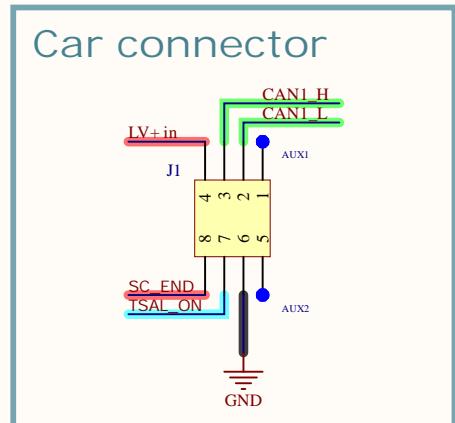
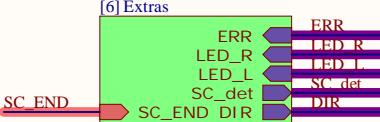
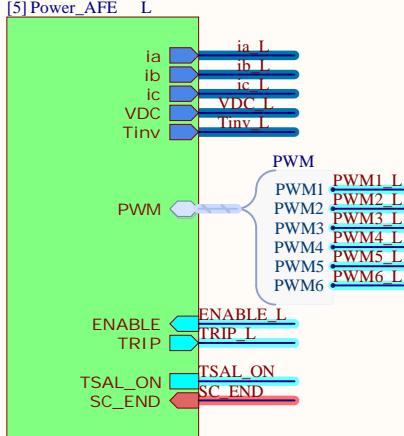
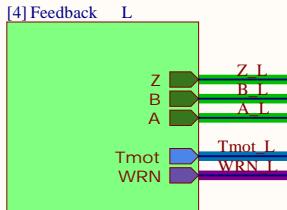
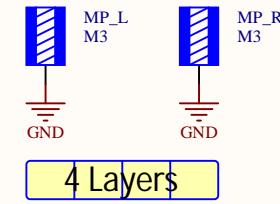
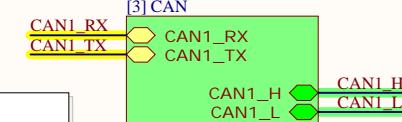
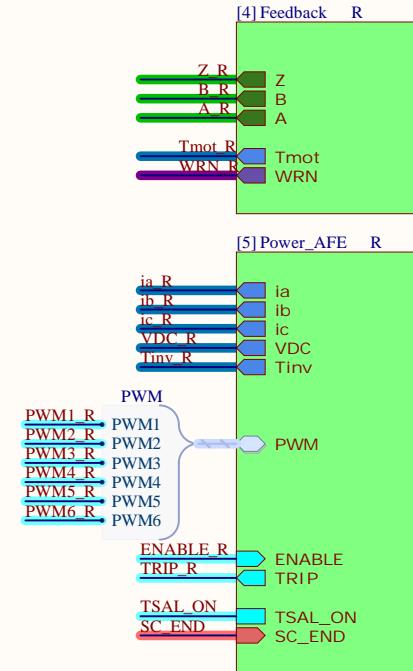
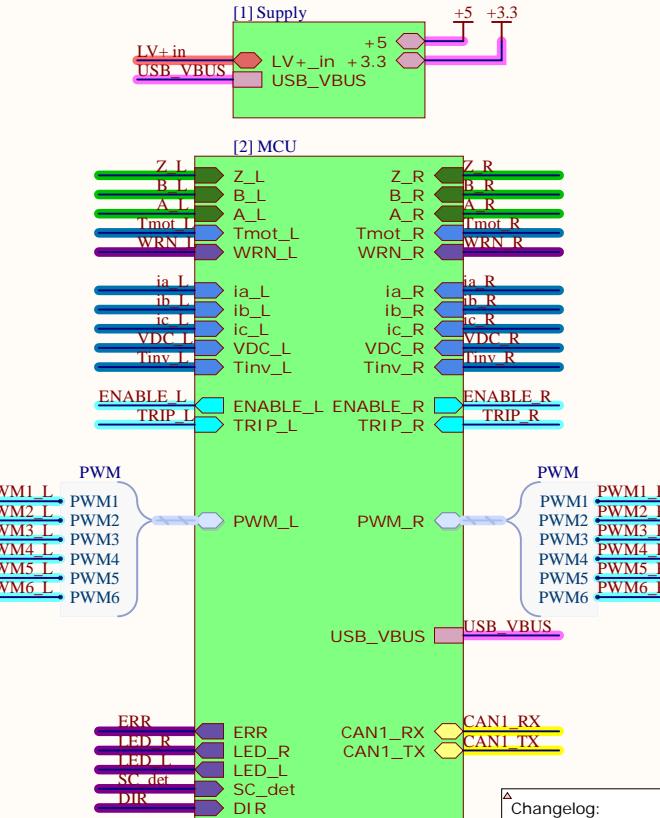


A



B



Changelog:

Version 1.0:

- Base version, sent to production 21-02-2024

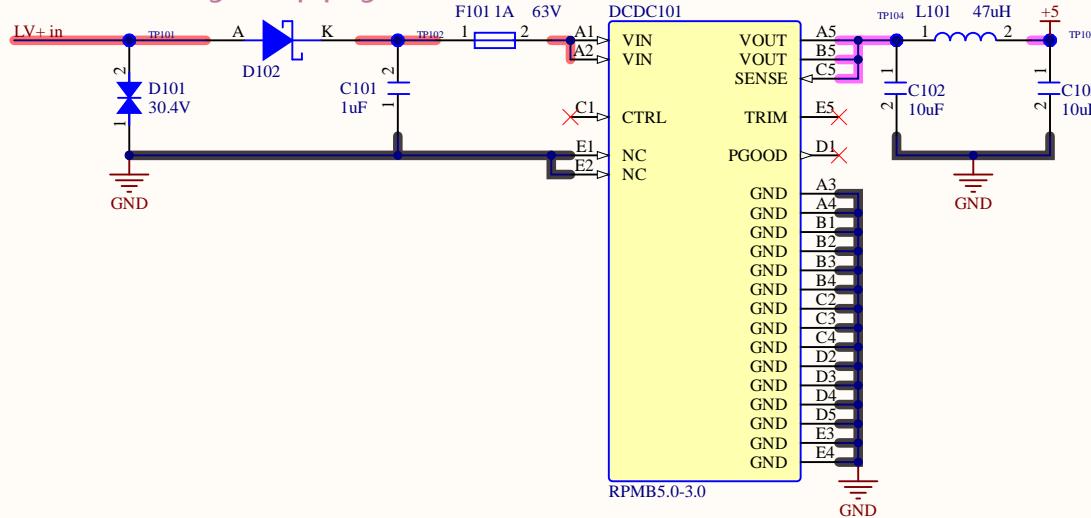
Version 1.1:

- Pull-up and pull-down added for BOOT0 control
- Added I2C pull-ups
- LV+_sns deleted, VBAT connected to 3.3V
- Extras LED color and names changed
- Added layers physical logo
- Moved supply filter to +5V
- Some silkscreen

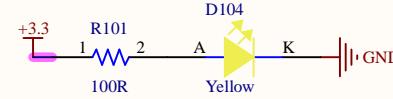
- ① Cyan nets indicate external signals.
- ② Purple nets indicate internal 3.3V signals.
- ③ Blue nets indicate analog signals read by the ADC.
- ④ Red nets indicate 20-30V.
- ⑤ Pink nets indicate treated supply.
- ⑥ Light green nets indicate CAN.
- ⑦ Yellow nets indicate serial communication.
- ⑧ Dark green nets indicate input capture.

