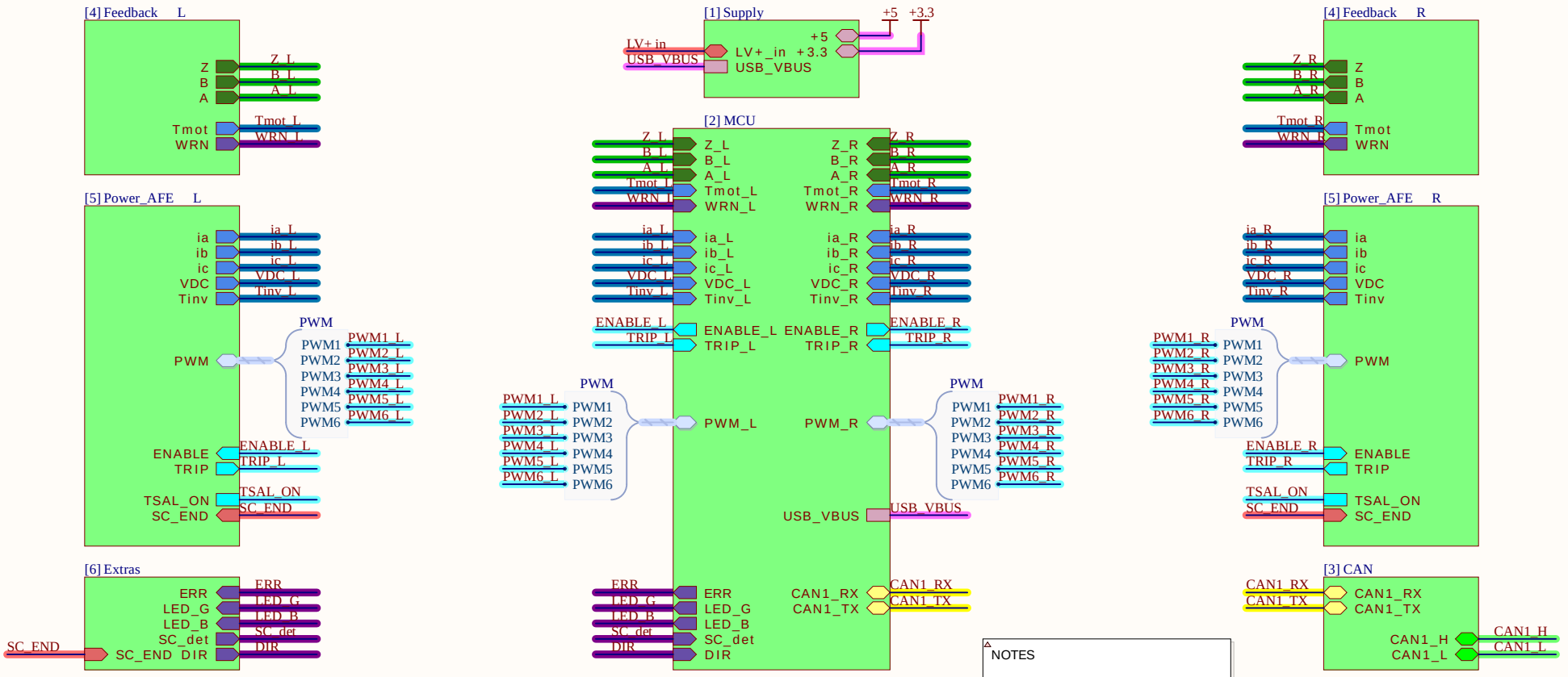
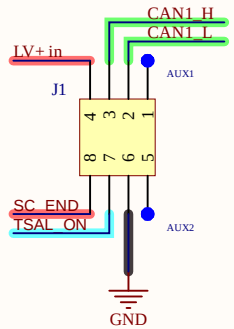


Car connector



- ⓘ Cyan nets indicate external signals.
- ⓘ Purple nets indicate internal 3.3V signals.
- ⓘ Blue nets indicate analog signals read by the ADC.
- ⓘ Red nets indicate 20-30V.
- ⓘ Pink nets indicate treated supply.
- ⓘ Light green nets indicate CAN.
- ⓘ Yellow nets indicate serial communication.
- ⓘ Dark green nets indicate input capture.

NOTES

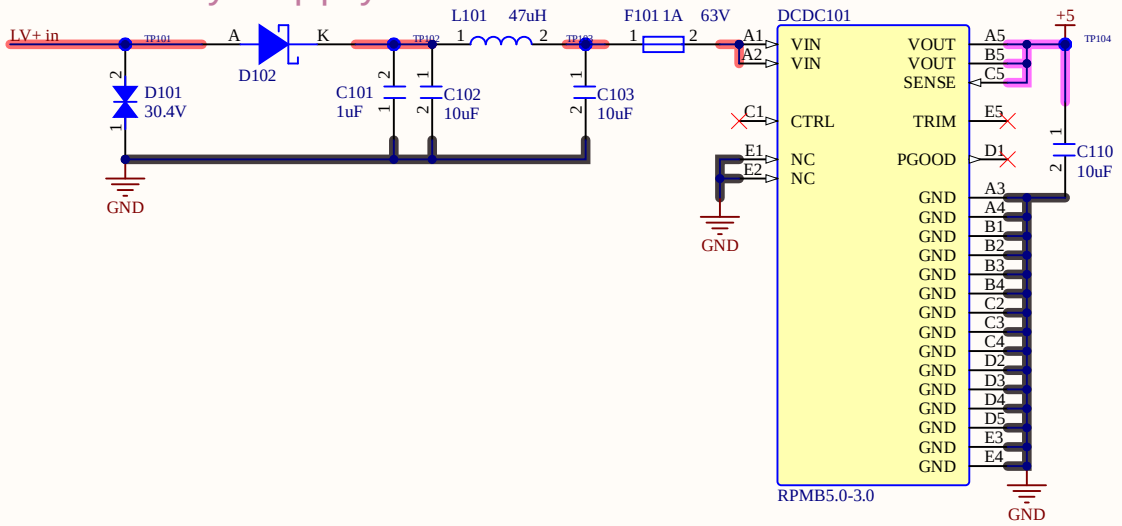
Sent to production on 21-02-2024.

