



**BSI Standards Publication**

## **Fibre optic sensors**

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

## National foreword

This British Standard is the UK implementation of EN IEC 61757-2-1:2021. It is identical to IEC 61757-2-1:2021.

The UK participation in its preparation was entrusted to Technical Committee GEL/86/3, Fibre optic systems and active devices.

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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)

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

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Comité Européen de Normalisation Electrotechnique  
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## **European foreword**

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The following dates are fixed:

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- latest date by which the national standards conflicting with the (dow) 2024-09-01 document have to be withdrawn

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## Annex ZA (normative)

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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) |                  | -           |

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

## FIBRE OPTIC SENSORS –

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

## FOREWORD

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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.

## 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.

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

## FIBRE OPTIC SENSORS –

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

#### 1 Scope

This part of IEC 61757 specifies the terminology, characteristic performance parameters and related test methods of optical temperature sensors based on fibre Bragg gratings (FBG) that carry out temperature measurements in the temperature range between –260 °C and 600 °C.

Generic specifications for fibre optic sensors are defined in IEC 61757.

#### 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 60050 (all parts), *International Electrotechnical Vocabulary (IEV)* (available at [www.electropedia.org](http://www.electropedia.org))

IEC 61757, *Fibre optic sensors – Generic specification*

IEC 61757-1-1:2020, *Fibre optic sensors – Part 1-1: Strain measurement – Strain sensors based on fibre Bragg gratings*

ISO/IEC GUIDE 98-3, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

#### 3 Terms, definitions, abbreviated terms and symbols of quantities

For the purposes of this document, terms and definitions given in IEC 60050 (all parts), IEC 61757, IEC 61757-1-1, and the following apply.

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>

### 3.1 Terms and definitions

#### 3.1.1

##### **Bragg wavelength under reference conditions**

$\lambda_{Bref}$

wavelength of maximal reflectance or minimal transmittance of a mechanically stress-free fibre Bragg grating at reference or standard temperature conditions, without the effect of a temperature change

Note 1 to entry: The term Bragg wavelength  $\lambda_B$  specified in the data sheet of the manufacturer of a fibre Bragg grating normally describes the Bragg wavelength without further details on reference or standard temperature conditions.

[SOURCE: IEC 61757-1-1:2020, 3.3, modified – transformed to temperature sensing.]

#### 3.1.2

##### **birefringence**

optical property of the directional dependence of the index of refraction of an optically anisotropic material having orientation-dependent refractive indices that lead to different propagation velocities of light in different propagation and polarization directions

Note 1 to entry: In fibre optic sensors terminology, the term "birefringence" is mainly applied when optical waveguides with birefringence properties, such as PANDA or bow-tie fibres, are used. Birefringence in fibre Bragg gratings becomes important only when polarized light is used for the measurement. Because of the properties of fibre Bragg gratings, this can lead to an additional systematic increase in the measurement uncertainty.

[SOURCE: IEC 61757-1-1:2020, 3.22, modified – clarified and Note modified.]

#### 3.1.3

##### **drift**

shift of the characteristic curve (or, rarely, change of the characteristic curve parameters) under the same measuring and operating conditions or reference conditions due to material ageing or/and mechanical and/or thermal continuous or alternating stress

#### 3.1.4

##### **dynamic measurement deviation**

$\Delta T(t)$

time-dependent thermal measurement deviation resulting from time-varying differences between the sensor temperature  $T_S(t)$  and the temperature of the medium  $T_M(t)$  with

$$\Delta T(t) = T_S(t) - T_M(t) \quad (1)$$

#### 3.1.5

##### **FBG peak**

reflection peak or transmission minimum in the Bragg grating reflectance or transmittance spectrum

Note 1 to entry: Maximum peak value is typically at the Bragg wavelength  $\lambda_B$ .

#### 3.1.6

##### **FBG peak spectral width**

full width at half maximum (FWHM) of the FBG peak

Note 1 to entry: Full width at half maximum of the FBG peak is the wavelength range of the spectrum for which the amplitude is greater than 50 % (3 dB).

[SOURCE: IEC 61757-1-1:2020, 3.7, modified – transformed for temperature sensor.]

**3.1.7****FBG period** $\Lambda$ 

distance between the periodically changing refractive index zones (grating planes) in an optical waveguide having an effective refractive index  $n_{\text{eff}}$

Note 1 to entry: The FBG period defines the Bragg wavelength  $\lambda_B$  through the formula

$$\Lambda = \frac{k \cdot \lambda_B}{2 n_{\text{eff}}} \quad \text{for } k = \text{positive integer} \quad (2)$$

[SOURCE: IEC 61757-1-1:2020, 3.18, modified – definition extended.]

**3.1.8****FBG temperature sensor**

fibre optic sensor that uses a fibre Bragg grating as a sensitive element for temperature measurements

Note 1 to entry: FBG temperature sensors can be used in a series configuration with multiple gratings allowing to perform distributed measurements.

**3.1.9****FBG temperature sensing system**

measurement set-up consisting of one or more serial arranged FBG temperature sensors connected to an interrogation unit consisting of a light source, detector module, processor, data archive, and user interface

Note 1 to entry: An FBG temperature sensing system normally works as follows: After light from the light source is sent into the fibre and partially reflected or transmitted by the FBG temperature sensor, it is guided to the detector module of the interrogator, which determines the FBG peak wavelength. From a shift of the FBG peak wavelength caused by temperature change, the temperature change can be quantitatively determined in the measuring units.

**3.1.10****maximum operating temperature**

highest value of temperature at which the FBG temperature sensor meets the specified performance

**3.1.11****minimum operating temperature**

lowest value of temperature at which the FBG temperature sensor meets the specified performance

**3.1.12****minimum bending radius**

minimum radius at which an FBG temperature sensor is bent without change of the specified performance parameters

Note 1 to entry: This value can differ from the minimum bending radius given for transport and storage.

[SOURCE: IEC 61757-1-1:2020, 3.16, modified – transformed for temperature sensor.]

**3.1.13****parasitic strain effect**

non-thermally induced deformation of the fibre Bragg grating during temperature measurement resulting in a change in the wavelength response of the FBG

Note 1 to entry: A non-reversible deformation of the FBG during temperature measurement occurs as an apparent temperature change in the response signal and shall therefore be excluded or be assessable.