ECHORD++ Flooring Fellow

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http://www.echord.eu/

D1.2
Detailed Technical Project

Delivery date: [31/12/2016]

Start date of project: 01/05/2015 Duration: 18 months

Organisation name of lead contractor for this deliverable: RT, IMER

Deliverable authors: Giancarlo Teti, Luca Volpi, Leandro Bandini, Alessandro Quercioli

Version: [1.5]

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Dissemination Level		
PU	Public	
PP	Restricted to other programme participants (including the Commission Service)	
RE	Restricted to a group specified by the consortium (including the Commission Service)	
CO	Confidential, only for members of the consortium (including the Commission Service)	**CO**

Document History

Version	Date	Author	Summary of Main Changes
1.0	21-01-2016	Giancarlo Teti (RT)	First version of the Deliverable and table of contents
1.1	23-12-2016	Alessandro Quercioli	Added contents to Annex 1
1.2	23-12-2016	Luca Volpi (RT)	Added contents to Annex 2 and Annex 3
1.2	23-12-2016	Leandro Bandini,	Added contents to Annex 4
1.4	28-12-2016	Giancarlo Teti	Added contents to Annex 5, Annex 6 and 7
1.5	28-12-2016	Giancarlo Teti (RT)	Final version

Table of Contents

Executive summary

Deliverable D1.2 “Detailed Technical Project” consists in the technical documentation accompanying the robot, and in particular of the documentation related to mechanical design, electronics design, software architecture and GUI.

The document is organised as follow: Section 1 describes briefly the general architecture of the system highlighting the main components of the robot. Follow a list of annexes:

- Annex 1: robot mechanical design
- Annex 2: brushless motor driver PCB schematic, layout, BOM and UART protocol
- Annex 3: main board PCB schematic, layout, BOM and UART protocol
- Annex 4 :wiring diagram
- Annex 5: ROS based software architecture
- Annex 6: robot parameters and settings
- Annex 7: GUI for PC, tablet and Smartphone

1 System Architecture

The 2F robot is based on the skeleton of the NEMH2O robot mobile base which integrates sponge tool and devices for sponge cleaning, battery pack, navigation sensor, quality control sensor and control electronics.

In more details, the 2F robot consists of the following components:

- NEMH2O mobile base with tracks (left and right) actuated by 2 brushless motors with integrated hall effect encoders;
- cross belt sponge tool actuated by brushless motor with integrated hall effect encoder, adjustable mechanical squeeze system, pump actuated flooding water system for cleaning the sponge and motor for lifting up and lowering the tool;
- water bucket;
- battery pack;
- laser scanner (navigation sensor);
- control system: compact PC, motor drivers (3) and related control electronics;
- USB cam and LED (quality control sensor);
- switches and devices for HRI.

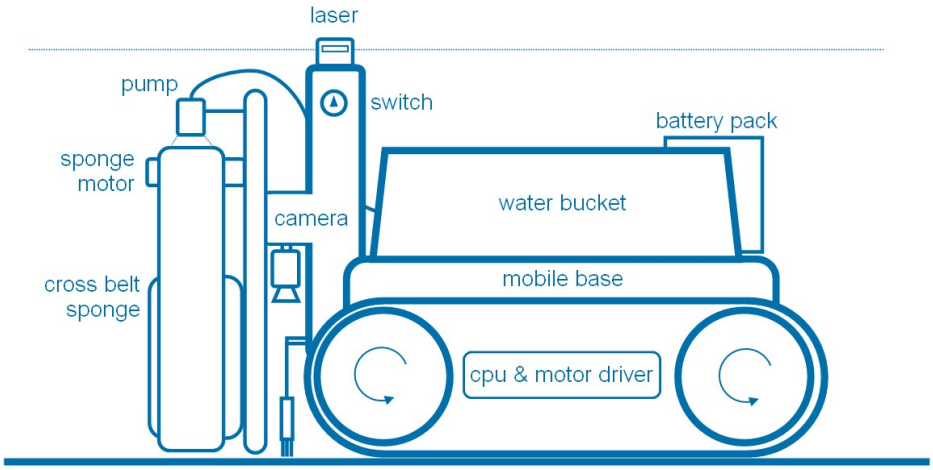


Figure 1: System architecture

The control system consist of a compact PC (INTEL NUC 5i3RYK) running the high level control software and the navigation software and of the low level control electronics. The low level control electronics consists of a microcontroller based board (STM32F103VCT6) for controlling the robot components and of 3 drivers implementing PID control for brushless motor. Laser (HOKUYO URG-04LX-UG01) and USB camera are connected to the PC. The following schema show the architecture of the control system.

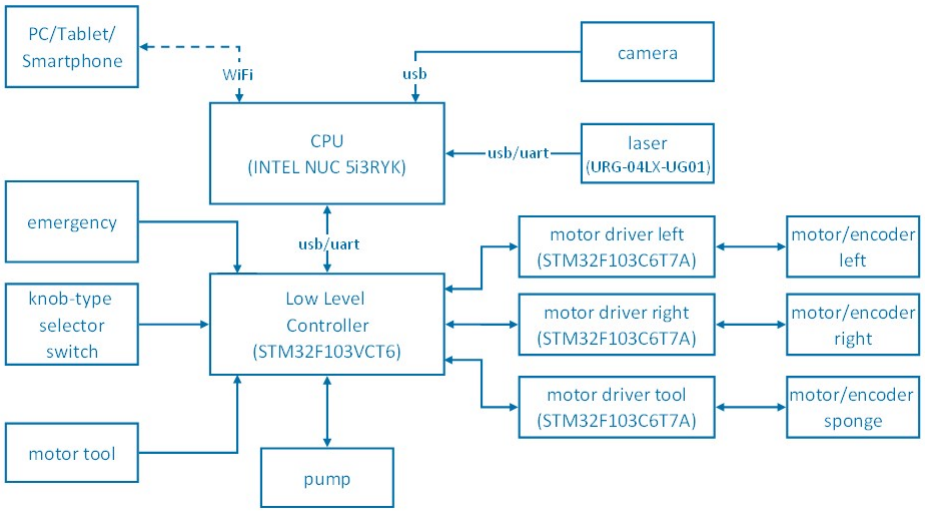


Figure 2: Control system architecture

Power is provided by a Lithium battery pack (Li-ion battery 25.9 VDC, 312 Wh). A main switch and a fuse are between the battery pack and the system devices. A VDC regulator on the main board provides power to the PC. Emergency button is between battery and motor drivers and shut off power when closed. The following schema show the connection of the power system.

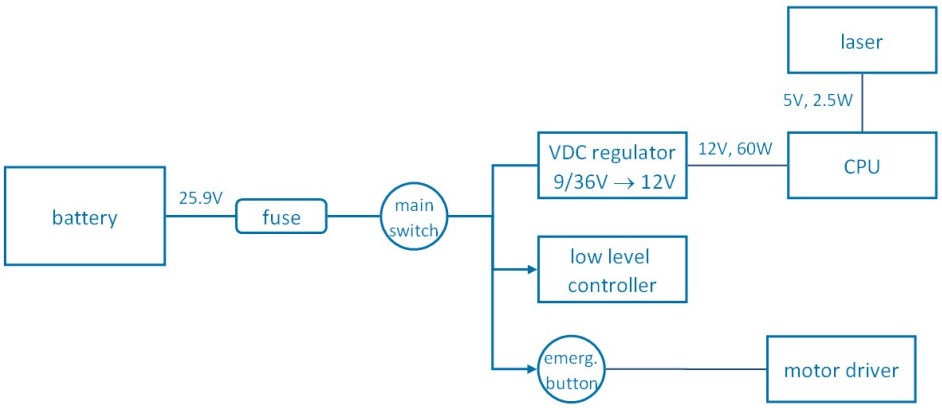
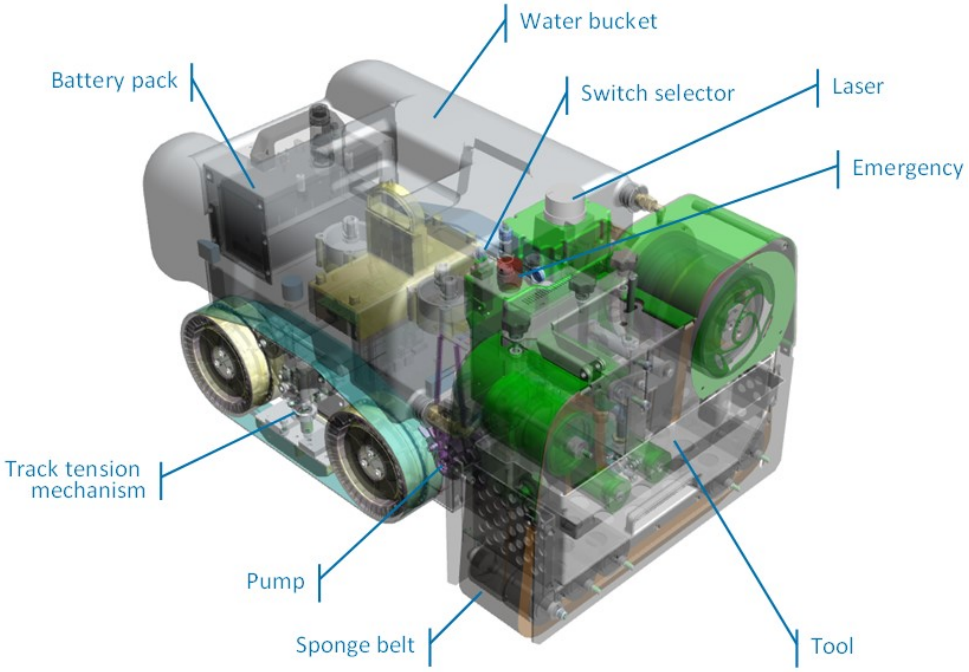


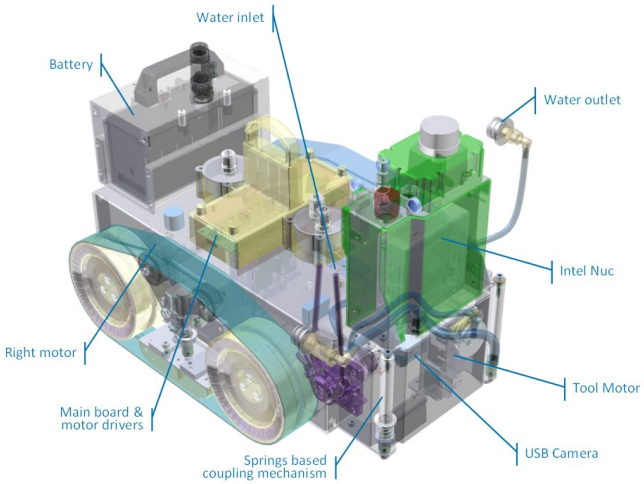
Figure 3: Power connection scheme

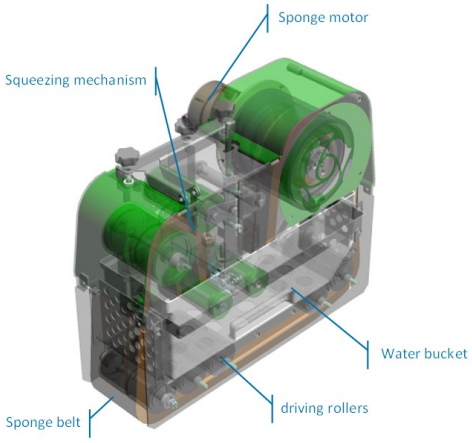
1.1 List of Components

Component	Product Code	Description	Quantity
PC control unit	INTEL NUC 5i3RYK	Intel Core i3-5250U processor 1.3 GHz up to 2.7 GHz Turbo, dual core DDR3L SODIMMs 1.35V, 1333 Mhz 4 x USB 3.0 ports, Intel wireless AC 7265 M.2 12-19V DC power input, 15 W TDP	1
Laser	URG-04LX-UG01	Beam: 240° Detection range: 5.6 m Sample rate: 10 Hz Angular resolution: 0.352 deg Power: 5V, 2.5W, Interface: UART/USB	1
Camera	ELP-USB130W01MT	CCD: 1/3 inch, Lens: 3.6mm Max. Resolution 1280(H)X960(V) Min. illumination 0. 01lux Power 5V, 100mA~160mA Working temperature: -20~75 Board size /Weight: 38X38mm / about 30g	1
Low Level Main Board	2F main board	STM32F103VCT6 microcontroller board, ARM - MCU 32BIT Cortex M3, Flash 256kB, clock frequency 72 MHz, 48kB RAM	1
Motor Driver	2F brushless motor driver board	STM32F103C6T7A microcontroller board, ARM - MCU 32BIT Cortex M3, clock frequency 72 MHz, 10kB RAM, max current 6A	3
Base motor	Fullin FL42RBL 64	24V, 5500 RPM	2
Sponge motor	Fullin FL42RBL 64	24V, 5500 RPM	1
Tool motor	Hella 6NW 009 424-791	24V	1
Reduction gear	IMS baseline PM42	Reduction ratio: 92:1	
Pump	PMT 30-SA-3.8x7-24VDC-PL	24V Brush DC motor, 700 ml per min	1
Knob type selector switch	A165S/W	Rated voltage: 30 VDC Resistive load: 3 A Led: 24V	1
Emergency button	A165E-LS6D – 02 (DPST)	Rated voltage: 30 VDC Resistive load: 3 A Led: 24V	1
Battery	Li-ion battery	25.9 VDC, 312 Wh	1

