Name and surname: **Irfan Khan**
Supervisor : **Prof. Andrea Tonoli**
Coordinator : **Prof. Luca GOGLIO**

PhD Program in Mechanical Engineering – XXXV Cycle (1st Year)
Department of MECHANICAL AND AEROSPACE ENGINEERING (DIMEAS)
Funded by: **Physis New Energy Technology srl**

❑ Research activities:

Powertrain electrification:

- Study of the impact of E-machine and its control strategies on the reliability of the components of the Dual clutch transmission(DCT), DMF and the crankshaft support bearings in P2.5 hybrid architecture.. (**FCA-CRF**)
- Integration of P2 hybrid module in the driveline and study of the impact in terms of packaging, reliability, performances in traction and in regenerative braking. (**Physis New Energy Technology srl**).

Autonomous Driving:

- Study, design and implementation of the control strategies for automated racing vehicles to improve the performance.
- Design, construction and implementation of steering and braking actuators for automated vehicles.

❑ Training activities and courses carried out during the year:

Politecnico di Torino

- 01UJJRO- Automotive transmissions
- 03OYCIV - Hybrid propulsion systems
- 01LCPRV - Experimental modeling: costruzione di modelli da dati sperimentali
- 01QORRO - Writing Scientific Papers in English

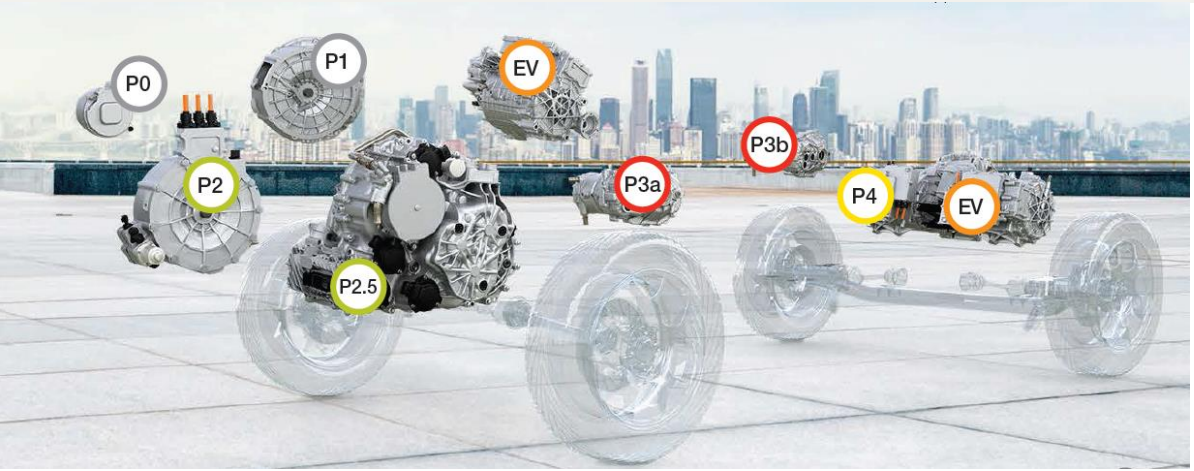
Training (DAYCO)

- Regulation 1151 – WLTC Cycle, Prof. F Cavallino (15 hours)
- Simdrive training from DAYCO (20 hours)

Webinar

Formula Student Germany Academy
Webinar: Driverless Workshop 2020
(powered by Waymo)

Powertrain electrification: State of the art

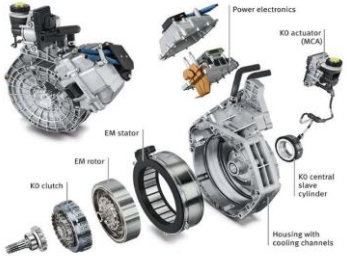


P2

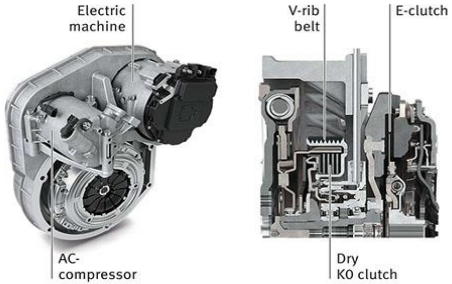
- e-machine is assigned to the transmission input shaft between coupling and transmission
- Boosting for improved acceleration
- Recuperation
- Start-Stop functionality
- Pure electric driving enabled in certain driving situations

