Engineering Literacy Online

MOOC to increase engineering literacy among secondary school teachers

Module 4 – E-Motor Introduction Version 2

Output 4 MOOC to increase engineering literacy among secondary school teachers

Co-funded by the Erasmus+ Programme of the European Union

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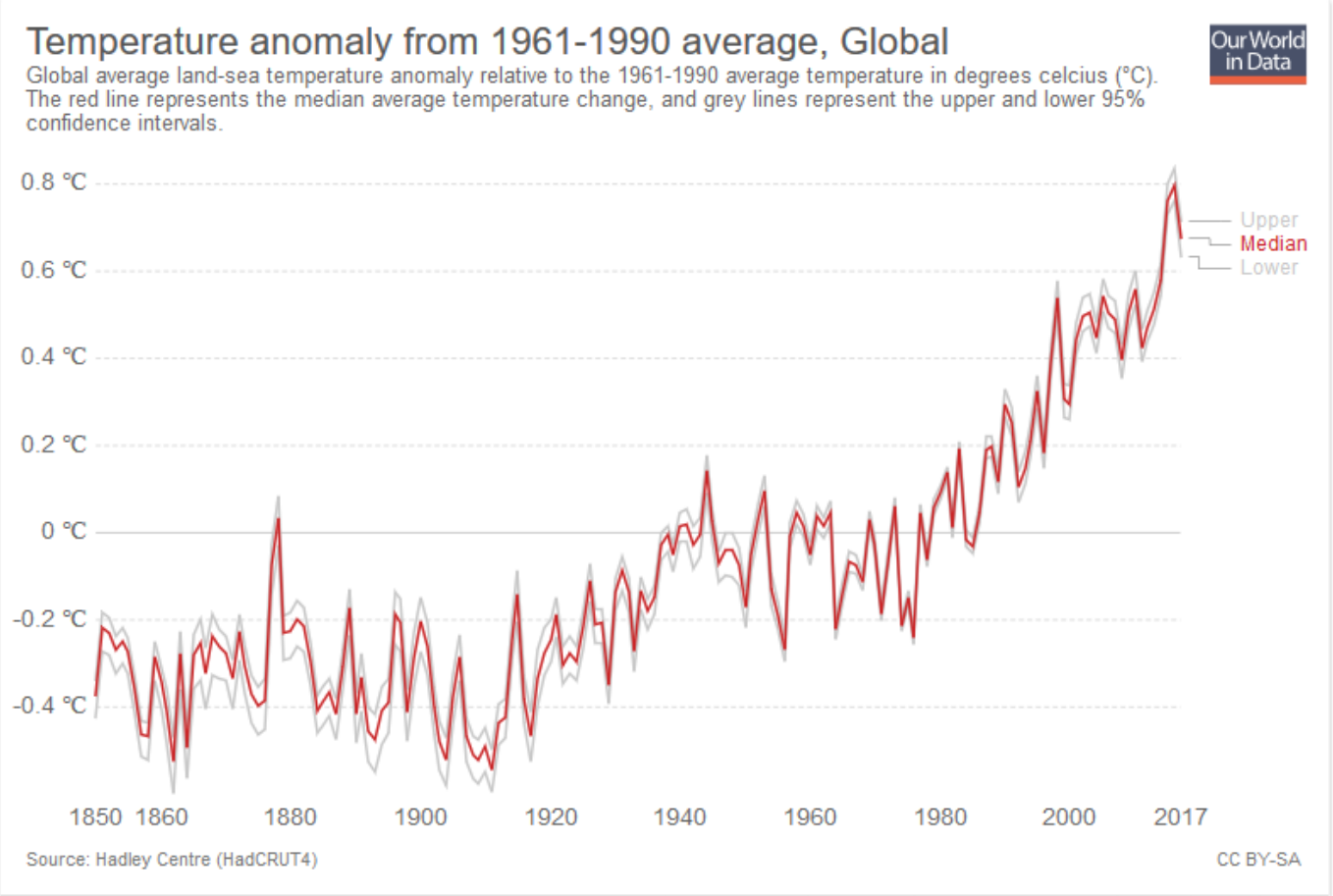
Did you know?



https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions

- Global warming is affecting us
  - rising sea level
  - more frequent and severe heat waves
  - increasing fire risks
  - Affecting animals and plants and potential famine
  - etc.
- An e-motor concept helps to reduce green house gases

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Did you know?