Changes on SCH since production:
- R204 and R205 added for BOOT0 control.
- R206 and R207 added as I2C pull-ups.
- LV+_sns deleted, VBAT connected to +3.3

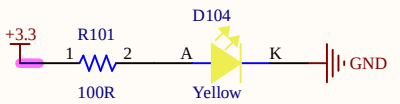
Changes on PCB since production:

Company: e-Tech Racing	e-techracing.es		
Project: Inverter Control	Variant: [No Variations]		
Size: -	Page Contents: Inverter_Control.SchDoc	Version: 1.0	
		Department: Powertrain	
Author: David Redondo	dredondovinolo@gmail.com	Sheet 1 of 1	
Checked by: _		Date: 01/03/2024	

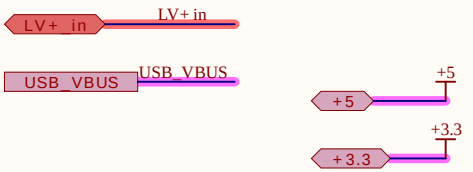
LV battery supply



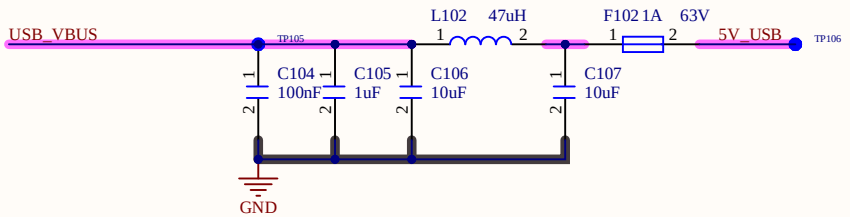
Supply OK



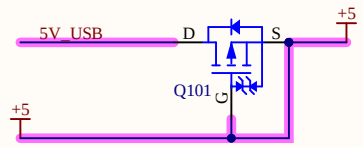
INPUTS/OUTPUTS



USB supply

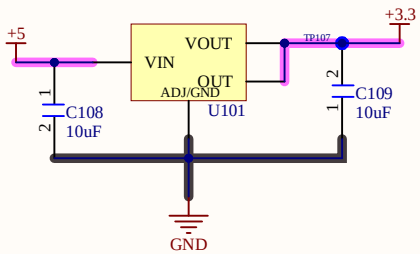


5 V selection



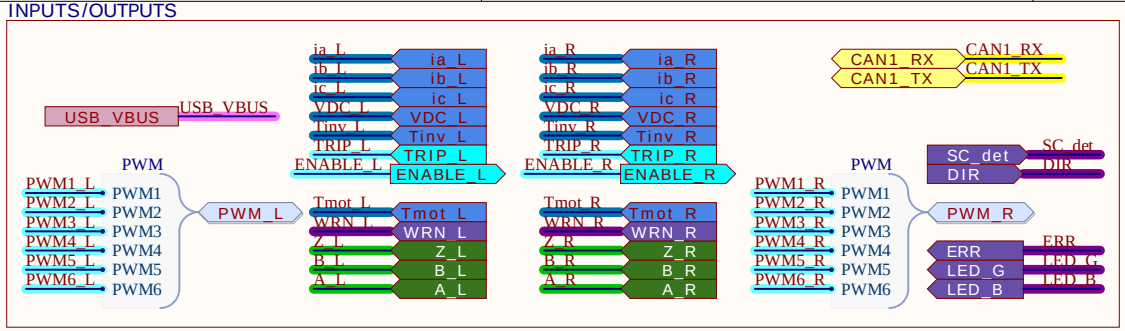
PMOS disconnects USB power when the DCDC is supplying. Gate drivers should be disabled when the DCDC is not supplying via software (read LV+_in).

LDO



Company: e-Tech Racing	e-techracing.es		
Project: Inverter Control	Variant: [No Variations]		
Size: -	Page Contents: [1] Supply.SchDoc	Version: 1.0	
		Department: Powertrain	
Author: David Redondo	dredondovinolo@gmail.com	Sheet * of *	
Checked by: _		Date: 01/03/2024	

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

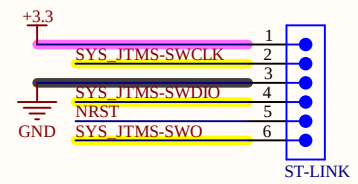
ADC

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)

