02

Subject-specific criteria of the Technical Committee 02 – Electrical Engineering/Information Technology

for the accreditation of Bachelor's and Master's degree programmes in electrical engineering and information technology

(as of 23 September 2022)

The following statements supplement the ASIIN "General Criteria for the Accreditation of Degree Programmes".

1 Preliminary note

1.1 Function and context

The Subject-Specific Criteria (SSC) of the Technical Committee 02 - Electrical Engineering/Information Technology are based on the premise that the learning outcomes formulated and aimed at by the higher education institutions on their own responsibility and in accordance with their higher education profile form the central benchmark for the curricular assessment of the study programmes submitted for accreditation.

In addition, the Subject-Specific Criteria of all ASIIN Technical Committees fulfil a number of important functions:

The SSC are the result of a regular assessment by the ASIIN Technical Committees, which summarise what is understood as good practice in higher education or demanded as future-oriented education quality by the labour market as supported by academia and professional practice alike. The expectations formulated in the SSC regarding the achievement of study objectives, learning outcomes and competence profiles are not static. Rather, they are subject to constant review in close cooperation with organisations of the "professional community", such as associations of faculties and departments, professional societies and associations of professional practice. Applicant higher education institutions are asked to critically reflect on the interplay of their own learning outcomes, curricula and related quality expectations with the help of the SSC and to position themselves in the light of their own goals.

In their function in the accreditation procedure, the SSC also represent a technically elaborated basis for the discussion of experts, higher education institutions and committees of ASIIN. They thus make an important contribution to the comparability of national and international accreditation procedures, as it should not be left to the coincidence of the judgments of individual experts which technical parameters are included in the discussion and the individual assessment. At the same time, the SSC specify those abilities, skills and competences that may typically be regarded as the current "state of the art" in a subject area, which, however, can always be exceeded and varied and, depending on the objectives of a higher education institution, also should be.

The SSC can provide reference points for the presentation and assessment of interdisciplinary and multidisciplinary study programmes as well. However, they are strongly oriented towards the core subjects of the individual disciplines.

ASIIN's SSC reflect international discussions and thus contribute to the realisation of the European Higher Education Area. They take up demands of the European "Bologna 2020" strategy to formulate subject-specific, discipline-oriented learning outcomes as one of the most important instruments for promoting academic and professional mobility in Europe. The SSC take into account, among other things, the diverse preliminary work within the framework of European projects (e.g. "Tuning") and professional networks within the discipline.

Against this background, the study objectives and learning outcomes for Bachelor's and Master's degree programmes in electrical engineering and information technology described in the following sections are intended to support both the application and the assessment in accreditation procedures.

1.2 Cooperation between Technical Committees

The Technical Committee Electrical Engineering/Information Technology cooperates with the other Technical Committees of ASIIN, especially in order to meet the requirements of interdisciplinary study programmes. The higher education institutions are requested to specify in the application what Technical Committee(s) the degree programme(s) should be assigned to for the purpose of the accreditation procedure.

In the case of study programmes with more than 50 % content from the area of electrical engineering and information technology, the Technical Committee for Electrical Engineering/Information Technology is usually in charge of the accreditation procedure and, if necessary, consults experts from other areas. In the case of interdisciplinary study programmes with a significant proportion of electrical engineering and information technology content (below and up to 50%), the Technical Committee for Electrical Engineering/Information Technology is jointly responsible with the disciplines involved or only provides experts for the assessment.

2 Study objectives and learning outcomes

The study objectives of a degree programme become clear by describing those learning outcomes that graduates will need in their careers or for further studies. The objectives of a study programme should always take into account the general profile of the higher education institution. Thus, depending on the categorisation of the higher education institution (into a university or university of applied sciences) and the study programmes (application-oriented or research-oriented), the study objectives must address the respective profile of the study programme and the university. In addition, the learning outcomes differ in terms of breadth and depth according to the different objectives of Bachelor's and Master's degree programmes.

