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## **Build your own EEDURO Delta**

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### **Document Revisions**

<b>Rev.</b>	<b>Date</b>	<b>Author</b>	<b>Changes</b>
0.1	2015-02-04	Martin Zueger	Initial version

# Contents

# 1 Introduction

TODO Stefan/Martin

## **2 Getting all necessary parts**

### **2.1 Manufacturing the mechanical parts**

TODO Stefan

### **2.2 Ordering the commercial parts**

TODO Stefan/Martin

# 3 Mechanical assembly

## 3.1 EEDURO Delta robot

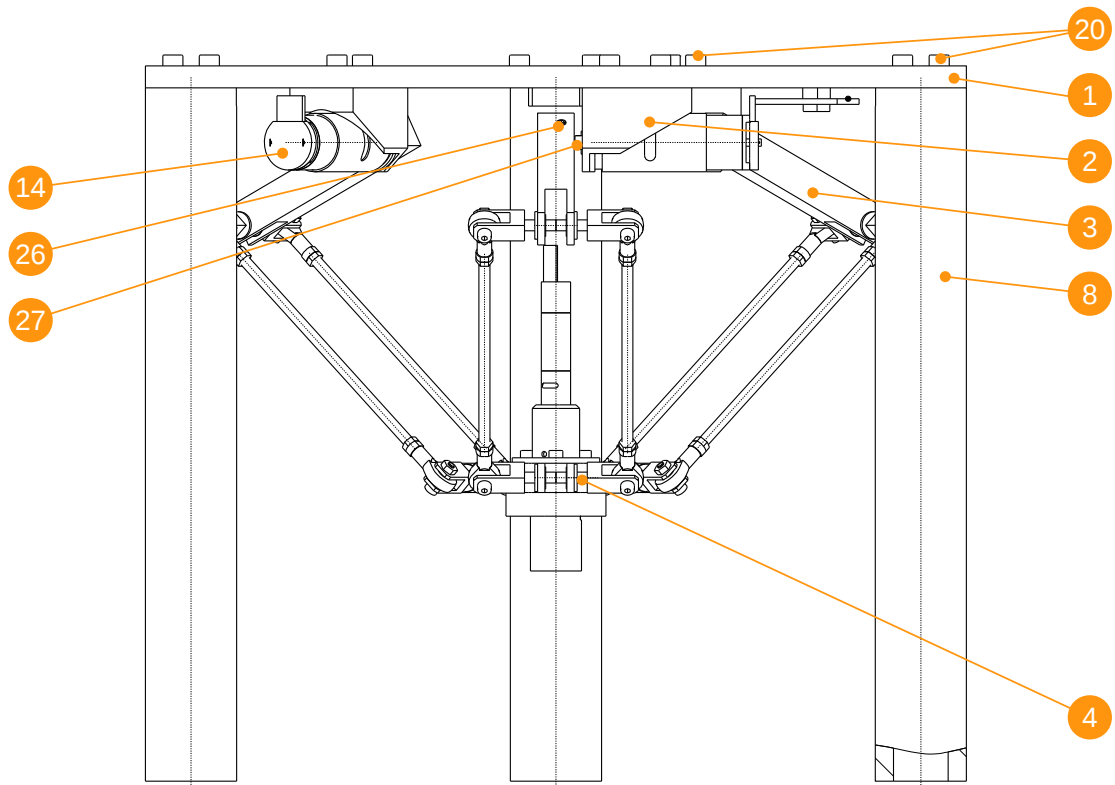


Figure 3.1: EEDURO delta

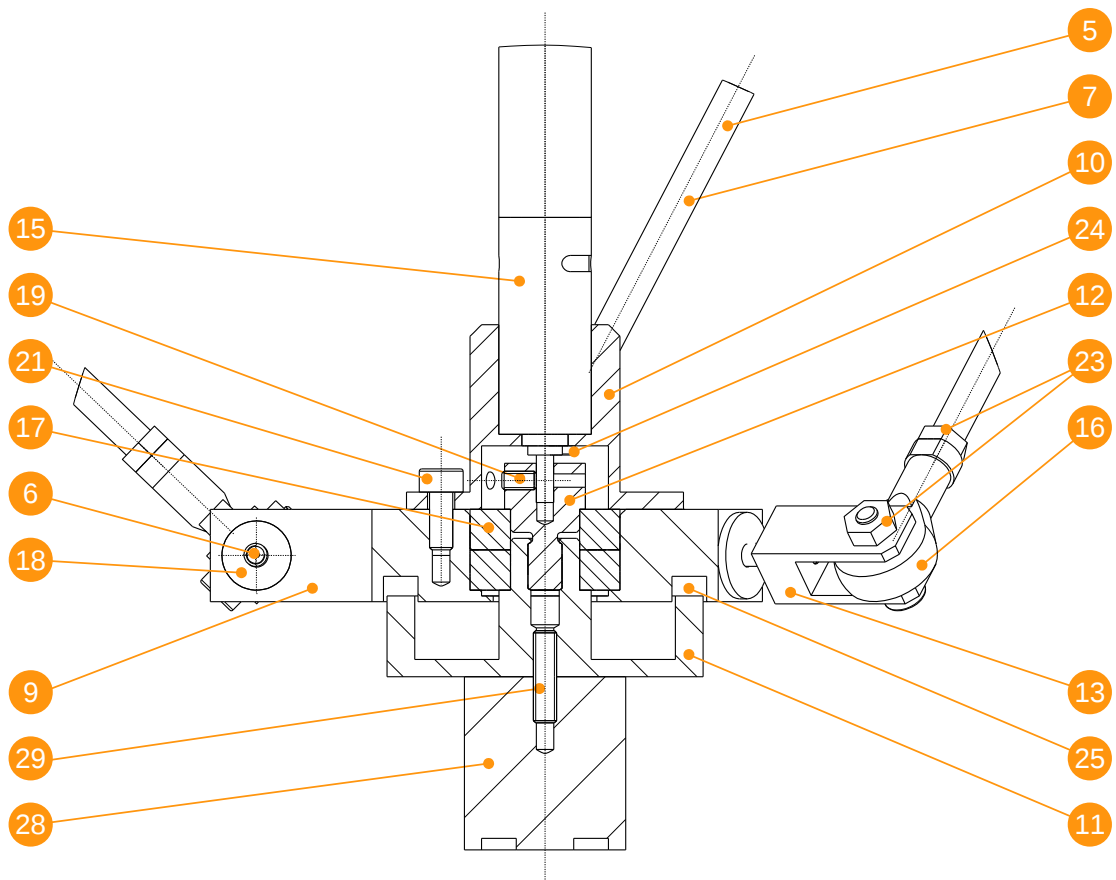
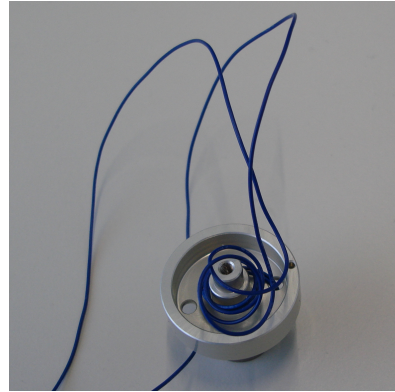


Figure 3.2: EEDURO delta TCP detail view (with mounted electro magnet)

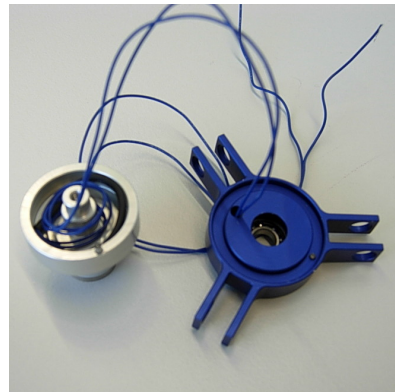
## Step 1: Mount the electro magnet

- Remove the heat shrink tubing from the cable of the electromagnets.
- Screw the rotating tool carrier (11) and the electromagnet (28) with the grub screw M2x8 (29) together and fix them with Loctite.
- Wind the cable of the electromagnet at least three or four times around the thicker flange of the tool carrier.



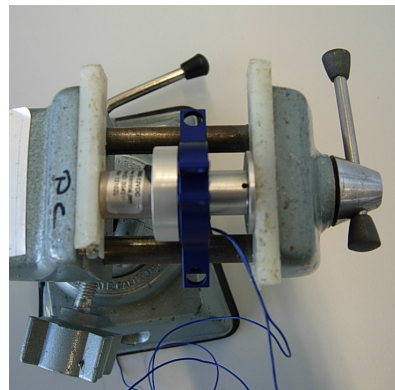
## Step 2

- Put a dowel pin (25) in the TCP link (9) and one in the rotating tool carrier. Measure how much the dowel pin protrudes from the rotating tool carrier (11). If it protrudes more than 1.4 mm, please abrade it. The two dowel pins will define the mechanical limit for the rotating tool carrier.
- Lead the cable of magnet through the hole of the TCP link.
- Put a groove ball bearing (17) in the TCP link.



