

AS33-M50M Series

50-bit Full Magnetic Energy Harvesting Multi-Turn Absolute Encoder Module



Introduction

Description

The Broadcom[®] AS33-M50M series encoder is an absolute magnetic encoder that offers 18-bit single-turn (ST) and 32-bit multi-turn (MT) counts, hence a combined 50-bit high resolution encoder. The design of the encoder features a state-of-the-art Energy Harvesting Multi-Turn technology. To improve system integrity and simplicity, a single magnetic solution is responsible for both ST and MT positions generation.

The key advantage of the AS33-M50M series encoder is the patented energy-harvesting technology for revolution tracking. This technology converts the rotating magnetic field into electrical energy, which powers the revolution tracking circuit. The beauty of the Energy Harvesting technology is that the same amount of energy is generated independent of the encoder rotation speed and direction. The generated energy is sufficient to power up the multi-turn counter circuitry. Therefore, no loss of revolution count occurs even in the absence of external power supply. On the other hand, when comparing to battery backed-up multi-turn counting, this technology does not require periodic maintenance of the battery backup components and the down time associated with it.

The AS33-M50M series encoder has a built-in communication protocol, which is supported by a full-duplex or half-duplex line transmission drive, offering good noise immunity for a more robust transmission of data up to 10 Mb/s in harsh industrial applications. As a magnetic

technology-based encoder, it resists contamination, such as dust and fingerprints on the sensing element. As a result, it requires less stringent control in production handling and harsh environments.

Operating Theory

The AS33-M50M series encoder contains two major blocks: the MT revolution tracking block and the ST absolute position block. Both MT and ST blocks are based on magnetic technology. The MT block uses energy harvesting technology, while the ST block implements a magnetic sensor for absolute position generation.

When encoder is powered up, the encoder absolute position is generated by synchronizing the MT revolution count to the ST absolute position; therefore, it is tracked by the ST absolute position.

Features

- Patented Energy Harvesting technology
- Total 50-bit resolution with 18-bit single-turn and 32-bit multi-turn
- Overall encoder outer diameter is 33 mm with a maximum height of 20 mm
- Built-in communication protocol (option): SSI, BiSS C, and RS-485 half-duplex
- Built-in temperature sensor
- Operating temperature range is -40°C to 115°C

Benefits

- No battery or capacitor is required for position detection during power failure
- Immediate position detection on power-up
- Cost-effective solution
- Robust environment

Applications

- Small motors and linear actuators
- Robotic automation and engineering
- Drones
- Test and measurement equipment

NOTE: The encoder is not recommended for use in life critical applications; for example, ABS braking systems, power steering, life support and critical care systems, and medical equipment. Contact a Broadcom sales representative if more clarification is needed.

Product Specifications

Table 1: Absolute Maximum Rating^a

Parameters	Symbol	Min.	Typ.	Max.	Units	Remarks
Supply Voltage	V_{DD}	-0.3	—	15	V	
Operating Temperature	T_J	-40	—	115	°C	
Storage Temperature	T_S	-40	—	115	°C	
Permissible Speed	—	—	—	12,000	rpm	Note ^b

a. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

b. The encoder works reliably up until this permissible speed.

Recommended Operating Conditions

Table 2: Electrical Specifications over $T_{amb} = 25^{\circ}\text{C}$

Parameters	Conditions	Min.	Typ.	Max.	Units	Remarks
Supply Voltage	—	4.5	—	5.5	V	AS33-M50M-x5x
		7	—	12.5	V	AS33-M50M-x7x
Supply Current	Without load	—	80	90	mA	AS33-M50M-x5x
		—	65	75	mA	AS33-M50M-x7x
System Accuracy	With electrical correction ^a	—	± 0.087	—	deg	At 25°C
		—	—	± 0.35	deg	Over -40°C to 115°C and 12,000 RPM

a. Under recommended magnetic shielding enclosure and calibration at an ambient temperature of 25°C.

