

Rotational Absolute Magnetic Kit Encoder Version 60 mm HP Position Sensor Version 2.1



LINKS TO ADDITIONAL RESOURCES



| QUICK REFERENCE DATA | |
|----------------------|--|
| Sensor type | ROTATIONAL, magnetic technology |
| Output type | Connector Würth Elektronik 687106182122 to plug a flat flex cable or connector Hirose DF58-6P-1.2V(21) to plug an external connector equipped of wires |
| Market appliance | Industrial |
| Dimensions | Diameter 60 mm |

FEATURES

- Especially dedicated to robotics applications
- High precision, high repeatability, high resolution, single or multi-turns variant
- Plug and play or self-calibration
- Memorization of last position before power off
- Not sensitive to external magnetic fields and temperature
- Not sensitive to moisture and pollution
- Especially dedicated for harsh conditions (vibrations, shocks, CEM...)
- Built-in self-monitoring
- Hall effect principle
- Option back-up battery connector
- Protected design, patent EP 2711663
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912


RoHS
COMPLIANT

| ELECTRICAL SPECIFICATIONS | |
|---|---|
| PARAMETER | |
| Voltage power supply (on sensor connector) | 5 V \pm 0.25 V |
| Supply current at 5 V | \leq 180 mA |
| Standard output format | SSI |
| Optional output format | Biss-C or SPI |
| Useful electrical angle | 360° |
| Accuracy at 25 °C | Better than 13 bits (0.044°) |
| Repeatability | > 16 bits |
| Resolution | \approx 0.001° (335 872 points, \approx 18.35 bits) |
| Startup time | \leq 20 ms |
| Data latency time | \leq 200 μ s |
| Maximum sampling rate | 9.2 kHz |
| Optional multi-turn counter without external battery | 16 bits counter |
| For multi-turns options | Memorization of the last angle value and the multi-turns counter at the power off |
| On request: multi-turns counter with external backup battery (not supplied) | 16 bits counter, battery: voltage 3.6 V to 5 V, I_{max} . 15 mA |

| MECHANICAL SPECIFICATIONS (All Versions) | |
|--|--------------------------------|
| PARAMETER | |
| Mechanical angle | 360° |
| Maximum speed rotation | 10 000 rpm (mechanical limits) |
| Rotor weight | < 40 g |
| Stator weight | < 15 g |

SAP PART NUMBERING GUIDELINES

| TYPE | MODEL | DESIGN | SIZE (mm) | TYPE | FUNCTION | ACCURACY (BITS) | RESOLUTION (BITS) | OUTPUT | PACKAGING | OPTION |
|----------------|-------|---------|-----------|------|----------|-----------------|-------------------|--|-----------|---------------------------|
| R = rotational | AM | K = kit | 060 | M | 1 | 13 | 19 | F = SPI CCW J = SSI CCW L = Biss-C | B = box | |
| | | | | | | | | F = SPI CCW | B = box | 661 = multi-turn counting |
| | | | | | | | | J = SSI CCW | B = box | 663 = multi-turn counting |
| | | | | | | | | L = Biss-C | B = box | 659 = multi-turn counting |

Note

- “Multi-turn with connection back-up battery” possible on request, please contact Vishay

ACCESSORY

| | |
|---|--------------------|
| Transfer adaptor (see section “Accessory on Request”) | ACCSRAMKADAPTCB067 |
|---|--------------------|

PERFORMANCE

| PARAMETER | |
|--------------------------------------|---|
| Standard operating temperature range | -40 °C to +85 °C |
| Storage temperature range | -55 °C to +105 °C |
| Humidity | ≤ 80 % no condensing |
| Environmental protection | Coating on PCB components side |
| Vibrations | 0.05 g ² /Hz, 20 Hz to 2000 Hz for 1 hour along three major axis |
| Shocks | 100 g, 14 ms, ½ sine (one on each axis) |
| Magnetic protection | <ul style="list-style-type: none"> - No influence up to 3 mT (typical value) (uniform magnetic field) - No permanent deviation greater than 0.03° if a magnet of 50 mT was in contact with the upper metallic shape of the rotor - No permanent deviation greater than 0.03° if a magnet of 50 mT was exposed at 5 mm of the magnetic rubber |