Health and Environmental Effects of Particulate Matter (PM)

Health Effects

The size of particles is directly linked to their potential for causing health problems. Small particles less than 10 micrometers in diameter pose the greatest problems, because they can get deep into your lungs, and some may even get into your bloodstream.

Exposure to such particles can affect both your lungs and your heart. Numerous scientific studies have linked particle pollution exposure to a variety of problems, including:

- premature death in people with heart or lung disease
- nonfatal heart attacks
- irregular heartbeat
- aggravated asthma
- decreased lung function
- increased respiratory symptoms, such as irritation of the airways, coughing or difficulty breathing.

People with heart or lung diseases, children, and older adults are the most likely to be affected by particle pollution exposure.

- Combustion engines produce fine particular matter (also called fine dust)
- WHO estimates 7 million death cases world-wide per year.
- An e-motor concept helps to achieve zero fine dust emission from cars

https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm

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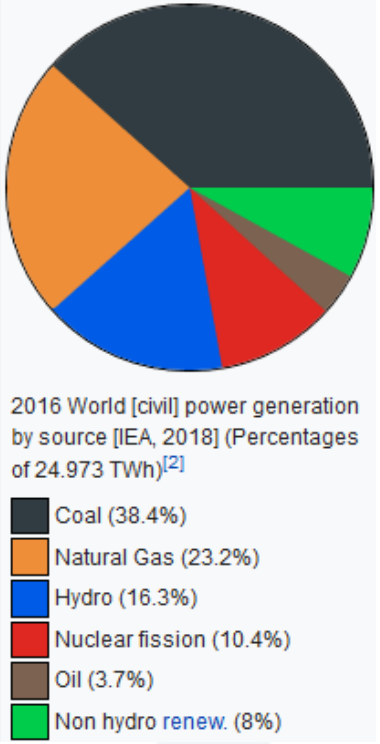

- Moving to an electric car concept does still not lead to zero CO_2 emission because power plants producing electricity emit CO_2.
  - Coal 38,4 %
  - Natural gas 23,2%
  - Oil 3,7 %
- Electric power plants produce CO_2

https://en.wikipedia.org/wiki/Wind_power

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Did you know?

Production Mercedes-Benz B-Class Electric Drive

- **Electric cars provide instant torque**, acceleration is faster. You apply current, you get acceleration, no matter where the rotor is. The energy conversion is about 90% efficient.
- **ICE (Internal Combustion Engine) efficiency is limited** by heat (thermodynamic laws) and friction. Average "thermal efficiency" is about 20%.
- **Car manufacturers in Germany and France** state that you have to consider the energy loss caused by producing electric power and transport via electric network as well (see previous slide, and [2]) the efficiency of the electric car is reduced to ca. 28%.

[1] https://www.quora.com/Why-are-electric-motors-able-to-provide-instant-torque-though-internal-combustion-engines-cannot

[2] https://en.wikipedia.org/wiki/Electric_car_energy_efficiency

[3] https://en.wikipedia.org/wiki/Mercedes-Benz_B-Class#B-Class_Electric_Drive

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What is System Engineering?

System engineering (https://en.wikipedia.org/wiki/Systems_engineering) is an **interdisciplinary field of engineering** and engineering management that focuses on how to design and manage complex systems over their life cycles. Nowadays the systems are so complex that it is impossible that one person can know everything. **Knowledge is shared in a team of experts. So DO NOT BE AFRAID that the system picture contains parts you may not understand, focus on those parts where you can contribute**.

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What elements do we need for an e-motor in the car?

