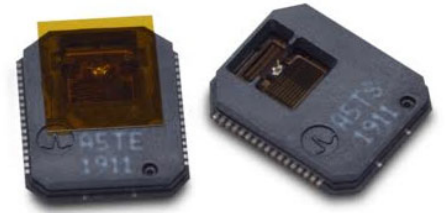


## AR35-LXXE/S

### AR35 Linear Series Miniature Programmable Single-Turn Absolute Encoder with Resolution Ranging from 17 Bits to 25 Bits



#### Description

The Broadcom<sup>®</sup> AR35-L25 series are reflective absolute linear encoders, and the Broadcom AR35-L80 series are reflective incremental linear encoders. The AR35 Linear Series encoders are designed for space-constrained motion control applications.

The AR35 Linear Series encoder is designed for linear scale application with optional incremental or absolute modes of resolution. Both the incremental mode and absolute mode offer user-programmable resolution.

For the incremental mode, the code strip window pitch is 80  $\mu\text{m}$  and the full code length is 40.96 mm. There are five programmable resolution outputs offering the quadrature output resolution ranging from 20  $\mu\text{m}$  to 1.25  $\mu\text{m}$  pitch.

For absolute mode, the code strip window pitch is 102.4  $\mu\text{m}$  running through the full code length of 52.42 mm. The programmable output of 17 bits to 25 bits provides the linear resolution of 400 nm and 1.56 nm pitch respectively.

The AR35 Linear Series offers an operating temperature range of  $-40^{\circ}\text{C}$  to  $115^{\circ}\text{C}$  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 Linear Series offers high accuracy with correction, which is unattainable by the magnetic encoder.

#### Features

- Miniature absolute encoder ASIC surface mount DFN package: 10.9 mm (L) x 9.1 mm (W) x 1.5 mm (H)
- User-programmable resolution ranging from:
  - 20  $\mu\text{m}$  to 1.25  $\mu\text{m}$  for incremental mode
  - 400 nm to 1.56 nm for absolute mode
- Differential output for ABI
- High temperature range of  $-40^{\circ}\text{C}$  to  $115^{\circ}\text{C}$  suitable for most industrial operations
- Dual-mode operating voltage of 3.3V and 5V enabling handheld and portable device applications
- Selectable absolute serial output communication protocols:
  - SSI mode
  - ESL (Encoder Serial Link)
- RoHS compliance

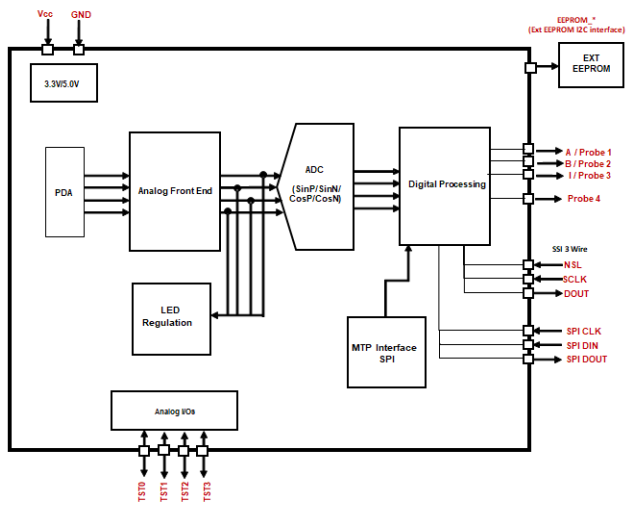
#### Applications

- Linear motor and linear actuator
- Laboratory and measurement equipment
- Robotic automation and engineering
- Factory automation and drone
- Medical and dentistry, devices, and equipment
- High-accuracy portable and handheld devices

