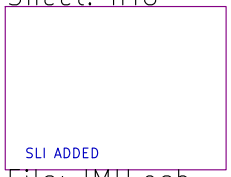
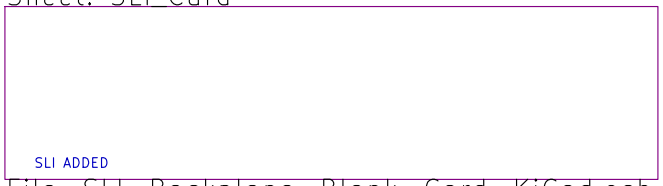
Sheet: IMU



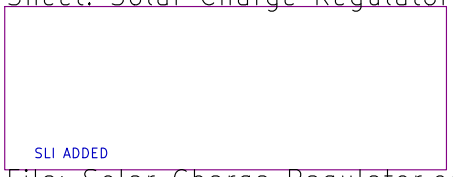
File: IMU.sch

Sheet: SLI_Card



File: SLI-Backplane-Blank-Card-KiCad.sch

Sheet: Solar Charge Regulator



File: Solar Charge Regulator.sch

SLI CHANGES ^^^

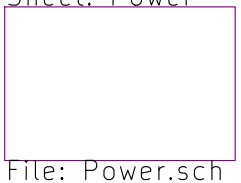
Sheet: Avionics

File: Avionics.sch

Sheet: Connectors

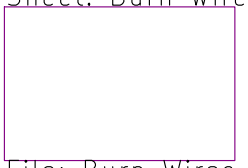
File: Connectors.sch

Sheet: Power



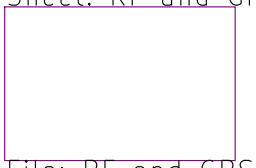
File: Power.sch

Sheet: Burn Wires



File: Burn_Wires.sch

Sheet: RF and GPS



File: RF_and_GPS.sch

Sheet: Bus Protection

File: Bus_Protection.sch

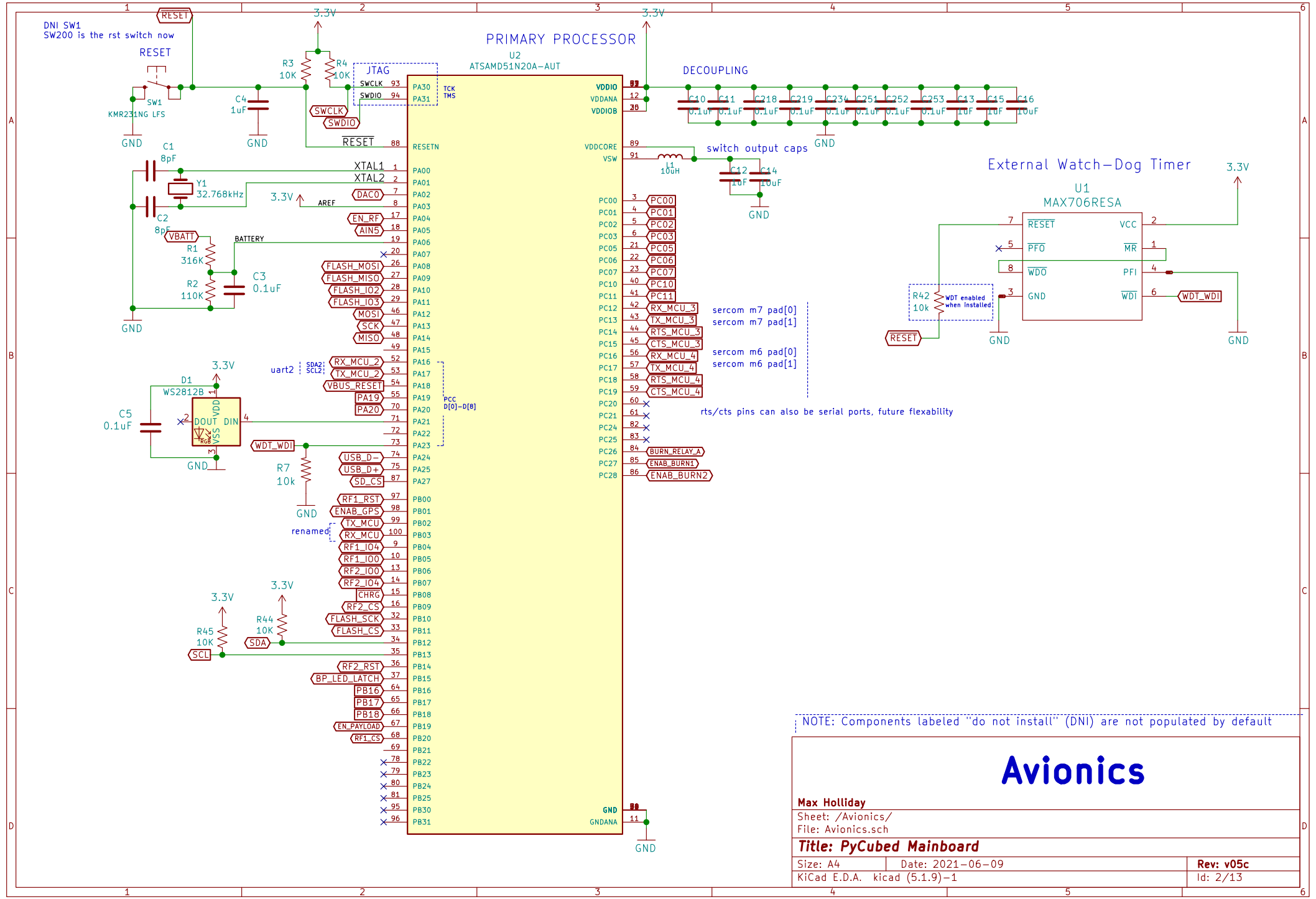
PyCubed

Max Holliday

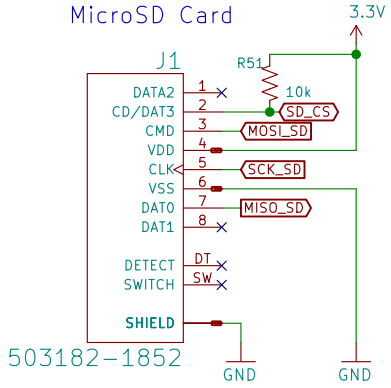
Sheet: /
File: mainboard.sch

Title: PyCubed Mainboard

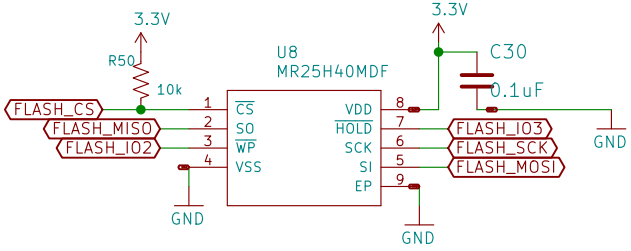
Size: A4	Date: 2021-06-09	**Rev: v05c**
KiCad E.D.A. kicad (5.1.9)-1		Id: 1/13


