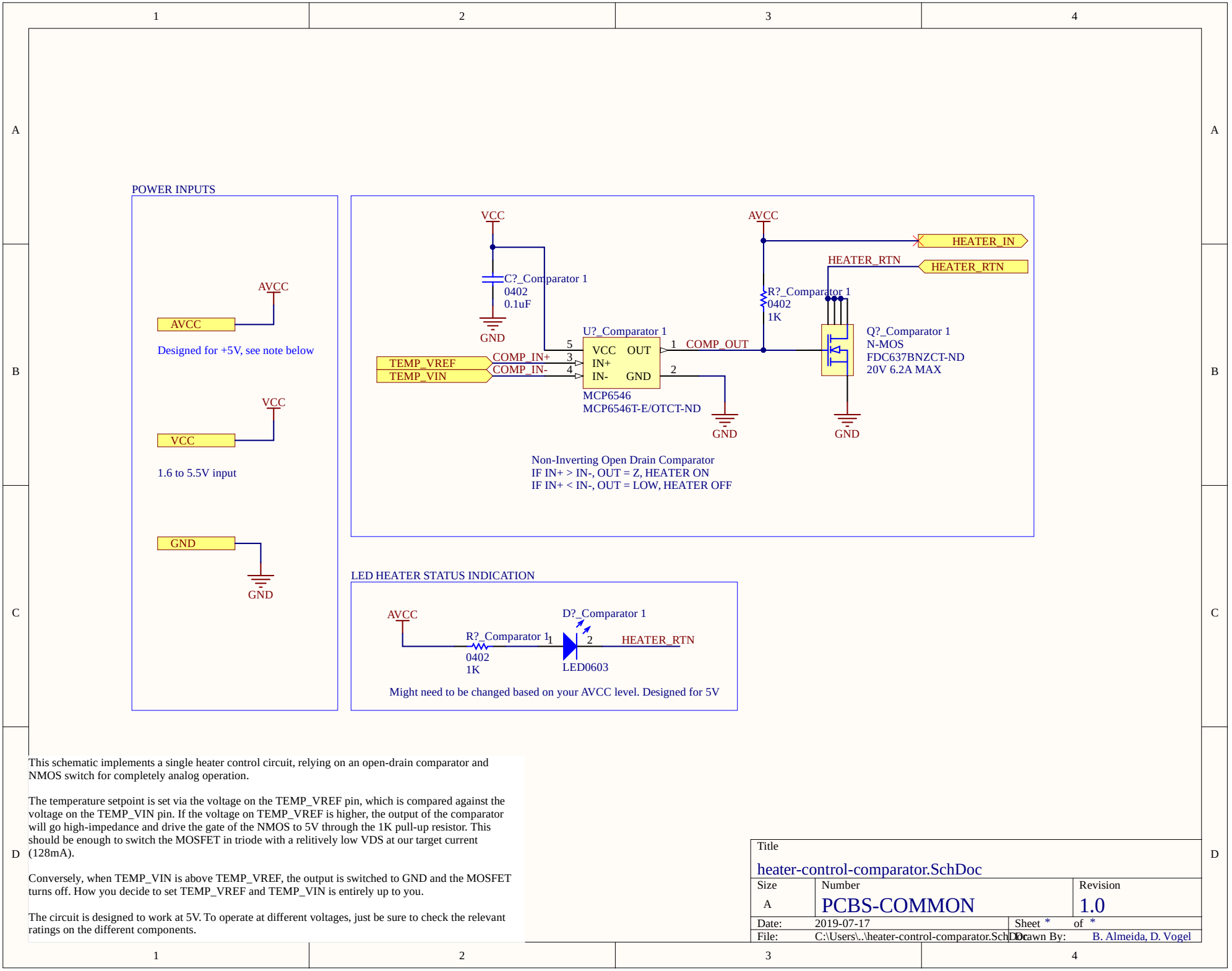


This schematic implements a single heater control circuit, relying on an open-drain comparator and NMOS switch for completely analog operation.

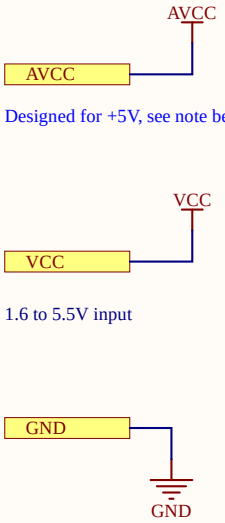
The temperature setpoint is set via the voltage on the TEMP_VREF pin, which is compared against the voltage on the TEMP_VIN pin. If the voltage on TEMP_VREF is higher, the output of the comparator will go high-impedance and drive the gate of the NMOS to 5V through the 1K pull-up resistor. This should be enough to switch the MOSFET in triode with a relitively low VDS at our target current (128mA).

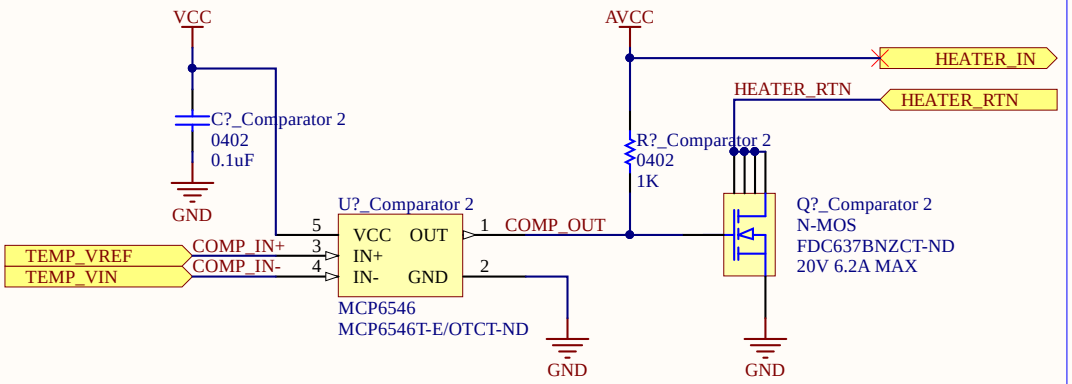
Conversely, when TEMP_VIN is above TEMP_VREF, the output is switched to GND and the MOSFET turns off. How you decide to set TEMP_VREF and TEMP_VIN is entirely up to you.

The circuit is designed to work at 5V. To operate at different voltages, just be sure to check the relevant ratings on the different components.

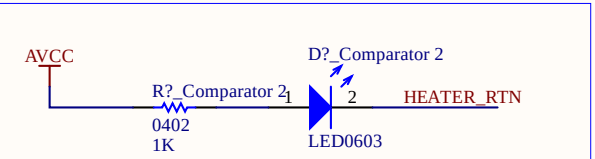
Title	heater-control-comparator.SchDoc	
Size: A	Number: PCBS-COMMON	Revision: 1.0
Date: 2019-07-17	Sheet * of *	
File: C:\Users\..\heater-control-comparator.SchDoc	Drawn By: B. Almeida, D. Vogel	

POWER INPUTS





LED HEATER STATUS INDICATION



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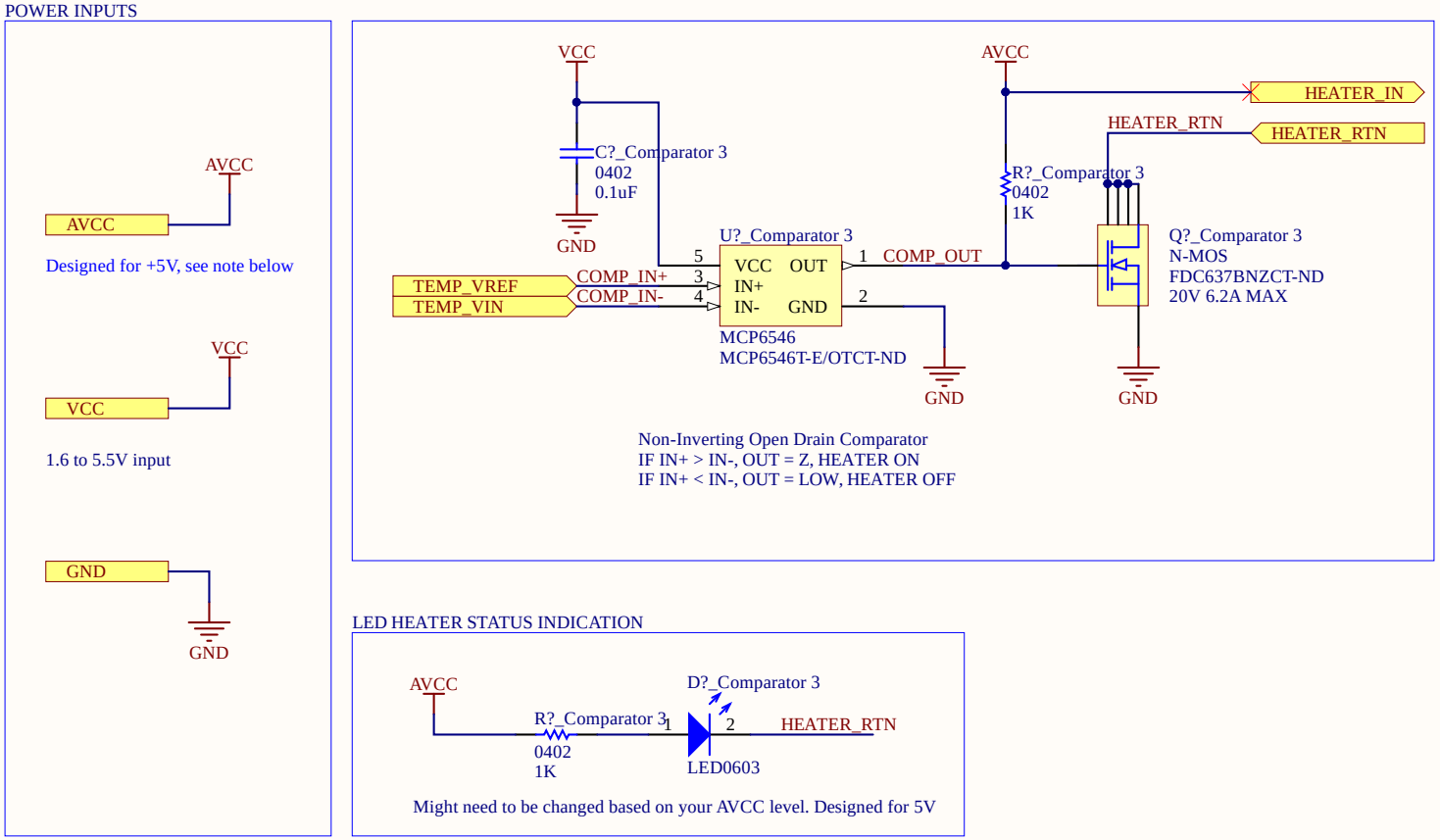
Title	heater-control-comparator.SchDoc	
Size: A	Number: PCBS-COMMON	Revision: 1.0
Date: 2019-07-17	Sheet * of *	
File: C:\Users\..\heater-control-comparator.SchDoc	Drawn By: B. Almeida, D. Vogel	