COMMUNICATION INTERFACES

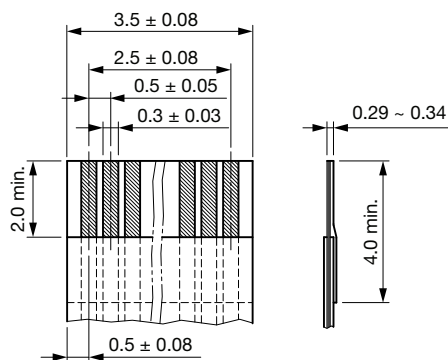
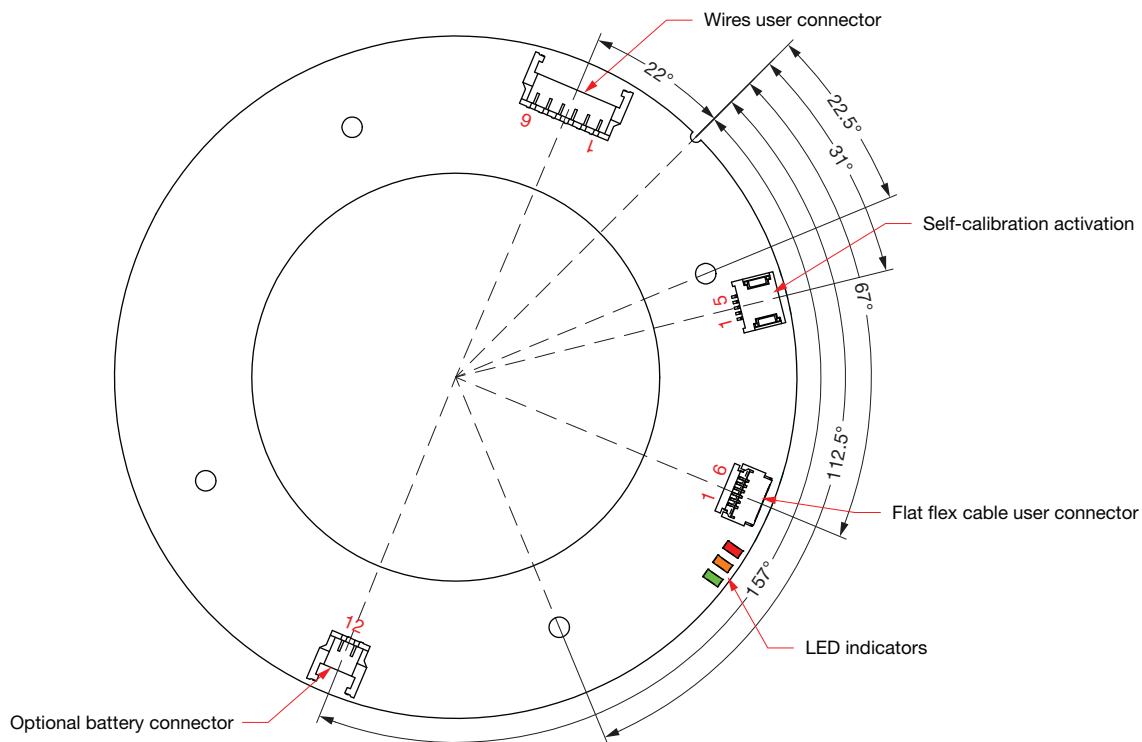
Three protocols are possible: SSI protocol, Biss-C protocol, or SPI protocol.

Connector Types

Connector to plug a flat flex cable: output connector FCC pitch 0.5 mm, thickness 0.3 mm bottom contacts connector Würth Elektronik 687106182122

Connector to plug an external connector equipped of wires: output connector wires connector on the PCB: Hirose DF58-6P-1.2V(21)

- User crimp socket: Hirose DF58-6S-1.2C
- User crimp contact: Hirose DF58-2830SCF

Recommended FCC (customer side)

Fig. 1 - Recommended FCC

Fig. 2 - User Connectors
Note

- See also last page for accessory which allows to provide a different pinning

SELF-MONITORING

All frame includes 3 status bits. These 3 status bits form a 3 bits word.

| 3 BITS STATUS WORD | | | | | | | | |
|---------------------------|--------|--------|--------|------------------|-------------------|---|---|-------------------|
| | BIT A1 | BIT A2 | BIT A3 | DECIMAL VALUE | LED STATUS | INFORMATION | ACTION | PRIORITY LEVEL |
| | MSB | | LSB | | | | | |
| Normal operation | 0 | 0 | 0 | 0 | Green | Frame without error or warning. | No action required. | - |
| Temperature overflow | 0 | 1 | 1 | 3 | Red | This error is set if the temperature of the sensor is superior to +85 °C or inferior to -40 °C. This information is sent until temperature is over range. | Set the environmental temperature between -40 °C to +85 °C . | 1 (highest) |
| Mechanical mounting error | 0 | 0 | 1 | 1 | Red | This error is set when the mechanical tolerances of the airgap parameter are out of range. This information is sent until power supply turns off. | The mechanical mounting must be adjusted. | 2 |
| Cells default | 0 | 1 | 0 | 2 | Red | This error occurs when a magnetic cell is temporary or completely out of order. This error is sent at each concerned frame. | Check the sensor integrity. | 3 |
| Need self-calibration | 1 | 0 | 0 | 4 | Orange | To get the best performances, a self-calibration is required. This information is available until power supply turns off. | The self-calibration shall be start. | 4 |
| Self-calibration error | 1 | 0 | 1 | 5 | Orange | This warning occurs when the self-calibration is not ended correctly. The factory settings are restored. This information is available until power supply turns off. | The self-calibration shall be restarted. | 5 |
| Multi-turn counter error | 1 | 1 | 0 | 6 | Green | This warning occurs when at the power on the sensor has detected an excessive displacement during the power off. This warning and the multi-turns counter are reset at the next power on. | No action required. | 6 |
| Internal angle correction | 1 | 1 | 1 | 7 | Orange stealthily | This warning occurs when the sensor has performed an internal correction error. This warning is sent at each concerned frame. | It is advisable to adjust the mechanical assembly or to perform a self-calibration. | 7 (lowest) |

**SSI INTERFACE** (Standard Output Format)**TABLE 1 - SSI CONNECTOR**

| PIN NO. | NAME |
|---------|------------------------------|
| 1 | V _{CC} power supply |
| 2 | CLK+ |
| 3 | CLK- |
| 4 | DATA+ |
| 5 | DATA- |
| 6 | GND power supply |

