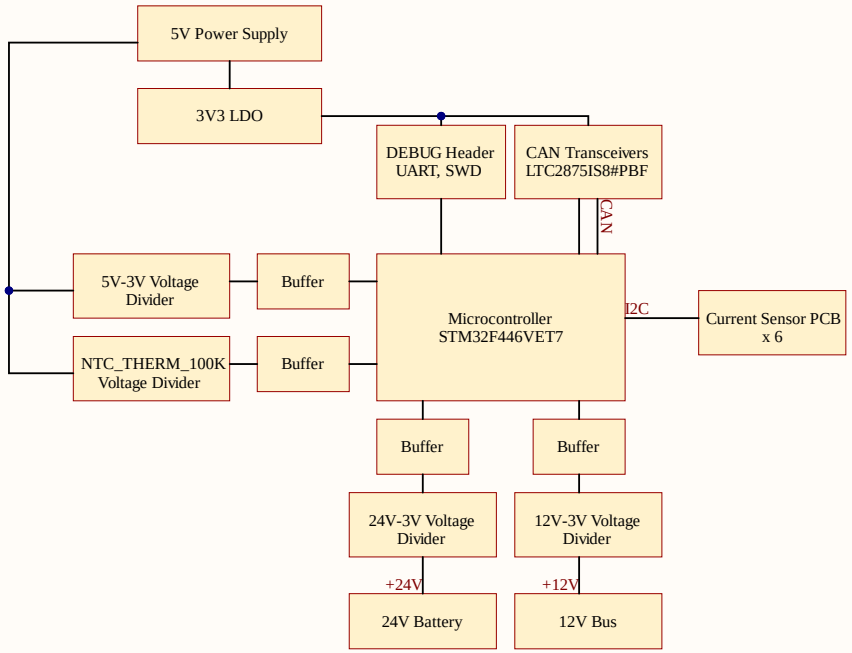
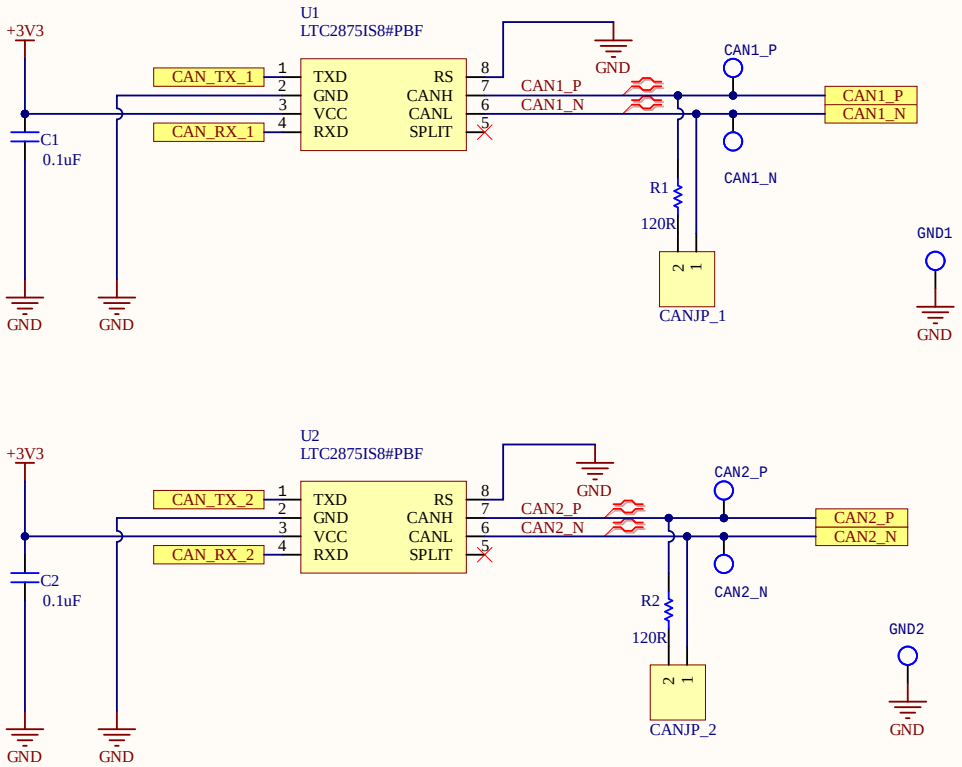
Safety Block Diagram



Title Safety - Block Diagram			UW Robotics 200 University Avenue Waterloo Ontario Canada N2L 3G6
Size: Letter	Drawn By: Qinyang Bao		
Date: 2020-04-01	Sheet of		
File: C:\Users\ayesh\Documents\GitHub\MarsRover2020-PCB\Projects\Safety\Rev2\sch\Block Diagram.SchDoc			

