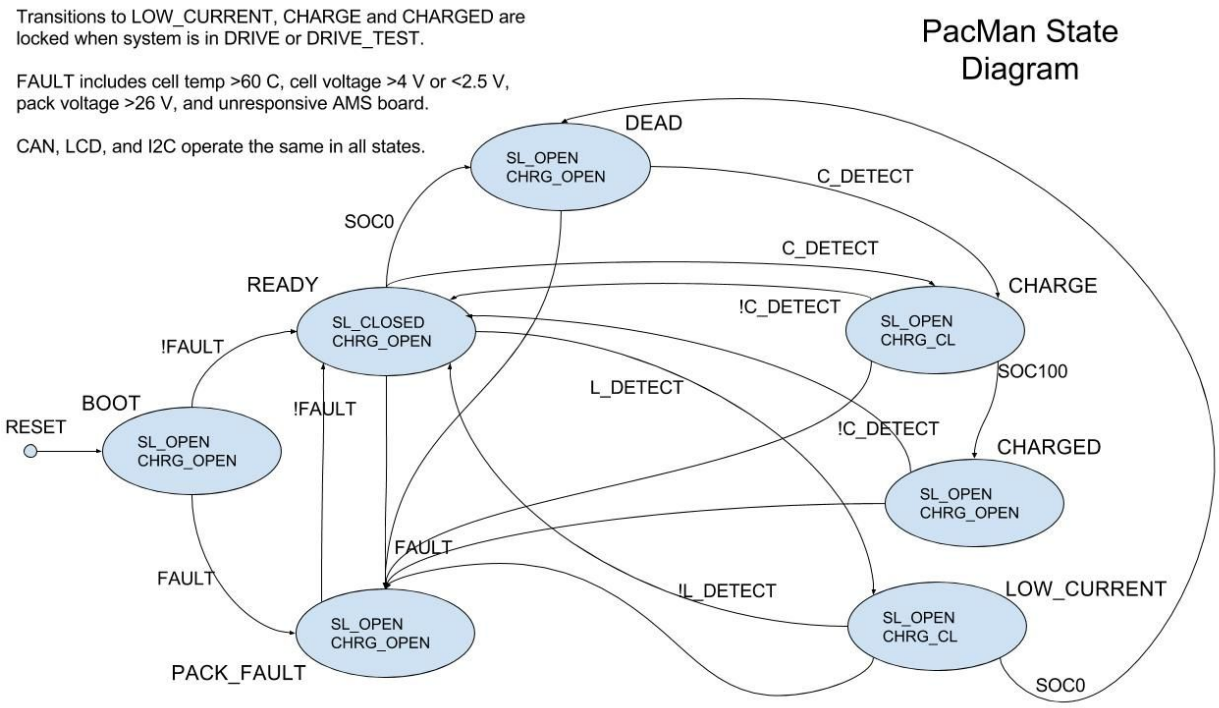
Calibration of sensors (pack and AMS sensors) is done by adjusting the values in params.h in source code.

Slope and offset values are used in all cases. Sensors should be calibrated in the test stand with lab power supplies providing power. To calibrate a sensor, its slope cal factor should be set to 1.0 and offset to 0.0. Output on the LCD screen will then be the raw sensor value. Data points at the high and low end of a sensor should be taken and compared with values measured with a calibrated device to calculate slopes and offsets.

Data collected for calibration (and the calculations of cal factors) can be found in xlsx format at the following address:

https://sites.lafayette.edu/ece492-sp16/files/2016/05/CalData.xlsx

State Transition Diagram



PacMan Software

The current version of PacMan software is v 0.14 and source code is available at the following address:

https://sites.lafayette.edu/ece492-sp16/files/2016/05/pacman_software_v0_14.zip

The tool chain is unchanged from previous versions of PacMan and details about it are available at the following address:

http://sites.lafayette.edu/ece492-sp15/files/2015/12/PACMAN_Programming_manual.pdf

The software is built on the Atom Threads RTOS. Atmel TWI and CAN libraries are utilized to achieve communication. All configurations (I2C addresses, CAN addresses, calibration factors) are stored in params.h

The code in main.c sets up tasks listed in tasklist.c and starts the RTOS. Functions that generate LCD screens are detailed in lcd.c. Functions that utilize TWI libraries to perform I2C communication are detailed in i2c.c. The remaining c files detail tasks that run continuously:

- task_button.c - retrieves button presses on the control panel
- task_can.c - transmits CAN messages
- task_charge.c - performs integration of current and calculates state of charge
- task_config.c - performs state transitions
- task_ gui.c - calls function in lcd.c to set the display output
- task_hearbeat.c - blinks an LED on PacMan to indicate the computer is operating
- task_i2c.c - calls functions to perform I2C communication tasks
- task_safety.c - opens and closes the safety loop relay
- task_watchdog.c - resets off chip watchdog

