

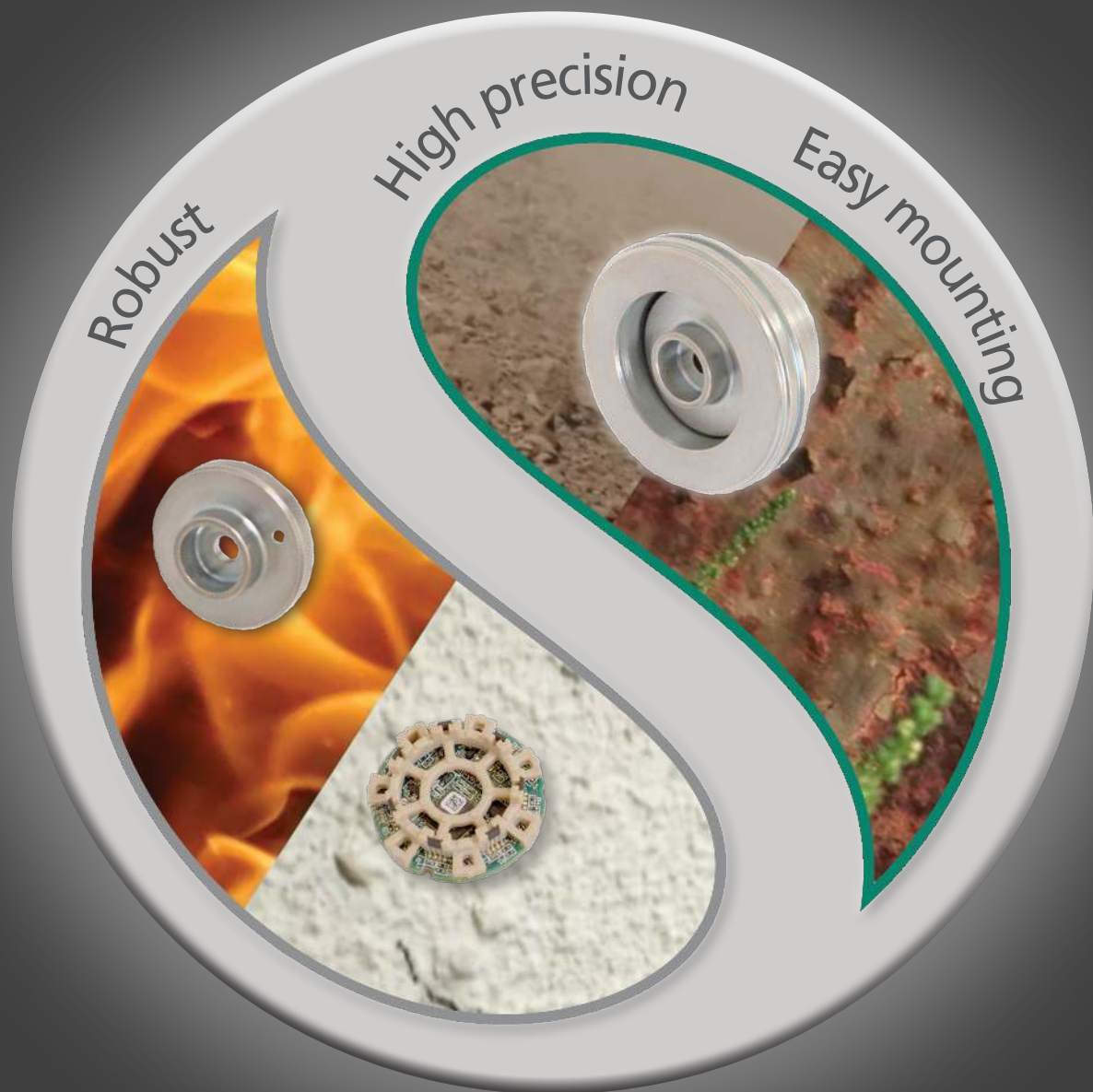
# ***sensAR***

SERVO MOTOR FEEDBACK SYSTEMS



**SERVOTRONIX**  
always in motion™

# Best in Class



## ABSOLUTE MOTOR FEEDBACK SYSTEM

The innovative sensAR™ magnetic absolute encoder combines high resolution and accuracy with robustness, durability and compact size, all at a competitive price.

### Simplicity

The sensAR magnetic absolute encoder features a simple mechanical design that provides the same level of resolution and accuracy as optical absolute encoders without the complexity or expense.

### Single-track magnetic system

The Gray code is obtained on a single track, unlike other encoders that tend to use at least two tracks (absolute and incremental) along with an array of sensors.

### High resolution and accuracy

The sensAR offers a resolution of up to 20-bit single-turn and an accuracy of  $\pm 60$  arc/sec. The multi turn version has an additional count of 16-bit (65,536) revolutions. Advanced signal processing applies a unique, patented method in which a digital position code is associated with a set of analog signals that represent a high resolution and accurate, absolute angular position.

### Robustness

Requiring few mechanical components and no optical elements, sensAR is less sensitive to contamination, shock, vibration and mechanical tolerance deviations. It is also more durable (no component degradation over time) than optical encoders. Life expectancy is greater due to the elimination of both optical components and bearings.

