Electronic Dosimetry Devices

Course description sheet

Basic information

Field of study Medical Physics **Major** All **Organisational unit** Faculty of Physics and Applied Computer Science **Study level** Second-cycle (engineer) programme **Form of study** Full-time studies **Profile** General academic	**Didactic cycle** 2022/2023 **Course code** JFMDS.IIi2K.2ea2cd225e37b3f6f4e68995f6bb5eeb.22 **Lecture languages** polish **Mandatoriness** Elective **Block** Core Modules **Course related to scientific research** Yes

Course coordinator	Andrzej Skoczeń
Lecturer	Andrzej Skoczeń

Period Semester 2	**Method of verification of the learning outcomes** Completing the classes **Activities and hours** Lectures: 10 Laboratory classes: 20	**Number of ECTS credits** 4

Goals

C1	Presentation of active electronic dosimetry methods.
C2	Presentation of the physics and electronics of ionization radiation damage (TID) in applications for the measurement of the absorbed dose.
C3	Presentation of physics and electronics of structural radiation damage (SD) in applications for the measurement of neutron fluency.
C4	Presentation of the physics and electronics of single radiation events (SEE) in applications for measuring the fluency of high-energy hadrons (HEH).

Course's learning outcomes

Code	Outcomes in terms of	Learning outcomes prescribed to a field of study	Methods of verification
Knowledge – Student knows and understands:			
W1	The student knows the basic structures of active electronic dosimeters and devices that read passive dosimeters	FMD2A_W01, FMD2A_W02, FMD2A_W03, FMD2A_W05	Activity during classes, Execution of laboratory classes, Test
W2	The student knows the structures and designs of the functional blocks that make up the signal path of the electronic dosimeter	FMD2A_W01, FMD2A_W02, FMD2A_W03, FMD2A_W05	Activity during classes, Execution of laboratory classes, Test
W3	The student knows the physical mechanisms of radiation damage in electronics and the use of these phenomena to measure the radiation dose	FMD2A_W01, FMD2A_W02, FMD2A_W05	Activity during classes, Execution of laboratory classes, Test
Skills – Student can:			
U1	The student is able to recognize phenomena and electronic modules useful in measuring the radiation dose	FMD2A_U04, FMD2A_U08	Execution of laboratory classes, Report
U2	The student can measure the technical parameters of electronic devices to measure the radiation dose	FMD2A_U04, FMD2A_U08	Execution of laboratory classes
Social competences – Student is ready to:			
K1	The student is able to work in a team, and he/she is able to independently acquire the appropriate knowledge and skills necessary to carry out his part of the task	FMD2A_K02	Execution of laboratory classes, Report
K2	The student can present the measurement performed in the form of a communicative report	FMD2A_K02	Execution of laboratory classes, Report

Program content ensuring the achievement of the learning outcomes prescribed to the module

The subject introduces the physical and constructional basics of active electronic dosimeters and devices reading passive dosimeters with particular emphasis on the issue of radiation damage

Student workload

Activity form	**Average amount of hours* needed to complete each activity form**
Lectures	10
Laboratory classes	20
Preparation for classes	15
Realization of independently performed tasks	40
Preparation of project, presentation, essay, report	15
Student workload	**Hours** 100
Workload involving teacher	**Hours** 30

* hour means 45 minutes

Program content

No.	Program content	Course's learning outcomes	Activities
1.	Passive and active dosimeters. Review of passive dosimeters. High dose dosimetry in the LHC. A brief overview of various passive dosimetry measurement techniques with particular emphasis on the high dose range.	W1, W2, W3, U1	Lectures
2.	Total ionization damage TID in electronics working in the radiation field. Physics of the MOS transistor. Review of physical phenomena leading to the degradation of the MOS transistor. MOS transistor employed as active dosimeter dedicated for absorbed dose measurement.	W1, W2, W3, U1	Lectures
3.	Displacement damage DE in electronics working in the non-ionising radiation field. Physic of p-n junction diode. A review of physical phenomena leading to the degradation of silicon electronic components. Applications for neutron fluency measurement - p-i-n diode dosimeter (active and passive).	W1, W2, W3, U1	Lectures
4.	Phenomena caused by the passage of single particles through the electronic system. Physics of single event effects SEE and implications for analogue and digital systems. Systems with a high level of security and reliability. Applications to measure the fluency of high-energy hadrons HEH.	W1, W2, W3, U1	Lectures
5.	Measurement of small ionization currents. Electrometers, specialized operational and instrumentation amplifiers.	W1, W2, W3, U1	Lectures