CAN Transceivers



Title CAN		UW Robotics 200 University Avenue Waterloo Ontario Canada N2L 3G6	UW ROBOTICS TEAM
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Date: 2020-04-01	Sheet of		
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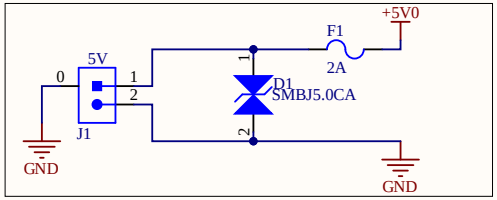
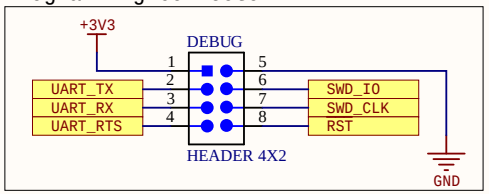
Connectors

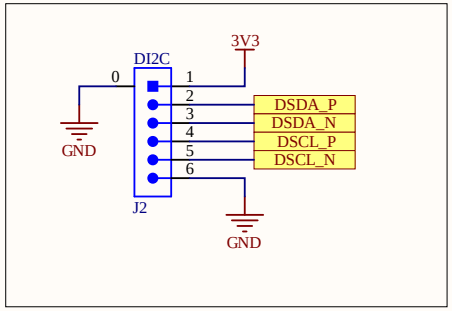
Power Connector



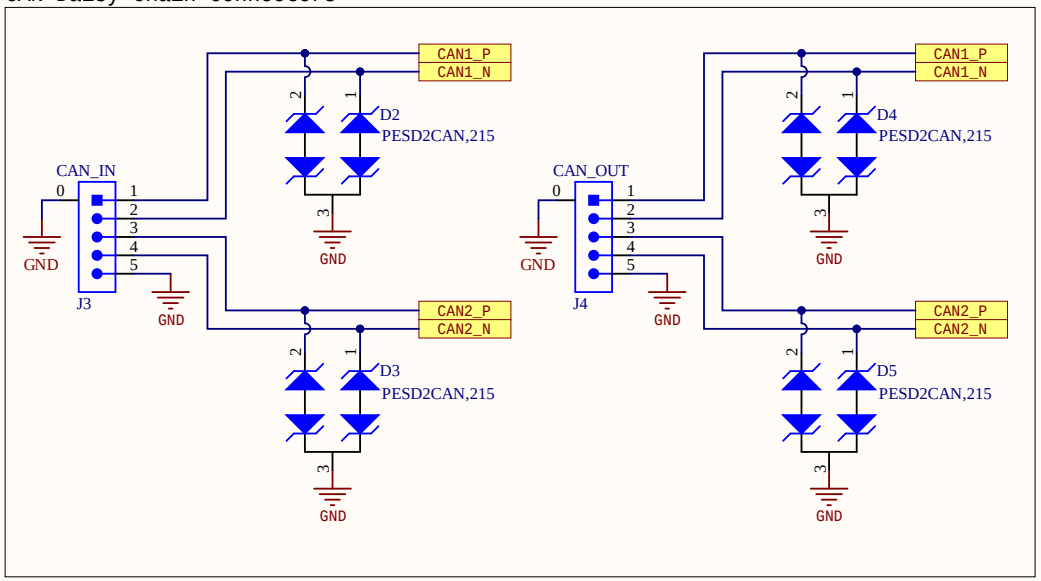
Programming Connector



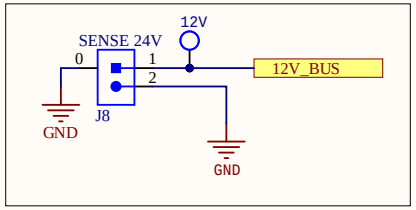
I2C Current Sensors



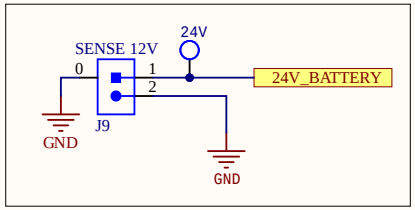
