HAUBER ELEKTRONIK

Safety Manual SIL 1

Vibration Monitoring Unit Series HE050

MADE IN GERMANY

IO-Link SIL 1

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- SIL 1, PL-c

englisch

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Safety manual

Vibration Monitoring Unit
Type HE050-SIL1

Version: 2025-03-21

Caution!
Before putting the product into service, the safety manual must be read and understood.

Please contact the company with any questions:
HAUBER-Elektronik GmbH
Fabrikstraße 6
D-72622 Nürtingen
Germany
Tel.: +49 (0) 7022 / 21750-0
Fax: +49 (0) 7022 / 21750-50
info@hauber-elektronik.de
www.hauber-elektronik.de

1 Contents

2 Scope of safety manual

This safety manual applies to the vibration monitoring unit of type HE050-SIL1 in the SIL 1 version.

3 Fields of application

The vibration monitoring unit of type HE050-SIL1 is used to measure and monitor absolute bearing vibrations in machines according to DIN ISO 10816 and 20816. The effective value of the vibration velocity, the effective value of the vibration acceleration or the peak value of the vibration acceleration serves as the measured variable.

The analogue current output maps the measured vibration value in the interval of 4...20 mA. When the adjustable vibration threshold value is exceeded, a signal will be sent to the switching contacts.

- Out 1 (not safe): Digital switching output (low-active)
- Out 2 (safe): Analogue current output (4…20 mA) or Digital switching output (low-active)

Output 2 (Out 2) was evaluated as the current output or switching contact when determining the safety function using the safety-related key figures according to the standards named in the "Relevant norms" on page 5.chapter.

4 Abbreviations and terms

SIL	Safety Integrity Level
HFT	Hardware Fault Tolerance
SFF	Safe Failure Fraction
CCF	Common Cause Failures
PFD_{avg}	Average Probability of Dangerous Failure on Demand
PFH	Probability of a Dangerous Failure per Hour
FMEDA	Failure Mode, Effects and Diagnostics Analysis
λ_{sd}	Rate for safe detected failure
λ_{su}	Rate for safe undetected failure
λ_{dd}	Rate for dangerous detected failure
λ_{du}	Rate for dangerous undetected failure
DC_S	Diagnostics Coverage of safe failures; $\mathrm{DC_s} = \lambda_{\mathrm{sd}}/(\lambda_{\mathrm{sd}} + \lambda_{\mathrm{su}})$
DC_D	Diagnostics Coverage of dangerous failures; $\mathrm{DC_D} = \lambda_{\mathrm{dd}}/(\lambda_{\mathrm{dd}} + \lambda_{\mathrm{du}})$
FIT	Failure In Time; $1\ \mathrm{FIT} = 1\ \mathrm{failure}/10\mathrm{h}$
MTBF	Mean Time Between Failure
MTTF	Mean Time To Failure
MTTR	Mean Time To Repair
CAT	Category according to EN ISO 13849-1:2008

Tab. 1: Abbreviations and terms

Other abbreviations and terms are defined in the IEC 61508-4.

5 Relevant norms

IEC 61508 Functional safety of electrical/electronic/programmable electronic safety-related systems. (IEC 61508:2010)
ISO 13849-1 Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design (ISO 13849-1:2015); German version EN ISO 13849-1:2016

6 Safety requirements

Safety integrity level	Operating mode with low requirement rate	Operating mode with high requirement rate
SIL	**PFD_{avg}**	**PFH**
4	$\geq 10^{-5} - < 10^{-4}$	$\geq 10^{-9} - < 10^{-8}$
3	$\geq 10^{-4} - < 10^{-3}$	$\geq 10^{-8} - < 10^{-7}$
2	$\geq 10^{-3} - < 10^{-2}$	$\geq 10^{-7} - < 10^{-6}$
1	$\geq 10^{-2} - < 10^{-1}$	$\geq 10^{-6} - < 10^{-5}$

Tab. 2: Failure limit values for a safety function depending on the SIL class (IEC 61508-1, 7.6.2)

