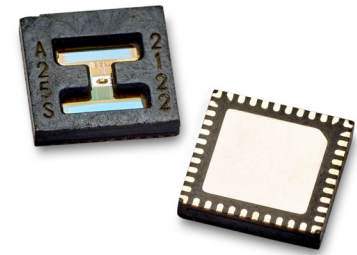


AR25

Smart Programmable 25-Bit Reflective Absolute Single-Turn Encoder



Overview

The Broadcom[®] AR25 is a miniature absolute encoder ASIC that is designed to cater the growing demand for space-constraint applications. Employing the advance reflective optical-encoding theory, the AR25 Series offers high position accuracy with correction algorithm, which is unattainable by the magnetic encoders.

The AR25 encoder is a one-chip solution that has the flexibility to cater variable overall diameters, ranging from 30 mm to 60 mm. The AR25 also supports through-hole solutions up to 30 mm in diameter. User-programmable resolutions are from 15-bit up to 25-bit single-turn absolute outputs. In addition, the AR25 also provides differential analog Sine/Cosine or digital incremental ABIUVW signals with configurable CPRs and pole-pairs. The AR25 also comes with a state-of-the-art Auto-Calibration feature that ease customer's integration into their end systems.

The AR25 series also supports integration with Broadcom proprietary battery-less Energy Harvesting Multi-Turn (EHMT) solution. Alternatively, other multi-turn solutions like gear-based and battery back-up are also supported by a dedicated MT interface port.

For power supply, the ASIC supports dual-mode operating voltages of either 3.3V or 5V, which are suitable for handheld and portable device applications. Operating temperature range is -40°C to 125°C , suitable for most industrial applications.

To enhance the user system-design flexibility, the AR25 offers various protocols that are selectable by the User. Among the protocols, available are encoder serial link (ESL) or RS485 half-duplex protocol, SSI, BiSS-C, and SPI 4-wire.

NOTE: This product is not specifically designed or manufactured for use in any specific devices. Customers are solely responsible for determining the suitability of the product for its intended application and solely liable for all loss, damage, expense, or liability in connection with such use.

Applications

- Robotic automation and engineering
- Factory automation and drone
- Medical and dentistry devices and equipment
- High-accuracy portable and handheld devices
- Miniature motor, servo motor, and linear actuator
- Through-shaft motor, gear motor, and speed reducer

Part Ordering

Table 1: Part Ordering Information

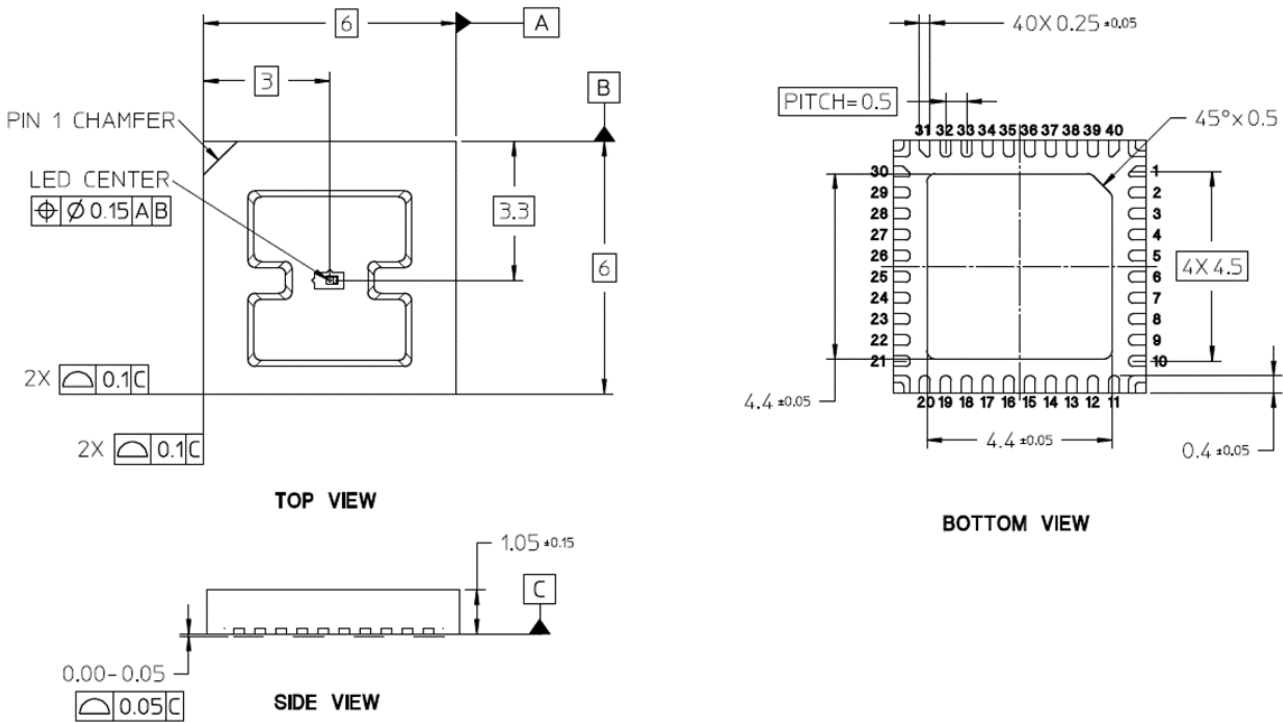
Ordering Information	Type	Description	
AR25-AS01	AR25 encoder	AR25 single-turn absolute encoder with standard protocols 100 pcs	
AR25-AB01	AR25 encoder	AR25 single-turn absolute encoder with BiSS-C protocols 100 pcs	
AR25-AS02	AR25 encoder	AR25 single-turn absolute encoder with standard protocols 1000 pcs	
AR25-AB02	AR25 encoder	AR25 single-turn absolute encoder with BiSS-C protocols 1000 pcs	
W1202-495249	AR25 bearing stage sample	AR25 PCBA on bearing stage with code wheel Consult factory for available options.	
AR25-AS1P-A12T	AR25 Evaluation PCBA + through-hole rotary code wheel	AR25 PCBA + code wheel hub 512CPR 6-mm through-hole, standard protocols	
AR25-AS1P-A13T		AR25 PCBA + code wheel hub 512CPR 8-mm through-hole, standard protocols	
AR25-AS1P-A18T		AR25 PCBA + code wheel hub 512CPR 12-mm through-hole, standard protocols	
AR25-AS1P-A15T		AR25 PCBA + code wheel hub 1024CPR 15-mm through-hole, standard protocols	
AR25-AS1P-A20T		AR25 PCBA + code wheel hub 1024CPR 20-mm through-hole, standard protocols	
AR25-AS1P-A30T		AR25 PCBA + code wheel hub 1024CPR 30-mm through-hole, standard protocols	
AR25-AB1P-A12T		AR25 PCBA + code wheel hub 512CPR 6-mm through-hole, BiSS-C protocols	
AR25-AB1P-A13T		AR25 PCBA + code wheel hub 512CPR 8-mm through-hole, BiSS-C protocols	
AR25-AB1P-A18T		AR25 PCBA + code wheel hub 512CPR 12-mm through-hole, BiSS-C protocols	
AR25-AB1P-A15T		AR25 PCBA + code wheel hub 1024CPR 15-mm through-hole, BiSS-C protocols	
AR25-AB1P-A20T		AR25 PCBA + code wheel hub 1024CPR 20-mm through-hole, BiSS-C protocols	
AR25-AB1P-A30T		AR25 PCBA + code wheel hub 1024CPR 30-mm through-hole, BiSS-C protocols	
AR25-AS1B-A12T		AR25 encoder + through-hole rotary code wheel	AR25 ASIC + code wheel hub 512CPR 6-mm through-hole, standard protocols
AR25-AS1B-A13T			AR25 ASIC + code wheel hub 512CPR 8-mm through-hole, standard protocols
AR25-AS1B-A18T			AR25 ASIC + code wheel hub 512CPR 12-mm through-hole, standard protocols
AR25-AS1B-A15T			AR25 ASIC + code wheel hub 1024CPR 15-mm through-hole, standard protocols
AR25-AS1B-A20T	AR25 ASIC + code wheel hub 1024CPR 20-mm through-hole, standard protocols		
AR25-AS1B-A30T	AR25 ASIC + code wheel hub 1024CPR 30-mm through-hole, standard protocols		
AR25-AB1B-A12T	AR25 ASIC + code wheel hub 512CPR 6-mm through-hole, BiSS-C protocols		
AR25-AB1B-A13T	AR25 ASIC + code wheel hub 512CPR 8-mm through-hole, BiSS-C protocols		
AR25-AB1B-A18T	AR25 ASIC + code wheel hub 512CPR 12-mm through-hole, BiSS-C protocols		
AR25-AB1B-A15T	AR25 ASIC + code wheel hub 1024CPR 15-mm through-hole, BiSS-C protocols		
AR25-AB1B-A20T	AR25 ASIC + code wheel hub 1024CPR 20-mm through-hole, BiSS-C protocols		
AR25-AB1B-A30T	AR25 ASIC + code wheel hub 1024CPR 30-mm through-hole, BiSS-C protocols		
AR25-E01	Programming + calibration set		AR25 reference design programming and calibration kit + software interface (SPI 4-wires)
AR25-AC25			AR25 reference design accuracy calibration station

NOTE:

- Standard protocols consist of encoder serial link (ESL), RS-485, synchronous serial interface (SSI), and serial peripheral interface (SPI 4-wire).
- BiSS-C protocols consist of BiSS-C, encoder serial link (ESL), RS-485, synchronous serial interface (SSI), and serial peripheral interface (SPI 4-wire).

