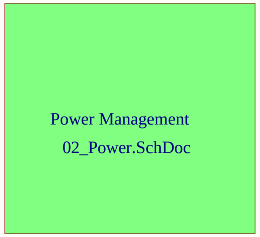
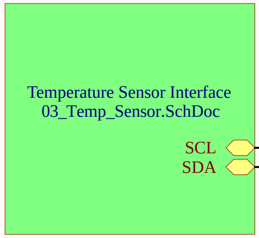
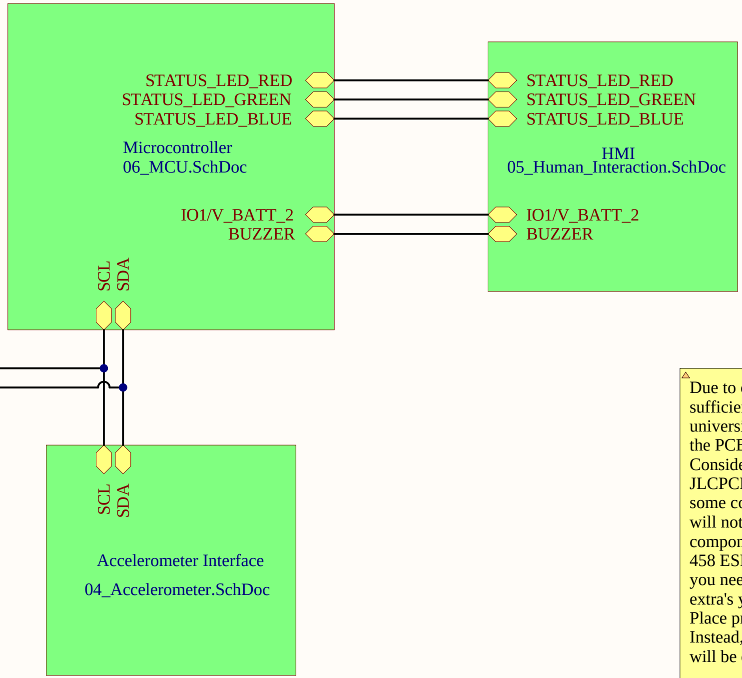
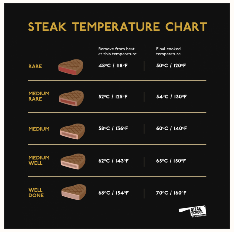
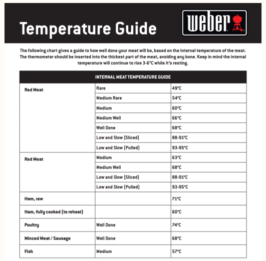










Product Specifications:
Battery Life: 2 hours

Temperature sensing range (max): 400°C (or roughly 350°C)

Module operating temperature range: roughly 60°C ambient on outside of module. With heat insulation in place, hopefully reduce ambient temperature to a max of 40°C (possibly lower)

Sensing accuracy (max): ±1°C (since meat has a 5°C range between doneness levels)

Interaction: rocker power switch, LEDs to indicate when grill needs to be turned, connect to mobile through WiFi and display GUI, run HTML web app with arelevant information and selection of presets

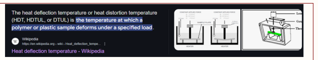
Accelerometer: to sense when the grid has been flipped

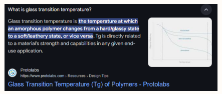
Storage: SD card

Due to complexity of the board and size constraints, a 2- layer board will not be sufficient for this project (which is what is available if I make it at the university), so the PCB will need to be made elsewhere. JLCPCB is chosen as the PCB manufacturing company.
Consideration was taken to order a fully, or partially, populated board from JLCPCB to save time and insure correct soldering. But JLCPCB doesn't have some components, the main one being the ESP32-C6-MINI-H8, and the board will not be able to go in a reflow oven again as this will damage the components (being heated a second time). Another thing is that a minimum of 458 ESP32 IC's need to be bought for some reason. Also, through JLCPCB, you need to order extra components for "attrition quantity", which is basically extra's you need to get in case components get lost or are damaged in the Pick n Place procedure.
Instead, the PCB will still be ordered from JLCPCB, and all the components will be ordered from DigiKey.

Info Regarding 3D printed housing

Temperature reading at the handle of the grid measured to be ±55°C, so the 3D printed housing should have a HDT (Heat Deflection Temperature) comfortably above that to ensure housing does not deform during use of product.
Also have to check the Glass Transition Temperature of the polymer.





https://omni3d.com/blog/filament-temperature-resistance-in-fdm-fff-3d-printing/

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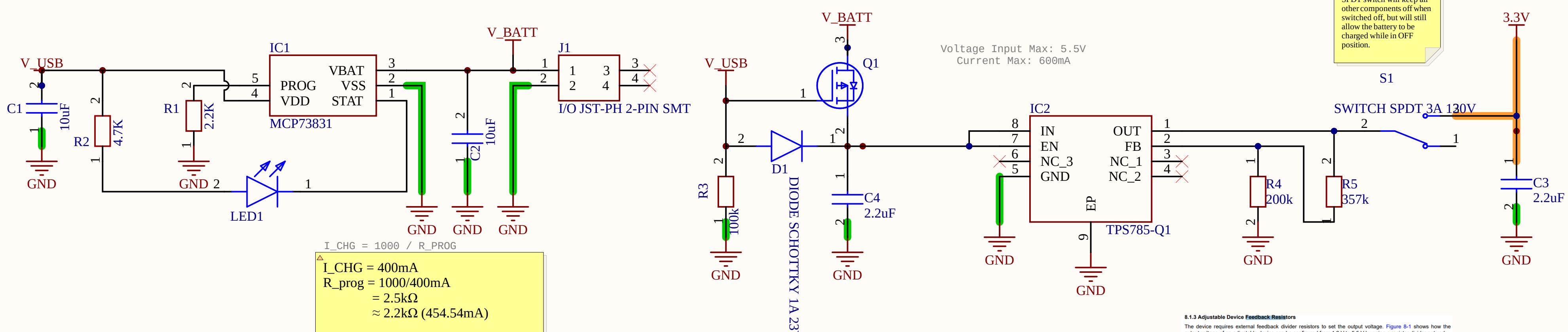
Battery Charger

3V3 Regulator

SPDT switch will keep all other components off when switched off, but will still allow the battery to be charged while in OFF position.



