Data Sheet

AS20-Series Miniature Encoder

Magnetic Absolute Kit Encoder with Energy Harvesting Multi-Turn

Overview

The Broadcom® AS20-Series Miniature Encoder is a magnetic sensing absolute multi-turn encoder kit based on Broadcom's proprietary Energy Harvesting (EH) technologies. The EH Multi-Turn (EHMT) offers battery-less and non-gear based solutions, eliminating the need for maintenance and contamination prevention.

The beauty of the EH effect is that the same amount of energy is generated independent of the rotation speed and direction. The generated energy is sufficient to power the revolution tracking circuitry. Hence, revolution counts are ensured even in the absence of an external power supply.

The AS20 offers bundles of intelligent features such as Built-In Temperature Sensor, User Programmable Resolution, Zero Reset, System Alarm, and more. It comes with a recommended high temperature range of –40°C to 115°C. The counter ASIC harvests the energy generated by the EH Sensor for processing rotational count and generates counting logics to the non-volatile memory, which updates and stores the counting.

The entire operation of energy generation, counting and storage processing is completed within a limited energy and short duration; hence, the kit encoder is suited for both low- and high-speed measurement.

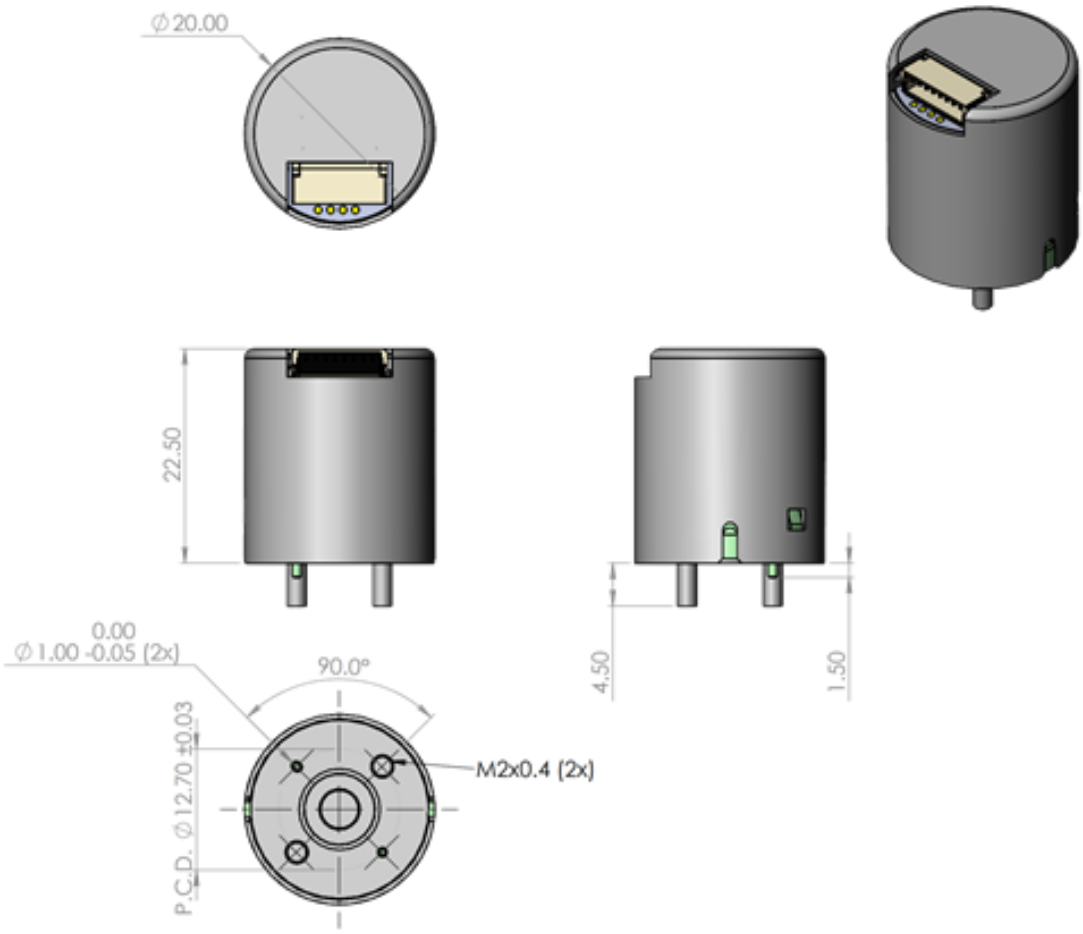
Features

- Patented Energy Harvesting technology
- All magnetic 18-bit single-turn (ST) and 32-bit multi-turn (MT) for a 50-bit combined resolution
- Overall diameter Ø20 mm
- Wide operating temperature range –40°C to 115°C
- SSI/RS-485/BiSS-C with integrated differential line transceivers
- SPI 4-Wire Single-Ended output
- Up to 10 Mbps communication clock rate
- Easy integration with miniature motors
- RoHS compliant

Applications

- Miniature servo motors and drives
- Linear actuator
- Medical and laboratory equipment
- Robotics
- Automated Guided Vehicles (AGV)
- Factory automation

Outline Dimensions



AS20 System Specifications

Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Unit	Remarks[a]
Operating Temperature	T_A	–40	115	°C	Up to 125°C maximum PCBA temperature
Storage Temperature	T_S	–40	115	°C	
Supply Voltage	V_{DD}	—	7	V	
ESD (HBM), JS-001-2014		—	±2k	V	
Permissible Speed		—	12,000	rpm	[b]
Relative Humidity	RH	—	90	%	T = 60°C (non-condensing)
Single-Turn Resolution		15	18	Bit	15 to 18 bits
Multi-Turn Resolution		12	32	Bit	12, 14, 16, 20, 24, 32 bits
Transmission Length[c]		—	25	meter	SSI/BiSS-C/RS-485 Differential Line

a. Exposure to absolute maximum rating conditions for extended periods may affect reliability. Stress greater than the absolute maximum rating may cause permanent damage to the device.

b. Encoder works reliably up until this permissible speed.

c. Twisted pair and shielded cable is recommended for robustness against environmental noise. Frame Ground (FG) termination near the motor frame is recommended.

