IoT-Vertebrae

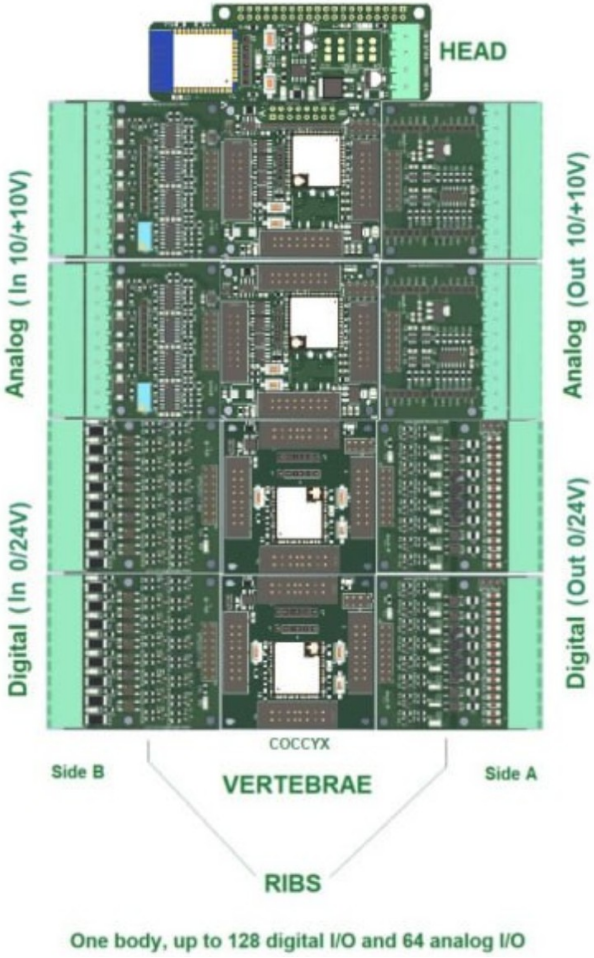
Bridging OT & IT

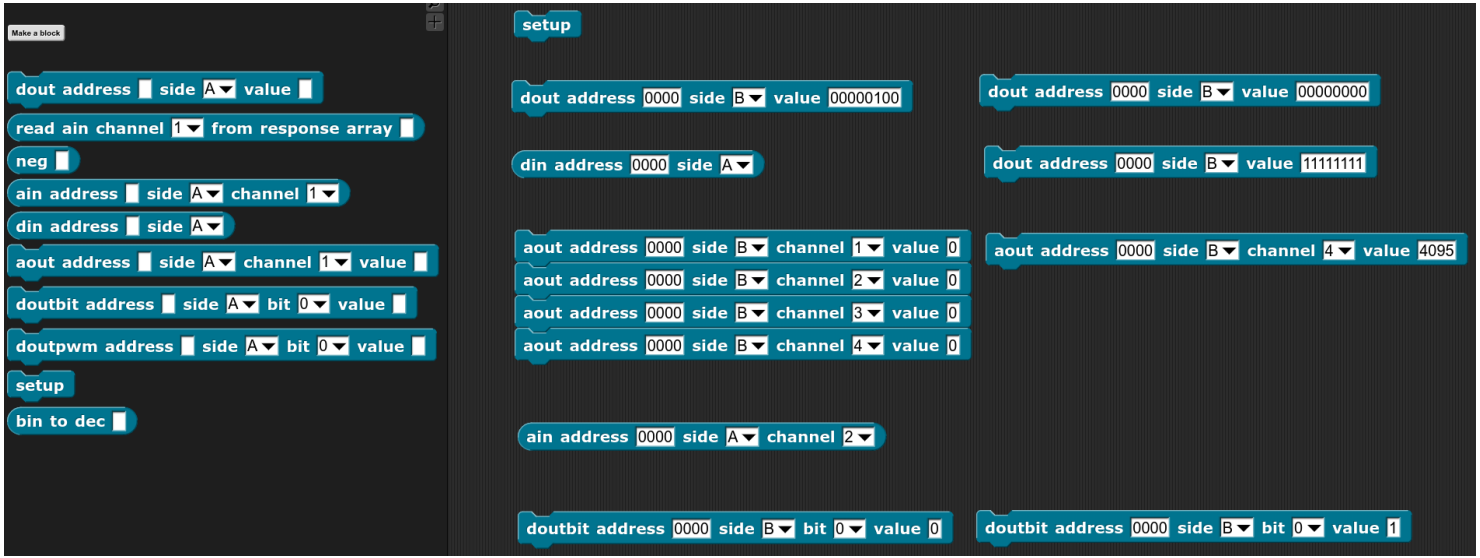
Jordi Binefa *(online from Israel)*

Xavier Pi *(presencially from Auditorium)*

Snap!Con - 2023

www.iotvertebrae.com





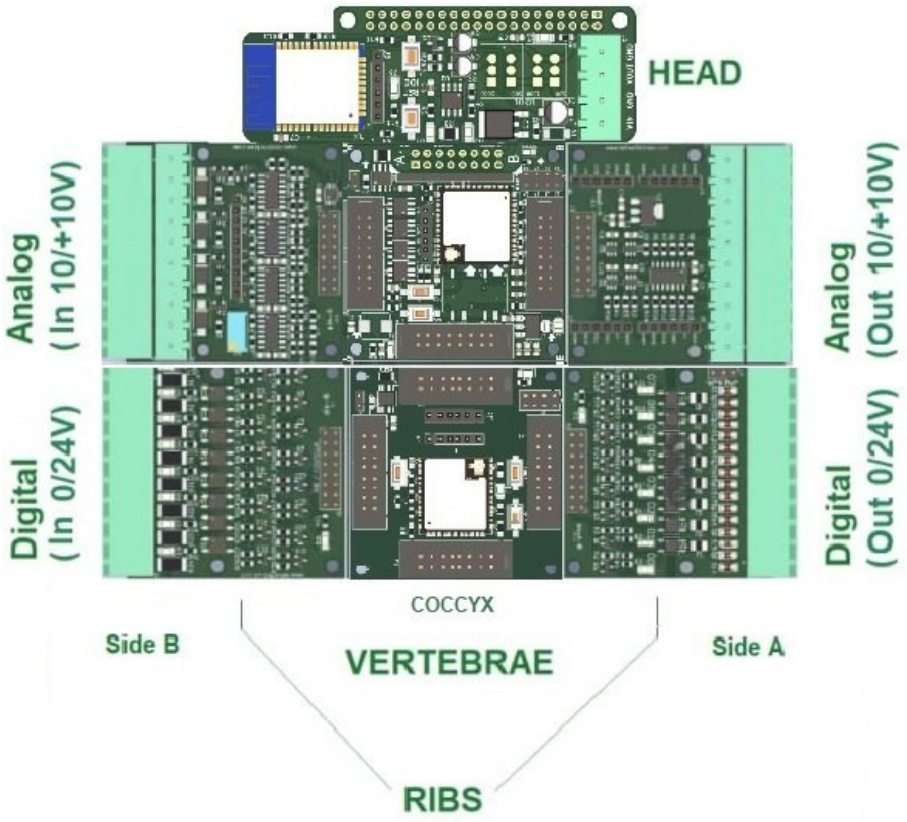
* Head
* Backbone
* Ribs

* Address
* Side

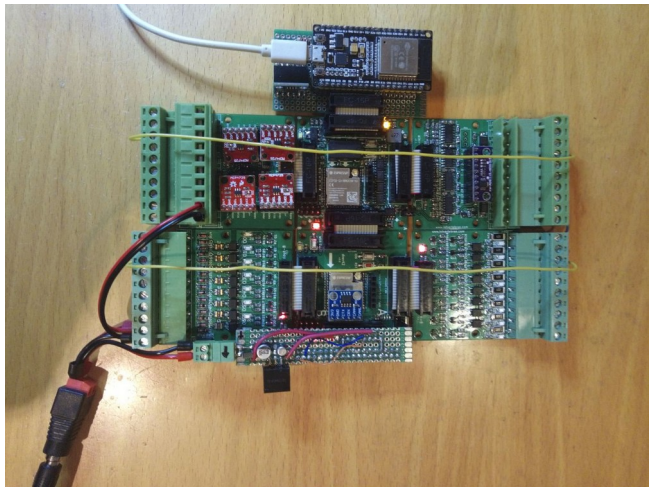
* Value
* Bit
* Channel

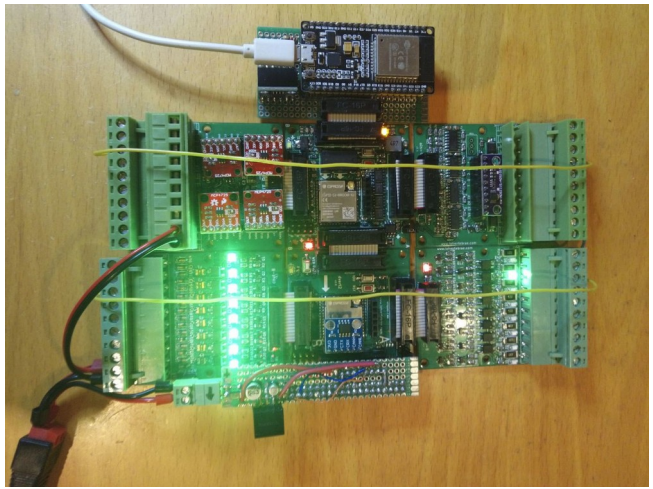
* dout
* din
* aout
* ain

* doutbit
* doutpwm

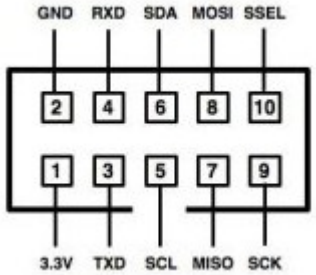


One body, up to 128 digital I/O and 64 analog I/O



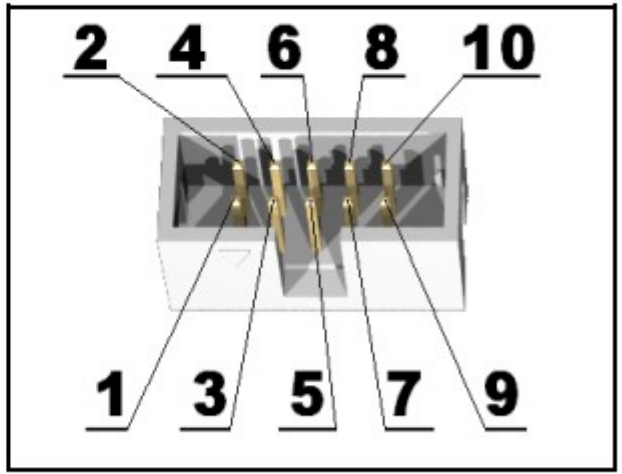


UEXT, an OLIMEX bus



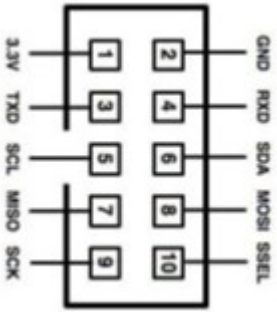
Connector pins description:

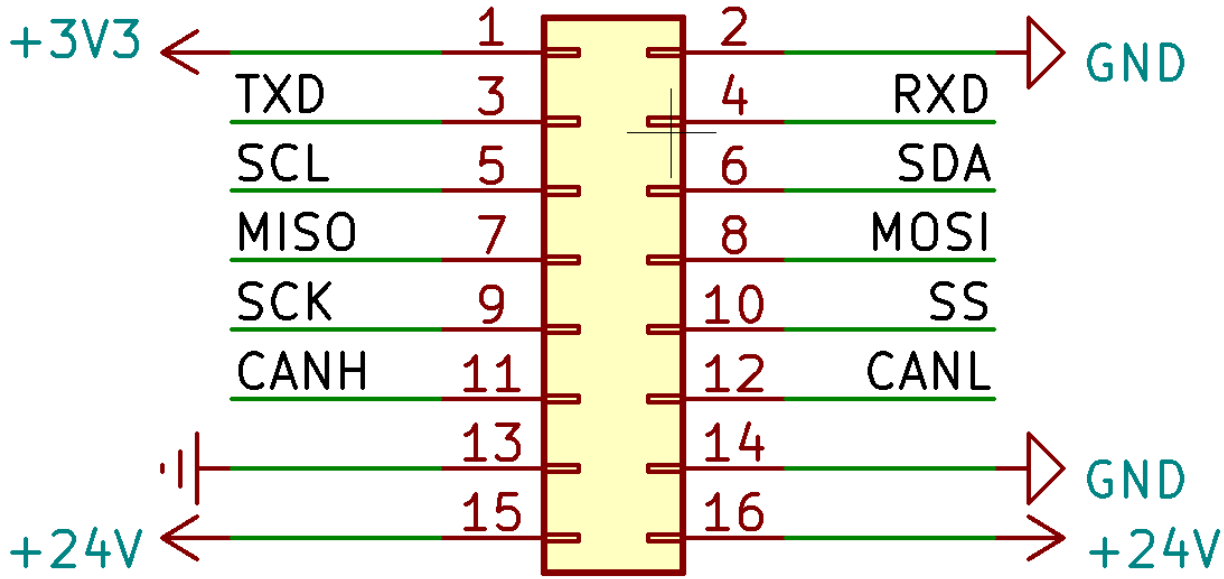
Pin #	Signal Name
1	3.3V
2	GND
3	TXD
4	RXD
5	SCL
6	SDA
7	MISO
8	MOSI
9	SCK
10	SSEL



https://www.olimex.com/Products/Modules/UEXT/

U2EXT (extended UEXT)