# Functional Block Diagram

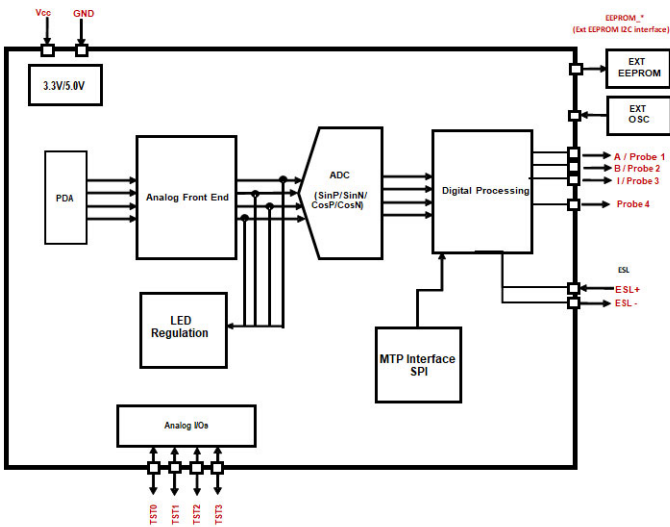
## With SSI 3-Wire Communication Protocol Selection

Figure 1: SSI 3-Wire Block Diagram



## With ESL Communication Protocol Selection

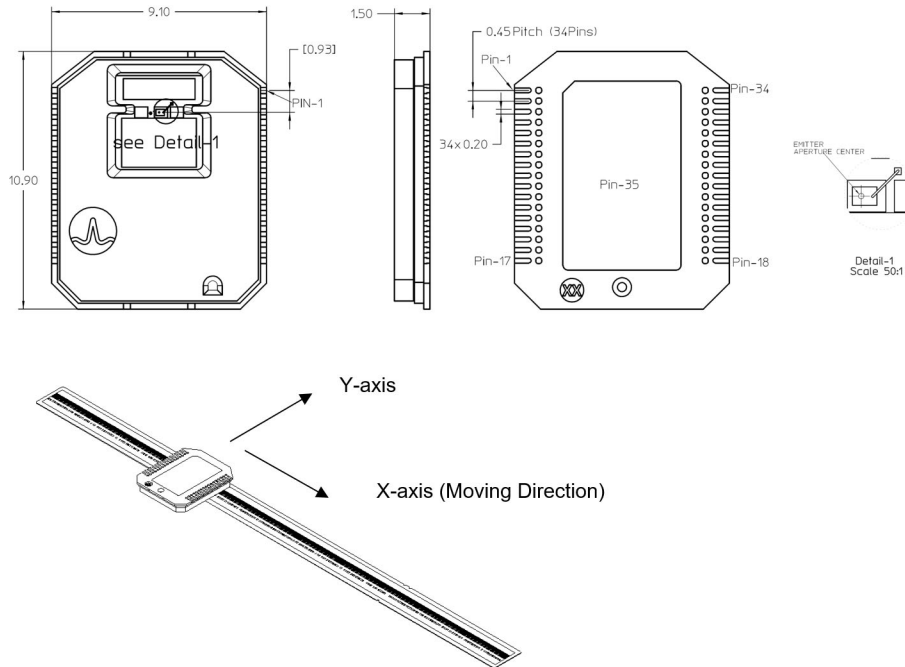
Figure 2: ESL Block Diagram



## Mechanical Specifications

### DFN Package Dimensions

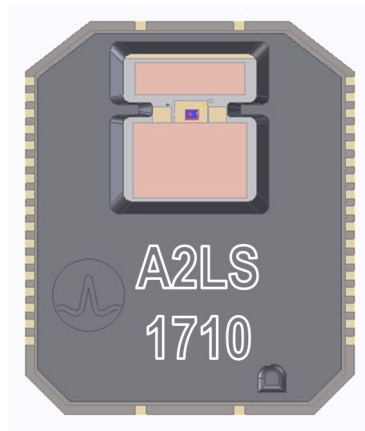
Figure 3: Overall Package Dimensions and Pinout



All dimensions given in mm. Tolerances of form and position according to JEDEC MO-220.