CAN Daisy Chain Connectors



Motor Voltage



Battery Voltage



Title Connectors		UW Robotics 200 University Avenue Waterloo Ontario Canada N2L 3G6
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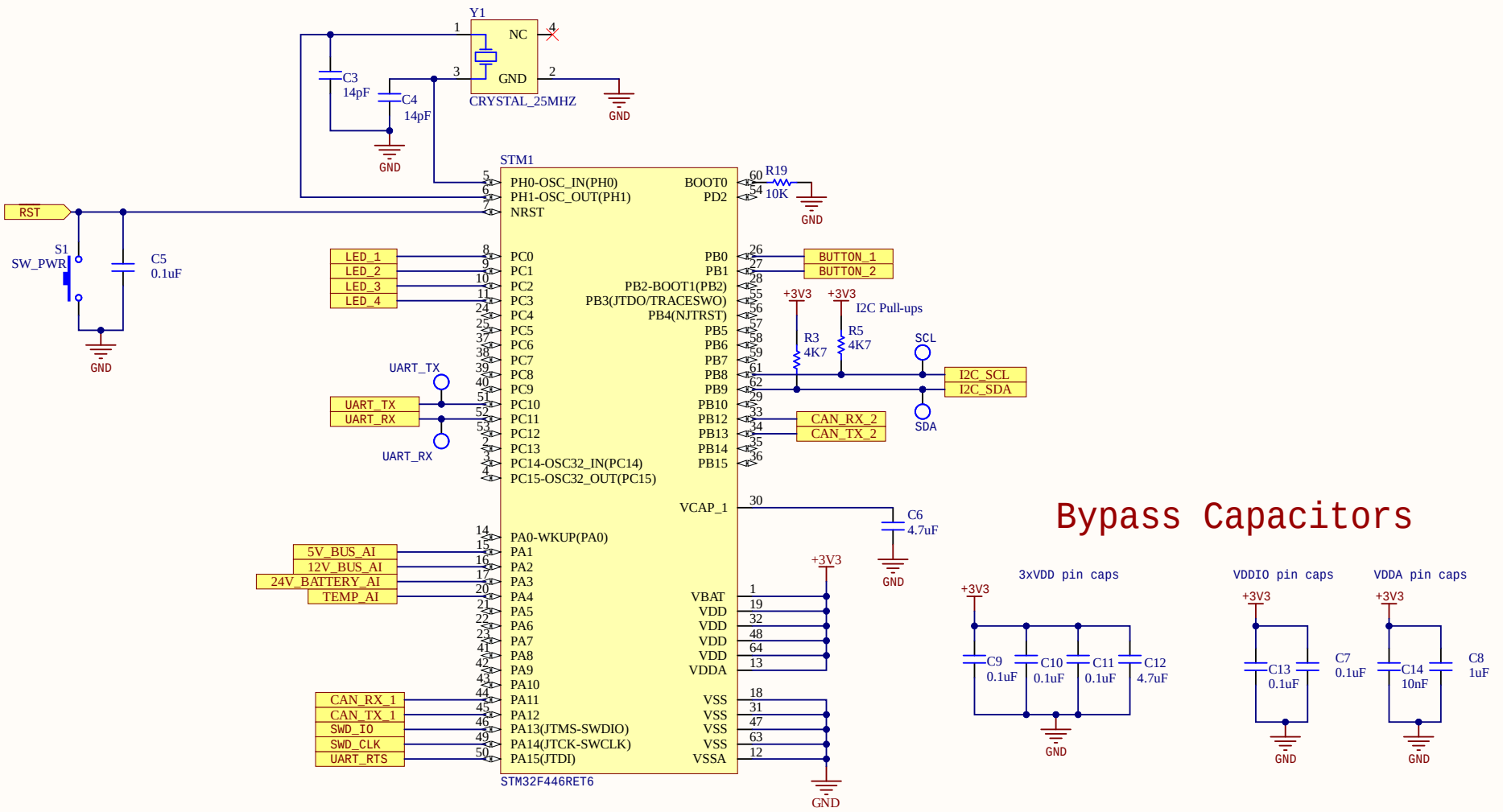
OffSheet

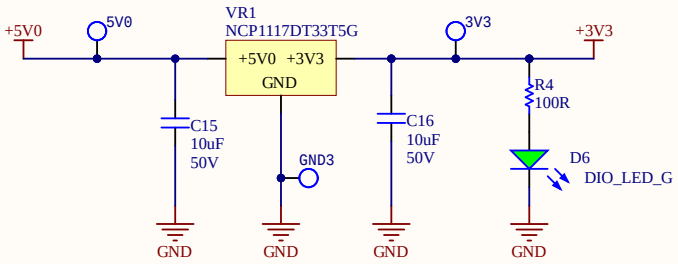
STM32F446RET6



Bypass Capacitors

Title MCU		UW Robotics 200 University Avenue Waterloo Ontario Canada N2L 3G6
Size: Letter	Drawn By: Qinyang Bao, Nicole Rosario	
Date: 2020-04-01	Sheet of	
File: C:\Users\ayesh\Documents\GitHub\MarsRover2020-PCB\Projects\Safety\Rev2\sch\MCU.SchDoc		