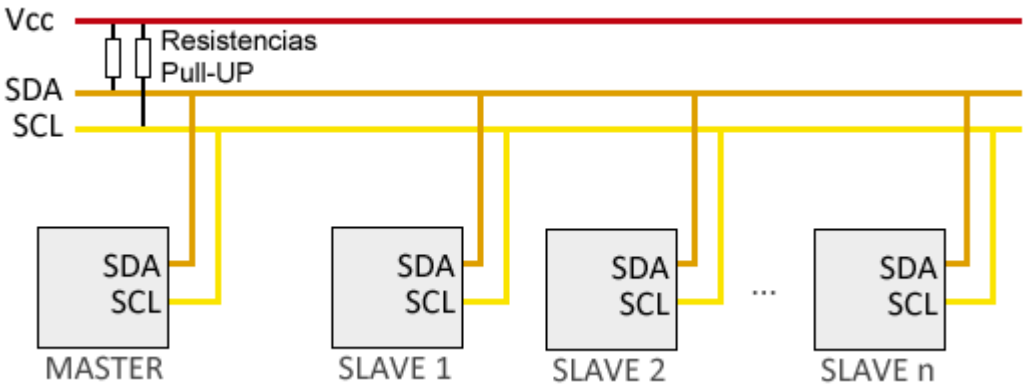


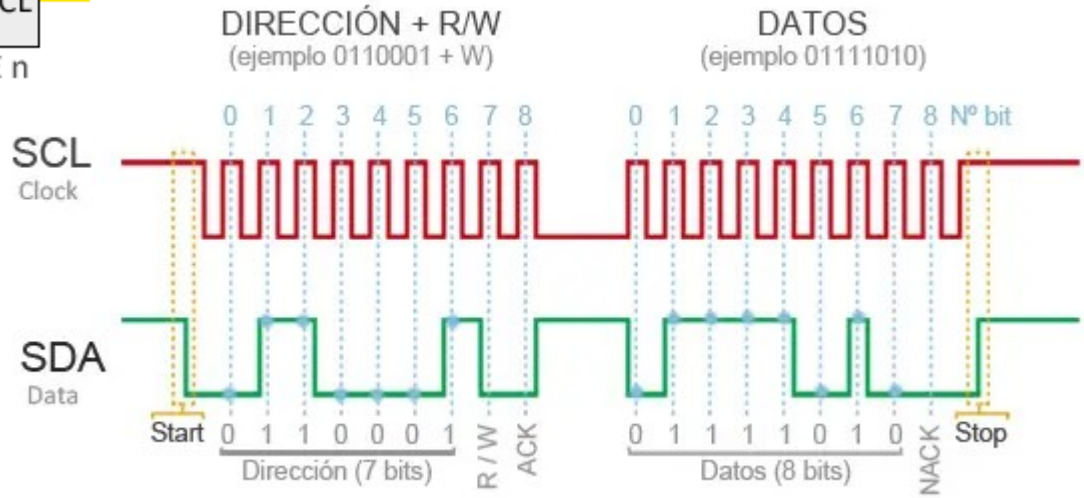


UEXT

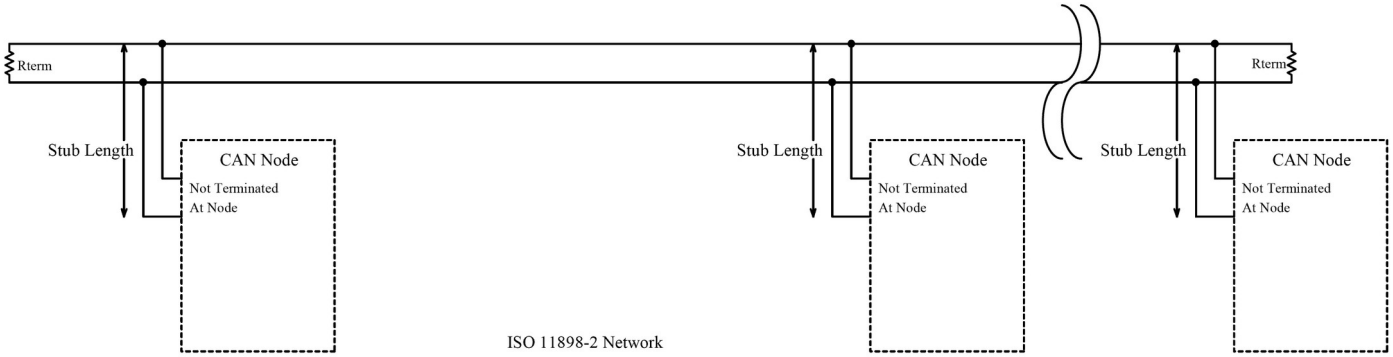
Extended UEXT

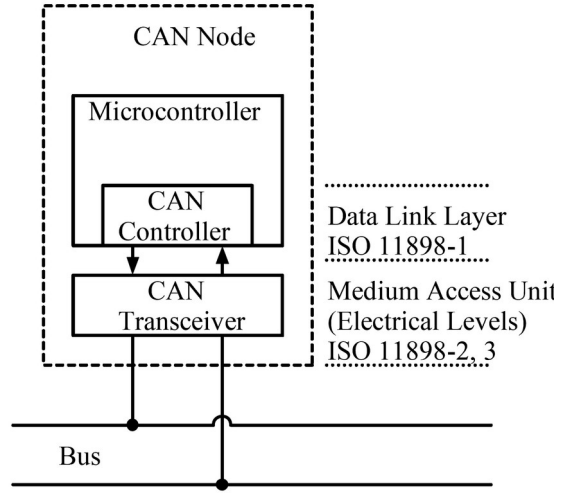
I2C Bus

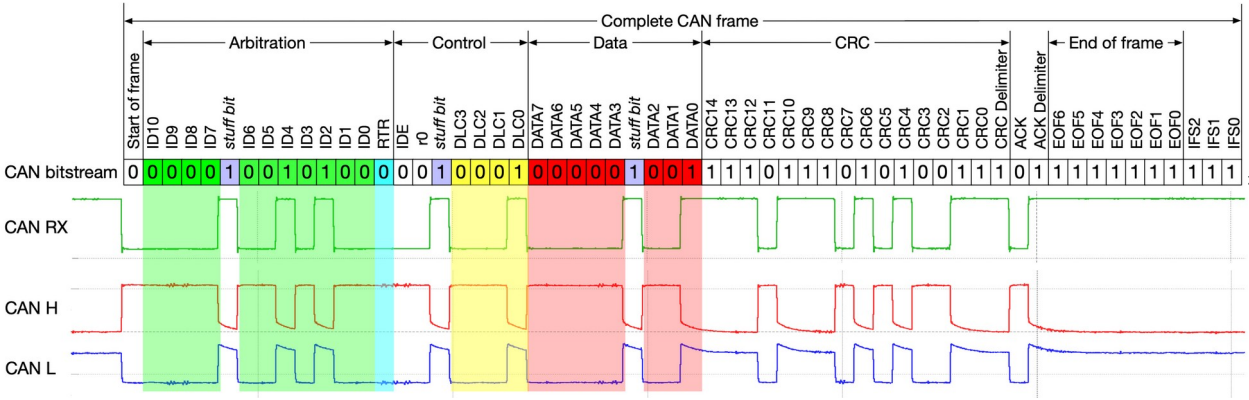

Vcc
Resistencias
Pull-UP
SDA
SCL
SDA
SCL
MASTER
SLAVE 1
SLAVE 2
SLAVE n

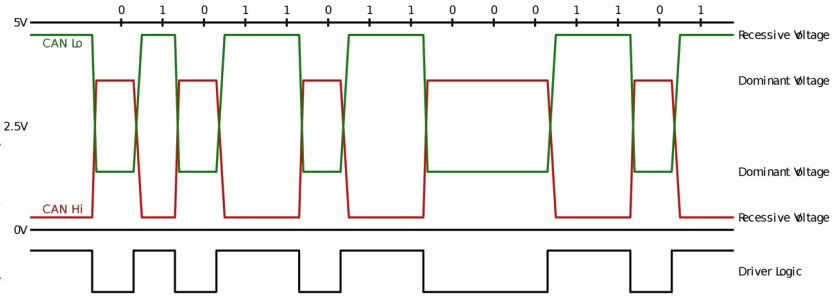

DIRECCIÓN + R/W
(ejemplo 0110001 + W)
DATOS
(ejemplo 01111010)
SCL
Clock
SDA
Data
Start
Dirección (7 bits)
R / W
ACK
Datos (8 bits)
NACK
Stop
Nº bit

CAN Bus



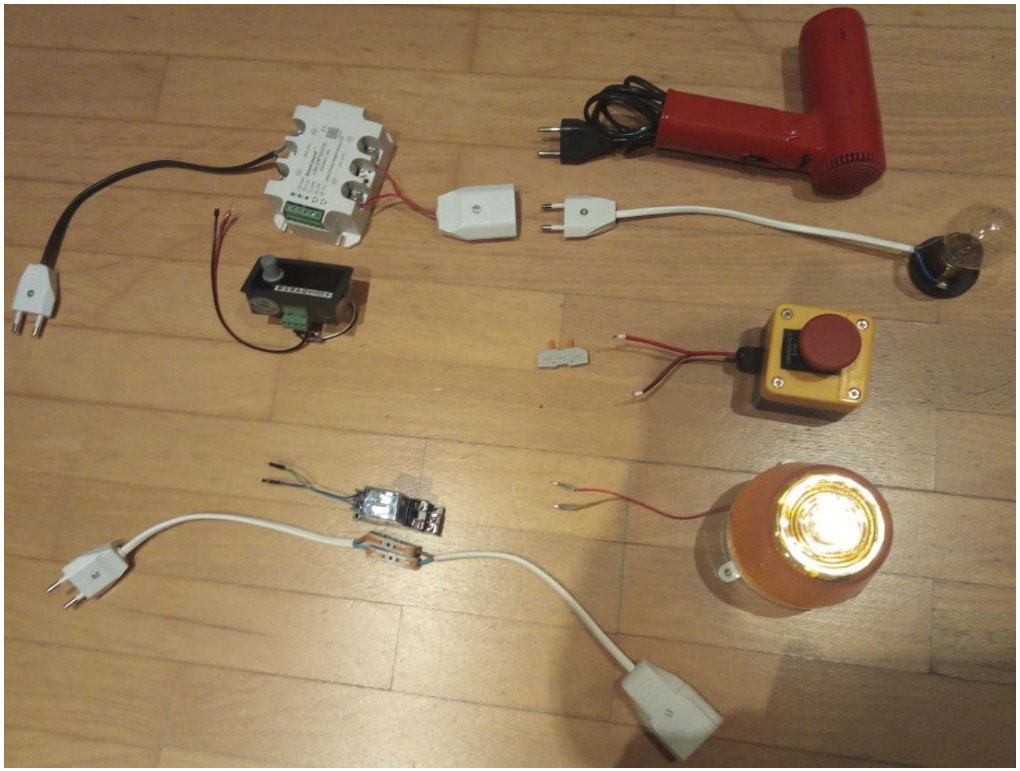






https://en.wikipedia.org/wiki/CAN_bus

Peripherals used in this session

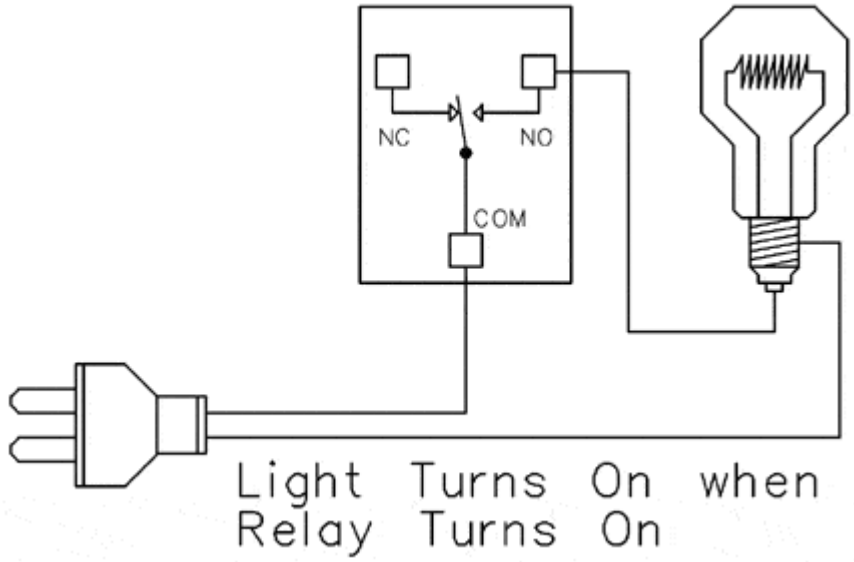


* Hair dryer (230VAC)
* Bulb lamp (230VAC)
* Emergency stop button (normally open)
* Sound and light alarm (24V)
* 24V Power relay
* 4-20mA generator with 500 ohms R (0-10V)
* 0-10V Dimmer

https://en.wikipedia.org/wiki/CAN_bus

Peripherals used in this session

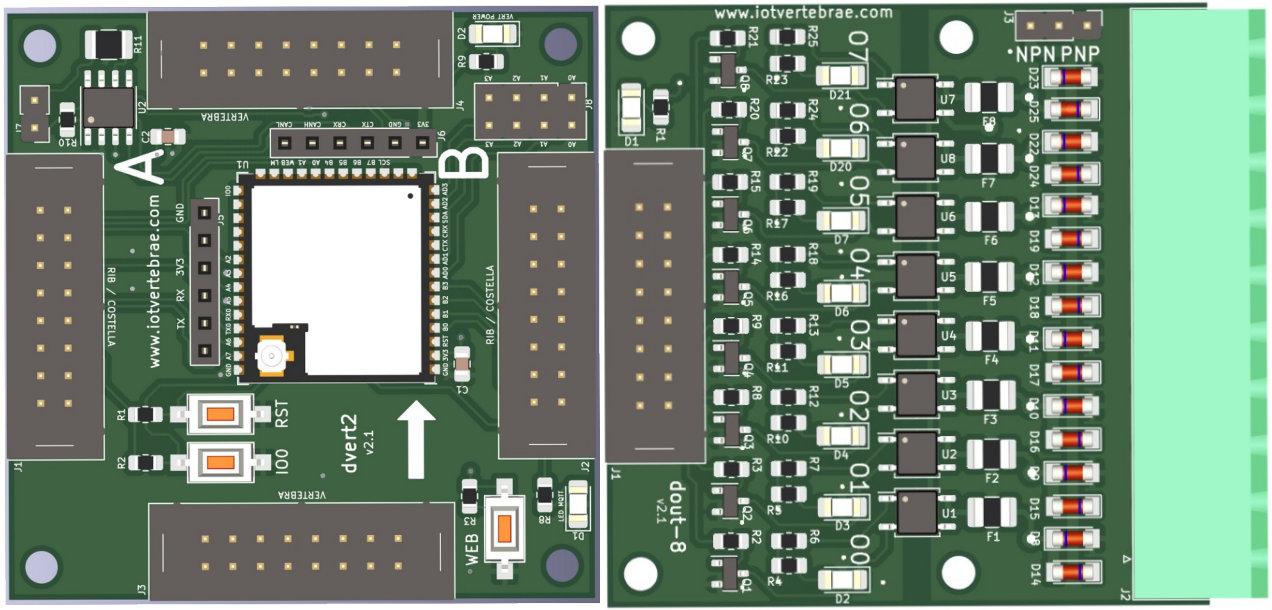
Power relay can be connected to 24V digital output.
It is a controlled switch between COM (common) and NO (normally open)

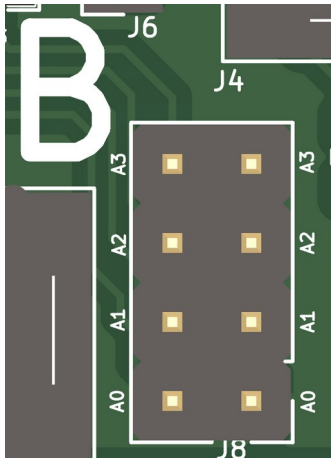


Setting values on digital output using Snap!

dout block

- Digital vertebra address is set with jumpers on J8 connector.
  (Bit with jumper is 1. Bit without jumper is 0)
- Side is where rib has been connected. It could be A or B.
- Value is a set of 8 bits (from O0 to O7). 1 is relay on. 0 is relay off.





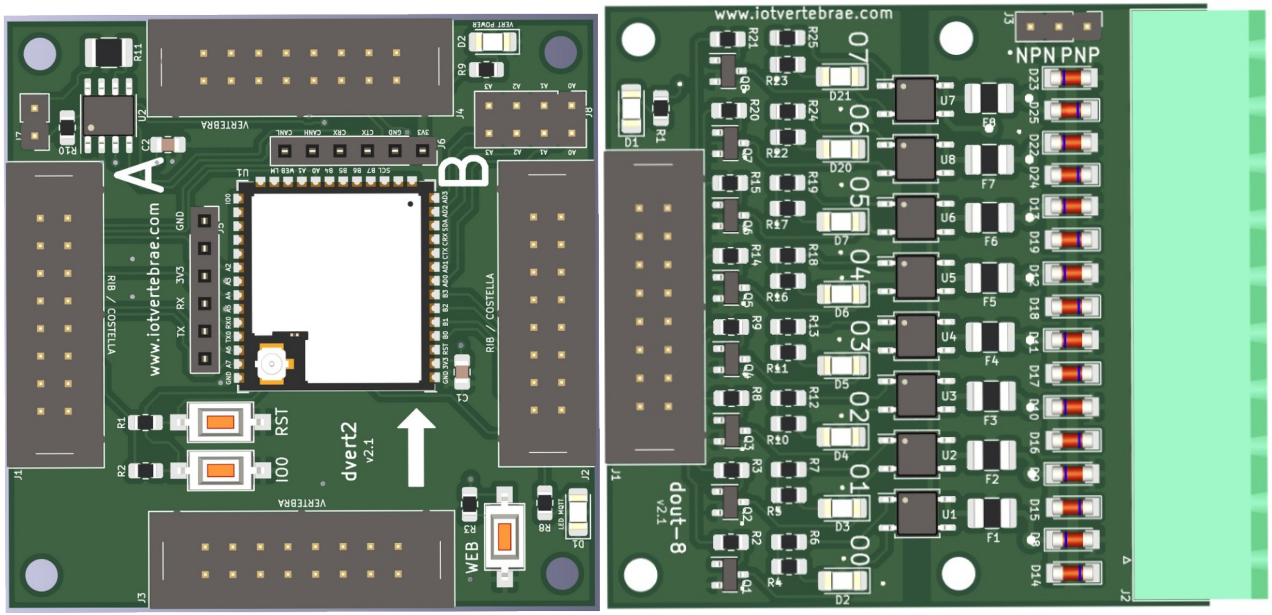
A3 A2 A1 A0
0 0 0 0

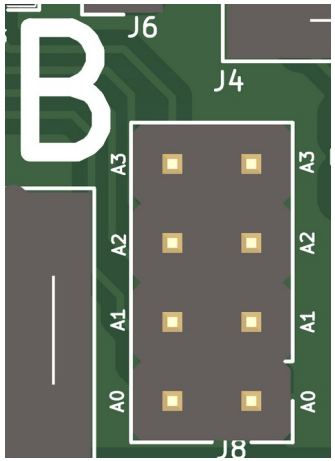
A3 A2 A1 A0
0 1 0 0

Setting values on digital output using Snap!

doutbit block

- Digital vertebra address is set with jumpers on J8 connector.
  (Bit with jumper is 1. Bit without jumper is 0)
- Side is where rib has been connected. It could be A or B.
- Bit is a number between 0 and 7 (O0 to O7 outputs).
- Value is 0 (relay off) or 1 (relay on).