Electronic Control Unit + Software

Electronic Control Unit with Software to control the currents of the motor (**it is like a PC motherboard but designed for Automotive**) and usually runs with 12 Volt power

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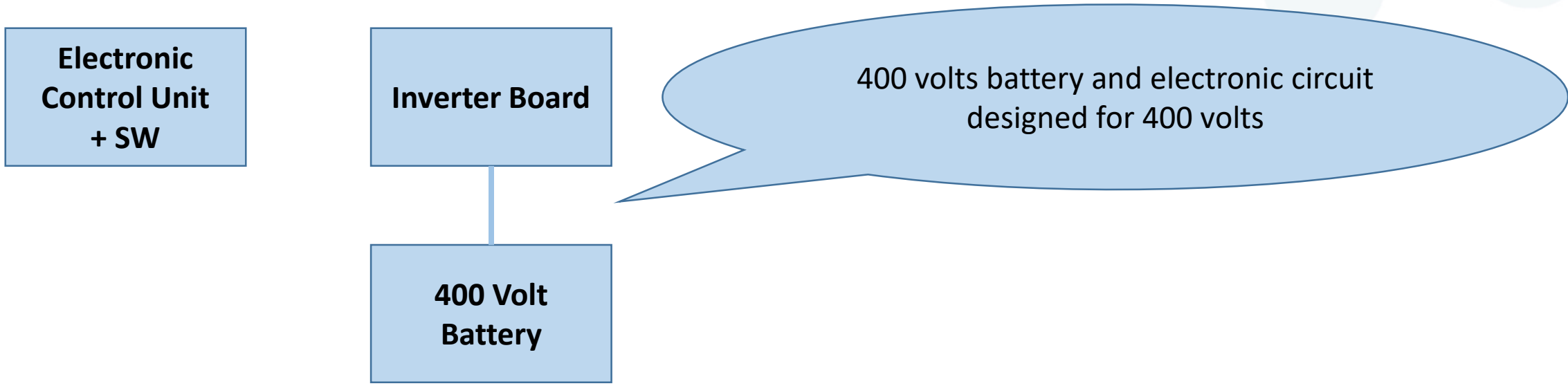
What elements do we need for an e-motor in the car?



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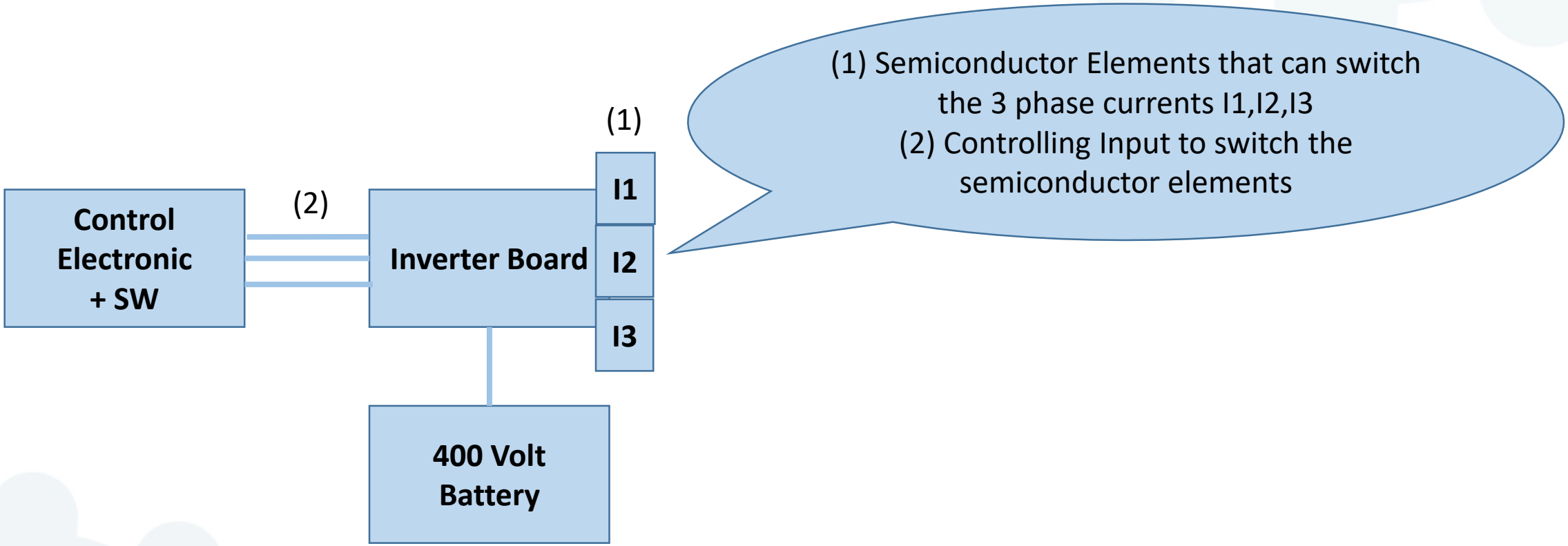