5V-3.3V LDO



Current Calculations

Green LED voltage drop: 2.2V
- I = (3.3-2.2V)/120 = 10.83mA

Title Power		UW Robotics 200 University Avenue Waterloo Ontario Canada N2L 3G6
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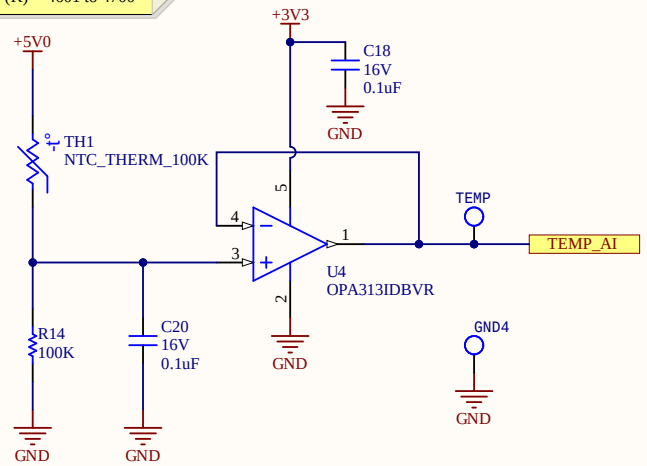
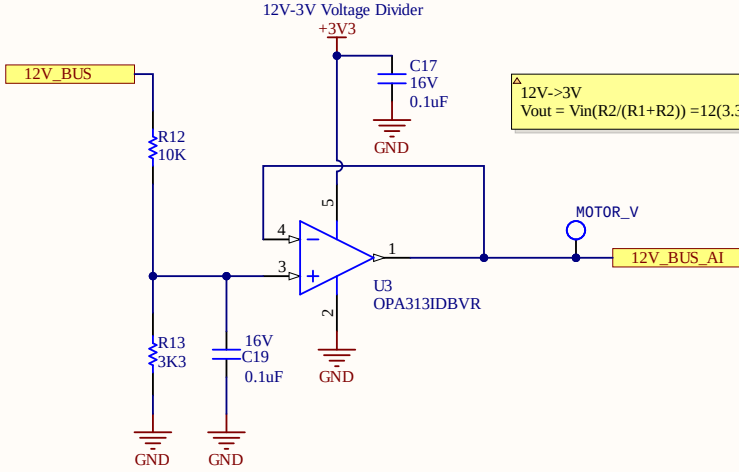
Date: 2020-04-01	Sheet of	
File: C:\Users\ayesh\Documents\GitHub\MarsRover2020-PCB\Projects\Safety\Rev2\sch\POWER.SchDoc		

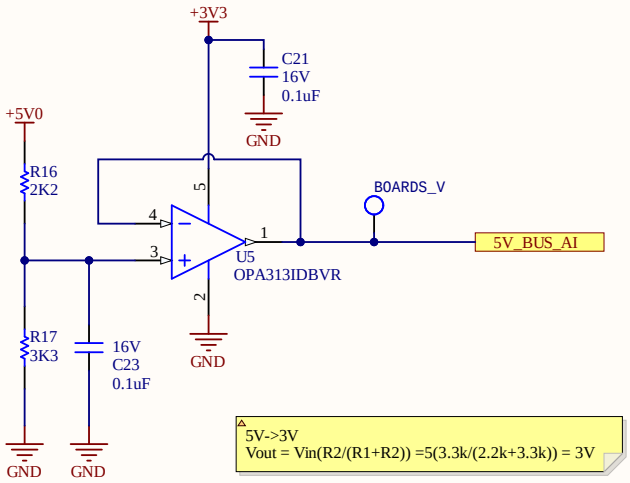
Thermistor Parameter:
Beta value (K) = 4601 to 4700



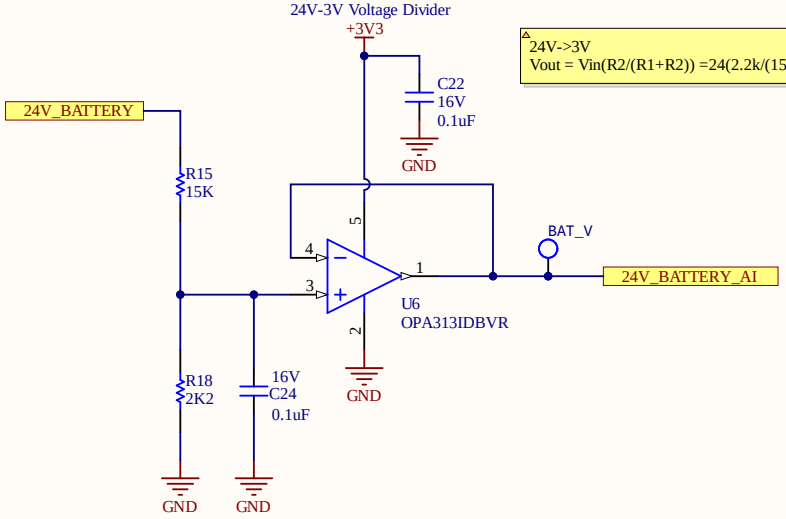
12V-3V Voltage Divider



5V-3V Voltage Divider



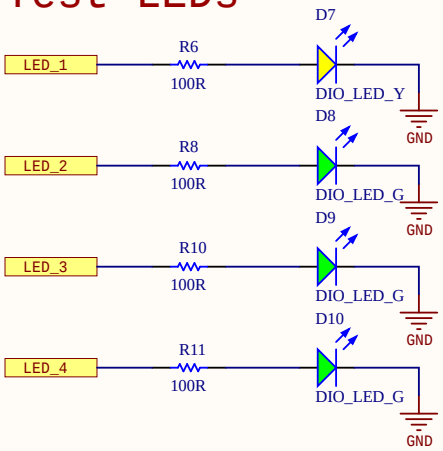
24V-3V Voltage Divider



Rev 2 TODO:
Consider putting two resistors in series for 24-3 voltage divider to reduce BOM line items