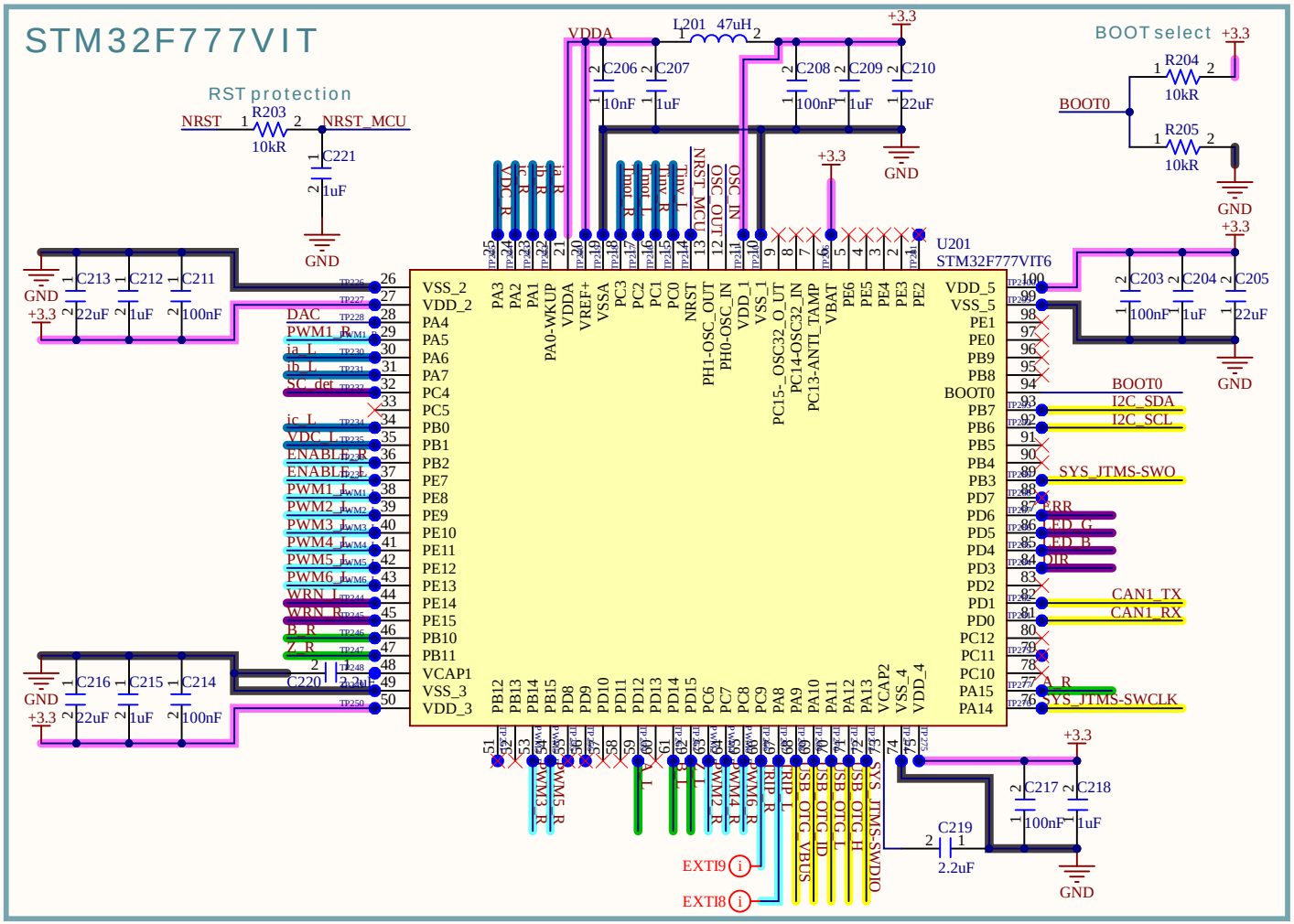
ADC3:
- Tinv_L (IN10)
- Tinv_R (IN11)
- Tmot_L (IN12)
- Tmot_R (IN13)

ST-link

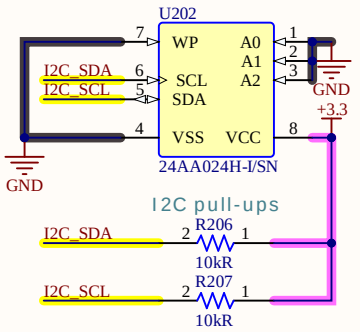


Serial Wire Debug

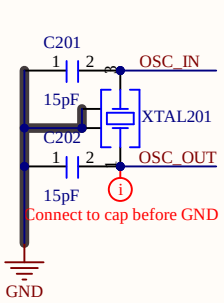
STM32F777VIT



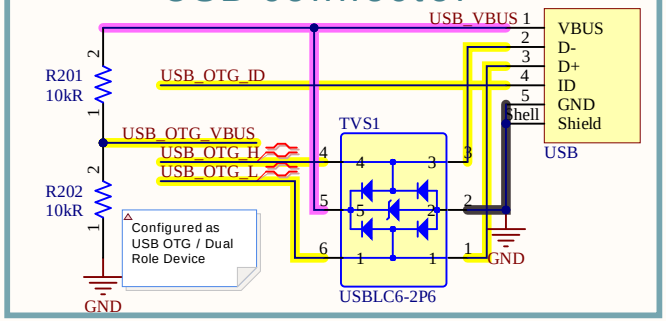
EEPROM (I2C1)



Oscillator

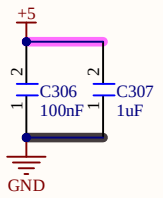


USB connector

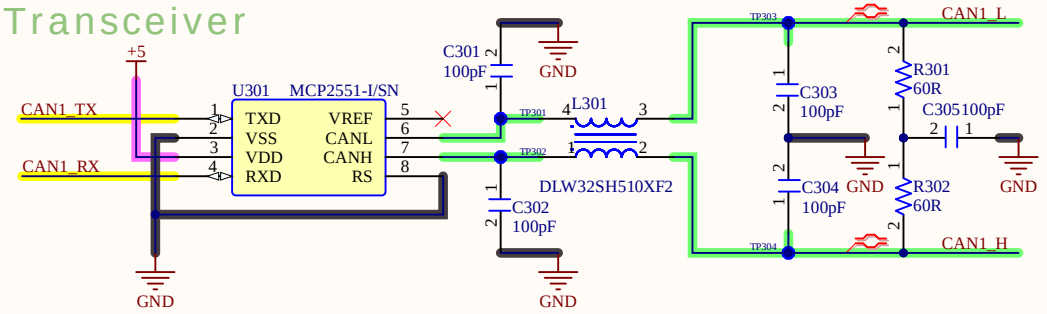


Company: e-Tech Racing	e-techracing.es		
Project: Inverter Control	Variant: [No Variations]		
Size: -	Page Contents: [2]MCU.SchDoc	Version: 1.0	
		Department: Powertrain	
Author: David Redondo	dredondovinolo@gmail.com	Sheet * of *	
Checked by: _		Date: 01/03/2024	

