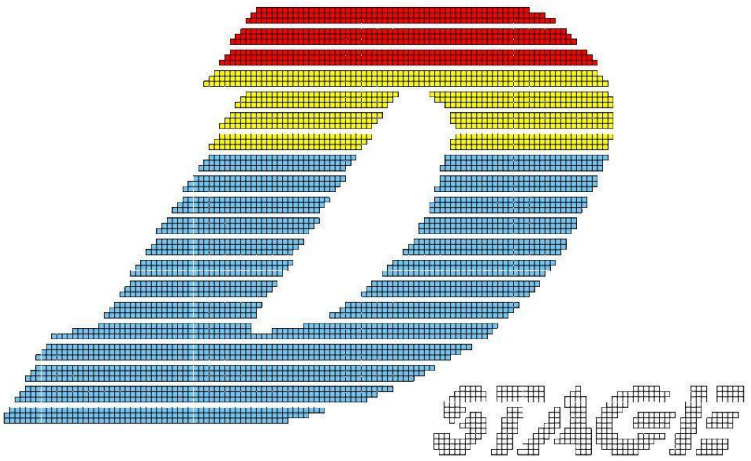


Electronic Throttle Controller

a.k.a.

Drive by Wire

ETC v1.3

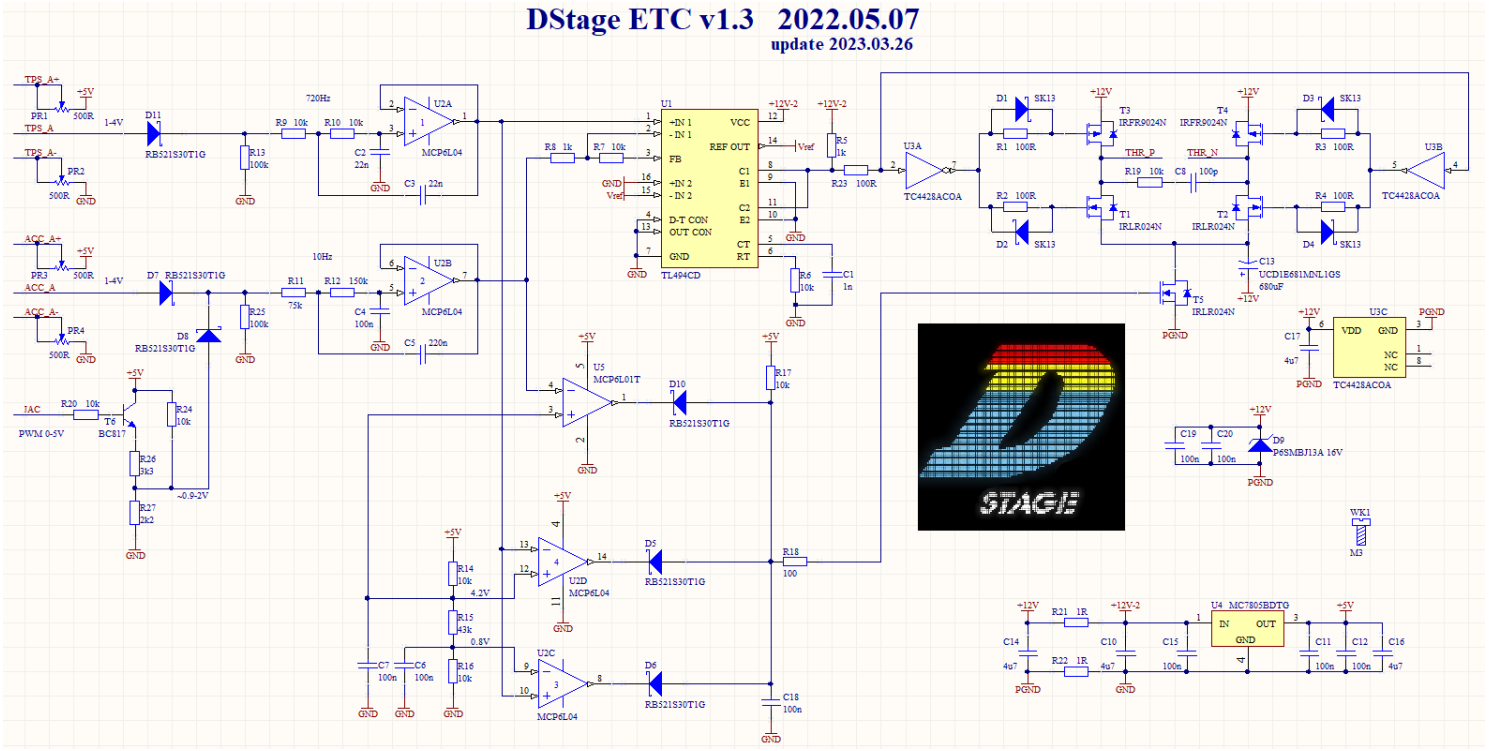
1. Introduction

The ETC v1.3 is an open project of a controller for electronic throttle for internal combustion engines. It allows control of the throttle by electronic gas pedal (accelerator) which is sometimes referred to as „drive by wire”. These are some of the features:

- Controls a DC motor based electronic throttle with H-bridge allowing for fast movement in both directions and closing the throttle beyond stationary position,
- Works with gas pedal incorporating potentiometers or voltage based output, highly adjustable input levels,
- IAC input allowing for ECU idle control with 5V PWM signal,
- Build in fail-safes for detecting broken connections or short circuits on wires connecting gas pedal and TPS,
- analogue circuit – no programming required, no risk of program failure, no risk of CPU going into race condition or resetting due to electromagnetic noise in hursh near-engine environment,
- PCB designed for enhancing immunity to noise.

DISCLAIMER:
This device is dedicated for stationary engines and vehicles driving on private closed properties. It should not be used on public roads!

2. Principle of operation



T.B.D.

3. Assembly / Ordering

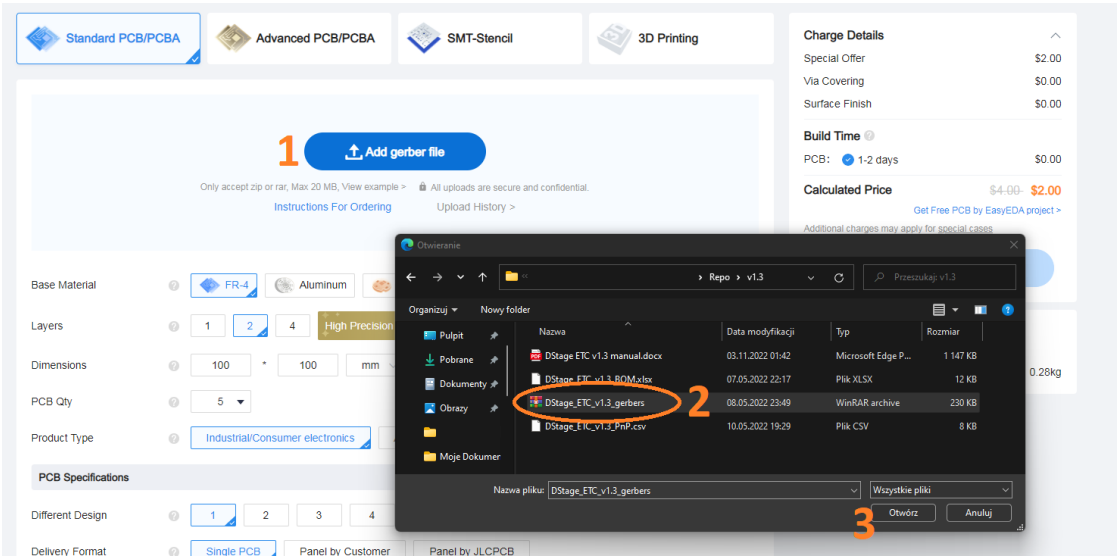
3.1 Automated assembly via JLCPCB

Automated assembly ordered in JLCPCB is by far the easiest option to get the controller in your hands. To order your PCBs together with components and assembly you will need to visit project repository site at https://github.com/DStageGarage/ElectronicThrottleController and download 3 files:

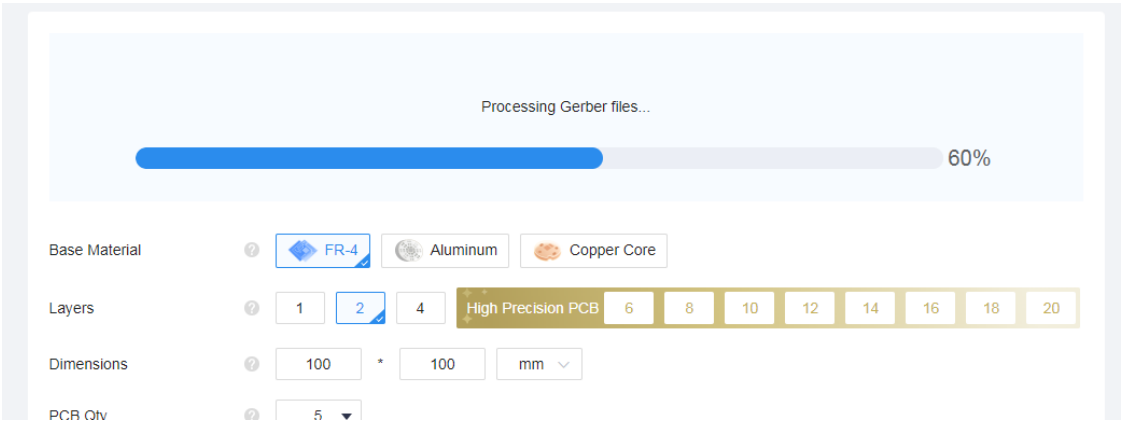
- *DStage_ETC_v1.3_gerbers.rar* - gerber files for all necessary PCB layers and drilling
- *DStage_ETC_v1.3_BOM.xlsx* - bill of materials in JLCPCB compatible format
- *DStage_ETC_v1.3_PnP.csv* - pick and place file also referred to as CPL

Then you can log into your account at JLCPCB and start the ordering process during which you will be asked for the above files (gerbers, bill of materials, pick and place file). Here's a detailed description of that process:

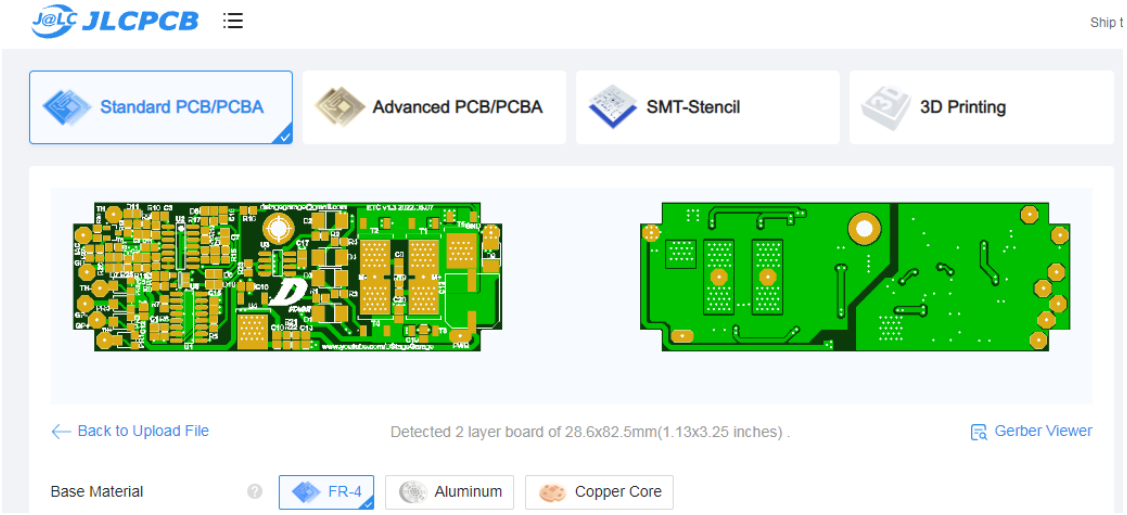
- upload gerbers on the first page of the ordering process by clicking on the button (1), then select file "*DStage_ETC_v1.3_gerbers.rar*" (2) and click "Open" (3).