Schematics

PacMan

Attached are schematics generated from KiCad. The KiCad project is available at the following address:

https://sites.lafayette.edu/ece492-sp16/files/2016/05/pacman_hardware_rev_0_5.zip

Accumulator

Attached are schematics generated from KiCad. The KiCad project is available at the following address:

https://sites.lafayette.edu/ece492-sp16/files/2016/05/accumulator.zip

Bill of Materials

PacMan

A csv BOM generated from KiCad is available at the following address:

https://sites.lafayette.edu/ece492-sp16/files/2016/05/pacman-main.csv

Accumulator

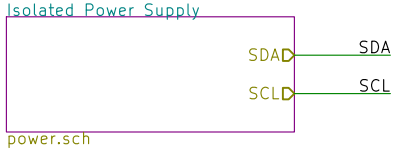
A csv BOM generated from KiCad is available at the following address:

https://sites.lafayette.edu/ece492-sp16/files/2016/05/accumulator.csv

POWER ELECTRONICS

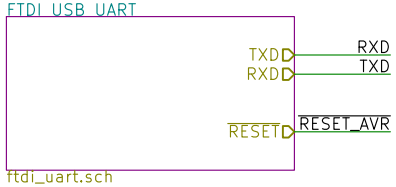
DC-DC Switching Power Regulation
5V and 3.3V outputs are isolated from High Voltage, but not each other