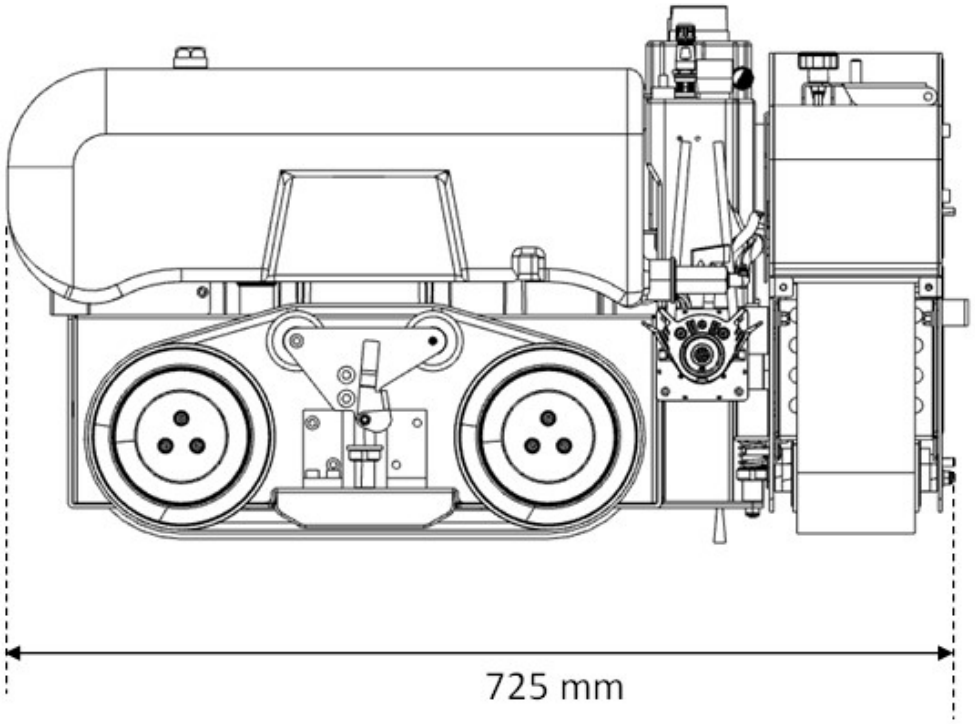
1.2 Robot Main Components

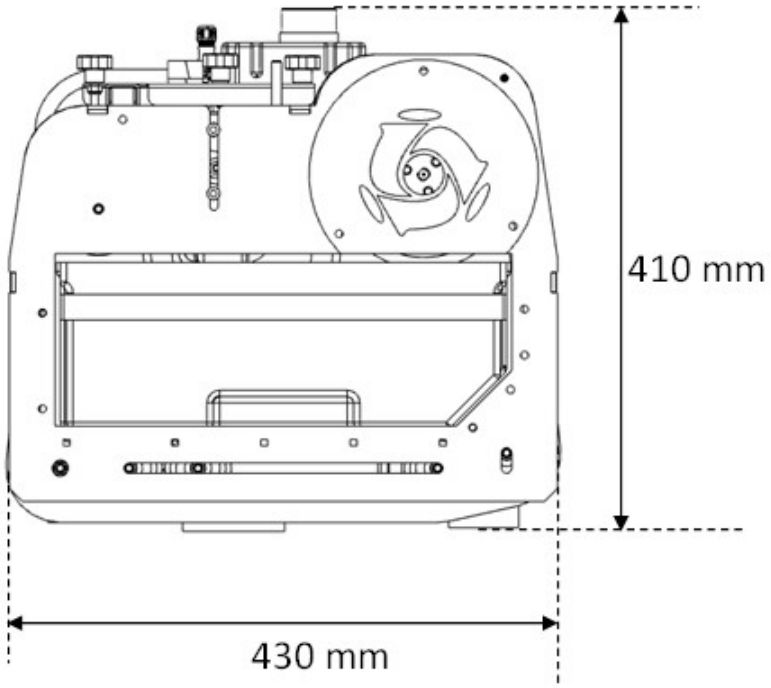




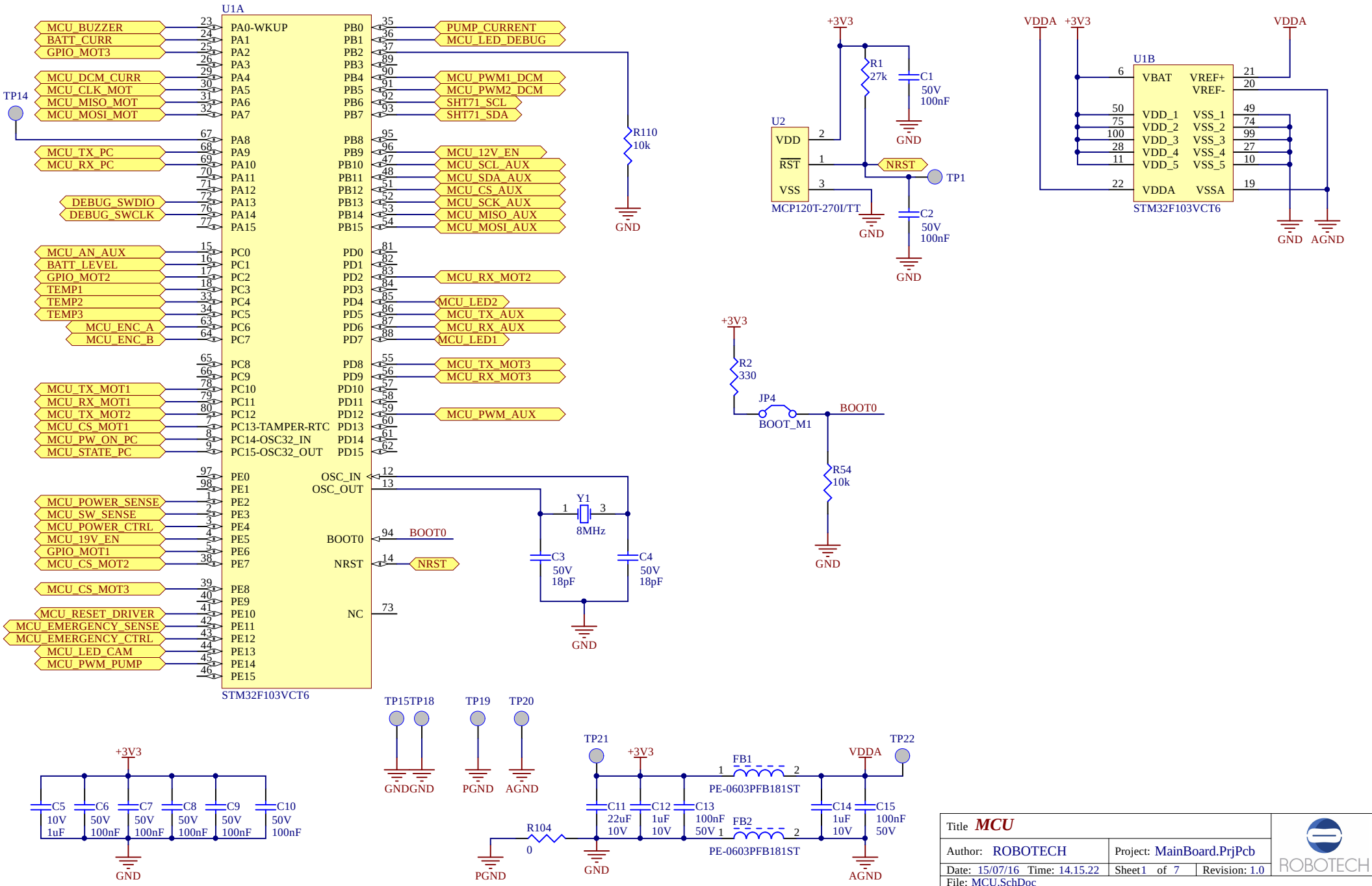


1.3 Robot dimensions



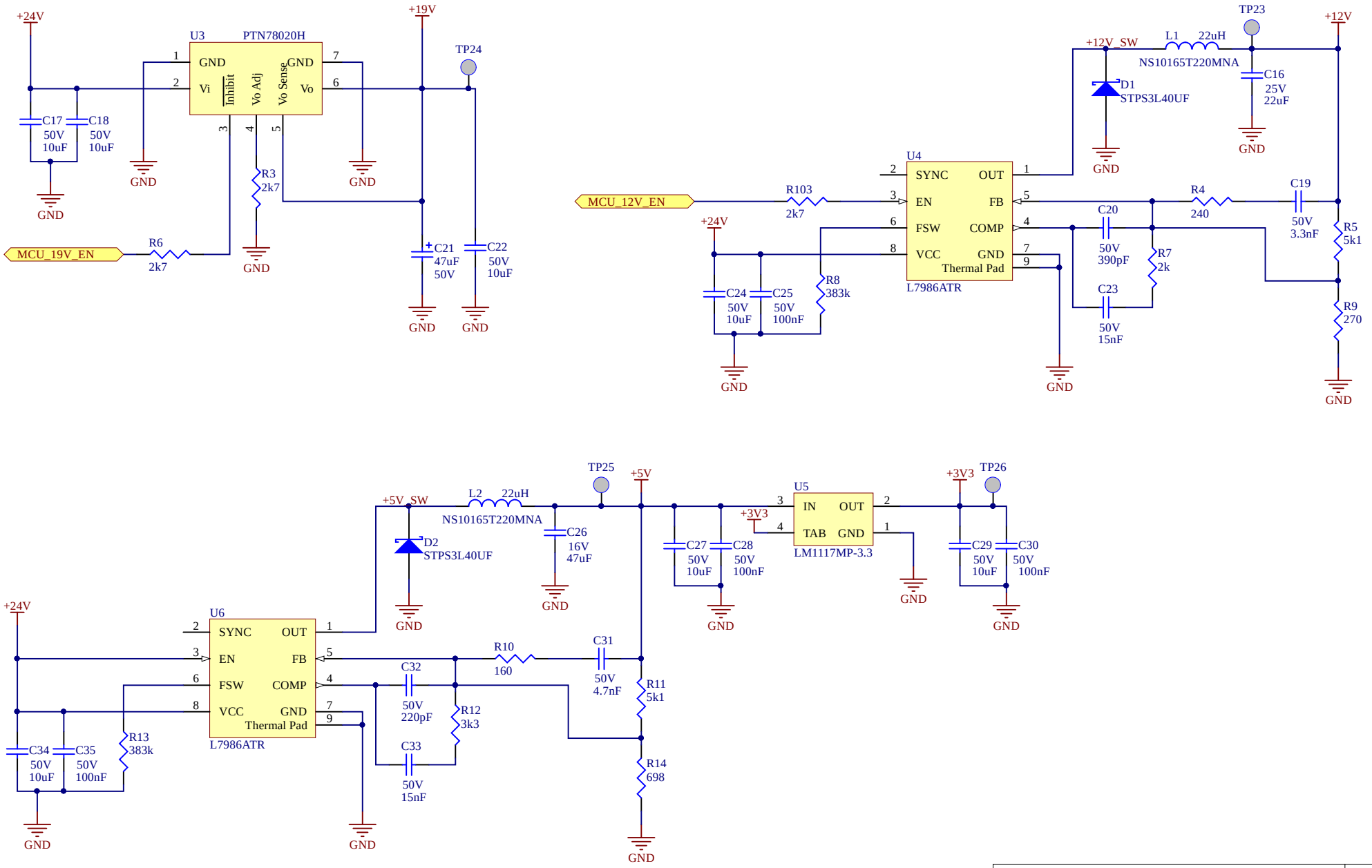


ANNEX 2
Main board
PCB schematic, layout, BOM and UART protocol



Title	***MCU***	
Author: ROBOTECH	Project: MainBoard.PrjPcb	
Date: 15/07/16 Time: 14.15.22	Sheet1 of 7	Revision: 1.0
File: MCU.SchDoc		

ROBOTECH



Title	***Power Supply***	
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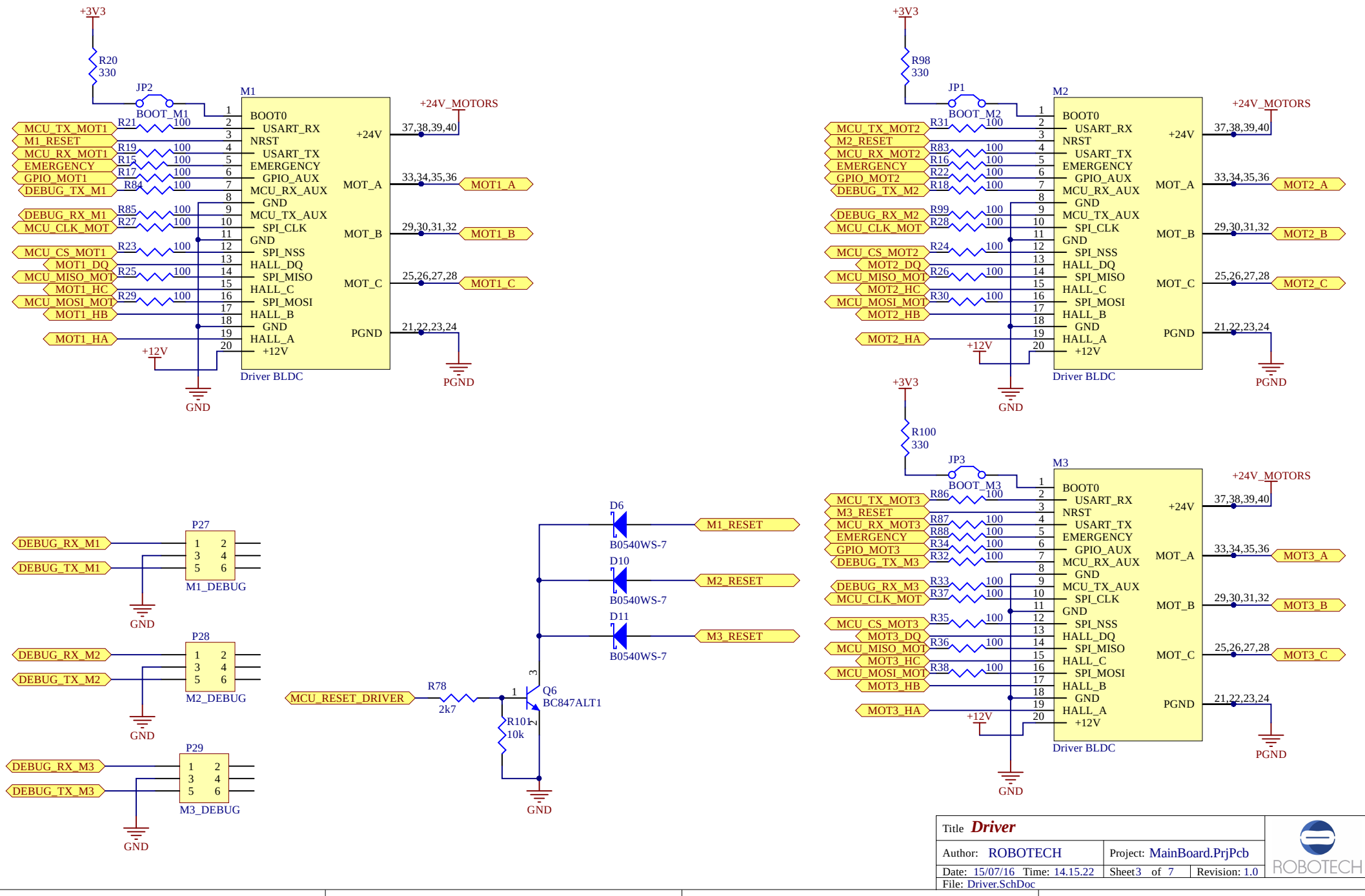
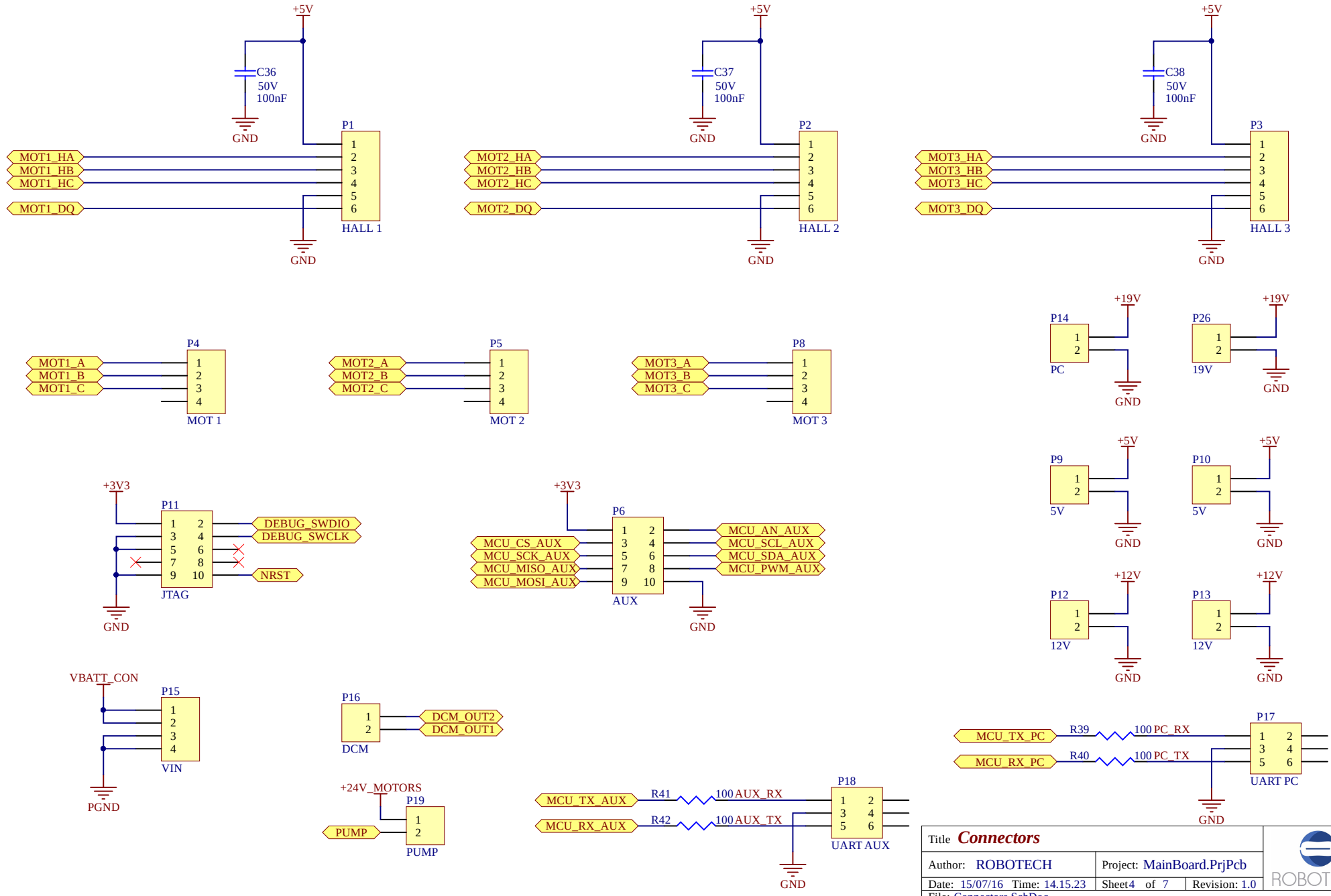
Date: 15/07/16 Time: 14.15.22	Sheet2 of 7	Revision: 1.0
File: PowerSupply.SchDoc		

ROBOTECH


+3V3
R20
330
JP2
BOOT_M1
M1
BOOT0
USART_RX
NRST
USART_TX
EMERGENCY
GPIO_AUX
MCU_RX_AUX
GND
MCU_TX_AUX
SPI_CLK
GND
SPI_NSS
HALL_DQ
SPI_MISO
HALL_C
SPI_MOSI
HALL_B
GND
HALL_A
+12V
+24V
MOT_A
MOT_B
MOT_C
PGND
+24V_MOTORS
37,38,39,40
33,34,35,36
29,30,31,32
25,26,27,28
21,22,23,24
MCU_TX_MOT1
M1_RESET
MCU_RX_MOT1
EMERGENCY
GPIO_MOT1
DEBUG_TX_M1
DEBUG_RX_M1
MCU_CLK_MOT
MCU_CS_MOT1
MOT1_DQ
MCU_MISO_MOT
MOT1_HC
MCU_MOSI_MOT
MOT1_HB
MOT1_HA
MOT1_A
MOT1_B
MOT1_C
R21
R19
R15
R17
R84
R85
R27
R23
R25
R29
100
+12V
GND
Driver BLDC
+3V3
R98
330
JP1
BOOT_M2
M2
MCU_TX_MOT2
M2_RESET
MCU_RX_MOT2
EMERGENCY
GPIO_MOT2
DEBUG_TX_M2
DEBUG_RX_M2
MCU_CLK_MOT
MCU_CS_MOT2
MOT2_DQ
MCU_MISO_MOT
MOT2_HC
MCU_MOSI_MOT
MOT2_HB
MOT2_HA
MOT2_A
MOT2_B
MOT2_C
R31
R83
R16
R22
R18
R99
R28
R24
R26
R30
Driver BLDC
+3V3
R100
330
JP3
BOOT_M3
M3
MCU_TX_MOT3
M3_RESET
MCU_RX_MOT3
EMERGENCY
GPIO_MOT3
DEBUG_TX_M3
DEBUG_RX_M3
MCU_CLK_MOT
MCU_CS_MOT3
MOT3_DQ
MCU_MISO_MOT
MOT3_HC
MCU_MOSI_MOT
MOT3_HB
MOT3_HA
MOT3_A
MOT3_B
MOT3_C
R86
R87
R88
R34
R32
R33
R37
R35
R36
R38
Driver BLDC
P27
DEBUG_RX_M1
DEBUG_TX_M1
M1_DEBUG
P28
DEBUG_RX_M2
DEBUG_TX_M2
M2_DEBUG
P29
DEBUG_RX_M3
DEBUG_TX_M3
M3_DEBUG
D6
D10
D11
B0540WS-7
M1_RESET
M2_RESET
M3_RESET
MCU_RESET_DRIVER
R78
2k7
R101
10k
Q6
BC847ALT1
Title Driver
Author: ROBOTECH
Project: MainBoard.PrjPcb
Date: 15/07/16 Time: 14.15.22
Sheet3 of 7
Revision: 1.0
File: Driver.SchDoc
ROBOTECH



