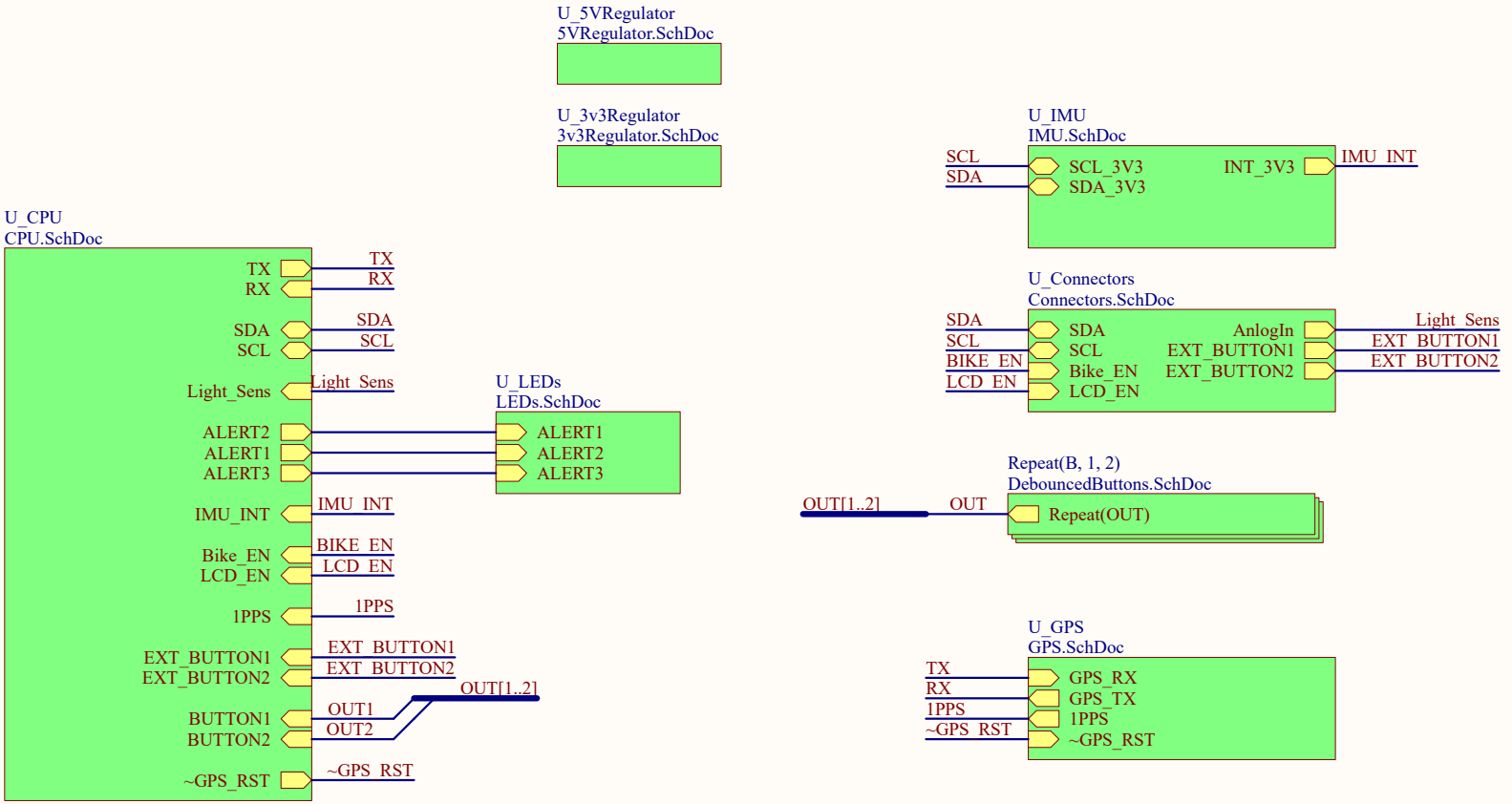

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Place one 0.1uF capacitor on each VDD/AVCC pin. 4.7uF just needs to be in the general area.

