Module description S7
Mechatronics

Exchange program Fall 2021-2022

Rev	Date	Description
1.0	2020 04 03	Baseline exchange program
1.1	2021 02 08	Change dates

Schema of all module's in semester 7

Exchange program Mechatronics autumn	
Semester 7	
Differentiation 1 **Advanced Motion Control**	**Differentiation 2** **Adaptive Automation Systems**
Applied Control Engineering 7 ACE7 4 EC	Mechatronic Systems 7 MSY7 4 EC
Dynamic Modelling & Design 7 DMD7 4 EC	Design for Adaptive Manufacturing 7 DAM7 4 EC
Observers 7 OBS7 4 EC	Autonomous and Intelligent Systems 7 AIS7 4 EC
EMC7: Electromagnetic Compatibility 7 2 EC	EMC7: Electromagnetic Compatibility 7 2 EC
Advanced Embedded Systems 7 AES7 4 EC	Advanced Embedded Systems 7 AES7 4 EC
Systems Engineering 7 SYE7 2 EC	Systems Engineering 7 SYE7 2 EC
Project S7 PRS7 10 EC	Project S7 PRS7 10 EC

Important

- In case of resit, an appointment with home University will be made.

Module : Applied Control Engineering 7
Code : MAACE7
Size : 4 EC (112 hours)

Course description

After completing this course students have to be able to analyse linear and non-linear time invariant systems and design and realize a controller, using various design methods in the time-, Laplace and frequency domain, which can control both linear as well as non-linear systems in the continuous or discrete domain.
A closed-loop position controlled servo-system is an example of an applied control problem. A servo-system has to be able to track a pre-defined reference trajectory. To be able to effectively track the reference, practical issues need to be addressed such as:

- limited actuator constraints (such as saturation, limited voltage and current etc.)
- robustness margins (the systems still needs to function within the desired specification even if the system under control starts deviating from the ideal model)
- and (sensor-)noise/disturbances.

The second part of the ACE course addresses:

- the theoretical background of time-discrete signals and systems
- Signal-and system analysis in the z-domain
- Sampling

Moreover, the design of digital controllers, the analysis of the controlled system and the computer implementation forms will be discussed. The design methods and rules are using the z-domain and mainly focus on pole-, zero-theory originating from the s-domain (root-locus plots).

Practical

There are 3 practical sessions in week 2,4,6 or week 1,3,5 in half-classes. The only period when practical sessions can be given is the lecture period of the 1st quartile. Each practical consists of experiments using Fontys-apparatus. The attendance is mandatory for each experiment. The form in which the students can finish the practical sessions is a final report. The resit for this practical will take place during the lab hours of Q2. There will be one session of two hours planned during this retake period. The student must contact the lab teacher to determine a suitable deadline in Q2. This resit chance can be offered depending on the availability of the labs, setups, and the supervision restrictions to use the setups. Important: To be eligible for this retake, the attendance and considerable effort of the student are musts. After Q2 has finished, the student is not allowed to retake the practical and should wait until Q2 of the next academic year.

Testing /assessment and grading

- Written exam (100 min) at the end of Q1, resit during Q2
- Practical must be graded satisfactory for the full allocation of the credits.

Required prior knowledge

Student is able to:
From MAS2:

- Draw up free-body-diagrams for mass-spring systems.
- Derive the mathematical models (differential equations) of basic mechanical, electrical, thermal and pneumatic dynamical systems.

- Recognize the similarity between the (mathematical) models of the above mentioned dynamical systems.
- Explain and apply the standard notation of 2nd and 4th order differential equations.
- Convert the mathematical dynamical models (differential equations) into block diagrams.
- Create block diagrams in Matlab / Simulink.
- Solve numerically the block diagrams in Matlab / Simulink.
- Present the solutions using the Matlab plot function.
- Explain and deploy the basic principles of feedback systems.

From ACT4

- Explain the general concepts of magnetic circuits applied to an electromagnet (linear actuator).
- Analyse a given linear actuator, implicitly using the laws of Faraday, Hopkinson and Lorentz.
- Analyse a given idealized linear DC machine (single-conductor machine) and set up its electrical model, implicitly using the laws of Faraday and Lorentz.
- Draw or interpret the force-speed characteristic of a given idealized linear DC machine.
- Analyse a given rotating DC machine (PM, shunt or series) and set up its electrical model, implicitly using the laws of Faraday and Lorentz.
- Draw or interpret the torque-speed characteristic of a given rotating DC machine.
- Analyse the thermal behaviour of an electric motor and draw or interpret the temperature curve, given all relevant (loss) parameters.