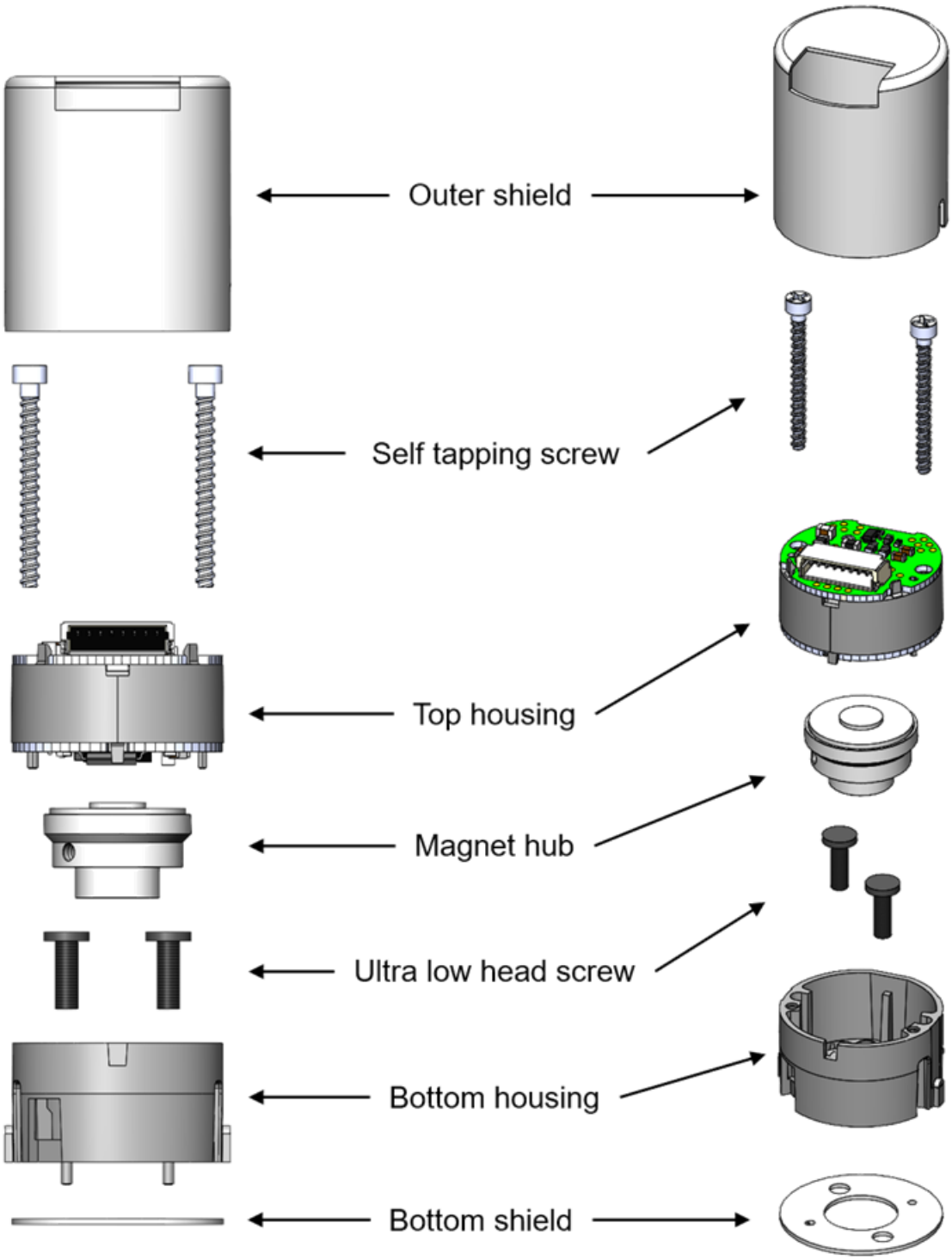
Electrical Characteristics

DC characteristics over recommended operating V_{DD} = 4.5V to 5.5V, T_A = –40°C to 115°C.

Parameter	Symbol	Min.	Typical	Max.	Unit	Remarks
Supply Voltage	V_{DD}	4.5	5.0	5.5	V	
Supply Current	I_{DD}	—	40	—	mA	
Single-Turn Accuracy		–0.1	—	+0.1	degrees	After assembly to motor and auto gain calibration completed
Power-on Standby		—	—	500	ms	
Protocol IO Drive Strength	I_{DIO}	5	20	40	mA	Differential driver
Differential Transceiver						
Hysteresis	V_{hys}	—	100	—	mV	220Ω termination
Opening	V_{open}	200	—	—	mV	
Peak-Peak Voltage	V_{PP}	—	2	—	V	
IO Line						
Output High Voltage	V_{OH}	4.4	—	—	V	No Load (V_{DD} = 5V)
Output Low Voltage	V_{OL}	—	—	0.5	V	
Input High Voltage	V_{IH}	2.8	—	5.5	V	
Input Low Voltage	V_{IL}	0	—	1.8	V	

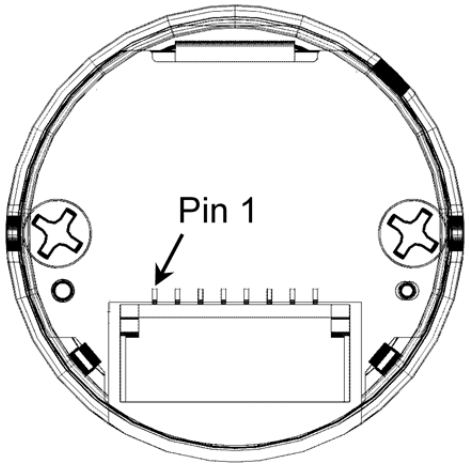
Mechanical Overview

Figure 1: Overview of the Main Encoder Components



Pinout

Figure 2: Pinout and Connector



Connector Model: SM08B-SRSS-TB(LF)(SN), JST Connector Header SMD Right Angle 8-Position 1 mm Pitch

Mating Connector Housing: SHR-08V-S or SHR-08V-S-B

Mating Connector Contact: SSH-003T-P0.2-H (AWG#32-38)

Table 1: Pinout Assignment for the Supported Communications Protocol Options

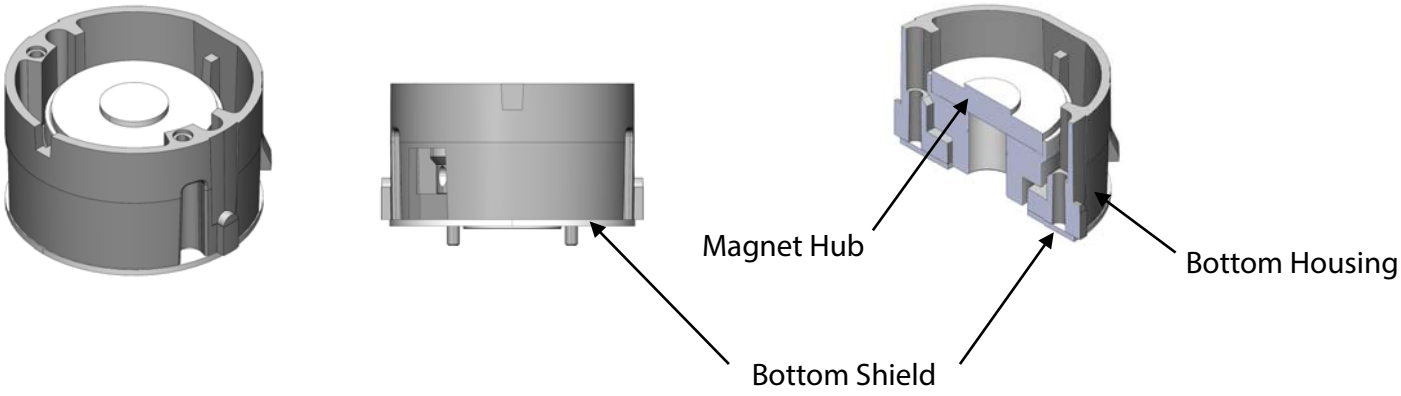
Pin	BiSS-C	SSI[a, b]	RS-485	SPI
1	+5V	+5V	+5V	+5V
2	0V	0V	0V	0V
3	MA+	SPI-CLK/SCLK+	DATA+	SPI-CLK
4	MA-	MOSI/SCLK-	DATA-	MOSI
5	SLO+	MISO/DATA+	NC	MISO
6	SLO-	SPI-NCS/DATA-	NC	SPI/NCS
7	NC	SEL1	NC	NC
8	NC	SEL2	NC	NC

a. SEL1 and SEL2 pins are required during calibration by switching to SPI communication mode.

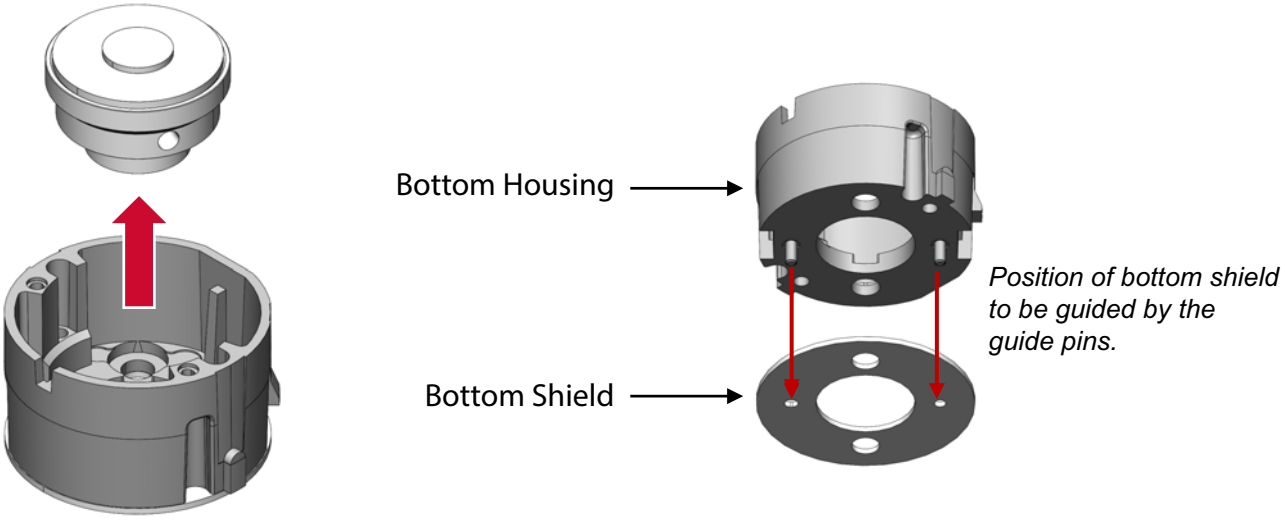
b. SSI option is configured via the shared SPI pins.

