University Racing Eindhoven

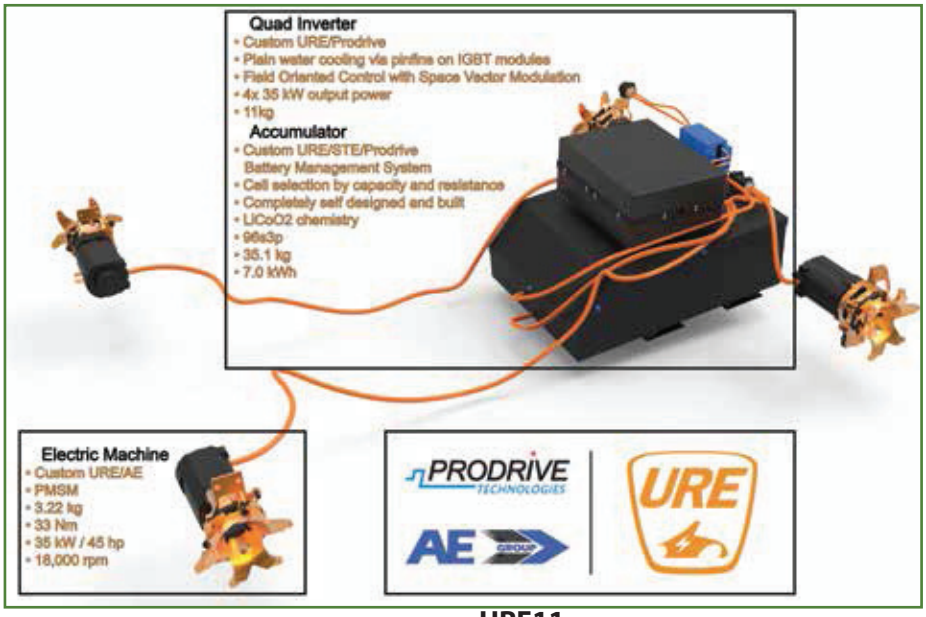
By: Jacky Pang

Would you believe a group of TU/e students have built an electric car that accelerates faster than a Tesla Model S, Bugatti Veyron and any other production car?

Meet University Racing Eindhoven (URE). We are a student team consisting of 50 passionate students from Eindhoven University of Technology and Fontys University of Applied Sciences. As the oldest automotive student team from Eindhoven we have over a decade of experience in completely developing and building racing cars from scratch, with the most recent one being the URE11 and the URE12 currently in production.

Formula Student

As the world's largest engineering competition with nearly 600 teams participating, Formula Student has grown from its first event in 1978 in the USA to multiple events on Formula 1 circuits all over the world. In the past we participated in Europe's four biggest events each summer, being in England (Silverstone Circuit), Austria (Red Bull Ring), Germany (Hockenheimring) and Spain (Circuit de Barcelona-Catalunya). This year England will be replaced by Formula Student Netherlands, which will be held for the first time at the TT Circuit Assen. At these events we compete with Europe's top universities. Recently one of our competitors broke the world record acceleration from 0-100 km/h for electric vehicles with a time of 1.513 seconds! The car is taken to its absolute limits at the competition's dynamic events; acceleration, skidpad, autocross, efficiency and endurance. At the acceleration event the car has to drive for 75 meters straight as fast as possible, at the skidpad a figure 8 has to be driven to test its cornering abilities, at the autocross the car has to drive one lap as fast as possible and at the endurance the car's durability is tested by a 22km long race, while simultaneously points are scored for efficiency by consuming less energy.