***senSAR***

## FEATURES AND BENEFITS

- Simple and compact mechanical design
- Absolute single turn resolution up to 20-bit
- Additional 16-bit multi turn (battery powered)
- Operating temperature range of -20°C to +120°C
- Resistant to contamination
- 30G shock and 200G vibration resistance
- Less sensitive to mechanical deviation
- Position/velocity feedback
- Less expensive four-wire cable
- Electronic motor type plate
- Robust signals with fully digital interface
- Built-in thermal sensor

### Customization options

- Form factor
- Communication protocols
- Extended temperature range
- Condition monitoring
- Mechanical mounting options
- Compatibility with resolver dimensions

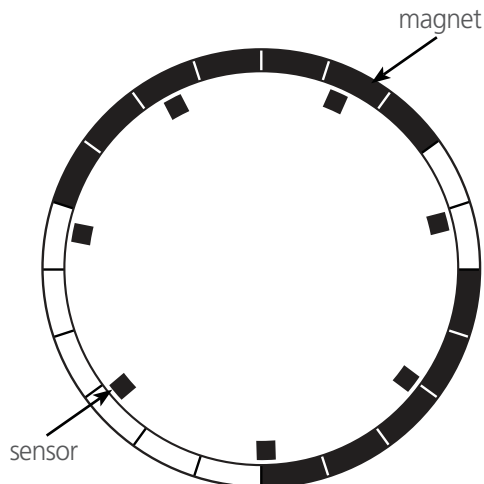
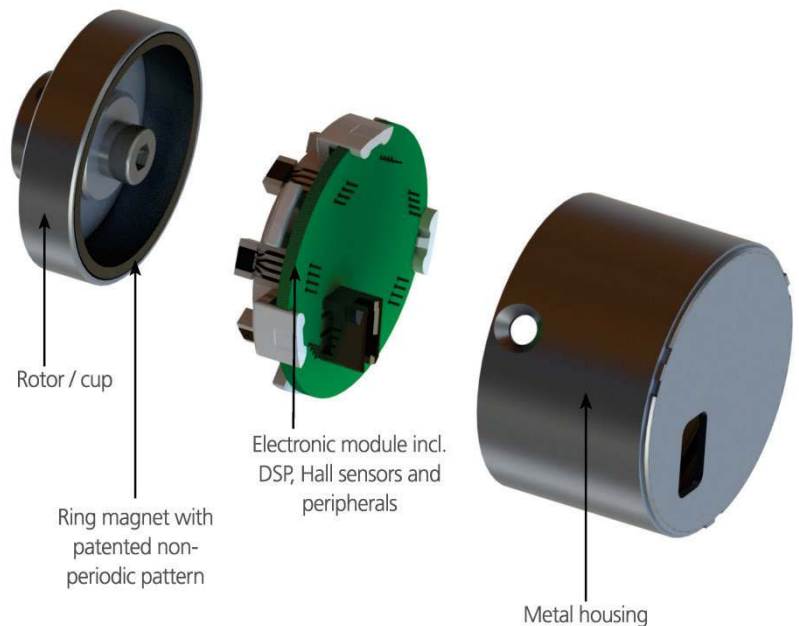
**RoHS REACH** ✓ **CE**

# INTEGRATED ROTARY ENCODERS FOR SERVO MOTORS

## CLOSED LOOP SERVO APPLICATIONS

Servotronics developed the sensAR encoder, a new magnetic absolute rotary encoder, to overcome many of the disadvantages of conventional absolute encoders.

The rotary encoder is assembled at the B side of the servo motor and protected by the motor housing. This configuration provides a high degree of protection, but requires a robust feedback device that can withstand operating conditions such as high temperatures, shock and vibrations, axial motion, tolerance compensation, and thermal expansion.



The sensAR encoder design has a number of permanent magnets of different sizes positioned along the outer edge of the encoder disk in one circular track, forming a magnetic code track whose pattern is non periodic. Magnetic (Hall) sensors are fixed to a static part of the encoder, spaced equidistantly from each other, arranged concentrically and in close proximity to the magnetic code track.

A patented algorithm generates a Gray code with a maximum number of positions for a given number of sensors from a non periodic pattern of a single magnetic code track.

In addition, the sensors' analog output signals directly provide a high-resolution absolute position, without needing additional incremental readings.

The sensors produce electrical signals proportional to the strength of the magnetic field generated by the facing magnet. These analog signals are first digitized by comparing them to a threshold value, thus generating a Gray code that describes an absolute position at a low resolution. A configuration of seven sensors and seven magnets, for example, creates a Gray code that identifies 98 positions.

To achieve a higher absolute resolution, an additional patented method for signal evaluation is applied. Two analog signals are associated with each Gray code according to a predefined signal table. The absolute position of the disk corresponds to the associated position value in a prerecorded position table for the analog signal whose value is closest to the threshold.

When put into practice, the Servotronics technology achieves 20-bit resolution using a 12-bit analog-to-digital converter and a configuration for seven sensors.



# INTEGRATED ROTARY ENCODERS FOR SERVO MOTORS

## SIMPLE MECHANICAL DESIGN AND HIGH PERFORMANCE MEASURING ACCURACY

The sensAR magnetic encoders are designed without integral bearing, and the attainable accuracy of the system is dependent on the mounting and application conditions.

Regarding error due to radial run out of the bearing, the measuring error is considered for a deviation of the motor shaft against the encoder axis, as illustrated in Figure 1.

Because the measuring error value cannot be calculated with a simple formula, the values are given in Figure 2 for measurements according to eccentricity value (e).

However, sensAR technology features a dynamic compensation within a certain axial play and eccentricity limit, which allows a lot of application freedom thanks to the unique scanning method. This leads to an easy to install encoder, lower cost motor parts, and wide mounting/operating tolerances. A fixed bearing is no longer required on the B side of the motor.