## Step 3

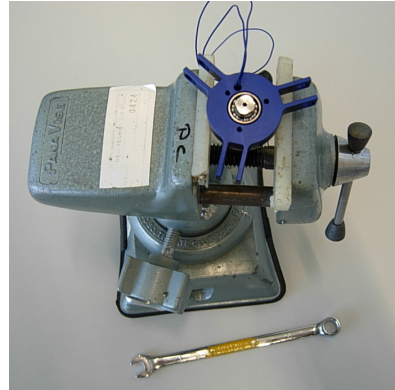
- Link the rotating tool carrier with the TCP link on the groove ball bearing.
- If the connection is severe, use a vise to use the TCP motor carrier (10) as a mounting aid. Mount everything together, setting the mechanical limit so that when the rotating tool carrier turns, the cables are not stretching or tangling.





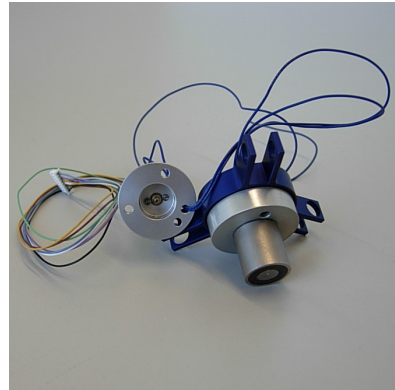
## Step 4

- Put a second groove ball bearing (17) in the TCP link.
- Screw the tool carrier motor adapter (12) in.
- Screw two grub screws (19) in the tool carrier motor adapter, but not too deep.



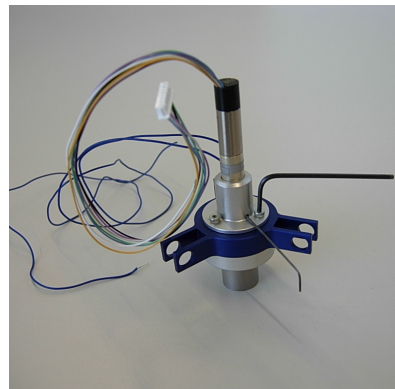
## Step 5

- Mount the motor (15) on the motor carrier (10) using the cheese screws M1.2x3 (24).
- Lead the cable of the magnet through the hole in the motor carrier.



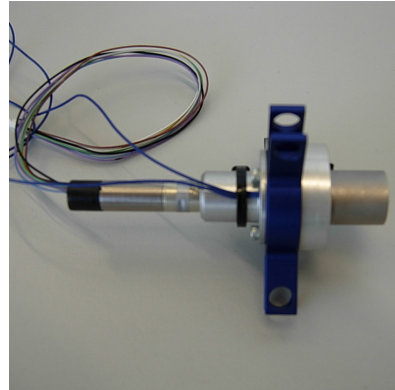
## Step 6

- Mount the motor carrier (10) with the cylinder head screw M2x5 (21) on the TCP link (9).
- Attach the motor shaft (15) to the tool carrier motor adapter (12) by screwing the two grub screws mounted in the tool carrier on step 4.



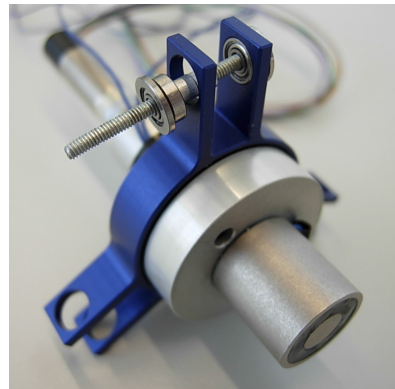
## Step 7

- Fix the cable of the magnet with a cable tie.



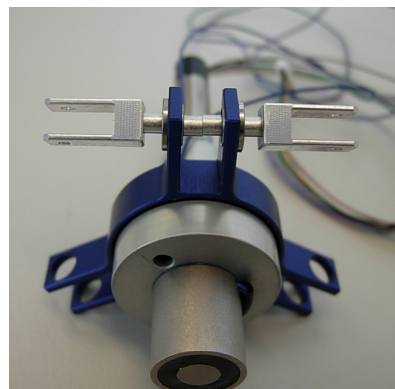
## Step 8

- Mount one threaded rod (6) with four distance sleeve (4) and two ball bearing (18) together.



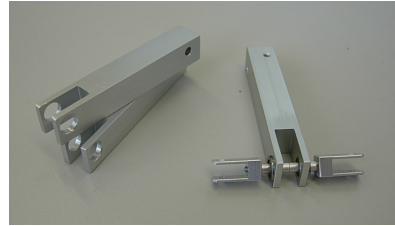
## Step 9

- Screw on both ends of the threaded rod a quicklink (13).
- Complete this step for all three joints.



## Step 10

- Repeat steps 8 and 9 also on the delta upper arms (3).
- Screw two grub screws M3x3 (xxx) in the Delta upper arms (3), but not too deep.