6.	Linear integrator with diode pump. Educational outcomes: • the student is able to build a simple electronic circuit on a quick assembly board, launch it and observe its operation, • the student is able to measure the conversion coefficient, and integral nonlinearity, and determine the nominal measuring range.	W1, W2, W3, U1, U2, K1, K2	Laboratory classes
7.	Frequency - voltage converter (f-U): Learning outcomes: • using a dedicated integrated circuit, the student is able to build an electronic circuit on a quick assembly board, • the student is able to observe the operation of the system and measure the conversion factor.	W1, W2, W3, U1, U2, K1, K2	Laboratory classes
8.	Converters voltage - frequency (U-f) and light intensity - number of counts: Learning outcomes: • using a dedicated integrated circuit, the student is able to build electronic circuits on a quick assembly board and run them, • the student is able to observe the operation of built systems and perform parameter measurements.	W1, W2, W3, U1, U2, K1, K2	Laboratory classes
9.	Voltage-current converter (U-I). Educational outcomes: • the student is able to build a voltage-controlled current source system on a quick-assembly board, • the student is able to measure the system conversion factor and estimate the output resistance of the system.	W1, W2, W3, U1, U2, K1, K2	Laboratory classes
10.	Pulse counting systems: Learning outcomes: • to build the counter, the student is able to use various technologies: MSI elements, microcontroller, FPGA system, • the student is able to start the pulse counting circuits, prepared in the microcontroller technique and in the FPGA technique.	W1, W2, W3, U1, U2, K1, K2	Laboratory classes

Extended information/Additional elements

Teaching methods and techniques:

Lecture, Workshop, Feedback, E-learning, Lectures

Activities	Methods of verification	Credit conditions
Lectures	Activity during classes, Execution of laboratory classes, Test, Report	attendance not obligatory
Lab. classes	Activity during classes, Execution of laboratory classes, Test, Report	obligatory attendance; passing quizzes; demonstration of the operation of built systems in the workshop; preparation reports from laboratory activities

Additional info

The course has a website with current information on the UPeL platform.

Conditions and the manner of completing each form of classes, including the rules of making retakes, as well as the conditions for admission to the exam

In the electronic laboratory, students work alone or in two-person teams in case when too few setups are available. They perform a number of exercises. The basis for passing each of them is a discussion during the measurements and over the finished report from the measurements.
Each meeting in the laboratory begins with a short quiz on the current topic discussed during the lecture. To be credited: each quiz must be evaluated at least 30% of the maximum possible number of points and the total number of points collected for all quizzes must exceed 50% of the total maximum possible number of points. Otherwise, the student is obligated to pass an additional review quiz. Its score replaces the weakest subscore.
Completion of the laboratory requires completion of all exercises listed in the description of the subject. The condition for obtaining credit for a single exercise is:

- correct assembly of the system and performing measurements,
- delivery of the report with the preparation of the results of observations and measurements.

In case the preparation of the results revealed significant design, assembly or measurement errors, the tutor may require the assembly and measurements to be repeated in an additional meeting.
The primary deadline for obtaining credit is the end of classes in a given semester. A student who does not get a pass on the primary deadline has the right to take the credit during two make-up dates. The second make-up period may not be possible due to the technological conditions of laboratory classes.

Method of determining the final grade

The final grade OK in the module is calculated as the normal average of the grade for the quizzes OL and the reports OS:
OK = 0.5 * OL + 0.5 * OP
OK - final grade
OL - average grade from quizzes
OS - average grade from reports

Manner and mode of making up for the backlog caused by a student justified absence from classes

At the end of the semester, there is an additional date for exercises (announced 2 weeks earlier on the website of the course and by the teacher), where you can perform work that the student could not complete on the original date due to random reasons. Students can also make up for any outstanding exercises.