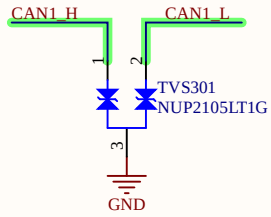
Decoupling



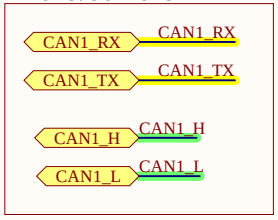
Transceiver



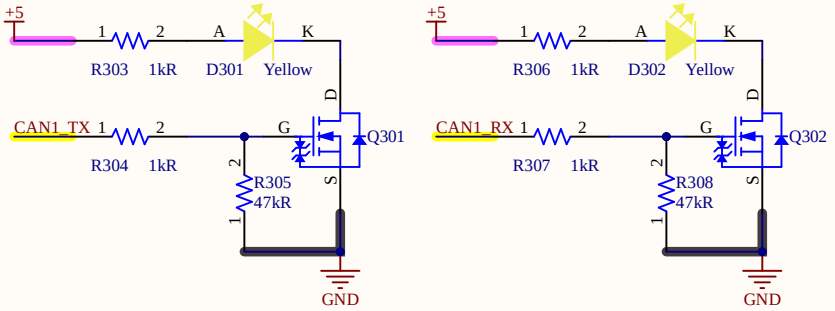
ESD



INPUTS/OUTPUTS

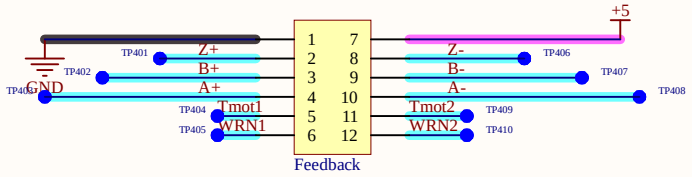


Status LEDs

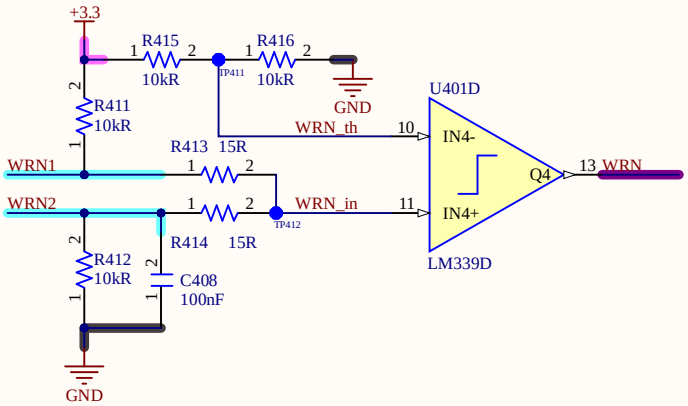


Company: e-Tech Racing	e-techracing.es		
Project: Inverter Control	Variant: [No Variations]		
Size: -	Page Contents: [3] CAN.SchDoc	Version: 1.0	
		Department: Powertrain	
Author: David Redondo	dredondovinolo@gmail.com	Sheet * of *	
Checked by: _		Date: 01/03/2024	

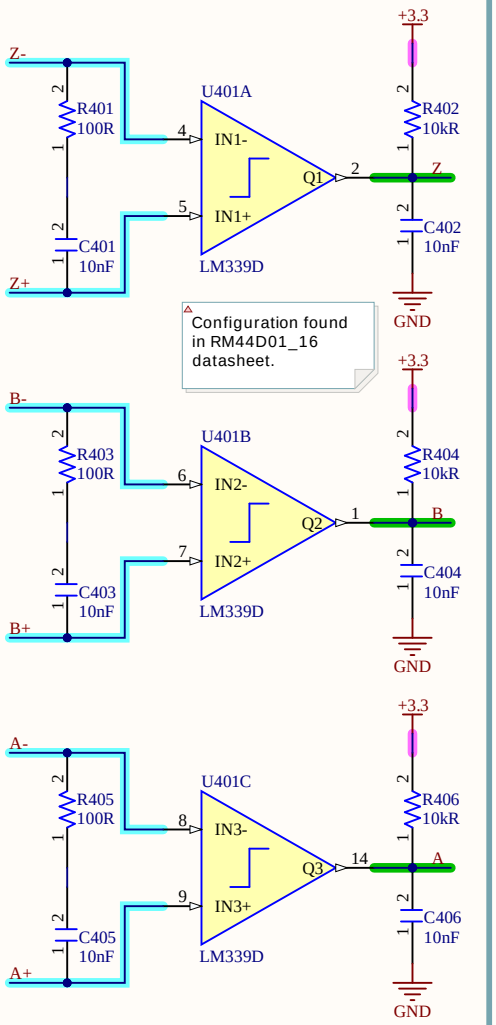
Feedback connector



Auxiliary warning (WRN)

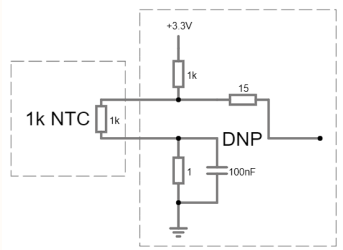


Incremental encoder



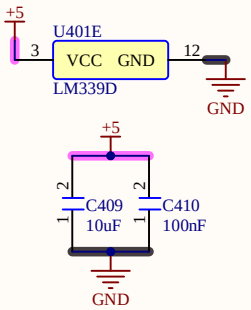
As the motors' temperature sensors are not specified, the user may modify the resistor combination to find a suitable input for the ADC, then load a custom lookup table to have an appropiate reading.

Example



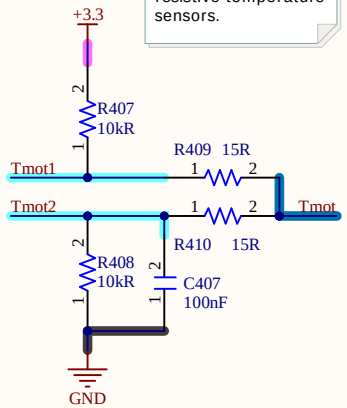
The WRN circuit can be used so that the MCU can detect a specified alarm. A resistive sensor can be used to detect any physical signal, such as overtemperature in any component (e.g. water outlet, gearbox, ...), underpressure of the cooling system, etc. Similar to the motor temperature sensors, the user 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.