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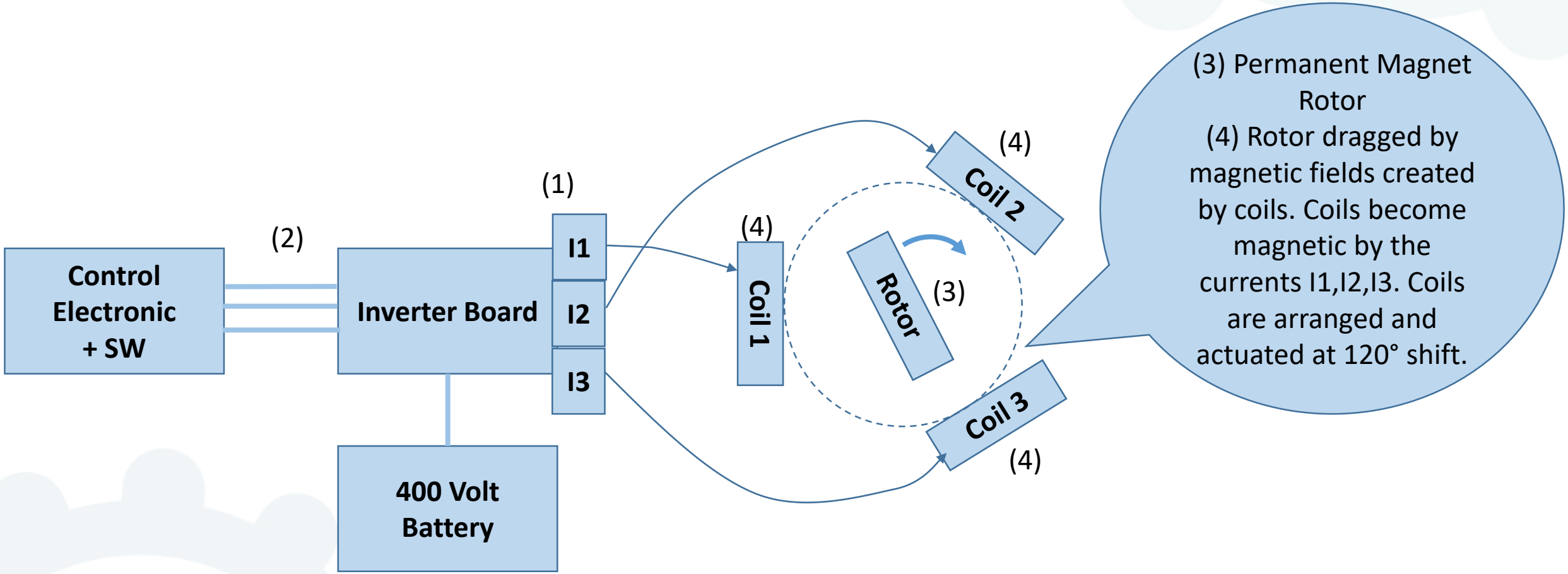