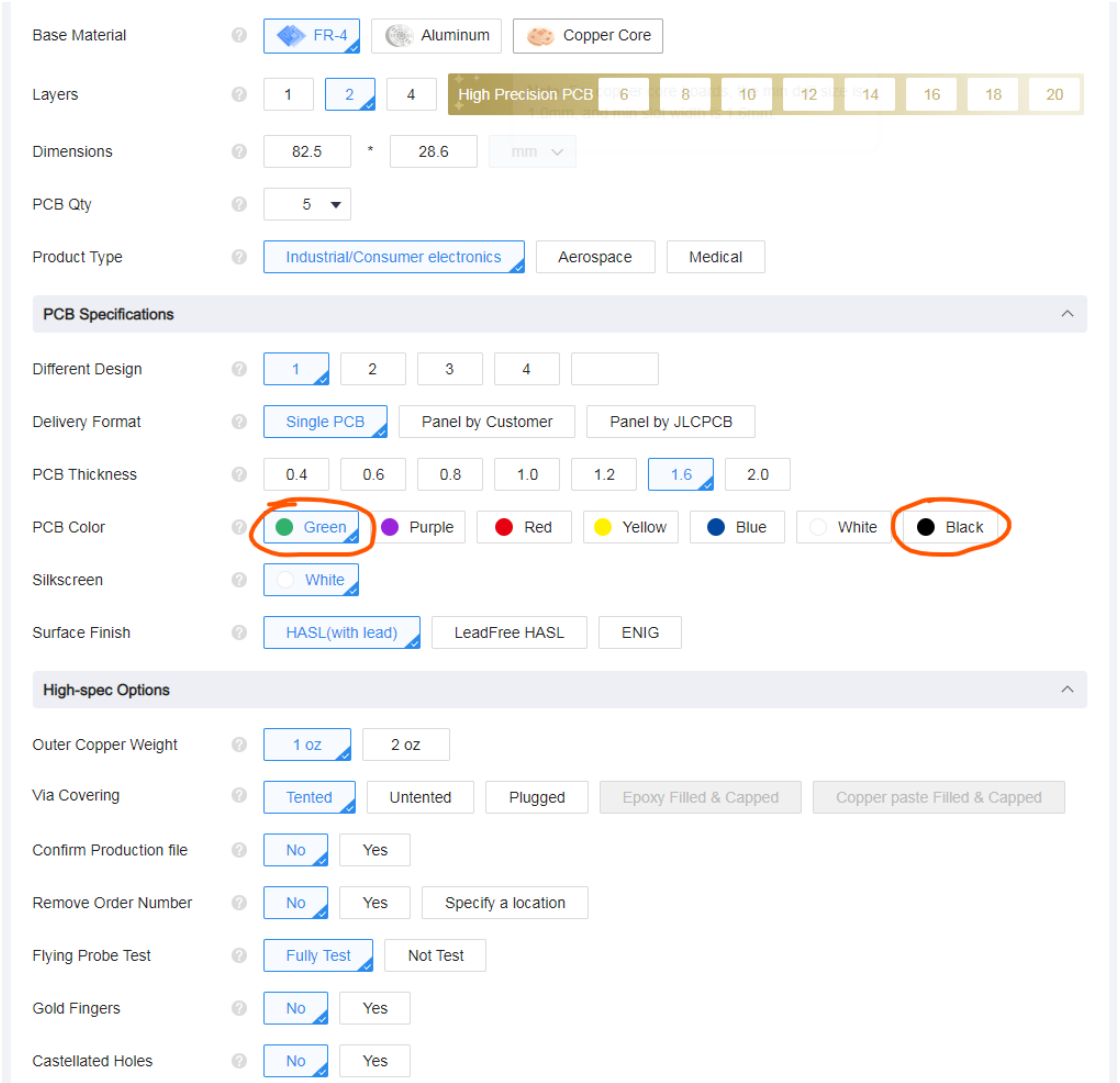
- wait a short while for the gerbers to upload



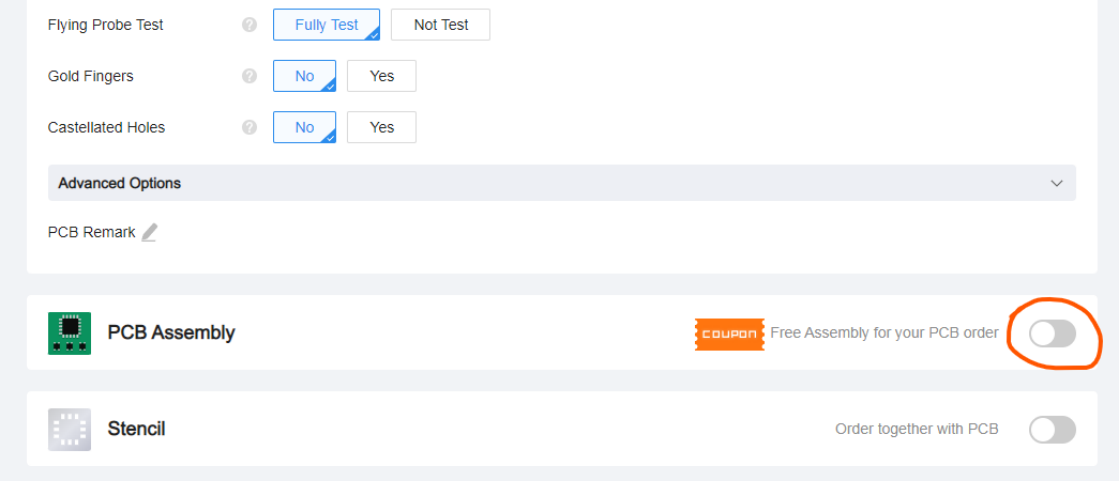
- once file is loaded correctly you should see such view:



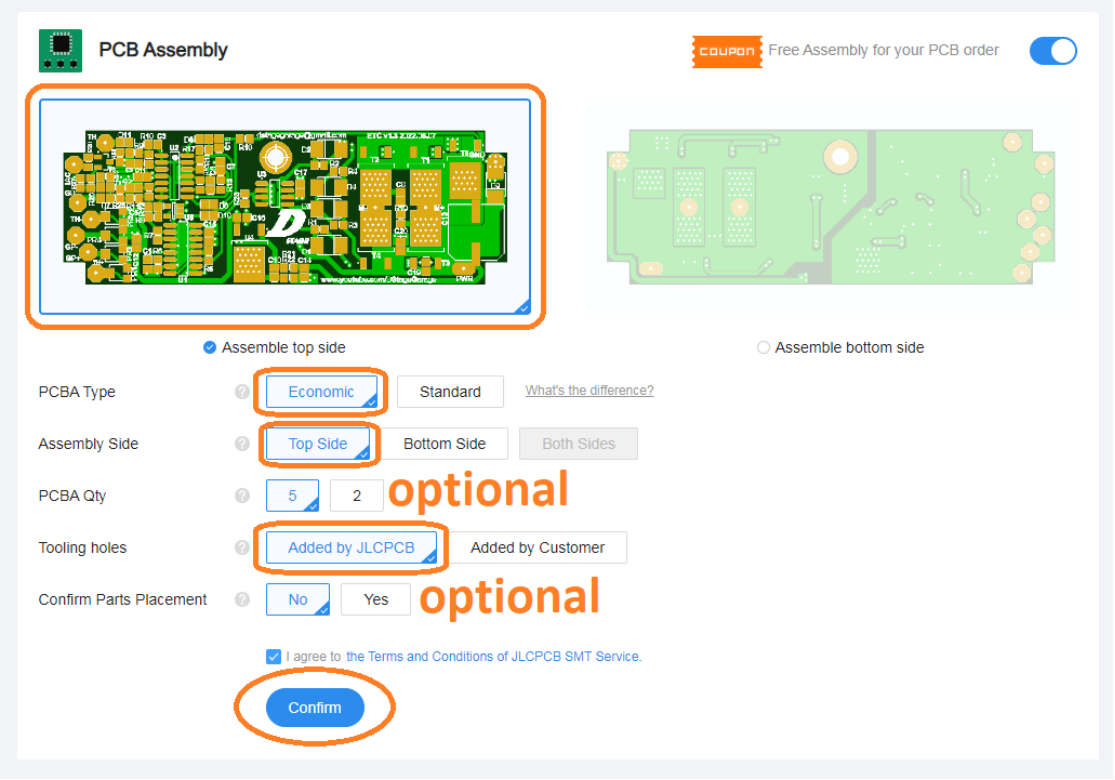
- when using the assembly option and JLCPCB you can only choose from green and black solder mask so make your selection next, everything else should remain unchanged



