Sheet: Power In, Battery Charge & PV MPPT
I2C_CLOCK
I2C_DATA
I2C_CLOCK
I2C_DATA
File: battery_mgmt.sch

Sheet: Battery Management
I2C_CLOCK
I2C_DATA
I2C_CLOCK
I2C_DATA
BQ_XALERT
File: battery_balance.sch

Sheet: External Device Power
GPIO_EXT_PWR_1
GPIO_EXT_PWR_2
GPIO_EXT_PWR_3
GPIO_EXT_PWR_4
EXT_PWR_EN_1
EXT_PWR_EN_2
EXT_PWR_EN_3
EXT_PWR_EN_4
File: external_power.sch

Sheet: External Device Triggers
EXT_TRG_EN_1
EXT_TRG_EN_2
EXT_TRG_EN_3
EXT_TRG_EN_4
EXT_TRG_EN_1
EXT_TRG_EN_2
EXT_TRG_EN_3
EXT_TRG_EN_4
File: external_triggers.sch

Sheet: BeagleBone Black Cape
I2C_CLOCK
I2C_DATA
I2C_CLOCK
I2C_DATA
BQ_XALERT
EXT_PWR_EN_1
EXT_PWR_EN_2
EXT_PWR_EN_3
EXT_PWR_EN_4
EXT_TRG_EN_1
EXT_TRG_EN_2
EXT_TRG_EN_3
EXT_TRG_EN_4
EXT_TRG_EN_1
EXT_TRG_EN_2
EXT_TRG_EN_3
EXT_TRG_EN_4
12V_EN
19V_EN
12V_EN
19V_EN
UMB_CONn
ROCKET_READYn
IGN_RTL
UMB_CONn
ROCKET_READYn
IGN_RTL
ROCKET_IGNITED
File: beaglebone_cape.sch

Sheet: DC-DC Converters
I2C_CLOCK
I2C_DATA
I2C_CLOCK
I2C_DATA
12V_EN
19V_EN
12V_EN
19V_EN
File: dcdc_converter.sch

