

**Department offering the program**: Industrial electronics and Control Engineering **Department offering the course**: Industrial electronics and Control Engineering

**Course Specification**

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| **1-Course basic information :** |
| **شعار وحدة الجودةCourse Code: ACE 323** | **Course Title:**Nonlinear Control Systems | **Academic year:2015/2016****Level (3 ) – Semester : 2nd** |
| **Department requirement** |  **Teaching hours: Lecture [2] - Tutorial [2]- Lab [0]** |
| **2- Course objectives** | 1. To acquire a good knowledge of the methods of describing Function analysis for nonlinear systems.
2. To define the different categories of Phase Plane
3. Allowing the students to know Stability methods of nonlinear systems .
4. To acquire a good knowledge of the techniques for the analysis and design of power converters.
5. To demonstrate Liapunov Stability Analysis methods for nonlinear systems.
6. To explain State space methods for nonlinear control systems and its linearization.
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| **3- Intended Learning Outcomes: (ARS)** | **Course (ILOs)** |
| **A- Knowledge and Understanding:** | a1) Explain Concepts and theories of mathematics and sciences appropriate to nonlinear control systems. a8) Describe Current engineering technologies as related to nonlinear control systemsa15) Interpret Principles of Analyzing and design of electronic circuits and components.a20) Explain The principles of sustainable design and development. | a1-1) Explain the concepts and theories of mathematics of linearization of nonlinear systems.a1-2) Explain the concepts and theories of mathematics of describing function analysis.a1-3) Explain the concepts and theories of mathematics of phase plane analysis of linear and nonlinear control systems.a1-4) Explain the concepts and theories of state space representation of nonlinear control systems.a8-1) Describe current engineering technologies as related to describing functions of nonlinear systems.a8-2) Describe current engineering technologies as related to nonlinear circuits design.a8-3) Describe current engineering technologies as related to phase plane stability.a15-1) Interpret the principles of analyzing of linearization of nonlinear control systems.a15-2) Interpret the principles of analyzing of nonlinear control systems based on Stability analysis.a15-3) Interpret the principles of analyzing of nonlinear control systems based on Liapunov stability analysis.a15-4) Interpret the principles of analyzing of nonlinear control systems based on phase plane analysis.a15-5) Interpret the principles of analyzing of nonlinear control systems based on state space representation.a20-1) Explain the he principles of sustainable design and development of State space representation to test the nonlinear linearity. |
| **B- Intellectual Skills** | b1) Select appropriate mathematical and computer-based methods for analyzing problems.b2) Select appropriate solutions for engineering problems based on analytical thinking.b3) Think in a creative and innovative way in problem solving and design.b12) Create systematic and methodic approaches when dealing with new and advancing technology. | b1-1) Select appropriate mathematical methods for analyzing linearization of nonlinear control systems.b1-2) Select appropriate mathematical methods for analyzing of describing function analysis.b1-3) Select appropriate mathematical methods for analyzing of phase plane analysis of linear and nonlinear control systems.b2-1) Select appropriate solutions for describing function stability problems based on analytical thinking.b2-2) Select appropriate solutions for phase plane stability problems based on analytical thinking.b2-3) Select appropriate solutions for state space stability problems based on analytical thinking.b3-1) Think in a creative and innovative way in problem solving and design for describing function linearization of nonlinear control systems.b3-2) Think in a creative and innovative way in problem solving phase plane stability.b12-1) Create systematic and methodic approaches when dealing with describing function stability.b12-2) Create systematic and methodic approaches when dealing with stability using phase plane method.b12-3) Create systematic and methodic approaches when dealing with state space analysis. |
| **C- Professional Skills** | c1) Apply knowledge of mathematics, science, information technology, design, business context and engineering practice integrally to solve engineering problems.c12) Prepare and present technical reports.c18) Manage field problem, identification, formulation and solution. c23) Apply modern techniques, skills and engineering tools to control systems | c1-1) Apply knowledge of science, design, business context and engineering practice integrally to solve describing function problems.c1-2) Apply knowledge of science, design, business context and engineering practice integrally to solve phase plane problems.c12-1) Prepare and present technical reports for nonlinear control systems.c18-1) Manage field problem, identification, formulation and solution for linearization of nonlinear systems.c18-2) Manage field problem, identification, formulation and solution for describing function stability.c18-3) Manage field problem, identification, formulation and solution for state space of nonlinear systems.c23-1) Apply modern techniques, skills and engineering tools to phase plane stability of nonlinear control systems.c23-2) Apply modern techniques, skills and engineering tools to state space nonlinear control systems. |
| **D- General Skills** | d3) Communicate effectively.d6) Effectively manage tasks, time, and resources.d7) Search for information and engage in life-long self learning discipline.d8) Acquire entrepreneurial skills. | d3-1) Communicate effectively in class room with his colleagues, and teaching staff member.d6.1) Effectively manage tasks, time, and resources in solving problems related to phase plane stability.d6.2) Effectively manage tasks, time, and resources in solving technical problems related to state space linearity of nonlinear systems.d7.1) Search for information and engage in life-long self learning discipline in subjects related to describing functiond7-2) Search for information and engage in life-long self learning discipline in subjects related to state space representation of nonlinear systems. d8-1) Acquire entrepreneurial skills related to phase plane and describing function of nonlinearity. |
| **4- Course Contents** | Introduction to Nonlinear Control Systems - Analysis of Nonlinear Control Systems - Describing Function Analysis - Introduction to Phase Plane - Phase Plane Analysis of linear control systems - Phase plane analysis of nonlinear control systems - Liapunov Stability Analysis - Stability analysis of nonlinear systems - State space methods for nonlinear control systems and its linearization |
| **5- Teaching and Learning Methods** | * Lectures
* Tutorials
* Research assignments
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| **6- Teaching and Learning Methods for disable students** | * Give the students specific tasks.
* Assign a teaching assistance to follow up the performance of this group of students.
* Repeat the explanation of some of the material and tutorials.
* Scheduled time in order to improve their skills.
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| **7- Student Assessment** |
| **a-Assessment Methods** | - Weekly sheet exercises at class room- Quizzes- Mid term, and final exams |
| **b- Assessment Schedule** | - Exercise sheet : Weekly- Quizz-1: Week no 5 - Mid-Term exam: Week no 8- Quizz-2: Week no 10- - Final – term examination: Week no 16 -18  |
| **c- Weighting of Assessment** | - Class tutorial and quizzes : 15 %- Mid-term examination: 15 % - Final – term examination: 70 %  Total 100 % |
| **8- List of text books and references:** |
| **a- Course notes** | There are lectures notes prepared in the form of a book authorized by the department |
| **b- Text books** | [1] Ogata K. , “Modern Control Engineering”, Prentice Hall, Englewood Cliffs , New Jersey, 2007 |
| **c- Recommended books** | [1] [D. Atherton](http://), “An Introduction to Nonlinearity in Control Systems”, Bookboon.com, ISBN: 978-87-7681-790-9, 1 edition, 2012 [2] D. Cheng‏ ،X. Hu‏،T. Shen‏, “Analysis and Design of Nonlinear Control Systems”, Springer, 2011.[3] Atherton D. P. , “Nonlinear Control Engineering” , Van Nostrand Reinhold Company Ltd., Berkshire, England, 2007. |
| **d- Periodicals, Web sites ……etc** | [http://inst.eecs.berkeley.edu/~ee222/sp15/](http://) |

