EE-565 – W1
INDUSTRIAL ELECTRONICS II
COURSE INTRODUCTION

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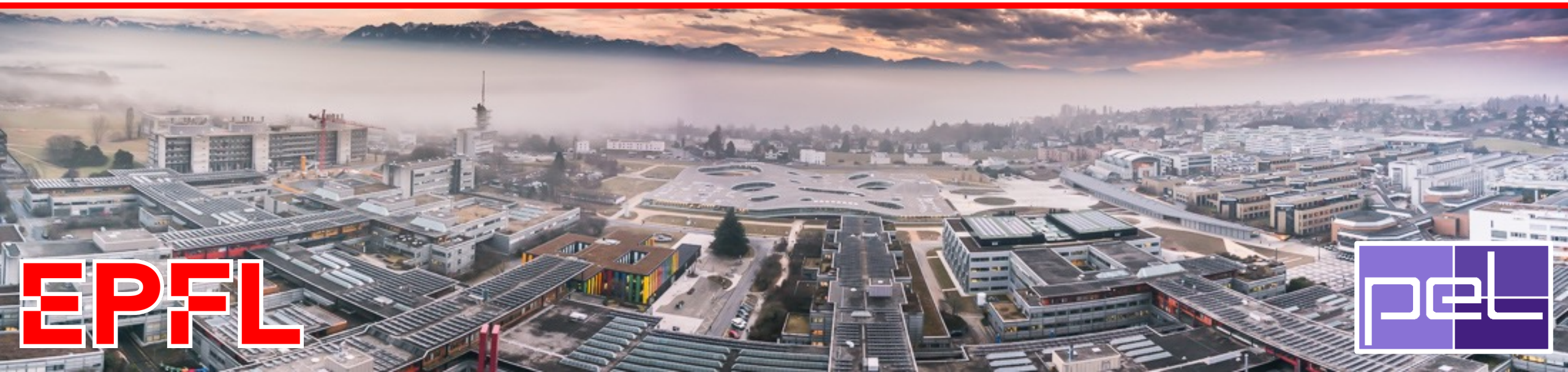
Power Electronics Laboratory
EPFL
Switzerland



INDUSTRIAL ELECTRONICS II

Course Aim and Organization

COURSE AIM

The aim of the course is to introduce and explain the main concepts of **High-Performance Variable Speed Electric Drives**

We will deal with modeling and simulation of:

Electrical Machines

- ► DC Machines
- ► Induction Machines (IMs)
- ► Wound Rotor Synchronous Machines (SMs)
- ► Permanent Magnet Synchronous Machines (PMSMs)

Power Electronics

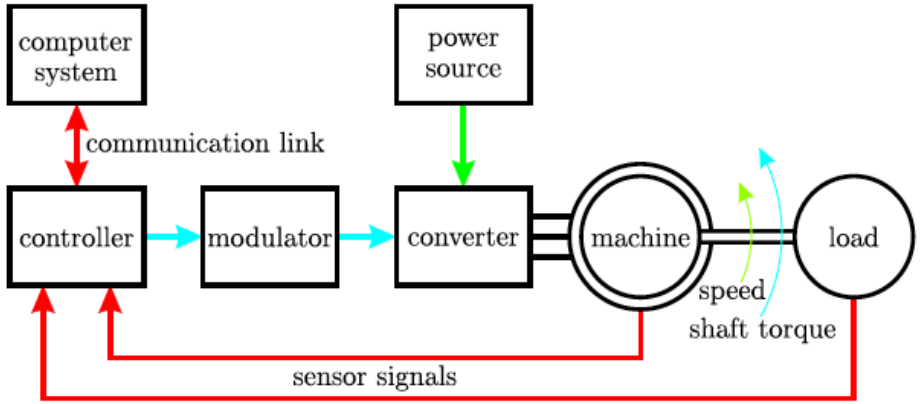
- ► DC-DC converters – for DC Machines
- ► DC-AC converters – for AC Machines

(many concepts taken from EE-465)