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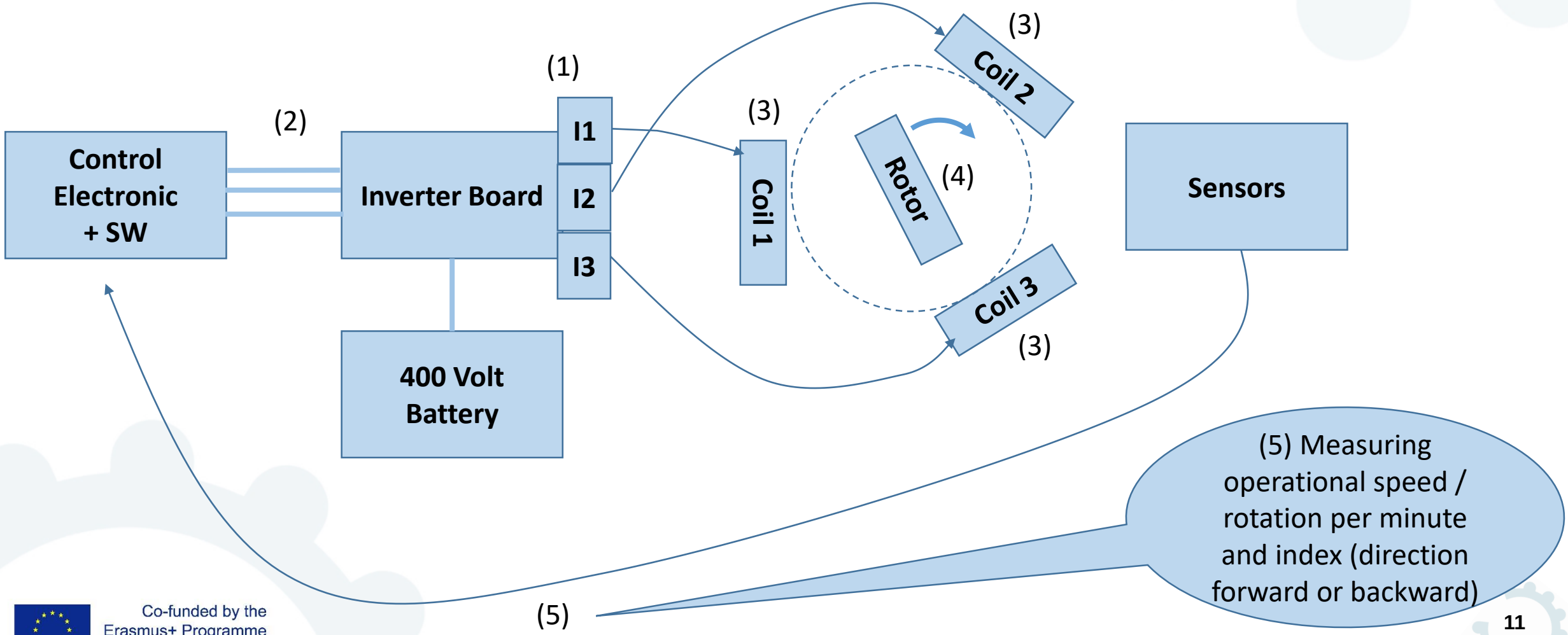

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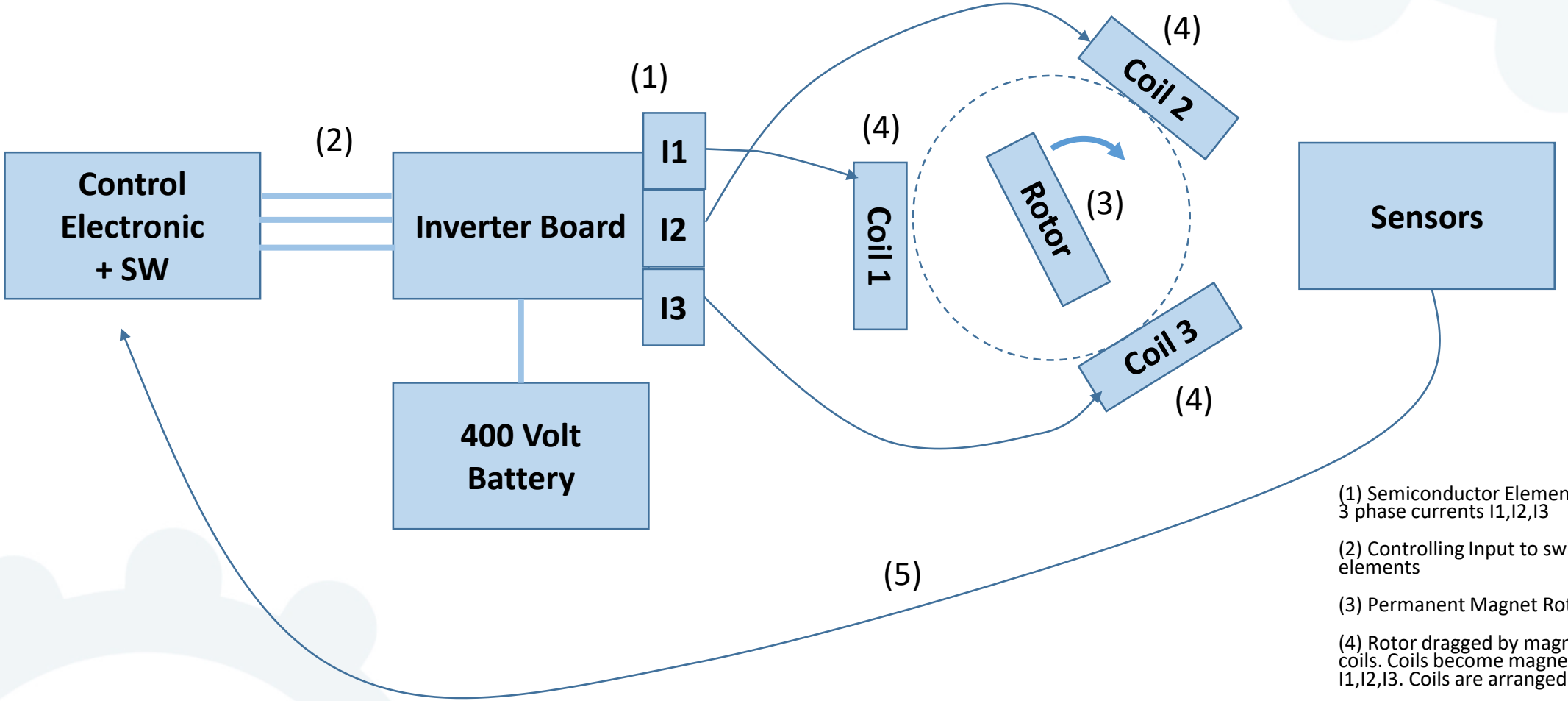

