Application Note

AR35-T25E/S

AR35 Through-Hole Series Programmable Absolute and Incremental Encoders

Introduction

The Broadcom® AR35-T25 series are programmable reflective absolute through-hole rotary encoders designed for space-constrained motion control applications.

The AR35-T25 series encoder has an overall diameter of 35 mm with a maximum axial through hole of 9.5 mm for through shaft motors and axial cabling.

The AR35-T25 series provides incremental ABI and UVW in differential mode. Both come with a recommended temperature range of –40°C to 115°C suitable for most industrial applications. Dual-mode operating voltages of 3.3V and 5V are suitable for handheld and portable device applications.

Employing Broadcom-patented Reflective Optical Encoding Theory, the AR35-T25 series offers high-accuracy with correction, which is unattainable by the magnetic encoder.

Application

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

Related Part Ordering Information

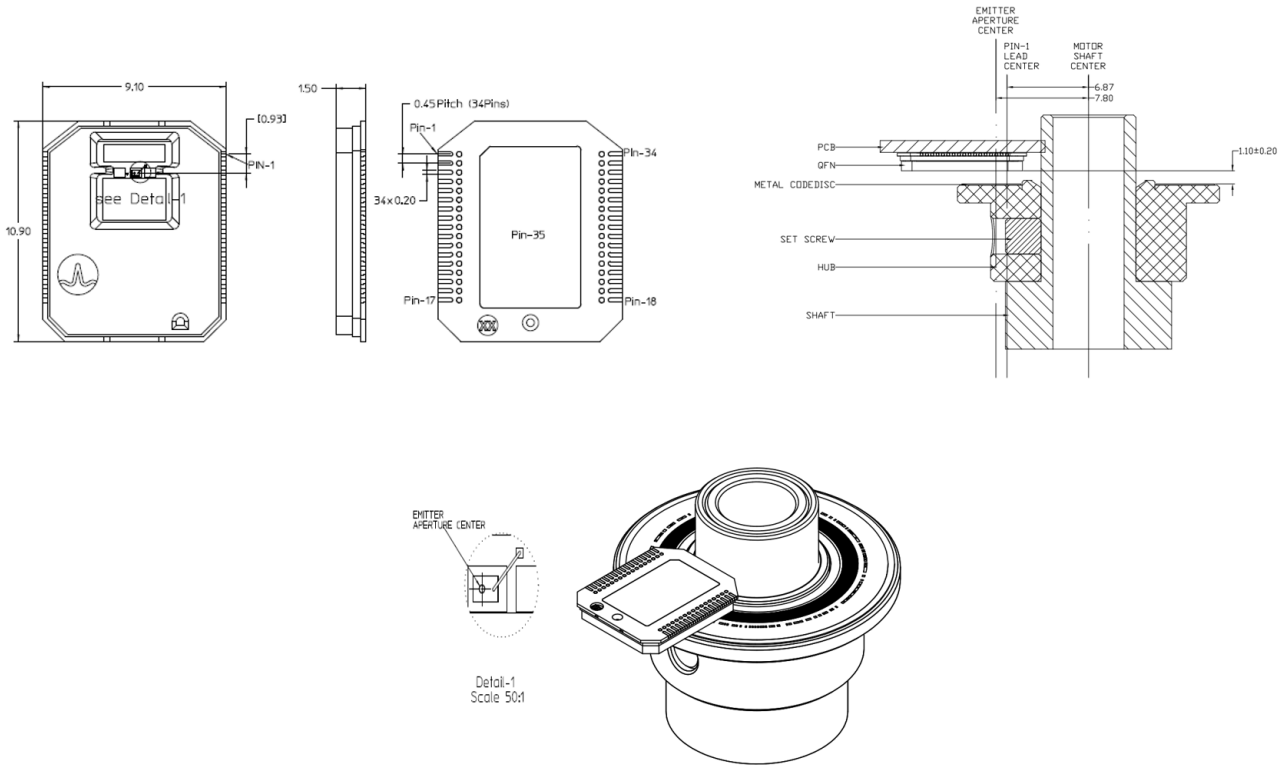
Ordering Information	Type
AR35-T25S/E	AR35 SSI/ESL Single-Turn Absolute Encoder

Mounting Requirements

Figure 1 shows the mounting requirements to set up the encoder to the optimum position for typical encoder performance. Overall mounting requirements applicable for the following items:

- AR35 DFN Encoder to code wheel operational gap.
- Code wheel placement.

Figure 1: Mounting Requirement



Notes on Assembly

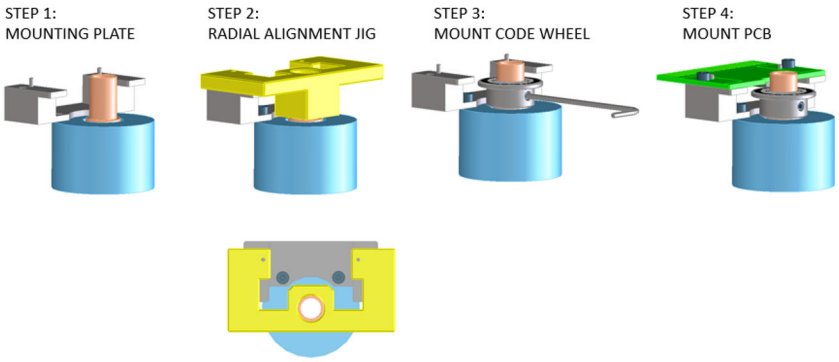
1. The encoder assembly requires a clean room condition of Class 100k or better.
2. The encoder must be enclosed with an IP50-rated enclosure.
3. Encoder has protective tape to prevent contamination. Remove the tape at the location, away from the ASIC slot as shown in Figure 2 to prevent scratches to the ASIC and damage to the LED wire bond after the SMD reflow processes.

Figure 2: Removal of Protective Tape

Evaluation Kit Mounting Concept with Alignment Jig

1. Place the mounting plate on the motor base.
2. Align the mounting plate guide pins to the motor shaft with the aid of the radial alignment jig, and secure the position with mounting screws.
3. Install the code wheel-hub assembly onto the motor shaft step. Secure the hub with a M3x3 set screw. (The recommended tightening torque is 0.15 Nm for the M3x3 set screw.)
4. Position the PCBA on the mounting plate guided by the guide pins. Secure the position with the mounting screws. (The recommended tightening torque is 0.15 Nm for the M2x6 cap screw.)

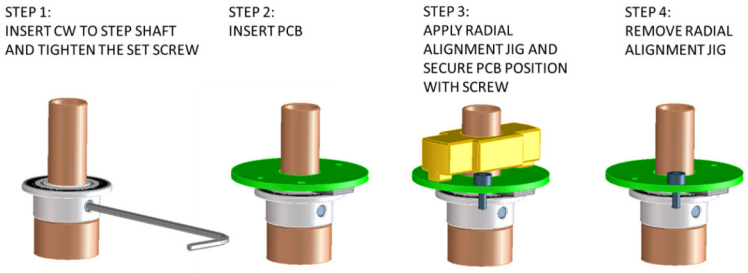
Figure 3: Mounting Concept with Alignment Jig



Recommended Mounting Concept with Alignment Jig

1. Insert the code wheel-hub assembly onto the step shaft. Tighten the set screw. (The recommended tightening torque is 0.15 Nm for the M3x3 set screw.)
2. Install the PCB over the motor shaft.
3. Apply the radial alignment jig. Secure the PCB position with a screw per the motor mounting requirements.
4. Remove the radial alignment jig.