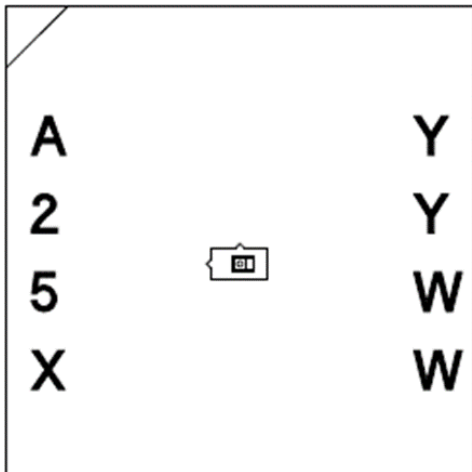
Mechanical Dimensions

Figure 1: AR25 Mechanical Dimensions



Package Marking

Figure 2: AR25 Package Marking



MARKING CONFIGURATION

PART NUMBER	PROTOCOL	MARKING
AR25S	STANDARD	A25S
AR25B	BISS	A25B

YYWW: YEAR, WORK WEEK

AR25 Pinout

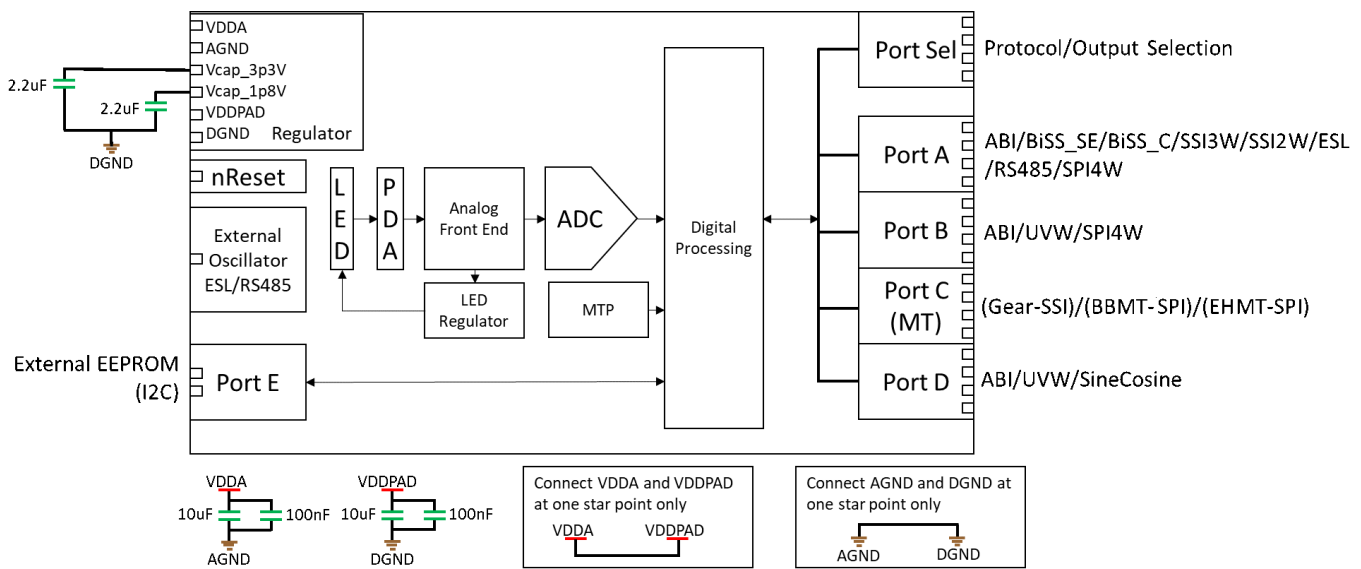
Table 2: Pinout

Pin No.	Name	Function
1	Port_B3	I/O protocol depends on the Port_SEL[3:0] or internal register selection.
2	Port_B2	
3	Port_B1	
4	Port_B0	
5	VDDPAD	Digital power 3.3V/5V.
6	DGND	Digital ground.
7	Port_A3	I/O protocol depends on the Port_SEL[3:0] or internal register selection.
8	Port_A2	
9	Port_A1	
10	Port_A0	
11	No Connection	Open/no connection.
12	No Connection	
13	No Connection	
14	No Connection	
15	No Connection	
16	No Connection	
17	No Connection	
18	No Connection	
19	No Connection	
20	No Connection	

Pin	Name	Function
21	Port_C0	Multi-turn I/O protocol depends on the Port_SEL[3:0] or internal register selection.
22	Port_C1	
23	Port_C2	
24	Port_C3	
25	AGND	Analog ground.
26	VDDA	Analog power 3.3V/5V.
27	Port_D0	Incremental and analog output depend on the Port_SEL[3:0] or internal register selection.
28	Port_D1	
29	Port_D2	
30	Port_D3	
31	nRESET	Power-up delay or ASIC reset pin.
32	Port_SEL0	Protocol selection or output selection pin. See Port Selections for details.
33	Port_SEL1	
34	Port_SEL2	
35	Port_SEL3	
36	Port_E0	I ² C SDA external EEPROM.
37	Port_E1	I ² C SCL external EEPROM.
38	VDDcap_1p8V	Buffer capacitor 1.8V.
39	VDDcap_3p3V	Buffer capacitor 3.3V.
40	External Oscillator	50-MHz external oscillator input.

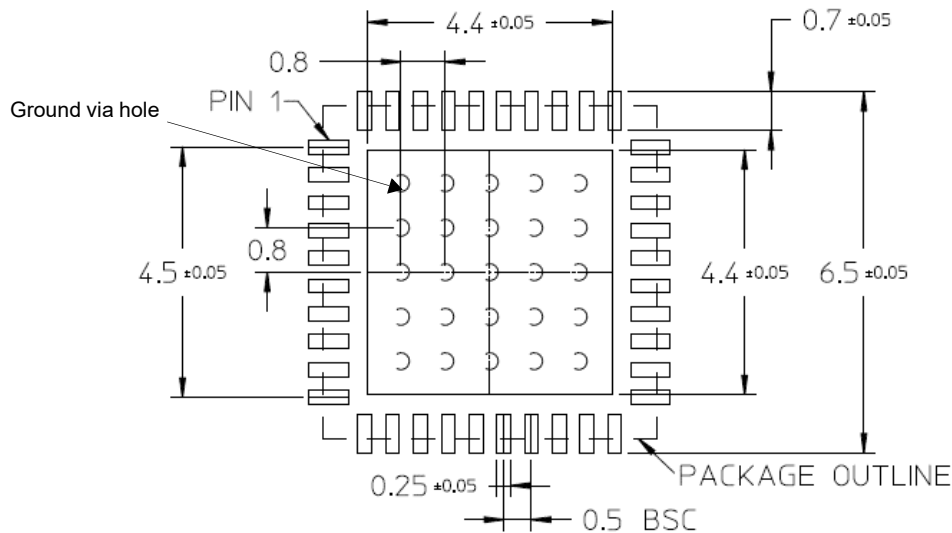
Functional Description

Figure 3: AR25 Block Diagram



Recommended PCB Land Pattern

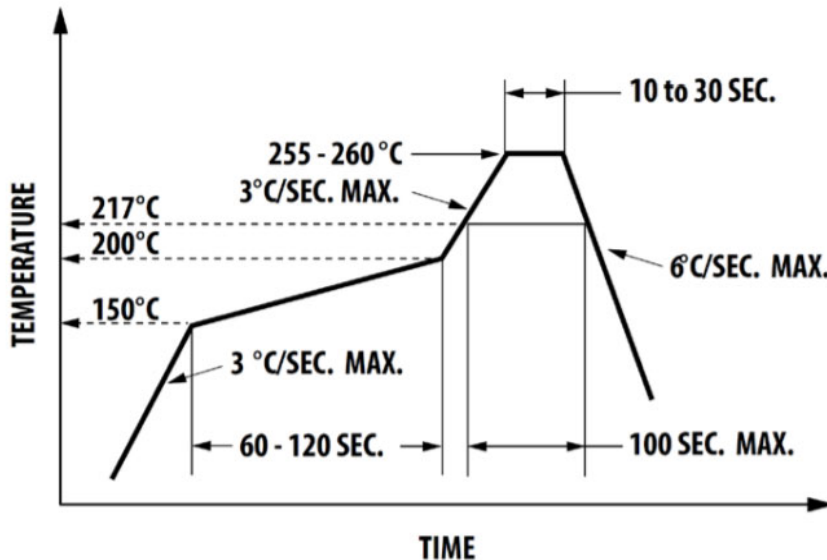
Figure 4: Recommended PCB Land Pattern Details