Sheet: Rocket Umbilical & Ignition Control
ROCKET_IGNITE
UMB_CONn
ROCKET_READYn
IGN_RTL
UMB_CONn
ROCKET_READYn
IGN_RTL
File: rocket_interface.sch
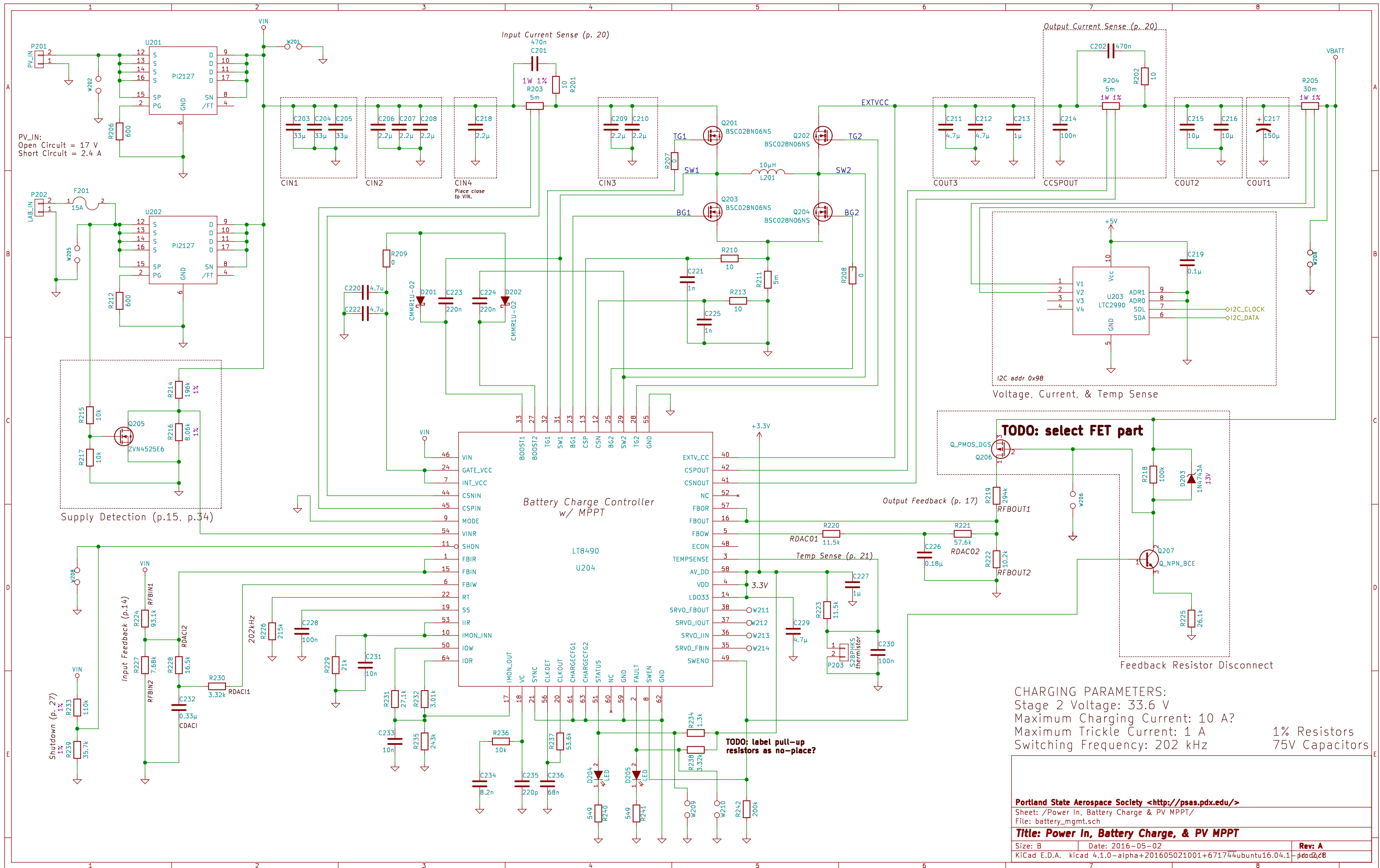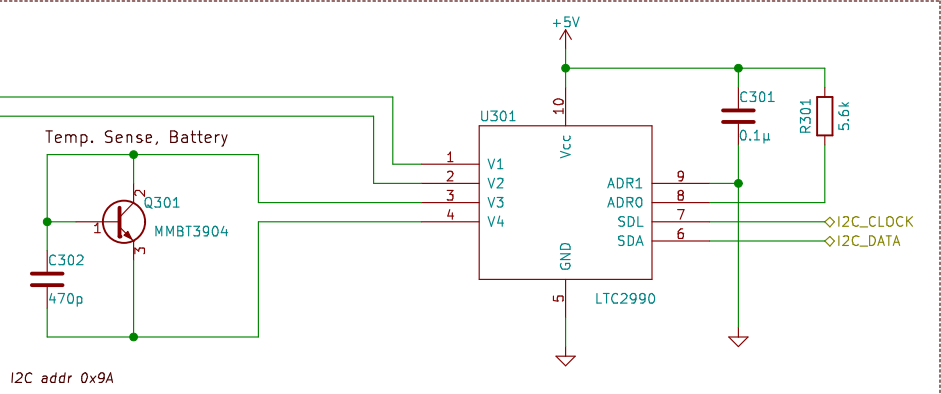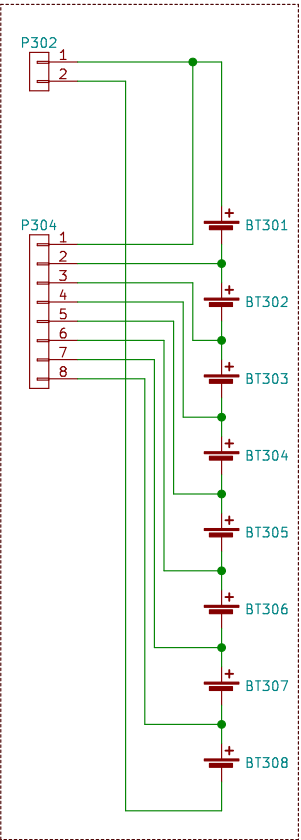
TODO:
* Create style legend.
* Consistent style:
  * No "embedded" multipliers in R vals.
* Add test points where appropriate.
  * Esp. around SMD packages, parts w/ no
    exposed leads, etc.
  * through-hole 2x1 pin header (1 to signal, other to gnd)

Power In, Battery Charge, & PV MPPT

PV_IN:
Open Circuit = 17 V
Short Circuit = 2.4 A

Input Current Sense (p. 20)

Output Current Sense (p. 20)

Supply Detection (p.15, p.34)

Voltage, Current, & Temp Sense

I2C addr 0x98

Battery Charge Controller
w/ MPPT

LT8490
U204

Input Feedback (p.14)

Shutdown (p. 27)

Temp Sense (p. 21)

Output Feedback (p. 17)

TODO: select FET part

Feedback Resistor Disconnect

TODO: label pull-up
resistors as no-place?

CHARGING PARAMETERS:
Stage 2 Voltage: 33.6 V
Maximum Charging Current: 10 A?
Maximum Trickle Current: 1 A
Switching Frequency: 202 kHz

1% Resistors
75V Capacitors

202kHz

3.3V

Place close
to VIN.

Component references

U201 PI2127, U202 PI2127, U203 LTC2990, U204 LT8490

Q201 BSC028N06NS, Q202 BSC028N06NS, Q203 BSC028N06NS, Q204 BSC028N06NS, Q205 ZVN4525E6, Q206 Q_PMOS_DGS, Q207 Q_NPN_BCE

L201 10µH

D201 CMMR1U-02, D202 CMMR1U-02, D203 1N4743A 12V, D204 LED, D205 LED

Voltage, Current, & Temp Sense

+5V

R311 1.78k
Q306 NDS9407

Temp. Sense, Battery
Q301 MMBT3904
C302 470p
U301 LTC2990
V1 1
V2 2
V3 3
V4 4
Vcc 10
ADR1 9
ADR0 8
SDL 7
SDA 6
GND 5
I2C_CLOCK
I2C_DATA
C301 0.1μ
R301 5.6k
I2C addr 0x9A

