embedded academy

E-Learning for Electromobility Software Developer

June 2024

The combination of courses is perfect for a software developer within electromobility.

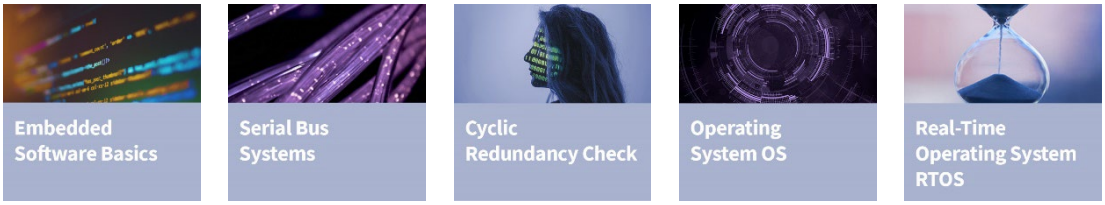
Courses within the e-learning package

The "Electromobility Software Developer" e-learning package is a comprehensive program that equips learners with essential knowledge and skills in the field of embedded software development and in addition to important electronics and electrical engineering knowledge needed for electromobility. This package covers a wide range of topics to provide a well-rounded understanding.

You can acquire the knowhow by a set of technical e-learning courses which we structured into 4 parts:

1. Embedded Software Development covering
    a. fundamentals of embedded software,
    b. serial bus systems,
    c. cyclic redundancy check CRC,
    d. operating system OS, and
    e. real-time operating system RTOS.
2. Electronics, electrical engineering, and battery technology with courses on
    a. electronics and electrical fundamentals,
    b. power electronics fundamentals,
    c. electrical machines,
    d. control of electrical machines,
    e. vector control,
    f. battery and battery systems.
3. E-mobility specific know-how provided by the following courses:
    a. e-mobility,
    b. EV charging,
    c. electrified powertrain,
    d. noise, vibration, and harshness NVH
4. Automotive processes and cybersecurity
    a. ASPICE Overview
    b. ASPICE - Engineering
    c. ASPICE - Supporting Processes
    d. Information security
    e. Automotive cybersecurity

1. Embedded Software Development: This first part is providing you with know-how to become proficient in embedded software development.



Recommended learning journey

Embedded software basics, dives into fixed-point arithmetic and floating-point arithmetic, essential for understanding numerical representation and calculations in embedded systems. …

Serial bus systems are a critical component of embedded systems, and learners will gain insights into their architecture, protocols, and components. The OSI model is also covered, providing an understanding of layered communication systems.

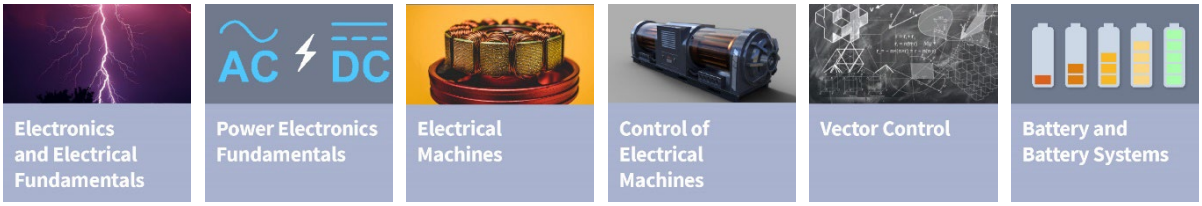
The cyclic redundancy check CRC provides important further details which are often needed in bus communication.

Operating systems, are explored in-depth, focusing on kernel operations, multitasking, safety considerations, and common challenges in embedded OS development.

The operating system in an embedded application has real-time requirements and thus a Real-Time Operating System is needed. We cover different real-time requirements, time and event-based tasks and more.

2. Electronics, electrical engineering, and battery technology

This second part is dedicated to electronics and electrical engineering and technology know-how which is the knowledge foundation for e-mobility.



Recommended learning journey

Electronics and electrical fundamentals encompassing topics like electronics and magnetism, circuitry, alternating current circuits, and the basics of power electronics.

Power electronics fundamentals is delving into semiconductors, introduces the concepts of the half bridge which is used to control electrical machines and finally is going into thermal design and application examples.