From ICE3

- 1a) Explain differences between harmonic, exponential and exponential-harmonic continuous-time and discrete-time signals (basic signals). 1b) Sketch basic continuous- and discrete-time signals such as harmonic, exponential and exponential-harmonic functions given amplitude, frequency, phase and/or decay and vice versa. Sketch the continuous- and discrete-time unit-impulse and the unit-step signals, calculate the formula using (shifted) unit-step and impulse signals given the plot and vice-versa. 1c) Translate continuous-time exponential and/or harmonic signals to the uniform complex notation and vice versa
- 2a) Apply the elementary operations as described in the reader on continuous- and discrete-time signals. 2b) Translate block-schemes consisting of basic operations, (both in time domain and frequency) to functions and vice versa.
- 3) Apply the uniform complex notation for continuous time signals to mathematically derive the transfer functions of the elementary operations.
- 4a) Explain and calculate the convolution of discrete-time and continuous-time signals. 4b) Explain the following system properties: linearity, time-invariance, stability, memory, causality, invertibility. Given a system, decide whether the system has those properties or not.
- 5a) Write down differential equations for LTI systems: electrical and mechanical systems. 5b) Write down the canonical form of a first and second order system and extract time constant, un-damped natural frequency and damping factor.
- 6a) Calculate magnitude and/or phase from a given transfer function. Do this in Db and factor. Use composition rules to draw Bode plots of any transfer function up to third order. 6b) Explain the use of Fourier series and transform in signal processing.
- 7a) Calculate the Laplace transform of a time-domain function, and the inverse Laplace transform of an s-domain function, based on tables. Prove basic properties of the Laplace transform and apply theorems related to it in applications. 7b) Calculate the transfer function of a system from the differential equation (and vice-versa).

From CEN4

- The transfer function in the Laplace domain establishes a 1st or 2nd order electrical scheme or mass spring damper system
- To set up a transfer function in the Laplace domain using a differential equation and vice versa

- For a given transfer function in the Laplace domain, set up the step response or impulse response in the time domain / Laplace domain (and vice versa), apply fractional splits if necessary.
- Given a set of differential equations, draw up a Simulink block diagram without differentiators
- Create a transfer function from a given Simulink block diagram.
- Create a function in the Laplace domain from a given poles / zeros image and vice versa.
- Describe a 2nd order transfer function in the Laplace domain to the standard form and from this determine the relative damping and undamped natural frequency.
- Explain the meaning of the following terms: relative damping, settling time, peak time, overshoot, undamped natural frequency, poles and zero points, damped natural frequency, final value (also being able to calculate this).
- For a given system in the Laplace domain, calculate the gain to make the unit feedback of the given system stable / unstable / edge stable

Learning materials

Feedback Control of Dynamic Systems, Global edition 7e Gene, F.; Pearson 9781292068909

Module : Dynamic Modelling and Design 7
Code : MADMD7
Size : 4 EC (112 hours)

Course description

Dynamic Modelling and Design (DMD) focuses on predicting the dynamic behaviour and the performance (the dynamic position error) of servo systems. Servo systems are actuated systems with feedback (feedback loop) of measured control parameters. The dynamic behaviour of the servo system is a result of the interaction between mechanics and electronics (actuator, amplifier, controller). The stability and the performance is co-determined by the chosen measurement system, the design profiles and the applied control technique.

To predict the servo system, dynamic models of mechanics and electronics are drafted. When drafting the dynamic models, assumptions are made. The dynamic models are therefore not an exact representation of reality.

The limitations of the dynamic models depend on the chosen description of the model and the chosen preconditions. To describe the dynamic models of (simple) servo systems, Ideal Physical Models (IFM), block diagrams and state equations will be used. Each description has its pros and cons.

In order to analyse the dynamic behaviour without the help of calculation tools, the dynamic models are reduced to (2nd and) 4th order dynamic models. When reducing the system, the reduction rules must be complied. This also implies, that not all systems can be reduced to 2nd or 4th order dynamic model.

Using (2nd and) 4th order dynamic models, it is possible to predict the dynamic behaviour and the performance of the servo system. There are 4 types of transfer functions that characterize all 4th order models. Dual Integrator, Resonance, Anti-Resonance-Resonance, and Resonance-Anti-Resonance.