DNI SW1
SW200 is the rst switch now
RESET
SW1
KMR231NG LFS
GND
C4
1uF
3.3V
R3
10K
R4
10K
JTAG
SWCLK
SWDIO
RESET
C1
8pF
C2
8pF
Y1
32.768kHz
XTAL1
XTAL2
VBATT
R1
316K
R2
110K
BATTERY
C3
0.1uF
D1
WS2812B
C5
0.1uF
DOUT
DIN
VDD
VSS
R7
10k
WDT_WDI
R45
10K
R44
10K
SDA
SCL
PRIMARY PROCESSOR
U2
ATSAMD51N20A-AUT
TCK
TMS
RESETN
AREF
DAC0
EN_RF
AIN5
FLASH_MOSI
FLASH_MISO
FLASH_IO2
FLASH_IO3
MOSI
SCK
MISO
uart2
SDA2
SCL2
RX_MCU_2
TX_MCU_2
VBUS_RESET
PA19
PA20
PCC
D[0]-D[8]
USB_D-
USB_D+
SD_CS
RF1_RST
ENAB_GPS
TX_MCU
RX_MCU
renamed
RF1_IO4
RF1_IO0
RF2_IO0
RF2_IO4
CHRG
RF2_CS
FLASH_SCK
FLASH_CS
RF2_RST
BP_LED_LATCH
PB16
PB17
PB18
EN_PAYLOAD
RF1_CS
VDDIO
VDDANA
VDDIOB
VDDCORE
VSW
GND
GNDANA
DECOUPLING
C10
C11
C218
C219
C234
C251
C252
C253
C13
C15
C16
0.1uF
1uF
10uF
L1
10uH
switch output caps
C12
C14
PC00
PC01
PC02
PC03
PC05
PC06
PC07
PC10
PC11
RX_MCU_3
TX_MCU_3
RTS_MCU_3
CTS_MCU_3
RX_MCU_4
TX_MCU_4
RTS_MCU_4
CTS_MCU_4
sercom m7 pad[0]
sercom m7 pad[1]
sercom m6 pad[0]
sercom m6 pad[1]
rts/cts pins can also be serial ports, future flexability
BURN_RELAY_A
ENAB_BURN1
ENAB_BURN2
External Watch-Dog Timer
U1
MAX706RESA
RESET
PFO
WDO
GND
VCC
MR
PFI
WDI
WDT_WDI
R42
10k
WDT enabled
when installed
NOTE: Components labeled "do not install" (DNI) are not populated by default
Avionics
Max Holliday
Sheet: /Avionics/
File: Avionics.sch
Title: PyCubed Mainboard
Size: A4
Date: 2021-06-09
Rev: v05c
KiCad E.D.A. kicad (5.1.9)-1
Id: 2/13

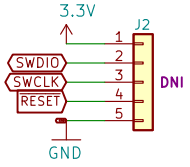
MicroSD Card



MRAM – Nonvolatile Memory (4MB storage)