1. RECOMMENDED SOLDER PAD PITCH AND DIMENSIONS
2. APPLY SOLDER MASK TO AREAS THAT ARE NOT SOLDERED
3. RECOMMEND TO USE 4 LAYERS PCB WITH 25X $\phi 0.3$ mm, PITCH=0.8mm VIA HOLE AT THE CENTER PAD AS SHOWN IN THE LAND PATTERN ABOVE
4. THE CENTER PAD HAS TO BE CONNECTED TO GND

Recommended SMT Reflow Soldering Profile

Figure 5: Recommended SMT Reflow Soldering Profile Details



NOTE: Pb-free SMT reflow soldering profile (according to JEDEC Pb-Free [J-STD-020D]).
Infrared reflow and no cleaning process to prevent contamination.
Peel off kapton tape on assembly process.

Port Selections

Port Selection (Port_SEL [3:0] Differential Protocols)

Table 3: Port_SEL Differential Protocols

Summary						ST	SPI4W/ABI	MT	INC/Analog	Ext EEPROM
No.	SEL0	SEL1	SEL2	SEL3	Clock Type 50 MHz	PORTA[3:0]	PORTB[3:0]	PORTC[3:0]	PORTD[3:0]	PORTE[1:0]
1	Lo	Lo	Lo	Lo	Internal	BiSS-C/SSI2W	ABI	EHMT(SPI4W)	UVW (Default)/SINCOS	Ext EEPROM
2	Lo	Lo	Lo	Mid	Internal	BiSS-C/SSI2W	ABI	Gear(SSI2W)	UVW (Default)/SINCOS	Ext EEPROM
3	Lo	Lo	Lo	Hi	Internal	BiSS-C/SSI2W	ABI	BBMT(SPI3W)	UVW (Default)/SINCOS	Ext EEPROM
4	Lo	Lo	Mid	Lo	Internal	BiSS-C/SSI2W	SPI4W (ST)	EHMT(SPI4W)	ABI (Default)/UVW/SINCOS	Ext EEPROM
5	Lo	Lo	Mid	Mid	Internal	BiSS-C/SSI2W	SPI4W (ST)	Gear(SSI2W)	ABI (Default)/UVW/SINCOS	Ext EEPROM
6	Lo	Lo	Mid	Hi	Internal	BiSS-C/SSI2W	SPI4W (ST)	BBMT(SPI3W)	ABI (Default)/UVW/SINCOS	Ext EEPROM
10	Lo	Mid	Lo	Lo	External	ESL	ABI	EHMT(SPI4W)	UVW (Default)/SINCOS	Ext EEPROM
11	Lo	Mid	Lo	Mid	External	ESL	ABI	Gear(SSI2W)	UVW (Default)/SINCOS	Ext EEPROM
12	Lo	Mid	Lo	Hi	External	ESL	ABI	BBMT(SPI3W)	UVW (Default)/SINCOS	Ext EEPROM
13	Lo	Mid	Mid	Lo	External	ESL	SPI4W (ST)	EHMT(SPI4W)	ABI (Default)/UVW/SINCOS	Ext EEPROM
14	Lo	Mid	Mid	Mid	External	ESL	SPI4W (ST)	Gear(SSI2W)	ABI (Default)/UVW/SINCOS	Ext EEPROM
15	Lo	Mid	Mid	Hi	External	ESL	SPI4W (ST)	BBMT(SPI3W)	ABI (Default)/UVW/SINCOS	Ext EEPROM
16	Lo	Mid	Hi	Lo	External	RS485	ABI	EHMT(SPI4W)	UVW (Default)/SINCOS	Ext EEPROM
17	Lo	Mid	Hi	Mid	External	RS485	ABI	Gear(SSI2W)	UVW (Default)/SINCOS	Ext EEPROM
18	Lo	Mid	Hi	Hi	External	RS485	ABI	BBMT(SPI3W)	UVW (Default)/SINCOS	Ext EEPROM
19	Lo	Hi	Lo	Lo	External	RS485	SPI4W (ST)	EHMT(SPI4W)	ABI (Default)/UVW/SINCOS	Ext EEPROM
20	Lo	Hi	Lo	Mid	External	RS485	SPI4W (ST)	Gear(SSI2W)	ABI (Default)/UVW/SINCOS	Ext EEPROM
21	Lo	Hi	Lo	Hi	External	RS485	SPI4W (ST)	BBMT(SPI3W)	ABI (Default)/UVW/SINCOS	Ext EEPROM

Port Selection (Port SEL [3:0] Single-Ended Protocols)

Table 4: Port_SEL Single-Ended Protocols

Summary						ST	SPI4W/ABI	MT	INC/Analog	Ext EEPROM
No.	SEL0	SEL1	SEL2	SEL3	Clock Type 50 MHz	PORTA[3:0]	PORTB[3:0]	PORTC[3:0]	PORTD[3:0]	PORTE[1:0]
28	Mid	Lo	Lo	Lo	Internal	ABI	UVW	EHMT(SPI4W)	SINCOS	Ext EEPROM
29	Mid	Lo	Lo	Mid	Internal	ABI	UVW	Gear(SSI2W)	SINCOS	Ext EEPROM
30	Mid	Lo	Lo	Hi	Internal	ABI	UVW	BBMT(SPI3W)	SINCOS	Ext EEPROM
34	Mid	Lo	Hi	Lo	Internal	SPI4W (ST)	ABI	EHMT(SPI4W)	UVW (Default)/SINCOS	Ext EEPROM
35	Mid	Lo	Hi	Mid	Internal	SPI4W (ST)	ABI	Gear(SSI2W)	UVW (Default)/SINCOS	Ext EEPROM
36	Mid	Lo	Hi	Hi	Internal	SPI4W (ST)	ABI	BBMT(SPI3W)	UVW (Default)/SINCOS	Ext EEPROM
55	Hi	Lo	Lo	Lo	Internal	BiSS-C/SSI3W	ABI	EHMT(SPI4W)	UVW (Default)/SINCOS	Ext EEPROM
56	Hi	Lo	Lo	Mid	Internal	BiSS-C/SSI3W	ABI	Gear(SSI2W)	UVW (Default)/SINCOS	Ext EEPROM
57	Hi	Lo	Lo	Hi	Internal	BiSS-C/SSI3W	ABI	BBMT(SPI3W)	UVW (Default)/SINCOS	Ext EEPROM
58	Hi	Lo	Mid	Lo	Internal	BiSS-C/SSI3W	SPI4W (ST)	EHMT(SPI4W)	ABI (Default)/UVW/SINCOS	Ext EEPROM
59	Hi	Lo	Mid	Mid	Internal	BiSS-C/SSI3W	SPI4W (ST)	Gear(SSI2W)	ABI (Default)/UVW/SINCOS	Ext EEPROM
60	Hi	Lo	Mid	Hi	Internal	BiSS-C/SSI3W	SPI4W (ST)	BBMT(SPI3W)	ABI (Default)/UVW/SINCOS	Ext EEPROM
64	Hi	Mid	Lo	Lo	External	ESL	ABI	EHMT(SPI4W)	UVW (Default)/SINCOS	Ext EEPROM
65	Hi	Mid	Lo	Mid	External	ESL	ABI	Gear(SSI2W)	UVW (Default)/SINCOS	Ext EEPROM
66	Hi	Mid	Lo	Hi	External	ESL	ABI	BBMT(SPI3W)	UVW (Default)/SINCOS	Ext EEPROM
67	Hi	Mid	Mid	Lo	External	ESL	SPI4W (ST)	EHMT(SPI4W)	ABI (Default)/UVW/SINCOS	Ext EEPROM
68	Hi	Mid	Mid	Mid	External	ESL	SPI4W (ST)	Gear(SSI2W)	ABI (Default)/UVW/SINCOS	Ext EEPROM
69	Hi	Mid	Mid	Hi	External	ESL	SPI4W (ST)	BBMT(SPI3W)	ABI (Default)/UVW/SINCOS	Ext EEPROM
70	Hi	Mid	Hi	Lo	External	RS485	ABI	EHMT(SPI4W)	UVW (Default)/SINCOS	Ext EEPROM
71	Hi	Mid	Hi	Mid	External	RS485	ABI	Gear(SSI2W)	UVW (Default)/SINCOS	Ext EEPROM
72	Hi	Mid	Hi	Hi	External	RS485	ABI	BBMT(SPI3W)	UVW (Default)/SINCOS	Ext EEPROM
73	Hi	Hi	Lo	Lo	External	RS485	SPI4W (ST)	EHMT(SPI4W)	ABI (Default)/UVW/SINCOS	Ext EEPROM
74	Hi	Hi	Lo	Mid	External	RS485	SPI4W (ST)	Gear(SSI2W)	ABI (Default)/UVW/SINCOS	Ext EEPROM
75	Hi	Hi	Lo	Hi	External	RS485	SPI4W (ST)	BBMT(SPI3W)	ABI (Default)/UVW/SINCOS	Ext EEPROM
79	Hi	Hi	Hi	Lo	External	SPI4W (ST)	ABI	EHMT(SPI4W)	UVW (Default)/SINCOS	Ext EEPROM
80	Hi	Hi	Hi	Mid	External	SPI4W (ST)	ABI	Gear(SSI2W)	UVW (Default)/SINCOS	Ext EEPROM
81	Hi	Hi	Hi	Hi	External	SPI4W (ST)	ABI	BBMT(SPI3W)	UVW (Default)/SINCOS	Ext EEPROM