Title	***Connectors***	
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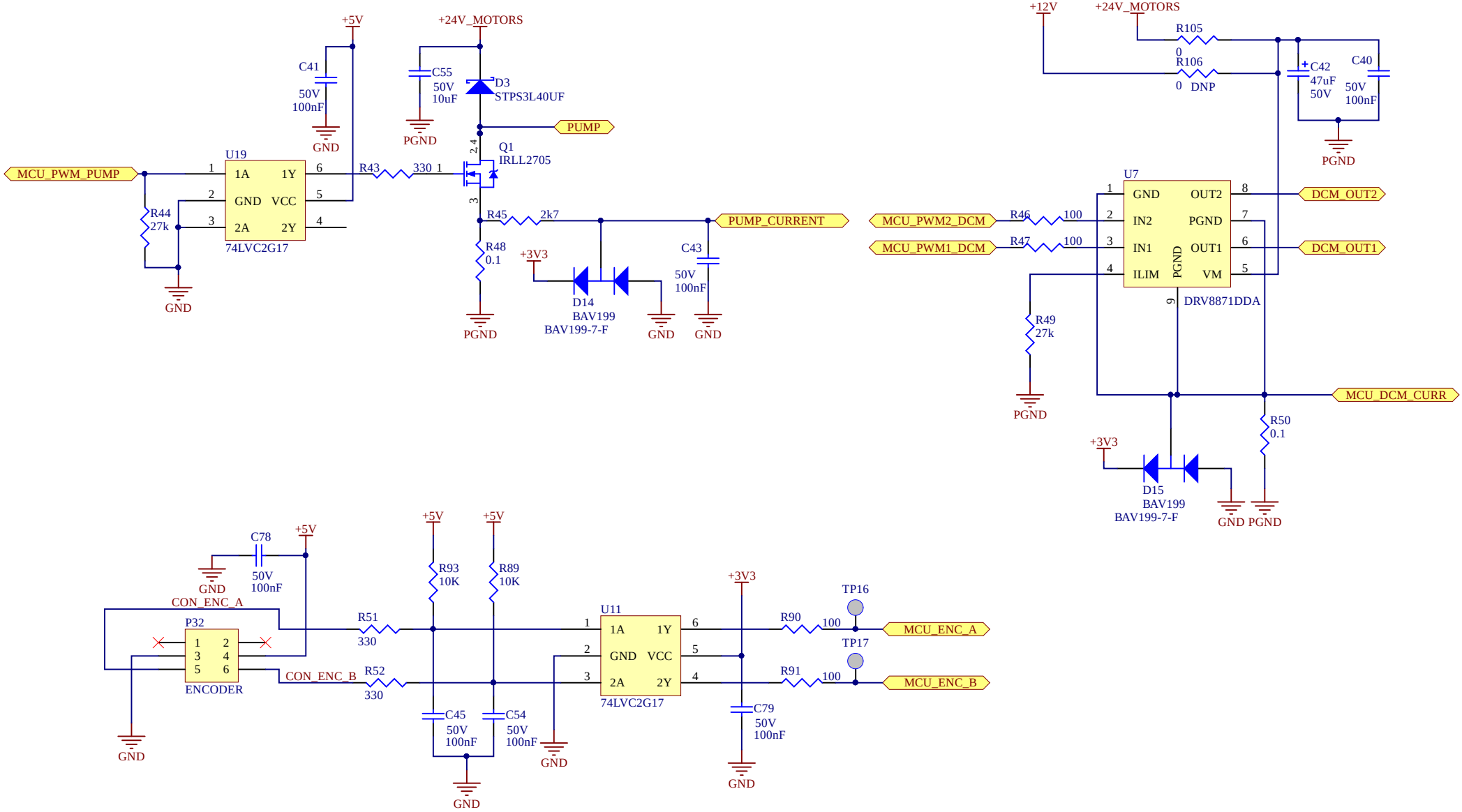
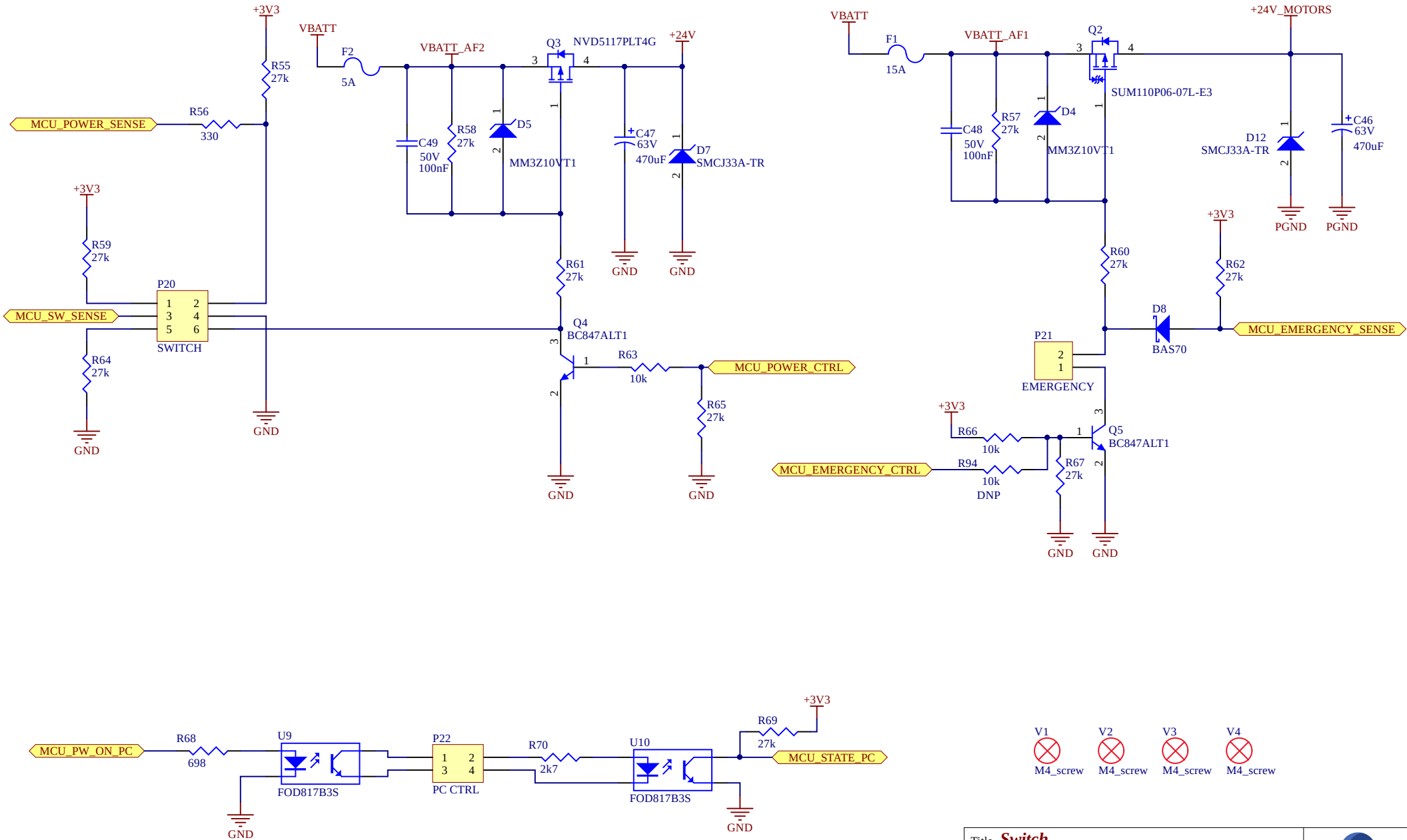
Date: 15/07/16 Time: 14.15.23	Sheet 4 of 7	Revision: 1.0
File: Connectors.SchDoc		

ROBOTECH



Title	***DC Motor - Pump***	
Author: ROBOTECH	Project: MainBoard.PrjPcb	
Date: 15/07/16 Time: 14.15.23	Sheet 5 of 7	Revision: 1.0
File: DC Motor & Pumps.SchDoc		

ROBOTECH


+3V3
VBATT
R55
27k
F2
5A
VBATT_AF2
Q3
NVD5117PLT4G
+24V
MCU_POWER_SENSE
R56
330
C49
50V
100nF
R58
27k
D5
MM3Z10VT1
C47
63V
470uF
D7
SMCJ33A-TR
GND
R59
27k
P20
1 2
3 4
5 6
SWITCH
MCU_SW_SENSE
R64
27k
R61
27k
Q4
BC847ALT1
R63
10k
MCU_POWER_CTRL
R65
27k
VBATT
F1
15A
VBATT_AF1
Q2
SUM110P06-07L-E3
+24V_MOTORS
C48
50V
100nF
R57
27k
D4
MM3Z10VT1
D12
SMCJ33A-TR
C46
63V
470uF
PGND
R60
27k
R62
27k
D8
BAS70
MCU_EMERGENCY_SENSE
P21
2
1
EMERGENCY
R66
10k
Q5
BC847ALT1
MCU_EMERGENCY_CTRL
R94
10k
DNP
R67
27k
MCU_PW_ON_PC
R68
698
U9
FOD817B3S
P22
1 2
3 4
PC CTRL
R70
2k7
U10
FOD817B3S
R69
27k
MCU_STATE_PC
V1
V2
V3
V4
M4_screw
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Author: ROBOTECH
Project: MainBoard.PrjPcb
Date: 15/07/16 Time: 14.15.23
Sheet6 of 7
Revision: 1.0
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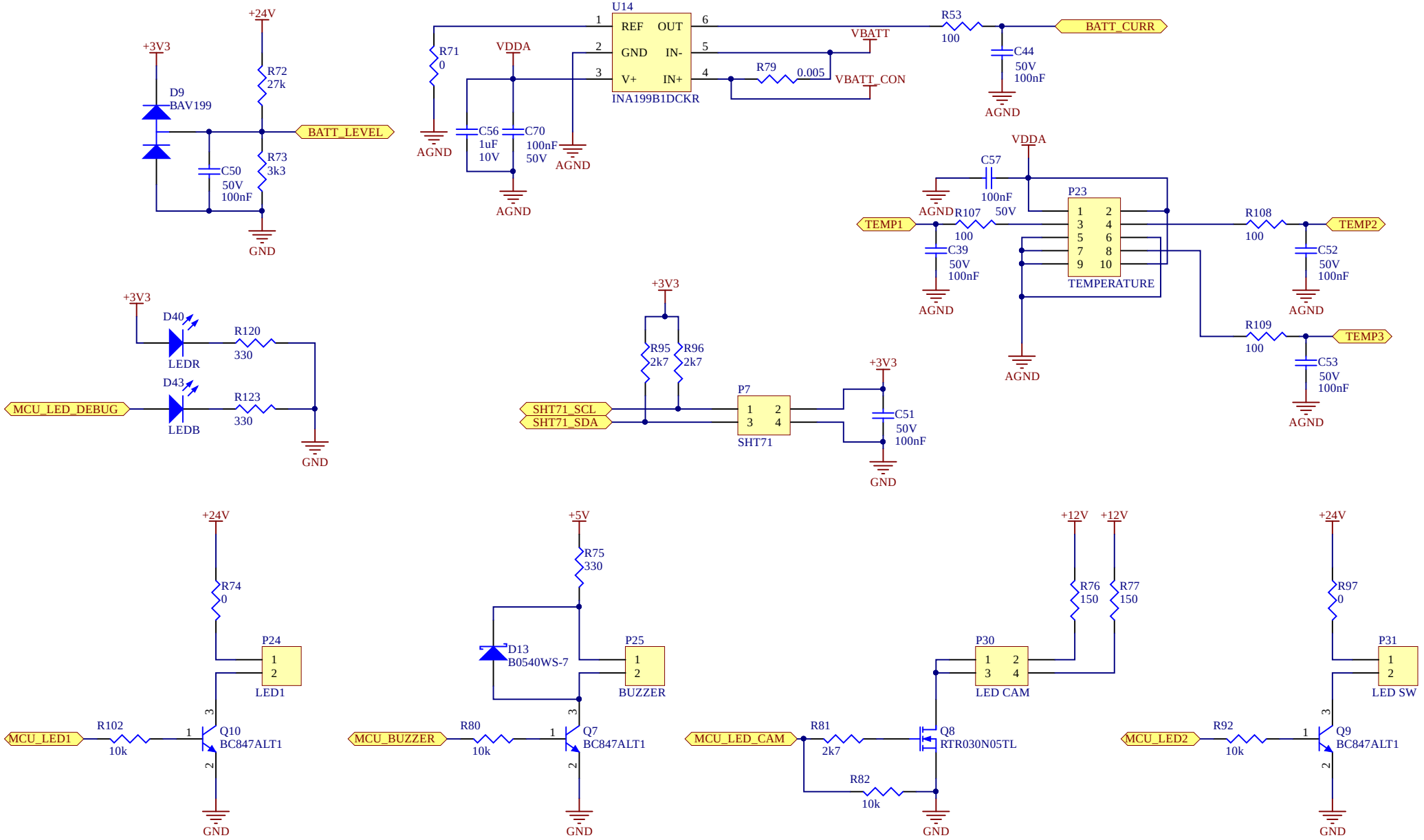
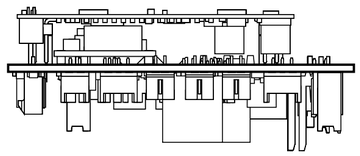
ROBOTECH

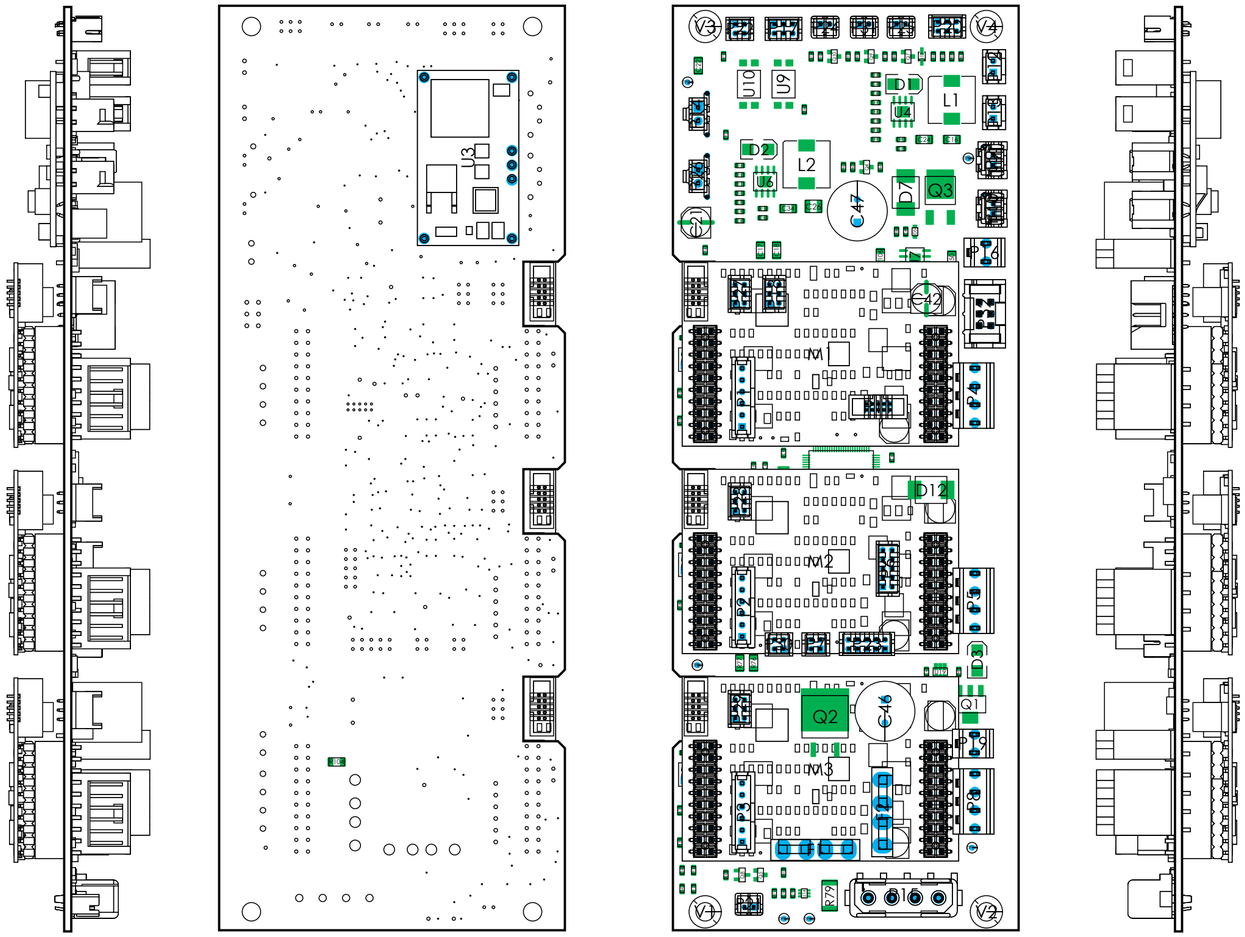

+24V
+3V3
D9
BAV199
R72
27k
BATT_LEVEL
C50
50V
100nF
R73
3k3
GND
U14
REF
OUT
GND
IN-
V+
IN+
INA199B1DCKR
R71
0
VDDA
C56
1uF
10V
C70
100nF
50V
AGND
VBATT
R79
0.005
VBATT_CON
R53
100
BATT_CURR
C44
50V
100nF
C57
100nF
50V
P23
TEMPERATURE
TEMP1
R107
100
C39
50V
100nF
R108
100
TEMP2
C52
50V
100nF
R109
100
TEMP3
C53
50V
100nF
D40
LEDR
R120
330
D43
LEDB
R123
330
MCU_LED_DEBUG
R95
2k7
R96
2k7
SHT71_SCL
SHT71_SDA
P7
SHT71
C51
50V
100nF
R74
0
P24
LED1
R102
10k
MCU_LED1
Q10
BC847ALT1
R75
330
D13
B0540WS-7
P25
BUZZER
R80
10k
MCU_BUZZER
Q7
BC847ALT1
+12V
R76
150
R77
150
P30
LED CAM
R81
2k7
MCU_LED_CAM
Q8
RTR030N05TL
R82
10k
R97
0
P31
LED SW
R92
10k
MCU_LED2
Q9
BC847ALT1
Title
Battery Level - Leds - Buzzer
Author: ROBOTECH
Project: MainBoard.PrjPcb
Date: 15/07/16 Time: 14.15.23
Sheet 7 of 7
Revision: 1.0
File: BatteryLevel.SchDoc
ROBOTECH

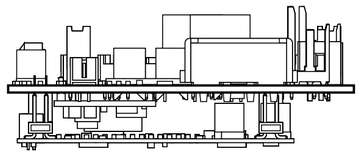
2F
MAIN BOARD
Bill of Material

Designator	Qty	PartNumber	Value	Footprint	Comment	Voltage
C1, C2, C6, C7, C8, C9, C10, C13, C15, C25, C28, C30, C35, C36, C37, C38, C39, C40, C41, C43, C44, C45, C48, C49, C50, C51, C52, C53, C54, C57, C70, C78, C79	33		100nF	C0603	Cap	50V
C3, C4	2		18pF	C0603	Cap	50V
C5, C12, C14, C56	4		1uF	C0603	cap	10V
C11	1		22uF	C0805	cap	10V
C16	1		22uF	C1206	Cap	25V
C17, C18, C22, C24, C27, C29, C34, C55	8		10uF	C1206	Cap	50V
C19	1		3.3nF	C0603	Cap	50V
C20	1		390pF	C0603	Cap	50V
C21, C42	2	UWT1V470MCL1GS	47uF	CAP POLARIZED SMD	35V	50V
C23, C33	2		15nF	C0603	Cap	50V
C26	1		47uF	C1210	16V	16V
C31	1		4.7nF	C0603	Cap	50V
C32	1		220pF	C0603	Cap	50V
C46, C47	2		470uF	CAPPR5-13X15	63V	63V
D1, D2, D3	3	STPS3L40UF		SMB_FLAT	STPS3L40UF	
D4, D5	2	MM3Z10VT1		ONSC-SOD-323-2-477-02_V	MM3Z10VT1	
D6, D10, D11, D13	4	B0540WS-7		SOD-323	B0540WS-7	
D7, D12	2	SMCJ33A-TR		ONSC-SMC-2-403-03_V	SMCJ33A-TR	
D8	1	BAS70-TP		SOT-23_N	BAS70	
D9, D14, D15	3	BAV199-7-F		SOT-23	BAV199	
D40	1			LED_0603	LEDR	
D43	1			LED_0603	LEDB	
F1	1	BK-6010		FUSE HOLDER	15A	
F2	1	BK-6010		FUSE HOLDER	5A	
FB1, FB2	2	PE-0603PFB181ST		R0603	FerriteBead	
JP1	1			HDR1X2	BOOT_M2	
JP2, JP4	2			HDR1X2	BOOT_M1	
JP3	1			HDR1X2	BOOT_M3	
L1, L2	2	NS10165T220MNA	22uH	IND_10.2X10.2	Inductor	
M1, M2, M3	3			BLDC_Driver	Driver BLDC	
P1	1	280372-1		280372-1	HALL 1	
P2	1	280372-1		280372-1	HALL 2	
P3	1	280372-1		280372-1	HALL 3	
P4	1	280610-1		AMP 280610-1	MOT 1	
P5	1	280610-1		AMP 280610-1	MOT 2	
P6	1	DF11-10DP-2DS		DF11-10DP-2DS	AUX	
P7	1	DF11-4DP-2DS		DF11-4DP-2DS	SHT71	
P8	1	280610-1		AMP 280610-1	MOT 3	
P9, P10	2	0559320210		0559320210	5V	
P11	1	3220-10-0100-00		DIL10_1.27mm_Debug	JTAG	
P12, P13	2	280370-2		280370-2	12V	
P14	1	2-1445093-2		2-1445093-2	PC	
P15	1	350211-1		350211-1	VIN	
P16	1	280609-1		AMP 280609-1	DCM	
P17	1	DF11-6DP-2DS		DF11-6DP-2DS	UART PC	
P18	1	DF11-6DP-2DS		DF11-6DP-2DS	UART AUX	
P19	1	280609-1		AMP 280609-1	PUMP	
P20	1	DF11-6DP-2DS		DF11-6DP-2DS	SWITCH	
P21	1	B2B-PH		B2B-PH	EMERGENCY	
P22	1	DF11-4DP-2DS		DF11-4DP-2DS	PC CTRL	
P23	1	DF11-10DP-2DS		DF11-10DP-2DS	TEMPERATURE	
P24	1	B2B-PH		B2B-PH	LED1	