JTAG



NOTE: Components labeled "do not install" (DNI) are not populated by default

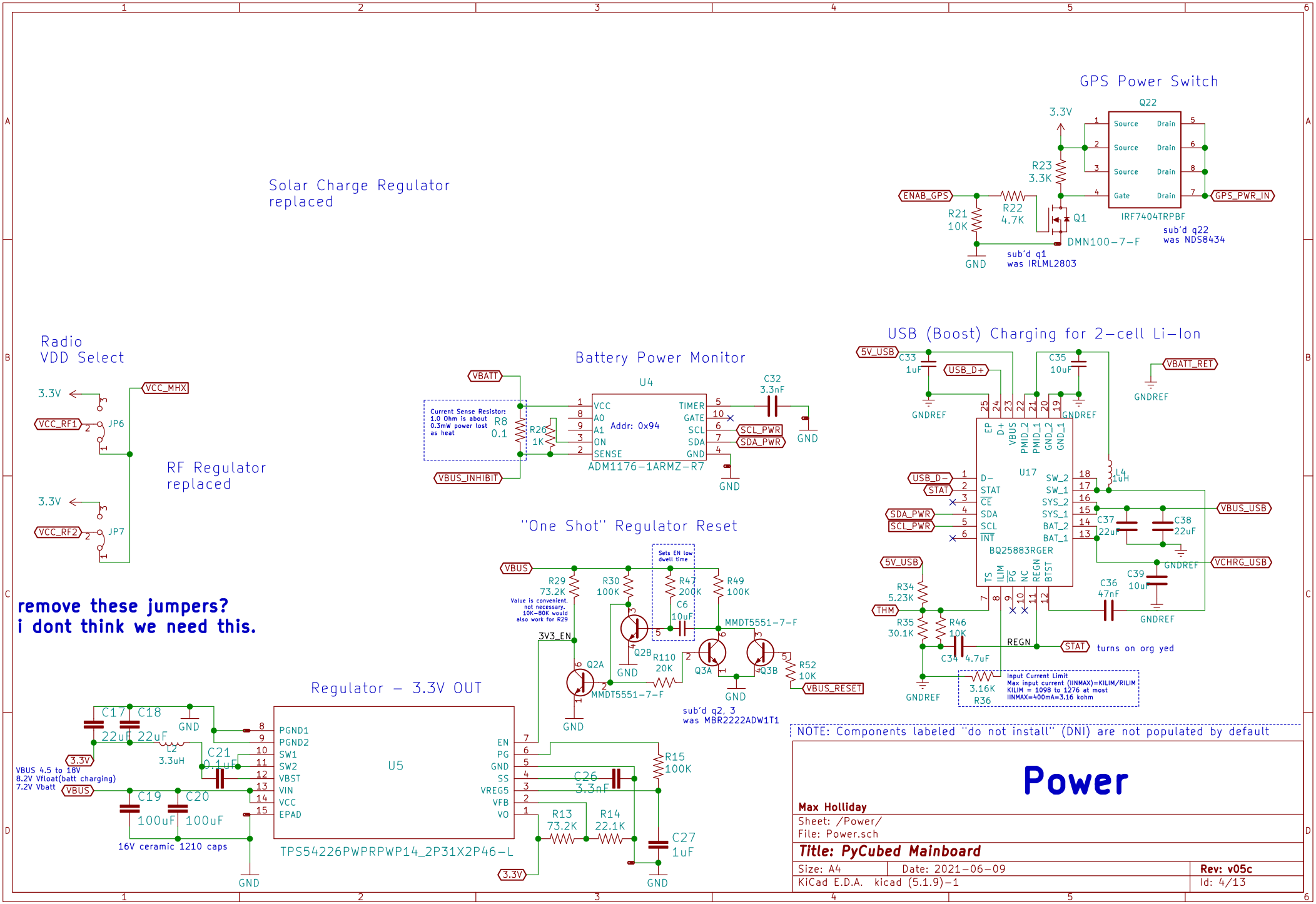
Connectors

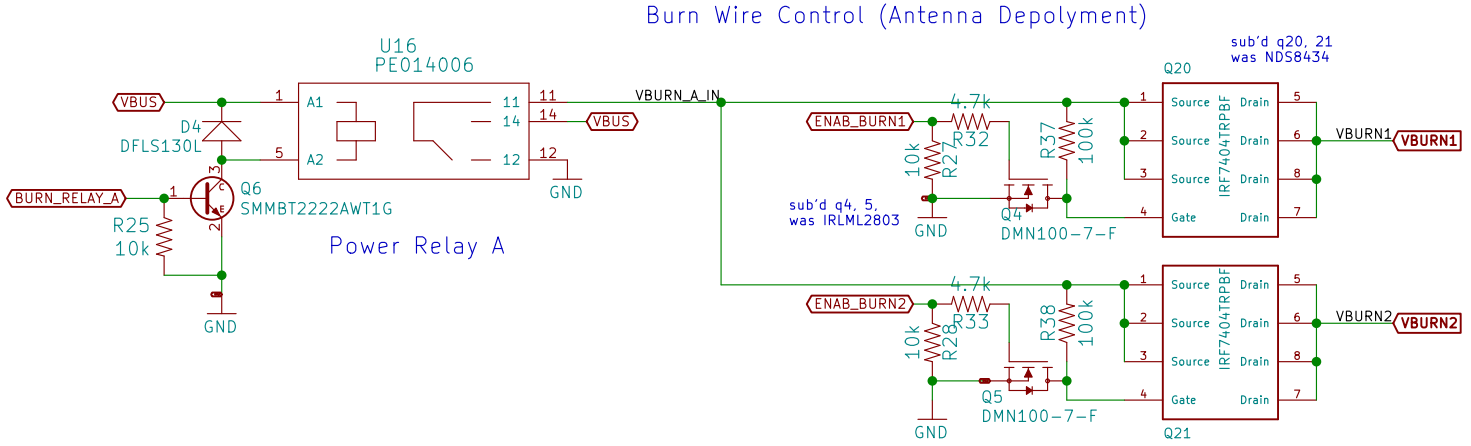
Max Holliday

Sheet: /Connectors/
File: Connectors.sch

Title: PyCubed Mainboard

Size: A4	Date: 2021-06-09	**Rev: v05c**
KiCad E.D.A. kicad (5.1.9)-1		Id: 3/13


Solar Charge Regulator
replaced
GPS Power Switch
Q22
3.3V
R23
3.3K
ENAB_GPS
R21
10K
R22
4.7K
Q1
DMN100-7-F
IRF7404TRPBF
sub'd q22
was NDS8434
GPS_PWR_IN
GND
sub'd q1
was IRLML2803
Radio
VDD Select
3.3V
VCC_MHX
VCC_RF1
JP6
RF Regulator
replaced
VCC_RF2
JP7
remove these jumpers?
i dont think we need this.
Battery Power Monitor
U4
VBATT
Current Sense Resistor:
1.0 Ohm is about
0.3mW power lost
as heat
R8
0.1
R26
1K
VCC
A0
A1
ON
SENSE
Addr: 0x94
TIMER
GATE
SCL
SDA
GND
C32
3.3nF
SCL_PWR
SDA_PWR
VBUS_INHIBIT
ADM1176-1ARMZ-R7
USB (Boost) Charging for 2-cell Li-Ion
5V_USB
C33
1uF
USB_D+
C35
10uF
VBATT_RET
GNDREF
U17
USB_D-
STAT
SDA_PWR
SCL_PWR
D-
STAT
CE
SDA
SCL
INT
BQ25883RGER
L4
1uH
VBUS_USB
C37
22uF
C38
22uF
VCHRG_USB
C39
10uF
C36
47nF
R34
5.23K
THM
R35
30.1K
R46
10K
C34
4.7uF
REGN
STAT
turns on org yed
3.16K
R36
Input Current Limit
Max input current (IINMAX)=KILIM/RILIM
KILIM = 1098 to 1276 at most
IINMAX=400mA=3.16 kohm
"One Shot" Regulator Reset
VBUS
R29
73.2K
Value is convenient,
not necessary.
10K-80K would
also work for R29
R30
100K
Sets EN low
dwell time
R47
200K
C6
10uF
R49
100K
3V3_EN
Q2B
Q2A
R110
20K
Q3A
Q3B
MMDT5551-7-F
R52
10K
VBUS_RESET
sub'd q2, 3
was MBR2222ADW1T1
Regulator - 3.3V OUT
C17
C18
22uF
22uF
L2
3.3uH
C21
0.1uF
C19
C20
100uF
100uF
16V ceramic 1210 caps
VBUS 4.5 to 18V
8.2V Vfloat(batt charging)
7.2V Vbatt
U5
PGND1
PGND2
SW1
SW2
VBST
VIN
VCC
EPAD
EN
PG
SS
VREG5
VFB
VO
C26
3.3nF
R15
100K
R13
73.2K
R14
22.1K
C27
1uF
TPS54226PWPRPWP14_2P31X2P46-L
NOTE: Components labeled "do not install" (DNI) are not populated by default
Power
Max Holliday
Sheet: /Power/
File: Power.sch
Title: PyCubed Mainboard
Size: A4
Date: 2021-06-09
Rev: v05c
KiCad E.D.A. kicad (5.1.9)-1
Id: 4/13



NOTE: Components labeled "do not install" (DNI) are not populated by default

Burn Wires

Max Holliday

Sheet: /Burn Wires/
File: Burn_Wires.sch

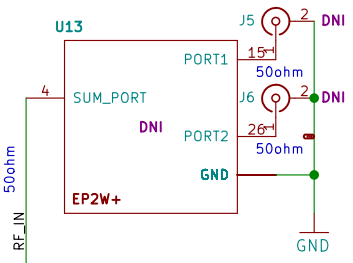
Title: PyCubed Mainboard

Size: A4	Date: 2021-06-09	**Rev: v05c**
KiCad E.D.A. kicad (5.1.9)-1		Id: 5/13

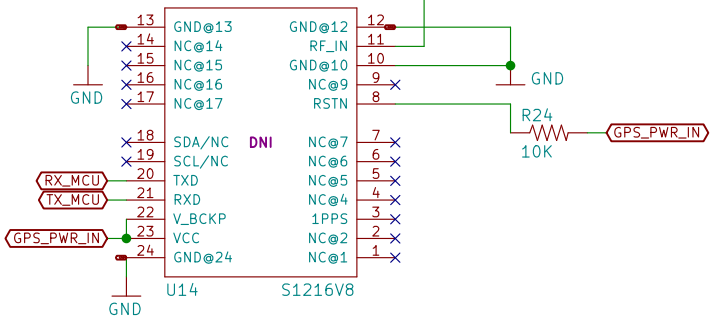
Modular Payloads

removed

RF Splitter (2 Way, 0deg DC-Pass)