Prerequisites and additional requirements

• Knowledge of the basics of dosimetry is recommended
• Knowledge of the basics of analogue and digital electronics recommended

Rules of participation in given classes, indicating whether student presence at the lecture is obligatory

Lecture (optional): Students participate in the lectures, learning about the subsequent contents of the teaching in

accordance with the description of the subject. Students should ask questions on an ongoing basis to clarify any doubts and ambiguities that arise. All presented content is available in the form of a presentation after the lecture. The audiovisual recording of the lecture requires the consent of the lecturer.
Laboratory exercises (obligatory): Students perform laboratory exercises in accordance with the materials provided by the teacher. The student is obliged to be prepared for the subject of the exercise and the information presented during the lecture. Each time it is verified by means of a short written quiz. Completion of the course is based on the presentation of the solution to the given problem. Passing the module is possible after passing all laboratory workshops.

Literature

Obligatory

1. Materiały z wykładu publikowane w systemie UPeL

Optional

1. M. Bagatin, S. Gerardin, Ionizing Radiation Effects in Electronics, From Memories to Imagers, CRC Press, 2016.
2. C. Leroy, P-G. Rancoita, Principles of radiation interaction in matter and detection. World Scientific Publishing 2012.
3. Ahmed, Syed Naeem, Physics and engineering of radiation detection. Elsevier, Academic Press, 2007.
4. K. Korbel, Ekstrakcja informacji z sygnału radiometrycznego. WFiIS AGH, Kraków 2006.
5. Piątkowski, W. Scharf, Elektroniczne mierniki promieniowania jonizującego.Wydaw. Min. Obrony Narodowej, Warszawa 1979.

Scientific research and publications

Research

1. Rozwój urządzeń ochrony akceleratora LHC

Publications

1. J. Steckert, A. Skoczeń, "Design of FPGA-based Radiation Tolerant Quench Detectors for LHC", 2017 JINST 12 T04005
2. P. Gryboś, M. Idzik, A. Skoczeń, "Design of low noise charge amplifier in sub-micron technology for fast shaping time", Analog Integr Circ S 49 (2): 107-114 Nov 2006

Learning outcomes prescribed to a field of study

Code	Content
FMD2A_K02	potrafi pracować indywidualnie i w zespole, myśląc i działając w sposób profesjonalny i przedsiębiorczy, wprowadzając korzystne ekonomicznie rozwiązania, mając jednocześnie świadomość odpowiedzialności za realizowane zespołowo cele przy przestrzeganiu zasad etyki zawodowej poczas pracy
FMD2A_U04	potrafi zaplanować pracę wieloetapową do rozwiązywania problemów inżynierskich oraz naukowo-badawczych o różnym stopniu trudności dobierając właściwe metody pomiarowe oraz metodologię a także ocenić czas jej ukończenia oraz koszty związane z jej realizacją
FMD2A_U08	potrafi wybrać, zastosować i ocenić przydatność dostępnych metod oraz narzędzi niezbędnych do rozwiązania wybranych problemów technicznych i biomedycznych o różnym stopniu skomplikowania i przeanalizować sposób działania i poddać krytycznej ocenie rozwiązania techniczne zastosowane w wybranych aparatach i urządzeniach medycznych
FMD2A_W01	posiada znajomość technik pomiarowych, szczegółową wiedzę dotyczącą podstaw fizycznych wybranych procesów biofizycznych, biomedycznych i biochemicznych niezbędną do prowadzenia złożonej analizy danych doświadczalnych, prezentowania uzyskanych wyników i wyciągania na ich podstawie wniosków
FMD2A_W02	ma szczegółową wiedzę z zakresu nowoczesnych metod diagnostycznych i terapeutycznych stosowanych w medycynie; zna działanie zaawansowanych układów elektronicznych oraz posiada ugruntowaną wiedzę z zakresu programowania, niezbędną do rozwiązywania wybranych problemów biomedycznych
FMD2A_W03	ma uporządkowaną wiedzę w zakresie fizyki, matematyki, chemii i biologii oraz innych dziedzin nauki (medycyna, informatyka) pozwalającą na formułowanie i rozwiązywanie zadań o różnym stopniu zaawansowania, w tym także z zakresu ochrony radiologicznej
FMD2A_W05	ma uporządkowaną wiedzę o współczesnych zastosowaniach fizyki w nowoczesnych technologiach biomedycznych, zna nowe osiągnięcia naukowe oraz aktualne kierunki badań i rozwoju głównych działów fizyki medycznej