Table 3: Mechanical Specifications

Parameters	Conditions	Min.	Typ.	Max.	Units
Maximum Axial Shaft Play	—	—	—	± 0.2	mm
Maximum Radial Shaft Play	—	—	—	± 0.05	mm
Vibration	Per IEC 60068-2-6	—	—	10G; 10 Hz ~ 2000 Hz	—
Shock	Per IEC 60068-2-27	—	—	6 ms; half sine; 200G	—

Table 4: Table 4. Environmental Specifications

Parameters	Conditions	Min.	Typ.	Max.	Units
Relative Air Humidity (Non-Condensing)	T _{amb} = 60°C	—	90	—	RH%
Electrostatic Discharge (Module Level)	Per IEC 61000-4-2	—	—	± 4	kV

Table 5: Internal Temperature Sensor Specifications

Parameters	Conditions	Min.	Typ.	Max.	Units	Remarks
Resolution	—	—	1	—	°C	
Accuracy of the Evaluation Circuit	25°C to 115°C	-5	—	5	°C	
	-40°C to 25°C	-7	—	7	°C	
Temperature Range	—	-40	—	125	°C	Notes ^a and ^b
Calculation Time	—	—	—	100	ms	

a. The temperature error alarm setting = 115°C.

b. The temperature sensor is not available for an SSI option product.

Table 6: Encoder Specifications

Parameter	Remarks
Single-turn Resolution	Single-turn 18 bits (262,143 counts)
Multi-turn Resolution	Multi-turn 32 bits (4,294,967,295 counts)
Counting Direction	Increase with counter-clockwise (CCW) motor shaft rotation, view from the top of the encoder
Initialization Time	< 1 second

Protocol Specifications

SSI Specifications

Table 7: SSI Interface

Interface	Circuit	Remark
Shift Clock (SCLK)	Receiver (P/N: ISL3283E)	
Data Output (DAT)	Transmitter (P/N: ISL3295E)	

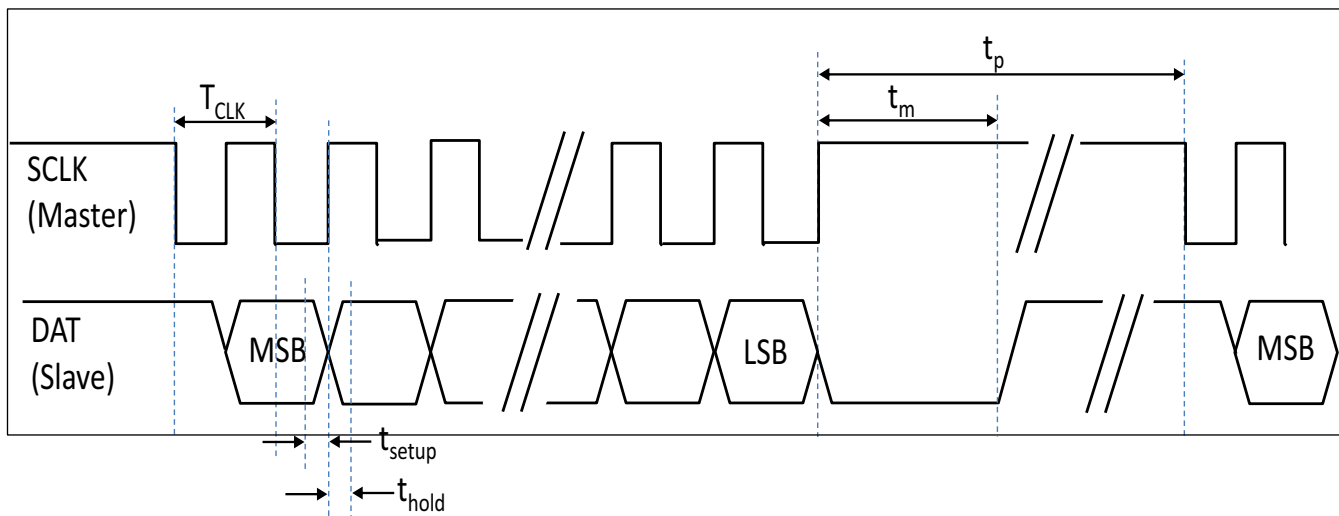
Table 8: SSI Timing Characteristics

Parameters	Symbol	Conditions	Min.	Typ.	Max.	Units	Remark
Clock Frequency	f_{CLK}	—	100	—	1000	kHz	
Clock Duty	DUT_{CLK}	—	—	50	—	%	
Monoflop Time	t_m	—	—	—	20	μs	
Pause Time	t_p	—	21	—	—	μs	

Table 9: SSI Data Fields

MT[31:0]	ST[17:0]	Status[0]	Alarm[0]
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Figure 1: SSI Interface Timing Diagram



BiSS C Specifications

Table 10: BiSS C Interface

Interface	Circuit	Remark
Serial Clock (MA)	Receiver (P/N: ISL3283E)	
Serial Data Output (SLO)	Transmitter (P/N: ISL3295E)	

