Annexe A: New/Revised Course Content in OBTL+ Format

Course Overview

Expected Implementation in Academic Year	AY2024-2025
Semester/Trimester/Others (specify approx. Start/End date)	Semester 2
Course Author * Faculty proposing/revising the course	Pui Tze Sian
Course Author Email	tspui@ntu.edu.sg
Course Title	Electronics for Biomedical Engineers
Course Code	BG2104
Academic Units	3
Contact Hours	39
Research Experience Components	Not Applicable

Course Requisites (if applicable)

Pre-requisites	
Co-requisites	
Pre-requisite to	
Mutually exclusive to	
Replacement course to	
Remarks (if any)	

Course Aims

The course aims to introduce you the fundamental of electronic devices and knowledge for design electronics circuits for biomedical applications. The knowledge and skills learnt will support you in preparation for future study (e.g. for course such as Bioinstrumentation and medical device design) and career in biomedical industry.

Course's Intended Learning Outcomes (ILOs)

Upon the successful completion of this course, you (student) would be able to:

ILO 1	Develop a comprehensive understanding of basic circuit analysis principles, including Ohm's law, Kirchhoff's law, and circuit simplification.
ILO 2	Analyze complex electronic circuits, such as circuit with many loops and nodes
ILO 3	Acquire a thorough understanding of the characteristics of semiconductors, including their electrical conductivity, band structure, and doping effects.
ILO 4	Develop a comprehensive understanding of NPN bipolar junction transistors (BJTs), including their structure, operating principles, and characteristic behaviors.
ILO 5	Explain operating principles, characteristics, and performance parameters of common emitter amplifiers
ILO 6	Analyze small signal models of common emitter amplifiers, understanding their voltage and current gains, input/output impedance, and distortion properties
ILO 7	Develop a deep understanding of modeling common emitter amplifiers using a box model circuit approach.
ILO 8	Develop a comprehensive understanding of multistage amplifiers, including their architecture, characteristics, and design considerations.
ILO 9	Develop a comprehensive understanding of N-channel Junction Field-Effect Transistor (JFETs), including their structure, operating principles, and characteristic behaviors.
ILO 10	Develop a comprehensive understanding of P-channel Junction Field-Effect Transistor (JFETs), including their structure, operating principles, and characteristic behaviors.
ILO 11	Gain a thorough understanding of operational amplifiers (op-amps), including their structure, operation principles, and characteristic behaviors.
ILO 12	Analyze the ideal and non-ideal properties of op-amps, such as input/output impedance, voltage gain, bandwidth, and slew rate.
ILO 13	Acquire a comprehensive understanding of frequency response analysis, encompassing the principles, methods, and applications of analyzing the behavior of systems in frequency domain.

Course Content

Fundamental principles of circuit theorems and circuit elements. Circuit analysis in frequency domain. Bipolar junction transistor. Field effect transistor. Operation amplifier (Op-Amp)

Reading and References

1. Electronics Devices, and Circuits, conventional flow version, Hassul & Zimmerman, Pearson, ISBN 9789810676896

2. Electronics Devices and Circuits, Conventional Current Version, Thomas L. Floyd, Pearson, ISBN 9781292025643

Planned Schedule

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
1	Basic circuit analysis with Ohm's law	1	Reading list [1]-[2]	In-person	Face to face lecture, Pre-tutorial video
2	Complex circuit analysis with nodal voltage and mesh current method	1,2	Reading list [1]-[2]	In-person	Face to face lecture, Tutorial 1
3	Characteristics of semiconductor diodes	3	Reading list [1]-[2]	In-person	Face to face lecture, Tutorial 2
4	The bipolar junction transistor	4	Reading list [1]-[2]	In-person	Face to face lecture, group assignment Tutorial 3
5	The Common emitter amplifier circuit	5,6	Reading list [1]-[2]	In-person	Face to face lecture, Tutorial 4
6	The box model	7	Reading list [1]-[2]	In-person	Face to face lecture, Tutorial 5
7	Multistage amplifier	8	Reading list [1]-[2]	In-person	Face to face lecture, Tutorial 6
8	The DC behaviour and states of the N-Channel JFET	9	Reading list [1]-[2]	In-person	Face to face lecture, tutorial 7
9	The DC behaviour and states of the P-Channel JFET	10	Reading list [1]-[2]	In-person	Face to face lecture Tutorial 8
10	Operational amplifier Part 1	11	Reading list [1]-[2]	In-person	Face to face lecture Tutorial 9
11	Operation amplifier Part 2	12	Reading list [1]-[2]	In-person	Face to face lecture Tutorial 10
12	Frequency response analysis	13	Reading list [1]-[2]	In-person	Face to face lecture, Tutorial 11
13	Bode gain plot	13	Reading list [1]-[2]	In-person	Face to face lecture, Tutorial 12