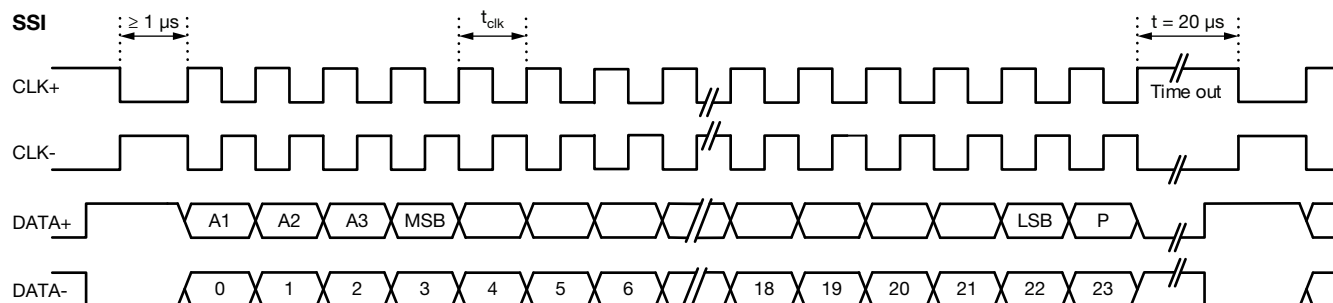


Fig. 3 - SSI Chronogram

TABLE 2 - SSI PARAMETERS

| PARAMETER | INFORMATION |
|--------------------------------------|--------------------------------------|
| CLK differential interface | RS422 according to the EIA-RS422 |
| DATA differential interface | |
| Output DATA | Binary two's complement left aligned |
| Clock frequency (t_{clk}) | 100 kHz to 3 MHz |
| Data bit status | 3 |
| Data bits (angle value) | 19 |
| Parity bit | ODD |
| Time out (time between two requests) | 20 μs minimum |

TABLE 3 - SSI DATA BITS FORMAT

| ANGLE VALUE SSI DATA BITS FORMAT | |
|------------------------------------|---------------|
| FRAME BITS (SSI CHRONOGRAM FIG. 3) | FUNCTION |
| Bit 0 | Status bit A1 |
| Bit 1 | Status bit A2 |
| Bit 2 | Status bit A3 |
| Bit 3 | Data MSB |
| Bit 21 | Data LSB |
| Bit 22 | Always = 0 |
| Bit 23 | Parity |

**BISS-C INTERFACE** (Optional)**TABLE 4 - BISS-C CONNECTOR**

| PIN NO. | NAME |
|---------|------------------------------|
| 1 | V _{CC} power supply |
| 2 | CLK+ |
| 3 | CLK- |
| 4 | DATA+ |
| 5 | DATA- |
| 6 | GND power supply |

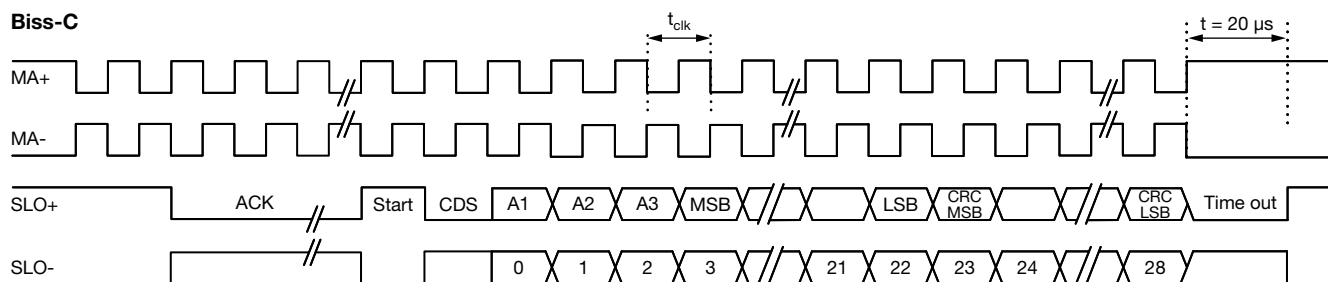
Biss-C

Fig. 4 - Biss-C Chronogram

TABLE 5 - BISS-C PARAMETERS

| PARAMETER | INFORMATION |
|--------------------------------------|--|
| Biss-C configuration | Point to point (multi-slave not supported) |
| CLK and data differential interface | RS422 according to the EIA-RS422 |
| Output DATA | Left aligned |
| Clock frequency (f_{clk}) | 5 MHz maximum (3 MHz tested) |
| ACK | 12 bits always equal to 0 |
| Start | 1 bit always equal to 1 |
| CDS | 1 bit always equal to 0 |
| Data bit status | 3 |
| Data bits (angle value) | 19 (see Table 6) |
| CRC | 6 bits inverted, $P(x) = X^3 + X^1 + 1$, (0 x 43) |
| Time out (time between two requests) | 20 μ s minimum |

TABLE 6 - BISS-C DATA BITS FORMAT

| ANGLE VALUE BISS-C DATA BITS FORMAT | |
|---------------------------------------|---------------|
| FRAME BITS (BISS-C CHRONOGRAM FIG. 4) | FUNCTION |
| Bit 0 | Status bit A1 |
| Bit 1 | Status bit A2 |
| Bit 2 | Status bit A3 |
| Bit 3 | Data MSB |
| Bit 21 | Data LSB |
| Bit 22 | Always = 0 |
| Bit 23 | CRC MSB |
| Bit 28 | CRC LSB |

**SPI INTERFACE** (Optional)**TABLE 7 - SPI CONNECTOR**

| PIN NO. | NAME |
|---------|------------------------------|
| 1 | V _{CC} power supply |
| 2 | CLK |
| 3 | DATA |
| 4 | CS |
| 5 | NC |
| 6 | GND power supply |