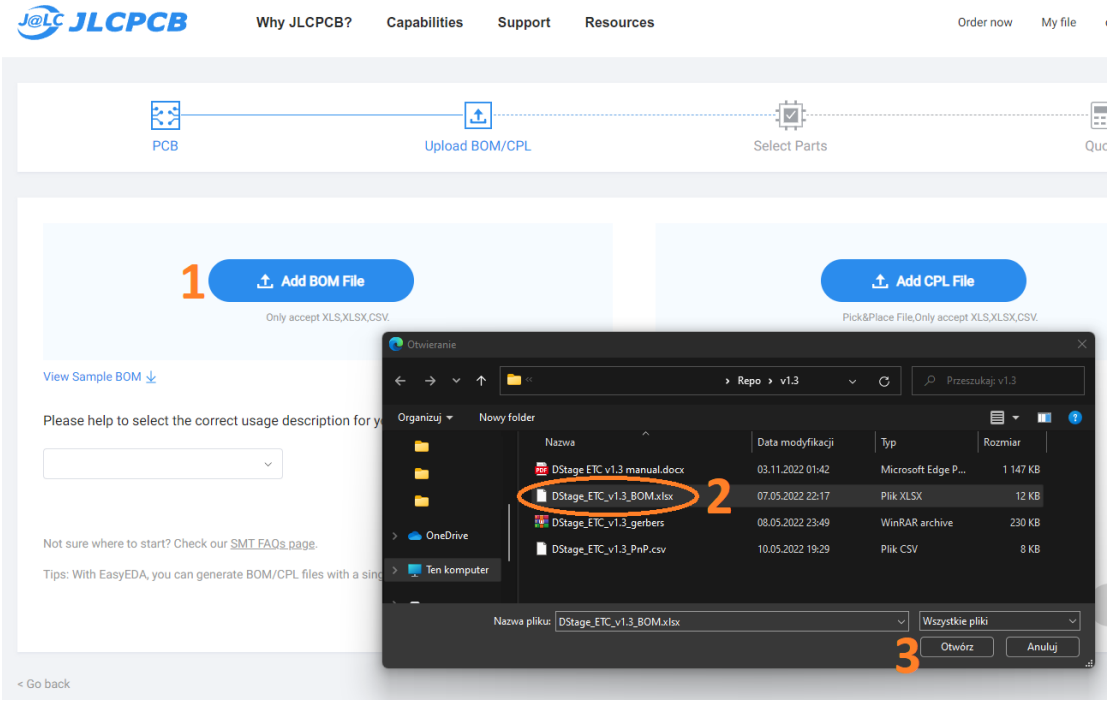
- now select the assembly option



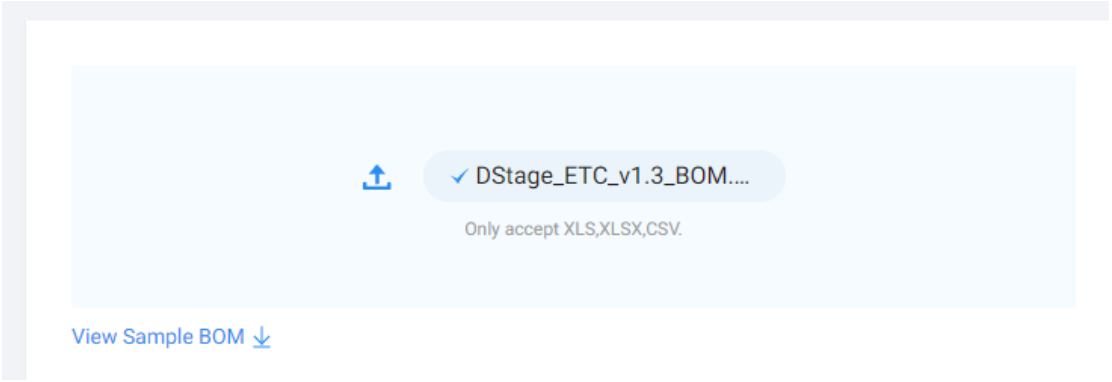
- once selected you will see the below image, please make sure you chose the right options, number of PCBs as well as additional confirmation from JLCPCB is up to you



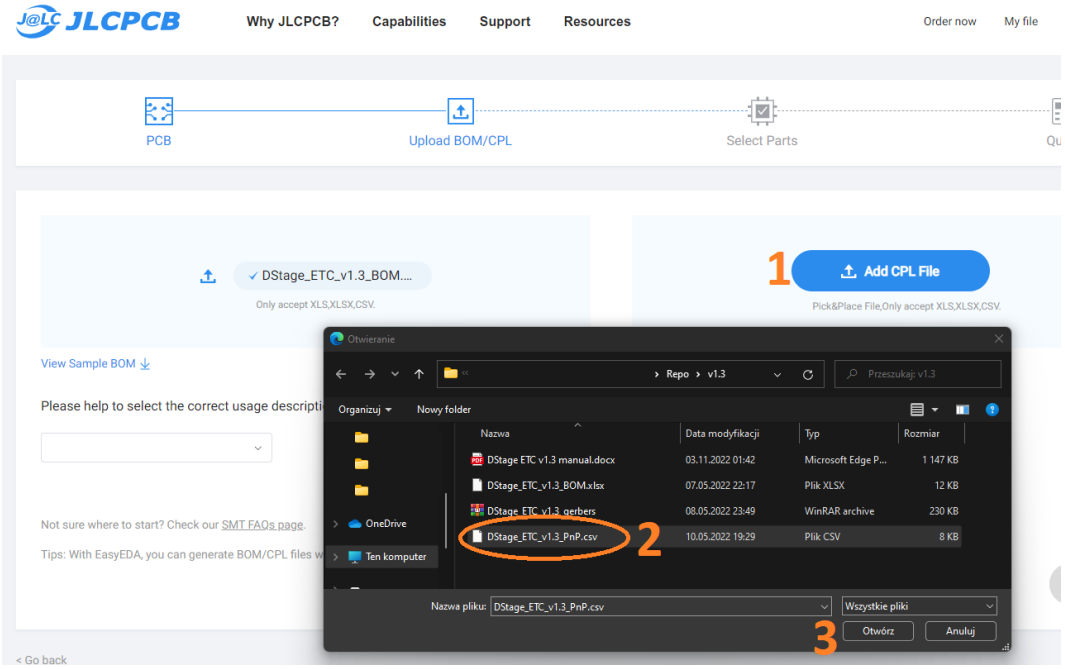
- on the next page you will have to first upload the BOM file by clicking the button (1), then select file "*DStage_ETC_v1.3_BOM.xlsx*" (2) and click "Open" (3)



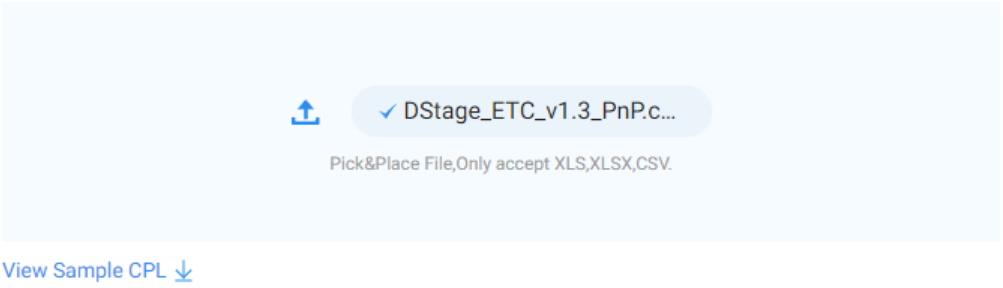
- once uploaded you will see the file name displayed in place of the button