Company:	e-Tech Racing	e-techracing.es	
Project:	Inverter Control	Variant: [No Variations]	
Size:	Page Contents: Inverter_Control.SchDoc	Version: 1.1	
		Department: Powertrain	
Author:	David Redondo	dredondovinolo@gmail.com	Sheet 1 of 1
Checked by:		Date: 21/03/2024	

LV battery supply



Supply OK



INPUTS/OUTPUTS

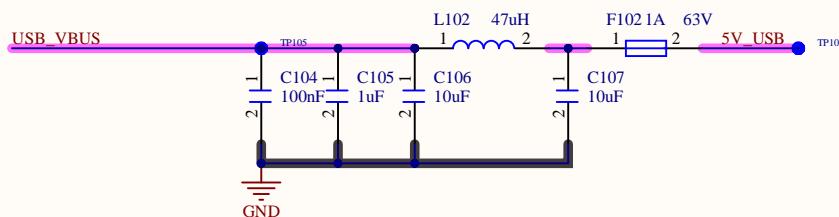
LV+_in

USB_VBUS

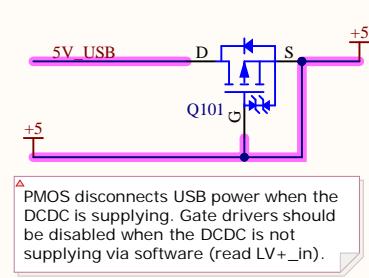
+5

+3.3

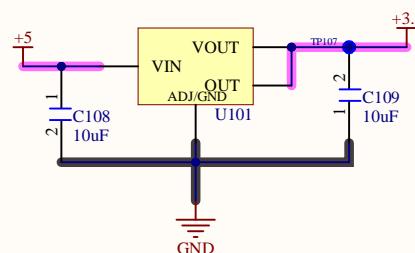
USB supply



5 V selection

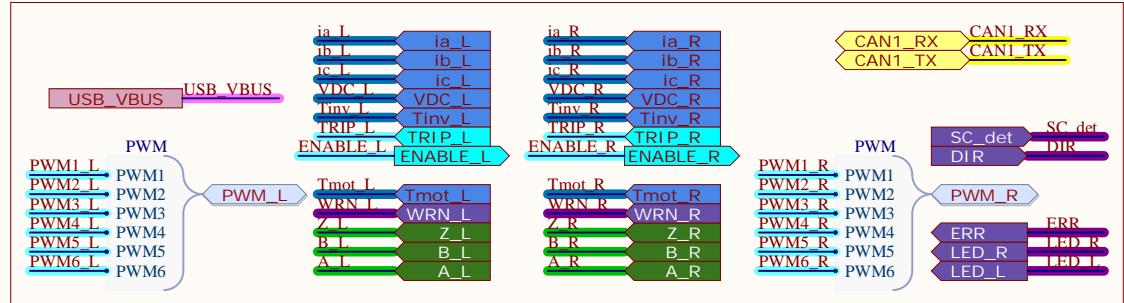


LDO

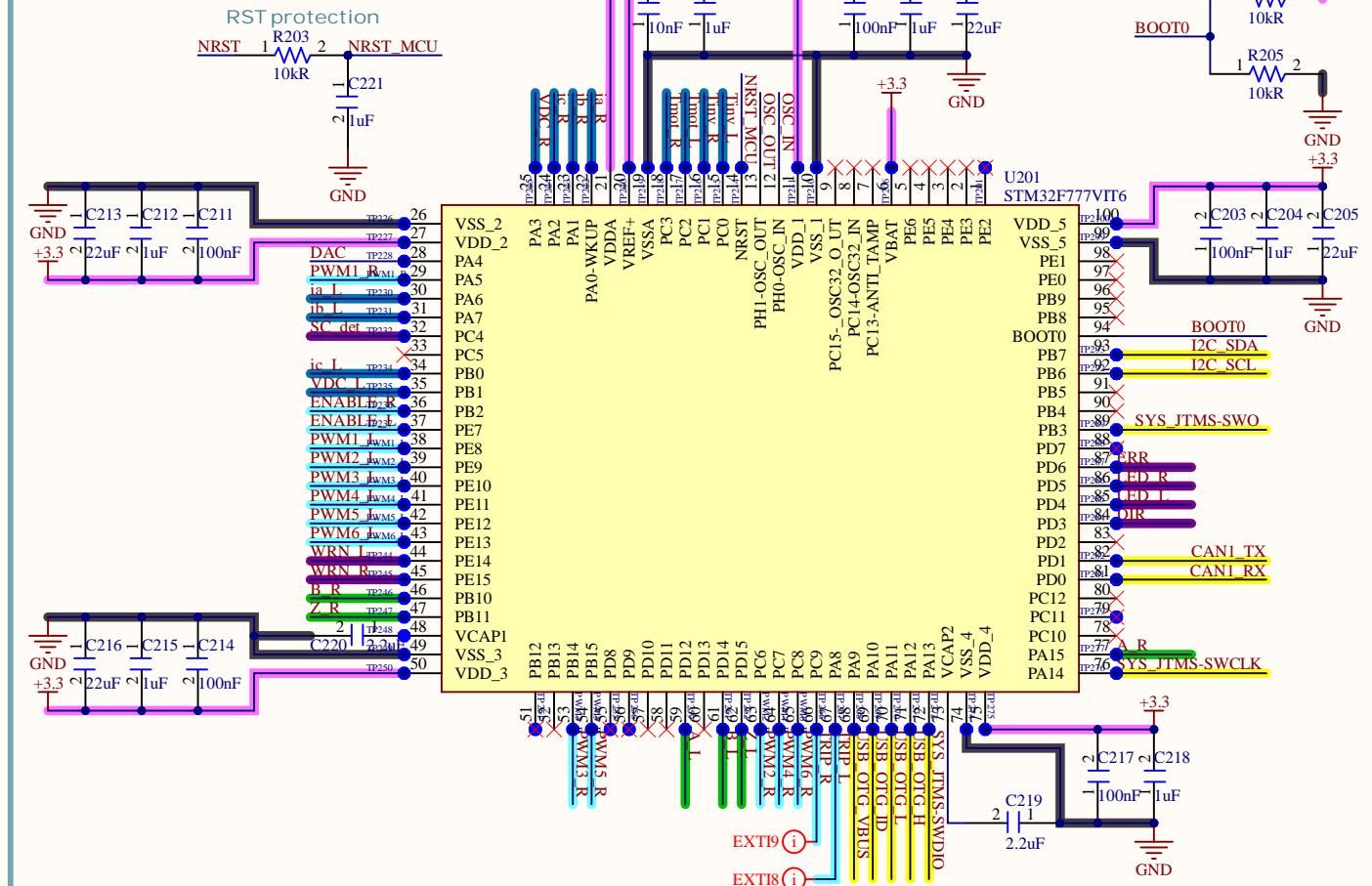


Company:	e-Tech Racing	e-techracing.es	
Project:	Inverter Control	Variant: [No Variations]	
Size:	Page Contents: [1]Supply.SchDoc	Version: 1.1	
-		Department: Powertrain	
Author:	David Redondo	dredondovinolo@gmail.com	Sheet * of *
Checked by:	*	Date: 21/03/2024	

INPUTS/OUTPUTS



STM32F777VIT



Timers

PWM L → TIM1
PWM R → TIM8
- PWM1 → CH1N
- PWM2 → CH1
- PWM3 → CH2N
- PWM4 → CH2
- PWM5 → CH3N
- PWM6 → CH3
Enc. L → TIM4
- A → CH1
- B → CH3
- Z → CH4
Enc. R → TIM2
- A → CH1
- B → CH3
- Z → CH4

ADC1:
- ia_meas_R (IN0)
- ib_meas_R (IN1)