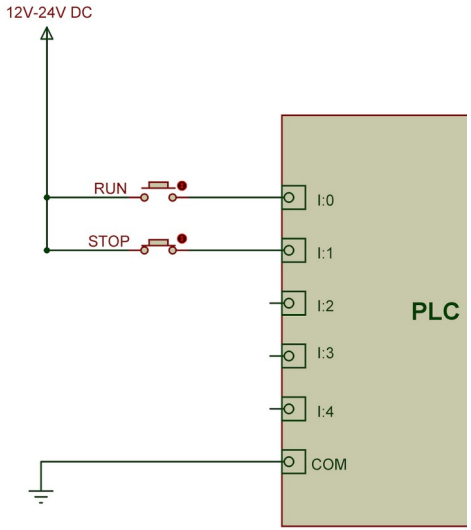


A3 A2 A1 A0
0 0 0 0

A3 A2 A1 A0
0 1 0 0

Peripherals used in this session

Emergency stop button is connected to 24V and digital input.

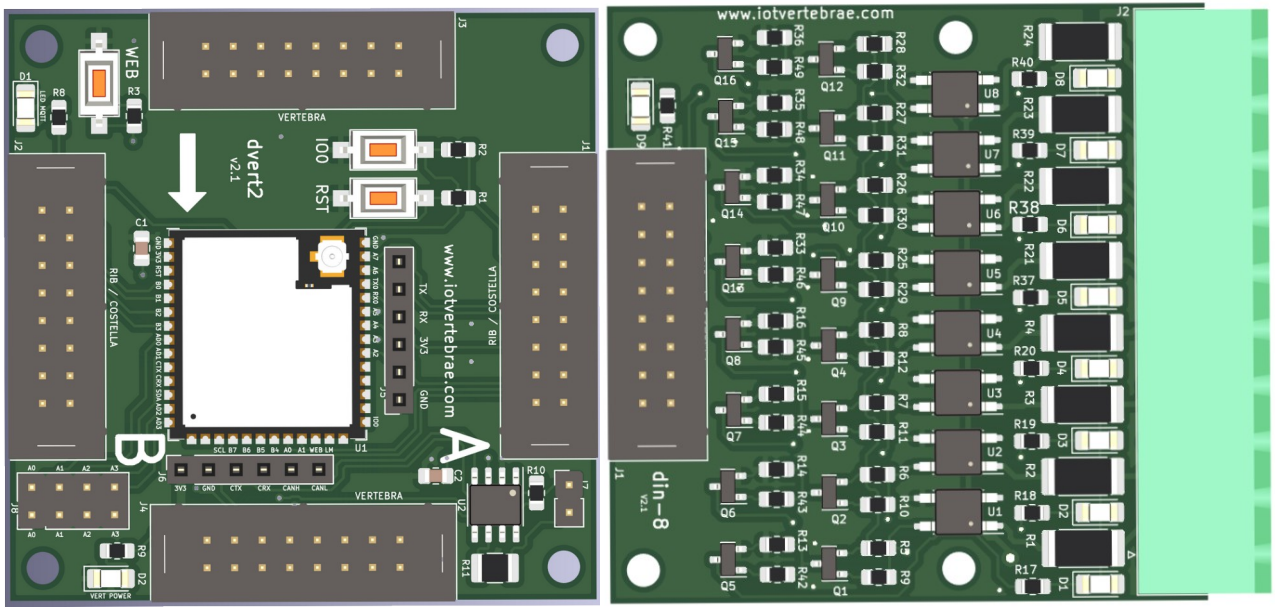


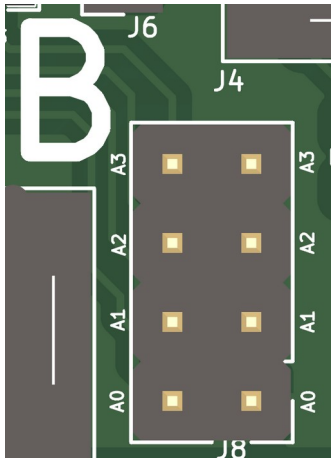
circuit2connect.blogspot.com

Reading values on digital input using Snap!

din block

- Digital vertebra address is set with jumpers on J8 connector.
  (Bit with jumper is 1. Bit without jumper is 0)
- Side is where rib has been connected. It could be A or B.
- Read value is reported by this block.





A3 A2 A1 A0
0 0 0 0

A3 A2 A1 A0
0 1 0 0

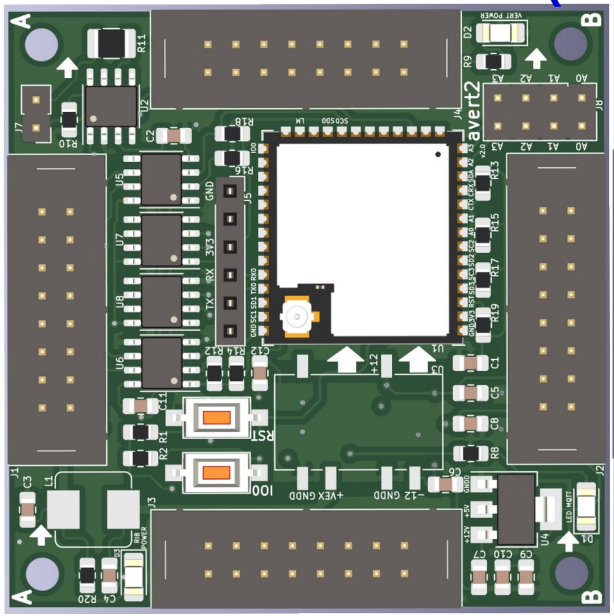
Peripherals used in this session

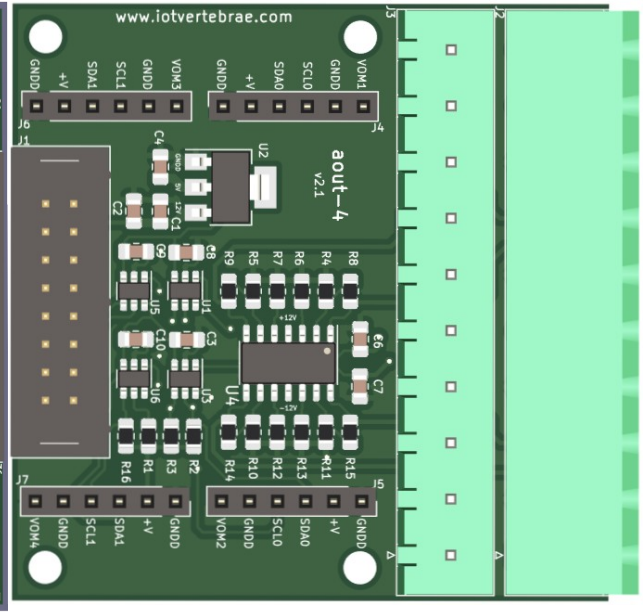
Dimmer. It dimmers 230VAC. In this session we are using 0-10V control.

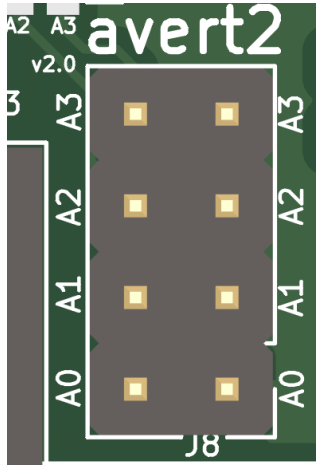
Setting values on analog output using Snap!

aout block

- Analog vertebra address is set with jumpers on J8 connector.
  (Bit with jumper is 1. Bit without jumper is 0)
- Side is where rib has been connected. It could be A or B.
- Channel is which channel we are about to write (1 to 4).
- Value is a 12 bit value (from 0 to 4095). 4095 is 10 volts and 0 is 0 volts.







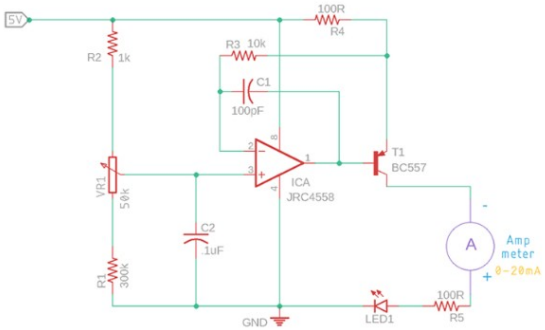
A3 A2 A1 A0
0 0 0 0

A3 A2 A1 A0
0 1 0 0

Peripherals used in this session

4-20mA Current loop emulator. Connecting a 500 ohms resistor creates 0-10V

Current Loop Tester



CIRCUITS DIY
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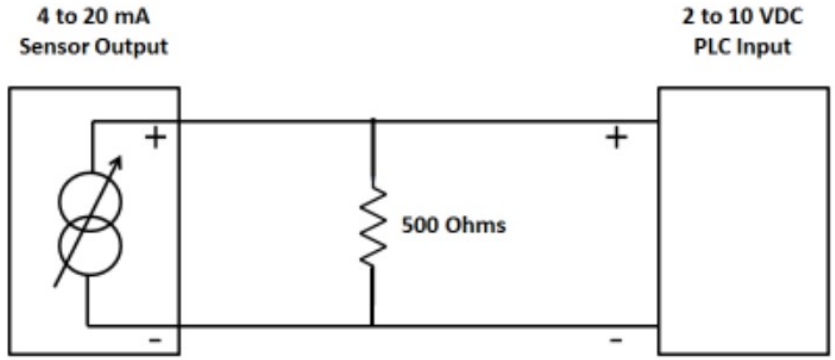
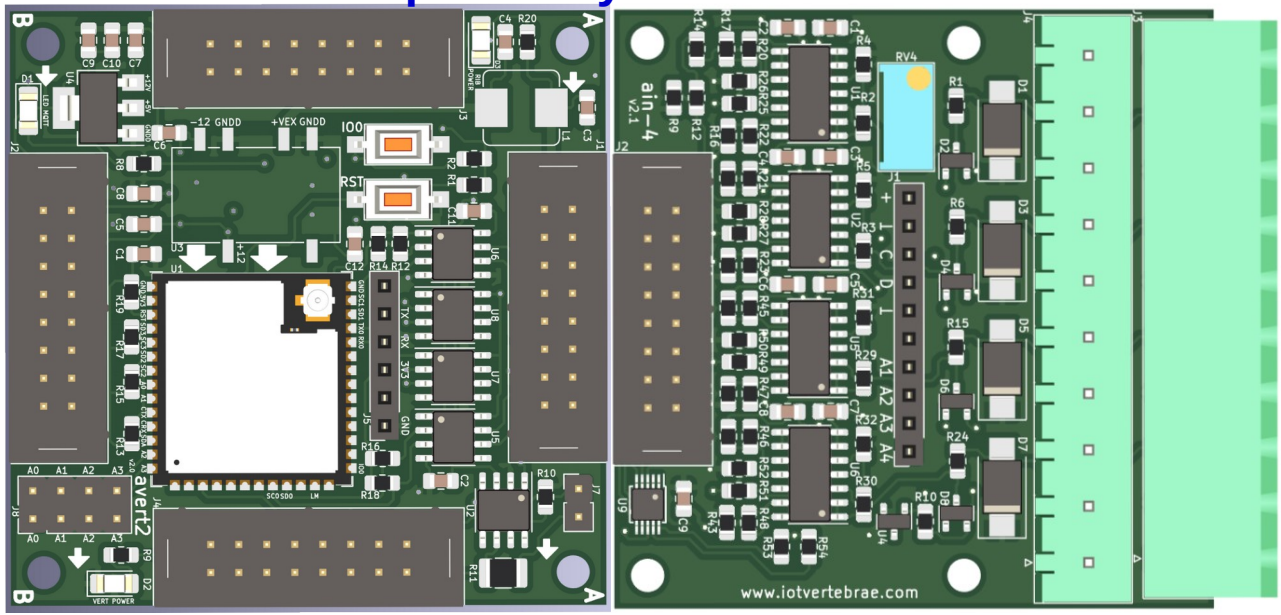
0-20 mA to 0-10 VDC : 500 Ohms resitor

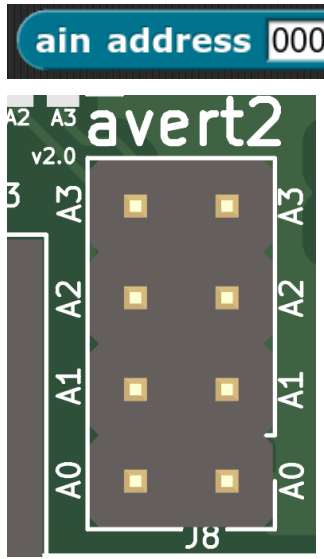


Reading values on analog input using Snap!

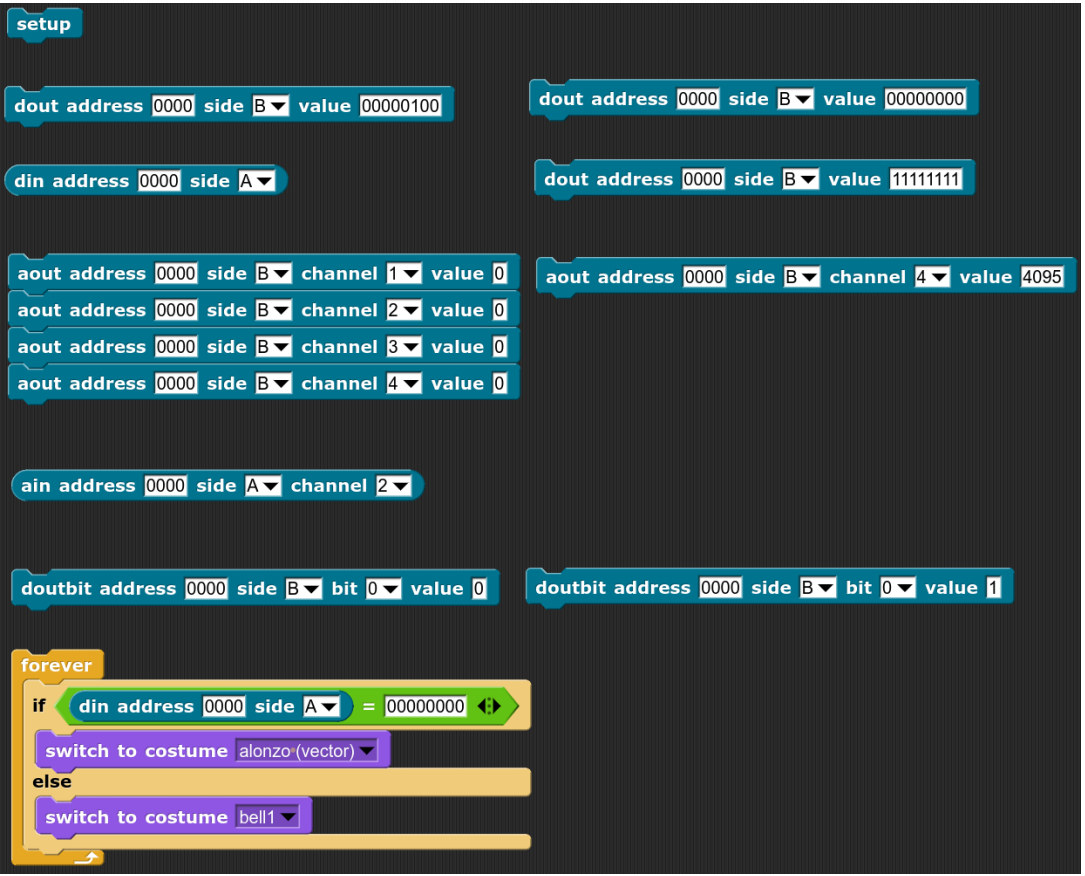
ain block

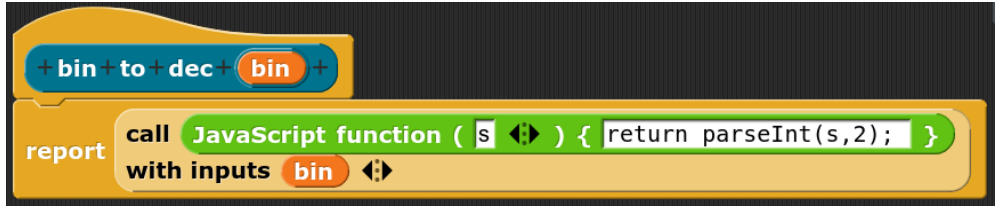
- Analog vertebra address is set with jumpers on J8 connector.
  (Bit with jumper is 1. Bit without jumper is 0)
- Side is where rib has been connected. It could be A or B.
- Channel is which channel we are about to read (1 to 4).
- Read value is reported by this block. 0 is -11.5 volts. 13280 is 0 volts. 26480 is 10 volts.