Figure 4: Recommended Mounting Concept with Alignment Jig



Evaluation Kit Jig Design Concept

The jig design is based on the AR35 Through Hole encoder with the 9.5 mm shaft mount.

Figure 5: Mounting Plate Concepts (PN: 5023-9406)

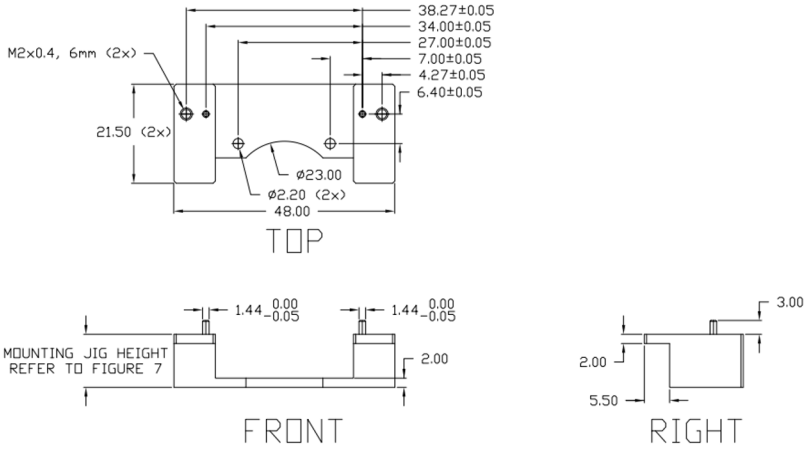
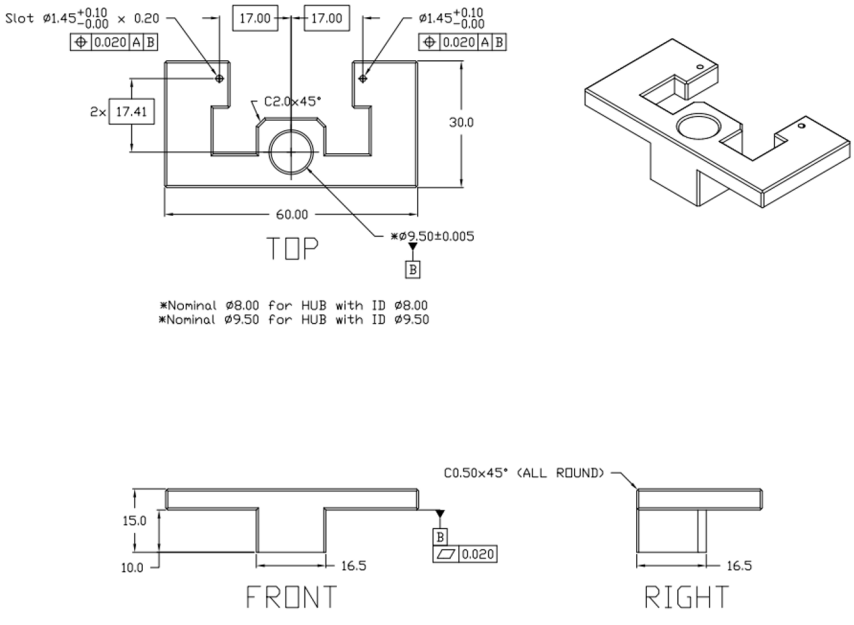


Figure 6: Radial Alignment Jig Concept (PN: 5023-9407)



Recommended Jig Design Concept

Figure 7: ID Alignment Jig Concept

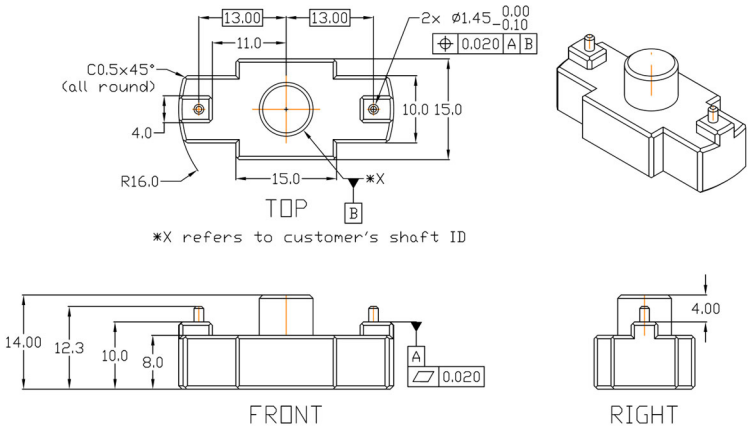


Figure 8: OD Alignment Jig Concept

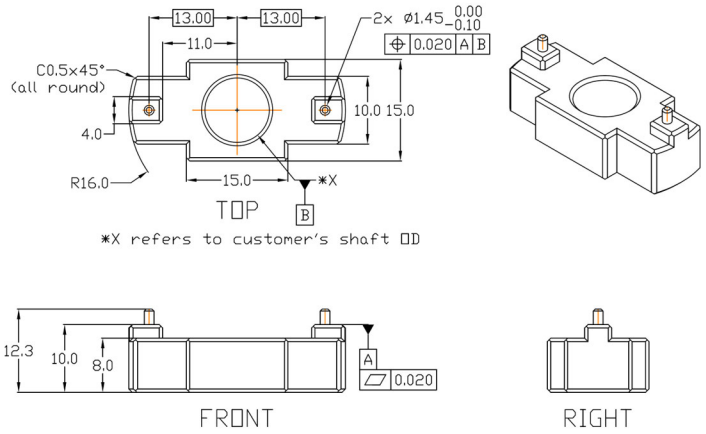


Figure 9: Jig Design Concept

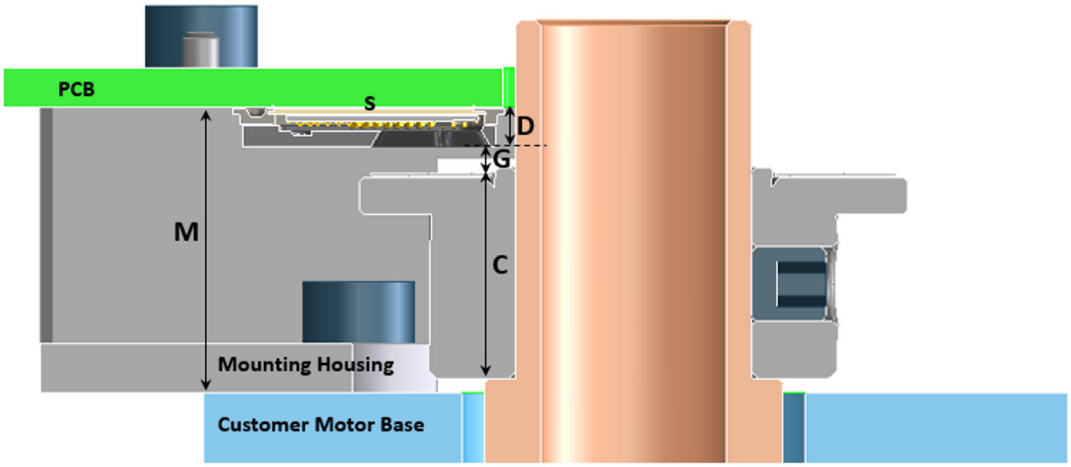


Table 1: Jig Design Concept

Number	Description	Symbol	Nominal Dimension
1	Mounting Jig Height	M	M = C + G + D + S
2	Code Wheel – Hub Height	C	8.25 mm
3	Gap DFN and Code Wheel	G	1.10 mm
4	DFN Package Height	D	1.50 mm
5	Solder Paste Thickness	S	0.05 mm