The application analysis must however produce values within mating motor dimension specifications and tolerances for all possible operating conditions, particularly under maximum load and over-temperature range. This is especially important for the following measurements:

- Maximum axial play of the motor shaft with respect to the mounting surface (refer to Technical Data on page 11)
- Maximum radial runout (eccentricity) of the motor shaft
- Maximum operating temperature influence on system accuracy, shown in Figure 3

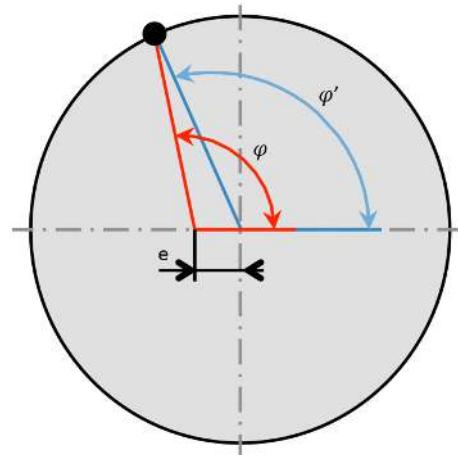


Figure 1. Eccentricity of the motor shaft (e)

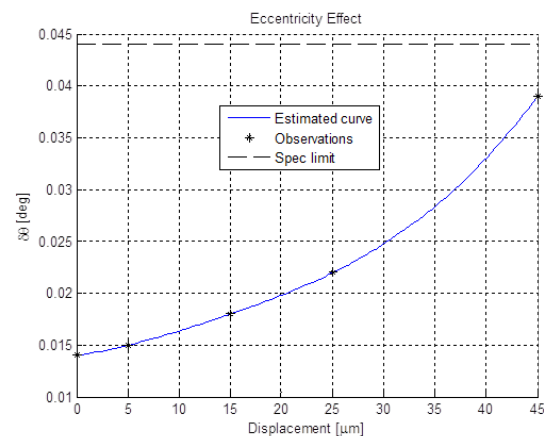


Figure 2. Effect of eccentricity on system accuracy  
Note: All values are given at 25°C

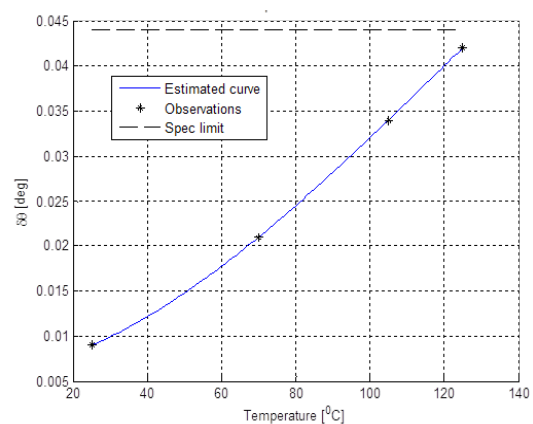
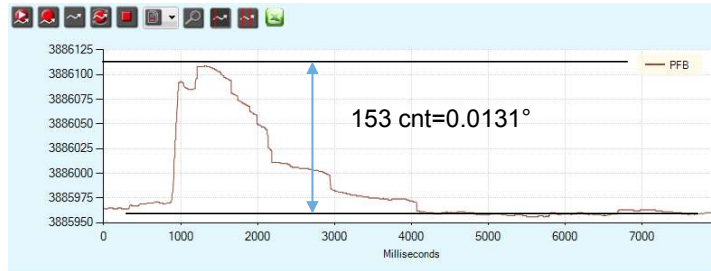


Figure 3. Effect of operating temperature on system accuracy

# INTEGRATED ROTARY ENCODERS FOR SERVO MOTORS

## IMMUNITY TO ELECTROMAGNETIC FIELD

With an encoder body composed of magnetic material and an encapsulated PCB board, the sensAR acts as a protection shield against strong magnetic fields generated by a servo motor magnetic brake. This design ensures that the change in position is smaller than the overall system accuracy, as shown in the figure.



To perform the measurements, the motor brake is activated during encoder calibration, so that the magnetic field interference is included for motor operation.

Figure 1. Change in position for a brake with 90%–100% of the maximum permitted air gap. Number of shocks  $\geq 60,500$

Furthermore, the transient jump in position when the brake is released is less than the mechanical shock movement from brake disengagement.

## ELECTROMAGNETIC COMPATIBILITY COMPLIANCE

### Declaration of Conformity

The SE36E encoder series meets electromagnetic emission and immunity requirements outlined in the following specifications:

CISPR 16-1-4: Electric Field Emission Measurements

IEC 61000-4-2:2008: Immunity to Electrostatic Discharge

IEC 61000-4-3:2002: Immunity to Radiated Electromagnetic Field

IEC 61000-4-4:1995: Immunity to Electrical Fast Transients (EFT) Amendment 1 (2000) Amendment 2 (2001)

