

I n t e r n a t i o n a l T e l e c o m m u n i c a t i o n U n i o n

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

K.130

(01/2018)

SERIES K: PROTECTION AGAINST INTERFERENCE

Neutron irradiation test methods for telecommunication equipment

Recommendation ITU-T K.130



International
Telecommunication
Union

Documents
Document Sharing Hub

Downloaded from https://www.ava.com

Recommendation ITU-T K.130

Neutron irradiation test methods for telecommunication equipment

Summary

Recommendation ITU-T K.130 describes soft error test methods for the telecommunication equipment that composes carrier telecommunications networks. The objective of soft error tests of the telecommunication equipment using an accelerator-driven neutron source is described first. An overview of the soft error tests and operating principles of an accelerator-driven neutron source are then introduced. The requirements of the accelerator-driven neutron sources and test sites are specified. The test conditions including test set-up, operational conditions and error monitoring and test procedures for the telecommunication equipment are specified. Notes for determining specific detailed test methods, such as the neutron flux to be used for irradiation and conditions for counting as failures in estimation of the reliability are also described.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T K.130	2018-01-13	5	11.1002/1000/13453

Keywords

Irradiation test, neutron, soft error.

* 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>.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at <http://www.itu.int/ITU-T/ipr/>.

© ITU 2018

All rights reserved. No part of this publication may be reproduced, by any means whatsoever, without the prior written permission of ITU.

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	Advantages and objectives of neutron irradiation tests	2
7	Overview of neutron irradiation test system for telecommunication equipment using an accelerator-driven neutron source	2
7.1	Configuration of neutron irradiation test facility.....	2
7.2	Target assembly requirements	3
7.3	Requirements for accelerator-driven neutron source.....	4
7.4	Elimination of unnecessary irradiation.....	6
7.5	Simultaneous neutron irradiation of EUTs.....	7
7.6	Irradiation area.....	7
7.7	Uniformity of neutron flux	7
7.8	Miscellaneous notes.....	8
8	Test set-up.....	8
8.1	Outline of test set-up	8
8.2	Configuration.....	8
8.3	Control terminals	9
8.4	Positioning of EUT	9
8.5	Control terminal and AEs installation	9
8.6	Signal measurement equipment.....	9
9	Operation of EUT and test procedure	10
9.1	Operation of EUT	10
9.2	Test procedures.....	10
9.3	Test report.....	13
	Appendix I – Method of calculation for neutron fluence.....	14
	Bibliography.....	15

Introduction

The implementation of measures to mitigate faults caused by soft errors is essential to meet the reliability requirements for telecommunication equipment, which is composed of highly integrated, miniaturized semiconductor devices. However, since soft errors occur very infrequently in telecommunication equipment, at a frequency as low as once every few years or decades, the reliability cannot be checked under normal environmental conditions, which makes it difficult to verify the effects of the measures designed to reduce failures and to check conformity to requirements. Therefore, it is necessary to test by irradiating equipment with an intense flux of high energy neutrons produced by an accelerator-driven neutron source at a very high rate, such as several million to several tens of million times that which exists in the natural environment. This enables soft errors to be generated quickly and allows verification of conformity to reliability requirements and the effects of mitigation measures against failures caused by soft errors.

However, to evaluate the reliability of the equipment using a neutron irradiation installation, it is necessary to appropriately determine the irradiation site, the irradiation intensity of the neutron beam, the set-up of the equipment under test (EUT) and the method used to validate operation of the EUT at the time of the test.

This Recommendation describes the outline of the neutron irradiation test and requirements for accelerator-driven neutron sources, test sites, test set-ups and test procedures for testing telecommunication equipment regarding failures caused by soft errors.