(1) Semiconductor Elements that can switch the 3 phase currents I1,I2,I3

(2) Controlling Input to switch the semiconductor elements

(3) Permanent Magnet Rotor

(4) Rotor dragged by magnetic fields created by coils. Coils become magnetic by the currents I1,I2,I3. Coils are arranged at 120° shift.

(5) Measuring operational speed / rotation per minute and index (direction forward or backward)

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Why are all subjects addressed?

System engineering integrates the knowledge of different disciplines.

Physics
Chemistry
Mathematics
Biology
Ethics
Informatics
Language
… and more …

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Physics

Current – to create magnetic fields with the coils and to drag the rotor

Voltage – provided by a battery to run the e-motor

Electric circuit – to create the Electronic Control Unit and the Inverter Board

Semiconductors – elements used to build the electronic and also to switch the currents

Magnets – the rotor is a permanent magnet

Magnetic fields – created by controlling currents for the coils

Coils – Windings of e.g. copper which create a magnetic field when providing current

Bus (**OSI layer model**) - to communiacte the speed, index, and state of the e-motor to the vehicle

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Chemistry

400V **Lithium (Li) Battery** – to provide the power for the e-motor, Lithium (Li) as an element

Silicon (Si) – element to build semiconductors

Rare Earth Materials – to create permanent magnets (for rotors) Element Neodymium (Nd) is important in magnet production.

Plumb (Pb) according to environmental norms is not allowed in building electronics (Electronic Control Unit, Inverter Board) any more since the 90s.

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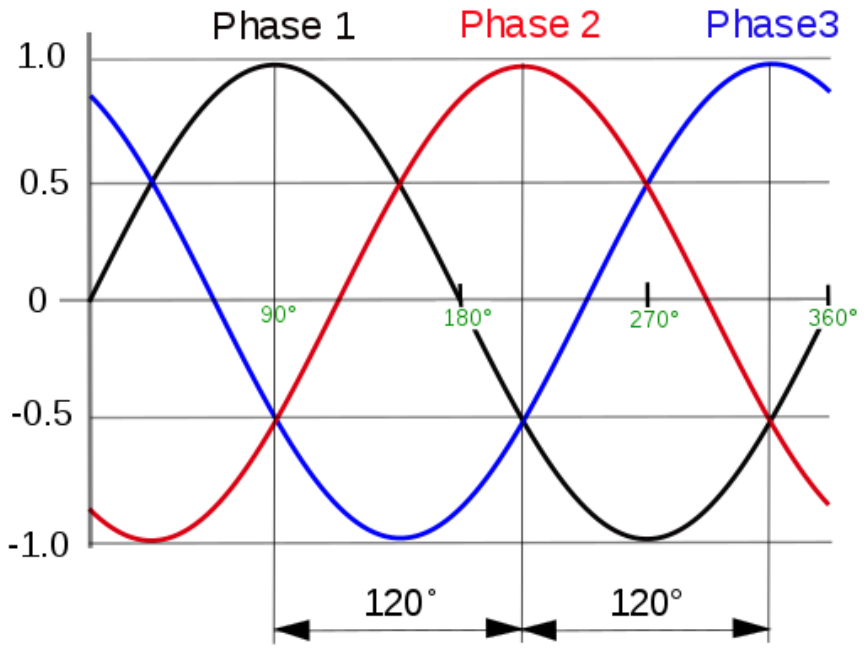
Mathematics