IEC 61000-4-5:1995: Immunity to Voltage Surge

IEC 61000-4-6:2003: Immunity to Conducted RF Stress

IEC 61000-4-8:2001: Immunity to Power Frequency Magnetic Field Measurements



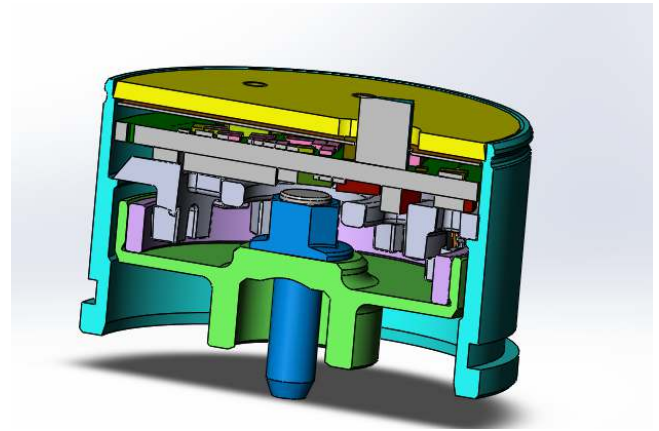


# INTEGRATED ROTARY ENCODERS FOR SERVO MOTORS

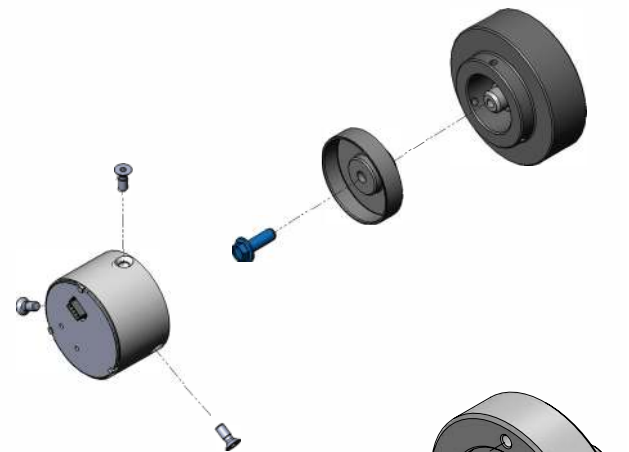
## MOUNTING

The sensAR magnetic encoders are mounted in an axial position at the back side of the motor. The rotor with a blind hollow shaft is fastened with a central screw.

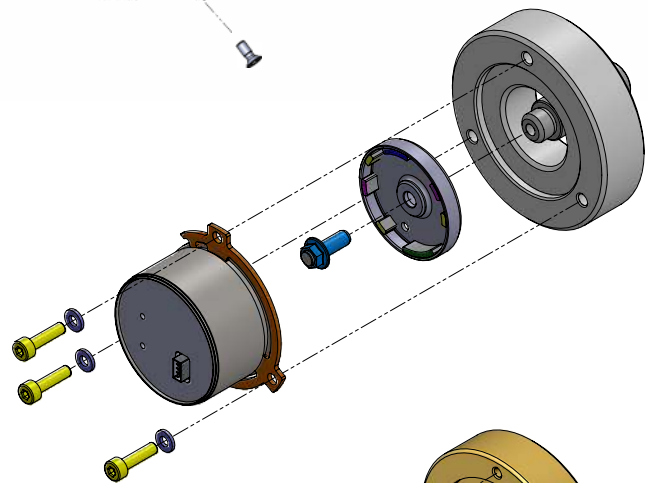
The stator of the encoder is clamped with three radial screws or, as on a resolver, with either three axial screws/washers or a clamping ring with two to three axial screws, depending on the motor configuration.



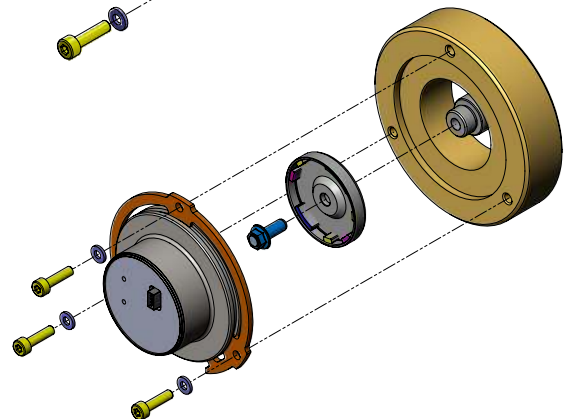
**Set screws version.** The B flange of the motor receives the centering bore of the encoder stator. Particularly suitable for small motor flange dimensions such as 40x40 mm – NEMA 16.



**Resolver 15 version.** A centering bore at the B flange of the motor receives the centering outer diameter of the encoder stator. Particularly suitable for motor flange sizes of 60x60 mm – NEMA 24.



**Resolver 21 version.** A centering bore at the B flange of the motor receives the centering synchro flange of the encoder stator. Particularly suitable for motor flange sizes of 180x180 mm and larger.



# INTEGRATED ROTARY ENCODERS FOR SERVO MOTORS

## MECHANICAL SPECIFICATIONS

Notes for all models

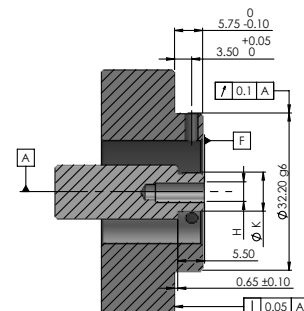
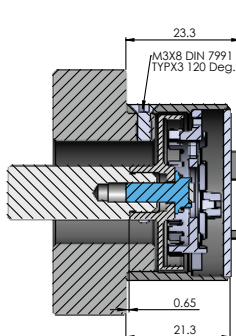
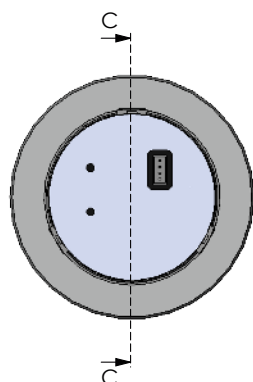
[A] = Bearing of mating shaft

[F] = Maximum permissible deviation between shaft and flange surfaces

Compensation of mounting tolerances and thermal expansion:

- Axial  $\pm 0.7$  mm
- Radial  $\pm 0.1$  mm (measuring accuracy specification given at  $\pm 0.025$  mm)

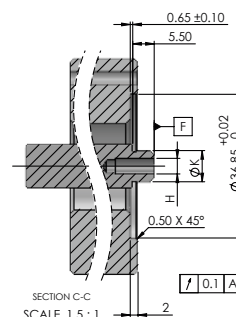
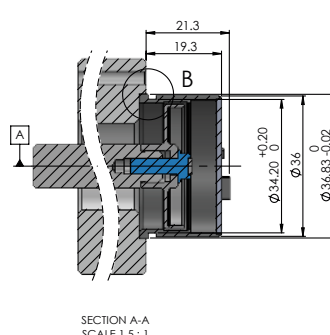
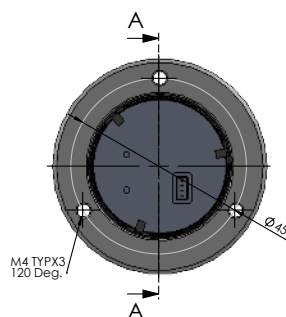
### SET SCREWS



### MOTOR DIMENSIONS

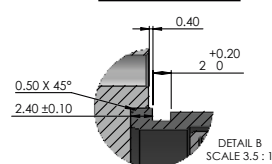
MECHANICAL INTERFACE OPTION	Ø ENCODER SHAFT Dia.	Ø K	H - THREAD
1	6 MM	6 h6	M3 X 7
2	8 MM	8 h6	M4 X 10

### RESOLVER 15

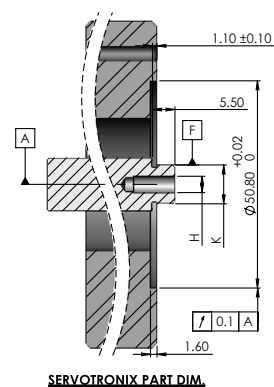
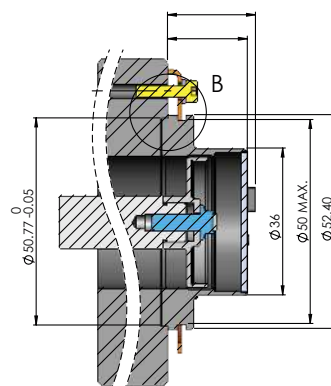
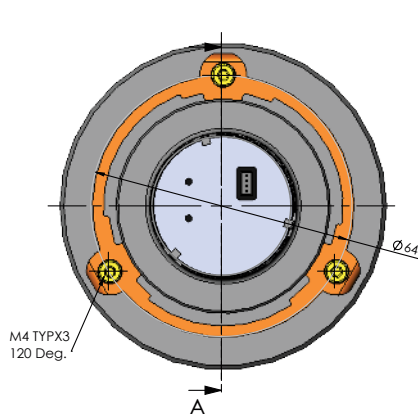


### MOTOR DIMENSIONS

MECHANICAL INTERFACE OPTION	Ø ENCODER SHAFT Dia.	Ø K	H - THREAD
3	6 MM	6 h6	M3 X 7
4	8 MM	8 h6	M4 X 10
5	9.52 MM	9.52 h6	M4 X 10

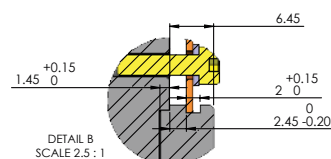


### RESOLVER 21



### MOTOR DIMENSIONS

MECHANICAL INTERFACE OPTION	Ø ENCODER SHAFT DIA.	Ø K	H - THREAD
6	9.52	9.52 h6	M4 X 10
7	12.7	12.7 h5	M5 X 12



# INTEGRATED ROTARY ENCODERS FOR SERVO MOTORS

## TECHNICAL DATA

Primary Encoder Specifications		SE36E-S20	SE36E-M36
Resolution single-turn <sup>1</sup>		up to 20 bit	up to 20 bit
Multi-turn counts			65,536 (16-bit)
Accuracy <sup>2</sup>		$\pm 0.016^\circ$ / 14.4 bit / 60 "	
Repeatability <sup>3</sup>		$\pm 0.015^\circ$ / 14.5 bit / 54 "	
Maximum rotational speed		12,000 rpm	
Maximum angular acceleration		100,000 rad/s <sup>2</sup>	
Data storage EEPROM <sup>1</sup>		up to 2040 bytes	

Mechanical Specifications	
Dimensions	Diameter: 36 mm, Height: 21.3 mm
Mass	57 g
Moment of inertia	$2.3 \times 10^{-6}$ kg·m <sup>2</sup>
Allowed shaft movement <sup>5</sup> (mounting)	Axial $\pm 0.7$ mm, radial $\pm 0.1$
Protection	IP20 (after encoder assembly)

Communication Interface		
Communication protocol	ServoSense <sup>7</sup>	BiSS/SSi <sup>8</sup>
Electrical interface	RS485 (UART)	RS422
Transmission rate	2.5 Mbps, ½ duplex	500 kbps
Access rate and synchronization	<16 kHz	<16 kHz
Data availability	Bi-directional, real-time	Uni-directional
Number of wires (total)	4	6

Ambient Conditions	
Operating temperature range	-20°C to 120°C
Storage temperature range	-30°C to 120°C
Humidity	90% RH
Vibration resistance 4 (EN 60 068-2-6)	30 g (10–2000 Hz)
Shock resistance 4 (EN 60 068-2-27)	200 g (6 ms)