The share of non-hazardous failures	Fault tolerance of the hardware for type B safety-related subsystems (IEC 61508-2, 7.4.3)		
SFF	**HFT = 0**	**HFT = 1**	**HFT = 2**
< 60%	Not allowed	SIL1	SIL2
60% – < 90%	SIL1	SIL2	SIL3
90% – < 99%	SIL2	SIL3	SIL4
≥ 99%	SIL3	SIL4	-

Tab. 3: Hardware fault tolerance, based on the rate of dangerous failures

The vibration monitoring unit model HE050-SIL1 is a development according to IEC-IEC-61508. The monitoring was developed as a “high-demand system”. It corresponds to a 1oo1 architecture with a diagnostic coverage of > 85%. The diagnostics are permanent and automatic during operation and the start-up phase of monitoring. The monitoring fulfils a safe failure fraction of 60...90 % and thus represents a sensor system according to SIL1.

7 Project planning

7.1 Safety functionality

The system includes 2 safety functions (depending on the selected configuration):

1. When the measured vibration value exceeds the set alarm limit value, output 2 (Out 2) switches from 24V DC to 0V after the delay time has elapsed. Output 2 (Out 2) is low-active.
2. The analogue current output maps the measured vibration value in the interval of 4...20 mA. The vibration value is the effective value of the vibration velocity, vibration acceleration or the peak value of the vibration acceleration, depending on the configuration.

NOTE

When the current output delivers less than 3.5 mA or more than 20.5 mA, the downstream control unit must trigger the shutdown.

7.2 Fail Safe State

When a fault cannot be corrected (e.g. hardware defect) the sensor switches to the Fail Safe State. Exiting this state is only possible by power cycling. The Fail Safe State can be identified by:

– the digital switching output 2 (Out 2) changes to 0V (low-active)
– the analogue current output (4..20 mA) changes to 0 mA

7.3 Description of failure categories

The following definitions for the failure of the device were considered to assess the failure behaviour of the vibration monitoring unit:

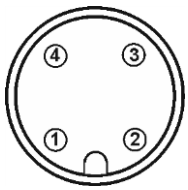
– Fail-Safe State
  Responds to a failure state by switching to a safe state. (fail safe state)
– Safe Failure (λsd + λsu)
  A safe failure (S) occurs when the measuring system switches to the defined safe state or error mode without requesting the process.
– Dangerous Failure (λdd + λdu)
  A dangerous failure (D) generally occurs when the measuring system switches to a dangerous or non-functional state.
– Dangerous Detected Failure (λdd)
  A dangerous detected failure occurs when the measuring system switches to a defined safe state or error mode when a process is requested.
– Dangerous Undetected Failure (λdu):
  A dangerous undetected failure occurs when the measuring system does not switch to a defined safe state or error mode when a process is requested.

8 Fault exclusions

The multi-pin connector was chosen according to ISO 13849-2 (Table D.7) to prevent a short circuit between any two adjacent connector pins.

9 Connection

Connector, M12, 4-pin



Pin 1:	L+	18 – 30 V DC
Pin 2:	Out 2	4…20 mA or switching contact
Pin 3:	L-	0V / GND
Pin 4:	Out 1	Switching contact

10 Assembly and installation

Pay attention to the assembly and installation notes in the operating manual. To do this, select threshold value settings so that the safety function is triggered before any damage can be done to the system.

NOTE

The sensor must be powered in safe operation by a SELV / PELV power supply.

11 Functional description

Type HE050-SIL1 is available in various configurations.

- Out 1 (not safe): Digital switching output (low-active)
- Out 2 (safe): Analogue current output (4…20 mA) or Digital switching output (low-active)

Switching outputs (Out 1 and Out 2):

When the value of the measured vibration variable exceeds the set alarm limit value, the output switches from 24 V DC to 0 V after the delay time has elapsed. The output is low-active. When the value drops below the limit value, the output automatically switches from 0 V to 24 V DC.

Current output (Out 2):

The current output provides a direct current of 4...20 mA proportional to the value of the vibration variable.

