COURSE CONTENT

Academic Year	AY2023-24	**Semester**	1
School/Programme	EEE / Master of Science (CCA)		
Course Code	EE6203		
Course Title	Computer Control Systems		
Pre-requisites	Nil		
No of AUs	3		
Contact Hours	39		
Expected Implementation date of new/revised course	AY2023-24 Semester 1		

Any cross-listing?
Is course opened to all Postgraduate students (including IGP) or specific program (please indicate)?

Within EEE							Outside EEE (Please specify)
MSc Programmes*					MEng	PhD	
CME	CCA	ET	PE	SP			
	SE		GE		√	√	*All Postgraduate research students under CoE and IGP*

* List of MSc programmes

- MSc Communication Engineering (CME) Programme
- MSc Computer Control & Automation (CCA) Programme
- MSc Electronics (ET) Programme
- MSc Power Engineering (PE) Programme
- MSc Signal Processing (SP) Programme

Course Aims

Control systems exist everywhere in our society. Practically all control systems that are implemented today are based on computer control. It is therefore important to understand computer-controlled systems well. The purpose of the subject is to provide a thorough background for understanding, analyzing and designing of computer-controlled systems. Graduate students who need to be equipped with the control theory that is relevant to the analysis and design of computer-controlled systems should take this course.

Intended Learning Outcomes (ILO)

By the end of this course, the students should be able to understand specific theories of computer-controlled systems, carry out the design of controllers to meet desired performance specifications through various design techniques such as the frequency and state space approaches, understand practical implementation techniques and considerations from a software and hardware point of view.

By the end of this course, you should be able to:

1. Understand concepts of computer-control systems, Z-transform and its properties, Inverse Z-transform
2. Understand the modelling of discrete-time systems and determine pulse transfer functions of various types of systems.
3. Understand the mapping between *s*- and z-domains, check system stability and carry out steady-state error analysis for stable systems.
4. Understand state-variables fundamentals and state-space modelling.
5. Understand and check discrete controllability and discrete observability.
6. Design state-feedback controllers, state observers, deadbeat controllers and understand the concept of integral control.
7. Understand the Principle of Optimality and dynamic programming. Design linear

quadratic controllers and solve the discrete Riccati equation.

8. Design digital controllers based on approximating continuous-time controllers, frequency domain and direct control approaches.
9. Understand two degrees of freedom feedback controller and design pole placement controller.
10. Understand implementation of digital controllers with direct programming and standard programming approaches. Analyze sensitivity to quantization of controller coefficients and how to reduce quantization errors.

Course Content

Topic 1 Discrete-time system modelling and analysis.
Topic 2 State-space design methods.
Topic 3. Optimal control.
Topic 4. Design based on transfer functions.
Topic 5. Implementation of digital controllers.

Assessment (includes both continuous and summative assessment)

Component	ILO Tested	Weighting	Team/Individual	Assessment Rubrics
1. Final Examination	ILO 1 – ILO 10	60%	Individual	
2. Continuous Assessment 1 (CA1): Quiz	ILO 1 to ILO 3	10%	Individual	
3. Continuous Assessment 2 (CA2): Quiz	ILO 4 to ILO 6	15%	Individual	
4. Continuous Assessment 3 (CA3): Quiz	ILO 8 – ILO 10	15%	Individual	
Total		100%		

Description of Assessment Components:
There will be three quizzes conducted on week 4, 8 and 13, one each to test students' basic understanding of topics covered.
There will be final examination lasting 3 hours in the university exam period to test students' comprehensive understanding of all major topics covered in the whole course.

Formative feedback

Students will receive their continuous assessment results. Feedback on how you solve the questions including mistakes made will also be provided. A report on the final exam will also be uploaded on NTULearn under the course sites after release of final result.

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?

Lecture	3-hr face-to-face lecture in the Lecture Theatre
TEL Video Recording	All the lectures will be recorded and all the slides will be uploaded so students can also learn on the website or review again at home.