Mounting Guide

1. Install the code wheel on the motor shaft and set the height per the motor shaft step.
2. Secure the hub with a M3x3 set screw. The recommended tightening torque is 0.15 Nm.
3. Mount the encoder PCBA on the mounting housing at the recommended height.

Recommended Motor Shaft Diameter Tolerance

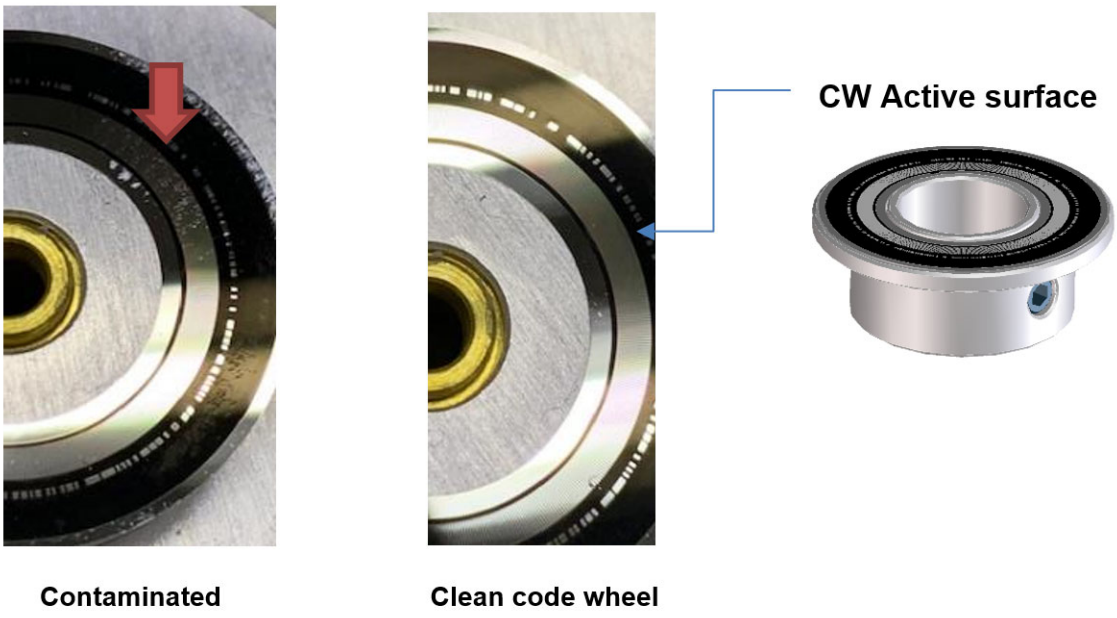
Table 2: Code Wheel Hub Tolerance

Hub ID	Hole Tolerance			Set Screw Size	Shaft OD	Shaft Tolerance		
(mm)	Lower	Upper	Hole Basis		(mm)	Lower	Upper	Shaft Basis
8.00	0	0.009	H6	M3	8.00	–0.005	–0.011	g5
9.50	0	0.009	H6	M3	9.50	–0.005	–0.011	g5

Code Wheel Handling Precaution

1. Wear finger cots to avoid contact with the active area.
2. Use delicate task wipers with isopropyl alcohol to wipe the code wheel. Do not use cotton buds (non-lint-free) because they can contaminate scratch the code wheel.

Figure 10: Code Wheel Handling



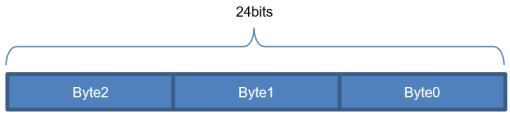
Encoder Zero Offset

Zero Offset with SSI 3-Wire and SPI

Table 3: Reference Memory Map (SPI) for Zero Offset

Number	Item	Address	Bits							
		Page 14	7	6	5	4	3	2	1	0
1	ST_Zero_Reset_0 (Byte 0)	0x0C	ST_ZR[7:0]							
2	ST_Zero_Reset_1 (Byte 1)	0x0D	ST_ZR[15:8]							
3	ST_Zero_Reset_2 (Byte 2)	0x0E	ST_ZR[23:16]							

Figure 11: Resolution Bits



1. With a static motor, read the position (using Figure 20) that SSI outputs, and patch zero to make it 24 bits.
   - If readout is in the 25 bits position, only store 24 bits MSB.
   - If readout is in the 23 bits position, patch 1 zero at LSB.
   - If readout is in the 21 bits position, patch 3 zero at LSB.
   - If readout is in the 17 bits position, patch 8 zero at LSB.
   - Split into 3 bytes as shown in Figure 11.
2. SPI Write offset value operation.
   - SPI write address 0x7F, value 0x08 (switch to EEPROM page 8).
   - SPI write address 0x00, value 0xAB (unlock write access).
   - SPI write address 0x7F, value 0x0E (switch to EEPROM page 14).
   - SPI write address 0x0C, value of Byte 0 (write LSB 8 bits of offset value).
   - SPI write address 0x0D, value of Byte 1 (write LSB+ 8 8 bits of offset value).
   - SPI write address 0x0E, value of Byte 2 (write MSB 8 bits of offset value).
   - SPI write address 0x1B, value 0x0F (unlock MTP for programming offset value).
   - SPI write address 0x40, value 0xC0 (perform MTP programming).
3. After approximately 30 ms, read the position that SSI outputs, and get position value 0.

Zero Offset with ESL Interface

Use Table 4 with the ESL protocol in Memory Read/Write Frame.

Method 1:

1. With a static motor, read the position (using Figure 20) that ESL outputs, and patch zero to make it 24 bits.
   - If readout is in the 25 bits position, only store 24 bits MSB.
   - If readout is in the 23 bits position, patch 1 zero at LSB.
   - If readout is in the 21 bits position, patch 3 zero at LSB.
   - If readout is in the 17 bits position, patch 8 zero at LSB.
   - Split into 3 bytes as shown in Figure 11.
2. SPI Write offset value operation.
   - SPI write address 0x7F, value 0x08 (switch to EEPROM page 8).
   - SPI write address 0x00, value 0xAB (unlock write access).
   - SPI write address 0x7F, value 0x0E (switch to EEPROM page 14).
   - SPI write address 0x0C, value of Byte 0 (write LSB 8 bits of offset value).
   - SPI write address 0x0D, value of Byte 1 (write LSB +8 8 bits of offset value).
   - SPI write address 0x0E, value of Byte 2 (write MSB 8 bits of offset value).
   - SPI write address 0x1B, value 0x0F (unlock MTP for programming offset value).
   - SPI write address 0x40, value 0xC0 (perform MTP programming).
3. After approximately 30 ms, read the position that ESL outputs, and get position value 0.