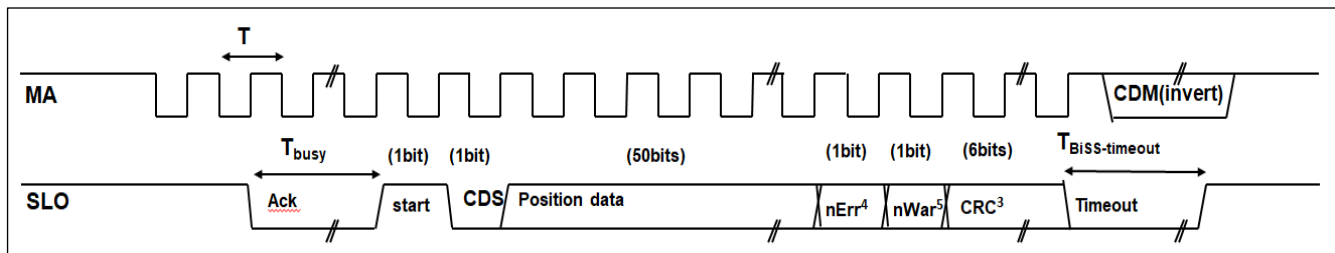
Table 11: BiSS C Timing Characteristics

Parameters	Symbol	Conditions	Min.	Typ.	Max.	Units	Remark
MA Frequency	f_{MA}	—	0.5	—	10	MHz	
MA Duty	DUT_{CLK}	—	—	50	—	%	
Busy	T_{busy}	—	$2/f_{MA} + 27.3 \mu s$	—	$18/f_{MA} + 27.6 \mu s$	μs	
Timeout	$t_{BiSS-timeout}$	—	2	—	5	μs	
Frame to Frame		—	9	—	—	μs	

Table 12: BiSS C Data Fields

MT[31:0]	ST[17:0]	Error[0]	Warning[0]	CRC[5:0]
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Figure 2: BiSS C Interface Timing Diagram



NOTE:

1. CRC polynomial = Invert of $(X^6 + X^1 + X^0)$.
2. nErr bit is active low. (Combine all of the error statuses and reflect in the nErr bit.)
3. nWar bit is active low. (Combine all of the warning statuses and reflect in the nWar bit.)

BiSS C Command List

Command	Register
8-bit Temperature Readout	Read address 0x75
50-bit Position Zero Reset	Write address 0x4A with data 0x03

Register Communication and Assignment

Refer to the BiSS Interface Protocol Description (BiSS C) Rev C6 document for detailed information at the following website:
https://www.ichaus.de/upload/pdf/BiSS_C_protocol_C6en.pdf

RS-485 Half-Duplex Specifications

Table 13: RS-485 Half-Duplex Interface

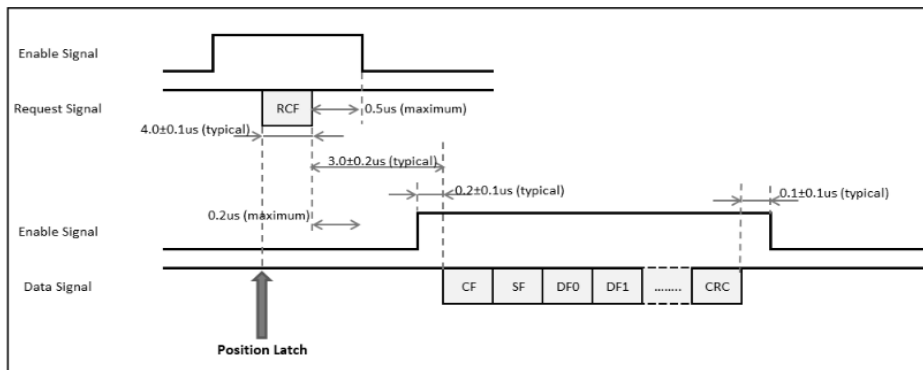
Interface	Circuit	Remark
RS-485 Serial Data (DAT)	Receiver (P/N: ISL3283E)	
RS-485 Serial Data (DAT)	Transmitter (P/N: ISL3295E)	

Table 14: RS-485 Half-Duplex Timing Characteristics

Parameter	Condition	Min.	Typ.	Max.	Units	Remark
Communication Baud Rate	—	—	—	2.5	MHz	
Frame Length	—	—	10	—	bit/frame	
Jitter	—	—	—	100	ns	

