ARISTURTLE

ARISTOTLE UNIVERSITY RACING TEAM
ELECTRIC & DRIVERLESS

powered by

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The Team

Aristotle University Racing Team Electric & Driverless, also known as **Aristurtle**, is a student research team from Aristotle University of Thessaloniki that designs, develops and manufactures **electric and driverless race cars**. The team belongs to the School of Electrical and Computer Engineering and is composed of **undergraduate students** from various fields, from Electrical Engineering, Mechanical Engineering to Physics and Economics. Working under the pressure of demanding deadlines, the members of the team are shouldered with duties that require full use of their **theoretical and practical skills** in order to be confronted successfully.

The faculty advisor, responsible for the representation of the team in the academic community, is **Mr. Minas Alexiadis**, Assistant professor of the School of Electrical and Computer Engineering at Aristotle University. Manufacturing of electric race cars is executed according to the rules and standards of **Formula Student**. This process is guided by three Electrical Systems Advisors, PhD graduates from the Electrical Machines Laboratory. The team is divided into eight subteams that work in different parts of the vehicle and cooperate according to their needs. The Chief Executive Officer is responsible for the coordination of all the subteams, in order to achieve a fully consolidated and perfectly functional result.

Goal

Aristurtle's goal is to design and manufacture excellent electric race cars and take part in international Formula Student competitions against academic institutions from all around the world.

Electra

Electra is the team's first race car and the beginning of a new era in Greek motorsport.

Iris

In mythology, Iris was the Gods' messenger. In our reality, Iris is the Aristurtle's third electric race cars.

Thetis DV

A new era in both Thetis' and the team's course began when it was transformed to an autonomous vehicle, the first in Greece.

Eve

It was the one who determined the standards for the future philosophy of the team's race cars.

Thetis

The awards and international podiums during the 2018-2019 season have established Thetis' place in history.

Nemesis

Designed with a pretty different approach in comparison to its predecessors, Nemesis built the foundation for a new mindset in Aristurtle's vehicles.

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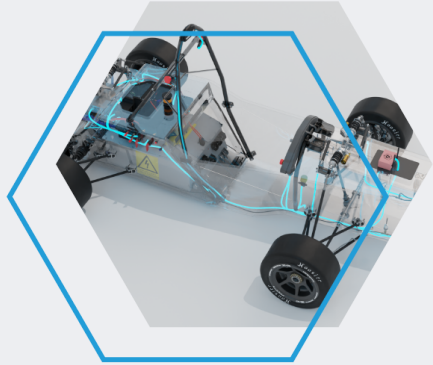
LOW VOLTAGE

The **Low Voltage System (LVS)** includes the Electronic Control Unit (ECU), the Shutdown Circuit (SDC) as well as the driver's interface. Moreover, it includes the data acquisition through sensors and process of them as well as the car's wiring that connects all parts of this system.
A team that participates in the Formula Student competitions must take good care of its **Shutdown Circuit (SDC)** in order to acquire the safety that's necessary. This circuit, as strictly specified by the Formula Student rules, is responsible for the electric separation of the Accumulator Container from the rest of the vehicle in case an error occurs.



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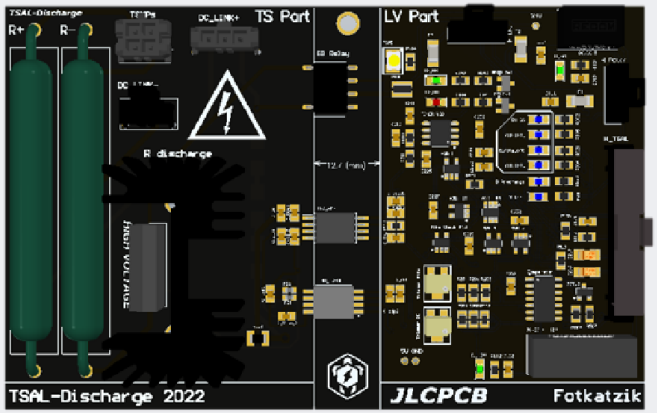
Tractive System Active Light (T.S.A.L.)

This Printed Circuit Board (PCB) is responsible for the function of a light indicator of the High Voltage System and has three separate states top inform everyone around the car. Green light specifies the absence of high voltage outside the Accumulator Container, while the flashing red light specifies the opposite. In the third state the T.S.A.L., taking into account several signals of the car and with the aid of hardware logic based on Formula Student rules, has an orange light which means that a serious error has occurred, and the car is not safe at all. This state does not shut down the car through SDC, but it is considered extremely critical for the responsible person to push the Shutdown Button.