**Course contents - ILOs Matrix**

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| **D- General and transferable skills** | **C- Professional and practical skills** | **B- Intellectual skills** | **A- Knowledge & Understanding** | **Week** | **Content Topics** |
| d3 | c12,c18 | b1, b3 | a1,a15 | 1 | 1 -Introduction to Nonlinear Control Systems and Analysis of Nonlinear Control Systems |
| d7,d8 | c1,c18 | b1,b2.b12 | a1,a8 | 2,3,4 | 2 -Describing Function Analysis and stability |
| d6,d8 | c1,c23 | b1,b2,b3,b12 | a1,a8,a15 | 5 | 3 –Introduction to Phase Plane  |
| d6,d8 | c1,c23 | b1,b2,b3,b12 | a1,a8,a15 | 6,7 | 4 –Phase Plane Analysis of linear control systems |
| d6,d8 | c1,c23 | b1,b2,b3,b12 | a1,a8,a15 | 8,9,10 | 5 – Phase plane analysis of nonlinear control systems |
| d3 | c12 |  | a15 | 11,12 | 6 -Liapunov Stability Analysis  |
| d3 |  | b12 | a15 | 13 | 7-Stability analysis of nonlinear systems |
| d6,d7 | c18,c23 | b2,b12 | a1,a15,a20 | 14 | 8- State space representation of nonlinear systems  |

**Teaching and Learning Methods - ILOs Matrix**

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| **Teaching and Learning Methods** | **A- Knowledge & Understanding** | **B- Intellectual skills** | **C- Professional and practical skills** | **D- General and transferable skills** |
| **Lectures** | a1,a8,a15,a20 | b1,b2,b3,b12 | c1,c12,c18,c23 | d3 |
| **Tutorials.** | a1,a8,a15,a20 | b1,b2,b3,b12 | c1,c12,c18,c23 | d3,d7,d8 |
| **Exercises** | a1,a8,a15,a20 | b1,b2,b3,b12 | c1,c12,c18,c23 | d6,d7,d8 |
| **Labs and/or case studies** |  |  |  |  |
| **Reports and assignments** | a1,a8,a15,a20 | b1,b2,b3,b12 | c1,c12,c18,c23 | d6,d7,d8 |

**Assessment Methods - ILOs Matrix**

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| **Assessment Methods** | **A- Knowledge & Understanding** | **B- Intellectual skills** | **C- Professional and practical skills** | **D- General and transferable skills** |
| **Weekly sheet exercises** | a1,a8,a15,a20 | b1,b2,b3,b12 | c1,c12,c18,c23 | d6,d7,d8 |
| **Reports** | a1,a8,a15,a20 | b1,b2,b3,b12 | c1,c12,c18,c23 | d7, d8 |
| **Quizzes** | a1,a8,a15,a20 | b1,b2,b3,b12 | c1,c12,c18,c23 | d6 |
| **Laboratory exam** |  |  |  |  |
| **Midterm, and Final Written exams** | a1,a8,a15,a20 | b1,b2,b3,b12 | c1,c12,c18,c23 | d6, d8 |

Authorized from department board at 13/9/2015

Authorized from college board at 04/10/2015

**Course Coordinator Head of Department**

Dr. Hosny Shohla Asso. Prof. Mohamed El-Brawany