



# E-Learning for Automotive Function Developer for Electromobility

June 2024

The combination of courses is perfect for an automotive function developer for electromobility.



## Courses within the e-learning package

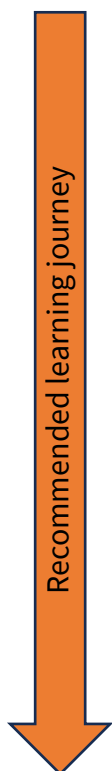
The "**automotive function developer for electromobility**" e-learning package is a comprehensive program that equips learners with essential knowledge and skills in the field of automotive system and software development and in addition to important electronics and electrical engineering knowledge needed 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 3 parts:

1. 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, and
  - e. vector control.
2. 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
3. Automotive processes and cybersecurity
  - a. ASPICE Overview
  - b. ASPICE - Engineering
  - c. ASPICE - Supporting Processes
  - d. Information security
  - e. Automotive cybersecurity

## 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.



**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.

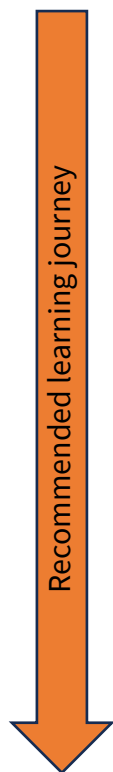
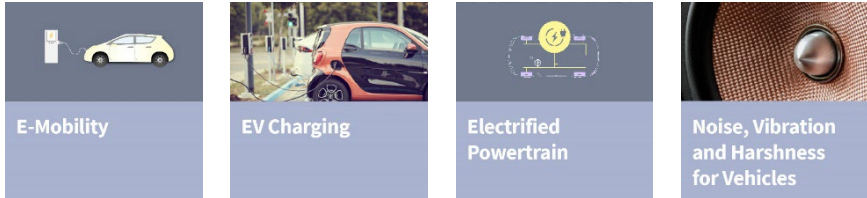
**Control of electrical machines** is bringing together power electronics, electrical machines, and embedded software. You will learn about field-oriented control as well as control design.

**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.



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.