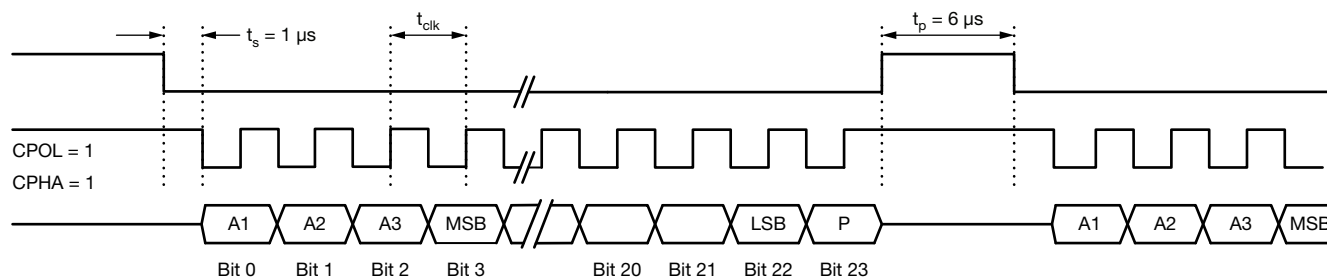
SPI Slave Mode

Fig. 5 - SPI Chronogram

TABLE 8 - SPI PARAMETERS

| PARAMETER | INFORMATION |
|--------------------------------------|-------------------|
| SPI configuration | Slave mode only |
| CLK and DATA | TTL 3.3 V or 5 V |
| Output DATA | Left aligned |
| Clock frequency (t_{clk}) | Up to 4 MHz |
| t_s (time to start) | 1 μ s minimum |
| Data bit status | 3 |
| Data bits (angle value) | 19 |
| Parity bit | ODD |
| Time out (time between two requests) | 6 μ s minimum |

TABLE 9 - SPI DATA BITS FORMAT

| ANGLE VALUE SPI DATA BITS FORMAT | |
|------------------------------------|---------------|
| FRAME BITS (SPI CHRONOGRAM FIG. 5) | FUNCTION |
| Bit 0 | Status bit A1 |
| Bit 1 | Status bit A2 |
| Bit 2 | Status bit A3 |
| Bit 3 | Data MSB |
| Bit 21 | Data LSB |
| Bit 22 | Always = 0 |
| Bit 23 | Parity |

OPTIONAL MULTI-TURNS COUNTER

First Possible Option: Counting of Turns Without Battery Backup Connector and Memorization of Last Position Before Power Off!

In normal operation when the power is on, the counting of the turns is made in the two directions, clockwise and anticlockwise. The maximum value of the counter is -32 768 anticlockwise turns to +32 767 clockwise turns. When the counter reaches the maximum value of 32 767, the next counter value is set to -32 768. When it reaches the minimum value of -32 768, the next value is set to 32 767.

The value of the turn counter is sent in the output frame in two complement. No counting during power off. When the power is off, the last position before power cutting (value of the multi-turn counter and value of the angle) is memorized in a non-volatile memory and the encoder can accept (during power off) a movement of encoder up to $\pm 90^\circ$ to calculate and release the new position as soon as the power comes back.

The number of non-volatile memory in write-in cycles is unlimited.

At the power on, if the variation of the angle is superior to $\pm 90^\circ$, the error flag of the frame is set and the multi-turn counter is reset at the next power on. This procedure could be used to reset the multi-turns counter.

The multi-turns counter is also reset when the sensor enters in the self-calibration mode.

Second Possible Option: Counting of Turns With Battery Backup Across Connector

After the power off, if the sensor turns, the number of revolutions are counted internally. The counting is made in the two directions, clockwise and anticlockwise. The maximum value of the counter is -32 767 anticlockwise turns to +32 767 clockwise turns. When the counter reaches the maximum value of 32 767, the next counter value is set to -32 768. When the counter reaches the minimum of -32 768, the next value is set to 32 767.

During the power is off, no data is sent to the output. With the backup battery connector plugged to external battery, with low consumption, the encoder counts the number of turns and stocks this data in memory. As soon as the power comes back, the encoder releases the data of number of turns and continues to count in normal conditions.

The multi-turns counter is also reset when the sensor enters in the self-calibration mode.

MULTI-TURNS SSI OUTPUT FORMAT

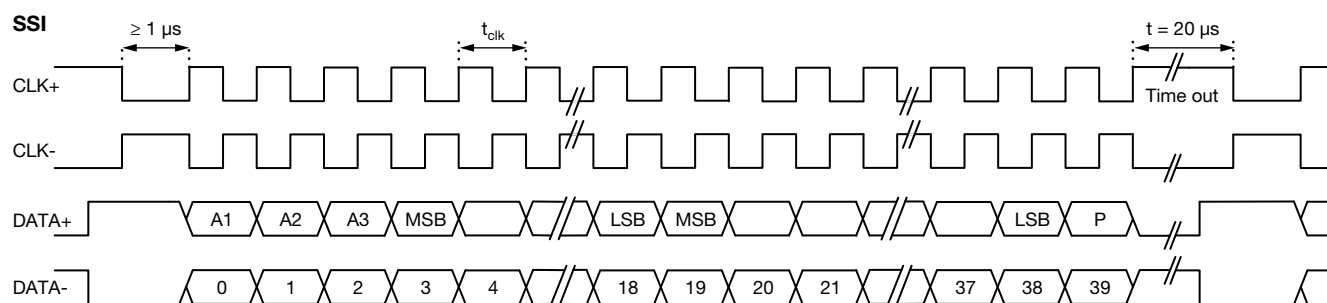


Fig. 6 - SSI Multi-Turns Chronogram

| TABLE 10 - SSI MULTI-TURN DATA BITS FORMAT | | | | |
|--|--------------|--------------|------------------|-------------------------------|
| SSI DATA BITS FORMAT | | | | |
| DATA BIT | MSB | LSB | DATA BITS LENGTH | INFORMATION |
| Status bits | Frame bit 0 | Frame bit 2 | 3 bits | See section "Self-Monitoring" |
| Multi-turns counter | Frame bit 3 | Frame bit 18 | 16 bits | See Fig. 6 |
| Angle value | Frame bit 19 | Frame bit 37 | 19 bits | See Table 3 |
| Parity | Frame bit 39 | - | 1 bit | |