2.1 Requirements for Bachelor's degree programmes

As mentioned in the previous section, the requirements for Bachelor's degree programmes should take into account the respective profile of the study programme and the university. In principle, all Bachelor's degree programmes must be oriented towards the fundamentals and methods of the discipline and offer students a solid basic education in mathematics and the natural sciences as well as a scientifically sound engineering education. Furthermore, the bachelor's degree should on the one hand serve as an entry point into professional life in the fields of electrical engineering and information technology, and on the other hand enable graduates to pursue further education both within and without electrical engineering or information technology.

The specific requirements for application- and research-oriented Bachelor programs are presented in the 'Fachqualifikationsrahmen' (qualifications framework) of the German *Fakultätentag für Elektrotechnik und Informationstechnik* (FTEI, 2020) and the position paper of the *Fachbereichstag Elektro- und Informationstechnik* (FBTEI, 2021).

The **FTEI** defines the study objectives for (research-oriented) Bachelor's degree programmes as follows:

"The degree programmes enable their graduates to produce scientifically based innovations and teach decision-making and judgement skills as well as the ability to self-reflect. The study programmes specifically aim to encourage students to conduct independent research and development through methodological and systems competence as well as an understanding of different scientific perspectives. Students learn to solve complex problems with scientifically sound methods as well as to stimulate and carry out meaningful further developments of methods and tools. The competence to solve problems in a scientifically sound and responsible manner and to communicate proposed solutions represents an important basis for the development of leadership skills. University graduates should explicitly also be able to recognise disruptive technical and social changes, e.g. the digital transformation, at an early stage, pick them up and shape them positively. [...] A key objective is to enable technology transfer: The university Bachelor's and Master's degree programmes prepare students to translate new scientific concepts and methods into practical solutions - including in the context of spin-offs - and to use these to open up new fields of application."

The **FBTEI** sets the following objectives for (application-oriented) Bachelor's degree programmes:

"The strongly practice-oriented profile of education at universities of applied sciences produces graduates who combine the methodological competence to solve operational engineering problems with the skills to work scientifically. Since the graduates have completed parts of their education in a company, they can be effectively employed in this environment immediately after graduation. Typical jobs can be found in design offices, experimental and testing departments, product development, manufacturing, production engineering and production management, project groups, but also in research and development departments. The different profiles of engineering education are also reflected in the curricula of Bachelor's and Master's degree programmes. This is a consistent development from the successful profiling of the Dipl.-Ing. (FH) to the degrees of Bachelor and Master."

In order to ensure the practical relevance of study programmes at universities of applied sciences, the FBTEI specifically proposes, among other things, that

- forms of teaching such as project-oriented learning and similar alternatives should be employed,
- a continuous internship semester is recommended,
- at least one engineering project (thesis) is carried out by the students.

Study programmes can be geared more towards electrical engineering or information technology by choosing focal points in the general fundamentals, in the subject-specific fundamentals and in the applied course. In addition, it should be noted that more and more application areas of electrical engineering and information technology have thematic overlaps with computer science, which is why various focal points are necessarily interdisciplinary. Examples of possible **application areas** in the fields of electrical engineering or information technology or combinations of both fields are:

- Automation technology
- Automotive/Electromobility
- Digital Technology
- Electronics
- Energy Technology
- Renewable energies
- High Frequency Technology
- Information Technology
- Communication/messaging technology
- Power electronics
- Lighting technology
- Mechatronics
- Medical Technology
- Microsystems Technology
- Optoelectronics
- Signal processing
- Systems engineering
- Computer engineering
- Theoretical electrical engineering

<table>
<tr><th>Qualification goals</th><th>Learning outcomes & examples of curricular content</th></tr>
<tr><td>Knowledge, understanding and application</td><td>
Graduates have in particular…

acquired a broad and well-founded basic knowledge of mathematics, natural sciences and engineering, which enables them to understand and analyse complex phenomena occurring in electrical engineering, information technology or computer science and to independently develop and apply practice-oriented or theory-oriented solutions
acquired an understanding of the broader ethical and multidisciplinary context of engineering.