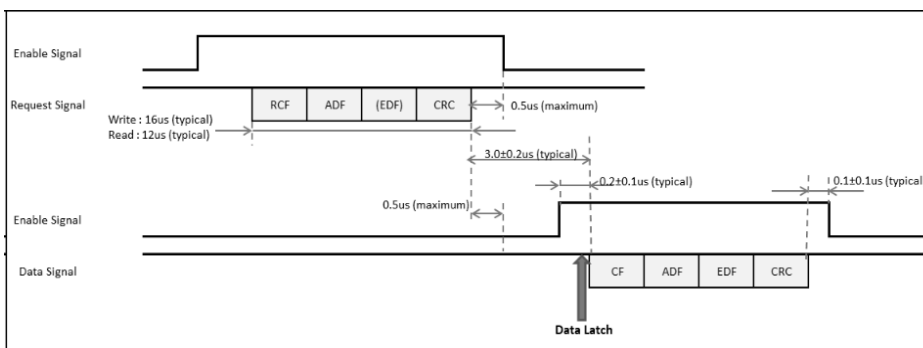
Position Read Frame

Figure 3: Timing Characteristics of Enable, Request, and Data Signals for the Position Read Frame



EEPROM Read/Write Frame

Figure 4: Timing Characteristics of Enable, Request, and Data Signals for the EEPROM Read/Write Frame

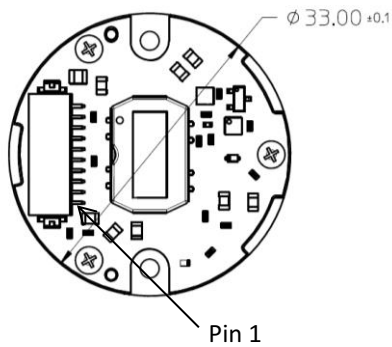


Register Communication and Assignment

Refer to the AS33-M50M software specification document for detailed information.

Table 15: Connector Output Assignment

Pin Number	SSI	BiSS C	RS485 Half-Duplex
1	GND	GND	GND
2	VDD	VDD	VDD
3	SCLK-	MA-	NC
4	SCLK+	MA+	NC
5	DAT-	SLO-	DATA-
6	DAT+	SLO+	DATA+
7	UART RX	NC	NC
8	UART TX	NC	NC
9	Zero reset	NC	NC
10	GND	GND	GND

Figure 5: Pin 1 Location Viewed from the Encoder Top

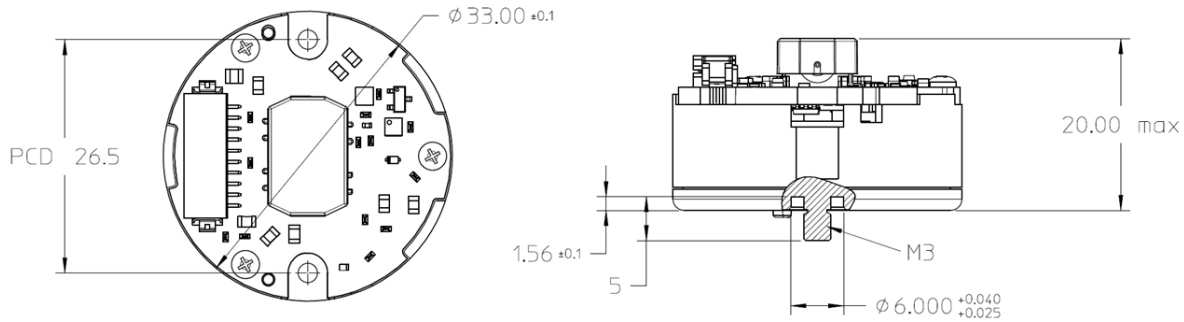
The following are the recommended mating connectors:

- Hirose Part No: DF13-10S-1.25C (CL No.536-0006-8)
- Hirose (Terminal Pin for Wire 26~30AWG): DF13-2630SCF (CL No.536-0300-5)