### Package Markings

Figure 4: Product Marking Information



Part Type:

- A2LS/E
- A8LS/E

Date Code:

- YYWW (Year, Work Week)

# Encoder Mounting

Figure 5: Encoder Mounting Guide

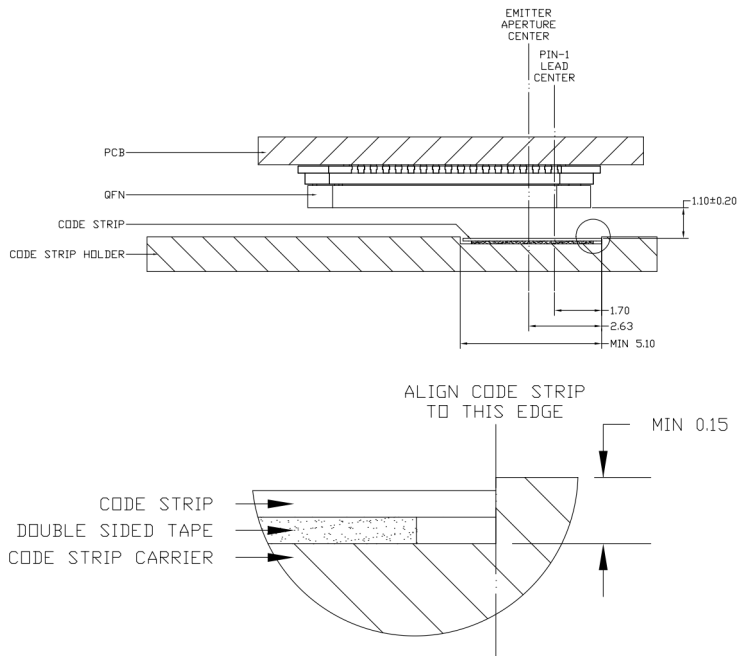
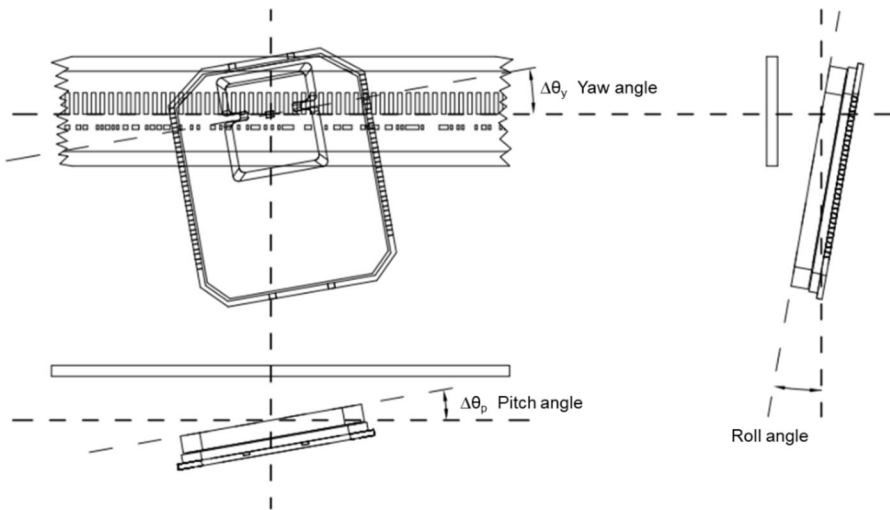


Figure 6: Encoder Yaw, Pitch and Roll Recommended Requirements



	Max (deg)
Yaw Angle, $\Delta\theta_y$	2
Pitch Angle, $\Delta\theta_p$	2
Roll Angle, $\Delta\theta_r$	1

Notes of assembly:

- The assembly of the encoder needs clean room condition, Class 100k or better.
- The encoder needs to be enclosed with IP50 enclosure.

