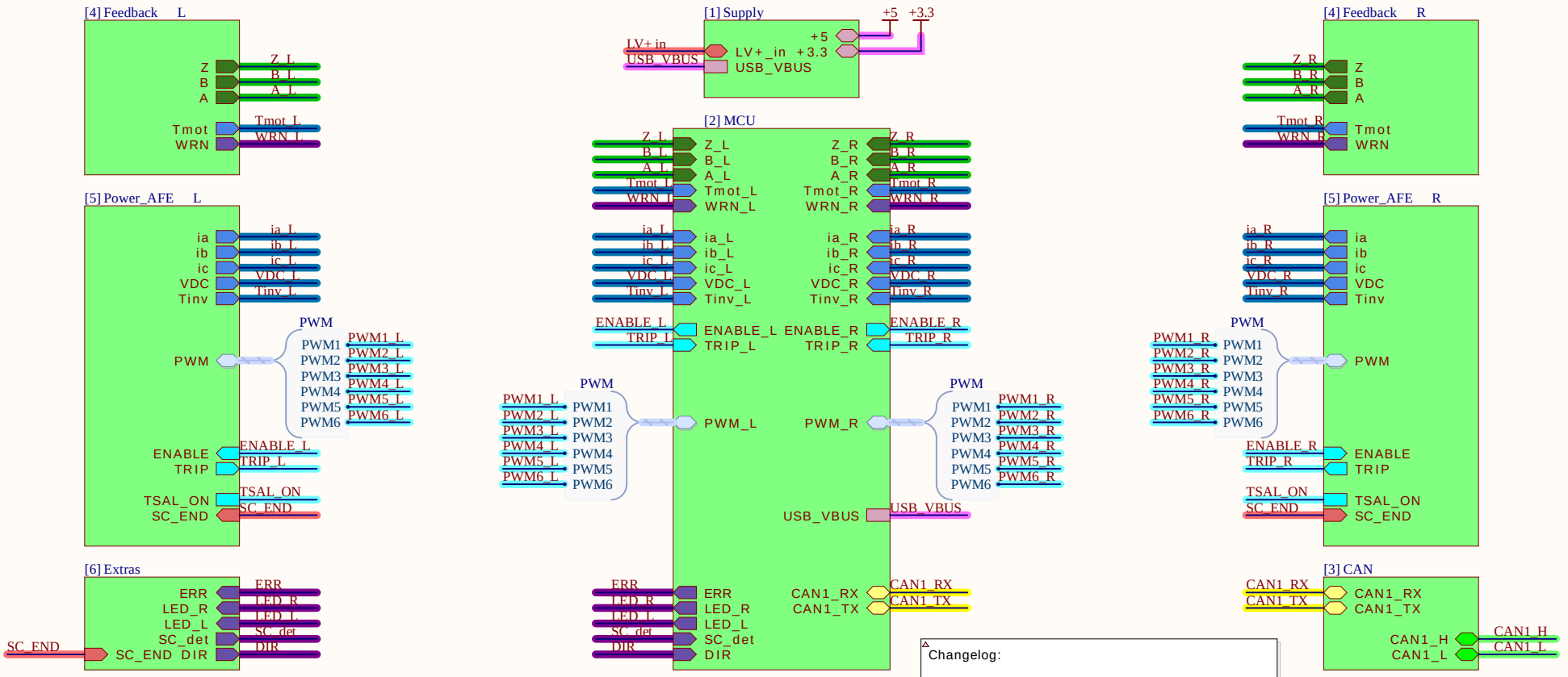
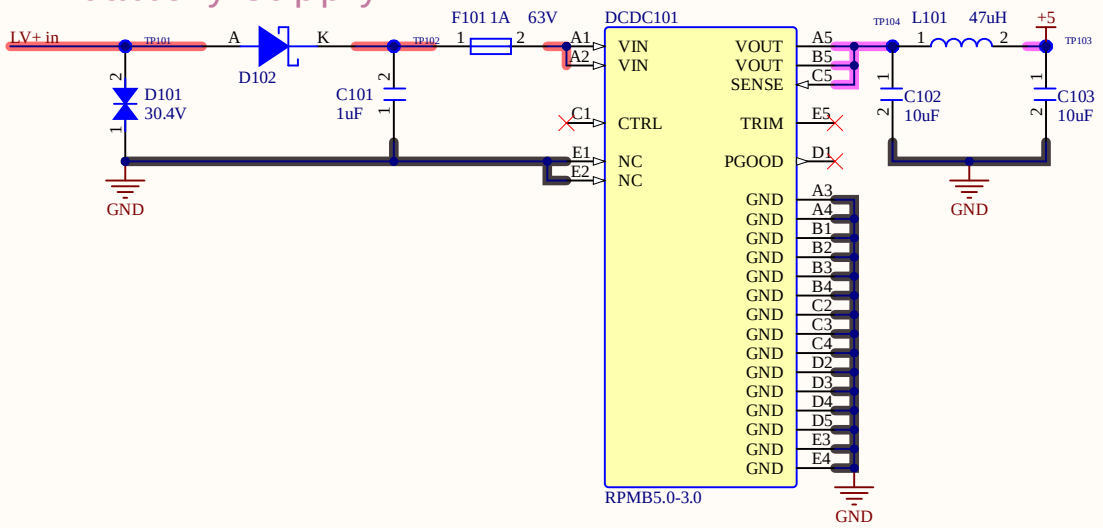
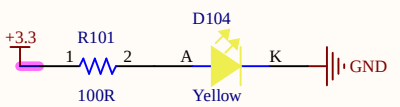


Company: e-Tech Racing	e-techracing.es		
Project: Inverter Control	Variant: [No Variations]		
Size: -	Page Contents: Inverter_Control.SchDoc	Version: 1.1	
		Department: Powertrain	
Author: David Redondo	dredondovinolo@gmail.com	Sheet 1 of 1	
Checked by: _		Date: 20/03/2024	