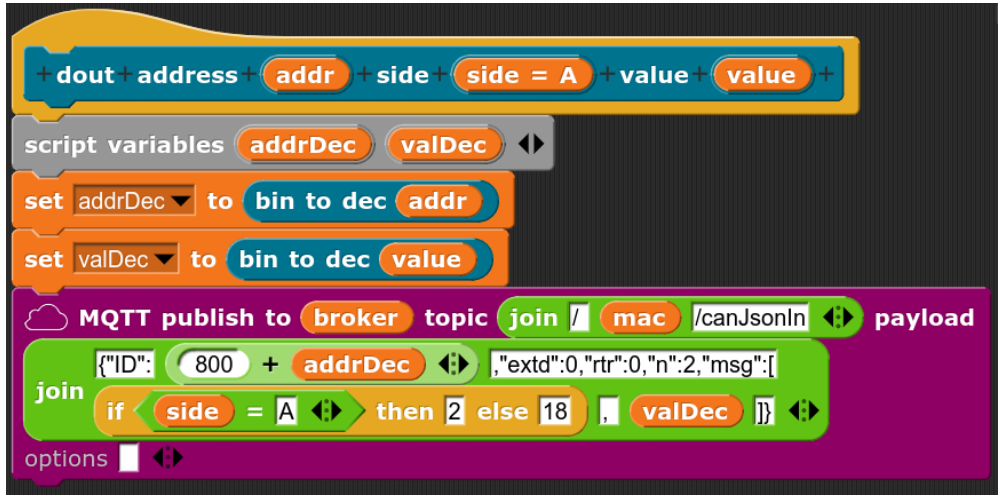




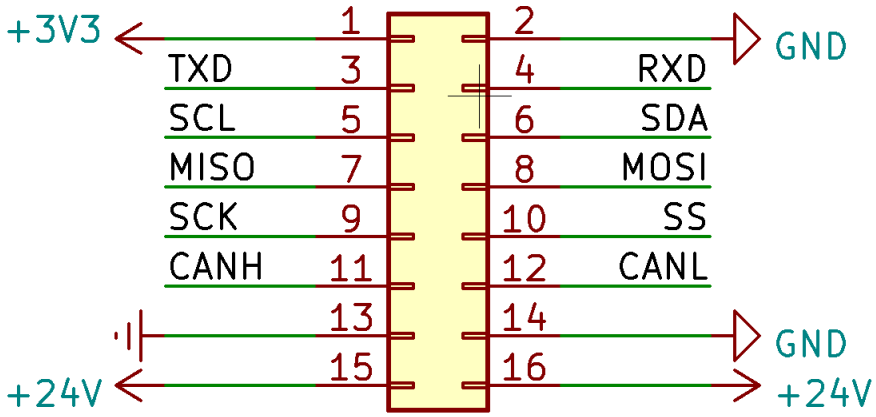
Using Snap! on IoT-Vertebrae

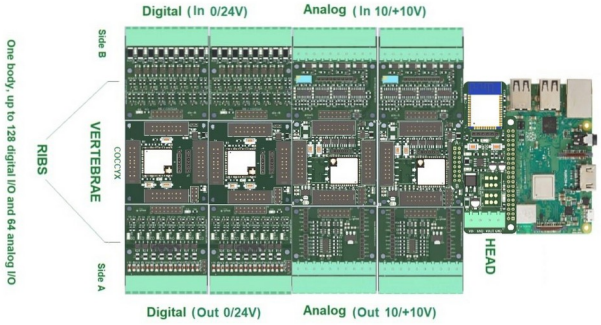


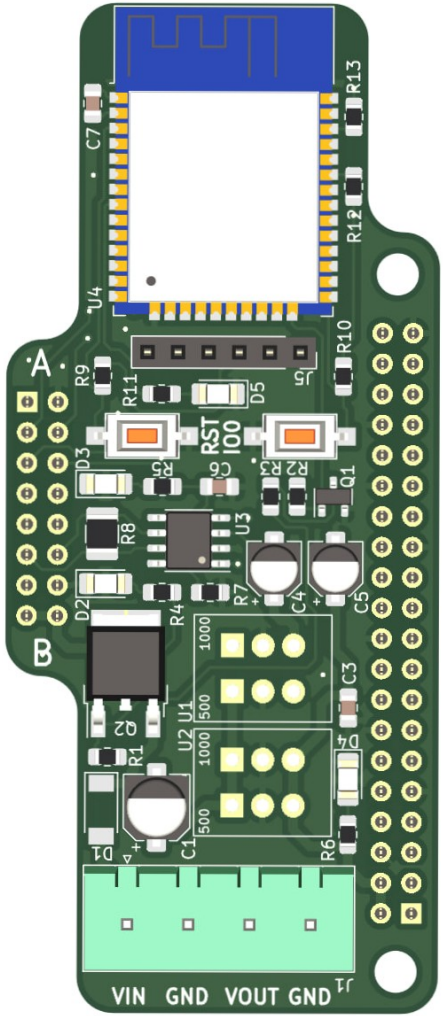


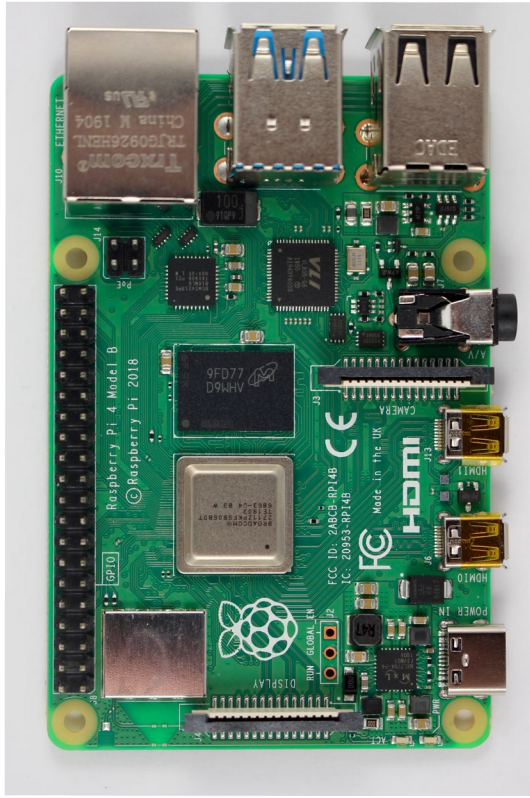


Head

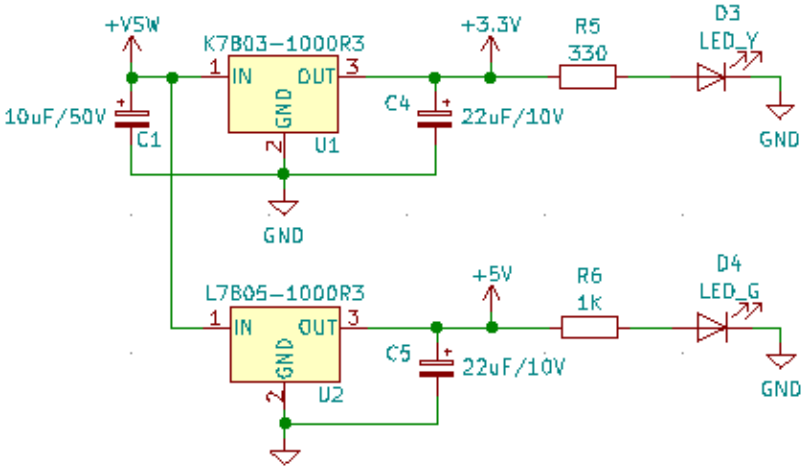

+3V3
1
2
GND
TXD
3
4
RXD
SCL
5
6
SDA
MISO
7
8
MOSI
SCK
9
10
SS
CANH
11
12
CANL
13
14
GND
15
16
+24V
+24V

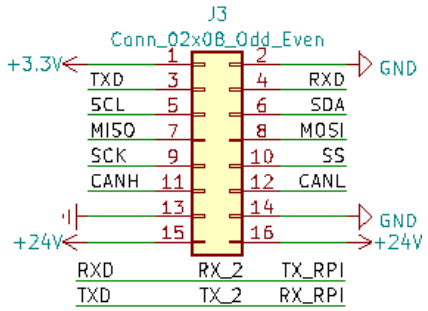

Digital (In 0/24V)
Analog (In 10/+10V)
Side B
One body, up to 128 digital I/O and 64 analog I/O
RIBS
VERTEBRAE
COCCYX
Side A
HEAD
Digital (Out 0/24V)
Analog (Out 10/+10V)

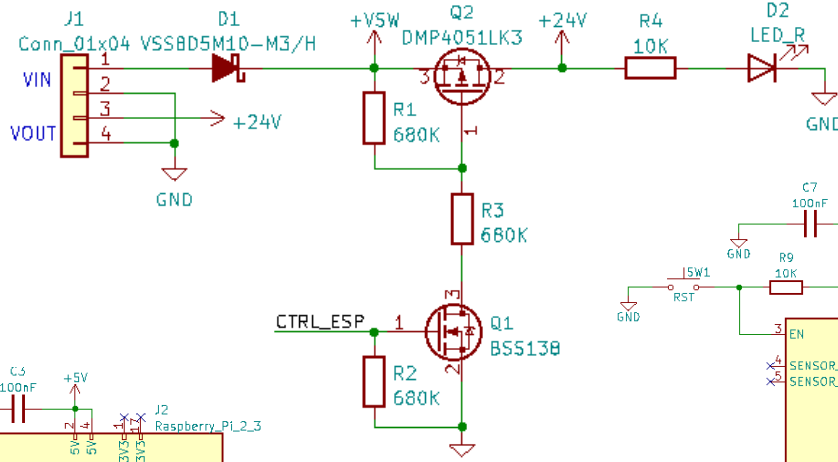

VIN GND VOUT GND

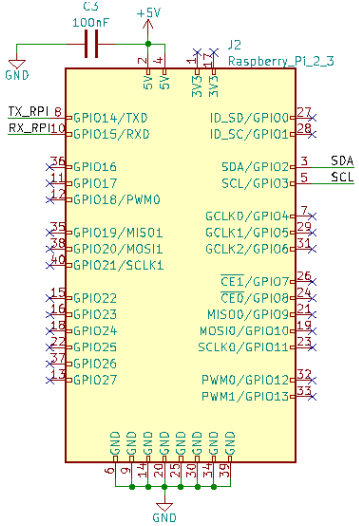


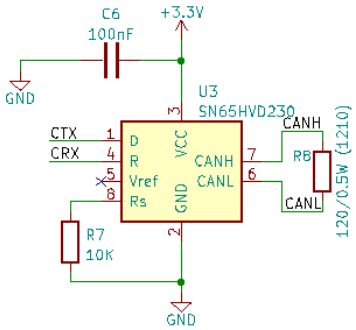
Head

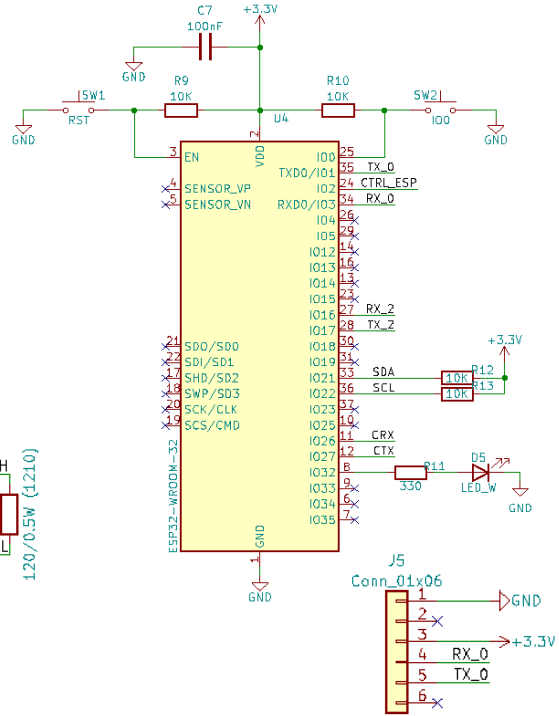

+V5W
K7B03-1000R3
IN
OUT
GND
U1
10uF/50V
C1
+3.3V
C4
22uF/10V
R5
330
D3
LED_Y
GND
L7B05-1000R3
U2
+5V
C5
22uF/10V
R6
1K
D4
LED_G


J3
Conn_02x0B_Odd_Even
+3.3V
GND
TXD
RXD
SCL
SDA
MISO
MOSI
SCK
SS
CANH
CANL
+24V
RXD
TXD
RX_2
TX_2
TX_RPI
RX_RPI

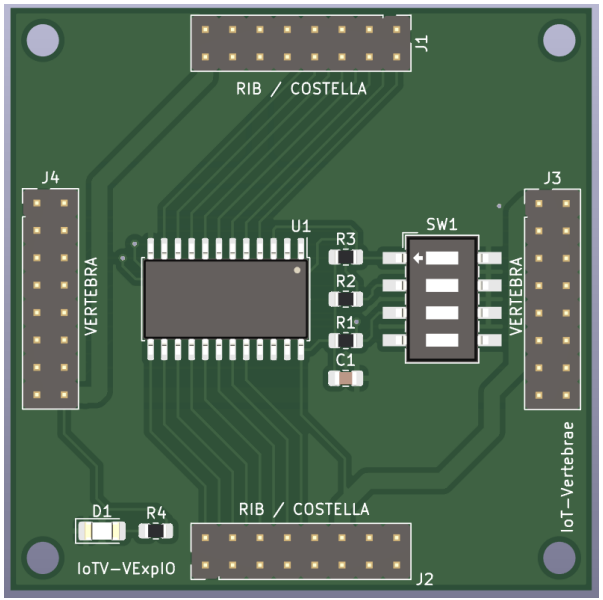

J1
Conn_01x04
VIN
VOUT
D1
VSSBD5M10-M3/H
+24V
GND
+V5W
Q2
DMP4051LK3
R1
680K
R3
680K
R2
680K
Q1
BS5138
CTRL_ESP
R4
10K
D2
LED_R

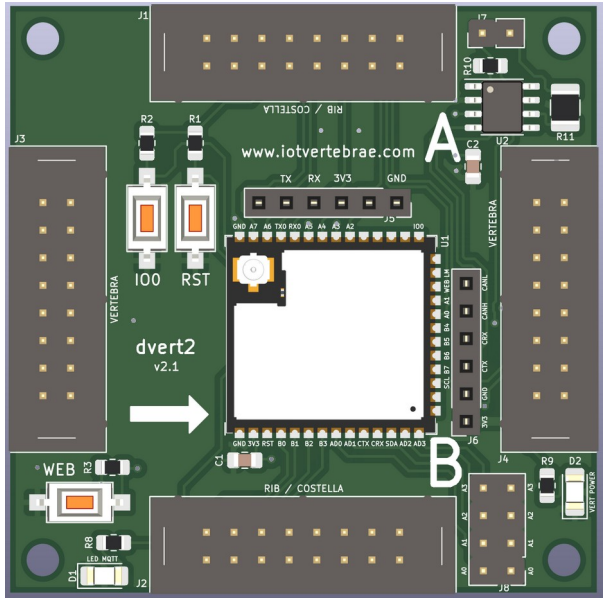

C3
100nF
+5V
J2
Raspberry_Pi_2_3
TX_RPI
RX_RPI
SDA
SCL
GND


C6
100nF
+3.3V
U3
SN65HVD230
CTX
CRX
CANH
CANL
R8
120/0.5W (1210)
R7
10K
GND

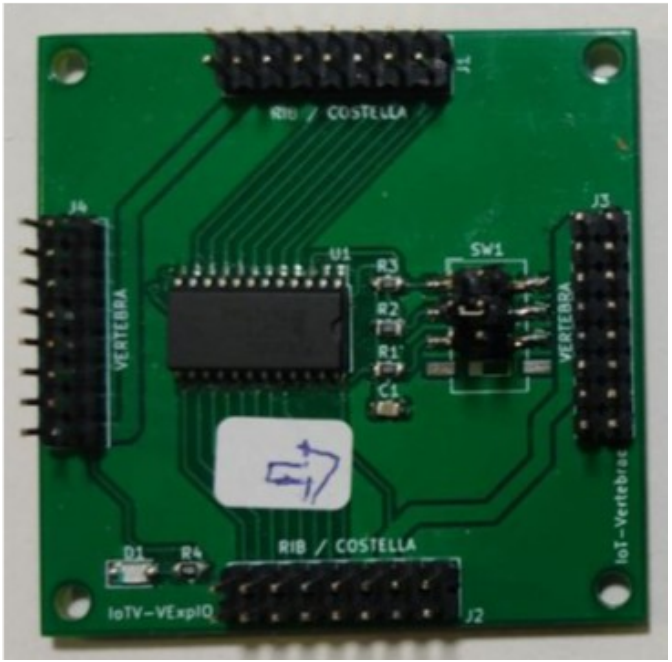

C7
100nF
+3.3V
R9
10K
R10
10K
SW1
SW2
U4
ESP32-WROOM-32
TX_0
RX_0
CTRL_ESP
RX_2
TX_2
SDA
SCL
R12
R13
CRX
CTX
R11
330
D5
LED_W
J5
Conn_01x06
GND
+3.3V