NOTE: The value of the position readout after a zero offset might fluctuate at 0 due to motor vibration at static.

Method 2:

Table 4: ESL Command ID List

ID	CF	SF	DF0	DF1	DF2	DF3	DF4	DF5	DF6	DF7	CRC	Remark	Frame Size
Data ID 4	Include CF & SF Status		ALMC	ABS0	ABS1	ABS2	ABS3	—	—	—	Include CRC	Position Read Command	8
Data ID 6			ABS0	ABS1	ABS2	ABS3	—	—	—	—			7
Data ID 8			ENID	—	—	—	—	—	—	—		Encoder ID Read Command	4
Data ID A			ALMC	—	—	—	—	—	—	—		Alarm Read Command	4
Data ID B			ALMC	ABS0	ABS1	ABS2	ABS3	—	—	—		Perform continuous 8× for ST clear command	8
Data ID C			ALMC	ABS0	ABS1	ABS2	ABS3	—	—	—		Perform continuous 8× for alarm clear command	8
Data ID E	CF	ADF	EDF	—	—	—	—	—	—	—		Memory or Register Read command	4
Data ID F	CF	ADF	EDF	—	—	—	—	—	—	—		Memory or Register Write command	4

1. With a static motor, read the position that ESL outputs (ID4) for reference only.
2. Execute ST clear command.
   – See Table 4 and use ESL (IDB) to send the command eight times continuously.
3. After approximately 30 ms, read the position that ESL outputs (ID4), and get position value 0.

NOTE: The value of the position readout after a zero offset might fluctuate at 0 due to motor vibration at static.

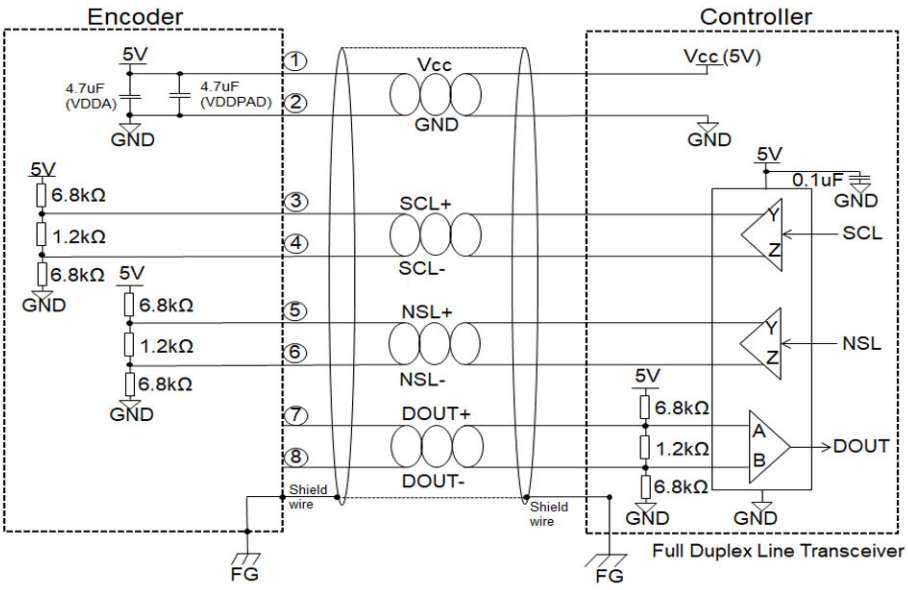
Recommended I/O Connection

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

ESL/SSI 3-Wire Differential Connections

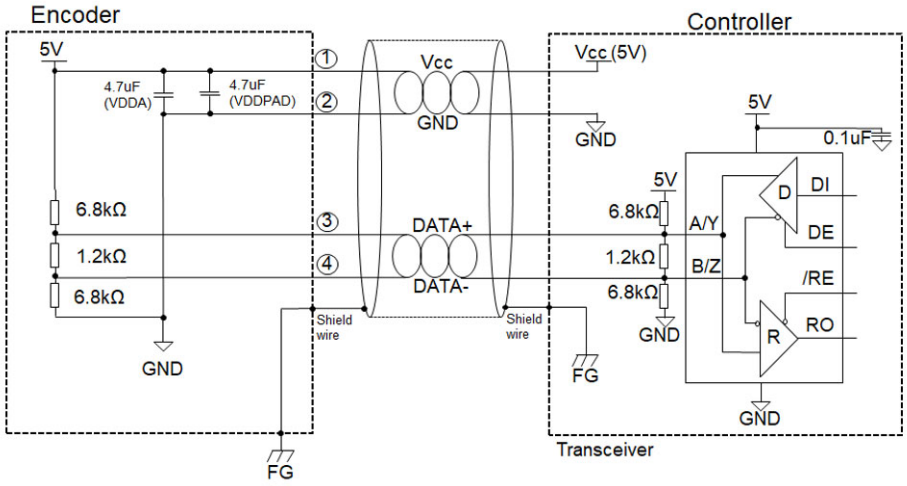
1. Provide the following encoder power supply:
   – For the 5.0V supply, V_{CC} should be within the range of 4.5V to 5.5V.
   – For the 3.3V supply, V_{CC} should be within the range of 3.0V to 3.6V.
2. For best noise immunity, use a twisted-pair shielded cable for connection to the servo driver.
3. To prevent undesirable signal reflection, terminate with 1200Ω resistors.

Figure 12: SSI Differential I/O Connections



ESL Half-Duplex Connection

Figure 13: ESL Half-Duplex I/O Connections

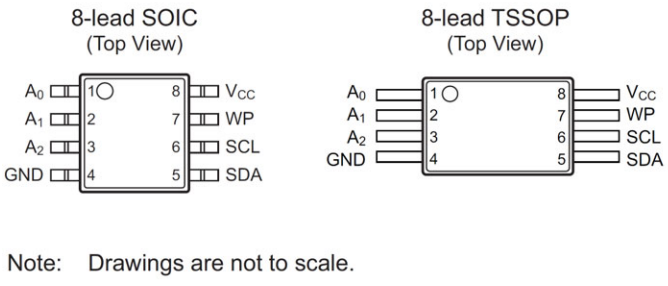


Recommended External EEPROM Device

Table 5: Recommended External EEPROM

Description	Part Number
ST Microelectronics, IC EEPROM 8K I2C 1MHZ 8TSSOP	M24C08-DRDW3TP/K
Microchip, 2-wire Automotive Temperature Serial EEPROMs	AT24C08C-XPD

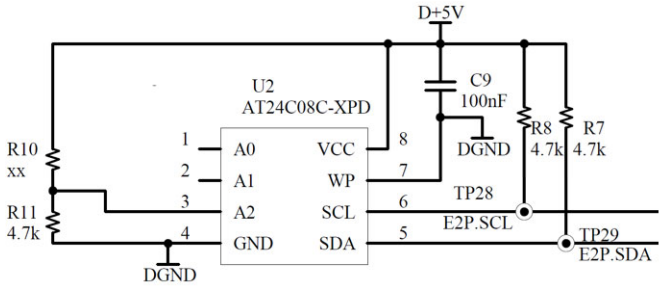
Figure 14: Recommended External EEPROM



Note: Drawings are not to scale.