- ic_meas_R (IN2)
- VDC_L (IN3)
- Vbat (LV+_sns) (IN18)

ADC2:
- ia_meas_L (IN6)
- ib_meas_L (IN7)
- ic_meas_L (IN8)
- VDC_L (IN9)

ADC3:
- Tinv_L (IN10)
- Tinv_R (IN11)
- Tmot_L (IN12)
- Tmot_R (IN13)

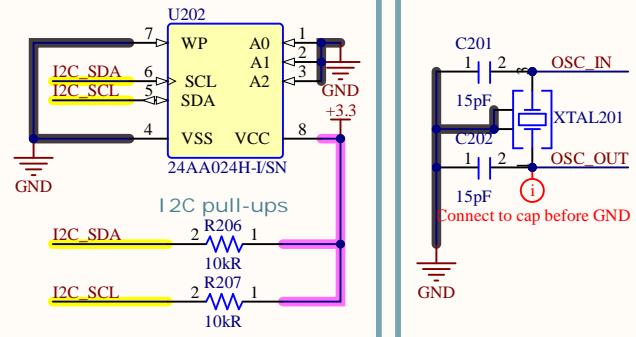
ADC

PWM L → TIM1
PWM R → TIM8
- PWM1 → CH1N
- PWM2 → CH1
- PWM3 → CH2N
- PWM4 → CH2
- PWM5 → CH3N
- PWM6 → CH3
Enc. L → TIM4
- A → CH1
- B → CH3
- Z → CH4
Enc. R → TIM2
- A → CH1
- B → CH3
- Z → CH4

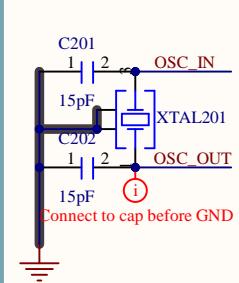
ADC1:
- ia_meas_R (IN0)
- ib_meas_R (IN1)
- ic_meas_R (IN2)
- VDC_L (IN3)
- Vbat (LV+_sns) (IN18)

ADC2:
- ia_meas_L (IN6)
- ib_meas_L (IN7)
- ic_meas_L (IN8)
- VDC_L (IN9)

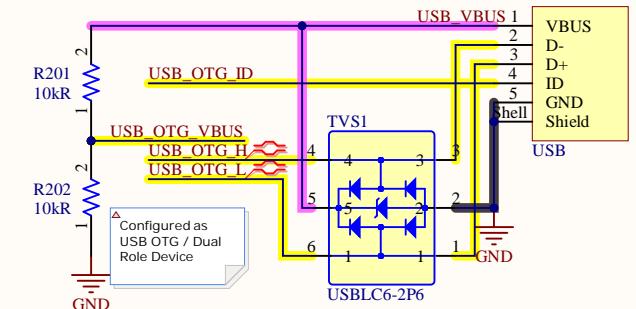
ADC3:
- Tinv_L (IN10)
- Tinv_R (IN11)
- Tmot_L (IN12)
- Tmot_R (IN13)

EEPROM (I₂C1)

Oscillator



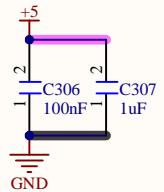
USB connector



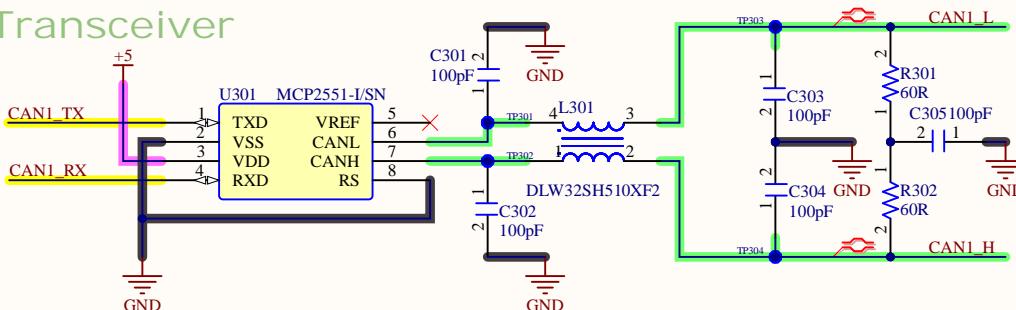
Company:	e-Tech Racing	e-techracing.es
Project:	Inverter Control	Variant: [No Variations]
Size:	Page Contents: [2]MCU.SchDoc	Version: 1.1
		Department: Powertrain
Author:	David Redondo	dredondovinolo@gmail.com
Checked by:		Date: 21/03/2024