Control of Variable Speed Drives

- ► Scalar Control – V/f
- ► Field Oriented Control (FOC) – Vector Control
- ► Direct Torque Control (DTC)

(implementation mostly based on PI controllers – EE-465)



COURSE SCHEDULE

Lectures
- Slides, Blackboard, PLECS
- ELD 120 (Monday)

Laboratory Exercises
- PLECS, PETS HIL, PETS
- ELD 040

Exam
- Three reports during the semester: 40% of the grade
- Oral exam: 60% of the grade

Teaching Assistants

- **Gaia Petrillo**
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- **Israel Yepez Lopez**
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	Monday	Tuesday	Wednesday	Thursday	Friday
8-9					
9-10					
10-11		ELD 040			
11-12					
12-13					
13-14					
14-15					
15-16					
16-17	ELD 120				
17-18					
18-19					
19-20					

(Note: the course schedule may be subject to changes)

COURSE SCHEDULE

	Dates	Class 1 - Monday	Class 2 - Tuesday	Reports Deadlines	
Week 1	17/18 February	Introduction, Electromechanical Energy Conversion	RT-HIL + PETS + Control RL single phase		
Week 2	24/25 February	DC Machine: Modeling, Characteristics	RT-HIL + PETS + Control RL three phase		
Week 3	3/4 March	DC Machine: Control	DC Machine Modeling		
Week 4	10/11 March	Sensors (speed, position, current)	DC Machine Control (offline + RT-HIL)		
Week 5	17/18 March	AC Windings: Modeling, MMF and Space Vectors	DC Machine Control (PETS)		
Week 6	24/25 March	Induction Machine Modeling	DC Machine Control (PETS)		
Week 7	31/01 Mar/April	Induction Machine Scalar Control	Induction Machine Modeling	REPORT DC Machine	7/04/2025
Week 8	7/8 April	Induction Machine: Field Oriented Control Basics	Induction Machine V/f Control (offline + RT-HIL)		
Week 9	14/15 April	Induction Machine: Direct/Indirect Flux Estimation	Induction Machine V/f Control (HIL + PETS)		
Week 10	21/22 April	BREAK	BREAK		
Week 11	28/29 April	Induction Machine: Direct Torque Control	Induction Machine FOC (offline + RT-HIL)	REPORT IM V/f	5/05/2025
Week 12	5/6 May	Synchronous Machine Modeling	Induction Machine FOC (offline + RT-HIL)		
Week 13	12/13 May	Synchronous Machine: Field Oriented Control	Induction Machine FOC (RT-HIL + PETS)		
Week 14	19/20 May	Synchronous Machine: Salient Poles, Reluctance	Induction Machine FOC (RT-HIL + PETS)		
Week 15	26/27 May	Doubly Fed Induction Machine	Induction Machine FOC (RT-HIL + PETS)	REPORT IM FOC	2/06/2025

Legend: Lecture Session | Exercise Session

(Note: the course schedule may be subject to changes)

EXERCISE SESSIONS

Exercise Sessions will be based on the **Power Electronics Teaching Setup (PETS)**

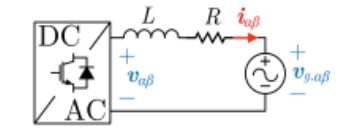
- **Theory** is presented during the lectures
- **Offline simulations** based on PLECS
- **Real-time Hardware-In-the-Loop** testing using PETS RT-HIL
- **Experimental validation** on PETS