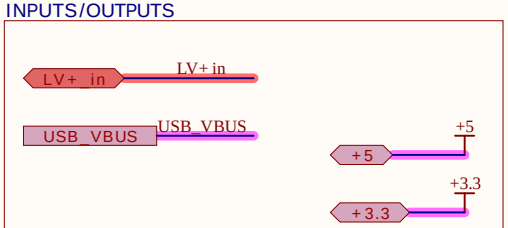
LV battery supply



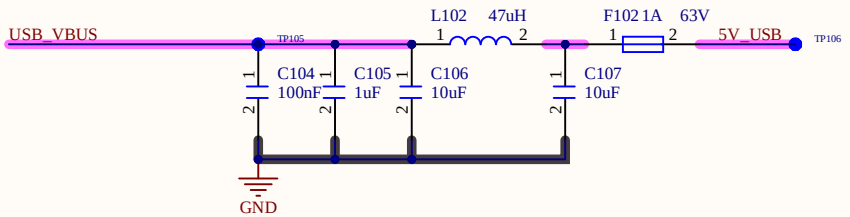
Supply OK



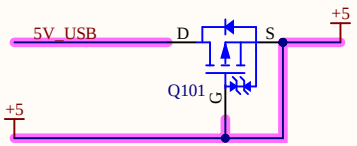
INPUTS/OUTPUTS



USB supply

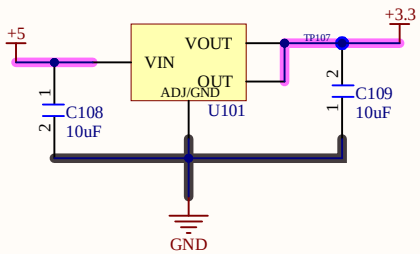


5 V selection



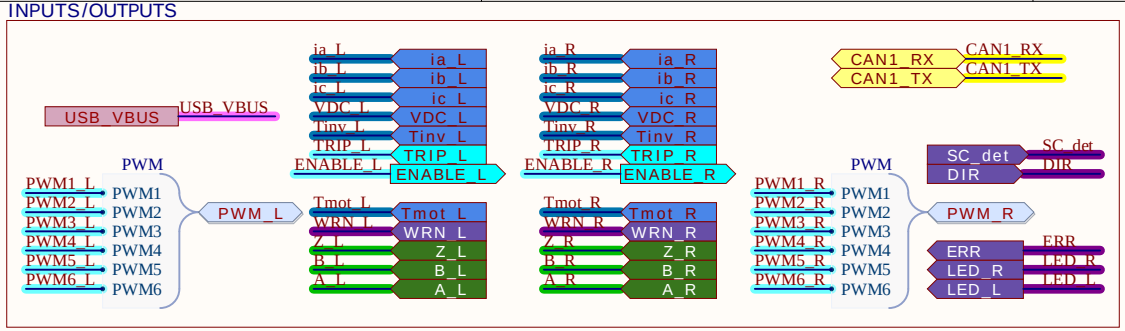
PMOS disconnects USB power when the DCDC is supplying. Gate drivers should be disabled when the DCDC is not supplying via software (read LV+_in).

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: 20/03/2024

INPUTS/OUTPUTS



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

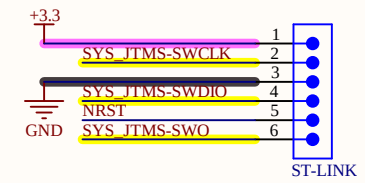
ADC

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

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

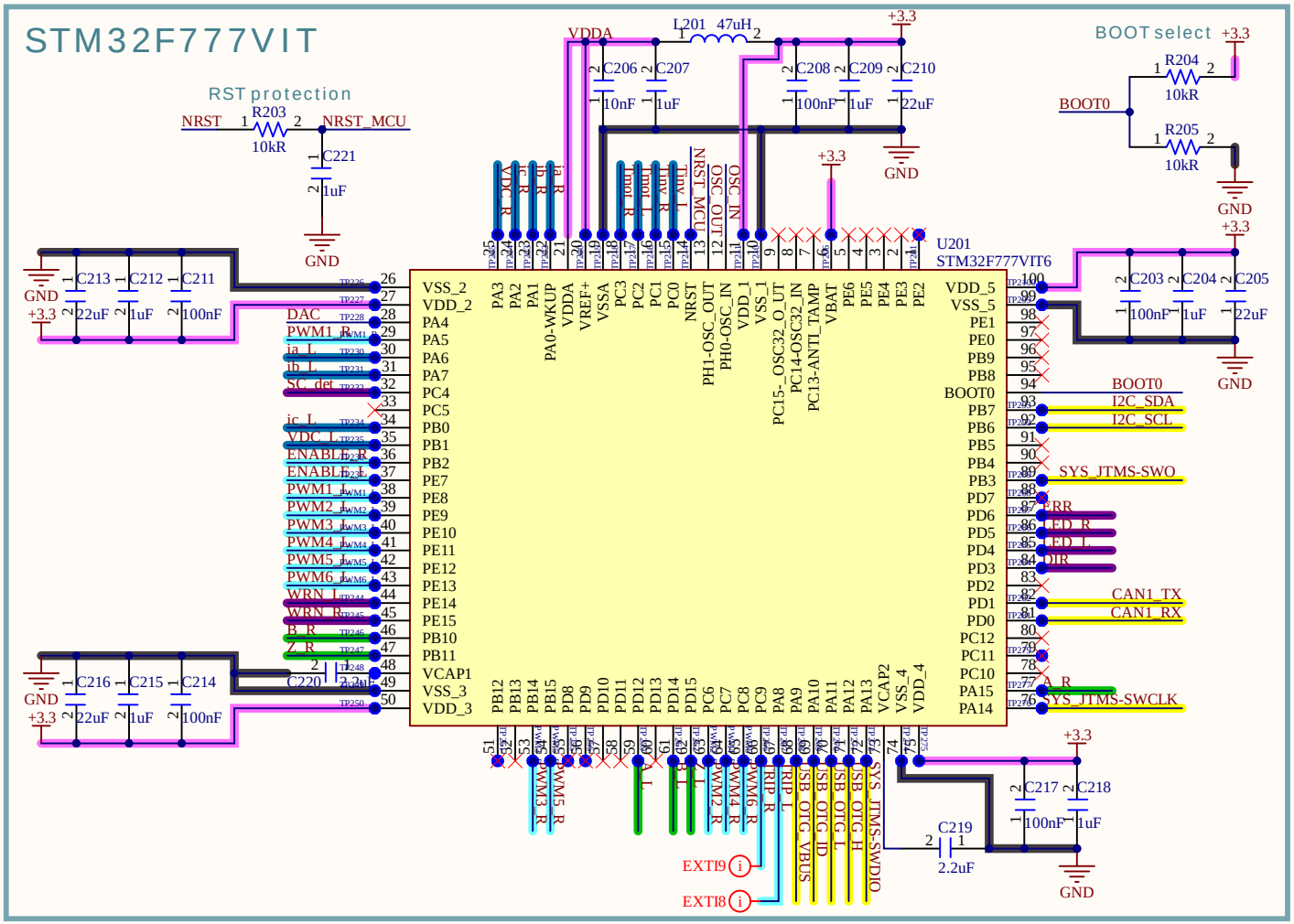
ADC3:
- Tinv_L (IN10)
- Tinv_R (IN11)
- Tmot_L (IN12)
- Tmot_R (IN13)