**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 in 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

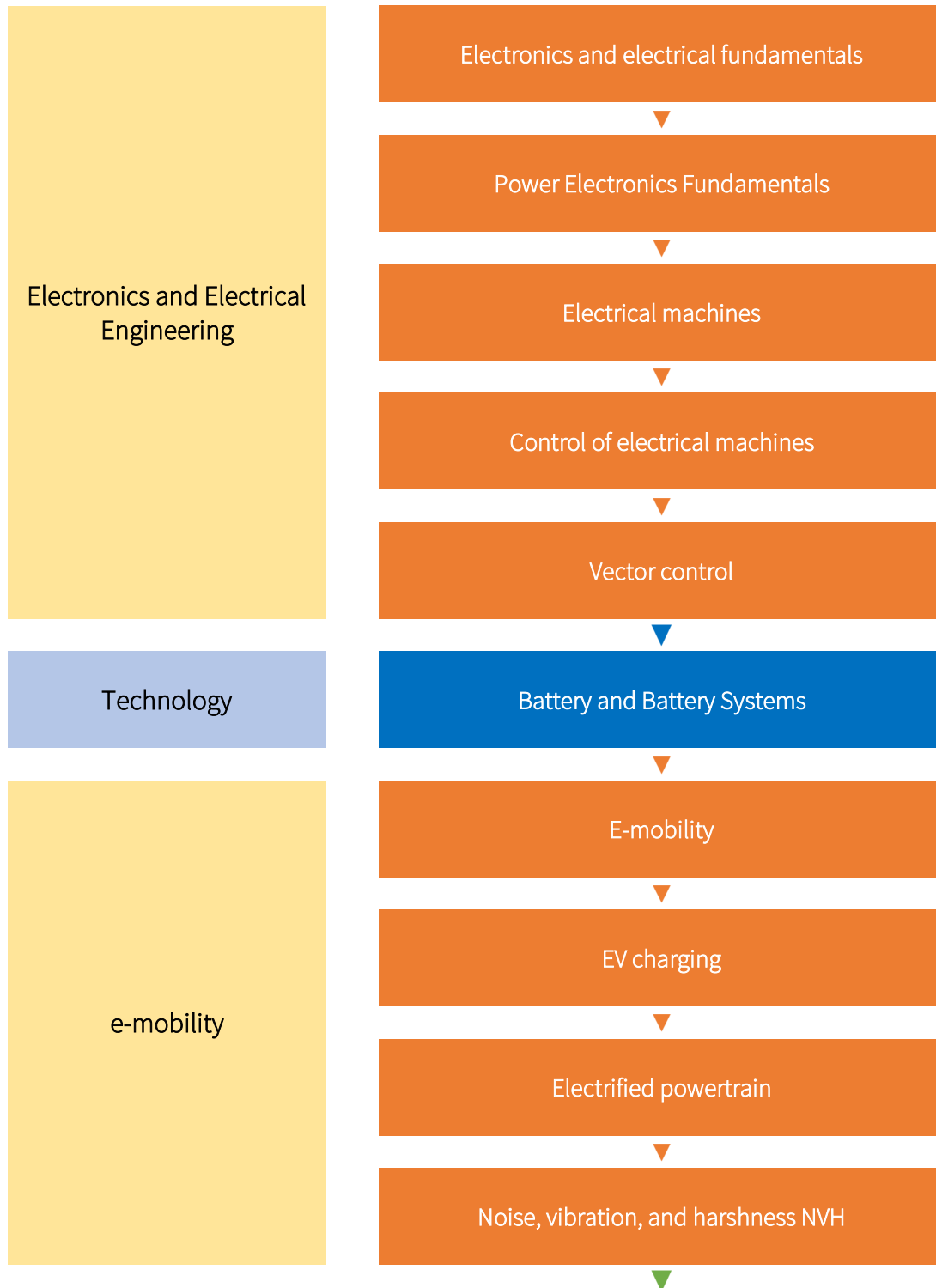
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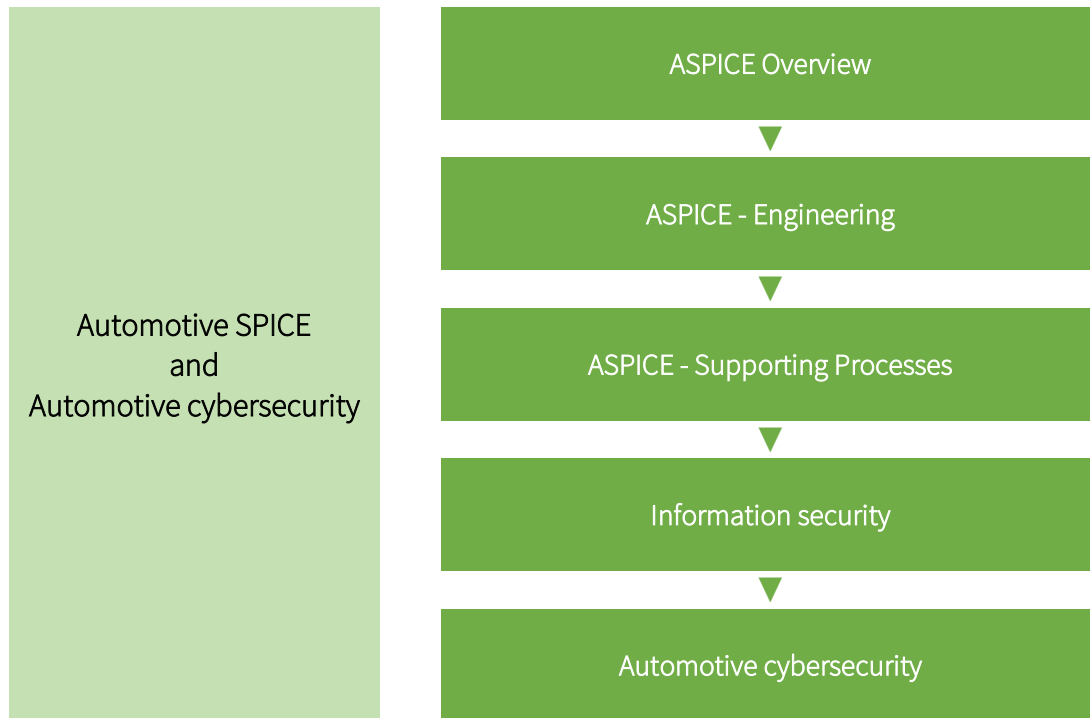
- for one user
- to all e-learning courses
- for the purchased time period

of the Embedded Academy.

## Recommended Learning Journey

The Automotive Function Developer for electromobility e-learning package is composed of several e-learning courses. We recommend the following order for learning.





## E-Learning Content

### 1) 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/>

## 2) 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/>

## 3) 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/>

#### 4) 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/>

#### 5) 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/>

#### 6) 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/>

## 7) 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/>

## 8) 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/>

## 9) 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/>

## 10) 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/>

### 11) V3.1/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** as 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/>

### 12) 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/>

### 13) 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: 8 hours, 45 minutes
- Further insights: <https://embedded-academy.com/en/courses/automotive-spice-supporting-processes-en/>

### 14) 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/>

### 15) 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/>