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
Lecture	Demonstrate how to carry out a procedure such as working through a problem, use incomplete handouts which enabling students participating in class.
Tutorial	TBL classroom discussion sessions on tutorial questions and related topics

Assessment Structure

Assessment Components (includes both continuous and summative assessment)

No.	Component	ILO	Related PLO or Accreditation	Weightage	Team/Individual	Rubrics	Level of Understanding
1	Summative Assessment (EXAM): Final exam(Final Examination)	1-13	EAB SLO a, b,	60	Individual	Analytic	Relational
2	Continuous Assessment (CA): Test/Quiz(CA1: Quiz)	1,2,3	EAB SLO a, b,	10	Individual	Analytic	Multistructural
3	Continuous Assessment (CA): Assignment(CA2: Assignment)	2,5,8,10	EAB SLO a, b,c,e,k	15	Team	Analytic	Relational
4	Continuous Assessment (CA): Test/Quiz(CA3: Quiz 2)	4,5,6,7,8	EAB SLO a, c,	15	Individual	Analytic	Multistructural

Description of Assessment Components (if applicable)

Formative Feedback

Examination results;
Marker's report on overall examination performance will be uploaded to NTUlearn;
Quiz answers will be discussed in class

NTU Graduate Attributes/Competency Mapping

This course intends to develop the following graduate attributes and competencies (maximum 5 most relevant)

Attributes/Competency	Level
Collaboration	Basic
Creative Thinking	Intermediate
Digital Fluency	Basic

Course Policy

Policy (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 website for more information. On the use of technological tools (such as Generative AI tools), different courses / assignments have different intended learning outcomes. Students should refer to the specific assignment instructions on their use and requirements and/or consult your instructors on how you can use these tools to help your learning. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Policy (General)

(1) General

Students are expected to complete all online activities and take all scheduled assignments and tests by due dates. Students are expected to take responsibility to follow up with course notes, assignments and course related announcements. Students are expected to participate in all tutorial discussions and activities

Policy (Absenteeism)

(2) Absenteesim

Continuous assessments make up a significant portion of students' course grade. Absence from continuous assessments without officially approved leave will result in no marks and affect students' overall course grade.

Policy (Others, if applicable)

Continuous assessments: Students are required to attend all continuous assessments

Appendix with Rubric (Assessment Criteria)

Please remember to attach the Appendix with Rubric (Assessment Criteria) if you have uploaded any.

Appendix BG2104.pdf

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Last Updated By: Song Juha (Assoc Prof)

Appendix : Rubric/Assessment Criteria for Components listed in Assessment Table

Appendix 1: Assessment Criteria for Quiz 1 and Quiz 2

Criteria	Unsatisfactory: <40%	Bordeline: 40% to 49%	Satisfactory: 50% to 69%	Very good: 70% to 89%	Exemplary: >90%
Knowledge Understanding scientific principles that apply to basic flow of electricity and the techniques in circuit analysis.	• Lacks understanding of theories, laws, concepts, and terms governing the basic flow of electricity. • Unable to apply the theories and concepts to solve circuit problems.	• Partial understanding of theories, laws, concepts, and terms governing the basic flow of electricity. • Can apply the theories and concepts to solve simple circuit problems	• Good understanding of the theories, laws, concepts, and terms governing the basic flow of electricity. • Can apply the theories and concepts to solve medium level circuit problems	• Good and comprehensive understanding of the theories, laws, concepts, and terms governing the basic flow of electricity • Can apply the theories and concepts to solve complicated circuit problems	• Very good and comprehensive understanding of theories, laws, concepts, and terms governing the basic flow of electricity • Can apply the theories and concepts to solve all circuit problems.
Analysis The ability to analyse complicate circuits, such as circuit with many loops and nodes.	• Unable to understand possible application of electronic systems and apply the knowledge to test and modify the system.	• Can read and partially understand possible application of electronics systems but unable to apply the knowledge to test and modify the system.	• Can read and understand possible application of electronics systems and apply the knowledge to test the system.	• Can read and understand possible application of electronics systems and apply the knowledge to test and modify the system.	• Can read and understand possible application of electronics systems and apply the knowledge to test, modify and optimize the system.