I_CHG = 400mA
R_prog = 1000/400mA
= 2.5kΩ
≈ 2.2kΩ (454.54mA)

For 1200mAh battery the max charge time will be ±2h30m.

8.1.3 Adjustable Device Feedback Resistors

The device requires external feedback divider resistors to set the output voltage. Figure 8-1 shows how the output voltage of an adjustable device can be configured from 1.2 V to 5.5 V by using a resistor divider network.

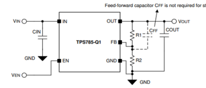


Figure 8-1. Adjustable Operation

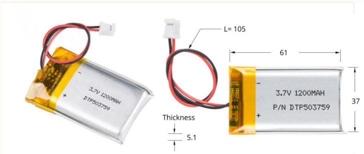
$$V_{OUT} = V_{FB} \times (1 + R_1 / R_2) + I_{FB} \times R_1 \quad (2)$$

V_{FB}	Feedback voltage	Adjustable output only	1.182	1.2	1.218	V
I_{FB}	Feedback pin current	Adjustable output only	–0.05	0.01	0.05	µA

To disregard the effect of the FB pin current error term in Equation 2 and to achieve best accuracy, choose R_2 to be equal to or smaller than 550 kΩ so that the current flowing through R_1 and R_2 is at least 100 times larger than the I_{FB} current listed in the *Electrical Characteristics* table. Lowering the value of R_2 increases the immunity against noise injection. Increasing the value of R_2 reduces the quiescent current for achieving higher efficiency at low load currents. Equation 3 calculates the setting that provides the maximum feedback divider series resistance.

$$(R_1 + R_2) \le V_{OUT} / (I_{FB} \times 100) \quad (3)$$

Vout = 3.3V
R2 = 200k
R1 = 350k → R1 = 357k
Vout_new = 3.342V



Battery LiPo 1200mAh 3.7V

Brand: Generic
Product Code: 503759
Weight: 0.026kg
Product Status : Active

Stock

Warehouse	Stock Status	Location
Centurion	In Stock	BAT-F
Stellenbosch	In Stock	D6007

We ship free of charge between branches to complete your order.

R68.00 (Inc Tax: R78.20)

Qty
1
Add to Cart

Battery has about 300 cycles. Include easy replacable battery slot in final design for if customers battery dies then it can be replaced.
Aim to have max power consumption of entire system to be 500mA so that product can last 2 hours of use.

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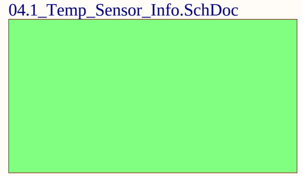
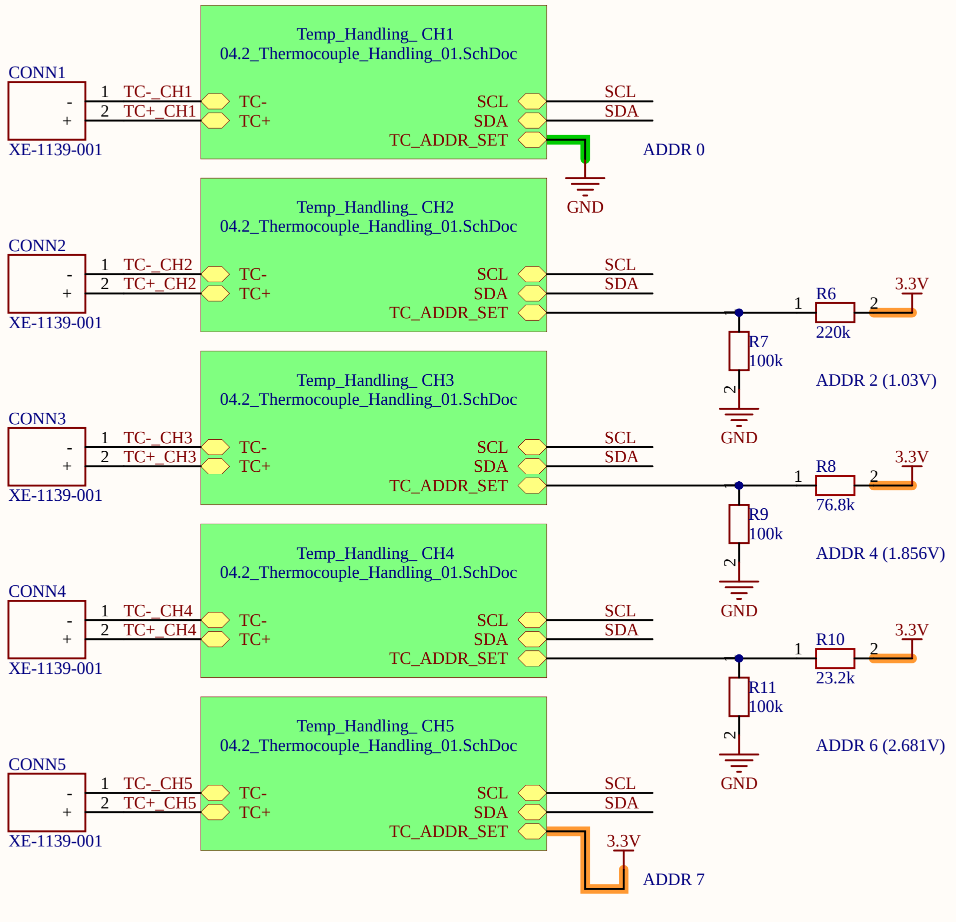
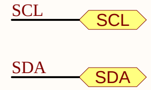
U_04.1_Temp_Sensor_Info
04.1_Temp_Sensor_Info.SchDoc








```
ADDR uses an internal ADC to check
the voltage on the pin to determine
the last three bits of the 7-bit I2C
address (1:1:0:0:A2:A1:A0).

Setting ADDR to GND = 1:1:0:0:0:0:0
Setting ADDR to VIN = 1:1:0:0:1:1:1

For other values and resistor divider
setup, see the DS for details.
```