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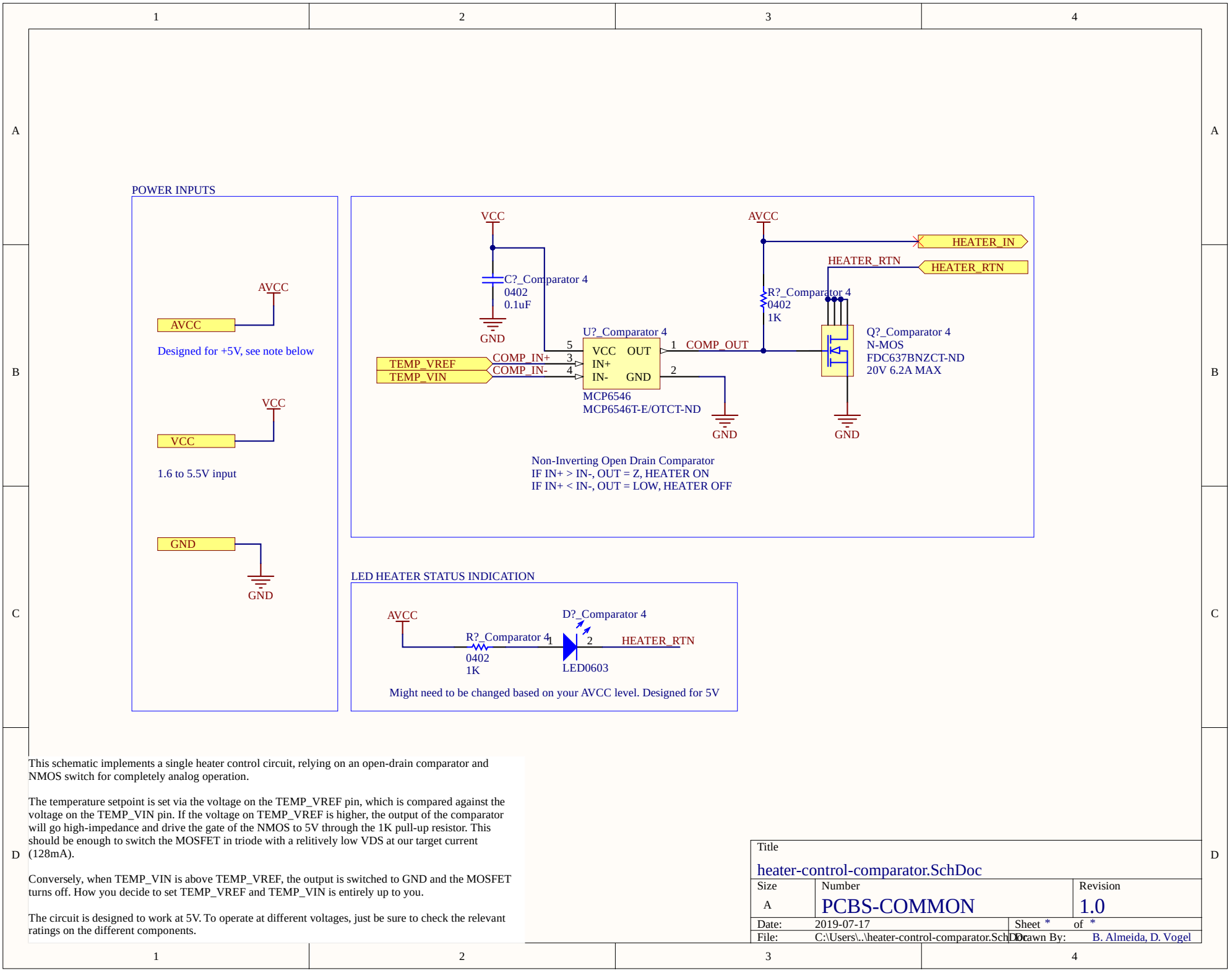
Size: A	Number: PCBS-COMMON	Revision: 1.0
Date: 2019-07-17	Sheet * of *	
File: C:\Users\..\heater-control-comparator.SchDoc	Drawn By: B. Almeida, D. Vogel	



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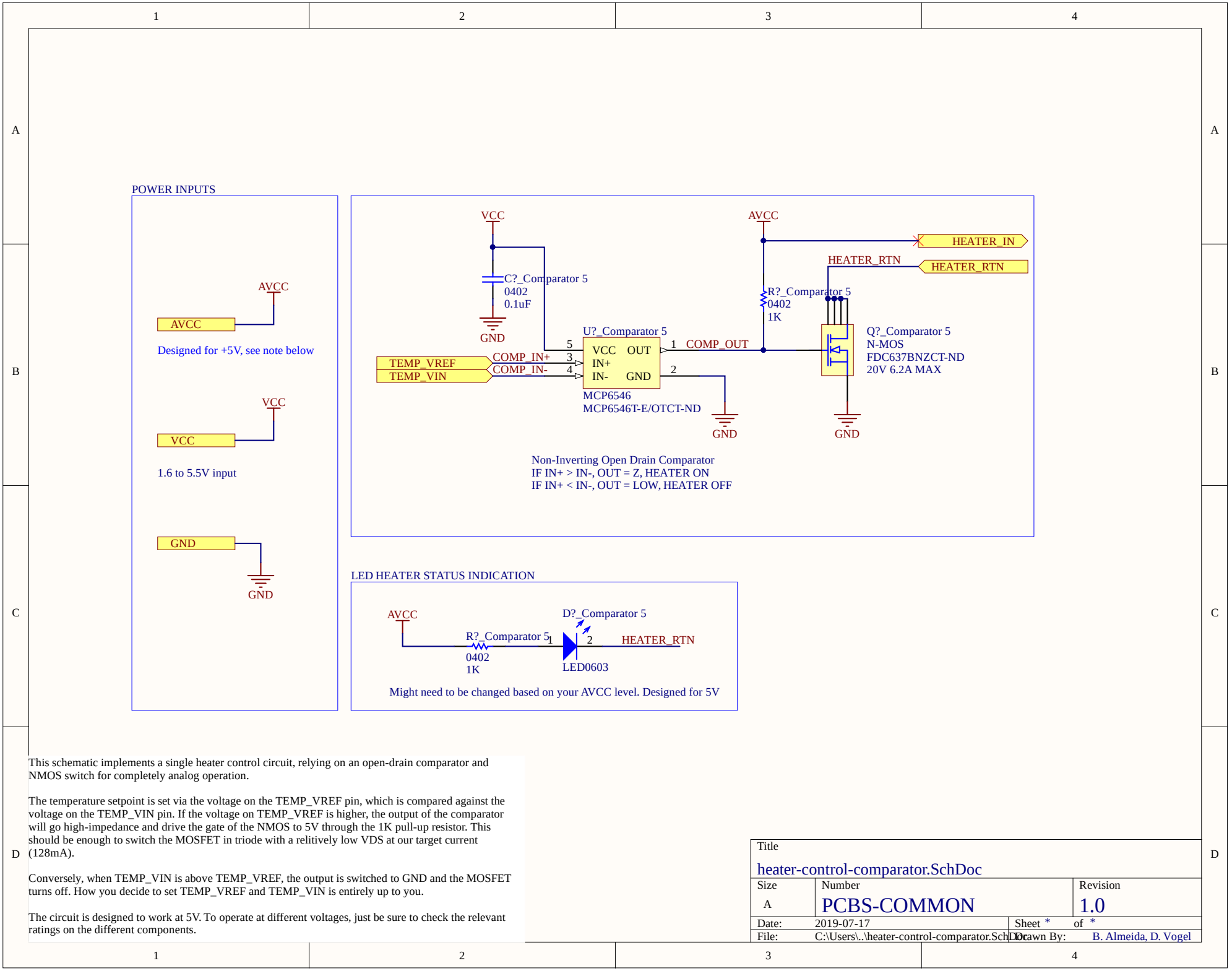
Size: A	Number: PCBS-COMMON	Revision: 1.0
Date: 2019-07-17	Sheet * of *	
File: C:\Users\..\heater-control-comparator.SchDoc	Drawn By: B. Almeida, D. Vogel	



This schematic implements a single heater control circuit, relying on an open-drain comparator and NMOS switch for completely analog operation.

The temperature setpoint is set via the voltage on the TEMP_VREF pin, which is compared against the voltage on the TEMP_VIN pin. If the voltage on TEMP_VREF is higher, the output of the comparator will go high-impedance and drive the gate of the NMOS to 5V through the 1K pull-up resistor. This should be enough to switch the MOSFET in triode with a relitively low VDS at our target current (128mA).

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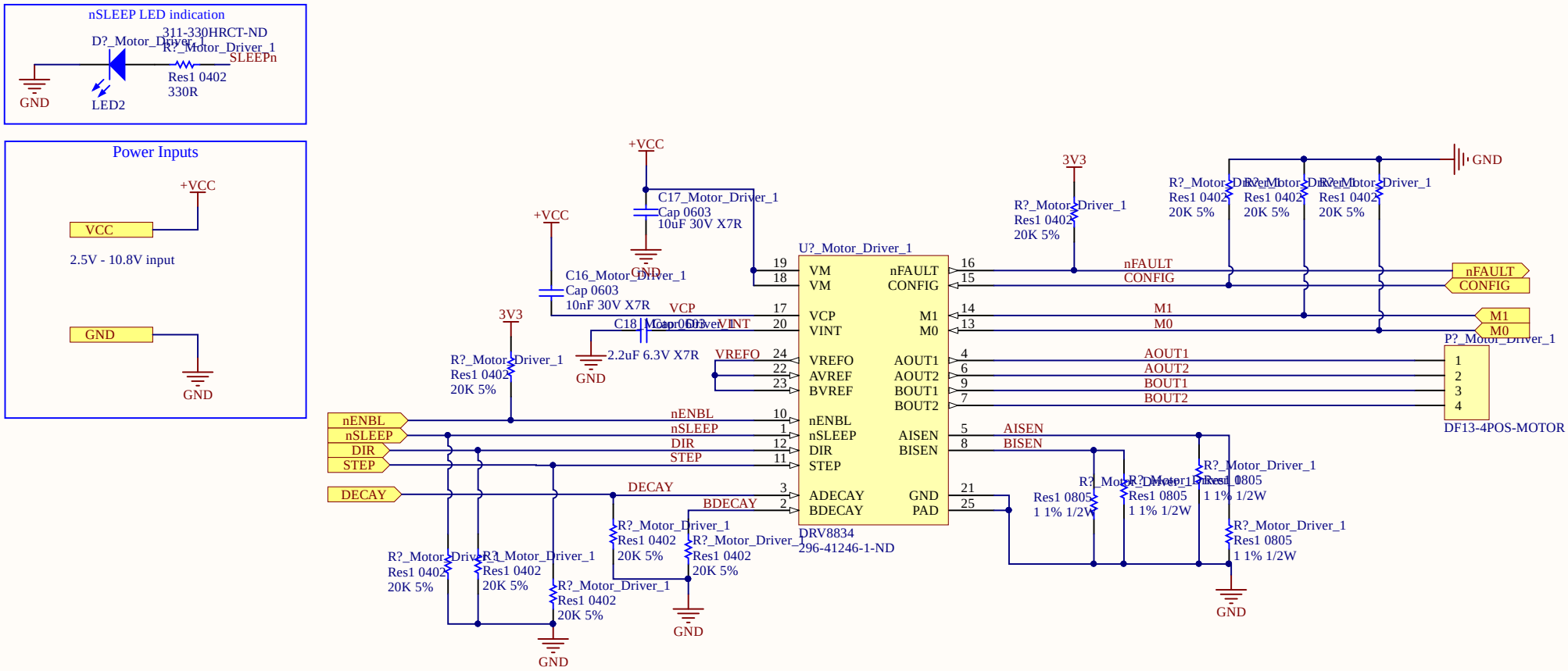
Title	heater-control-comparator.SchDoc	
Size: A	Number: PCBS-COMMON	Revision: 1.0
Date: 2019-07-17	Sheet * of *	
File: C:\Users\..\heater-control-comparator.SchDoc	Drawn By: B. Almeida, D. Vogel	