A

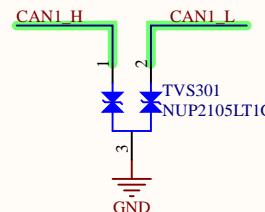
Decoupling



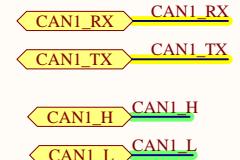
Transceiver



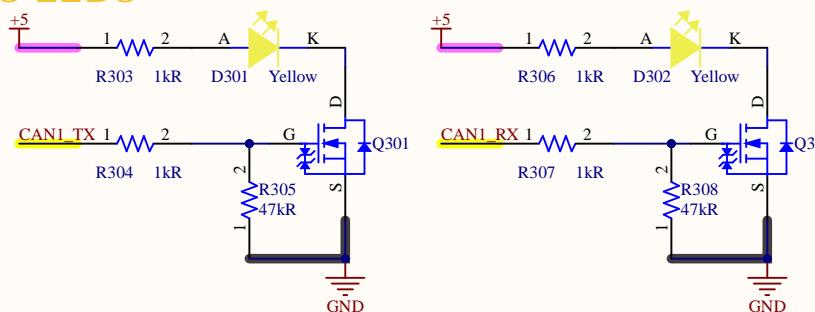
ESD



INPUTS/OUTPUTS



Status LEDs



Company: e-Tech Racing e-techracing.es



Project: Inverter Control Variant: [No Variations]

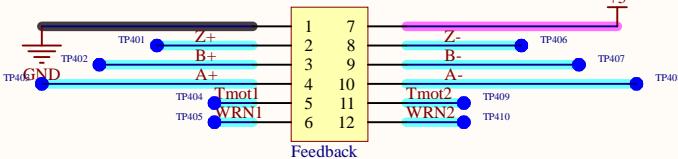
Size: - Page Contents: [3]CAN.SchDoc Version: 1.1

Department: Powertrain

Author: David Redondo dredondovinolo@gmail.com Sheet * of *

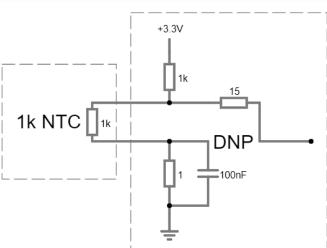
Checked by: _ Date: 21/03/2024

Feedback connector



As the motors' temperature sensors are not specified, the user may modify the resistor combination to find a suitable input for the ADC, then load a custom lookup table to have an appropriate reading.

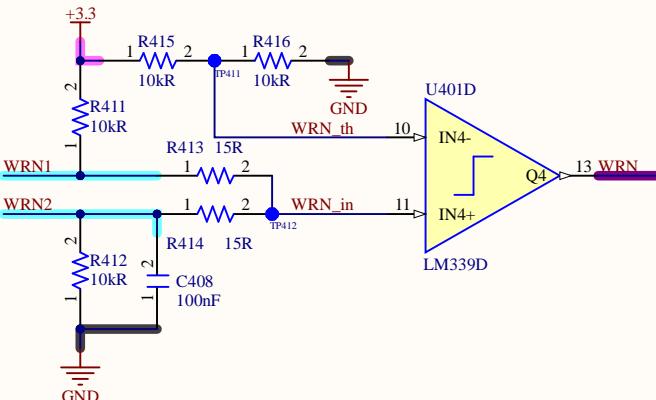
Example



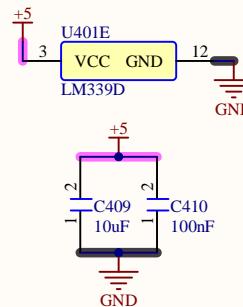
INPUTS/OUTPUTS



Auxiliary warning (WRN)

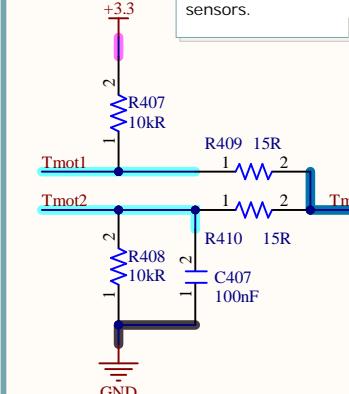


Comparator supply

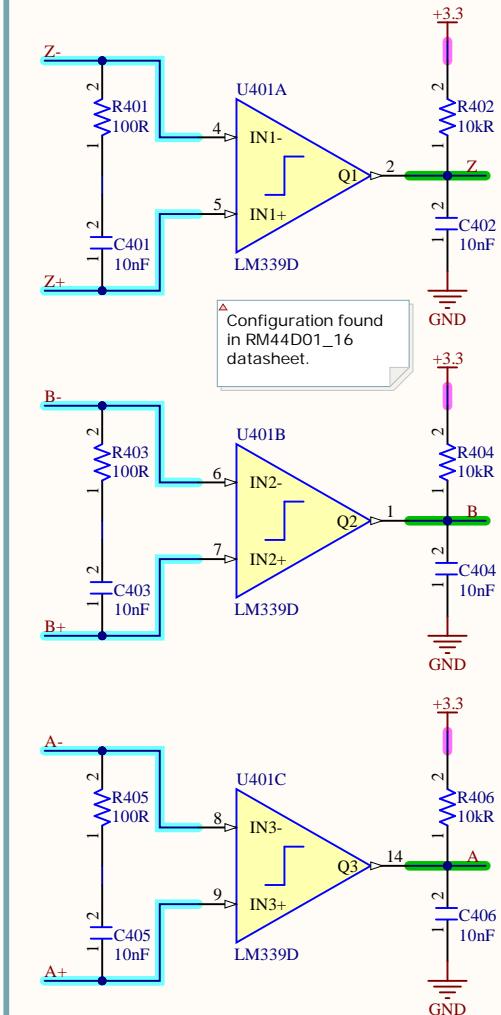


Motor thermistor

Only compatible with resistive temperature sensors.



