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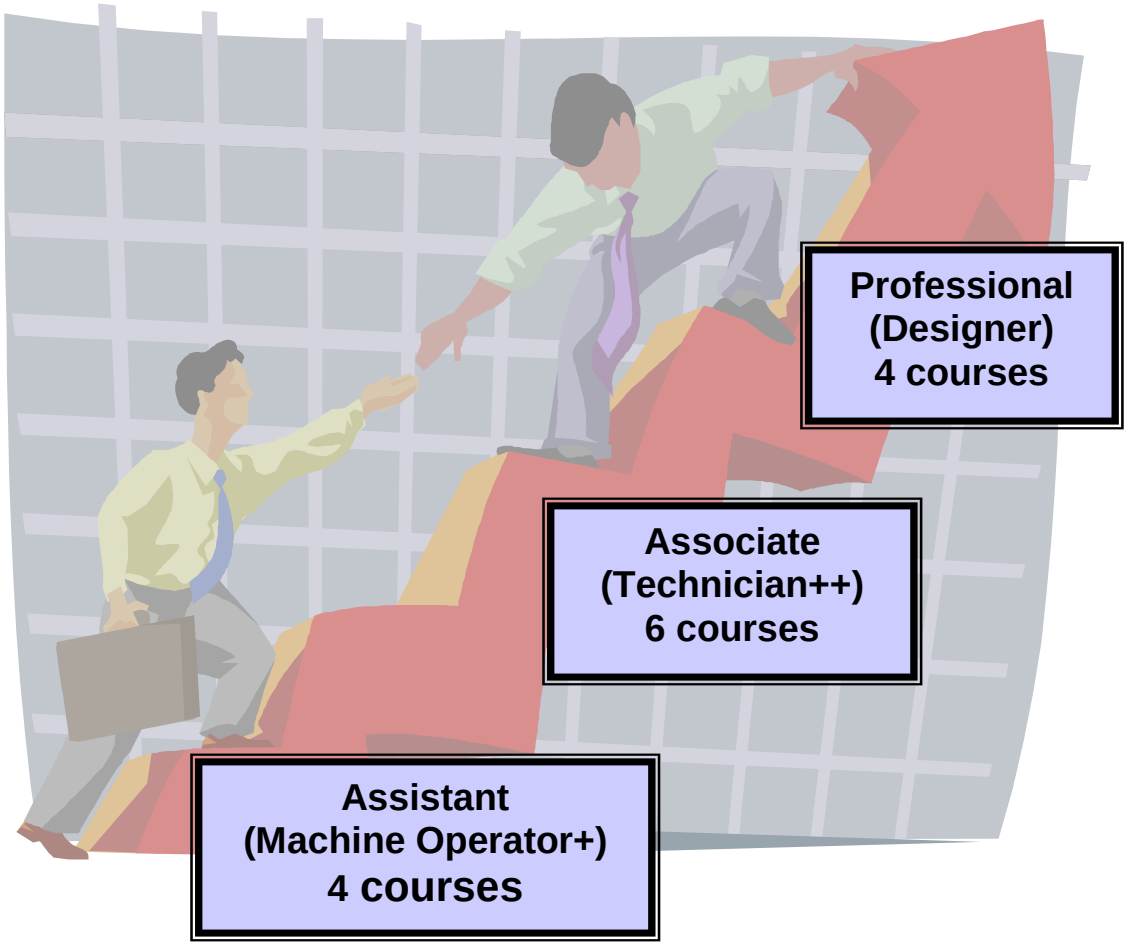
Siemens Mechatronic Systems Certification Program



Program Overview

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Siemens Mechatronic Systems Certification Program
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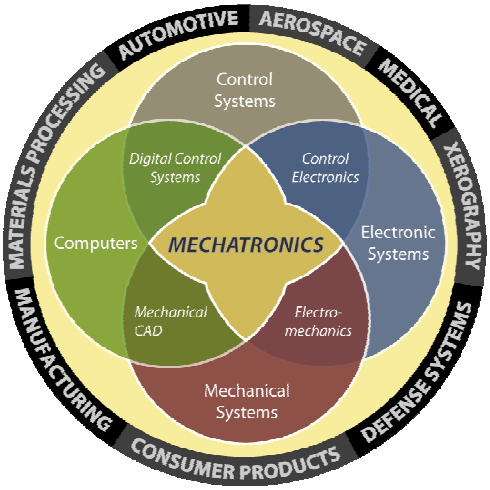
Philosophy of the Certification Program – why is it different?

Underlying the curriculum for all the three Levels of the Certification Program is the System Approach, which has been used with a high degree of effectiveness for the training of Siemens own trainees and engineers in Germany.

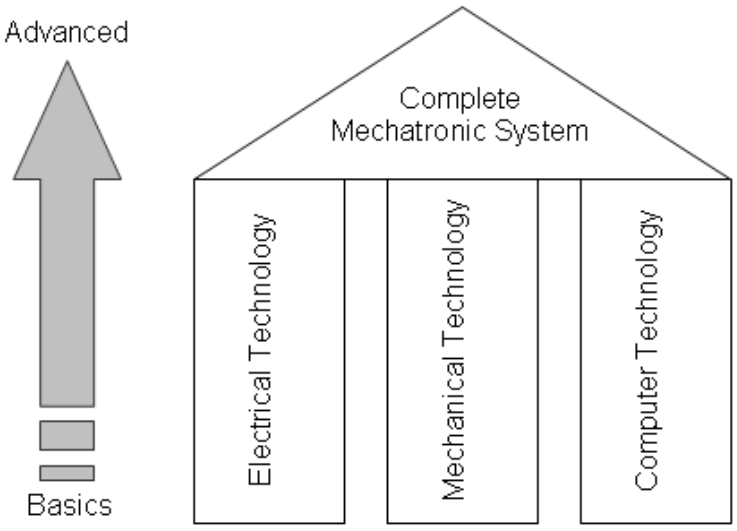


Mechatronics

Teaching Approach

Mechatronics is not only the marriage of electrical, mechanical and computer technologies; it is also a philosophy for looking at systems. Under traditional methods of teaching mechatronics, students learn about each of these fields separately from one another. Sometimes, there is a course or two at the end of the course of study which tries to pull all of these topics together.

Traditional Approach to Mechatronics Education

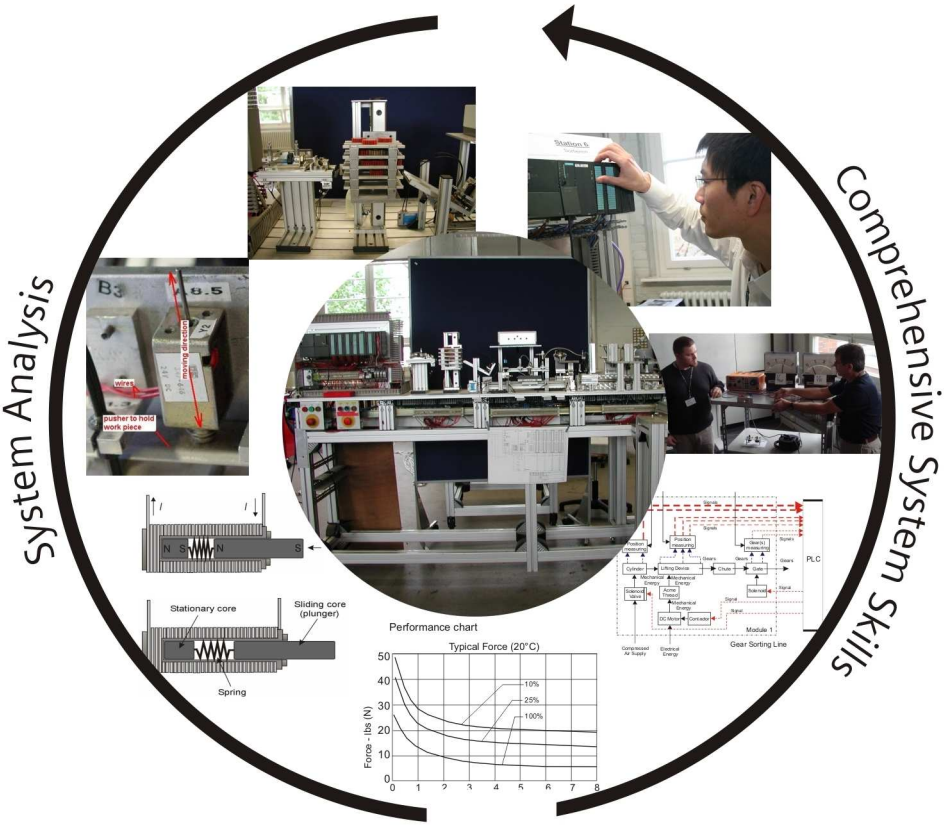


Each of the three areas is taught in Isolation.
Synthesis is the last step!!!

Because of the isolation of these fields, there is little appreciation or understanding of the inter-relationships. Even a final capstone course which attempts to tie the three fields of technology together often cannot convey fully the complexity of mechatronic systems.

Under the System Approach, students learn about the complexities of the system in a holistic fashion. This means that from the very first day, they are confronted with a complete complex system and learn about its various parts by examining their roles in the system, always keeping the “big picture” in mind.

Starting at the macro level, students first see the full system and learn about its function. From there they go into one of the system modules, examining the components contained within the module and their inter-relationships with one another.



System Approach: System as focal point – Closed Loop Learning

At the component or device level, students learn about the physical properties of each component in the system, and, coupled with their knowledge of the flow of energy and information within the system, they will learn to carry out the measurements required to pinpoint where malfunctions are occurring. They will be able to determine whether a component is defective, whether the energy or information flow is incorrect, or if the hardware of the control system is defective – in other words moving from the micro-level back up to the macro-level in the troubleshooting process.

As a result, Siemens Certified Mechatronic Systems Assistants learn how to work their way into a new system, and by means of the troubleshooting strategies which they learn, they are able to transfer their knowledge and expertise easily to another system.

This makes for an employee who is flexible, autonomous and professional in his or her dealings with such complex system.

Hardware Requirements

SMSCP partner schools must have a mechatronic training system on site. This system must meet certain requirements and feature a number of specific components. For details on SMSCP hardware requirements, please see the publication entitled “Hardware Requirements”.