Note

- Bit 38 always = 0

MULTI-TURNS BISS-C OUTPUT FORMAT

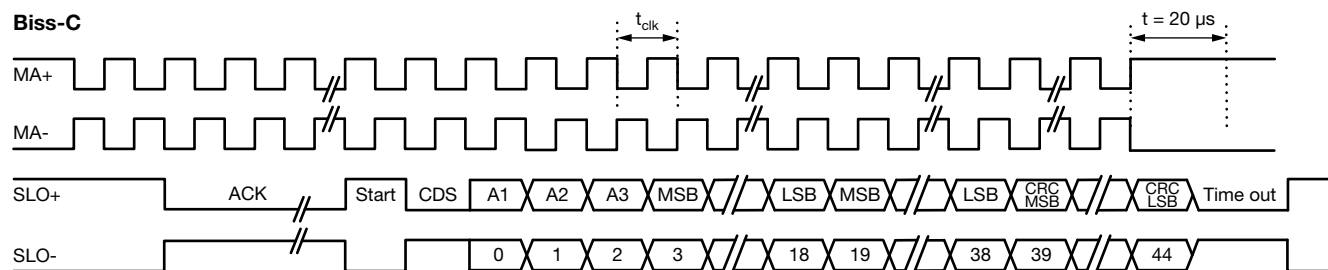


Fig. 7 - Biss-C Multi-Turns Chronogram

| TABLE 11 - BISS-C MULTI-TURN DATA BITS FORMAT | | | | |
|---|--------------|--------------|------------------|-------------------------------|
| BISS-C DATA BITS FORMAT | | | | |
| DATA BIT | MSB | LSB | DATA BITS LENGTH | INFORMATION |
| Status bits | Frame bit 0 | Frame bit 2 | 3 bits | See section "Self-Monitoring" |
| Multi-turns counter | Frame bit 3 | Frame bit 18 | 16 bits | See Fig. 7 |
| Angle value | Frame bit 19 | Frame bit 37 | 19 bits | See Table 6 |
| CRC | Frame bit 39 | Frame bit 44 | 6 bits | |

Note

- Bit 38 always = 0

MULTI-TURNS SPI OUTPUT FORMAT

SPI Slave Mode

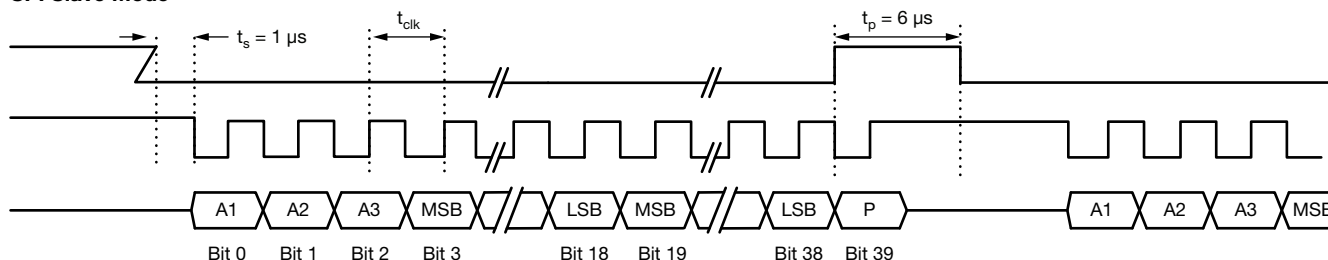


Fig. 8 - SPI Multi-Turns Chronogram

| TABLE 12 - SPI MULTI-TURN DATA BITS FORMAT | | | | |
|--|--------------|--------------|------------------|-------------------------------|
| SPI DATA BITS FORMAT | | | | |
| DATA BIT | MSB | LSB | DATA BITS LENGTH | INFORMATION |
| Status bits | Frame bit 0 | Frame bit 2 | 3 bits | See section "Self-Monitoring" |
| Multi-turns counter | Frame bit 3 | Frame bit 18 | 16 bits | See Fig. 8 |
| Angle value | Frame bit 19 | Frame bit 37 | 19 bits | See Table 9 |
| Parity | Frame bit 39 | - | 1 bit | |