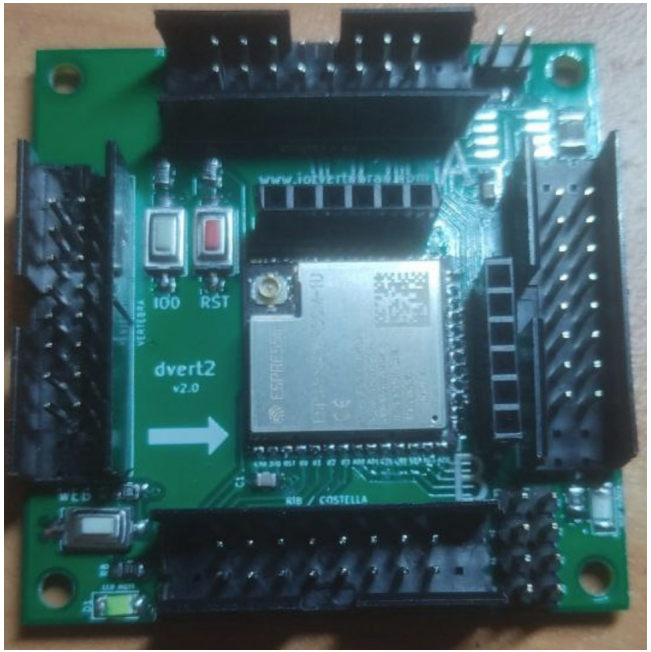
Digital vertebra (v1.0 –> v2.1)



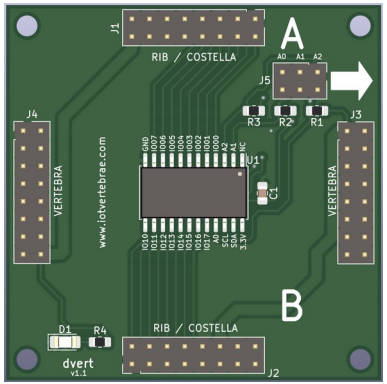


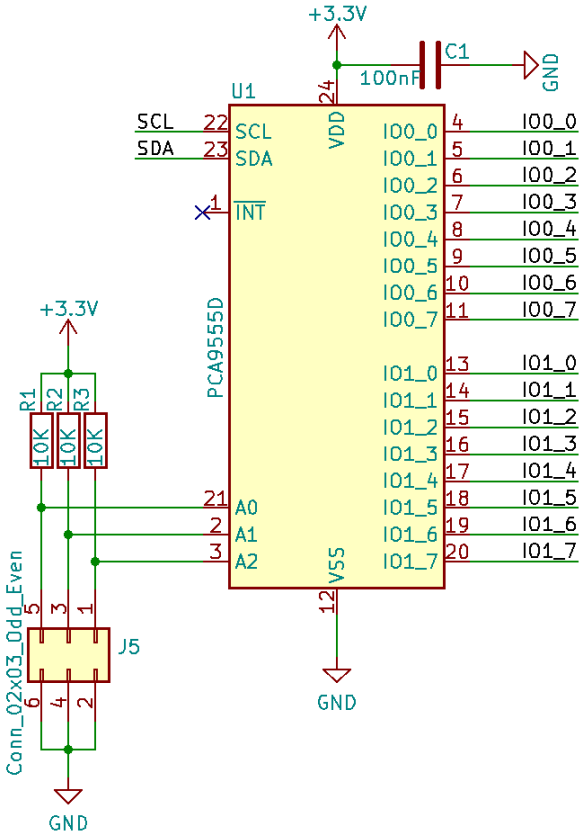
Digital vertebra (v1.0 –> v2.1)

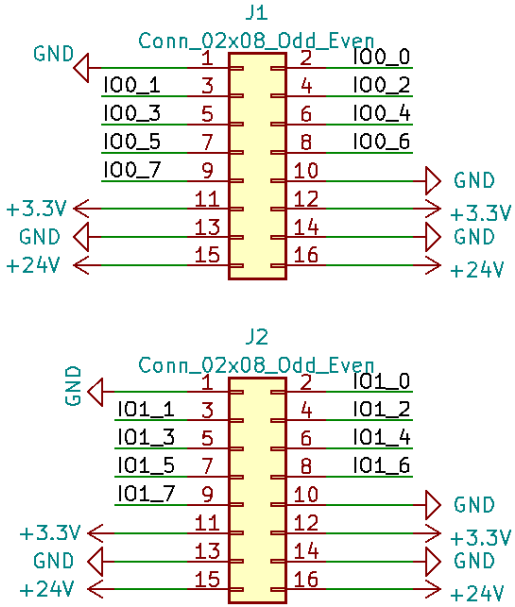




Digital vertebra (v1.0)







Digital vertebra

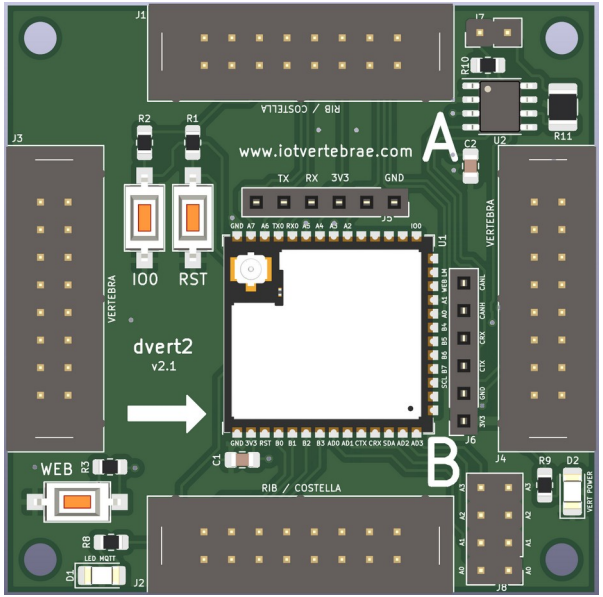
v1.0

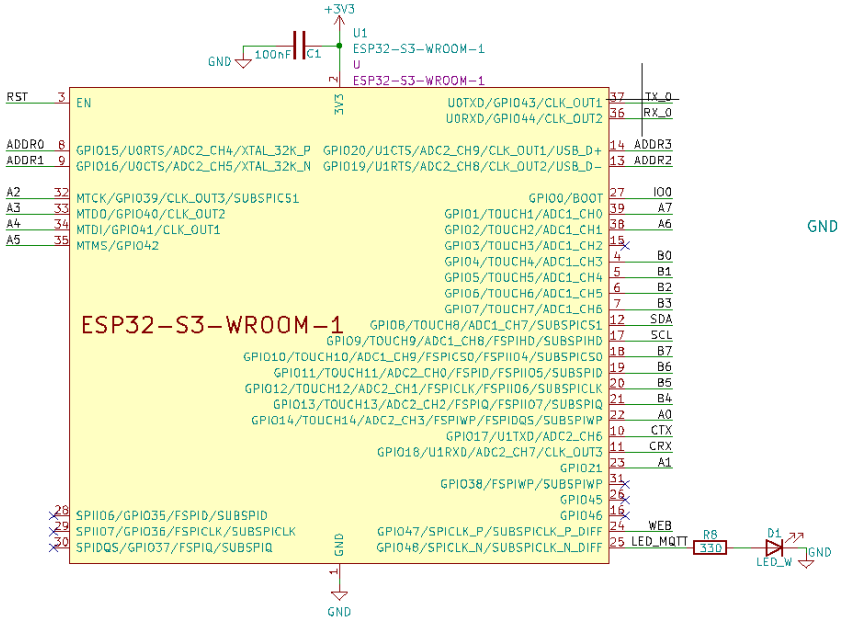
- PCA9555D
  (I/O expander 16 bit I2C)
- 3 bit address (0x20 .. 0x27)
- I2C communication
- Direct communication vert/rib

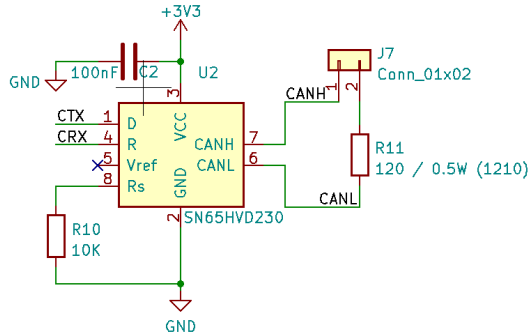
v2.1

- ESP32-S3
  (Microcontroller)
- 4 bit address (0x20 .. 0x2F)
- I2C and CAN communication
- Indirect communication vert/rib

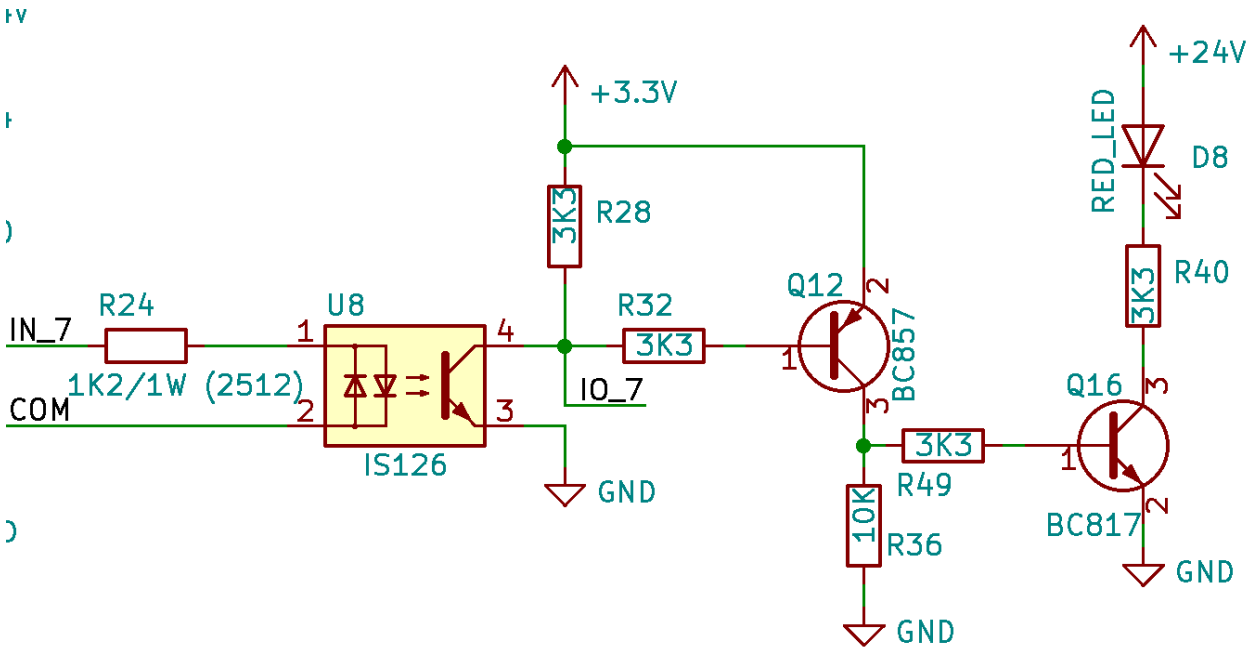
Digital vertebra (v2.1)



