

# TECHNICAL REPORT

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

IEC TR 62343-6-6:2011  
<https://standards.iteh.ai/catalog/standards/sis/064b5421-068e-4e47-8789-f32021fe8f3b/iec-tr-62343-6-6-2011>

Withhold



**THIS PUBLICATION IS COPYRIGHT PROTECTED**  
**Copyright © 2011 IEC, Geneva, Switzerland**

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester.

If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de la CEI ou du Comité national de la CEI du pays du demandeur.

Si vous avez des questions sur le copyright de la CEI ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de la CEI de votre pays de résidence.

IEC Central Office  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland  
Email: [inmail@iec.ch](mailto:inmail@iec.ch)  
Web: [www.iec.ch](http://www.iec.ch)

### 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.

- Catalogue of IEC publications: [www.iec.ch/searchpub](http://www.iec.ch/searchpub)

The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: [www.iec.ch/online\\_news/justpub](http://www.iec.ch/online_news/justpub)

Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

- Electropedia: [www.electropedia.org](http://www.electropedia.org)

The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: [www.iec.ch/webstore/custserv](http://www.iec.ch/webstore/custserv)

If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: [csc@iec.ch](mailto:csc@iec.ch)  
Tel.: +41 22 919 02 11  
Fax: +41 22 919 03 00

# TECHNICAL REPORT

---

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

<https://standards.iteh.ai/catalog/standards/sis/064b9421-068e-4e47-8789-f32021fe8f3b/iec-tr-62343-6-6-2011>

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

PRICE CODE

T

---

ICS 33.180.20

ISBN 978-2-88912-327-8

## CONTENTS

FOREWORD.....	3
1 Scope.....	5
2 Normative references .....	5
3 Consideration of types of dynamic modules .....	6
4 Typical failure points .....	6
5 Failure modes and known failure mechanisms.....	6
Bibliography.....	25
Table 1 – Categorization based on the structure and how to evaluate.....	7
Table 2 – Failure mode and known failure mechanisms for the optical units of dynamic devices.....	8

iTeh STANDARD PREVIEW  
(standards.iteh.ai)

IEC TR 62343-6-6:2011

<https://standards.iteh.ai/catalog/standards/sis/064b9421-068e-4e47-8789-f32021fe8fbb/iec-tr-62343-6-6-2011>

Withhold

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**DYNAMIC MODULES –****Part 6-6: 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.

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

Enquiry draft	Report on voting
86C/944/DTR	86C/959/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 of 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: 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 which 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. The IEC 61300-2 series defines environment and mechanical tests. This technical report describes the dominant failure mode for dynamic modules and relevant tests from the IEC 61300-2 series.

#### 2 Normative references

The following reference documents are indispensable for the application 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, *Fibre 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*

IEC 62005-3, *Reliability of fibre optic interconnecting devices and passive components – Part 3: Relevant tests for evaluating failure modes and failure mechanisms for passive components*

### 3 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; MEMS (micro electro mechanical system), stepping motor, electromagnet, thermo optics, magnet optics, electro optics, LCD (liquid crystal devices), and so on.

Table 1 shows the first guidance of categorization of dynamic modules to consider how to evaluate. 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 their reliability, and those which it is not easy to divide. It is necessary to consider how to evaluate according to these structures.

NOTE This technical report 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.

### 4 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, displacement for joint points, and so on. Moreover, these elements may have their acceleration factor of degradation; for example, joint points fixed by adhesive are generally weak against high humidity, and so on. 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 a hermetic sealing structure is used, the damp heat test may be omitted because it can generally prevent humidity from entering the package. When using MEMS, operating shock and vibration tests 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.

### 5 Failure modes and known failure mechanisms

For some dynamic modules, failure mode and effect analysis (FMEA) was 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. 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 how to evaluate**

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, DCDC, DCE, Matrix switch, channel monitor, performance monitor
	Difficult to divide optical and electrical unit	To evaluate as integrated dynamic module	Wavelength blocker, wavelength selectable switch
<p>NOTE 1 Optical active and passive components should comply to the reliability qualification requirement defined in the IEC 62572 series for active components and IEC 62009-9 series for passive optical components, respectively. In cases in which it is difficult to divide optical and electrical units, integrated modules should be tested.</p> <p>NOTE 2 Electrical circuit boards should be qualified individually. The following standard series are useful references for the quality of electrical circuit boards: IEC 61188, IEC 61189, IEC 61190, and IEC 61191.</p> <p>NOTE 3 Three pieces should be tested.</p>			

iTeh STANDARD PREVIEW  
(standards.iteh.ai)