P25	1	B2B-PH		B2B-PH	BUZZER	
P26	1	2-1445093-2		2-1445093-2	19V	
P27	1	DF11-6DP-2DS		DF11-6DP-2DS	M1_DEBUG	
P28	1	DF11-6DP-2DS		DF11-6DP-2DS	M2_DEBUG	
P29	1	DF11-6DP-2DS		DF11-6DP-2DS	M3_DEBUG	
P30	1	DF11-4DP-2DS		DF11-4DP-2DS	LED CAM	
P31	1	B2B-PH		B2B-PH	LED SW	
P32	1	75869-131LF		75869-131LF	ENCODER	
Q1	1	IRLL2705TRPBF		SOT-223_N	IRLL2705	
Q2	1	SUM110P06-07L-E3		ONSC-TO-263-2L-3_V	SUM110P06-07L-E3	
Q3	1	NVD5117PLT4G		ONSC-DPAK-3-369C-01_V	NVD5117PLT4G	
Q4, Q5, Q6, Q7, Q9, Q10	6	BC847ALT1		ONSC-SOT-23-3-318-08_V	BC847ALT1	
Q8	1	RTR020N05TL		SOT23_M	RTR030N05TL	
R1, R44, R49, R55, R57, R58, R59, R60, R61, R62, R64, R65, R67, R69, R72	15		27k	R0603	Res3	
R2, R20, R43, R51, R52, R56, R75, R98, R100, R120, R123	11		330	R0603	Res3	
R3, R6, R45, R70, R78, R81, R95, R96, R103	9		2k7	R0603	Res3	
R4	1		240	R0603	Res3	
R5, R11	2		5k1	R0603	Res3	
R7	1		2k	R0603	Res3	
R8, R13	2		383k	R0603	Res3	
R9	1		270	R0603	Res3	
R10	1		160	R0603	Res3	
R12, R73	2		3k3	R0603	Res3	
R14, R68	2		698	R0603	Res3	
R15, R16, R17, R18, R19, R21, R22, R23, R24, R25, R26, R27, R28, R29, R30, R31, R32, R33, R34, R35, R36, R37, R38, R39, R40, R41, R42, R46, R47, R53, R83, R84, R85, R86, R87, R88, R90, R91, R99, R107,	42		100	R0603	Res3	
R48, R50	2		0.1	R1206	Res3	
R54, R63, R66, R80, R82, R89, R92, R93, R101, R102,	11		10k	R0603	Res3	
R71, R74, R97	3		0	R0603	Res3	
R76, R77	2		150	R1206	Res3	
R79	1	TLR2BWDTD5L00F75	0.005	RESC6332	DNP	
R94	1		10k	R0603	Res3	
R104, R105	2		0	R1206	Res3	
R106	1		0	R1206	Res3	
U1	1	STM32F103VCT6		STM-LQFP100_N	STM32F103VCT6	
U2	1	MCP120T-270I/TT		SOT-23-TT3_N	MCP120T-270I/TT	
U3	1	PTN78020HAH		PTN78020H	PTN78020H	
U4, U6	2	L7986ATR		HSOP8-D1_N	L7986ATR	
U5	1	LM1117MP-3.3		MP04A_N	LM1117MP-3.3	
U7	1	DRV8871DDA		HSOP8-D1_N	DRV8871DDA	
U9, U10	2	FOD817B3S		4-smd	FOD817B3S	
U11, U19	2	SN74LVC2G17DBVR		SOT23-6_M	74LVC2G17	
U14	1	INA199B1DCKR		ONSC-SC70-6-419B-02_V	INA199B1DCKR	
V1, V2, V3, V4	4			M4_screw	M4_screw	
Y1	1	ABM3-8.000MHZ-D2Y-T		2-smd crystal	8MHz	







NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±
ANGULAR: MACH± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		22/12/16
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

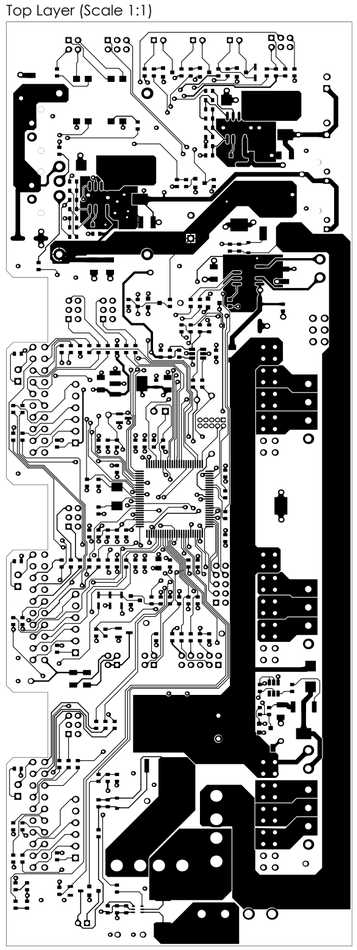
COMMENTS:

TITLE

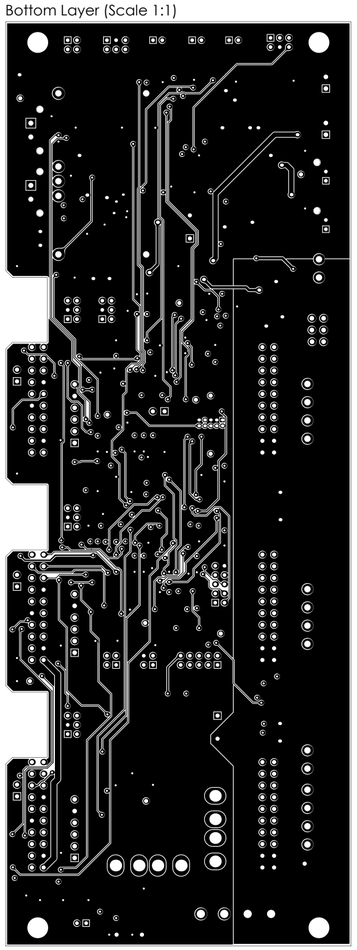
SIZE	DWG. NO.	

SCALE: 1:1	WEIGHT:	SHEET 1 OF 2

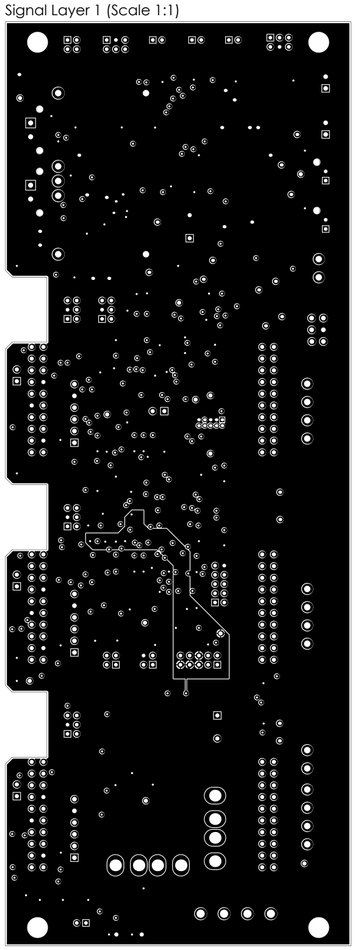
Top Layer (Scale 1:1)



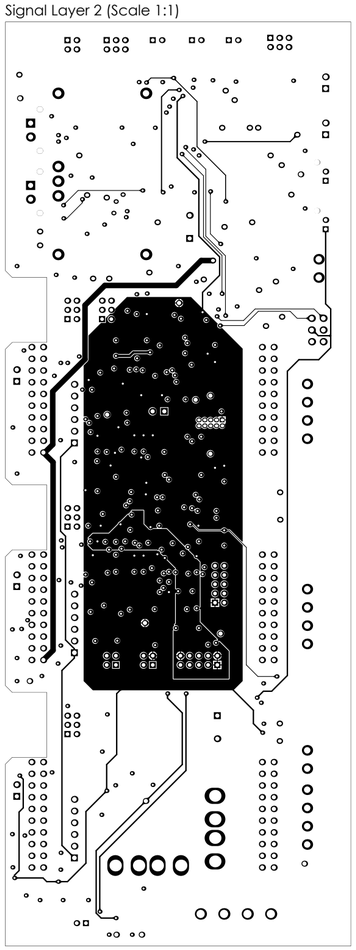
Bottom Layer (Scale 1:1)



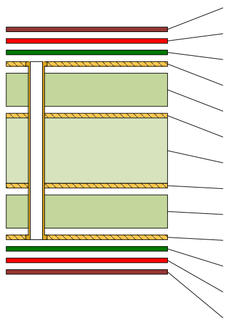
Signal Layer 1 (Scale 1:1)



Signal Layer 2 (Scale 1:1)



Layer Stack Legend



Material	Layer	Thickness	Dielectric Material	Type	Gerber
	Top Paste			Paste Mask	GTP
	Top Overlay			Legend	GTO
Surface Material	Top Solder	0.010mm	Solder Resist	Solder Mask	GTS
Copper	Top Layer	0.018mm		Signal	GTL
Prepreg		0.360mm	PR7628	Dielectric	
Copper	Signal Layer 1	0.036mm		Signal	G1
Core		0.710mm	FR-4	Dielectric	
Copper	Signal Layer 2	0.036mm		Signal	G2
Prepreg		0.360mm	PR7628	Dielectric	
Copper	Bottom Layer	0.018mm		Signal	GBL
Surface Material	Bottom Solder	0.010mm	Solder Resist	Solder Mask	GBS
	Bottom Overlay			Legend	GBO
	Bottom Paste			Paste Mask	GBP

Total thickness: 1.558mm

NEXT ASSY | USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±
ANGULAR: MACH± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		22/12/16
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

TITLE

SIZE	DWG. NO.	
SCALE: 1:1	WEIGHT:	SHEET 2 OF 2

ECHORD++ Flooring Fellow

Grant Agreement number: 601116
Project acronym: 2F
Project title: Flooring Fellow
Funding project: Flooring Fellow is an experiment of ECHORD++ - The European Coordination Hub for Open Robotics Development
Funding scheme: CP - Collaborative project
Project website address: http://www.robotechsrl.com/flooringfellow/
http://www.echord.eu/

Main Board UART Protocol

Document date: [23/12/2016]

Start date of project: 01/05/2015 Duration: 18 months

Organisation name of lead contractor for this deliverable: RT, IMER

Deliverable authors: Giancarlo Teti, Luca Volpi

Version: [1.3]

Project co-funded by the European Commission within the Seventh Framework Programme (2007-2013)		
Dissemination Level		
PU	Public	
PP	Restricted to other programme participants (including the Commission Service)	
RE	Restricted to a group specified by the consortium (including the Commission Service)	
CO	Confidential, only for members of the consortium (including the Commission Service)	**CO**

Main Board UART Protocol

UART Settings

Baud rate: 115200, Parity: None, Data Bits: 8, Stop Bits: 1, Handshake: None

Messages always end with carriage return (\r) and line feed (\n).

Parameters are separated by spaces.

Command List

Command	Description	Note
enable	Enable motor control	
disable	Disable motor control	
set duty [l] [r]	set left duty [l] and right duty [r] in %	every 100 ms r, l ∈ [-100,100] (1)
set pulse [l] [r]	set target left [l] and right [r] hall effect sensor pulses	r, l ∈ [-1000,1000]
set tool [t]	set target tool hall effect sensor pulses [t]	t ∈ [-1000,1000]
set tool [p]	set tool position [p]	p ∈ {up, down, off}
set tool duty d	set tool duty [d] in %	d ∈ [-100,100] (1)
set pump [d]	set pump duty [d] in %	d ∈ [0,100]
set led [l] [p]	set led [l] on/off/blink	l ∈ {sw, aux} p ∈ {on, off, blink}
set led cam [d]	set led cam duty [d] in %	d ∈ [0,100]
set buzzer [p]	set buzzer on/off (not implemented)	p ∈ {on, off}
set pid [m] [kp] [ki]	set motor [m] pid parameters Kp [kp] and Ki [ki]	m ∈ {left, right, tool} kp, ki ∈ [0,255]
set max current [c]	set motor max current [c] in mA	c ∈ [0,10000]
set i2t [m][i]	set max i2t /1024 [i] for motor [m]	m ∈ {left, right, tool} i ∈ [0,24000]

(1) if a DC motor is connected to the driver board, duty is limited to 50% by the driver to guarantee 12V output for 12V DC motors

set control freq [f]	set control freq [f] in Hz	f ∈ [10,100]
get config	get robot configuration	
set diagnostic [m] [p]	set motor [m] diagnostic messages on/off	m ∈ {left, right, tool, main} p ∈ {on, off}
fw driver upload	Reset all drivers for uploading firmware with debug UART	

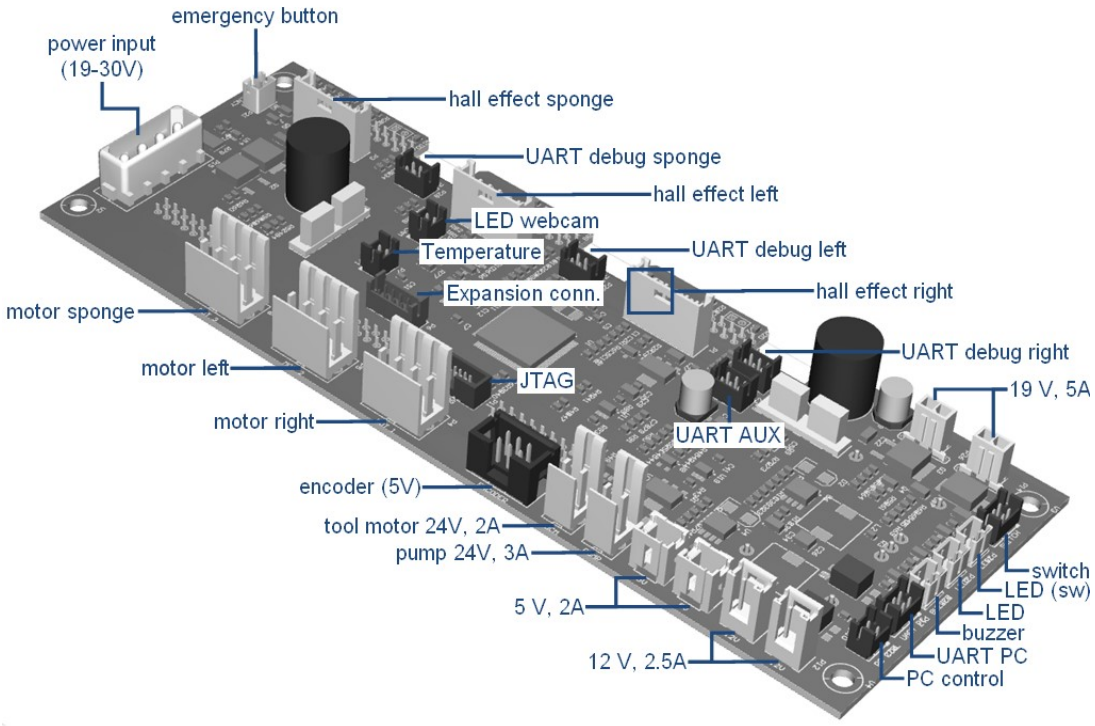
Status Message List

Message	Description	Note
status t, LP *lp*, RP *rp*, TP *tp*, B *b*, C *c*, P *p*, E *e*, S *s, SM sm, SL sl, SR sr, ST st*	*t* timestamp *lp* left pulses in the sampling period *rp* right pulses in the sampling period *tp* tool pulses in the sampling period *b* battery voltage (V) *c* current (mA) *p* pump status {0,1} *e* emergency button status {0,1} *s* selector switch status {1,2,3} *sm* main board status (1) *sl* left driver status (2) *sr* right driver status (2) *st* tool driver status (2)	every 100 ms
diagnostic t, LC *lc*, RC *rc*, TC *tc*, MLT *mlt*, MRT *mrt*, MTT *mtt*, DLT *dlt*, DRT *drt*, DTT *dtt*	*t* timestamp *lc* left current *rc* right current *tc* tool current *mlt* motor left temperature *mrt* motor right temperature *mtt* motor tool temperature *dlt* driver left temperature *drt* driver right temperature *dtt* driver tool temperature	every 100 ms
config LKP *lkp*, LKI *lki*, RKP *rkp*, RKI *rki*, TKP *tkp*, TKI *tki*, CMAX *cm, LI2T li2t,*	*lkp* left motor kp parameter *lki* left motor ki parameter	on request