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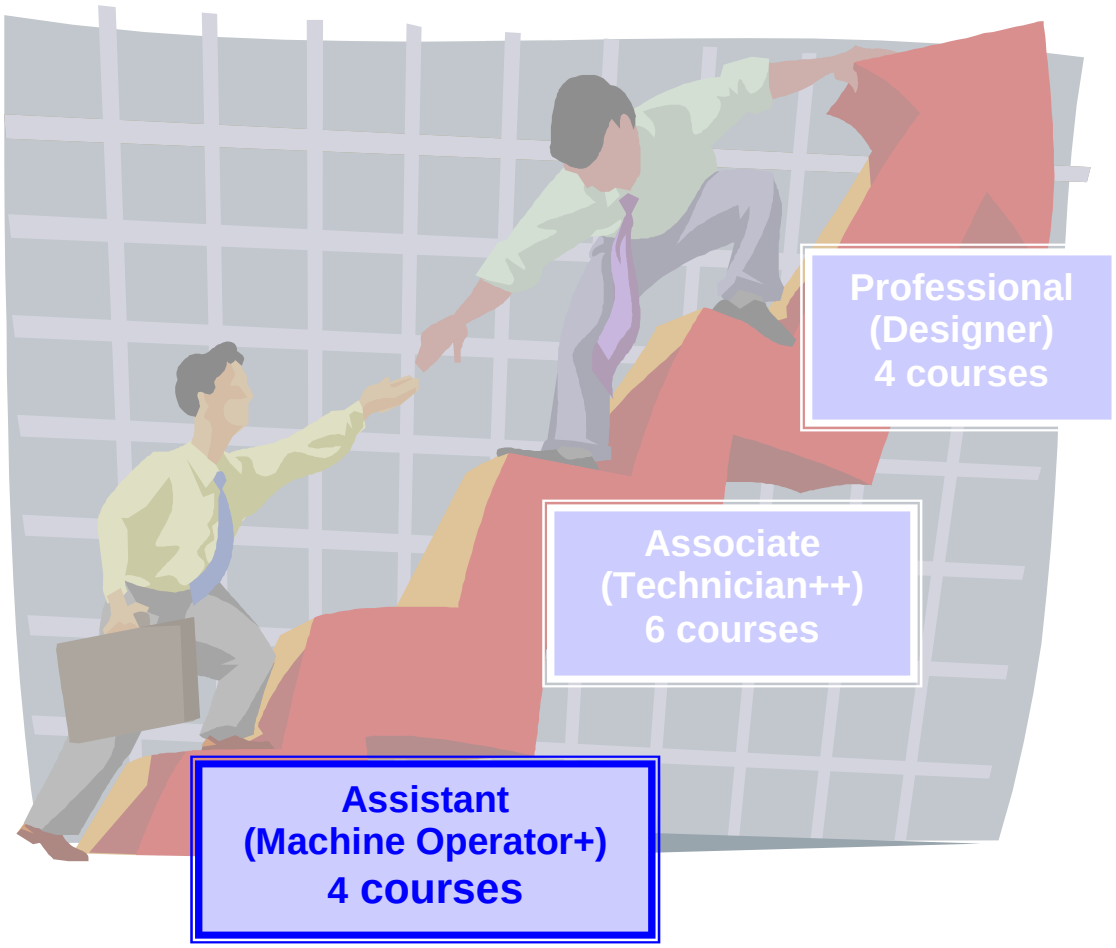

Level 1 (Mechatronic Systems Assistant)

Overview Level 1 (Mechatronic System Assistant)

The Mechatronic Systems Assistant certification is the first of three certifications in a series. Each certification is based upon a specified, industry-driven job profile which helps an employer determine where this person can be best placed within the organization.

Job Profile

A Siemens Certified Mechatronic Systems Assistant will function as a well-grounded machine operator in a complex system, with responsibility for efficient operation of the equipment with minimal down-times. Normally a Siemens Certified Mechatronic Systems Assistant would carry out their work at plant assembly sites, workshops or in connections with service operation which utilize complex mechatronic systems.

He or she will be able to:

- Localize , identify causes and sources, correct where possible and/or document malfunctions to be passed on to the appropriate experts for resolution, or (where appropriate) exchange or replace defective components
- Recognize potential or impending malfunctions and contact expert assistance in order to keep the production line functioning and to prevent production loss
- Perform routine, preventive maintenance
- Understand and explain the principal operations of the mechatronic subsystems in a complex system
- Understand and explain how these subsystems work together
- Read and understand the technical documents, reports and outlines specific to the system and subsystems, and be able to consult with experts
- Work effectively as a team-member and coordinate the activities with upstream and downstream operations
- Understand and implement safety regulations required for operation of the system

Siemens Certified Mechatronic Systems Assistants understand the full system. In this certification level, they view the components or devices in terms of their roles within the system, and work to keep the system running at maximum capacity. Because the individual components or devices are viewed as “black boxes” in this certification level, they will not be responsible for carrying out repairs of defective devices. However, they will be able to identify correctly where malfunctions are occurring and be able to communicate with experts who can carry out the required repairs.

The Curriculum

Level 1 (Assistant) Certification consists of four standardized courses, designed to be integrated within a college curriculum or to be implemented as continuing education. Each course consists of roughly 60 hours of classroom instruction with additional laboratory work on a physical system located at the training institution, on PC- and web-based simulations, etc.

Each of the four courses has a main focus, although the “big picture” perspective is maintained throughout the program. The main foci of the four courses are:

Course 1: Electrical Components
Course 2: Mechanical Components and Electrical Drives
Course 3: (Electro) Pneumatic and Hydraulic Control Circuits
Course 4: Digital Fundamentals and PLCs

Once a student has successfully completed all four courses, he/she should be well-prepared to sit for the Level 1 certification examination. This will be administered through a neutral testing center. Only by successfully passing the Level 1 Certification Examination will the student be awarded the certification of Siemens Certified Mechatronic Systems Assistant.

System Approach in Level 1

These four courses prepare students for the certification as a Siemens Certified Mechatronic Systems Assistant. The job profile for which the Level 1 certification prepares students is that of a machine operator, who has a well-rounded understanding of the complex inter-relationships and inter-workings of a mechatronic system.

All courses within the Certification Program are based upon a System Approach. Students learn about individual components and system characteristics within the context of an actual mechatronic system. At the beginning of this course, students should first be presented with a complex system. This system should be physically available at the educational institution and within the first class meetings should be visited by the students. By focusing on an actual system, students understand clearly why they are learning the subject material. This increases significantly the learning effect and promotes a fuller understanding of the material being learned. By viewing the system as a whole, learning retention is also increased, as the student experiences the components as part of a whole, rather than in isolation.

Of great importance is that the student is able to transfer the knowledge learned to a new system and is able to quickly familiarize him-or herself with the new system. This understanding leads to a better informed employee who has sufficient knowledge to make well-informed decisions about the running of the system upon which he or she is working on.

Syllabus
Level 1, Course 1
Electrical Components

Course Description

This course covers the basics of electrical components in a complex mechatronic system. Based upon a physical system, students will learn the basic functions and physical properties of electrical components, and the roles they play within the system. Technical documentation such as data sheets, schematics, timing diagrams and system specifications will also be covered. By understanding the complete system, the flow of energy through it and measurements on the components, students will learn and apply troubleshooting strategies to identify, localize and (where possible) correct malfunctions. Preventive maintenance and safety issues for electrical components within the system will be discussed.

Course Goals

Upon completion of the course, students should:

- Understand what a mechatronic system is, and the inter-relationships of components and modules with a system.
- Understand the flow of energy, mass and information in the system.
- Understand the role of electrical components in complex mechatronic system and subsystems.
- Understand troubleshooting, maintenance and safety issues within a mechatronic system.

Course Objectives

At the conclusion of this course, students will be able to:

- Describe what comprises a mechatronic system or module.
- Explain the role of various electrical components within a given system or module.
- Trace and describe the flow of energy in a given mechatronic system or subsystem.
- Describe the basic physical properties of electrical components.
- Read, analyze and utilize the technical documents such as data sheets, timing diagrams, operation manuals, schematics, etc. for a mechatronic system.
- Carry out measurements on electrical components in a mechatronic system.
- Correctly localize, identify and document causes of malfunctions in electrical components, based upon the technical documentation.
- Where possible correct malfunctions, or correctly identify the expertise required to correct a malfunction.
- Apply safety rules while working on the system.
- Transfer the knowledge learned from one system to another system.

Course Content

Content to be covered within this course includes the following topics:

- Basic elements and quantities
- Circuit diagrams, data sheets, schematics
- Measurements
- Energy sources
- Actuators
- Sensors
- Overcurrent protection
- Safety issues, including local regulations
- Preventive and routine maintenance of components
- Troubleshooting of the electrical components within a module or system

NOTE: The order in which the content will be discussed is dependent upon the mechatronic system which is being used. In each case, the component and/or class of components will be discussed within the context of the system and the module in which the component is located. This means that the exact order of presentation will vary according to the system available for instruction. It is also important that all classes of electrical components be discussed, whether available in the training system or not.
Focus in all cases is on the role of the components within a module and system, identification of problems, routine maintenance, troubleshooting, and safety issues with the goal of preventing system downtime or reducing them to a minimum.

Course Prerequisites

Basic knowledge of algebra.

Course Materials

Recommended basic course materials are in digital form:

Course materials provided by SMSCP Partner Schools to their students are at the partner school's discretion, and may include special software such as SIMIT, Diagnostic Kit software, etc. If desired, a supporting textbook on electrical components may required by the school or instructor.

Students must also have access to a mechatronic training system containing all or most of the basic component types covered in the course. Please see the SMSCP "Hardware Requirements" document for more information on system requirements for Level 1 instruction.

Syllabus
Level 1, Course 2
Mechanical Components and Electrical Drives

Course Description

This course covers the basics of mechanical components and electrical drives in a complex mechatronic system. Based upon a physical system, students will learn the basic functions and physical properties of mechanical components as well as electrical drives (AC and DC), and the roles they play within the system. They will also learn about mechanical components which lead and support the energy through a mechanical system to increase efficiency and to reduce wear and tear. Materials, lubrication requirements and surface properties will be examined. Technical documentation such as data sheets and specifications of mechanical elements and electrical drives will also be covered. By understanding the interworkings of the complete system, students will learn and apply troubleshooting strategies to identify, localize and (where possible) correct malfunctions. Preventive maintenance of mechanical elements and electrical drives as well as safety issues within the system will be discussed.

Course Goals

Upon completion of the course, students should:

- Understand the role of mechanical components and electrical drives in complex mechatronic systems, modules and subsystems.
- Understand the flow of energy in the system.
- Understand troubleshooting, preventive maintenance and safety issues revolving around mechanical components and electrical drives within a mechatronic system.

