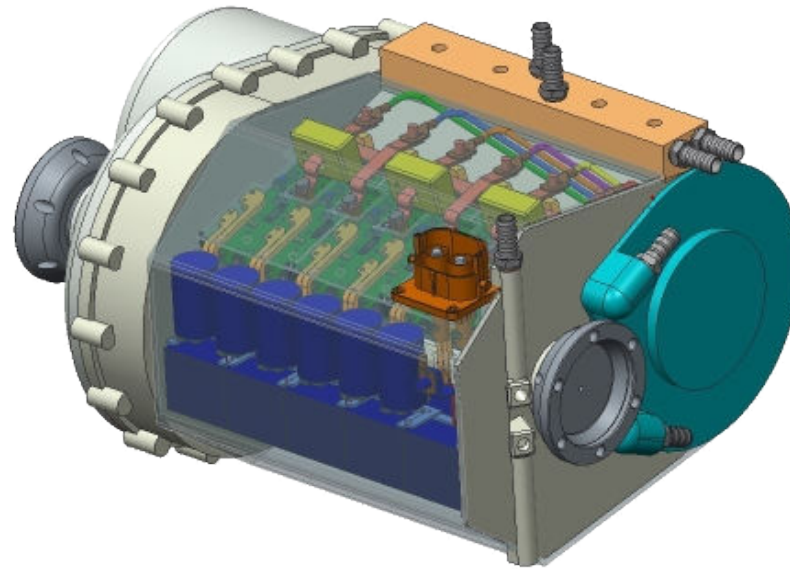


Innovative and Highly Integrated Modular Electric Drivetrain

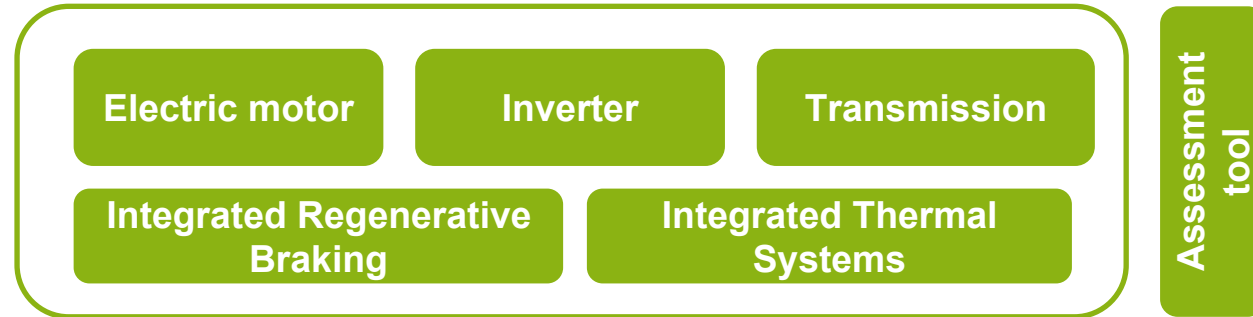
Jonas Hemsén
Daniel Kieninger
Prof. Dr. L. Eckstein
Mathias R. Lidberg
Dr. ir. H. Huisman
Prof. Dr. E.A. Lomonova



Daniel Oeschger
Charley Lanneluc
Olivier Tosoni
Patrick Debal
Michael Ernstorfer
Rémi Mongellaz

Overview

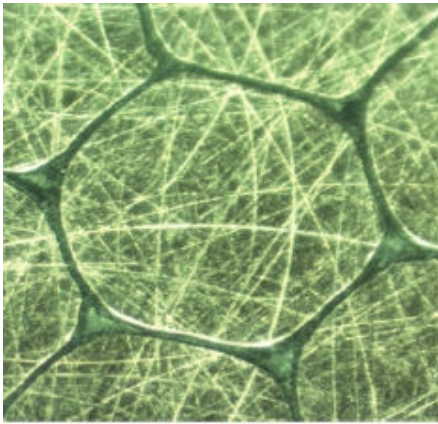
Modular Powertrain



- R&D on innovative modular powertrain platform including electric machine, transmission and inverter in one housing
- An regenerative braking with adaptive brake force distribution and extended range of energy recuperation
- R&D on assessment tool in order to be able to virtually design, simulate, optimize and select the right components depending on vehicle specifications
- Full scale demonstration integrated in a small BEV.

