

Fibre Optic Sensors - Part 2-1: Temperature measurement - Temperature sensors based on fibre Bragg gratings

This document is a preview generated by EVS

## EESTI STANDARDI EESSÕNA

## NATIONAL FOREWORD

See Eesti standard EVS-EN IEC 61757-2-1:2021 sisaldab Euroopa standardi EN IEC 61757-2-1:2021 ingliskeelset teksti.	This Estonian standard EVS-EN IEC 61757-2-1:2021 consists of the English text of the European standard EN IEC 61757-2-1:2021.
Standard on jõustunud sellekohase teate avaldamisega EVS Teatajas.	This standard has been endorsed with a notification published in the official bulletin of the Estonian Centre for Standardisation and Accreditation.
Euroopa standardimisorganisatsioonid on teinud Euroopa standardi rahvuslikele liikmetele kättesaadavaks 17.09.2021.	Date of Availability of the European standard is 17.09.2021.
Standard on kättesaadav Eesti Standardimis- ja Akrediteerimiskeskusest.	The standard is available from the Estonian Centre for Standardisation and Accreditation.

Tagasisidet standardi sisu kohta on võimalik edastada, kasutades EVS-i veebilehel asuvat tagasiside vormi või saates e-kirja meiliaadressile [standardiosakond@evs.ee](mailto:standardiosakond@evs.ee).

ICS 33.180.99

**Standardite reprodutseerimise ja levitamise õigus kuulub Eesti Standardimis- ja Akrediteerimiskeskusele**

Andmete paljundamine, taastekitamine, kopeerimine, salvestamine elektroonsesse süsteemi või edastamine ükskõik millises vormis või millisel teel ilma Eesti Standardimis- ja Akrediteerimiskeskuse kirjaliku loata on keelatud.

Kui Teil on küsimusi standardite autoriõiguse kaitse kohta, võtke palun ühendust Eesti Standardimis- ja Akrediteerimiskeskusega: Koduleht [www.evs.ee](http://www.evs.ee); telefon 605 5050; e-post [info@evs.ee](mailto:info@evs.ee)

**The right to reproduce and distribute standards belongs to the Estonian Centre for Standardisation and Accreditation**

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, without a written permission from the Estonian Centre for Standardisation and Accreditation.

If you have any questions about standards copyright protection, please contact the Estonian Centre for Standardisation and Accreditation: Homepage [www.evs.ee](http://www.evs.ee); phone +372 605 5050; e-mail [info@evs.ee](mailto:info@evs.ee)

ICS 33.180.99

English Version

Fibre optic sensors - Part 2-1: Temperature measurement -  
Temperature sensors based on fibre Bragg gratings  
(IEC 61757-2-1:2021)

Capteurs fibroniques - Partie 2-1: Mesure de la température  
- Capteurs de température basés sur des réseaux de Bragg  
à fibres  
(IEC 61757-2-1:2021)

Lichtwellenleitersensoren - Teil 2-1: Temperaturmessung -  
Temperatursensoren auf der Basis von Faser-Bragg-Gittern  
(IEC 61757-2-1:2021)

This European Standard was approved by CENELEC on 2021-09-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.



European Committee for Electrotechnical Standardization  
Comité Européen de Normalisation Electrotechnique  
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

## European foreword

The text of document 86C/1725/FDIS, future edition 1 of IEC 61757-2-1, prepared by SC 86C "Fibre optic systems and active devices" of IEC/TC 86 "Fibre optics" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 61757-2-1:2021.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2022-06-01
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2024-09-01

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

Any feedback and questions on this document should be directed to the users' national committee. A complete listing of these bodies can be found on the CENELEC website.

### Endorsement notice

The text of the International Standard IEC 61757-2-1:2021 was approved by CENELEC as a European Standard without any modification.

## Annex ZA (normative)

### Normative references to international publications with their corresponding European publications

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.

NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: [www.cenelec.eu](http://www.cenelec.eu).

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60050	(series)	International Electrotechnical Vocabulary- (IEV)		-
IEC 61757	-	Fibre optic sensors - Generic specification	EN IEC 61757	-
IEC 61757-1-1	2020	Fibre optic sensors - Part 1-1: Strain measurement - Strain sensors based on fibre Bragg gratings	EN IEC 61757-1-1	2020
ISO/IEC Guide 98-3-		Uncertainty of measurement - Part 3:- Guide to the expression of uncertainty in measurement (GUM:1995)		-

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE

**Fibre optic sensors –  
Part 2-1: Temperature measurement – Temperature sensors based on fibre  
Bragg gratings**

**Capteurs fibroniques –  
Partie 2-1: Mesure de la température – Capteurs de température basés  
sur des réseaux de Bragg à fibres**



## THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2021 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 l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

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

Tel.: +41 22 919 02 11  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://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 corrigendum or an amendment might have been published.

#### IEC publications search - [webstore.iec.ch/advsearchform](http://webstore.iec.ch/advsearchform)

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](http://webstore.iec.ch/justpublished)

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

#### IEC Customer Service Centre - [webstore.iec.ch/csc](http://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: [sales@iec.ch](mailto:sales@iec.ch).

#### IEC online collection - [oc.iec.ch](http://oc.iec.ch)

Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

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

The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 18 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

### A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

### A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

#### Recherche de publications IEC - [webstore.iec.ch/advsearchform](http://webstore.iec.ch/advsearchform)

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études, ...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

#### IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

#### Service Clients - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: [sales@iec.ch](mailto:sales@iec.ch).

#### IEC online collection - [oc.iec.ch](http://oc.iec.ch)

Découvrez notre puissant moteur de recherche et consultez gratuitement tous les aperçus des publications. Avec un abonnement, vous aurez toujours accès à un contenu à jour adapté à vos besoins.

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

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 000 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 16 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE

**Fibre optic sensors –  
Part 2-1: Temperature measurement – Temperature sensors based on fibre  
Bragg gratings**

**Capteurs fibroniques –  
Partie 2-1: Mesure de la température – Capteurs de température basés  
sur des réseaux de Bragg à fibres**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

COMMISSION  
ELECTROTECHNIQUE  
INTERNATIONALE

ICS 33.180.99

ISBN 978-2-8322-1009-5

**Warning! Make sure that you obtained this publication from an authorized distributor.  
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

## CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references .....	7
3 Terms, definitions, abbreviated terms and symbols of quantities.....	7
3.1 Terms and definitions.....	8
3.2 Abbreviated terms.....	11
3.3 Symbols of quantities.....	12
4 Design and characteristics of an FBG temperature sensor.....	13
4.1 Fibre Bragg grating (FBG).....	13
4.2 Dependence of Bragg wavelength on temperature .....	13
4.3 Design features.....	14
5 Performance parameters .....	14
6 Test apparatuses for performance parameter determination .....	15
6.1 Temperature calibration equipment.....	15
6.2 Optical spectrum analyzer and interrogator .....	16
6.3 Broadband light source .....	16
7 Test procedures of performance parameters.....	16
7.1 Sample preparation and test set-up .....	16
7.2 Bragg wavelength $\lambda_{\text{Bref}}$ .....	17
7.2.1 Measuring procedure .....	17
7.2.2 Evaluation .....	18
7.2.3 Reporting.....	18
7.3 FBG peak spectral width .....	18
7.3.1 Measuring procedure .....	18
7.3.2 Evaluation .....	18
7.3.3 Reporting.....	18
7.4 FBG reflectivity .....	18
7.4.1 Measuring procedure .....	18
7.4.2 Evaluation .....	18
7.4.3 Reporting.....	19
7.5 Side-lobe suppression ratio.....	19
7.5.1 Measuring procedure .....	19
7.5.2 Evaluation .....	20
7.5.3 Reporting.....	20
7.6 Signal-to-noise ratio.....	21
7.6.1 Measuring procedure .....	21
7.6.2 Evaluation .....	21
7.6.3 Reporting.....	21
7.7 Characteristic curve .....	22
7.7.1 Measuring procedure .....	22
7.7.2 Evaluation .....	23
7.7.3 Reporting.....	27
7.8 Thermal time constant.....	28
7.8.1 Measuring procedure .....	28
7.8.2 Evaluation .....	28