Electrical Specifications	
Nominal voltage	4 – 5.25 VDC
Current consumption	80 mA
Insulation resistance	Greater than 1 MΩ
Lifetime <sup>6</sup>	786,401 hours / 90 years
Standby period at power-on	500 ms
Maximum cable length	80 m

## Notes

1. Maximum value depends upon the communication protocol. Refer to the datasheet ServoSense and Optional Protocols.
2. Achieved after ¼ revolution, at 25°C after motor calibration. 12 bit within the initial 1/4 turn.
3. The white noise as control ripple and electrical spikes is reduced by factor  $\sqrt{1999}$ .
4. Test performed by independent certification body Carmel Environmental Test Laboratories (Israel).
5. Accuracy reduced when axial play is in the range  $+0.2$  mm/(-1 bit) > shaft movement >  $+0.7$  mm/(-2 bit)
6. fiXtress Analysis performed by BQR Reliability Engineering Ltd (Israel). MTBF at 80°C. The failure rate prediction is based on Parts Stress method of MILHDBK- 217F. This MTBF assumes the system is operated all the time, which is the worst case scenario.
7. Proprietary protocol. Free user licenses.
8. On request.

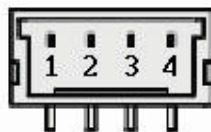
# INTEGRATED ROTARY ENCODERS FOR SERVO MOTORS

## CABLES AND WIRING

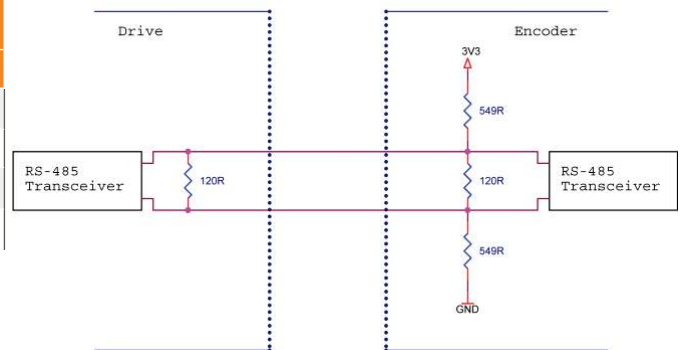
### ELECTRICAL CONNECTION

Mating Connector			Pinout		
Item	Manufacturer	Part Number	Pin	Function	Description
Housing	MOLEX	501330-0400	1	Vcc	5 VDC supply
Crimp pin	MOLEX	501334-0400	2	GND	5 VDC return
Protective Ground Conductor Connections			3	Data+	RS485
			4	Data-	RS422

Ground the motor via a grounding screw near the cable connector. Use parts with suitable corrosion protection.

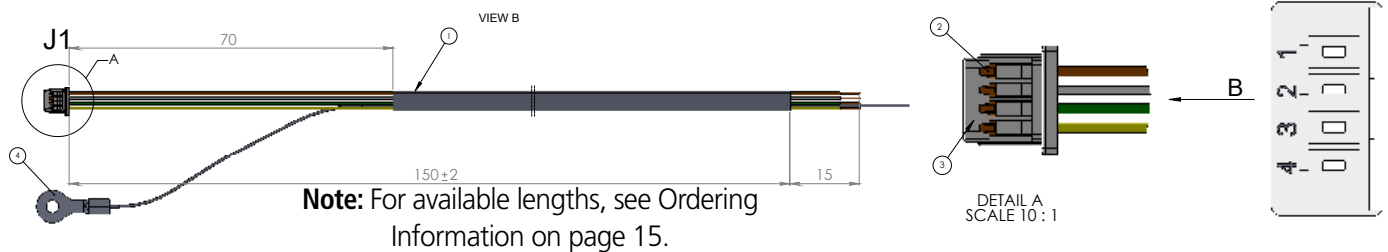


### PHYSICAL LAYER



### OPTIONAL MOTOR INTERNAL CABLE FOR SE36E ENCODER

#### Motor Internal Cable Options



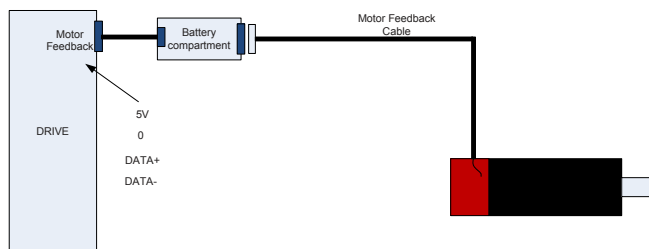
### Specifications

Item	Specification	
Cable		
Shield	Braid shield 85% coverage	
Jacket	Insulation 28AWG 30V	
Wire gauge	Thermoplastic insulation UL 2589	
Length options	Rated 105C minimum	
Connections		
J1 Pin Number	Wire	Color
1	Twisted Pair	Brown
2		White
3	Twisted Pair	Green
4		Yellow
G		Shield

# INTEGRATED ROTARY ENCODERS FOR SERVO MOTORS

## sensAR MULTI TURN FUNCTION

The multi turn function of the sensAR encoder is implemented by means of a revolution counter. The drive reads the multi turn position from the encoder at power up and during runtime. To prevent loss of the absolute position data when the power supply to the encoder is disconnected or disrupted, the sensAR must be operated with an external battery.

