Ultrasonic sensor module USSM1.0 PLUS-FS

with built-in ASIC for front chassis mounting

Series/Type:	**W2110W111**
Ordering code:	**B59110W2111W032**
Date:	2024-03-28
Version:	1.2

Table of Contents

PPD PTC

2024-03-28

Please read C*autions and warnings* and
Important notes at the end of this document.

Page 2 of 19

Introduction

Highlights

The USSM1.0 PLUS-FS is a versatile and reliable ultrasonic Time-of-Flight (ToF) range sensor which offers a user-friendly all-in-one package that already includes the driver, providing advanced ultrasonic signal processing using a high-end application-specific integrated circuit chip (ASIC). It allows custom-specific parametrization and provides reliable signal readings through its interface.

TDK's USSM1.0 PLUS-FS is a front chassis mounting sensor with an integrated socket connector. It supports mounting with a threaded locking nut and via snap hooks. The sensor is dust and water resistant on the front side. With an optional flat gasket, a water and dust protected seal can be easily achieved towards the chassis in which it is installed. The sensor works in a wide range of light conditions, including full sunlight, and provides centimeter-accurate distance measurements independent of the target's color and optical transparency. This and its robust sensor housing make the sensor ideal for many outdoor applications. The sensor's detection characteristics can be customized and optimized to the application needs through programmable thresholding and measurement profiles. Several algorithms can further process the range information for a variety of use cases in a broad spectrum of applications.

The USSM1.0 PLUS-FS is a pulse-echo product intended for range-finding and presence-detection applications, using a single sensor for the transmission and reception of ultrasonic pulses (solo mode). For close-range detection down to 4 cm, two or more USSM1.0 PLUS-FS can be used in the so-called pitch-and-catch mode where one sensor is the sender, and the others act as receivers for the ultrasonic pulse echoes. For best performance and efficiency in pitch-and-catch mode all sensors are frequency matched.

Potential applications

- Automated guided vehicles and automated mobile robots
- Obstacle avoidance in air
- Obstacle detection and proximity/presence sensing
- Distance measurement in air
- Level measurement in air

PPD PTC   2024-03-28

Features

◼ Fast and accurate range finding

- Std. operating range from 4 cm [1] / 18 cm to 5 m
- Sample rate up to 50 samples/second
- Programmable modes optimized for medium and short-range sensing
- Digitally adjustable detection characteristic
- Symmetric directivity of ±35° [2]
- Multi-object detection and differentiation

◼ Easy to integrate

- Integrated socket connector for 3-wire interface for power supply and communication
- For front chassis mounting applications
- Integrated slots for snap-hook mounting
- Built-in mounting thread for direct chassis mounting with locking nut
- Single sensor for send and receive (solo mode) or pitch-and-catch mode (split emitter and receiver operation) for very close-range applications
- Only one power supply (8 to 18 V) is needed to drive all electronics

◼ Robust and reliable

- Self-diagnostic functions available for monitoring sensor status
- Works in a wide range of lighting conditions, including full sunlight to complete darkness
- Detects transparent surfaces, insensitive to object color and density
- Water/dust protected chassis integration up to IP65/67 (EN60529)
- Operating temperature range -40 to +85 °C
- High immunity against electromagnetic interferences (EMI) noise

---

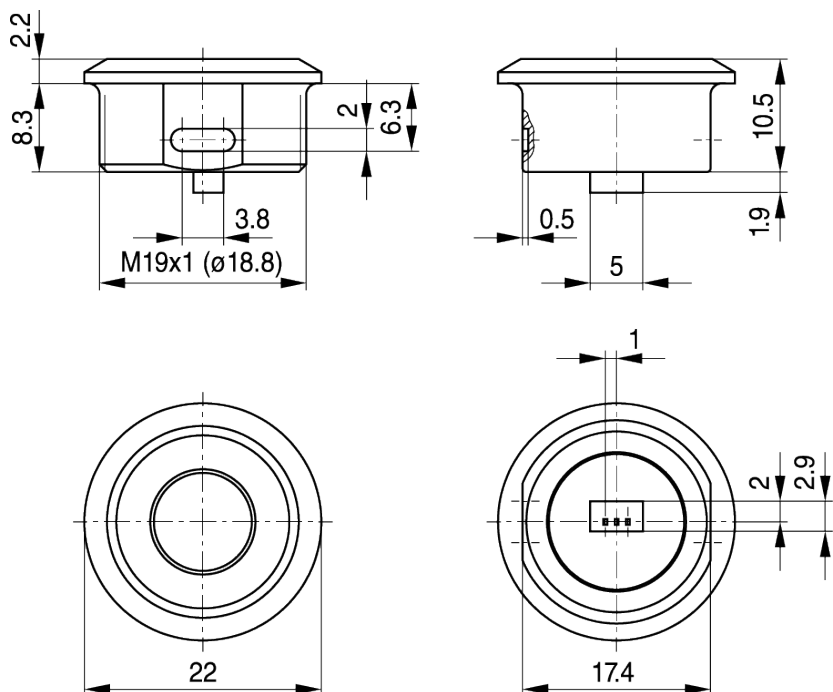[1] In pitch-and-catch mode; requires two sensors in which one is the emitter and the second the receiver

[2] -6 dB sound pressure level, circular beam

Please read Cautions and warnings and
Important notes at the end of this document.