I^2C Address Selection Levels (Note 1)						
Command Byte [1100 000x]	V_{ADDR}	GND	—	—	V	Address = 0
Command Byte [1100 001x]		V_{ADDR_L} (Note 2)	V_{ADDR_TYP} (Note 2)	V_{ADDR_H} (Note 2)		Address = 1
Command Byte [1100 010x]						Address = 2
Command Byte [1100 011x]						Address = 3
Command Byte [1100 100x]						Address = 4
Command Byte [1100 101x]						Address = 5
Command Byte [1100 110x]						Address = 6
Command Byte [1100 111x]		—	—	V_{DD}		Address = 7

Note 1 The ADDR pin can be tied to V_{DD} or V_{SS}. For additional addresses, a resistive divider network can be used to set voltage levels that are rationed to V_{DD}. The device supports up to eight levels (see Section 6.3.1 "I2C Addressing" for recommended resistor values).

2 V_{ADDR_TYP} = Address * $V_{DD}/8 + V_{DD}/16$,
$V_{ADDR\_L} = V_{ADDR\_TYP} - V_{DD}/32$ and
$V_{ADDR\_H} = V_{ADDR\_TYP} + V_{DD}/32$ (where: Address = 1, 2, 3, 4, 5, 6).

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A

Option 1

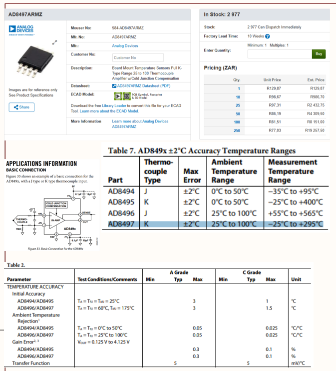
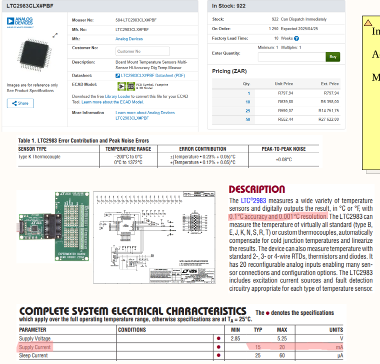


Table 7. AD849x ±2°C Accuracy Temperature Ranges

Part	Thermo-couple Type	Max Error	Ambient Temperature Range	Measurement Temperature Range
AD8494	J	±2°C	0°C to 50°C	−35°C to +95°C
AD8495	K	±2°C	0°C to 50°C	−25°C to +400°C
AD8496	J	±2°C	25°C to 100°C	+55°C to +565°C
AD8497	K	±2°C	25°C to 100°C	−25°C to +295°C

Accuracy: ±2°C
Gain error

Option 4



DESCRIPTION

The LTC®2983 measures a wide variety of temperature sensors and digitally outputs the result, in °C or °F with 0.1°C accuracy and 0.001°C resolution. The LTC2983 can measure the temperature of virtually all standard (type B, E, J, K, N, S, R, T) or custom thermocouples, automatically compensate for cold junction temperatures and linearize the results. The device can also measure temperature with standard 2-, 3- or 4-wire RTDs, thermistors and diodes. It has 20 reconfigurable analog inputs enabling many sensor connections and configuration options. The LTC2983 includes excitation current sources and fault detection circuitry appropriate for each type of temperature sensor.

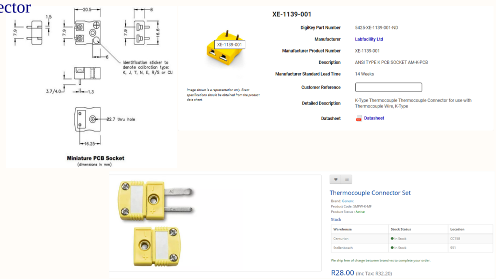
COMPLETE SYSTEM ELECTRICAL CHARACTERISTICS

Interface: SPI

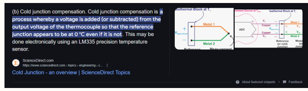
Accuracy: 0.1°C

Multiple inputs: 20 channels

Thermocouple probe connector



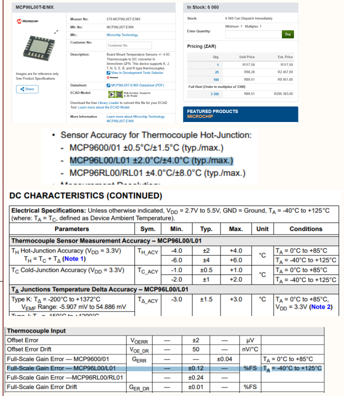
Cold junction compensation



Cold junction compensation is necessary to get accurate readings from thermocouples.

B

Option 2



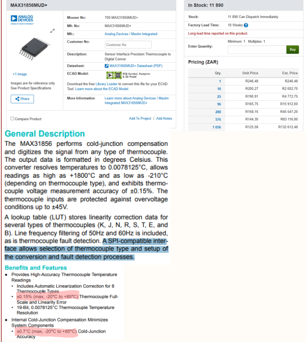
- Sensor Accuracy for Thermocouple Hot-Junction:
  - MCP9600/01 ±0.5°C/±1.5°C (typ./max.)
  - MCP96L00/L01 ±2.0°C/±4.0°C (typ./max.)
  - MCP96RL00/RL01 ±4.0°C/±8.0°C (typ./max.)