DRV8834 Motor Driver Notes

Datasheet: http://www.ti.com/lit/ds/symlink/drv8834.pdf

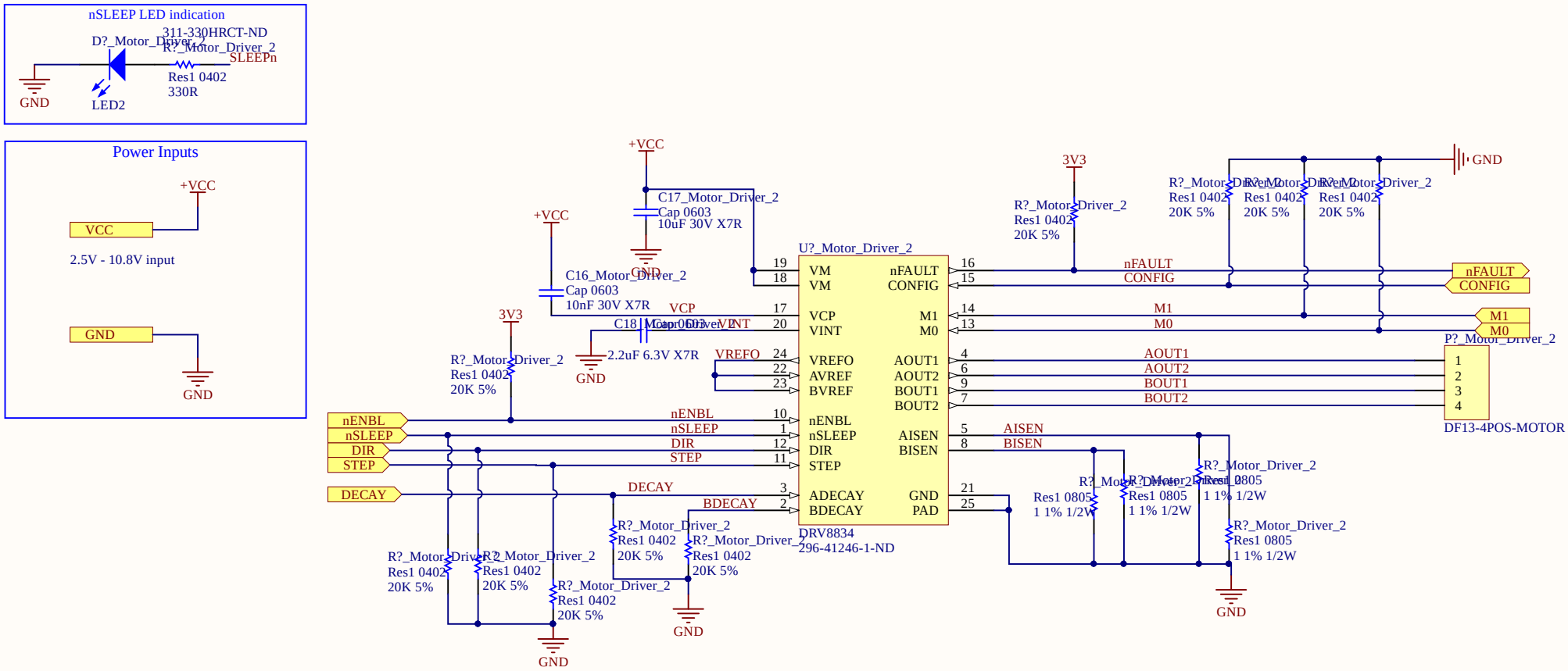
Tempted to set M1/M0 to 00 so that the device will always use Full Step in Indexer mode. Indexer mode, full step will be the most relevant to our case, but for flexibility I will leave them to the MCU for now.

Indexer mode work with the STEP and DIR pin, while the STEP is like a clock configuration and the internal indexer travels a certain step according a table given in the datasheet everytime the STEP has a rising edge. DIR is used to control the travelling direction of the indexer.

In Indexer mode, only ADECAY is controllable. When current is in the increasing stage in the step table, slow decay mode is always used; when current is in the decreasing stage, the decay mode is commended by the ADECAY pin.

Probably need a voltage divider to set-up the xVREF voltage if want to modify xISEN and the resistor later. Currently not sure what VREFO outputs, need to double check with pay-ssm-v3 circuit.

Title		
Size: A4	Number	Revision
Date: 2019-07-17	Sheet of	
File: C:\Users\..\motor_control.SchDoc	Drawn By:	



DRV8834 Motor Driver Notes

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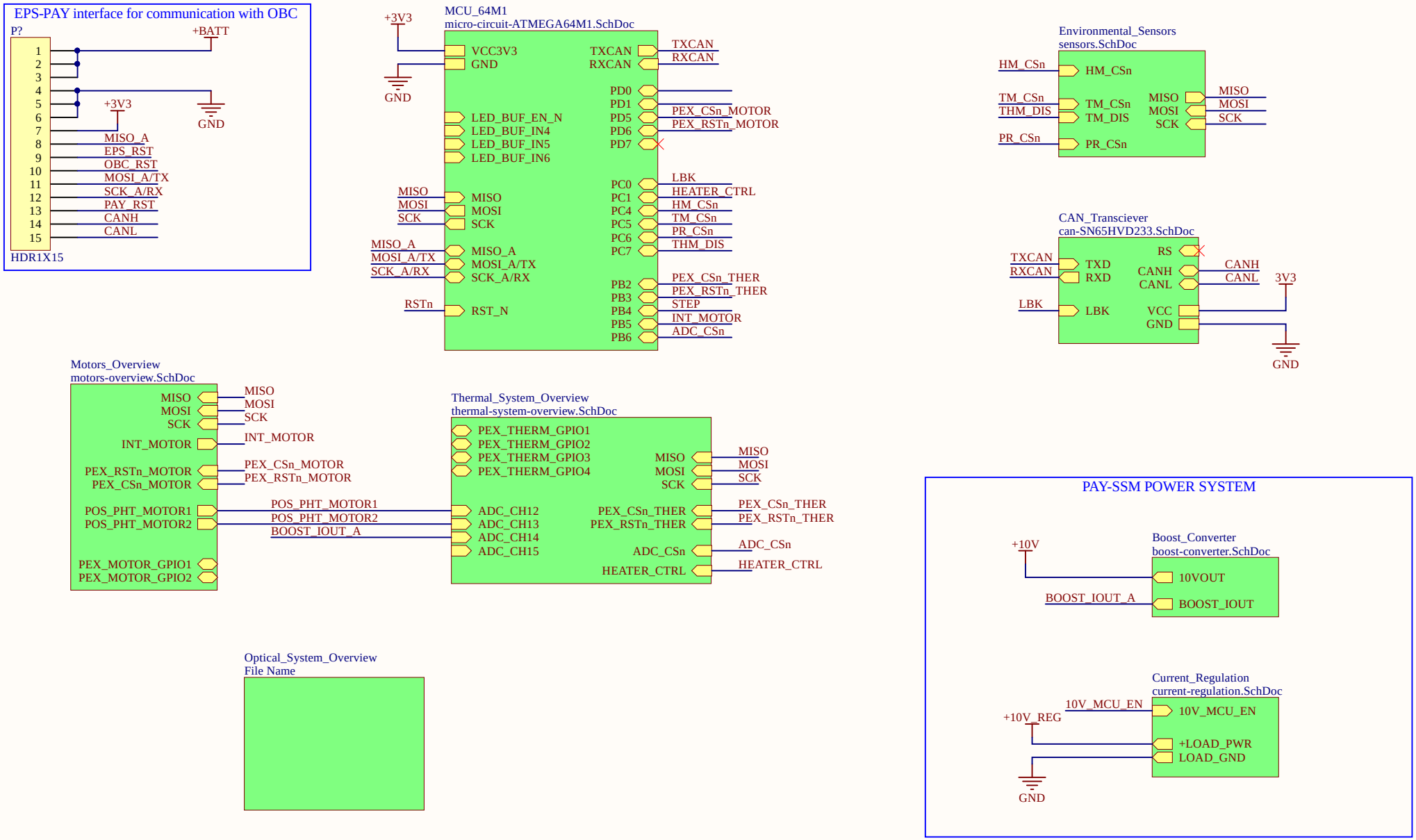
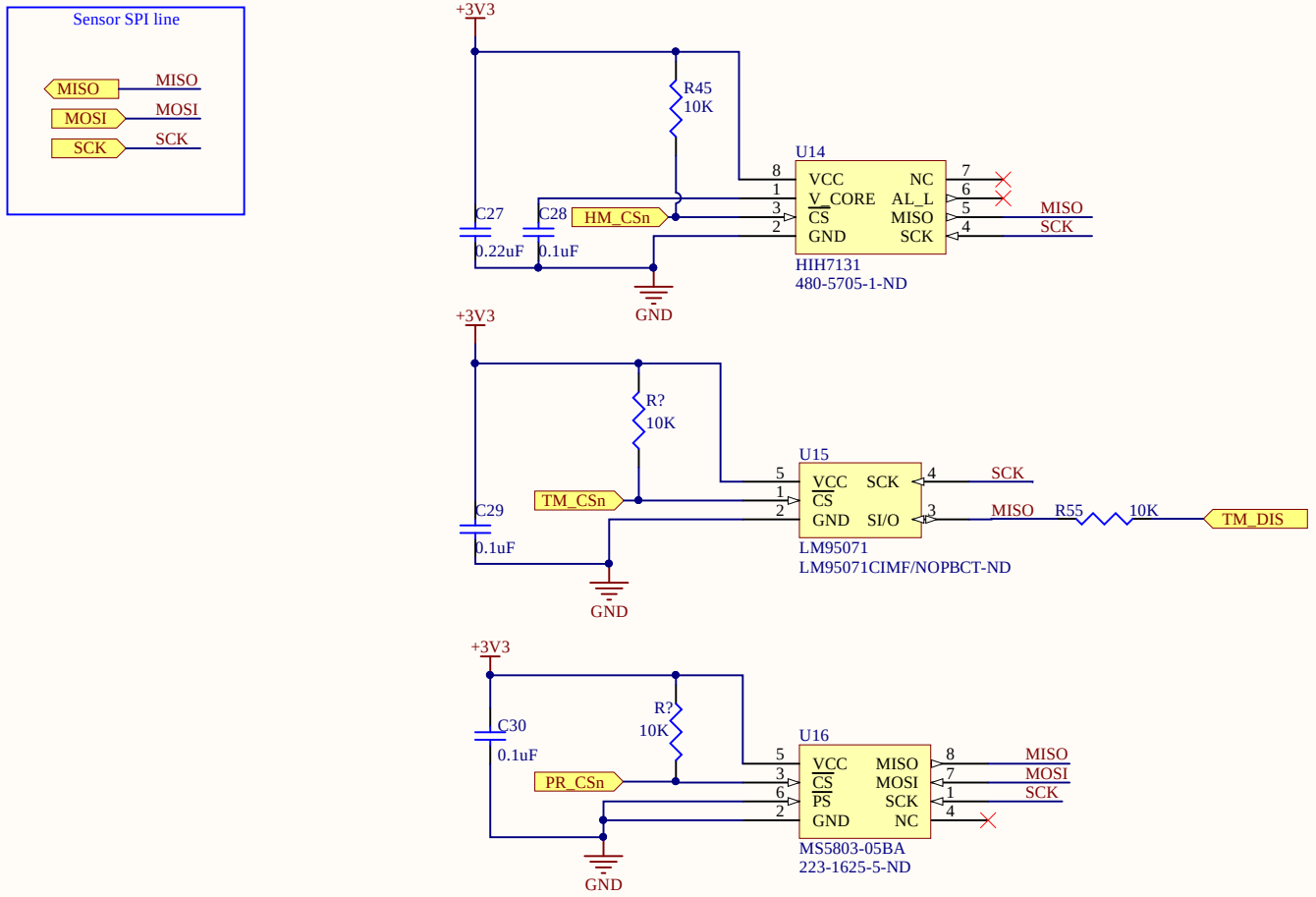
Title		
Size: A4	Number	Revision
Date: 2019-07-17	Sheet of	
File: C:\Users\..\motor_control.SchDoc	Drawn By:	

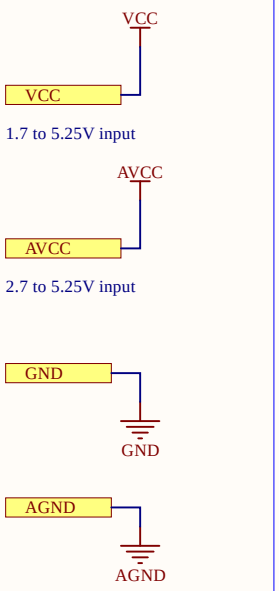

EPS-PAY interface for communication with OBC
P?
+BATT
+3V3
GND
MISO_A
EPS_RST
OBC_RST
MOSI_A/TX
SCK_A/RX
PAY_RST
CANH
CANL
HDR1X15
MCU_64M1
micro-circuit-ATMEGA64M1.SchDoc
+3V3
GND
VCC3V3
GND
TXCAN
RXCAN
LED_BUF_EN_N
LED_BUF_IN4
LED_BUF_IN5
LED_BUF_IN6
PD0
PD1
PD5
PD6
PD7
PEX_CSn_MOTOR
PEX_RSTn_MOTOR
MISO
MOSI
SCK
PC0
PC1
PC4
PC5
PC6
PC7
LBK
HEATER_CTRL
HM_CSn
TM_CSn
PR_CSn
THM_DIS
MISO_A
MOSI_A/TX
SCK_A/RX
PB2
PB3
PB4
PB5
PB6
PEX_CSn_THER
PEX_RSTn_THER
STEP
INT_MOTOR
ADC_CSn
RSTn
RST_N
Environmental_Sensors
sensors.SchDoc
HM_CSn
TM_CSn
THM_DIS
PR_CSn
MISO
MOSI
SCK
CAN_Transciever
can-SN65HVD233.SchDoc
TXCAN
RXCAN
LBK
TXD
RXD
RS
CANH
CANL
VCC
GND
3V3
Motors_Overview
motors-overview.SchDoc
INT_MOTOR
PEX_RSTn_MOTOR
PEX_CSn_MOTOR
POS_PHT_MOTOR1
POS_PHT_MOTOR2
PEX_MOTOR_GPIO1
PEX_MOTOR_GPIO2
BOOST_IOUT_A
Thermal_System_Overview
thermal-system-overview.SchDoc
PEX_THERM_GPIO1
PEX_THERM_GPIO2
PEX_THERM_GPIO3
PEX_THERM_GPIO4
ADC_CH12
ADC_CH13
ADC_CH14
ADC_CH15
HEATER_CTRL
PAY-SSM POWER SYSTEM
+10V
Boost_Converter
boost-converter.SchDoc
10VOUT
BOOST_IOUT
Current_Regulation
current-regulation.SchDoc
10V_MCU_EN
+10V_REG
+LOAD_PWR
LOAD_GND
Optical_System_Overview
File Name