## Step 11

- The arms can be built using two nuts (23), a thread rod (7), a carbon tube (5) and two Igubal rod end spherical bearings (16).
- Make six arms.



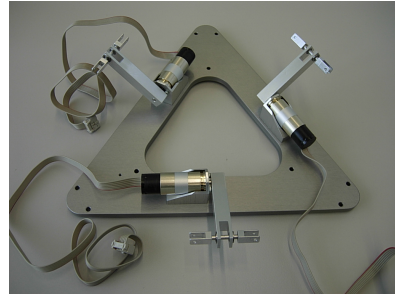
## Step 12

- Attach the motor (14) on the delta motor carrier (2) with two cylinder head screws M2x4 (xxx). Screw the two grub screws mounted on step 10 on the delta upper arms. Important: the grub screws have to press on the straight surface of the motor shaft.



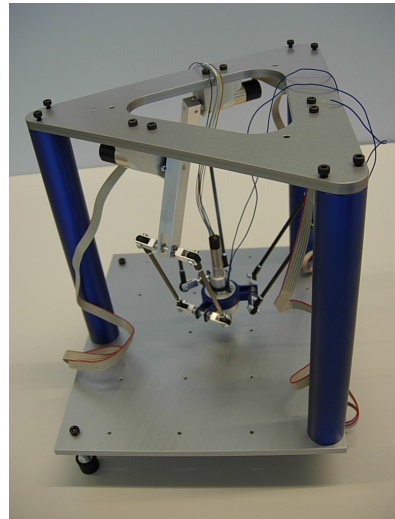
### Step 13

- Mount the three delta motor carrier (2) on the delta top carrier (1), note that the orientation of the motors must be counter clockwise.



### Step 14

- Connect the TCP link (9) to the delta upper arms (3) through the arms that were built at step 11, using the cylinder screws M2x8 (22) and nuts (23).
- The image gives an overview of the whole construction. Please ignore the orientation of the motors in this image, since it is not the same as for your robot.



TODO: replace Image

## 3.2 Base Case

TODO Stefan

## 3.3 Remote Case

TODO Stefan

## 3.4 Tile playing field

TODO Stefan

# 4 PCB assembly

## 4.1 Main board

TODO Martin

## 4.2 HMI extension board

The HMI extension board connects three buttons with integrated LEDs to the FPGA on the main board. For connecting both boards, a 20 wire ribbon cable is used (see Appendix ?? at page ?? for detailed information about the cable). This cable connects P1 on the main board with P1 on the extension board.

The buttons are connected with 4 wire ribbon cables as described in appendix ???. Use U1 to connect the blue button, U2 for the red and U3 for the green.

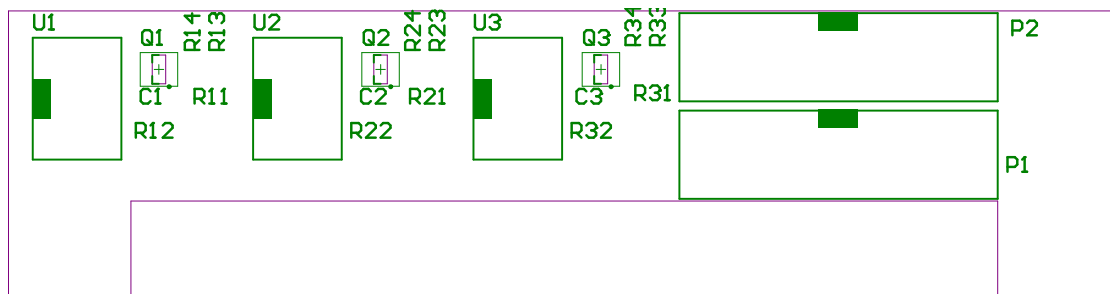


Figure 4.1: EEDURO HMI extension board assembly drawing

On the EEDURO main board Revision 3 or older, a reset circuit for the FPGA is missing. As a workaround this can be assembled instead of P2 on the extension board. There is also no support voltage available on P1 of the main board. Therefore a two way Molex connector P6 is used. Figure ?? shows the necessary modification.