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 15: Recommended EEPROM Connection



Recommended External Oscillator Device

Table 6: Recommended External Oscillator Device

Description	Part Number
SEIKO EPSON, 50MHz Crystal Oscillator	SG-210SCB 50.000000MHz

Figure 16: Recommended External Oscillator Device

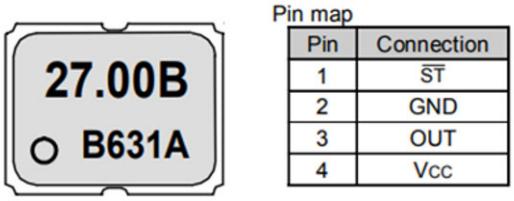
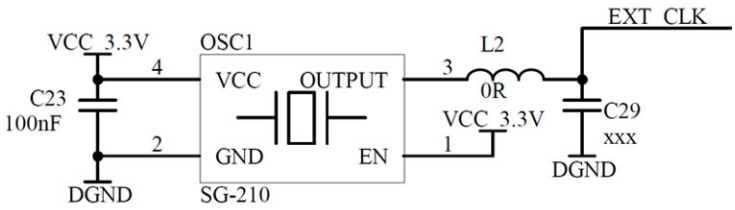


Figure 17: Recommended Oscillator Connection



ESL: Half-Duplex

Table 7: ESL Interface

Interface	Circuit
ESL Serial Data (DATA +)	Transceiver (part number: ISL8485E)
ESL Serial Data (DATA –)	Transceiver (part number: ISL8485E)

Table 8: Timing Characteristics

Parameter	Min.	Typ.	Max.	Units
Communication Baud Rate	—	—	2.5 or 10.0	MHz
Frame Length	—	10	—	Bits/Frame

Position Read Frame (10 µs Wait Time)

Figure 18: Position Read Frame (2.5 Mb/s)

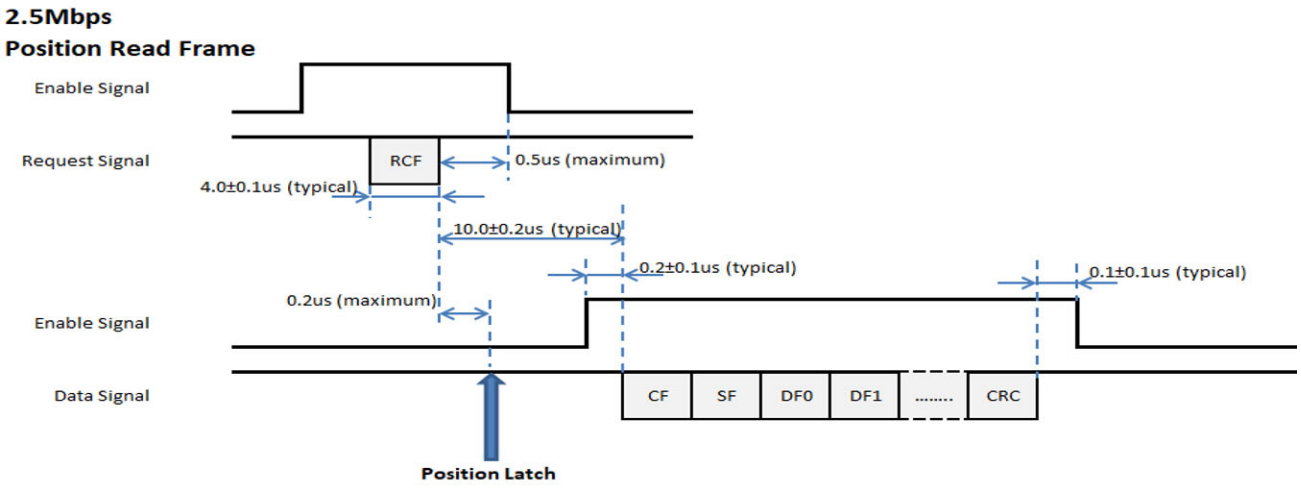
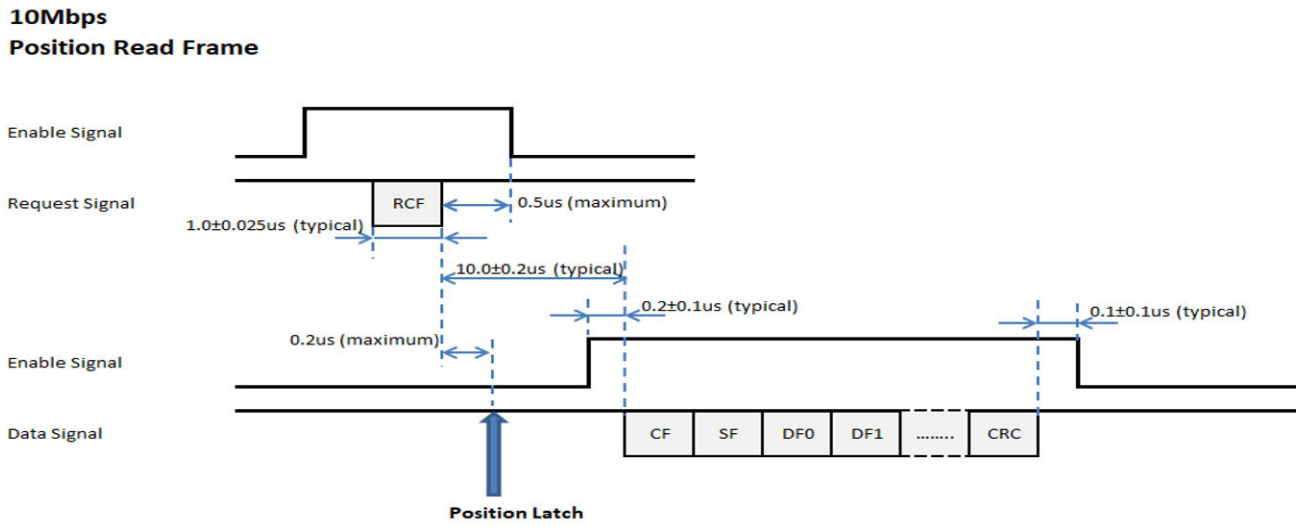


Figure 19: Position Read Frame (10 Mb/s)



Memory Read/Write Frame

Figure 20: Timing Characteristics of Enable, Request, and Data Signals (2.5 Mb/s)