Course Objectives

At the conclusion of this course, students will be able to:

- Explain the role of various mechanical components within a given system or module.
- Trace and describe the flow of energy in a given mechatronic system or subsystem.
- Describe the basic physical properties of mechanical components including materials, lubrication requirements and surface properties.
- Carry out adjustments on mechanical components in a mechatronic system.
- Read, analyze and utilize the technical data sheets for the mechanical components and electrical drives within a mechatronic system.
- Correctly localize, identify and document causes of malfunctions in mechanical components or electrical drives, based upon the technical documentation.
- Correct malfunctions where possible, or correctly identify the expertise required to correct a malfunction.
- Apply safety rules while working on the system.
- Transfer the knowledge learned from one system to another system.

Course Content

Content to be covered within this course includes the following topics:

- Mechanical systems and subsystems in support of flow of energy in the system
- Components for transmitting torque (e.g., gears)
- Support components (e.g., bearings)
- Fasteners
- Couplings and clutches
- Basics of electrical drives (AC and DC)
- Technical documentation
- Safety issues, including local regulations
- Preventive and routine maintenance of components including lubrication requirements, surface properties, and prevention of friction
- Troubleshooting of the mechanical components within a module or system

NOTE: The order in which the content will be discussed is dependent upon the mechatronic system which is being used. In each case, the component and/or class of components will be discussed within the context of the system and the module in which the component is located. This means that the exact order of presentation will vary according to the system available for instruction. It is also important that all classes of electrical components be discussed, whether available in the training system or not.
Focus in all cases is on the role of the components within a module and system, identification of problems, routine maintenance, troubleshooting, and safety issues with the goal of preventing system downtime or reducing them to a minimum.

Course Prerequisites

Basic knowledge of algebra.

Course Materials

Recommended basic course materials are in digital form:

Course materials provided by SMSCP Partner Schools to their students are at the partner school's discretion, and may include special software such as SIMIT, Diagnostic Kit software, etc. If desired, a supporting textbook on mechanical components and electric drives may required by the school or instructor.

Students must also have access to a mechatronic training system containing all or most of the basic component types covered in the course. Please see the SMSCP "Hardware Requirements" document for more information on system requirements for Level 1 instruction.

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Syllabus
Level 1, Course 3
(Electro) Pneumatic and Hydraulic Control Circuits

Course Description

This course covers the basics of pneumatic, electropneumatic and hydraulic control circuits in a complex mechatronic system. Students will learn the functions and properties of control elements based upon physical principles, and the roles they play within the system. Technical documentation such as data sheets, circuit diagrams, displacement step diagrams and function charts will also be covered. By understanding and performing measurements on the pneumatic and hydraulic control circuits, students will learn and apply troubleshooting strategies to identify, localize and (where possible) correct malfunctions. Preventive maintenance of (electro) pneumatic and hydraulic components as well as safety issues within the system will be discussed.

Course Goals

Upon completion of the course, students should:

- Understand what a mechatronic system is, and the inter-relationships of components and modules within a complex mechatronic system with a focus on (electro)pneumatic and hydraulic control systems.
- Understand the role of (electro) pneumatic and hydraulic control systems in complex mechatronic system and subsystems.
- Understand troubleshooting, maintenance and safety issues revolving around (electro) pneumatic and hydraulic circuits within a mechatronic system.

Course Objectives

At the conclusion of this course, students will be able to:

- Explain the role of various (electro) pneumatic and hydraulic components within a given system or module.
- Trace and describe the flow of energy in a given mechatronic system or subsystem.
- Describe the basic physical properties of pneumatic and hydraulic components.
- Carry out measurements and adjustments on pneumatic and hydraulic components in a mechatronic system.
- Read, analyze and utilize the technical documents such as data sheets, circuit diagrams, displacement step diagrams, timing diagrams and function charts for the pneumatic and hydraulic components within a mechatronic system.
- Correctly localize, identify and document causes of malfunctions in pneumatic and hydraulic circuits, based upon the technical documentation.
- Correct malfunctions in pneumatic and hydraulic circuits, where possible, or correctly identify the expertise required to correct a malfunction.

- Apply safety rules while working on the system.
- Transfer the knowledge learned from one system to another system.

Course Content

Content to be covered within this course includes the following topics:

- Pneumatics and Electropneumatics
  - Introduction
  - Electropneumatic Control System
  - Signal Processing Structure
  - Function Diagram and Pneumatic Circuit Diagram
  - Actuation of Pneumatic Cylinders
  - Sequence Control Systems
  - Electrically Actuated Directional Control Valves (DCVs)
  - Displacement-Step Diagram
  - Pneumatic Actuators
  - Stroke Speed Regulation of Pneumatic Actuators
  - Basic Electropneumatic Control Circuits
  - Air Generation and Distribution
  - Terminal Connections
  - Electrical Control Devices
  - Safety Regulations
- Hydraulics
  - Overview
  - Circuit Symbols
  - Design of Circuit Symbols
  - Physical Principle
  - Transmissions
  - Pressure Transfer and Flow Rate
  - Solenoid Activated Directional Control Valves

NOTE: The order in which the content will be discussed is dependent upon the mechatronic system which is being used. In each case, the component and/or class of components will be discussed within the context of the system and the module in which the component is located. This means that the exact order of presentation will vary according to the system available for instruction. It is also important that all classes of electrical components be discussed, whether available in the training system or not.
Focus in all cases is on the role of the components within a module and system, identification of problems, routine maintenance, troubleshooting, and safety issues with the goal of preventing system downtime or reducing them to a minimum.

Course Prerequisites

Basic knowledge of algebra.

Course Materials

Recommended basic course materials are in digital form:

Course materials provided by SMSCP Partner Schools to their students are at the partner school's discretion, and may include special software such as SIMIT, Diagnostic Kit software, etc. If desired, a supporting textbook on pneumatic and hydraulic systems may required by the school or instructor.

Students must also have access to a mechatronic training system containing all or most of the basic component types covered in the course. Please see the SMSCP "Hardware Requirements" document for more information on system requirements for Level 1 instruction.

Syllabus
Level 1, Course 4
Digital Fundamentals and Programmable Logic Controllers

Course Description

This course covers the fundamentals of digital logic and an introduction to programmable logic controllers (PLCs) in a complex mechatronic system with a focus on the automation system SIMATIC S7-300 and the appropriate programming software STEP7. Using computer simulation, students will learn the role PLCs play within a mechatronic system or subsystem. They will also learn basic elements of PLC functions by writing small programs and testing these programs on an actual system. Students will learn to identify malfunctioning PLCs, as well as to apply troubleshooting strategies to identify and localize problems caused by PLC hardware.

Course Goals

Upon completion of the course, students should:

- Understand the role of programmable logic controllers in complex mechatronic systems, modules and subsystems.
- Understand the flow of information in the system.
- Understand and apply troubleshooting, maintenance and safety rules.

Course Objectives

At the conclusion of this course, students will be able to:

- Explain the role of programmable logic controllers within a given system or module.
- Trace and describe the flow of information in a given mechatronic system or subsystem with a focus on the control function of PLCs in the system.
- Describe the basic functions and design of PLCs.
- Read, analyze and utilize the technical documents such as data sheets, timing diagrams, operation manuals, schematics, and ladder diagrams.
- Correctly localize, identify and document system malfunctions in or caused by PLC hardware , based upon the technical documentation.
- Apply safety rules while working on the system.
- Transfer the knowledge learned from one system to another system.

Course Content

Content to be covered within this course includes the following topics:

- Function and design of a programmable logic controller (PLC)
- Types of signals in control systems

- Number systems and digital logic
- Configuration of a PLC
- Basic function modules of PLC
- Program processing
- Basic fundamentals of the programming language STEP7
- Testing and simulation of a PLC program
- Safety issues, including local regulations
- Preventive and routine maintenance of PLCs
- Troubleshooting of the PLC hardware within a module or system

NOTE: The order in which the content will be discussed is dependent upon the mechatronic system which is being used. In each case, the component and/or class of components will be discussed within the context of the system and the module in which the component is located. This means that the exact order of presentation will vary according to the system available for instruction. It is also important that all classes of electrical components be discussed, whether available in the training system or not.
Focus in all cases is on the role of the components within a module and system, identification of problems, routine maintenance, troubleshooting, and safety issues with the goal of preventing system downtime or reducing them to a minimum.

Course Prerequisites

Basic knowledge of algebra. Successful completion of, or parallel enrollment in Courses 1, 2, and 3 of the certification program is recommended but not required.

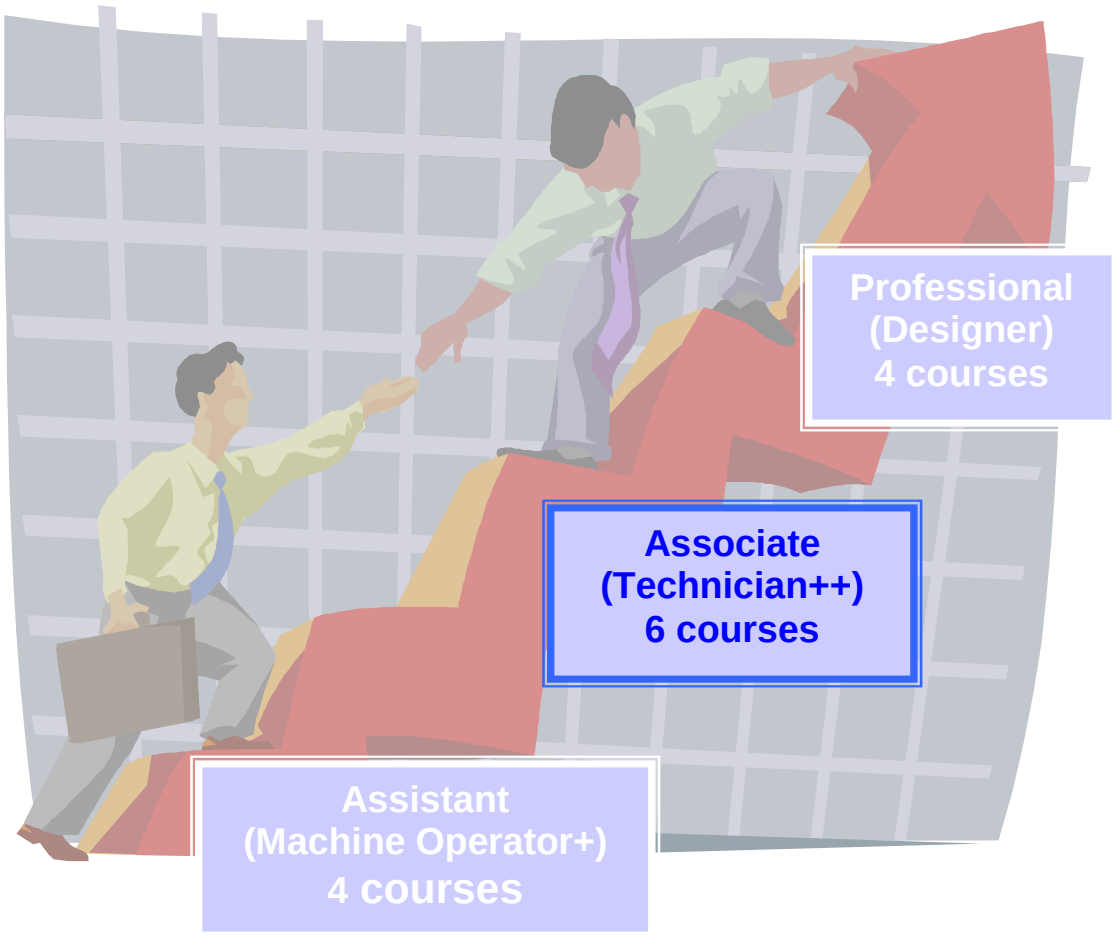
Course Materials

Recommended basic course materials are in digital form:

Course materials provided by SMSCP Partner Schools to their students are at the partner school's discretion, and may include special software such as SIMIT, Diagnostic Kit software, etc. If desired, a supporting textbook on basic PLC topics may required by the school or instructor.

Students must also have access to a mechatronic training system containing all or most of the basic component types covered in the course. Please see the SMSCP "Hardware Requirements" document for more information on system requirements for Level 1 instruction.

Siemens Mechatronic Systems Certification Program



Level 2 (Mechatronic Systems Associate)

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Overview Level 2 (Mechatronic Systems Associate)

The Mechatronic Systems Associate certification is the second of three certifications in a series. Each certification is based upon a specified, industry-driven **job profile** which can help an employer determine where the certified person can be best placed within their organization. The job profile is a guiding or steering document that helps to determine many other administrative and content-related attributes of the level.

Further, the job profile helps to differentiate Level 2 from the levels immediately above and below. A person who successfully completes the training and passes the exam for Level 2 should be able to perform job functions as given in the job profile. Note: Certification is not a guarantee of performance but rather a recognition of achievement.

Job Profile

A Siemens Certified Mechatronic Systems Associate will function as a highly skilled technician who can work with modules and components in complex mechatronic systems as well as be able to assess and analyze the system as a whole. A certified Associate can manage, investigate, repair and troubleshoot mechatronic systems, with the aim of operational efficiency and cost and process control. A Siemens Certified Mechatronic Systems Associate would usually carry out their work at production facilities, workshops, or in service sites that use complex mechatronic systems.

Job skills and activities include:

- Understanding and analyzing the technical specification of mechatronic systems, subsystems, modules and components;
- Deriving and determining parameters for mechatronic systems and system elements;
- Measuring, interpreting and analyzing electrical, PLC/microcontroller and mechanical values;
- Assembling and installing tools and hardware systems;
- Performing scheduled and preventive maintenance;
- Installing, implementing and modifying software tools used in mechatronic systems;
- Using troubleshooting skills to identify, foresee and prevent possible problems, conflicts and failures, and to systematically and intelligently make repairs;
- Programming mechatronic modules and systems, especially PLCs;
- Implementing PLC networks, including configuration and data transfer using bus systems;
- Analyzing system logs;
- Incorporating relevant technical literature into understanding of system operation and using this information to propose procedural and operational changes;
- Observing and incorporating safety standards;
- Applying knowledge of process control technology, including all regulator types;
- Observe, follow, and influence cost control and process efficiency procedures;
- Executing all of the above as an effective member of a team.

Siemens Certified Mechatronics Systems Associates can see the system as a whole, but can also dive in and work with particular system components. More importantly, they understand how the components work together. Compared to those certified at Level 1 (Siemens Certified Mechatronics Systems Assistant), they will be both a high- and low-level mechatronic systems expert.

The Curriculum

Level 2 (Associate) Certification consists of six standardized courses, designed to be integrated within a college curriculum or to be implemented as continuing education. Each course consists of roughly 60 hours of classroom instruction with additional laboratory work on a physical system located at the training institution, on PC- and web-based simulations, etc. The main foci of the courses are:

Course 1: Process control technologies
Course 2: Introduction to Totally Integrated Automation
Course 3: Automation systems
Course 4: Motor control
Course 5: Mechanics and machine elements
Course 6: Manufacturing processes

Once a student has successfully completed all six courses, she should be well-prepared to sit for the Level 2 certification examination. This will preferably be administered through a neutral testing center, but could be administered in other ways as well at the discretion of the SMSCP Management.
Only by successfully passing the Level 2 Certification Examination will the student be awarded the certification of Siemens Certified Mechatronic Systems Associate.

System Approach in Level 2

Underlying the curriculum of the Certification Program is the System Approach, which has been used with high effectiveness for the training of Siemens' own co-workers in Germany.

This process is the same at all three levels of the Certification Program; as Level 1 progresses into Level 2, emphasis is moved away from learning how to work through systems and more toward process- and project management, investigation and troubleshooting, and even repair.

As a result, Siemens Certified Mechatronic Systems Associates learn how to work their way into and through a new system, and by means of the troubleshooting strategies which they learn, they are able to transfer their knowledge and expertise easily to another system. This makes for an employee who is flexible, autonomous and professional in his or her dealings with such complex system.

Syllabus
Level 2, Course 1
Process Control Technologies

Course Description

This course covers topics in Closed Loop Control and technologies used in Process Control in the context of a complex mechatronic system. Based on a real system, students will learn the basic functions related to obtaining knowledge of plant documentation and manuals, making suggestions for use in future analysis, creating sets of suggestions for future analysis, and creating diagrams that show the interaction between controllers, sensors and actuators.

The course focuses in helping students to be able to characterize a system by its step response function, and creating and interpreting charts with diagrams for time-based changes of measured values. Students will learn how to establish controller operating parameters and learn the difference between the types of controllers that are typically used in mechatronic systems. PID controllers will be introduced and discussed, along with strategies for optimizing them. Based on the step response functions mentioned above, students will learn how to determine which controller is the best one to use. The advantages and disadvantages of ON/OFF and PID controllers are covered in certain systems. Finally, optimization and troubleshooting of industry controllers is covered.

Course Philosophy

For this course particularly, the entire system will be analyzed, the individual processes examined, and the use of automated processes control techniques and their types will be discussed. Next, modules with process control will be individually examined in the context of the whole mechatronic system, and its constituent control systems will be studied. For each of these parts, students will be given sets of tasks. By completing them, they will work with an actual mechatronic system and come to understand the control technologies contained inside.

Course Goals

Upon completion of the course, students should:

- Understand the role of control devices within mechatronic system, and the inter-relationships with components and modules within that system.
- Understand the different control strategies and their use for different applications.
- Understand why control technology is important for process control in mechatronic systems.
- Know how to identify malfunctions of control systems because of knowing their influence on the system itself.
- Be able to troubleshoot and optimize control systems.

Course Objectives

At the conclusion of this course, students will be able to:

- Monitor the operation of permanently installed plants
- Perform regular maintenance
- Perform fault troubleshooting, diagnosis and elimination
- Exchange and replacement of components, including plant controllers
- Apply process control technology knowledge, including fluency with all regulator types

Course Content

Content to be covered within this course includes the following topics:

- Introduction to Control Technologies
- Plant Model
  - Bottling Plant
  - Level Control Plant
  - Temperature Control Plant
  - Heater-Cooler Plant
- Control Technology
  - Process Automation
  - Process Control Technique
  - Closed Loop Control
  - ON/OFF Control
  - PID Control
  - Step Response
  - Tuning the Controller
  - Three Position Control
  - Trouble Shooting
  - PWM
- Technical Components
  - Reading Diagrams
  - Controller Types
  - Amplifier and Electronic
  - Operating Tools
  - Sensors
  - Actuators

NOTE: The order in which the content will be discussed is dependent upon the mechatronic system which is being used. In each case, the component and/or class of components will be discussed within the context of the system and the module in which the component is located. This means that the exact order of presentation will vary according to the system available for instruction. It is also important that all classes of electrical components be discussed, whether available in the training system or not.
Focus in all cases is on the role of the components within a module and system, identification of problems, routine maintenance, troubleshooting, and safety issues with the goal of preventing system downtime or reducing them to a minimum.

Course Prerequisites

Basic knowledge of algebra. Basic knowledge of sensors and actuators, from exposure to courses in the Siemens Mechatronic Systems Certification Program Level 1 or equivalent.

Course Materials

Recommended basic course materials are in digital form:

Course materials provided by SMSCP Partner Schools to their students are at the partner school's discretion, and may include special software such as LabView or other visualization/simulation software. If desired, a supporting textbook on closed loop control and/or process control technology may required by the school or instructor.

Students must also have access to a mechatronic training system containing all or most of the basic component types covered in the course. Please see the SMSCP "Hardware Requirements" document for more information on system requirements for Level 2 instruction.

Syllabus
Level 2, Course 2
Introduction to Totally Integrated Automation

Course Description

This course introduces the Siemens concept Totally Integrated Automation by looking at the automation pyramid. Students will start at the field level with analogue sensors and actuators and later on go up to the control level with programming and networking PLCs.

The course begins with connecting different analogue sensors (for example voltage, current, and resistance sensors) to analogue modules. In order to write a PLC program with analogue values, course participants need to know how to use real numbers. In order to work with these and other kinds of numbers, the participants also need to get to know additional STEP 7 functions like comparison, memory, arithmetic, conversion, and jump functions.
Later in the course, participants will learn the basics of MPI-Bus and PROFIBUS systems. PLCs will be connected to each other with a bus cable in order to create an MPI network with the corresponding data configuration in STEP 7. PROFIBUS modules are going to be wired with bus cables to a PLC.
Additionally, maintenance and troubleshooting of these bus systems are essential components of the course.