For a common configuration, actuator attached to the fixed world, a method has been developed to determine optimal control parameters and key mechanical properties without requiring simulation techniques. The method uses dimensionless numbers, with which the (2nd and 4th) 4th order models can be written in a general form. NOTE: Valid for a specific configuration.

This method will be discussed in more detail than other control strategies (such as feed forward, PID controller, lead-lag and Notch filters). This because they are dealt with extensively during the Applied Control Engineering (ACE7).

Teaching methods and teaching organization
The duration of the module is 6 weeks. Each week consist of 2x 2 hours 'theory'. In addition, there are 3 practical of 2 consecutive hours (supervised). See schedule for the data.

The theory lessons will consist of lectures, do-it-yourself assignments and flipping the classroom. The intention is that the teacher performs a coaching role and the students shape the lessons and the content.

The practical part is intended to gain experience with dynamic modelling and to get familiar with the modelling software program 20-Sim.

Learning objectives
The learning objectives for the subject can be found in the test content specification under the heading 'assessment and testing'.

Practical

The purpose of the practical is to connect theory and practice through assignments and self-study. The assignments and self-study will help to develop a 'FEEL' for mass's, Inertia, stiffness's and dynamic systems in general. This is essential to make a good assessment of (construction) elements that are important for establishing a correct dynamic model. This includes masses, stiffness's, damping, friction and transmissions.

If time permits, the measured transfer function and modelled behaviour will be compared and the discrepancies will be discussed / explained. To this end, a number of parameters must be measured to validate and complete the dynamic model.
• Presence (= compulsory)
• Contains at least 20-SIM simulation software, drafting dynamic models, drafting a dynamic model of an existing system and measuring this system.

Required prior knowledge

The DMD module is an umbrella subject and uses Mechanics, Electrical Engineering and Measurement and Control Technology.
Therefore, prior knowledge is required of:
• Mechanics (Static and dynamic)
• Control technology:

From ICE3

- 1a) Explain differences between harmonic, exponential and exponential-harmonic continuous-time and discrete-time signals (basic signals). 1b) Sketch basic continuous- and discrete-time signals such as harmonic, exponential and exponential-harmonic functions given amplitude, frequency, phase and/or decay and vice versa. Sketch the continuous- and discrete-time unit-impulse and the unit-step signals, calculate the formula using (shifted) unit-step and impulse signals given the plot and vice-versa. 1c) Translate continuous-time exponential and/or harmonic signals to the uniform complex notation and vice versa
- 2a) Apply the elementary operations as described in the reader on continuous- and discrete-time signals. 2b) Translate block-schemes consisting of basic operations, (both in time domain and frequency) to functions and vice versa.
- 3) Apply the uniform complex notation for continuous time signals to mathematically derive the transfer functions of the elementary operations.
- 4a) Explain and calculate the convolution of discrete-time and continuous-time signals. 4b) Explain the following system properties: linearity, time-invariance, stability, memory, causality, invertibility. Given a system, decide whether the system has those properties or not.
- 5a) Write down differential equations for LTI systems: electrical and mechanical systems. 5b) Write down the canonical form of a first and second order system and extract time constant, un-damped natural frequency and damping factor.

- 6a) Calculate magnitude and/or phase from a given transfer function. Do this in Db and factor. Use composition rules to draw Bode plots of any transfer function up to third order. 6b) Explain the use of Fourier series and transform in signal processing.
- 7a) Calculate the Laplace transform of a time-domain function, and the inverse Laplace transform of an s-domain function, based on tables. Prove basic properties of the Laplace transform and apply theorems related to it in applications. 7b) Calculate the transfer function of a system from the differential equation (and vice-versa).

From CEN4

- The transfer function in the Laplace domain establishes a 1st or 2nd order electrical scheme or mass spring damper system
- To set up a transfer function in the Laplace domain using a differential equation and vice versa
- For a given transfer function in the Laplace domain, set up the step response or impulse response in the time domain / Laplace domain (and vice versa), apply fractional splits if necessary.
- Given a set of differential equations, draw up a Simulink block diagram without differentiators
- Create a transfer function from a given Simulink block diagram.
- Create a function in the Laplace domain from a given poles / zeros image and vice versa.
- Describe a 2nd order transfer function in the Laplace domain to the standard form and from this determine the relative damping and undamped natural frequency.
- Explain the meaning of the following terms: relative damping, settling time, peak time, overshoot, undamped natural frequency, poles and zero points, damped natural frequency, final value (also being able to calculate this).
- For a given system in the Laplace domain, calculate the gain to make the unit feedback of the given system stable / unstable / edge stable

