



**Fakultät  
Elektrotechnik**

# **Module Handbook**

Faculty of Electrical Engineering:

Courses in English

Technical University of Applied

Sciences Augsburg

## **Communications (with mini project)**

### Codes

- simulation of a communication channel, rudiments of number theory and algebra, programming
- field arithmetic, theory of channel codes and codes of information security, application of the codes to communication systems; source coding.

### Protocols

- Protocol Layers, Media Access Control, Packet Formats, Addressing, Ethernet, Wireless Networks,
- Collision Detection and Avoidance, Packet Acknowledge and Retransmission, Routing,
- Switching, Flow Control, IP, TCP, UDP, RTP, ICMP, DNS, Quality of Service, Network Security.

### Signal processing algorithms

- e. g. modulation and demodulation; automatic gain control; receiver synchronisation;
- adaptive and non-adaptive digital filters, recursive digital filters, resampling filters
- Implementations
- DSP implementations; FPGA implementations; transceiver architectures; oversampling; quantization

## **Computer Science**

- Fundamentals
- Elementary data types
- Variables and constants
- Input / output
- Operators (arithmetical, boolean, assignment)
- Functions: usage of given functions and implementation of user-defined functions
- Control structures: branches and loops
- Aggregated and structured types

## **Control & Automation (with mini project)**

### Content:

- Petri Net basics, timed models, application in programming tools for programmable controllers.
- Introduction to stochastic systems, discrete- and continuous-time Markov chains.
- Review of the programming concept for PLCs according to the norm IEC 61131-3.
- Connectivity between SoftPLCs, Input/Output devices and commercial applications, e.g. visualisation based on OPC or industrial ethernet.
- Design and verification of safety related programmable control systems according to European standards.
- Modelling of nonlinear characteristics of temperature, magnetic, optic and chemical sensors.
- Modelling of dynamic effects and limitations of sensors, e.g. cut-off frequency and parasitic elements.

# **Cryptography and IT Security**

## **1) Cryptography**

- a. Symmetric Cryptographic Algorithms
- b. Asymmetric Cryptographic Algorithm
- c. Digital Signature Algorithms
- d. Key Exchange Protocols
- e. Authentication Protocols
- f. Secure Hash Algorithms

## **2) IT-Security**

- a. Basic Terms
- b. Protection Goals and attack classification
- c. Critical infrastructures
- d. Communication protocols
  - i. IT-networks
  - ii. Field bus systems
  - iii. Examples of network attacks
- e. Attacks on device level
  - i. Introduction controlling units (x86/ARM)
  - ii. Memory protection mechanisms
  - iii. Runtime behaviour and memory management
  - iv. Examples of attacks on device level

## **3) Basics of the ISO/IEC 62443**

## **Electric Power Systems (with mini project)**

### **Network components**

- Transformers
- Operational behaviour of Power Lines
- Reactive Power Compensation in High Voltage Grids
- High Voltage DC transmission

### **Transmission and distribution system planning**

- Load-flow, methods of network calculation
- Network protection

### **Network operation**

- Monitoring and control
- Reliability and stability

### **Energy Storage Systems**

### **Power system economics**

- Current regulatory framework
- Energy markets
- Electricity tariffs

### **Smart Grids**

- Impact of renewable generation on networks
- Smart generation
- Smart consumption
- Smart distribution grids
- Examples

Presentation of selected technologies by demonstrations and excursions.

## **Electronics**

### Analogue Electronics

- Amplifier as a black box.
- Introduction to Negative Feedback.
- Operational Amplifiers: inverting, non-inverting, and summing circuits, comparator, Schmitt-Trigger.
- PN Junction Diode, Zener Diode and Light Emitting Diode: structure, physical operation, terminal characteristics, models, and circuit applications.
- Bipolar Junction Transistor (NPN & PNP Types): structure, physical operation and terminal characteristics.
- Metal Oxide Semiconductor Field Effect Transistor (MOSFET): biasing, models, analysis and design.
- BJT and MOSFET Amplifiers: biasing, models, analysis and design.
- Passive electronic Components: properties and characteristics of real (non-ideal) resistors, capacitors and inductors.

### Digital Electronics

- Digital Concepts
- Number Systems & Codes
- Combinational Logic: Logic Gates, Circuits, Truth-Tables
- Boolean Algebra: Laws, Manipulation, and Simplification (Minimisation).
- Sequential Logic: latches, flipflops, registers, asynchronous and synchronous counters.
- CMOS Logic, properties, circuitry of inverter and simple gates.