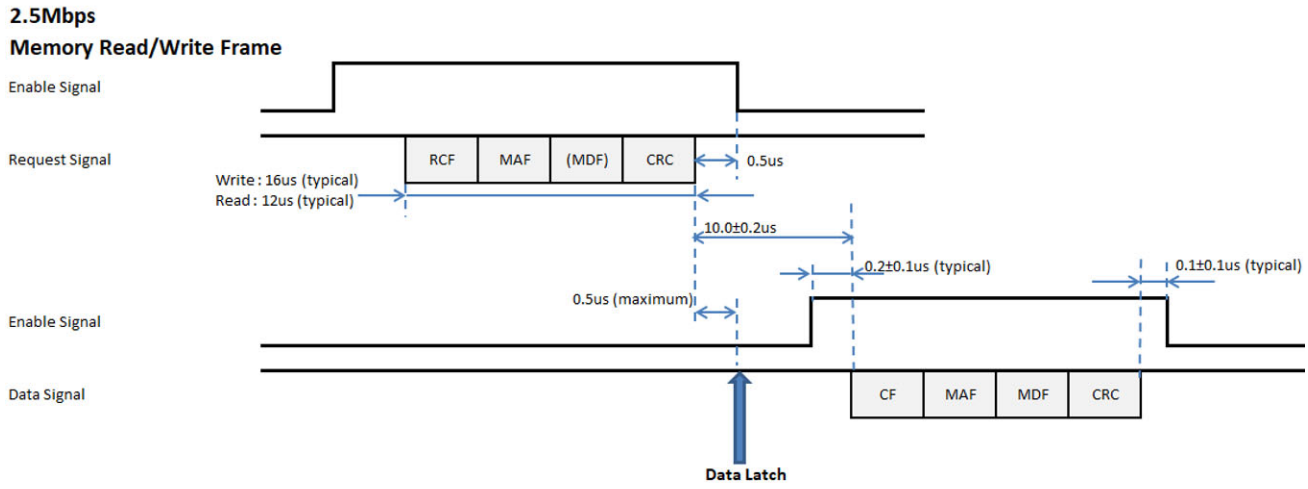
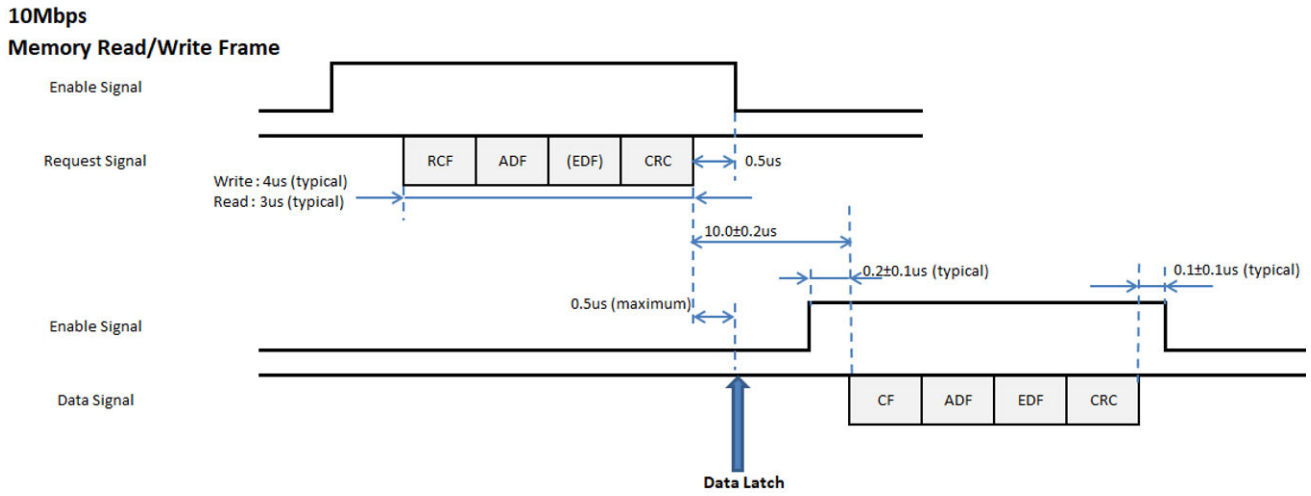


Figure 21: Timing Characteristics of Enable, Request, and Data Signals (10 Mb/s)



Register Communication and Assignment

Refer to the AR35-Series-SS100 software specification document for detailed information.

Memory Map

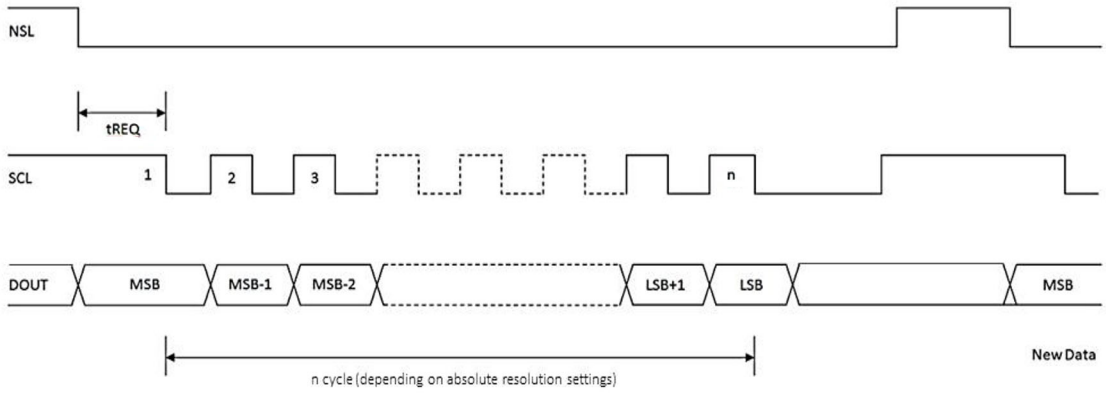
Table 9: Memory Map

Number	Item	Address	Bits							
			7	6	5	4	3	2	1	0
1	Customer Configuration1	0x09	EEPROM Disable	—	CW Direction	—	—	ESL Encoder ID		
2	Customer Configuration2	0x0A	UVW Setting			I-width Setting		CPR Setting		
3	Customer Configuration3	0x0B	—						abs resolution	
4	ST_Zero_Reset_0	0x0C	ST_ZR[7:0]							
5	ST_Zero_Reset_1	0x0D	ST_ZR[15:8]							
6	ST_Zero_Reset_2	0x0E	ST_ZR[23:16]							

SSI 3-Wire Differential Output

SSI 3-Wire Timing

Figure 22: Timing Diagram



NSL toggles from high to low to start request position data.

SCL maximum frequency is 10 MHz.

tREQ= 10 µs is the time of data request processing with 8x averaging.