Learning materials

Design Principles for precision mechanisms, 1st edition, Soemers,H., T-Point Print Vof 9789036531030
Dynamic Modelling and design, Koster,M.P., Studystore 9998000051751

Module: Observers for State Space Systems 7
Code : MAOBS7
Size : 4 EC (112 hours)

Course description

In this course the modern control system design will be taught using state space techniques. The course can be seen as a continuation of the prerequisite course ACE7. Introduction to state space has been covered in ACE7 however the use of this method in control engineering has not been deeply taught. It is even possible to replace the sensors in the system by intelligently building and simulating the dynamics at every time step to find out what the unused sensor output would be (a.k.a. observers). You can even control the system using the output of that unused sensor. This way it is possible to reduce the amount of sensor in the system or change their places to more suitable locations. An engineer being aware of these techniques will be more careful during the design process.

The topics will be covered are mainly the design of state variable feedback systems, pole placement, Ackermann's formula, limitations of state variable feedback, controllability, observability, and state observers (estimators).

The objectives:
-To understand why Control Engineering is important for a mechatronics engineer
-To acknowledge the significance of integrated control and design phase
-To understand when the plant is easy or difficult to control
-To gain enough mathematical background
-To solve simple linear SISO control problems and to be aware of difficult control problems
-To recognize that some expensive sensors can be replaced by intelligent control algorithms
-To be comfortable with the computational tools (MATLAB) in control and observer design
After taking this course, the student must be able to design various linear state space controllers and observers for SISO systems whose model is known to achieve desired closed-loop performance. In particular, students should be able to:
- Identify how feedback makes a system insensitive to uncertainties (plant parameter variations, external disturbances, noise etc.)
- Design State feedback controller for SISO systems both in time and frequency domains
-Describe design trade-offs
-Design linear observers
- Use MATLAB/Simulink in control system design and validation of the design

Practical

There are 2 practicals in week 3 and 5 or week 2 and 4 in half-classes. The only period when practicals can be given is the lecture period of the 2nd quartile. Each practical consists of experiments using Fontys-apparatus. The attendance is mandatory for each experiment. The form in which the students can finish the practicals is a final report. The resit for this practical will take place at the end of Q2. There will be one session of two hours planned during the project weeks. The student must contact the lab teacher to determine a suitable deadline inside Q2. This retake chance can be offered depending on the availability of the labs, setups, and the supervision restrictions to use the setups. Important: To be eligible for this retake, the attendance and considerable effort of the student are musts. After Q2 has finished, the student is not allowed to retake the practicals and should wait until Q2 of the next academic year.

Testing /assessment and grading

1) Digital exam (100 min) at the end of the course using your own laptops and Matlab/Simulink. (If not ready on time, a written exam will be done)
2) The 2nd retake (3rd attempt) is not open to everybody. There are certain conditions to meet to be eligible for the 2nd retake. Condition1: The student has attended either the regular exam or the 1st retake of the current academic year. Condition2: The highest grade of the regular exam or the 1st retake is at least (or equal to) 4,5. Condition3: The students need to register for the 2nd retake via personally visiting the student administration, note that the other exams in S7 do not require registrations but since there are conditions to be eligible for 2nd retake, registration is needed. 3) Practicals must be graded satisfactory for the full allocation of the credits.

Required prior knowledge

- ACE7 (see this document),
- From MAT4A
  - Wiskundige symbolen, begrippen en notatiewijzen uitleggen en hanteren.
  - Het werk inzichtelijk en overdraagbaar maken voor derden.
  - De lengte van een vector, de hoek tussen twee vectoren en de (on)afhankelijkheid van vectoren bepalen.
  - Matrices optellen, aftrekken en vermenigvuldigen. De getransponeerde, inverse en determinant van een matrix berekenen.
  - Singulariteit van matrices vaststellen m.b.v. de inverse matrix of de determinant.
  - Stelsels van vergelijkingen omzetten in matrices en (indien mogelijk) deze oplossen met de inverse matrix, de eliminatiemethode van Gauss en/of de regel van Cramer.
  - De eigenwaarden en eigenvectoren bepalen van een vierkante matrix.
  - Transformatiematrices opstellen.
  - De volgende begrippen uitleggen: stochast, populatie, steekproef, kansverdeling, spreiding en centrale limietstelling.
  - De verwachtingswaarde, variantie en standaarddeviatie berekenen.
  - De verschillende typen kansverdeling en hun eigenschappen uitleggen: algemeen, binomiaal, Poisson, normaal, continu, discreet en continue benadering.
  - In een gegeven situatie het type kansverdeling herkennen en de kans op de gevraagde situatie berekenen.
  - Stochastische variabelen combineren en daarmee zgn. passingsproblemen oplossen.
  - De omvang van een steekproef bepalen aan de hand van een gewenst betrouwbaarheidsinterval.
- Besides that, a decent knowledge of MATLAB and Simulink is a must.