Incremental encoder



Company: e-Tech Racing e-techracing.es



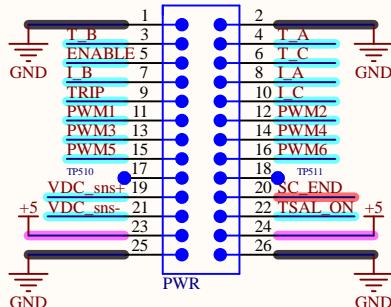
Project: Inverter Control Variant: [No Variations]

Size: - Page Contents: [4]Feedback.SchDoc Version: 1.1
Department: Powertrain

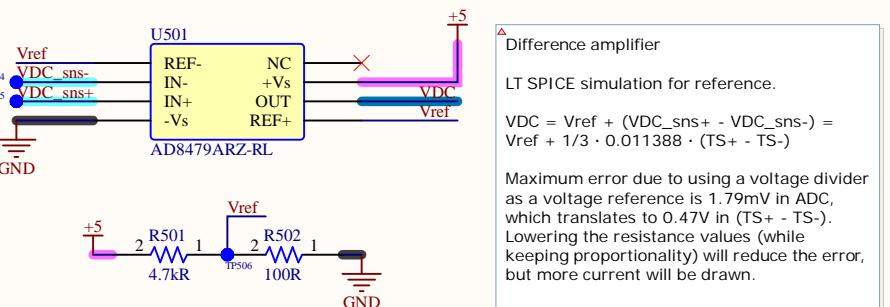
Author: David Redondo dredondovinolo@gmail.com Sheet: * of *

Checked by: _ Date: 21/03/2024

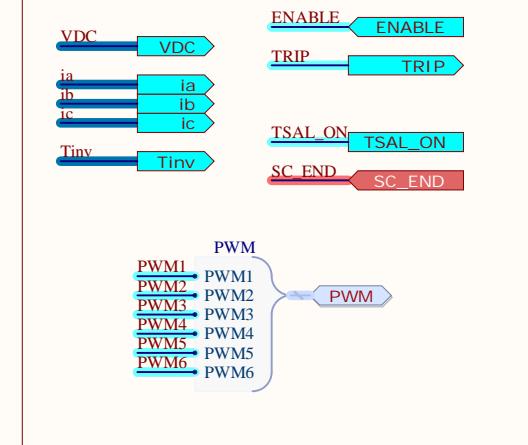
Power PCB Connector



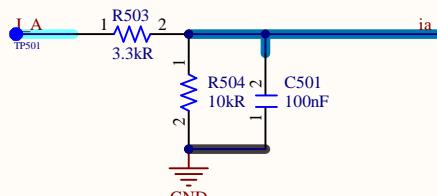
VDC sense AFE



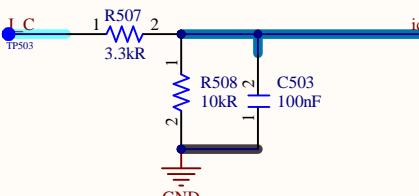
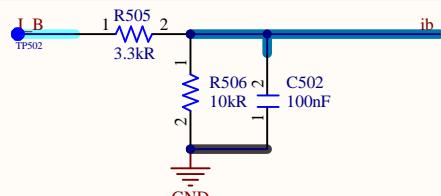
INPUTS/OUTPUTS



Current sense



Resistor combination can be adjusted for increased measuring range at the cost of lower resolution.

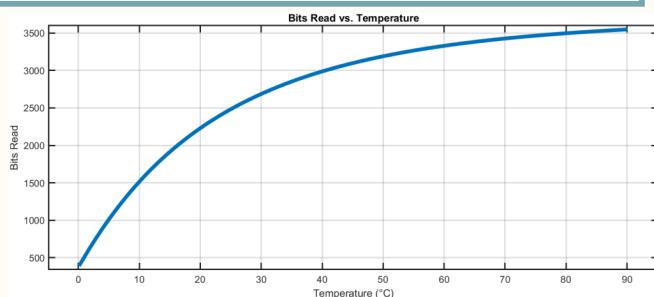


ENABLE is output directly from the MCU, it has been checked that UC21732 is able to detect it at 3.3V. Similarly, TRIP comes at 5V, and uses a 5V tolerant GPIO in the MCU.

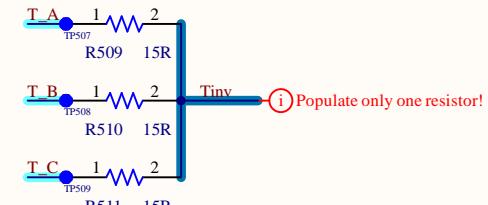
$VDC_offset = Vref \cdot 2^{12} \text{ bits} / (3.3V) = 0.02083 \cdot 2^{12} \text{ bits} / (3.3V) = 2333 \text{ bits}$
 $VDC_gain = 1 / ((1/3 \cdot 0.011388 \text{ V/V}) \cdot (2^{12} \text{ bits} / 3.3 \text{ V})) = 0.0484609962 \text{ A/bit}$
 $VDC_max = 0.212240269 \text{ V/bit} \cdot 2^{12} \text{ bits} = 869.34 \text{ V}$

$ix_offset = (10k / (3.3k + 10k)) \cdot 2.5V \cdot 2^{12} \text{ bits} / (3.3V) = 0.02083 \cdot 2^{12} \text{ bits} / (3.3V) = 129 \text{ bits}$
 $ix_gain = (10k / (3.3k + 10k)) / (12.5 \text{ mV/A} \cdot (2^{12} \text{ bits} / 3.3 \text{ V})) = 0.0484609962 \text{ A/bit} \cdot 2^{12} \text{ bits} / 2 = +/- 99 \text{ A}$

Inverters temperature should be calculated with a lookup table according to this graph. The lookup table and graph is generated with a MATLAB script which can be found in the simulations folder.



Temperature selection



Tiny is a pulsed signal that can read directly as a PWM input or be passed through an RC filter (Inverter_Power) to convert it into an analog signal. This board intends to read it with the ADC. The reading itself is in the TS part of the power board and connected to the AIN pin of UCC21732.