Encoder Assembly

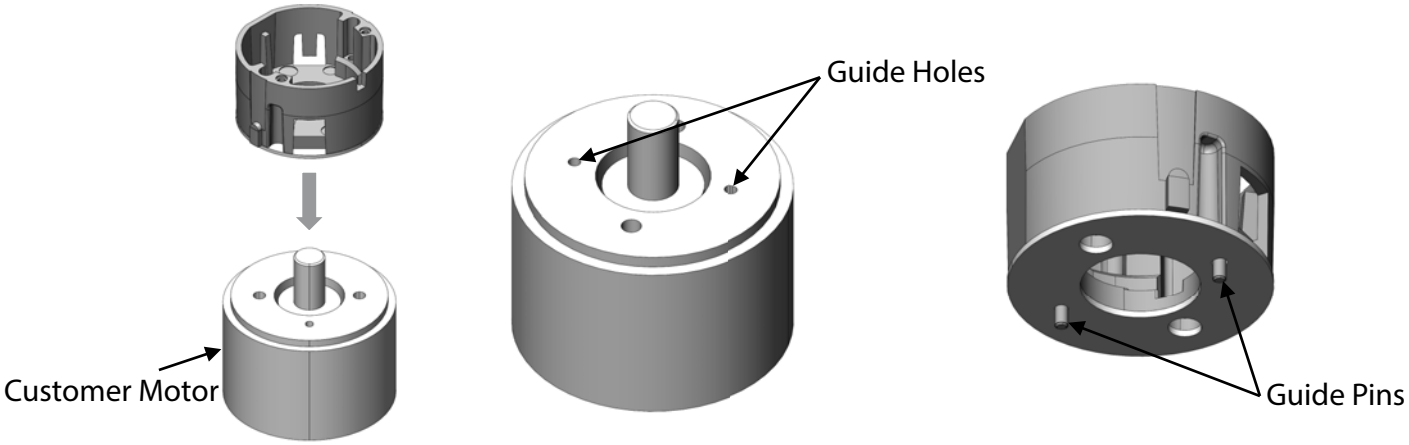
1. Remove the bottom housing, bottom shield, and the magnet-hub from the packing tray.



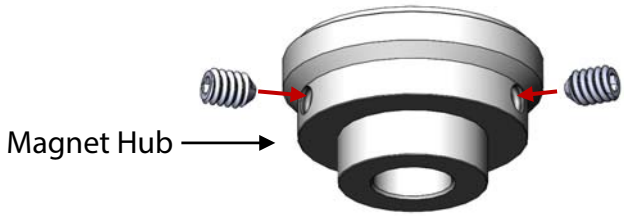
2. Remove the magnet from the housing. Handle carefully to prevent bottom shield from falling. Note that the bottom shield is guided by the two guide pins of the bottom housing.



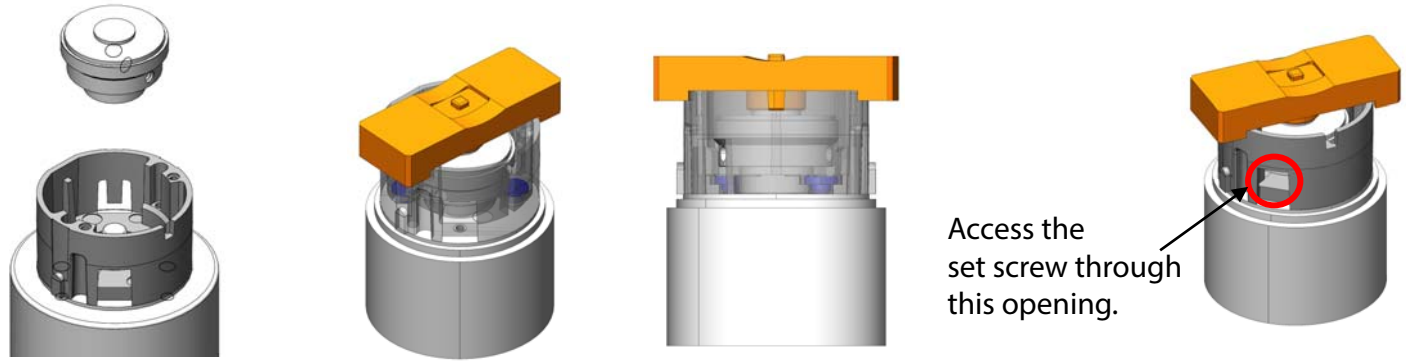
3. Install the bottom housing to the motor. Make sure the encoder guide pins at the bottom housing are inserted to the motor guide holes. Install the M2X6 ultra low head screws and tighten with the recommended torque of 0.12 Nm or 12 cNm. Thread-lock is recommended.



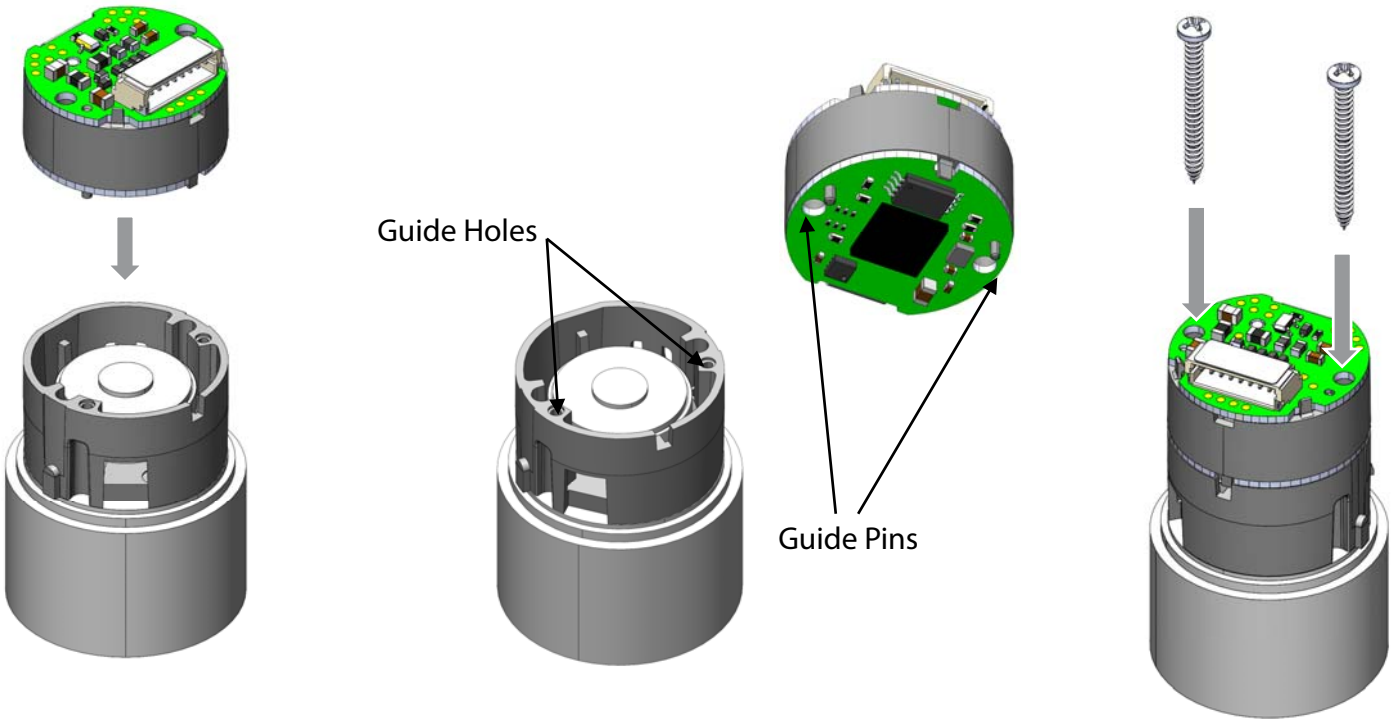
4. Install 2x M2 set screws to the magnet hub. Make sure the screw position does not block or interfere with the motor shaft or bottom housing. Thread-lock is recommended.