ST-link

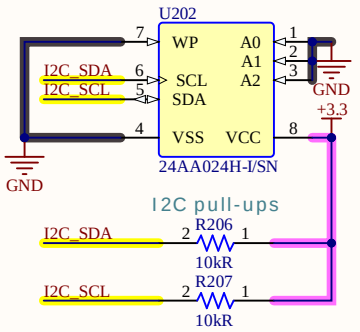


Serial Wire Debug

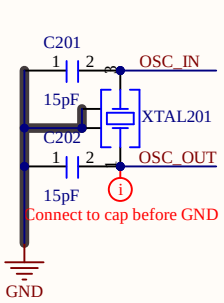
STM32F777VIT



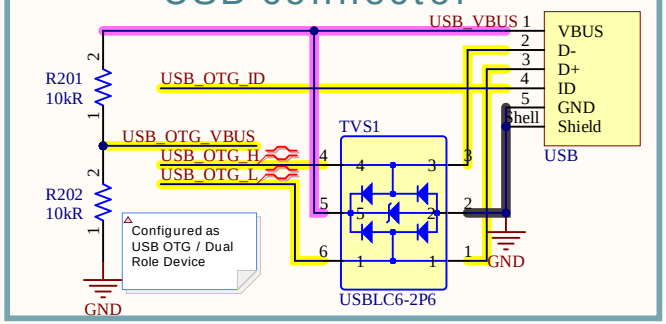
EEPROM (I2C1)



Oscillator

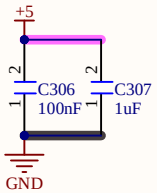


USB connector

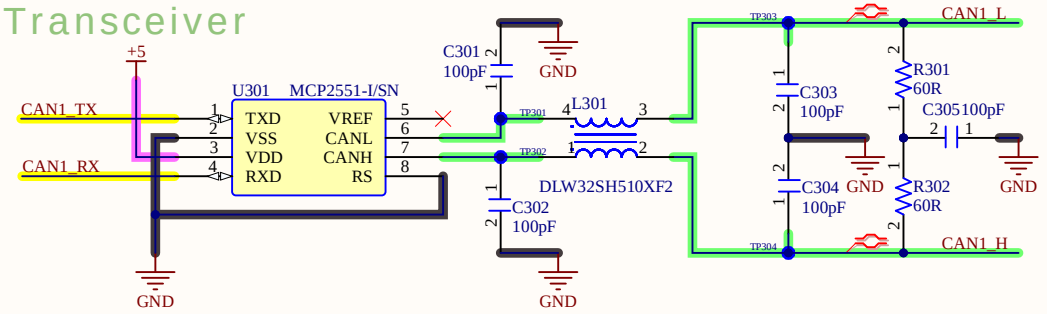


Company: e-Tech Racing	e-techracing.es		
Project: Inverter Control	Variant: [No Variations]		
Size: -	Page Contents: [2]MCU.SchDoc	Version: 1.1	
		Department: Powertrain	
Author: David Redondo	dredondovinolo@gmail.com	Sheet * of *	
Checked by: _		Date: 20/03/2024	