NOTE: Hi = High (VDD input voltage level)
Lo = Low (GND voltage level)
Mid = Middle (VDD/2 input voltage level)

Port Connections

Conventions:

(IN PD): Internal pull-down

(IN PU): Internal pull-up

(OUT): Output drive

(Analog): Battery voltage-level detection

Nil: Not in use

EHMT: Broadcom energy harvesting multi-turn

BBMT: Battery backup multi-turn

Port A Connection

Table 5: Port_A Connections

Transmission Type	Protocol	PORTA[3:0] (Digital)			
		IN/OUT	IN/OUT	IN	IN
		PORTA[3]	PORTA[2]	PORTA[1]	PORTA[0]
Differential	BiSS-C	BiSS-C_SLO+	BiSS-C_SLO-	BiSS-C_MA+	BiSS-C_MA-
	SSI	SSI_DATA+	SSI_DATA-	SSI_CLK+	SSI_CLK-
	ESL	ESL+	ESL-	Nil	Nil
	RS485	RS485+	RS485-	Nil	Nil
Single-ended	BiSS-C	BiSS-C_SLO+	Nil	BiSS-C_MA+	Nil
	SSI	SSI_DOUT (OUT)	Nil	SSI_NSL (IN PU)	SSI_SCL (IN PU)
	SPI4W	MISO (OUT)	MOSI (IN PD)	NCS (IN PU)	SCK (IN PU)
	ESL	ESL_D (OUT)	ESL_DE (OUT)	Nil	ESL_RO (IN PU)
	RS485	RS485_D (OUT)	RS485_DE (OUT)	Nil	RS485_RO (IN PU)
	SPI3W	SPI_DOUT (OUT)	Nil	SPI_DIN (IN PU)	SPI_CLK (IN PU)
	Incremental ABI	Nil	I	B	A

Port B Connection

Table 6: Port_B Connections

Transmission Type	Protocol	PORTB[3:0] (Digital/Analog)			
		OUT	IN/OUT	IN/OUT	IN/OUT
		PORTB[3]	PORTB[2]	PORTB[1]	PORTB[0]
Single-ended	Incremental ABI	Nil	I	B	A
	Incremental UVW	Nil	W	V	U
	SPI4W	MISO (OUT)	MOSI (IN PD)	NCS (IN PU)	SCK (IN PU)

Port C Connection

Table 7: Port_C Connections

Transmission Type	Protocol	PORTC[3:0] (Digital/Analog)			
		OUT	IN/OUT	IN/OUT	IN/OUT
		PORTC[3]	PORTC[2]	PORTC[1]	PORTC[0]
Single-ended	EHMT (SPI4W)	MT_MISO (IN PD)	MT_MOSI (OUT)	MT_SCK (OUT)	MT_NCS (OUT)
	Gear (SSI2W)	Nil	SSI_DATA (IN PU)	SSI_CLK (OUT)	Nil
	Hall-BBMT (SPI3W)	SPI_DIN (IN PD)	SPI_DOUT (OUT)	SPI_CLK (OUT)	VBAT (Analog)

Port D Connection

Table 8: Port_D Connections

Transmission Type	Protocol	PORTD[3:0] (Digital/Analog)			
		IN/OUT	IN/OUT	IN/OUT	IN/OUT
		PORTD[3]	PORTD[2]	PORTD[1]	PORTD[0]
Single-ended	Incremental ABI	Nil	I	B	A
	Incremental UVW	Nil	W	V	U
	Analog Sine/Cosine	CN	CP	SN	SP

Port E Connection

Table 9: Port_E Connections

Transmission Type	Protocol	PORTE[2:0] (Digital)	
		IN/OUT Open-Drain	IN/OUT Open-Drain
		PORTE[1]	PORTE[0]
Single-ended	I ² C	EEPROM_SCL_I2C	EEPROM_SDA_I2C