Electric Motor

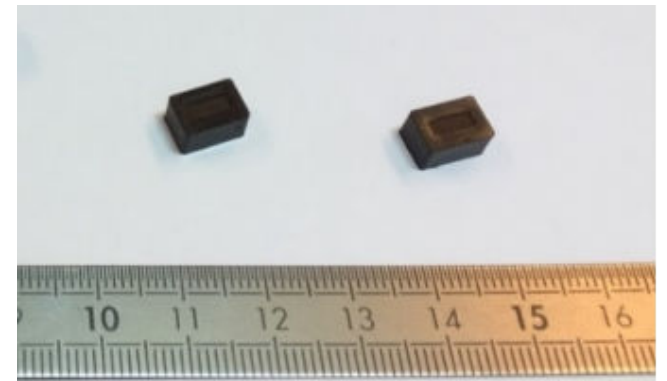
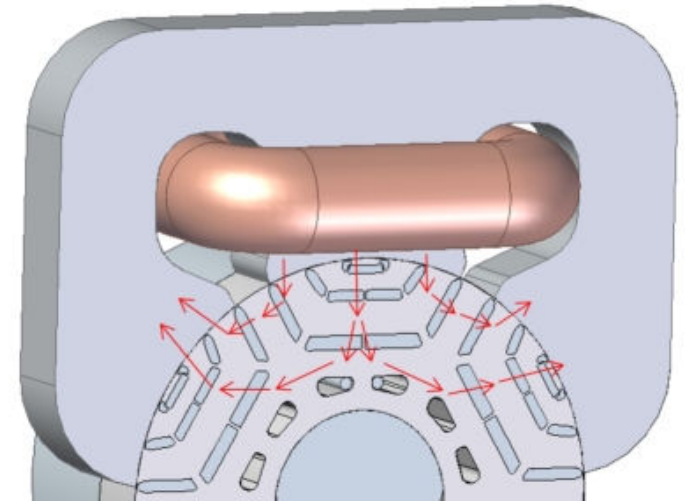
- High-speed permanent magnet assisted Synchronous Reluctance Motor – 6 phases
- 160 Nm, 22.500 rpm, 134 kW
- Uses „Formed Litz Wire“



		Efficiency [%] including winding, iron and bearing losses															
Torque [Nm]	160	54,82	70,73	82,66	90,16	92,88	94,25	95,04	95,55	95,89	96,12						
	140	57,75	73,11	84,26	91,08	93,52	94,72	95,41	95,85	96,13	96,32	96,41	96,10				
	120	60,86	75,55	85,85	91,98	94,13	95,17	95,76	96,12	96,35	96,50	96,60	96,42				
	100	64,21	78,07	87,43	92,86	94,71	95,60	96,08	96,37	96,55	96,66	96,72	96,68	95,81			
	80	67,79	80,65	89,01	93,71	95,27	96,00	96,38	96,60	96,72	96,78	96,81	96,83	96,35	95,30	93,77	
	60	71,74	83,37	90,61	94,55	95,80	96,36	96,64	96,78	96,84	96,86	96,84	96,81	96,73	96,13	95,18	93,89
	40	76,09	86,22	92,25	95,39	96,35	96,74	96,91	96,98	96,99	96,96	96,91	96,85	96,90	96,69	96,21	95,47
	20	81,55	89,61	94,13	96,35	96,96	97,17	97,22	97,20	97,14	97,06	96,97	96,87	96,61	96,55	96,70	96,40
	15	83,51	90,75	94,71	96,59	97,05	97,18	97,17	97,11	97,01	96,90	96,78	96,65	96,33	96,01	96,23	96,44
	10	86,32	92,35	95,51	96,89	97,16	97,17	97,08	96,94	96,79	96,63	96,47	96,30	95,89	95,49	95,11	95,70
	5	90,88	94,73	96,50	96,99	96,85	96,58	96,27	95,96	95,66	95,36	95,06	94,78	94,10	93,46	92,86	92,28
		250	500	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	12500	15000	17500	20000
		Speed [rpm]															