Course Philosophy

With knowing basics of digital fundamentals and PLC technology, this course introduces the Siemens concept Totally Integrated Automation. After knowing PLC and the main components from Level 1 Course 4 “Digital Fundamentals and PLCs” this course focuses on the extension of this knowledge with regard to the automation pyramid, of course starting in the field level at analogue sensors and actuators. Later on they will go up to control level with networking and programming PLCs.

For this course in particular, students will build on their previous knowledge of PLCs, either as part of the Level 1 course entitled “Digital Fundamentals and PLCs”, or through equivalent education or experience. The knowledge of digital basics will be built upon to not only include more functions and advanced topics but to focus on communications between PLCs as well.

Course Goals

At the end of this course, participants should be prepared to:

- Understand the role of analogue sensors, actuators and modules in PLC technology.
- Understand the use and function of PROFIBUS and MPI Bus.
- Apply the knowledge to ensure proper performance of networks.
- Use STEP 7 networking PLC components.
- Carry out troubleshooting and preventive maintenance of PLC networks.

Course Objectives

At the conclusion of this course, students will be able to:

- Connect different analogue sensors and actuators to different analogue modules of the SIMATIC S7 product family
- Handle different formats of real numbers within an S7 program
- Scale and unscale analogue values with the appropriate functions
- Use advanced programming instructions (arithmetic, conversion, jump) in a PLC program
- Setup and configure PROFIBUS and MPI networks
- Troubleshoot PLC networks with the help of the appropriate functions

Course Content

The course covers content according to the following outline:

- Analogue values in PLC technology
  - Connecting analogue modules to sensors and actuators
  - Working with analogue values in the PLC program
  - Scaling and unscaling
- Advanced PLC programming
  - Comparison functions
  - Accumulator functions
  - Arithmetic functions
  - Conversion functions
  - Jump functions
- MPI and PROFIBUS
  - Hardware
  - Implementation of bus systems in SIMATIC Step7
  - Data Traffic
  - Maintenance and Troubleshooting

NOTE: The order in which the content will be discussed is dependent upon the mechatronic system which is being used. In each case, the component and/or class of components will be discussed within the context of the system and the module in which the component is located. This means that the exact order of presentation will vary according to the system available for instruction. It is also important that all classes of electrical components be discussed, whether available in the training system or not.
Focus in all cases is on the role of the components within a module and system, identification of problems, routine maintenance, troubleshooting, and safety issues with the goal of preventing system downtime or reducing them to a minimum.

Course Prerequisites

Basic knowledge of algebra; previous education or experience with PLCs (installation and/or programming).

Course Materials

Recommended basic course materials are in digital form:

Course materials provided by SMSCP Partner Schools to their students are at the partner school's discretion, and may include special software such as LabView or other visualization/simulation software.

Students must also have access to a mechatronic training system containing all or most of the basic component types covered in the course. Please see the SMSCP "Hardware Requirements" document for more information on system requirements for Level 2 instruction.

Syllabus
Level 2, Course 3
Automation Systems

Course Description

The Automation Systems course in the Level 2 certification program is divided into two main branches; Manufacturing Technologies, including CNC, CAD and CAM; and Microcontrollers and Programming, which constitute essential tools in modern manufacturing, particularly in mechatronic systems.

When breaking down a system into its constituent modules, it is likely to find a microcontroller as the intelligent core of the entire structure. The microcontroller section begins to explain the theory behind microcontroller and microprocessor architecture, and focuses later on its features and ways of interaction with other electronic elements understanding its particular function, and its role as part of a whole. This theory is complemented with practical exercises that reflect the importance of microcontrollers in a mechatronic system. The use of component data sheets for reference, calculations and design is also explained. The course culminates with the instruction of Assembly Language programming, which is applied when operating microcontrollers and designing and constructing devices that include this type of element. Basic programming skills can be taught parallel to the instruction of the Assembly syntax at the earlier stages as needed. This section makes up for approximately 60% of the total material for Manufacturing Automation.

For the remainder of the class, the emphasis turns to manufacturing automation. In this section the main concepts to be covered include Metal Cutting, Modal Analysis, CNC, CAM and CAD. These tools provide students with part of the skill set necessary to maintain and improve mechatronic systems. The class can concentrate on one or more of these topics as needed in each particular case and depending the students' background. The metal cutting section includes references on material properties, tool geometry and mechanics for manufacturing processes. The section on CNC is one of the main focuses of this part of the course and it includes different types of commands, an introduction to CNC design and general algorithms. The CAM section explains the use of NC, APT, parametric definitions as well as tool geometry. The course ends with a general CAD instruction that can be extended as needed.

Course Philosophy

The main goal of Course 3 is to give a clear view to students about the different tools that they can use to maintain and improve mechatronic systems used in manufacturing environments. A Level 2 Siemens Mechatronics associate is expected to have a solid background concerning manufacturing methods and devices. Within this goal, the knowledge and familiarity with common concepts in manufacturing such as CNC, CAM and CAD is essential to form a highly skilled technician with "Handlungskompetenz" who will be able to

interact with the environment, incorporate improvements, and remain flexible when changes are required.

In addition to this knowledge this course emphasizes in microcontroller technology and computer programming, which are of great importance in modern manufacturing as the main bridges between classical manufacturing and rapidly evolving technology. Microcontrollers are covered to the extent where students are able to construct, program and operate such devices to control one or several modules within a mechatronic system.

Course Goals

Upon completion of the course students should:

- Be able to apply knowledge about automation manufacturing to maintain and improve mechatronic systems.
- Realize the importance of microcontrollers and automated tools as essential components on a mechatronic system.
- Understand the relationship of these elements as part of a whole and how they interact with others in a way that allows for successful operation and continuous improvement.

Course Objectives

Upon completion of the course, students should be able to:

- Operate, assemble and interconnect microcontrollers.
- Make use of microcontrollers in a mechatronic system taking advantage of its features to expedite automation systems.
- Program mechatronic modules and systems.
- Recognize metal cutting methods, tool geometries and general material properties.
- Use CAD, CAM and CNC general concepts to maintain and improve mechatronic systems.
- Understand CNC fundamentals and basic notions on CNC programming.
- Identify general aspects about CAM, its applications and advantages in a automated manufacturing environment.
- Represent models for mechatronic components by using CAD tools.

Course Content

Content to be covered in the microcontroller part of this course includes the following:

- Fundamentals
    - Microcontroller, microprocessor and microcomputer
    - Numbering systems
    - Busses - Overview and classification.
- Components of a microcontroller
    - CPU
    - ALU

    - RAM
    - ROM
- Introduction to 8085
    - Data sheet and diagram interpretation
    - Multiplexed address data bus
    - Clocks and clock signals
    - I/O ports
- Programming
    - Assembly syntax
    - Program instructions
    - Applied project

Content to be covered in the manufacturing part of this course includes the following:

- Introduction
- Metal cutting
    - Fundamentals
    - Work piece material properties
    - Tool geometry
    - Cutting conditions
    - Oblique geometry
    - Mechanics for manufacturing processes
- Tool Wear
- Static deformation
- Vibrations
- Modal analysis
- CNC – Computer numerical control (Automated Manufacturing)
    - CNC Fundamentals
    - Standard NC commands
    - Motion commands
    - Miscellaneous commands
    - CNC design
    - General algorithms
- CAM – Computer aided manufacturing
    - Use of NC
    - APT – Automatic programmed tooling
    - Parametric definitions
    - Part and tool geometry
    - CL – Cutler location
- CAD – Computer aided design
    - Fundamentals
    - General overview

NOTE: The order in which the content will be discussed is dependent upon the mechatronic system which is being used. In each case, the component and/or class of components will be discussed within the context of the system and the module in which the component is located. This means that the exact order of presentation will

vary according to the system available for instruction. It is also important that all classes of electrical components be discussed, whether available in the training system or not.
Focus in all cases is on the role of the components within a module and system, identification of problems, routine maintenance, troubleshooting, and safety issues with the goal of preventing system downtime or reducing them to a minimum.

Course Prerequisites

Basic knowledge of algebra. Basic knowledge of electronics and digital fundamentals from exposure to Siemens Mechatronic Systems Certification Program Level 1 or equivalent.

Course Materials

Recommended basic course materials are in digital form:

Course materials provided by SMSCP Partner Schools to their students are at the partner school's discretion, and may include special software such as microcontroller programming software as well as a combination of appropriate CAD/CAM/CNC software.

Students must also have access to a mechatronic training system containing all or most of the basic component types covered in the course. Please see the SMSCP "Hardware Requirements" document for more information on system requirements for Level 2 instruction.

Syllabus
Level 2, Course 4
Motor Control

Course Description

This course covers principles of motor control in part as a continuation of the SMSCP Level 1 course on Mechanical Components and Electric Drives. Even though this course builds on the concepts of the related Level 1 course, the Level 1 course is not a prerequisite; equivalent knowledge gained elsewhere will also suffice.

In the first part of the course, General Machine Operation, different types of braking and loads on a motor are addressed, as well as questions of improving motor efficiency and power. Different control techniques are then discussed, including different methods of starting a motor, controlling voltage and frequency, and the role of different sensors in relation to motor operation.

Troubleshooting techniques and an examination of the various causes of motor failure are discussed; preventive measures that can be taken in order to protect motors are also taught.

Course Philosophy

For this course students will be challenged to build on previous knowledge of electric drives (either acquired from the SMSCP Level 1 Course 2: Mechanical Components and Electric Drives or from equivalent electric drives course(s)) by not only looking at details of the various control and protection methods used in motors but also to see motors as parts of systems and as systems themselves.

Course Goals

Upon completion of the course, students should:

- Understand the general principles of motors and machine operation.
- Understand the importance of motor efficiency as well as various techniques to improve efficiency.
- Understand motor notation symbology and control strategies, including voltage and frequency control.
- Understand the role of motor control circuits in power electronics.
- Understand how to protect motors and prevent motor failure.

Course Objectives

At the conclusion of this course, students will be able to:

- Start a motor in the correct way, using the correct method.

- Set up a motor control circuit
- Use control logic programs in motor control contexts.
- Set up sensors in order to give feedback to a control circuit.
- Choose and install the correct safety devices for specific control circuits.
- Detect and prevent possible malfunctions.