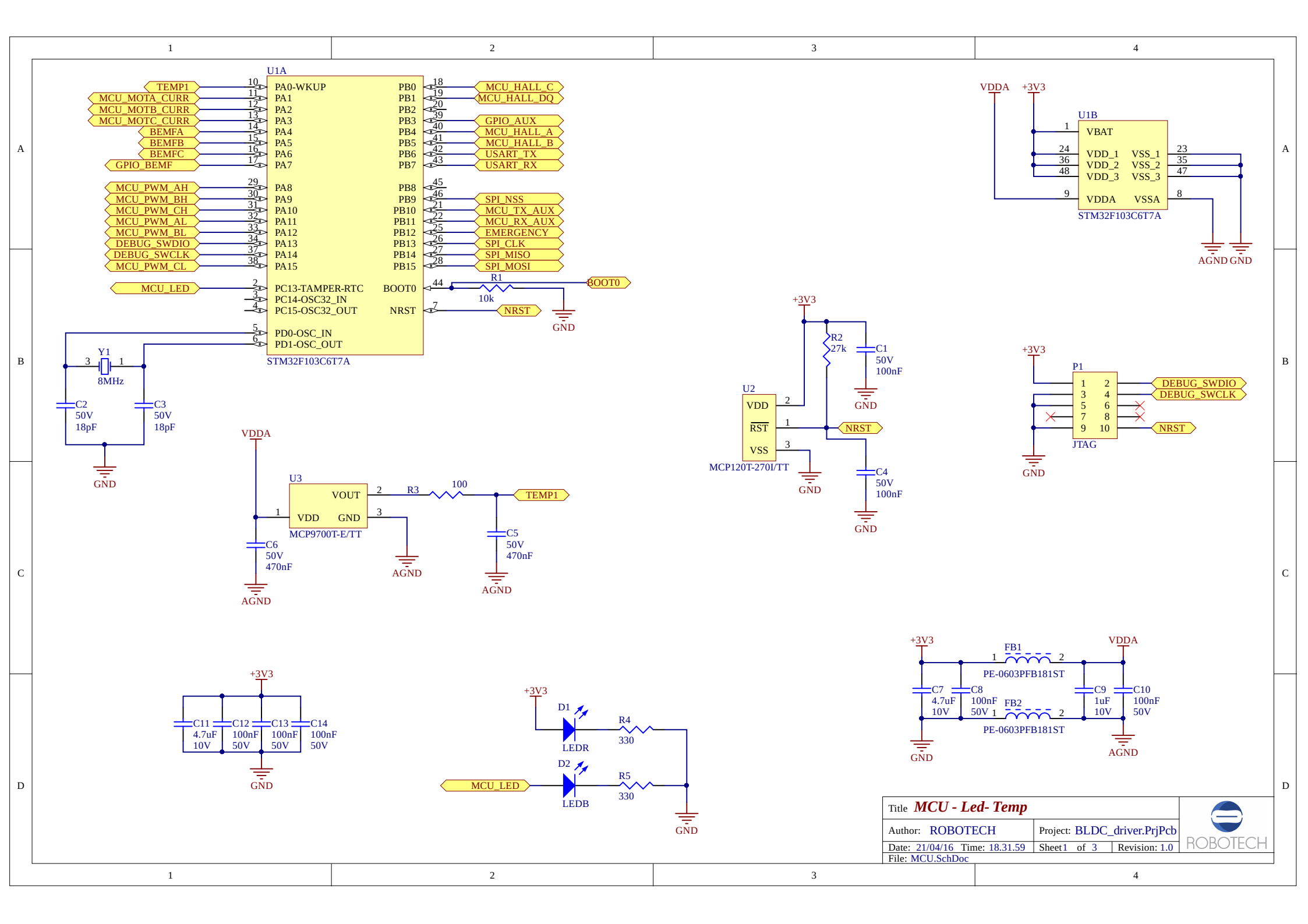
RI2T ri2t, TI2T ti2t, FREQ ct	*rkp* right motor kp parameter *rki* right motor ki parameter *tkp* toll motor kp parameter *tki* tool motor ki parameter *cm* max motor current li2t max I2T left ri2t max I2T right ti2t max I2T tool *ct* control time	

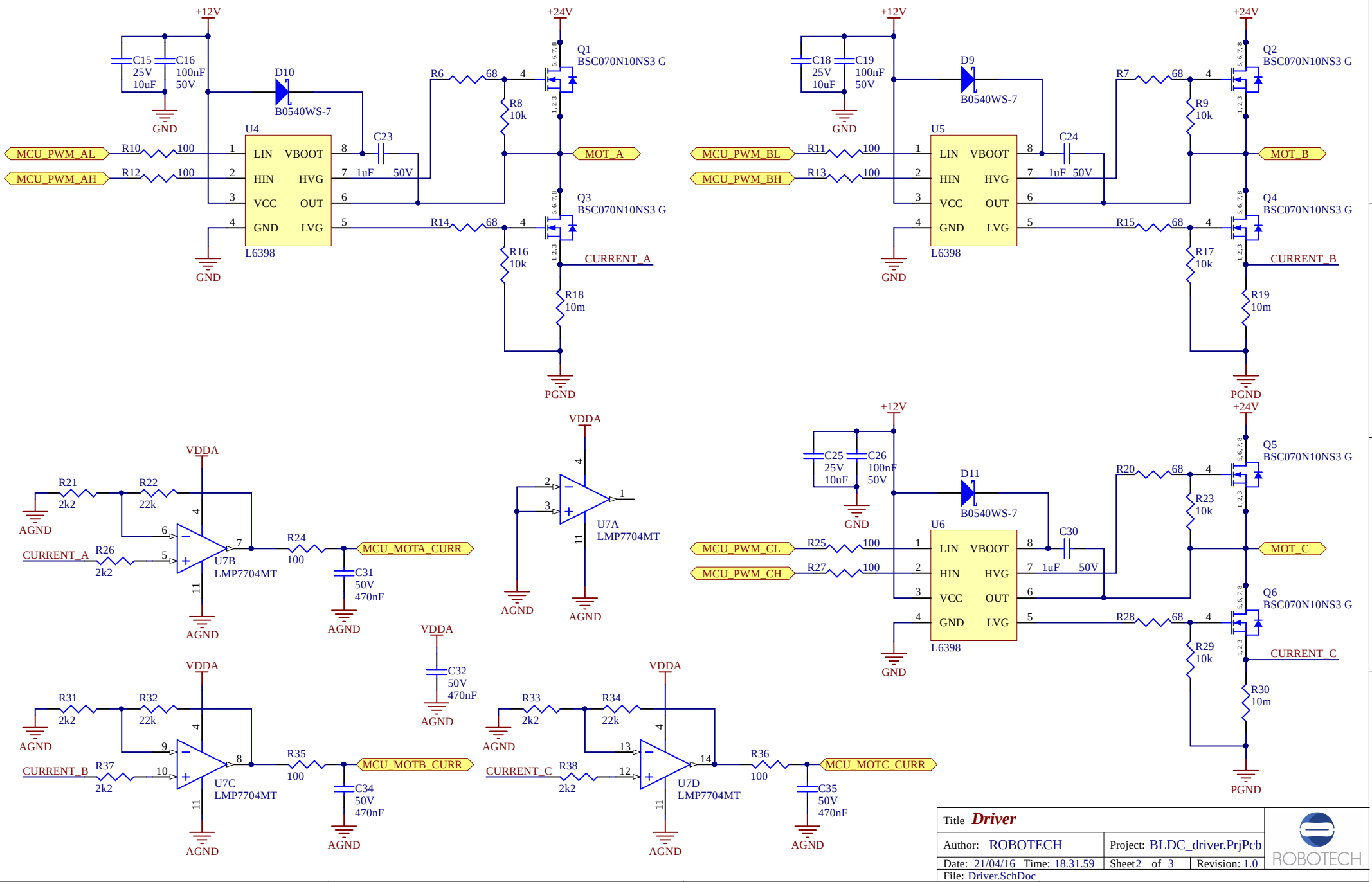
Status table	Description	Note
(1) Main status	*1* enabled *2* left driver n/a *4* right driver n/a *8* tool driver n/a	This is an ASCII representation of the 8 bits mask status of the main board
(2) Driver status	*1* over current *2* motor over temperature *4* driver over temperature *8* I2T exceeded *16* hall sensor not detected, m motor/sensor n/a 32 motor blocked 64 not used *128* DC motor configured	This is an ASCII representation of the 8 bits mask status of the driver board

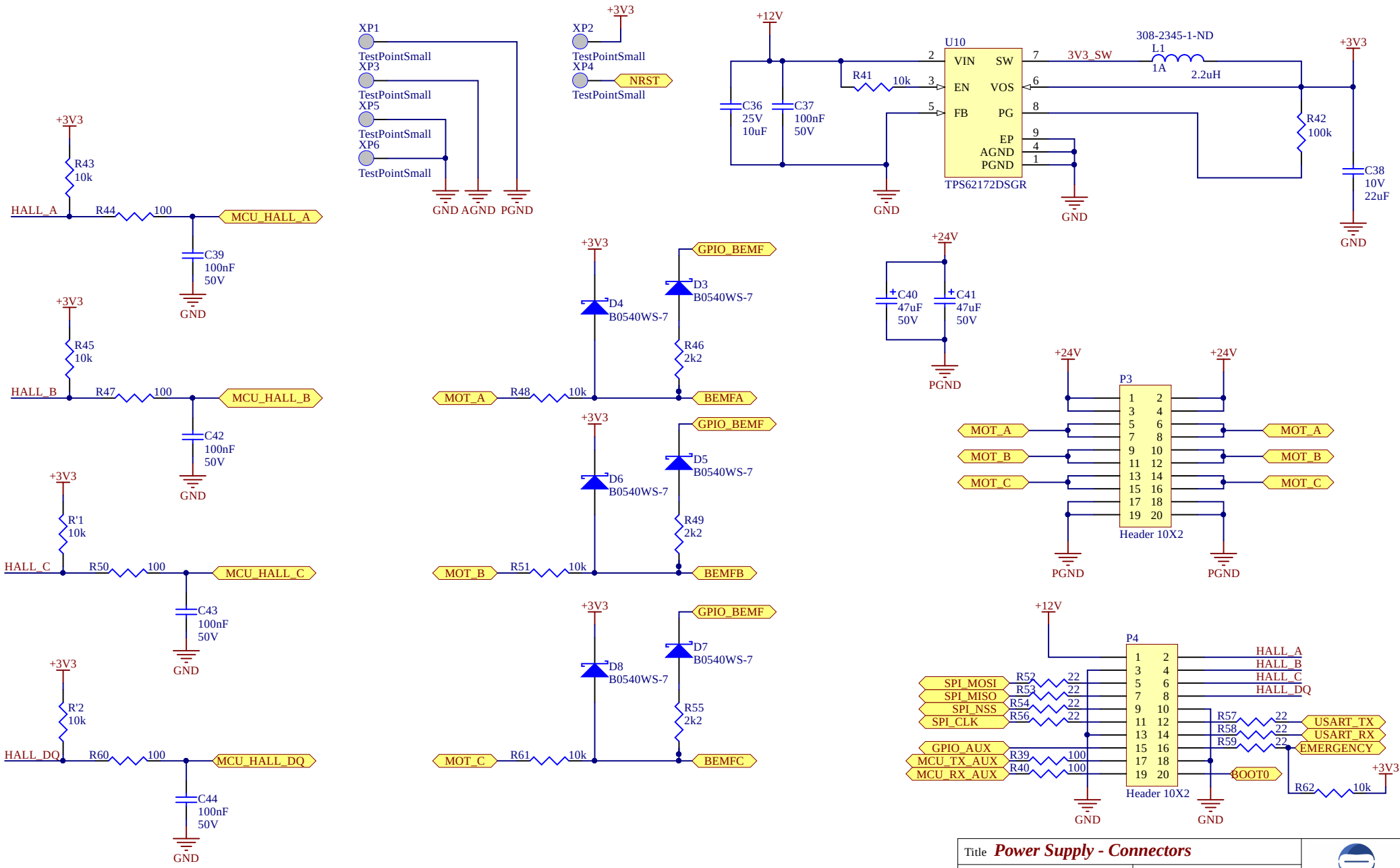
Main Board Connector View



ANNEX 3
Brushless motor driver
PCB schematic, layout, BOM and UART protocol


U1A
TEMP1
MCU_MOTA_CURR
MCU_MOTB_CURR
MCU_MOTC_CURR
BEMFA
BEMFB
BEMFC
GPIO_BEMF
MCU_PWM_AH
MCU_PWM_BH
MCU_PWM_CH
MCU_PWM_AL
MCU_PWM_BL
DEBUG_SWDIO
DEBUG_SWCLK
MCU_PWM_CL
MCU_LED
PA0-WKUP
PA1
PA2
PA3
PA4
PA5
PA6
PA7
PA8
PA9
PA10
PA11
PA12
PA13
PA14
PA15
PC13-TAMPER-RTC
PC14-OSC32_IN
PC15-OSC32_OUT
PD0-OSC_IN
PD1-OSC_OUT
PB0
PB1
PB2
PB3
PB4
PB5
PB6
PB7
PB8
PB9
PB10
PB11
PB12
PB13
PB14
PB15
BOOT0
NRST
MCU_HALL_C
MCU_HALL_DQ
GPIO_AUX
MCU_HALL_A
MCU_HALL_B
USART_TX
USART_RX
SPI_NSS
MCU_TX_AUX
MCU_RX_AUX
EMERGENCY
SPI_CLK
SPI_MISO
SPI_MOSI
STM32F103C6T7A
R1
10k
BOOT0
NRST
GND
Y1
8MHz
C2
50V
18pF
C3
50V
18pF
GND
VDDA
U3
VOUT
VDD
GND
MCP9700T-E/TT
R3
100
TEMP1
C6
50V
470nF
AGND
C5
50V
470nF
AGND
+3V3
C11
4.7uF
10V
C12
100nF
50V
C13
100nF
50V
C14
100nF
50V
GND
+3V3
D1
LEDR
R4
330
D2
LEDB
R5
330
MCU_LED
GND
+3V3
R2
27k
C1
50V
100nF
U2
VDD
RST
VSS
MCP120T-270I/TT
NRST
GND
C4
50V
100nF
GND
VDDA
+3V3
U1B
VBAT
VDD_1
VDD_2
VDD_3
VDDA
VSS_1
VSS_2
VSS_3
VSSA
STM32F103C6T7A
AGND
GND
+3V3
P1
JTAG
DEBUG_SWDIO
DEBUG_SWCLK
NRST
GND
+3V3
FB1
PE-0603PFB181ST
C7
4.7uF
10V
C8
100nF
50V
FB2
PE-0603PFB181ST
C9
1uF
10V
C10
100nF
50V
GND
VDDA
AGND
Title MCU - Led- Temp
Author: ROBOTECH
Project: BLDC_driver.PrjPcb
Date: 21/04/16 Time: 18.31.59
Sheet1 of 3
Revision: 1.0
File: MCU.SchDoc
ROBOTECH


+12V
C15
25V
10uF
C16
100nF
50V
GND
D10
B0540WS-7
+24V
Q1
BSC070N10NS3 G
R6
68
R8
10k
MCU_PWM_AL
R10
100
MCU_PWM_AH
R12
100
U4
LIN
HIN
VCC
GND
VBOOT
HVG
OUT
LVG
L6398
C23
1uF
50V
MOT_A
Q3
BSC070N10NS3 G
R14
68
R16
10k
CURRENT_A
R18
10m
PGND
C18
25V
10uF
C19
100nF
50V
D9
B0540WS-7
Q2
BSC070N10NS3 G
R7
68
R9
10k
MCU_PWM_BL
R11
100
MCU_PWM_BH
R13
100
U5
C24
1uF
50V
MOT_B
Q4
BSC070N10NS3 G
R15
68
R17
10k
CURRENT_B
R19
10m
VDDA
R21
2k2
R22
22k
AGND
CURRENT_A
R26
2k2
U7B
LMP7704MT
R24
100
MCU_MOTA_CURR
C31
50V
470nF
U7A
LMP7704MT
C32
50V
470nF
R31
2k2
R32
22k
CURRENT_B
R37
2k2
U7C
LMP7704MT
R35
100
MCU_MOTB_CURR
C34
50V
470nF
R33
2k2
R34
22k
CURRENT_C
R38
2k2
U7D
LMP7704MT
R36
100
MCU_MOTC_CURR
C35
50V
470nF
C25
25V
10uF
C26
100nF
50V
D11
B0540WS-7
Q5
BSC070N10NS3 G
R20
68
R23
10k
MCU_PWM_CL
R25
100
MCU_PWM_CH
R27
100
U6
C30
1uF
50V
MOT_C
Q6
BSC070N10NS3 G
R28
68
R29
10k
CURRENT_C
R30
10m
Title
Driver
Author: ROBOTECH
Project: BLDC_driver.PrjPcb
Date: 21/04/16 Time: 18.31.59
Sheet2 of 3
Revision: 1.0
File: Driver.SchDoc
ROBOTECH



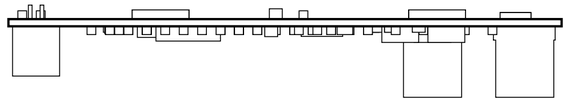
Title	**Power Supply - Connectors**
Author: ROBOTECH	Project: BLDC_driver.PrjPcb
Date: 21/04/16 Time: 18.32.00	Sheet3 of 3 Revision: 1.0
File: Power Supply And Connector.SchDoc	

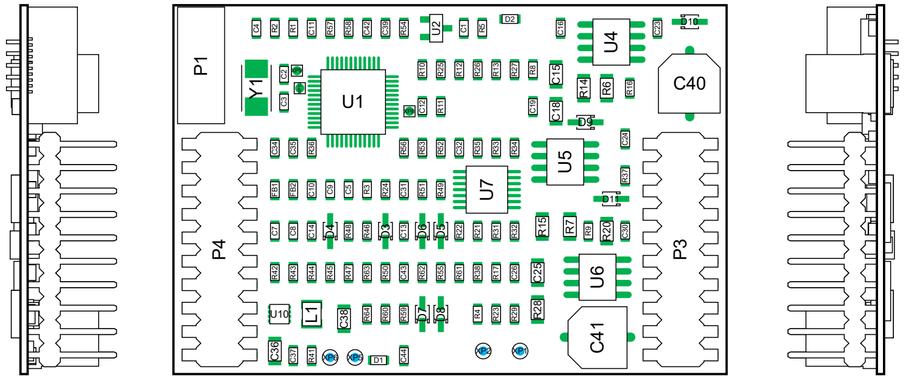
ROBOTECH

2F
BLDC DRIVER
Bill of Material

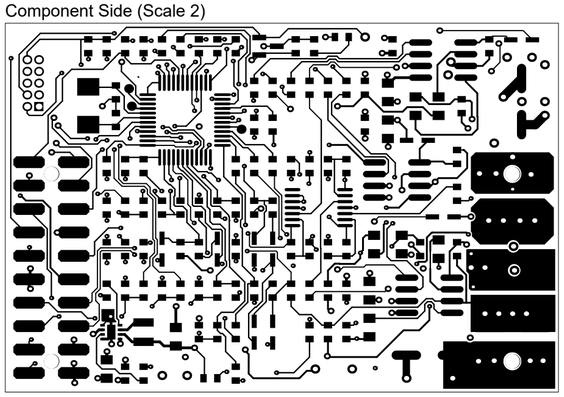
Designator	Qty	PartNumber	Footprint	Value	Description	Voltage
C1, C4, C5, C6, C8, C10, C12, C13, C14, C16, C19, C26, C31, C32, C34, C35, C37, C39, C42, C43, C44	21		C0603	100nF	Capacitor (Semiconductor SIM Model)	50V
C2, C3	2		C0603	18pF	Capacitor (Semiconductor SIM Model)	50V
C7, C11	2		C0603	4.7uF	Capacitor (Semiconductor SIM Model)	10V
C9, C23, C24, C30	4		C0603	1uF	Capacitor (Semiconductor SIM Model)	50V
C15, C18, C25, C36	4		C0805	10uF	Capacitor (Semiconductor SIM Model)	25V
C38	1		C0805	22uF	Capacitor (Semiconductor SIM Model)	10V
C40, C41	2	EDK476M050A9HAA	CAP POLARIZED SMD	47uF	Polarized Capacitor (Radial)	50V
D1	1		LED_0603		Typical RED, GREEN, YELLOW, AMBER GaAs LED	
D2	1		LED_0603		Typical RED, GREEN, YELLOW, AMBER GaAs LED	
D3, D4, D5, D6, D7, D8, D9, D10, D11	9	B0540WS-7	SOD-323		Schottky Diode	
FB1, FB2	2	PE-0603PFB181ST	R0603			
L1	1		IndM2520	2.2uH	Inductor	
P1	1		DIL10_1.27mm_Debug		Header, 5-Pin, Dual row	
P3, P4	2	015916202	HEADER20_SMD_V		Header, 10-Pin, Dual row	
Q1, Q2, Q3, Q4, Q5, Q6	6	BSC070N10NS3 G	INF-PG-TDSON-8-1_V		N-Channel OptiMOS 3 Power-Transistor, 100 V VDS, 90 A ID, -55 to 150 degC, PG-TDSON-8-1, Reel, Green	
R1, R8, R9, R16, R17, R23, R29, R41, R43, R45, R48, R51, R61, R62, R'1, R'2	16		R0603	10k	Resistor	
R2, R22, R32, R34, R42	5		R0603	22k	Resistor	
R3, R10, R11, R12, R13, R24, R25, R27, R35, R36, R39, R40, R44, R47, R50, R52, R53, R54, R56, R57, R58, R59, R60	23		R0603	100	Resistor	
R4, R5	2		R0603	330	Resistor	
R6, R7, R14, R15, R20, R28	6		R0805	68	Resistor	
R18, R19, R30	3		RESC6332M	10m	Resistor	
R21, R26, R31, R33, R37, R38, R46, R49, R55	9		R0603	2k2	Resistor	
U1	1	STM32F103C6T7A	STM-LQFP48_N		ARM Cortex-M3 32-bit MCU, 32 KB Flash, 10 KB Internal RAM, 37 I/Os, 48-pin LQFP, -40 to 105 degC, Tray	