Learning with your PETS

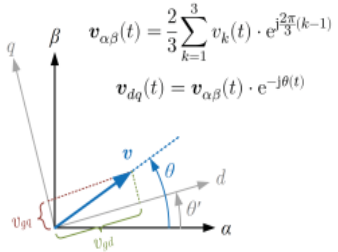
Power Hardware

Control Software

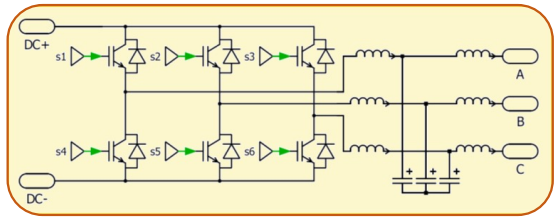
Theory

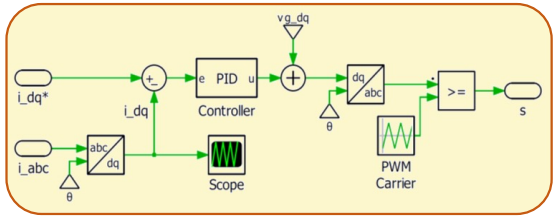


$$\boldsymbol{v}_{\alpha\beta} = R\,\boldsymbol{i}_{\alpha\beta} + L\frac{\mathrm{d}\boldsymbol{i}_{\alpha\beta}}{\mathrm{d}t} + \boldsymbol{v}_{g,\alpha\beta}$$

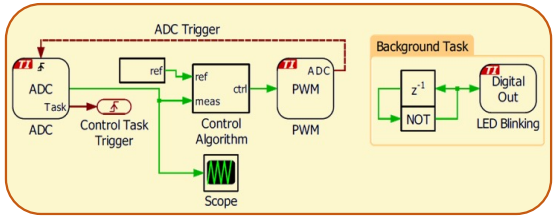


Offline Simulations





HIL Testing

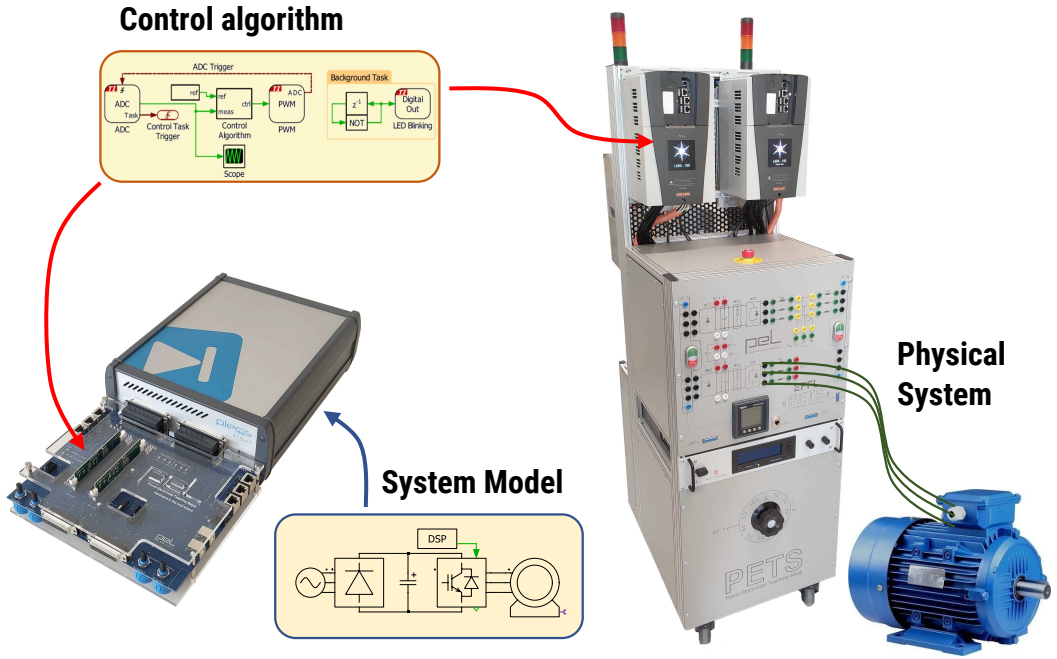


PETS

TEMPLATES AND REPORTS

PETS Template

- A PLECS template will be provided for use with PETS
- RT-Box block, to deploy the model of the physical system (for offline and HIL simulations)
- DSP blocks (x2) to deploy control algorithms
- PLECS Coder will be used to generate executable code