DC CHARACTERISTICS (CONTINUED)

Accuracy: ±2.0°C/±4.0°C (typ./max.)

Interface: I2C & SPI

Option 5



General Description

The MAX31856 performs cold-junction compensation and digitizes the signal from any type of thermocouple. The output data is formatted in degrees Celsius. This converter resolves temperatures to 0.0078125°C, allows readings as high as +1800°C and as low as -210°C (depending on thermocouple type), and exhibits thermocouple voltage measurement accuracy of ±0.15%. The thermocouple inputs are protected against overvoltage conditions up to ±45V.

A lookup table (LUT) stores linearity correction data for several types of thermocouples (K, J, N, R, S, T, E, and B). Line frequency filtering of 50Hz and 60Hz is included, as is thermocouple fault detection. A SPI-compatible interface allows selection of thermocouple type and setup of the conversion and fault detection processes.

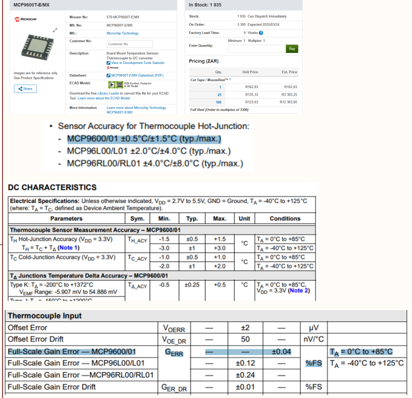
Thermocouple Accuracy: ±0.15% (max, -20°C to +85°C)
Thermocouple FullScale and Linearity Error
CJC Accuracy: ±0.7°C (max, -20°C to +85°C) Cold-Junction Accuracy

Ineface: SPI
Want to interface with I2C so this will not be viable as an option. Price is also a factor as three of these IC's are needed.

Another option is to get an analog amplifier with a separate ADC module (as ESP32 module ADC usually isn't as accurate).
The setback regarding this option is the cumulative cost of getting both an analog thermocouple amplifier and an ADC is more expensive than getting a standalone thermocouple amplifier with built in ADC with I2C

C

Option 3



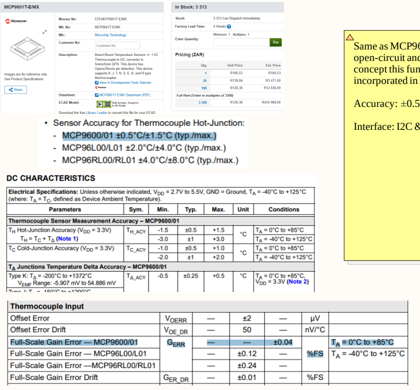
- Sensor Accuracy for Thermocouple Hot-Junction:
  - MCP9600/01 ±0.5°C/±1.5°C (typ./max.)
  - MCP96L00/L01 ±2.0°C/±4.0°C (typ./max.)
  - MCP96RL00/RL01 ±4.0°C/±8.0°C (typ./max.)

DC CHARACTERISTICS

Accuracy: ±0.5°C/±1.5°C (Typ./Max.)

Interface: I2C & SPI

Option 6



- Sensor Accuracy for Thermocouple Hot-Junction:
  - MCP9600/01 ±0.5°C/±1.5°C (typ./max.)
  - MCP96L00/L01 ±2.0°C/±4.0°C (typ./max.)
  - MCP96RL00/RL01 ±4.0°C/±8.0°C (typ./max.)

DC CHARACTERISTICS

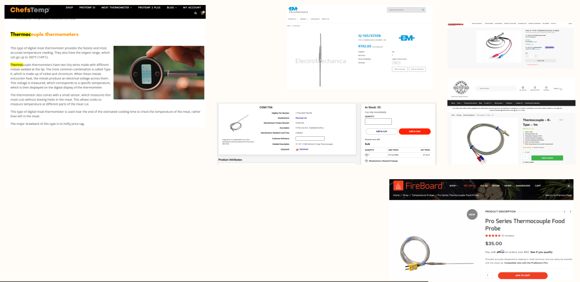
- Thermocouple Electromotive Force (EMF) to °C Converter:
  - Integrated cold-junction compensation
  - Integrated thermocouple open-circuit and short-circuit detection (MCP9601/L01/RL01)

Same as MCP9600, but the MCP9601 has additional open-circuit and short-circuit detection. For proof of concept this function is not necessary, but can be incorporated in later version of the product.

Accuracy: ±0.5°C/±1.5°C (Typ./Max.)

Interface: I2C & SPI

Thermocouple probe



Need two probes (left and right) to measure temperature over the coals to tell when temperature is correct to start braaing, and whether the heat is evenly distributed. Thermocouples to measure coals temperature doesn't need to have a penetrative tip (sharp tip) since it won't have to be inserted into anything.

Need one (minimum) probe to measure temperature in the meat. The probe will have to have a penetrative tip so as to not damage the meat upon inserting into the meat.

Can have multiple thermocouples for professional/commercial use, and have a smaller module for everday customers