Technical specification

Dimensional data

Parameter	Symbol	Unit	Typical
Outer diameter	D1	mm	22
Thread size	D2	mm	M19x1
Width of locking surfaces	W1	mm	17.4
Height	H1	mm	10.5
Thread length	H3	mm	8.3
Dome height	H4	mm	2.2
Snap-hook shoulder height	H5	mm	6.3
Snap-hook slit height	H6	mm	2
Snap-hook slit width	W2	mm	3.8
Snap-hook slit depth	T1	mm	0.5
Connector height	C1	mm	1.9 ±0.5
Connector width	C2	mm	5
Connector depth	C3	mm	2.9
Connector offset	O1	mm	2
Connector pitch	P1	mm	1
Maximum chassis thickness for mounting with locking nut	T2	mm	4
Weight (without locking nut and gasket)	X	g	3.7
Recommended mounting torque for locking nut	M1	Nm	2
Maximum mounting torque for locking nut	M1max	Nm	5

PPD PTC

2024-03-28

Please read *Cautions and warnings* and
Important notes at the end of this document.

Page 5 of 19

Dimensional drawings

TPT2041-F

Drawings not to scale
Dimensions in mm

Pin configuration and connector type

Pin	Name	Description
1	VSUP	Power supply connection
2	IO	Digital communication line
3	GND	Electric ground connection
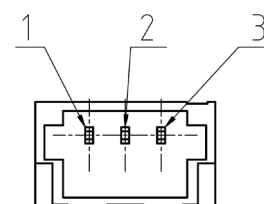
The connector is from SWB and has the type declaration 1002WVS-03E-LPSW.

Electrical characteristics

Parameter	Symbol	Unit	Typical
Supply voltage	VSUP	V	12
Current consumption	I	mA	5.5
Power down mode	I	mA	< 1
Communication interface [1]	proprietary bidirectional IO, point to point architecture		

Acoustic operating characteristics [2]

#	Parameter	Symbol	Unit	Typical
1	Minimal measuring distance in solo mode [3]	DMIN	mm	180
2	Minimal measuring distance in pitch-and-catch mode [4]	DMIN	mm	40
3	Maximum measuring distance [5]	DMAX	mm	5000
4	Directivity of emitted acoustic signal [6]	α	°	±35
5	Detection field of view [7]	δMIN δMAX	°	±10 ±45
6	Acoustic operating frequency	f	kHz	74.5

All listed parameter values use the standard ASIC parametrization (except #5) and can be modified according to application needs within the ASIC boundaries (except #4 and #6).