## Recommended PCB Land Pattern

Figure 7: PCB Land Pattern

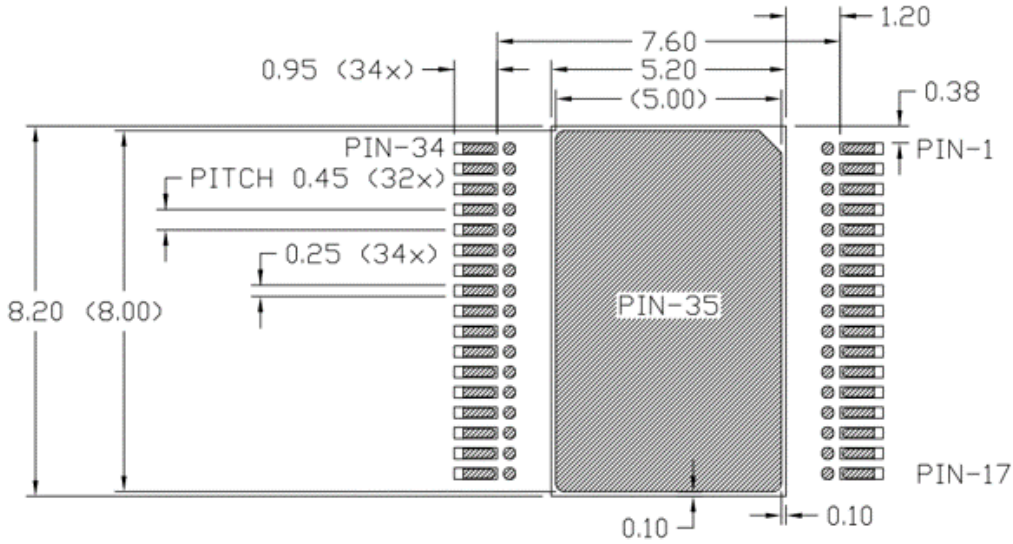
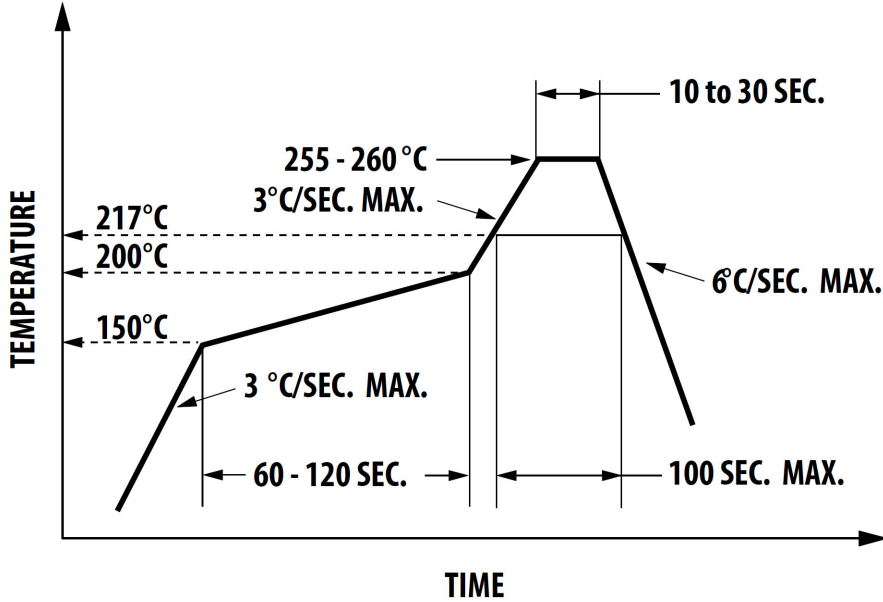


Figure 8: Recommended Pb-Free SMT Reflow Soldering Profile According to JEDEC Pb-Free (J-STD-020D)