The course on electrical machines is starting with the general basics and then is going into details for different machine types. Those are permanent magnet synchronous machines, synchronous machines, induction machines, DC and brushless DC machines.

Control of electrical machines is bringing together power electronics, electrical machines, and embedded software. You will learn about field-oriented control as well as control design.

Vector control is providing more details on this specific mathematical background which you need for field-oriented control.

For e-mobility battery and battery systems are important for energy storage. First you learn all you need to know about battery cells, then battery systems are explained in detail followed by an introduction to battery management systems.

3. E-mobility specific know-how

After having learned about electronics and electrical engineering it is time to bring it all together in the context of electromobility.

Recommended learning journey

The first course **E-Mobility** ensures that the learner is getting to know the overall context. This includes trends, used cases, and market aspects. You will get an overview on electric charging and get to know the electric vehicle system including the powertrain system, the electric drive system, functional safety and energy management.

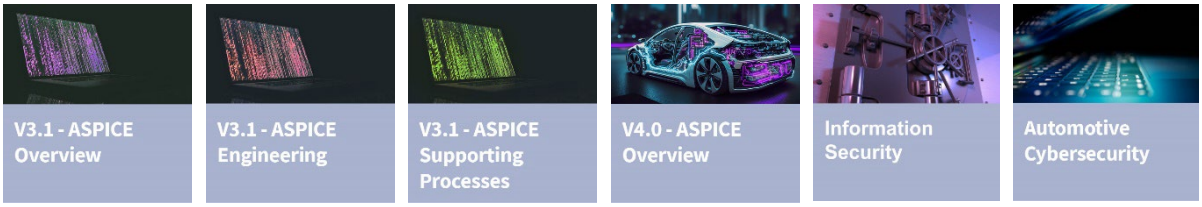
Next, we go into more detail on **EV charging**. This includes general charging know-how on automated charging, charging use cases and grid interaction. After this we delve into the charging communication which takes place between the electric vehicle and the charging station.

The **electrified powertrain** provides you with a lot of know-how to understand how electromobility is implemented in electric vehicles. This includes power electronics, an overall view on electrical machines and the control of electrical machines as well as battery and battery systems.

Last but not least, you will learn about **noise, vibration, and harshness NVH for vehicles**. This includes the general aspects like physical description of sound, psychoacoustics, noise contribution and propagation as well as sound design in the vehicle context.

4. Automotive processes and cybersecurity

This additional final part deals with Automotive specific processes which are mandatory when working on the software development for electric vehicles. This includes ASPICE as well as automotive cybersecurity.



Recommended learning journey

Automotive SPICE is structured into several courses. We recommend to start with the introduction to the process model in ASPICE Overview.

You will certainly need to know about the ASPICE engineering processes, which we recommend to take next. Here you learn about system engineering as well as software engineering.

And finally, you learn all about ASPICE supporting processes. The access will also give you the opportunity to learn about the ASPICE management processes as well as acquisition and supply.

Information security is the first e-learning course dealing with IT-security and introduces you to all the basic terms ins this field.

Based on this the next e-learning is going into the details and specific requirements and process required by automotive cybersecurity.

This e-learning package is tailored for those aspiring to, whether you are a beginner or seeking to enhance your existing skills. Upon completion, you will possess the knowledge and capabilities required to excel in automotive software development.