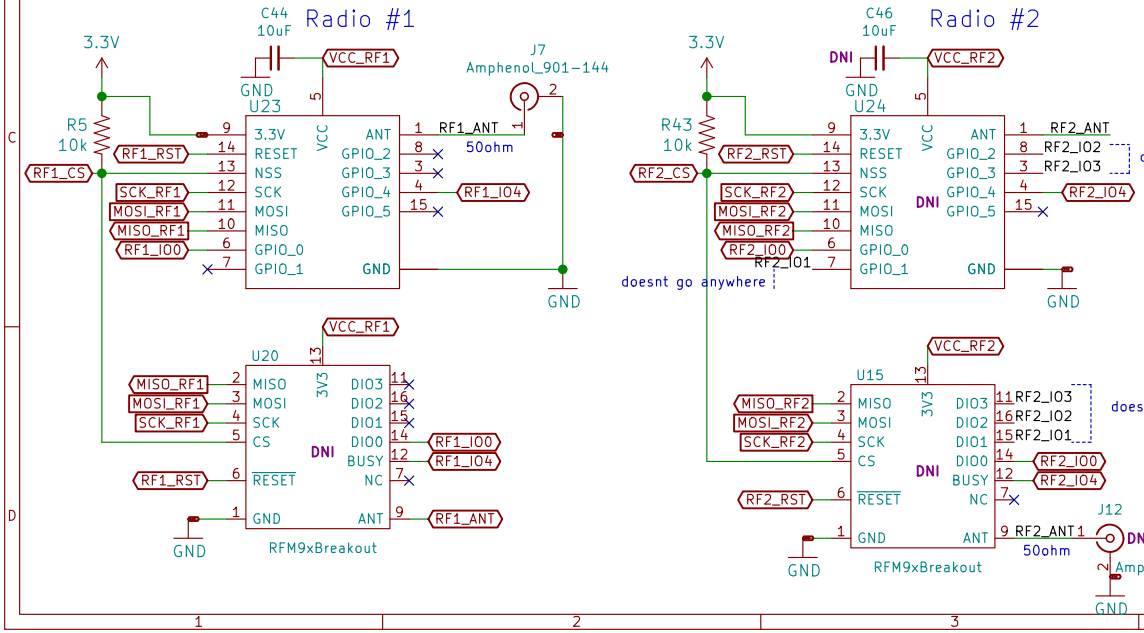
GPS Module



doesnt go anywhere

this gps appears to be obsolete, may have to change FP / pins

Modular Radios (HopeRF format)



NOTE: Components labeled "do not install" (DNI) are not populated by default

Radio, GPS, Payloads

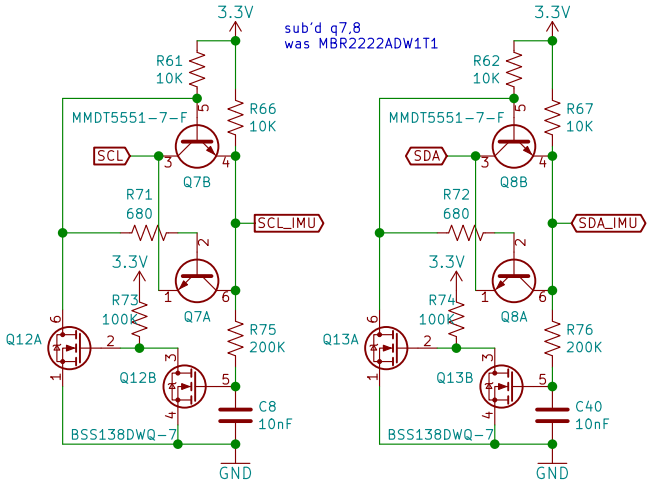
Max Holliday

Sheet: /RF and GPS/
File: RF_and_GPS.sch

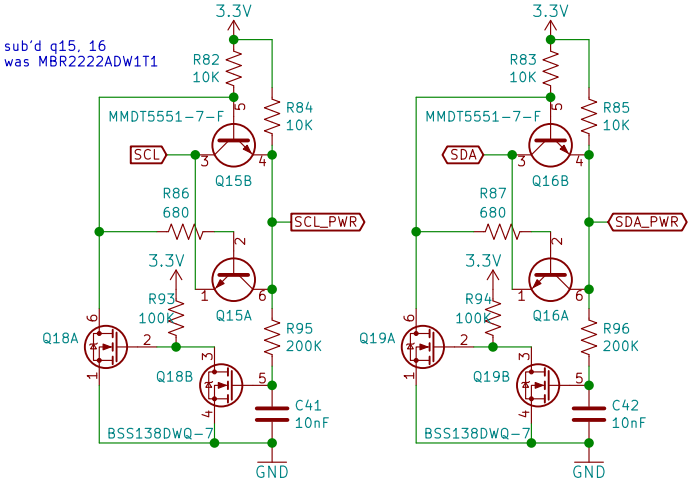
Title: PyCubed Mainboard

Size: A4	Date: 2021-06-09	**Rev: v05c**
KiCad E.D.A. kicad (5.1.9)-1		Id: 6/13

I2C Bus Protection – IMU



I2C Bus Protection – Power Monitor & USB Charger



NOTE

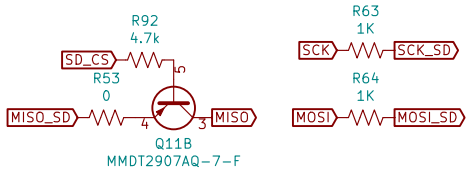
These novel bus protection circuits prevent traditional I2C/SPI failure modes where a single slave failure can disable the entire bus.

Learn more:
https://doi.org/10.36227/techrxiv.15166620

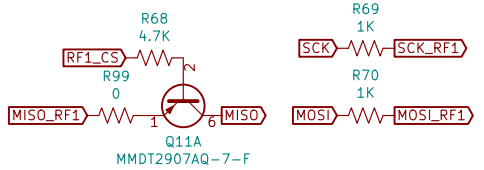
By default, slave clock and/or data lines can be held low and the Master (SAMD51) will still be able to communicate with the remainder of the bus.

They can individually be bypassed by removing the transistor(s) and soldering the 0ohm the jumpers below.

SPI Bus Protection – SD Card and Payloads

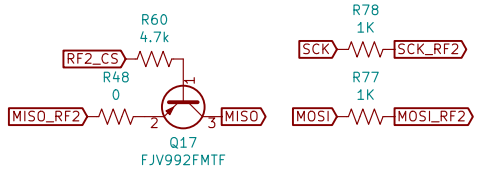


SPI Bus Protection – Radio 1



sub'd q11
was MMBT2907

SPI Bus Protection – Radio 2



sub'd q17
was MMBT2907

Bus Protection – Bypass Jumpers

NOTE: Components labeled "do not install" (DNI) are not populated by default

Bus Protection

Max Holliday

Sheet: /Bus Protection/
File: Bus_Protection.sch

Title: PyCubed Mainboard

Size: A4	Date: 2021-06-09	**Rev: v05c**
KiCad E.D.A. kicad (5.1.9)-1		Id: 7/13

SLI Backplane Card Default Edge Connector

First 104 pins follow pumpkin CSK bus (Rev E) pins
Some user and IO pins have been assigned by SLI
(that are not used by any other functions)