Title Sense		UW Robotics 200 University Avenue Waterloo Ontario Canada N2L 3G6
Size: Letter	Drawn By: Qinyang Bao, Kyle Hong	
Date: 2020-04-01	Sheet of	
File: C:\Users\ayesh\Documents\GitHub\MarsRover2020-PCB\Projects\Safety\Rev2\sch\Sense.SchDoc		

Test LEDs

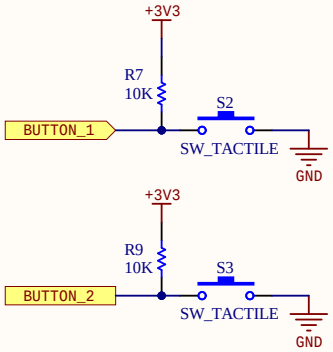


Current Calculations

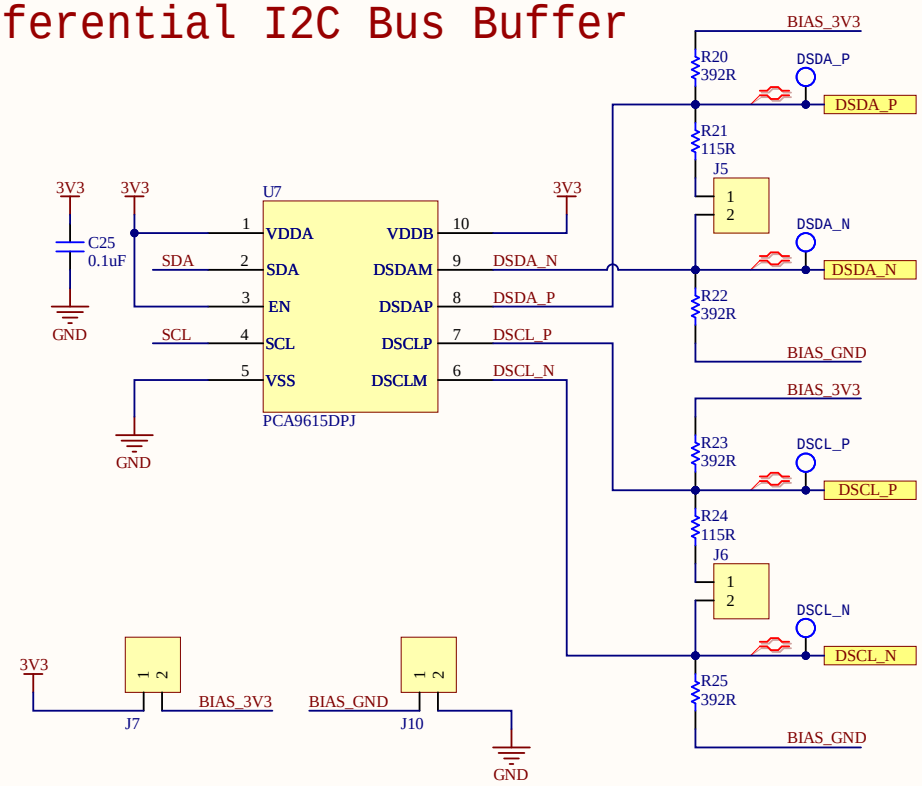
Yellow LED voltage drop: 2.2V
- I = (3.3-2.2V)/120 = 10.83mA

Green LED voltage drop: 2.2V
- I = (3.3-2.2V)/120 = 10.83mA

Test Buttons



Differential I2C Bus Buffer



Characteristic impedance of cable= Zo = 100 Ohms
Cable: https://www.digikey.ca/product-detail/en/general-cable-carol-brand/C0601A-41-10/C0601AG-50-ND/7313814
Calculations & Theory: http://www.ti.com/lit/an/snla031/snla031.pdf pg3
Terminating resistance = Zo =100Ohm = Rc = Rb
Bias resistors for FAILSAFE BIAS = Rd = Ra
Vfsb = Vcc(Rc//Rb / (Rc//Rb + Rd + Ra))
Parallel terminating resistance = 100//100 = 50Ohms, Vcc = 3.3V, Vfsb= 0.2V (for FAILSAFE bias)
Therefore, Ra = Rd = (50*3.3/0.2 - 50)/2 = 387.5 Ohms
Recalculating total terminating resistance: 100// (387.5*2) = 88.6 Ohms
88.6 is more than 10% diff from Zo, therefore recalculate Rc using Zo = Rc//(Ra+Rd)=100
Rc = Zo*(Ra+Rd)/(Ra+Rd-Zo)= 114.8Ohms
Using 1% tolerance: Rc = 115 Ohms Ra=Rd=392Ohms
Check:
Rc//(Ra+Rd)=100.3=Zo
Fsb = Vcc(Rc//Rb / (Rc//Rb + Rd + Ra))= 3.3(115//100 / (115//100 + 2*392)) = 0.21V

Termination resistor(s) should only be used on Safety board and last current sensor in the chain of current sensors (ie the first and last node).