## Electrical Specifications

### Recommended Operating Condition

Parameter	Symbol	Min.	Typical	Max.	Unit	Notes
DC Supply Voltage	$V_{dd}$	+4.5	+5.0	+5.5	V	—
DC Supply Voltage	$V_{dd}$	+3.0	+3.3	+3.6	V	—
Ripple of Supply Voltage	—	—	—	100	mVpp	100 kHz
Output Current per channel	—	—	—	±5	mA	—
Rise Time	$t_r$	—	30	—	ns	$C_L = 50 \text{ pF}$
Fall Time	$t_f$	—	30	—	ns	$R_L = 1.2 \text{ k}\Omega$
Ambient Temperature	$T_{amb}$	—	+25	—	°C	—
Operational Temperature	$T_A$	-40	+25	+115	°C	—
Storage Temperature	$T_S$	-40	+25	+115	°C	—
Humidity	RH	—	—	85	%	Temp = 40°C
INC Operating Frequency	—	—	—	128	kHz	Linear speed/Analog pitch
Y-Misalignment	—	-200	0	+200	$\mu\text{m}$	—
Linear Max Speed	—	—	—	10	m/s	318 LPI
	—	—	—	13	m/s	248 LPI

**NOTE:** Movement direction in X-axis

### Recommended Code Strip Characteristics

Parameter	Symbol	Min.	Typical	Max.	Unit	Notes
Specular Reflectance	$R_f$	60%	—	—	—	Reflective area
		—	—	5%	—	Non-reflective area
Code Strip Length	L	—	106.83	—	mm	248 LPI absolute
			86.68		mm	318 LPI incremental

**NOTE:** Characteristic based on qualified code strip supplier. Refer to factory for qualified reflective code strip supplier.

### Absolute Maximum Ratings

Parameter	Symbol	Value
Storage Temperature	$T_S$	-40°C to 115°C
Operating Temperature	$T_A$	-40°C to 115°C
Supply Voltage	$V_{dd}$	7V
ESD (HBM), JS-001-2014	—	± 2 kV
Moisture Sensitive Level	MSL	3 (Maximum floor life = 168 hours)

## DC Characteristics

DC characteristics over recommended operating range, typical at 25 °C.

Parameter	Symbol	Conditions	Value			Notes
			Min.	Typ.	Max.	
V <sub>dd</sub> Supply Current	I <sub>dd</sub>	V <sub>dd</sub> = 3.3V/5V	—	70	—	mA
Absolute Single Turn Resolution	—	—	—	17/400	—	Bit/nm
			—	2 /25	—	Bit/nm
			—	23/6.25	—	Bit/nm
			—	25/1.56	—	Bit/nm
Incremental Resolution	—	—	—	1.25	—	μm
			—	2.50	—	μm
			—	5.00	—	μm
			—	10.00	—	μm
			—	20.00	—	μm

## Encoder Characteristics

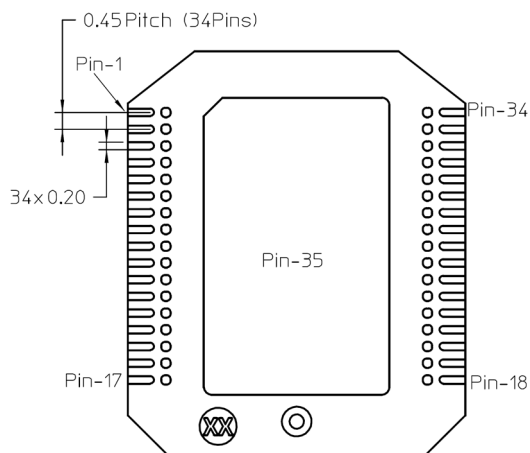
Incremental encoder characteristics over recommended operating condition, at 25 °C (318 LPI).

Parameter	Symbol	Min.	Typ.	Max. <sup>a</sup>	Units
ABI Cycle Error	ΔC	—	—	45	°e
ABI State Error	ΔS	—	—	45	°e
Index Pulse Width	P <sub>o</sub>	—	90,180, 360	—	°e
System Resolution	—	512	—	8192	Count
Sine, Cosine	—	—	1	—	V

a. Maximum values represent the encoder performance across the range of recommended mounting tolerance.