Based on the sensed voltage, the duty cycle (D) of the UCC21732 isolated output signal is calculated using the following relationship: $D = -20 \cdot V_{AIN} + 100$

If filtered, the voltage at Tiny is calculated as: $V_{Tiny} = VCC_GD \cdot D/100 = 5V \cdot (-20 \cdot V_{AIN} + 100)/100$

Company:	e-Tech Racing	e-techracing.es	e-tech RACING FORMULA STUDENT TEAM
Project:	Inverter Control	Variant: [No Variations]	
Size:	Page Contents: [5] Power_AFE.SchDoc	Version: 1.1	
Author:	David Redondo	dredondovinolo@gmail.com	
Checked by:		Sheet * of *	Date: 21/03/2024

A

B

C

D

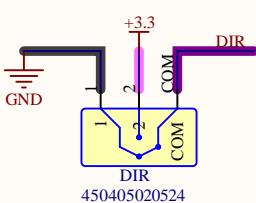
A

B

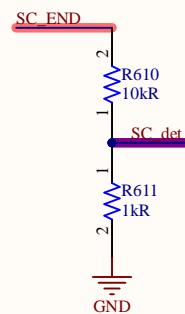
C

D

Reverse direction



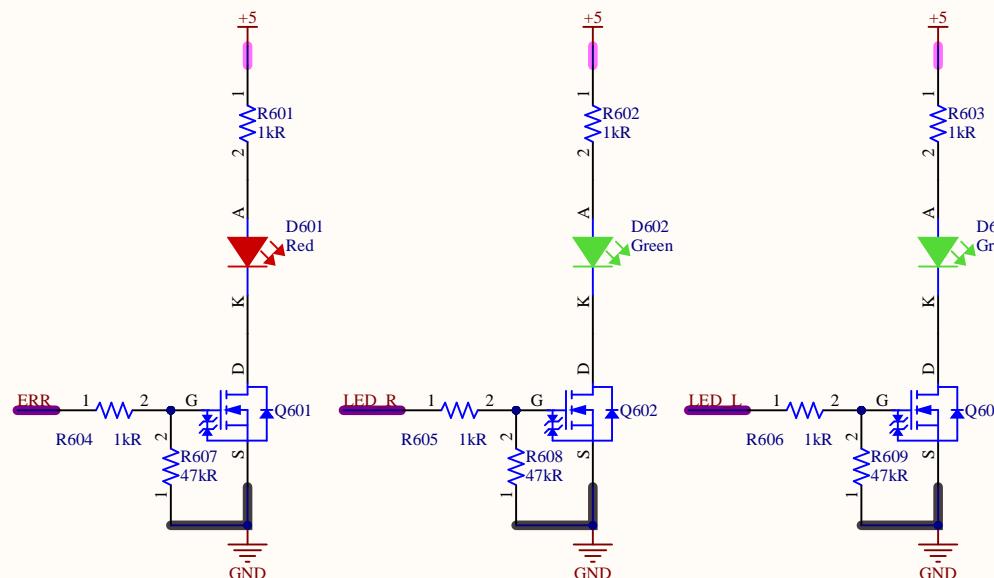
SC detection



INPUTS/OUTPUTS

ERR	ERR
LED_R	LED_R
LED_L	LED_L
DIR	DIR
SC_det	SC_det
SC_END	SC_END

Status LEDs



Company: e-Tech Racing e-techracing.es



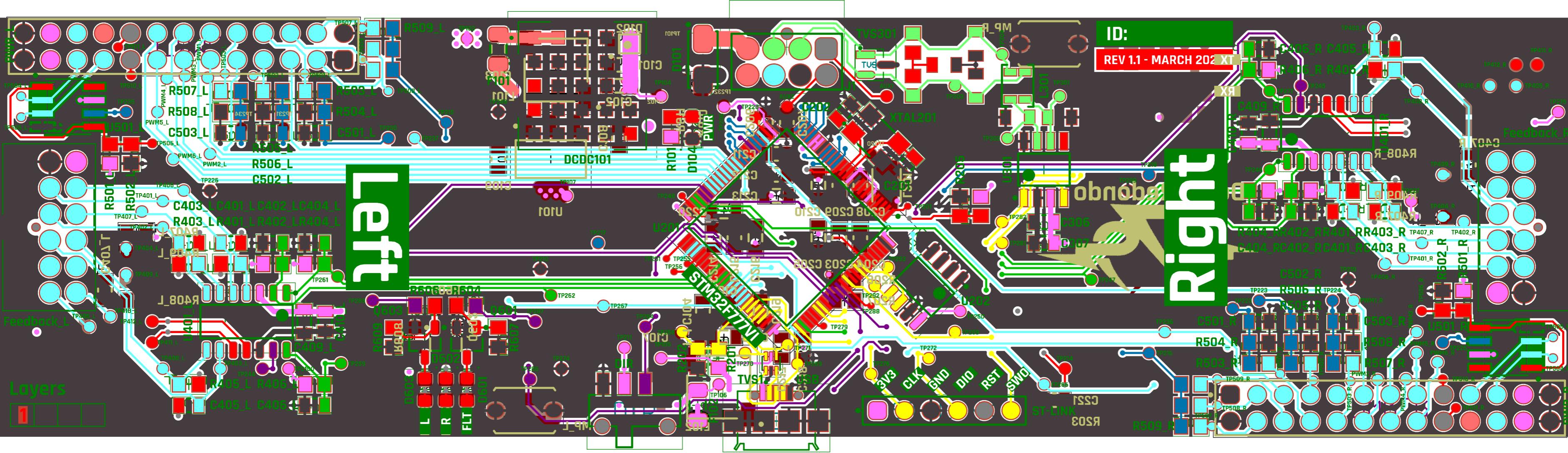
Project: Inverter Control Variant: [No Variations]

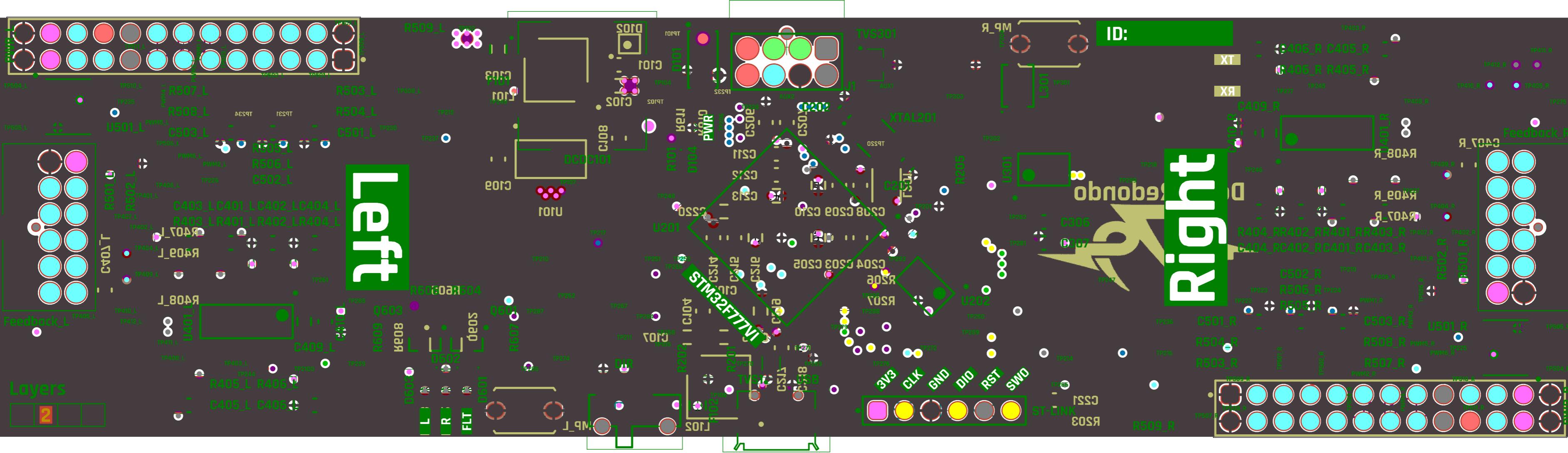
Size: - Page Contents: [6] Extras.SchDoc Version: 1.1

