AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Module name:	Analogue Electronic Circuits 1
Academic year:	2014/2015
Code:	IES-1-306-s
ECTS credits:	7
Faculty of:	Computer Science, Electronics and Telecommunications
Field of study:	Electronics and Telecommunications
Specialty:	—
Study level:	First-cycle studies
Form and type of study:	Full-time studies
Lecture language:	English
Profile of education:	Academic (A)
Semester:	3
Course homepage:	—
Responsible teacher:	dr hab. inż. Machowski Witold (witold.machowski@agh.edu.pl)
Academic teachers:	dr hab. inż. Machowski Witold (witold.machowski@agh.edu.pl)

Description of learning outcomes for module

MLO code	Student after module completion has the knowledge/ knows how to/is able to	Connections with FLO	Method of learning outcomes verification (form of completion)
Social competence			
M_K001	Student understands the necessity and knows possibilities of lifelong learning and improving the professional competencies and qualifications	ES1A_K01	Test
M_K002	Student is aware of the importance of non-technical aspects and consequences of his/her activity as an electronic engineer including responsibility for possible impact on environment	ES1A_K02	Test
Skills			
M_U001	Student can design analog electronic circuit using appropriate methods, techniques and tools.	ES1A_U16	Test
M_U002	Student can utilize circuit implementations of analog blocks with taking into account performance and non-technical (eg. costs) issues.	ES1A_U09	Test
M_U003	Student is able to formulate design specification for simple electronic systems and subsequently verify it.	ES1A_U15	Test
Knowledge			

M_W001	Student knows basic bipolar and CMOS circuit implementations of most important functional blocks	ES1A_W21, ES1A_W16	Examination
M_W002	Student knows principles of analysis and design of analog electronic circuits	ES1A_W15, ES1A_W12	Examination

FLO matrix in relation to forms of classes

MLO code	Student after module completion has the knowledge/ knows how to/is able to	Form of classes										
		Lectures	Auditorium classes	Laboratory classes	Project classes	Conversation seminar	Seminar classes	Practical classes	Fieldwork classes	Workshops	Others	E-learning
Social competence												
M_K001	Student understands the necessity and knows possibilities of lifelong learning and improving the professional competencies and qualifications	+	+	+	-	-	-	-	-	-	-	-
M_K002	Student is aware of the importance of non-technical aspects and consequences of his/her activity as an electronic engineer including responsibility for possible impact on environment	+	+	+	-	-	-	-	-	-	-	-
Skills												
M_U001	Student can design analog electronic circuit using appropriate methods, techniques and tools.	+	+	+	-	-	-	-	-	-	-	-
M_U002	Student can utilize circuit implementations of analog blocks with taking into account performance and non-technical (eg. costs) issues.	+	+	+	-	-	-	-	-	-	-	-
M_U003	Student is able to formulate design specification for simple electronic systems and subsequently verify it.	+	+	+	-	-	-	-	-	-	-	-
Knowledge												
M_W001	Student knows basic bipolar and CMOS circuit implementations of most important functional blocks	+	+	-	-	-	-	-	-	-	-	-

M_W002	Student knows principles of analysis and design of analog electronic circuits	+	+	-	-	-	-	-	-	-	-	-

Module content

Lectures

Module comprises lectures (30 hr) discussion class (30 hr) and laboratory exercises (30 hr) Lectures