P1
Card Edge for HSEC8-160-01-S-DV-A-K-TR

SEP1	1	2	SEP2
-Z_SOLAR_TLE	3	4	+X_SOLAR_TLE
-Z_SOLAR_RTN	5	6	+X_SOLAR_RTN
-Z_SOLAR_PWR	7	8	+X_SOLAR_PWR
H1-1	9	10	H1-2
H2-1	11	12	H2-2
H1-3	13	14	H1-4
H2-3	15	16	H2-4
H1-5	17	18	H1-6
H2-5	19	20	H2-6
H1-7	21	22	H1-8
H2-7	23	24	H2-8
H1-9	25	26	H1-10
H2-9	27	28	H2-10
H1-11	29	30	H1-12
H2-11	31	32	H2-12
H1-13	33	34	H1-14
H2-13	35	36	H2-14
RBF	37	38	H1-16
H2-15	39	40	H2-16
H1-17	41	42	H1-18
H2-17	43	44	H2-18
H1-19	45	46	H1-20
H2-19	47	48	H2-20
H1-21	49	50	H1-22
H2-21	51	52	H2-22
H1-23	53	54	H1-24
H2-23	55	56	H2-24
H1-25	57	58	H1-26
H2-25	59	60	H2-26
H1-27	61	62	H1-28
H2-27	63	64	H2-28
RESET	65	66	H1-30
GND	67	68	GND
H1-31	69	70	5V_USB
AGND	71	72	GND
H1-33	73	74	H1-34
H2-33	75	76	H2-34
H1-35	77	78	H1-36
H2-35	79	80	H2-36
H1-37	81	82	H1-38
H2-37	83	84	H2-38
H1-39	85	86	H1-40
H2-39	87	88	H2-40
H1-41	89	90	H1-42
H2-41	91	92	H2-42
H1-43	93	94	H1-44
H2-43	95	96	H2-44
H1-45	97	98	H1-46
H2-45	99	100	H2-46
SELF_TEST	101	102	USER_1
GND	103	104	GND
USER_2	105	106	H1-50
H2-49	107	108	H2-50
H1-51	109	110	H1-52
H2-51	111	112	H2-52
+Y_SOLAR_TLE	113	114	-X_SOLAR_TLE
+Y_SOLAR_RTN	115	116	-X_SOLAR_RTN
+Y_SOLAR_PWR	117	118	-X_SOLAR_PWR
SEP3	119	120	SEP4

Start of CSK Bus Pins

End of CSK Bus Pins

< < not implemented

SELF_TEST
USER_2

currently unused, going to go somehwere eventually?

GPIO can also be ADC inputs
H2-5 PC00
H2-6 PC01
H2-7 PC02
H2-8 PC03

regular GPIO
H1-5 PC05
H1-6 PC06
H1-7 PC07
H1-8 PA19
H1-11 PC10
H2-24 PC11
H2-23 PB16
H2-22 PB17 enable irridium
H2-21 PB18 enable openLST

USER_1 BP_LED_LATCH

installing jumper will allow data but disable usb pwr sourcing

SLI Backplane Card Default Circuitry

USB 2.0 microB

J201
1 5V_USB
2 USB_EN

unused currently pulled low
unused currently open drain

5V_USB → USB_VCC
USB_EN → USB_EN
USB_FLAG → USB_FLG
USB_D+ → USB_D+
USB_D- → USB_D-
LED_GND
GND
USB_GND
CHS

LED_VCC → 5V_USB
RED_LED → VBATT
YEL_LED
ORG_LED → STAT
GRN_LED → 5V_USB
SW_VCC
SW_NO → RESET <<resets pycubed processor
SW_COM

VBATT_RET

green led turns on when 5Vusb is high

Sheet: Blank-Card-Default
File: Blank-Card-Default.sch

per my calculations, full power consumption exceeds USB's capabilities.

Edge Connector to Schematic Signals

Power
does each array need a balancing diode?

VSOLAR ← -X_SOLAR_PWR, +Y_SOLAR_PWR, +X_SOLAR_PWR, -Z_SOLAR_PWR
+X_SOLAR_RTN, -Z_SOLAR_RTN, +Y_SOLAR_RTN, -X_SOLAR_RTN → AGND, GND

VBATT ← H2-46, H2-45
VBATT_RET ← H2-49, H2-50

VCC_MHX ← H1-33 (5V @2A capacity with the switcher otherwise 1.5A (using linear regulator))
BATT_NTC ← H2-1 (NTC needs to be added to batt board)

vref0 ← H1-26, H2-27, H2-28
3.3V
VCC_PAYLOAD ← H2-25, H2-26

Burn Wires
VBURN1 ← H1-1
VBURN2 ← H1-2
possible move these to microJSTs?

Data
H1-41 SCL, H1-43 SDA — main i2c bus, pycubed processor is master. the pull ups on the backplane need to be DNP
H1-19 Rx RX_MCU_2, H1-20 Tx TX_MCU_2 — uart bus to the openMV H7 module if reconfigured as i2c, slave needs to have pull-ups
H1-23 MOSI, H1-22 MISO, H1-21 SCK — spi bus -- not currently used by any other cards
RESET — PuCubed microcontroller reset, pulled up on MCU

openLST UART if reconfigured as i2c, slave needs to have pull-ups
H1-39 RX_MCU_3
H1-40 TX_MCU_3
H1-35 RTS_MCU_3
H1-36 CTS_MCU_3

Irridium UART if reconfigured as i2c, slave needs to have pull-ups
H1-18 TX_MCU_4
H1-17 RX_MCU_4
H1-10 RTS_MCU_4
H1-9 CTS_MCU_4

Electrical Inhibits and RBF per Nanoracks ICD

vbatt voltage & RBF removed & (sep1 low) & (sep2 low) & (sep3 low) = main bus powered
RBF keeps satellite in an unpowered state regardless of sep switches
Sep switches are N/O to GND
RBF is N/O to gnd when removed

D204 1N4148WSTR, D205 1N4148WSTR
Sep_Sw_Vcc is an OR of solar and batt inputs, allowing either to enable the bus
VBATT, VSOLAR
R217 2.2Meg, R247 2.2Meg
VBATT_RET

if gndref is d/c from gnd these resistors allow a refrence to still be made to turn the fets on

D3 per Nanoracks ICD
Battery Low-Side Switch
SEP1 → R212 10k → Q204 MMBT3906-7-F
R215 100k
Q208 IRF7458
VBATT_RET

RBF is NO to gnd when removed
double check this circuit tmmr

VBUS_INHIBIT
Sep_Sw_Vcc → R220 100k → SEP2 → Q211 IRF7404
Sep_Sw_Vcc → R221 100k → SEP3 → Q212 IRF7404
D1 and D2 per Nanoracks ICD
Load High Side Switches

RBF INHIBIT
Sep_Sw_Vcc → R248 100k → Q209 MMBT3906-7-F
R249 10k, R250 4.7k
RBF → Q221 MMBT4401-7-F
Q220 IRF7404
VBUS

USB Charge / Debug Inhibts

5Vusb + RBF not installed = usb battery charge and powers bus
5Vusb + RBF installed = usb battery charge bus unpowered

5V_USB → R216 100k → Q207 IRF7404 → VBATT
VCHRG_USB
R213 4.7k, Q205 MMBT4401-7-F

5V_USB → R219 100k → Q213 IRF7404 → VBUS_USB
R218 4.7k, Q210 MMBT4401-7-F

5V_USB → R214 100k → Q206 IRF7458 → VBATT_RET
RBF

Sheet: Payload_Regulator
Vout → VCC_PAYLOAD
EN → EN_PAYLOAD
File: 5V_regulator.sch

Payload regulator (also magnetotorqer and wheel(s))

Sheet: RF_Regulator
More efficient RF regulator,
our more active Tx for streaming data
makes low eff lin reg more costly
Vout → VCC_MHX
EN → EN_RF
File: 5V_regulator.sch