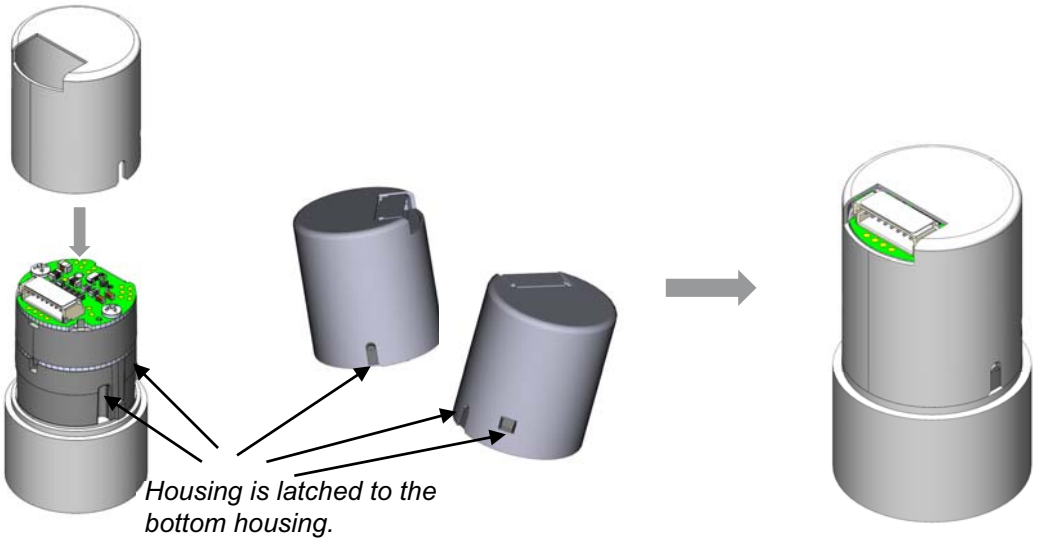
5. Install the magnet hub to the motor shaft. Use the set height jig to control the magnet height before tightening the set screws. Recommended torque 0.12 Nm or 12 cNm.



6. Top encoder housing with the PCBA is assembled to the bottom encoder housing. Make sure the guide pins from the top housing are guided into the guide holes of the bottom housing. Two M1.7x18 self tapping screws are used to lock the top encoder housing to the bottom housing: Recommended torque 0.12 Nm or 12 cNm.

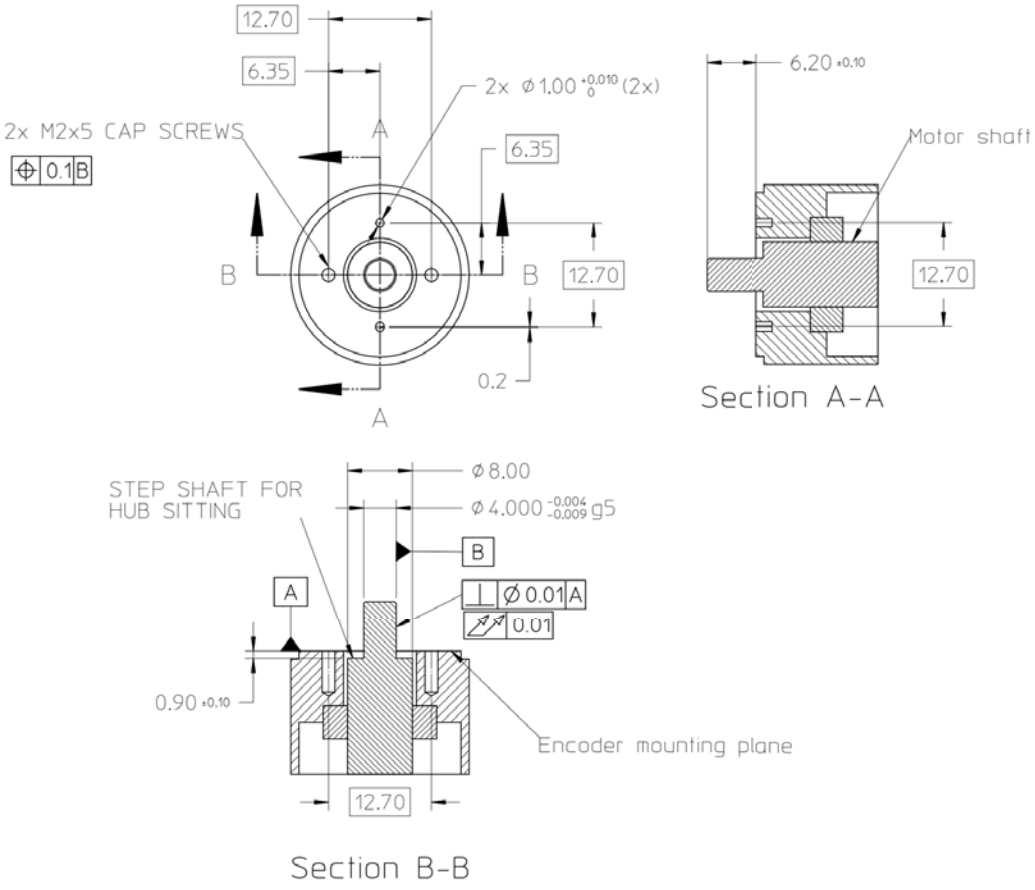


7. Outer shield is assembled to the encoder unit. Encoder has been assembled completely, and ready to perform the calibration.