Title Support		UW Robotics 200 University Avenue Waterloo Ontario Canada N2L 3G6	UW ROBOTICS TEAM
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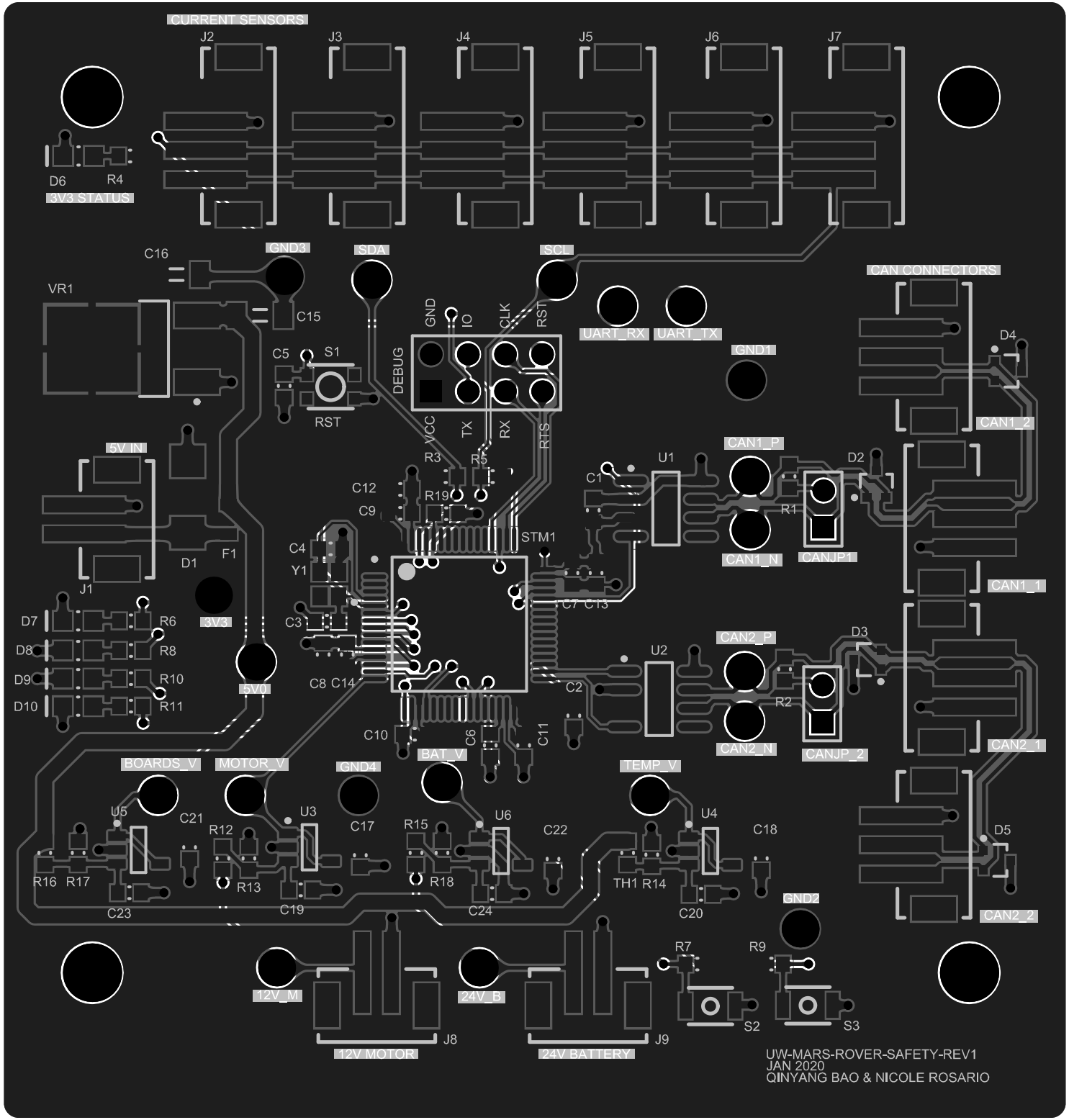
File: C:\Users\ayesh\Documents\GitHub\MarsRover2020-PCB\Projects\Safety\Rev2\sch\Support.SchDoc			


CURRENT SENSORS
J2
J3
J4
J5
J6
J7
D6
R4
3V3 STATUS
C16
GND3
SDA
SCL
VR1
C15
C5
S1
RST
DEBUG
GND
IO
CLK
RST
VCC
TX
RX
RTS
UART_RX
UART_TX
GND1
CAN CONNECTORS
D4
CAN1_2
5V IN
R3
R5
C12
C9
R19
U1
C1
CAN1_P
D2
R1
CAN1_N
CANJP1
CAN1_1
STM1
C4
Y1
C7 C13
D1
F1
J1
3V3
D7
D8
D9
D10
R6
R8
R10
R11
C3
5V0
C8 C14
C2
U2
CAN2_P
D3
R2
CAN2_N
CANJP_2
CAN2_1
C10
C6
C11
BAT_V
BOARDS_V
MOTOR_V
GND4
TEMP_V
U5
C21
R12
U3
C17
R15
U6
C22
U4
C18
R16
R17
R13
C23
C19
R18
C24
TH1
R14
C20
D5
CAN2_2
GND2
R7
R9
12V_M
24V_B
S2
S3
J8
J9
12V MOTOR
24V BATTERY
UW-MARS-ROVER-SAFETY-REV1
JAN 2020
QINYANG BAO & NICOLE ROSARIO