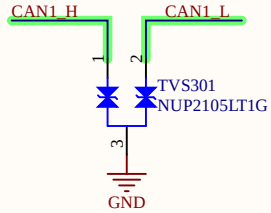
Decoupling



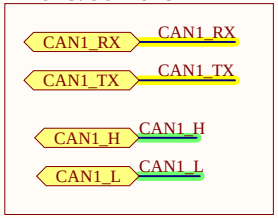
Transceiver



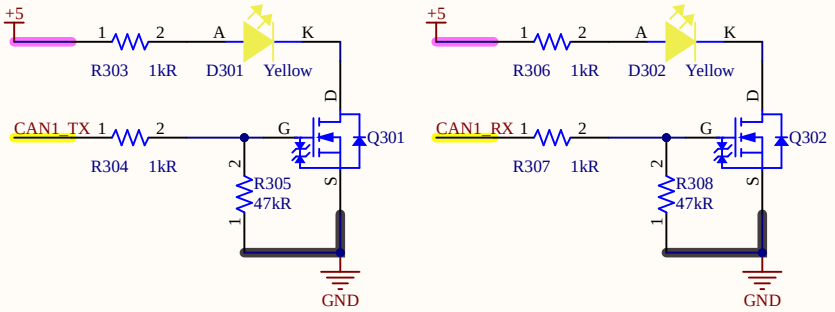
ESD



INPUTS/OUTPUTS

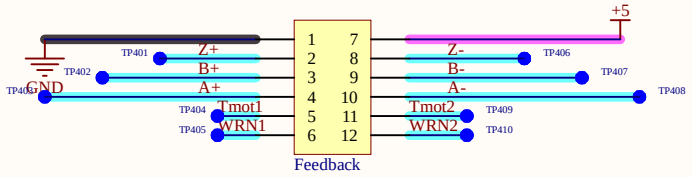


Status LEDs

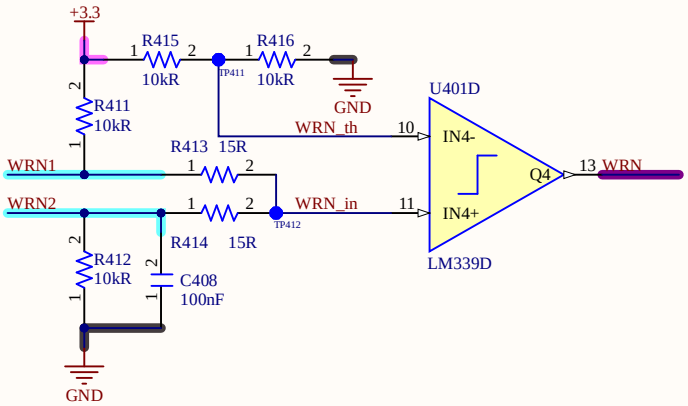


Company: e-Tech Racing	e-techracing.es		
Project: Inverter Control	Variant: [No Variations]		
Size: -	Page Contents: [3] CAN.SchDoc	Version: 1.1	
		Department: Powertrain	
Author: David Redondo	dredondovinolo@gmail.com	Sheet * of *	
Checked by: _		Date: 20/03/2024	

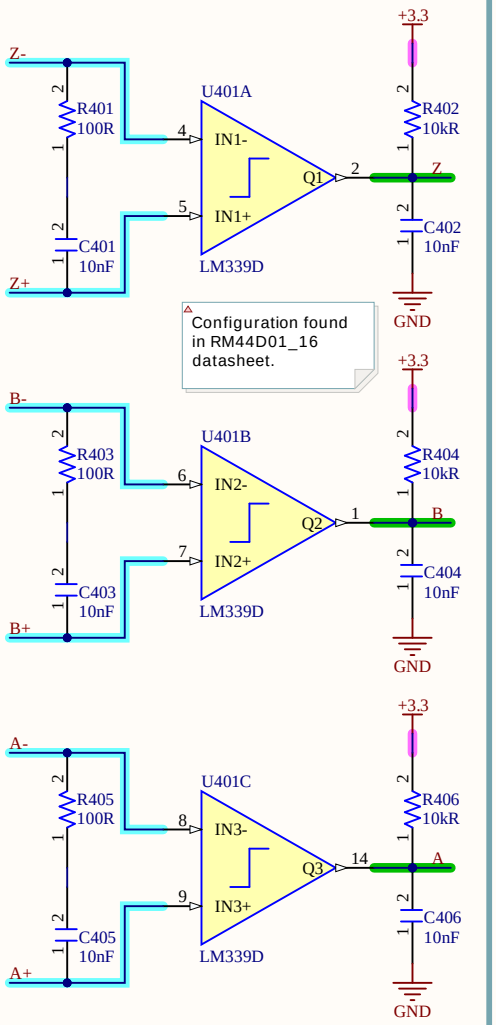
Feedback connector



Auxiliary warning (WRN)

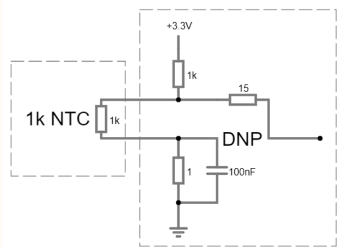


Incremental encoder



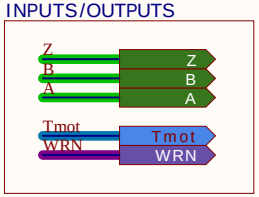
As the motors' temperature sensors are not specified, the user may modify the resistor combination to find a suitable input for the ADC, then load a custom lookup table to have an appropiate reading.

Example

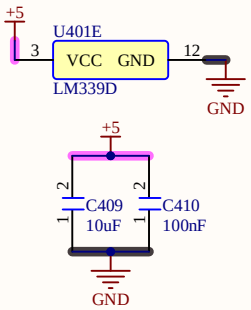


The WRN circuit can be used so that the MCU can detect a specified alarm. A resistive sensor can be used to detect any physical signal, such as overtemperature in any component (e.g. water outlet, gearbox, ...), underpressure of the cooling system, etc. Similar to the motor temperature sensors, the user may modify the resistor combination to have a suitable reading and adjust the voltage divider in order to set the treshold. Other types of sensors can be used, given a previous study and correct implementation.

INPUTS/OUTPUTS

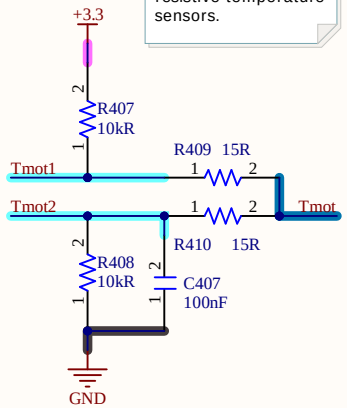


Comparator supply



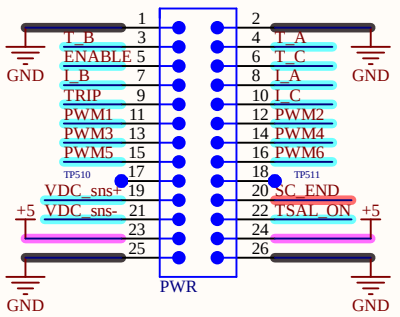
Motor thermistor

Only compatible with resistive temperature sensors.

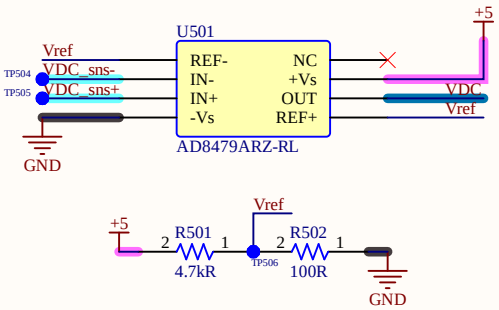


Company: e-Tech Racing e-techracing.es		
Project: Inverter Control	Variant: [No Variations]	
Size: -	Page Contents: [4] Feedback.SchDoc	Version: 1.1
		Department: Powertrain
Author: David Redondo dredondovinolo@gmail.com		Sheet * of *
Checked by: _		Date: 20/03/2024

Power PCB Connector



VDC sense AFE



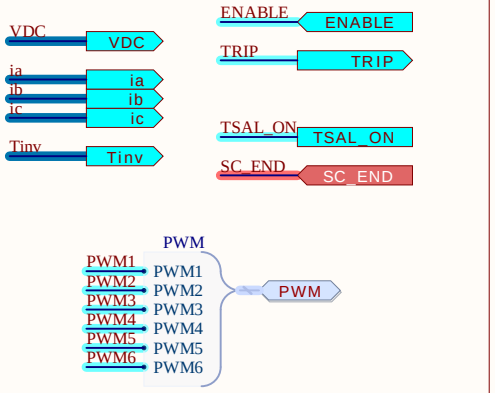
Difference amplifier

LT SPICE simulation for reference.