Note

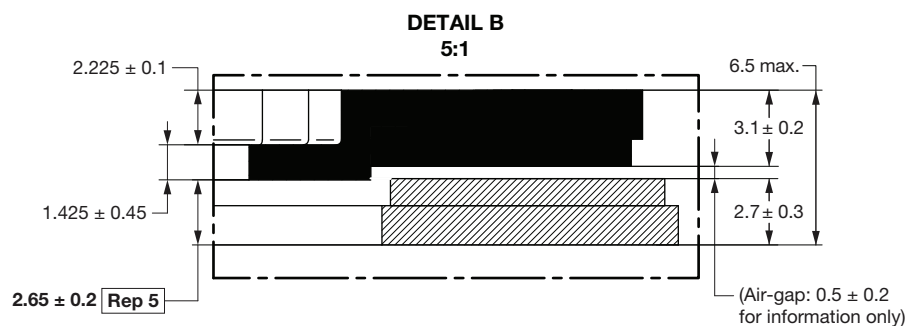
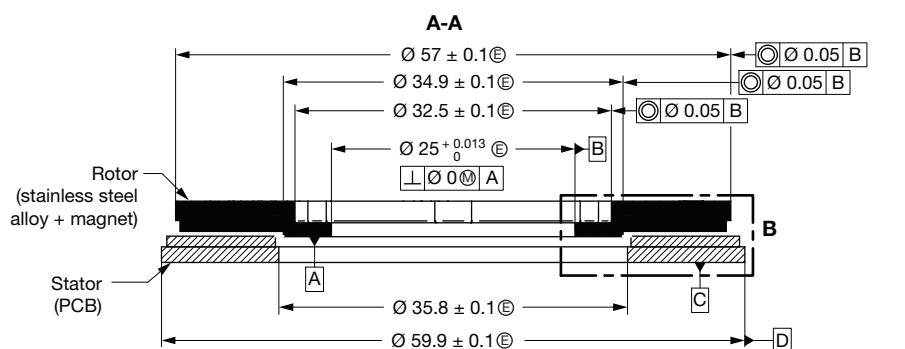
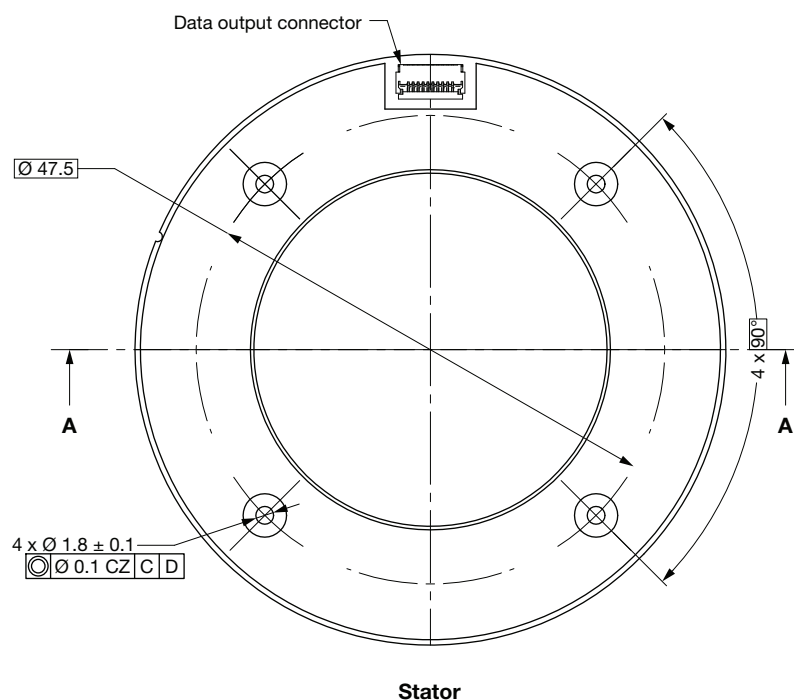
- Bit 38 always = 0

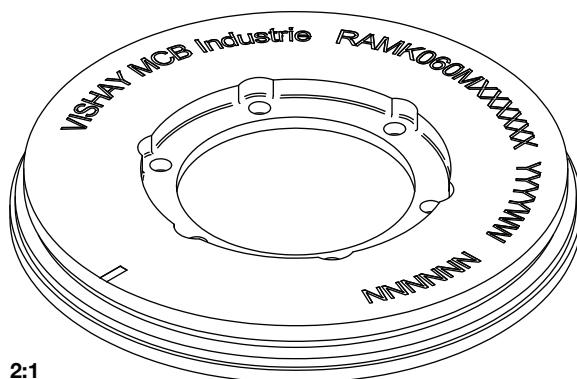
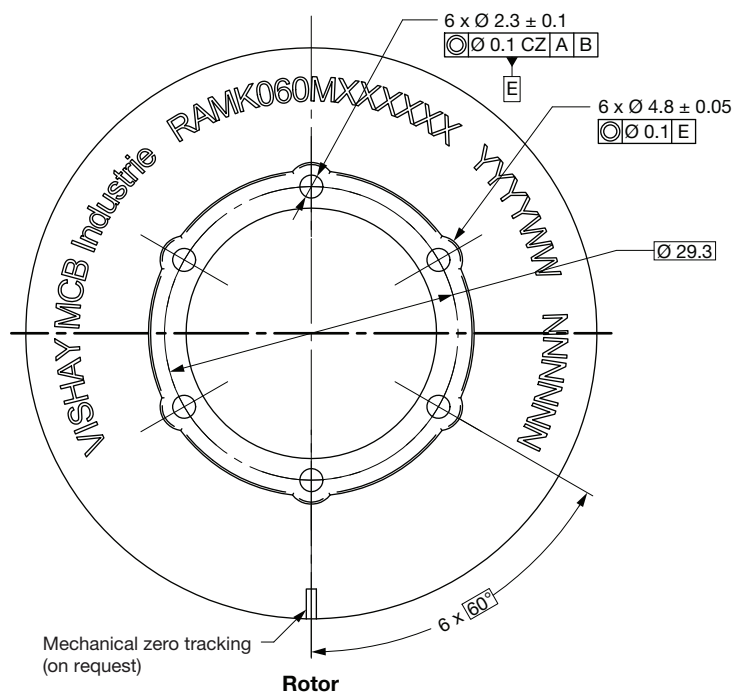
OPTIONAL BATTERY BACKUP CONNECTOR

- Header on the PCB: Hirose SMD 7 106 (666-1001-0-21)
- Crimp socket: Hirose DF58-2S-1.2C (Hirose number 666-1006-0 00)
- Crimp contact: Hirose DF58-2830SCF (Hirose number 666-1011-0 00)