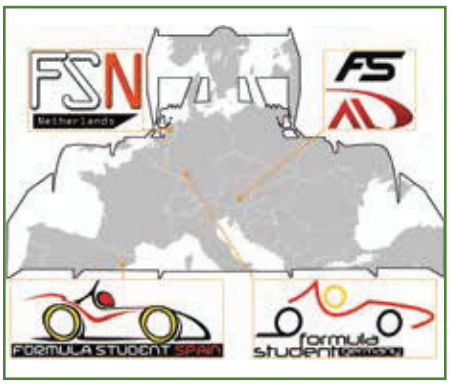
Whilst the dynamic events are the absolute pinnacle of the competition, perhaps the static events are even more important. These events include cost, business and engineering design. At the cost event every single bolt has to be documented, and it has to be shown that the car is not only fast but also cheap. The business event consists of convincing potential investors by presenting your plan to sell the car to the public. Finally the main static event is engineering design. At this event experienced engineers from the automotive industry (including Formula 1) have to be convinced that your design is the best.

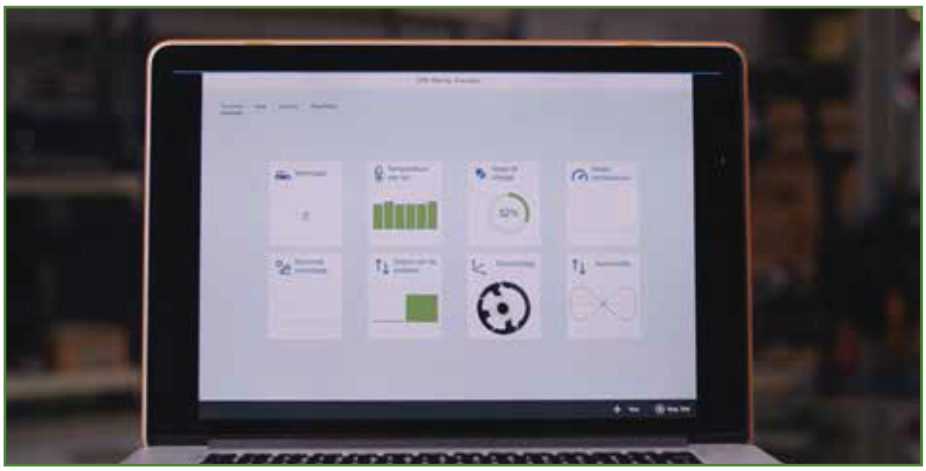
URE11

The URE11 is the 12th car (7th electric) completely developed and built by URE. What sets us apart from other teams is that our powertrain is also completely self-developed by students.

This starts from the accumulator from which only the battery cells themselves are bought. The cells are tested and sorted by their capacity and internal resistance. In total the URE11 features 288 lithium battery cells which have an energy density of 200Wh/kg. With a total capacity of 7.0kWh the total weight from the cells comes down to only 35.1kg. This capacity was chosen after optimisation for the endurance event, which is the longest distance the car has to be able to drive. These cells are put in a 96s3p configuration, which results in maximum 400V and are further divided into six battery modules, such that working on the accumulator can happen in a safe manner.

The accumulator has a battery management system, or BMS in short, self-developed by students in cooperation with Prodrive Technologies. The BMS keeps track of the cells such that they are not taken outside of the boundaries of their specifications such as current and temperature, where 94% of the cells are monitored for their temperature. The BMS consists of a main module and





a slave board at each module. Furthermore it has an integrated battery balancing function. Housed together with the BMS is a self-developed 300W dual active bridge DC/DC converter to supply the low-voltage system of the car through the high-voltage battery, this saves weight due to not needing a separate low-voltage battery. The other advantage is that this converter has an efficiency of over 94%, which is more than the commercial solutions.

From the battery the next part is the inverter/motor controller, which is also self-developed in cooperation with our main partner Prodrive Technologies. Since the car is a four-wheel drive, this means a quad inverter is used. It is water-cooled together with the electric machines and is housed in a carbon fibre casing. The inverter makes use of field-oriented control, which gives full control of the motor's torque and internal flux.