SSI 3-Wire Pin-Out and Relevant Registers

Figure 23: SSI 3-Wire Pinout

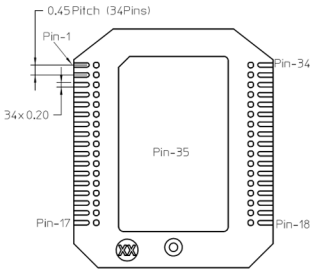


Table 10: SSI 3-Wire Pinout

Pin	Name	Function
10	SSI DOUT	SSI Data Output
12	SSI NSL	SSI Input
14	+ SSI SCL	SSI Clock (+)

AR35TH SSI 3-Wire Output

Figure 24: AR35TH Output

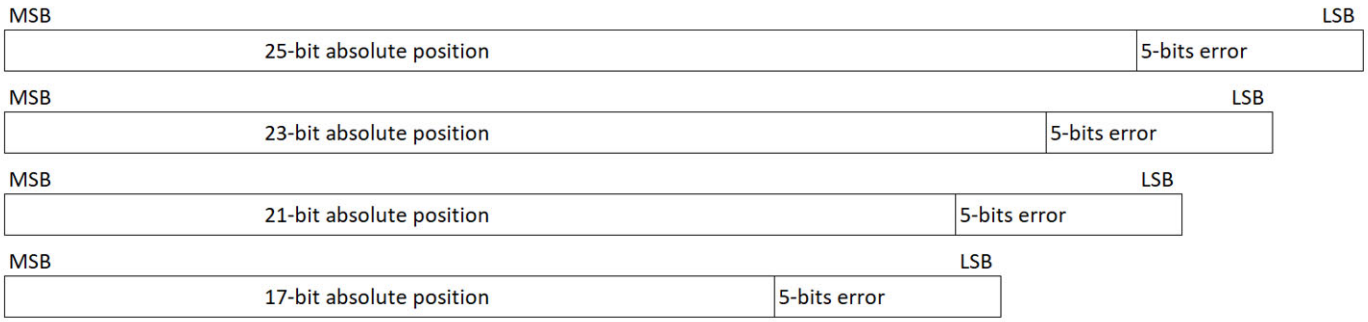


Table 11: 5-Bits Error Definition

Bit [4]	Bit [3]	Bit [2]	Bit [1]	Bit [0]
LED Error	MEM Error	LIS Error	MLS Error	ST Error

Encoder Alarm Definition

The following table shows the encoder alarms and their definition.

Table 12: Alarms and Definition Table

Number	Alarms	Alarms Definition
1	ST_Err (Single-turn Counting Error)	To check the integrity of single-turn position. 1: error in single-turn position. 0: no error in single-turn position.
2	MLS_Err (Absolute Code Error)	To detect error in the absolute MLS (pseudo-random code) generation. 1: MLS code error. 0: MLS code good.
3	Lis_Err (Lissajous Error)	To check integrity of the single-turn Sine & Cosine signals by means of the Lissajous specifications. 1: Lissajous out of specification. 0: Lissajous within specification.
4	MEM_Err (Memory Error)	To indicate EEPROM content loading status upon encoder power up. 1: Fail to load EEPROM memory data. 0: EEPROM memory data loaded successfully.
5	LED_Err (LED Error)	To indicate if LED current is out of operating range. 1: LED out of operating range. 0: LED within operating range.

Encoder Calibration

Perform encoder calibration after the completion of the code strip and encoder installation. Perform encoder calibration using the Broadcom Calibration Kit, A25E-0030.

Do not power cycle the encoder during calibration. Power cycle the unit *only* after the completion of calibration and programming of EEPROM.

NOTE: Encoder calibration can also be performed manually through the SPI/ESL interface. Request from the factory the encoder calibration flow document, AR35L-Series-CAL100.

Calibration Kit

You can perform encoder calibration with the Broadcom Calibration Kit. The kit part number is A25E-0030 – 25 Bits, Linear and Through Hole, AR35 Calibration Kit.

Calibration Kit Pinout

Connect the supplied ribbon cable to the encoder as shown in Table 13.

Table 13: J2 (Ribbon Cable) – 26 Pins Connector Version

Calibration Kit	Connector's Pin	Connection to Encoder Pin
1	VDD_PAD	8
2	VSSA	27
3	VDDA	28
4	VSS	9
9	SN_TST1	3
10	CN_TST3	1
11	SP_TST0	4
12	CP_TST2	2
13	SSI SCL	14
14	ESL_SEL	17
15	SSI NSL	12
16	SSI DOUT– / ESL Dout–	11
17	SSI DOUT+ / ESL Dout+	10
18	SPI_CLK	7
19	SPI_IN	6
20	SPI_DOUT	5
22	I+	26
24	B+	24
25	PROBE4+	30
26	A+	22

Calibration Kit Interface

1. Log in as user.
   The software auto detects the encoder type.
2. Configure the encoder using the User Config interface as shown in Figure 26. After configuration, click **Write** then **Save Configuration**.
3. Set up the encoder to the motor.
4. Run the encoder at 60 rpm ± 5 rpm.

NOTE: To save the calibration result, check **Save Cal Log** before Start as shown in Figure 28.

5. Click **Start** as shown in Figure 28 and wait for the calibration to end (Green Circle).
6. Set the encoder zero reset and absolute position read out using the User Config interface as shown in Figure 26.
   a. Click **Start Read** to read absolute position.
   b. Stop at the position for zero reset and click **Zero Reset Position**.

