Special curriculum in radiation effects in electronics

**Name of course**: Radiation effects in electronic systems and components

**Course responsible**: Ketil Røed

**Credits**: 10 ECTS

**Teaching:** Special curriculum / self-study. A one-hour colloquium every other week may be considered if more than one student is following the course.

**Semester**: Autumn and spring

**Course content**

This course focuses on radiation effects in electronic systems and components. An introduction to radiation and how radiation interacts with matter is covered to provide a good background for understanding radiation effects in electronics. The course also gives and overview of radiation environments relevant for electronic systems in space and high energy physics applications.

**Learning outcome:**

After completing the course:

* you have a basic knowledge about how radiation interacts with matter and how these interactions my affect electronic components
* you have basic knowledge about and can describe the main differences between various radiation environments in the context of radiation effects in electronic components.
* you have a good understanding of the most common radiation effects in electronic components (single event effects, total ionizing dose, displacement damage), and when an in which environment these effects are relevant to consider
* you have knowledge about test methods used to characterize the radiation sensitivity and tolerance of electronic systems and components
* you have knowledge about the most common techniques applied to mitigate the effects of radiation in electronics systems and components

**Recommended previous knowledge**

A basic understanding of semiconductor devices and integrated circuits.

**Suggested teaching material / curriculum**

A combination of textbook material, magazine articles, and various scientific papers.

Textbooks (approx.. 224 pages):

Robert Baumann and Kirby Kruckmeyer. Radiation handbook for electronics. A compendium of radiation effects topics for space, industrial and terrestrial applications. Texas Instruments, 2019. Chapters 1 – 10 (approx. 110 pages). Available from [www.ti.com/radbook](http://www.ti.com/radbook).

**G. F. Knoll, Radiation detection and measurement. Third or fourth edition. Whiley 2010. (64 pages).**Chapter 1: Radiation sources p. 1-28 Chapter 2: Radiation interactions p. 29-64

Michael Nicolaidi. Soft errors in modern electronic system. Frontiers in Electronic Testing, vol. 41. Springer Boston, 2011. Available from <https://doi.org/10.1007/978-1-4419-6993-4>

Chapter 1: T. Heijmen. Soft errors from space to ground: historical overview, empirical evidence, and future trends. (24 pages).

Chapter 2: R. Gaillard. Single event effects: mechanism and classification (26 pages).

Magazine articles (approx. 15 pages):

J. Mazur, An overview of the space radiation environment. Crosslink Vol. 4, No. 4, 2003 (5 pages). Available: <http://aerospace.wpengine.netdna-cdn.com/wp-content/uploads/crosslink/CrosslinkV4N2.pdf>

J. Scarpulla and A. Yarbrough, What Could Go Wrong, The Effects of Ionizing radiation on Space Electronics. Crosslink Vol. 4, No. 4, 2003. (5 pages) Available: <http://aerospace.wpengine.netdna-cdn.com/wp-content/uploads/crosslink/CrosslinkV4N2.pdf>

S. Crain and R. Koga, Heavy-Ion Testing for Single-Event Effects, Crosslink Vol. 4, No. 4, 2003. (4 pages) Available: <http://aerospace.wpengine.netdna-cdn.com/wp-content/uploads/crosslink/CrosslinkV4N2.pdf>

Scientific papers (approx. 110 pages):

E. L. Petersen et al., The single event revolution. Transactions on Nuclear Science, Volume 60, Issue 3, 2013. <https://doi.org/10.1109/TNS.2013.2248065> (11 pages)

R. C. Baumann, Radiation-induced soft errors in advanced semiconductor technologies. IEEE Transaction on Nuclear Science, Vol. 5, No. 3, December 2005 (10 Pages). Available: <http://ieeexplore.ieee.org/document/1545891/>

C. C. Foster, Total Ionizing Dose and Displacement Damage Effects in Mircoelectronics, MRS Bulletin February 2003. (5 Pages) <https://doi.org/10.1557/mrs2003.42>

F. Faccio, COTS for the LHC radiation environment: the rules of the game, Proceedings of the 6th Workshop on Electronics for LHC Experiments, September 2000. (16 pages) Available: <https://cds.cern.ch/record/478245/files/p50.pdf>

Alía et al., Single event effects in high-energy accelerators. Semiconductor Science and Technology, Volume 32, Number 3, 2017. (10 pages) <https://doi.org/10.1088/1361-6641/aa5695>

Schwank, Radiation hardness assurance testing of Microelectronic devices and integrated circuits: Test guideline for proton and heavy ion single event effects. Transactions on Nuclear Science, Volume 60, Issue 3, June 2013 <https://doi.org/10.1109/TNS.2013.2261317> (17 pages)

R. Ecoffet. Overview of in-orbit radiation induced spacecraft anomalies. Transactions on Nuclear Science, Volume 60, Issue 3, June 2013. <https://doi.org/10.1109/TNS.2013.2262002>

(24 pages)

Sinclair and Dyer, Radiation effects and COTS parts in SmallSats. Small Satellite Conference, 2013. (11 pages) <https://digitalcommons.usu.edu/smallsat/2013/all2013/69/>

Bagatin et al., Space and terrestrial radiation effects in flash memories. Semiconductor Science and Technology, Volume 32, Number 3, 2017. (9 pages) <https://doi.org/10.1088/1361-6641/32/3/033003>