+3V3
C1 4.7uF
C2 0.1UF
C3 0.1UF
GND

+3V3 +3V3
R6 10k 1206
R7 10k 1206
SDA
SCL
SDA
SCL

+3V3
R30 10k 1206

U1

IMU_INT	12	PB[0] (PCINT0/X10/Y18/CLKO/ICP1)	
~GPS_RST	13	PB[1] (PCINT1/X11/Y19/OC1A)	
pMosi	14	PB[2] (PCINT2/X12/Y20/OC1B/SS0)	
pMiso	15	PB[3] (PCINT3/X13/Y21/OC2A/TXD1/MOSI0)	
pSCK	16	PB[4] (PCINT4/X14/Y22/RXD1/MISO0)	
SysCLK	17	PB[5] (PCINT5/X15/Y23/XCK1/SCK0)	
Bike_EN	7	PB[6] (PCINT6/XTAL1/TOSC1)	
	8	PB[7] (PCINT7/XTAL2/TOSC2)	
LCD_EN	23	PC[0] (PCINT8/ADC0/Y0/MISO1)	
1PPS	24	PC[1] (PCINT9/ADC1/Y1/SCK1)	
EXT_BUTTON1	25	PC[2] (PCINT10/ADC2/Y2)	
EXT_BUTTON2	26	PC[3] (PCINT11/ADC3/Y3)	
SDA	27	PC[4] (PCINT12/ADC4/Y4/SDA0)	
SCL	28	PC[5] (PCINT13/ADC5/Y5/SCL0)	
~Reset	29	PC[6] (RESET/PCINT14)	
TX	30	PD[0] (PCINT16/X0/Y8/OC3A/RXD0)	
RX	31	PD[1] (PCINT17/X1/Y9/OC4A/TXD0)	
	32	PD[2] (INT0/PCINT18/X2/Y10/OC3B/OC4B)	
ALERT1	1	PD[3] (INT1/PCINT19/X3/Y11/OC2B)	
ALERT2	2	PD[4] (PCINT20/X4/Y12/T0/XCK0)	
ALERT3	9	PD[5] (PCINT21/X5/Y13/OC0B/T1)	
BUTTON1	10	PD[6] (PCINT22/AIN0/X6/Y14/OC0A)	
BUTTON2	11	PD[7] (PCINT23/AIN1/X7/Y15)	
	3	PE[0] (PCINT24/ACO/X8/Y16/ICP4/SDA1)	
	6	PE[1] (PCINT25/X9/Y17/TC4/SCL1)	
	19	PE[2] (PCINT26/ADC6/Y6/ICP3/SS1)	
Light_Sens	22	PE[3] (PCINT27/ADC7/Y7/T3/MOSI1)	
	20	AREF	
+3V3	4	VCC	
	18	AVCC	
	5	GND	
	21	GND	

ATMEGA328PB-AU

Using internal reference as high ADC resoution is not required

C33 0.1UF
GND

ISP Programming Interface

+3V3
R27 10k 1206
J1A
1 pMiso
3 pSCK
5 ~Reset
J1B
+3V3
2 2
4 4 pMosi
6 6
GND
SBH11-NBPC-D03-ST-BK
SBH11-NBPC-D03-ST-BK