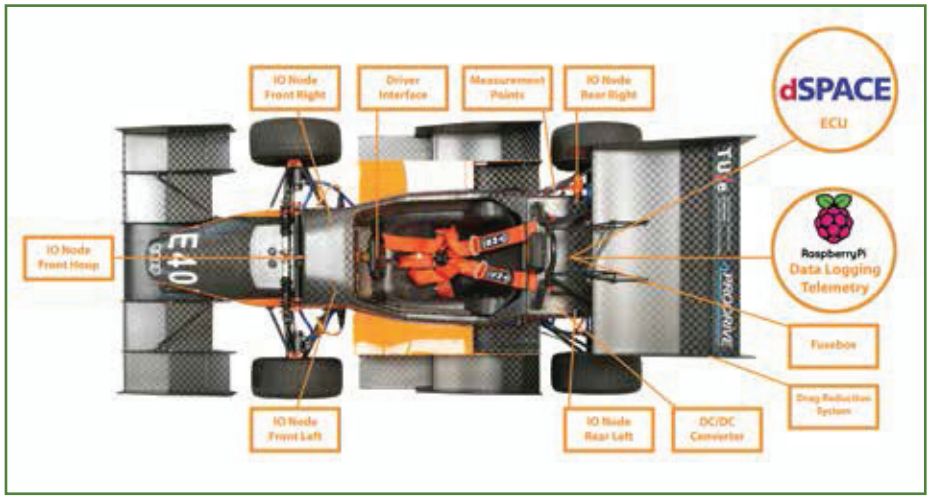
The final parts of the powertrain are the electric machines themselves. The URE11 features four in-wheel motors which have been self-developed together with AEGROUP. They are permanent magnet synchronous machines which have the advantage that they are very efficient and require little maintenance compared to DC machines with brushes. The machines run up to 18,000rpm and have a final drive reduction of 12:1. In total this results in a power output of 180hp whilst the car itself also weighs 180kg, giving a 1:1 horsepower to kilogram ratio.

Electronics

The wiring harness is the biggest electronic part of the car as it connects every electronic device in the car to the ECU. Communication is done through the use of two CAN buses, one for the powertrain and one for the sensors and actuators. This reduces the busload on each CAN bus and prevents messages getting lost.

All the electronic devices in the car are connected to the central ECU. In order to save weight this is done through the use of so called 'IO Nodes' which are located near each wheel, they are able to convert both A/D and D/A signals. This significantly reduces the required wiring thus also weight and complexity. These IO Nodes are connected to the central ECU via a CAN bus. For the ECU the dSPACE MicroAutoBox is used, which is one of the few components which are actually not self-developed and/or self-produced. The MicroAutoBox is Simulink programmable, which enables our entire vehicle software model to be created by engineers with little programming knowledge and reduces possible errors. Since making changes to the vehicle software model can be done quickly through Simulink, this greatly reduces testing time.

The display of data is done through two ways. First the steering wheel is self-designed in order to house a display which supplies the driver with crucial information such as battery charge and temperature. This display communicates through the CAN bus and thus allows the driver to change settings such as the torque limit on the ECU through the steering wheel. The other way is on the laptop, which is done through the use of data logging with a Raspberry Pi and telemetry. Together with McCoy & Partners a digital real-time dashboard has been created based on a SAP backend. With this dashboard data from the car can be read real-time on any computer from the cloud.



Challenge

Are you looking for a challenge? Enthusiastic Electrical Engineering and Automotive students from all years are always welcome to help push the boundaries of engineering! As most of our team members are part time, the team consists of a variety of students from all years and different disciplines.

Opportunities exist in the form of part-time assignments, end projects and sometimes even internships. Do you want to challenge yourself and gain valuable practical experience? Visit our website at www.universitytyracing.nl or contact us through universityracing@tue.nl.

Do you want to see the URE12 in action? We will participate in Formula Student Netherlands which will be held on the TT Circuit in Assen. The event is held between the 17th and the 20th of July in 2017 and is open for visitors! ■