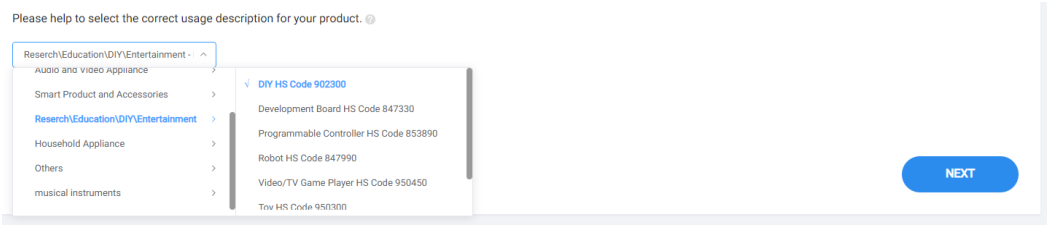
- now proceed with uploading of pick'n'place/CPL file by clicking the button (1), select file "*DStage_ETC_v1.3_PnP.csv*" (2) and click "Open" (3)



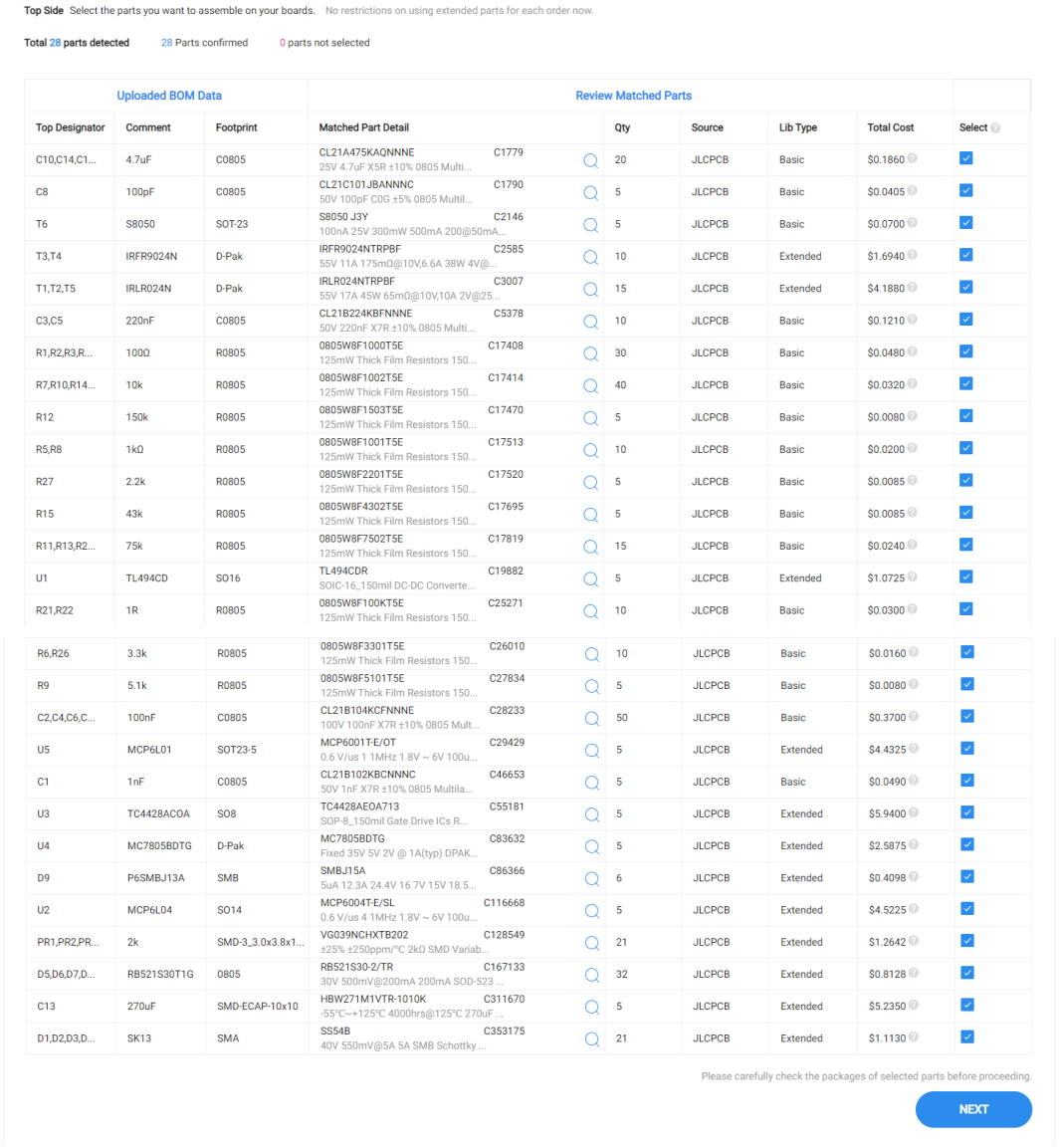
- once again you will see a confirmation in form of file name in place of the button



- choose the product usage for example us such and click "Next"



- You will now see the complete list of components used on the board, if all are available it should look more or less like in the picture below (a few small corrections might be added to the BOM along the way). click “Next”



Top Side Select the parts you want to assemble on your boards. No restrictions on using extended parts for each order now.

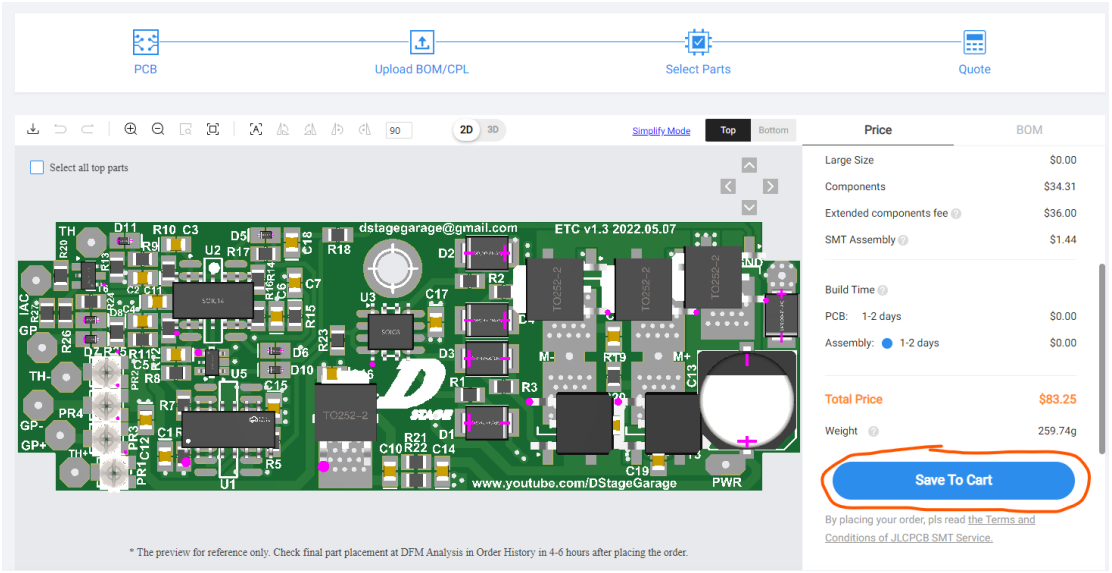
Total 28 parts detected 28 Parts confirmed 0 parts not selected