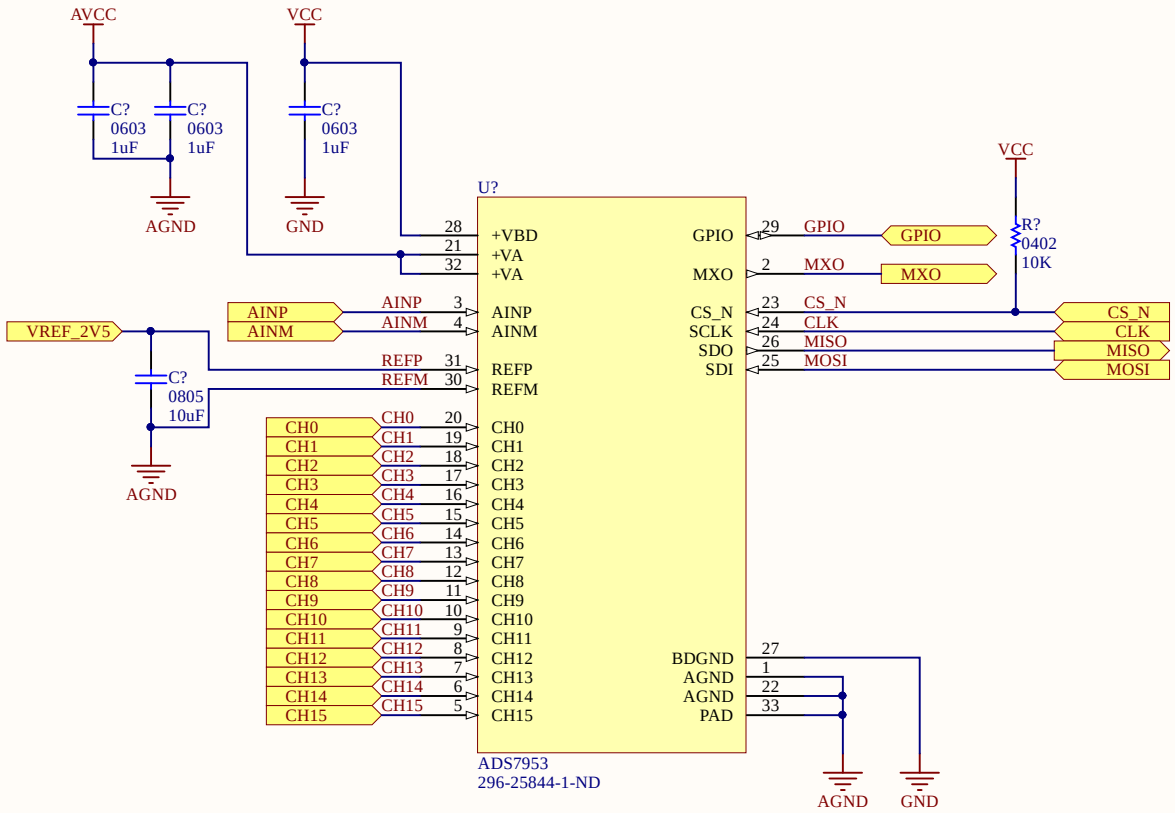
Title		
Size A4	Number	Revision
Date: 2019-07-17		Sheet of
File: C:\Users\..\sensors.SchDoc		Drawn By:

POWER INPUTS

AVCC >= VCC (pg 51)



See pg 53, each +VA pin should have it's own 1uF

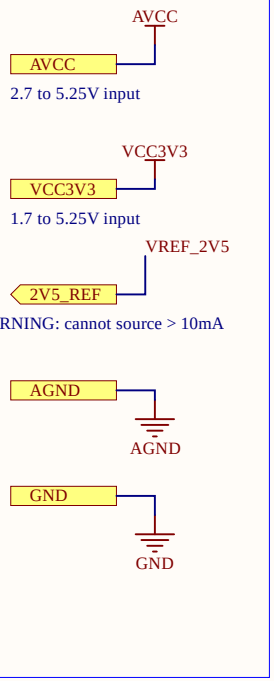


16 CHANNEL ADC

Title	adc-ADS7953.SchDoc	
Size: A4	Number: PCBS-COMMON	Revision: 1.1
Date: 2019-07-17	Sheet * of *	
File: C:\Users\..\adc-ADS7953.SchDoc	Drawn By: Dylan Vogel	

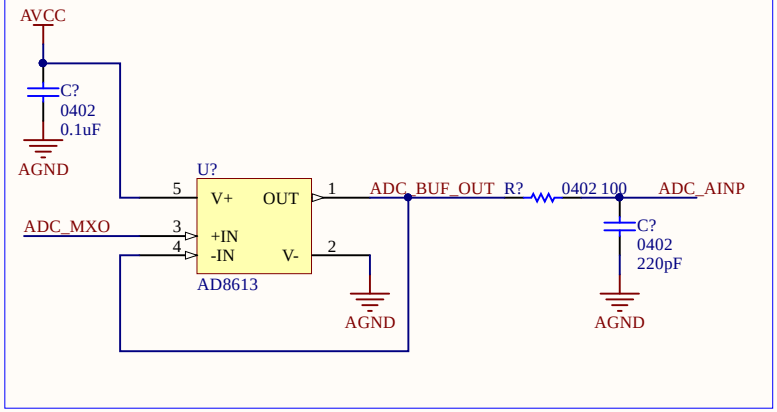
POWER PORTS

AVCC >= VCC (pg 51)



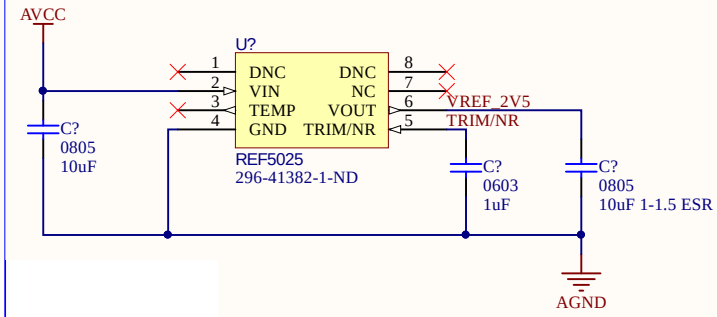
ADC INPUT BUFFER

See pg. 50 for discussion of unity buffer design procedure

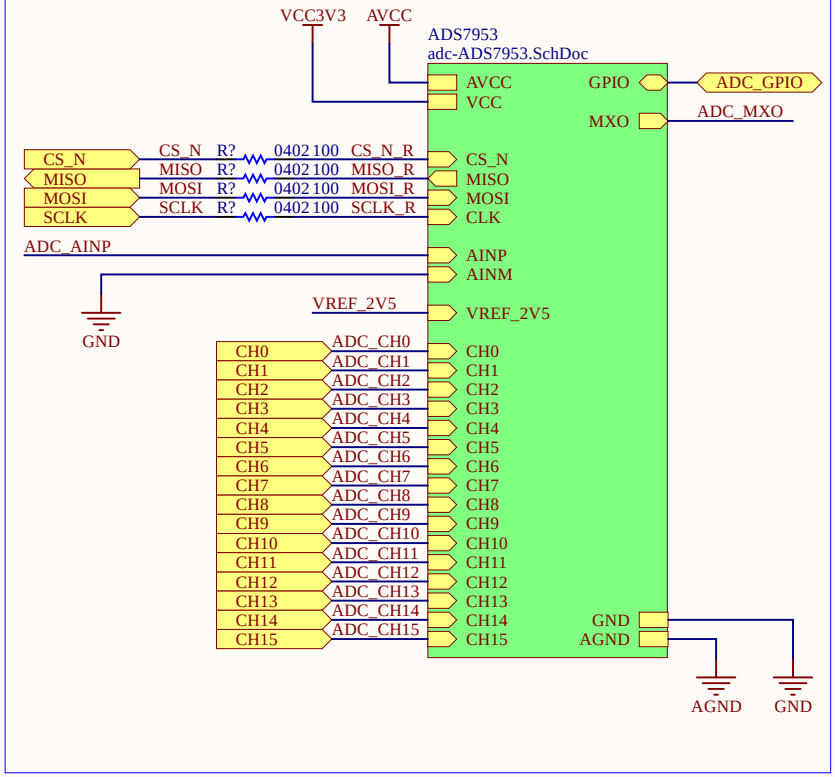


2V5 REFERENCE

Output cap should have ESR from 1 - 1.5 ohm (see pg. 21)



ADC



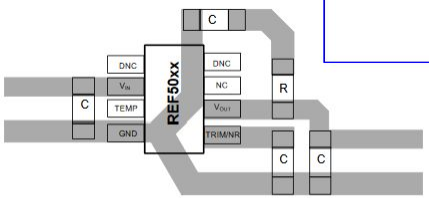


Figure 44. Layout Example

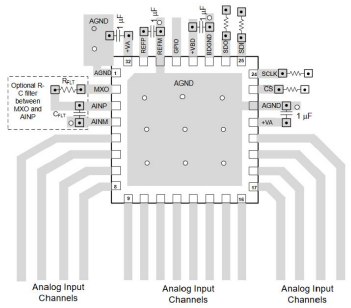
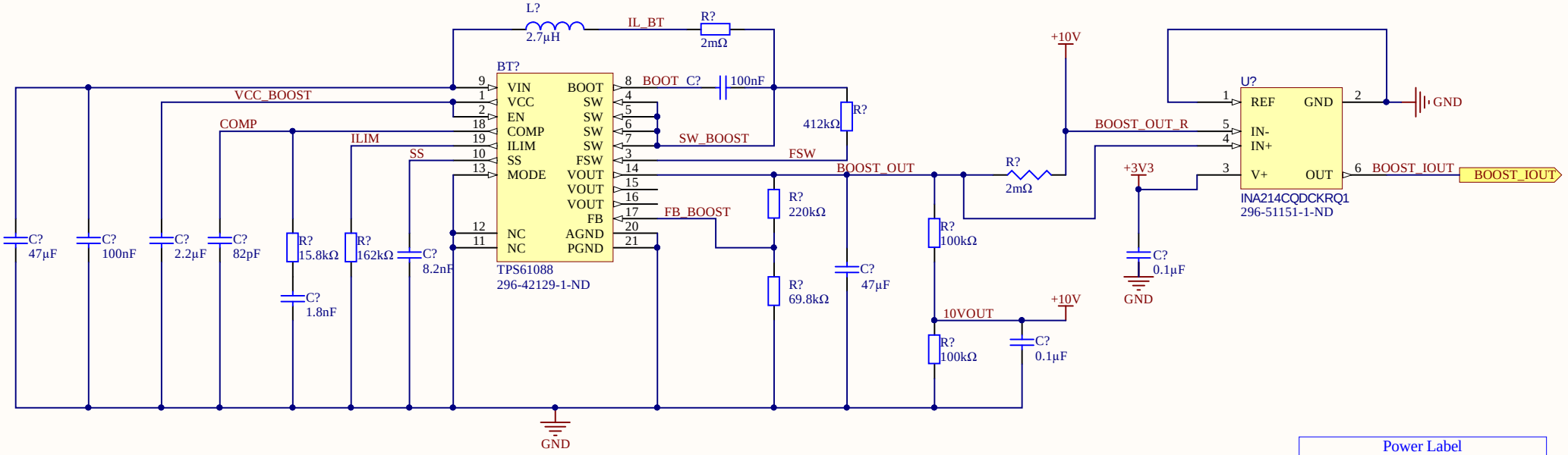