Comparator supply

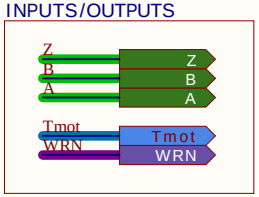


Motor thermistor

Only compatible with resistive temperature sensors.

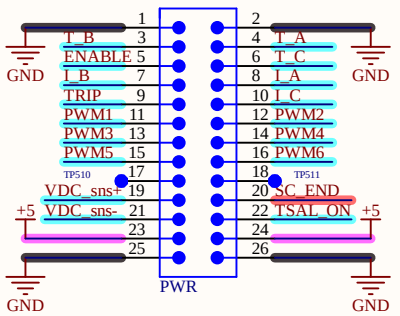


INPUTS/OUTPUTS

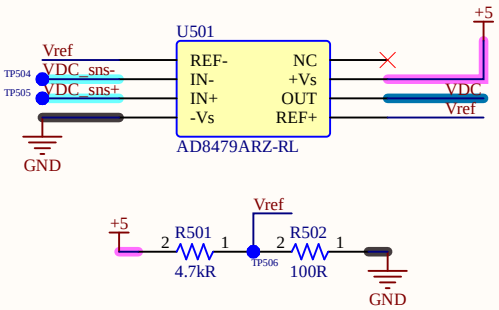


Company: e-Tech Racing	e-techracing.es		
Project: Inverter Control	Variant: [No Variations]		
Size: -	Page Contents: [4] Feedback.SchDoc	Version: 1.0	
		Department: Powertrain	
Author: David Redondo	dredondovinolo@gmail.com	Sheet * of *	
Checked by: _		Date: 01/03/2024	

Power PCB Connector



VDC sense AFE



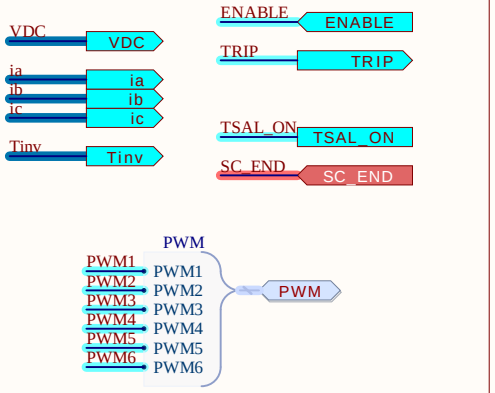
Difference amplifier

LT SPICE simulation for reference.

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

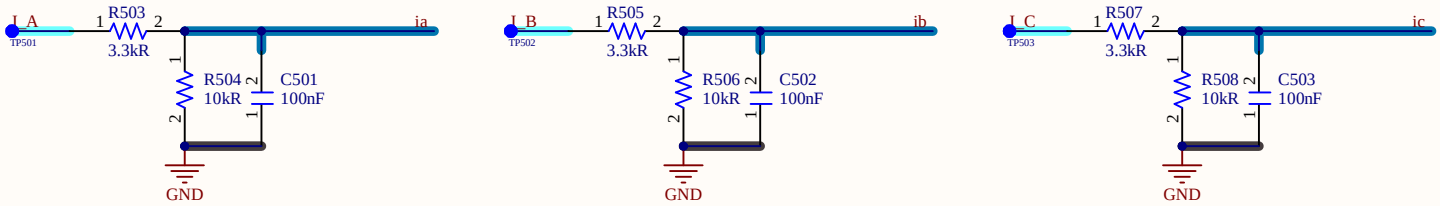
Maximum error due to using a voltage divider as a voltage reference is 1.79mV in ADC, which translates to 0.47V in (TS+ - TS-). Lowering the resistance values (while keeping proportionality) will reduce the error, but more current will be drawn.

INPUTS/OUTPUTS

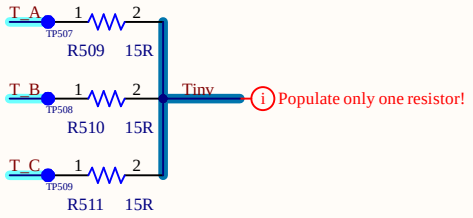


Current sense

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



Temperature selection

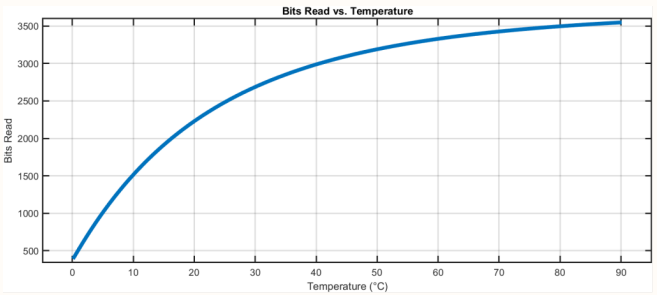


ENABLE is output directly from the MCU, it has been checked that UC21732 is able to detect it at 3.3V. Similarly, TRIP comes at 5V, and uses a 5V tolerant GPIO in the MCU.

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.



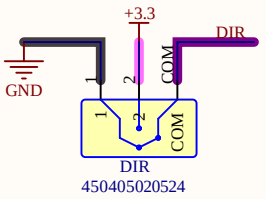
Tinv is a pulsated signal that can read directly as a PWM input or be passed through an RC filter (in Inverter_Power) to convert it into an analog signal. This board intends to read it with the ADC. The reading itself is in the TS part of the power board and connected to the AIN pin of UCC21732.