Oscillator Circuit

7.3728MHz XO (Standard) HCMOS,

+3V3
Y1
1 EOH
VCC 4
OUTPUT 3 SysCLK
GND 2
CB3LV-3C-7M372800
+3V3
C8 10nF
GND
GND

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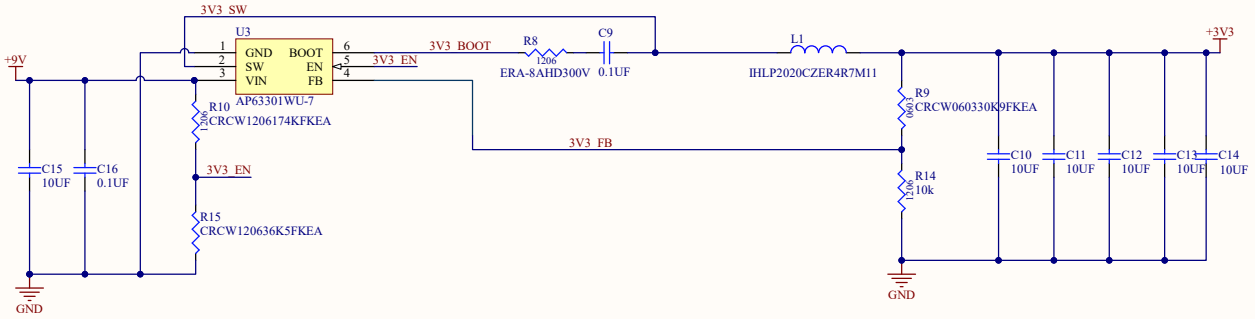
Detailed Description: https://docs.google.com/document/d/19abL1aBHLYX8nfU6Of9tHgjSovLs3Mp-xGCQXi2pRSE/edit?usp=sharing

3V3 REGULATOR



This switching voltage regulator can supply up to 3A of current at 5V. Input battery voltage is 9V-5.7V. Ripple voltage should be about 13.3 mV at max load.

Title		
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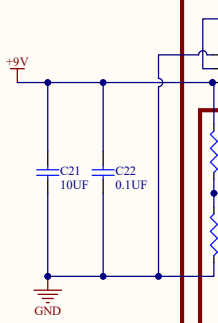
File: C:\Users\..\3v3Regulator.SchDoc		Drawn By:

Detailed Description: https://docs.google.com/document/d/19abL1aBHLYX8nfU6Of9tHgjSovLs3Mp-xGCQXi2pRSE/edit?usp=sharing

5V REGULATOR

INPUT CAPACITOR



Datasheet: TI recommends an input ceramic capacitor over 10 µF for the decoupling capacitor. An additional 0.1-µF capacitor from the VIN pin to ground is recommended to provide additional high frequency filtering. The capacitor voltage rating needs to be greater than the maximum input voltage (in this case, 18V). The capacitor must also have a ripple current rating greater than the maximum input current ripple of the TPS56339, which can be calculated using the following equation.

$$I_{CIRMS} = I_{OUT} \cdot \sqrt{\frac{V_{OUT}}{V_{IN\_MIN}} \cdot \frac{V_{IN\_MIN} - V_{OUT}}{V_{IN\_MIN}}}$$

V_OUT = 5V
V_IN_MIN = 5.7V (when battery is empty)
I_OUT = 3A (max provided by this chip)

$$3\sqrt{\frac{5}{5.7}\cdot\frac{5.7-5}{7}} = 0.89\ [A]$$

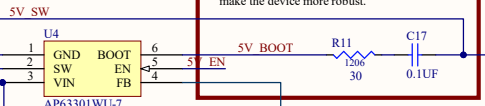
Because the decoupling capacitor is almost always conducting current to stabilize the input, the max ripple current is important to consider to ensure that the power dissipation does not cause an excessive amount of heat generated in the capacitor.

$(1.494\ \text{A (amperes)})^2 \times 0.025\ \Omega\ \text{(ohms)} = 0.056\ \text{W (watts)}$

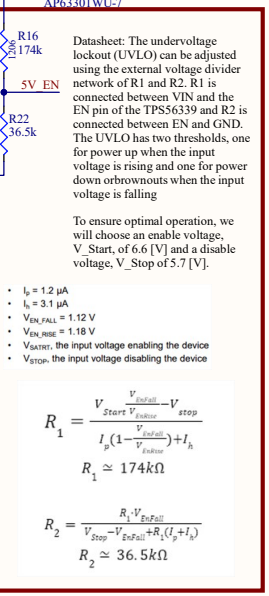
not bad!

BOOTSTRAP

Datasheet: A 30-Ω boot resistor and a 0.1 µF bootstrap capacitor are required between BOOT and SW. The voltage on this cap carries the gate drive voltage for the internal high-side MOSFET. TI recommends using a ceramic capacitor with X5R or better grade dielectric. The capacitor must have a 10-V or higher voltage rating. In addition, TI requires the 30 Ohm boot resistor to make the device more robust.