Isolated Power Supply



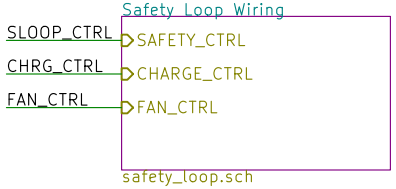
FTDI USB UART

FTDI USB UART



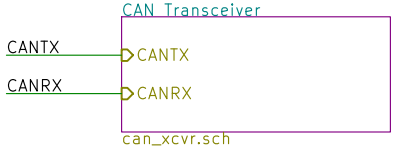
SAFETY LOOP WIRING

Safety Loop Wiring



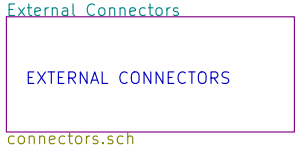
CAN TRANCEIVER

CAN Transceiver

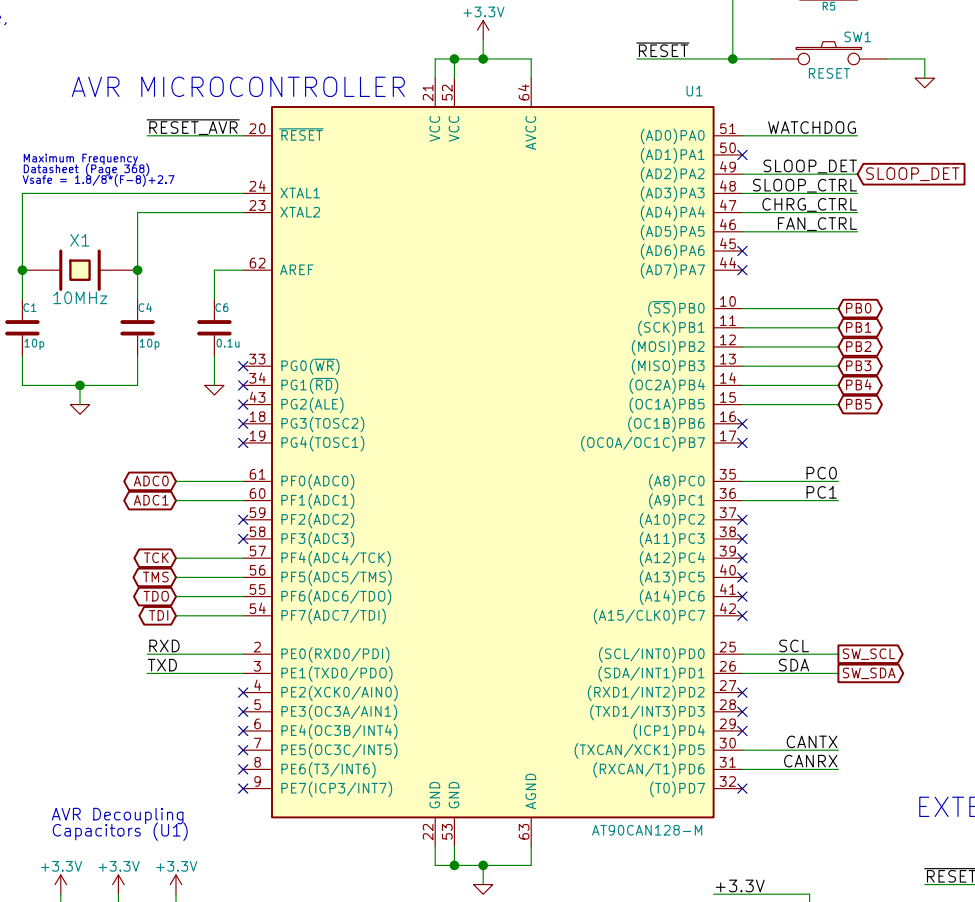


CONNECTORS

External Connectors

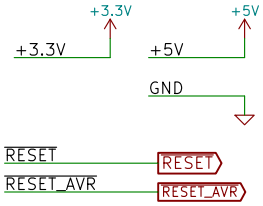


AVR MICROCONTROLLER

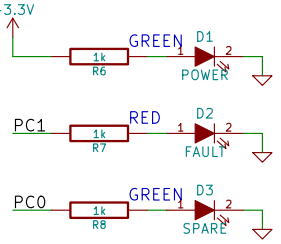


AVR Reset Switch

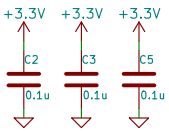
GROUNDED LOW VOLTAGE



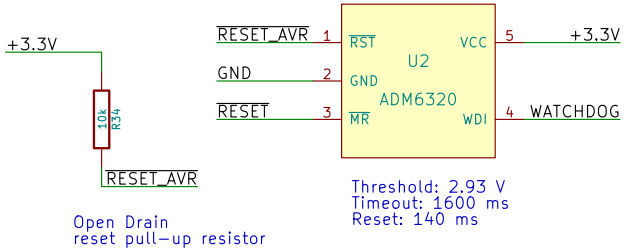
SYSTEM STATUS LEDS



AVR Decoupling Capacitors (U1)



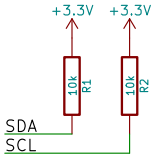
EXTERNAL WATCHDOG



Open Drain
reset pull-up resistor

Threshold: 2.93 V
Timeout: 1600 ms
Reset: 140 ms

I2C PULLUP



DEVELOPMENT ONLY
Engineer: Geoff Nudge
Supervisor: Christopher Nadovich
Spring Semester 2015
Lafayette College

Sheet: /
File: pacman-main.sch

Title: Battery Pack Management Computer

Size: USLetter	Date: 2016-04-01	**Rev: 0.5**
KiCad E.D.A. kicad 4.0.2-4+622538ubuntu14.04.1-stable		Id: 1/6

HIGH VOLTAGE INTERFACES

BATT+
PACK+
PACK−
LOW_DET
CHRG_DET
SDA_HV
SCL_HV
5V_AMPS
AMPS_1
AMPS_2

PWR_FLAG
HV_GND PACK−
PWR_FLAG
5V_HV

HIGH VOLTAGE POWER

This power supply is responsible for delivering non−isolated 5V power to the high voltage electronics. All AMS bus connected devices are powered from this regulator. Maximum current draw 250mA. This Switcher was selected for its high efficiency even at light load.

PACK+ F1 5 A D5 SK310A−LTP HV_PWR
PWR_FLAG
R13 1.1k
C10 220u
C11 1u
HV_GND

350uA
U6 LTC3638
Vin SW RUN VFB OVLO SS VPRG2 VPRG1 GND
L1 220u
D6 SK310A−LTP
R14 1k
C15 10u
C12 10u
5V_HV
HV_GND

HIGH VOLTAGE

5V_HV
AMS_RESET

LOW VOLTAGE

PWR_FLAG PWR_FLAG
+5V
GND

SDA
SCL

PACK VOLTAGE SENSOR AND CHARGE SENSOR

PACK+ 5V_HV
U4 INA_226
ALERT VBUS VS A1 A0 IN+ IN− SDA SCL GND
R3 0.001 1%
BATT+ HV_GND
SDA_HV SCL_HV

I2C Address 0x44
(see datasheet page 18)
Additional documentation
of the use of this component
is req'd.

Bypass Capacitor (U4)
C23 0.1u C8 0.1u
5V_HV HV_GND

Bypass Capacitor (U5)

I2C Address 0x48
(see datasheet page 14)

5V_HV
U5 ADS1115
AIN0 AIN1 AIN2 AIN3 VCC ADDR RDY SDA SCL GND
AMPS_1 AMPS_2
HV_GND SDA_HV SCL_HV

I2C PULLUP

5V_HV
1mA
R19 1k R20 1k
SDA_HV SCL_HV

I2C ISOLATOR

5mA
5V_HV SDA_HV SCL_HV HV_GND
C14 0.1u C25 0.1u C13 0.1u
U8 Si8600
VDD1 SDA1 SCL1 GND1 ISO OPTO VDD2 SDA2 SCL2 GND2
5mA
+3.3V SDA SCL GND
C17 0.1u

HIGH VOLTAGE DIGITAL I/O

This I/O expander is responsible for relaying digital signals accross the HV−LV isolation barrier via the I2C bus.