Figure 70. Recommended Layout for the VQFN Packaged Device

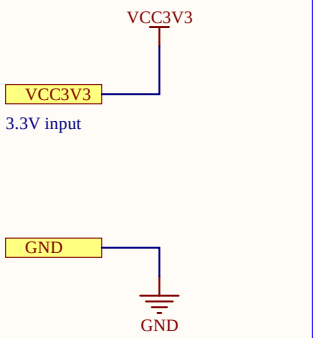
This schematic implements the ADS7953 analog-to-digital converter with a 2.5V reference and a unity-gain buffer on the output of the internal multiplexer.
- Recommended input impedance should be < 1K. Higher source impedances possible with slower sampling.
- Breaks out 2V5 for use as reference outside the circuit
- All necessary bypassing and pull-ups implemented in the ADS7953 schematic
- In most low-performance applications, AVCC and VCC can be tied together
- In the layout, the pins tied to AGND should be put on a local GND pour and then tied to the global ground plane with low-impedance.
- 100 ohm resistors on the SPI input help to isolate the ADC from digital noise

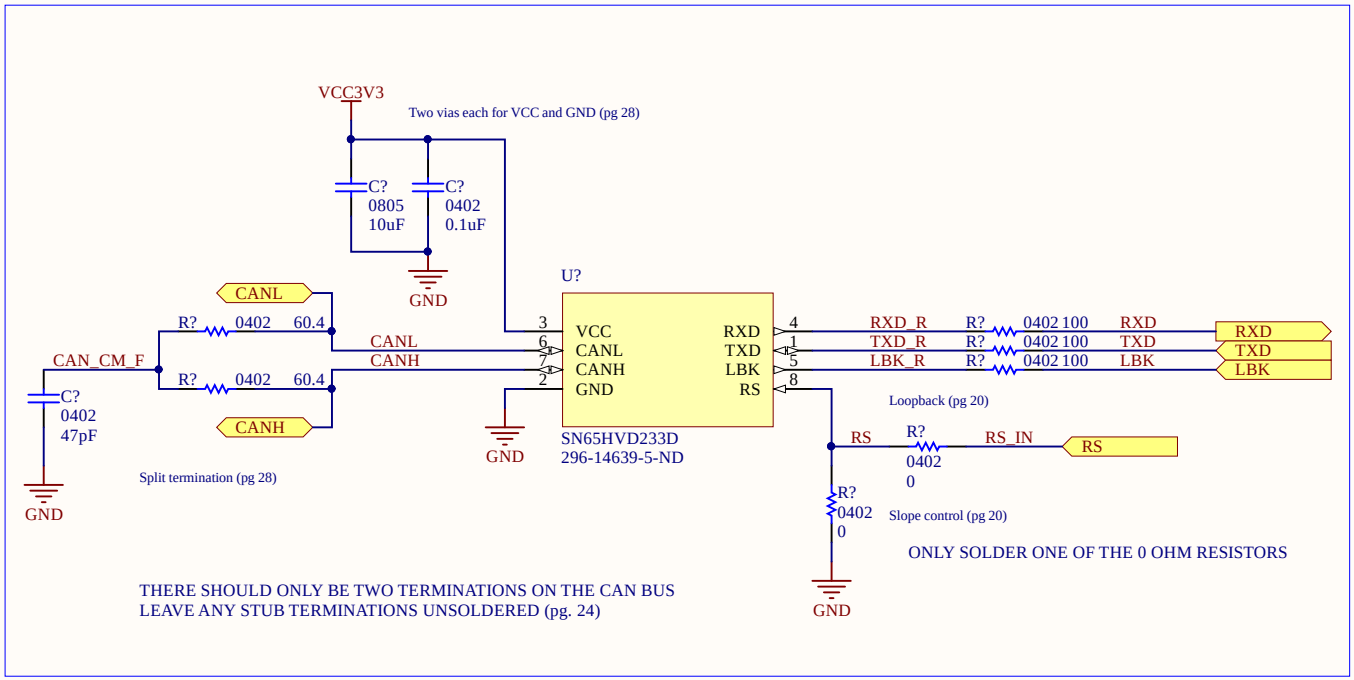
Title	adc-circuit-ADS7953.SchDoc	
Size: A4	Number: PCBS-COMMON	Revision: 1.1
Date: 2019-07-17	Sheet * of *	
File: C:\Users\..\adc-circuit-ADS7953.SchDoc	Drawn By: Dylan Vogel	



Title		
Size: A4	Number	Revision
Date: 2019-07-17		Sheet of
File: C:\Users\..\boost-converter.SchDoc		Drawn By:

POWER INPUT





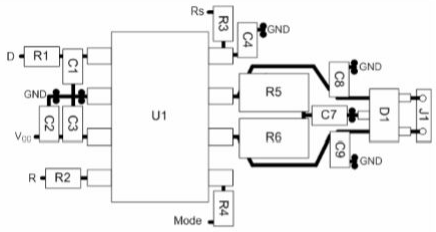


Figure 41. Layout Example Schematic

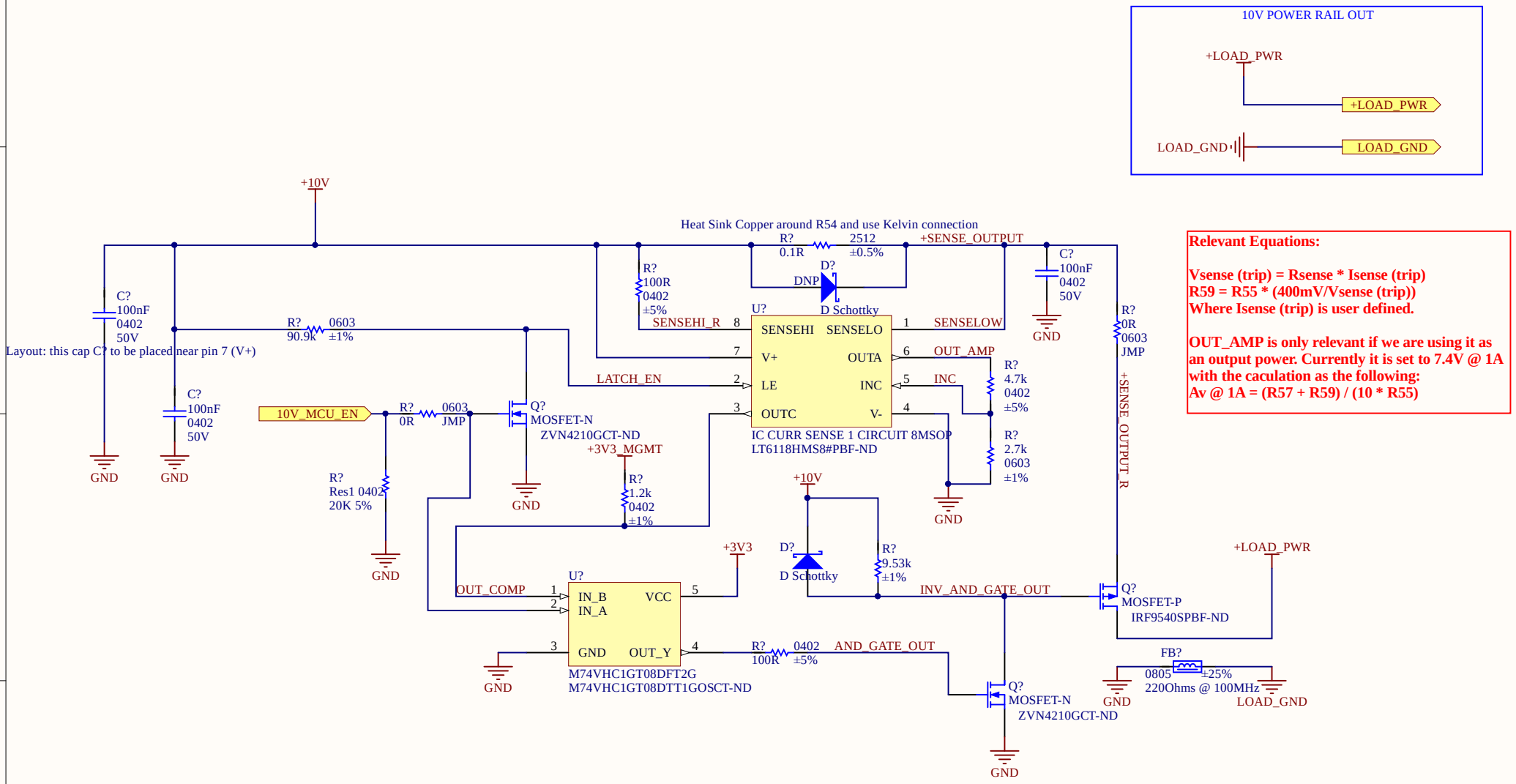
See pg. 28 of the datasheet for layout guidelines

This schematic implements the SN65HVD233 CAN transciever with loopback control and two options for slope control.

A 0 Ohm resistor can be soldered to GND to permanently put the device in high speed mode (20 V / us slew), or a 0 Ohm resistor can be soldered to the RS port to control the device via an external microcontroller. Connecting the RS pin to a microcontroller allows the device to be put into low-power mode by setting the RS pin high.

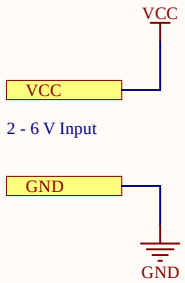
- Device is meant to be used in a 3.3 V system
- 100 Ohm current limiting resistors placed on the digital lines to minimize digital noise to the device
- Only two CAN transcievers on the bus should have 120 ohm terminations. Other devices should be placed on 'stub' networks where the terminations are left unsoldered

Title	can-SN65HVD233.SchDoc		
Size	A4	Number	PCBS-COMMON
Revision	1.2		
Date:	2019-07-17	Sheet * of *	
File:	C:\Users\..\can-SN65HVD233.SchDoc	Drawn By:	Dylan Vogel