Recommendation ITU-T K.130

Neutron irradiation test methods for telecommunication equipment

1 Scope

This Recommendation provides guidance on soft error test methods using an accelerator-driven neutron source for confirming the validity of soft error mitigation measures. It also describes the requirements for test conditions, such as the neutron generator, test site, test set-up and test procedure for testing conformity to the reliability requirements of the equipment. This Recommendation is applicable to telecommunication equipment installed at telecommunications centres for carrier networks, including core network equipment (link and node equipment) and access network equipment.

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.

- | | |
|------------------|---|
| [ITU-T K.124] | Recommendation ITU-T K.124 (2016), <i>Overview of particle radiation effects on telecommunication systems</i> . |
| [ITU-T K.131] | Recommendation ITU-T K.131 (2018), <i>Design methodologies for telecommunication systems applying soft error measures</i> . |
| [ITU-T K-Sup.11] | ITU-T K-series Recommendations – Supplement 11 (2017), <i>ITU-T K.131 – Soft error measures of field programmable gate arrays</i> . |

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

This Recommendation defines the following term:

3.2.1 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.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

- | | |
|-----|-------------------------|
| AE | Associate Equipment |
| AR | Alert Reliability |
| EUT | Equipment Under Test |
| MR | Maintenance Reliability |
| SR | Service Reliability |

5 Conventions

None.

6 Advantages and objectives of neutron irradiation tests

Soft errors are caused by both high energy neutrons coming from outside of the equipment and alpha particles emitted from radioactive materials contained in semiconductor device packages. The occurrence rates of soft errors in semiconductor devices depend on their causes, i.e., the two kinds of particles; however, the phenomena and impact on the equipment do not vary regardless of the different causes. The failure modes after a soft error occurrence and the effects of the countermeasures do not vary regardless of the kind of particle causing the soft error in the telecommunication equipment. Since alpha particles do not penetrate deeply into solid material, it is difficult to test using alpha particles as it is necessary to remove the plastic packaging around the semiconductor devices to expose them to alpha particles. Thus, it is recommended to use neutrons for reliability tests for telecommunication equipment since their intensity is easily controlled during the test.

Neutrons are classified here into high energy neutrons and thermal neutrons and both types of neutron cause soft errors. The probability of the occurrence of soft errors caused by either type of neutron depends on the device type and feature size. However, considering the actual environment of telecommunication equipment, thermal neutrons are less likely to cause soft errors since cosmic-ray neutrons are mainly composed of high energy neutrons and thermal neutrons are shielded by the walls of telecommunications centres made of concrete etc.,. In addition, since soft errors generated by either type of neutron have the same effect on system operation, this Recommendation applies tests using high energy neutrons. The necessity for soft error tests using thermal neutrons is a subject for future study.

The purpose of this test using an accelerator-driven neutron source is to confirm the following by soft error tests:

- Conformity to the soft error reliability requirements
- Normal operation of soft error detection and correction functions
- Normal operation of alerts and event notification functions when soft errors occur
- Normal operation of functions (e.g., switching controls of redundant components, package reset start-up functions) in case of a failure caused by soft errors.

7 Overview of neutron irradiation test system for telecommunication equipment using an accelerator-driven neutron source

7.1 Configuration of neutron irradiation test facility

By using an accelerator, it is possible to generate a neutron flux which causes a soft error in a relatively short period of time. As shown in Figure 7-1, a particle accelerator facility that can be used for soft error tests consists of a cyclotron/linear accelerator chamber, a target chamber, a neutron irradiation chamber (some facilities do not have a separate one) and an accelerator control chamber. The cyclotron/linear accelerator chamber, target chamber and neutron irradiation chamber are designated as radiation controlled areas. The neutron flux is generated by a nuclear reaction by irradiating the target in the target chamber with protons / electrons accelerated by the accelerator in the cyclotron chamber. The neutron beam generated from the target directly irradiates the equipment under test (EUT) in the same room or is guided through the neutron flight tube in the shielding wall between rooms to irradiate the EUT in the next irradiation chamber.

The soft errors produced by the neutron irradiation are observed from the safely shielded accelerator control chamber by a control terminal to check the status of the EUT.