IEC TR 62343-6-6

Edition 2.0 2017-01

TECHNICAL REPORT

Dynamic modules – Part 6-6: Design guide – Failure mode effect analysis for optical units of dynamic modules

IEC TR 62343-6-6:2017-01(en)

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue
The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org
The world's leading online dictionary of electronic and electrical terms containing 20 000 terms and definitions in English and French, with equivalent terms in 15 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
65 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

IEC TR 62343-6-6

Edition 2.0 2017-01

TECHNICAL REPORT

Dynamic modules – Part 6-6: Design guide – Failure mode effect analysis for optical units of dynamic modules

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 33.180.20

ISBN 978-2-8322-3719-9

CONTENTS

FOREWORD 3
1 Scope 5
2 Normative references 5
3 Terms and definitions 6
4 Consideration of types of dynamic modules 6
5 Typical failure points 6
6 Failure modes and known failure mechanisms 7
Bibliography 29

Table 1 – Categorization based on the structure and mode of evaluation 7
Table 2 – Failure mode and known failure mechanisms for the optical units of dynamic devices 8

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

DYNAMIC MODULES –

Part 6-6: Design guide – Failure mode effect analysis for optical units of dynamic modules

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC 62343-6-6, which is a Technical Report, has been prepared by subcommittee 86C: Fibre optic systems and active devices, of IEC technical committee 86: Fibre optics.

This second edition cancels and replaces the first edition published in 2011. It constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) addition of the LCOS based and the DLP based wavelength selective switch (WSS);

b) addition of the multicast optical switch module (MCOS).

The text of this technical report is based on the following documents:

DTR	Report on voting
86C/1396/DTR	86C/1421/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62343 series, published under the general title *Dynamic modules*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

DYNAMIC MODULES –

Part 6-6: Design guide – Failure mode effect analysis for optical units of dynamic modules

1 Scope

This part of IEC 62343, which is a Technical Report, describes failure mode effect analysis (FMEA) for optical units of dynamic modules. FMEA is one of the effective and useful analysis methods to determine the reliability evaluation test items and conditions that are defined in future reliability qualification documents.

In order to estimate the lifetime for a module, there is a typical procedure. The first step is to identify the dominant failure modes. The second step is to determine the acceleration tests according to these failure modes. The third step is to carry out the test. The fourth step is to estimate the acceleration factors. Finally, the fifth step is to calculate the lifetime of the dynamic module.

IEC 61300-2 (all parts) defines environment and mechanical tests. This Technical Report describes the dominant failure mode for dynamic modules and relevant tests from IEC 61300-2 (all parts).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61300-2-1, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-1: Tests – Vibration (sinusoidal)*

IEC 61300-2-4, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-4: Tests – Fibre/cable retention*

IEC 61300-2-9, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-9: Tests – Shock*

IEC 61300-2-17, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-17: Tests – Cold*

IEC 61300-2-18, F*ibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-18: Tests – Dry heat – High temperature endurance*

IEC 61300-2-19, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-19: Tests – Damp heat (steady state)*

IEC 61300-2-22, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-22: Tests – Change of temperature*

IEC 61300-2-44, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-44: Tests – Flexing of the strain relief of fibre optic devices*

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

4 Consideration of types of dynamic modules

There are many types of dynamic modules: dynamic channel equalizer, tuneable optical chromatic dispersion compensator, dynamic gain tilt equalizer, wavelength selective switch, wavelength blocker, optical performance monitor, optical switch, and so on. The main feature of dynamic modules is to control their performances during operation. In order to achieve their features, many kinds of control mechanisms are used for dynamic modules; micro electro mechanical system (MEMS), stepping motor, electromagnet, thermo optics, magnet optics, electro optics, liquid crystal device (LCD), and so on.

Table 1 shows the first guidance of categorization of dynamic modules and their mode of evaluation. Dynamic modules without an electrical circuit board can be considered similar to passive optical components for purposes of evaluation. On the other hand, for dynamic modules with a control circuit board, it is necessary to give special consideration. There are mainly two types of internal design for dynamic modules: those for which it is easy to divide the constituting parts to consider the reliability, and those for which it is not easy to divide. It is necessary to consider how to evaluate according to these structures.