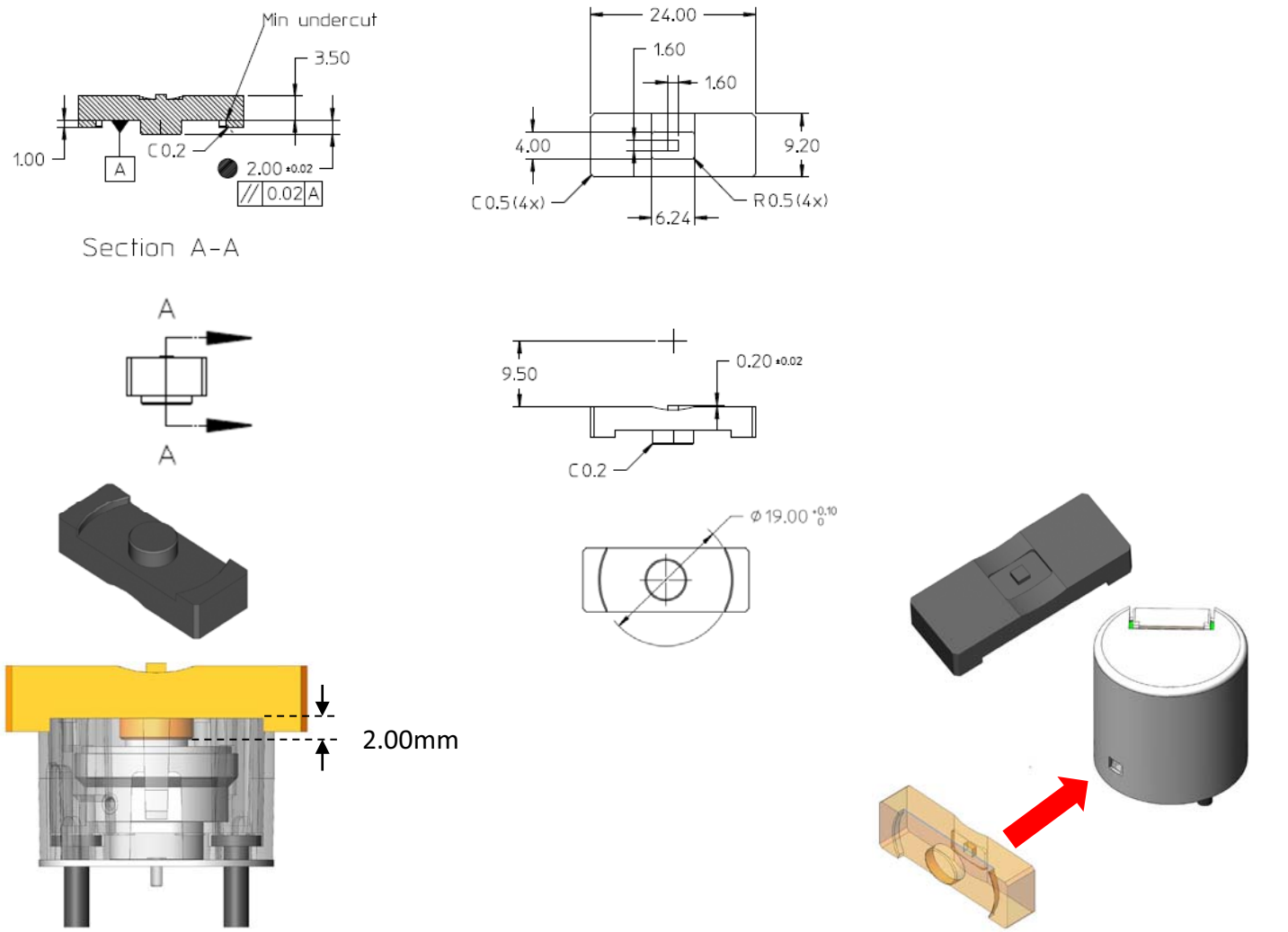
Customer Mounting Considerations

Recommended customer motor mounting dimensions for 4 mm shaft size.



Alignment Tool

Figure 3: Set Height and Housing Latch Release Tool



For height setting between magnet and the top-housing

For releasing of cover

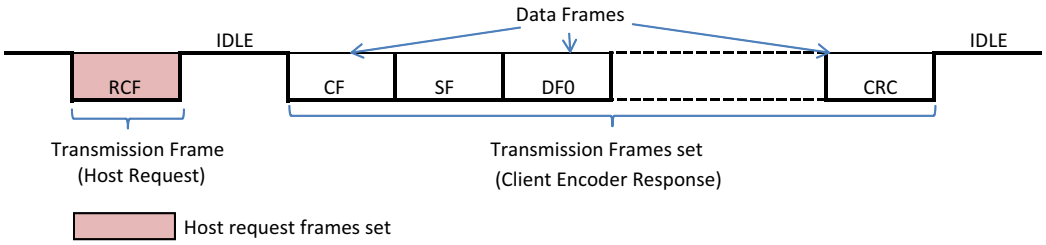
NOTE:

1. Suggested material: Mild Steel with Nickel plating.
2. Internal and external radii 0.25 mm max.
3. Dual-use tool for gap setting and also for releasing the latch for the external housing.

AS20-M42M-Kxx with RS-485 Half-Duplex Protocol

A one-to-one half-duplex serial communication is established between the client encoder and the host (for example, a servo driver). The communications are in a differential transmission format. The encoder will carry out specific operations based on the command requests made by the host. An acknowledgment of the command request is necessary before the encoder executes the requested operation, that is, by checking the Start Bit, Information Data Field and Stop Bit. Failing this checking, the encoder will not acknowledge and execute the received command request.

Figure 4: General Transmission Frames Format on Half-Duplex Line



NOTE:

- **Start of transmission frames set**: Upon detecting of the first logic of Low State 0 on the transmission line after an idling state, and if the following three bits conform to the sync code, the encoder will acknowledge it as a valid Request Control Field (RCF) and indicates the start of a transmission frame set. Otherwise, the encoder will continue to search for the next available logic of Low State 0.
- **End of transmission frames set**: After the Command Frame is detected, if there is no Start Bit after the End Bit of the last frame read, and no subsequent frame detected, end of transmission frame set is concluded.
- **Idle state**: Idle state means a space between each transmission frames set and subsequent transmission frames. At idling state, logic of output in transmission line is kept to high state 1.

Table 2: RS-485 Protocol Specifications

Over recommended operating V_{DD} = 4.5V to 5.5V, T_A = –40°C to 115°C

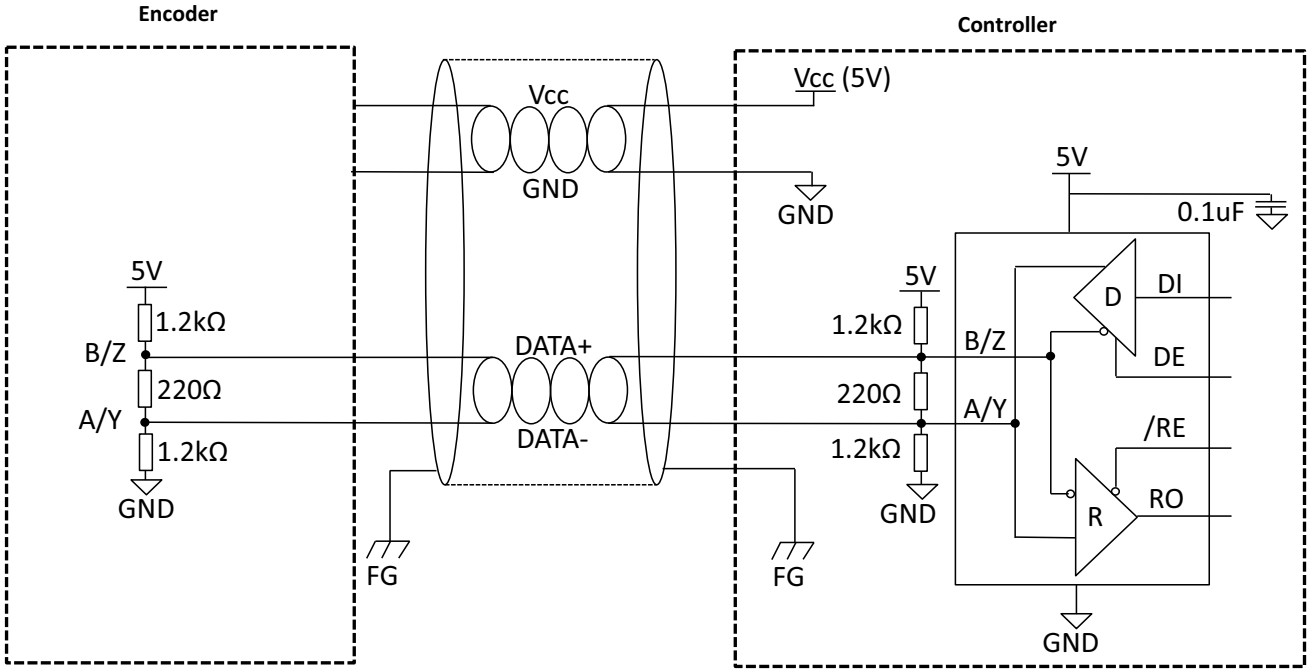
Parameters	Conditions	Min.	Typ.	Max.	Units	Remarks
Communication Baud Rate		—	2.5	10	Mbps	2.5, 5, 10 Mbps
Frame Length		—	10	—	Bit/Frame	
Cycle Time Between Frames Sets Request	Command ID3	62.5	—	—	µs	2.5 Mbps
		35	—	—	µs	5 Mbps
		20	—	—	µs	10 Mbps
Jitter	Every Frame	—	—	100	ns	2.5 Mbps
		—	—	50	ns	5 Mbps
		—	—	25	ns	10 Mbps

RS-485 Differential Connection

The recommended I/O connection between the encoder and the host driver has the following basic requirements.