[1] The IO line is not equipped with a pull-up resistor.
[2] Overall system performance depends on mounting conditions
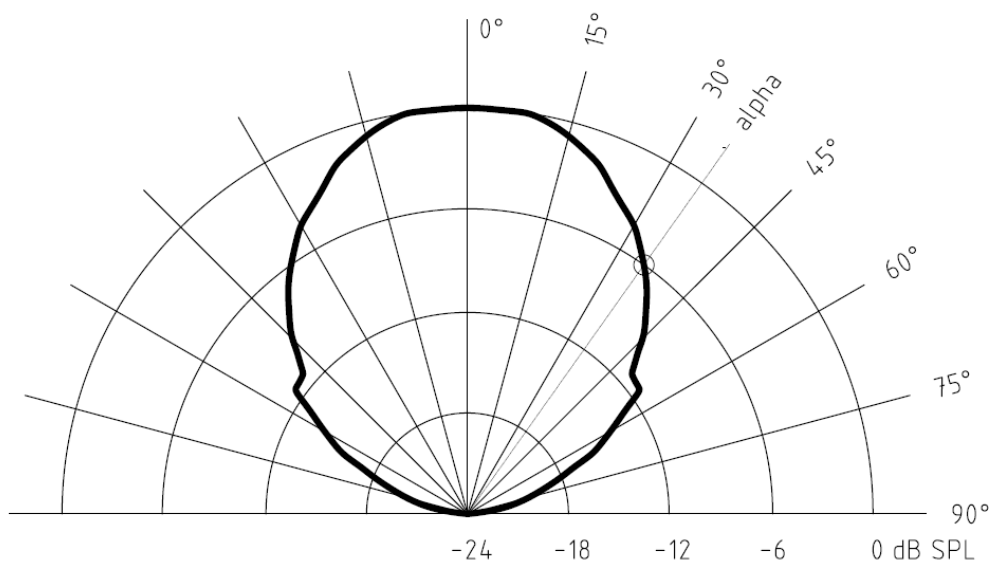[3] Default setting. Test target: cylindrical pole, 75 mm diameter, 1 m height, standard conditions for temperature and humidity
[4] EPD='0'. Test target: cylindrical pole, 75 mm diameter, 1 m height, standard conditions for temperature and humidity
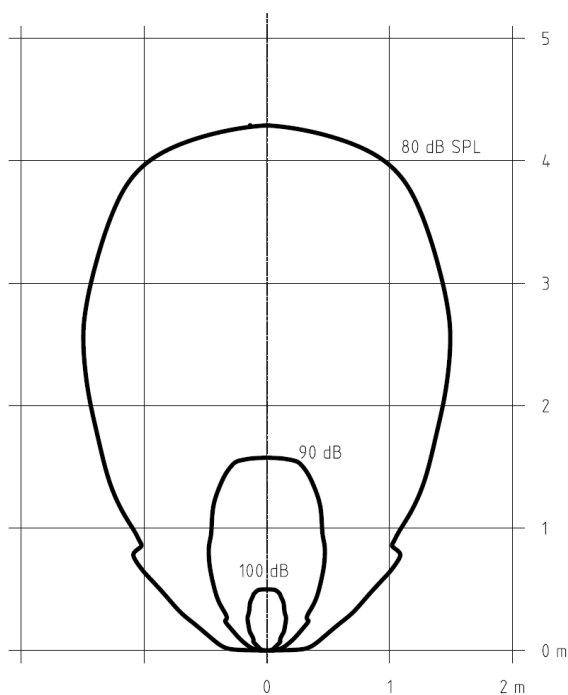[5] Default DMAX = 2000 mm
[6] -6 dB sound pressure level relative to forward direction, circular beam
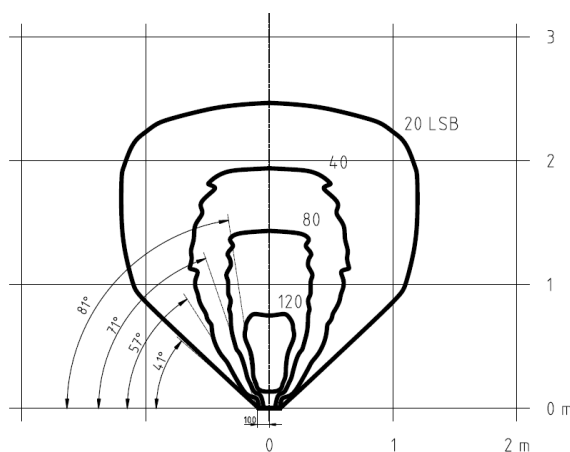[7] The detection field of view depends strongly on the threshold settings and on the target size and acoustic properties.

PPD PTC   2024-03-28

Please read Cautions and warnings and   Page 7 of 19
Important notes at the end of this document.

Typical directivity pattern (SPL relative to forward direction)

Typical acoustic emission curve [8]

Detection curve in solo mode
(reported echo amplitude value) [9]

---

[8] Under ideal conditions and with default settings

[9] Only valid for ISO-Pole target (75 mm PVC cylinder) under ideal conditions and with default settings. In pitch-and-catch mode these
curves vary strongly by the distance between sender and receiver and the cross angle. LSB refers to the echo-height digitized with 8 bit
ADC (0 to 255 LSB).

PPD PTC

2024-03-28

Compliant protection ratings

The stated protection ratings apply for the sensor front only if the sensor is mounted into a chassis according to the mounting recommendations defined in this document. The rear side of the sensor must be reasonably dust free, dry, and in non-corrosive condition to ensure proper connection of the electric cable and proper functionality.

| #	Test	According to	Effective against
1	IP6X	EN 60529:1991	No ingress of dust; complete protection against contact (dust-tight). A vacuum must be applied. Test duration of up to 8 hours based on airflow. Talcum powder, diameter of talcum particle 0 to 75 µm.
2	IP6kX	ISO20653:2013	No ingress of dust; complete protection against contact (dust-tight). Test duration 6 s movement of air-dust mixture at intervals of 15 min, 20 cycles. A2 (Arizona dust) according to ISO 12103-1.
3	IPX5	EN 60529:1991 ISO 20653:2013	Water jet projected by a nozzle (6.3 mm) against enclosure from any direction. 3 min duration at flowrate 12.5 l/min ±5%, water temperature 20 ±5 °C and at a distance of 2.5 to 3.0 m.
4	IPX7	EN 60529:1991 ISO 20653:2013	Immersion in water, up to 1 meter depth. Duration 30 min at 20 ±5 °C water temperature

Absolute maximum ratings

#	Description	Condition	Symbol	Min	Max	Unit
1	Supply voltage		VSUP	-0.3	36	V
2	Supply voltage	t < 500 ms	VSUP	-0.3	40	V
3	Voltage at pin IO		VIO	-0.3	36	V
4	Voltage at pin IO	t < 500 ms	VSUP	-0.3	40	V
5	Measurement rate[10]		SMAX		50	Hz
6	Storage temperature		TS	-25	45	°C
7	Operation temperature		TO	-40	85	°C

---

[10] Number of times per seconds the result of a ToF measurement can be provided on the digital IO line.