Course Content

Content to be covered within this course includes the following topics:

General Machine Operation

- Motor
- Generator
    - Electrical Braking
    - Regenerative Braking
- Motor Loads
    - Constant Torque
    - Constant Power
    - Constant Speed
- Efficiency
    - High Efficiency Motors
    - Power Electronics Effects (Harmonics)
    - Power Factor (incl. how to improve)

Motor Control Techniques

- Symbology (Motors. Power Circuit, Control Circuits)
- Starting Methods
    - Full Voltage
    - Reduced Voltage
        - Wye-Delta
    - Soft Starting
- Control Strategies
    - Voltage
    - Frequency
- Sensors / Encoders

Motor Failures and Protection

- Fuse / Circuit Breaker
- Thermal Protection
- Insulation
- Mechanical Failures
    - Bearings
    - Brushes, Armature
    - Belt and Shaft Alignment

- Overload - Application Abuse
- Stopping Methods - Mechanical Braking

NOTE: The order in which the content will be discussed is dependent upon the mechatronic system which is being used. In each case, the component and/or class of components will be discussed within the context of the system and the module in which the component is located. This means that the exact order of presentation will vary according to the system available for instruction. It is also important that all classes of electrical components be discussed, whether available in the training system or not.
Focus in all cases is on the role of the components within a module and system, identification of problems, routine maintenance, troubleshooting, and safety issues with the goal of preventing system downtime or reducing them to a minimum.

Course Prerequisites

Education and/or experience equivalent to SMSCP Level 1 Course 2: Mechanical Components and Electric Drives and SMSCP Level 1 Course 1: Electrical Components.

Course Materials

Recommended basic course materials are in digital form:

Course materials provided by SMSCP Partner Schools to their students are at the partner school's discretion, and may include special software for mathematics, simulation and/or microcontroller programming.

Students must also have access to a mechatronic training system containing all or most of the basic component types covered in the course. Please see the SMSCP "Hardware Requirements" document for more information on system requirements for Level 2 instruction.

Syllabus
Level 2, Course 5
Mechanics and Machine Elements

Course Description

This course focuses on the study of the mechanical components that are included in a complex mechatronic system. It begins with an overview of Statics and Kinetics, which includes force system analysis, study of equilibrium, frames and machines, friction and effects of forces on the motion of objects among other basic topics.

The second part of the course focuses on Machine Elements, fundaments and classification of a variety of components expanding the material into calculations involving force, stress and wear analysis, as well as calculations to determine the different features from a particular component required in given a system. The course focuses on the employment of these techniques for supporting mechatronic systems and to ensure its proper function, correct possible defects that may interrupt the process and to plan preventive maintenance operations on them, observing and incorporating locally enforced and general safety standards. Course 5 of Level 2 provides a deeper insight into the principles behind the different components of the system. The course aims to form both high and low level mechatronic experts at production and development facilities.

Course Philosophy

For this course students will be challenged to build on previous knowledge of mechanical components (either acquired from the SMSCP Level 1 Course 2: Mechanical Components and Electric Drives or from equivalent electric drives course(s)) by not only looking at details of the various mechanical components but also seeing these as parts of systems and as systems themselves. By knowing the components and their function within the mechatronic system, a deeper look into the function and characteristics of the components is taken.

Course Goals

At the end of this course, students should be prepared to:

- Understand the role of mechanical components in complex mechatronic systems.
- Apply this knowledge to ensure proper performance of the mechanical parts in the system
- Understand troubleshooting, preventive maintenance and safety issues revolving around mechanical components within a mechatronic system.

Course Objectives

At the conclusion of this course, students are able to:

- Resolve problems involving Statics principles such as:

- Trace and describe the flow of energy in a given mechatronic system or subsystem.
- Describe the basic physical properties of mechanical components including materials, lubrication requirements and surface properties.
- Carry out adjustments on mechanical components in a mechatronic system.
- Explain the different classifications and roles of various mechanical components within a given system or module including:
- Correctly localize, identify and document causes of malfunctions in mechanical components, based upon the use of applied formulas and technical documentation.
- Correct malfunctions where possible, or correctly identify the expertise required to correct a malfunction.
- Apply safety rules while working on the system.
- Transfer the knowledge learned from one system to another system.

Course Content

Content to be covered into within this course includes the following:

- *Statics Overview*
  - Fundamentals
  - Force Systems
  - Moments and Couples
  - Equilibrium of a Rigid Body
  - Centre of Gravity and Centroids
  - Frames and Machines
  - Friction
- *Kinetics*
  - Translation
  - Rotation
  - Work, Energy and Efficiency
- *Machine Elements*
  - Rolling Contact Bearings
  - Shafting
  - Gears
  - Flexible Elements
  - Shaft Couplings
  - Clutches

NOTE: The order in which the content will be discussed is dependent upon the mechatronic system which is being used. In each case, the component and/or class of components will be discussed within the context of the system and the module in which the component is located. This means that the exact order of presentation will vary according to the system available for instruction. It is also important that all classes of electrical components be discussed, whether available in the training system or not.
Focus in all cases is on the role of the components within a module and system, identification of problems, routine maintenance, troubleshooting, and safety issues with the goal of preventing system downtime or reducing them to a minimum.

Course Prerequisites

Knowledge of Mechanical Components from Siemens Mechatronic Systems Certification Program Level 1 Course 2 Mechanical Components and Electrical Drives or equivalent.

Course Materials

Recommended basic course materials are in digital form:

Course materials provided by SMSCP Partner Schools to their students are at the partner school's discretion, and may include special software.

Students must also have access to a mechatronic training system containing all or most of the basic component types covered in the course. Please see the SMSCP "Hardware Requirements" document for more information on system requirements for Level 2 instruction.

Syllabus
Level 2, Course 6
Manufacturing Processes

Course Description

This course is divided into two major parts: a section on process management and a section on the function and importance of a hands-on design project. In each case, a blueprint is presented to instructors that they can use when implementing the course at their school.

For the process management component, a factory simulation is conducted. Each participant is assigned a role and the rules of the simulation are discussed. After a series of runs of the simulation, a discussion and presentation is made, where participants not only present their performance and progress data but also track what they learned.

For the hands-on design project component, instructors are encouraged and supported in creating a useful design project for students. Students are divided into teams, informed of the rules of the project, given a timeline, budget and a "customer", as well as other parameters. After completing the project, students present their results and learning outcomes.

Course Philosophy

For this course it is recognized as very important the ability for engineering technology students to have an awareness of what it is like to work with customers, timelines, budgetary restrictions, and in general to include some basic business sense in the spirit of their work. While this course is not a business course by any means, it emphasizes business-related factors that employers express an increased desire for when selecting mechatronics technicians at this level.

Course Goals

Upon completion of the course, students should:

- Understand the concepts presented in the factory simulation, including Cycle Time, Production Time, First Pass Yield, and Barrier Identification.
- Understand how to make a process map.
- Understand how to read a Cost Breakdown.
- Understand the various roles on Project Teams.
- Understand Project Team Organization and Evaluation.

Course Objectives

At the conclusion of this course, students will be able to:

- Work with mechatronic systems with a process-oriented perspective

- Give meaningful recommendations on how to improve manufacturing and work processes.
- Express an appreciation for the role of the customer in the larger manufacturing picture.
- Work on a project with significant time and budgetary constraints.
- Work as an effective member of a team.
- Evaluate project work in such a way that translates to future increased effectiveness in such tasks.

Course Content

Support material for the process management simulation part of this course includes the following topics:

- Introduction
- The simulation
- Basic layout
- Participants
- Sample schedule
- Concepts covered by the simulation
    - Process Definition
    - Total Cycle Time
    - Production Time
    - Productivity and Process Improvement
    - Quality
    - Process Mapping
    - Factory Layout
    - First Pass Yield
    - Barriers and Low Hanging Fruit
    - Visual Systems and Process Transparency
    - Benchmarking
    - Balanced Score Card
    - Cost Analysis and Pricing strategies
    - Continuous Improvement Process (CIP)
- Conclusion

Support material for the student design project part of this course includes the following topics:

- Introduction to Student Project Phase
- Professions/ Teambuilding and Regulation
- Didactical Concept – Action- oriented learning and teaching concept
- Learning Outcomes
- Project Management (definition, planning, accomplishment, completion)
- Time Schedule

- Communication
- Cost Calculation
- Project Management

Course Prerequisites

None. Proficiency with MS Office or related tools can be useful.

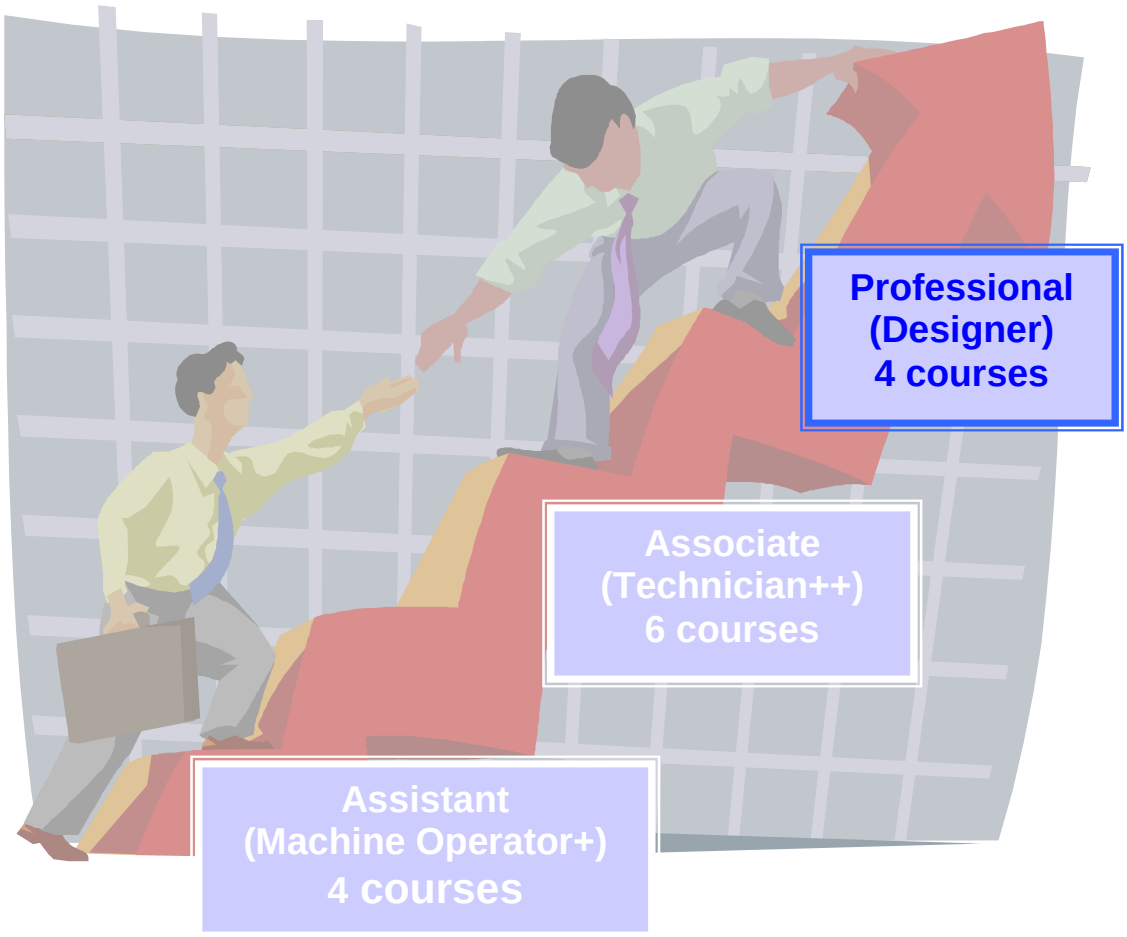
Course Materials

Recommended basic course materials are in digital form:

Course materials provided by SMSCP Partner Schools to their students are at the partner school's discretion, and may include software such as Microsoft Office with Visio and CAD tools for the design project part of the course.