UNDERVOLTAGE LOCK-OUT



Datasheet: The undervoltage lockout (UVLO) can be adjusted using the external voltage divider network of R1 and R2. R1 is connected between VIN and the EN pin of the TPS56339 and R2 is connected between EN and GND. The UVLO has two thresholds, one for power up when the input voltage is rising and one for power down orbrownouts when the input voltage is falling

To ensure optimal operation, we will choose an enable voltage, V_Start, of 6.6 [V] and a disable voltage, V_Stop of 5.7 [V].

- I_p = 1.2 µA
- I_h = 3.1 µA
- V_{EN_FALL} = 1.12 V
- V_{EN_RISE} = 1.18 V
- V_{STRT}, the input voltage enabling the device
- V_{STOP}, the input voltage disabling the device

$$R_1 = \frac{V_{Start}\frac{V_{EnFall}}{V_{EnRise}} - V_{stop}}{I_p\left(1 - \frac{V_{EnFall}}{V_{EnRise}}\right) + I_h}$$

$$R_1 \simeq 174k\Omega$$

$$R_2 = \frac{R_1 \cdot V_{EnFall}}{V_{Stop} - V_{EnFall} + R_1(I_p + I_h)}$$

$$R_2 \simeq 36.5k\Omega$$

OUTPUT INDUCTOR

Datasheet: to calculate the value of the output inductor, use the following equation. K_IND is a coefficient that represents the amount of inductor ripple current relative to the maximum output current. The inductor ripple current is filtered by the output capacitor. For this part, TI recommends K_IND no less than 30%.

$$L_{MIN} = \frac{V_{OUT}}{V_{IN\_MAX}} \cdot \frac{V_{IN\_MAX} - V_{OUT}}{K_{IND} \cdot I_{OUT} \cdot f_{SW}}$$

$$\frac{5}{9}\cdot\frac{9-5}{0.3\cdot 3\cdot 500[kHz]} = 4.93\ [\mu H]$$

Datasheet: Inductor ripple current can be found with the following equation, which is necessary to calculate the output ripple voltage.

$$I_{RIPPLE} = \frac{V_{OUT}}{V_{IN\_MAX}} \cdot \frac{V_{IN\_MAX} - V_{OUT}}{L_I \cdot f_{SW}}$$

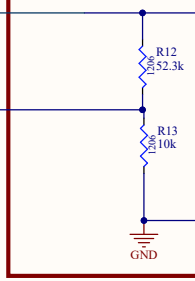
$$I_{ripple} = \frac{5}{9}\cdot\frac{9-5}{4.7[\mu H]\cdot 500[kHz]} = 0.946\ [A]$$

OUTPUT VOLTAGE SETTING

Datasheet: the output voltage is set with a resistor divider from the output node to the FB pin. TI recommends using 1% tolerance or better divider resistors. Referring to the application schematic of Figure 17, we use a 10 kΩ resistor for the bottom leg and use the following equation to calculate the top leg. V_REF is nominally 0.802V.

$$R_6 = \frac{V_{OUT} - V_{REF}}{V_{REF}} \cdot R_7$$

$$\frac{5-0.802}{0.802}\,10k = 52.3k$$



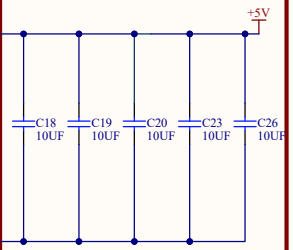
OUTPUT CAPACITORS

Choosing the output capacitors affects the output ripple. To minimize output ripple, we will try to choose a lower cutoff frequency. Using the range of allowable inductor * capacitor values in the datasheet to ensure a stable control loop (Table 2 and Eqn. 14), we know the pole (cutoff) frequency must be between 8.7kHz and 16.5 kHz. We choose to target 10kHz.

$$f_P = \frac{1}{2\pi\sqrt{L_I \cdot C_{OUT\_E}}}$$

Solving this equation and using 4.7uH for L1 and 10KHz for the pole frequency, we arrive at 30.9 uF of output capacitance.

$$C_o = \frac{1}{(2\pi\cdot 10\times 10^3)^2 \cdot 4.7\times 10^{-6}} = 53\ [\mu F]$$



We can calculate the voltage ripple on the output using the inductor ripple current and ESR of the three capacitors.