D

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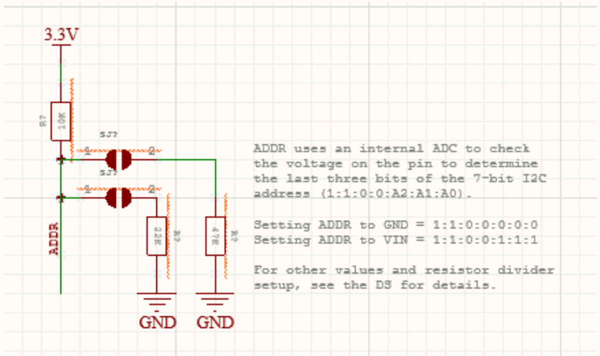
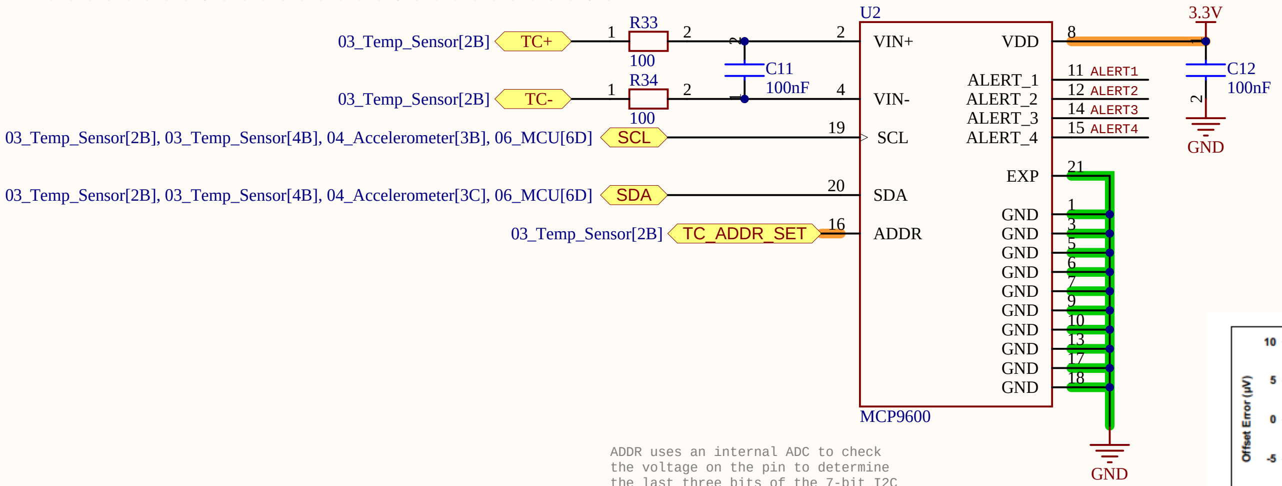
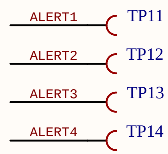




ADDR uses an internal ADC to check the voltage on the pin to determine the last three bits of the 7-bit I2C address (1:1:0:0:A2:A1:A0).

Setting ADDR to GND = 1:1:0:0:0:0:0
Setting ADDR to VIN = 1:1:0:0:1:1:1

For other values and resistor divider setup, see the DS for details.



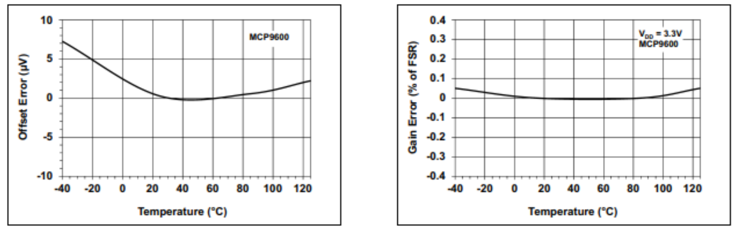


FIGURE 2-15: *Input Offset Error Voltage (V_{IN+}, V_{IN-}).*

FIGURE 2-18: *Full-Scale Gain Error.*

- Measurement Resolution:
  - Hot and cold-junctions: +0.0625°C (typical)
- Four Programmable Temperature Alert Outputs:
  - Monitor hot or cold-junction temperatures
  - Detect rising or falling temperatures
  - Up to 255°C of programmable hysteresis

Resolution of 0.0625°C.

Look into setting temperature alerts when desired preset temperatures are reached.

Input offset voltage and full-scale gain error are both at theirminimal at a temperature of 30°C.
Aim to have ambient temperature inside module to be 30°C.

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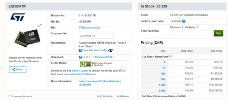
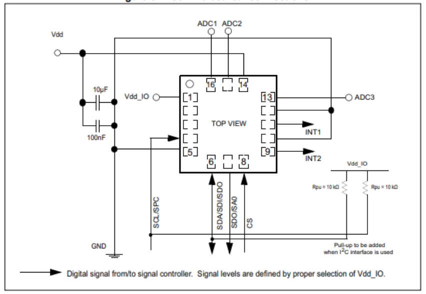


Figure 5. LIS3DH electrical connections



The device core is supplied through the Vdd line while the I/O pads are supplied through the Vdd_IO line. Power supply decoupling capacitors (100 nF ceramic, 10 µF aluminum) should be placed as near as possible to pin 14 of the device (common design practice).

All the voltage and ground supplies must be present at the same time to have proper behavior of the IC (refer to *Figure 5*). It is possible to remove Vdd maintaining Vdd_IO without blocking the communication bus, in this condition the measurement chain is powered off.

The functionality of the device and the measured acceleration data is selectable and accessible through the I²C or SPI interfaces.When using the I²C, CS must be tied high.

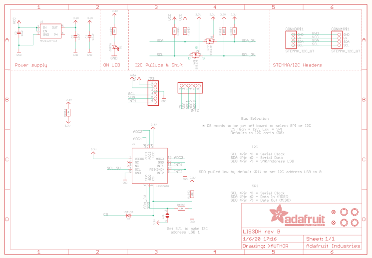
ADC1, ADC2 & ADC3 if not used can be left floating or connected to Vdd or GND.