VBATT
R303 10k
D301 1SS355
C303 4.7n
D302 SMAZ16 16V
D305 SMAZ16 16V
R304 1M
SUM110P08-11 Q302
Q304 SUM110P08-11
R309 1k
SUM110P08-11 Q303
Q305 SUM110P08-11
R305 1M
D303 SMAZ16 16V
D306 SMAZ16 16V
C304 4.7n
R307 390k
R310 1k
R308 820k
D304 1SS355
R306 100k
C306 2.2μ
C305 2.2μ
R302 30m
F301 10A

W301 W303 W302

C307 4.7μ
C308 1μ
C309 1μ

5.0VDC
3.3VDC
C313 2.2μ
C314 2.2μ
R315 6.89k
R318 61.9k
C316 10n
P305 S2BPHKS to therm.
W306
C320 0.1μ
R322 200
R323 200
R324 1m
1W, ±275ppm

Li-Ion Cell Balance and Protection
BQ77PL900
U302

CP1 6
CP2 5
CP3 4
CP4 3
CPOUT 2
PMS 46
PACK 47
CHG 49
DSG 8
VREG1 42
VREG2 40
TOUT 39
TIN 38
XRST 28
VLOG 32
SDATA 26
SCLK 27
XALERT 25
EEPROM 24
CNF2 35
CNF1 34
CNF0 33
ZEDE 36
VOUT 31
IOUT 29
GPOD 44
BAT 9
VC1 10
VC2 11
VC3 12
VC4 13
VC5 14
VC6 15
VC7 16
VC8 17
VC9 18
VC10 19
VC11 20
GND 21
GND 30
GND 37
GND 41
SRBGND 22
SRPGND 23

I2C_DATA
I2C_CLOCK
BQ_XALERT
W304
W305
W307
P306 CONN_01X02

R312 500
C310 0.1μ
R313 500
C311 0.1μ
R314 500
C312 0.1μ
R316 500
C315 0.1μ
R317 500
C317 0.1μ
R319 500
C318 0.1μ
R320 500
C319 0.1μ
R321 500

P301 CONN_BATT_MAIN
1
2

P303 CONN_BATT_SENSE
1 2 3 4 5 6 7 8

P302
1
2

P304
1 2 3 4 5 6 7 8

Main Battery
BT301 BT302 BT303 BT304 BT305 BT306 BT307 BT308
* Off-Board
* Voltage Min/Max: 25.6/33.6

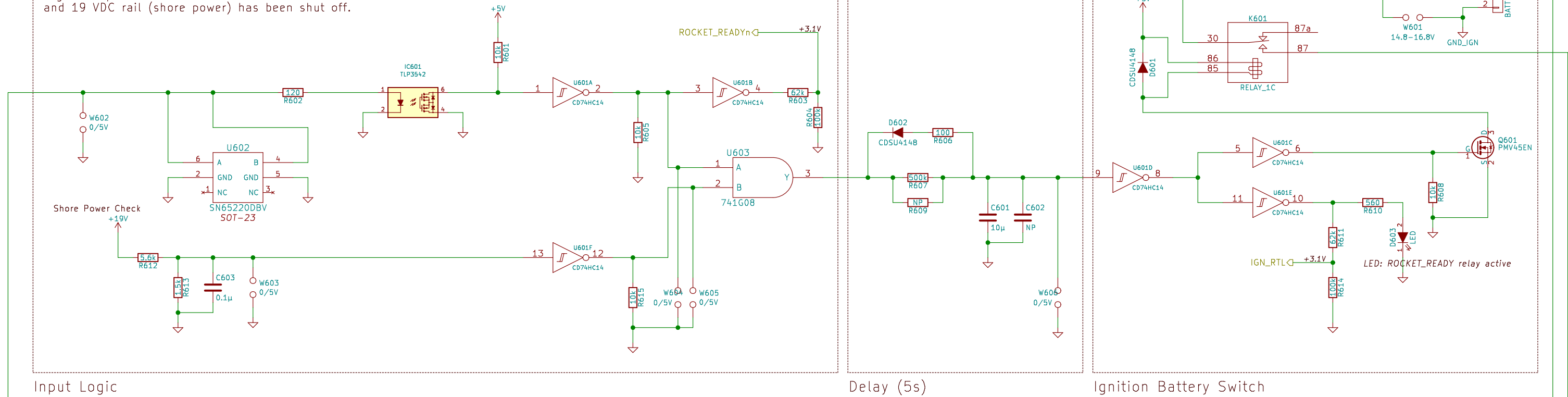**NOTES:**
* Page references are to the bq datasheet.
* Do not assign footprints to off-board components.
* bq77PL900 I2C addr is 0x10 (p.38).
* D301 and D304 are used to peak detect transients,
  and may not be necessary. Include footprints on PCB,
  but do not place parts.