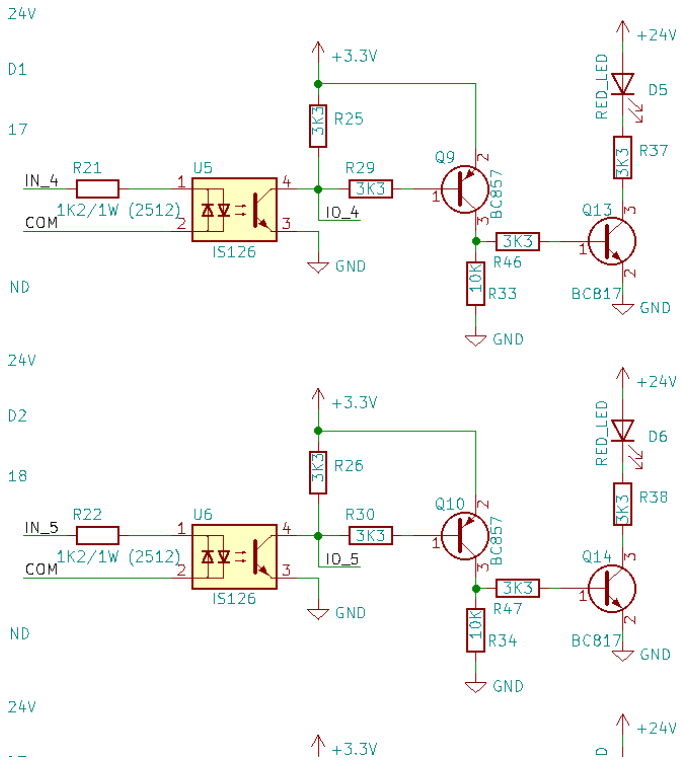


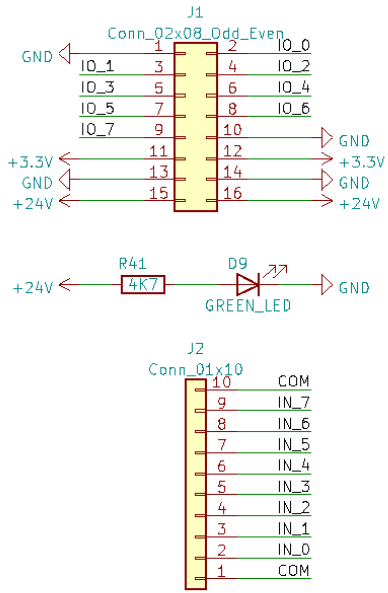


Digital Inputs Rib

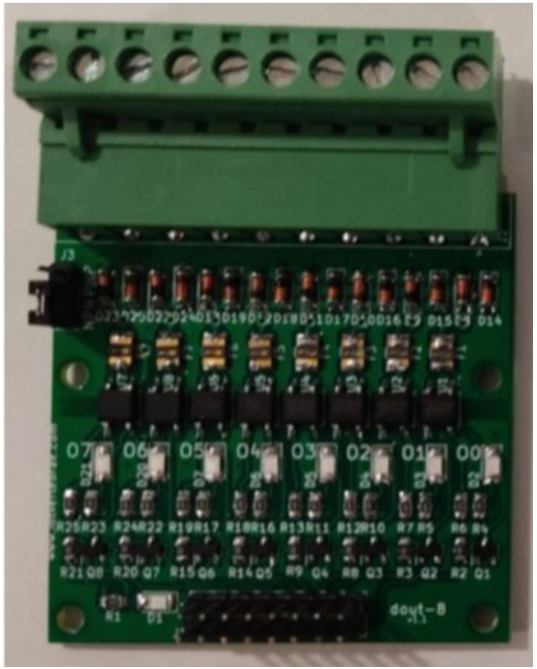


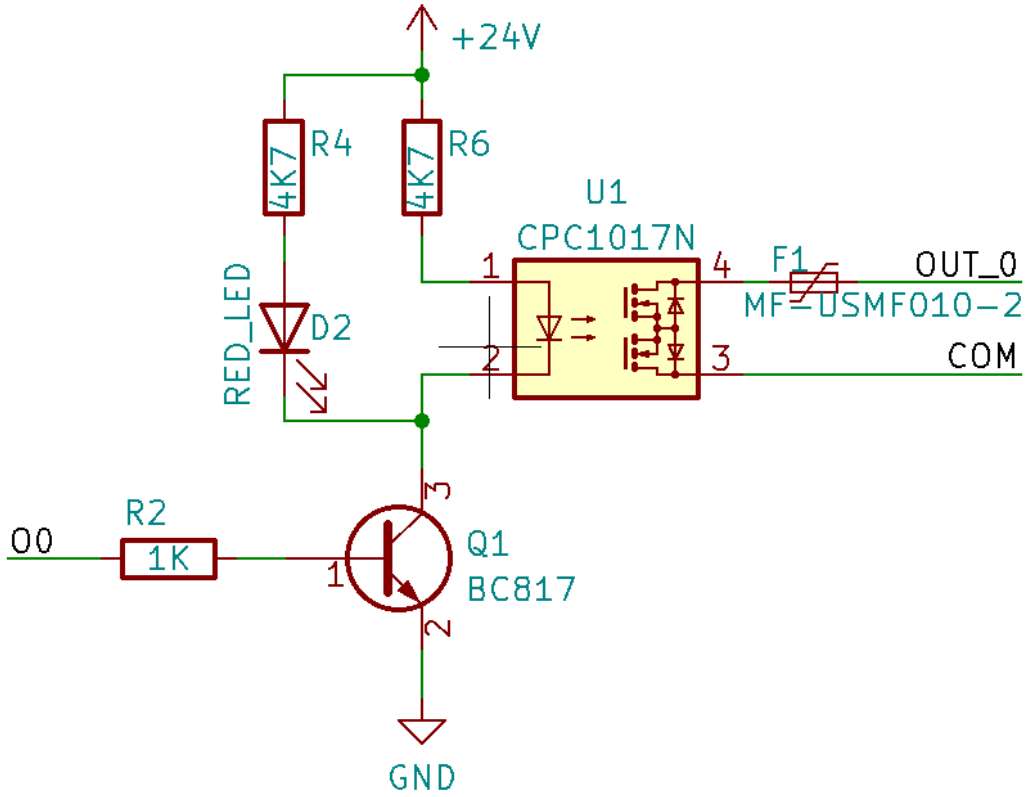
Digital Inputs Rib





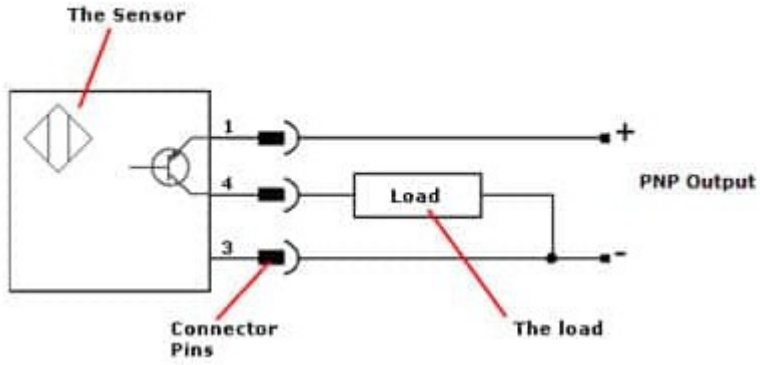
Digital Outputs Rib



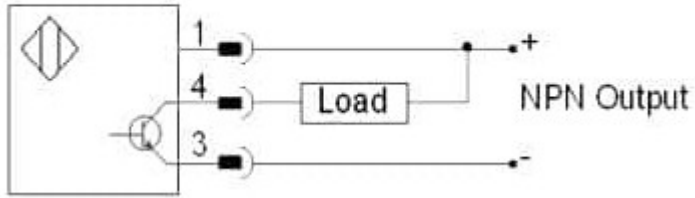


PNP and NPN Outputs

PNP 3-wire Standard Diagram

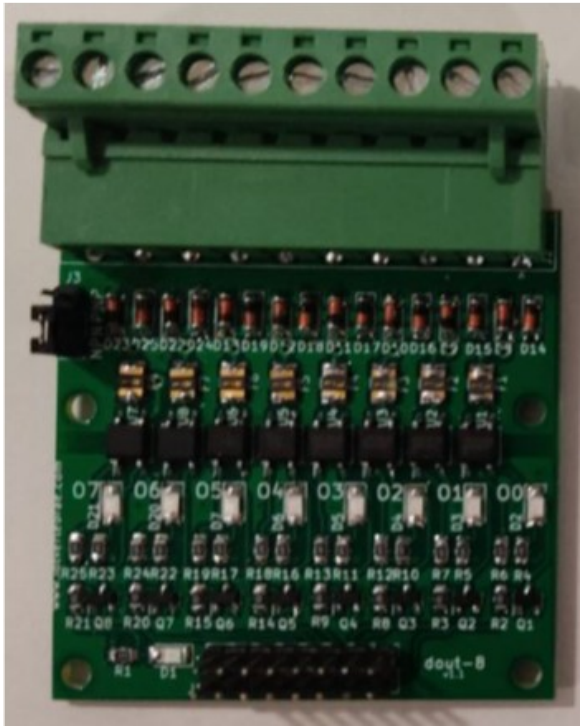


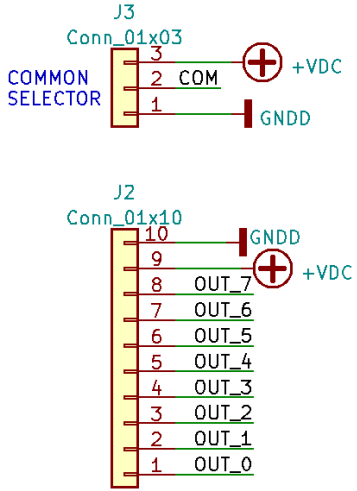
NPN 3-wire Standard Diagram

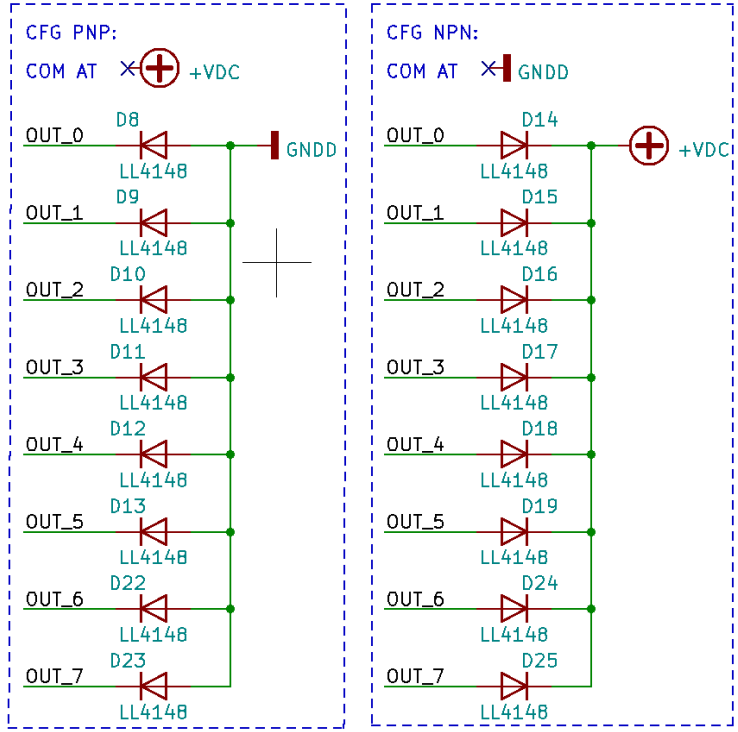


https://www.learnrobotics.org/blog/difference-between-pnp-and-npn/

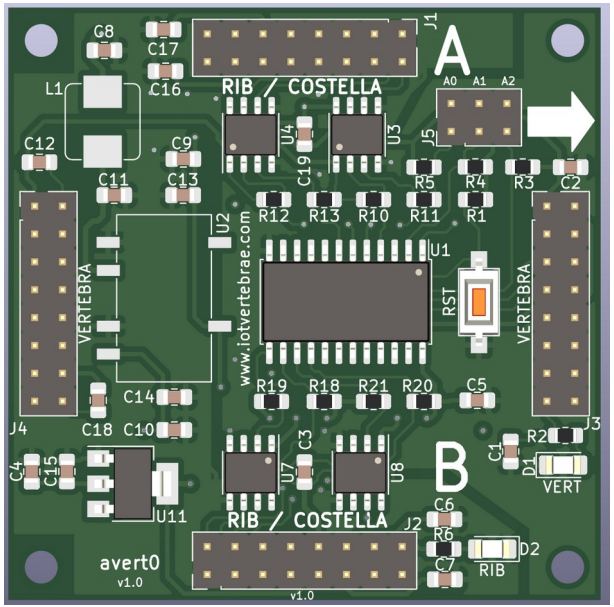
Digital Outputs Rib

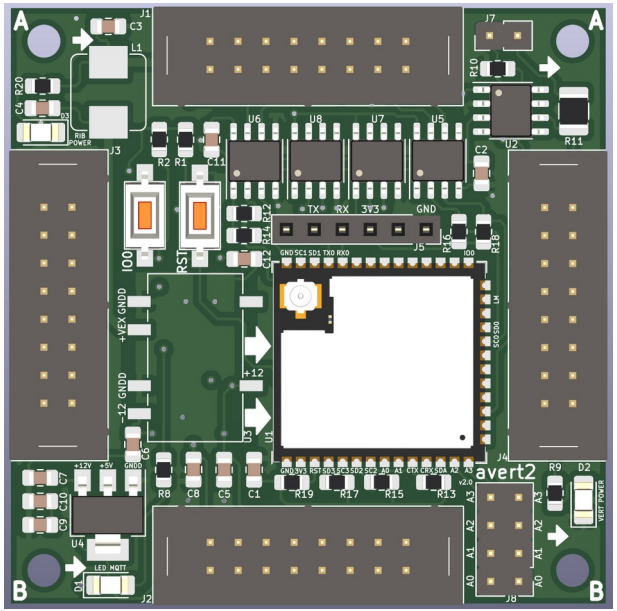




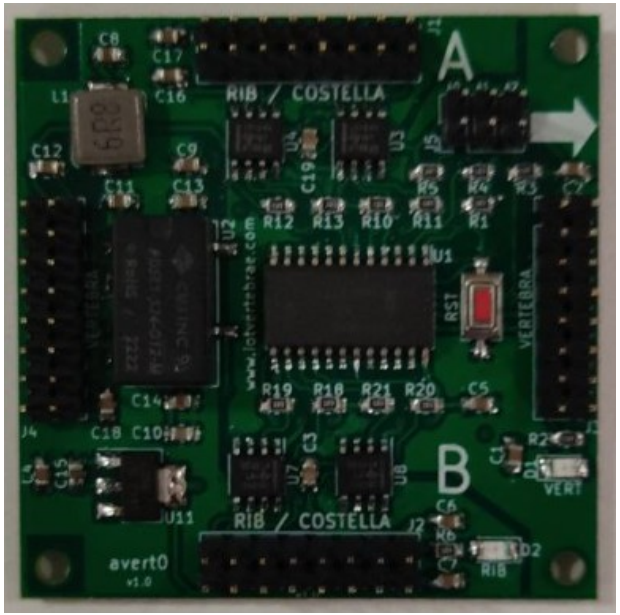


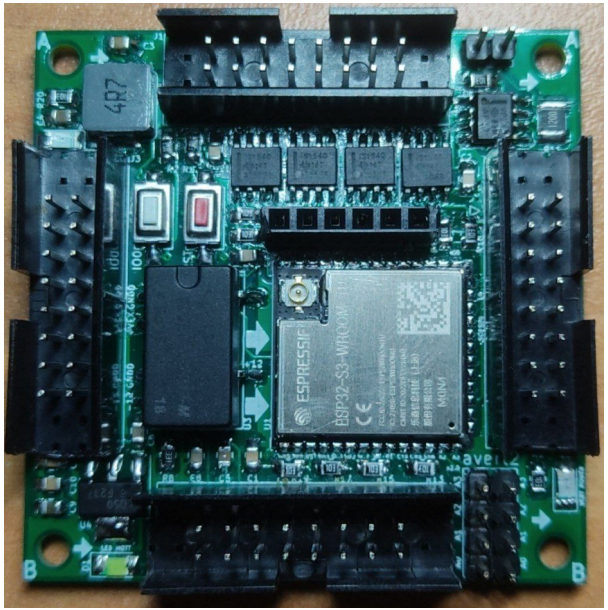
Analog vertebra (v1.0 –> v2.1)



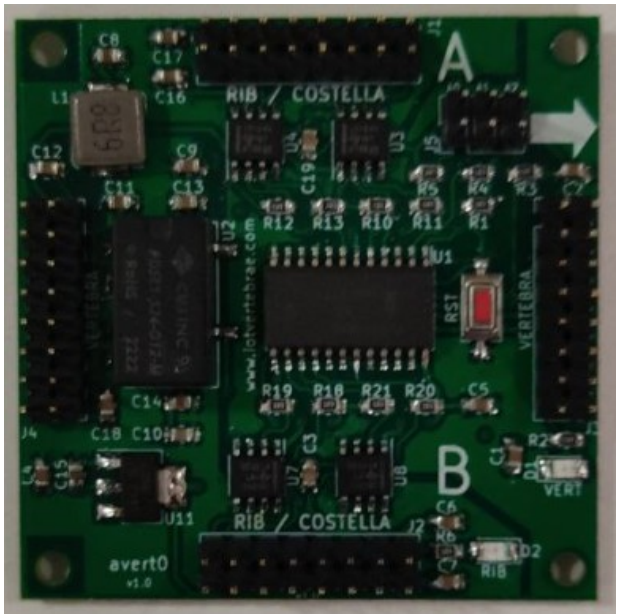


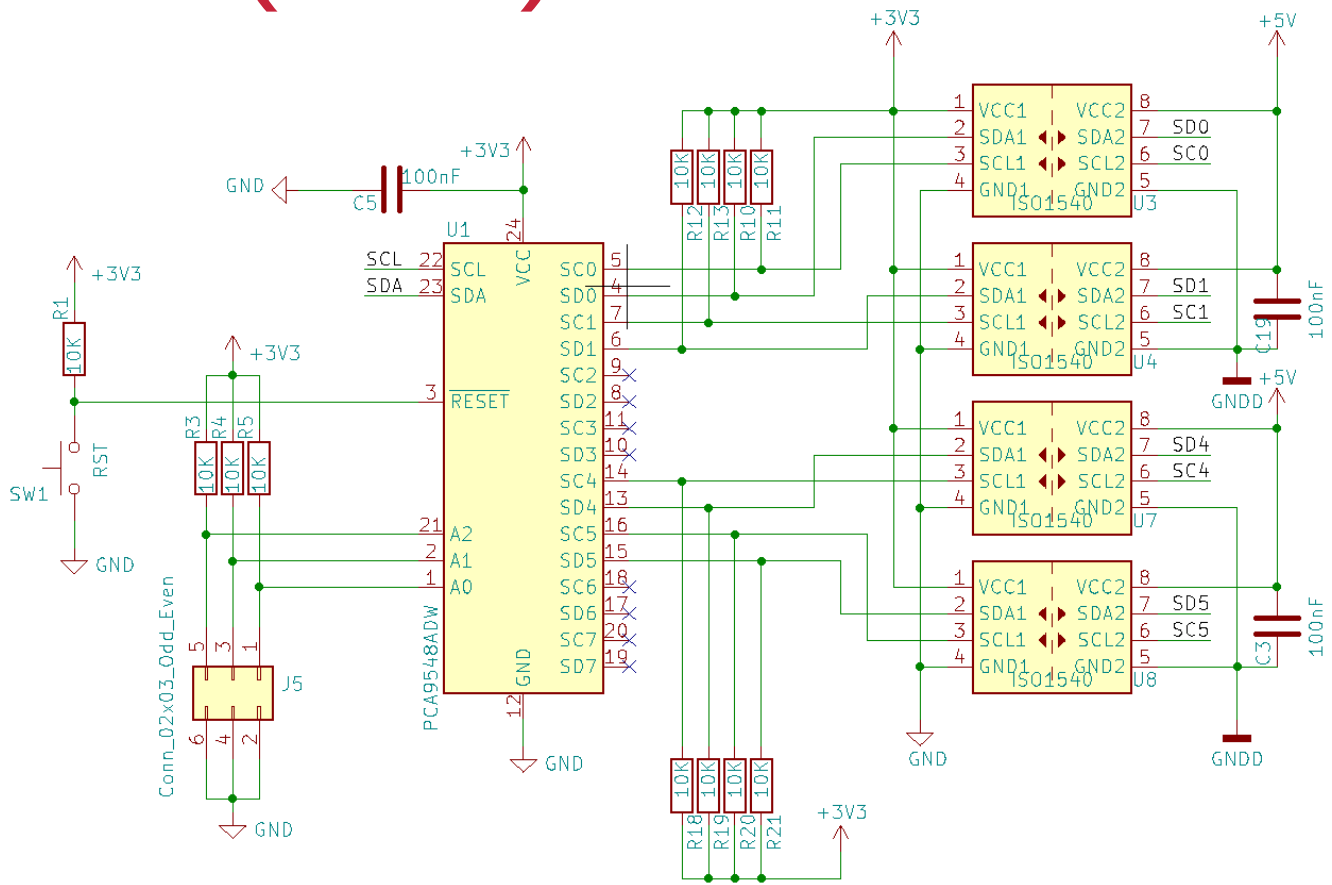
Analog vertebra (v1.0 –> v2.1)