PPD PTC

2024-03-28

Please read Cautions and warnings and
Important notes at the end of this document.

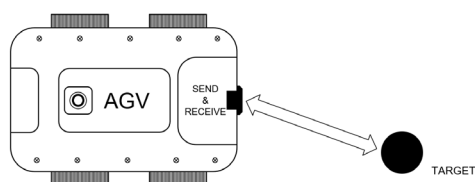Page 9 of 19

Functional description

Ultrasonic distance measurement

In a Time-of-Flight (ToF) sensor like the USSM1.0 PLUS-FS, the time difference T between a triggered acoustic burst and its reflected echo from an object is measured. The relationship L=c*T/2, where c is the velocity of sound, allows to directly calculate the distance L from the reflection time difference T.
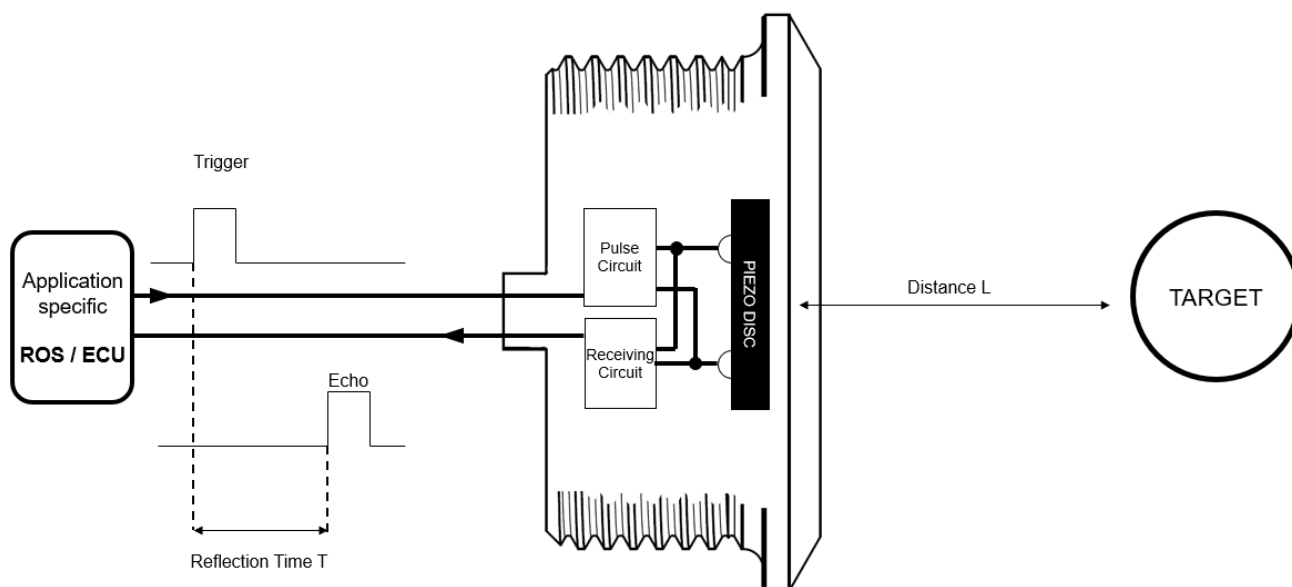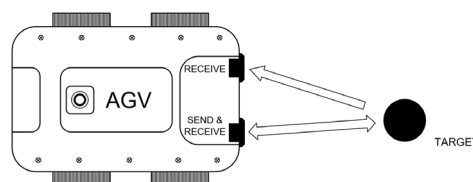

The USSM1.0 PLUS-FS is capable of transmitting an ultrasonic burst and capturing the reflected echo. The same piezo element is used for those two tasks. This approach, the so-called solo or direct measurement mode, allows for a very compact setup.

In some cases, it can be beneficial to separate the signal emitting process from the echo receiving process. The USSM1.0 PLUS-FS supports this approach, which is referred to as pitch-and-catch. With this approach, one sensor is used as a dedicated sender, whilst one or multiple additional sensors work as a receivers. This is referred to as pitch-and-catch mode or indirect measurement mode and is illustrated below. Object detection in solo mode only allows for distance measurement, while in pitch-and-catch mode triangulation and thus spatial localization is also possible. Furthermore, the minimum detection range is improved relative to a single sensor in solo-mode operation.


Solo-mode operation

Pitch-and-catch operation

PPD PTC

2024-03-28

Please read Cautions and warnings and
Important notes at the end of this document.