UNCONNECTED PINS
* VOUT and IOUT are internally connected to ground
  when disabled (pp. 30, 33).
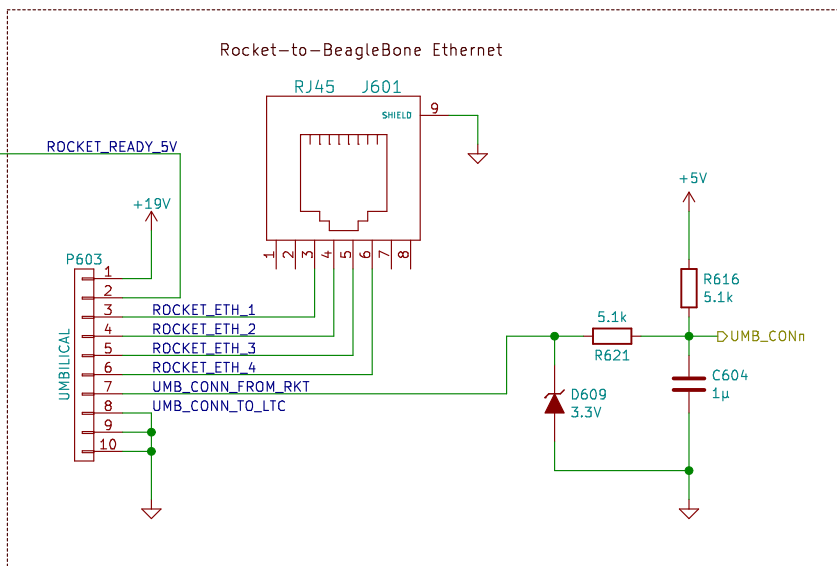* XRST is an open-drain output with an internal
  3k pull-up to VLOG (p. 35).

+5V DC Supply

VBATT
C402 1µ C403 2.2µ
ceramic, X[57]R
U401 PTN78020W
V_IN V_OUT
GND INHIBIT V_ADJ V_SENSE GND
R401 0.1 1W 1% +5V
C404 470µ C405 1µ
W401
U405A CD74HC14
Q401 BSS138
W402
R402 21k 1%, 50mW

+12V DC Supply

VBATT
C408 4.7µ C409 4.7µ C410 4.7µ C411 4.7µ
ceramic, X[57]R
U403 PTN78020H
V_IN V_OUT
GND INHIBIT V_ADJ V_SENSE GND
R403 60m 1W 1% +12V
C406 470µ C407 1µ
W403
U405B CD74HC14
Q402 BSS138
W404
R406 2.91k 1%, 50mW

+19V DC Supply

VBATT
C414 4.7µ C415 4.7µ C416 4.7µ C417 4.7µ
ceramic, X[57]R
U404 PTN78020H
V_IN V_OUT
GND INHIBIT V_ADJ V_SENSE GND
R408 60m 1W 1% +19V
C412 470µ C413 1µ
W405
U405C CD74HC14
Q403 BSS138
W406
R410 2.91k 1%, 50mW

Voltage, Current, & Temp Sense

+5V
C401 0.1µ
LTC2991 U402
Vcc
V1 V2 V3 V4 V5 V6 V7 V8
ADR2 15 ADR1 14 ADR0 13 PWM 12 SCL 11 SDA 10
GND
I2C_CLOCK
I2C_DATA
I2C addr 0x90

Current Sense Resistors
full-scale voltage = 0.300 V
$R\_sense\_max = 0.300/Imax$
1 A = 300mΩ
3 A = 100mΩ
5 A = 60mΩ
10 A = 30mΩ

+3.3V
5V_ENABLE_INVERTER
12V_ENABLE_INVERTER
12V_END
19V_ENABLE_INVERTER
19V_END
P401
MicroFit3 2x5 header 43045-1000

P402
MicroFit3 2x5 recept. 43025-1000
SW401 SPDT
SW402 SP3T
SW403 SP3T

Manual Override Switches, Front Panel

Toggle 5V converter's enable signal between +3.3V and ground. Toggle 12V and 19V converters' enable signal between the BeagleBone, +3.3V, or ground.

NOTES
1. V_sense should connect as close as possible to the largest load on the given power rail.
2. Place Rset resistors as close to package pins as possible.
3. Ceramic (Cin) capacitors should be located within 0.5 in of the input pins.
4. We may need heat sinks on the converters. The datasheet indicates a range of 2W to 5W of power dissipation given our specs.
5. Pay attention to the datasheet's recommendations regarding capacitor selection.

BeagleBone Expansion Headers

P501
BeagleBone_Black_Expansion_Header_P8

Pin	Signal		Signal	Pin
1	GND		GND	2
3	R9/GPIO1_6		T9/GPIO1_7	4
5	R8/GPIO1_2		T8/GPIO1_3	6
7	R7/TIMER4		T7/TIMER7	8
9	T6/TIMER5		U6/TIMER6	10
11	R12/GPIO1_13		T12/GPIO1_12	12
13	T10/EHRPWM2B		T11/GPIO0_26	14
15	U13/GPIO1_15		V13/GPIO1_14	16
17	U12/GPIO0_27		V12/GPIO2_1	18
19	U10/EHRPWM2A		V9/GPIO1_31	20
21	U9/GPIO1_30		V8/GPIO1_5	22
23	U8/GPIO1_4		V7/GPIO1_1	24
25	U7/GPIO1_0		V6/GPIO1_29	26
27	U5/GPIO2_22		V5/GPIO2_24	28
29	R5/GPIO2_23		R6/GPIO2_25	30
31	V4/UART5_CTSN		T5/UART5_RTSN	32
33	V3/UART4_RTSN		U4/UART3_RTSN	34
35	V2/UART3_CTSN		U3/UART3_CTSN	36
37	U1/UART5_TXD		U2/UART5_RXD	38
39	T3/GPIO2_12		T4/GPIO2_13	40
41	T1/GPIO2_10		T2/GPIO2_11	42
43	R3/GPIO2_8		R4/GPIO2_9	44
45	R1/GPIO2_6		R2/GPIO2_7	46