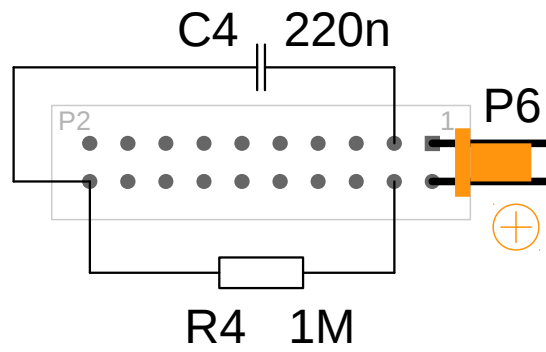


Figure 4.2: EEDURO HMI extension board modifications

### 4.3 Line receiver board

### 4.4 Line transmitter board

# 5 Wiring

## 5.1 Delta robot with base case

TODO

## 5.2 Delta robot with remote case

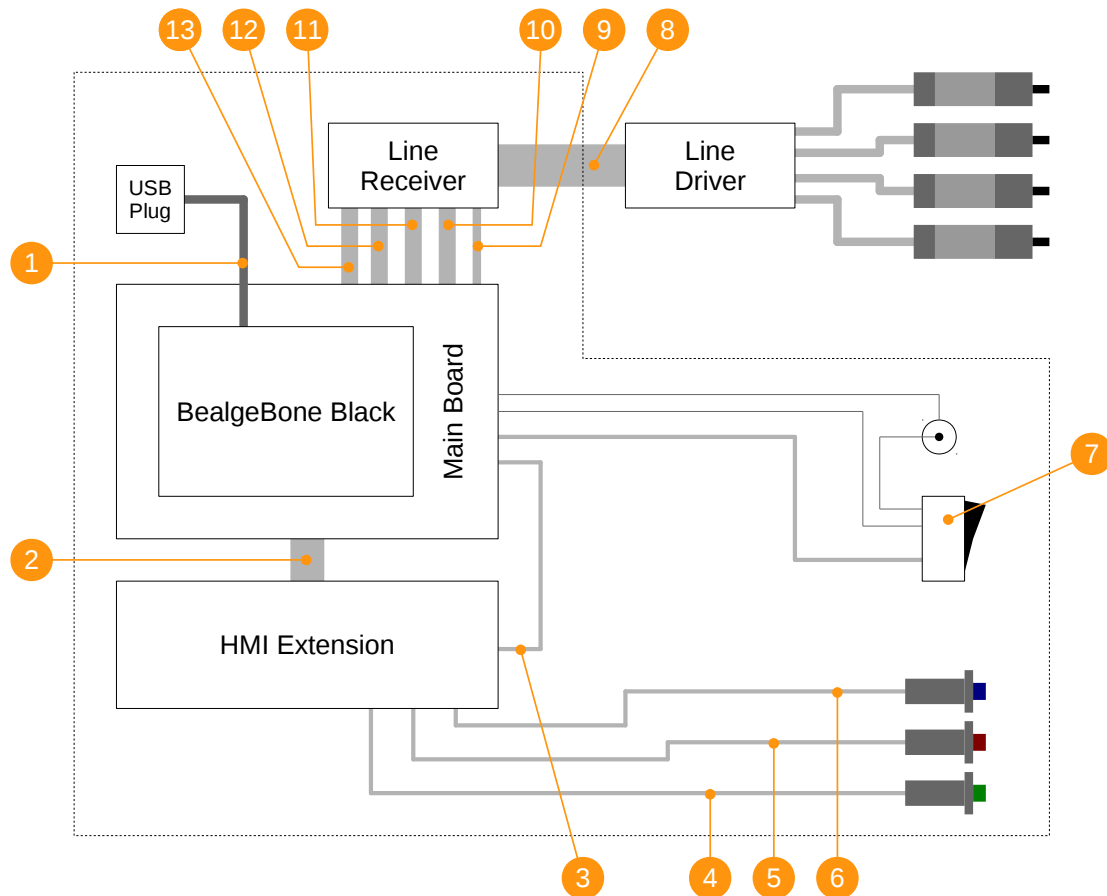


Figure 5.1: Cabling overview for the EEDURO delta robot with a remote control case

Build instructions for the cables can be found in appendix ?? on page ??.

- (1) USB extension cable with panel jack, see part list in appendix ?? at page ??. Connect to *USB Host* (P3) on the BeagleBone Black.

- (2) 20 wire ribbon cable, connects P1 on the main board with P1 on the HMI extension board.
- (3) HMI extension board power cable. Connects P6 on the extension board to the power terminal P2 on the main board. Consider the polarity!
- (4) Green button with integrated LED for user interaction. Connect to U3 on the HMI extension board.
- (5) Red button with integrated LED for user interaction. Connect to U2 on the HMI extension board.
- (6) Blue button with integrated LED for user interaction. Connect to U1 on the HMI extension board.
- (7) Connect the black ground wire (coming from the power connector X5) and the red wire (coming from the power switch) to the terminal P2 on the main board. Also connect the two wire cable for the power LED to the P2 terminal.
- (8) 34 way ribbon cable to the robot. Use X4 of the remote case.
- (9) 4 way ribbon cable for the electro magnet (Position 28 in Figure ?? at page ??) and the supply voltage for the line receiver board. Connect P1 on the line receiver board with POUT on the mainboard.
- (10) 6 way ribbon cable for axis 1 (Motor 0). Connect MOT1 on the line receiver board with MOTOR0 on the mainboard.
- (11) 6 way ribbon cable for axis 2 (Motor 1). Connect MOT2 on the line receiver board with MOTOR1 on the mainboard.
- (12) 6 way ribbon cable for axis 3 (Motor 2). Connect MOT3 on the line receiver board with MOTOR2 on the mainboard.
- (13) 6 way ribbon cable for axis 4 (Motor 3). Connect MOT4 on the line receiver board with MOTOR3 on the mainboard.