V_ripple = (inductor ripple) * ESR

$$0.946 \cdot 5 \times 0.003 = 14.19\ [mV]$$

This switching voltage regulator can supply up to 3A of current at 5V. Input battery voltage is 9V-5.7V. Ripple voltage should be about 14.19 mV at max load.

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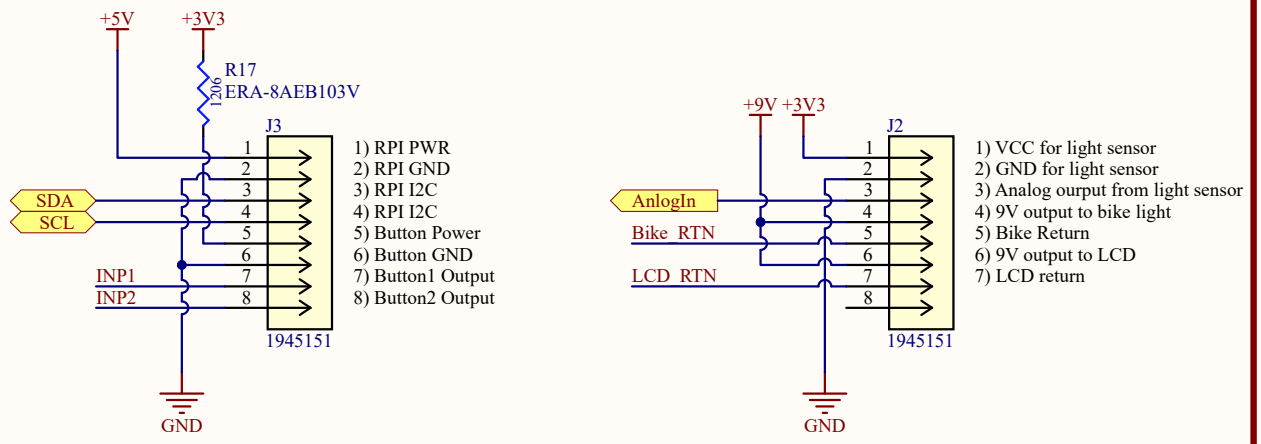
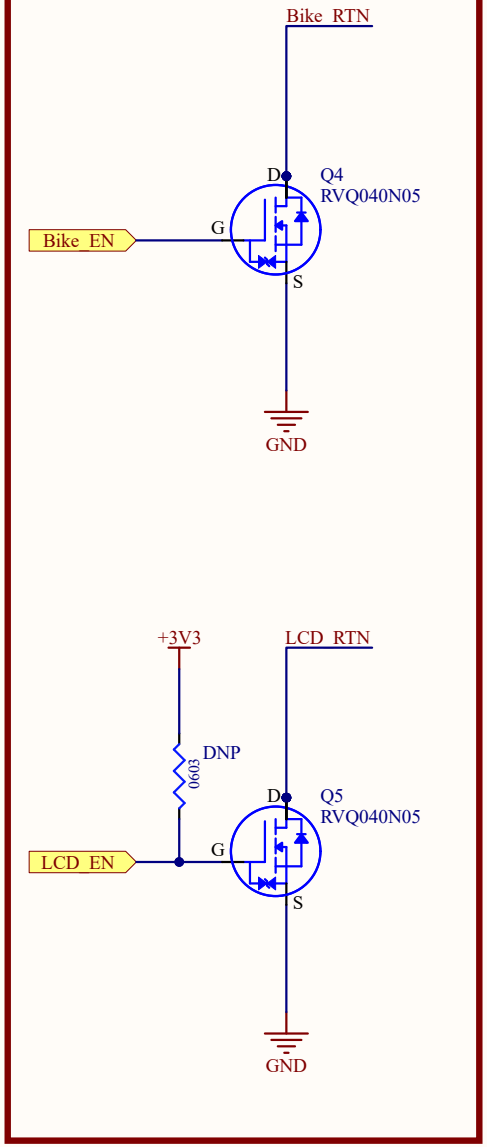
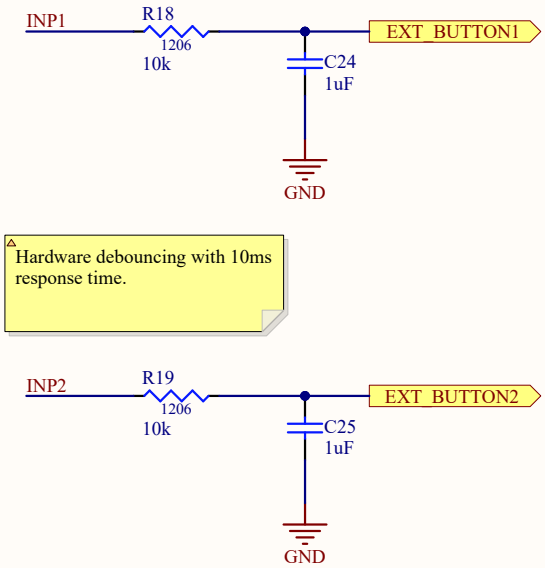
Connectors to External Periferals