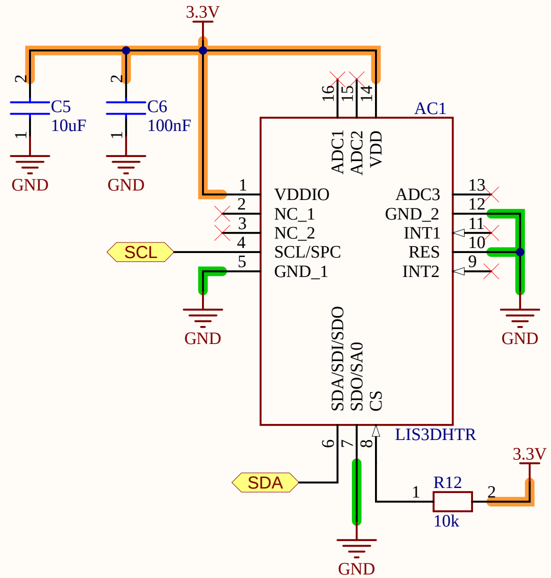
The functions, the threshold and the timing of the two interrupt pins (INT1 and INT2) can be completely programmed by the user through the I²C/SPI interface.

Table 13. Internal pin status

Pin#	Name	Function	Pin status
1	Vdd_IO	Power supply for I/O pins	
2	NC	Not connected	
3	NC	Not connected	
4	SCL SPC	I²C serial clock (SCL) SPI serial port clock (SPC)	Default: input high impedance
5	GND	0 V supply	
6	SDA SDI SDO	I²C serial data (SDA) SPI serial data input (SDI) 3-wire interface serial data output (SDO)	Default: (SDA) input high impedance
7	SDO SA0	SPI serial data output (SDO) I²C less significant bit of the device address (SA0)	Default: input with internal pull-up[1]
8	CS	SPI enable I²C/SPI mode selection: 1: SPI idle mode / I²C communication enabled 0: SPI communication mode / I²C disabled	Default: input high impedance
9	INT2	Inertial interrupt 2	Default: push-pull output forced to GND
10	RES	Connect to GND	
11	INT1	Inertial interrupt 1	Default: push-pull output forced to GND
12	GND	0 V supply	
13	ADC3	Analog-to-digital converter input 3	Default: input high impedance
14	Vdd	Power supply	
15	ADC2	Analog-to-digital converter input 2	Default: input high impedance
16	ADC1	Analog-to-digital converter input 1	Default: input high impedance

1. In order to disable the internal pull-up on the SDO/SA0 pin, write 90h in *CTRL_REG0 (1Eh)*.





7[1]	SDO SA0	SPI serial data output (SDO) I²C less significant bit of the device address (SA0)

1. SDO/SA0 pin is internally pulled up. Refer to *Table 3* for the internal pull-up values (typ.).

Table 3. Internal pull-up values (typ.) for SDO/SA0 pin

Vdd_IO	Resistor value for SDO/SA0 pin
	Typ. (kΩ)
1.7 V	54.4
1.8 V	49.2
2.5 V	30.4
3.6 V	20.4

I2C address LSB will not need to changed so tie pin 7 (CS) low.

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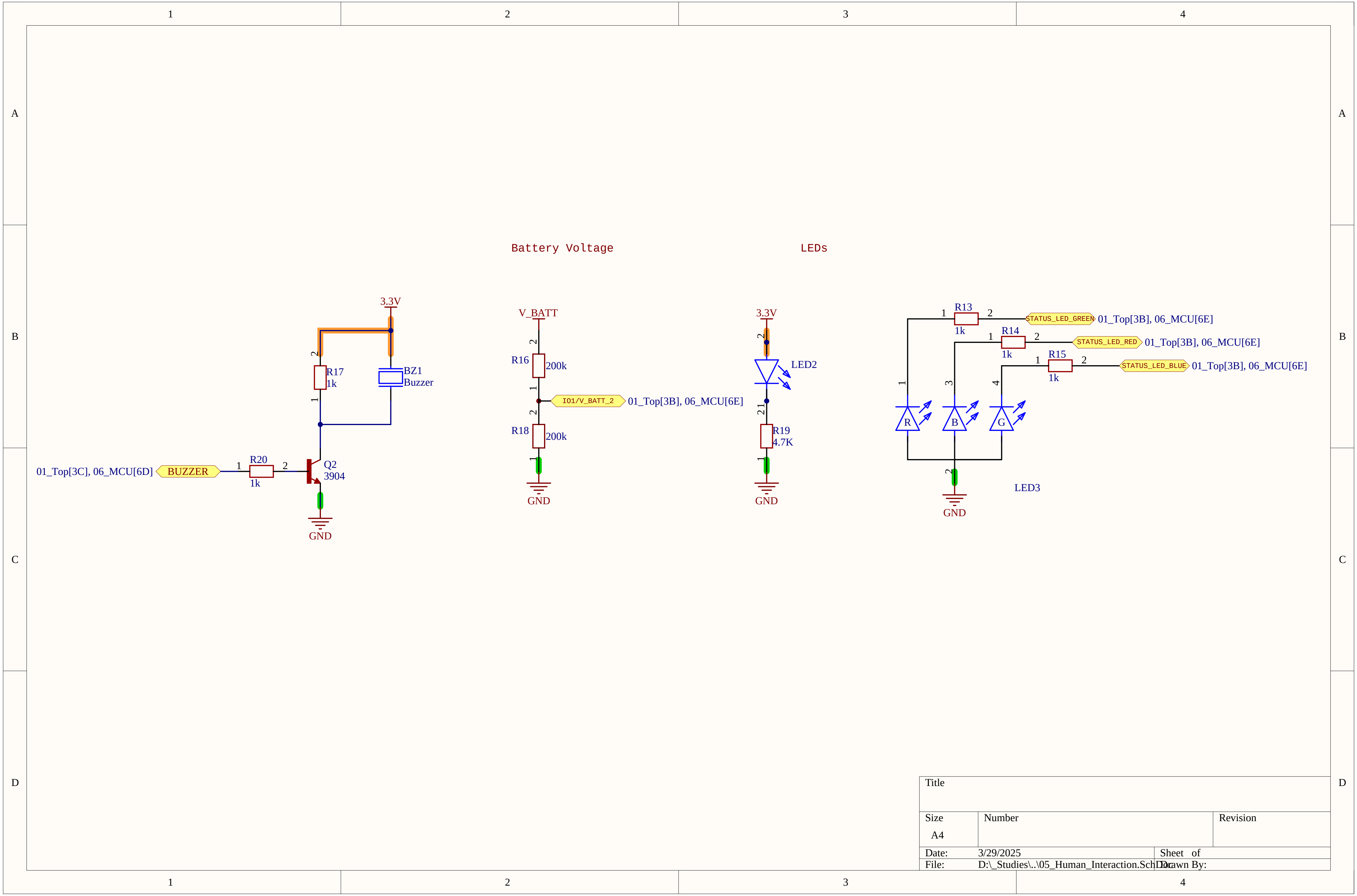