5V_HV R10 10k
I2C Address 0x40
(see datasheet page 13)
PCF8574A U3
40uA
P0 P1 P2 P3 P4 P5 P6 P7 VDD VSS SCL SDA A0 A1 A2 INT
CHRG_DET AMS_RESET LOW_DET
SCL_HV SDA_HV HV_GND HV_GND HV_GND
Q4 RRR015P03TL
5V_AMPS 5V_HV
R11 10k
5V_HV HV_GND

5V_HV
C22 0.1u Bypass Capacitor (U3)
HV_GND

HIGH VOLTAGE | LOW VOLTAGE

HV_PWR HV_GND
C9 10u
U7 NCS6S1205C
VIN+ VIN+ VIN− VIN− VOUT+ VOUT− NC
D9 SK310A−LTP
+5V
C16 220u C24 0.1u D20 NZH5V1B
U9 NCP1117ST33T3G
VI VO GND
+3.3V
C18 0.1u
GND

3.3V Linear Regulator

The flyback regulator responsible for delivering 5V isolated power to low voltage systems has been replaced with an isolated DC/DC converter. This is due to the insufficient output current (300mA) available when assembled. Cost is comparable.

Maximum Current Draw on 5V output: 1.2A

DEVELOPMENT ONLY
Engineer: Geoff Nudge
Supervisor: Christopher Nadovich
Fall Semester 2015
Lafayette College
Sheet: /Isolated Power Supply/
File: power.sch

Title: Battery Pack Management Computer

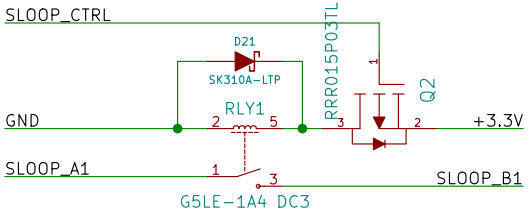
Size: USLetter	Date: 2016−04−01	**Rev: 0.5**
KiCad E.D.A. kicad 4.0.2−4+622538ubuntu14.04.1−stable		Id: 2/6

SAFETY_CTRL SLOOP_CTRL
CHARGE_CTRL CHRG_CTRL
FAN_CTRL FAN_CTRL
SLOOP_DET SLOOP_DET

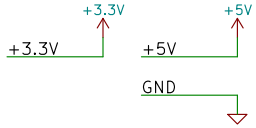
SAFETY LOOP RELAY

This relay is responsible for switching the PACMAN safety loop connection ON/OFF. The lights show the user at a glance if the safey loop is open or closed.

This relay is capable of switching 8A.
The SLOOP_CTRL signal is active low.

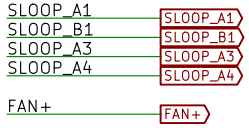


GROUNDED LOW VOLTAGE



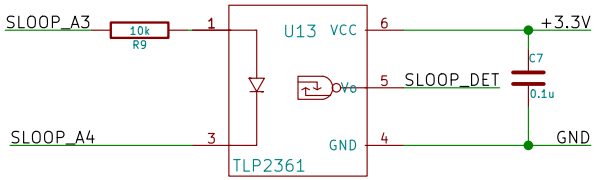
A1 and B1 pins are shorted together only when the safety loop is not opened by this board.

Voltage between A3 and A4 greater than 0 means the safety loop is not opened by any other component in the system.



OPTO-ISOLATOR ON SL CLOSED SIGNAL

This device provides a galvanically isolated signal to the microcontroller to let it know the safety loop is closed in all components. The HV current sensor is enabled as a result. This mean the AIRs should be closed if functional.

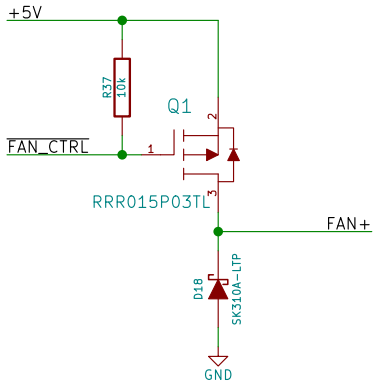


FAN CONTROL P-FET

This MOSFET is responsible for switching the charge fan ON/OFF.

The fan will not come on automatically when charging begins, it is controlled by the software.

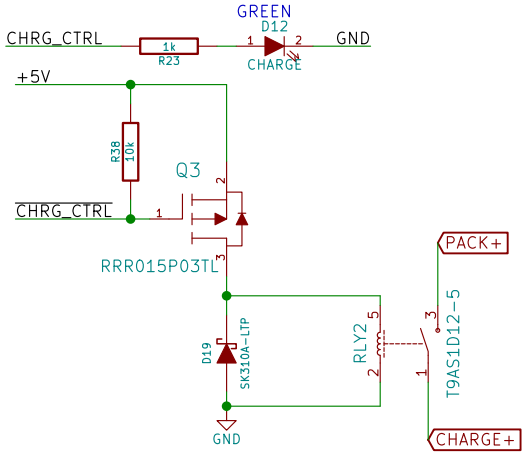
Fan Output Voltage: 5V



CHARGE CONTROL P-FET

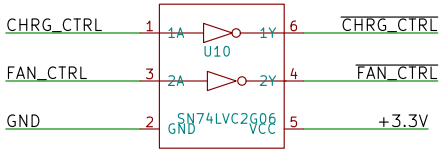
This MOSFET is responsible for connecting the CHARGE relays when the pack charger has been connected. Power is supplied from either the pack terminals, or USB connector.