Mechanical Dimensions

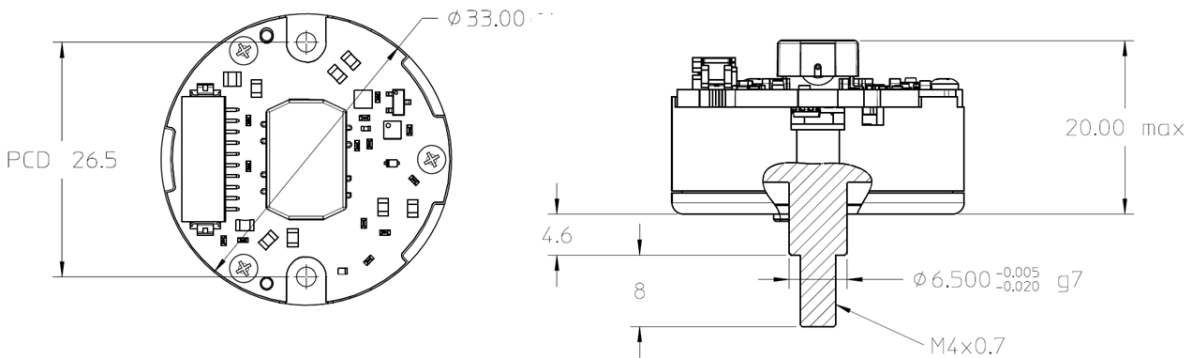
M3 Hub Screw

Figure 6: Package Dimensions for an M3 Hub Screw



M4 Hub Screw

Figure 7: Package Dimensions for an M4 Hub Screw



NOTE:

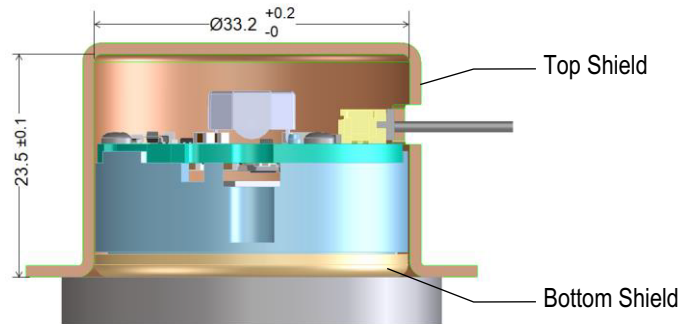
1. Dimensions are in millimeters.
2. Unless otherwise specified, all tolerances are within ± 0.5 mm.
3. Do not use a ferro-magnetic shaft for the motor.

Magnetic Shield Design Guidelines

To eliminate or minimize the influence of external magnetic field interference on the encoder operation, use of shielding is mandatory. A recommended design of shielding is made of 1.2-mm mild steel (SPCC) as shown in Figure 6.

Figure 8: Recommended Magnetic Shield Design

Shield Requirement
 Minimum Thickness: 1.2 mm
 Material: Ferromagnetic

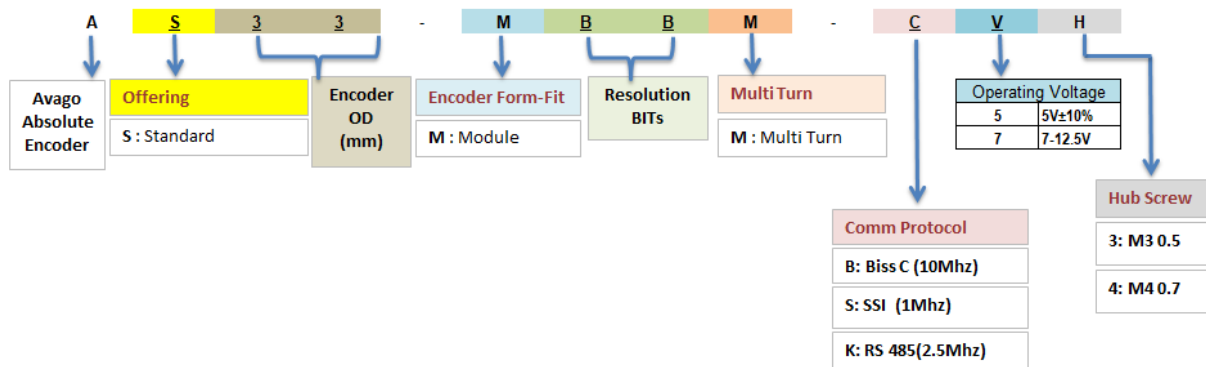


NOTE:

1. External magnetic interference varies by the application and operating environment.
2. Proper study of external magnetic fields and appropriate shield design is required.
3. Consult the factory for technical assistance.

Ordering Information

Encoder Part Numbers



NOTE: Refer to the factory for sample orders and lead times.

Calibration Kit Tools

- AS33-M50-010 Electronic Accuracy Calibration Kit
- AS33-M50-020 Radial Centering Jig

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