Learning materials

Feedback Control of Dynamic Systems, Global edition 7th, Gene,F., Pearson 9781292068909

Module : Mechatronic Systems 7
Code : MBMSY7
Size : 4 EC (112 hours)

Course description

This module teaches the students how to construct an integral system architecture or a mechatronic system. The mechatronic system module has two main parts: 1) the first part (multi-physics modelling) remark on analogies and coupling through power / energy transfer between the various mechatronic disciplines (electrical, mechanical and control / software) to obtain a model based system design that is properly balanced between these disciplines; 2) the second part on model-based design (MBD) methodology to systematically control mechatronic systems.

Learning objectives:
After completing this module, the students will be able to construct an integral model based system architecture for a mechatronic system. In the first part, the students evaluate the subsystems and recognize the basic physical processes involved. They learn to live the dynamic equations or the basic physical processes or a mechatronic system and convert them into a state-space representation. In the second part, the students learn how to systematically model a mechatronic system, design a clean controller for the model, simulate the controller and finally deploy the designed controller on the real system following the MBD methodology.

Learning goals:

Student is able to:

- Evaluate the subsystems and recognize the basic physical processes involved
- Derive the (partial)differential equations of the basic physical processes of a mechatronic system and convert them into a state-space notation consisting of the effort and flow variables as state variables
- Evaluate the multi-physics models to derive a cost and/or energy efficient design
- Evaluate the multi-physics models to obtain insight into relevant parameters for sensor and/or actuator choice/location
- Evaluate the multi-physics models to derive feasible reference trajectories
- Evaluate the multi-physics models to perform error budgeting of a mechatronic system

Practical projects for model-based design part:

Each group of 5 students receives an assignment for the model-based design (MBD) part to design a controller for a mini-quadcopter (Parrot Mambo) to be able to follow a line autonomously. The students can find a proper model and a controller in Matlab/Simulink 2019. The system modeling, control design, simulation and validation has to be done in the Matlab/Simulink environment. In fact, the students need to improve the current model and controller to achieve the given goal.
The MBD part (report and video) is graded as fail or pass. This is a group mark for each project group and will be conditional for awarding the individual written exam grade. The final grade is based on the multi-physics modeling part in the form of an individual written exam.

Project deliverable:

Each group has to deliver
1. A report in the form of a paper of 5 to 6 pages length in IEEE format, describing the system modeling, designing the controller and simulating the designed controller. The students need to show a proper understanding about
2. A video of the simulation showing the mini-quadcopter follows the line given in the virtual environment of Matlab/Simulink.

Extra activity (bonus):

Deployment of the designed controller on the real mini-quadcopter Parrot Mambo and follow such that the drone can follow a line.

Required prior knowledge

The mechatronic bachelor program of Fontys Engineering Eindhoven from semester 1 till semester 4 (check requirements listed bij Applied Control Engineering 7)

Learning materials

- Mechatronic Systems, Bosch, P.P.J. van den; Studystore 9998000051768
- Systems Engineering with SysML/UML: Modeling, analysis, design; Tim Weilkiens; Elsevier9780123742742
- Reader: "Dynamic Models of physical processes", PPJ van den Bosch
  Lecture notes: lecture notes published at N@tschool

Module: Design for Adaptive Manufacturing 7
Code : MBDAM7
Size : 4 EC (112 hours)

Course description

The course Design for Adaptive Manufacturing focuses on the design of a manufacturing process to enable flexible automation.
Based on conditions such as serial size and desired flexibility, the course aims at the design of a flexible production street and / or production cell.
These include aspects such as optimizing the production layout, designing tooling concepts (such as grippers) that can be used for multiple (variants of) products, as well as topics such as quality. In addition, mechanical design aspects, such as exactly constrained design, light and stiff design, are presented in detail. This with the goal to achieve requirements as accuracy and good dynamic behaviour.