Coil Output Voltage: 5V



HIGH SIDE P-FET DRIVER

This device is responsible for driving the high side p-fet switches.



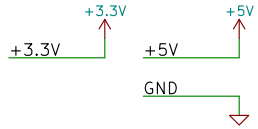
DEVELOPMENT ONLY
Engineer: Geoff Nudge
Supervisor: Christopher Nadovich
Fall Semester 2015
Lafayette College

Sheet: /Safety Loop Wiring/
File: safety_loop.sch

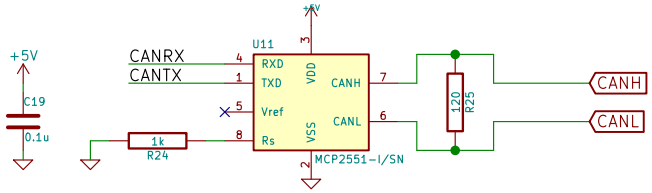
Title: Battery Pack Management Computer

Size: USLetter	Date: 2016-04-01	**Rev: 0.5**
KiCad E.D.A. kicad 4.0.2-4+622538ubuntu14.04.1-stable		Id: 3/6

GROUNDED LOW VOLTAGE



CAN TRANCEIVER



NOTE: DO NOT populate R26.

R26 provides the ability to use this board
as a terminating CAN node in development only.

DEVELOPMENT ONLY Engineer: Geoff Nudge Supervisor: Christopher Nadovich Fall Semester 2015 **Lafayette College**		
Sheet: /CAN Transceiver/ File: can_xcvr.sch		
Title: Battery Pack Management Computer		
Size: USLetter	Date: 2016-04-01	**Rev: 0.5**
KiCad E.D.A. kicad 4.0.2-4+622538ubuntu14.04.1-stable		Id: 4/6

GROUNDED LOW VOLTAGE

+3.3V
+5V
GND

VUSB
USBD+
USBD−

RESET
TXD
RXD

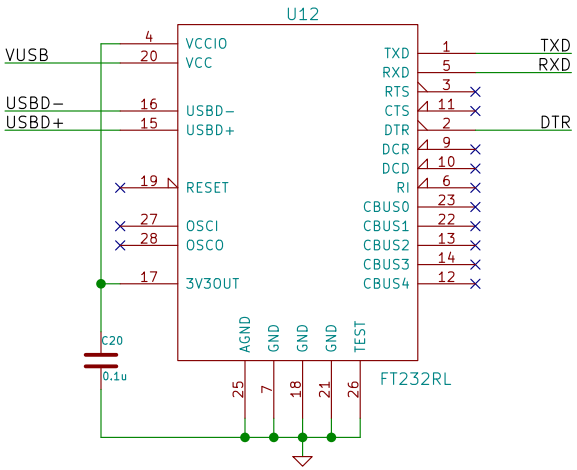
USB BOOTSTRAP POWER

This diode is used to power the PACMAN computer board when the battery pack has been fully discharged. If voltage is not present between PACK+ and PACK−, then this diode will allow the USB port to supply up to 500mA of sustained current. For periods less than 0.1 seconds, 1A can be drawn.

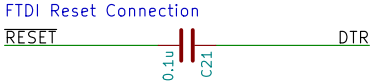
USB UART

This is an FTDI USB Serial Converter IC, it can be used to upload code, configure the device, or transfer debugging information if the software is configured properly.

Drivers available for Windows, Mac OS & Linux

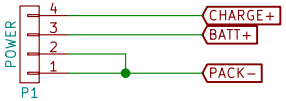


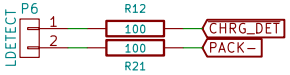
FTDI Reset Connection



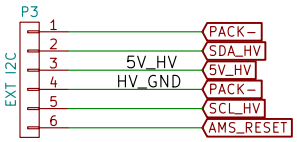
DEVELOPMENT ONLY	
Engineer: Geoff Nudge	
Supervisor: Christopher Nadovich	
Fall Semester 2015	
Lafayette College	
Sheet: /FTDI USB UART/	
File: ftdi_uart.sch	
Title: Battery Pack Management Computer	
Size: USLetter | Date: 2016-04-01	**Rev: 0.5**
KiCad E.D.A. kicad 4.0.2-4+622538ubuntu14.04.1-stable	Id: 5/6

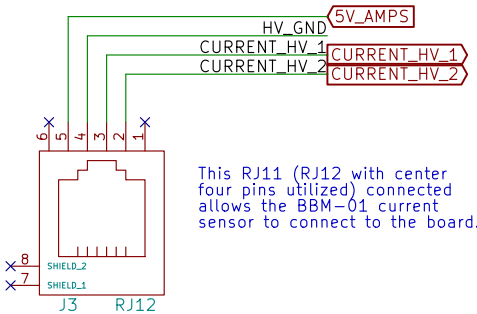
HIGH VOLTAGE





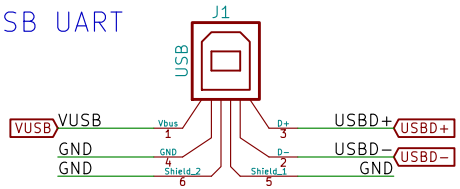
A jumper in the Anderson charge connector pulls an input low on the HV I2C expander, corresponding to either charge or low current output.