Mechanical Design

Figure 6: Mechanical Design Details

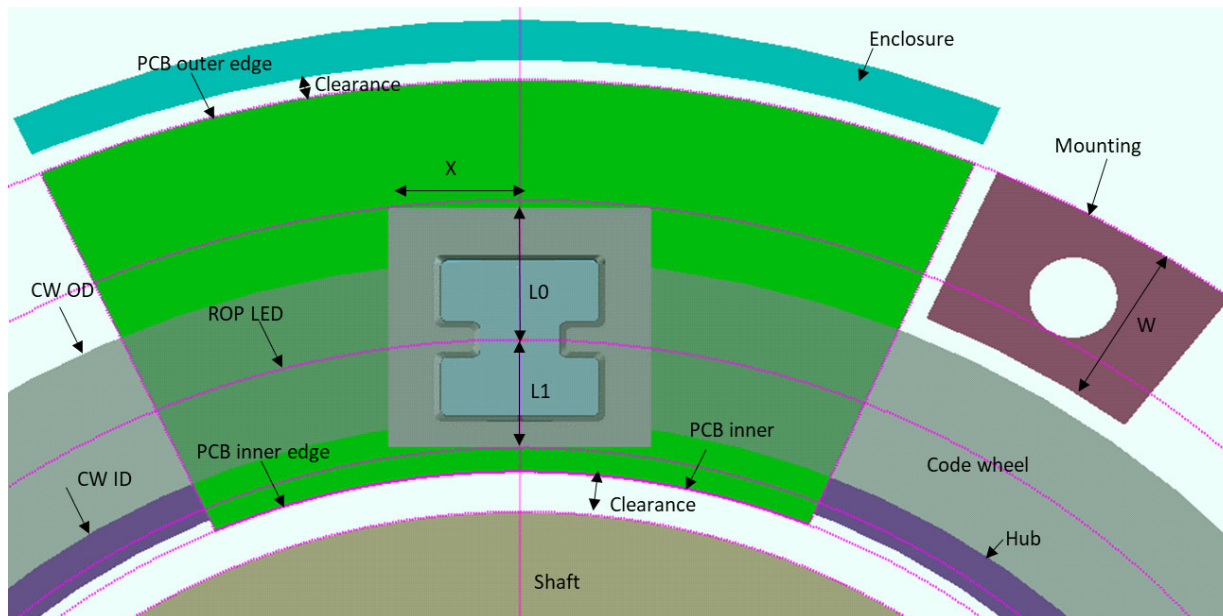


Table 10: Mechanical Design Consideration

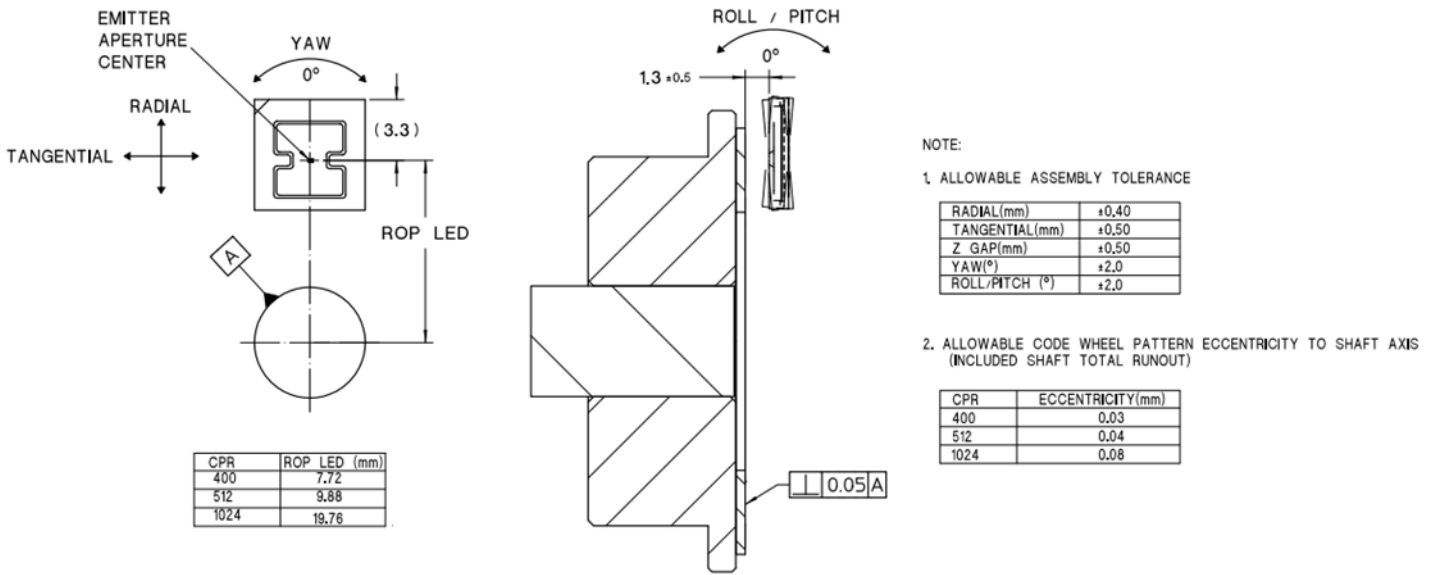
LED LPI	209.46	209.46	209.46
Incremental cycle per revolution [CPR]	400	512	1024
Operating radius (ROP) of LED (mm) [ROP_LED]	7.720	9.881	19.763
ROP LED to package outer edge, L0	3.3	3.3	3.3
Package width/2, X	3	3	3
ROP_LED to package inner edge, L1	2.7	2.7	2.7
Radius to package boundary	11.420	13.519	23.257
PCB outer edge from package (design in 3 mm)	3.0	3.0	3.0
Clearance between PCB and housing at radial direction (min. 0.3 mm)	0.5	0.5	0.5
Wall thickness for enclosure (min. 0.5 mm, 0 mm if no enclosure)	0.0	0.0	0.0
PCB inner edge to package inner edge (min. 0.6 mm)	0.6	0.6	0.6
Clearance between shaft and PCB ID (min. 0.5 mm)	0.5	0.5	0.5
ROP_LED to CW OD	2	2	2
ROP_LED to CW ID	2	2	2
Hub guide wall thickness	1	1	1
Clearance between CW OD and mounting feature (min. 0.5 mm)	0.5	0.5	0.5
Mounting feature width_W (min. 4 mm for M2 screw)	4	4	4
Min. code wheel outer diameter [CW OD] (mm)	19.44	23.76	43.53
Max. code wheel outer diameter [CW OD] (mm)	11.44	15.76	35.53
Min. PCB outer diameter (mm)	28.84	33.04	52.51
Min. product outer diameter (mm)	29.84	34.04	53.51
Max. motor shaft size (mm)	7.84	12.16	31.93

Mounting Requirements

The figure below shows the mounting requirements to set up the encoder to the optimum position for typical encoder performance. Overall mounting requirements are applicable for the following items:

- AR25 QFN encoder to code wheel operational gap.
- Code wheel placement.

Figure 7: Mounting Requirements Details

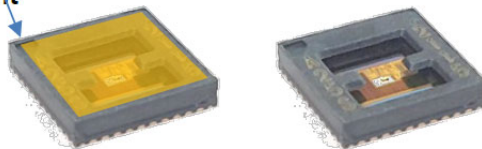


NOTE:

1. The encoder assembly requires a clean room condition of Class 100K or better.
2. The encoder must be enclosed with an IP50-rated enclosure.
3. The encoder has protective tape to prevent contamination. Remove the tape at the location, away from the ASIC slot as shown in [Figure 8](#) to prevent scratches to the ASIC after the SMT reflow processes.

Figure 8: Removal of Protective Tape

Protective Tape Removal Point



Tilt and Wobbling Design Control Relationship

Table 11: Tilt and Wobbling Design Control Relationship

LPI_LED	209.462	209.462	209.462	209.462	209.462	209.462
CPR	512	512	512	1024	1024	1024
INC ROP (mm)	9.881	9.881	9.881	19.762	19.762	19.762
Additional CW track length from ROP INC	1.7	1.7	1.7	2	2	2
Shaft size	6	6	12	20	30	6
Clearance, (Max OD-Min OD)/2 (mm)	0.012	0.012	0.017	0.020	0.011	0.009
Hub engagement length (mm)	8	12	8	12	5	5
Tilt angle (mechanical degree)	0.085	0.057	0.125	0.097	0.126	0.103
Wobbling, ± (mm)	0.017	0.011	0.025	0.037	0.047	0.039

Figure 9: Encoder Mechanical Placement Design

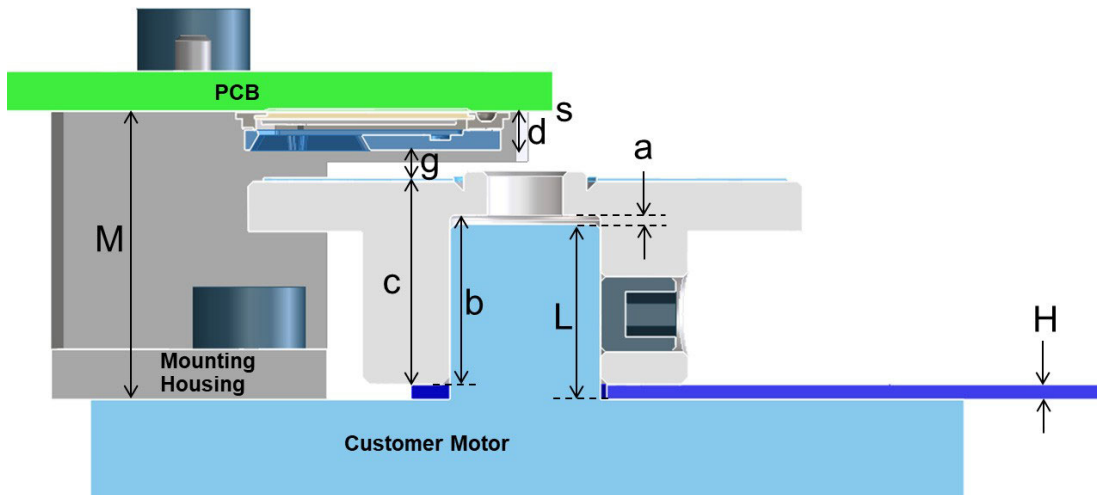


Table 12: Encoder Mechanical Design Considerations

No.	Parameter	Symbol	AR25 (Nominal Dimension)
1	Mounting jig height	M	$M = H + c + g + d + s$
2	Height jig thickness	H	$H = L - (b - a)$
3	Gap QFN and code wheel	g	1.30 mm
4	Shaft to hub clearance	a	0.30 mm to 0.60 mm
5	Code wheel - hub height	c	8.25 mm
6	Motor shaft height	L	Based on the customer shaft height
7	QFN package height	d	1.50 mm
8	Solder paste thickness	s	0.05 mm
9	Hub inner ID depth	b	6.50 mm
10	Hub engagement length	E	$E = b - a$