1. Ensure the encoder power supply, V_{CC}, should be within the range of 4.5V ~ 5.5V.
2. For best noise immunity, use a twisted-pair shielded cable for connection to the servo driver.
3. To prevent undesirable signal reflection, terminate with 220Ω resistors.
4. Terminate the shield-wire to Frame Ground (FG) at both ends of the communication line.

Figure 5: RS-485 Half-Duplex I/O Connection



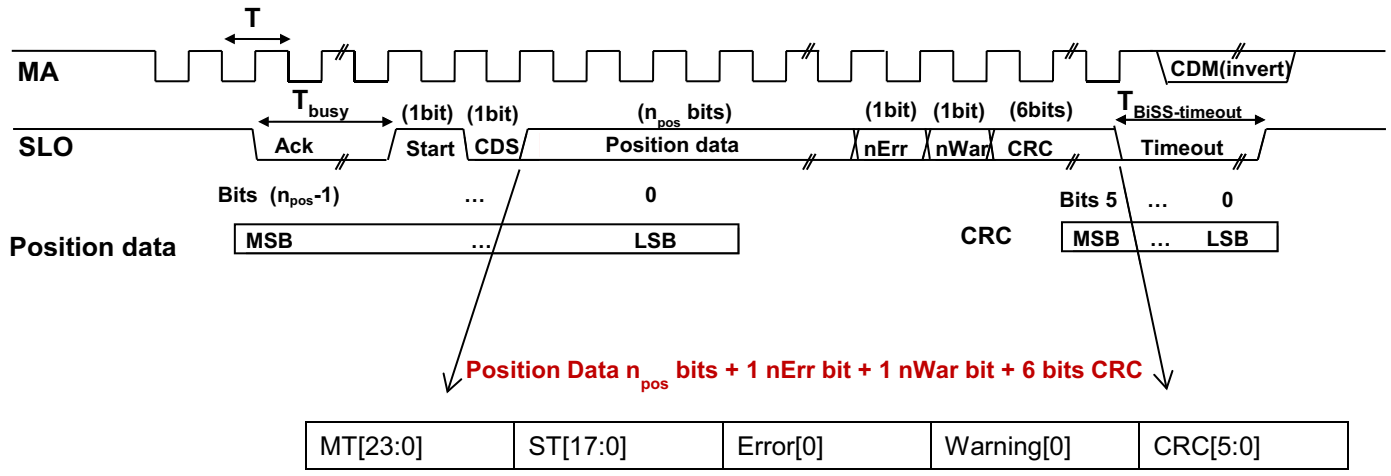
AS20-M42M-Bxx with BiSS-C Serial Interface

Table 3: BiSS-C Timing Characteristics

Over recommended operating V_{DD} = 4.5V to 5.5V, T_A = –40°C to 115°C

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units	Notes
MA Frequency	f_{MA}	—	0.08	—	10	MHz	
MA Duty	DUT_{CLK}	—	—	50	—	%	
Busy	T_{busy}	f_{MA} = 5 MHz to 10 MHz	—	$2/f_{MA}$	—	µs	
		100 kHz ≤ f_{MA} < 5 MHz	—	$1/f_{MA}$	—		
		—	—	—	5		
Timeout	$t_{BISS\text{-}timeout}$	—	$1.5/f_{MA}$	—	5	µs	
Frame to Frame		—	—	—	1	µs	

Figure 6: BiSS-C Data Field and Interface Timing Diagram



NOTE:

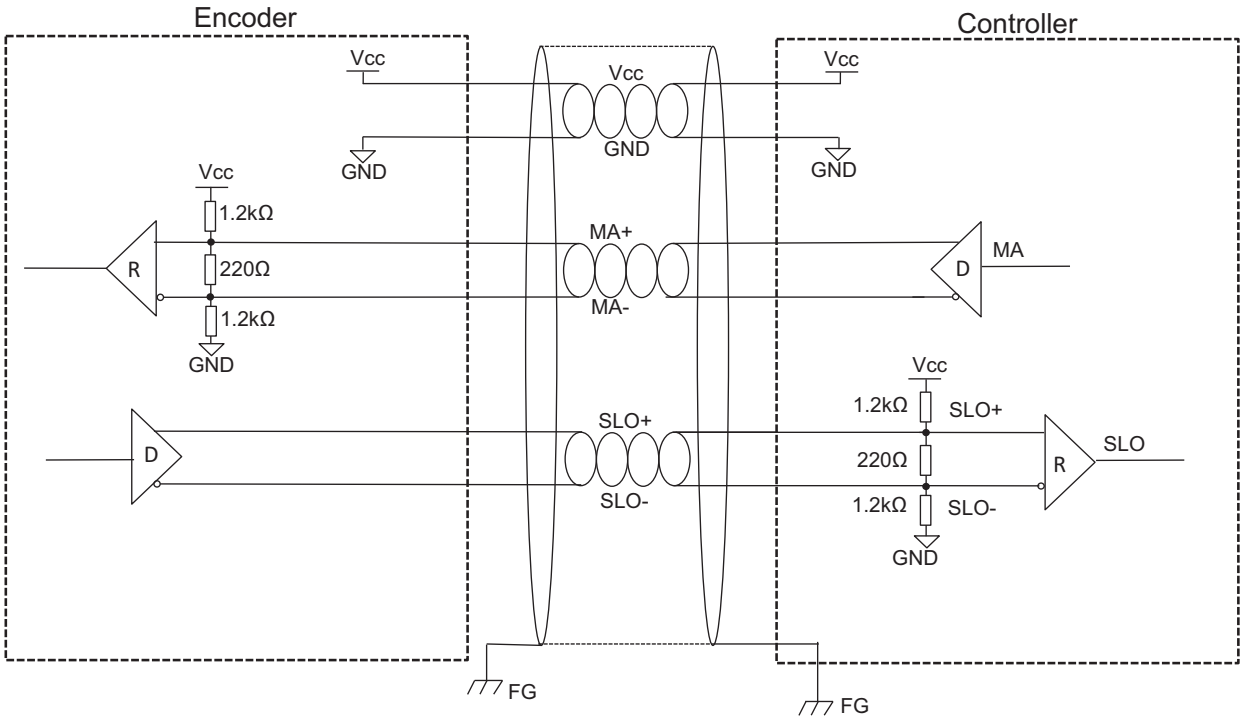
1. CRC Polynomial = Invert of (X6 + X1 + X0).
2. nErr bit is active low. (Combine all the Error Status and reflect in nErr bit)
3. nWar bit is active low. (Combine all the Warning Status and reflect in nWar bit)
4. Position data varies depending on Single-turn and Multi-turn resolution.

The recommended I/O connection between the encoder and the master driver has the following basic requirements.

BiSS-C Full-Duplex Connection

1. Provide the following encoder power supply:
   a. For the 5.0V supply, V_{CC} should be within the range of 4.5V ~ 5.5V.
2. For best noise immunity, use a twisted-pair shielded cable for connection to the servo driver.
3. To prevent undesirable signal reflection, terminate with 220Ω resistors.
4. Terminate the shield-wire to Frame Ground (FG) at both ends of the communication line.