This RJ11 (RJ12 with center four pins utilized) connected allows the BBM−01 current sensor to connect to the board.

USB UART

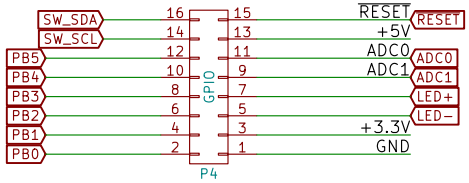


PACK WIRING HARNESS APPLICATION NOTE

Port J2 is a DB−37 backplane connector, which will be connected to the pack wiring harness via solder pot connections. The wiring of this connector, and its inputs/outputs are described in more detail in the pack wiring diagram.

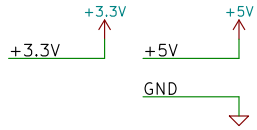
GPIO HEADER

0.1" IDC Connector
External User Interface Board



This connector contains pins for I2C communication with the LCD screen, input from control panel push buttons, and to illuminate the pack alile LED. . If, at a later time, more complicated LCDs, or more I/O is required these pins can be utilized.

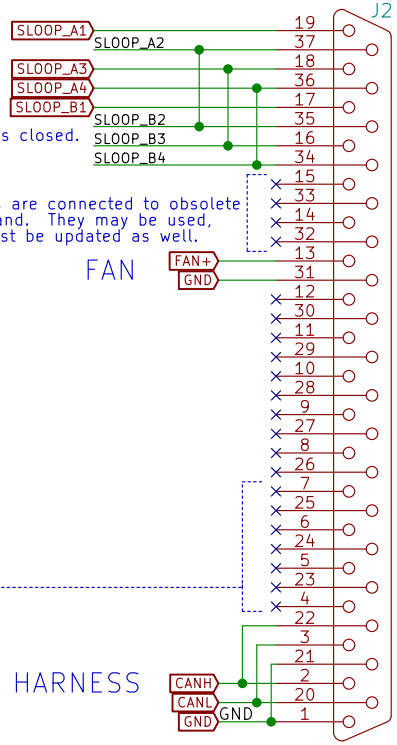
GROUNDED LOW VOLTAGE



SAFETY LOOP A/B

SLOOP_A1 and SLOOP_B1 pins are shorted together only when the safety loop is closed.

Pins in these sections are connected to obsolete signals in the test stand. They may be used, but the test stand must be updated as well.