Page 10 of 19

IO interface and parametrization

The single-wire IO interface of the 3-pin connector is used to communicate between the sensor and the application specific ECU (electronic control unit) or ROS (robot operating system). Data (including measurements and registers read/write) is exchanged between ECU and sensor using a proprietary protocol based on PWM encoding (Pulse-Width-Modulation). The sensor supports 6 different 'SEND' and 'RECEIVE' and 11 various control commands, such as sensor parameter customization and status register read/write commands. Additionally, the echo detection, noise filtering, and detection threshold can be adjusted such that the functionality of the sensor in optimized.

Signal processing

The signal processing of the sensor contains analog/digital filters, amplifier/gain stages as well as signal enhancement stages. The sensitivity, which is set by default for optimum detection, can be adjusted to meet specific application requirements, which may be dependent on the ToF. Optimization of the sensitivity to the application needs can result in improved long-distance detection as well as in better short range distance detection performance. Echo detection is performed by comparing the echo envelope signal of the digital filter output with time-dependent fully customizable threshold values.
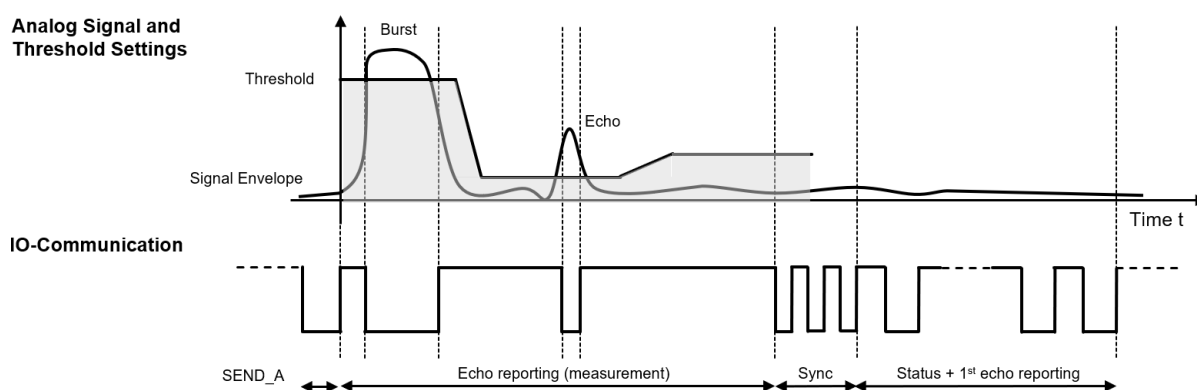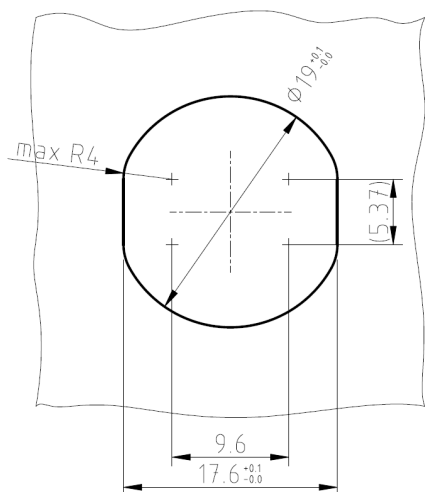
Example of measurement and IO communication handling a SEND_A command

Status information

The USSM1.0 PLUS-FS allows to send additional information with each measurement. Each measurement is followed by a sequence of pulses which contain additional status information. This includes flags describing sensor conditions during measurements as-well as echo-height of first echo-detection.

PPD PTC

2024-03-28

Please read C*autions and warnings* and
Important notes at the end of this document.