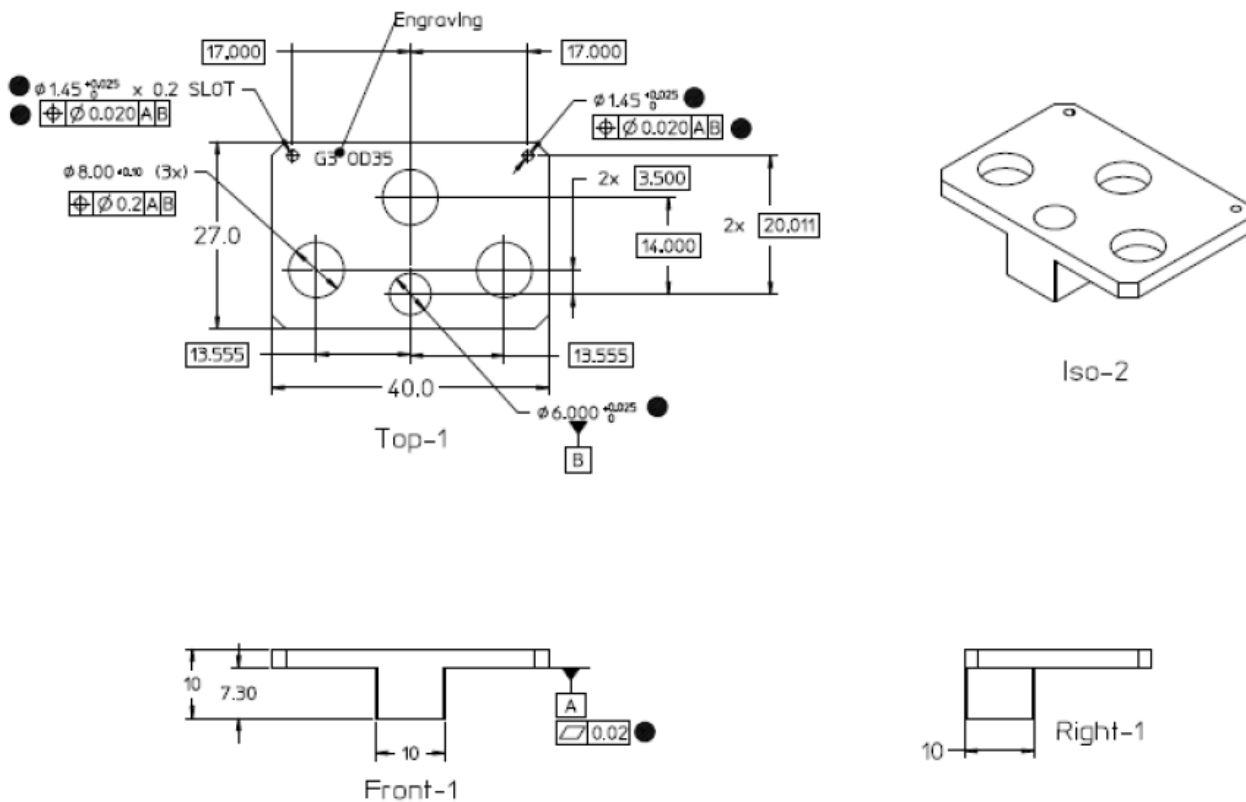
Recommended Hub and Shaft Tolerances

Table 13: Code Wheel Hub-to-Shaft Tolerances

Hub ID (mm)	Hole Tolerance			Set Screw Size	Shaft OD (mm)	Shaft Tolerance		
	Lower	Upper	Hole Basis			Lower	Upper	Shaft Basis
2	0	0.008	H7	#2-56	2	-0.004	-0.009	g6
3	0	0.008	H7	#2-56	3	-0.004	-0.009	g6
4	0	0.008	H7	M3	4	-0.004	-0.009	g6
6	0	0.008	H7	M3	6	-0.004	-0.009	g6
8	0	0.009	H7	M3	8	-0.005	-0.011	g6
10	0	0.009	H7	M3	10	-0.005	-0.011	g6
30	0	0.009	H7	M3	30	-0.005	-0.011	g6