U2	1	MCP120T-270I/TT	SOT-23-TT3_N		Microcontroller Supervisory Circuit with Open Drain Output, 3-Pin SOT-23, Industrial Temperature, Tape and Reel	
U3	1	MCP9700T-E/TT	SOT-23-TT3_N		Low-Power Linear Active Thermistor IC, 3-Pin SOT-23, Extended Temperature, Tape and Reel	
U4, U5, U6	3		SOIC127P600-8M		High voltage high and low-side driver	
U7	1	LMP7704MT	MTC14_N		Precision, CMOS Input, RRIO, Wide Supply Range Amplifiers, 14-pin TSSOP	
U10	1	TPS62172DSGR	DSG8-1600X900TP		Buck Step Down Regulator with 3 to 17 V Input and 3.3 V Output, -40 to 85 degC, 8-Pin WSON (DSG), Green (RoHS & no Sb/Br)	
XP1, XP2, XP4, XP5, XP6	5		TESTPOINT-SMALL		tespoint	
XP7, XP8, XP9, XP10	4		TESTPOINT-SMD		tespoint	
Y1	1	ABM3-8.000MHZ-D2Y-T	2-smd crystal		ABM3-8.000MHZ-D2Y-T	

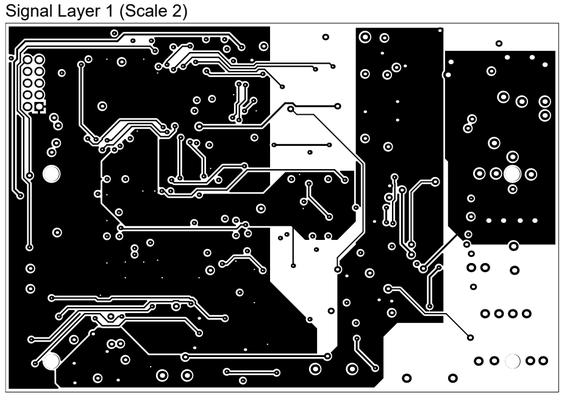


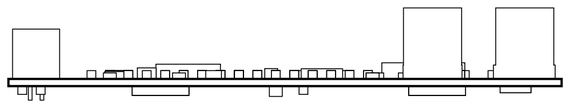


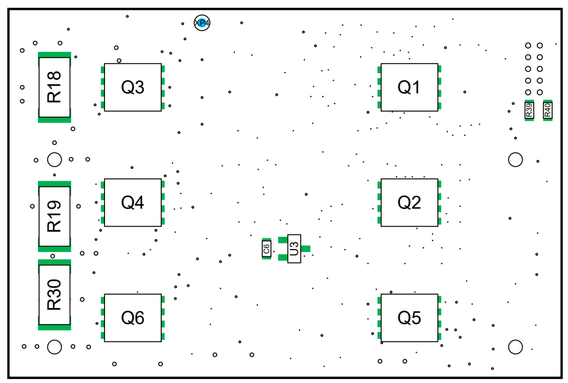
Component Side (Scale 2)



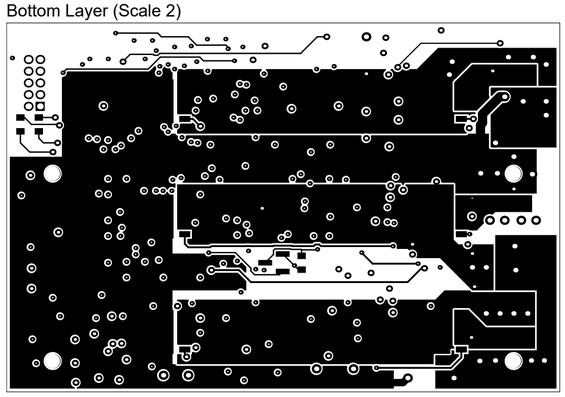
Signal Layer 1 (Scale 2)



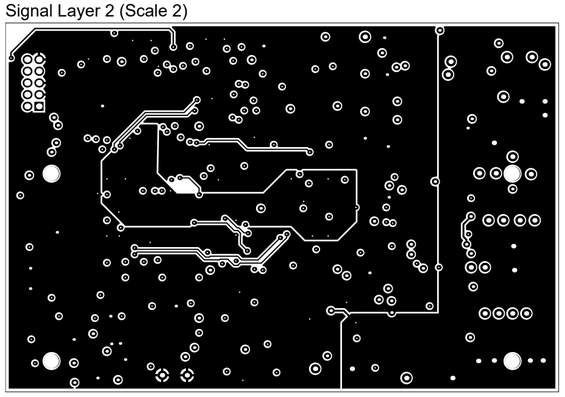




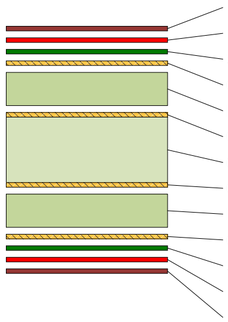
Bottom Layer (Scale 2)



Signal Layer 2 (Scale 2)



Layer Stack Legend



Material	Layer	Thickness	Dielectric Material	Type	Gerber
	Top Paste			Paste Mask	GTP
	Top Overlay			Legend	GTO
Surface Material	Top Solder	0.01mm	Solder Resist	Solder Mask	GTS
Copper	Component Side	0.036mm		Signal	GTL
Prepreg		0.36mm	PR7628	Dielectric	
Copper	Signal Layer 1	0.036mm		Signal	G1
Core		0.71mm	FR4	Dielectric	
Copper	Signal Layer 2	0.036mm		Signal	G2
Prepreg		0.36mm	PR7628	Dielectric	
Copper	Bottom Layer	0.036mm		Signal	GBL
Surface Material	Solder Side	0.01mm	Solder Resist	Solder Mask	GBS
	Bottom Overlay			Legend	GBO
	Bottom Paste			Paste Mask	GBP

Total thickness: 1.593mm

NEXT ASSY | USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±
ANGULAR: MACH± BEND±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		22/12/16
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

RoboTech srl

TITLE: 2F BLDC

SIZE | DWG. NO.

SCALE: 1:1 | WEIGHT: | SHEET 1 OF 1

ECHORD++ Flooring Fellow

Grant Agreement number: 601116
Project acronym: 2F
Project title: Flooring Fellow
Funding project: Flooring Fellow is an experiment of ECHORD++ - The European Coordination Hub for Open Robotics Development
Funding scheme: CP - Collaborative project
Project website address: http://www.robotechsrl.com/flooringfellow/
http://www.echord.eu/

Motor Driver UART Protocol

Document date: [22/12/2016]

Start date of project: 01/05/2015 Duration: 18 months

Organisation name of lead contractor for this deliverable: RT, IMER

Deliverable authors: Luca Volpi

Version: [1.1]

Project co-funded by the European Commission within the Seventh Framework Programme (2007-2013)		
Dissemination Level		
PU	Public	
PP	Restricted to other programme participants (including the Commission Service)	
RE	Restricted to a group specified by the consortium (including the Commission Service)	
CO	Confidential, only for members of the consortium (including the Commission Service)	**CO**

Motor Driver UART Protocol

UART Settings

Baud rate: 115200, Parity: None, Data Bits: 8, Stop Bits: 1, Handshake: None

Messages always end with carriage return (\r) and line feed (\n). Parameters are separated by spaces.

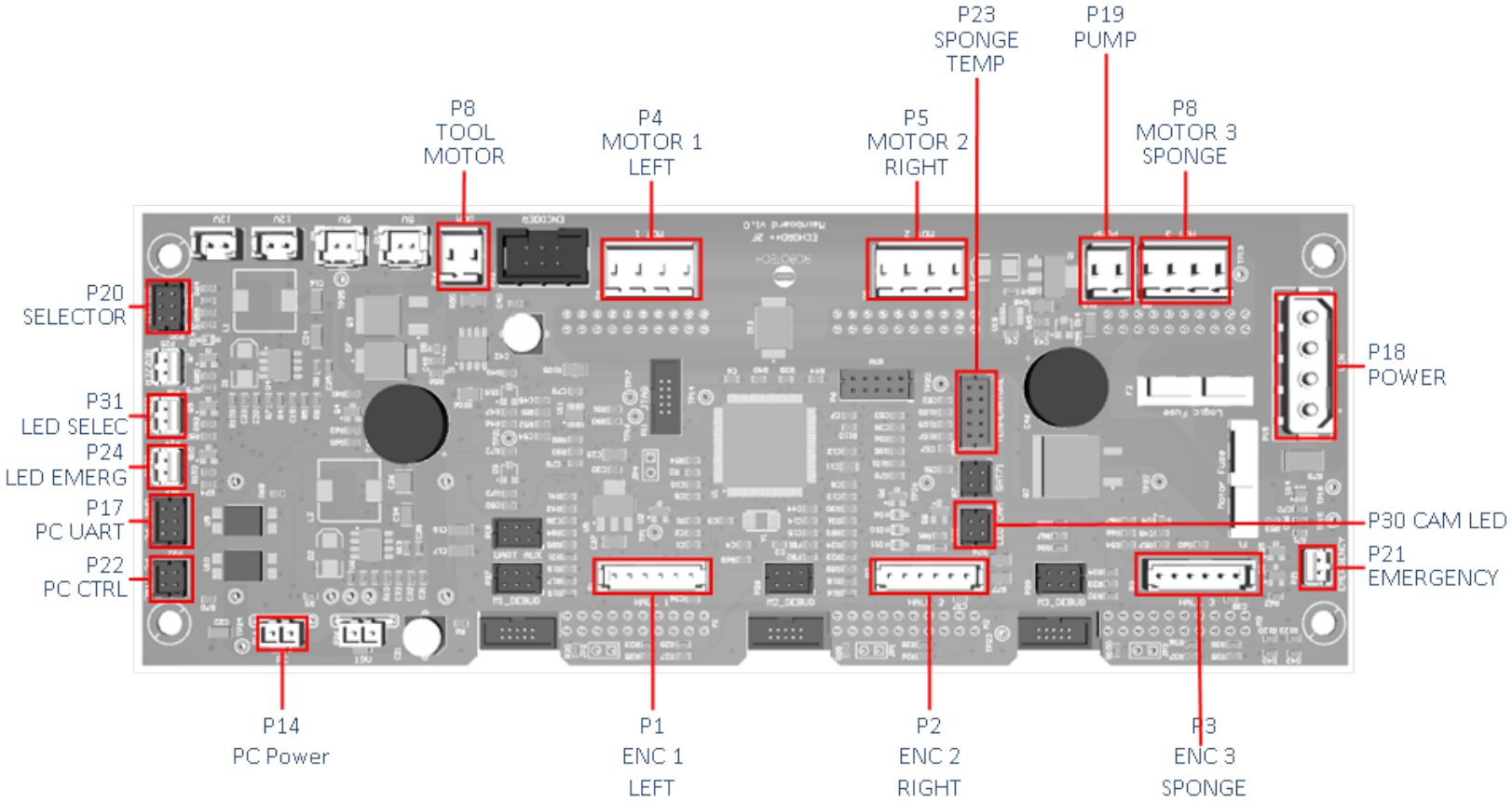
Command List

Command	Parameters	Description	Note
kpar	kp, ki	Set PID parameter	"kpar %d %d\r\n", kp, ki kp, ki ∈ [0,100] default kp 0, ki 0
speed	n	Set motor speed in number of rise/fall edge target in the control time	"speed %d\r\n", n n ∈ [-1000,1000] This message must be sent every 200ms
duty	d	Set motor duty in %	"duty %d\r\n", d d ∈ [-100,100] This message must be sent every 200ms
current	c	Set current limit in mA	"current %d\r\n", c c ∈ [0,10000] default 5000
temperature	t	Set temperature limit in °C	"temperature %d\r\n", t t ∈ [0,99]
time	t	Set control time in ms	"TIME %d\r\n", t t ∈ [10,200] default 50
pwm	f	Set PWM frequency in KHz	"pwm %d\r\n", f f ∈ [1,20] default 20
get config		Get configuration	"get config\r\n"

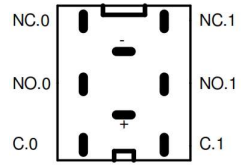
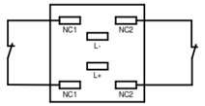
Status Message List

Message	Body	Description
status	Timestamp, nEdge, duty, current, temperature	"status %04d %03d %02d %05d %02d\r\n", timestamp, nEdge, duty, current, temperature This message is sent every 100ms
config	CurrentLim, TempLim, timeControl, Frequency, KP, KI	"CONFIG %05d %02d %03d %02d %03d %03d\r\n", CurrentLim, TempLim, timeControl, Frequency, KP, KI

ANNEX 4
Wiring diagram



Title: 2F wiring scheme	
Author: ROBOTECH srl, IMER	
Sheet: 1 of 3	Revision: 1.0

Cable 00 - Main											
Function	Main Board Connector	Function	Connector Type	Pin Type	Pin Number	Cable Color	Connector Type	Pin Number	Connect or Type	Pin Number	Cable Color
PC Power	P14	+19V	TE 1-480424-0	TE 60619-1	1	red	1634 02 luberg	+ inner			
					1	red/brown					
		GND			2	black		- outer			
					2	black/white					
PC Control	P22	PW_ON_PC	DF11-4DS-2C HIROSE	DF11-2428SCF	1	blue	5x2 pin 2mm step	6			
		STATE_PC			2	brown		2			
		GND_PC			3	pink		8			
		GND			4	violet		4			
PC UART	P17	PC_RX	DF11-6DS-2C HIROSE	DF11-2428SCF	1	green/white	USB FTDI TTL UART to USB	yellow			
		GND			3	grey		black			
		PC_TX			5	green/brown		orange			
Pump	P19	+24V_MOTOR			1	green	Faston	+			
		PUMP			2	white		-			
Selector Switch	P20	+3V3	DF11-6DS-2C HIROSE	DF11-2428SCF	2	yellow	Faston	NC.0-NO.1			
		SW_SENSE			3	pink/brown		C.0			
		GND			4	white/blue		NO.0 - C.1			
		POWER_CTRL			6	blue/brown		NC.1			
Selector LED	P31	+V	JST PHR2	JST SPH-002T-P0.5L	1	red/white	Faston	+			
		LED CMD			2	grey/pink		-			
Emergency LED	P24	+V	JST PHR2	JST SPH-002T-P0.5L	1	yellow/brown	Faston	L+			
		LED 1 CMD			2	grey/white		L-			
Emergency	P21	GND	JST PHR2	JST SPH-002T-P0.5L	1	yellow/white	Faston	NC1			
		EMERGENCY			2	red/blue		NC1			
Cam LED	P30	LED CAM CMD	DF11-4DS-2C HIROSE	DF11-2428SCF	1	pink/white		VDC			
		+12V			2	grey/brown		GND			

Title: 2F wiring scheme	
Author: ROBOTECH srl, IMER	
Sheet: 2 of 3	Revision: 1.0

Cable 00 - Main											
Function	Main Board Connector	Function	Connector Type	Pin Type	Pin Number	Cable Color	Connector Type	Pin Number	Connector Type	Pin Number	Cable Color
Sponge Motor Power	P8	PHASE A	DF11-10DS-2C HIROSE	DF11-2428SCF	1	blue/red	WEIPU SP2110/S9	1	WEIPU SP2112/P9	1	yellow
		PHASE A			1	green/white		1		1	yellow
		PHASE B			2	brown		2		2	red
		PHASE B			2	green/brown		2		2	red
		PHASE C			3	yellow/white		3		3	black
		PHASE C			3	yellow/brown		3		3	black
Sponge Motor Hall	P3	5V	DF11-10DS-2C HIROSE	DF11-2428SCF	1	red		5		5	black
		HALL A			4	blue		4		4	white
		HALL B			3	green		9		9	green
		HALL C			2	white		7		7	blue
		GND			5	black		8		8	red
Sponge Motor Temperature	P23	GND	DF11-10DS-2C HIROSE	DF11-2428SCF	5	yellow		10		10	black
		TEMP			3	violet		11		11	white
		VDDA			1	grey/pink		12		12	red

Title: 2F wiring scheme	
Author: ROBOTECH srl, IMER	
Sheet: 2 of 3	Revision: 1.0

ECHORD++ Flooring Fellow

Grant Agreement number: 601116
Project acronym: 2F
Project title: Flooring Fellow
Funding project: Flooring Fellow is an experiment of ECHORD++ - The European Coordination Hub for Open Robotics Development
Funding scheme: CP - Collaborative project
Project website address: http://www.robotechsrl.com/flooringfellow/
http://www.echord.eu/

Software Architecture

Delivery date: [31/12/2016]

Start date of project: 01/05/2015 Duration: 18 months

Organisation name of lead contractor for this deliverable: RT

Deliverable authors: Giancarlo Teti

Version: [1.1]