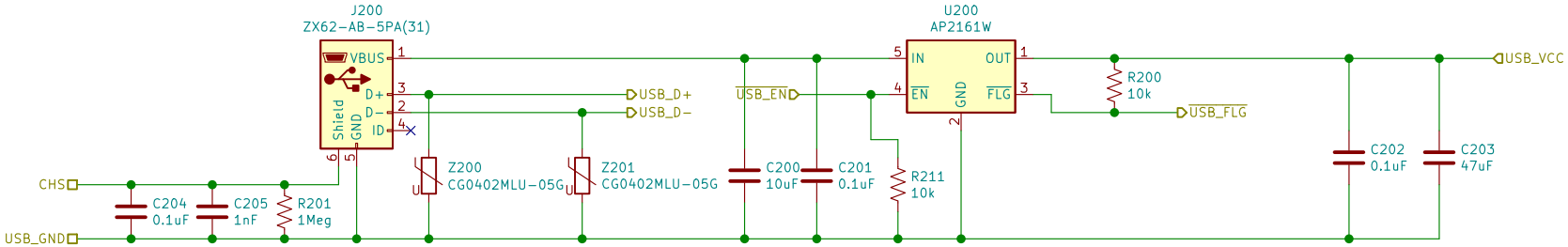
RF regulator replacement (more efficient)

Sierra Lobo INC	
Sheet: /SLI_Card/	
File: SLI-Backplane-Blank-Card-KiCad.sch	
Title: Blank Card for SLI Backplane	
Size: B	Date: 2021-11-05
KiCad E.D.A. kicad (5.1.9)-1	Id: 8/13

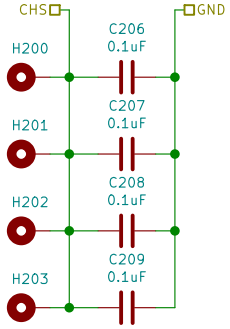
Rev: A

USB protection

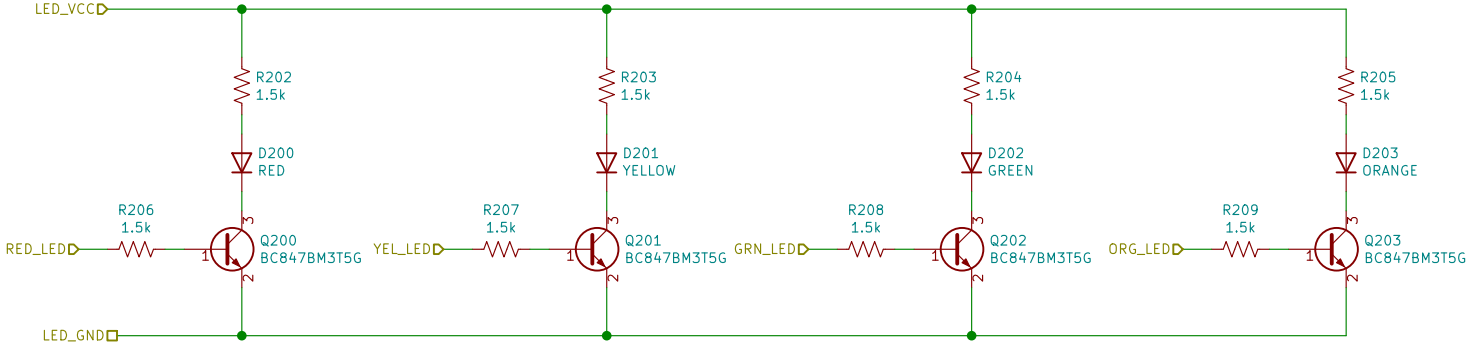
U200 limits USB current to 1.5A (1A rec by mfr.)