Uploaded BOM Data			Review Matched Parts					
Top Designator	Comment	Footprint	Matched Part Detail	Qty	Source	Lib Type	Total Cost	Select
C10,C14,C1...	4.7uF	C0805	CL21A475KAQNNNE C1779 25V 4.7uF X5R ±10% 0805 Multi...	20	JLCPCB	Basic	$0.1860	☑
C8	100pF	C0805	CL21C101JBANNNC C1790 50V 100pF C0G ±5% 0805 Multil...	5	JLCPCB	Basic	$0.0405	☑
T6	S8050	SOT-23	S8050 J3Y C2146 100nA 25V 300mW 500mA 200@50mA...	5	JLCPCB	Basic	$0.0700	☑
T3,T4	IRFR9024N	D-Pak	IRFR9024NTRPBF C2585 55V 11A 175mΩ@10V,6.6A 38W 4V@...	10	JLCPCB	Extended	$1.6940	☑
T1,T2,T5	IRLR024N	D-Pak	IRLR024NTRPBF C3007 55V 17A 45W 65mΩ@10V,10A 2V@25...	15	JLCPCB	Extended	$4.1880	☑
C3,C5	220nF	C0805	CL21B224KBFNNNE C5378 50V 220nF X7R ±10% 0805 Multi...	10	JLCPCB	Basic	$0.1210	☑
R1,R2,R3,R...	100Ω	R0805	0805W8F1000T5E C17408 125mW Thick Film Resistors 150...	30	JLCPCB	Basic	$0.0480	☑
R7,R10,R14...	10k	R0805	0805W8F1002T5E C17414 125mW Thick Film Resistors 150...	40	JLCPCB	Basic	$0.0320	☑
R12	150k	R0805	0805W8F1503T5E C17470 125mW Thick Film Resistors 150...	5	JLCPCB	Basic	$0.0080	☑
R5,R8	1kΩ	R0805	0805W8F1001T5E C17513 125mW Thick Film Resistors 150...	10	JLCPCB	Basic	$0.0200	☑
R27	2.2k	R0805	0805W8F2201T5E C17520 125mW Thick Film Resistors 150...	5	JLCPCB	Basic	$0.0085	☑
R15	43k	R0805	0805W8F4302T5E C17695 125mW Thick Film Resistors 150...	5	JLCPCB	Basic	$0.0085	☑
R11,R13,R2...	75k	R0805	0805W8F7502T5E C17819 125mW Thick Film Resistors 150...	15	JLCPCB	Basic	$0.0240	☑
U1	TL494CD	SO16	TL494CDR C19882 SOIC-16_150mil DC-DC Converte...	5	JLCPCB	Extended	$1.0725	☑
R21,R22	1R	R0805	0805W8F100KT5E C25271 125mW Thick Film Resistors 150...	10	JLCPCB	Basic	$0.0300	☑
R6,R26	3.3k	R0805	0805W8F3301T5E C26010 125mW Thick Film Resistors 150...	10	JLCPCB	Basic	$0.0160	☑
R9	5.1k	R0805	0805W8F5101T5E C27834 125mW Thick Film Resistors 150...	5	JLCPCB	Basic	$0.0080	☑
C2,C4,C6,C...	100nF	C0805	CL21B104KCFNNNE C28233 100V 100nF X7R ±10% 0805 Mult...	50	JLCPCB	Basic	$0.3700	☑
U5	MCP6L01	SOT23-5	MCP6001T-E/OT C29429 0.6 V/us 1 1MHz 1.8V ~ 6V 100u...	5	JLCPCB	Extended	$4.4325	☑
C1	1nF	C0805	CL21B102KBCNNNC C46653 50V 1nF X7R ±10% 0805 Multila...	5	JLCPCB	Basic	$0.0490	☑
U3	TC4428ACOA	SO8	TC4428AE0A713 C55181 SOP-8_150mil Gate Drive ICs R...	5	JLCPCB	Extended	$5.9400	☑
U4	MC7805BDTG	D-Pak	MC7805BDTG C83632 Fixed 35V 5V 2V @ 1A(typ) DPAK...	5	JLCPCB	Extended	$2.5875	☑
D9	P6SMBJ13A	SMB	SMBJ15A C86366 5uA 12.3A 24.4V 16.7V 15V 18.5...	6	JLCPCB	Extended	$0.4098	☑
U2	MCP6L04	SO14	MCP6004T-E/SL C116668 0.6 V/us 4 1MHz 1.8V ~ 6V 100u...	5	JLCPCB	Extended	$4.5225	☑
PR1,PR2,PR...	2k	SMD-3_3.0x3.8x1...	VG039NCHXTB202 C128549 ±25% ±250ppm/°C 2kΩ SMD Variab...	21	JLCPCB	Extended	$1.2642	☑
D5,D6,D7,D...	RB521S30T1G	0805	RB521S30-2/TR C167133 30V 500mV@200mA 200mA SOD-523 ...	32	JLCPCB	Extended	$0.8128	☑
C13	270uF	SMD-ECAP-10x10	HBW271M1VTR-1010K C311670 -55°C~+125°C 4000hrs@125°C 270uF ...	5	JLCPCB	Extended	$5.2350	☑
D1,D2,D3,D...	SK13	SMA	SS54B C353175 40V 550mV@5A 5A SMB Schottky ...	21	JLCPCB	Extended	$1.1130	☑

Please carefully check the packages of selected parts before proceeding.

NEXT

- after a short while you will be shown a picture of PCB with components, you do not have to worry about some of them being rotated the wrong way, it will be corrected by JLCPCB engineer later, just make sure that everything is there and you can finish the ordering proces by clicking “Save To Cart”



Please note that JLCPCB is not related to the ETC project in any way. It is just mentioned here as they provide an easy and convenient way of ordering printed circuit boards with assembly.

In case of issues such as component shortages or file problems please contact us at dstagegarage@gmail.com for help.

3.2 Manual assembly

The figure 3.1 shows the ETC v1.1 PCB view (v1.3 is nearly identical in component placement) with extra designators overlayed for clarity. All components are surface mounted on the top layer only.