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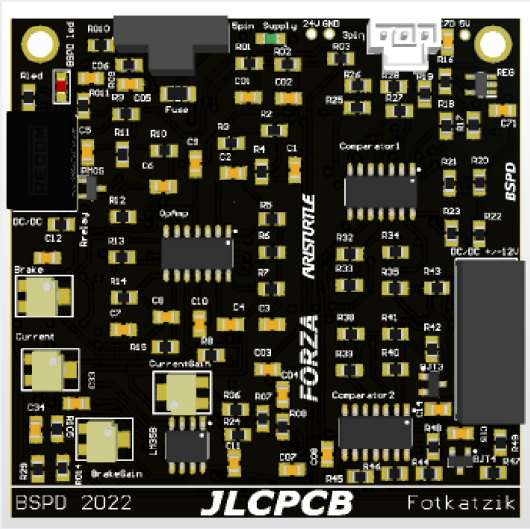
Brake System Plausibility Device (B.S.P.D.)

B.S.P.D. is considered one of the mandatory circuits that any Formula Student team must have in its car as specified by the rules. The role of this PCB is to monitor the Brake System and to detect whether it is used at the same time with the accelerator pedal. In case this happens above a certain threshold, the supply to the motors is cut.



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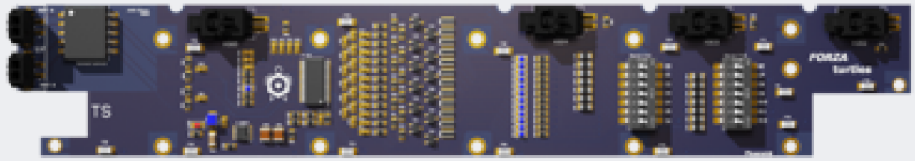
Battery Management System (B.M.S.)

The Battery Management System is a combination of hardware and software, and it forms a fundamental part of the electrical energy storage unit of an electric vehicle (Accumulator Container). Aristurtle designs its own BMS based on the architecture of distributed topology Master-Slave. Measurement units (Slaves) oversee the voltage and temperature measurements of the battery cells, perform diagnostic tests, and include voltage balancing circuits. Accordingly, Master is responsible for the supervision of the whole system, communication with ECU and actuation of the Shutdown Circuit if the measurements exceed the limits specified from the cells' constructor.



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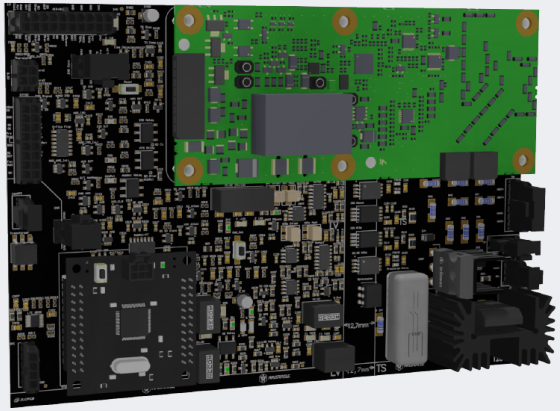
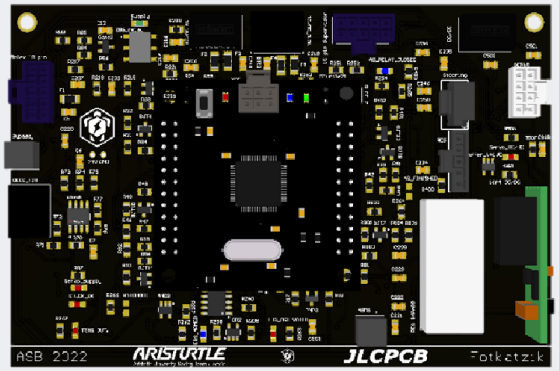
Fusebox

Fusebox PCB is located inside the Accumulator Container and performs a variety of functions for the operation of the Low Voltage System. It includes a big part of the Shutdown Circuit, some high voltage measurements, control of insulation errors between High and Low Voltage, and the microcontroller (Master) for the BMS. The microcontroller in parallel with the data from the battery cells collects the most important signals of the PCB and sends them via CAN (Controller Area Network) so that the driver is informed, the Telemetry is updated, and the Data Logger keeps track of them. Finally, one of the most significant operations of this PCB is to charge smoothly the DC-LINK capacitor of the Inverters to prevent their damage during the start-up process of the car and the energy flow from the Accumulator Container to the rest of the vehicle.



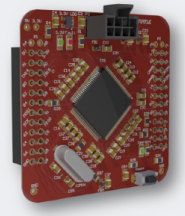
Autonomous System Brake (A.S.B.)