BQ_XALERTn
ROCKET_READYn
UMB_CONn — GPIO2_22
IGN_RTLn — GPIO2_23
EXT_TRG_EN_3 — GPIO0_10
EXT_TRG_EN_2 — GPIO0_9
EXT_TRG_EN_1 — GPIO0_8

GPIO2_23 — BQ_EEPROM
GPIO2_22 — EXT_PWR_EN_4
GPIO1_0 — EXT_PWR_EN_3
GPIO1_4 — EXT_PWR_EN_2
GPIO1_30 — EXT_PWR_EN_1
GPIO0_11 — EXT_TRG_EN_4

P502
BeagleBone_Black_Expansion_Header_P9

+5V | +5V

Pin	Signal		Signal	Pin
1	GND		GND	2
3	DC_3.3V		DC_3.3V	4
5	VDD_5V		VDD_5V	6
7	SYS_5V		SYS_5V	8
9	PWR_BUT		A10/SYS_RESETn	10
11	T17/UART4_RXD		U18/GPIO1_28	12
13	U17/UART4_TXD		U14/EHRPWM1A	14
15	R13/GPIO1_16		T14/EHRPWM1B	16
17	A16/I2C1_SCL		B16/I2C1_SDA	18
19	D17/I2C2_SCL		D18/I2C2_SDA	20
21	B17/UART2_TXD		A17/UART2_RXD	22
23	V14/GPIO1_17		D15/UART1_TXD	24
25	A14/GPIO3_21		D16/UART1_RXD	26
27	C13/GPIO3_19		C12/SPI1_CS0	28
29	B13/SPI1_D0		D12/SPI1_D1	30
31	A13/SPI1_SCLK		VADC	32
33	C8/AIN4		AGND	34
35	A8/AIN6		B8/AIN5	36
37	B7/AIN2		A7/AIN3	38
39	B6/AIN0		C7/AIN1	40
41#	D14/CLKOUT2_D13/GPIO3_20		C18/GPIO0_7_B12/GPIO3_18	42@
43	GND		GND	44
45	GND		GND	46

I2C_CLOCK
12V_EN
19V_EN
I2C_DATA

GPIO1_16 — ROCKET_IGNITE

R503 5.6k | R504 5.6k
W502 | W501

Cape EEPROM

+5V | +5V | +5V | +5V

C501 0.1µ
R502 5.6k
R501 5.6k

U501 24C256

Pin		Pin
1	A0	Vcc 8
2	A1	WP 7
3	A3	SCL 6
	GND 4	SDA 5

WR_ENABLE JP501

I2C addr 0x54

I2C Devices

ADDR	Part	Type	Location
0x10	U203	BQ77PL900	B/PM
0x54	U501	EEPROM	BBB
0x90	U402	LTC2991	DC-DC
0x98	U203	LTC2990	Power In
0x9A	U301	LTC2990	B/PM

NOTES:
* Do NOT change ROCKET_IGNITE, pin default reset state is High−Z w/ pulldown resistor. Other pins can be configured in EEPROM at boot time.
* All I2C devices on LTC3 are slaves. The BBB is the only master so the LTC will not need arbitration.

Ignition battery pack disconnected until
flight computer has asserted ROCKET_READY
and 19 VDC rail (shore power) has been shut off.