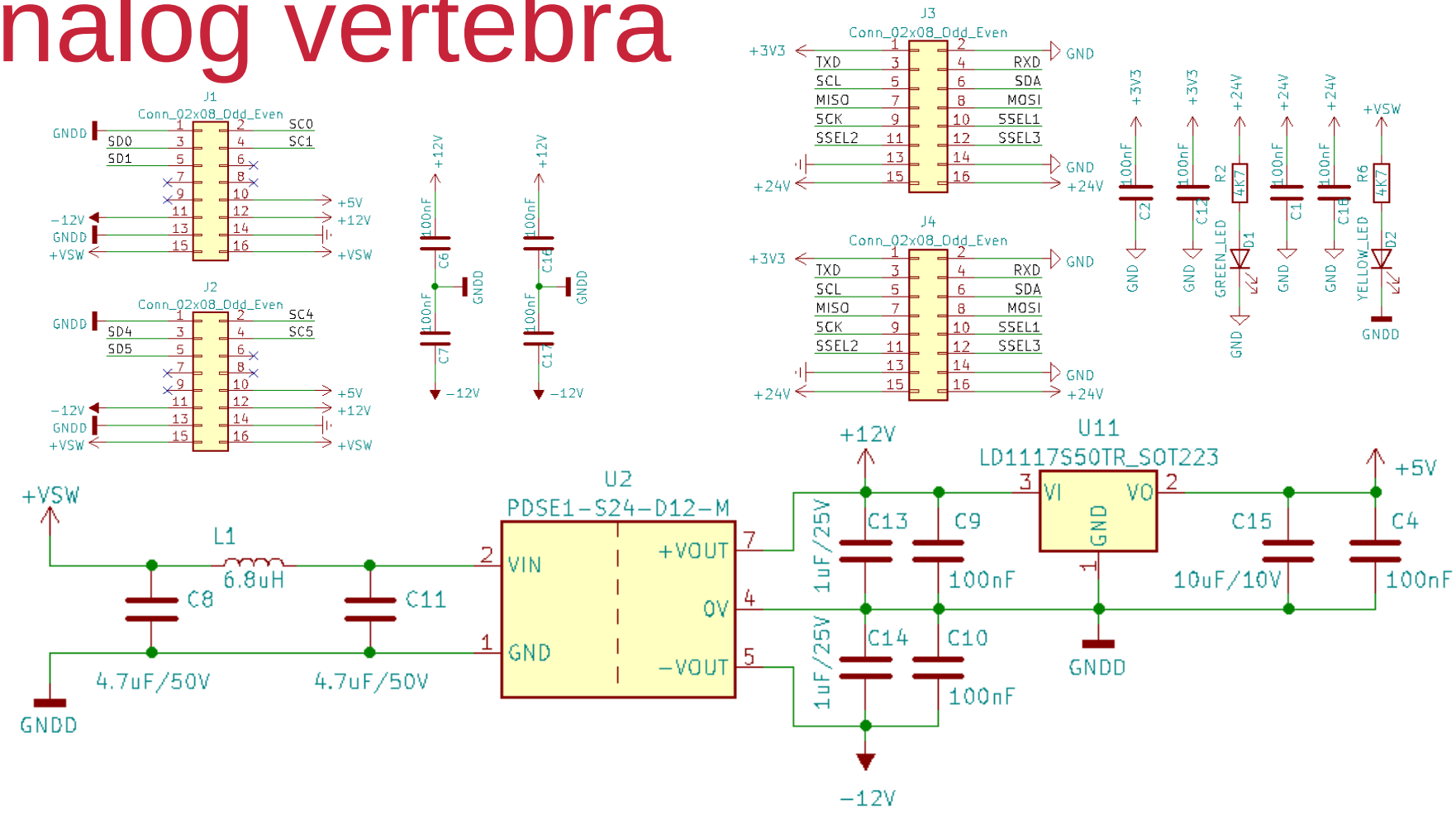


Analog vertebra (v1.0)





Analog vertebra



Analog vertebra

v1.0

- PCA9548ADW
  (8 Channel I2C switch)
- 3 bit address (0x70 .. 0x77)
- I2C communication
- Direct communication vert/rib

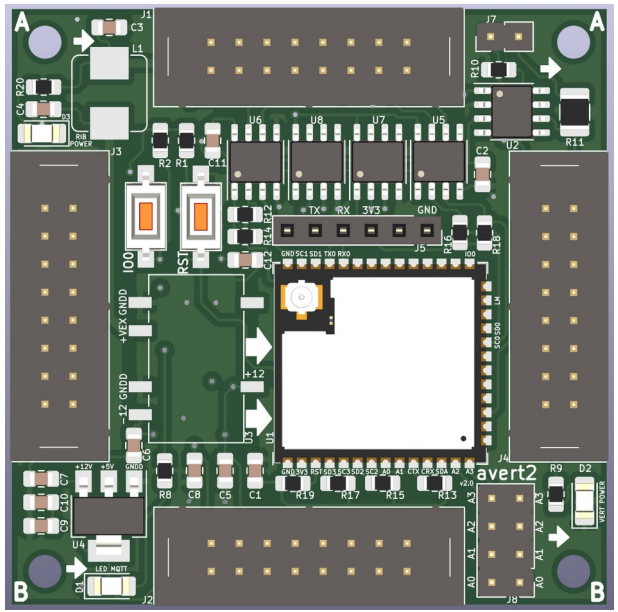
v2.1

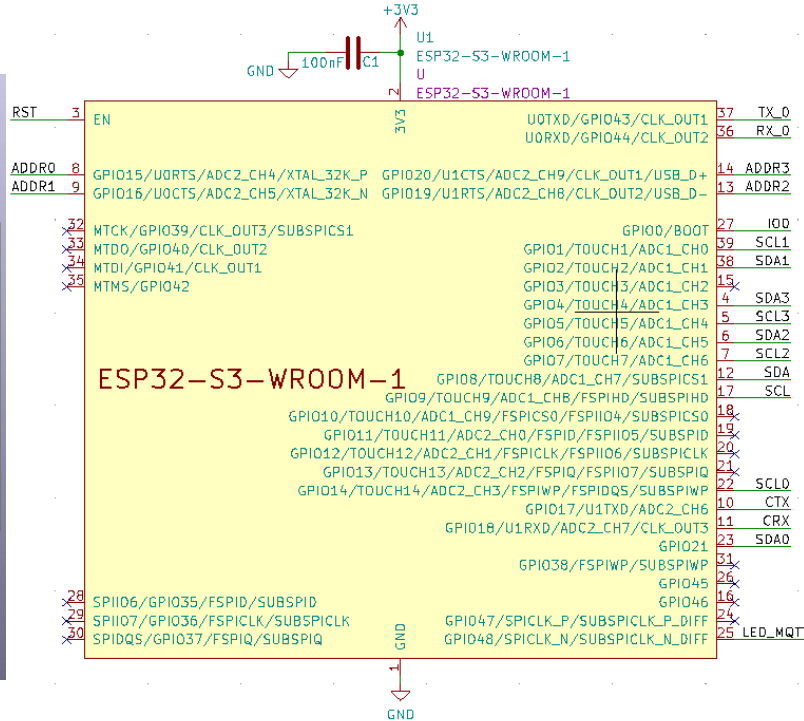
- ESP32-S3
  (Microcontroller)
- 4 bit address (0x10 .. 0x1F)
- I2C and CAN communication
- Indirect communication vert/rib

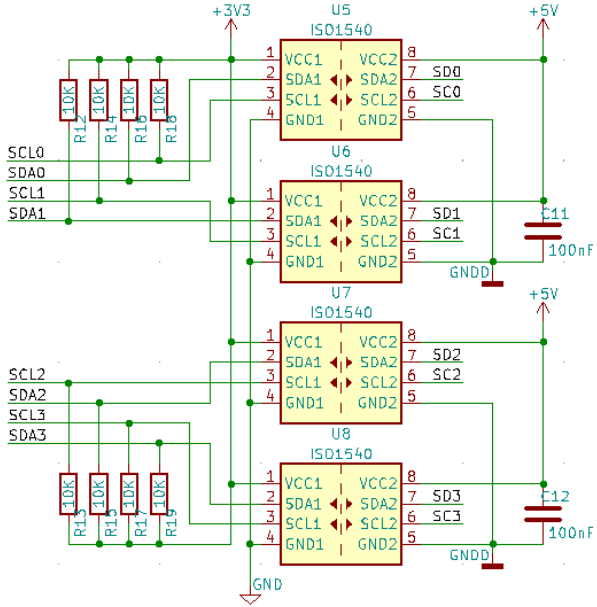
Common in both versions

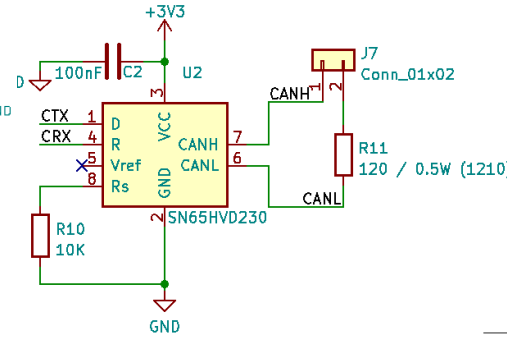
- Isolated I2C communication (3V3 vertebra, 5V rib)
- Isolated supply between vertebra and rib
- Vertebra converts external 24V from rib to +/- 12V

Analog vertebra (v2.1)

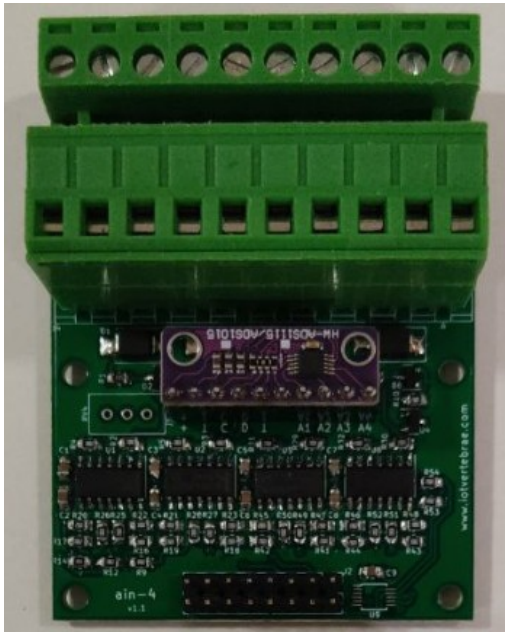


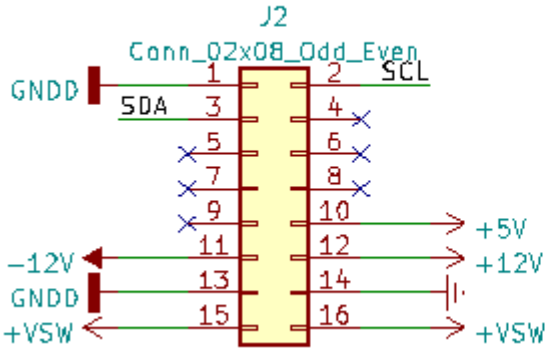


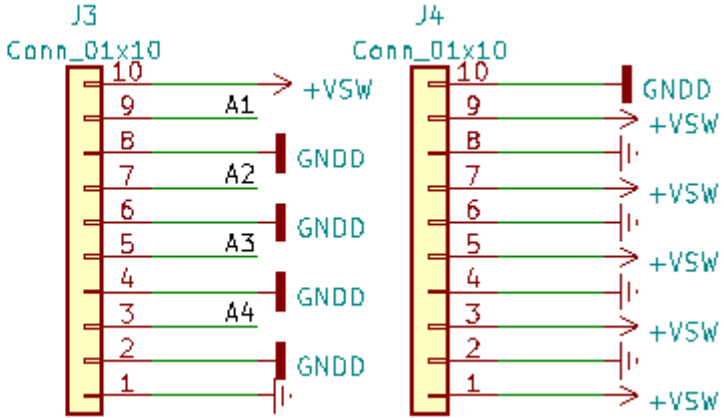




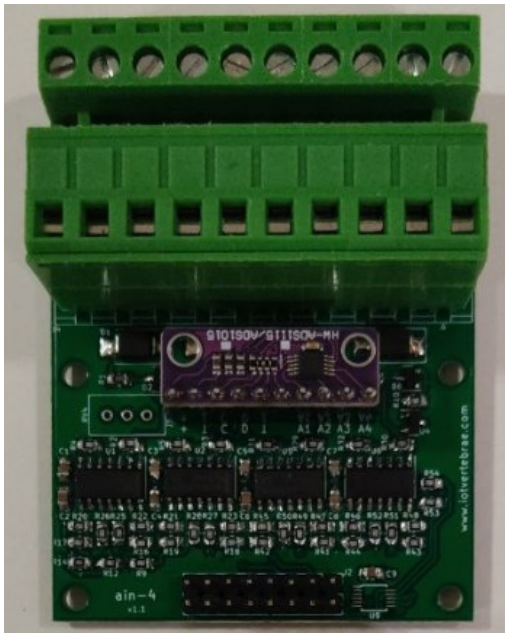
4 analog inputs (-10V to 10V)