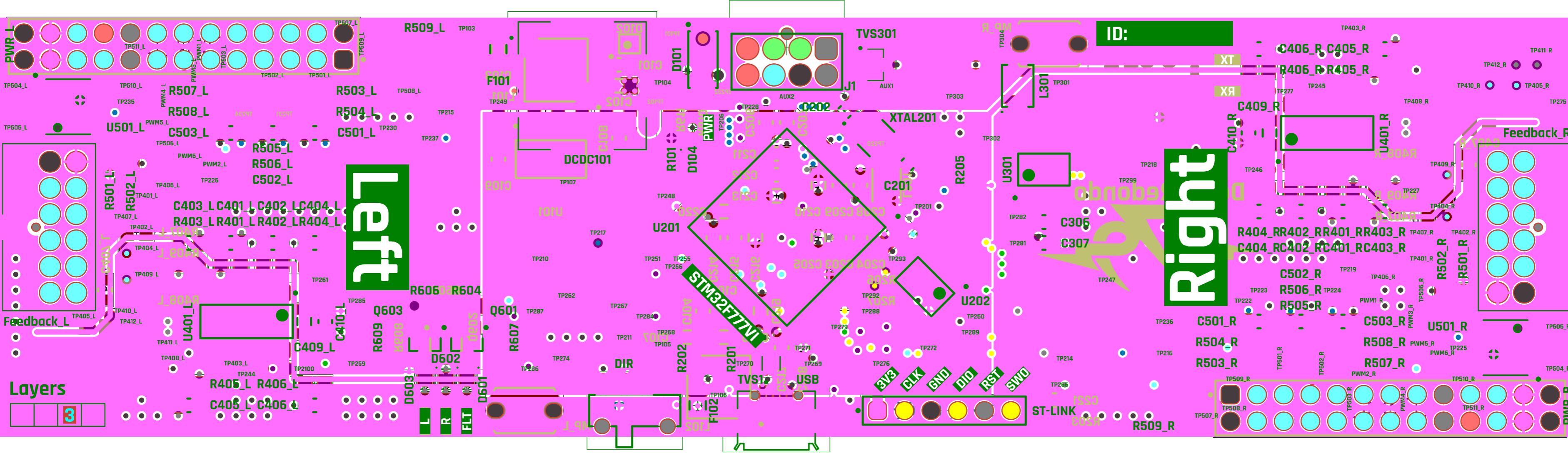
Department: Powertrain

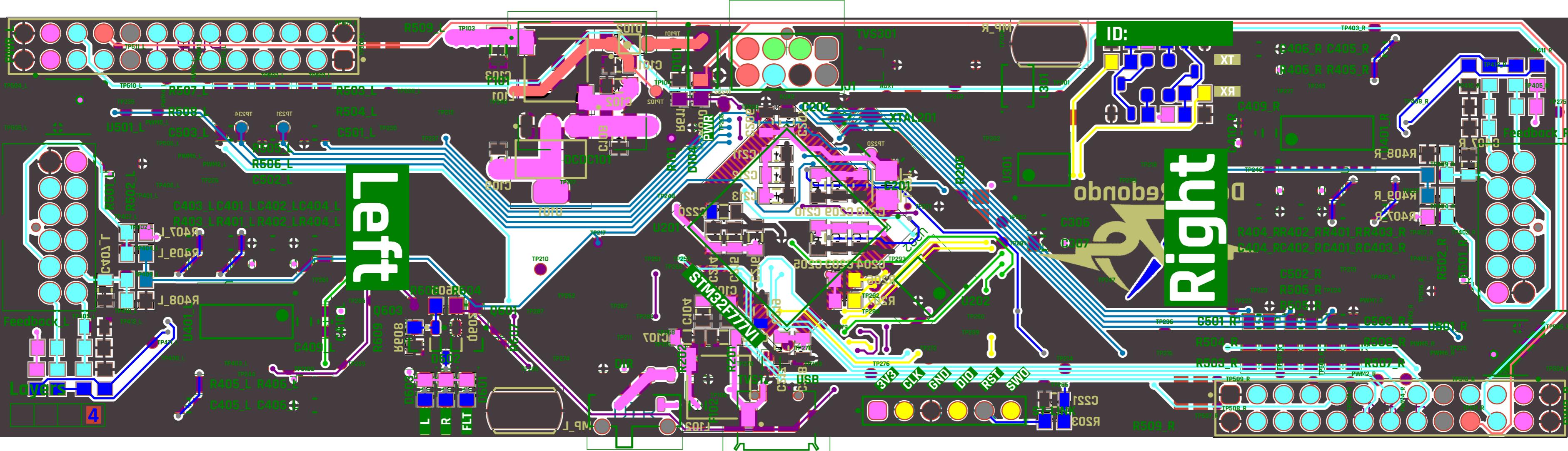
Author: David Redondo dredondovinolo@gmail.com Sheet: * of *