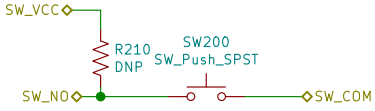
Mounting Holes



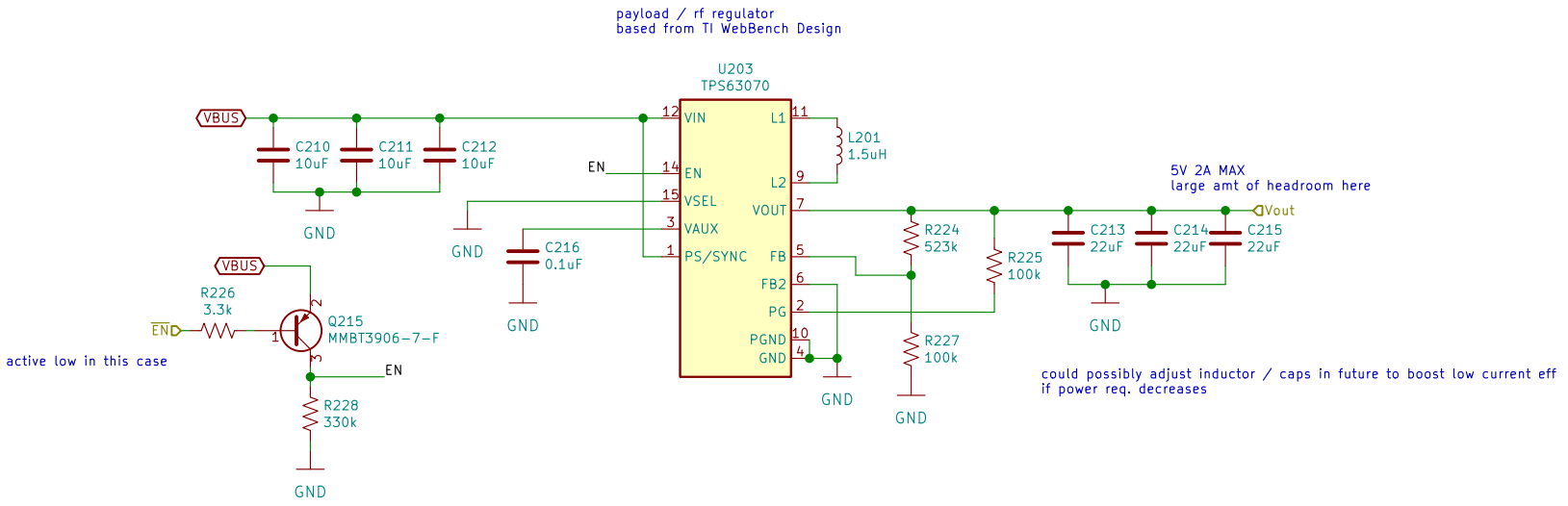
LEDs



Switch



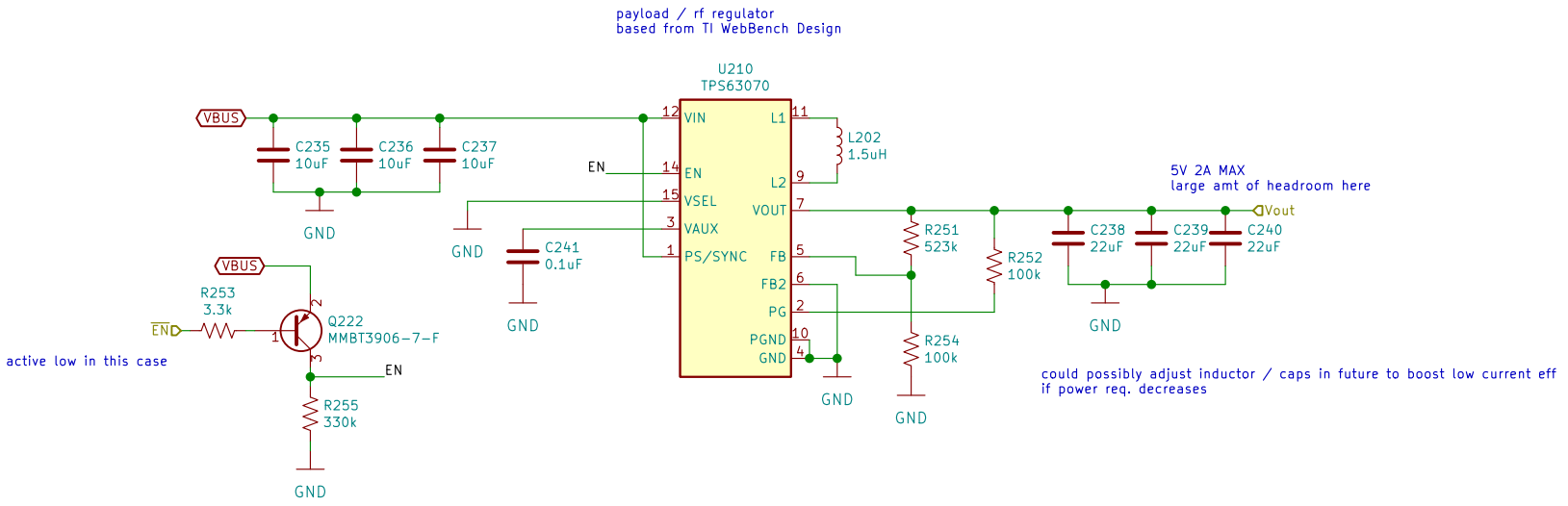
Sheet: /SLI_Card/Blank-Card-Default/		
File: Blank-Card-Default.sch		
Title:		
Size: A4	Date:	**Rev:**
KiCad E.D.A. kicad (5.1.9)-1		Id: 9/13



Sheet: /SLI_Card/RF_Regulator/
File: 5V_regulator.sch

Title:

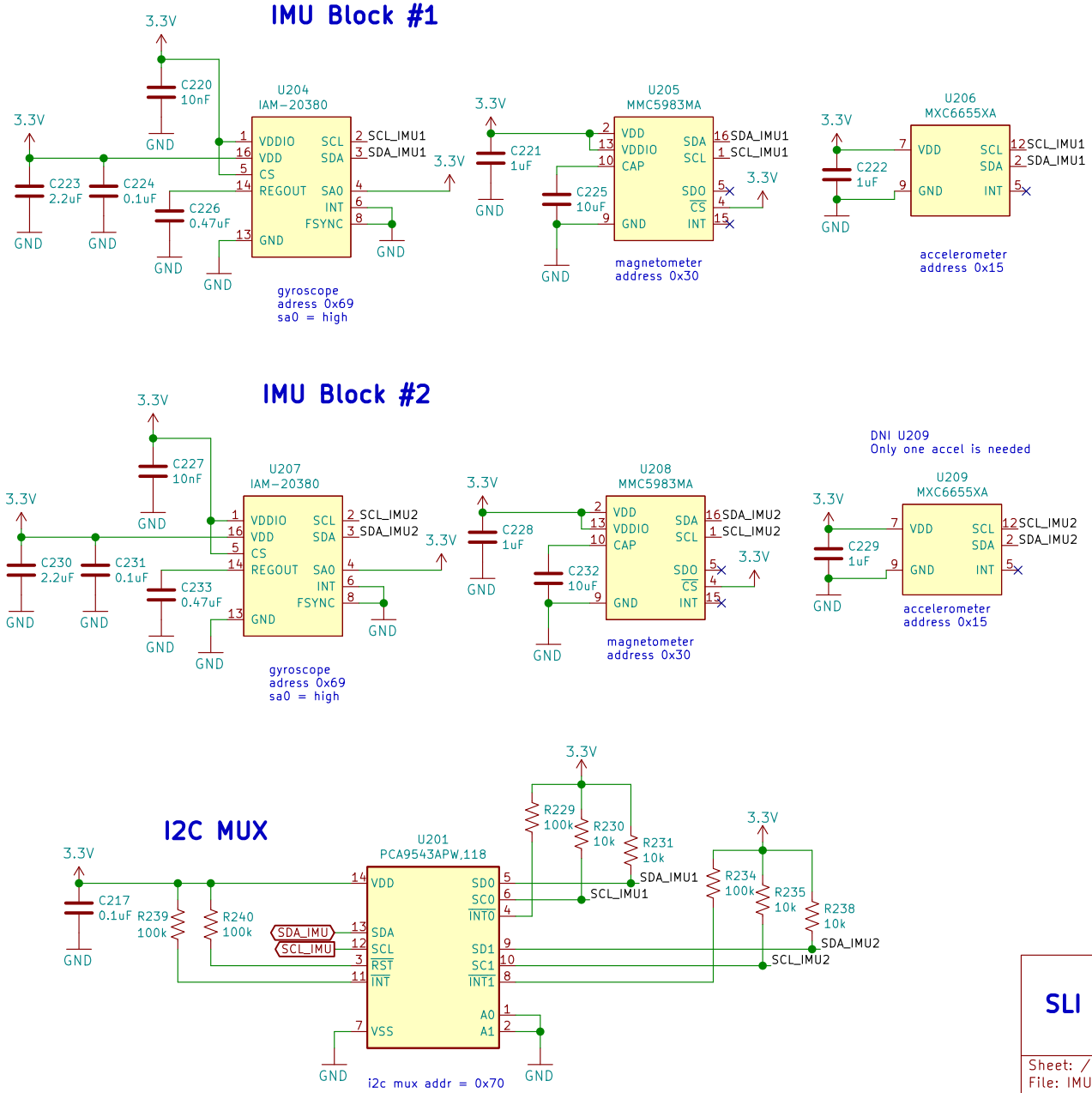
Size: A4	Date:	**Rev:**
KiCad E.D.A. kicad (5.1.9)-1		Id: 10/13