This document describes FMEA only for optical units for dynamic modules. It is necessary to evaluate whole dynamic modules including control circuit boards and firmware if used.

5 Typical failure points

In addition to control circuit boards and control of moving parts, a typical optical unit for a dynamic module consists of the following parts: optical element, outer package, fibre pigtails, optical semiconductor chips, and joint points of these elements. These elements have their own failure mode; for example, break for pigtails and displacement for joint points. Moreover, these elements may have their acceleration factor of degradation; for example, joint points fixed by adhesive are generally weak against high humidity. This failure mode analysis can be referred to FMEA for passive optical components (refer to IEC 62005-3).

There are special considerations for dynamic modules. The following are some examples:

- when using MEMS, operating shock and vibration test are necessary because MEMS are sensitive to mechanical shock and vibration;
- when temperature control is used, the temperature cycling test is recommended because temperature control functions generally produce thermal stress;
- The temperature cycling test can accelerate thermal stress.

6 Failure modes and known failure mechanisms

For some dynamic modules, FMEA is carried out. Table 2 shows known failure mechanisms, failure effects, failure modes, relevant tests, and IEC test document numbers for dynamic modules. If new technology and new dynamic modules become commercially available, they will be added to Table 2 in later revisions of this document. Relevant tests are listed with the failure effect and the dominant failure mechanism. As other relevant tests or methods of failure mode excitation become known, these will also be added.

Table 1 – Categorization based on the structure and mode of evaluation

Electrical circuits		How to evaluate	Examples
Without electrical circuits	N.A.	As optical component	VOA, 1x2/2x2 optical switch, DGTE
With electrical circuit	Easy to divide optical and electrical unit	As optical and electrical units individually, and as integrated dynamic module	VOA, VOA-MUX, TDC (DCDC), DCE, matrix switch, channel monitor, performance monitor
	Difficult to divide optical and electrical unit	To evaluate as integrated dynamic module	Wavelength blocker (WB), Wavelength selective switch (WSS)
Optical active and passive components should comply with the reliability qualification requirement defined in IEC 62572 (all parts) for active components and IEC 62005-9 (all parts) for passive optical components, respectively. In cases in which it is difficult to divide optical and electrical units, integrated modules should be tested. Electrical circuit boards should be qualified individually. The following standards series are useful references for the quality of electrical circuit boards: IEC 61188 (all parts), IEC 61189 (all parts), IEC 61190 (all parts), and IEC 61191 (all parts). Three pieces should be tested.			

Table 2 – Failure mode and known failure mechanisms for the optical units of dynamic devices

Dynamic devices		Constitution parts	Known failure mechanisms	Failure modes	Degradation acceleration factors	Relevant tests	IEC references
Variable optical attenuators	MEMS type	MEMS	Stacking the moving part	Uncontrollable	Mechanical stress Excess driving power	Shock (storage) Vibration (storage) Maximum absolute rating test (electrical) On/off driving test	IEC 61300-2-9 IEC 61300-2-1 Under study Under study
			Distortion of hinge/mirror	Insertion loss increase Attenuation change Return loss decrease Dynamic range of attenuation decrease PDL increase WDL increase	Mechanical stress Thermal stress Excess driving power	Shock (storage) Vibration (storage) Shock and vibration (operating) Change of temperature Maximum absolute rating test On/off driving test	IEC 61300-2-9 IEC 61300-2-1 Under study IEC 61300-2-22 Under study Under study
			Reflectance of mirror changing	Insertion loss increase Attenuation change Return loss decrease PDL increase WDL increase	High humidity (non-hermetic sealed)	Damp heat	IEC 61300-2-19
		Collimator	Dislocation of fixing points of optical parts	Insertion loss increase Attenuation change Dynamic range of attenuation decrease PDL increase WDL increase	Thermal stress High humidity (non-hermetic sealed and using adhesive) Mechanical stress	Change of temperature High temperature Damp heat Shock (storage) Vibration (storage)	IEC 61300-2-22 IEC 61300-2-18 IEC 61300-2-19 IEC 61300-2-9 IEC 61300-2-1
		Pigtail	Fibre broken, micro-bending	Insertion loss increase No operation	Mechanical stress for pigtail	Fibre cable retention Optical fibre cable flexing	IEC 61300-2-4 IEC 61300-2-44