A full wired remote case is shown in figure ?? on page ??.



## 6 Testing

TODO

# Appendix

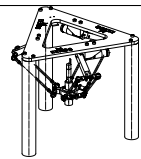
## A Part list

### A.1 Overview

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EEDURO Delta Robot

sub parts see appendix ?? at page ??



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EEDURO Base case

sub parts see appendix ?? at page ??

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EEDURO Remote Case

sub parts see appendix ?? at page ??

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EEDURO Tile Play Set

sub parts see appendix ?? at page ??














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EEDURO Delta Pencil Tool

sub parts see appendix ?? at page ??




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## A.2 EEDURO Delta Robot





Qty	Description	Details		Reference
1	Delta top carrier	Drawing EEDURO-D-001		1
3	Delta motor carrier	Drawing EEDURO-D-002		2
3	Delta upper arm	Drawing EEDURO-D-003		3
24	Distance sleeve ( $\varnothing 2/3 \times 2.8$ )	Drawing EEDURO-D-004		4
6	Carbon tube ( $\varnothing 2/3 \times 72$ )	Drawing EEDURO-D-005		5
6	Threaded rod ( $M2 \times 25$ )	Drawing EEDURO-D-006		6
6	Threaded rod ( $M2 \times 85$ )	Drawing EEDURO-D-007		7
3	Pillar	Drawing EEDURO-D-008		8
1	TCP link	Drawing EEDURO-D-009		9
1	TCP motor carrier	Drawing EEDURO-D-010		10
1	Rotating tool carrier	Drawing EEDURO-D-011		11
1	Tool carrier motor adapter	Drawing EEDURO-D-012		12
12	Quicklink	Drawing EEDURO-D-013		13
3	Faulhaber DC-Motor with gear	1524E012SR + IEH2-4096 + 15/8-76:1		14
1	Faulhaber DC-Motor with gear	0816D012SR-K256 + HEM3-256-W + 08/3-120:1		15
12	Igubal rod end spherical bearing	Igus KBRM-02		16
2	Groove ball bearing 16/6x3.5	Type 686		17
12	Ball bearing F692ZZ	Type F692ZZ		18

<b>Qty</b>	<b>Description</b>	<b>Details</b>	<b>Reference</b>
2	Grub screw M1.6x3		19
12	Cylinder head screw M3x10	ISO 4762	20
3	Cylinder head screw M2x5	ISO 4762	21
12	Cylinder head screw M2x8	ISO 4762	22
24	Nut M2	ISO 4032	23
2	Cheese screw M1.2x3		24
2	Dowel pin $\varnothing 1.5 \times 5h6$		25
6	Grub screw M2.5x3		26
6	Cylinder head screw M2x4	ISO 4762	27
1	Electro magnet	Tremba GTO-14-0.5000	28
1	Grub screw M2x8		29






### A.3 Base case

Qty	Description	Details		Reference
1	EEDURO base case	Drawing EEDURO-001		1
1	Base case cover (plexiglas)	Drawing EEDURO-002		2
1	EEDURO main board	sub parts see appendix ??		3
1	HMI extension board	sub parts see appendix ??		4
1	Power connector with switch	sub parts see appendix ??		5
1	Power supply 12 V, 1.5 A	TBD		6
1	USB cable with panel jack	Ampire XUB060		7
1	USB mini extension cable	Length: ca. 200 mm		8
1	USB mini panel mount	Drawing EEDURO-003		9
4	Cylindric rubber pad M3	Norelem 26106-00800855		10
6	Cylinder head screw M3x12	ISO 4762		11
2	Countersunk head screw, M3x12	ISO 10642		12
2	Washer M3			13
2	Nut M3	ISO 4032		14