Appendix 2: Assessment Criteria for assignment 1

Criteria	Unsatisfactory: <40%	Bordeline: 40% to 49%	Satisfactory: 50% to 69%	Very good: 70% to 89%	Exemplary: >90%
Comprehension The ability to comprehend multiple electronic component and their connection to design functioning electronic circuit	Unable to understand the components and recognize various type of circuit configurations	Some understanding of the components but unable to recognize the circuit configurations	Understands the components, their functions and the circuit configurations.	Understands the components and functionality in their respective configuration very well and most likely can predict the behavior.	A thorough understanding of the components and their function. Can tell the circuit configuration used to develop specific functions.
Application Applying theories and use appropriate methods to diagnose faults in diode or transistor circuit.	Unable to understand possible application of electronic systems and apply the knowledge to test and modify the system.	Can read and partially understand possible application of electronics systems but unable to apply the knowledge to test and modify the system.	Can read and understand possible application of electronics systems and apply the knowledge to test the system.	Can read and understand possible application of electronics systems and apply the knowledge to test and modify the system.	Can read and understand possible application of electronics systems and apply the knowledge to test, modify and optimize the system.

Appendix 3 Assessment Criteria for Final exam

Criteria	Unsatisfactory: <40%	Borderline: 40% to 49%	Satisfactory: 50% to 69%	Very good: 70% to 89%	Exemplary: >90%
Knowledge Understanding scientific principles that apply to basic flow of electricity and the techniques in circuit analysis.	• Lacks understanding of theories, laws, concepts, and terms governing the basic flow of electricity. • Unable to apply the theories and concepts to solve circuit problems.	• Partial understanding of theories, laws, concepts, and terms governing the basic flow of electricity. Can apply the theories and concepts to solve simple circuit problems	• Good understanding of the theories, laws, concepts, and terms governing the basic flow of electricity. Can apply the theories and concepts to solve medium level circuit problems	• Good and comprehensive understanding of the theories, laws, concepts, and terms governing the basic flow of electricity Can apply the theories and concepts to solve complicated circuit problems	• Very good and comprehensive understanding of theories, laws, concepts, and terms governing the basic flow of electricity Can apply the theories and concepts to solve all circuit problems.
Analysis The ability to analyse complicate circuits, such as circuit with many loops and nodes.	• Unable to understand possible application of electronic systems and apply the knowledge to test and modify the system.	• Can read and partially understand possible application of electronics systems but unable to apply the knowledge to test and modify the system.	• Can read and understand possible application of electronics systems and apply the knowledge to test the system.	• Can read and understand possible application of electronics systems and apply the knowledge to test and modify the system.	• Can read and understand possible application of electronics systems and apply the knowledge to test, modify and optimize the system.
Comprehension The ability to comprehend multiple electronic component and their connection to design functioning electronic circuit	• Unable to understand the components and recognize various type of circuit configurations	• Some understanding of the components but unable to recognize the circuit configurations	• Understands the components, their functions and the circuit configurations.	• Understands the components and functionality in their respective configuration very well and most likely can predict the behavior.	• A thorough understanding of the components and their function. Can tell the circuit configuration used to develop specific functions.
Application Applying theories and use appropriate methods to diagnose faults in diode or transistor circuit.	• Unable to understand possible application of electronic systems and apply the knowledge to test and modify the system.	• Can read and partially understand possible application of electronics systems but unable to apply the knowledge to test and modify the system.	• Can read and understand possible application of electronics systems and apply the knowledge to test the system.	• Can read and understand possible application of electronics systems and apply the knowledge to test and modify the system.	• Can read and understand possible application of electronics systems and apply the knowledge to test, modify and optimize the system.