Sin, cos functions – to program the controller with a 120 degree **phase shift** to actuate the three semiconductor elements that can switch the 3 phase currents I1,I2,I3

Angle speed – to calculate the speed of the rotor



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Biology

No CO_2 emission – by not using a combustion engine any more

No NO_x emission – no NO_x gases which are usually produced from the reaction among nitrogen and oxygen during combustion of fuels.

Zero Emission – is that possible? The answer is no, since electric power is produced by plants which produce CO_2.

Lithium disposal – possibility of recycling (like with rechargeable batteries)

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Ethics

Change of Society – accepting problems of global warming and contributing to a healthy climate and world

Change by politics – no combustion engines allowed in large cities any more in future, the reduction of CO2 emission by law (Euro6 norm, etc.).

Global industry change – petroleum industry redirecting investments to building more electric power and batteries.

Global conflicts – what happens when petroleum industry is decreasing and countries depend on that industry?

Open Innovation Mindset – Building future city and e-mobility service scenario.

Ask the new generation to hold us solving these issues.

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Informatics

Usually the software is programmed with **standard C**.

Programming rules for Automotive SW development are applied by all companies (MISRA standard)

Software

- **SW Program to control the phase currents** based on the sin function and a 120 degree phase shift
- **SW Program to calculate the rotation per minute** based on frequency input.
- **SW Program to read the index sensor** and know the direction of the motor

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Language

Development of e-motor concepts is international involving Europe, USA, China, etc. The common language is English.

Technical English is needed to provide communication between the international teams.

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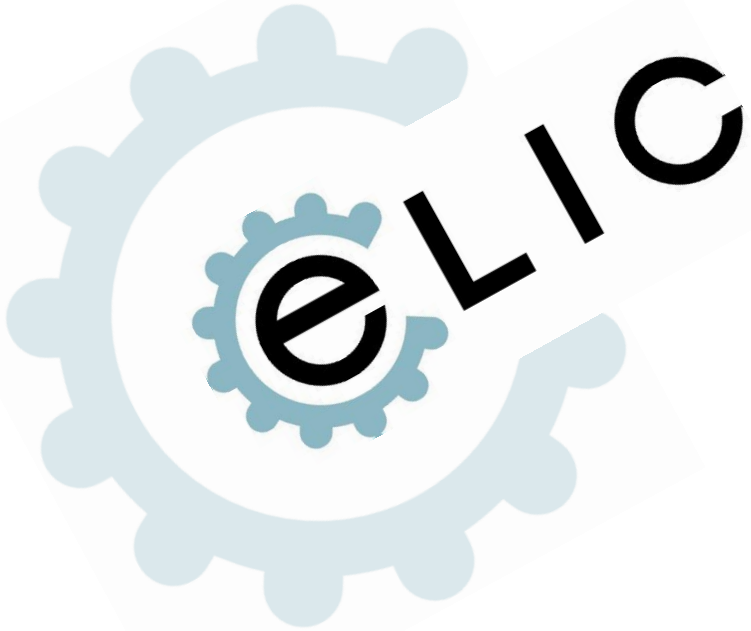

www.elic.fh-joanneum.at

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www.elic-mooc.com

FH | JOANNEUM
Fahrzeugtechnik / Automotive Engineering

Hochschule Düsseldorf
University of Applied Sciences
HSD

ISCN
International Software Consulting Network

VSB TECHNICAL UNIVERSITY OF OSTRAVA | FACULTY OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

Pascal-Gymnasium
GREVENBROICH

crewaiz
TEACHING/GUIDING/SEARCHING

brgkepler

I.S.I.S. FERMO SOLARI

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