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Overview of particle radiation effects on telecommunication systems

Recommendation ITU-T K.124



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Recommendation ITU-T K.124

Overview of particle radiation effects on telecommunication systems

Summary

Recommendation ITU-T K.124 provides basic guidance on soft errors that are caused by particle radiation and that affect telecommunication systems. This Recommendation details the phenomena of soft errors that arise from particle radiation. A brief explanation of the procedures for design, test and mitigation measures are also included in this Recommendation.

History

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* To access the Recommendation, type the URL <http://handle.itu.int/> in the address field of your web browser, followed by the Recommendation's unique ID. For example, <http://handle.itu.int/11.1002/1000/11830-en>.

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Table of Contents

		Page
1	Scope.....	1
2	References.....	1
3	Definitions	1
3.1	Terms defined elsewhere	1
3.2	Terms defined in this Recommendation.....	1
4	Abbreviations and acronyms	1
5	Conventions	2
6	Mechanism by which particle radiation causes soft errors	2
6.1	Particle radiation which causes soft errors	2
6.2	Effect of geographical conditions and solar activity on soft error rate	5
6.3	The effect of building and installation conditions on soft error occurrence in telecommunication equipment	7
6.4	Types of soft errors.....	10
7	Impact of soft errors generated in telecommunication equipment and mitigation methods.....	10
7.1	The increase of soft errors in telecommunication equipment	10
7.2	Impact of soft errors on operation of telecommunication systems and mitigation measures.....	11
7.3	Mitigation measures for soft errors in telecommunication equipment.....	13
8	Necessity of this Recommendation for soft errors	14
9	Development procedures for telecommunication equipment	15
	Bibliography.....	17

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Introduction

As more highly integrated semiconductor devices are deployed in telecommunication equipment, soft errors caused by particle radiation occur more frequently on carrier telecommunication networks and have a more severe impact on network operations and the quality of signal transmission. Accordingly, measures to mitigate the effect of soft errors are required for telecommunication equipment. A large amount of telecommunication equipment is installed in remotely supervised telecommunication networks. A single soft error within a piece of telecommunication equipment can have a disastrous impact on services if the equipment is not appropriately designed to mitigate the effect of soft errors. Therefore, it is important during the design and development of telecommunication equipment to determine the impact of soft errors and to apply additional measures to mitigate this impact in order to achieve the target quality of the system.

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Overview of particle radiation effects on telecommunication systems

1 Scope

This Recommendation presents an overview of the effects of particle radiation and design methods to mitigate the impact of soft errors. The Recommendation is applicable to the telecommunication equipment that composes a terrestrial carrier telecommunication network, including core network equipment (i.e., link and node equipment) and access network equipment that are installed in telecommunication centres.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

None.

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 neutron irradiation test : A means to evaluate soft error quality through the use of neutron irradiation emitted by a neutron source driven by a compact accelerator.

3.2.2 soft error: A phenomenon in which one or more bits within the data on the device have their values reversed. A soft error does not constitute damage to the actual semiconductor device.

3.2.3 soft error rate: Occurrence number of soft error in a unit time.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

CRAM	Configuration Random Access Memory
DICE	Dual Interlocked Storage Cell
ECC	Error Correction Code
EUT	Equipment under test
FIT	Failure In Time
FPGA	Field-Programmable Gate Array
LSI	Large Scale Integration

MCU	Multiple Cell Upset
NE	Network Equipment
RCC	Replication, Comparison, Checkpointing
SCU	Single Cell Upset
SEB	Single-Event Burnout
SEL	Single-Event Latch-up
SEU	Single-Event Upset
SRAM	Static Random Access Memory
TMR	Triple Modular Redundancy

5 Conventions

None

6 Mechanism by which particle radiation causes soft errors

A soft error does not damage the semiconductor device itself; instead it is a phenomenon that affects the data within the device by reversing the value of one or more bits within the data. The semiconductor device itself is not damaged, therefore its operation will be restored to normal operation condition after the reversed bit is rewritten to the device or the semiconductor device is initialized in order to reset the data in memory to its default values. This Clause will explain the phenomena that produces particle radiation, which is the cause of soft errors, as well as the mechanism by which soft errors occur in semiconductor devices.

6.1 Particle radiation which causes soft errors

Soft errors are mainly caused by particle radiation of neutrons and alpha particles. Neutrons are generated by cosmic rays and alpha particles are generated by minute quantities of radioisotopes contained in materials used within the semiconductor devices.

6.1.1 Mechanism by which alpha particles cause soft errors

Materials for the packages and wiring that compose an integrated circuit contain minute quantities of radioisotopes such as uranium²³⁸ or thorium²³². When an alpha particle produced by the radioisotope invades the interior of the material used in an integrated circuit, electron hole pairs are generated along the path of the alpha particle as shown in Figure 6-1. The electron hole pairs generated in and around the depletion layer drift and accumulate within the memory cell. Once the accumulated charge exceeds a threshold level specific to the semiconductor gate, the value of the bit within the memory cell is reversed (from 0 to 1 or 1 to 0).

The occurrence of soft errors caused by alpha particles can be reduced by using high purity materials such as low alpha particle plastics.