Checked by: _ Date: 21/03/2024









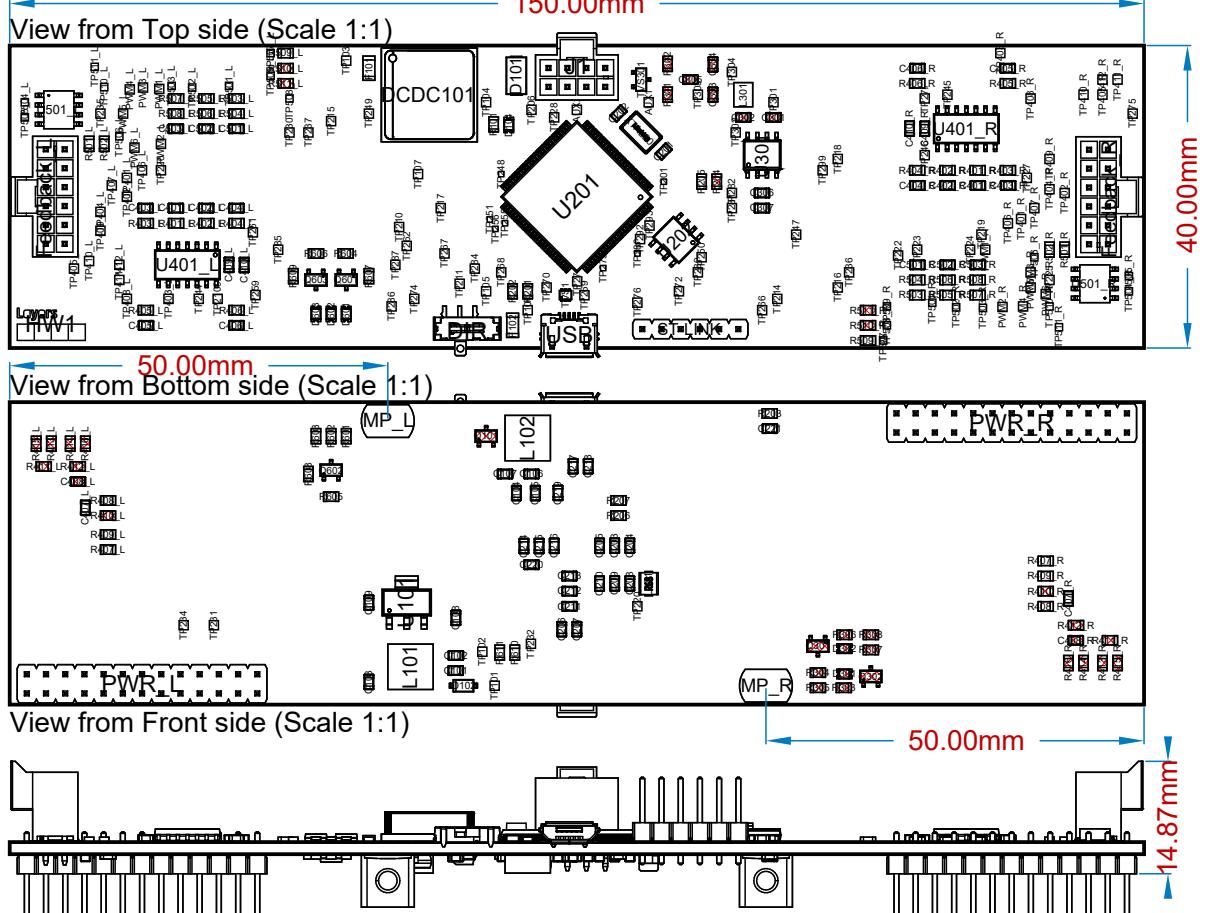
Inverter Control

Bill Of Materials

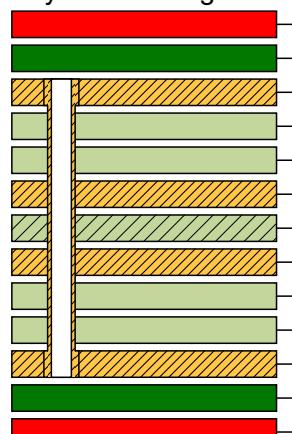
Designator	Name	Quantity
C101, C105, C204, C207, C209, C212, C215, C218, C221, C307	885012207103	10
C102, C103, C106, C107, C409_L, C409_R	10uF	6
C104, C203, C208, C211, C217, C306, C407_L, C407_R, C410_L, C410_R, C501_L, C501_R, C502_L, C502_R, C503_L, C503_R	885012207098	17
C108, C109	885012107014	2
C205, C210, C213, C216	885012007052	2
C206, C401_L, C401_R, C402_L, C402_R, C403_L, C403_R, C404_L, C404_R, C405_L, C405_R, C406_L, C406_R	885012107011	4
D101	885012107092	13
D102	2.2uF	2
D104	824501261	1
D601	MBR0530	1
D602, D603	150080YST5000	1
DIR	150080RS75000	1
F101, F102	150080GS75000	2
Feedback_L, Feedback_R	RPMB5.0-3.0	1
HW1	450405020524	1
J1	0437001.WRA	2
L101, L102	1053101112	2
L201	LOGO CAPAS (4)	1
L301	105310-1108	1
MP_L, MP_R	47uH	2
PWR_L, PWR_R	744764147	1
Q601, Q602, Q603	DLW32SH10XF2	1
R101, R401_L, R401_R, R403_L, R403_R, R405_L, R405_R, R502_L, R502_R	M3	2
R201, R202, R203, R205, R206, R207, R402_L, R402_R, R404_L, R404_R, R406_L, R406_R, R504_L, R504_R, R506_L, R506_R, R508_L, R508_R, R610	61302621121	2
R407_L, R407_R, R601, R602, R603, R604, R605, R606, R611	CPH3455-TL-H	3
R408_L, R408_R, R409_L, R409_R, R509_L, R509_R	CR0805-FX-1000ELF	9
R501_L, R501_R, R503_L, R503_R, R505_L, R505_R, R507_L, R507_R	CR0805-JW-103ELF	19
R607, R608, R609	CR0805-JW-102ELF	9
ST-LINK	CPF0805B15RE	6
TVS1	61300611121	1
TVS301	USBLC6-2P6	1
U101	Diode 4D	1
U201	LM1117IMP-3.3/NOPB	1
U202	STM32F777VIT6	1
U301	24AA024H-I/SN	1
U401_L, U401_R	MCP2551-I/SN	1
U501_L, U501_R	LM339D	2
USB	AD8479ARZ-RL	2
XTAL201	629105136821	1
	20MHz	1

Material	Layer	Thickness	Dielectric Material	Type	Gerber
Surface Material	Top Overlay				GTO
CF-004	TOP	0.035mm	Solder Resist	Signal	GTS
Prepreg		0.100mm	PP-006	Dielectric	GTL
Prepreg		0.100mm	PP-006	Dielectric	G1
Copper	GND	0.035mm		Signal	G2
Prepreg		1.040mm	FR-4	Dielectric	G1
Copper	PWR	0.035mm	PP-006	Signal	G2
Prepreg		0.100mm	PP-006	Dielectric	G2
Prepreg		0.100mm	PP-006	Dielectric	GBL
CF-004	BOT	0.035mm	Solder Resist	Signal	GBS
Surface Material	Bottom Solder	0.010mm		Solder Mask	GBO
	Bottom Overlay			Legend	GBO

Total thickness: 1.600mm



Layer Stack Legend



A

B

C

D

E