Page 11 of 19

Recommended mounting

Mounting with threaded locking nut for chassis thicknesses up to 4 mm

Dimensions of the recommended mounting bore for front chassis mounting
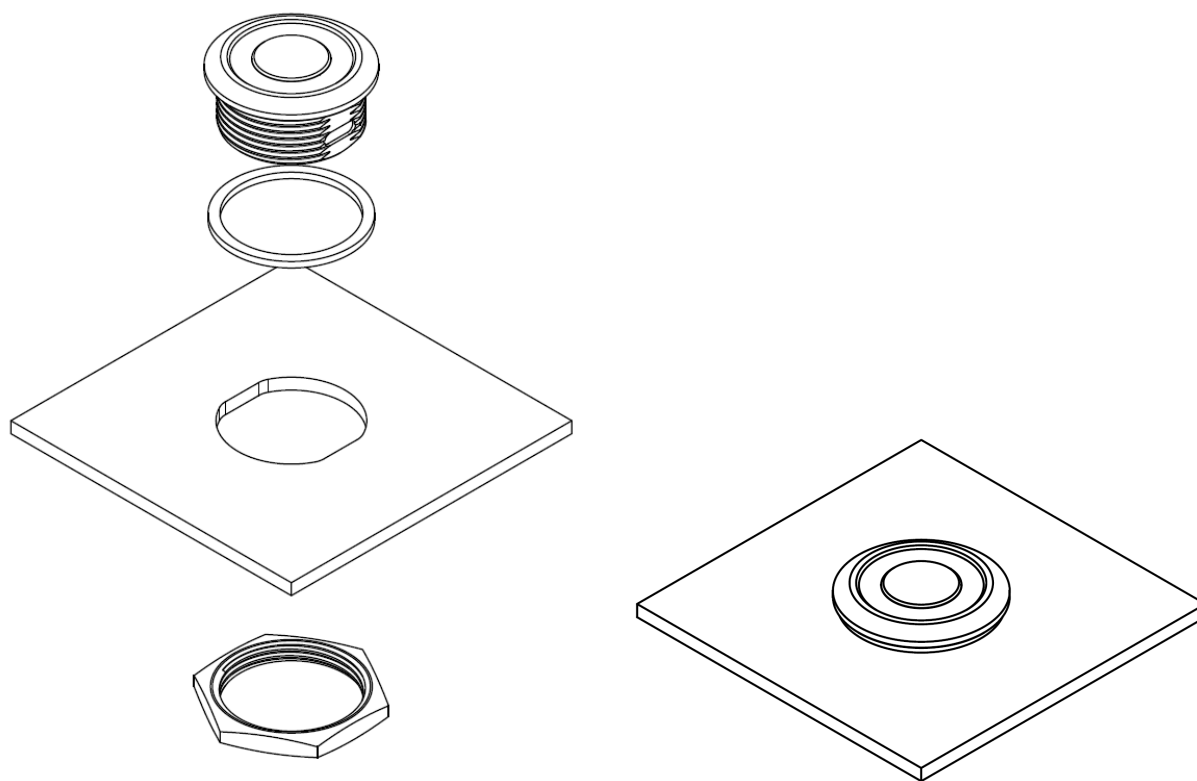

Side view   Bottom view

Example of mounting with threaded locking nut for front chassis mounting with flat gasket sealing and locking nut in 3 mm chassis plate

PPD PTC   2024-03-28

Please read C*autions and warnings* and   Page 12 of 19
Important notes at the end of this document.

Explosion schematics of mounting with threaded locking nut showing locking nut,
flat gasket sealing, chassis plate, and USSM1.0 PLUS-FS

PPD PTC

2024-03-28

Please read Cautions and warnings and
Important notes at the end of this document.

Page 13 of 19

🔲TDK

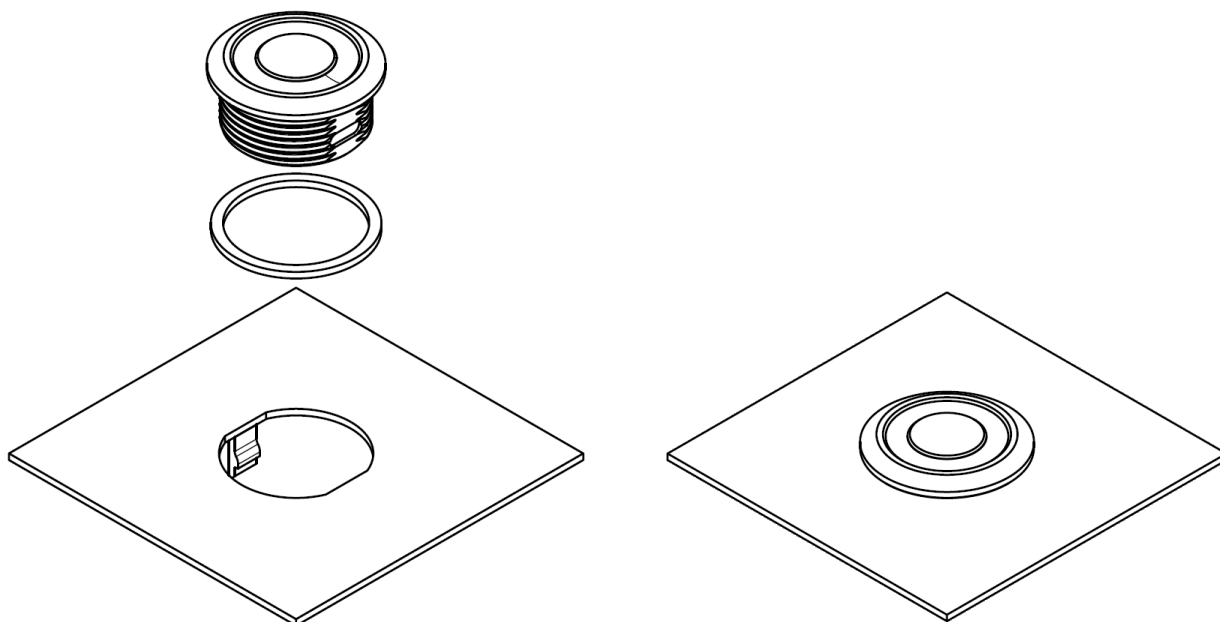| Ultrasonic sensor module USSM1.0 PLUS-FS | B59110W2111W032 |
| with built-in ASIC for front chassis mounting | W2110W111 |