Students must also have access to a mechatronic training system containing all or most of the basic component types covered in the course. Please see the SMSCP "Hardware Requirements" document for more information on system requirements for Level 2 instruction.

Siemens Mechatronic Systems Certification Program



Level 3 (Mechatronic Systems Professional)

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Overview Level 3 (Mechatronic Systems Professional)

The Mechatronic Systems Professional certification is the third of three certifications in a series. Each certification is based upon a specified, industry-driven **job profile** which can help an employer determine where the certified person can be best placed within their organization. The job profile is a guiding or steering document that helps to determine many other administrative and content-related attributes of the level as well as content.

Further, the job profile helps to differentiate Level 3 from the levels immediately below. A person who successfully completes the training and passes the exam for Level 3 should be able to perform job functions as given in the job profile. Note: Certification is not a guarantee of performance but rather a recognition of achievement.

Job Profile

A Siemens Certified Mechatronic Systems Professional will function as a skilled designer of and expert on complex mechatronic systems. A Certified Professional will be responsible for high-level design, management, and improvement of mechatronic systems based upon customer and user needs. Normally a Siemens Certified Mechatronics Systems Professional would carry out most of their work in an engineering office environment; however they may also carry out some of their work at production facilities, workshops, and service sites that use complex mechatronic systems.

He or she will be able to:

- Define the functional requirements of a mechatronic system with ‘use cases’, interviews with customers and users, and systems modeling techniques;
- Perform high-level design by defining appropriate mechatronic systems to perform specific tasks;
- Utilize knowledge of machine elements, actuators, pneumatics, and electric drives to design particular mechatronic systems;
- Select the correct automation technology based on the mechanical and electronic composition of the system, while taking into account the functional requirements of the system;
- Communicate design ideas using CAD tools;
- Program and troubleshoot PLC networks;
- Establish a routine maintenance schedule;
- Review past system performance and carry out comprehensive system tests, with the aim of locating ways to optimize operations for cost, quality, and efficiency;
- Design and implement system optimization techniques in an existing mechatronic system
- Maintain knowledge of the current state-of-the-art in mechatronic systems, such that upgrades and modifications reflect the most up-to-date and effective methodology.
- Develop specifications for automation system communication integration

Siemens Certified Mechatronic Systems Professionals understand at a high level how mechatronic systems function. In contrast to those certified at Levels 1 and 2 (Siemens Certified Mechatronic Systems Assistant and Associate), they will understand why a mechatronic system is designed the way it is. In addition to designing and managing new systems, they will be able to optimize and improve existing systems.

The Curriculum

Level 3 (Professional) Certification consists of four standardized courses, designed to be integrated within a college curriculum or to be implemented as continuing education. Each course consists of roughly 60 hours of classroom instruction with additional laboratory work on a physical system located at the training institution, on PC- and web-based simulations, etc.

The main foci of the courses are:

Course 1: Mechatronics Systems Design
Course 2: Customized Automation Solutions with TIA
Course 3: Feedback Control Systems and Optimization
Course 4: Dynamics and Kinematics of Machinery

Once a student has successfully completed all four courses, he or she should be well-prepared to sit for the Level 3 certification examination. This will preferably be administered through a neutral testing center, but could be administered in other ways as well at the discretion of the SMSCP Management.

Only by successfully passing the Level 3 Certification Examination will the student be awarded the certification of Siemens Certified Mechatronic Systems Professional.

System Approach in Level 3

Underlying the curriculum of the Certification Program is the System Approach, which has been used with high effectiveness for the training of Siemens' own co-workers in Germany. This process is the same at all three levels of the Certification Program, as Level 2 progresses into Level 3, emphasis is moved to designing, networking and optimizing complex mechatronic systems.

Siemens Certified Mechatronic Systems Professionals learn how to work their way into and through a new system, and by means of the designing and optimization process which they learn, they are able to transfer their knowledge and expertise easily to another system.

This makes for an employee who is flexible, autonomous and professional in his or her dealings with complex systems.

Syllabus
Level 3, Course 1
Mechatronics System Design

Course Description

This course presents specifics in the mechanical design of mechatronic systems. Its main foci are problem analysis, conceptualization & drawing, design/material selection, and performance analysis to create complete functional mechatronic systems. Topics include requirements of mechanical subsystems as components of the whole and design methods. Components like bills of materials and economic analysis will also be covered in lecture.

This study is oriented towards a design project with the goal of developing a complete dynamic mechatronic system based upon optimal solution and materials considerations, economic considerations, quality and reliability.

Projects and assignments are therefore essential elements of this course. Students will carry out a design project from start to finish, which can be geared toward any application of mechatronics, such as robotics and manufacturing systems. These deliverables are a great opportunity to gain a hands-on experience in designing and building a mechatronic system. The intent of this course is also to provide the student with a cooperative working experience within a team.

Course Philosophy

Within this course students design a complete mechatronic system on their own. Therefore the instructor will not act like a real teacher but more as a moderator leading the class in the right direction. Therefore students have to find the necessary tools, methods and ideas for designing and constructing on their own.

Course Goals

Upon completion of the course, students should be able to:

- Understand the theory of mechatronics system design.
- Acquire design skills, organizational capabilities, and skills of putting theory and industrial exposure to practice.
- Understand the range of techniques available in designing a mechatronic system.
- Understand the influence of software, mechanical, electrical/electronic, materials and economical components in design of a mechatronic system.
- Develop an understanding of the graphical construction techniques in Engineering Graphics.
- Understand the basic concepts used in Computer Applications, Manufacturing Processes and Engineering Drawing & Modeling.
- Develop an understanding of computer networking for communication and control.

- Gain experience designing and constructing basic mechatronic system

Course Objectives

At the conclusion of this course, students will be able to:

- Select an appropriate type of sensor and actuator for a specified application.
- Design a mechatronic system or subsystem based upon”use case” and needs of users and customers.
- Design a mechatronic system including the prediction of its dynamic behavior.
- Design an integrated system which includes an actuator, sensor, and microprocessor controller.
- Draw orthographic projections on a 2-D/3-D CAD package so as to be able to generate orthographic views, carry out Engineering Graphics, and produce 3-dimensional models of mechatronic system and subsystem.
- Use commercially available application software for curve design, surface design and solid modeling.

Course Content

Content to be covered within this course includes the following topics:

Design Theory:

- Problem statement
- Problem definition
- Selection Design
- Benchmarking
- Drawings
- Concept generation
- Engineering modeling
- Performance/economic analysis
- Bill of Materials
- Fabrication, assembly, testing

Design Project

Students will carry out a design project from start to finish.
The project can be geared toward any application of mechatronics, such as robotics or manufacturing systems.

Course Prerequisites

Basic knowledge of material science, education and/or experience equivalent to SMSCP Level 1 Course 2 - Mechanical Components and Electric Drives, Level 1 Course 3 - (Electro) Pneumatics and Hydraulic Control Circuits, Level 2 Course 3 – Automation System and Level 2 Course 5 - Mechatronics and Machine Elements.

Course Materials

Recommended basic course materials are in digital form:

Course materials provided by SMSCP Partner Schools to their students are at the partner school's discretion, and may include special systems design software.

Students must also have access to a mechatronic training system containing all or most of the basic component types covered in the course. Please see the SMSCP "Hardware Requirements" document for more information on system requirements for Level 3 instruction.

Syllabus
Level 3, Course 2
Customized Automation Solutions with TIA

Course Description

In this course, students will analyze and create a functional description of a complete system utilizing all sensors and actuators. The students will define their own unified programming specifications as well as system specifications according to industrial standards. After that, the participants will program complete modules of the real system including Graphical User Interfaces (GUIs) on Human Machine Interfaces (HMIs) and the connection of different modules via PROFINET as well as safety integration and the implementation of advanced motor control.
Software handling will be an essential part of the course. The participants will learn to work with the Step7 software with its different features for programming and network setup, to create GUIs with WinCC Flexible and to use simulation tools such as SIMIT to test and evaluate their programs.
The participants will read, analyze und use datasheets and diagrams of sensors and actuators implemented in the system. Additionally, they will use intelligent troubleshooting strategies to narrow down and pinpoint defective components on the real system.

Course Philosophy

For this course in particular, students will build on their previous knowledge of PLCs, either as part of the Level 2 course entitled “Introduction to Totally Integrated Automation”, or through equivalent education or experience. The knowledge of digital basics will be built upon to not only include more functions and advanced topics but to focus on communications between PLCs via PROFINET and creation of Graphical User Interfaces as well.
During the course the students should commission a complete complex module of the mechatronic training system alone. The instructor will only guide the class so that the students will find all necessary tools and functions to commission the module on their own.

Course Goals

Upon completion of this course, students should:

- Understand the interconnection and interaction of sensors, actuators and control system within complex mechatronic subsystems.
- Realize the importance of modularization and understand the different ways of connecting/networking subsystems as a whole.
- Be able to apply knowledge about TIA to commission, install and improve automated mechatronic systems.
- Realize the importance of safety integration in mechatronic systems.
- Be able to apply knowledge to unknown mechatronic systems and new software versions.