VDC = Vref + (VDC_sns+ - VDC_sns-) = Vref + 1/3 · 0.011388 · (TS+ - TS-)

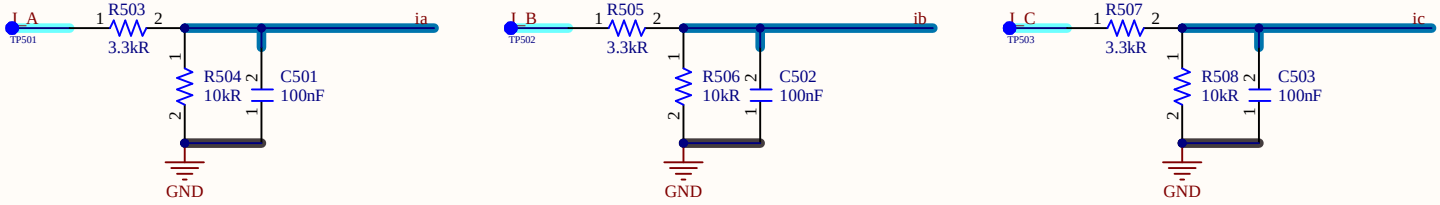
Maximum error due to using a voltage divider as a voltage reference is 1.79mV in ADC, which translates to 0.47V in (TS+ - TS-). Lowering the resistance values (while keeping proportionality) will reduce the error, but more current will be drawn.

INPUTS/OUTPUTS

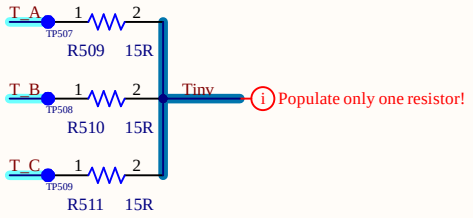


Current sense

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



Temperature selection

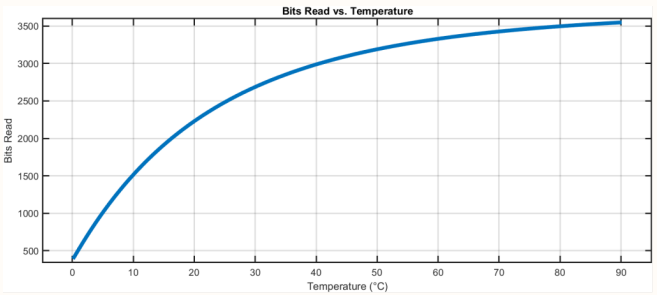


ENABLE is output directly from the MCU, it has been checked that UC21732 is able to detect it at 3.3V. Similarly, TRIP comes at 5V, and uses a 5V tolerant GPIO in the MCU.

VDC_offset = Vref · 2^12 bits / (3.3V) = 0.02083 · 2^12 bits / (3.3V) = 129 bits
VDC_gain = 1/((1/3 · 0.011388 V/V) · (2^12 bits / 3.3 V)) = 0.212240269 V / bit
VDC_max = 0.212240269 V / bit · 2^12 bits = 869.34V

ix_offset = (10k/(3.3k+10k)) · 2.5V · 2^12 bits / (3.3V) = 2333 bits
ix_gain = (10k/(3.3k+10k)) / (12.5 mV/A · (2^12 bits / 3.3 V))) = 0.0484609962 A / bit
ix_max(+/-) = +/- 0.0484609962 A / bit · 2^12 bits / 2 = +/- 99 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.



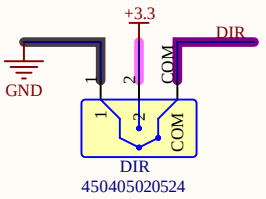
Tinv is a pulsated signal that can read directly as a PWM input or be passed through an RC filter (in Inverter_Power) to convert it into an analog signal. This board intends to read it with the ADC. The reading itself is in the TS part of the power board and connected to the AIN pin of UCC21732.

Based on the sensed voltage, the duty cycle (D) of the UCC21732 isolated output signal is calculated using the following relationship: D = -20 · V_AIN + 100

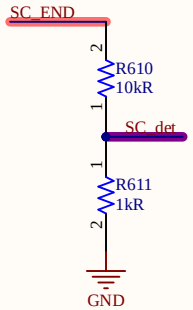
If filtered, the voltage at Tinv is calculated as: V_Tinv = VCC_GD · D/100 = 5V · (-20 · V_AIN + 100)/100

Company: e-Tech Racing	e-techracing.es		
Project: Inverter Control		Variant: [No Variations]	
Size: -	Page Contents: [5] Power_AFE.SchDoc		Version: 1.1
			Department: Powertrain
Author: David Redondo	dredondovinolo@gmail.com		Sheet * of *
Checked by: _			Date: 20/03/2024