Mapping of Course ILOs to EAB Graduate Attributes

Course Code & Title	BG 2104 & Electronics for Biomedical Engineers
Course Type	Core

Overview										
(a)	●	(b)	●	(c)	◐	(d)		(e)	◐	(f)	
(g)		(h)		(i)		(j)		(k)	O		

Legend:

●	Fully consistent (contributes to more than 75% of Student Learning Outcome)
◐	Partially consistent (contributes to about 50% of Student Learning Outcome)
O	Weakly consistent (contributes to about 25% of Student Learning Outcome)
Blank	Not related to Student Learning Outcome

Course ILOs		**EAB Graduate Attributes**
1)	Develop a comprehensive understanding of basic circuit analysis principles, including Ohm's law, Kirchhoff's law, and circuit simplification.	a
2)	Analyze complex electronic circuits, such as circuit with many loops and nodes	a, b, e
3)	Acquire a thorough understanding of the characteristics of semiconductors, including their electrical conductivity, band structure, and doping effects.	a
4)	Develop a comprehensive understanding of NPN bipolar junction transistors (BJTs), including their structure, operating principles, and characteristic behaviors.	a,b,c
5)	Explain operating principles, characteristics, and performance parameters of common emitter amplifiers	a,b
6)	Analyze small signal models of common emitter amplifiers, understanding their voltage and current gains, input/output impedance, and distortion properties	a,b,c
7)	Develop a deep understanding of modeling common emitter amplifiers using a box model circuit approach.	a,b
8)	Develop a comprehensive understanding of multistage amplifiers, including their	a,b

	architecture, characteristics, and design considerations.	
9)	Develop a comprehensive understanding of N-channel Junction Field-Effect Transistor (JFETs), including their structure, operating principles, and characteristic behaviors.	a,b
10)	Develop a comprehensive understanding of P-channel Junction Field-Effect Transistor (JFETs), including their structure, operating principles, and characteristic behaviors.	a,b
11)	Gain a thorough understanding of operational amplifiers (op-amps), including their structure, operation principles, and characteristic behaviors.	a ,b ,e
12)	Analyze the ideal and non-ideal properties of op-amps, such as input/output impedance, voltage gain, bandwidth, and slew rate.	a, b
13)	Acquire a comprehensive understanding of frequency response analysis, encompassing the principles, methods, and applications of analyzing the behavior of systems in frequency domain.	a, b, c

EAB Graduate Attributes

a) **Engineering Knowledge**: Apply the knowledge of mathematics, natural science, computing and engineering fundamentals, and an engineering specialisation as specified in WK1 to WK4 respectively to the solution of complex engineering problems.

b) **Problem Analysis**: Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences with holistic considerations for sustainable development. (WK1 to WK4)

c) **Design / Development of Solutions**: Design creative solutions for complex engineering problems and design systems, components or processes that meet identified needs with appropriate consideration for public health and safety, whole-life cost, net zero carbon as well as resource, cultural, societal, and environmental considerations as required. (WK5)

d) **Investigation**: Conduct investigations of complex problems using research-based knowledge (WK8) and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

e) **Modern Tool Usage**: Create, select and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering problems, with an understanding of the limitations. (WK2 and WK6)

f) **The Engineer and the World**: When solving complex engineering problems, analyse and evaluate sustainable development impacts to: society, the economy, sustainability, health and safety, legal frameworks and the environment (WK1, WK5, and WK7).

g) **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice and adhere to relevant national and international laws. Demonstrate an understanding of the need for diversity and inclusion (WK9).

h) **Individual and Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse and inclusive teams and in multidisciplinary, face-to-face, remote and distributed settings (WK9).

i) **Communication**: Communicate effectively and inclusively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions, taking into account cultural, language, and learning differences.

j) **Project Management and Finance**: Demonstrate knowledge and understanding of engineering management principles and economic decision-making, and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

k) **Life-long Learning**: Recognise the need for, and have the preparation and ability to (i) engage in independent and life-long learning, and (ii) adapt to new and emerging technologies, and (iii) think critically, in the broadest context of technological change (WK8).

No	Knowledge Profile
WK1	A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences
WK2	Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline
WK3	A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline
WK4	Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline
WK5	Knowledge including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts that supports engineering design and operations in a practice area
WK6	Knowledge of engineering practice (technology) in the practice areas in the engineering discipline
WK7	Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline such as the professional responsibility of an engineer to public safety and sustainable development.
WK8	Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues
WK9	Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc with mutual understanding and respect, and of inclusive attitudes

Reference: EAB Accreditation Manual