## A.4 Remote case

Qty	Description	Details		Reference
1	Remote case	Hammond 1455T2201BU, see Drawing TBD		1
1	Main board	sub parts see appendix ??		2
1	HMI extension board	sub parts see appendix ??		3
1	Line Receiver board	sub parts see appendix ??		4
1	Power connector with switch	sub parts see appendix ??		5
1	Power supply 12 V, 1.5 A	Nordic Power AM04151A-12V		6
1	USB cable with panel jack	Ampire XUB060		7
4	Spacer bolt M3x5 mm	Distrelec 340962		8
6	Countersunk head screw, M3x6	ISO 10642		9
4	Nut M3	ISO 4032		10
8	Polyamid washer $\varnothing 7/3.2 \times 0.5$	ISO 7089		11
2	Spacer block M3, 6x6x12	Ettinger 05.60.233, Farnell 1466866		12
1	Line Driver board	sub parts see appendix ??		13
1	EEDURO robot base plate	Drawing EEDURO-004		14
6	Cylinder head screw M3x12	ISO 4762		15



## A.5 EEDURO Tile Play Set

Qty	Description	Details		Reference
1	Tile 1	Drawing EEDURO-A-001		1
1	Tile 2	Drawing EEDURO-A-002		2
1	Tile 3	Drawing EEDURO-A-003		3
1	Tile playing field	Drawing EEDURO-A-004		4
4	Spacer bolt M3x15 mm	TBD		5
4	Cylinder head screw M3x12	ISO 4762		6
4	Washer M3			7

## A.6 EEDURO Delta Pencil Tool

Qty	Description	Details	Reference
1	Lead mount	Drawing EEDURO-D-014	

## A.7 Power connector with switch

Qty	Description	Details		Reference
1	Rocker switch 19.6 mm x 13 mm	Miyama DS-850-K-F1-LG Conrad 706032		
1	Coaxial power plug $\varnothing 5.8/2.5$	Conrad 716916		
1	Litz wire, 1.0 mm <sup>2</sup> , red	Length 450 mm		
1	Litz wire, 1.0 mm <sup>2</sup> , red	Length 430 mm		
1	Litz wire, 1.0 mm <sup>2</sup> , black	Length 210 mm		
1	Two-Wire cable, 2x0.22 mm <sup>2</sup>	Length 430 mm		
1	Axial-lead resistor	1k $\Omega$		





## A.8 Main board

Qty	Description	Reference
1	BeagleBone Black, BBB-CNCT-O	BBB
1	Buck Converter TPS5432, SO-PPAD-DDA-8	U5
1	Buck Converter TPS54531, SO-PPAD-DDA-8	U4
1	Capacitor 15pF, 0603	C2
1	Capacitor 2.2nF, 0603	C27
1	Capacitor 22pF, 0603	C30
1	Capacitor 6.8nF, 0603	C37
1	Capacitor 68pF, 0603	C38
17	Capacitor 100nF, 0603	C9, C11, C12, C14, C15, C16, C17, C18, C19, C21_H01, C21_H23, C22_H01, C22_H23, C23, C32, C34, C47
2	Capacitor 22uF, 1206	C35, C36
2	Capacitor 4.7uF, 1206	C24, C25
2	Capacitor 47uF, 1206	C28, C29
4	Capacitor 100uF, 1206	C45_H01, C45_H23, C46_H01, C46_H23
4	Capacitor 10uF, 1206	C10, C33, C40, C42
7	Capacitor 330nF, 0603	C1, C5, C7, C13, C41, C43, C44
9	Capacitor 10nF, 0603	C3, C4, C6, C8, C20_H01, C20_H23, C26, C31, C39
1	DC Input Plug, DCJACK	P3
2	DUAL H-BRIDGE DRIVER IC DRV8841PWPR, TI_HTSSOP(PWP)-(R-PDSO-G28)_R	U3_H01, U3_H23
1	Dual N-Channel MOSFET FDC6561AN, SuperSOT-6	Q1
1	Header 2x2, H100P2X2-F	POUT
1	Header 9X2, H100P2x9	P1
4	HEM3, Molex-51021-8	MOT0, MOT1, MOT2, MOT3
4	IE2, IE2	MOTOR0, MOTOR1, MOTOR2, MOTOR3
1	Inductor - Power 3.3uH, XAL4020	L2
1	Inductor - Power 4.7uH, XAL4020	L1
1	JTAG Connector JTAG, JTAG	JTAG
2	Jumper, H100P2x2	J1, J2
1	LDO Linear Regulator LP38852, DDPAK-7	U6
1	MOSFET Driver FAN3227, SOIC127P600X175-8M	U1
1	Oszillator 48MHZ, KC5032A	X1