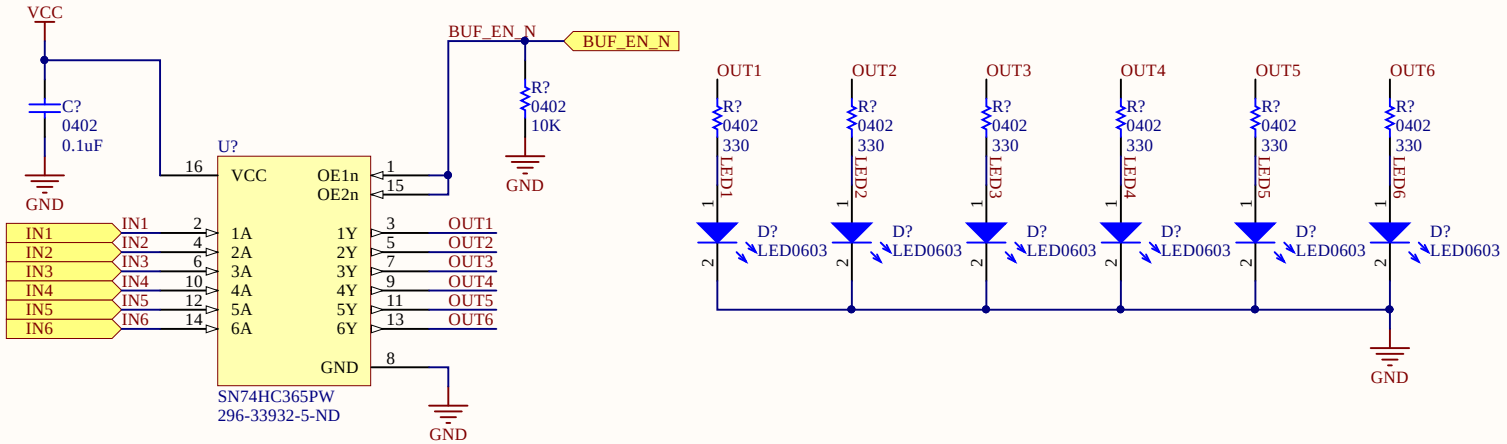

10V POWER RAIL OUT
+LOAD_PWR
+LOAD_PWR
LOAD_GND
LOAD_GND
Relevant Equations:
Vsense (trip) = Rsense * Isense (trip)
R59 = R55 * (400mV/Vsense (trip))
Where Isense (trip) is user defined.
OUT_AMP is only relevant if we are using it as an output power. Currently it is set to 7.4V @ 1A with the caculation as the following:
Av @ 1A = (R57 + R59) / (10 * R55)
+10V
Heat Sink Copper around R54 and use Kelvin connection
R? 0.1R 2512 ±0.5%
+SENSE_OUTPUT
C? 100nF 0402 50V
R? 100R 0402 ±5%
D? DNP
D Schottky
U?
SENSEHI_R
SENSEHI
SENSELO
SENSELOW
V+
OUTA
OUT_AMP
LATCH_EN
LE
INC
INC
OUTC
V-
IC CURR SENSE 1 CIRCUIT 8MSOP
LT6118HMS8#PBF-ND
R? 4.7k 0402 ±5%
R? 2.7k 0603 ±1%
R? 0R 0603 JMP
+SENSE_OUTPUT_R
C? 100nF 0402 50V
Layout: this cap C? to be placed near pin 7 (V+)
R? 90.9k 0603 ±1%
C? 100nF 0402 50V
10V_MCU_EN
R? 0R 0603 JMP
Q? MOSFET-N ZVN4210GCT-ND
+3V3_MGMT
R? Res1 0402 20K 5%
R? 1.2k 0402 ±1%
GND
+10V
D? D Schottky
R? 9.53k ±1%
+3V3
U?
OUT_COMP
IN_B
IN_A
VCC
GND
OUT_Y
M74VHC1GT08DFT2G
M74VHC1GT08DTT1GOSCT-ND
INV_AND_GATE_OUT
Q? MOSFET-P IRF9540SPBF-ND
+LOAD_PWR
R? 100R 0402 ±5%
AND_GATE_OUT
Q? MOSFET-N ZVN4210GCT-ND
FB? 0805 ±25% 220Ohms @ 100MHz
LOAD_GND
Title
Size A4
Number
Revision
Date: 2019-07-17
Sheet of
File: C:\Users\..\current-regulation.SchDoc
Drawn By:

HEATER_CTRL
HEATER1_EN
HEATER2_EN
HEATER3_EN
HEATER4_EN
HEATER5_EN
HEATER_CTRL
HEATER1_EN
HEATER2_EN
HEATER3_EN
HEATER4_EN
HEATER5_EN
GND
+3V3
+10V_REG
U?
IN_B
IN_A
VCC
GND
OUT_Y
M74VHC1GT08DFT2G
M74VHC1GT08DTT1GOSCT-ND
HEATER1_OUT
HEATER2_OUT
HEATER3_OUT
HEATER4_OUT
HEATER5_OUT
R?
Res1 0402
20K 5%
10K 5%
50K 5%
HEATER_CTRL_AMP
VCC+
IN1-
IN1+
IN2-
IN2+
VCC-
OUT1
OUT2
LM158DT
497-6990-1-ND
Q?
MOSFET-P
DMG2305UX-13DICT-ND
HEATER1_PWR
HEATER2_PWR
HEATER3_PWR
HEATER4_PWR
HEATER5_PWR
simple amplifier, but it's slew rate might be a bit slow (0.6V/us). This means that changing from 3.3V to 10V takes about 11us. PWM rate limit is then 90.9KHz.
Figure 20: Non-inverting DC amplifier
10kΩ
1/2 LM158
R2 1MΩ
R1 10kΩ
+5V
Title
Size A4
Number
Revision
Date: 2019-07-17
Sheet of
File: C:\Users\..\heater-selection.SchDoc
Drawn By:

INPUT POWER



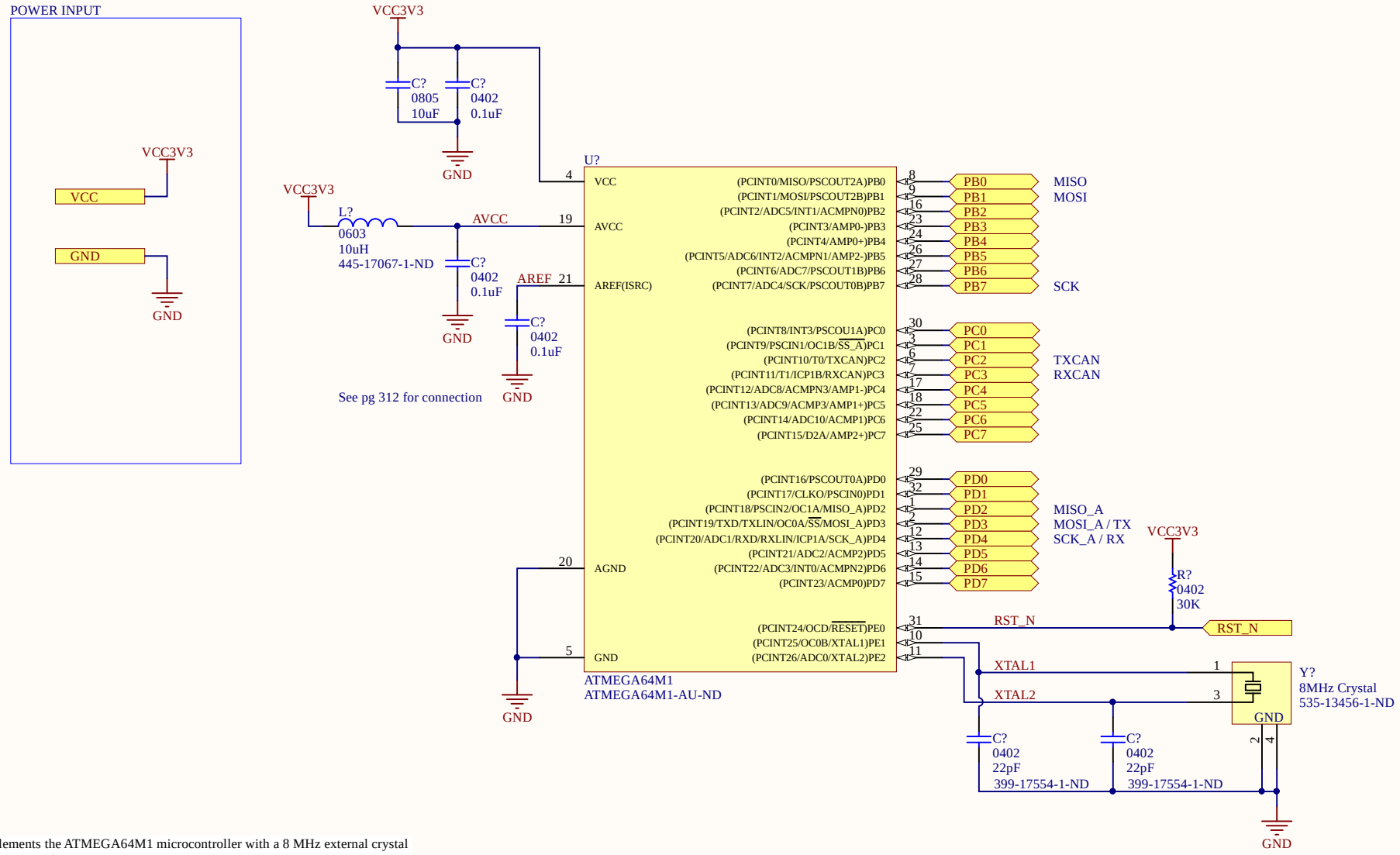
LED BUFFER



This schematic implements the SN74HC365PW non-inverting, tri-state hex buffer as an LED monitoring circuit. Connecting a signal to IN[1:6] will light up the corresponding LED on OUT[1:6].

- The BUF_EN_N input can be connected to a mircocontroller to control the buffer. An input HIGH will set the outputs to high-impedance and disable the LEDs.
- In the schematic symbol which references this schematic sheet, parameters LED[1:6] can be added to specify the colour of each LED. See the micro-circuit common sheet for an example of this.
- Unconnected inputs should be grounded if you don't want random flickering of the LEDs.

Title	led-monitoring-SN74HC365PW.SchDoc	
Size: A4	Number: PCBS-COMMON	Revision: 1.1
Date: 2019-07-17	Sheet * of *	
File: C:\Users\..\led-monitoring-SN74HC365PW.SchDoc	Drawn By: Dylan Vogel	

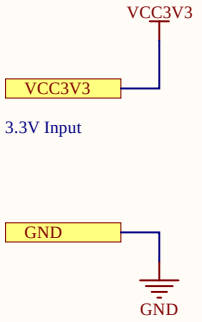


This schematic implements the ATMEGA64M1 microcontroller with a 8 MHz external crystal and necessary power connections.

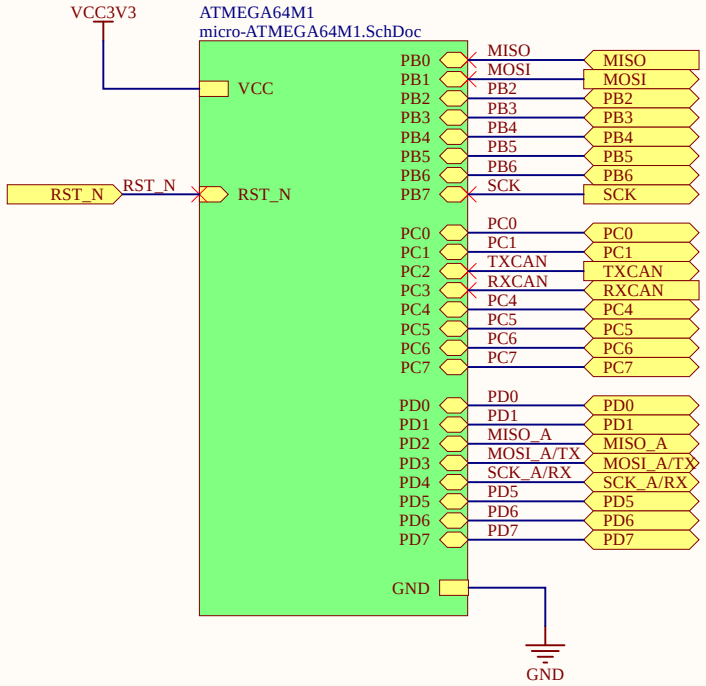
- Crystal is connected in a Pierce configuration, values of the capacitors were calculated based on the capacitance of the crystal and ESR.
- I would read through 18.5.2 and 18.6.2 of the complete 64M1 datasheet if you're interested in the motivation behind the ADC input connections. They recommend connecting AVCC through a RC lowpass network to minimize noise.
- If the ADC functionality of the device is used, either AVCC or the internal 2.56 V source can be seleted in software as the reference voltage.