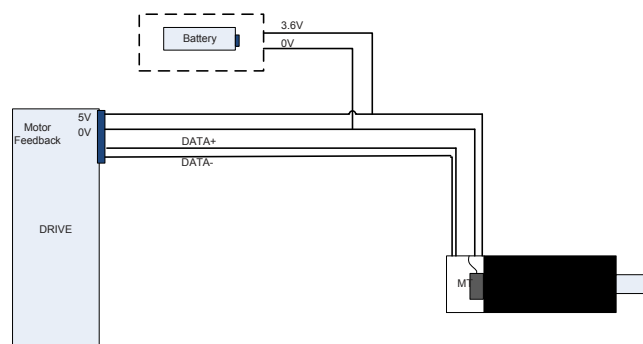


The BCM-M3 is a battery compartment for the sensAR encoder. It is designed for installation on the motor feedback cable (refer to page 14). The battery compartment comprises an enclosure and an electronic board whose function is to regulate the power supply to the encoder. Correct polarity of the battery is ensured within the BCM-M3. The certified battery typically has a service life of more than 5 years under appropriate conditions (ambient temperature 20°C; typical self-discharge).

If the battery voltage falls below certain limits, the sensAR issues either warnings or error fault messages over the communication interface:

- "Battery charge" warning 3.10 V to 3.25 V (typically below 3.15 V): The battery should be replaced but multi turn position is not lost.
- "Power Failure" error message 2.90 V to 3.05 V (typically below 3.00 V): Multi turn position is lost and the encoder needs a new reference.

After battery replacement, the warning/error message must be cleared. The sensAR uses low battery current even during normal operation. The amount of current depends on the ambient temperature.

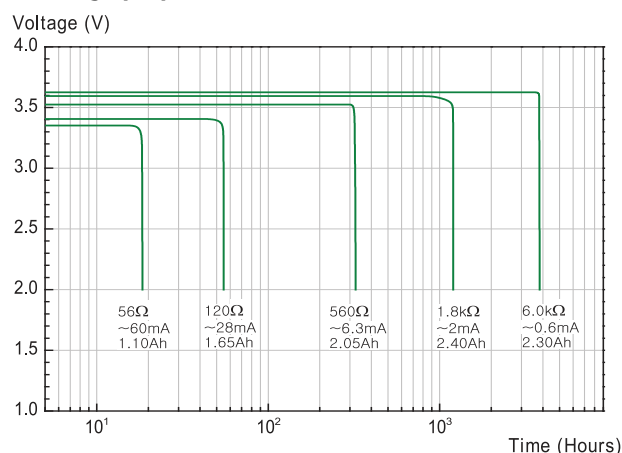


## BATTERY SPECIFICATIONS

Nominal capacity (at 2 mA/20°C/68°F / 2.0 V cut-off)	2.4 Ah
Nominal voltage	3.6 V
Max. recommended continuous current	60 mA
Max. pulse current capability*	200 mA
Operating temperature range	-55°C to 85°C
Lithium metal content	approx. 0.7 g
Weight	17 g
Volume	8.0 cm <sup>3</sup>
UL Approval	MH28122

**Note:** Maximum pulse capability reading over 3.0V at 200 mA/0.1 sec. every 2 min. at 20°C, 10 µA/cm<sup>2</sup> base current with fresh batteries.