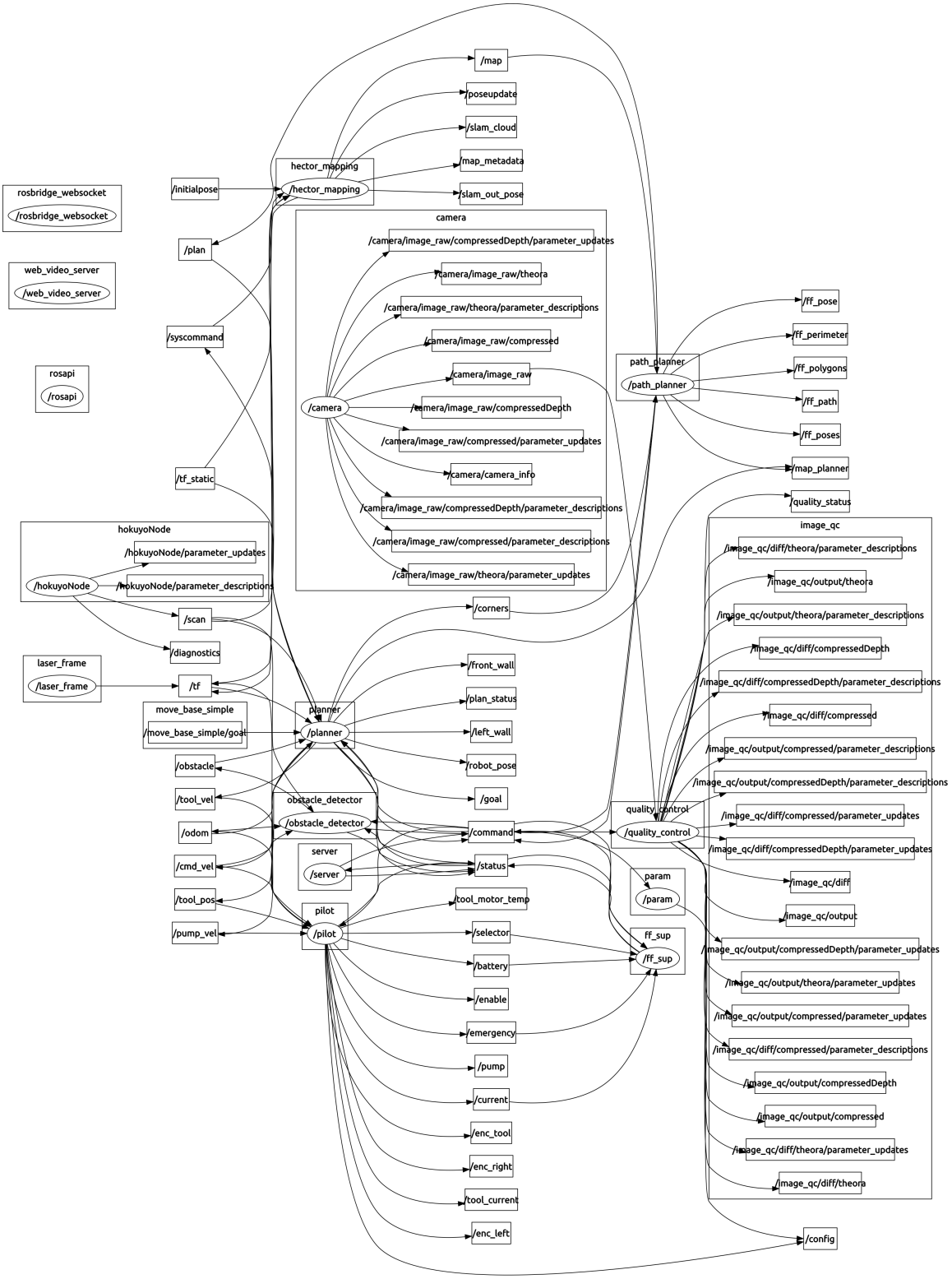
Project co-funded by the European Commission within the Seventh Framework Programme (2007-2013)		
Dissemination Level		
PU	Public	
PP	Restricted to other programme participants (including the Commission Service)	
RE	Restricted to a group specified by the consortium (including the Commission Service)	
CO	Confidential, only for members of the consortium (including the Commission Service)	**CO**

Document History

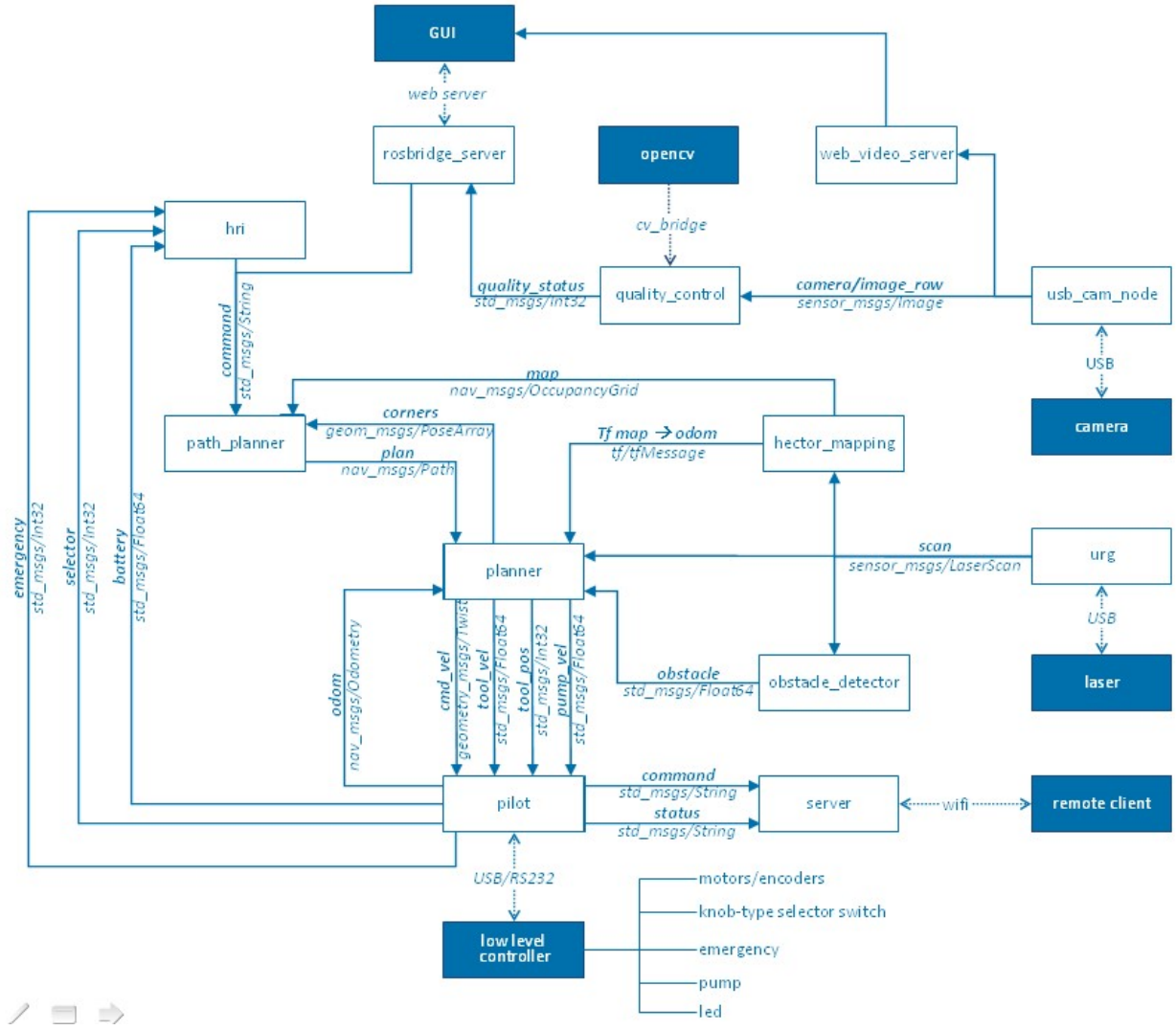
Version	Date	Author	Summary of Main Changes
1.0	23-12-2016	Giancarlo Teti (RT)	First version of the Deliverable and table of contents
1.1	28-12-2016	Giancarlo Teti (RT)	Final version

Table of Contents

1 Software Architecture



2 Software Core Nodes



3 ROS Nodes

3.1 pilot_node

ff_controller is the interface with the low level controller. Publishes on the topics the device status (emergency, switch position, battery, encoders, etc.) and set commands for the devices (led, motors, etc.). Computes and publishes robot odometry estimated on the base of encoder readings, and transforms linear and rotational velocity commands in messages for the motor driver.

3.1.1 Subscribed Topics

cmd_vel (geometry_msgs::Twist)

The velocity commands for the mobile base.

tool_vel (std_msgs/Float64)

The velocity commands in RPM for the sponge motor.

tool_pos (std_msgs/Int32)

The position commands for the tool: -1 down, 0 off, 1 up.

pump_vel (std_msgs/Float64)

The velocity commands for the pump in % between 0 and 100.

command (std_msgs/String)

The commands for the low level controller.

3.1.2 Published Topics

enc_left (std_msgs/Int32)

The left motor speed in encoder pulses in the control period.

enc_right (std_msgs/Int32)

The right motor speed in encoder pulses in the control period.

enc_tool (std_msgs/Int32)

The tool motor speed in encoder pulses in the control period.

enable (std_msgs/Int32)

The enable status of the low level controller: 0 disabled, 1 enabled.

pump (std_msgs/Int32)

The motor pump status: 0 off, 1 on.

emergency (std_msgs/Int32)

The emergency button status: 0 button not pushed, 1 button pushed.

selector (std_msgs/Int32)

The switch selector status: 1 off position, 1 on position, 2 start position.

battery (std_msgs/Float64)

The battery level in volts.

current (std_msgs/Float64)

The current power in Ampere.

odom (nav_msgs::Odometry)

The robot odometry speed and position.

config (std_msgs::String)

The current settings of low level controller and planner.

status (std_msgs::String)

The robot status messages, including all messages from the low level controller.

tool_motor_temp (std_msgs/Float64)

The tool motor temperature in Celsius degree.

tool_current (std_msgs/Float64)

The tool motor current in Ampere.

3.1.3 Parameters

~counts_per_turn (int, default: 3600)

The motor encoder counts per turn.

~wheel_diam (float, default: 0.155)

The wheel diameter in meters for odometry computation.

~wheel_distance (float, default: 0.54)

The wheel distance in meters for odometry computation.

~tool_reduction (float, default: 92.0)

The tool reduction gear parameter for RPM computation.

~controller_freq (float, default: 10.0)

The low level controller frequency in Hz for odometry computation.

3.2 planner_node

planner_node executes the cleaning programs: aligns the robot to the closest room wall, follows the room wall and identifies the room corners, gets the cleaning trajectories from the path planner node, and executes the trajectories.

3.2.1 Subscribed Topics

command (std_msgs/String)

The commands for the planner. The node gets here the following commands:

- prog1: 'spiral' trajectory cleaning program, parallel trajectories to the room walls.
- prog2: 'zig zag' trajectory cleaning program, 45° trajectories wrt the room walls.
- prog3: fast 'spiral' trajectory cleaning program.
- pause: pauses execution of the current cleaning program if any.
- resume: resumes execution of the current cleaning program if paused.
- stop: stops the current running program if any.
- run: starts the cleaning program according to the selected program.
- get plan: publishes the corners detected during the perimeter following procedure.
- set config [*param_name*] [*param_value*]: update the param_name parameter to the new value param_value.

scan (sensor_msgs::LaserScan)

The laser scan readings used by the node to identify front and left walls.

odom (nav_msgs::Odometry)

The robot odometry speed and position.

plan (nav_msgs::Path)

The plan trajectories to follow.

obstacle (std_msgs::Float64)

The distance from an obstacle which collide the robot along the moving trajectory.

3.2.2 Published Topics

command (std_msgs::String)

The commands for path planner node, quality control node and low level controller:

- plan spiral: ask the path planner to plan a spiral trajectory plan.
- plan zigzag: ask the path planner to plan a zig zag trajectory plan.
- qc on: to start quality control node activity
- qc off: to stop quality control node activity

- set led cam 50: to switch on camera led used by the quality control node
- set led cam 0: to switch off camera led used by the quality control node

status (std_msgs::String)

The error messages for the GUI:

- 'Error Planner: plan list empty, cannot run plan'

cmd_vel (geometry_msgs::Twist)

The velocity commands for the mobile base.

tool_vel (std_msgs/Float64)

The velocity commands in RPM for the sponge motor.

tool_pos (std_msgs/Int32)

The position commands for the tool: -1 down, 0 off, 1 up.

pump_vel (std_msgs/Float64)

The velocity commands for the pump in % between 0 and 100.

plan_status (std_msgs/String)

The planner node status:

- ready: the node is in stand by and ready for any operation.
- run align: robot is aligning itself to the side wall.
- run follow: robot is following the wall to acquire room perimeter and corners.
- run plan: robot is planning the cleaning trajectories.
- run stop: robot is stopping any operation.
- run [*p*]% step [*i*] of [*n*]: robot is running step [i] of a total of [n] steps of the plan, and completed [p]% of the total activity.

corners (geometry_msgs::PoseArray)

The room corners the robot is detecting following the room walls.

robot_pose (geometry_msgs::Point)

The robot pose in the map reference system (for GUI purposes).

goal (geometry_msgs::PoseStamped)

The goal in the map reference system (for GUI purposes).

map_planner (nav_msgs::OccupancyGrid)

The map of points followed by the robot during of the room perimeter (for GUI purposes).

syscommand (std_msgs::String)

The commands to reset the hector node at the beginning of each plan.

3.2.3 Parameters

~linear_speed (float, default: 0.1)

The robot linear speed in m/s (obsolete, replaced by program speeds).

~min_linear_speed (float, default: 0.05)

The minimum robot linear speed in m/s.

~rotational_speed (float, default: 0.3)

The robot rotational speed in rad/sec while turning on the spot.

~min_rotational_speed (float, default: 0.05)

The minimum robot rotational speed.

~turn_l_speed (float, default: 0.1)

The robot linear speed while turning.

~turn_r_speed (float, default: 0.2)

The robot rotational speed while turning.

~turn_radius (float, default: 0.4)

The robot turn radius at turn_l_speed and turn_r_speed speeds.

~tool_rpm (float, default: 30)

The tool speed in RPM (obsolete, replaced by program speeds).

~pump_speed (float, default: 0)

The pump speed in percentage (obsolete, replaced by program speeds).

~base_length (float, default: 0.6)

The base length in m.

~base_width (float, default: 0.4)

The base width in m.

~turn_on_the_spot (bool, default: false)

Define the turn strategy of the robot: turn on the spot (linear speed null) or normal curve (linear speed not null).

~wall_dist (float, default: 0.4)

The minimum distance the robot maintain from the wall during the operations.

~overlap_factor (float, default: 0.2)

The distance between the parallel trajectories.

~avoid_obstacle (bool, default: true)

Define if robot avoid or not obstacle.

~quality_control (bool, default: false)

Define if robot do the quality control or not.

~p1_linear_speed (float, default: 0.2)

Cleaning program 1 robot linear speed in m/s.

~p1_tool_rpm (float, default: 30)

Cleaning program 1 tool rotational speed in rpm.

~p1_pump_speed (float, default: 0)

Cleaning program 1 pump speed in %.

~p2_linear_speed (float, default: 0.2)

Cleaning program 2 robot linear speed in m/s.

~p2_tool_rpm (float, default: 30)

Cleaning program 2 tool rotational speed in rpm.

~p2_pump_speed (float, default: 0)

Cleaning program 2 pump speed in %.

~p3_linear_speed (float, default: 0.2)

Cleaning program 3 robot linear speed in m/s.

~p3_tool_rpm (float, default: 30)

Cleaning program 3 tool rotational speed in rpm.

~p3_pump_speed (float, default: 0)

Cleaning program 3 pump speed in %.

3.3 path_planner_node

planner_node on the base of the room corners and overlap factor plans the robot trajectories in terms of waypoints to cover the wall area.

3.3.1 Subscribed Topics

map (nav_msgs::OccupancyGrid)

The map of the room acquired by the robot while following the wall perimeter.

corners (geometry_msgs::PoseArray)

The room corners detected by the robot while following the wall perimeter.

command (std_msgs/String)

The commands for the path planner. The node gets here the following commands:

- plan: plans 'spiral' trajectory, parallel trajectories wrt the room walls.
- plan spiral: plans 'spiral' trajectory, parallel trajectories wrt room walls.
- plan zigzag: plans 'zig zag' trajectory, 45° trajectories wrt room walls.
- get plan: publishes the plan.

3.3.2 Published Topics

plan (nav_msgs::Path)

The planned trajectories.

command (std_msgs::String)

The commands for the planner node:

- run: to start trajectory execution.

3.3.3 Parameters

~wall_dist (float, default: 0.4)

The minimum distance the robot maintain from the wall during the operations.

~overlap_factor (float, default: 0.2)

The distance between the parallel trajectories.

~area_min (float, default: 0.2)

Minimum polygon area dimension in square meters.

3.4 obstacle_detector_node

obstacle_detector_node on the bases of laser readings, current speed, robot geometry and safety margin distances, detects if there will be a collision between robot and obstacles.

3.4.1 Subscribed Topics

scan (sensor_msgs::LaserScan)

The laser scan readings used by the node to identify front and left walls.

odom (nav_msgs::Odometry)

The robot odometry speed and position.

3.4.2 Published Topics

obstacle (std_msgs::Float64)

The distance from an obstacle which collide the robot along the moving trajectory. = means no obstacle collision.

3.4.3 Parameters

~avoid_obstacle (bool, default: true)

Define if the node detect or not obstacle collision.

~front_dist (float, default: 0.2)

The distance in m between laser and robot front side.

~side_dist (float, default: 0.22)

The distance in m between laser and robot left side..

~obst_front_dist (float, default: 0.05)

The front safety distance in m between robot and obstacle to consider for collision.

~obst_side_dist (float, default: 0.22)

The side safety distance in m between robot and obstacle to consider for collision.

~ obst_proj_time (float, default: 500)

The projection time in ms to determine robot position at the current speed.

3.5 hri_node

hri_node manages the switch selector, controls the battery level and manages the switch led and emergency led. When active the green led pulses off for a while every 4 seconds.

3.5.1 Subscribed Topics

selector (std_msgs/Int32)

The selector position. Positions are 1 for 'off', 2 for 'on' and 3 for 'start'. When the value changes publishes the proper command for the planner: if selector position is 3 starts program 1 (spiral trajectory cleaning), if selector position is 1 or 2 stop any program.

battery (std_msgs/Float64)

The battery level in volts. If the battery level is below 25 set the emergency LED to blink.

emergency (std_msgs/Int32)

The emergency button position. Positions are 0 for button not pushed and 1 for button pushed. When the value changes publishes the proper command for the low level controller: if selector position is 0 enable motor output.

3.5.2 Published Topics

command (std_msgs/String)

Commands for low level controller and planner:

- set led sw off: to switch off green led (pulse off every 4 second).
- set led sw on: to switch on green led.
- stop: to stop any robot activity.
- enable: to enable motor driver output.
- prog1: to start program 1 spiral trajectory cleaning program.
- set led aux blink: to blink red led for low battery alarm.

3.6 log_node

log_node publishes and saves to a text file the status of the robot: battery level, current, linear speed, rotational speed, position x y, orientation, tool rpm and tool current.