11.1 Operating conditions

Operating state	Reading	Switching contacts
OK	≤ Limit value	24 V DC
ALARM	> Limit value	0 V (low level)
Fail Safe State	No measured value, 0 mA	0 V (low level)
De-energized	No measured value, 0 mA	0 V (low level)

12 Behaviour during operation and when errors occur

Occurring errors are described in the fault table in the operating manual. If errors are detected, the entire vibration monitoring unit must be taken out of operation and other measures must be taken to keep the process in a safe state. The operating manual describes how to replace the vibration monitoring unit.

13 Self-diagnostic and recurring checks

The sensor has a set of self-diagnostic measures. These are divided into 2 categories:

1. Start-up diagnostic:

   These tests are only run in the sensor’s initial start-up phase. Among other things, hardware-critical pathways are tested here that cannot be switched off once the device is in operation. One of these critical tests is the diagnostics of the switching outputs for the alarm. To ensure the functionality of the outputs over the product lifetime, the system operator / owner must ensure that the vibration monitoring unit runs a power cycle annually.

2. Cyclical monitoring:

   Cyclical monitoring is fully automated and ensures that all tests are performed and evaluated within 12 hours for a diagnostics coverage of >85%.

14 Service life

The measuring system has a service life of 10 years.

15 Key indicators related to safety

Failure category	**Failure rate (FIT)**
Σλ Safe / Fail Safe Detected (λSD)	120
Σλ Dangerous / Fail Dangerous Detected (λDD)	100
Σλ no part	5
Σλ Total	225
Σλ Dangerous Undetected / Fail Dangerous Undetected (λDU)	5

SFF	94%
SIL	1
Performance Level	C
Category	2
PFD_{avg}	$\geq 10^{-2} – < 10^{-1}$
PFH	$< 3*10^{-6}$ 1/h With an average expected requirement rate of fewer than 25 times per year
Diagnostics coverage	>85%

Tab. 4: Failure rates

MTTF	984898hrs = 112.43 years
DC_{avg}	>85% Diagnostics Coverage
$MTTF_d$	2889526hrs = 329.85 years = **HIGH**
CCF	75 (fulfilled)
Response time	300 ms

Tab. 5: Key indicators related to safety according to ISO 13849-1

16 EU / UK declaration of conformity

Declaration of conformity

HAUBER-Elektronik GmbH
Fabrikstraße 6
D-72622 Nürtingen-Zizishausen

declares under our sole responsibility that the products listed below that relate to this declaration meet the basic health and safety requirements of the norms and directives below.

Product series

HE050, HE055

Norms and directives

EU Directive	Norms
2014/30/EU **UKSI 2016:1091**	EN 55011:2016 + A1:2017 + A11:2020 EN 61000-6-3:2007 + A1:2011
Supplementary:	*EN 61000-6-7:2015*
2011/65/EU **UKSI 2012:3032**	EN IEC 63000:2018

Signature

Nürtingen, 21/03/2025

Place and date

Tobias Bronkal, Managing Owner

17 SIL manufacturer declaration

Functional safety according to IEC 61508.

HAUBER-Elektronik GmbH
Fabrikstraße 6
72622 Nürtingen, Germany

declares that the failure rates listed below were determined for the product listed below in safety-related applications according to IEC 61508.
The failure rates were determined using FMEDA (Failure Modes, Effects and Diagnostic Analysis) according to IEC 61508.

Product
HE050.1

Failure category	**Failure rate (FIT)**
Σλ Safe / Fail Safe Detected (λSD)	120
Σλ Dangerous / Fail Dangerous Detected (λDD)	100
Σλ no part	5
Σλ Total	225
Σλ Dangerous Undetected / Fail Dangerous Undetected (λDU)	5

SFF	94%
SIL	1
Performance Level	C
Category	2
PFD_{avg}	$\geq 10^{-2} – < 10^{-1}$
PFH	$< 3*10^{-6}$ 1/h With an average expected requirement rate of fewer than 25 times per year
Diagnostics coverage	>85%

Tab. 6: Failure rates

Signature

Nürtingen, 25/07/2023 — T. Bronkal

Place and date — Tobias Bronkal, Managing Proprietor