Magnet Injection Moulding

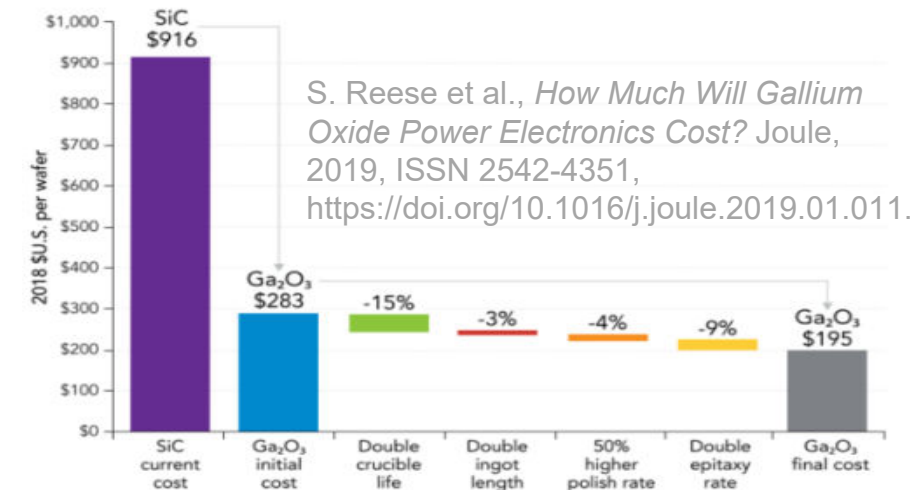
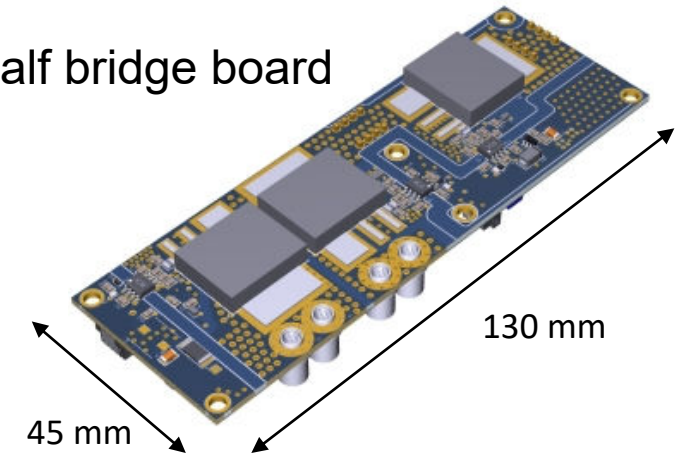
- Magnets are injection moulded into the rotor
- Permanent magnet material is dissolved in a plastic matrix
- During injection into the rotor cavities a strong magnetic field is applied
- « organic » shape of magnets possible
- Potential for low production effort as all magnets are injected at the same time