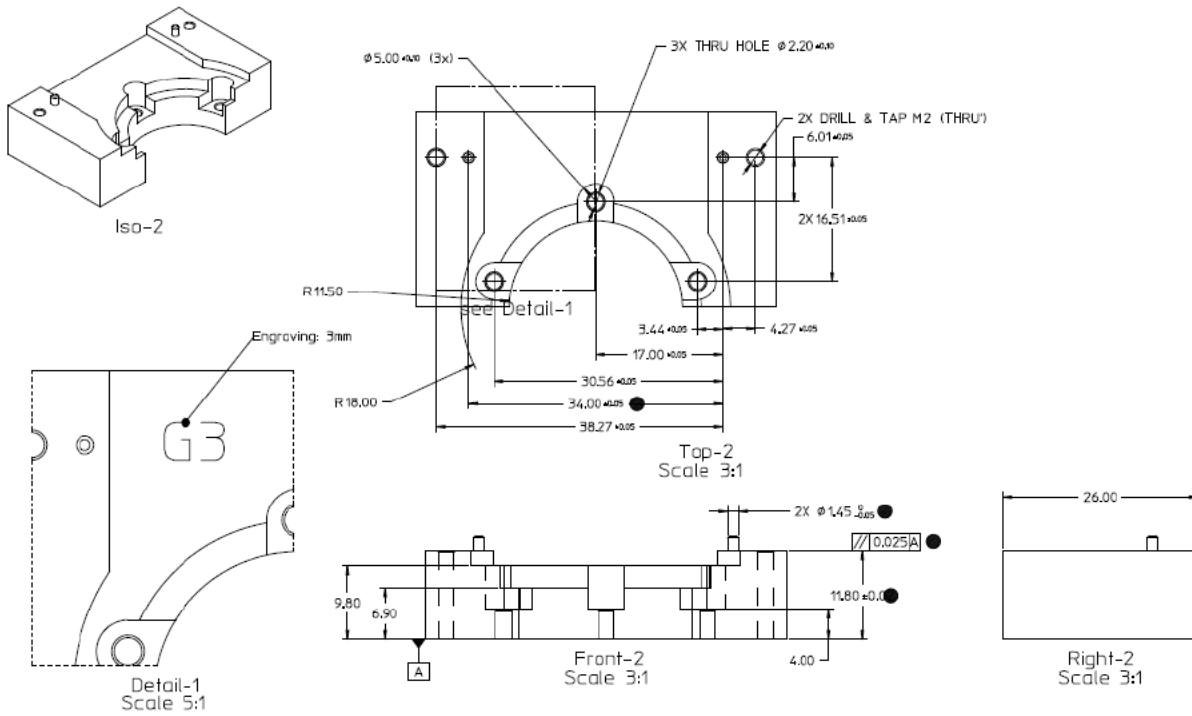
Alignment Jig Design Concept

Figure 10: PCB to Shaft Alignment Jig Design Concept and Tolerance Guide



PCB Base Plate Design Concept

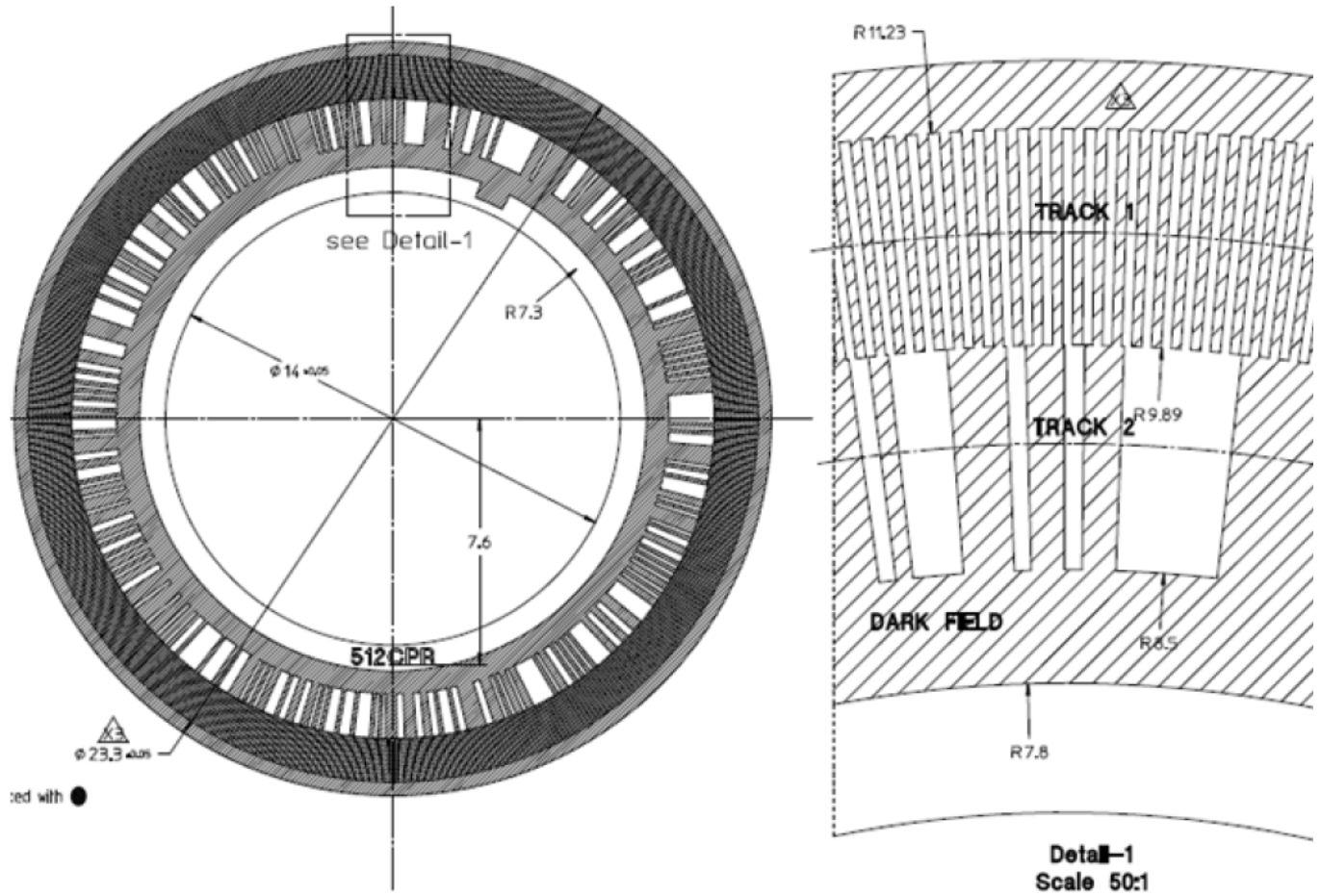
Figure 11: PCB Base Plate Design Concept Details



Code Wheel Mechanical Dimension

Material Type	Stainless Steel/Aluminum
Code wheel CPR	400 CPR up to 1024 CPR (1 CPR increment)
Standard CPR design	400, 512, 1024

Figure 12: Code Wheel Mechanical Dimensions



Code Wheel Handling

Wear a finger cot when touching the active area.

Use delicate task wipers with IPA to clean the code wheel. Do not use cotton buds (non-lint-free) because they can scratch the code wheel.

Figure 13: Code Wheel Handling



Unlock Memory

Standard protocol steps:

1. Write Address 0x7F = 0x09 (Page 9).
2. Write Address 0x00 = 0xAB.

BiSS-C protocol steps:

1. Write Address 0x40 = 0x12 (Bank 18).
2. Write Address 0x00 = 0xAB.

Program Memory

Standard protocol steps:

1. Write Address 0x7F = 0x09 (Page 9).
2. Write Address 0x01 = 0xC0.

BiSS-C protocol steps:

1. Write Address 0x40 = 0x12 (Bank 18).
2. Write Address 0x01 = 0xC0.

NOTE: Page 9 Programming Command **must** be executed immediately upon changes at the EMEM page.
Page 9 Programming Command **must not** be executed if the previous page is any of the External EEPROM page.

Auto-Calibration

Turn the motor at a constant speed [500~1000RPM].

Standard protocol steps:

1. Write Address 0x7F = 0x09 (Page 9).
2. Write Address 0x00 = 0xAB.
3. Write Address 0x04[1] = 1b.
4. Loop Read Calibration Status Address 0x28.
5. If Address 0x28[1:0] = 00b Calibration in progress; 01b Calibration Done; 10b Calibration Error.

BiSS-C protocol steps:

1. Write Address 0x40 = 0x12 (Bank 18).
2. Write Address 0x00 = 0xAB.
3. Write Address 0x04[1] = 1b.
4. Loop Read Calibration Status Address 0x28.
5. If Address 0x28[1:0] = 00b Calibration in progress; 01b Calibration Done; 10b Calibration Error.

Auto-Calibration with Accuracy

Turn the motor at a constant speed [500~1000RPM].

Standard protocol steps:

1. Write Address 0x7F = 0x09 (Page 9).
2. Write Address 0x00 = 0xAB.
3. Write Address 0x04[0] = 1b.
4. Loop Read Calibration Status Address 0x28.
5. If Address 0x28[1:0] = 00b Calibration in progress; 01b Calibration Done; 10b Calibration Error.

BiSS-C protocol steps:

1. Write Address 0x40 = 0x12 (Bank 18).
2. Write Address 0x00 = 0xAB.
3. Write Address 0x04[0] = 1b.
4. Loop Read Calibration Status Address 0x28.
5. If Address 0x28[1:0] = 00b Calibration in progress; 01b Calibration Done; 10b Calibration Error.

Auto Zero-Reset (Single-Turn)

Stop the motor.

Standard protocol steps:

1. Write Address 0x7F = 0x09 (Page 9).
2. Write Address 0x00 = 0xAB.
3. Write Address 0x2[1] = 1b.
4. Write Address 0x01 = 0xC0.

BiSS-C protocol steps:

1. Write Address 0x40 = 0x12 (Bank 18).
2. Write Address 0x00 = 0xAB.
3. Write Address 0x2[1] = 1b.
4. Write Address 0x01 = 0xC0.

Auto Zero-Reset (Multi-Turn)

Stop the motor.

Standard protocol steps:

1. Write Address 0x7F = 0x09 (Page 9).
2. Write Address 0x00 = 0xAB.
3. Write Address 0x2[0] = 1b.
4. Write Address 0x01 = 0xC0.

BiSS-C protocol steps:

1. Write Address 0x40 = 0x12 (Bank 18).
2. Write Address 0x00 = 0xAB.
3. Write Address 0x2[0] = 1b.
4. Write Address 0x01 = 0xC0.

Alarm Clear

Standard protocol steps:

1. Write Address 0x7F = 0x09 (Page 9).
2. Write Address 0x00 = 0xAB.
3. Write Address 0x2[2] = 1b.

BiSS-C protocol steps:

1. Write Address 0x40 = 0x12 (Bank 18).
2. Write Address 0x00 = 0xAB.
3. Write Address 0x2[2] = 1b.

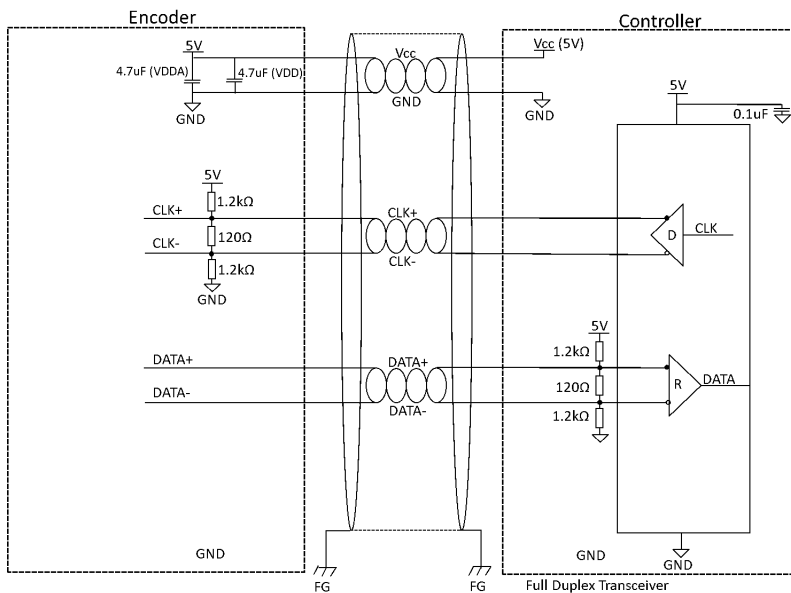
Recommended I/O Connection

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

SSI/BiSS-C 3-Wire Differential Connection

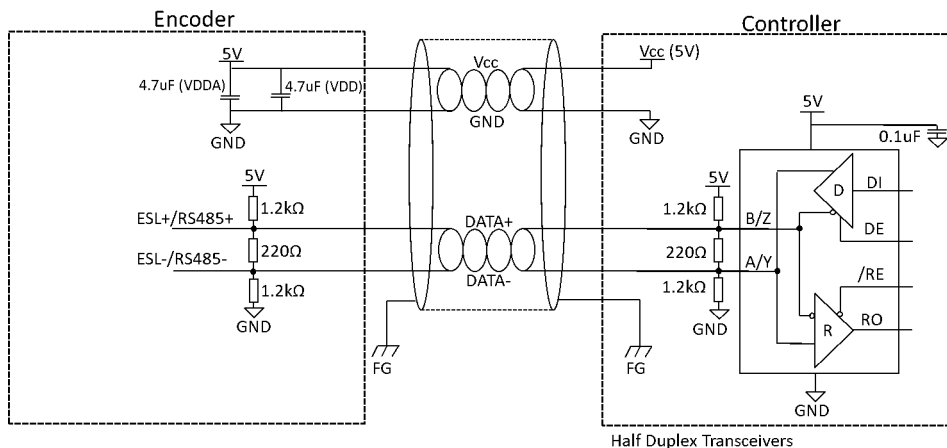
- Provide the following encoder power supply:
 - For the 5.0V supply, the V_{CC} should be within the range of 4.5V ~ 5.5V.
 - For the 3.3V supply, the V_{CC} should be within the range of 3.0V ~ 3.6V.
- For best noise immunity, use a twisted-pair shielded cable for connection to the servo driver.
- To prevent undesirable signal reflection, terminate with 120Ω resistors.

Figure 14: SSI Differential I/O Connections



ESL/RS485 Half-Duplex Connection

Figure 15: ESL/RS485 Half-Duplex I/O Connections

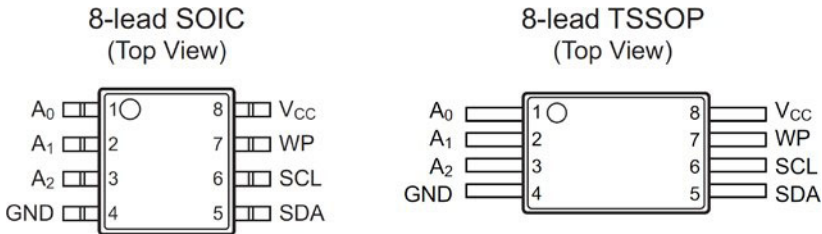


Recommended External EEPROM

Table 14: Recommended External EEPROM

Description	Part Number
Microchip, 2-wire automotive temperature serial EEPROMs	AT24C08C-XPD

Figure 16: Recommended External EEPROM



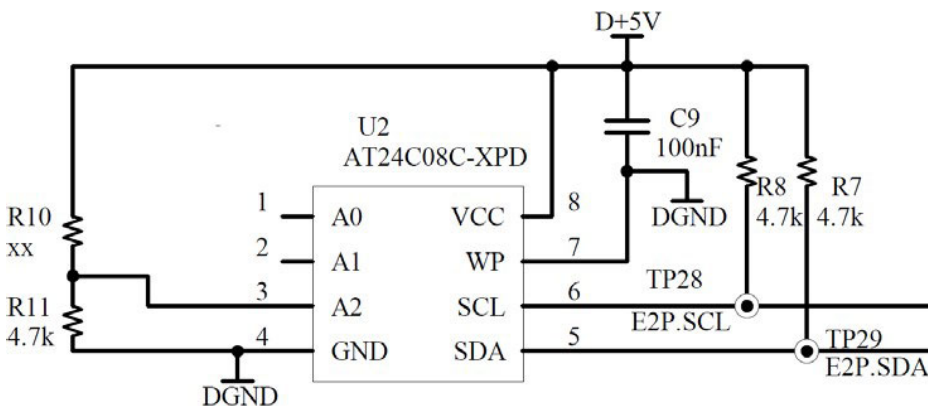
Note: Drawings are not to scale.

- Options to support up to 128 Kb.
- A₀ to A₂ pins connections MUST be connected accordingly to the types used, [Figure 17](#) is an example for the 8 Kb.

Table 15: Pin Names and Functions

Pin Name	Function
A ₀	Address input (1K and 2K)
A ₁	Address input (1K, 2K, and 4K)
A ₂	Address input (1K, 2K, 4K, and 8K)
GND	Ground
SDA	Serial data
SCL	Serial clock input
WP	Write protect
V _{CC}	Device power supply

Figure 17: Recommended External EEPROM Connections



Memory Map

Table 16: Memory Map General (Page 9)

No.	Item (Page 9)	Address	Bits						
			7	6	5	4	3	2	1
1	Unlock Memory	0x00	Unlock Level 1 (0xAB)						
2	Program Memory	0x01	pg_prog (0xC0)						
3	Clear Alarm/Position	0x02	—				Alarm Clear	Single-Turn Zero Reset	Multi-Turn Zero Reset
4	Calibration	0x04	—				Auto-Calibration	Auto-Calibration with Accuracy	
5	Calibration Status	0x28	—				Calibration Error	Calibration Done	

Table 17: Memory Map for Incremental Output Resolution Settings

Register Name	Customer Configuration1							
Page	7 (Standard); 14 (BiSS-C)				Address		0x17 to 0x19	
Access	RW				Value		Bit [7:0]	
Bit Field	7	6	5	4	3	2	1	0
Address 0x17	INC_OUT_OFF			ABI_CPR[20:16]				
Address 0x18	ABI_CPR[15:8]							
Address 0x19	ABI_CPR[7:0]							
Address 0x1A	—			Index Polarity		lphase Select[1:0]		lwidth Select[1:0]
Address 0x1B	—	abi_uvw sel		UVW_Select[5:0]				
Description	For Incremental Output Settings							

Table 18: Memory Map for Incremental Output and Absolute Resolution Settings

Register Name	Customer Configuration2							
Page	7 (Standard); 14 (BiSS-C)				Address		0x16	
Access	RW				Value		Bit [7:0]	
Bit Field	7	6	5	4	3	2	1	0
	—	MT_Select[2:0]			ST_Select[3:0]			
Description	For Absolute Resolution Settings							

Table 19: Encoder ID and Baud Rate Settings

Register Name	Customer Configuration3							
Page	7 (Standard)				Address		0x1D	
Access	RW				Value		Bit [7:0]	
Bit Field	7	6	5	4	3	2	1	0
	—	—			Baudrate_setting[1:0]		Encoder_ADDR[2:0]	
Description	For Absolute Resolution Settings							

Incremental Output Settings

1. Unlock the EEPROM.
2. Set Page 0x07 (Standard Protocols) or 0x0E (BiSS-C Protocol).
3. Write in the settings and read back to ensure the setting is written successfully.
4. Program the EEPROM.

Table 20: Incremental Output Settings

Address	Bits	Name	Settings	Output
0x17 [20:16]	4:0	ABI Setting [20:0]	1000 0000_ 0000 0000_ 0000 0000	1048576 CPRs
0x18 [15:8]	7:0		1000 0000_0000 0000	32768 CPRs
0x19 [7:0]	7:0		1000 0000	128 CPRs
0x1A [1:0]	3:2	lphase Select[1:0]	00	90 edeg (electrical degree)
			01	180 edeg
			10	270 edeg
			11	360 edeg
0x1A [1:0]	1:0	lwidth Select[1:0]	00	90 edeg
			01	180 edeg
			10	270 edeg
			11	360 edeg
0x1B [5:0]	5:0	UVW_Select[5:0]	10 0000	32 pole-pairs

Absolute Resolution Settings

1. Unlock the EEPROM.
2. Set Page 0x07 (Standard Protocols) or 0x0E (BiSS-C Protocol).
3. Write in the settings and read back to ensure the setting is written successfully.
4. Program the EEPROM.

Table 21: Absolute Resolution Settings

Address	Bits	Name	Settings	ESL/SSI/BiSS-C/SPI4W Output	RS485 24-Bit Output	RS485 25-Bit Output
0x16	6:4	MT_Select [2:0]	000	0	0	0
			001	12	12	12
			010	14	14	14
			011	16	16	16
			100	18	18	—
			101	20	20	—
			110	22	22	—
			111	24	24	—
0x16	3:0	ST_Select [3:0]	0000	15	17	15
			0001	16	18	16
			0010	17	19	17
			0011	18	20	18
			0100	19	21	19
			0101	20	22	20
			0110	21	23	21
			0111	22	24	22
			1000	23	—	23
			1001	24	—	24
			1010	25	—	25

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