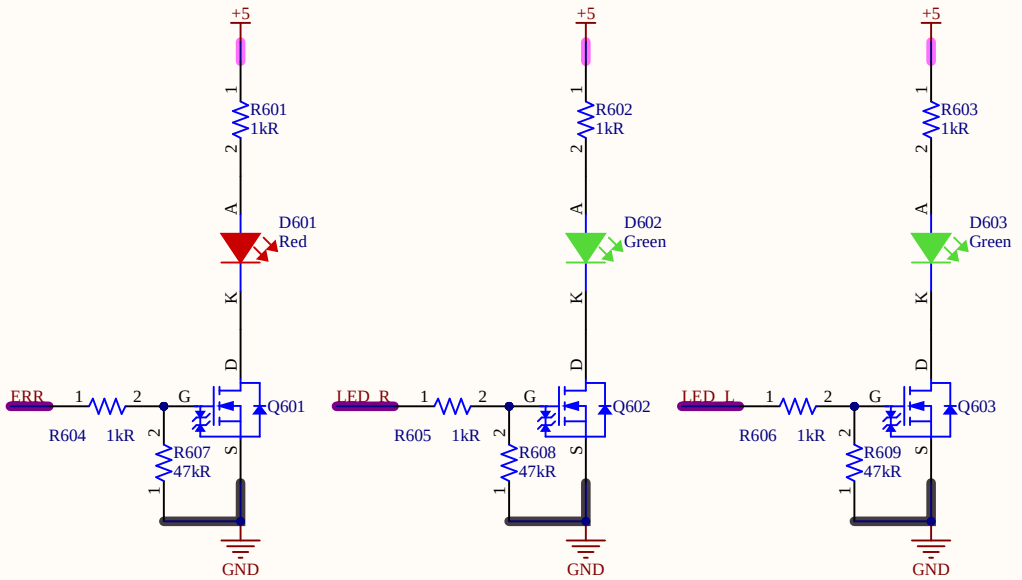
Reverse direction



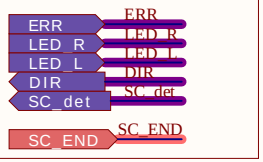
SC detection



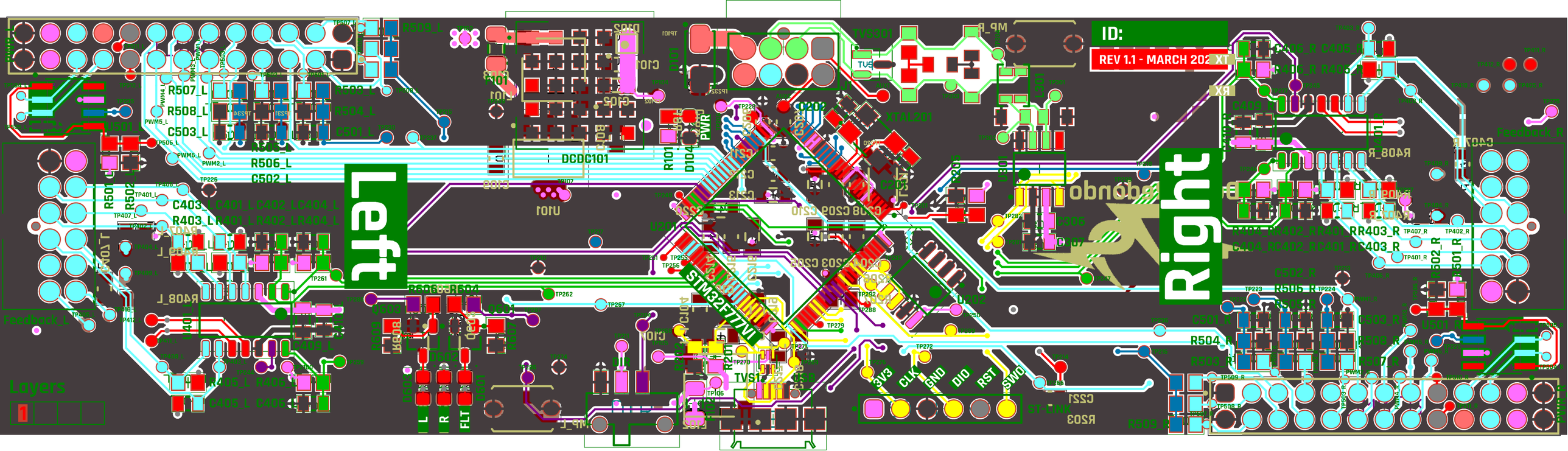
Status LEDs



INPUTS/OUTPUTS



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: 20/03/2024	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REV 1.1 - MARCH 202
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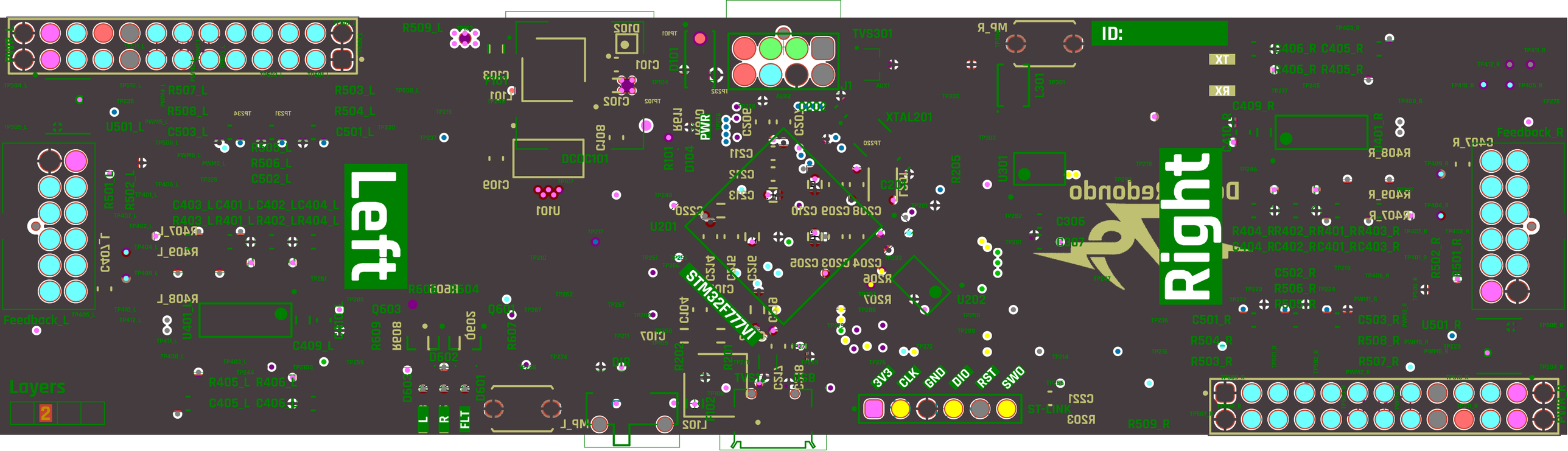
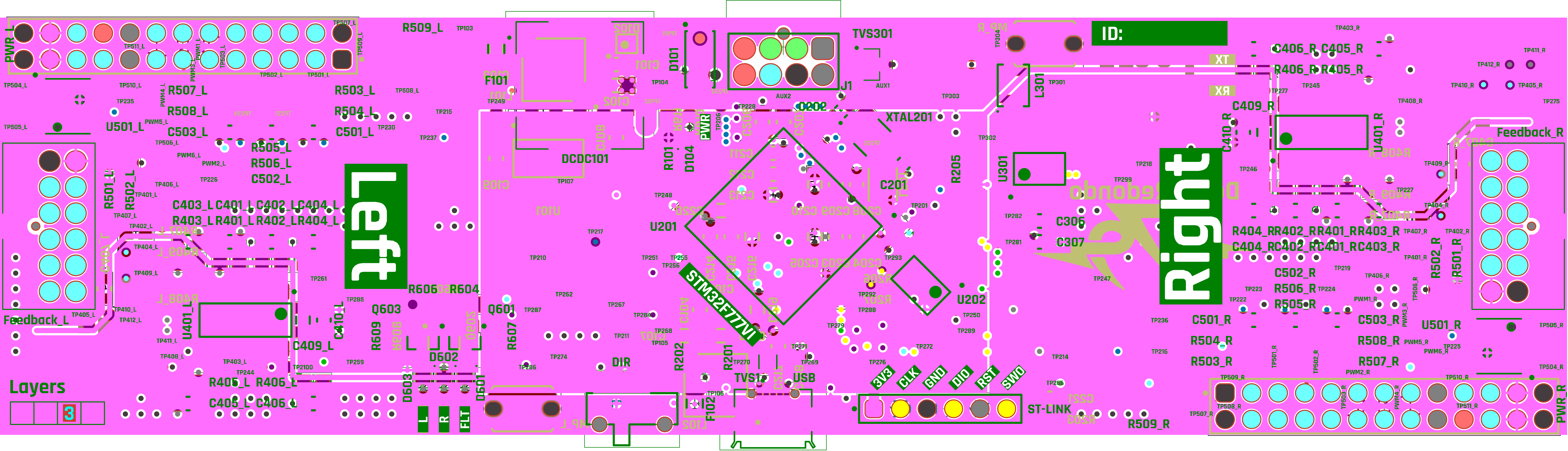
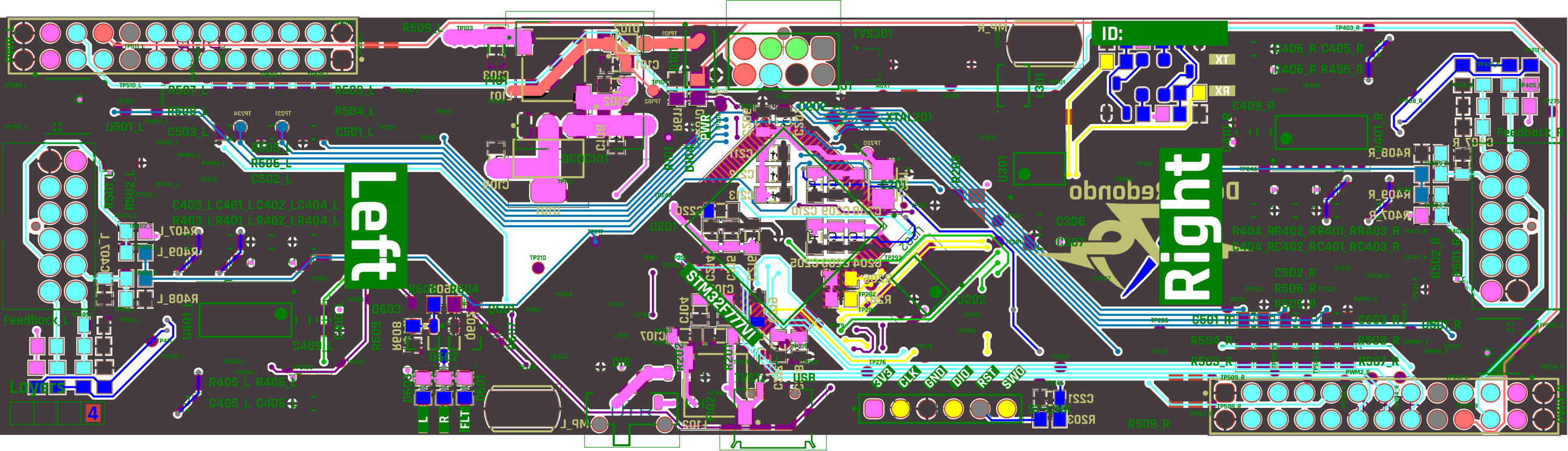
Right
STM32F777VI
DCDC101
XTAL201
TVS301
TVS101
3V3
CLK
GND
DIO
RST
SWO
Layers
1


Left
Right
STM32F777VI
ID:
XT
RX
3V3
CLK
GND
DIO
RST
SWD
L
R
FLT
Layers
2



PWR_L
R509_L
F101
D101
TVS301
ID:
XT
XR
C406_R C405_R
R406_R R405_R
L301
J1
R507_L
R503_L
R508_L
R504_L
U501_L
C503_L
C501_L
XTAL201
C409_R
Feedback_R
R505_L
R506_L
C502_L
DCDC101
PWR
R101
D104
R205
U301
C201
U401_R
R501_L
R502_L
C403_L C401_L C402_L C404_L
R403_L R401_L R402_L R404_L
Left
U201
C306
C307
Right
R404_R R402_R R401_R R403_R
C404_R C402_R C401_R C403_R
C502_R
R506_R
R505_R
R502_R
R501_R
R606
R604
Q603
Q601
U202
STM32F777VI
Feedback_L
U401_L
C410_L
R609
R607
C501_R
C503_R
U501_R
C409_L
D602
R504_R
R508_R
R503_R
R507_R
DIR
R202
R201
TVS1
USB
3V3
CLK
GND
DIO
RST
SWO
Layers
3
R405_L R406_L
C405_L C406_L
D603
D601
L
R
FLT
F102
ST-LINK
R509_R
PWR_R