Delivery Content

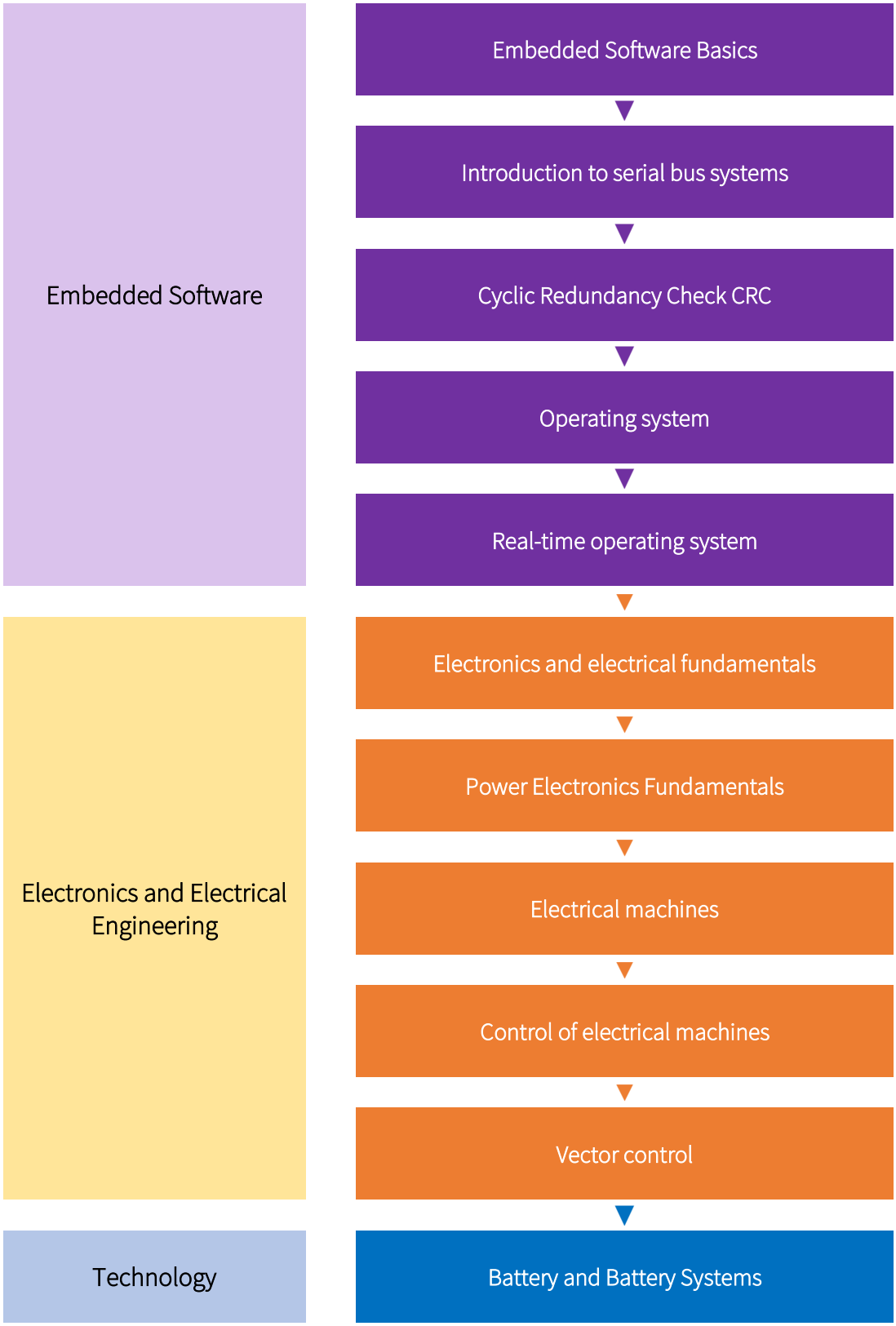
Access

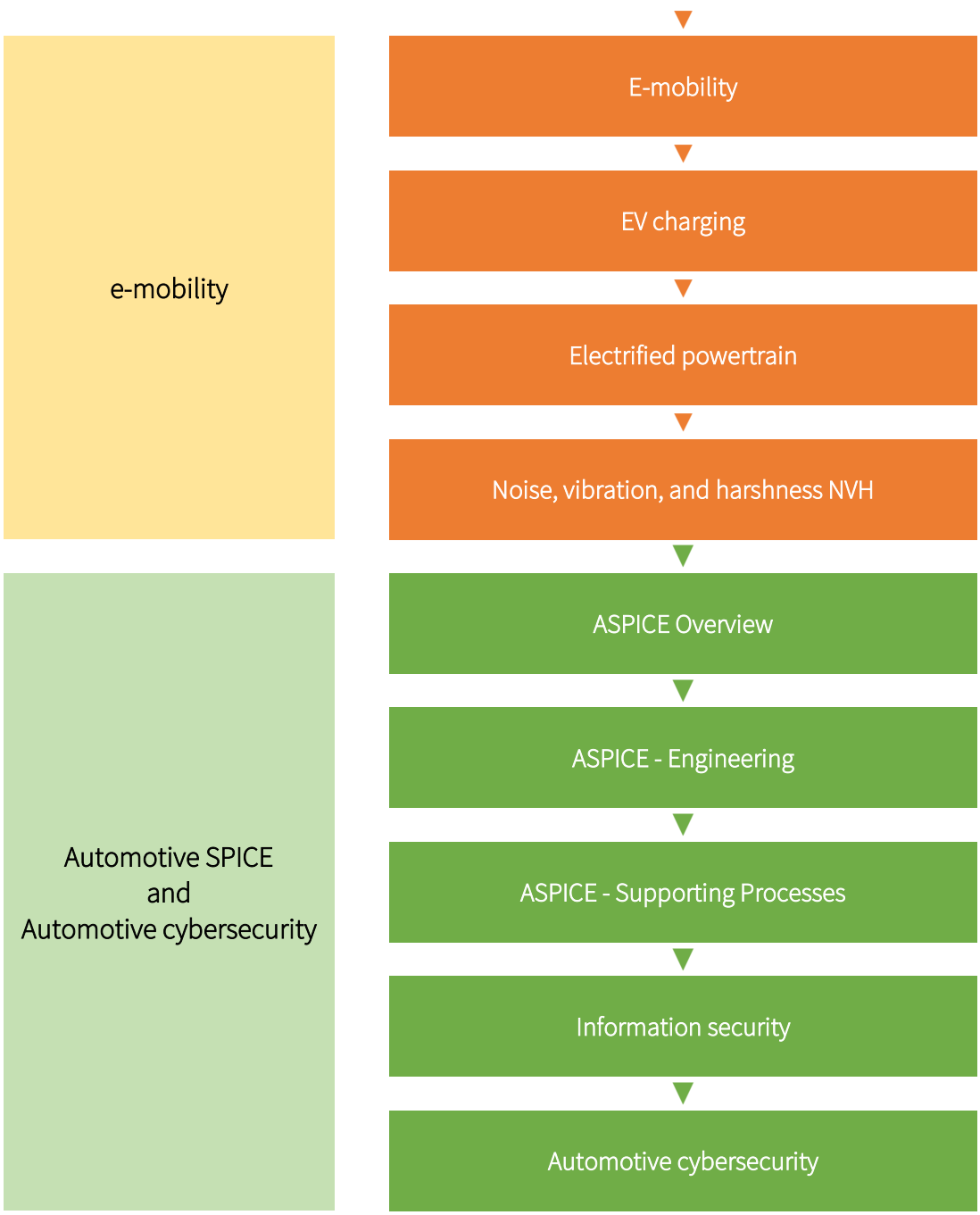
- for one user
- to all e-learning courses
- for the purchased time period

of the Embedded Academy.

Recommended Learning Journey

The Electromobility Software Developer e-learning package is composed of several e-learning courses. We recommend the following order for learning.




e-mobility
E-mobility
EV charging
Electrified powertrain
Noise, vibration, and harshness NVH
Automotive SPICE
and
Automotive cybersecurity
ASPICE Overview
ASPICE - Engineering
ASPICE - Supporting Processes
Information security
Automotive cybersecurity

E-Learning Content

1) Embedded Software Basics

- Language: English, German
- Course objective: The aim of this course is to provide a sound basic knowledge on which other topics, such as AUTOSAR, can build.
- Course content: This course provides an e-learning on **fixed point arithmetic** and on **floating point arithmetic**. Two ways of storing binary numbers are described, and limitations and typical errors of the methods are explained. This helps to avoid beginner mistakes and enables a quick introduction to the basics of embedded software.
- Duration: 1 hours, 15 minutes
- Study time: 6 hours, 15 minutes
- Further insights: https://embedded-academy.com/en/courses/embedded-software-basics/