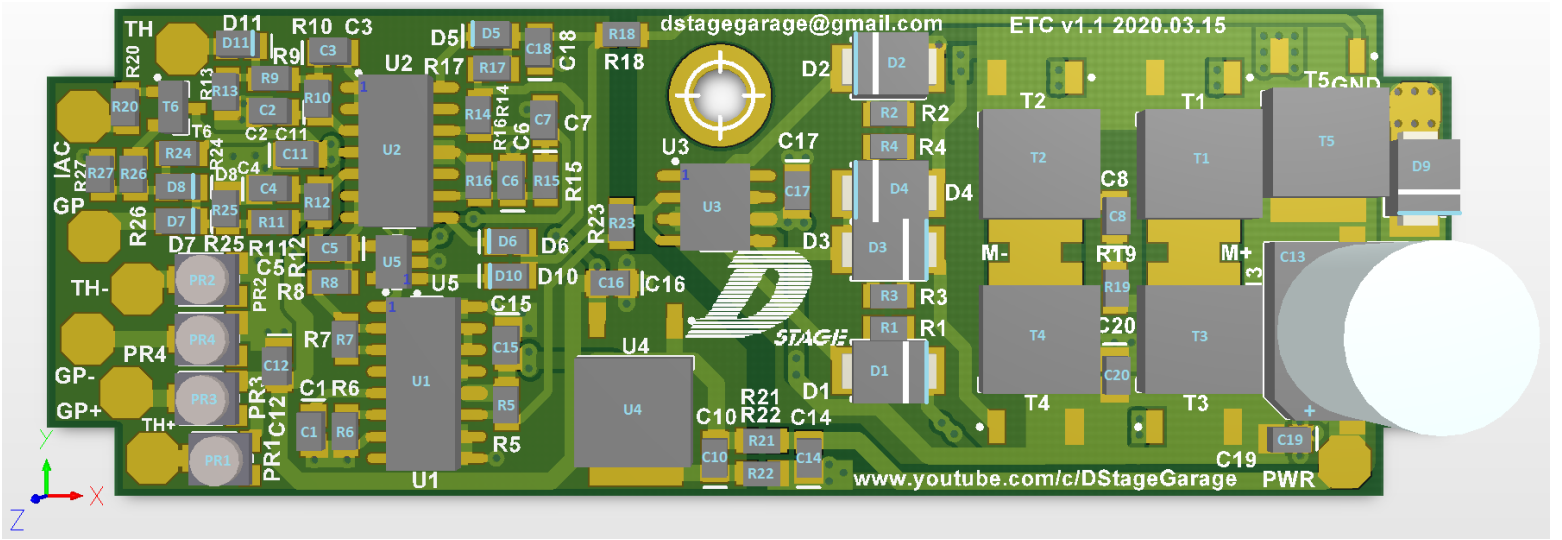


Figure 3.1 PCB assembly

For ease of assembly it is recommended to start with integrated circuits paying attention to correct positioning of pin #1. On SO cases (U1, U2, U3) there are a few different ways to mark this pin.

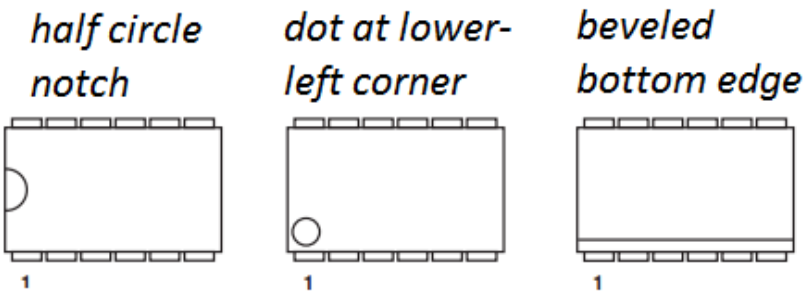


Figure 3.2 How to recognize pin #1 on ICs

There can be a notch on the left side, printed or molded dot in the left bottom corner or beveled bottom side. Refer to figure 3.2 for hints. On PCB silkscreen there is a dot marking where pin #1 should be. You can also check figure 3.1 for clarity. Positioning of U5 is easy as it has 2 pins on one side and 3 on the other.

Assembly can be followed-up by small passive components i.e. resistors and ceramic capacitors as well as diodes and T6 transistor. Resistors and ceramic capacitors are non polarized components so it does not matter how you orient them on pads (line to the side of capacitors footprints is only there to easier distinguish them from resistors). In case of diodes it is important to match the bar on case with the bar/line printed on silksreen. Please refer to figure 3.1. Positioning of T6 is self explanatory (1 pin on one side, 2 on the other).

Now the assembly can be finished by populating potentiometers, bigger transistors T1-T5 and electrolytic capacitor C13 as the last component as it's the largest one. Such capacitors are polarized so it is important to place them in the correct way. It usually has a black bar at the negative side (-) and notched corners at the base on the positive side (+). Please check figure 3.1 for clarity.

4. Wiring (connecting to the vehicle/engine/ECU)

To keep PCB compact there are no connectors. Instead all wiring is done via direct soldering of wires to 11 pads. Figure 4.1 shows the layout of those pads and wires for particular functions.

On the right side there are two power pads – ground at the top and 12V power at the bottom. Please make sure that the power is fed with a fuse not larger than 5A to ensure safe operation in case of the throttle motor failure etc.

The motor of the electronic throttle is connected to pads located very close to H-bridge. Please note that in ETC v1.1 the M+ and M- pad markings will be most likely reversed for most types of electronic throttles. Figure 4.1 already shows that the polarity should be reversed. The markings on later versions of PCB have been corrected.

On the left hand side there are 7 pads in total. The one marked as IAC should be connected to the ECU idle PWM signal.

The group of 3 pads marked GP, GP+ and GP- is meant for connecting the gas pedal (accelerator). Usually electronic gas pedals have 6 pins, 3 for one potentiometer or circuit imitating the potentiometer and 3 for another one. Those two outputs depending on a particular type of gas pedal can be configured in different manner. The output signal can have different offset, direction or characteristics (slope, especially in models using voltage output instead of true potentiometers). What is important is to make sure the output used with ETC has the voltage increasing when the pedal is pushed (pot slider going towards positive side) and decreasing when released (pot slider going towards negative side). More on different accelerator types in one of the following chapters.

The last group of 3 pads is dedicated to the feedback position of the throttle. Usually electronic throttles use double potentiometer with combined ends and separate outputs which results in 4 pins being used for that purpose. Typically one potentiometer travels one direction and the second one in the opposite direction with throttle movement. Again, make sure to use the output that increases the voltage (pot slider traveling towards the positive side) when the throttle is opened more. This can be checked by measuring resistance change across the pins while manually moving the throttle. More on that in one of the following chapters.