Learning goals

- The student can describe the evolvement and effects of industrial automation up to and including Industry 4.0
- The student is able to explain terms like product life cycle, quality related terms (like for example 6Sigma in his or her own words.
- The student can present and explain different industry process/factory layouts.
- The student can suggest and motivate approaches for process/factory layouts to achieve optimal and adaptive production process.
- The student can design a (concept) work cell for flexible automation (based on given boundary conditions like size of the production series, required accuracy, speed of process, etc.)
- The student is able to design a (concept) production line/machine taking into account important mechanical aspects, that include:
    - Exactly constrained design
    - Effective usage of material
    - Stiffness and strength calculations
    - With the aim to achieve optimal static and dynamic behaviour of the process/machine

Assessment and grading

- Two assignments have to be performed and shown in written reports (Details on assignments, including a format for the reports will be given in lecture week 1)
- The assignments will be made in groups consisting of 3 members, and have to be handed in before the given deadlines. Deadlines will be communicated during the first lectures.
- An individual exam will be given in the final week of the course, the content will be based on the given assignments (60% - 80%), and on the lecture material (20% - 40%)
- For the course to be graded sufficient:
    - The weighted average of the assignments must be 5,5 or higher.
    - The result of the exam (verbal assessment) must be 5,5 or higher.
- In case the weighted average of the assignments is insufficient then:
  When only one of the assignments or the verbal assessment is graded insufficient (<5,5) a repair (or verbal assessment retake) can be taken for that specific insufficient grade, The grading of this repair

assignment (or verbal retake) counts as the new grade. This repair opportunity will take place in Q2. When more than one assignments are graded insufficient (<5,5), a new individual assignment with components of all the different assignments will be given, the result of this individual assignment will replace the previous grade of the weighted average for all the group assignments . A resit deadline will be communicated. Students will be able to finish this in this academic year.

- As a future Engineer, it is important that you conduct your work in a professional way. Delivering products on the given deadline is an important aspect of that professionalism. Therefore, the following conditions apply regarding the grading:
    - Missing a deadline by up to 3 days will result in deduction of the grade with 1 out of 10 (per assignment).
    - Missing a deadline by 4-7 days will result in deduction of the grade with 2 out of 10 (per assignment).
    - Missing a deadline by more than 7 days (per assignment) means you (or your group) will fail the entire course. As a resit, the whole course needs to be retaken. This means a full new set of assignments will be handed out.

Required prior knowledge

- Drawing (Solidworks)
- Read & explain and explain fits and tolerances from given 2D drawings.
- Prepare / construct fits and tolerances for machine parts.
- Perform power calculations on machine parts.
- Recognize and name the different load situations on machine parts.
- Calculate and graph transverse forces and moment lines.
- Calculate loads on shafts, keys, bearings and bolts, and then calculate the effect of these loads so that he can select / design machine parts based on loads.
- Explain design rules for shafts, splines, bearings and bolts.
- The elastic line of a construction part which is loaded by one or more forces, moments or q-loads or to demonstrate that it complies with an equation.
- Using the basic forget-me-nots, calculate the displacements and angular deflections at any point of clamped or hinged beams, both numerically and using letter variables.
- Using the basic forget-me-nots, calculate the displacements and angular distortions at any point of portal constructions, both numerically and using letter variables.
- Using the basis, staples forget to determine the support reactions of statically indefinite constructions and then calculate the deformations that occur, both numerically and with the help of letter variables.
- Draw deformations of statically (un) defined structures (including portal structures) using N, V, M lines.

Learning materials

Materials on N@tschool

Module: Autonomous and Intelligent Systems 7
Code : MBAIS7
Size : 4 EC (112 hours)

Course description

The foundation of many autonomous and adaptive products is based on intelligent algorithms. These algorithms often act as decision makers for a given task or situation. Simple algorithms are reactive, meaning that a given input is interpreted with some simple rules and results in a direct action. More advance algorithms first compute every possible outcome, and then makes a decision that is most optimal given the current knowledge and input values. Learning algorithms analyse historic input data and try to predict or influence the outcome based on this previous "knowledge". Making valid decisions while dealing with non-accurate measurements or assumptions is the field of probabilistic algorithms. In this module we will take an applied approach to these type of algorithms, that are used in many Autonomous and Intelligent Systems.