2) Introduction to Serial Bus Systems

- Language: English, German
- Course objective: The aim of this course is to introduce learners to all the important basic terms for the topic of serial bus systems.
- Course content: This course is designed to introduce you to important basic terms related to serial bus systems. Terms concerning hardware and software are explained.
  The focus of the first e-learning lies on very **general basic terms** that are relevant to most bus systems. For example, the terms bit rate, baud rate, latency, clock signal and router are explained, or what a protocol and a protocol stack actually are. At the beginning of the e-Learning, typical application areas of serial bus systems and their advantages over other systems are described.
  The second e-learning deals with the **OSI model**, which is a reference model for communication systems and protocols. Two components of this model are particularly relevant for bus systems: the so-called physical layer and the data link layer.
  The last two e-learning courses are based on these mentioned layers. One of them covers basic terms of the **physical layer**, the other one those of the **data link layer**.
- Duration: 2 hours, 50 minutes
- Study time: 14 hours, 10 minutes
- Further insights: https://embedded-academy.com/en/courses/introduction-to-serial-bus-systems-en/

3) Cyclic Redundancy Check CRC

- Language: English, German

- Course objective: The aim of this course is to understand how to calculate various CRC checksums
- Course content: The e-learning course consists of three e-learning units:

  “CRC Definition," "CRC-8," and "CRC-16." In this course, you will acquire the necessary knowledge to understand the calculation of CRC checksums. The first module imparts the definition and function of the CRC checksum. The modules are organized in ascending order of CRC sums, and the calculations are always explained using examples.

  In the "CRC Definition" module, we uncover its significance, explore various CRC lengths, and delve into its principles, including functionality, polynomial representation, and generator polynomial.

  In "E-Learning CRC-8," we delve deeper into CRC-8 calculation, explaining steps with examples. Explore how the sender generates the CRC-8 checksum and how the receiver verifies message accuracy.

  Continuing the journey, "CRC-16" explores CRC-16 calculation through detailed examples. Learn how CRC-16 is generated and verified, addressing diverse message lengths. Whether new to CRC or seeking a deep dive, this course empowers your understanding.
- Duration: 1 hour, 20 minutes
- Study time: 6 hours, 20 minutes
- Further insights: https://embedded-academy.com/en/courses/cyclic-redundancy-check-crc/

4) Operating System

- Language: English
- Course objective: The aim of this course is to provide a basic knowledge of operating systems and the various components and functions they contain.
- Course content: In this course, you learn what an operating system is. Therefore, you are familiarized with the kernel, which holds the core functionality of the operating system and you get to know the scheduler, which controls the execution of multiple tasks and allocates resources to them. This is covered in greater detail in the chapter “Multitasking”. To complete this course, safety and other advanced aspects are covered as well as the characteristics of embedded operating systems.
- Duration: 55 minutes
- Study time: 4 hours, 40 minutes
- Further insights: https://embedded-academy.com/en/courses/operating-system/

5) Real-Time Operating System

- Language: English

- Course objective: The aim of this course is to provide a basic knowledge of real-time operating systems. The learner will understand what a real-time operating system is and how it works.
- Course content: You will learn when real-time operating systems are needed and which requirements they have. In particular, we cover the difference between soft real-time requirements and hard real-time requirements. You will also encounter the term "timing analysis" and learn about the difference between time-based tasks and event-based tasks. At the end you will be familiarized with three scheduling algorithms, before we cover three typical problems: task starvation, deadlock and race conditions.
- Duration: 1 hour, 5 minutes
- Study time: 5 hours, 25 minutes
- Further insights: https://embedded-academy.com/en/courses/real-time-operating-system-en/

6) Electronics and Electrical Fundamentals

- Language: English
- Course objective: The aim of this course is to provide a basic technical understanding of all relevant topics in the area of electricity.
- Course content: The first e-learning unit of this course is called "Electronics and Magnetism". It covers the relationship between current, voltage and resistance, which is expressed by Ohm's law. In addition, electric and magnetic fields are contrasted and different types of magnets are considered.
  The second e-learning unit deals with the important components of a circuit, the capacitor and the coil, as well as the resulting phenomena and physical laws, the Lorentz Force, the Hall Effect and the principle of induction.
  Furthermore, direct current and alternating current are analyzed. For the analysis of circuits, Kirchhoff's Laws and the circuit types parallel circuit and series circuit are explained. With regard to alternating current, the Star connection and the Delta connection are considered. The topic of AC circuits is covered in greater detail. Therefore, the complex numbers are explained in order to then discuss the complex voltage and the complex current. Furthermore, this chapter covers the impedance and the Root Mean Square.
  The last part of the e-learning contains an introduction to power electronics, which is based on semiconductor elements. In addition to teaching technical basics, it explains how various components can be constructed using semiconductors. Here, special attention is paid to the diode and the MOSFET. The user is therefore familiarized with the concept of the p-n-junction.
- Duration: 3 hours, 10 minutes
- Study time: 15 hours, 50 minutes
- Further insights: https://embedded-academy.com/en/courses/electronics-and-electrical-fundamentals/