7.8.3	Reporting.....	28
7.9	Sensor stability .....	29
7.9.1	Measuring procedure .....	29
7.9.2	Evaluation .....	29
7.9.3	Reporting.....	29
Annex A	(informative) Blank detail specification .....	30
A.1	General.....	30
A.2	Mechanical and optical set-up.....	30
A.3	Operational characteristics .....	30
A.4	Limiting parameters .....	31
A.5	Further information given upon request.....	31
Annex B	(informative) Examples of specific temperature calibration equipment.....	32
B.1	Simple liquid bath .....	32
B.2	Liquid tube-thermostat .....	33
B.3	Solid-state calibration equipment .....	34
Annex C	(informative) Contributions to measurement uncertainty .....	37
Bibliography	.....	38
Figure 1	– Principal test set-up for FBG .....	17
Figure 2	– Determination of the FBG reflectivity from the reflection spectrum (left) and transmission spectrum (right).....	19
Figure 3	– Side-lobes in the case of a single FBG temperature sensor.....	20
Figure 4	– Signal-to-noise ratio determination.....	21
Figure 5	– Example of a polynomial fit of calibration points $\lambda_{B,i}(T_{N,i})$ .....	24
Figure 6	– Example of a third-order polynomial fit .....	25
Figure 7	– Example of a fourth-order polynomial fit .....	26
Figure 8	– Example of a polynomial fit of the sensitivity .....	27
Figure 9	– Typical response time curve.....	28
Figure B.1	– Schematic representation of a simple liquid bath [3] .....	32
Figure B.2	– Schematic representation of liquid calibration device for connection to laboratory liquid thermostats [4] .....	33
Figure B.3	– Schematic representation of a long-tube fluid calibration device [3] .....	34
Figure B.4	– Schematic representation of a solid-state calibration device for higher temperatures [4] .....	35
Figure B.5	– Schematic representation of a dry-block calibrator for calibrating an FBG temperature sensor at higher temperatures.....	36
Table 1	– Calibration bath fluids.....	15

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

## FIBRE OPTIC SENSORS –

Part 2-1: Temperature measurement –  
Temperature sensors based on fibre Bragg gratings

## 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.

IEC 61757-2-1 has been prepared by subcommittee 86C: Fibre optic systems and active devices, of IEC technical committee 86: Fibre optics. It is an International Standard.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
86C/1725/FDIS	86C/1737/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at [www.iec.ch/members\\_experts/refdocs](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/standardsdev/publications](http://www.iec.ch/standardsdev/publications).

A list of all parts in the IEC 61757 series, published under the general title *Fibre optic sensors*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under [webstore.iec.ch](http://webstore.iec.ch) in the data related to the specific document. At this date, the document will be

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

This document is a preview generated by EVS

## INTRODUCTION

This document is based on the guideline VDI/VDE 2660 Blatt 2:2020-04, *Technical temperature measurement – Optical temperature sensor based on fibre Bragg gratings – Recommendation on temperature measurement and statement of measurement uncertainty* [1]<sup>1</sup>. It was prepared in cooperation with VDI/VDE-GMA Technical Committee 2.17 "Fibre optic measurement techniques".

The IEC 61757 series is published with the following logic: the sub-parts are numbered as IEC 61757-M-T, where M denotes the measure and T, the technology.

---

<sup>1</sup> Numbers in square brackets refer to the Bibliography.