## Discharge properties at +20°C

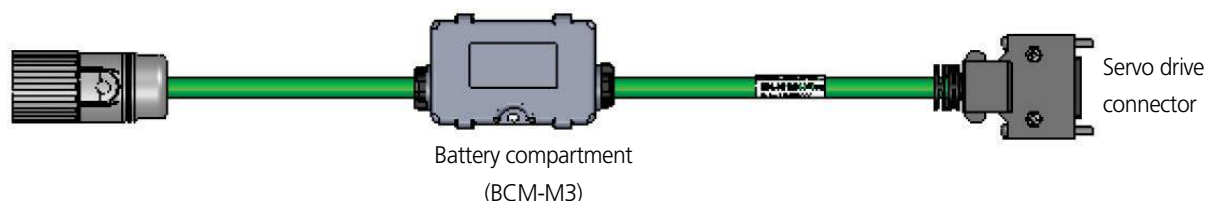


# INTEGRATED ROTARY ENCODERS FOR SERVO MOTORS

## MULTI TURN FUNCTION WITH EXTERNAL BATTERY

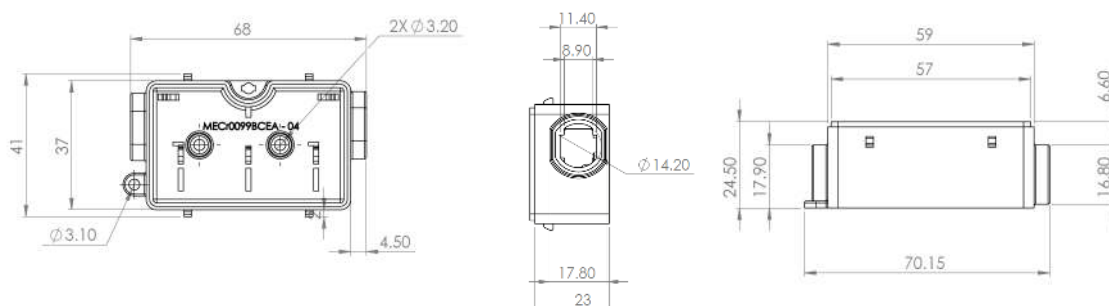
### Motor feedback cable

Motor connector  
(or cable plug)  
connected to the  
encoder internal  
cable



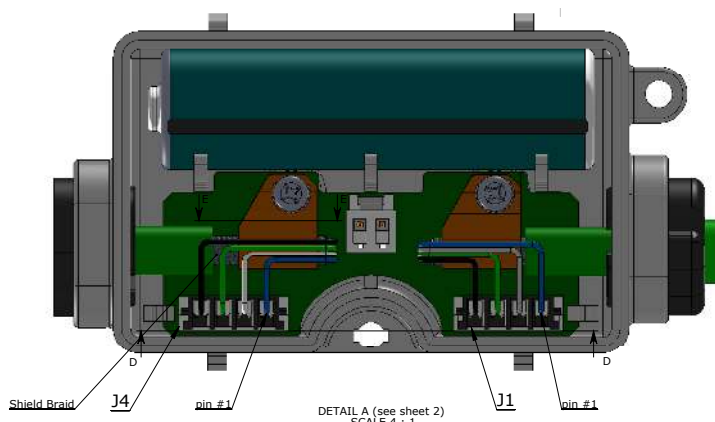
### BCM-M3 Battery Compartment Dimensions

41 mm x 70 mm x 23 mm



### BCM-M3 Battery Compartment Specifications

Item	Specification
<b>Operating Enviroment</b>	
Temperature Range	-40 to +55 ° C
Relative Humidity	+5% to 95%
Vibration	Class 3M4: 3.0 mm @ 2 Hz – 9 Hz 10 m/s <sup>2</sup> @ 9 Hz – 200 Hz
Shock	Class 3M4: 100 m/s <sup>2</sup> Type I (11 ms)
<b>Storage Enviroment</b>	
Temperature range	-40°C to +70°C
Relative humidity	+5% to 100%
Vibration	Class 3M4: 3.0 mm @ 2 Hz ... 9 Hz 10 m/s <sup>2</sup> @ 9 Hz ... 200 Hz
Protection	IP20
<b>Cable</b>	
Wires and Gauge	Twisted pairs, AWG 24 (0.21mm <sup>2</sup> )
Cable Jacket Diameter	Ø 6.5–7.3mm
Overall Shield	Tinned copper braid; coverage > 85%



Pin	Function
1	5V
2	GND
3	Data+
4	Data-

J1 and J4 have the same pinout.  
J1 must be connected to the drive.  
J4 must be connected to the  
encoder

### Tool for Assembly



A strain relief assembly tool is  
required for installing the strain reliefs  
on each side of the compartment.  
Manufacturer: Heyco. Part No.  
0030. Not supplied. Strain reliefs are  
supplied with BCM-M3.



# INTEGRATED ROTARY ENCODERS FOR SERVO MOTORS

## ORDER INFORMATION

		SE36E	S20	A	1	00
SE36E Rotary Encoder						
	Absolute Servo Motor Feedback					
Resolution						
S20	Single turn absolute 20-bit/revolution					
M36	Multi-turn absolute 20-bit/revolution and 16-bit number of turns					
Communication Interface						
A	ServoSense proprietary asynchronous protocol with 4 wires (free license)					
B	BiSS Safety serial protocol (free license)					
Mechanical Interface						
	Encoder Body	Rotor Shaft				
1	Set screw	Blind 6 mm hollow shaft with M3 axial screw				
2	Set screw	Blind 8 mm hollow shaft with M4 axial screw				
3	Resolver size 15 compatible	Blind 6 mm hollow shaft with M3 axial screw				
4	Resolver size 15 compatible	Blind 8 mm hollow shaft with M4 axial screw				
5	Resolver size 15 compatible	Blind 9.52 mm hollow shaft with M4 axial screw				
6	Resolver size 21 compatible	Blind 9.52 mm hollow shaft with M4 axial screw				
7	Resolver size 21 compatible	Blind 12.7 mm hollow shaft with M5 axial screw				
S	Customer-specific	Customer-specific				
Options						
00	Customization code					

## Battery Compartment for Multi-turn Function

Part Number	Description
BCM-M300	Battery compartment for sensAR SE36E-M36 absolute multi-turn encoder. Battery included. Minimum order: 10 units
BCM-M30N	Battery compartment for sensAR SE36E-M36 absolute multi-turn encoder. Battery not included. Minimum order: 10 units
Kitr99BCB00A-00	Backup battery. Minimum order: 50 units

## Motor Internal Cable for SE36E Encoder

Part Number	Description
CBL-994A1600	Motor internal cable 165 mm total length
CBL-994A3500	Motor internal cable 350 mm total length
CBL-994A5000	Motor internal cable 500 mm total length

# **sensAR**

## **SERVO MOTOR FEEDBACK SYSTEMS**

### **About Servotronix**

Servotronix Motion Control develops and manufactures both off-the-shelf motion control products and customized automation systems. Founded in 1987, Servotronix has developed several generations and series of high performance servo drives. The company designs and develops motion control solutions per customer specifications, meeting the strictest requirements of form, functionality and cost.

Servotronix operates worldwide, with headquarters in Israel and subsidiaries in Germany and China. A global customer base includes leading machine builders and automation system suppliers. The company focuses on motion control solutions for a diverse range of applications and industries, such as robotics, CNC and machining tools, medical equipment, electronics, printing, textile, food and beverage, and renewable energy.

Servotronix is guided by the principles of high-quality products, cost-effective solutions, and on-time deliveries.

A controlling share of Servotronix was acquired in 2017 by Midea Group of China, a Fortune 500 company with over 200 subsidiaries and more than 130 thousand employees worldwide. Midea manufactures and markets household appliances, air conditioning systems, robotics and automation systems. The strategic alliance allows the two companies to leverage each other's capabilities and resources, leading to new products and growth for both Servotronix and Midea in the field of industrial automation and intelligent manufacturing.