7) Power Electronics Fundamentals

- Language: English
- Course objective: The aim of this course is to provide a better understanding of power electronics fundamentals for engineers who are beginning to work in this field.
- Course content: In the first e-learning we clarify what power electronics is and where it is applied. It also includes an explanation of the electronic switch. We deal with an example of an electronic circuit, from which we derive basic components. In the e-learning "Components of Power Electronics" you learn about the semiconductor basics and components including MOSFETs and IGBT. The third e-learning is about the half bridge, that is used to control AC electrical machines and the last e-learning covers the topic of thermal design and assembly.
- Duration: 2 hours, 25 minutes
- Study time: 12 hours, 5 minutes
- Further insights: https://embedded-academy.com/en/courses/power-electronics-fundamentals/

8) Electrical Machines

- Language: English
- Course objective: The aim of this course is to introduce the learner to electrical machines and provide information about important machine types.
- Course content: The first e-learning of this course gives an introduction into the basics of electrical machines where some general information is presented. Afterwards, four e-learnings offer an overview on different machine types: Permanent Magnet Synchronous Machine (PSM), Synchronous Machine (SM), Induction Machine (IM) and DC & Brushless DC Machines.

  The e-learning on control design focusses first on the procedure of control parameterization. This includes topics such as decoupling, pre-control, simplification of the mathematical description, and control optimization methods. This is followed by the cascaded control, where we also discuss current control vs. torque control, field-weakening control, anti-shuffle control and speed control.
- Duration: 1 hour, 45 minutes
- Study time: 8 hours, 45 minutes
- Further insights: https://embedded-academy.com/en/courses/electrical-machines/

9) Control of Electrical Machines

- Language: English
- Course objective: The objective of this course is to impart knowledge on the control of electrical machines.

- Course content: In the e-learning on **field-oriented control**, we look at some basic physical concepts (torque, electromagnetic force) and consider them in relation to the DC motor. This also includes torque control. Discussing field-oriented control then allows us to understand how to incorporate this concept into electric control. We then move on to actually focus on electrical machines as controlled systems as well as the inverter as a control actuator. A short outlook on other machine types is also included.
- Duration: 3 hours
- Study time: 15 hours
- Further insights: https://embedded-academy.com/en/courses/control-of-electrical-machines/

10) Vector Control

- Language: English
- Course objective: The aim of this course is to introduce the user to the basic information on vector control. This knowledge is essential for further topics, such as Electrical Machines.
- Course content: Currently, an e-learning on the **Park and the Clarke Transformation** is available. In this e-learning, the reasons for using these transformations are discussed. By explaining the mathematical theory behind them, a solid understanding of the transformations themselves can be achieved which supports later application in practice.
- Duration: 45 minutes
- Study time: 3 hours, 45 minutes
- Further insights: https://embedded-academy.com/en/courses/vector-control/

11) Battery and Battery Systems

- Language: English
- Course objective: The objective of this course is to gain a better understanding of the design and control of battery systems.
- Course content: In the first e-learning, we get to know the **battery cell** itself in more detail. We learn what materials it can be made of and how it works when it is charged and discharged. At the end, we will look at the parameters that influence the battery's performance. The second e-learning is about the **battery system** of an electric vehicle, different cell types and battery safety. We take a look at the 48V battery as an example.
- Duration: 1 hour, 30 minutes
- Study time: 7 hours, 30 minutes
- Further insights: https://embedded-academy.com/en/courses/battery-and-battery-system-fundamentals/

12) E-Mobility

- Language: English
- Course objective: The aim of this course is to introduce you to the topic of electric vehicles.
- Course content: The e-learning introduce the user to different topics relevant to understand the relevance and scope of e-mobility.