Dynamic devices		Constitution parts	Known failure mechanisms	Failure modes	Degradation acceleration factors	Relevant tests	IEC references
	Liquid crystal type	LCD	Degradation of LCD	Insertion loss increase Attenuation change Return loss decrease Dynamic range of attenuation decrease PDL increase WDL increase	Thermal stress High humidity (non-hermetic sealed) Mechanical stress	Change of temperature High temperature Damp heat Shock (storage) Vibration (storage)	IEC 61300-2-22 IEC 61300-2-18 IEC 61300-2-19 IEC 61300-2-9 IEC 61300-2-1
			Electrical polarization of LCD	Uncontrollable	Excess driving power	Maximum absolute rating test On/off driving test	Under study Under study
			Freezing of LCD	Uncontrollable	Low temperature	Cold	IEC 61300-2-17
		Collimator	Same as MEMS type				
		Pigtail	Same as MEMS type				
	Magnet optic type	Magnet optic part	Dislocation of magnet, Faraday rotator and birefringent crystal	Insertion loss increase Attenuation change Return loss decrease Dynamic range of attenuation decrease PDL increase WDL increase	Thermal stress High humidity (non-hermetic sealed and using adhesive) Mechanical stress	Change of temperature High temperature Damp heat Shock (storage) Vibration (storage)	IEC 61300-2-22 IEC 61300-2-18 IEC 61300-2-19 IEC 61300-2-9 IEC 61300-2-1
		Collimator	Same as MEMS type				
		Pigtail	Same as MEMS type				
	Mechanical type	Moving part	Stacking the moving part	Uncontrollable	Mechanical stress High humidity (non-hermetic) Excess driving power	Shock (storage) Vibration (storage) Damp heat Maximum absolute rating test (electrical) On/off driving test	IEC 61300-2-9 IEC 61300-2-1 IEC 61300-2-19 Under study Under study

Dynamic devices		Constitution parts	Known failure mechanisms	Failure modes	Degradation acceleration factors	Relevant tests	IEC references
			Degradation of moving part	Driving power increase	Mechanical stress Thermal stress Excess driving power High humidity (non-hermetic sealed)	Shock (storage) Vibration (storage) Shock and vibration (operating) Change of temperature Maximum absolute rating test On/off driving test Damp heat	IEC 61300-2-9 IEC 61300-2-1 Under study IEC 61300-2-22 Under study Under study IEC 61300-2-19
			Distortion of mirror	Insertion loss increase Return loss decrease Crosstalk increase PDL increase	Mechanical stress Thermal stress Excess driving power	Shock (storage) Vibration (storage) Change of temperature Maximum absolute rating test On/off driving test	IEC 61300-2-9 IEC 61300-2-1 IEC 61300-2-22 Under study Under study
			Reflectance of mirror changing	Insertion loss increase Attenuation change Return loss decrease PDL increase WDL increase	High humidity (non-hermetic sealed)	Damp heat	IEC 61300-2-19
		Collimator	Same as MEMS type				
		Pigtail	Same as MEMS type				
	Planar waveguide type (thermal optic effect)	Waveguide	Refractive index changing	Insertion loss increase Attenuation change Return loss decrease Dynamic range of attenuation decrease PDL increase	Thermal stress High humidity (non-hermetic sealed and using adhesive) Mechanical stress	Change of temperature High temperature Damp heat Shock (storage) Vibration (storage)	IEC 61300-2-22 IEC 61300-2-18 IEC 61300-2-19 IEC 61300-2-9 IEC 61300-2-1