Figure 25: Login Menu

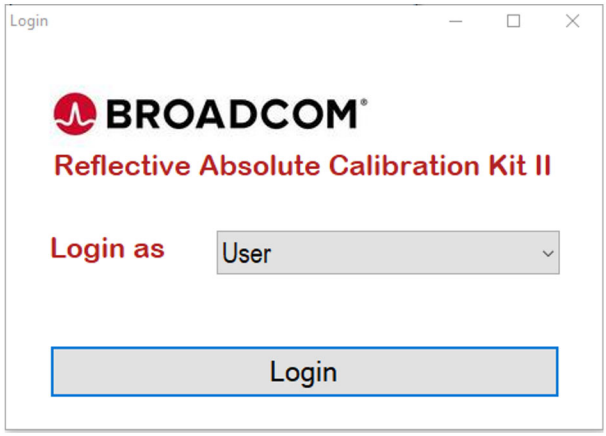


Figure 26: 35TH SSI User Configuration Interface

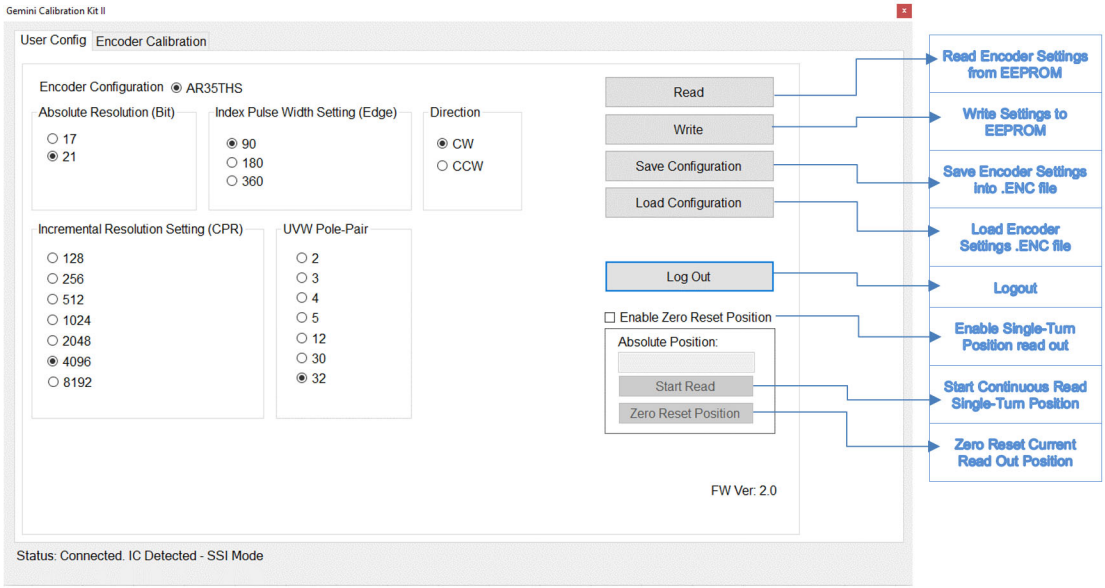


Figure 27: 35TH ESL User Configuration Interface

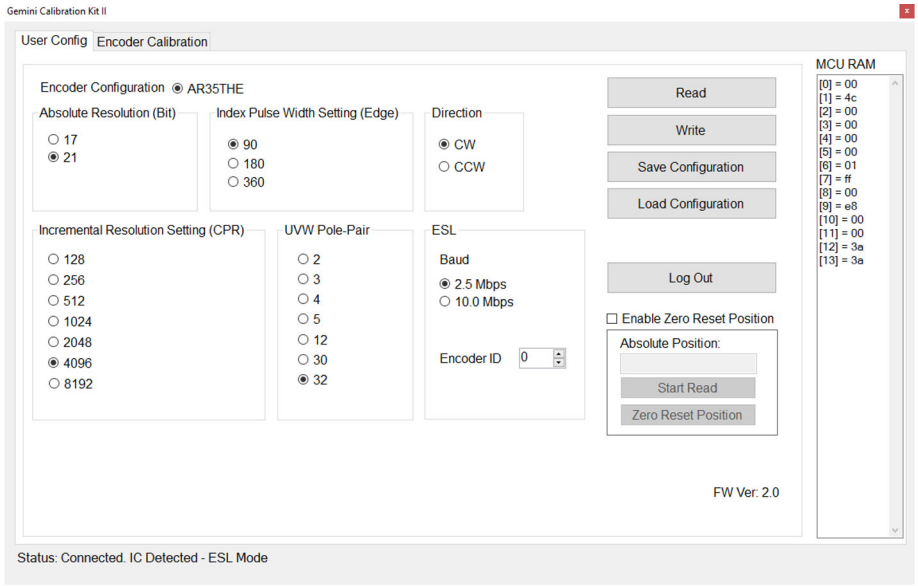
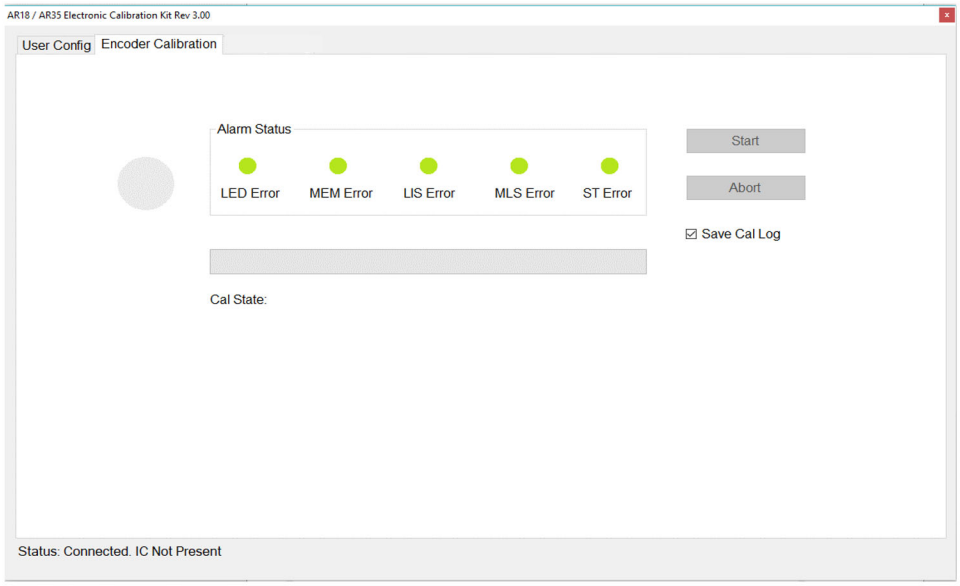


Figure 28: Encoder Calibration Interface



Encoder Troubleshooting

Table 14: Encoder Troubleshooting Table

Number	Description	Causes	Counter Measure
1	No output	Encoder power supply is too low	Check if V_{CC} versus ground potential is within 4.5 to 5.5V
		Poor connectivity between the encoder connector to customer connector	Check encoder connector and customer connector connectivity
		Wrong wire connection assignment	Check connector wire connection assignment
		Detector IC faulty/shorted	Perform power cycle. If problem still exist, please consult factory.
2	Encoder high current consumption (>200 mA at 25˚C)	LED faulty/ shorted	
		Detector IC faulty/shorted	
3	LED_Err triggered	LED faulty	
4	MEM_Err triggered	Opto-ASIC memory block or EEPROM faulty	
5	Lis_Err triggered	LED faulty	Clean code wheel and perform power cycle. If problem still exists, please consult factory.
		Detector IC faulty	
		Code wheel contaminated/damaged	
6	MLS_Err triggered	LED faulty	
		Detector IC faulty	
		Code wheel contaminated/damaged	
7	Single-turn Counting Error triggered	Detector IC faulty	
		Code wheel contaminated/damaged	

Dos and Don'ts

Do

1. Ensure that the environment is clean during installation.
2. Ensure that operators wear finger cots during the code wheel assembly.
3. Ensure that the code wheel is clean by using lint-free delicate task wipers with isopropyl alcohol (IPA) to clean the metal code wheel when necessary.
4. Ensure that there is adequate protection from dust and moisture when encoders are used in a harsh environment.
5. Ensure that the pin configuration is correct per the data sheet.
6. Ensure that the encoder power supply is within tolerance.
7. Ensure that all ESD precaution is observed during installation or handling of the encoder.

Don't

1. Do not overload the transceiver by using the wrong termination resistor.
2. Do not hammer the code wheel hub into the motor shaft during installation.
3. Do not reverse the power source polarity.
4. Do not operate the encoder under extreme temperatures over long periods of time.

X-ON Electronics

Largest Supplier of Electrical and Electronic Components

Click to view similar products for Calibration Equipment ***category:***

Click to view products by Broadcom ***manufacturer:***

Other Similar products are found below :

A25E-0030 AX-C830 AKT7113100 AKT8R111200 AKT8R112100 AKT8R112200 AKT4R1112001 AKT4R1121001 AKT4R1122001 12890 461950 AR604/P CLS 4-20MA 461750 461825 461830 461891 AX-C800 AX-C850 RT-820 FLUKE-805 AKT4R111100 AKT4R111200 AKT4R112100 AKT4R112200 AKT7111100J AKT7211100J AKT7212100J AKT7213100 AKT8R111100 REF2510R K39-LCRR 350456 CAL73 412355A 412400 461831 461893 461895 461920 461995 480400 480403 HD780 PRC10 PRC15 PRC20 RPM40 FLUKE 707 FLUKE-715