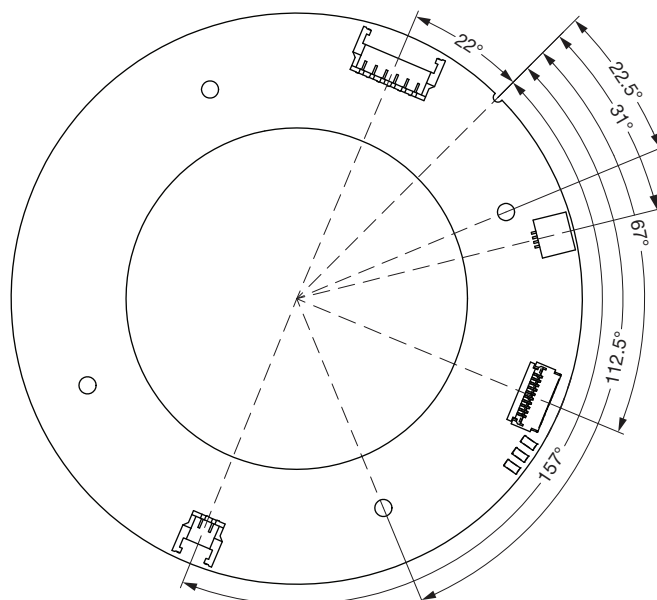
MOUNTING INFORMATION (All Versions)

SENSOR DIMENSIONS





2:1



MOUNTING DATA AND SELF-MONITORING

After the mounting and throughout the use of the sensor, the encoder provides across the LED colors and also across data bits of self-monitoring the status of correct mounting and of correct operation. Look at section “Self-Monitoring” and the table “Summary” in section “Approach No. 2”, “Self-Calibration Procedure” of §1.

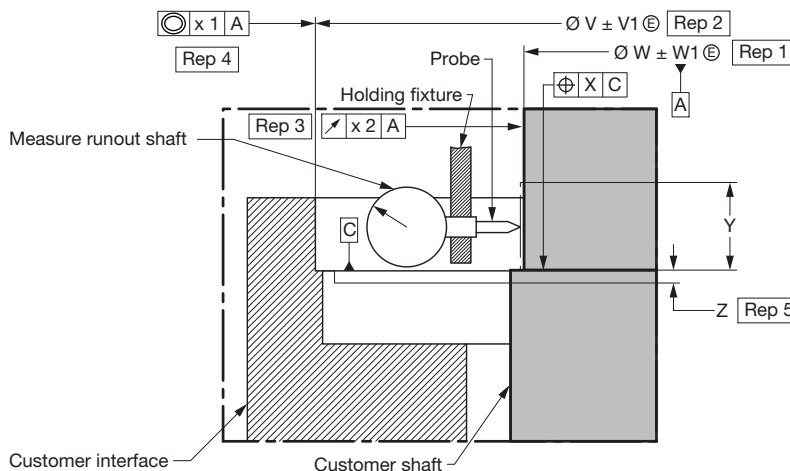


Fig. 9 - Mounting Detail

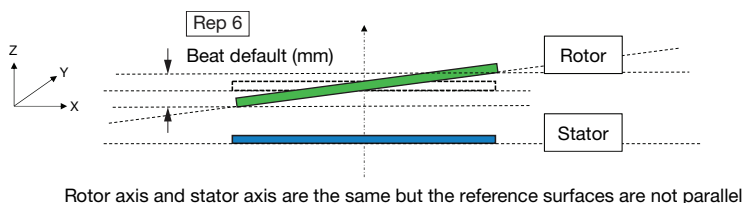


Fig. 10 - Beat

APPROACH NO. 1: TOTALLY PLUG AND PLAY WITHOUT SELF-CALIBRATION

Comment: it is the case for the customer's equipment whose mechanical tolerances are under control (requirements described in Table 13).

| TABLE 13 - RECOMMENDED DIMENSIONS AND TOLERANCES OF CUSTOMER INTERFACES | | |
|---|--|---------------------------|
| Rep 1 | Customer shaft diameter for centering of the rotor (see Fig. 9) | 25 mm + 0 mm / - 0.010 mm |
| Rep 2 | Customer interface diameter for centering of the stator (see Fig. 9) | 60 mm + 0.060 mm / 0 mm |
| Rep 3 | Diameter runout of the customer shaft for the rotor centering (see Fig. 9) | < 0.005 mm |
| Rep 4 | Concentricity of the stator centering diameter versus shaft centering diameter (see Fig. 9) | < 0.020 mm |
| Rep 5 | Position of the stator reference bottom surface versus rotor reference bottom surface (see Fig. 9) | 2.65 mm ± 0.1 mm |
| Rep 6 | Total beat included in the air-gap between Ref. C (rotor) and Ref. D (stator) (see Fig. 10) | < 0.2 mm |



APPROACH NO. 2: SELF-CALIBRATION

Comment: it is the case for the customer's equipment whose mechanical tolerances are NOT under the tolerances described in Approach No. 1, a self-calibration can be used to compensate the misalignment (= eccentricity between rotor axis and stator axis) and the runout of the customer shaft for the rotor centering (eccentricity mounting of the rotor).

Other case where the self-calibration has to be used, it is when the sensor sets the auto-calibration flag (conditions to use the self-calibration procedure: Table 14).

Self-Calibration Procedure

1. How to know if the encoder needs a self-calibration

- Mount the encoder
- Plug the connector
- Turn-on the power supply
- Turn the rotor (at least 360°)
- Look at the LED color

Case 1 Green LED: ON
 Red LED: OFF
 Orange LED: OFF The encoder is ready to be used with full performances

Case 2 Green LED: OFF
 Red LED: ON
 Orange LED: OFF Bad mechanical position, adjust the mechanical position

Case 3 Green LED: OFF
 Red LED: OFF
 Orange LED: ON Do the self-calibration

| SUMMARY | | |
|-----------|--|--------------------------------|
| LED COLOR | STATUS | ACTION |
| Green | Ready to use with full performances | None |
| Orange | The resolution and / or the accuracy might be out of specification | Do the self-calibration |
| Red | Bad mechanical position | Adjust the mechanical position |
| No light | No power | Check the power supply |

Reminder: similar data are available across the output frame "status bits of self-monitoring":