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

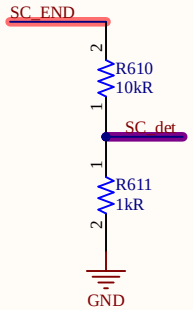
If filtered, the voltage at Tinv is calculated as: V_Tinv = VCC_GD · D/100 = 5V · (-20 · V_AIN + 100)/100

Company: e-Tech Racing	e-techracing.es		
Project: Inverter Control		Variant: [No Variations]	
Size: -	Page Contents: [5] Power_AFE.SchDoc		Version: 1.0
			Department: Powertrain
Author: David Redondo	dredondovinolo@gmail.com		Sheet * of *
Checked by: _			Date: 01/03/2024

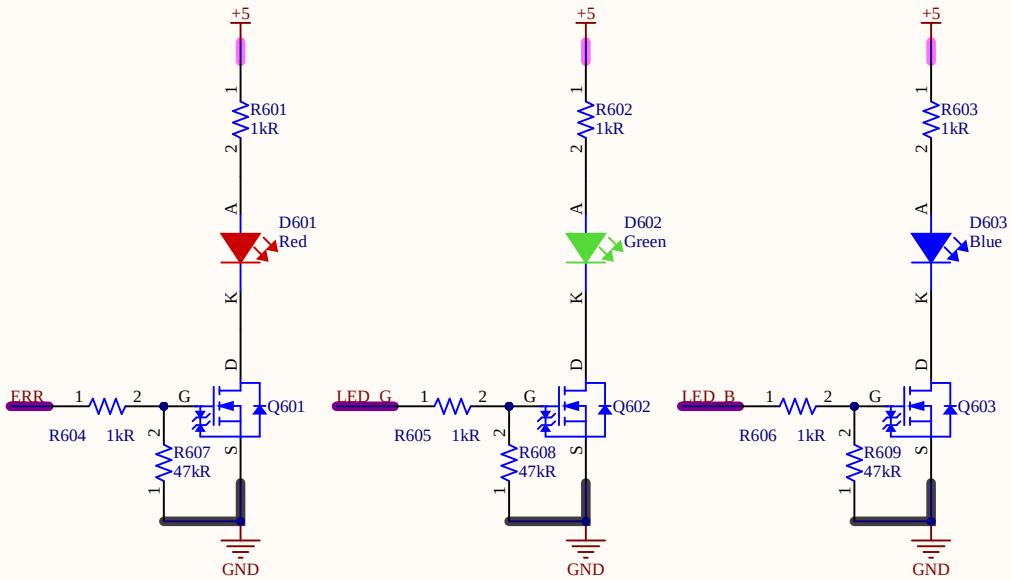
Reverse direction