  First of all, the learner will be introduced to the correct terminology to talk about this topic. We will have a look at which trends influenced the growth of electric mobility and how this might have changed the (automotive) market. This also includes highlighting the different use cases of electric vehicles and explaining the model of the total cost of ownership (TCO), which allows for a calculation of the total costs of a vehicle during its lifetime.

  The next e-learning then focusses more closely on charging itself. The basics of EV charging will be explained, as well as different charging standards and modes, charging plugs or bidirectional charging.

  The unit on „Electric Vehicle Systems" concentrates on the system architecture and elements of the system powertrain. This includes discussing basic electric drive system design, considering aspects of functional safety and highlighting various elements of the system energy management.
- Duration: 2 hours, 20 minutes
- Study time: 11 hours, 40 minutes
- Further insights: https://embedded-academy.com/en/courses/e-mobility/

13) EV Charging

- Language: English, German
- Course objective: The aim of this course is to first introduce the learner to all important aspects of electric vehicle charging and then educate them about the more advanced topic of communication in electric vehicle charging.
- Course content: First of all, the learner is made familiar with the basics of EV charging (charging modes, standards, levels). Afterwards, one e-learning focusses in particular on automated charging. To place EV charging into relation to our everyday life, use cases of EV charging are discussed as well. Moreover, it is also important to be informed about the grid interaction, which includes topics such as energy production and green energy.

  The focus of the next two e-learnings is then on communication in electric vehicle charging. Therefore, first the concepts of the pilot signal and the duty cycle are introduced, before various communication mechanisms are described, the low-level and high-level communication for instance. Low level communication is, roughly speaking, the basic handshake, while high-level communication involves the transmission of much more data – including encrypted data.
- Duration: 2 hours, 10 minutes
- Study time: 10 hours, 50 minutes
- Further insights: https://embedded-academy.com/en/courses/ev-charging/

14) Electrified Powertrain

- Language: English
- Course objective: The aim of this course is to provide knowledge on different topics relevant for the field of the electrified powertrain of electric vehicles.
- Course content: The e-learning on **power electronics** will introduce the main elements of an electric circuit, their pros and cons and other semiconductor devices. We will focus on the half-bridge as a central element in power electronics before giving an outlook on thermal design and assembly.
  Next, an e-learning on the **basics of electrical machines** introduces you to the different types of electrical machines relevant for the electrified powertrain and approaches their application in practice.
  In addition to the e-learning on electrical machines, there is an introductory e-learning on the **control of electrical machines** available, which shortly explains some basics of control systems (system theory, time domain / frequency domain, transfer functions) as well as some basic principles of AC and DC machines. It closes by discussing some elements of control design and strategy.
  In the e-learning "**Battery and BMS**", we center on the battery with a focus on electric vehicle application. This includes an introduction into the anatomy of the battery (chemistry, classification, pack structure) as well as a discussion of battery management systems, short BMS.
- Duration: 4 hours, 45 minutes
- Study time: 23 hours, 45 minutes
- Further insights: https://embedded-academy.com/en/courses/electrified-powertrain/

15) Noise, Vibration and Harshness (NVH) for Vehicles

- Language: English
- Course objective: The aim of this course is to introduce you to the basics of Noise, Vibration and Harshness with are relevant in the context of electric vehicles.
- Course content: In in this course, we will focus on basics of NVH relevant for the electrified powertrain. We will explain the physical description of sound, the relation between sound pressure, sound intensity and SPL as well as look at psychoacoustics and some aspects of sound design as well as noise propagation.
- Duration: 30 minutes
- Study time: 2 hours, 30 minutes
- Further insights: https://embedded-academy.com/en/courses/noise-vibration-and-harshness-nvh-for-vehicles/

16) V3.1 ASPICE - 1 – Overview

- Language: English, German
- Course objective: The aim of this course is to understand ASPICE and to get to know the purpose of this standard.
- Course content: The course "V3.1 ASPICE – Overview" is divided into two e-learning units and provides basic knowledge about Automotive SPICE. The first E-Learning provides reasons that speak for Automotive SPICE and introduces further standards that are relevant to the topic of Automotive SPICE. The second E-Learning provides an overview of the contents of the process model. The Process Reference Model (PRM) and the Process Assessment Model (PAM) are explained in detail. The concept of the standard is explained using an example process.
- Duration: 1 hour, 5 minutes
- Study time: 5 hours, 25 minutes
- Further insights: https://embedded-academy.com/en/courses/automotive-spice-overview/