Exemplary curricular contents
For more details, see the FBTEI's qualifications framework (http://www.ftei.de/docs_ftei/ftei_docs_2020/FTEI-Fachqualifikationsrahmen-2020.pdf) and the FBTEI's position paper (https://www.fbtei.de/images/pdfs/FBTEI-Elektrotechnik_Positionspapier_21-11-12_VV-FBTEI.pdf).

Mathematics: algebra (systems of linear equations, complex numbers), analysis (vector calculus, differential and integral calculus, differential equations, functions of several variables, Fourier series, Laplace transformation), probability theory and statistics, discrete and numerical mathematics
Physics/Chemistry: Mechanics (rigid and deformable bodies), oscillations and waves (flows in gases and liquids, acoustics), optics, structure of matter (basics of bonding types, magnetic materials, superconductivity), thermodynamics (phase diagrams), basics of electrochemistry, metallurgy (alloys, dielectrics, ferroelectric ceramics, piezo materials), basics of solid state physics
Electrical circuits for direct current and sinusoidal alternating current (complex alternating current calculation), network theory and analysis, networks for non-sinusoidal currents and voltages, switching operations in electrical networks, non-linear circuits
Basics of electrostatics, basics of stationary magnetic fields, energy and forces in magnetic fields, quasi-static fields, law of induction, transformer, skin effect, mutual coupling of electric and magnetic fields (electromagnetic waves)
Boolean algebra, information and coding theory, building blocks of circuit technology, digital circuit design, principles of programming, practical programming, programs and machines, software engineering, algorithms and data structures, basics of computer architecture.
Measurement technology, control engineering, automation technology, signals and systems (linear vs. non-linear systems), components of electrical engineering, optoelectronic semiconductor components, analogue circuit technology, energy conversion and energy transport, theoretical electrical engineering, control engineering, electrical machines (direct current, asynchronous, synchronous motor), electrical systems, communication technology, microelectronics, high-frequency technology, S-parameters, basics of antennas, communications engineering
Computer architecture, software engineering, embedded systems, computer engineering, computer networks, media technology, application-oriented computer systems, internet technology

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Interdisciplinary competences	**Graduates ...** • can analyse and present technical contexts from their own and related fields in a comprehensible way, • are able to work on technical tasks in a team and, if necessary, take over the coordination of the team, • know and understand the methods of project management and economic methods such as risk and change management as well as their limits, • recognise the need for independent, lifelong learning and are able to pursue it, • have knowledge of foreign languages relevant to professional practice, • are able to identify problems and solve them using various research and working techniques, • can work in an interdisciplinary environment, • possess social and professional ethical competences and are able to shape social processes critically, reflectively and with a sense of responsibility and in a democratic spirit. These interdisciplinary competences should be anchored in the curricula as part of existing or independent modules.

Job-related competences

Qualification goals	Learning outcomes
Engineering methodology	**Graduates are qualified to...** • select and apply the current modelling, calculation, design and test methods for their specialisation, • research technical literature and other sources of information on problems posed, • design and conduct experiments and computer simulations and interpret the data obtained, • use databases, standards, codes of good practice and safety regulations.

Engineering development	**Graduates…** • have special skills in the development of analogue and digital, electrical and electronic circuits, systems and products, • are proficient in the use of the process elements modelling, simulation and testing in a problem-oriented way as well as their integration during development, • are capable of developing saleable products for the global market.
Engineering practice and product development	**Graduates…** • can apply their knowledge and understanding to gain practical skills for solving problems, carrying out investigations and developing systems and processes, • can draw on experience of the possibilities and limitations of the application of materials, computer-aided model designs, systems, processes and tools when solving complex problems, • know the practice and requirements in production operations, • are able to research technical literature and other sources of information, • demonstrate an understanding of the health, safety and legal implications of engineering practice and the impact of engineering solutions in a social and environmental context, • undertake to act in accordance with the professional principles and standards of engineering practice, • to transfer new results of engineering and natural sciences into industrial and commercial production, taking into account sustainability, environmental compatibility as well as economic and safety requirements, • to deepen the acquired knowledge independently, • are aware of the non-technical implications of engineering, • are capable of developing saleable products for the global market.