TODO: import CSV

### **A.9 HMI extension board**

TODO: import CSV

### **A.10 Line driver board**

TODO: import CSV

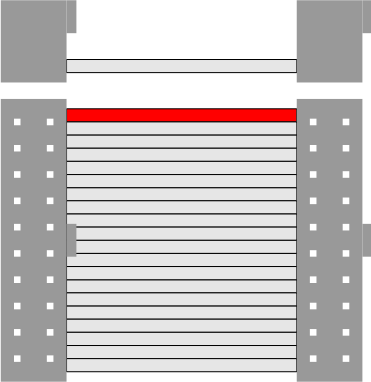
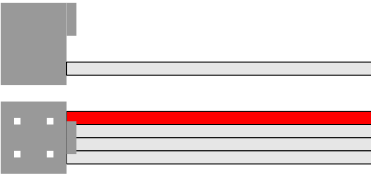
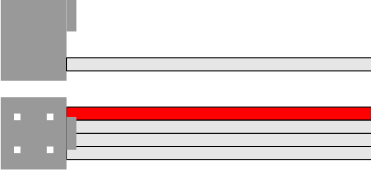
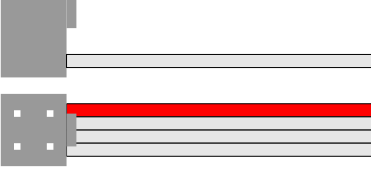
### **A.11 Line receiver board**

TODO: import CSV

## B Cable build instructions

### B.1 Power supply cables

### B.2 HMI extension cables

Cable	Pins	Length	Connector alignment
xxxxx	20	2.0 cm	
xxxxx	4	45.5 cm	
xxxxx	4	42.5 cm	
xxxxx	4	41.5 cm	

The Buttons has to be soldered as shown in figure ???. Cut the LED pins to the same length as the button pins before soldering. Use a heat shrink tube to isolate the soldering.

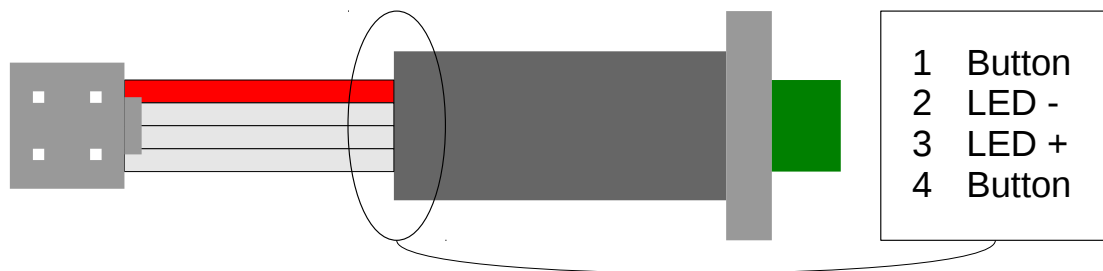
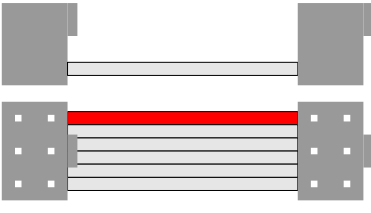
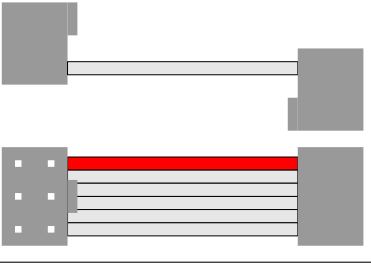
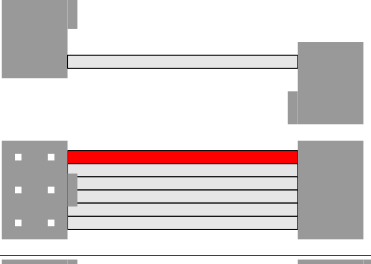
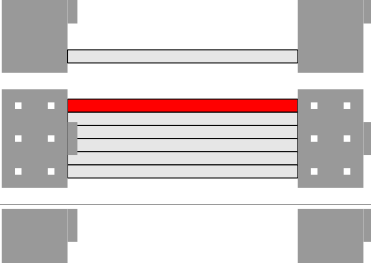
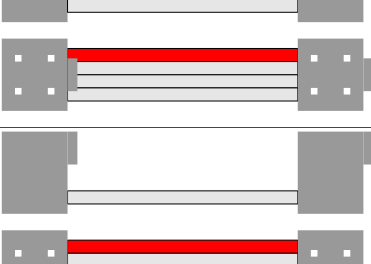


Figure B.1: Pin assignment for the buttons



### B.3 Line receiver and line driver cables

Cable	Pins	Length	Connector alignment
xxx.001	6	7.5 cm	
xxx.002	6	10.5 cm	
xxx.003	6	15.0 cm	
xxx.004	6	15.0 cm	
xxx.005	4	18.0 cm	
xxx.zzz	34	custom	