Input Logic
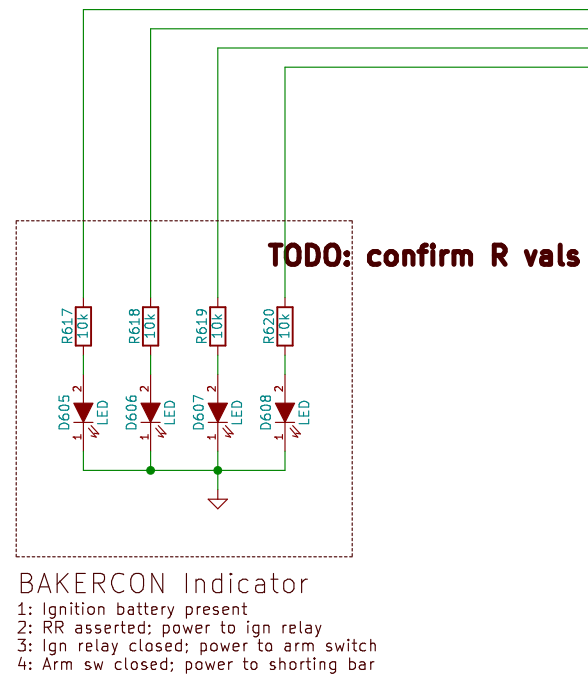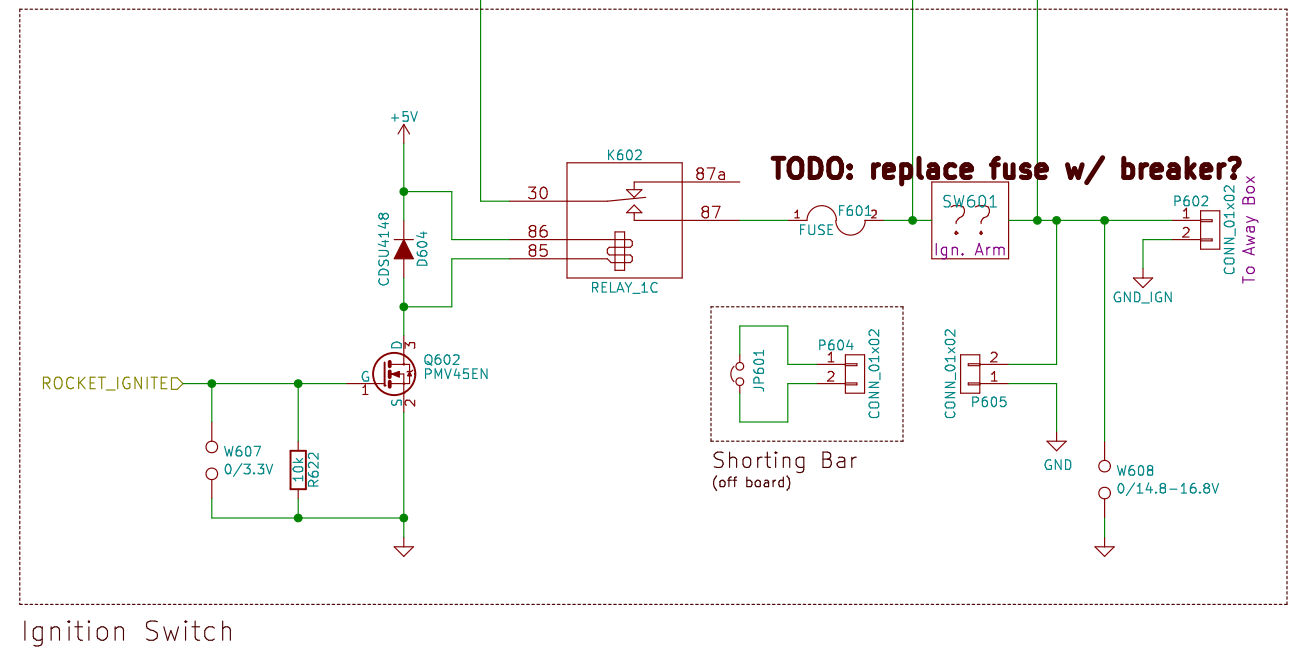
Shore Power Check

IC601
TLP3542
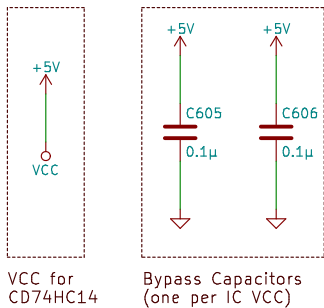
U601A
CD74HC14

U601B
CD74HC14

ROCKET_READYn

+3.1V

+5V

R601
100k

R602
120

R603
62k

R604
100k

R605
10k

U602
SN65220DBV
SOT-23

A   B
GND GND
NC   NC

W602
0/5V

+19V

R612
5.6k

R613
3.3k

C603
0.1µ

W603
0/5V

U601F
CD74HC14

R615
10k

W604
0/5V

W605
0/5V

U603
741G08

A
B   Y

R607
500k

R609
NP

C601
10µ

C602
NP

W606
0/5V

Delay (5s)