2.2 Requirements for Master's degree programmes

The specific design of Master's degree programmes is based on the individual strengths of the higher education institution offering the programme.

The creation of a profile in electrical engineering or information technology is achieved by offering suitable fundamentals, especially in the areas of more advanced, specific electrical engineering and information technology fundamentals, as well as through focal points in the application areas mentioned above (cf. **Fehler! Verweisquelle konnte nicht gefunden werden.**).

Qualification target	Learning outcomes & examples of curricular content
Knowledge, understanding and application	**Graduates…** • have in-depth knowledge of advanced methods in mathematics and science, • have in-depth knowledge of advanced subject-specific methods in electrical engineering or information technology, • have in-depth knowledge in one of the above-mentioned key application areas, • are able to develop theory-based solutions independently. **Exemplary curricular contents** can be found in the FTEI's qualifications framework (http://www.ftei.de/docs_ftei/ftei_docs_2020/FTEI-Fachqualifika-tionsrahmen-2020.pdf) and the FBTEI's position paper (https://www.fbtei.de/images/pdfs/FBTEI-Elektrotechnik_Positionspapier_21-11-12_VV-FBTEI.pdf).
Engineering methodology	**Graduates…** • can assess complex, new modelling, calculation, design and test methods with regard to their relevance, effectiveness and efficiency and develop new methods independently.
Engineering development	**Graduates…** • have special skills for the design, development and operation of complex technical systems and services, • are able to assemble the components of these systems in an optimal way, taking into account the interaction of the systems with their environment as well as technical, social, economic and ecological aspects.

Investigation and evaluation	**Graduates…** • can develop suitable methods to design, carry out and evaluate detailed investigations into technical issues according to their level of knowledge and understanding.
Engineering practice and product development	**Graduates are capable of...** • methodically classifying and systematically combining knowledge from different fields and of dealing with complexity, • using and developing their knowledge and skills to gain practical skills for solving problems, conducting investigations and developing systems and processes, • familiarising themselves methodically and systematically with new and unknown things, • assessing applicable methods and their limitations, • systematically reflecting on the non-technical effects of engineering activities to responsibly incorporate them into their actions, • developing saleable products for the global market.
Interdisciplinary competences	**Graduates are...** • empowered to lead and shape complex, changing work or learning contexts that require new strategic approaches, • capable of assuming responsibility for scientific contributions to professional knowledge and practice, and/or • empowered to review the strategic performance of teams.

2.3 Practical training (industry internships)

Practical training is an essential element of an engineering education and is preferably completed in an industry company to deal with real-world problems both before and during the studies.

The aim of a pre-study internship is to get to know the world of work from a technical perspective before beginning the Bachelor's degree programme. In accordance with this goal, the pre-study internship is ideally completed before the start of the degree program and thus could represent an admission requirement. Since it is not part of the curriculum and is not supervised by the university, no credits are awarded for it.

In an internship during the degree programme, the specialist and methodological knowledge acquired at the university is applied and expanded or deepened within the framework of typical engineering activities in an industrial environment. Preferred areas include development, construction, planning and application technology. This internship is supervised by the university as part of the curriculum, completed with a colloquium and credits are awarded for it.

3 Curriculum

3.1 Specialisations and fields of study

Published study plans serve as orientation for students. If students are able to choose their own study plan, for instance through specialisations or other forms of elective content, the higher education institution shall make suitable arrangements to ensure that the individual study plans are coherent, meaningful and appropriate to the level and intended competence profile of the programme.

3.2 Master’s degree programmes

The curricula of Master's degree programmes map the specific research and development competences of the higher education institution and thus ensure that the programme adheres to the Master's level. When deciding on admission to Master's degree programmes, particular consideration is given to the individual skills and competences of the applicants.

For applicants who are not sufficiently qualified, appropriate measures will be taken to achieve such qualification.