

Subject (course) name: <b>Analog Circuits</b>		
Field of study: <b>Electronics and Communications</b> Specialization: <b>all</b>		Subject code: <b>21K</b>
		Title graduate: <b>Engineer</b>
Type of course: <b>major course, obligatory</b>	Course level: <b>First-cycle studies</b>	Year: <b>II</b> Semester: <b>IV</b> Semester: <b>summer</b>
Form of classes: <b>Lectures, Classes, Labs, Seminar, Project</b>	Number of hours per week: <b>2L, 1, 2Lab, 0, 0</b>	Credit points: <b>5 ECTS</b>

## GUIDE TO SUBJECT

### SUBJECT OBJECTIVES

- C1. General knowledge of analog electronic circuits.
- C2. Techniques of analysis and design of analog circuits.
- C3. Practical skills in measurement of basic performance metrics of analog circuits.

### SUBJECT REQUIREMENTS

- 1. Math fundamentals.
- 2. Basic knowledge of circuit theory.
- 3. Basic knowledge of semiconductor devices
- 4. General ability of individual and group work
- 5. General ability to search in literature

### LERNING OUTCOMES

- EK 1 - Student will be able to classify basic electronic circuits and explain their principle of operation.
- EK 2 - Student will be able to conduct an analysis of basic analog circuits and formulate simple conclusions.
- EK3 - Student will be able to design simple and typical analog circuits.
- EK4 - Student will be able to conduct the measurements of the basic parameters of analog circuits and process the measurement data.

### SUBJECT CONTENT

#### Form of classes - lectures

Topic	Hours
<b>W1</b> – Frequency characteristics of linear systems (Bode asymptotes)	<b>2</b>
<b>W2</b> – Frequency characteristics of an RC-coupled transistor stage	<b>2</b>
<b>W3</b> – Operational amplifier; internal structure; basic applications	<b>2</b>
<b>W4</b> – Analog filters: general classification	<b>2</b>
<b>W5</b> – Analysis and design of a Sallen-Key filter	<b>2</b>
<b>W6</b> – Switched capacitor circuits: general information	<b>2</b>
<b>W7</b> – Feedback in electronic circuits	<b>2</b>
<b>W8</b> – General properties of circuits with a negative feedback. Stability of analog circuits	<b>2</b>
<b>W9</b> – AM modulators and demodulators	<b>2</b>
<b>W10</b> – FM modulators/VCO generators/Mixers	<b>2</b>
<b>W11</b> – Phase detectors	<b>2</b>

<b>W12</b> – Phase locked loops; basic characteristics, linear model, PLL's transmittance	<b>2</b>
<b>W13</b> – Basic applications of phase locked loops	<b>2</b>
<b>W14</b> – Power amplifiers	<b>2</b>
<b>W15</b> – Voltage regulators	<b>2</b>
<b>Total</b>	<b>30</b>

#### Form of classes – exercise classes

Topic	Hours
<b>C1</b> – Frequency characteristics of linear circuits; Bode asymptotes	<b>1</b>
<b>C2</b> – Frequency analysis of passive RC circuits	<b>1</b>
<b>C3</b> – Frequency analysis of active linear systems	<b>1</b>
<b>C4</b> – Design of linear systems	<b>1</b>
<b>C5</b> – Analysis and design of a second-order Thomas-Tow filter	<b>1</b>
<b>C6</b> – Transconductance amplifiers and their applications	<b>1</b>
<b>C7</b> – Test no. 1	<b>1</b>
<b>C8</b> – Negative feedback in electronic systems	<b>1</b>
<b>C9</b> – AM modulators	<b>1</b>
<b>C10</b> – Mixers	<b>1</b>
<b>C11</b> – Phase detectors	<b>1</b>
<b>C12</b> – Static characteristics of a PLL circuit	<b>1</b>
<b>C13</b> – PLL-based FM/PM modulator/demodulator	<b>1</b>
<b>C14</b> – Voltage regulators	<b>1</b>
<b>C15</b> – Test no. 2	<b>1</b>
<b>Total</b>	<b>15</b>

#### Form of classes – laboratory

Topic	Hours
<b>L0</b> – Introduction	<b>2</b>
<b>L1</b> – AM modulators	<b>2</b>
<b>L2</b> – Mixers	<b>2</b>
<b>L3</b> – Phase locked loops	<b>2</b>
<b>L4</b> – Basic applications of phase locked loops	<b>2</b>
<b>L5</b> – Sinusoidal and non-sinusoidal oscillators	<b>2</b>
<b>L6</b> – Negative feedback	<b>2</b>
<b>L7</b> – QAM modulators	<b>2</b>
<b>L8</b> – Frequency synthesizer	<b>2</b>
<b>L9</b> – Non-ideal op-amps	<b>2</b>
<b>L10</b> – Voltage comparators	<b>2</b>
<b>L11</b> – Function generator	<b>2</b>
<b>L12</b> – Power amplifiers	<b>2</b>
<b>L13</b> – Spare term	<b>2</b>
<b>L14</b> – Final class	<b>2</b>
<b>Total</b>	<b>30</b>