Figure 7: BiSS-C Full-Duplex I/O Connection



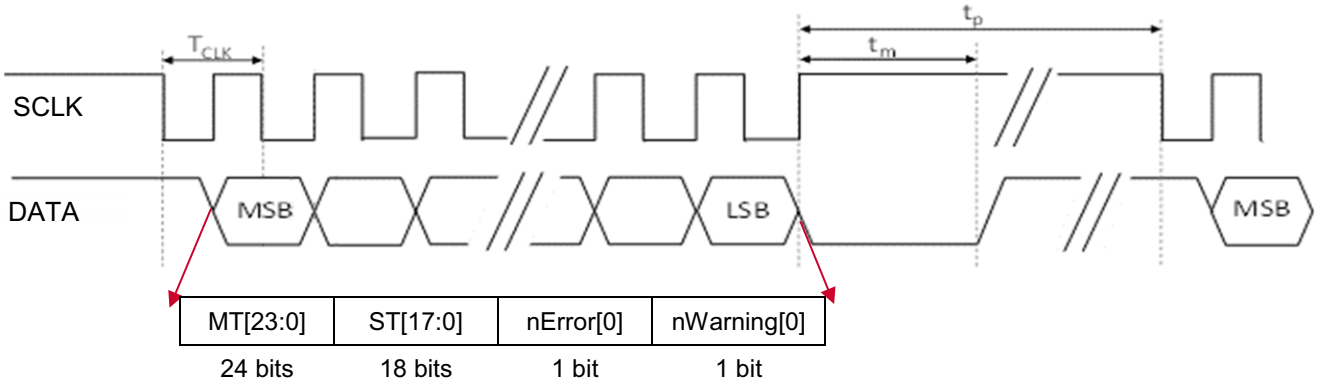
AS20-M42M-Sxx with SSI 2-Wire Serial Interface

Table 4: SSI Protocol Specifications

Over recommended operating V_{DD} = 4.5V to 5.5V, T_A = –40°C to 115°C

SSI Communication Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units	Remarks
Clock Frequency	f_{CLK}	—	100	—	10,000	kHz	
Clock Duty	DUT_{CLK}	—	—	50	—	%	
Monoflop Time	t_m	—	—	—	20	µs	
Pause Time	t_p	—	21	—	—	µs	

Figure 8: SSI Data Field and Timing Diagram



For the SSI option, the encoder calibration and device configuration is achieved by switching to the SPI mode during calibration. By toggling the logic levels of SEL1 and SEL2 pins, the SPI calibration mode can be enabled.

Table 5: Pinout Assignment for the SSI Option for Normal Operation and Calibration Mode

Pin	SSI (Normal Operation)	SPI (Calibration Mode)
1	+5V	+5V
2	0V	0V
3	SCLK+	SPI-CLK
4	SCLK–	MOSI
5	DATA+	MISO
6	DATA–	SPI-NCS
7	SEL1 = L	SEL1 = H
8	SEL2 = H	SEL2 = L

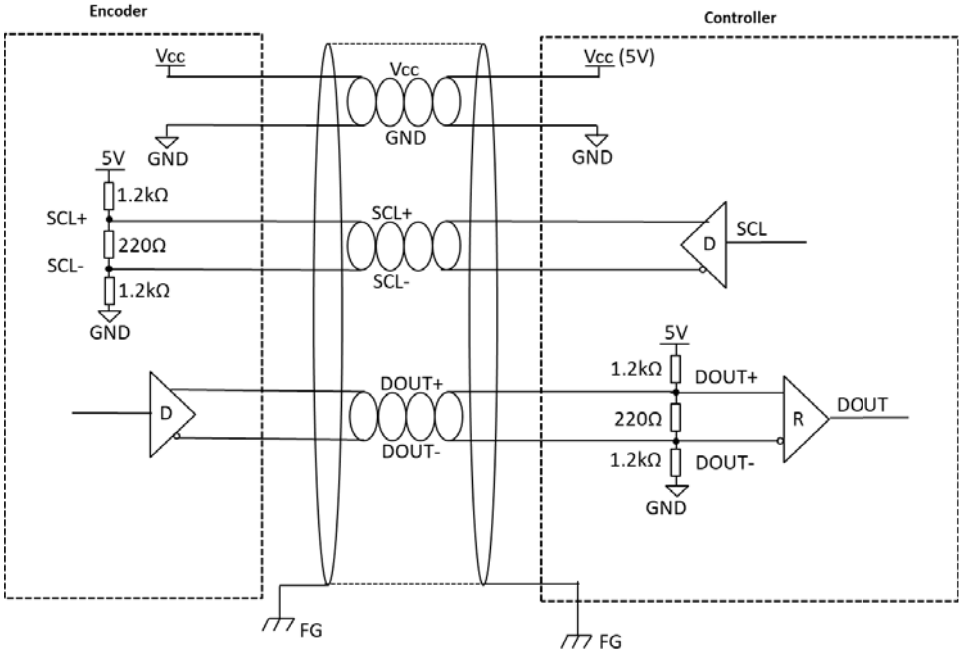
NOTE:

1. SSI option is configured using the shared SPI pins and setting the correct logic level to the SEL1 and SEL2 pins.
2. The SPI-CLK and MOSI lines require a strong driver current. This can be achieved with a level shifter or a line driver circuit.

SSI 2-Wire Full-Duplex Connection

1. Provide the following encoder power supply:
   a. For the 5.0V supply, V_{CC} should be within the range of 4.5V ~ 5.5V.
2. For best noise immunity, use a twisted-pair shielded cable for connection to the servo driver.
3. To prevent undesirable signal reflection, terminate with 220Ω resistor.
4. Terminate the shield-wire to Frame Ground (FG) at both ends of the communication line.

Figure 9: SSI Full-Duplex Connection



AS20-M42M-Pxx with API 4-Wire Protocol

Figure 10: SPI Timing Diagram

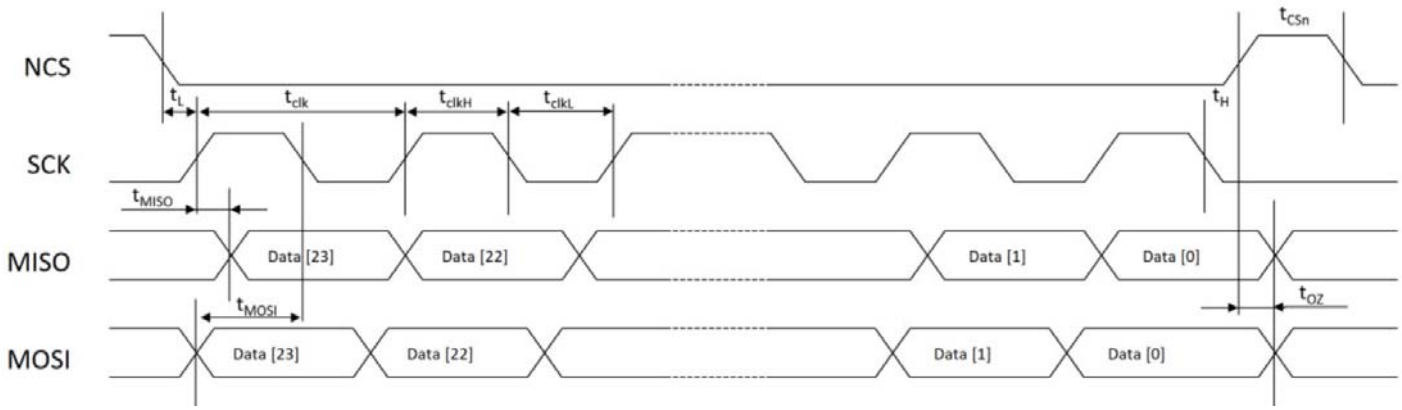


Table 6: SPI Protocol Specifications

Over recommended operating V_{DD} = 4.5V to 5.5V, T_A = –40°C to 115°C

Symbol	Description	Min.	Typ.	Max.	Units
t_L	Time between NCS falling edge and CLK rising edge	350	—	—	ns
t_{clk}	Serial clock period	100	—	—	ns
t_{clkL}	Low period of serial clock	50	—	—	ns
t_{clkH}	High period of serial clock	50	—	—	ns
t_H	Time between last falling edge of SCK and rising edge of NCS	$t_{clk}/2$	—	—	ns
t_{NCS}	High time of NCS between two transmissions	350	—	—	ns
t_{MOSI}	Data input valid to clock edge	20	—	—	ns
t_{MISO}	SCK edge to data output valid	—	51	—	ns
t_{OZ}	Time between NCS rising edge and MISO Hi-Z	—	10	—	ns

NOTE: The user should read back data to confirm data is written successfully.