17) V3.1 ASPICE – Engineering

- Language: English, German
- Course objective: The aim of this course is to understand ASPICE and to get detailed information about the engineering processes.
- Course content: The course "V3.1 ASPICE – Engineering and Management" is divided into four e-learning units. Each of them explains one or more processes. It covers all processes of the System Engineering Process Group SYS and the Software Engineering Group SWE.
- Duration: 2 hours, 50 minutes
- Study time: 14 hours, 10 minutes
- Further insights: https://embedded-academy.com/en/courses/automotive-spice-engineering-en/

18) V3.1 ASPICE – Supporting Processes

- Language: English
- Course objective: The aim of this course is to get detailed information about of Supporting Process Group and Supplier Monitoring of V3.1 ASPICE.
- Course content: In this course we focus on the processes which are part of the VDA Scope and thus mandatory for more or less every automotive electronics and software project. For the supporting processes this applies to Quality Assurance SUP.1, Configuration Management SUP.8, Problem Resolution Management SUP.9, and Change Request Management SUP.10. The course is divided into several e-learning units. Each of them covers one process and its work products. At the beginning of each e-learning the respective process group is introduced and you get to know the connections between the different

processes. The e-learnings highlight connection between different topics. This is particularly helpful for practical application work when processes and relationships need to be understood.

- Duration: 1 hour, 45 minutes
- Study time: 3 hours, 45 minutes
- Further insights: https://embedded-academy.com/en/courses/automotive-spice-supporting-processes-en/

19) V4.0 ASPICE – 1 – Overview

- Language: English
- Course objective: The target of this course is to understand V4.0 ASPICE and to get to know the purpose of this standard.
- Course content: The course "V4.0 ASPICE Overview" is structured into three e-learning units and provides you with a general knowledge about Automotive SPICE.
  The first e-learning presents a motivation for using Automotive SPICE and covers the process dimension of the process assessment model. It focuses in particular on the measurement framework. The most important aspects of the measurement framework are the capability levels, the process attributes and NPLF rating scale.
  The second e-learning provides an overview of the contents of the process dimension of process assessment model. In this e-learning, the process reference model is explained in detail.
  Finally, the concept of the standard is explained by using the project management process an example. This e-learning provides detailed information about the process purpose, the process outcomes, the base practices and the output information items.
- Duration: 1 hour, 40 minutes
- Study time: 8 hours, 20 minutes
- Further insights: https://embedded-academy.com/en/courses/v4-0-aspice-1-overview/

20) Information Security

- Language: English, German
- Course objective: The aim of this course is to provide an overview of information security so that its interrelationships and importance become clear.
- Course content: The course is divided into two topics. First, important terms of information security are defined and the underlying goals are explained. Furthermore, it is clarified who is affected by information security and what it is needed for.
  In the second e-learning unit, the practical implementation of information security is explained. Here, risks and threats are presented and explained using examples. Afterwards, the information security management system is defined and its functioning is explained. The introduction of this system is, among other things, the task of the information security officer.

Finally, direct measures are explained on the basis of the 14 reference measure objectives, using ISO 27001 as a source.

- Duration: 1 hour
- Study time: 5 hours
- Further insights: https://embedded-academy.com/en/courses/information-security-en/

21) Automotive Cybersecurity

- Language: English
- Course objective: The aim of this course is to get an overview of what is relevant in the topic of automotive cybersecurity. The learner will be aware why automotive cybersecurity is important and how it is regulated, implemented, and controlled.
- Course content: In the first e-learning unit of this course, you learn why automotive cybersecurity matters. You get introduced to the main reasons for the implementation as well as the top attack points. In the following, you get to know the upcoming regulations and standards as well as the role of cybersecurity in the product life cycle. Then, you get to know the cybersecurity threat analysis and risk assessment, also known as TARA. It is explained through an example so it is easy to understand. At the end of this course, you will learn what the cybersecurity controls and requirements are and you will take a closer look at the cybersecurity verification and validation testing.
- Duration: 1 hour
- Study time: 5 hours
- Further insights: https://embedded-academy.com/en/courses/automotive-cybersecurity-en/