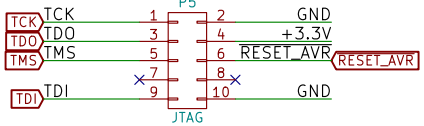


FAN

GLV HARNESS

AVR DEBUGGING

JTAG Programming/Debug Header

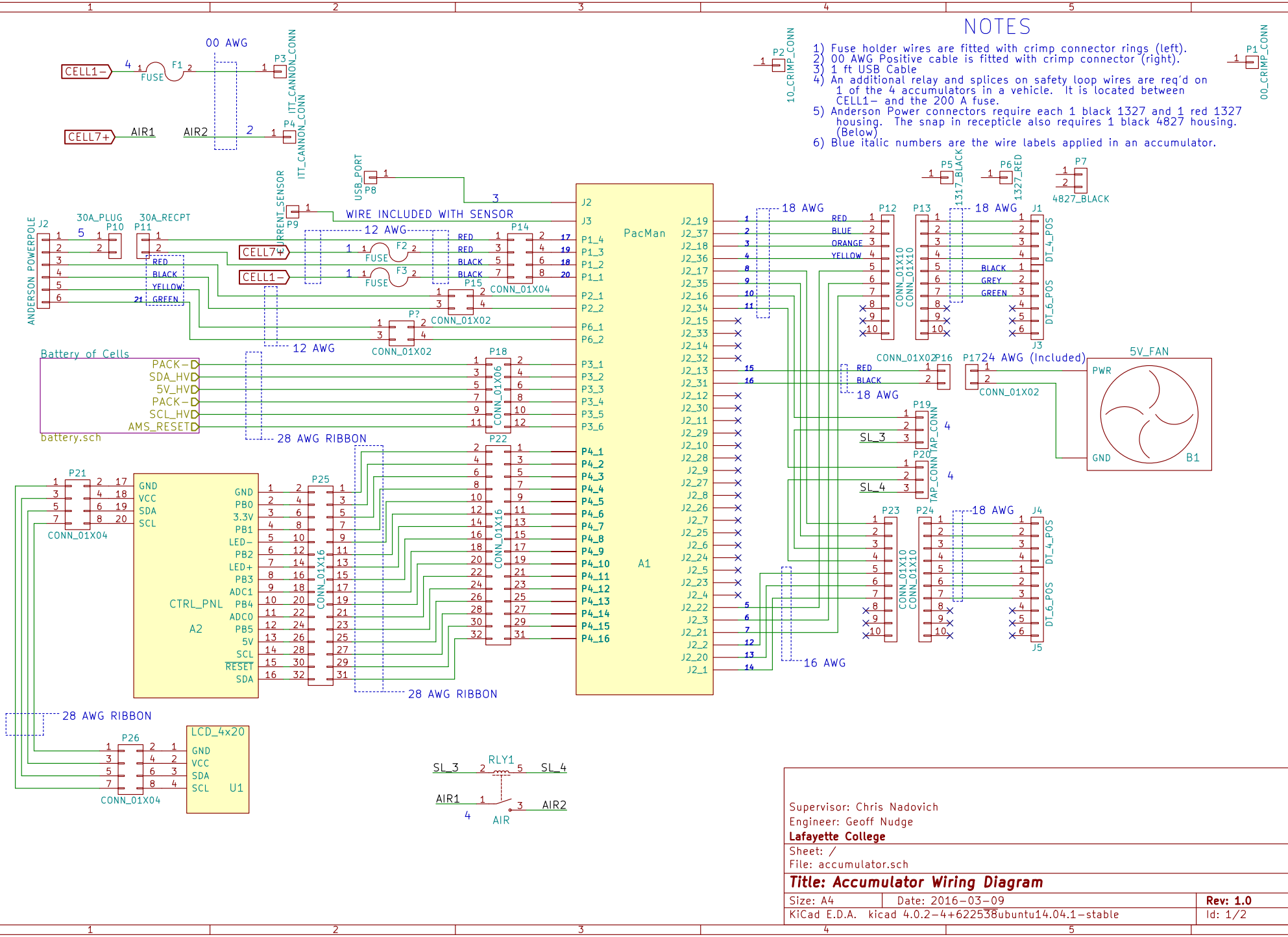


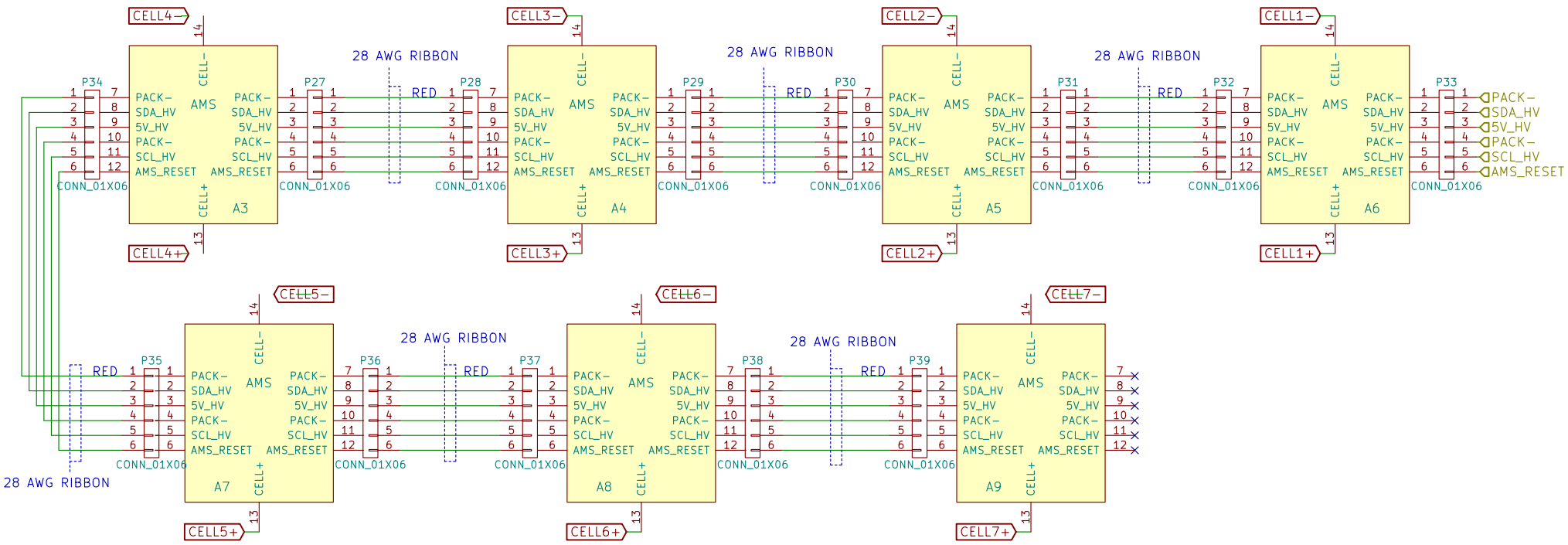
DEVELOPMENT ONLY
Engineer: Geoff Nudge
Supervisor: Christopher Nadovich
Spring Semester 2016
Lafayette College