1. Electronics and microelectronics. Filters, amplifiers and other two-ports. Basic classes of amplifiers. Input and output impedance. OpAmp as a Black Box. Analysis of linear applications with OpAmps – inverting and non-inverting configuration.
2. Frequency response of simple RC circuits. Behavioral description of open loop OpAmp’s gain. Gain-bandwidth exchange in OpAmp circuits. Other OpAmp non-idealities and their impact on application performance. OpAmp based differentiator and integrator. Instrumental amplifiers.
3. Large and small-signal models of BJT. Relationship between collector current and small signal parameters. Impedance seen from base, collector and emmiter. Roboust BJT biasing in discrete and integrated technology. BJT amplifiers configurations – OE OB and emmiter follower. Benchmark parameters for different configurations.
4. Frequency response of transistor circuits. Miller effect.Intristic gain and fT.
5. MOSFET models for hand calculations. Body effect. Short channel MOSFETS. MOSFET biasing and amplifier configurations – CS, CG and CD.
6. Active biasing and load in bipolar and CMOS integrated circuits. Current sources/sinks and mirrors. Cascode configuration and its advantages. Folded cascode.
7. Feedback topologies. Sensing and return schemas. Feedback’s impact on amplifier parameters. Practical feedback circuit examples. Stability issues degenerative and regenerative feedback.
8. DC amplifiers. Long tail bipolar and MOSFET pair. Common mode and differential signals. Transfer curves for diffpair.
Small signal analysis of differential ammlifiers. CMRR and PSRR. Internal structure of OpAmp. Frequency compensation. Slew rate. Rail-to-rail amplifiers.
9. Active filters. Types of filters. Approximation, implementation and filter synthesis. Integrators, biquads.
Discrete time analog circuits – SC and SI filters.
10. Noise in electronic circuits. Noise origin in electronic devices. Noise parameters. Noise optimization and reduction. Interference noise and shielding.
11. Output stages and power amplifiers. Thermal issues in electronics. Safe operation area. Overheat protection. Thermal resistance.
12. Rectifiers and voltage regulators. Parametric stabilizers. Voltage regulators topology. Short protection and foldback. Pulse regulators and DC voltage converters.

Laboratory classes

Laboratory class
The main philosophy of this lab is “learning by doing”.
Students work in teams and assembly practical circuits using solderless protoboards and THT elements/devices.
Subsequent themes are described more detailedly in lab manuals posted on the course webpage.
1. Introductory exercises. Safety rules in the laboratory. Getting familiar with laboratory equippment. Simple experiments with RC cicruics stimulated with sine and

pulse waveforms.
2. OpAmp based circuits (inverting, noninverting, adder etc.)
3. OpAmp applications – students realize own project approved by the laboratory instructor.
4. BJT – biasing circuits
5. Single BJT amplifiers
6. Single CMOS amplifiers
7. BJT/CMOS differential pair
8. Voltage regulators
9. Final practical test – each student is expected to practically perform part of the lab exercise previously made with his/her team

Auditorium classes

Discussion class:
1. Analysis and design of linear OpAmp applications.
2. Frequency response of OpAmp circuits. Stability of feedback circuits. Phase/gain margin concepts.
3. Bias calulations based on large signal models. Bias current sensitivity. Role of approximate calculations. Small-signal operation concept and models.
4. Analysis of small-signal parameters for different types of amplifier configurations.
5. Design procedures for amplifiers with desired gain and input/output impedance. Trade-offs in electronic circuit design. Impact of elements' tolerances on performance.
6. Feedback circuit analysis. Basic topologiers. Intuitive sensing and return mechanism recognition.
7. Analysis of differential pairs. Active loads. Designing current mirrors.
8. Analysis and design of voltage regulators

Method of calculating the final grade

Final grade will be issued after successful assesment of both discussion and laboratory class as well as passing the final exam. The final grade is weighted sum of auditory class assesment (20%), lab class assesment (20%), final exam (50%) and lecture quizzes (10%)

Prerequisites and additional requirements

Background in mathematics (calculus, matrix algebra, complex numbers), circuit theory, semiconductor devices. Basic laboratory skills – multimeter, oscilloscope, signal generator use.

Recommended literature and teaching resources

B. Razavi Fundamentals of Microelectronics, Willey, 2008
A. Sedra, K.C. Smith, Microelectronic Circuits, Oxford UP 2010
R. Jaeger, T. Blalock, Microelectronic Circuit Design,McGraw Hill 2003
A. Agarwal, J.H Lang, Foundations of Analog and Digital Electronic Circuits, Elsevier 2005

Scientific publications of module course instructors related to the topic of the module

W. Machowski "Niskonapięciowe układy analogowe bazujące na inwerterach CMOS w scalonych systemach VLSI" monografia habilitacyjna, Wydawnictwa AGH, 2012

Additional information

None

Student workload (ECTS credits balance)

Student activity form	Student workload
Participation in lectures	28 h
Realization of independently performed tasks	46 h
Participation in laboratory classes	28 h
Preparation for classes	45 h
Participation in auditorium classes	28 h
Summary student workload	175 h
Module ECTS credits	7 ECTS