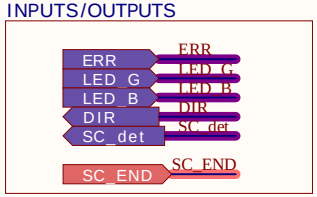
SC detection



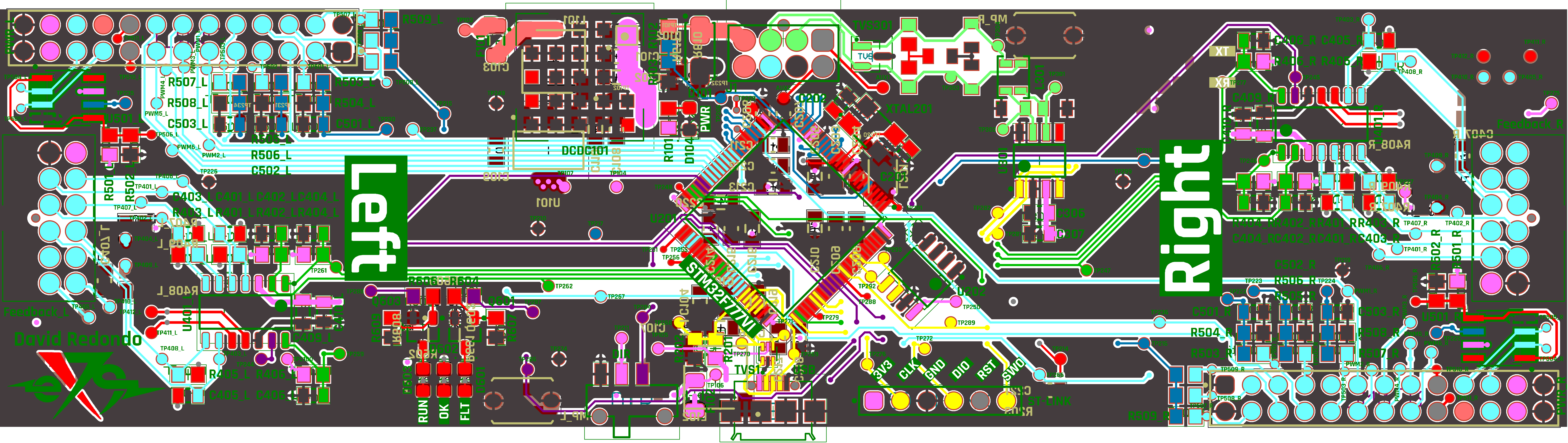
Status LEDs

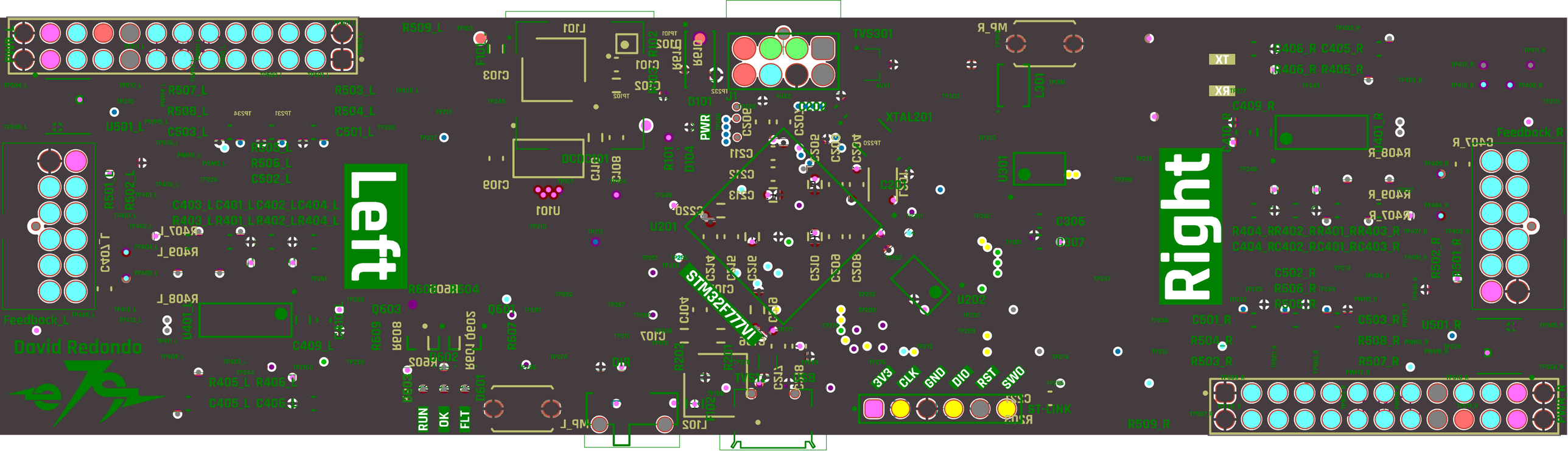


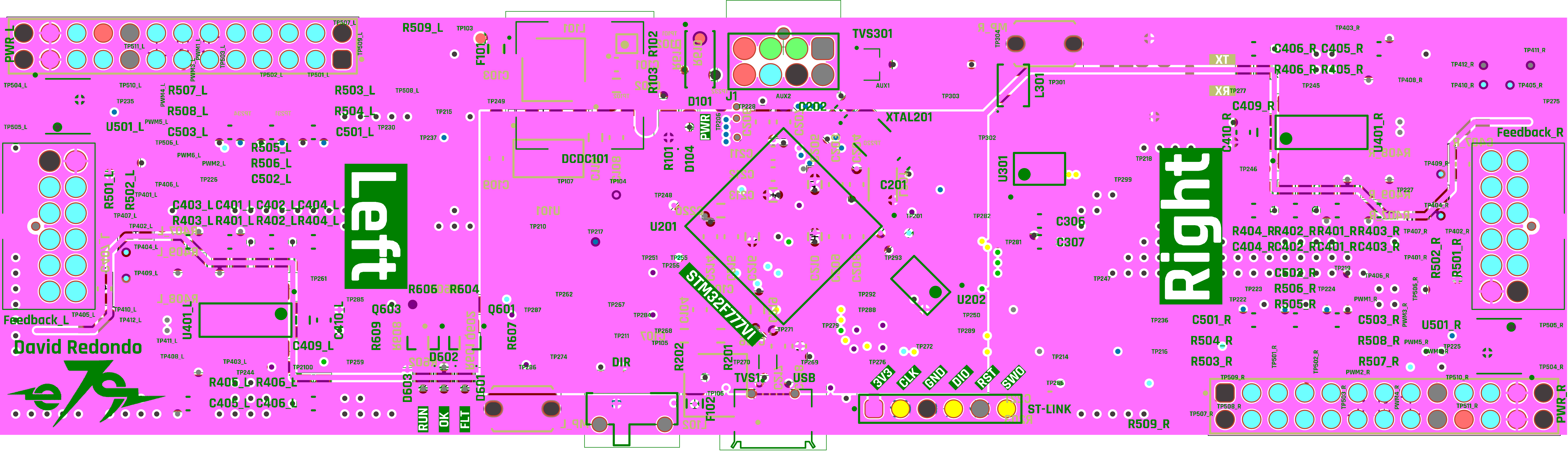
INPUTS/OUTPUTS



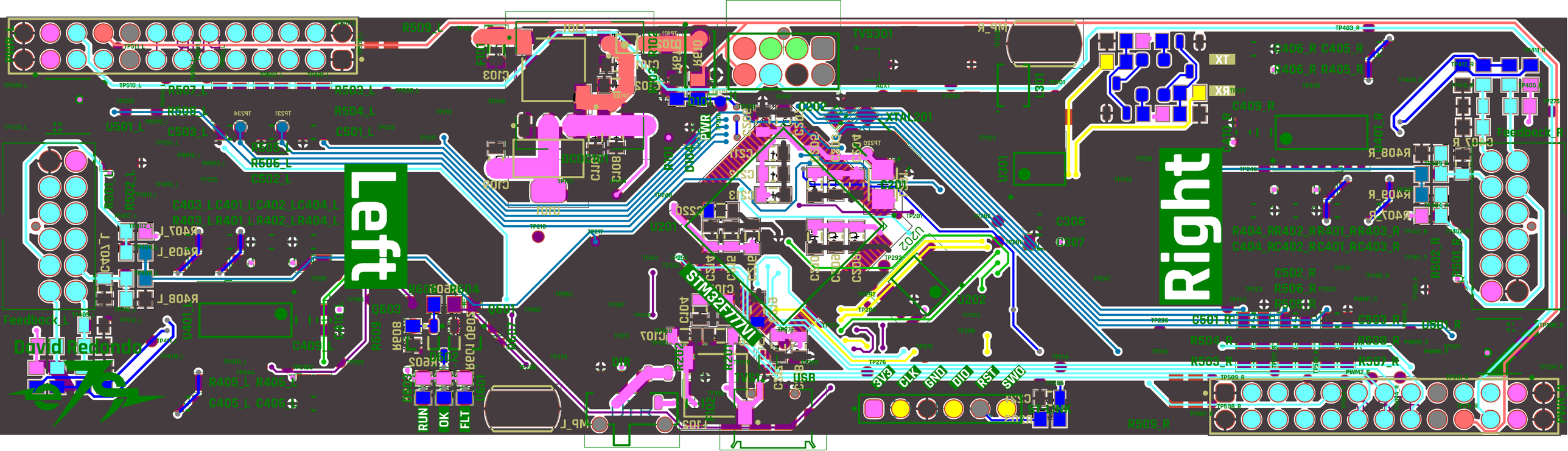
Company: e-Tech Racing	e-techracing.es	
Project: Inverter Control	Variant: [No Variations]	
Size: -	Page Contents: [6] Extras.SchDoc	Version: 1.0
		Department: Powertrain
Author: David Redondo	dredondovinolo@gmail.com	Sheet * of *
Checked by: _		Date: 01/03/2024