Left
Right
STM32F777VI
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3V3
CLK
GND
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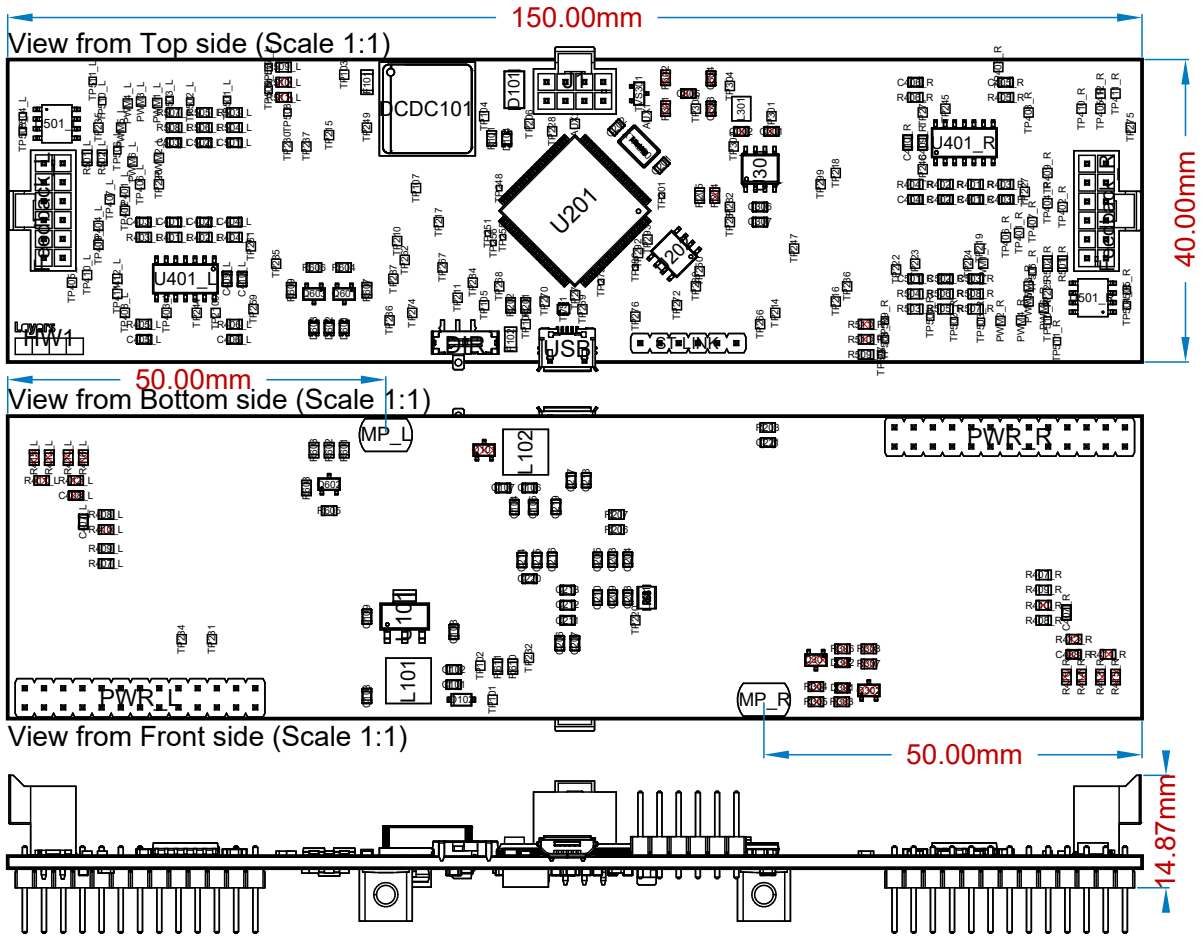
RST
SWO
USB
L
R
FLT
Layers
4

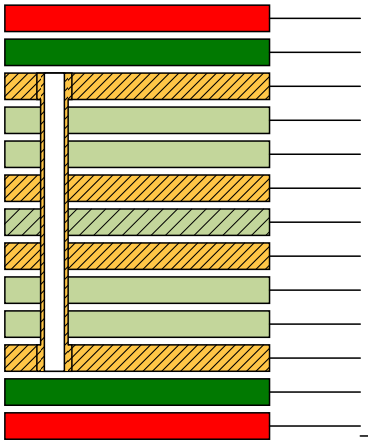
Inverter Control



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, C214, 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
C201, C202	885012007052	2
C205, C210, C213, C216	885012107011	4
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	885012207092	13
C219, C220	2.2uF	2
D101	824501261	1
D102	MBR0530	1
D104	150080YS75000	1
D601	150080RS75000	1
D602, D603	150080GS75000	2
DCDC101	RPMB5.0-3.0	1
DIR	450405020524	1
F101, F102	0437001.WRA	2
Feedback_L, Feedback_R	1053101112	2
HW1	LOGO CAPAS (4)	1
J1	105310-1108	1
L101, L102	47uH	2
L201	744764147	1
L301	DLW32SH510XF2	1
MP_L, MP_R	M3	2
PWR_L, PWR_R	61302621121	2
Q601, Q602, Q603	CPH3455-TL-H	3
R101, R401_L, R401_R, R403_L, R403_R, R405_L, R405_R, R502_L, R502_R	CR0805-FX-1000ELF	9
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	CR0805-JW-103ELF	19
R407_L, R407_R, R601, R602, R603, R604, R605, R606, R611	CR0805-JW-102ELF	9
R408_L, R408_R, R409_L, R409_R, R509_L, R509_R	CPF0805B15RE	6
R501_L, R501_R, R503_L, R503_R, R505_L, R505_R, R507_L, R507_R	CR0805-JW-472ELF	8
R607, R608, R609	47kR	3
ST-LINK	61300611121	1
TVS1	USBLC6-2P6	1
TVS301	Diode 4D	1
U101	LM1117IMP-3.3/NOPB	1
U201	STM32F777VIT6	1
U202	24AA024H-I/SN	1
U301	MCP2551-I/SN	1
U401_L, U401_R	LM339D	2
U501_L, U501_R	AD8479ARZ-RL	2
USB	629105136821	1
XTAL201	20MHz	1

Layer Stack Legend



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

Total thickness: 1.600mm