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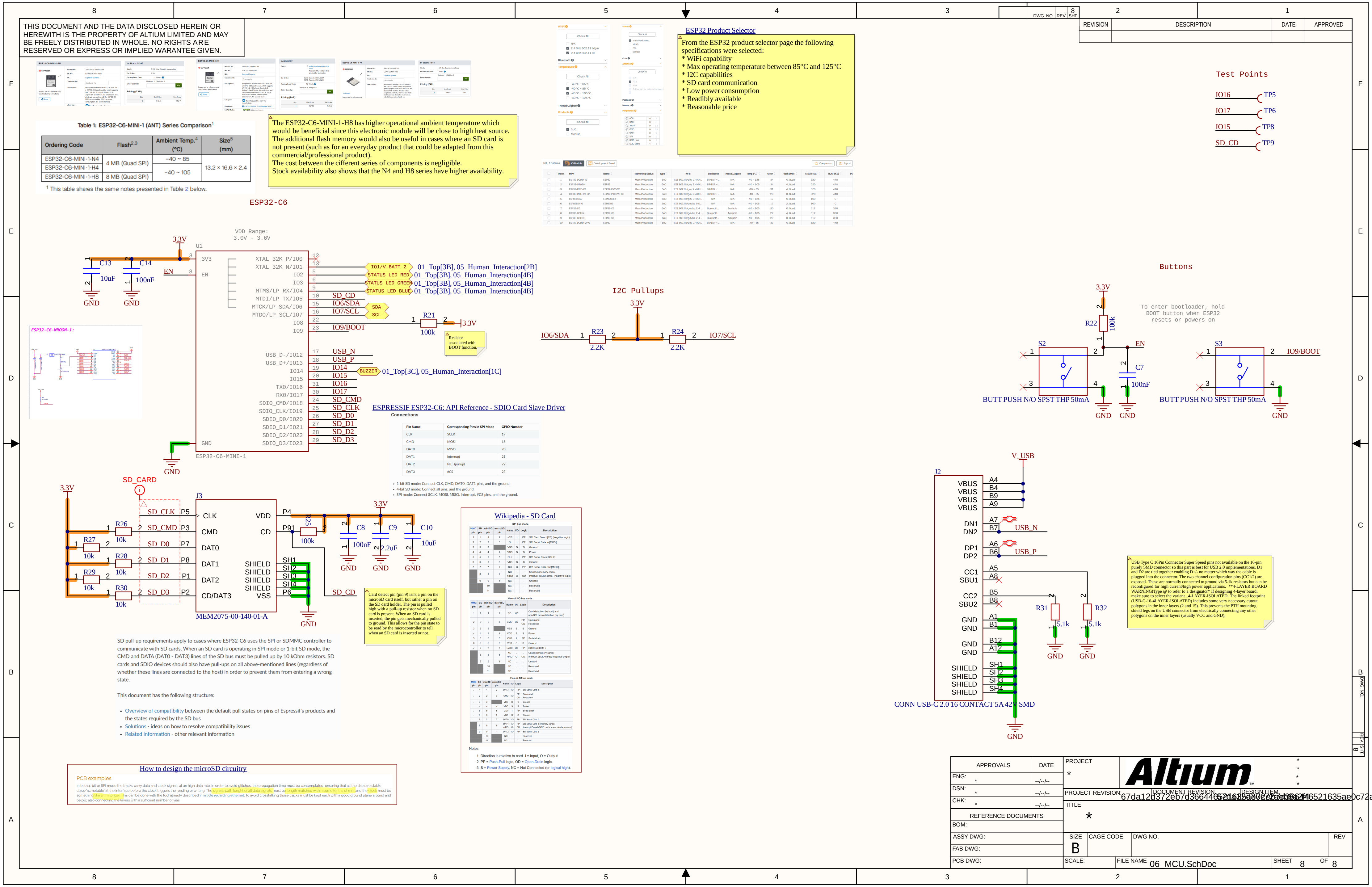