- "Normal operation" = green color
- "Need self-calibration" = orange color
- "Mechanical mounting error" = red color

2. How to do the self-calibration

- The encoder is mounted, the connector is unplug
- Plug the shunt supplied by Vishay and turn-on the power supply (the red LED is blinking)
- Turn the rotor with a maximum rotation speed of 10 rpm (at least 360°) (acquisition of data = the orange LED is blinking)
- When the green and orange LEDs are blinking, the correction calculation is in progress
- When the green LED is blinking, the correction calculation is finished
- Turn off the power supply and unplug the shunt
- Plug the connector, turn-on the power supply, turn the rotor (at 360°) and look at the LED color.
Green LED: ON | Red LED: OFF | Orange LED: OFF
- The encoder is ready to be used with full performances

Note

- The procedure of self-calibration is also described in video available to ask for Vishay

The self-calibration is operational when the requirements are in accordance with Table 14.

TABLE 14 - RECOMMENDED DIMENSIONS AND TOLERANCES OF CUSTOMER INTERFACES TO USE THE SELF-CALIBRATION PROCEDURE

| | | |
|-------|--|---|
| Rep 3 | Diameter runout of the customer shaft for the rotor centering (included gap between customer shaft and inner rotor diameter) (see Fig. 9) | < 0.08 mm |
| Rep 4 | Misalignment: concentricity of the stator centering diameter versus shaft centering diameter (included tolerances of customer holder and stator interface) (see Fig. 9) | ± 0.8 mm |
| Rep 5 | Position of the stator reference bottom surface versus rotor reference bottom surface (see Fig. 9) (air-gap: the condition of previous line avoids to measure the air-gap) | 2.65 mm ± 0.2 mm (air-gap = 0.5 mm ± 0.2 mm) |
| Rep 6 | Total beat included in the air-gap between Ref. C (rotor) and Ref. D (stator) (see Fig. 10) | < 0.2 mm |

Note

- Values at room temperature
- Recommended screws for the rotor: M2 ISO 4762 (stainless steel A4) with recommended torque = 0.3 Nm ± 10 % + narrow washer M2 NFE 25514 “Z” type (stainless steel A4) thickness 0.5 mm. It is recommended to add glue on screws threads function of environmental and use conditions
- Recommended screws for the stator: M1.6 ISO 1207 (stainless steel A4, screw head diameter ≤ 3.2 mm and screw head height ≤ 1 mm) with recommended torque = 0.10 Nm ± 10 % + washer M1.6 DIN 125 (**insulated raw material**) thickness 0.3 mm. It is recommended to add glue on screws function of environmental and use conditions

OTHER INFORMATION



ATTENTION!
Observe Precautions for Handling Electrostatic Sensitive Devices!



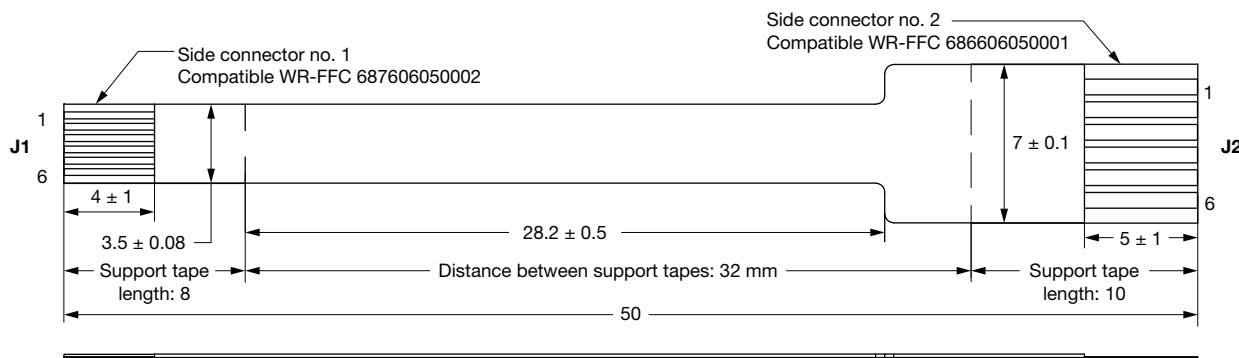
Do not use magnetic parts around the encoder!

WARNING: the rotor and the stator must have the same serial number!

- Do not damage the magnetic disk surface
- Do not put the disk in contact with metallic particles
- Do not use cleaning product or chemical product

ACCESSORY ON REQUEST

TRANSFER ADAPTOR TO PROVIDE A FLAT FLEX CABLE WITH DIFFERENT PINNING AT THE OUTPUT



| CONNECTOR J1 | | | CONNECTOR J2 | | |
|-------------------|---------------|------------|----------------------|---------------|------------|
| ENCODER RAMK SIDE | | | CUSTOMER DEVICE SIDE | | |
| PIN NO. | SPI | SSI/Biss-C | PIN NO. | SPI | SSI/Biss-C |
| 1 | VCC | VCC | 1 | VCC | VCC |
| 2 | CLK | CLK+ | 2 | Not connected | Data- |
| 3 | MISO | CLK- | 3 | MISO | CLK- |
| 4 | CS | Data+ | 4 | CLK | CLK+ |
| 5 | Not connected | Data- | 5 | CS | Data+ |
| 6 | GND | GND | 6 | GND | GND |

| CONNECTOR J1 | | CONNECTOR J2 |
|--------------|--------------|--------------|
| Pin 1 | connected to | Pin 1 |
| Pin 2 | connected to | Pin 4 |
| Pin 3 | connected to | Pin 3 |
| Pin 4 | connected to | Pin 5 |
| Pin 5 | connected to | Pin 2 |
| Pin 6 | connected to | Pin 6 |



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