Reporting

- Latex report templates will be provided
- Reports should be no longer than 10 pages each
- It is a technical report, not an essay
- Be precise, punctual, clear, and keep it simple
- Use graphics to convey your message better
- Acknowledge sources and references
- **Submissions deadlines are fixed**
- **Reports will account for 40% of the overall grade**

Report Submission on Moodle

- Upload your report in **pdf**
- Upload your **PLECS Model** for that report

VARIABLE SPEED DRIVES

Introduction

VARIABLE SPEED ELECTRIC DRIVES

Power Supply:
- AC: 1-phase, 3-phase
- DC: Battery

Power Electronic Converter:
- Unidirectional or Bidirectional
- Two-level or multilevel

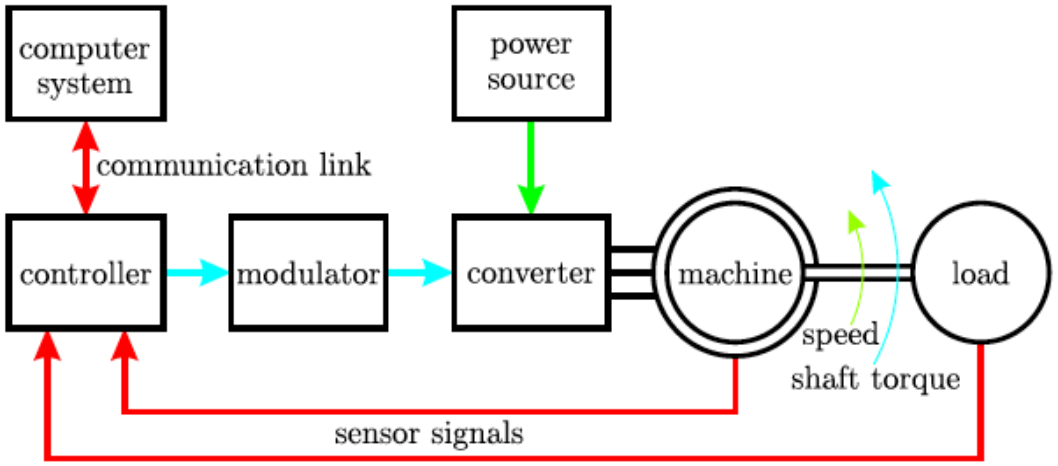
Load:
- Fan, pump, mechanical load

Controller:
- DSP, FPGA

Actuators:
- Pulse Width Modulator
- Gate Drivers

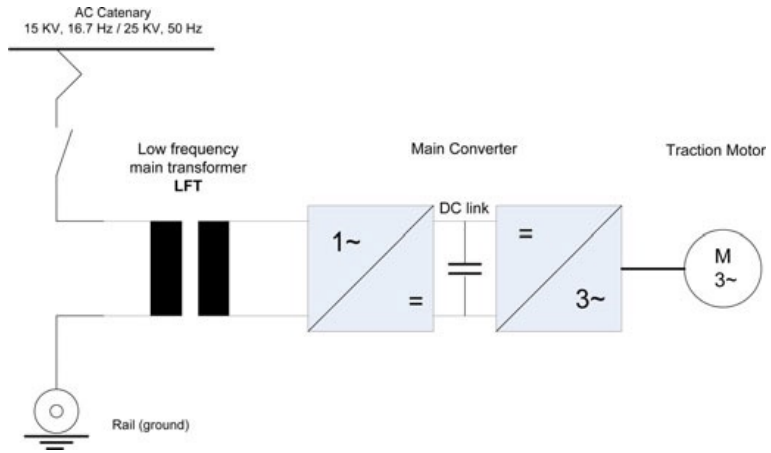
Sensors:
- Currents, Voltages, Speed, Angle