Learning goals

- The student gains insights in different A.I. (learning) techniques.
- The student is able to differentiate and explain different A.I. learning approaches and their current application domains.
- The student can investigate multiple A.I. (learning) approaches that can lead to solve given problems, in different domains.
- The student can select A.I. learning methods, based on given criteria in different problem domains.
- The student can implement A.I (learning) methods on given problems.

Assessment and grading

* Two assignments have to be performed and shown in a written report & supporting video material (details on these assignments, including a format for the report will be given in lecture week 1)
* The assignments will be made in groups consisting of 3 members, and have to be handed in before the given deadlines. Deadlines will be communicated during the first lectures.
* An individual exam will be given in the final week of the course, the content will be based on the given assignments, and on the lecture material.
* For the course to be graded sufficient:
  - Each of the assignments must be 5,5 or higher.
  - The result of the exam must be 5,5 or higher.
* In case that one of the assignments is graded insufficient (<5,5) one repair option for that specific assignment can be taken, the grading of this repair assignment counts as the new grade. A resit deadline will be communicated.
* In case the result of the exam is insufficient, a re-sit opportunity is scheduled in the exam roster.
* As a future Engineer, it is important that you conduct your work in a professional way. Delivering products on the given deadline is an important aspect of that professionalism. Therefore, the following conditions apply regarding the grading of the assignments:
  - Missing a deadline up to 3 days will result in deduction of the grade with 0.5 out of 10 (per assignment).

- Missing a deadline by 4-7 days will result in deduction of the grade with 1 out of 10 (per assignment).
- Missing a deadline by more than 7 days (per assignment) means you (or your group) will fail the entire course. As a resit, the whole course needs to be retaken next academic year. This means a full new set of assignments will be handed out next academic year.

Required prior knowledge

For this module the student must have sufficient programming skills;
Fundamental knowledge of MATLAB or Python is advisable.
The student can prepare for this course by following the MATLAB courses online:
matlabacademy.mathworks.com --> MATLAB Fundamentals

Learning materials

Materials on N@tschool

Module : Advanced Embedded Systems 7
Code : MBAES7
Size : 4 EC (112 hours)

Course description

In the mechatronics environment high advanced embedded systems are used for the high-tech industry and robotics. The course advanced embedded systems is using the hardware description language VHDL and embedded systems for developing an advanced digital system. In the course, the ZYNQ chip from Xilinx will be used to create and advanced embedded system. The ZYNQ chip consist of an ARM9microcontroller with an FPGA. In the course students will learn how to create an architecture digital design with the ZYNQ chip, by using the ARM9microcontroller and the FPGA. In the course Vivado will be used as a software platform.

Learning goals

- The student is able to setup an architecture of an advanced digital system (FPGA & embedded controller)
- The student is able to design and implement a digital system using programmable logic
- The student can explain and punt into practice techniques interfacing with different types of hardware block
- The student can test and debug advanced embedded systems using modern tools
- The student can write a professional report
- The student can defends their work during an oral

Required prior knowledge

FPGA programming, C-programming, Digital fundamentals

Learning materials

Python, Visual Studio Code, Some slides on n@tschool, The Internet

Module : Electromagnetic Compatibility 7
Code : MAEMC7
Size : 2 EC (56 hours)

Course description

Electromagnetic compatibility (EMC) is the branch of electrical engineering concerned with the unintentional generation, propagation and reception of electromagnetic energy which may cause unwanted effects such as electromagnetic interference (EMI) or even physical damage in operational equipment. The goal of EMC is the correct operation of different equipment in a common electromagnetic environment.

EMC pursues two main classes of issue. Emission is the generation of electromagnetic energy, whether deliberate or accidental, by some source and its release into the environment. EMC studies the unwanted emissions and the countermeasures which may be taken in order to reduce unwanted emissions. The second class, susceptibility is the tendency of electrical equipment, referred to as the victim, to malfunction or break down in the presence of unwanted emissions, which are known as Radio frequency interference (RFI). Immunity is the opposite of susceptibility, being the ability of equipment to function correctly in the presence of RFI, with the discipline of "hardening" equipment being known equally as susceptibility or immunity. A third class studied is coupling, which is the mechanism by which emitted interference reaches the victim.

Interference mitigation and hence electromagnetic compatibility may be achieved by addressing any or all of these issues, i.e., quieting the sources of interference, inhibiting coupling paths and/or hardening the potential victims. In practice, many of the engineering techniques used, such as grounding and shielding, apply to all three issues. During the design of electronic circuits, control systems and installations are taught to take account of EMC phenomena, then the undue influence by these phenomena, by proper design methodologies, to a minimum. The acquired knowledge and skills will be used when designing electromagnetic compatible circuits/systems and machines.