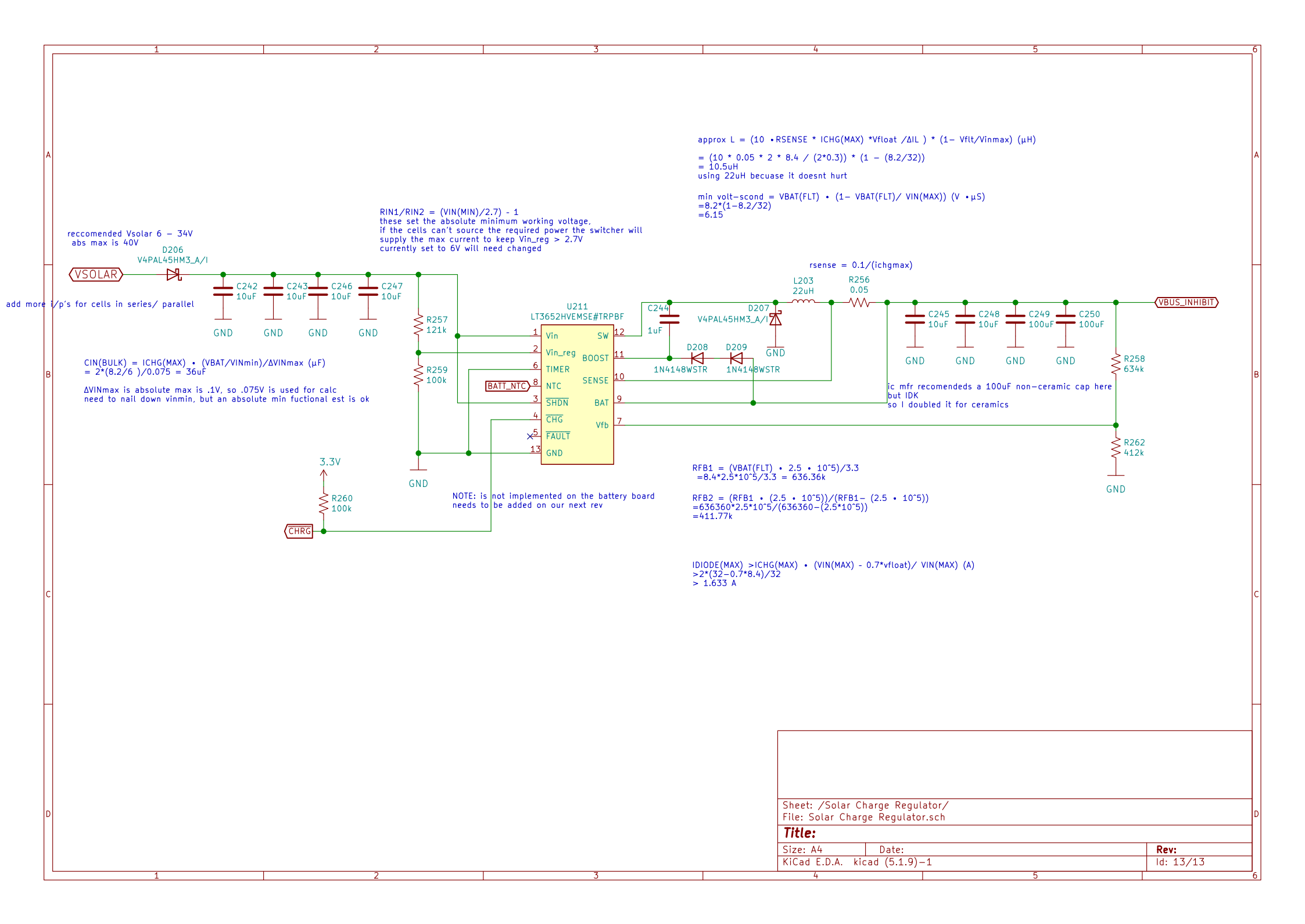


Sheet: /SLI_Card/Payload_Regulator/
File: 5V_regulator.sch

Title:

Size: A4	Date:	**Rev:**
KiCad E.D.A. kicad (5.1.9)-1		Id: 11/13


IMU Block #1
3.3V
C220
10nF
GND
U204
IAM-20380
VDDIO
VDD
CS
REGOUT
SCL
SDA
SA0
INT
FSYNC
GND
SCL_IMU1
SDA_IMU1
C223
2.2uF
C224
0.1uF
C226
0.47uF
gyroscope
adress 0x69
sa0 = high
U205
MMC5983MA
VDD
VDDIO
CAP
SDO
CS
C221
1uF
C225
10uF
magnetometer
address 0x30
U206
MXC6655XA
C222
1uF
accelerometer
address 0x15
IMU Block #2
C227
10nF
U207
C230
2.2uF
C231
0.1uF
C233
0.47uF
SCL_IMU2
SDA_IMU2
C228
1uF
C232
10uF
DNI U209
Only one accel is needed
U209
C229
1uF
I2C MUX
U201
PCA9543APW,118
VSS
SDA_IMU
SCL_IMU
RST
INT
SD0
SC0
INT0
SD1
SC1
INT1
A0
A1
C217
0.1uF
R239
100k
R240
100k
R229
100k
R230
10k
R231
10k
R234
100k
R235
10k
R238
10k
i2c mux addr = 0x70
SLI IMU Additions
Sheet: /IMU/
File: IMU.sch
Title:
Size: A4
Date:
Rev:
KiCad E.D.A. kicad (5.1.9)-1
Id: 12/13


approx L = (10 •RSENSE * ICHG(MAX) *Vfloat /ΔIL) * (1− Vflt/Vinmax) (µH)
= (10 * 0.05 * 2 * 8.4 / (2*0.3)) * (1 − (8.2/32))
= 10.5uH
using 22uH becuase it doesnt hurt
min volt−scond = VBAT(FLT) • (1− VBAT(FLT)/ VIN(MAX)) (V •µS)
=8.2*(1−8.2/32)
=6.15
RIN1/RIN2 = (VIN(MIN)/2.7) - 1
these set the absolute minimum working voltage,
if the cells can't source the required power the switcher will
supply the max current to keep Vin_reg > 2.7V
currently set to 6V will need changed
reccomended Vsolar 6 − 34V
abs max is 40V
D206
V4PAL45HM3_A/I
VSOLAR
add more i/p's for cells in series/ parallel
C242 10uF
C243 10uF
C246 10uF
C247 10uF
GND
R257 121k
R259 100k
CIN(BULK) = ICHG(MAX) • (VBAT/VINmin)/ΔVINmax (µF)
= 2*(8.2/6)/0.075 = 36uF
ΔVINmax is absolute max is .1V, so .075V is used for calc
need to nail down vinmin, but an absolute min fuctional est is ok
U211
LT3652HVEMSE#TRPBF
Vin
Vin_reg
TIMER
NTC
SHDN
CHG
FAULT
GND
SW
BOOST
SENSE
BAT
Vfb
BATT_NTC
3.3V
R260 100k
CHRG
NOTE: is not implemented on the battery board
needs to be added on our next rev
rsense = 0.1/(ichgmax)
L203 22uH
R256 0.05
C244 1uF
D207
V4PAL45HM3_A/I
D208
D209
1N4148WSTR
1N4148WSTR
C245 10uF
C248 10uF
C249 100uF
C250 100uF
VBUS_INHIBIT
R258 634k
R262 412k
ic mfr recomendeds a 100uF non−ceramic cap here
but IDK
so I doubled it for ceramics
RFB1 = (VBAT(FLT) • 2.5 • 10^5)/3.3
=8.4*2.5*10^5/3.3 = 636.36k
RFB2 = (RFB1 • (2.5 • 10^5))/(RFB1− (2.5 • 10^5))
=636360*2.5*10^5/(636360−(2.5*10^5))
=411.77k
IDIODE(MAX) >ICHG(MAX) • (VIN(MAX) - 0.7*vfloat)/ VIN(MAX) (A)
>2*(32−0.7*8.4)/32
> 1.633 A
Sheet: /Solar Charge Regulator/
File: Solar Charge Regulator.sch
Title:
Size: A4
Date:
Rev:
KiCad E.D.A. kicad (5.1.9)−1
Id: 13/13