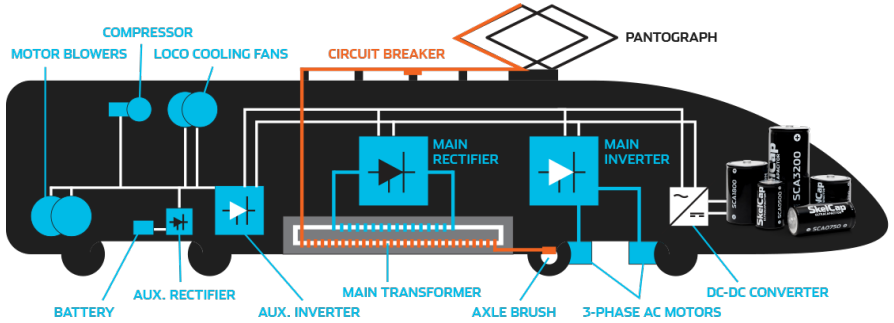
Protections:
- Overcurrents, Overvoltages/Undervoltages, Overspeed

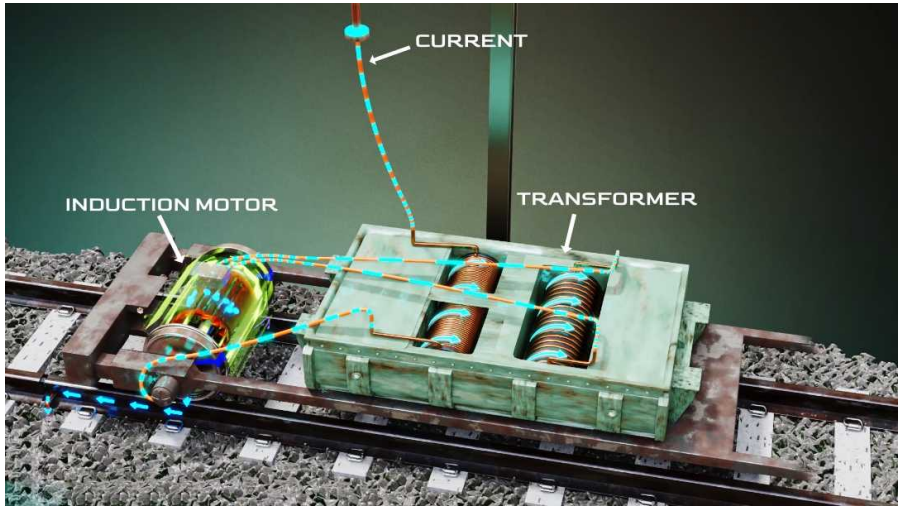


APPLICATIONS – PROCESS INDUSTRY