D602
CDSU414B

R606
100

U601D
CD74HC14

Ignition Battery Switch

+5V

K601

30   87a
86   87
85

RELAY_1C

D601
CDSU414B

IGN_BATT_P

W601
14.8-16.8V

GND_IGN

P601
BATT-IN

U601C
CD74HC14

U601E
CD74HC14

Q601
PMV45EN

R608
10k

R610
560

R611
6.2k

R614
100k

D603
LED

IGN_RTL

+3.1V

LED: ROCKET_READY relay active

Rocket Umbilical

Rocket-to-BeagleBone Ethernet

RJ45 J601

SHIELD

ROCKET_READY_5V

+19V

+5V

R616
5.1k

P603
UMBILICAL

ROCKET_ETH_1
ROCKET_ETH_2
ROCKET_ETH_3
ROCKET_ETH_4
UMB_CONN_FROM_RKT
UMB_CONN_TO_LTC

R621
5.1k

UMB_CONn

D609
3.3V

C604
1µ

BAKERCON Indicator

TODO: confirm R vals

R617
10k

R618
100

R619
10k

R620
100

D605
LED

D606
LED

D607
LED

D608
LED

1: Ignition battery present
2: RR asserted; power to ign relay
3: Ign relay closed; power to arm switch
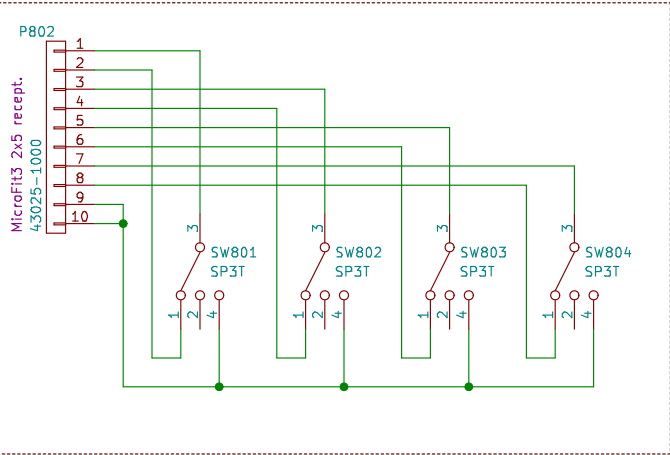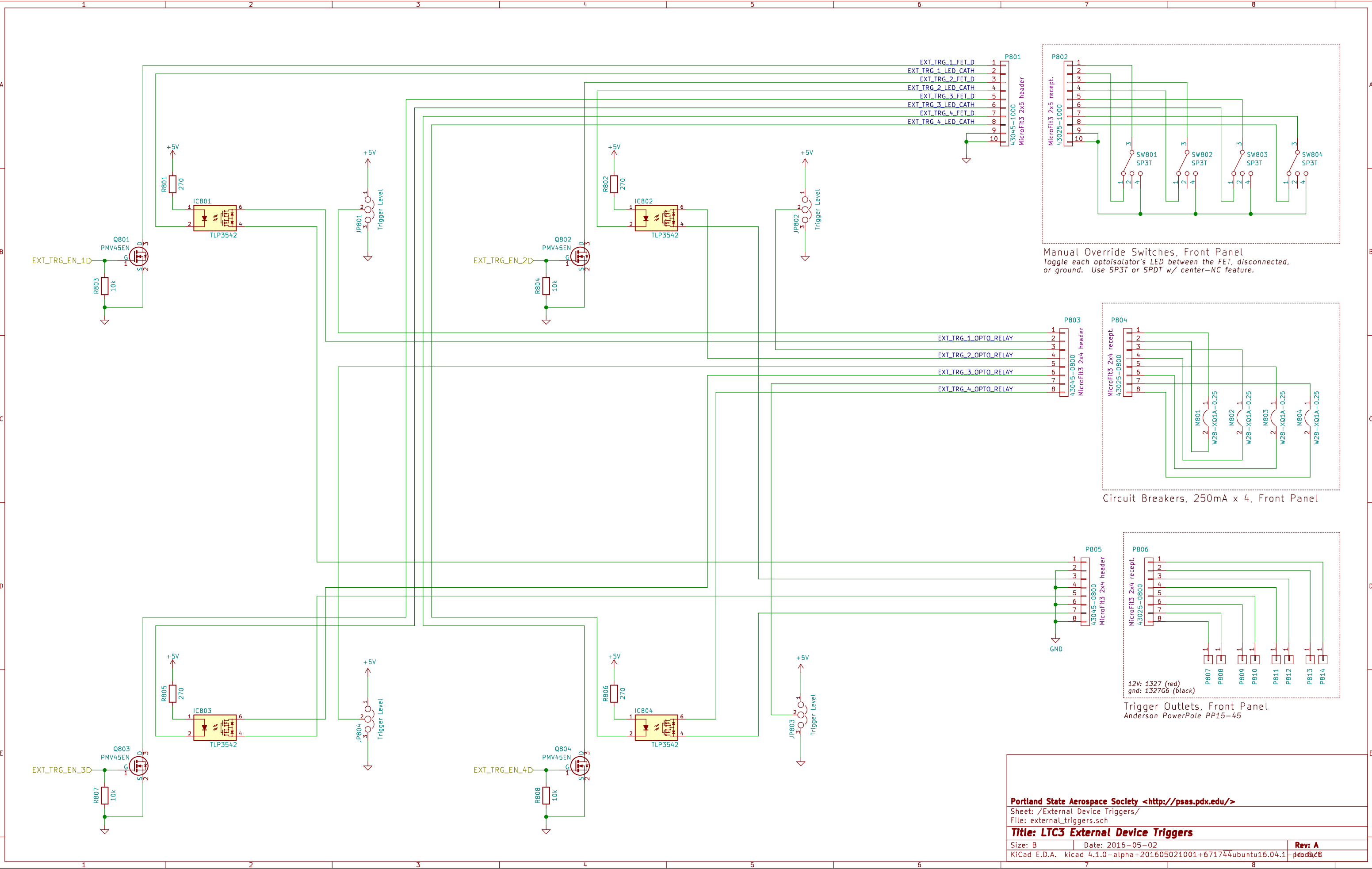4: Arm sw closed; power to shorting bar

Ignition Switch

TODO: replace fuse w/ breaker?