P2.5

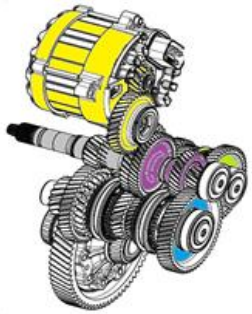
- e-machine is integrated in the hybrid transmission
- No change in installation length
- No additional clutch between ICE and transmission required
- Boosting for improved acceleration
- Torque fill capability
- Recuperation
- Start-Stop functionality
- Pure electric driving enabled in certain driving situations



Coaxial P2 hybrid module



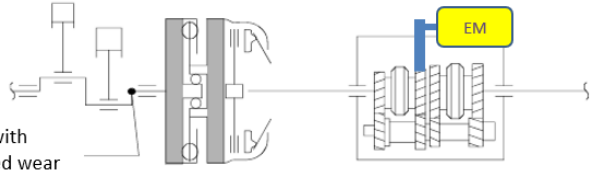
P2 hybrid module with parallel axis installation

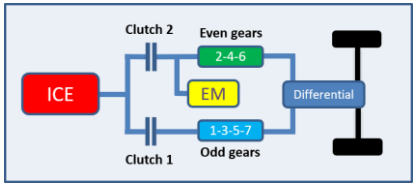


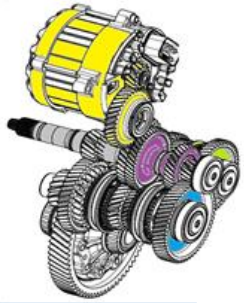
P2.5 hybrid module

❑ Powertrain electrification: P2.5 hybrid architecture

***Objective*: To study the impact of E-machine and its control strategies on the reliability of the components of the Dual clutch transmission(DCT), DMF and the crankshaft support bearings in P2.5 hybrid architecture.**

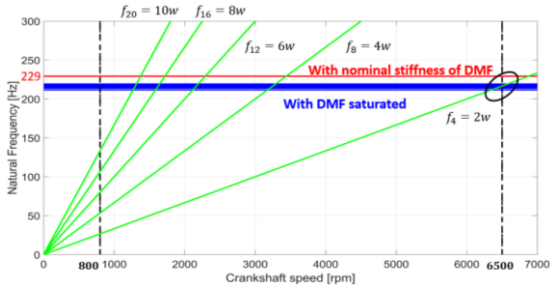




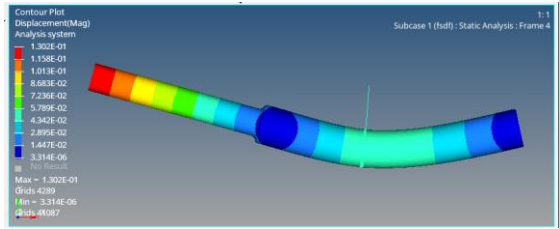


P2.5 Hybrid architecture layout

- Frequency analysis of the linear powertrain model with ICE and EM.



- FEM analysis of the Primary shaft of the Dual Clutch transmission due to EM torque transmission during boost and recuperation.

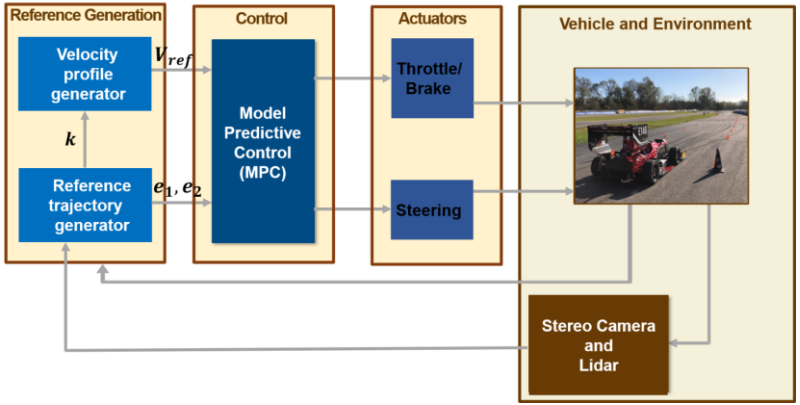


- **Future work plan:**
  - Simulation with a detailed driveline model.
  - Instrumentation and testing of the driveline components on a test bench of P2.5 Hybrid architecture with FCA-CRF.