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Course Objectives

At the conclusion of this course students will be able to:

- Create and analyze system specifications of previously **unencountered** PLC controlled mechatronic systems including sensors and actuators utilized.
- Commission complete mechatronic, PLC controlled systems including:
  - PROFINET installations.
  - GUIs on Human Machine Interfaces
  - Advanced motor control (frequency converters, PWM, …)
  - Safety Integration.
- Use simulation tools to test and evaluate PLC programs.
- Use intelligent troubleshooting strategies to narrow down and pinpoint system faults.

Course Content

- Introduction
- Structured Programming
  - How a PLC processes Information
  - Different Modes of Operation
  - Use of OBs, FCs, FBs and DBs
  - Chain Cascade Programming
  - Basic Rules for Structured Programming
- PROFINET
  - Ethernet Basics and Protocols
  - PROFINET – Industrial Ethernet
  - PROFINET with SIMATIC Step7
- Operating Machines with HMI Systems
  - Basic Overview WinCC flexible
  - Design and Program HMIs
- Support Material

NOTE: The order in which the content will be discussed is dependent upon the mechatronic system which is being used. In each case, the component and/or class of components will be discussed within the context of the system and the module in which the component is located. This means that the exact order of presentation will vary according to the system available for instruction. It is also important that all classes of electrical components be discussed, whether available in the training system or not.
Focus in all cases is on the role of the components within a module and system, identification of problems, routine maintenance, troubleshooting, and safety issues with the goal of preventing system downtime or reducing them to a minimum.

Course Prerequisites

Knowledge of sensors, actuators and PLC programming from exposure to courses in the Siemens Mechatronic Systems Certification Program Level 2 or equivalent.

Course Materials

Recommended basic course materials are in digital form:

Course materials provided by SMSCP Partner Schools to their students are at the partner school's discretion, and may include special software such as SIMIT, Step 7, and WinCC.

Students must also have access to a mechatronic training system containing all or most of the basic component types covered in the course. Please see the SMSCP "Hardware Requirements" document for more information on system requirements for Level 3 instruction.

Syllabus
Level 3, Course 3
Feedback Control Systems and Optimization

Course Description

This course presents the theories and applications of feedback control systems to mechatronic systems. Topics covered involve feedback control systems design such as control system performance specifications, block diagram formulation, pole position & dynamic system response, root-locus design, frequency response design, digital control topics such as AD / DA converters and digital PID implementation, as well as numerical simulation using Matlab/Simulink. A deep understanding of PID-control and systems approach is required for the course.

Based on the lectures, design exercises, laboratory works and seminars, students will learn both classical and digital methods of controlling and optimizing mechatronic systems.

This course aims to give the students the ability to design, troubleshoot, improve and optimize the mechatronic control system according to customer and user needs. Special emphasis will placed on knowledge and hands-on experience of PID-controllers, because most of the course content is based on analysis and simulation of PID-controllers.

Course Philosophy

All course material should be taught using the systems approach method, i.e. in the context of a (or multiple) real mechatronic system(s). This is necessary so that students understand the application of the theory they are learning to real life. For this course in particular, traditional lab work can be replaced by simulation projects based on USB data acquisition devices, although the actual design and application of feedback control to simple real systems (i.e. DC motors, other laboratory setups) is preferred. USB devices for simulations have the benefit that students will be able to finish most of the analysis, control or simulation projects anywhere, and anytime they please. During the laboratory and simulation assignments, the students should work as much on their own as they can. The instructors will only guide them in the correct direction by making goals clear. The methods and work of getting to these results will be done by the students alone (as far as they can).

Course Goals

Upon completion of the course, students should be able to:

- Understand intuitively how mechatronic systems function
- Understand the application and theory of systems approach
- Understand at a high level how a PID-control system works
- Understand the methodology behind applying feedback control
- Analyze and model dynamic systems using mathematical techniques

- Gain experience in system modeling and optimization
- Gain experience in dynamic system and PID-controller simulation

Course Objectives

At the conclusion of this course, students will be able to:

- Analyze and control mechatronics systems independently
- Design and set up feedback control systems and digital control systems
- Find solutions to control and optimize mechatronic systems both classically and numerically
- Perform troubleshooting, diagnosis and optimization
- Select the best control design in consideration of both accuracy and speed

Course Content

Content to be covered within this course includes the following topics:

Control Systems Introduction

- Stability Criteria
- Block Diagrams
- Standard Forms of Models (State Variables, Input/Output, etc.)
- Transfer Functions
- Frequency Response (Bode-Diagram)
- Pole/Zero Locations & Time Domain Response
- Structures of Closed Loop Control Systems

Control Systems

- Overview of Control Technology
- Performance Specifications
- Feedback control design
    - Controllers
        - P Controllers
        - PI Controllers
        - PD Controllers
        - PID Controllers
    - Design procedure
    - Controller/Actuator Saturation
    - Integral Anti-Windup
    - Root Locus Design
    - Frequency Response Design
    - Controller Implementation using Analog Electronics
    - Obtaining System Models from Experimental Data
- Aspects of Digital Control

- A/D-D/A Converters
- Algorithms
- Z-Plane Root Locus Design

Simulation

- Testing/Optimization of Controller Design using Matlab/Simulink

NOTE: The order in which the content will be discussed is dependent upon the mechatronic system which is being used. In each case, the component and/or class of components will be discussed within the context of the system and the module in which the component is located. This means that the exact order of presentation will vary according to the system available for instruction. It is also important that all topics are discussed, whether available in the training system or not.
Focus in all cases is on the role of the components within a module and system, identification of problems, routine maintenance, troubleshooting, and safety issues with the goal of preventing system downtimes or reducing them to a minimum.

Course Prerequisites

Education and/or experience equivalent to SMSCP Level 2 Course 3: Motor control and Course 1 Process control technologies. Previous education or electronics experience with OpAmps, bipolar transistors, MOSFET and sensor technologies; Knowledge of mathematics: original linear differential equations.

Course Materials

Recommended basic course materials are in digital form:

Course materials provided by SMSCP Partner Schools to their students are at the partner school's discretion, and may include special calculation and simulation software such as Matlab and Simulink.

Students must also have access to a mechatronic training system containing all or most of the basic component types covered in the course. Please see the SMSCP "Hardware Requirements" document for more information on system requirements for Level 3 instruction.

Syllabus
Level 3, Course 4
Dynamics and Kinematics of Machinery

Course Description

This course covers topics in dynamics and kinematics of machinery and its applications. Based on lectures, seminars, projects and laboratory work, students will learn how to analyze translational/rotational motions in machinery, understand machine vibrations from both theoretical and practical standpoints and be able to prevent, measure, diagnose and solve problems involving such vibrations. They will gain the skills necessary to design, select and evaluate the mechanisms for various applications, such as gear trains and cams. Projects involve using graphical, analytical, and numerical techniques for the dynamic analysis and synthesis of machines.

The aim of this course is to get a deeper understanding of machine behavior, understand and carry out the design and troubleshooting of reciprocating and rotating mechanical systems, and learn dynamic analysis and dynamic synthesis techniques. Students will be able to understand how to synthesize and analyze mechanisms and machine elements with regard to their kinematics.

The labs will consist of selecting teams, preparation for discussion and completing the lab project, which will consist of constructing a model of a simple machine. The model may be either virtual (e.g., using Working Model), real, or both and must be used to address some hypothesis.

Course Philosophy

All course material should be taught using the systems approach method, i.e. in the context of a (or multiple) real mechatronic (mechanical) system(s). This is necessary so that students understand the application of the theory they are learning to real life mechatronic systems. During the lab portions, students should work most of the time on their own, and the instructor will only guide them so the correct results can be achieved. Once the goal is clear to the students, they should use what they are taught in their own way to attain it.

Course Goals

Upon completion of the course, students should be able to:

- Understand kinematics as applied to familiar experiences and practical applications
- Use a wide range of possibilities for developing their knowledge of the major concepts within machine dynamics
- Develop skills for designing and analyzing cams, gears and crank mechanisms
- Develop skills for use of mathematics software and for writing computer programs to solve kinematics and machine dynamics problems

Course Objectives

At the conclusion of this course, students will be able to:

- Perform kinematic synthesis of planar cam-follower systems, linkages, and gear trains.
- Perform kinematic and dynamic analysis of gear trains and cam-follower systems, as well as systems composed of all of these
- Create mathematical models of planar mechanisms and carry out successfully the displacement, velocity and acceleration analysis.
- Analyze the kinematics of a linkage to determine position, velocity and acceleration variation throughout its range of motion.
- Perform activities to collect and analyze data on objects in motion.
- Perform activities to collect and analyze vibration data and differentiate between normal and abnormal vibrations
- Diagnose, troubleshoot and solve machine vibration problems.
- Solve planar mechanism-based design and machine vibration design problems and communicate the results of their efforts.
- Design a gear train or cam to produce a desired motion.

Course Content

Content to be covered within this course includes the following topics:

Dynamics of Machinery

- Applications of Machine Mechanisms
    - Planetary Gear Trains
    - Cam/Follower Mechanisms
- Applied Machine Vibrations
    - Natural Frequencies, Resonance and Harmonics
    - Vibration Measurement Devices and Data Interpretation
    - Rotational Imbalance & Balancing
    - Diagnosis of Common Machine Vibrations (Gear Mesh Frequencies, Bearing Defect Frequencies, Shaft Misalignment, etc.)
    - Critical Speeds of Rotors
    - Machine Beating Frequencies
    - Vibration Isolation and Damping

Kinematics

- Translation in Machinery
    - Uniform Motion
    - Non-Uniform Motion
- Rotation in Machinery
    - Uniform Motion
    - Non-Uniform Motion

NOTE: The order in which the content will be discussed is dependent upon the mechatronic system which is being used. In each case, the component and/or class of components will be discussed within the context of the system and the module in which the component is located. This means that the exact order of presentation will vary according to the system available for instruction. It is also important that all classes of electrical components be discussed, whether available in the training system or not.
Focus in all cases is on the role of the components within a module and system, identification of problems, routine maintenance, troubleshooting, and safety issues with the goal of preventing system downtime or reducing them to a minimum.

Course Prerequisites

Education and/or experience equivalent to SMSCP Level 2 Course 5: Mechanics and Machine Elements.

Course Materials

Recommended basic course materials are in digital form:

Course materials provided by SMSCP Partner Schools to their students are at the partner school's discretion, and may include special software.

Students must also have access to a mechatronic training system containing all or most of the basic component types covered in the course. Please see the SMSCP "Hardware Requirements" document for more information on system requirements for Level 3 instruction.

Contact

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