Inverter

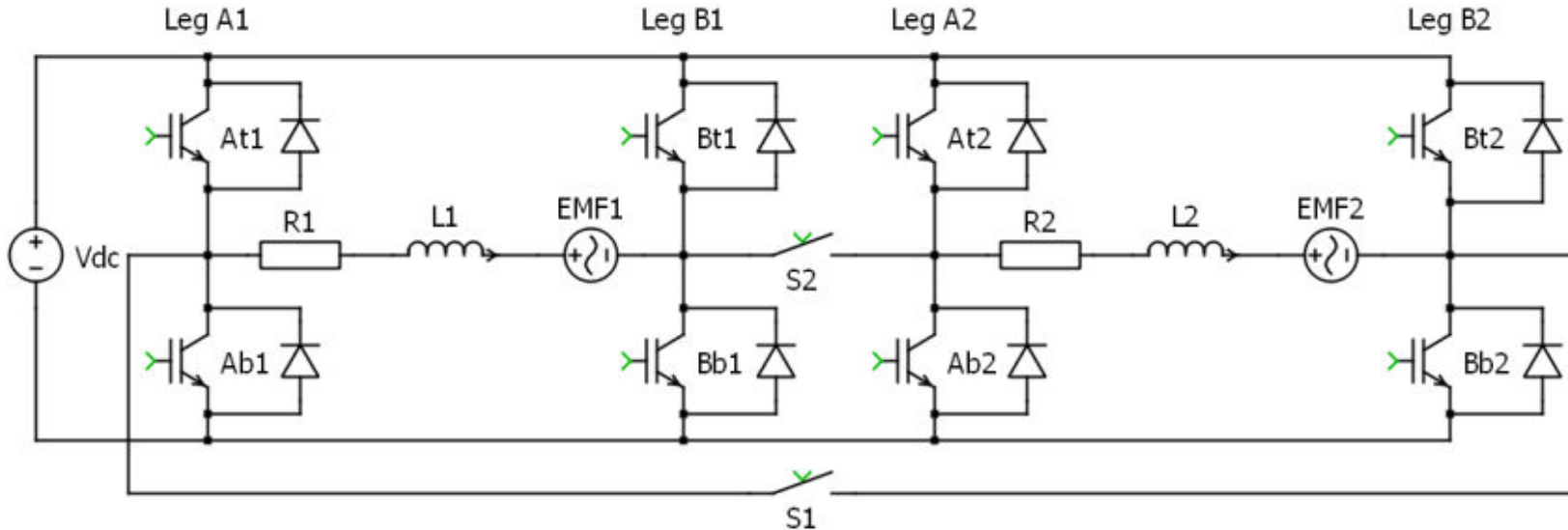
- Gallium Nitride (GaN) switch based
- Very compact
- Allows for ultra fast switching with low losses
- Low on-resistance
- Cost GaN wafer <<< SiC wafer