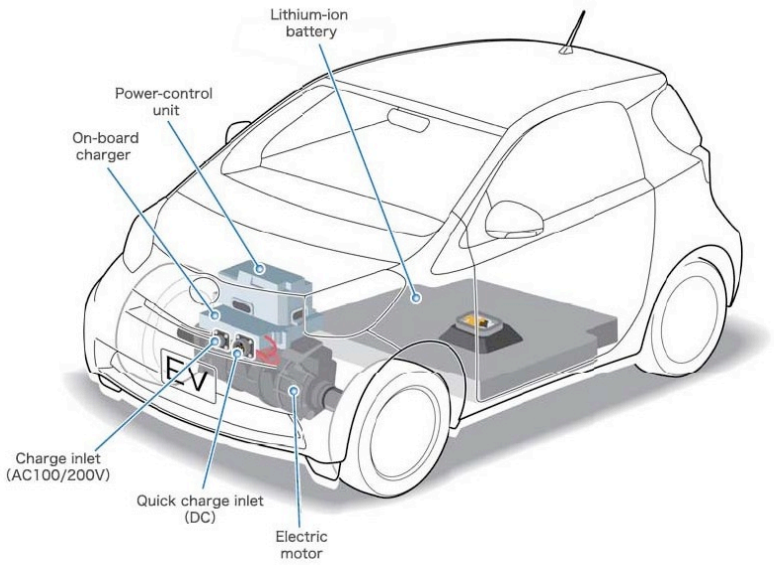
APPLICATIONS – RAILWAY TRACTION

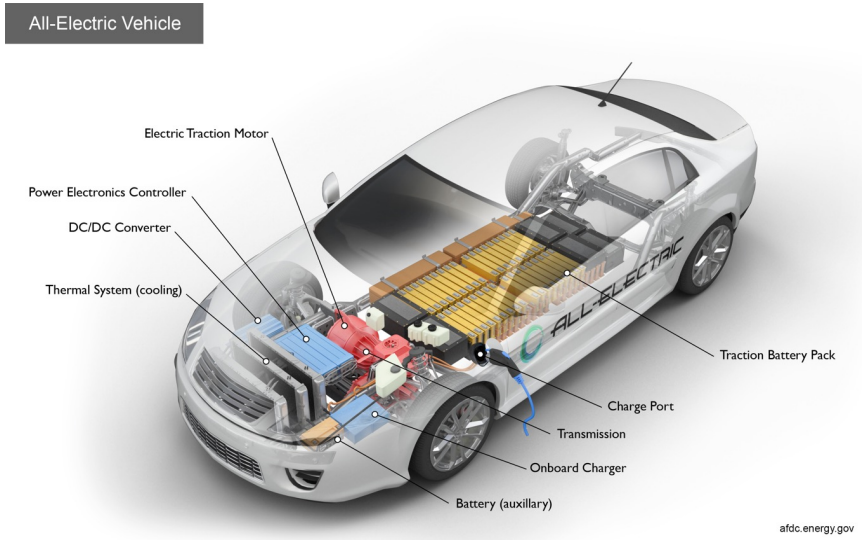


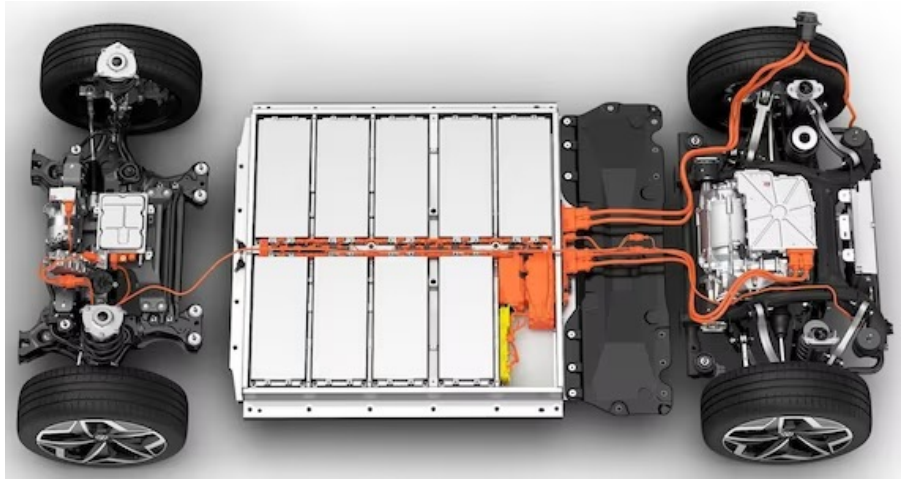


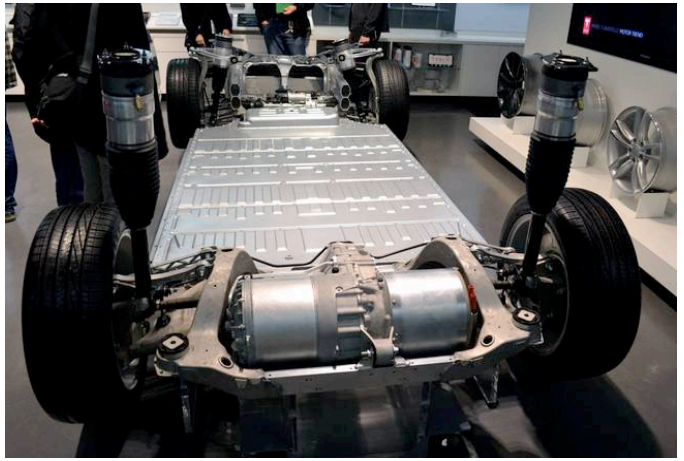