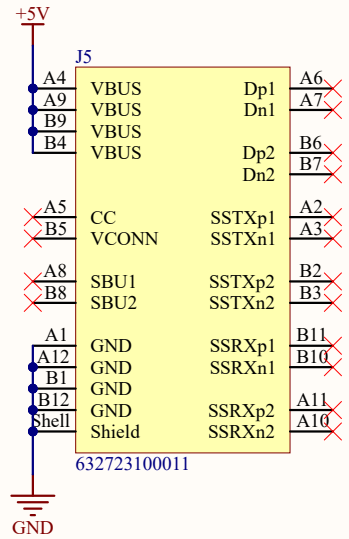
Light and LCD Control



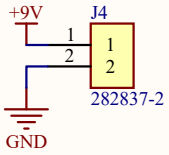
External Button Debouncing



USBC for RPI



Battery Input



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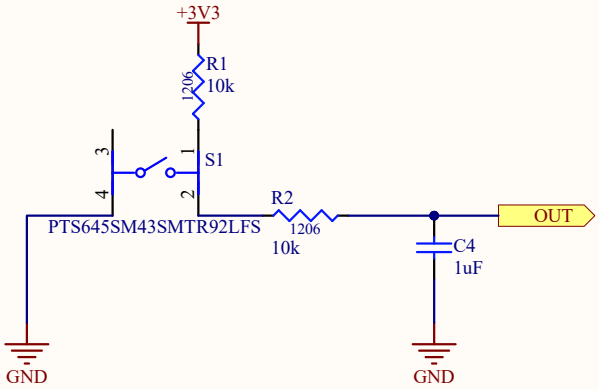
For resistor-capacitor circuits:

$\tau = RC$

Hardware debouncing with 10ms response time.



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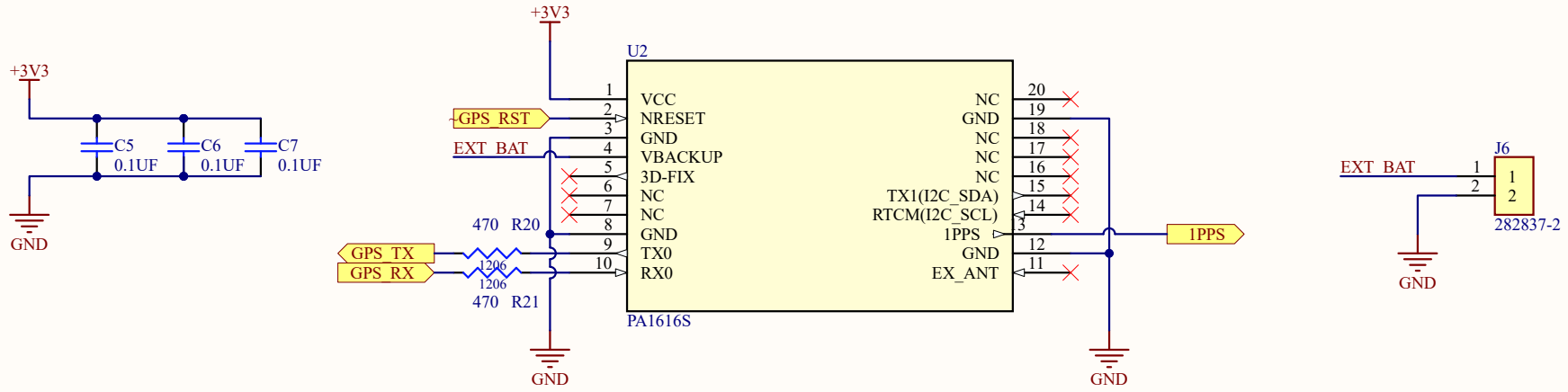