## **Electrotechnics (lab course)**

Implementation of the theoretically learned lecture material in a practical experimental set-up.  
Metrological proof of the laws of electrical engineering.

- Digital multimeter
- Passive components
- Oscilloscope
- Single-phase power measurement
- Direct current bridges

## **Embedded Security**

### **1) Fundamental Building Blocks**

- a. Basic Structure of Embedded Systems
- b. Physical Unclonable Functions (PUFs)
- c. True Random Number Generators (TRNGs)
- d. Cryptographic Implementations

### **2) Physical Attacks**

- a. Simple Power Analysis (SPA)
- b. Differential Power Analysis (DPA)
- c. Fault Analysis

### **3) Embedded Security Concepts**

- a. Firmware and Data Protection
- b. Secure Microcontrollers

## **Formula Student Electric**

### **(intensive)**

- Elaboration of the requirements for the subsystem and Coordination in the team (requirements freeze: presentation 1)
- Creation of a design and coordination of the interfaces with the adjacent components (design freeze: Presentation 2)
- Implementation / production of the subsystem (presentation prototype: presentation 3)
- Component / subsystem testing (presentation of the test results against the requirements: Presentation 4)
- Integration of the component / subsystem into the overall system and execution of integration tests (Presentation of the integration test results with focus on the component / subsystem: presentation 5)
- Support of the subsystem during the race in the vehicle (Presentation of success / outlook: presentation 6)

In addition to the actual presentations, the regular team meetings take place to coordinate the procedure and to determine the development status.

# **Introduction to Safety, Security and Human Machine Interaction**

## **1) Introduction to safety, security and human machine interaction**

- Fundamental terms
- Real-world examples
- Relevance of the topics

## **2) Legal regulations and standards**

- European guidelines and recommendations
- Safety related standards
- Human factors design guidelines

## **3) Terms, components and methods of safety**

- Fundamental terms of functional safety for industrial control systems
- Components of safety related electric, electronic and programmable electronic control systems
- Safety related communication via industrial bus systems (incl. safety profiles)
- Functional safety of speed variable drive systems
- Verification and validation (effectiveness, experimental and model based proof test)

## **4) Security for industrial automation and control systems**

- Fundamental terms of the security for industrial automation and control systems (IACS)
- Overview of the ISO/IEC 62443
- Security requirements and security levels
- Security program requirements for providers of integration and maintenance services for IACS

## **5) Terms and methods of human machine interaction**

- Human-centered design process (ISO 9241-210)
- Analysis of the context of use of technical systems (work system, manual and supervisory control, methods for task analysis, taskload/workload/performance)
- Specification of user requirements
- Implementation and evaluation of prototypes
- Characteristics of human operators (perception, information processing, action execution, human error)

## **LabView**

- Structure of the hardware
- Operation of LabVIEW
- Finding and correcting errors in VIs
- Implementing a VI
- Summarising data
- Managing resources
- Developing modular applications
- Design methods and patterns
- Using variables

## **Matlab/ Simulink**

### **Matlab:**

- introduction (real and complex calculations, polynomials, vectors, and matrices)
- import and export of data
- functions, control structures
- graphics (2D/3D)
- data analysis and statistics
- differential equations
- LTI systems
- GUI programming

### **Simulink:**

- libraries and models
- continuous and discrete systems
- data rates
- communication with MATLAB

## **Measurement (lab course)**

5 Practical experiments:

- Measuring with microcontrollers
- Strain gauge
- Operational amplifier
- Transistor circuits
- Non-linear components

## **Mechatronics (with mini project)**

### Review:

Overview, Introduction to MATLAB and SIMULINK.

### Modelling and Simulation of Dynamic Systems:

Differential equations, state space models, transfer functions.

### Closed Loop Control:

Definitions; state space concepts; analogue and digital control systems.

### Design of Control Systems with MATLAB:

Exercises with selected Problems (Tutorial and exercises).

### SIMULINK – a Graphical Simulation Environment:

Real time systems; Rapid Control Prototyping

### Bonding:

- Various bonding technologies such as flip-chip and wire bonding; advantages and disadvantages.
- Design and manufacturing issues.
- Influence of material problems especially of lead-free solder materials and progressing miniaturisation on the reliability of electronic and mechatronic systems.
- Basics of thermal management and future techniques.