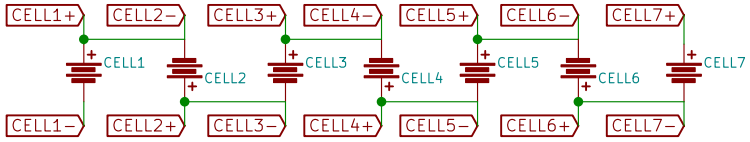
Sheet: /External Connectors/
File: connectors.sch

Title: Battery Pack Management Computer

Size: USLetter	Date: 2016−04−01	**Rev: 0.5**
KiCad E.D.A. kicad 4.0.2−4+622538ubuntu14.04.1−stable		Id: 6/6


NOTES
1) Fuse holder wires are fitted with crimp connector rings (left).
2) 00 AWG Positive cable is fitted with crimp connector (right).
3) 1 ft USB Cable
4) An additional relay and splices on safety loop wires are req'd on 1 of the 4 accumulators in a vehicle. It is located between CELL1− and the 200 A fuse.
5) Anderson Power connectors require each 1 black 1327 and 1 red 1327 housing. The snap in recepticle also requires 1 black 4827 housing. (Below)
6) Blue italic numbers are the wire labels applied in an accumulator.
00 AWG
CELL1−
FUSE
F1
P3
ITT_CANNON_CONN
CELL7+
AIR1
AIR2
P4
P2
10_CRIMP_CONN
P1
00_CRIMP_CONN
P5
1317_BLACK
P6
1327_RED
P7
4827_BLACK
USB_PORT
P8
CURRENT_SENSOR
P9
WIRE INCLUDED WITH SENSOR
12 AWG
F2
F3
P14
P15
CONN_01X04
P?
CONN_01X02
ANDERSON POWERPOLE
J2
30A_PLUG
P10
30A_RECPT
P11
RED
BLACK
YELLOW
GREEN
PacMan
A1
J2
J3
P1_4
P1_3
P1_2
P1_1
P2_1
P2_2
P6_1
P6_2
P3_1
P3_2
P3_3
P3_4
P3_5
P3_6
P4_1
P4_2
P4_3
P4_4
P4_5
P4_6
P4_7
P4_8
P4_9
P4_10
P4_11
P4_12
P4_13
P4_14
P4_15
P4_16
J2_19
J2_37
J2_18
J2_36
J2_17
J2_35
J2_16
J2_34
J2_15
J2_33
J2_14
J2_32
J2_13
J2_31
J2_12
J2_30
J2_11
J2_29
J2_10
J2_28
J2_9
J2_27
J2_8
J2_26
J2_7
J2_25
J2_6
J2_24
J2_5
J2_23
J2_4
J2_22
J2_3
J2_21
J2_2
J2_20
J2_1
18 AWG
P12
P13
CONN_01X10
CONN_01X10
J1
DT_4_POS
DT_6_POS
J3
Battery of Cells
PACK−
SDA_HV
5V_HV
PACK−
SCL_HV
AMS_RESET
battery.sch
12 AWG
P18
CONN_01X06
28 AWG RIBBON
P22
CONN_01X16
P16
CONN_01X02
P17
24 AWG (Included)
5V_FAN
PWR
GND
B1
P19
TAP_CONN
SL_3
P20
SL_4
P21
CONN_01X04
CTRL_PNL
A2
GND
VCC
SDA
SCL
GND
PB0
3.3V
PB1
LED−
PB2
LED+
PB3
ADC1
PB4
ADC0
PB5
5V
SCL
RESET
SDA
P25
CONN_01X16
16 AWG
P23
P24
J4
J5
28 AWG RIBBON
P26
CONN_01X04
LCD_4x20
GND
VCC
SDA
SCL
U1
RLY1
SL_3
SL_4
AIR1
AIR2
AIR
Supervisor: Chris Nadovich
Engineer: Geoff Nudge
Lafayette College
Sheet: /
File: accumulator.sch
Title: Accumulator Wiring Diagram
Size: A4
Date: 2016−03−09
Rev: 1.0
KiCad E.D.A. kicad 4.0.2−4+622538ubuntu14.04.1−stable
Id: 1/2





SEE MECHANICAL DRAWINGS FOR DETAILS OF ALUMINUM BARS USED TO CONNECT CELLS

Sheet: /Battery of Cells/
File: battery.sch

Title:

Size: A4	Date:	**Rev:**
KiCad E.D.A. kicad 4.0.2-4+622538ubuntu14.04.1-stable		Id: 2/2