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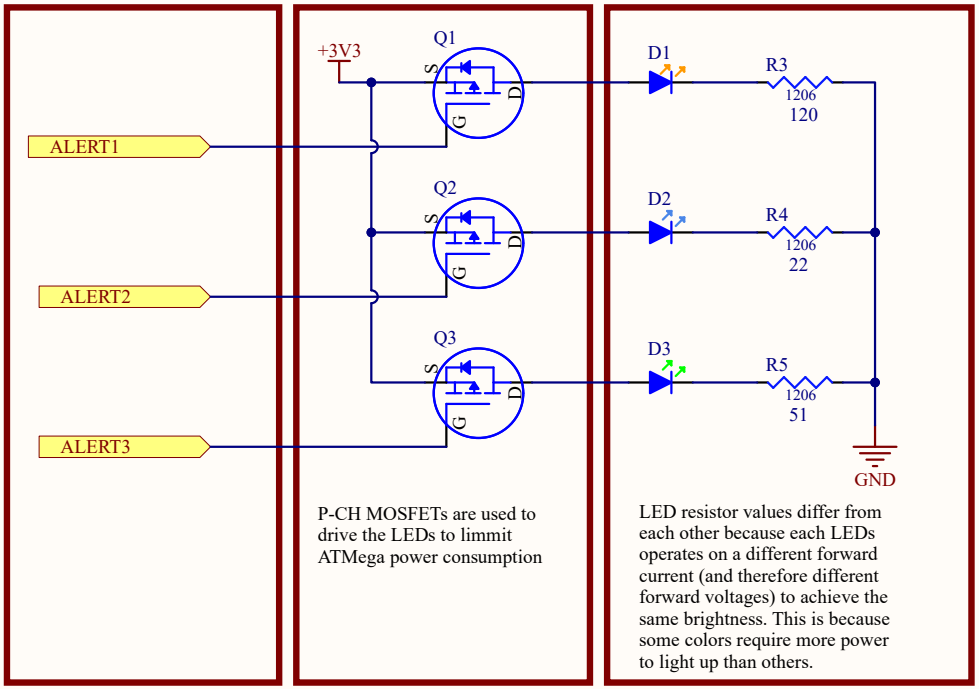
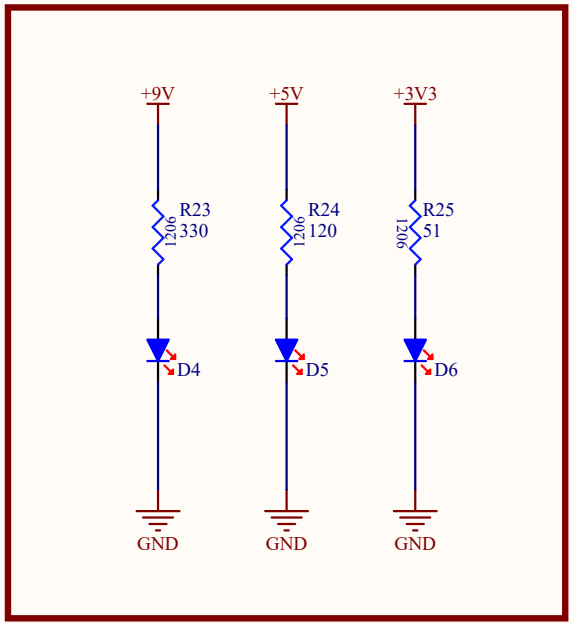
GPIO ALERT LEDS