### STUDY METHODS

<b>1.</b> Lectures
<b>2.</b> Exercises – analysis and design of electronic circuits
<b>3.</b> Laboratory – measurement of electronic circuits – teamwork

### EDUCATIONAL TOOLS

<b>1.</b> Textbook with exercises for individual practice
<b>2.</b> Laboratory instructions
<b>3.</b> Measurement equipment

### METHODS OF ASSESSMENT (F – Forming, P – Summary)

<b>F1.</b> assessment of laboratory reports
<b>F2.</b> two tests during the course of study
<b>P1.</b> lecture – final test
<b>P2.</b> exercise classes – average result from two tests during the course of study

**P3. laboratory – average result from all laboratory reports during the course of study**

## STUDENT WORKLOAD

Form of activity	Averaged workload (hours)		
	[h]	∑ [h]	ECTS
Participation in class activities	30	75	3
lecture	15		
exercise classes	30		
laboratory	30		
Preparation for tutorials (reading literature)	6	60	2
Preparation for lab classes	12		
Preparation of lab reports	12		
Preparation for tests (exercise classes)	12		
Preparation for final exam	18		
<b>Total</b>		<b>135</b>	<b>5</b>

### A. BASIC READING

1. T.F. Floyd, D.M. Buchla, "Electronics fundamentals", 8-th ed. Prentice Hall, 2009
2. J.B. Hagen, "Radio frequency electronics: Circuits and applications", 2-nd ed. Cambridge Univ. Press 2009
3. S.A. Pactitis, "Active filters: theory and design", CRC press 2009

### B. FURTHER READING

1. R.J. Baker, "CMOS circuit design, layout and simulation", 2-nd ed, IEEE/Wiley 2008
2. P.E. Allen, D.R. Holberg, "CMOS analog circuits design" 2-nd ed. Oxford Univ. Press, 2002

Learning objectives	In relation to the learning outcomes specified for the field of study	Subject objectives	Subject content	Course study methods	Methods of assessment
EK1	K_W13 K_U07 K_U09 K_U15	C1, C2	lecture	1	P1
EK2	K_W13 K_U07 K_U09 K_U15	C2	exercise classes	2	F2,P2
EK3	K_W13 K_U07 K_U09 K_U15	C1,C2	lecture, exercise classes	1,2	F2,P2
EK4	K_W13	C1,C3	laboratory	3	F1, P3

## II. EVALUATION

Grade	Outcome
<b>EK1</b>	<b>Student is able to classify and explain the principle of operation of basic analog circuits</b>
2 (F)	Student is <u>not</u> able to draw a schematic diagram of a circuit, nor explain its principle of operation
3 (E)	Student is able to draw a schematic of a circuit and roughly explain its principle of operation
4 (C)	Student is able to draw a schematic of a circuit and explain its principle of operation giving basic characteristics and formulas
5 (A)	Student is able to draw a schematic of a circuit and explain its principle of operation giving basic characteristics and formulas. Student has a knowledge of second-order effects and possible modifications of the circuit
<b>EK2</b>	<b>Student is able to analyze the operation of basic analog circuits and formulate basic conclusions</b>
2 (F)	Student grade for solving a set of exercises is lower than 50%
3 (E)	Student grade for solving a set of exercises is equal to 50%
4 (C)	Student grade for solving a set of exercises is equal to 70%
5 (A)	Student grade for solving a set of exercises is equal to 90%
<b>EK3</b>	<b>Student is able to design simple and typical electronic circuits</b>
2 (F)	Student grade for solving a set of exercises is lower than 50%
3 (E)	Student grade for solving a set of exercises is equal to 50%

4 (C)	Student grade for solving a set of exercises is equal to 70%
5 (A)	Student grade for solving a set of exercises is equal to 90%
<b>EK4</b>	<b>Student is able to design the measurements of the basic parameters of analog circuits and process the measurement data</b>
2 (F)	Student is <u>not</u> able to conduct the correct measurements and calculations
3 (E)	Student is able to present at least 50% of correct measurements and calculations
4 (C)	Student is able to present at least 80% of correct measurements, calculations and correct conclusions
5 (A)	S Student is able to present at least 95% of correct measurements, calculations and correct conclusions

### **III. OTHER USEFUL INFORMATION**

1. All information for students on the schedule are available on the notice board and on the website: [www.el.pcz.pl](http://www.el.pcz.pl)
2. Information on the consultation shall be provided to students during the first lecture and will be placed on the website [www.el.pcz.pl](http://www.el.pcz.pl)
3. Terms and conditions of credit courses will be provided to students during the first lecture