Half bridge board



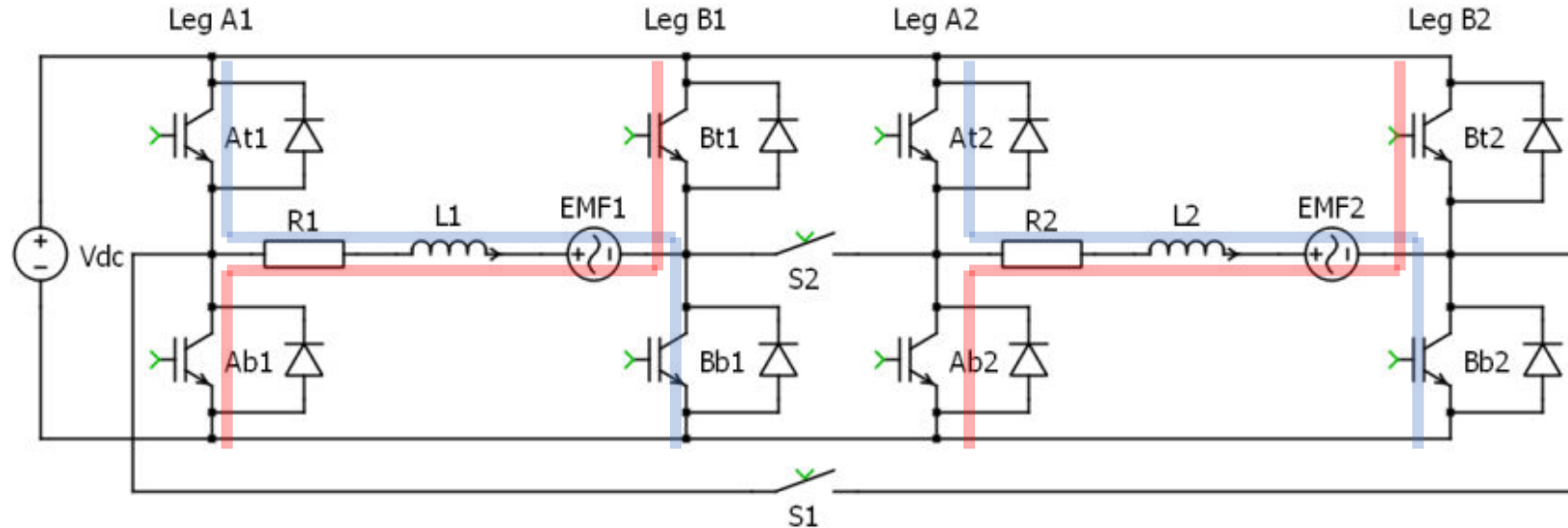
Winding Reconfiguration

- « *Series* » or « *individual* » operation of 2 motor phases
- Saving of losses when low power is requested



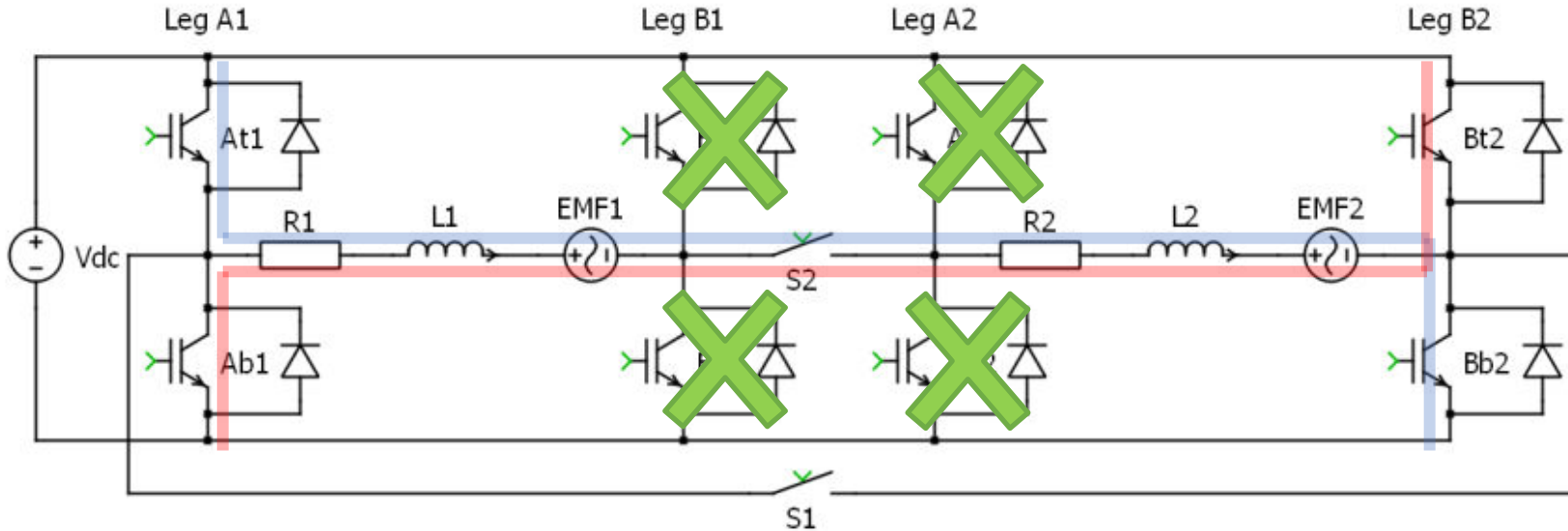
Winding Reconfiguration

- S1 and S2 are open: Individual operation of phases
- Full voltage at each phase