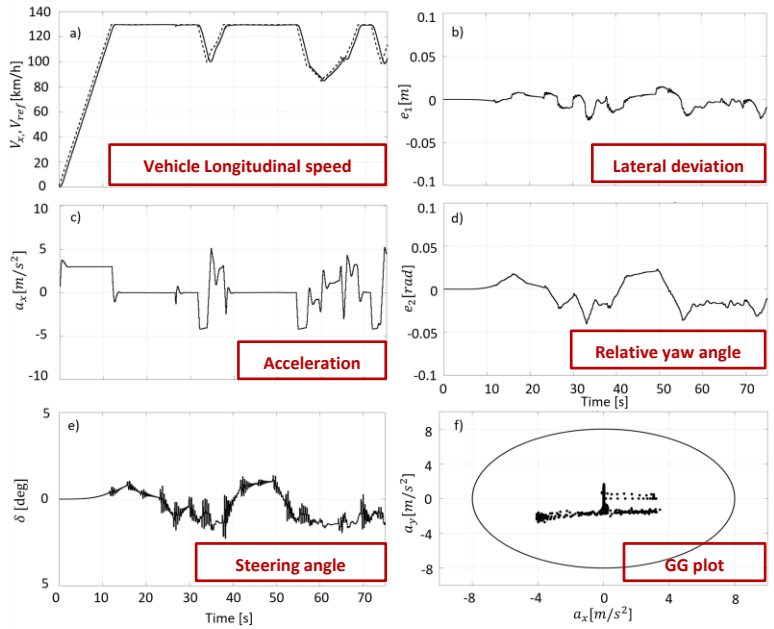
❑ Autonomous driving: Control based on MPC

***Objective*: Design, implementation and testing of control strategies and actuators for an Autonomous racing vehicle. They are being developed for an Electric vehicle(4WD) for the Formula student driverless competition and will be tested on a racetrack.**

- Combined lateral and longitudinal control based on Model Predictive Control.
- Reference velocity and trajectory generation based on the lane information obtained using the camera and lidar.
- Generate acceleration and steering angle signal to the actuators.



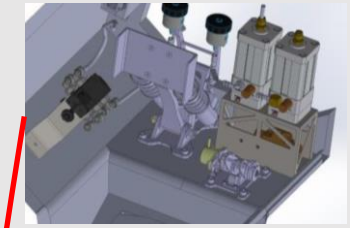
- ***Simulation results :***

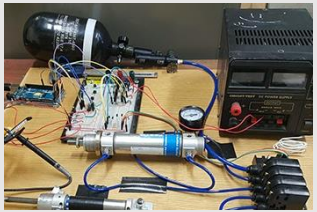


❑ Autonomous driving: Actuators

- Emergency braking system
- Hydro-pneumatic intensifiers to pressurize the braking circuit.
- Time of actuation < 0.15s
- Remotely controlled.

❑ Braking actuator



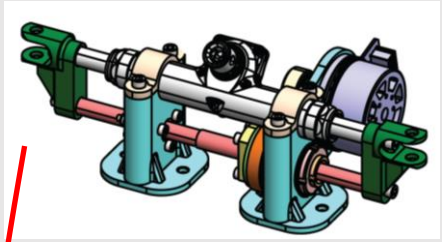


Design of actuators

Test bench setup

On vehicle implementation and testing

❑ Steering actuator



- BLDC Motor Maxon 150W, 24V
- Bosch Ball Screw
- CAN communication with dSpace

Publications

List of accepted papers

1. Irfan Khan, Stefano Feraco, Angelo Bonfitto, and Nicola Amati. " A Model Predictive Control Strategy for Lateral and Longitudinal Dynamics in Autonomous Driving." *Proceedings of the ASME 2020 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference,* 22nd International Conference on Advanced Vehicle Technologies (AVT). (Accepted for publication - DETC2020-22287).

2. Stefano Feraco, Angelo Bonfitto, Irfan Khan, Nicola Amati, and Andrea Tonoli. " Optimal Trajectory Generation Using an Improved Probabilistic Road Map Algorithm for Autonomous Driving." *Proceedings of the ASME 2020 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference,* 22nd International Conference on Advanced Vehicle Technologies (AVT). (Accepted for publication - DETC2020-22311).

THANKS FOR YOUR ATTENTION