POWER STATUS LEDS



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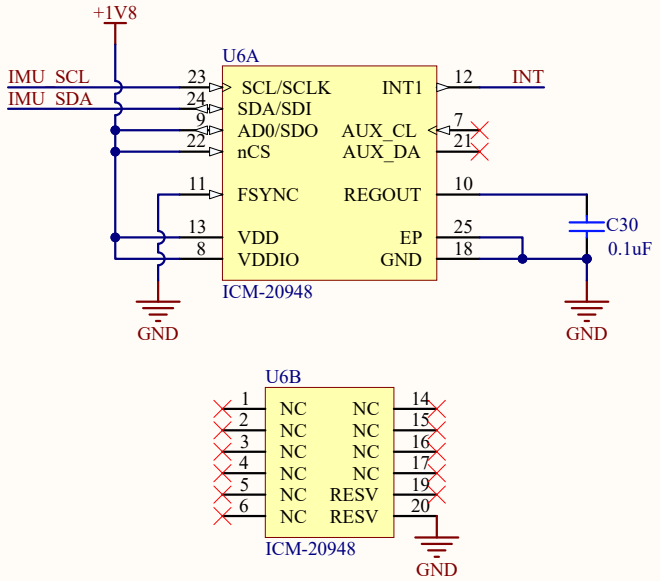
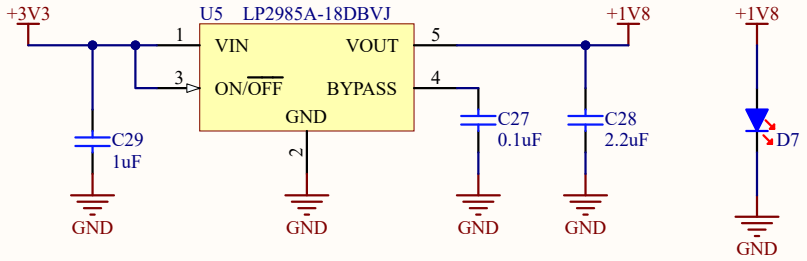
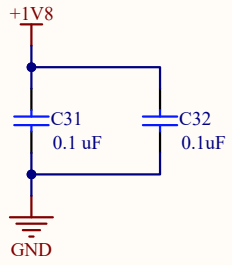
ICM-20948 IMU

IMU Adress: b1101000



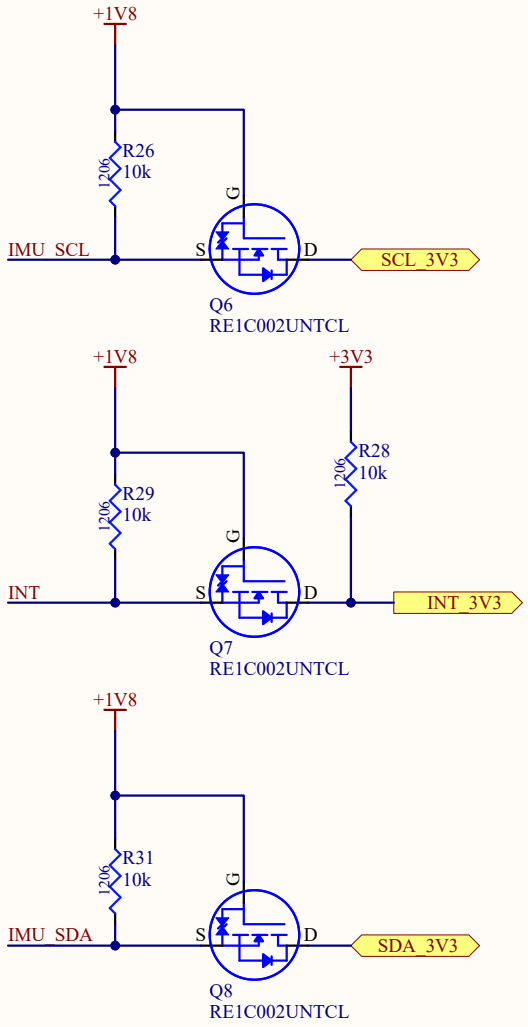
3.3V-1.8V Voltage Regulator





Filtering Capaciters

I2C/INT Level Shifters



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