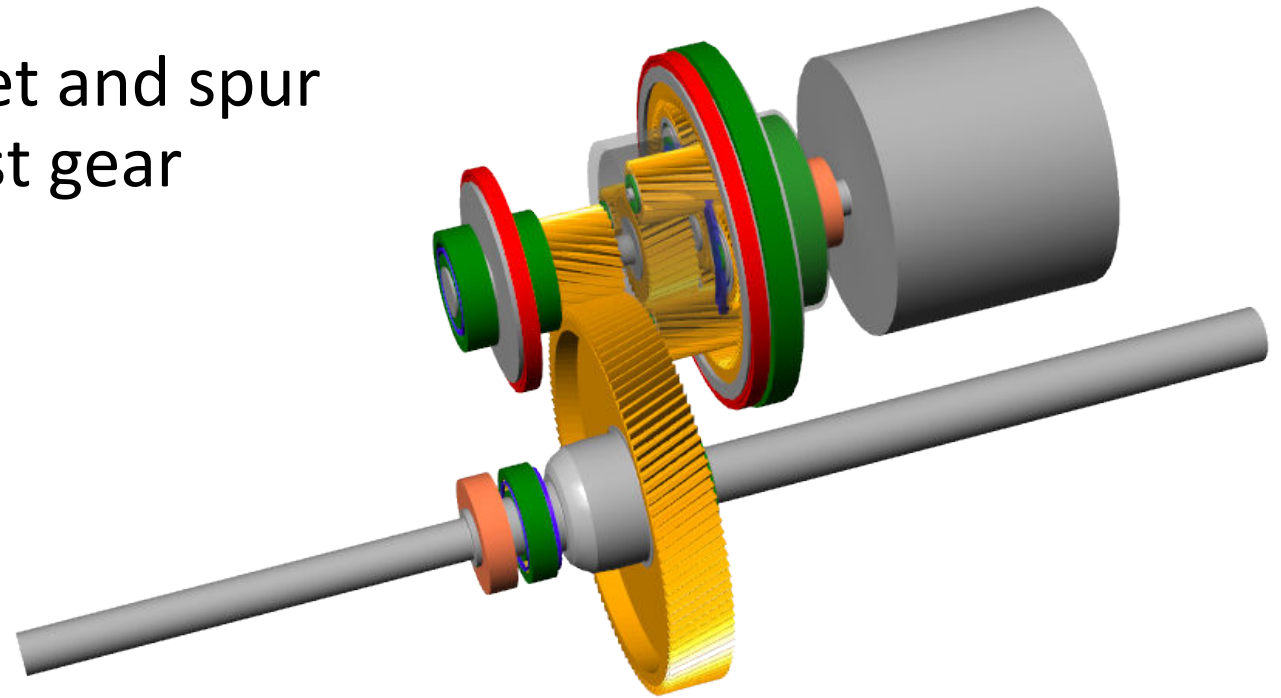
Winding Reconfiguration

- S2 is closed: Series operation of the phases
- $\frac{1}{2}$ of full voltage at each phase