Line #	Name	Description	Designator	Quantity	Manufacturer 1	Manufacturer Part Number 1	Manufacturer Lifecycle 1	Supplier 1	Supplier Part Number 1	Supplier Unit Price 1	Supplier Subtotal 1
	TESTPOINT_LOOP	Loop testpoint through-hole pad	3V3, 5V0, 12V, 24V, BAT_V, BOARDS_V, CAN1_N, CAN1_P, CAN2_N, CAN2_P, GND1, GND2, GND3, GND4, MOTOR_V, SCL, SDA, TEMP, UART_RX, UART_TX	20	Keystone Electronics	5002	Volume Production	Digi-Key	36-5002-ND		
	CAP_0.1uF_16V_0603	CAP CER 0.1UF 16V X7R 0603	C1, C2, C5, C7, C9, C10, C11, C13, C17, C18, C19, C20, C21, C22, C23, C24	16	Yageo	CC0603KRX7R7BB104	Volume Production	Digi-Key	311-1088-1-ND		
	CL10C140JB8NNNC	Cap Ceramic 14pF 50V C0G 5% SMD 0603 125C Cardboard T/R	C3, C4	2	Samsung	CL10C140JB8NNNC	Volume Production	Digi-Key	1276-2187-1-ND		
	CAP_4.7uF_0603	CAP CER 4.7UF 6.3V X5R 0603	C6, C12	2	Yageo	CC0603KRX5R5BB475	Volume Production	Digi-Key	311-1521-1-ND		
	CAP_1uF_16V_0603	CAP CER 1UF 16V Y5V 0603	C8	1	Yageo	CC0603ZRY5V7BB105	Volume Production	Digi-Key	311-1372-1-ND		
	CAP_10nF_0603	CAP CER 10000PF 16V X7R 0603	C14	1	Yageo	CC0603KRX7R7BB103	Volume Production	Digi-Key	311-3369-1-ND		
	10uF	CAP CER 10UF 50V X5R 1206	C15, C16	2	Murata	GRT31CR61H106KE01L	Volume Production	Digi-Key	490-12456-1-ND		
	CAP_0.1uF_50V_0805	CAP CER 0.1UF 50V X7R 0805	C25	1	Murata	GCD21BR71H104KA01L		Digi-Key	490-11955-1-ND		
	JUMPER_2	HEADER 2X1	CANJP_1, CANJP_2, J5, J6, J7, J10	6	TE Connectivity	87220-2	Volume Production	Digi-Key	A26542-ND		
	TVS_DIODE_BIDIRECTIONAL	TVS DIODE 5V 9.2V DO214AA	D1	1	Littelfuse	SMBJ5.0CA	Volume Production	Digi-Key	SMBJ5.0CALFCT-ND		
	TVS_DIODE_CAN	TVS DIODE 24V 41V SOT323-3	D2, D3, D4, D5	4	Nexperia	PESD2CAN.215		Digi-Key	1727-3891-1-ND		
	DIO_LED_G	LED GREEN DIFFUSED 0805 SMD	D6, D8, D9, D10	4	Osram Opto	LGR971-KN-1	Volume Production	Digi-Key	475-1410-1-ND		
	DIO_LED_Y	LED YELLOW DIFFUSED 0805 SMD	D7	1	Osram Opto	LYR976-PS-36	Volume Production	Digi-Key	475-2560-1-ND		
	HEADER 4X2	CONN HEADER VERT 8POS 2.54MM	DEBUG	1	Harwin	M20-9980445	Volume Production	Digi-Key	952-2122-ND		
	FUSE_2A_0603	FUSE SMD 2A 32V	F1	1	Littelfuse	0467002.NRHF	Volume Production	Digi-Key	F7132CT-ND		
	5V	CONN HEADER SMD RIGHT ANGLE 2MM PITCH	J1	1	Molex	5024940270		Digi-Key	WM15810CT-ND		
	DI2C	CONN HEADER SMD RIGHT ANGLE 2MM PITCH	J2	1	Molex	502494-0670		Digi-Key	WM2283CT-ND		
	CAN_IN	CONN HEADER SMD RIGHT ANGLE 1.5MM PITCH	J3	1	Molex	5025850570		Digi-Key	WM14469CT-ND		
	CAN_OUT	CONN HEADER SMD RIGHT ANGLE 1.5MM PITCH	J4	1	Molex	5025850570		Digi-Key	WM14469CT-ND		
	SENSE 24V	CONN HEADER SMD RIGHT ANGLE 2MM PITCH	J8	1	Molex	5024940270		Digi-Key	WM15810CT-ND		
	SENSE 12V	CONN HEADER SMD RIGHT ANGLE 2MM PITCH	J9	1	Molex	5024940270		Digi-Key	WM15810CT-ND		