Title	micro-ATMEGA64M1.SchDoc	
Size: A4	Number: PCBS-COMMON	Revision: 1.1
Date: 2019-07-17	Sheet * of *	
File: C:\Users\..\micro-ATMEGA64M1.SchDoc	Drawn By: Dylan Vogel	

POWER INPUTS

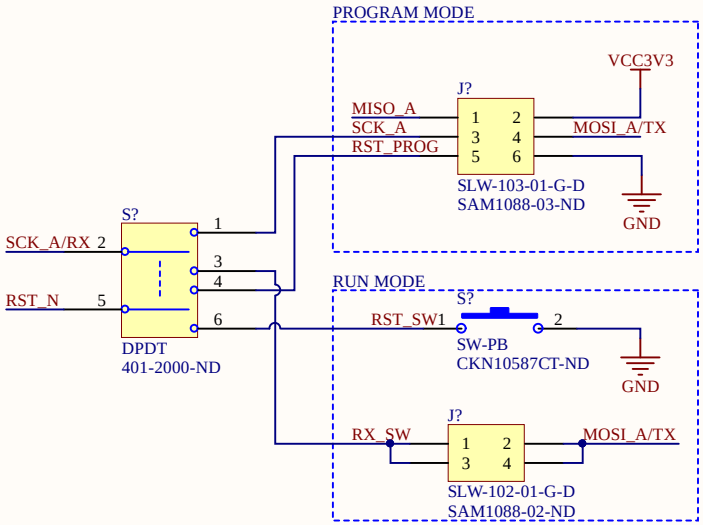


ATMEGA32M1

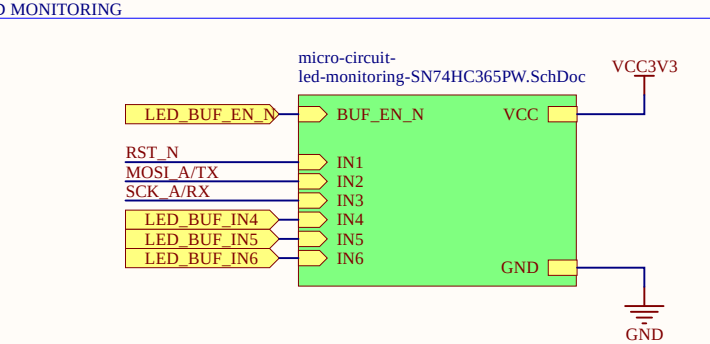


Specific No-ERCs placed for I/O Port and Bidirectional Sheet Entry

MODE SELECT CIRCUITRY



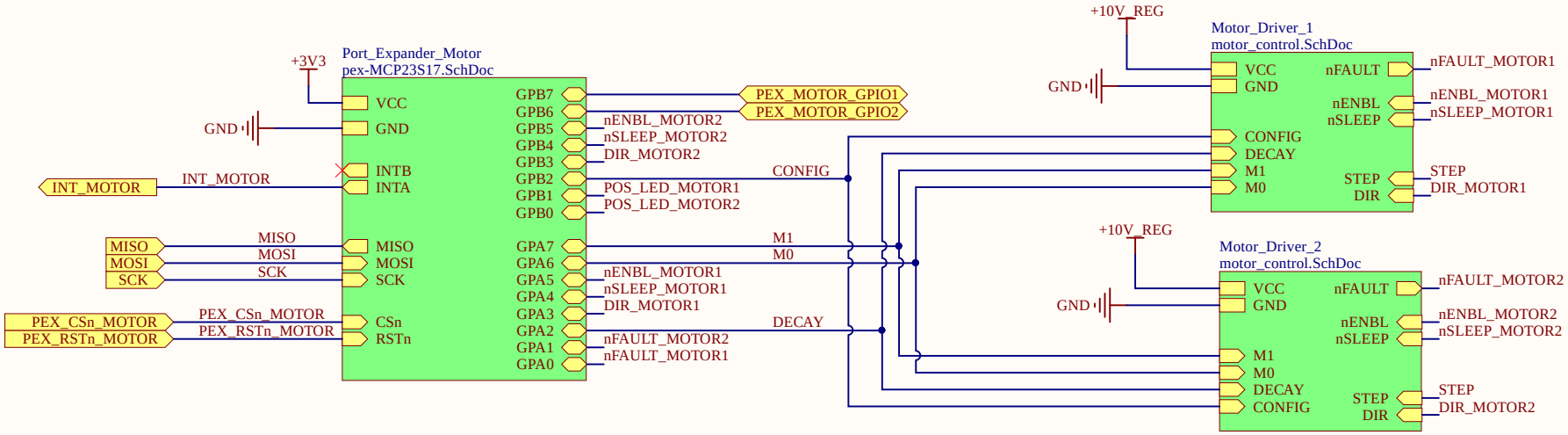
LED MONITORING



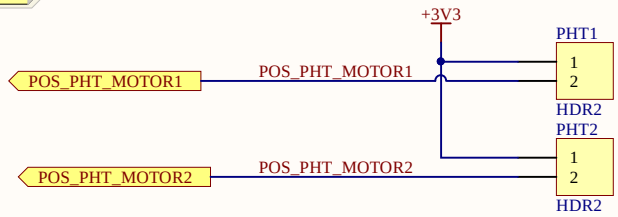
This schematic extends the functionality already included in the micro-ATMEGA32M1 schematc, adding a mode select switch, programming header, reset button and LED indication for TX, RX and RSTn.

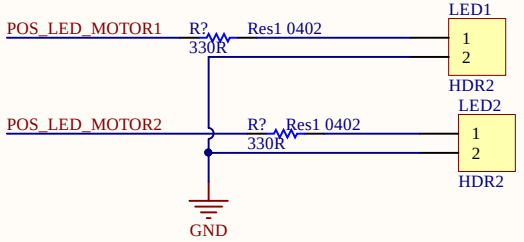
- IN[4:6] of the LED buffer have been left unconnected, but are broken out on ports LED_BUF_IN[4:6]. They can be connected in the schematic which includes this sheet to monitor up to an additional 3 lines. Highly recommend more blinking lights.

Title	micro-circuit-ATMEGA64M1.SchDoc	
Size: A4	Number: PCBS-COMMON	Revision: 1.1
Date: 2019-07-17	Sheet *	of *
File: C:\Users\..\micro-circuit-ATMEGA64M1.SchDoc	Drawn By:	Dylan Vogel



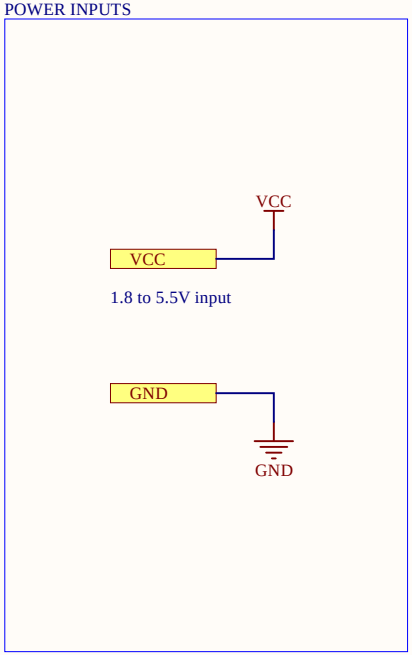
Need 4 limit switches implementation

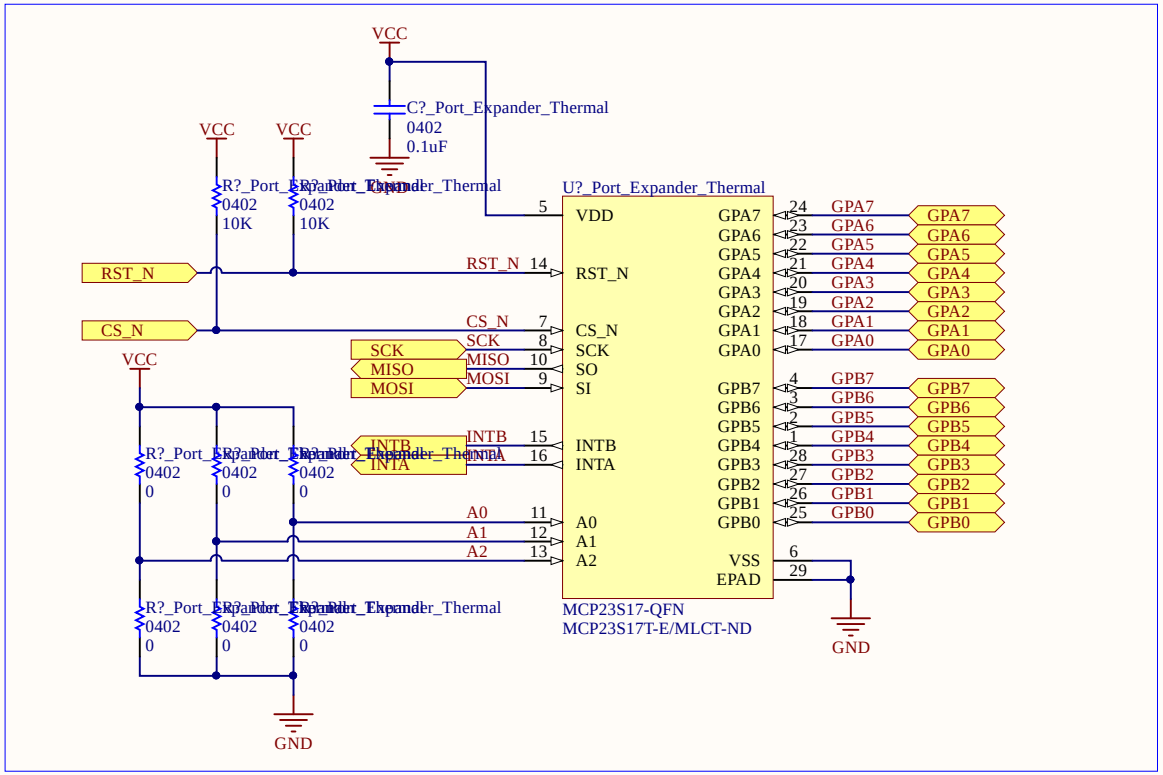




Title		
Size: A4	Number	Revision
Date: 2019-07-17	Sheet of	
File: C:\Users\..\motors-overview.SchDoc	Drawn By:	

POWER INPUTS





ADDRESS:

CHANNEL SELECTION

ONLY SOLDER ONE 0 OHM FROM EACH PAIR
PEX ADDRESS = A2 A1 A0
VCC == 1 GND == 0

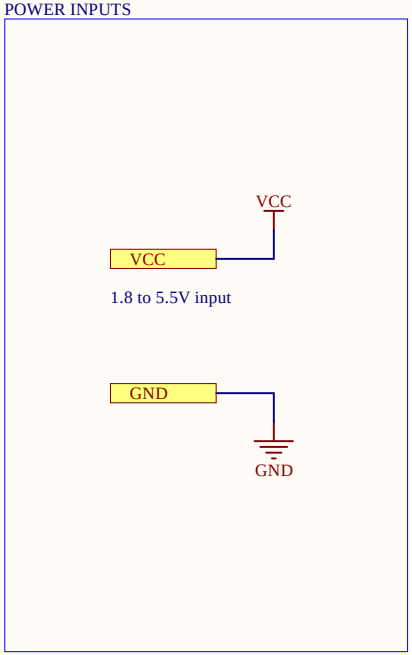
This schematic implements the MCP23S17 SPI port expander, and does some common-sense things like adding a bypass capacitor to the power supply and pull-up resistors to RST_N and CS_N.

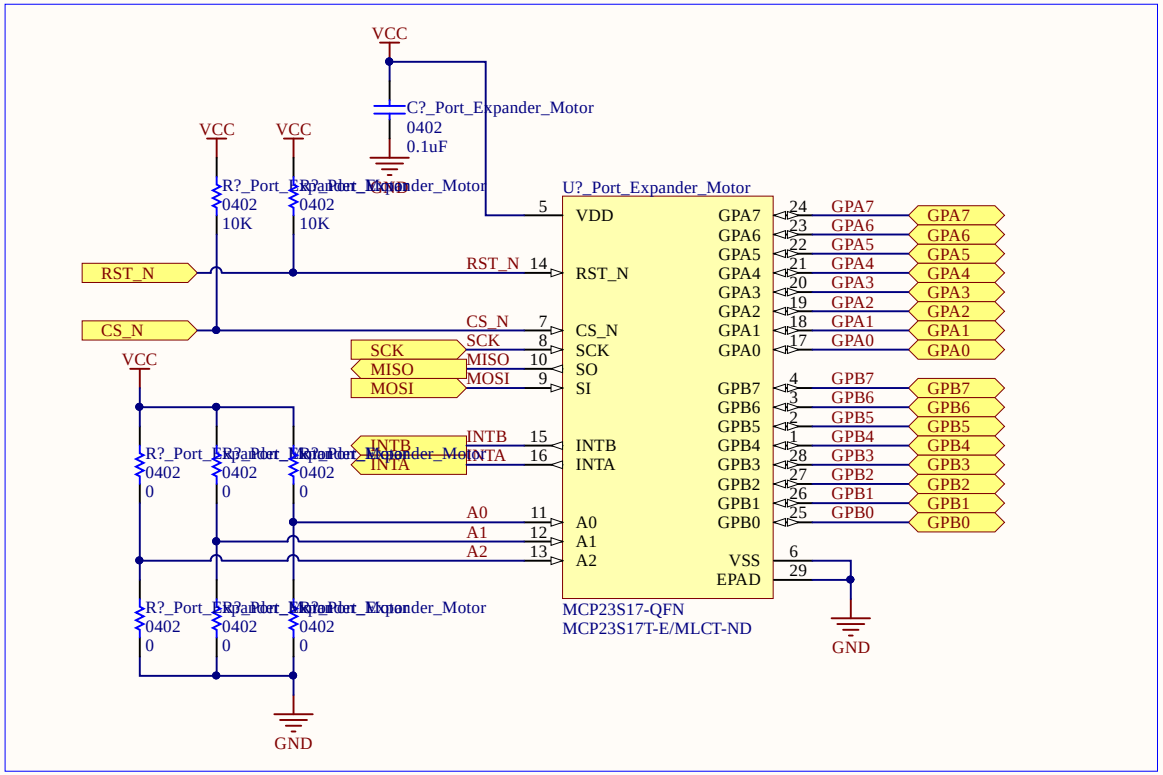
Multiple port expanders can be connected to the same CS_N line, and accessed via a device address that is used during software communication. This address is set in hardware via the A2, A1 and A0 pins. Soldering a 0 ohm resistor to VCC will set that bit to 1, and soldering to GND will set that bit to 0.