## **MEMS Materials and System Simulations (with mini project)**

- Micro- and Nanomechanics
  - Solid state physics
    - dislocation motion in bulk metals
    - dislocation motion in small structures like thin films, pillars, ...
  
- Measurement techniques
  - Nanoindentation (nano hardness) and its application
    - measuring Young's Modulus, hardness, yield stress and work hardening behavior
    - estimating the influence of creep and strain rate sensitivity
    - determining stress intensity factor
    - nanoindentation and thin films
  - Bulge testing of thin films
  
- Basic principles of the finite element method
  
- Modelling techniques
  - Geometry entry
  - Meshing
  - Physical phenomena and appropriate boundary conditions
  - Study types
  - Visualizing simulation results
  
- Showcase models e.g.:
  - Microresistor beam
  - Electrostatically actuated cantilever
  - RF MEMS switch
  - Micropump
  - Piezoelectric energy harvester
  - Capacitive pressure sensor
  - Surface micromachined accelerometer
  - Capacitive micromotor

## **Power Electronics and Electrical Drives (with mini project)**

### **Part: Power Electronics**

#### Review:

Overview of the contents and Introduction in modern power semiconductor, space vector theory, three-phase- inverter

#### Modern power Semiconductor:

Physical behaviour of:

- vertical structure MOSFET with and without trench – technology,
- NPT, PT and filed stopp – IGBTs
- Influence of Si-, Si-Carbide and GaN- devices

#### Space vector:

- Basic theory of the space vector
- Calculation of harmonics and power in switch three phase systems
- Space vector modulation techniques

#### Three-phase inverter:

- Basic topology of a three- phase inverter
- Control algorithms and simulations using the space vector
- High efficient control techniques
- EMI- analysis, simulations and development of design rules

### **Part: Electrical Drives**

#### Electric Machines – Analysis and Design

- Modelling and analysis with concentrated parameters
- Finite element modelling and analysis
- Electric machines design and optimization

#### Advanced Electric Drives

- Advanced modelling for transients
- Advanced control strategies
- Simulation techniques

## **Renewable Energies (lab course)**

- Introduction, importance of renewable generation
- Solar radiation
- Photovoltaics, solar thermal energy
- Wind energy, hydropower
- Use of biomass
- Geothermal energy, fuel cells
- Economic feasibility studies
- Grid integration of renewable generation

## Smart Grid Fundamentals

The development of Smart Grids in different parts of the world reflects the regional resources and needs. We have seen large scale integration of wind generators and solar energy devices into the power grids. Very large off-shore wind farms are on the horizon. Increasingly automated and intelligent distribution systems are in operation in various countries.

On the transmission side, a significant number of Phasor Measurement Units (PMUs) are now collecting a massive amount of information for monitoring of power system dynamics. Demand side response and other programs for customers' choice are being developed and enhanced by the power industry.

To enable the demand side response and customers' services, millions of smart meters are acquiring the customers' electric energy consumption data. These new smart features of the power grid rely on the information and communications technology (ICT) that brings critical connectivity for all elements of the Smart Grid.

The increasing degree of integration in a Smart Grid from renewable generations to the power grid, from transmission to distribution, and from smart meters to the distribution system brings a new vision and opportunities for the future power grids. Although we are well under way toward this unprecedented creation, it is also important to recognize the challenges that Smart Grid development is facing from the diverse viewpoints of technology, economics, sociology, and public policy.

The lecture is accompanied by a team work. In this team work you focus in a team of two students on special aspects of smart grids and present your findings in the classroom.

## **VLSI Design (with mini project)**

### Design Styles:

Full custom design; standard cell approach; hardware and behaviour description entry approach;  
functional abstraction; rules and hints on decision-making.

### Design Flow:

Function entry; verification; timing analysis; synthesis layout.

### Hierarchical Design Styles:

Cells; blocks; buses; high-level hardware description language (HDL).

### Hardware Description Language Entry:

Behavioural, structural and functional function entry using VHDL.

### CAD Tools:

Compilation; simulation; synthesis; static timing analysis; routing. placement.;  
Guide to verifying complex systems.

### Introduction to Testing:

Manual and automatic test pattern generation. Design for Testability: rules; procedures;  
methods.

### Management Issues:

Splitting designs into blocks; releases and release management; bug tracking; design rules.