	RES_120R_0603	RES SMD 120 OHM 5% 1/10W 0603	R1, R2	2	Yageo	RC0603JR-07120RL	Volume Production	Digi-Key	311-120GRCT-ND		
	RES_4K7_0603	RES SMD 4.7K OHM 5% 1/10W 0603	R3, R5	2	Yageo	RC0603JR-074K7L	Volume Production	Digi-Key	311-4.7KGRCT-ND		
	RES_100R_0603	RES SMD 100 OHM 1% 1/10W 0603	R4, R6, R8, R10, R11	5	Yageo	RC0603FR-07100RL	Volume Production	Digi-Key	311-100HRCT-ND		
	RES_10K_0603	RES SMD 10K OHM 5% 1/10W 0603	R7, R9, R12, R19	4	Yageo	RC0603JR-0710KL	Volume Production	Digi-Key	311-10KGRCT-ND		
	RES_3K3_0603	RES SMD 3.3K OHM 5% 1/10W 0603	R13, R17	2	Yageo	RC0603JR-073K3L	Volume Production	Digi-Key	311-3.3KGRCT-ND		
	RES_100K_0603	RES SMD 100K OHM 5% 1/10W 0603	R14	1	Yageo	RC0603FR-07261KL	Volume Production	Digi-Key	311-261KHRCT-ND		
	RES_15K_0603	RES SMD 15K OHM 5% 1/10W 0603	R15	1	Yageo	RC0603J*-**15KL		Digi-Key	311-15KGRCT-ND		
	RES_2K2_0603	RES SMD 2.2K OHM 1% 1/10W 0603	R16, R18	2	Yageo Phycomp	RC0603FR-072K2L	Volume Production	Digi-Key	311-2.20KHRCT-ND		
	RES_392R_0805	RES SMD 392 OHM 1% 1/8W 0805	R20, R22, R23, R25	4	Yageo	RC0805FR-07392RL		Digi-Key	311-392CRCT-ND	0.15 CAD	
	RES_115R_0805	RES SMD 115 OHM 1% 1/8W 0805	R21, R24	2	Yageo	RC0805FR-07115RL		Digi-Key	311-115CRCT-ND	0.14476 CAD	
	SW_PWR	Power Switch (Red)	S1	1	ITT C&K	PTS830GM140SMTRLFS	Volume Production	Digi-Key	CKN10587CT-ND		
	SW_TACTILE	Tactile Switch (Grey)	S2, S3	2	Omron	B3U-1100P	Volume Production	Digi-Key	SW1021CT-ND		
	STM32F446RET6	ARM Cortex-M4 32-bit MCU+FPU, 512 KB Flash, 128 KB Internal RAM, 50 I/Os, 64-Pin LQFP, -40 to 85 degC, Tray	STM1	1	STMicroelectronics	STM32F446RET6	Volume Production	Digi-Key	497-15376-ND		
	NTC_THERM_100K	THERM NTC 100KOHM 4700K 0603	TH1	1	Panasonic	ERT-J1VV104J	Volume Production	Digi-Key	P10555CT-ND		
	DSDA_P	Loop testpoint through-hole pad	TP1	1	Keystone Electronics	5002		Digi-Key	36-5002-ND		
	DSDA_N	Loop testpoint through-hole pad	TP2	1	Keystone Electronics	5002		Digi-Key	36-5002-ND		
	DSCL_P	Loop testpoint through-hole pad	TP3	1	Keystone Electronics	5002		Digi-Key	36-5002-ND		
	DSCL_N	Loop testpoint through-hole pad	TP4	1	Keystone Electronics	5002		Digi-Key	36-5002-ND		
	IC TXRX CAN	IC TXRX CAN 4MBPS 8SO	U1, U2	2	Analog Devices / Linear Technology	LTC2875IS8#PBF	Volume Production	Digi-Key	LTC2875IS8#PBF-ND		
	OPA313IDBVR	IC OPAMP GP 1 CIRCUIT SOT23-5	U3, U4, U5, U6	4	Texas Instruments	OPA313IDBVR	Volume Production	Digi-Key	296-35607-1-ND		
	DIFF_I2C_BUFFER	IC DIFF I2C BUFFER 2CH 10TSSOP	U7	1	NXP Semiconductors	PCA9615DPJ		Digi-Key	568-11484-1-ND		
	5V0_3V3_LDO	IC REG LINEAR 3.3V 1A DPAK	VR1	1	ON Semiconductor	NCP1117DT33T5G	Volume Production	Digi-Key	NCP1117DT33T5GOSCT-ND		
	CRYSTAL_25MHZ	CRYSTAL 25.0000MHZ 12PF SMD	Y1	1	Kyocera AVX	CX2520DB25000H0FLJC1	Volume Production	Digi-Key	1253-1724-1-ND		