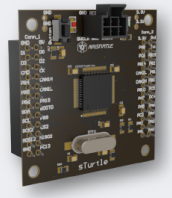
This PCB, as said by its name, controls the actuation of the brake system of the autonomous. It consists of a microcontroller called Supervisor and a Non-Programmable Logic (NPL). The Supervisor communicates with the Autonomous Processing Unit (APU) and depending on the state and the mission of the Autonomous System, it sends the appropriate signals to the NPL. In an event of a failure, it will trigger the Shutdown Circuit of the vehicle which will enable the mechanical actuator (pneumatic cylinder). Thus, the car can brake and come to a safe stop. Also, it controls the servo motor which acts as an EBS Redundancy.



Microcontrollers

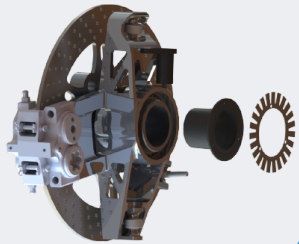
Customized for the team's needs, microcontrollers play a big part in the Low Voltage System. Aristurtle uses two kinds of microcontrollers, STM32F4 from ST Microelectronics and TMS320 from Texas Instruments. Placed in crucial parts of the vehicle, they are charged with the data acquisition and processing as well as the monitoring of the state of the vehicle. Fundamental role in their interconnection has the CAN protocol, the most widely used communication protocol in the automotive industry. This collection of microcontrollers could not operate without efficient and reliable coding.

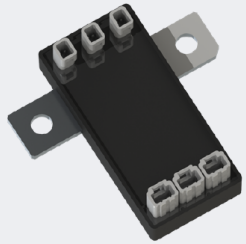




Sensors

To exploit the multitude of data extracted from several parts of the vehicle (suspension, steering, wheels), it is required a proportional number of sensors charged with this exact duty. Each one is different and its placement in the vehicle must be well thought along with its integration in the electrical system. This is done with the aids of appropriate communication protocol, writing of the necessary pieces of code and extensive testing to achieve proper operation with the rest of the Low Voltage System.

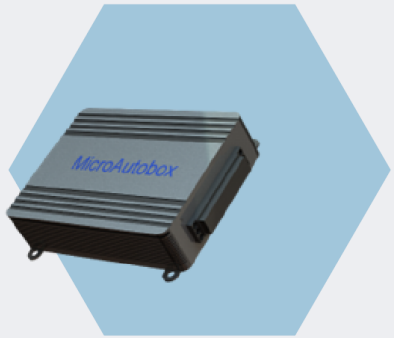


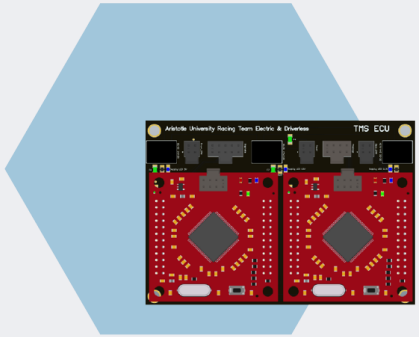


Electronic Control Unit

Like every car, so are Aristurtle's vehicles need a precise control from an Electronic Control Unit (ECU), which has at its disposal data from all vehicle's sensors. The ECU is processing them very quickly and performs functions like all the necessary safety checks, sends torque orders to the motor controllers and manages the CAN fieldbus flow. Furthermore, the ECU contains a power limiter which is useful for being rules compliant with Formula Student rules and managing the energy that the TSAC contains. For Aristurtle, all these ECU's functions are shouldered in the MicroAutoBox II model of dSpace.

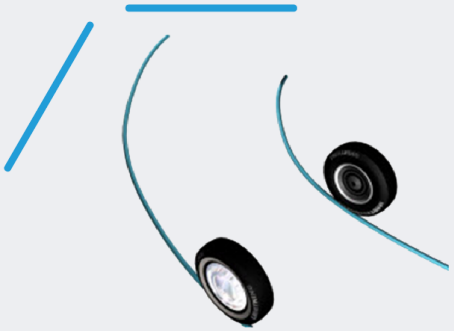
Last year, Aristurtle managed to design and implement a custom ECU which consists of two commercially available microcontrollers of Texas Instruments. This ECU was placed on our vehicle, and it was proved that it can work without problems and delay on signal processing.