+5V

K602

30   87a
86   87
85

RELAY_1C

D604
CDSU414B

F601
FUSE

SW601
Ign. Arm

P602
CONN_01x02
To Away Box

GND_IGN

Q602
PMV45EN

ROCKET_IGNITED

W607
0/3.3V

R622
10k

JP601

P604
CONN_01x02

Shorting Bar
(off board)

P605
CONN_01x02

GND

W608
0/14.8-16.8V

VCC for
CD74HC14

+5V

VCC

Bypass Capacitors
(one per IC VCC)

+5V   +5V

C605
0.1µ

C606
0.1µ
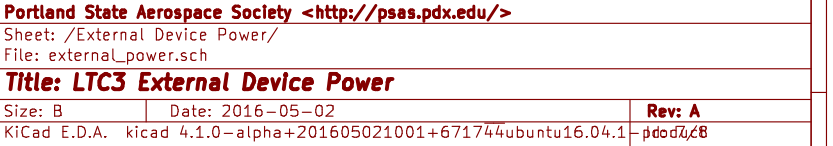
Manual Override Switches, Front Panel
Toggle each optoisolator's LED between the FET, disconnected, or ground. Use SP3T or SPDT w/ center-NC feature.

Circuit Breakers, 1A x 4, Front Panel

Power Outlets, Front Panel
Anderson PowerPole PP15-45

12V: 1327 (red)
gnd: 1327G6 (black)

P701
P702
P703
P704
P705
P706

EXT_POW_1_FET_D
EXT_POW_1_LED_CATH
EXT_POW_2_FET_D
EXT_POW_2_LED_CATH
EXT_POW_3_FET_D
EXT_POW_3_LED_CATH
EXT_POW_4_FET_D
EXT_POW_4_LED_CATH

EXT_POW_1_OPTO_RELAY_P
EXT_POW_2_OPTO_RELAY_P
EXT_POW_3_OPTO_RELAY_P
EXT_POW_4_OPTO_RELAY_P

EXT_PWR_EN_1
EXT_PWR_EN_2
EXT_PWR_EN_3
EXT_PWR_EN_4

Q701 PMV45EN
Q702 PMV45EN
Q703 PMV45EN
Q704 PMV45EN

IC701 TLP3542
IC702 TLP3542
IC703 TLP3542
IC704 TLP3542

R701 270
R702 270
R707 270
R708 270

R703 51k
R704 51k
R709 51k
R710 51k

R705 10k
R706 10k
R711 10k
R712 10k

C701 1µ
C702 1µ
C703 1µ
C704 1µ

SW701 SP3T
SW702 SP3T
SW703 SP3T
SW704 SP3T

M701 W28-XQ1A-1
M702 W28-XQ1A-1
M703 W28-XQ1A-1
M704 W28-XQ1A-1

P707 P708 P709 P710 P711 P712 P713 P714

+5V
+12V
GND

EXT_TRG_1_FET_D
EXT_TRG_1_LED_CATH
EXT_TRG_2_FET_D
EXT_TRG_2_LED_CATH
EXT_TRG_3_FET_D
EXT_TRG_3_LED_CATH
EXT_TRG_4_FET_D
EXT_TRG_4_LED_CATH

P801
43045-1000
MicroFit3 2x5 header

P802
MicroFit3 2x5 recept.
43025-1000

SW801 SP3T
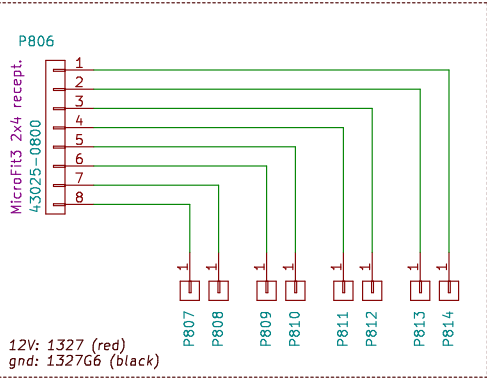SW802 SP3T
SW803 SP3T
SW804 SP3T

Manual Override Switches, Front Panel
Toggle each optoisolator's LED between the FET, disconnected,
or ground. Use SP3T or SPDT w/ center-NC feature.

+5V
R801 270
IC801
TLP3542
+5V
JP801 Trigger Level

Q801 PMV45EN
EXT_TRG_EN_1
R803 10k

+5V
R802 270
IC802
TLP3542
+5V
JP802 Trigger Level

Q802 PMV45EN
EXT_TRG_EN_2
R804 10k

EXT_TRG_1_OPTO_RELAY
EXT_TRG_2_OPTO_RELAY
EXT_TRG_3_OPTO_RELAY
EXT_TRG_4_OPTO_RELAY

P803
43045-0800
MicroFit3 2x4 header

P804
MicroFit3 2x4 recept.
43025-0800

M801 W28-XQ1A-0.25
M802 W28-XQ1A-0.25
M803 W28-XQ1A-0.25
M804 W28-XQ1A-0.25

Circuit Breakers, 250mA x 4, Front Panel

P805
43045-0800
MicroFit3 2x4 header

P806
MicroFit3 2x4 recept.
43025-0800

GND

P807 P808 P809 P810 P811 P812 P813 P814

12V: 1327 (red)
gnd: 1327G6 (black)

Trigger Outlets, Front Panel
Anderson PowerPole PP15-45

+5V
R805 270
IC803
TLP3542
+5V
JP804 Trigger Level

Q803 PMV45EN
EXT_TRG_EN_3
R807 10k

+5V
R806 270
IC804
TLP3542
+5V
JP803 Trigger Level

Q804 PMV45EN
EXT_TRG_EN_4
R808 10k