Mounting with snap hook
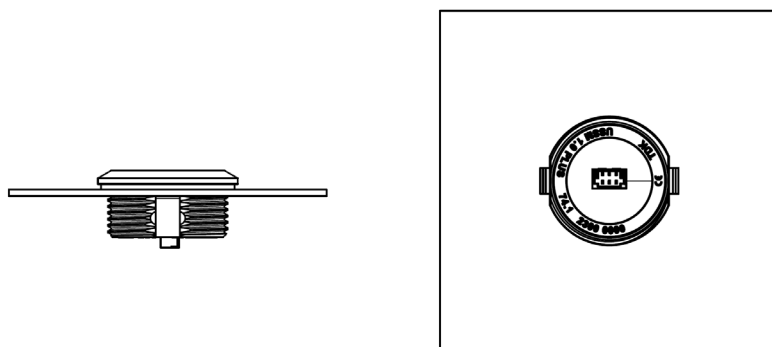
Example of mounting with snap-hook front chassis mounting with flat gasket sealing and snap hooks

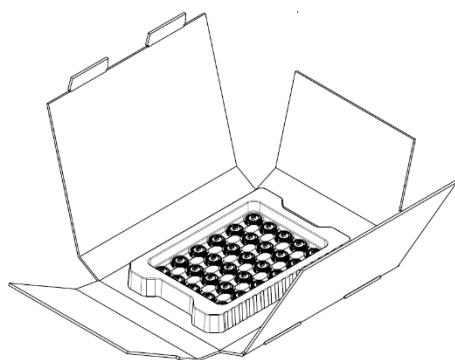

Explosion schematics of mounting with snap hook showing chassis plate with integrated snap hooks, flat gasket sealing, and USSM1.0 PLUS-FS

PPD PTC   2024-03-28

Please read Cautions and warnings and   Page 14 of 19
Important notes at the end of this document.

TDK

| Ultrasonic sensor module USSM1.0 PLUS-FS | B59110W2111W032 |
| with built-in ASIC for front chassis mounting | W2110W111 |

Scope of supply

- 1 USSM1.0 PLUS-FS ultrasonic sensor
- Locking nut M19x1 (complies to ISO68 and ANSI/ASME B1.13M-2005 (R2015)) with wrench size 22 according to DIN934
- Flat gasket sealing with 21.5 mm outer diameter and 18 mm inner diameter, 0.9 mm thickness and hardness of Shore A 80. Material: Nitril

Labeling and packaging specification

- Delivered in a cardboard box
- Sorted in plastic protective trays and vacuum packed
- Locking nuts and flat gaskets supplied loose in plastic bag
- Packaging protects against dust and moisture
- 30 pcs. per box:

Packaging inlay architecture excluding vacuum packaging bag

PPD PTC   2024-03-28

Please read Cautions and warnings and   Page 15 of 19
Important notes at the end of this document.

■ Each sensor is marked with the following information:
  – TDK: Manufacturer
  – USSM1.0 PLUS-FS: Product and variant identification code
  – YYCW XXXX: Serial number including year and week of production
  – CE mark
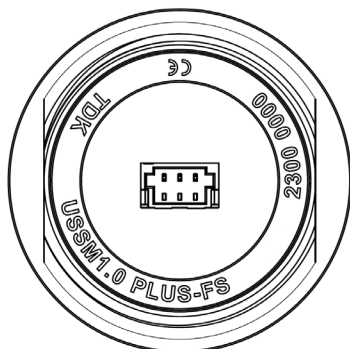
■ A label is attached to the packaging box. The information provided on the label includes:
  – (1P) PROD ID: Product identification number
  – (9K) PROD ORDER NO: Production order number
  – (D) D/C: Packaging date in moisture proof vacuum-sealed bag
  – (T) BATCH NO: Production batch number
  – (Q) QTY: Number of components in the packaging
  – 2D barcodes: Contain product identification number, production order number, and production batch number

Layout of packaging label

PPD PTC   2024-03-28

Please read **C**autions and warnings and   Page 16 of 19
Important notes at the end of this document.

Application-specific support

To assist a quick and easy integration into the target application several different documents and sources are available:

- The available application note gives a general introduction to the sensor integration and illustrates the setup and design-in process into range finding applications for automated guided vehicles (AGVs)
- To assist the mechanical design-in process into the application, CAD files in *.STEP file format are available for
  - CAD model of the sensor and its accessories
  - Acoustic emission profile of the sensor
  - Detection curves for solo mode and pitch-and-catch mode
  - For ASIC specific support a detailed manual is available in which all features are described.
- The TDK evaluation board with its software package allows the user to monitor the sensor in many operation modes. The digital IO and the analogue readout of the echo traces can be displayed. This board assists in the early and later stages of development as it visualizes what the sensor can detect and how it responds in certain scenarios.
- An Arduino sketch and an Arduino library show the simple and straight forward implementation into an Arduino platform.