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Table 1: ESP32-C6-MINI-1 (ANT) Series Comparison[1]
Ordering Code | Flash[2,3] | Ambient Temp.[4] (°C) | Size[5] (mm)
ESP32-C6-MINI-1-N4 | 4 MB (Quad SPI) | −40 ~ 85 | 13.2 × 16.6 × 2.4
ESP32-C6-MINI-1-H4 | | −40 ~ 105 |
ESP32-C6-MINI-1-H8 | 8 MB (Quad SPI) | |
[1] This table shares the same notes presented in Table 2 below.
The ESP32-C6-MINI-1-H8 has higher operational ambient temperature which would be beneficial since this electronic module will be close to high heat source. The additional flash memory would also be useful in cases where an SD card is not present (such as for an everyday product that could be adapted from this commercial/professional product).
The cost between the different series of components is negligible.
Stock availability also shows that the N4 and H8 series have higher availability.
ESP32 Product Selector
From the ESP32 product selector page the following specifications were selected:
* WiFi capability
* Max operating temperature between 85°C and 125°C
* I2C capabilities
* SD card communication
* Low power consumption
* Readibly available
* Reasonable price
Test Points
IO16 TP5
IO17 TP6
IO15 TP8
SD_CD TP9
ESP32-C6
VDD Range:
3.0V - 3.6V
3.3V
C13 10uF
C14 100nF
GND
EN
U1
3V3
XTAL_32K_P/IO0
XTAL_32K_N/IO1
IO2
IO3
MTMS/LP_RX/IO4
MTDI/LP_TX/IO5
MTCK/LP_SDA/IO6
MTDO/LP_SCL/IO7
IO8
IO9
USB_D-/IO12
USB_D+/IO13
IO14
IO15
TX0/IO16
RX0/IO17
SDIO_CMD/IO18
SDIO_CLK/IO19
SDIO_D0/IO20
SDIO_D1/IO21
SDIO_D2/IO22
SDIO_D3/IO23
GND
ESP32-C6-MINI-1
IO1/V_BATT_2 01_Top[3B], 05_Human_Interaction[2B]
STATUS_LED_RED 01_Top[3B], 05_Human_Interaction[4B]
STATUS_LED_GREEN 01_Top[3B], 05_Human_Interaction[4B]
STATUS_LED_BLUE 01_Top[3B], 05_Human_Interaction[4B]
SD_CD
IO6/SDA SDA
IO7/SCL SCL
IO9/BOOT
R21 100k
3.3V
Resistor associated with BOOT function.
USB_N
USB_P
IO14 BUZZER 01_Top[3C], 05_Human_Interaction[1C]
IO15
IO16
IO17
SD_CMD
SD_CLK
SD_D0
SD_D1
SD_D2
SD_D3
ESP32-C6-WROOM-1:
I2C Pullups
3.3V
IO6/SDA R23 2.2K
R24 2.2K IO7/SCL
ESPRESSIF ESP32-C6: API Reference - SDIO Card Slave Driver
Connections
Pin Name | Corresponding Pins in SPI Mode | GPIO Number
CLK | SCLK | 19
CMD | MOSI | 18
DAT0 | MISO | 20
DAT1 | Interrupt | 21
DAT2 | N.C. (pullup) | 22
DAT3 | #CS | 23
1-bit SD mode: Connect CLK, CMD, DAT0, DAT1 pins, and the ground.
4-bit SD mode: Connect all pins, and the ground.
SPI mode: Connect SCLK, MOSI, MISO, Interrupt, #CS pins, and the ground.
Buttons
3.3V
R22 100k
To enter bootloader, hold BOOT button when ESP32 resets or powers on
S2
EN
C7 100nF
BUTT PUSH N/O SPST THP 50mA
S3
IO9/BOOT
BUTT PUSH N/O SPST THP 50mA
GND
SD_CARD
3.3V
J3
SD_CLK P5 CLK
R26 10k SD_CMD P3 CMD
R27 10k SD_D0 P7 DAT0
R28 10k SD_D1 P8 DAT1
R29 10k SD_D2 P1 DAT2
R30 10k SD_D3 P2 CD/DAT3
VDD P4
CD P9
SHIELD SH1
SHIELD SH2
SHIELD SH3
SHIELD SH4
VSS P6
MEM2075-00-140-01-A
R25 100k
C8 100nF
C9 2.2uF
C10 10uF
SD_CD
Card detect pin (pin 9) isn't a pin on the microSD card itself, but rather a pin on the SD card holder. The pin is pulled high with a pull-up resistor when no SD card is present. When an SD card is inserted, the pin gets mechanically pulled to ground. This allows for the pin state to be read by the microcontroller to tell when an SD card is inserted or not.
SD pull-up requirements apply to cases where ESP32-C6 uses the SPI or SDMMC controller to communicate with SD cards. When an SD card is operating in SPI mode or 1-bit SD mode, the CMD and DATA (DAT0 - DAT3) lines of the SD bus must be pulled up by 10 kOhm resistors. SD cards and SDIO devices should also have pull-ups on all above-mentioned lines (regardless of whether these lines are connected to the host) in order to prevent them from entering a wrong state.
This document has the following structure:
• Overview of compatibility between the default pull states on pins of Espressif's products and the states required by the SD bus
• Solutions - ideas on how to resolve compatibility issues
• Related information - other relevant information
How to design the microSD circuitry
PCB examples
Wikipedia - SD Card
V_USB
J2
VBUS A4
VBUS B4
VBUS B9
VBUS A9
DN1 A7
DN2 B7 USB_N
DP1 A6
DP2 B6 USB_P
CC1 A5
SBU1 A8
CC2 B5
SBU2 B8
GND A1
GND B1
GND B12
GND A12
SHIELD SH1
SHIELD SH2
SHIELD SH3
SHIELD SH4
R31 5.1k
R32 5.1k
CONN USB-C 2.0 16 CONTACT 5A 42V SMD
USB Type C 16Pin Connector Super Speed pins not available on the 16-pin purely SMD connector so this part is best for USB 2.0 implementations. D1 and D2 are tied together enabling D+/- no matter which way the cable is plugged into the connector. The two channel configuration pins (CC1/2) are exposed. These are normally connected to ground via 5.1k resistors but can be reconfigured for high current/high power applications. **4-LAYER BOARD WARNING!Type @ to refer to a designator* If designing 4-layer board, make sure to select the variant _4-LAYER-ISOLATED. The linked footprint (USB-C-16-4LAYER-ISOLATED) includes some very necessary cutout polygons in the inner layers (2 and 15). This prevents the PTH mounting shield legs on the USB connector from electrically connecting any other polygons on the inner layers (usually VCC and GND).
REVISION | DESCRIPTION | DATE | APPROVED
APPROVALS | DATE
ENG: * --/--/--
DSN: * --/--/--
CHK: * --/--/--
REFERENCE DOCUMENTS
BOM:
ASSY DWG:
FAB DWG:
PCB DWG:
PROJECT *
Altium
PROJECT REVISION: DOCUMENT REVISION: DESIGN ITEM:
TITLE *
SIZE B
CAGE CODE
DWG NO.
REV
SCALE:
FILE NAME 06_MCU.SchDoc
SHEET 8 OF 8