In the schematic which includes this file, you should make some note of the relevant hardware address that should be soldered during manufacturing.

Title	pex-MCP23S17.SchDoc	
Size: A4	Number: PCBS-COMMON	Revision: 1.1
Date: 2019-07-17	Sheet * of *	
File: C:\Users\..\pex-MCP23S17.SchDoc	Drawn By: Dylan Vogel	

POWER INPUTS





ADDRESS:

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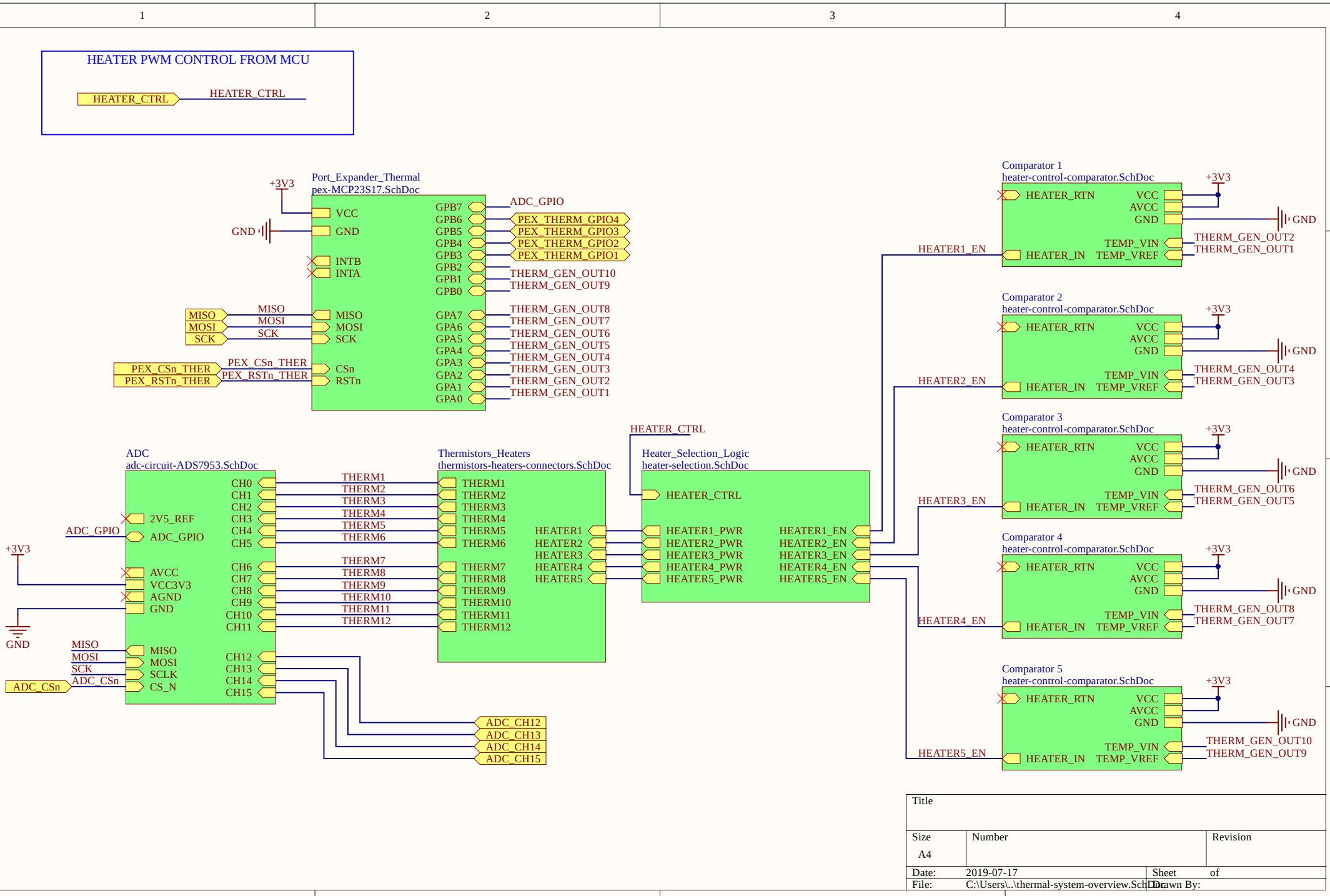
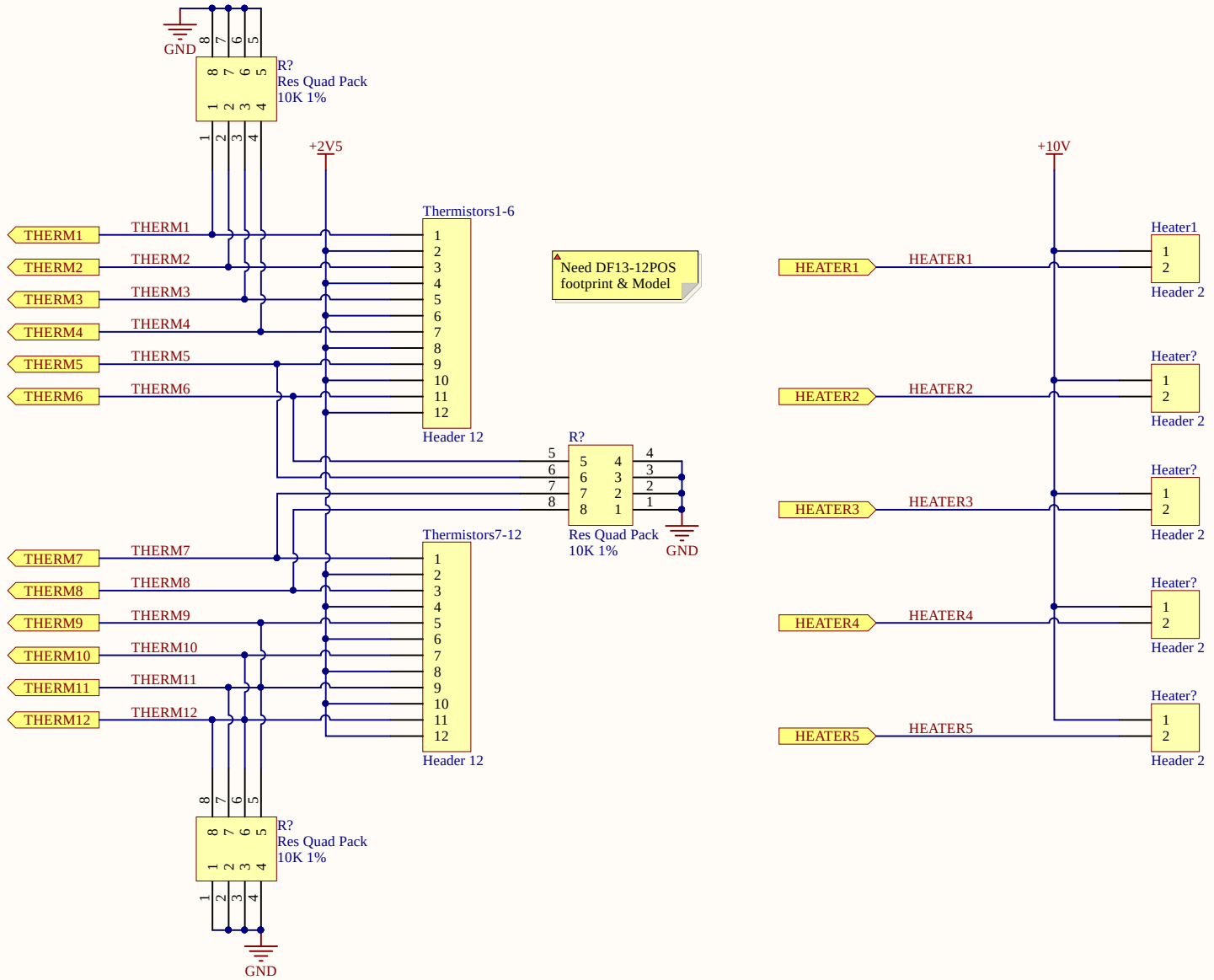
Title	pex-MCP23S17.SchDoc	
Size: A4	Number: PCBS-COMMON	Revision: 1.1
Date: 2019-07-17	Sheet * of *	
File: C:\Users\..\pex-MCP23S17.SchDoc	Drawn By: Dylan Vogel	


HEATER PWM CONTROL FROM MCU
HEATER_CTRL
HEATER_CTRL
Port_Expander_Thermal
pex-MCP23S17.SchDoc
+3V3
GND
VCC
GND
INTB
INTA
MISO
MOSI
SCK
CSn
RSTn
GPB7
GPB6
GPB5
GPB4
GPB3
GPB2
GPB1
GPB0
GPA7
GPA6
GPA5
GPA4
GPA3
GPA2
GPA1
GPA0
ADC_GPIO
PEX_THERM_GPIO4
PEX_THERM_GPIO3
PEX_THERM_GPIO2
PEX_THERM_GPIO1
THERM_GEN_OUT10
THERM_GEN_OUT9
THERM_GEN_OUT8
THERM_GEN_OUT7
THERM_GEN_OUT6
THERM_GEN_OUT5
THERM_GEN_OUT4
THERM_GEN_OUT3
THERM_GEN_OUT2
THERM_GEN_OUT1
PEX_CSn_THER
PEX_RSTn_THER
ADC
adc-circuit-ADS7953.SchDoc
2V5_REF
ADC_GPIO
AVCC
VCC3V3
AGND
GND
MISO
MOSI
SCLK
CS_N
ADC_CSn
CH0
CH1
CH2
CH3
CH4
CH5
CH6
CH7
CH8
CH9
CH10
CH11
CH12
CH13
CH14
CH15
THERM1
THERM2
THERM3
THERM4
THERM5
THERM6
THERM7
THERM8
THERM9
THERM10
THERM11
THERM12
Thermistors_Heaters
thermistors-heaters-connectors.SchDoc
HEATER1
HEATER2
HEATER3
HEATER4
HEATER5
HEATER_CTRL
Heater_Selection_Logic
heater-selection.SchDoc
HEATER1_PWR
HEATER2_PWR
HEATER3_PWR
HEATER4_PWR
HEATER5_PWR
HEATER1_EN
HEATER2_EN
HEATER3_EN
HEATER4_EN
HEATER5_EN
ADC_CH12
ADC_CH13
ADC_CH14
ADC_CH15
Comparator 1
heater-control-comparator.SchDoc
Comparator 2
heater-control-comparator.SchDoc
Comparator 3
heater-control-comparator.SchDoc
Comparator 4
heater-control-comparator.SchDoc
Comparator 5
heater-control-comparator.SchDoc
HEATER_RTN
HEATER_IN
VCC
AVCC
GND
TEMP_VIN
TEMP_VREF
HEATER1_EN
HEATER2_EN
HEATER3_EN
HEATER4_EN
HEATER5_EN
THERM_GEN_OUT2
THERM_GEN_OUT1
THERM_GEN_OUT4
THERM_GEN_OUT3
THERM_GEN_OUT6
THERM_GEN_OUT5
THERM_GEN_OUT8
THERM_GEN_OUT7
THERM_GEN_OUT10
THERM_GEN_OUT9
Title
Size
A4
Number
Revision
Date:
2019-07-17
Sheet
of
File:
C:\Users\..\thermal-system-overview.SchDoc
Drawn By:



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Size: A4	Number	Revision
Date: 2019-07-17	Sheet of	
File: C:\Users\..\thermistors-heaters-connectors.SchDoc	Drawn By:	