APPLICATIONS – AUTOMOTIVE

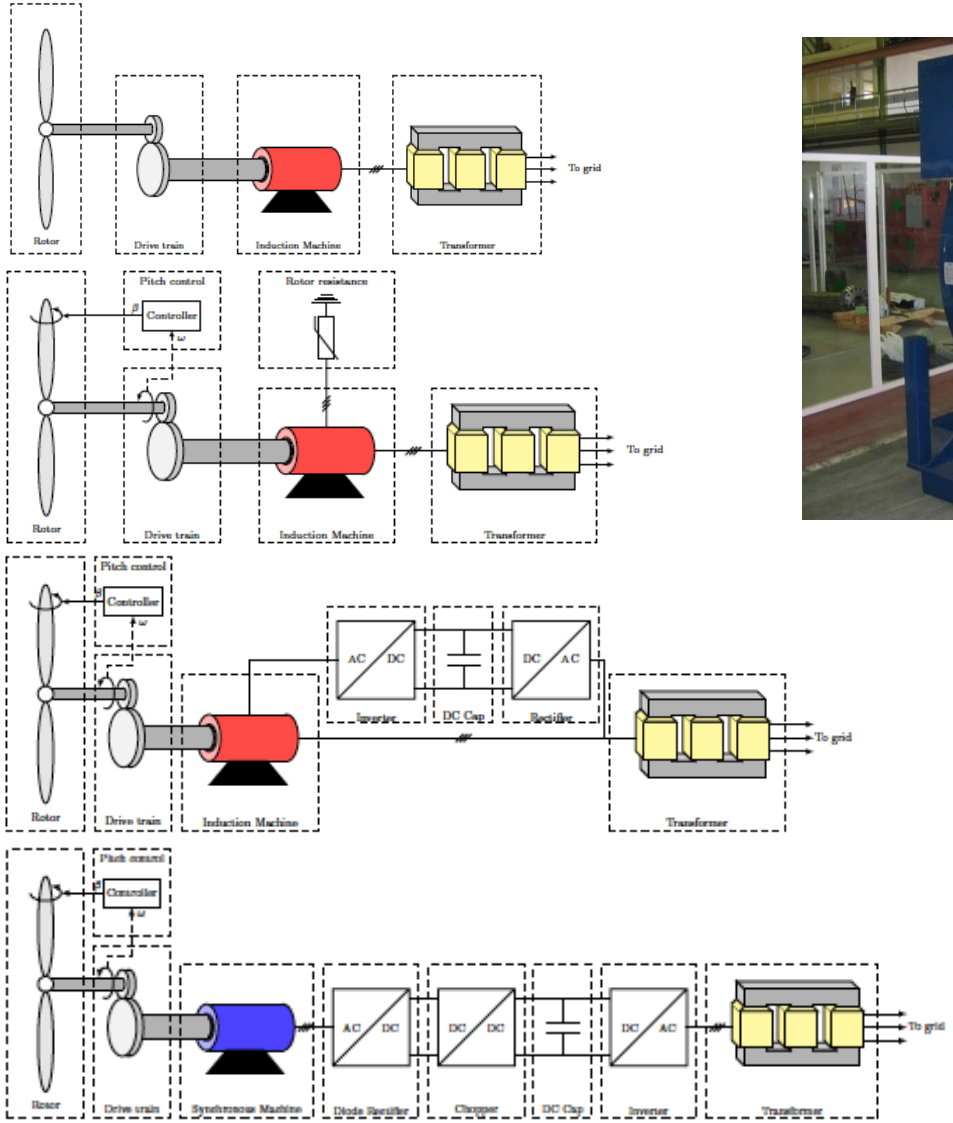




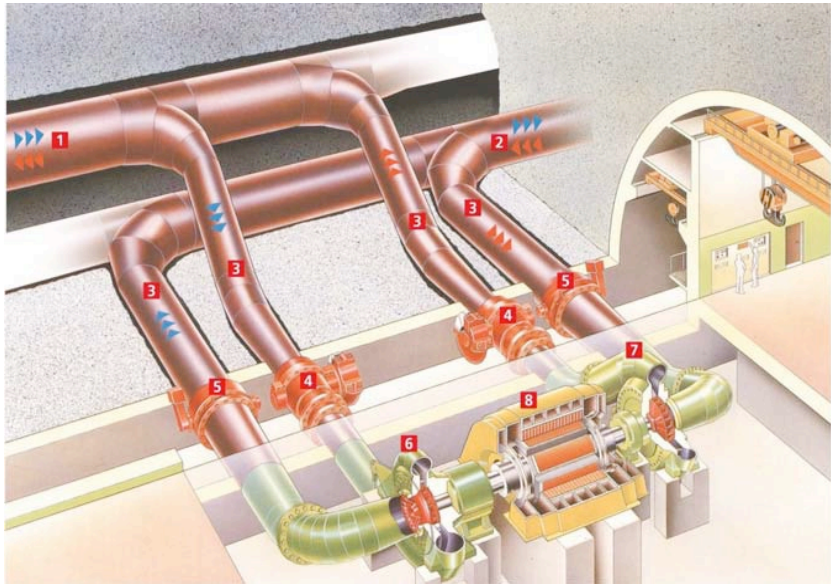


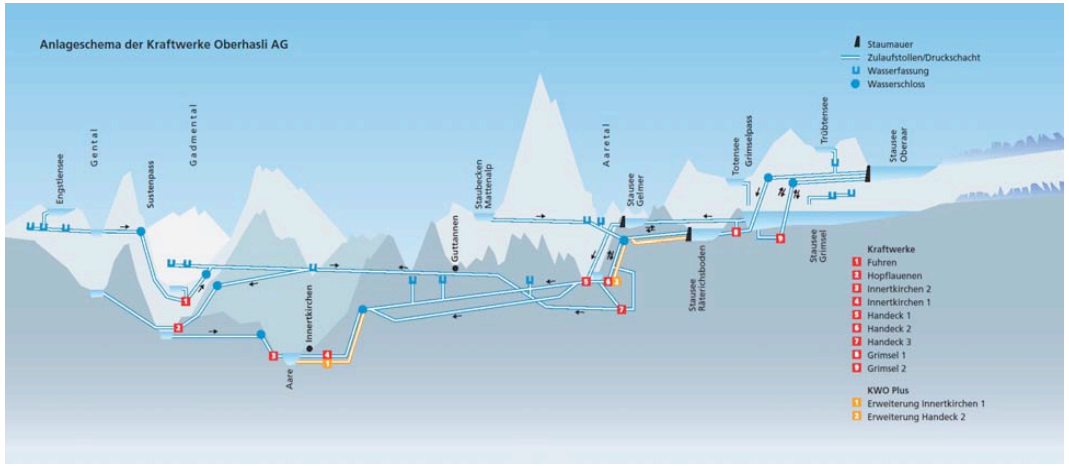


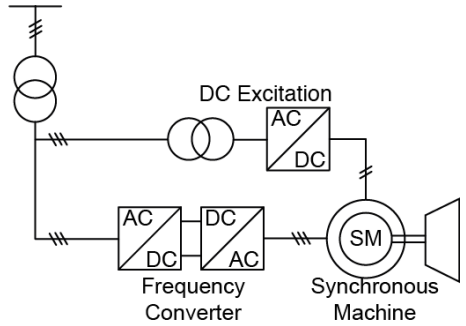
APPLICATIONS – WIND GENERATION

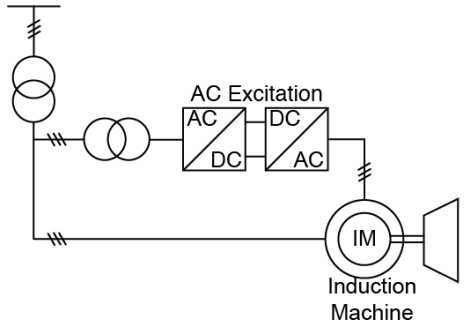


APPLICATIONS – PUMPED HYDRO STORAGE PLANTS









APPLICATIONS – HIGH POWER DRIVES