Left
Right
STM32F777VI
David Redondo
DCDC101
XTAL201
TVS301
Feedback_L
Feedback_R
ST-LINK
3V3
CLK
GND
DIO
RST
SWO
RUN
OK
FLT
PWR

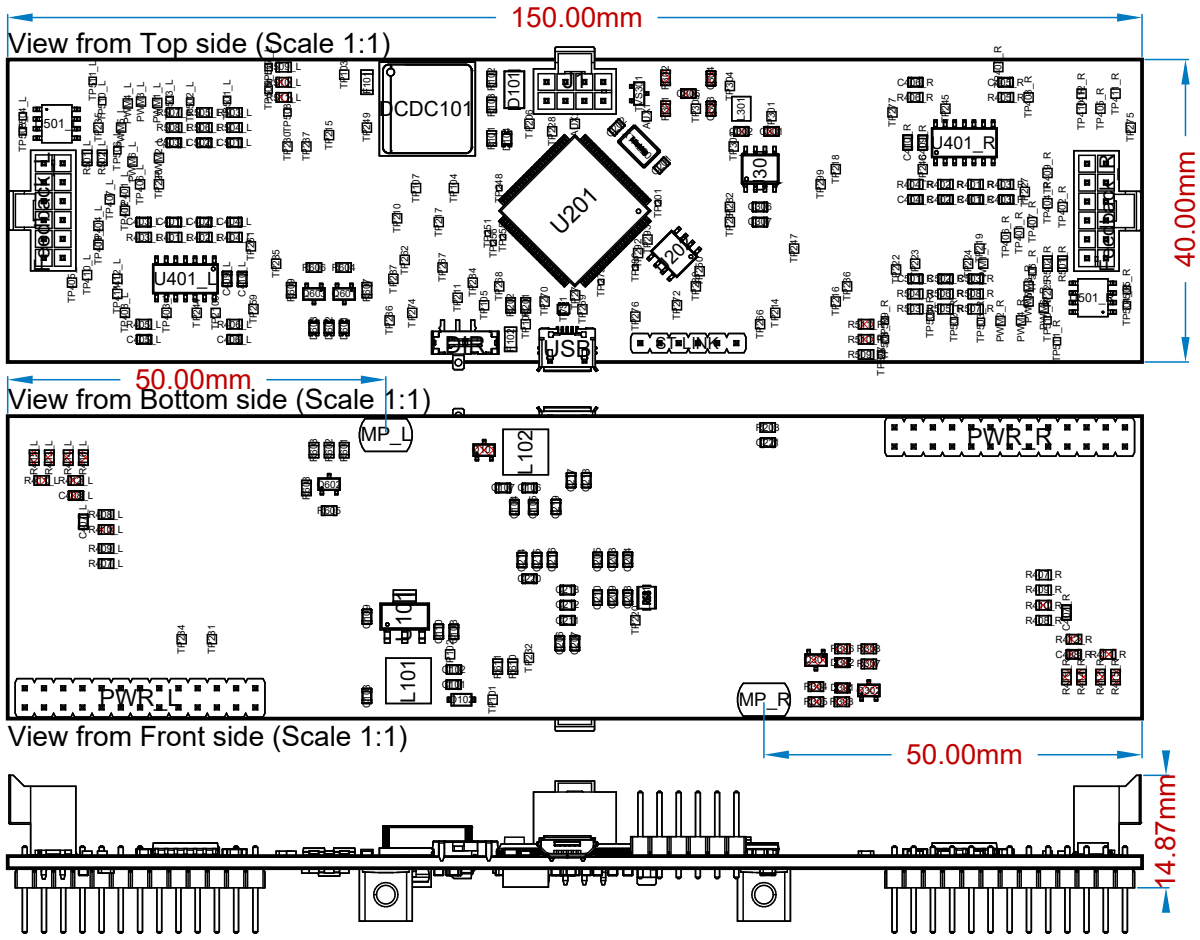

Left
Right
STM32F777VI
Feedback_L
Feedback_R
David Redondo
RUN
OK
FLT
3V3
CLK
GND
DIO
RST
SWO
XT
XR



Left
Right
STM32F777VI
David Redondo
Feedback_L
Feedback_R
PWR_L
PWR_R
ST-LINK
3V3
CLK
GND
DIO
RST
SWO
RUN
OK
FLT
USB
DIR
PWR
J1
TVS301
XTAL201
DCDC101
U201
U202
U301
U401_L
U401_R
U501_L
U501_R
XT


Left
Right
STM32F777VI
David Redondo
RUN
OK
FLT
3V3
CLK
GND
DIO
RST
SWO
XT
XTAL201
TVS301
USB
PWR
Feedback_L
Feedback_R
PWM2_R

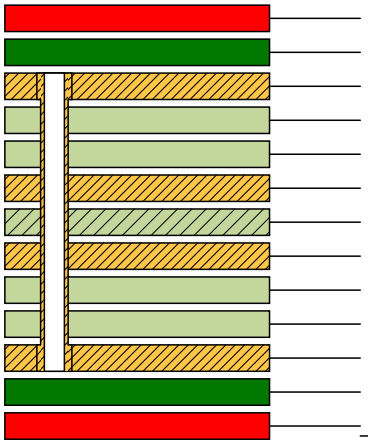
Inverter Control



Bill Of Materials

Designator	Name	Quantity
C101, C105, C204, C207, C209, C212, C215, C218, C221, C307	885012207103	10
C102, C103, C106, C107, C110, C409_L, C409_R	10uF	7
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	150080GS75000	1
D603	150080BS75000	1
DCDC101	RPMB5.0-3.0	1
DIR	450405020524	1
F101, F102	0437001.WRA	2
Feedback_L, Feedback_R	1053101112	2
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
R102, R607, R608, R609	47kR	4
R103, R501_L, R501_R, R503_L, R503_R, R505_L, R505_R, R507_L, R507_R	CR0805-JW-472ELF	9
R201, R202, R203, 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	16
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
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