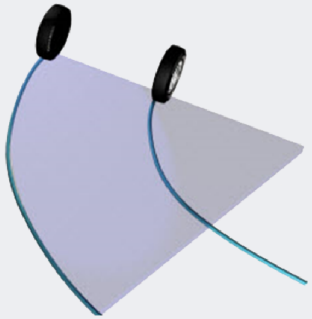


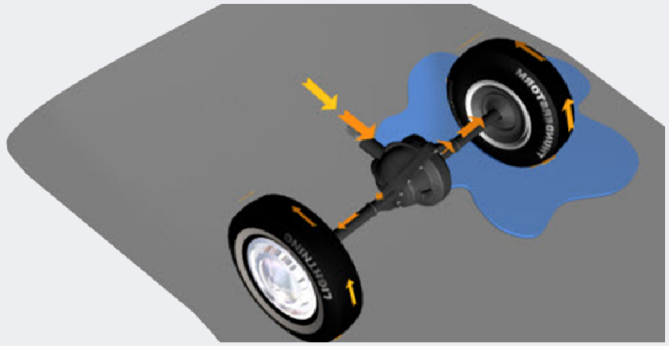


Control Systems

An integral part of the ECU are the control systems, namely systems that aim to optimize vehicle's performance. The first one is regenerative braking, which exists in order to convert the kinetic energy to electric in order to minimize the energy consumption. Additionally, the traction control is responsible for limiting the commanded torque to the wheels if they slip and therefore saving energy. The final control system is the electronic differential which differentiates the motors' commanded torque when the vehicle turns.

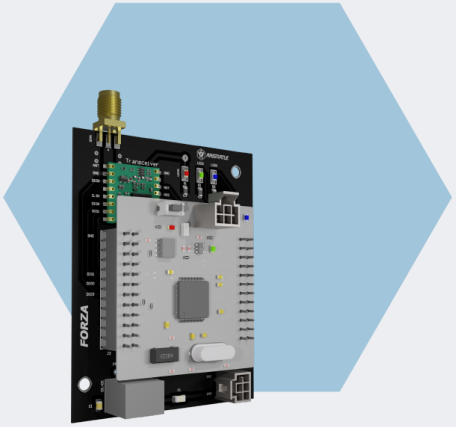






Telemetry

The telemetry system provides us wireless access into more than 128 sensor values, like cell voltages and temperatures which are critical for both the safety of the driver and the car. Also, by using bidirectional techniques, we can also tweak and modify parameters of control systems regarding traction control, the configuration of inverters and torque vectoring. Our transceivers with LoRa technology combine low power consumption and long-distance (at least 500m) wireless connections while managing to keep a constant data speed.



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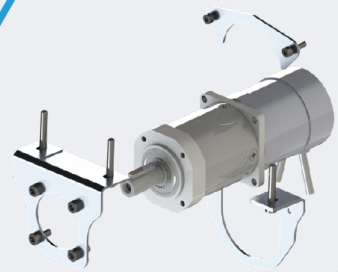
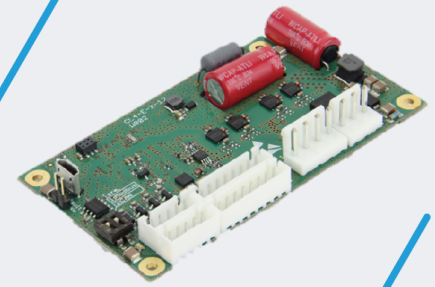
Steering System Actuator

From last year, Aristurtle's vehicles are designed properly in order to be driven in a driverless way. For this reason, an actuator is needed in order to make the steering wheel turn. So, Aristurtle uses a BLDC motor which fulfills the torque and speed specifications needed for the steering wheel to turn.

The BLDC motor can work only as a closed loop system. This means that a sensor is used which returns position feedback. In our case, an encoder is used, which is integrated in the motor from the company.

In order to control the motor, a programmable motor controller (inverter) is needed to give the user the opportunity to select the control mode he wants (torque, speed or position control). Furthermore, the user would be able to adjust several control settings. In addition, the controller is connected to one of the four CAN channels, so it can communicate with other vehicle's micro-controllers.





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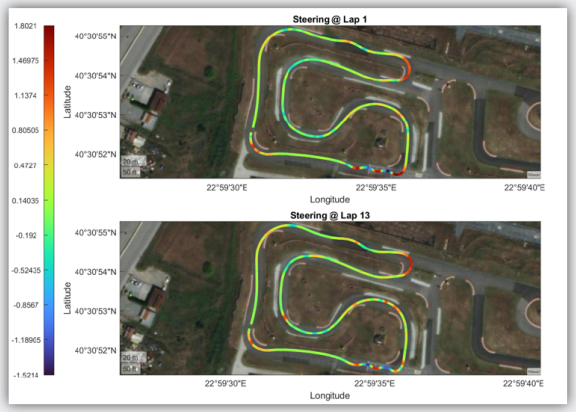
Aristurtle Visualize

Our vehicle's ECU has the ability to log any data we need and they are useful for a more extensive study after every time our vehicle run on the track. In order to plot the data, Aristurtle uses an app that was developed by Aristurtle's members, the Aristurtle Visualize app. This app is handy enough and it does not require any programming knowledge. So, every Aristurtle's member has the ability to use it.



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Το μέλλον της ενέργειας

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