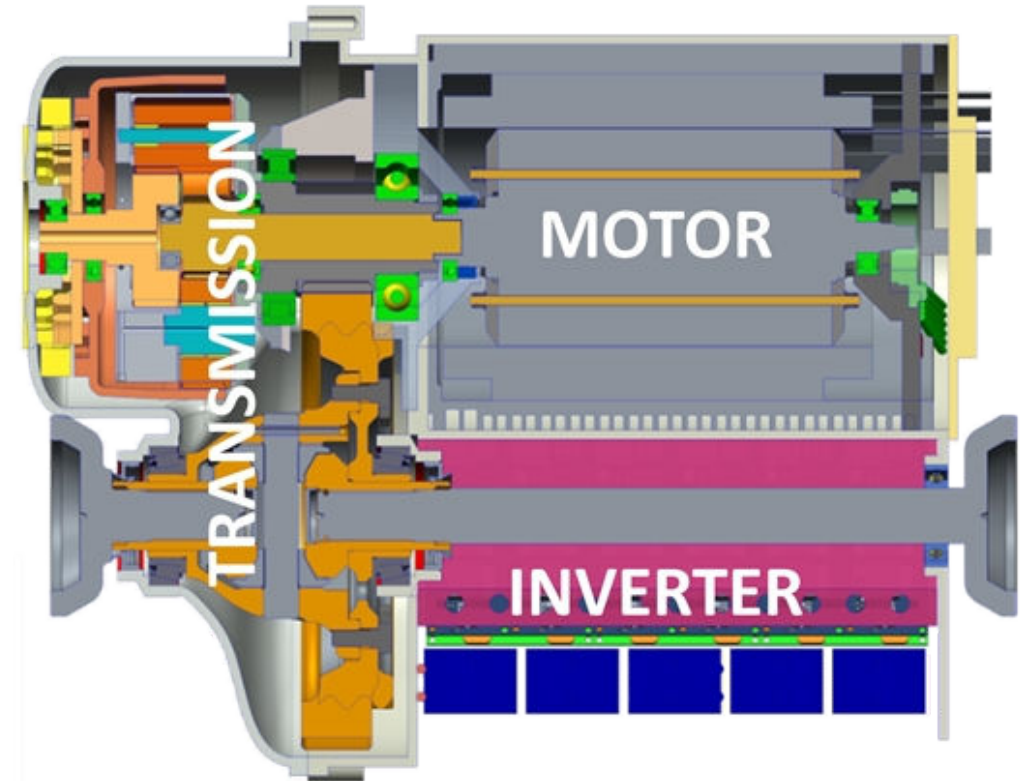
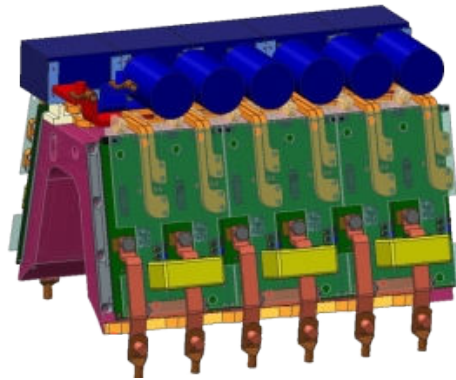
Transmission

- Dual ratio (12.2 / 21.7) automatic transmission
- Combination of Ravigneaux gear set and spur gear stage for very high ratio in first gear

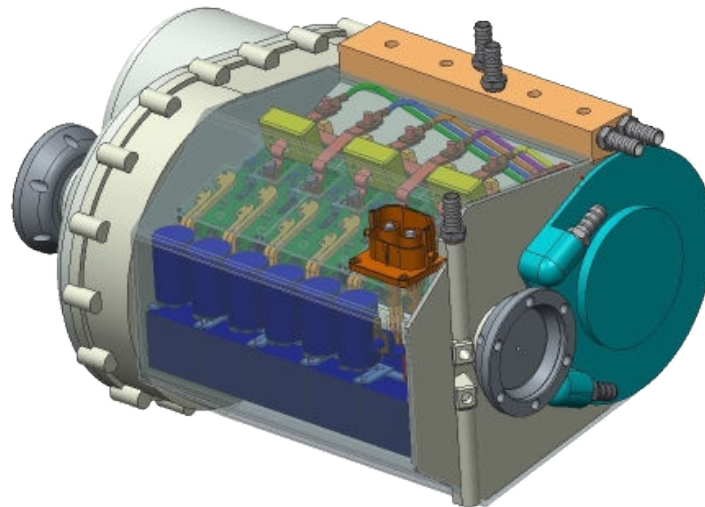


Module Assembly

- Improved efficiency through high motor speed
- Cost reduction:
 - Reduced part count
 - Less interfacing
- Compact unit: L 513 x W 405 x H 275
- Max torque at wheels: 3100 Nm



Thank you for your attention.
Any questions are welcome!



For more info visit <http://www.moduled-project.eu/>

Holistic Design and Assessment Tool