The module in this format is new this year. Therefore this module description can change during the course.

Learning goals

Electromagnetic compatibility is a knowledge-oriented practical module.

For a simple EMC-problem the student:

- Has knowledge of the theoretical background
- Recognizes EMC problems
- Analyses EMC phenomes in a practical manner
- Is able to made an electric circuit model of an EMC problem
- Knows how to reduce the problem

Required prior knowledge

- Recognize electrical components (resistor, coil, capacitor, IC) and determine their value or data.
- Assemble a PCB (Printed Circuit Board) by soldering.
- Install and activate NI (National Instruments) software: LabVIEW, Multisim and myDAQ drivers.
- Simulate a simple electrical circuit using Multisim.
- Perform a voltage and resistance measurement using the DMM (Digital Multi Meter) of the myDAQ.
- Magnitudes and units current , voltage, resistance, power and labour

- Ohms law, Kirchfoff's current and voltage law
- Concepts voltage and current division, ideal and non ideal voltage and current sources, dependent sources
- Superposition, Norton and Thevenin equivalent circuits
- Node current and mesh voltage analysis
- Concepts average, top, and RMS value of currents and voltages. (crossover) frequency, bandwidth, impendance, two terminal networks, attenuation, modulus, argument, gain and Q factor
- Reactive and active power in phasor diagrams Amplitude and argument diagrams of first and second order circuits
- Calculations of (simple) electrical circuit using Phasors and complex impedances
- Determination of transient function of first and second order circuits. Determine wether a two pordt represents a high/low/band pass or notch filer
- Calculations concerning idealised and moddeled circuits using Euler
- Using complex signals: mesh voltage, node current, superposition, Norton Thevenin analysis
- Draw, dimension or analyze a circuit with diodes (a (bridge) rectifier, a "clipper" or "clamp" circuit or a zener-diode voltage regulator) based on a given circuit and/or given specifications. Sketching signals is often an essential part of the analysis.
- Dimension or analyze a BJT amplifier circuit (DC and/or AC), based on a given circuit and/or given specifications.
- Dimension or analyze a FET circuit based on a given circuit and/or given specifications.
- Dimension or analyze an Op-Amp circuit, based on a given circuit and/or given specifications.

Learning materials

Reader, sheets, and experiment descriptions on N@Tschool
Tutorials: http://www.cvel.clemson.edu/emc
Presentations, experiment description on N@tschool

Module : System Engineering 7
Code : MBSYE7
Size : 2 EC (56 hours)

Course description

After 2 study years obtaining insights and methods on technical design processes, you know how to design a well-functioning product or system. Requirements however mainly refer to the functionality of that product. But a well-designed product does not give automatically a guarantee for being successful in the market. The success is very dependent on other influences of the environment, like a growing attention to sustainability, the market, presence of a financial crisis, styling, price, service and quality perception of the consumers. These influences may (strongly) change in time and may make or break the success of a well-functioning product. These influences are difficult to change. A product or system designer however can take the probability of these environmental influences into account. Thus, it is important while focusing on the design criteria to incorporate those, taking external influences into account, with a wide and strategic view.
After this module the students will be widely and profoundly introduced into the influences of these themes to a successful product. They know the most important aspects and know how to estimate the value, and how to take these into account while performing a design process.

Required prior knowledge

- Applying technical knowledge from the training to arrive at a working product
- Learning to work together in a multidisciplinary team on a (business) assignment
- Design and describe the product in a methodical way
- Design and substantiate the product with theory from your study
- Write project aspects effectively according to the reporting guidelines
- Make a correct presentation in terms of content. Present and defend the results in front of a jury
- To contribute effectively to an end result as an individual in a (multidisciplinary) team
- Methodological design and project management.

Learning materials

Materials on N@tschool

Module : Project Semester 7
Code : MAPRS7
Size : 10 EC (280 hours)

Course description

General goal: One of the pillars of the educational model of the Fontys school of engineering is to provide students with the opportunity to show that they are competent in the practical application of the techniques and theory that has been given in the domain specific modules in a real project environment. The projects in semester 7 are pre-selected, but the students have the freedom to choose and subscribe for a specific project.

The registration for the projects takes place in the first week of the semester. Before that, all projects will be pitched by their representative.

Required prior knowledge

no specific prior knowledge required