IEC TR 62343-6-6:2011

<https://standards.iteh.ai/catalog/standards/sis/064b9421-068e-4e47-8789-f32021fe83bb/iec-tr-62343-6-6-2011>

Withhold

**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	Stacking the moving part Distortion of hinge/mirror	Uncontrollable Insertion loss increase Attenuation change Return loss decrease Dynamic range of attenuation decrease PDL increase WDL increase	Mechanical stress Excess driving power	Shock (storage) Vibration (storage) Maximum absolute rating test (electrical) On/off driving test	61300-2-9 61300-2-1 Under study Under study
		Reflectance of mirror changing	Insertion loss increase Attenuation change Return loss 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	61300-2-9 61300-2-1 Under study 61300-2-22 Under study
	Collimator	Dislocation of fixing points of optical parts	Insertion loss increase Attenuation change Dynamic range of attenuation decrease PDL increase WDL increase	High humidity (non-hermetic sealed)	Damp heat	Under study 61300-2-19
	Pigtail	Fibre broken, micro-bending	Insertion loss increase No operation	Thermal stress High humidity (non-hermetic sealed and using adhesive) Mechanical stress	Change of temperature High temperature Damp heat	61300-2-22 61300-2-18 61300-2-19
Liquid crystal type	LCD	Degradation of LCD	Insertion loss increase Attenuation change Return loss decrease Dynamic range of attenuation decrease PDL increase WDL increase	Mechanical stress for pigtail Thermal stress High humidity (non-hermetic sealed) Mechanical stress	Shock (storage) Vibration (storage) Fibre cable retention Optical fibre cable flexing	61300-2-9 61300-2-1 61300-2-4 61300-2-44
		Electrical polarization of LCD	Uncontrollable	Excess driving power	Change of temperature High temperature Damp heat	61300-2-22 61300-2-18 61300-2-19
	Collimator	Freezing of LCD	Uncontrollable	Low temperature	Shock (storage) Vibration (storage)	61300-2-9 61300-2-1
	Pigtail	Same as MEMS type Same as MEMS type	Uncontrollable	Low temperature	Maximum absolute rating test On/off driving test	Under study Under study
					Cold	61300-2-17

Table 2 (continued)

Dynamic devices	Constitution parts	Known failure mechanisms	Failure modes	Degradation acceleration factors	Relevant tests	IEC references
Variable optical attenuators	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)	61300-2-22 61300-2-18 61300-2-19  61300-2-9 61300-2-1
	Collimator					
Mechanical type	Pigtail	Same as MEMS type	Uncontrollable			
	Moving part	Stacking the moving part		Mechanical stress High humidity (non-hermetic) Excess driving power	Shock (storage) Vibration (storage) Damp heat  Maximum absolute rating test (electrical) On/off driving test	61300-2-9 61300-2-1 61300-2-19 Under study Under study
		Degradation of moving part	Driving power 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 Damp heat	61300-2-9 61300-2-1 Under study 61300-2-22 Under study Under study 61300-2-19
		Distortion of mirror	Insertion loss increase Return loss decrease Crosstalk increase PDL increase	High humidity (non-hermetic sealed) Mechanical stress Thermal stress Excess driving power	Shock (storage) Vibration (storage) Change of temperature Maximum absolute rating test On/off driving test	61300-2-9 61300-2-1 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	Under study 61300-2-19
		Collimator	Same as MEMS type			
	Pigtail	Same as MEMS type				

Table 2 (continued)

Dynamic devices	Constitution parts	Known failure mechanisms	Failure modes	Degradation acceleration factors	Relevant tests	IEC references
Variable optical attenuators	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)	61300-2-22 61300-2-18 61300-2-19 61300-2-9 61300-2-1
		Electrode degradation	Dynamic range of attenuation decrease	High humidity (non-hermetic sealed and using adhesive) Excess driving power	Damp heat Maximum absolute rating test Diving test	61300-2-19 Under study Under study
	Fixing point between waveguide and fibres	Dislocation by the degradation of adhesive	Insertion loss increase	Thermal stress High humidity (non-hermetic sealed and using adhesive)	Change of temperature Damp heat	61300-2-22 61300-2-19
	Pigtail	Same as MEMS type				