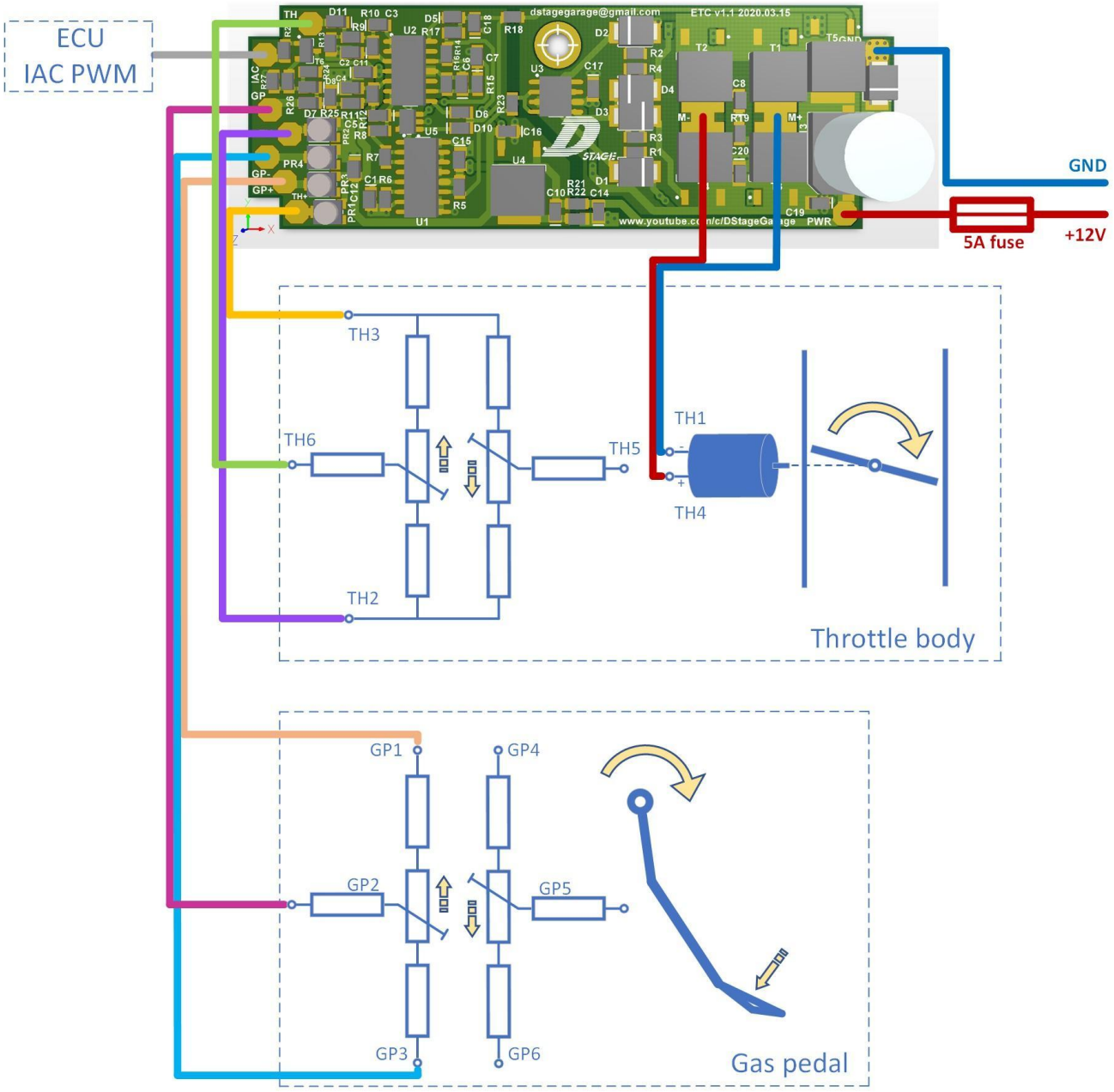


Figure 4.1 Wiring diagram

5. Calibration

We start with the throttle position sensing:

1. Connect the TH, TH+ and TH- to the throttle but DO NOT yet connect the motor (M+ and M-).

2. With throttle closed measure the voltage at TH and adjust PR2 so the voltage is close to 1V (doesn't have to be spot on as long it is reasonably higher than 0.8V).

3. Now fully open the throttle manually and check the voltage on TH. Then adjust PR1 so the voltage is close to 4V (doesn't have to be spot on as long it is reasonably lower than 4.2V).

4. Close the throttle and repeat point number 2 and then number 3 a few times until voltage on TH is close to 1V with the throttle closed and 4V with the throttle open without further touching of the pots.

Now the gas pedal/accelerator - basically same procedure:

1. Connect the GP, GP+ and GP- to one of the gas pedal potentiometers.
2. With the gas pedal unpressed measure the voltage at GP and adjust PR4 so the voltage is close to 1V (doesn't have to be spot on as long it is reasonably higher than 0.8V).

3. Now press the gas pedal and check the voltage on GP. Then adjust PR3 so the voltage is close to 4V (doesn't have to be spot on as long it is reasonably lower than 4.2V).

4. De-press the gas pedal and repeat point number 2 and then number 3 a few times until voltage on GP is close to 1V with the pedal unpressed and 4V with the pedal fully pressed without further touching of the pots.Ideally those voltages should be closely matching those measured at the end of TPS calibration procedure.

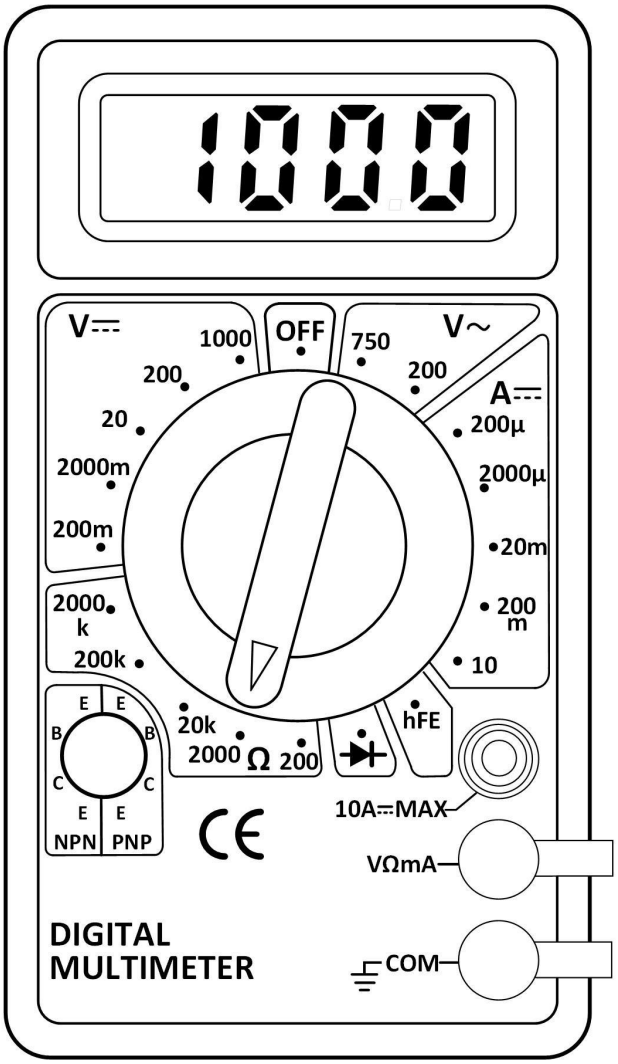
Now you can connect the M+ and M- and fingers crossed it should work.
In case of issues please contact us for help at dstagegarage@gmail.com.

6. Different gas pedal (accelerator) types and how to use them

T.B.D.

7. Basic multimeter measurements.

T.B.D.



8. History of changes.

Date	By	Changes
2022.01.05	DStage	Spelling checked ;-)
2022.05.08	DStage	automated assembly chapter, calibration
2022.11.03	DStage	minor corrections and clarifications
2022.12.13	DStage	detailed description of JLCPCB ordering process