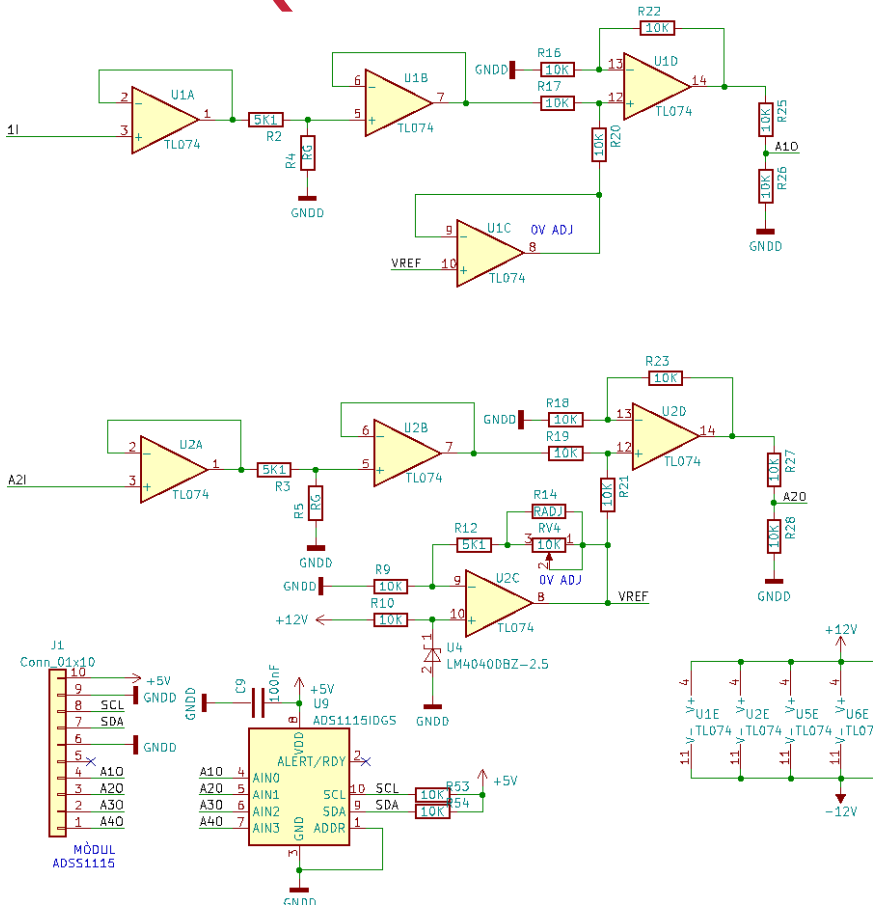


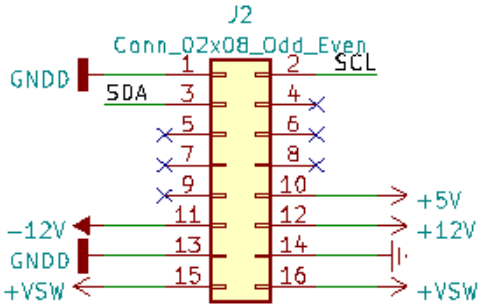




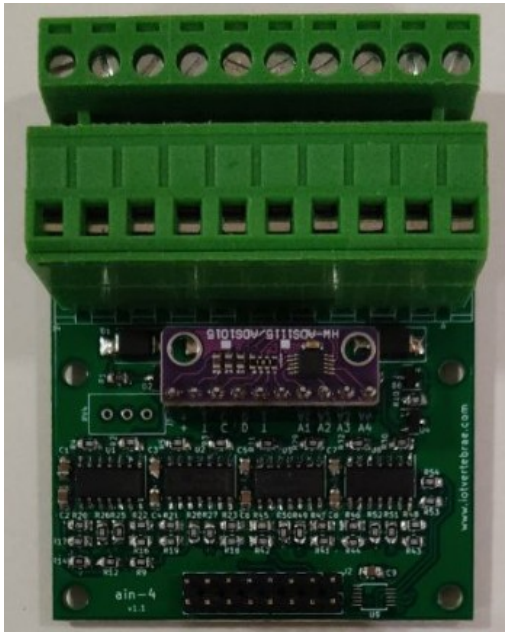
4 analog inputs (-10V to 10V)

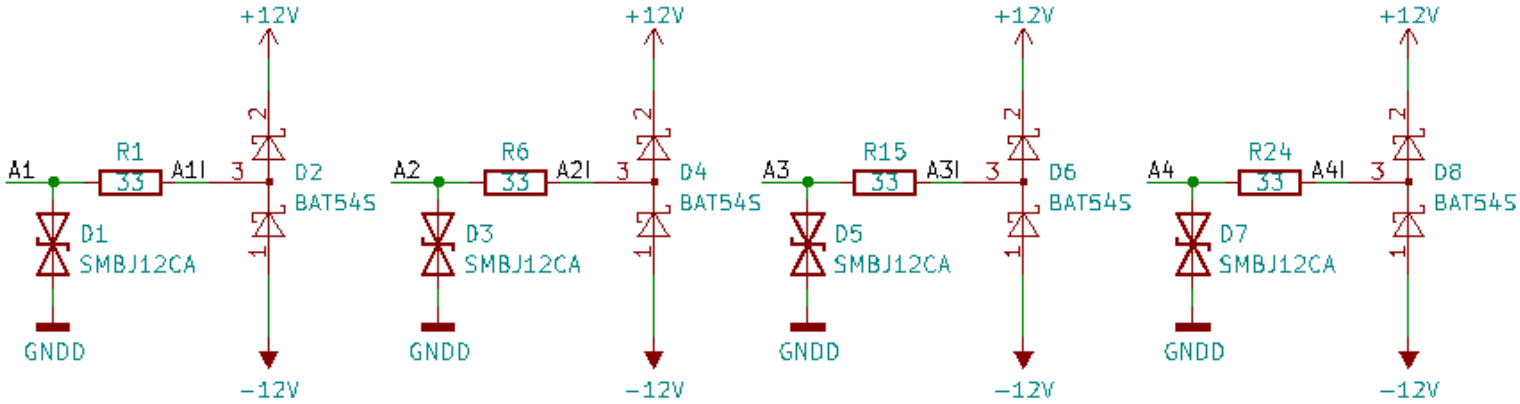




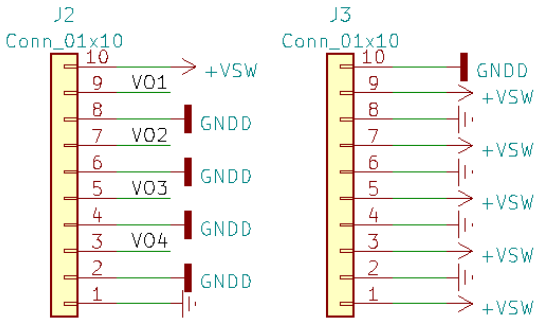


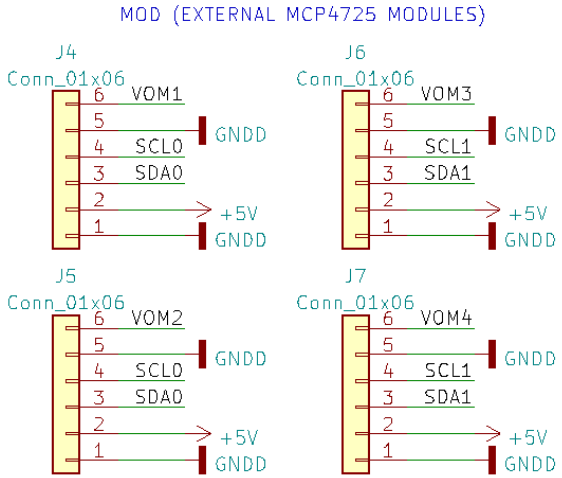
4 analog inputs (-10V to 10V)



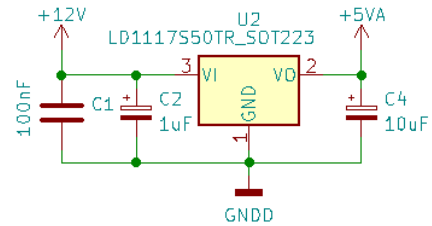


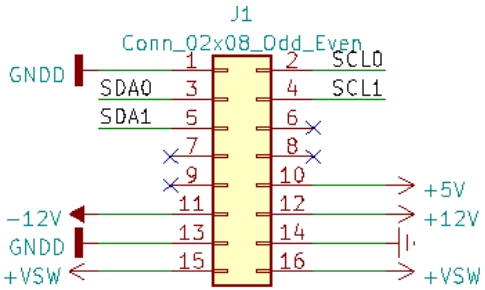
4 analog outputs (0 to 10V)

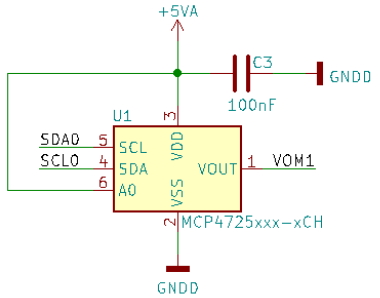


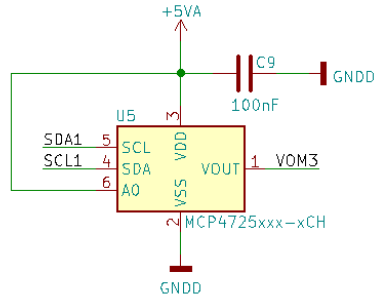


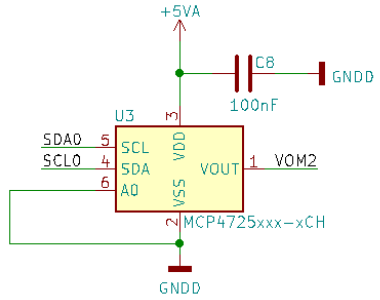
4 analog outputs (0 to 10V)

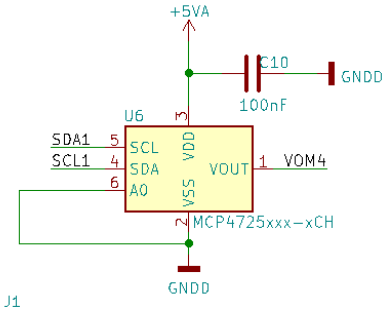




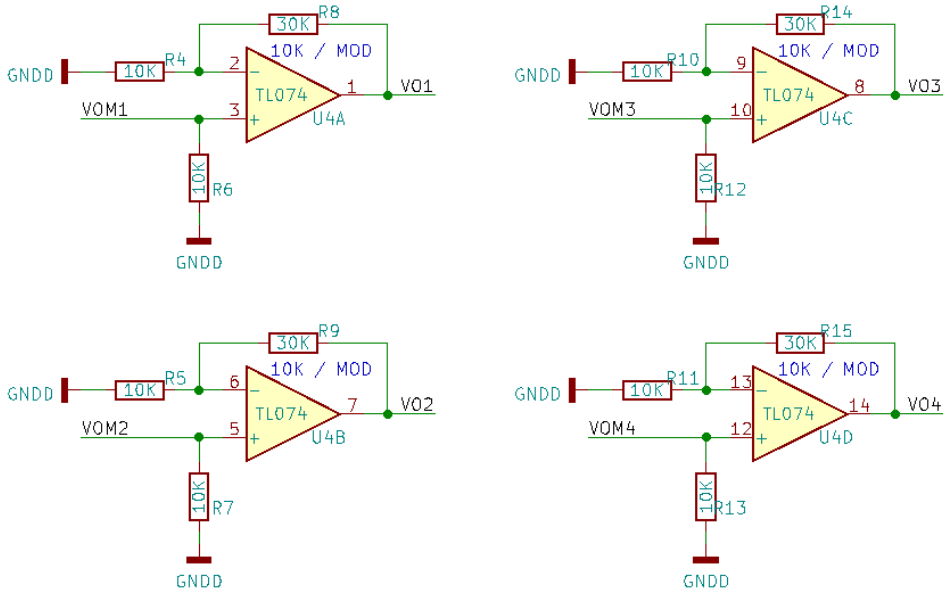


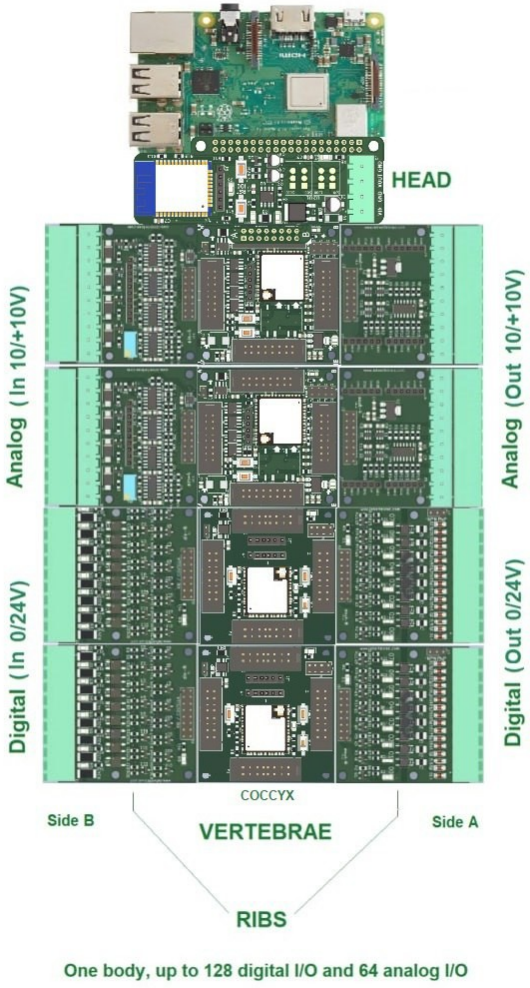


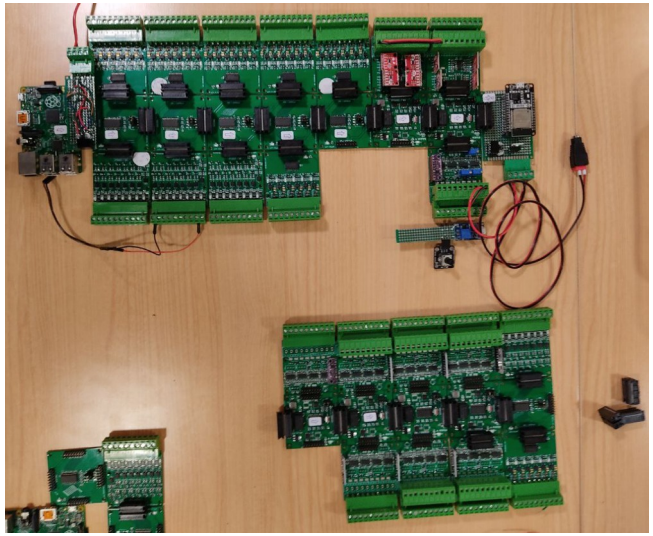


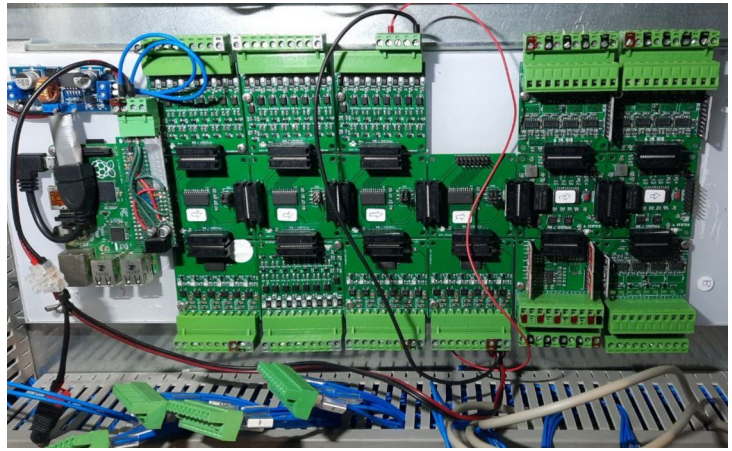


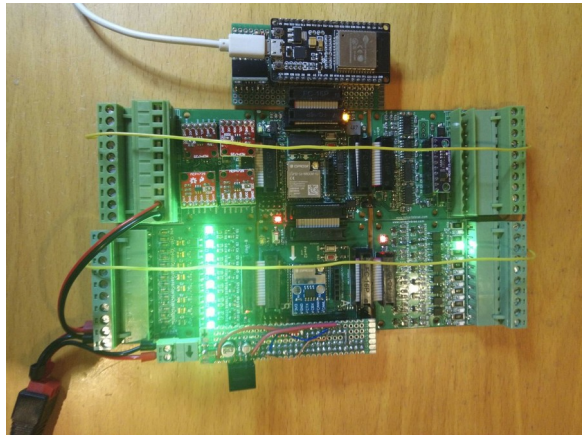
4 analog outputs (0 to 10V)

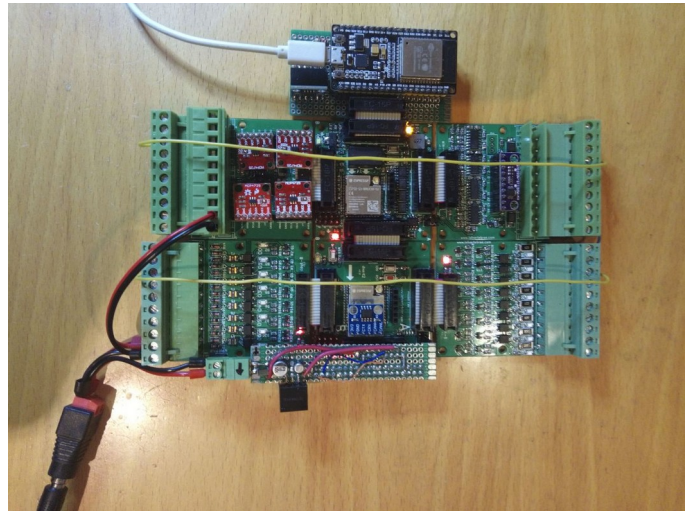



HEAD
Analog (In 10/+10V)
Analog (Out 10/+10V)
Digital (In 0/24V)
Digital (Out 0/24V)
COCCYX
Side B
VERTEBRAE
Side A
RIBS
One body, up to 128 digital I/O and 64 analog I/O









Question Time