Cautions and warnings

- Do not drop the sensor.
- Do not use defect/dropped sensors.
- Do not touch the open electrical leads without ESD protection.
- Avoid exposure of the sensor to corrosive environments.
- Do not rub, scratch, or pinch the silicone seal at the front face of the sensor.
- Only clean the front face of the sensor with a soft tissue and mild chemicals, e.g. window cleaning detergents.
- To effectively clean and remove dust from the silicone at the front face of the sensor, conventional sticky tape for office applications can be used. The tape is applied and then instantly removed, taking away any dust.
- The product shall not be used in safety relevant applications.

Display of ordering codes for TDK electronics products

The ordering code for one and the same product can be represented differently in data sheets, data books, other publications, on the company website, or in order-related documents such as shipping notes, order confirmations and product labels. **The varying representations of the ordering codes are due to different processes employed and do not affect the specifications of the respective products**. Detailed information can be found on the Internet at www.tdk-electronics.tdk.com/orderingcodes.

PPD PTC

2024-03-28

Please read C*autions and warnings* and
Important notes at the end of this document.

Page 17 of 19

The following applies to all products named in this publication:

1. Some parts of this publication contain **statements about the suitability of our products for certain areas of application**. These statements are based on our knowledge of typical requirements that are often placed on our products in the areas of application concerned. We nevertheless expressly point out **that such statements cannot be regarded as binding statements about the suitability of our products for a particular customer application.** As a rule we are either unfamiliar with individual customer applications or less familiar with them than the customers themselves. For these reasons, it is always ultimately incumbent on the customer to check and decide whether a product with the properties described in the product specification is suitable for use in a particular customer application.

2. We also point out that **in individual cases, a malfunction of electronic components or failure before the end of their usual service life cannot be completely ruled out in the current state of the art, even if they are operated as specified.** In customer applications requiring a very high level of operational safety and especially in customer applications in which the malfunction or failure of an electronic component could endanger human life or health (e.g. in accident prevention or life-saving systems), it must therefore be ensured by means of suitable design of the customer application or other action taken by the customer (e.g. installation of protective circuitry or redundancy) that no injury or damage is sustained by third parties in the event of malfunction or failure of an electronic component.

3. **The warnings, cautions and product-specific notes must be observed.**

4. In order to satisfy certain technical requirements, **some of the products described in this publication may contain substances subject to restrictions in certain jurisdictions (e.g. because they are classed as hazardous)**. Useful information on this will be found in our Material Data Sheets on the Internet (www.tdk-electronics.tdk.com/material). Should you have any more detailed questions, please contact our sales offices.

5. We constantly strive to improve our products. Consequently, **the products described in this publication may change from time to time**. The same is true of the corresponding product specifications. Please check therefore to what extent product descriptions and specifications contained in this publication are still applicable before or when you place an order.

   We also **reserve the right to discontinue production and delivery of products**. Consequently, we cannot guarantee that all products named in this publication will always be available. The aforementioned does not apply in the case of individual agreements deviating from the foregoing for customer-specific products.

6. Unless otherwise agreed in individual contracts, **all orders are subject to our General Terms and Conditions of Supply.**

7. **Our manufacturing sites serving the automotive business apply the IATF 16949 standard.** The IATF certifications confirm our compliance with requirements regarding the quality management system in the automotive industry. Referring to customer requirements and customer specific requirements ("CSR") TDK always has and will continue to have the policy of respecting individual agreements. Even if IATF 16949 may appear to support the acceptance of unilateral requirements, we hereby like to emphasize that **only requirements mutually agreed upon can and will be implemented in our Quality Management System.** For clarification purposes we like to point out that obligations from IATF 16949 shall only become legally binding if individually agreed upon.

8. The trade names EPCOS, CarXield, CeraCharge, CeraDiode, CeraLink, CeraPad, CeraPlas, CSMP, CTVS, DeltaCap, DigiSiMic, FilterCap, FormFit, InsuGate, LeaXield, MediPlas, MiniBlue, MiniCell, MKD, MKK, ModCap, MotorCap, PCC, PhaseCap, PhaseCube, PhaseMod, PhiCap, PiezoBrush, PlasmaBrush, PowerHap, PQSine, PQvar, SIFERRIT, SIFI, SIKOREL, SilverCap, SIMDAD, SiMic, SIMID, SineFormer, SIOV, SurfIND, ThermoFuse, WindCap, XieldCap are **trademarks registered or pending** in Europe and in other countries. Further information will be found on the Internet at www.tdk-electronics.tdk.com/trademarks.

Release 2024-02