AS20-M42-E01 Programming and Calibration Kit

For the benefit of the customers to evaluate the AS20 series encoders, an MCU based programming kit is available. This programming kit supports the various AS20 protocol options, with the same hardware and Windows-based GUI.

Figure 11: Programming Kit GUI Window

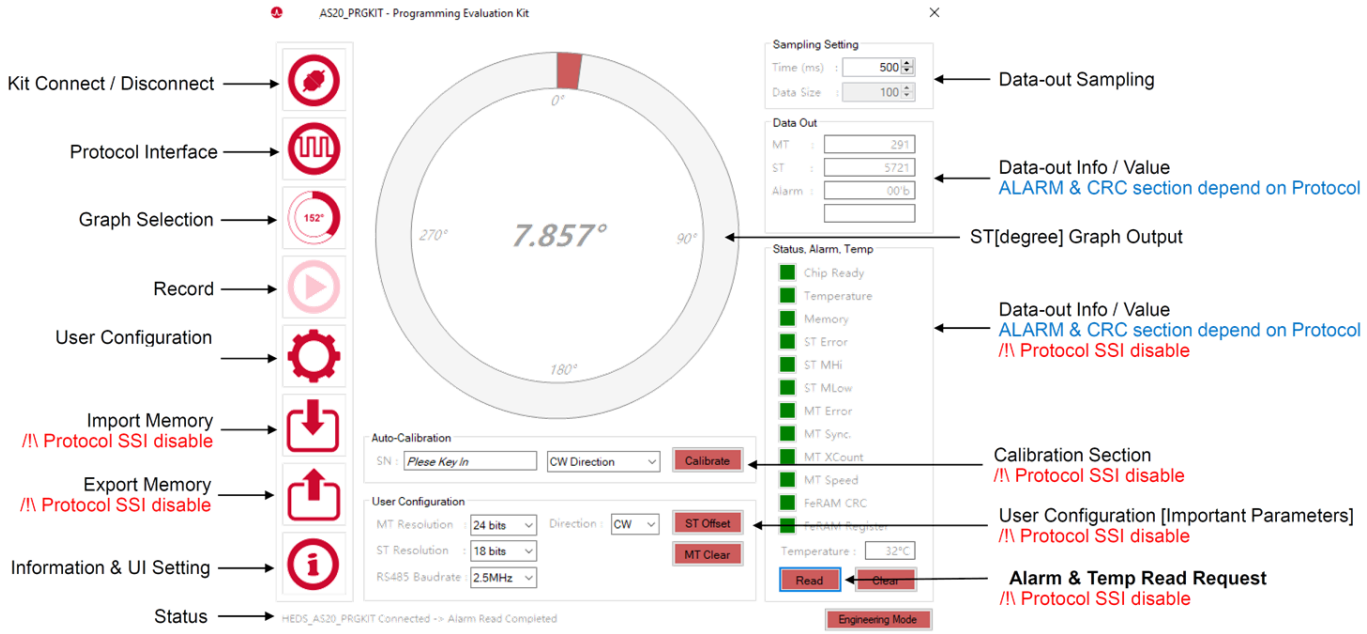
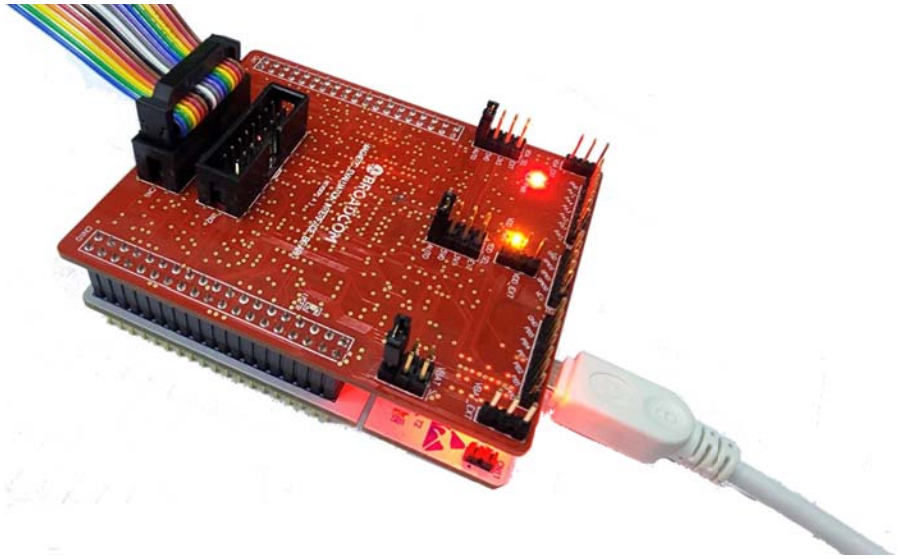


Figure 12: AS20-M42-E01 Programming and Calibration Kit



Part Number Information

Figure 13: Encoder Part Number Definition

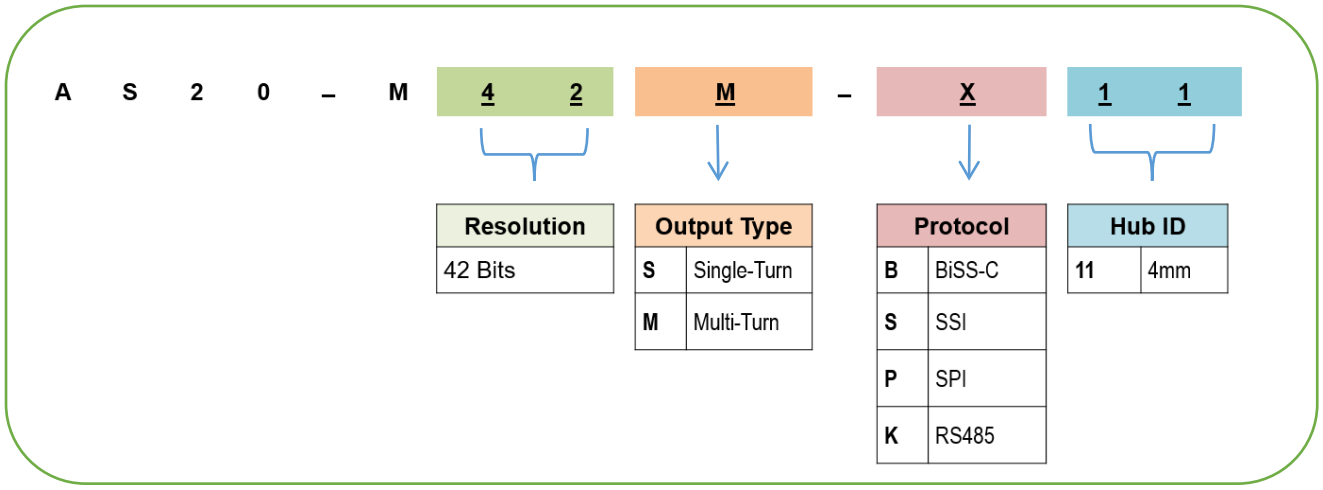


Table 7: Available Part Numbers

Part Number	Product Description	Standard Packing Increments (SPI)	Packing Method
AS20-M42M-B11	20 mm Kits 42 bits MT 5V 4 mm BiSS-C	120	12 pieces/tray, 10 trays per carton
AS20-M42M-B11	20 mm Kits 42 bits MT 5V 4 mm SSI 2-Wire	120	12 pieces/tray, 10 trays per carton
AS20-M42M-P11	20 mm Kits 42 bits MT 5V 4 mm SPI 4-Wire	120	12 pieces/tray, 10 trays per carton
AS20-M42M-K11	20 mm Kits 42 bits MT 5V 4 mm RS-485	120	12 pieces/tray, 10 trays per carton
AS20-C300	AS20-Series 300 mm 8 Pins Cable Connector	100	100 pieces per box
AS20-M42-010	AS20-Series Set Height Jig	1	1 piece per box
AS20-M42-E01	AS20-Series Programming Kit	1	1 piece per box