Reading and References

Textbook:

1. K. Ogata, Discrete-Time Control Systems, 2nd Edition, Prentice Hall, 1995.
2. Fadali, M. Sami; Visioli, Antonio, Digital Control Engineering - Analysis and Design (e-book), Elsevier, 2013.

References:

1. Kannan M. Moudgalya, Digital Control, John Wiley & Sons, Ltd, 2007
2. Computer Controlled Systems : Theory and Design By Karl J Astrom and Bjorn Wittenmark, Dover Publications Inc, 2012, 3rd Edition. (1st Edition, 1984 Published by Prentice Hall)
3. Digital Control Systems by Benjamin C Kuo, Oxford University Press, 2nd edition, 1995.
4. Digital Control Systems Analysis and Design by Charles L Philips and H Troy Nagle, Pearson Education, 4th edition, 2015.

Course Policies and Student Responsibilities

(1) General

You are expected to complete all assigned pre-class readings and activities, attend all seminar classes punctually and take all scheduled assignments and tests by due dates. You are expected to take responsibility to follow up with course notes, assignments and course related announcements for seminar sessions they have missed. You are expected to participate in all seminar discussions and activities.

(2) Absenteeism

Absence from class without a valid reason will affect your overall course grade. Valid reasons include falling sick supported by a medical certificate and participation in NTU's approved activities supported by an excuse letter from the relevant bodies.

If you miss a lecture, you must inform the course instructor via email prior to the start of the class.

Academic Integrity

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the Academic Integrity Intranet Site for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Industry Participation

Company Name	**Description of involvement (e.g., co-curation of course, speaker or instructor), include no. of course hours if known.**	**Contact Person**	**Email**
TBC			

Planned Weekly Schedule

Week	**Topic**	**ILO**	**Readings/ Activities**
1 -4	Discrete Time System Modelling and Analysis (12 hours) Introduction, Sampling process, Z-transform and its properties, Inverse Z-transform, Modelling of digital control systems, Pulse transfer functions, Mapping between S- and Z-domains, System stability, Steady-state error analysis for stable systems. CA 1: Quiz	ILO 1 to ILO 3	Read materials related to the topics in the lecture notes, text books and references. Work on some exercises on the topics in the text books and references. A quiz will be conducted in Week 4
5 - 8	State Space Design Methods (12 hours) State-variables fundamentals and state-space modelling. Discrete controllability and discrete observability. State-feedback controllers. State observers. Deadbeat Control. Systems with Inputs. Integral	ILO 4 to ILO 6	Read materials related to the topics in the lecture notes, text books and references. Work on some exercises on the topics in the text

	Control. CA 2 : Quiz		books and references. A quiz will be conducted in Week 8
9	<u>Optimal Control (3 hours)</u> The Principle of Optimality and dynamic programming. Linear quadratic control. Solution of the discrete Riccati equation.	ILO 7	Read materials related to the topics in the lecture notes, text books and references. Work on some exercises on the topics in the text books and references.
10 -12	<u>Design Based on Transfer Functions (9 hours)</u> Design of simple loops. Approximating continuous-time controllers. Frequency response design. Lead compensation. Lag compensation. Lag-lead compensation. Direct Control Design. Two Degrees of Freedom Feedback Controller. Pole Placement Controller	ILO 8 and ILO 9	Read materials related to the topics in the lecture notes, text books and references. Work on some exercises on the topics in the text books and references.
13	<u>Implementation of digital controllers (3 hours)</u> Direct Programming. Standard Programming. Analysis of Sensitivity to Quantization of Controller Coefficients. Reduction of Quantization Errors. CA 3: Quiz	ILO 10	Read materials related to the topics in the lecture notes, text books and references. Work on some exercises on the topics in the text book and references. A quiz will be conducted in Week 13

Other information(s)

Nil