3.6.1 Subscribed Topics

battery (std_msgs/Float64)

The battery level in volts.

current (std_msgs/Float64)

The current power in Ampere.

tool_current (std_msgs/Float64)

The tool motor current in Ampere.

enc_tool (std_msgs/Int32)

The tool motor speed in encoder pulses in the control period.

odom (nav_msgs::Odometry)

The robot odometry speed and position.

robot_pose (geometry_msgs::Point)

The robot pose in the map reference system (for GUI purposes).

plan (nav_msgs::Path)

The planned trajectories.

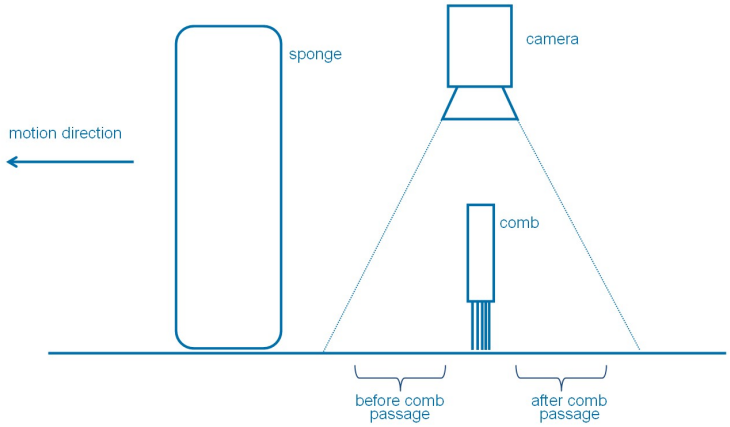
3.6.2 Published Topics

log (std_msgs::String)

The robot status: [battery level] [current] [linear speed] [rotational speed] [position x] [position y] [orientation] [tool rpm] [tool current].

3.7 quality_control_node

quality_control_node measures the goodness of the grout removal of the sponge by comparing the floor before and after the passage of a comb, positioned after the sponge, on the floor: if the sponge is working properly, the passage of the comb does not effect the floor status. Vice versa, if the sponge is not working properly and grout is not well removed from the floor, the comb do effect on the floor by removing the residual grout during is passage. quality_control_node compares the status of the floor before and after the passage of the comb and provides an indication of the cleaning quality. While the robot moves the status of the floor is monitored with the camera positioned over the comb and pointing down. The quality_control_node compares the images before and after the passage of the comb on the floor: if images are 'different' means that the floor changed after the passage of the comb i.e. the sponge is not cleaning properly the floor. Vice versa, if the image are comparable, the sponge is cleaning properly the floor.



3.7.1 Subscribed Topics

camera/image_raw (sensor_msgs/Image)

Image from USB camera.

command (std_msgs/String)

Commands for the node:

- qc on: start continuous quality control
- qc off: stop continuous quality control

3.7.2 Published Topics

image_qc/output (sensor_msgs/Image)

Pre-elaborated image with region of interest indicated (for debug purposes).

image_qc/diff (sensor_msgs/Image)

Elaborated image: difference between part of the image before the comb and part of the image after the comb (same size).

quality_status (std_msgs/Int32)

results of the elaboration: the number of different pixels between part of the image before the comb and part of the image after the comb (same size).

3.7.3 Parameters

~continuous (bool, default: true)

Define if the node performs continuous or spot control (every 5 seconds).

~roi_width (float, default: 100)

The length of ROI in pixel.

~roi_height (float, default: 20)

The height of ROI in pixel.

~roi_shift_before (float, default: 30)

The top/down position of the ROI before the comb wrt the center of the image.

~roi_shift_after (float, default: 30)

The top/down position of the ROI after the comb wrt the center of the image.

~roi_shift_left (float, default: 0)

The left position of the ROI wrt the center of the image.

~th_pixel (float, default: 70)

The threshold for pixel comparison.

~th_alarm (float, default: 5)

The threshold percentage for comparison failure (min value).

3.8 param_node

param_node read and update the yaml configuration file.

3.8.1 Subscribed Topics

command (std_msgs/String)

The commands for the param node:

- get config: publish on the config topic the current low level and high level configuration.
- set config [*param_name*] [*param_value*]: update the param_name parameter to the new value param_value.

3.8.2 Published Topics

config (std_msgs::String)

The low level and high level configuration of the system.

3.9 server_node

server_node is a TCP/IP server, accepts connections from remote clients, writes to the command topic all incoming messages and sends to remote clients all incoming messages on the topic status.

3.9.1 Subscribed Topics

status (std_msgs/String)

Messages from low level controller.

3.9.2 Published Topics

command (std_msgs/String)

Commands for planner and low level controller.

3.10 Other nodes

3.10.1 urg_node

urg_node s the driver for the Hokuyo URG-04LX-UG01 and provides laser readings.

3.10.2 usb_cam_node

usb_cam_node interfaces with the USB camera and publishes images

3.10.3 hector_mapping

hector_mapping is a SLAM node that can be used without odometry. Gets input from laser scan and provides 2D pose estimates at scan rate of the sensors.

4 Summary of messages of the command topic

Message	Receiver	Description
prog1	planner	Start a cleaning program with ‘spiral’ trajectory
prog2	planner	Start a cleaning program with ‘zig zag’ trajectory
prog3	planner	Start a fast cleaning program with ‘spiral’ trajectory
pause	planner	Pause current cleaning program operations
resume	planner	Resume current cleaning program operations
stop	planner all	Stop current cleaning program operations Stop any robot activity
run	planner	Start the last plan
get plan	planner path_planner	Require the current plan (corners and trajectories)
qc on	quality_control	Start quality control
qc off	quality_control	Stop quality control
get config	planner low level controller	Require planner and low level controller
enable	low level controller	Enable motor driver output
disable	low level controller	Disable motor driver output
set pulse [l] [r]	low level controller	set target left [l] and right [r] hall effect sensor pulses
set tool [t]	low level controller	Set target tool hall effect sensor pulses [t]
set tool [up/down]	low level controller	Set tool position [p] up or down
set tool duty d	low level controller	Set tool duty [d] in %
set pump [d]	low level controller	Set pump duty [d] in %
set led [sw/aux] [p]	low level controller	Set led [l] switch or emergency on/off/blink

set led cam [d]	low level controller	Set led cam duty [d] in %
set pid [m] [kp] [ki]	low level controller	Set motor [m] left, right or tool pid param [kp] and [ki]
set max current [c]	low level controller	Set motor max current [c] in mA
set i2t [m][i]	low level controller	Set max i2t /1024 [i] for motor [m] left, right or tool
set control freq [f]	low level controller	Set low level control freq [f] in Hz
set diagnostic [m] [p]	low level controller	Set motor [m] left, right, tool diagnostic messages on/off

5 Configuration file

config.yaml

```
counts_per_turn: 3600
wheel_diam: 0.155
wheel_distance: 0.55
controller_freq: 10
tool_reduction: 92
base_length: 0.60
base_width: 0.40
quality_control: true
turn_on_the_spot: false
avoid_obstacle: true
overlap_factor: 0.15
linear_speed: 0.1
rotational_speed: 0.2
wall_dist: 0.20
tool_rpm: 35
pump_speed: 0
obst_front_dist: 0.30
obst_side_dist: 0.22
turn_radius: 0.40
p1_linear_speed: 0.07
p1_pump_speed: 15
p1_tool_rpm: 30
p2_linear_speed: 0.07
p2_pump_speed: 15
p2_tool_rpm: 30
p3_linear_speed: 0.25
p3_pump_speed: 30
p3_tool_rpm: 20
```

ECHORD++ Flooring Fellow

Grant Agreement number: 601116
Project acronym: 2F
Project title: Flooring Fellow
Funding project: Flooring Fellow is an experiment of ECHORD++ - The European Coordination Hub for Open Robotics Development
Funding scheme: CP - Collaborative project
Project website address: http://www.robotechsrl.com/flooringfellow/
http://www.echord.eu/

Robot Parameters and settings

Document date: [23/12/2016]

Start date of project: 01/05/2015 Duration: 18 months

Organisation name of lead contractor for this deliverable: RT, IMER

Deliverable authors: Giancarlo Teti

Version: [1.0]

Project co-funded by the European Commission within the Seventh Framework Programme (2007-2013)		
Dissemination Level		
PU	Public	
PP	Restricted to other programme participants (including the Commission Service)	
RE	Restricted to a group specified by the consortium (including the Commission Service)	
CO	Confidential, only for members of the consortium (including the Commission Service)	**CO**

Network and OS Settings

Name	Value	Description
SSID name	Flooring	The WiFi access point name
SSID password	flooringfellow	The WiFi access point password
Login username	flooringfellow	The Linux root login username
Login password	2f	The Linux root login password
Home page address	10.42.0.1	The home page address of the WEB page remote control GUI

Robot Parameters and Settings

Parameter	Value	Description
Base length (m)	0.73	The robot base length
Base width (m)	0.43	The robot base width
Wheel diameter (m)	0.155	The robot wheel diameter
Wheel distance	0.55	The robot wheel distance for odometry computation
Counts per turn	3600	The wheel and tool encoder counts per turn
Tool reduction gear	92	The tool reduction gear
Laser X position	0.12	The X coordinate of thee laser WRT the robot center
Laser Y position	0.02	The X coordinate of thee laser WRT the robot center

Low Level Control Parameters and Settings

Parameter	Value	Description
Control Frequency	10	The frequency of the low level controller in Hz
Max current	5 A	The max current provided by the drivers
Left Motor KP	20	The left motor PI control proportional parameter
Left Motor KI	60	The left motor PI control integral parameter
Left Motor I2T	4000	The left motor I2T control max value
Right Motor KP	20	The right motor PI control proportional parameter
Right Motor KI	60	The right motor PI control integral parameter
Right Motor I2T	4000	The right motor I2T control max value
Tool Motor KP	20	The tool motor PI control proportional parameter
Tool Motor KI	60	The Tool motor PI control integral parameter
Tool Motor I2T	20000	The Tool motor I2T control max value

ECHORD++ Flooring Fellow

Grant Agreement number: 601116
Project acronym: 2F
Project title: Flooring Fellow
Funding project: Flooring Fellow is an experiment of ECHORD++ - The European Coordination Hub for Open Robotics Development
Funding scheme: CP - Collaborative project
Project website address: http://www.robotechsrl.com/flooringfellow/
http://www.echord.eu/

HRI and user interface

Document date: [23/12/2016]

Start date of project: 01/05/2015 Duration: 18 months

Organisation name of lead contractor for this deliverable: RT, IMER

Deliverable authors: Giancarlo Teti

Version: [1.0]

Project co-funded by the European Commission within the Seventh Framework Programme (2007-2013)		
Dissemination Level		
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HRI and user interface

The user interface has been extremely simplified in order to reduce the number of devices on the robot and includes:

- knob type selector switch (3 positions) with led used to switch on/off the robot (ON and OFF position) and to start the automatic grout removing procedure (START position). The led indicate when the robot is ON.
- emergency stop button: to and shut off power to motor driver in case of emergency or pause the robot operations.

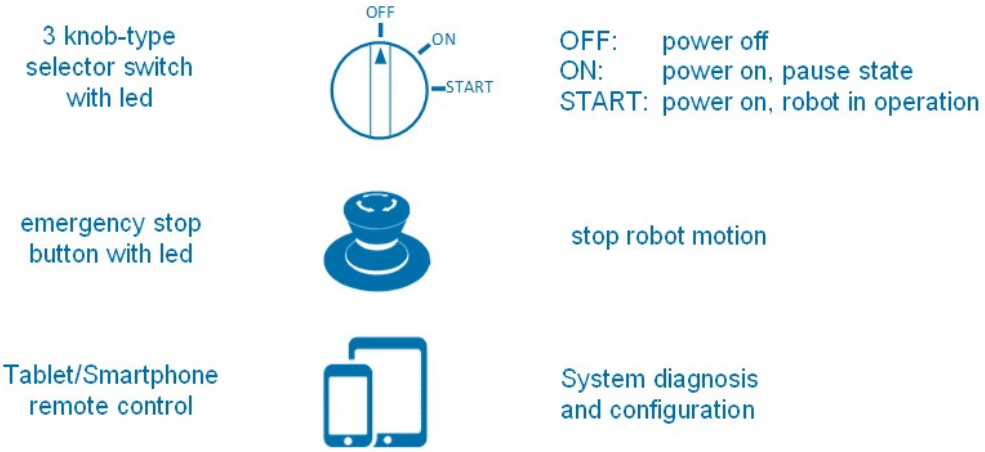
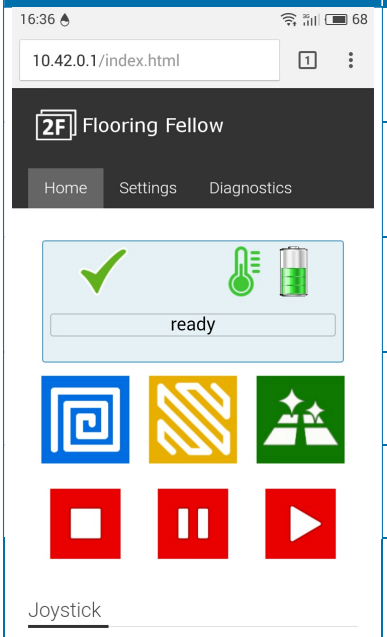
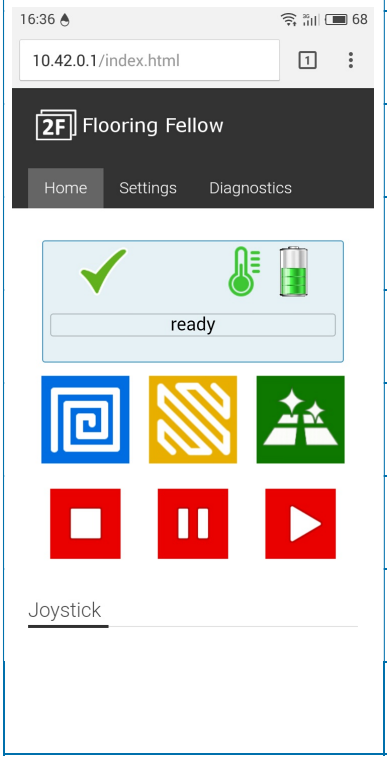


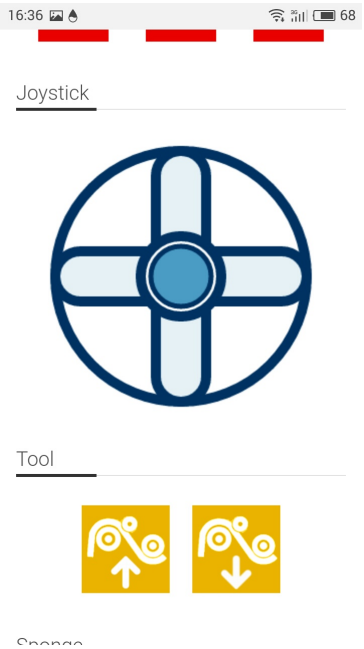
Figure 1: Switches and physical HRI devices

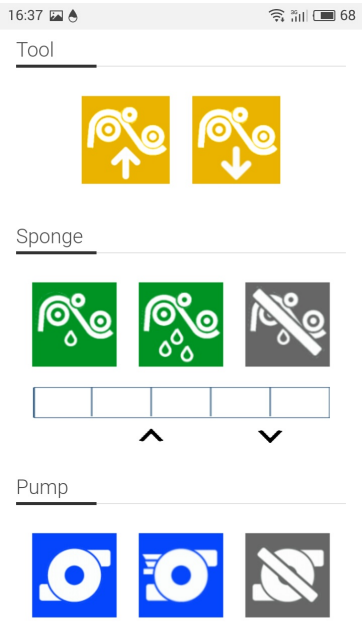
Remote control, system configuration and diagnosis are available on PC, tablet and smartphone throughout browser and WiFi connection. WiFi network SSID is 'flooring', WiFi password is 'flooringfellow', home page address is 10.42.0.1.

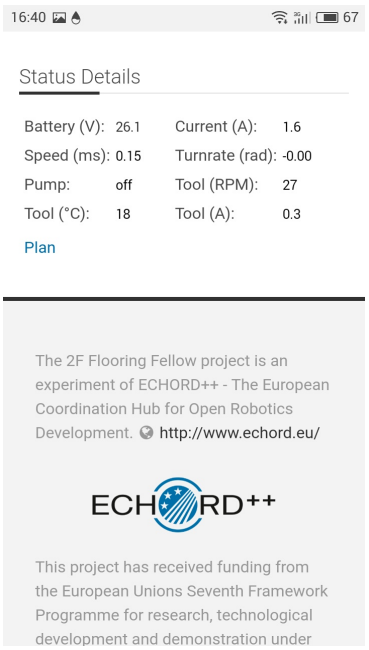
LED	Color	Status	Description
Switch	Green	off	Robot off
		on	Robot on, no ready
		1 pulse off every 4 second	Robot ready
Emergency	Red	off	Emergency stop button off
		on	Emergency stop button active
		blink	Battery low

Home page: command panel	Description	
	Program 1	Start cleaning program 1: the robot follows a 'spiral' trajectory moving parallel to the walls: speed: 0.07 m/s, tool speed: 30 rpm
	Program 2	Start cleaning program 2: the robot follows a 'zig zag' trajectory moving 45° wrt the walls: speed: 0.07 m/s, tool speed: 30 rpm
	Program 3	Start cleaning program 3: the robot follows a 'spiral' trajectory moving parallel to the walls: speed: 0.25 m/s, tool speed: 20 rpm
	Stop	Stop the cleaning operations
	Pause	Pause the cleaning operations
	Resume	Resume the cleaning operations after a stop

Home page: status panel	Description	
	Ready	Robot is ready for operations
	Running	Robot is running for cleaning operations
	Pause	Robot is in pause state
	Emergency	Emergency button is pressed
	Obstacle	Obstacle in front of the robot
	Error	Error
	Quality control	Quality control error
	Temperature	Tool motor temperature: green normal, yellow warning, red: alarm
	Battery	Battery level: completely green full charge, yellow low battery, red battery exhausted

Home page: joystick panel	Description		
	**Command icons**		
		Forward	Move forward, speed is proportional to the distance from the centre.
		Backward	Move backward, speed is proportional to the distance from the centre.
		Left	Turn left, rotational speed is proportional to the distance from the center
		Right	Turn right, rotational speed is proportional to the distance from the center
		Other position	Move forward and right, lineare and rotational speeds are proportional to the distance from the center

Home page: tool panel	Description		
		Tool up	Move the tool up
		Tool down	Move the tool down
		Tool on	Start the sponge rotation 20 rpm
		Tool on fast	Start the sponge rotation 35 rpm
		Tool off	Stop the sponge rotation
		Pump on	Start the pump 30%
		Pump on fast	Start the pump 50%
		Pump off	Stop the pump

Home page: status details	Description	
	Battery (V)	The battery level in V
	Current (A)	The total current of the robot in A
	Speed (ms)	The robot speed in m/s
	Turnrate (rad)	The robot rotational speed in rad/s
	Pump	The pump status on/off
	Tool (RPM)	The tool speed in RPM
	Tool (°C)	The tool motor temperature
	Tool (A)	The tool current in A