## Encoder Pin Function

Figure 9: Pinouts from Top View



## SSI 3-Wire Option Pinout Configuration

**NOTE:** Pin 35 must be grounded to VSSA and pin 17 connect to common GND.

Pin	Name	Function	Pad type	Analog/Digital	Input/Output
1	CN/TST3	Analog Voltage Output NCOS	5V/3.3V pads	Analog	I/O
2	CP/TST2	Analog Voltage Output PCOS	5V/3.3V pads	Analog	I/O
3	SN/TST1	Analog Voltage Output NSIN	5V/3.3V pads	Analog	I/O
4	SP/TST0	Analog Voltage Output PSIN	5V/3.3V pads	Analog	I/O
5	SPI DOUT	SPI Data Output	3.3V/5V (VDDPAD)	Digital	Output
6	SPI DIN	SPI Data Input	3.3V/5V (VDDPAD)	Digital	Input
7	SPI CLK	SPI Clock	3.3V/5V (VDDPAD)	Digital	Input
8	VDD	Digital Supply Voltage	3.3V/5V (VDDPAD)	Digital	Power
9	VSS	Digital GND	Digital ground	Digital ground	Ground
10	+SSI DOUT	SSI Data Output (+)	3.3V/5V (VDDPAD)	Digital	I/O
11	-SSI DOUT	SSI Data Output (-)	3.3V/5V (VDDPAD)	Digital	I/O
12	+SSI NSL	SSI Input (+)	3.3V/5V (VDDPAD)	Digital	I/O
13	-SSI NSL	SSI Input (-)	3.3V/5V (VDDPAD)	Digital	Input
14	+SSI SCL	SSI Clock (+)	3.3V/5V (VDDPAD)	Digital	Input
15	-SSI SCL	SSI Clock (-)	3.3V/5V (VDDPAD)	Digital	Input
16		—			
17	ESL SEL	Protocol Selection	Selection (GND)	Ground	Ground
18	EEPROM SCL	EXT EEPROM Clock	3.3V/5V (VDDPAD)	Digital	I/O
19	EEPROM SDA	EXT EEPROM Data	3.3V/5V (VDDPAD)	Digital	I/O
20	EEPROM WP	EXT EEPROM Write Protect	3.3V/5V (VDDPAD)	Digital	Output
21	-A	Incremental -A Output	3.3V/5V (VDDPAD)	Digital	Output
22	+A/PROBE1	Incremental +A Output	3.3V/5V (VDDPAD)	Digital	Output
23	-B	Incremental -B Output	3.3V/5V (VDDPAD)	Digital	Output
24	+B/PROBE2	Incremental +B Output	3.3V/5V (VDDPAD)	Digital	Output
25	-I	Incremental -Index Output	3.3V/5V (VDDPAD)	Digital	Output
26	+I/PROBE3	Incremental +Index Output	3.3V/5V (VDDPAD)	Digital	Output
27	VSSA	Analog GND	Analog ground	Analog ground	Ground
28	VDDA	Analog Supply Voltage	3.3V/5V (VDDPAD)	Analog	Power
29		—			
30	PROBE4	Calibration Output <sup>a</sup>	3.3V/5V (VDDPAD)	Digital	Output
31		—			
32		—			
33		—			
34		—			
35	Common GND (VSSA)	Ground to VSSA	Analog ground	Analog ground	Ground

a. Calibration output is only required during initial calibration.



## ESL Option Pinout Configuration

**NOTE:** Pin 35 must be grounded to VSSA and pin 17 connect to VDD (5V/3.3V).

Pin	Name	Function	Pad type	Analog/Digital	Input/Output
1	CN/TST3	Analog Voltage Output NCOS	5V/3.3V pads	Analog	I/O
2	CP/TST2	Analog Voltage Output PCOS	5V/3.3V pads	Analog	I/O
3	SN/TST1	Analog Voltage Output NSIN	5V/3.3V pads	Analog	I/O
4	SP/TST0	Analog Voltage Output PSIN	5V/3.3V pads	Analog	I/O
5		—			
6		—			
7		—			
8	VDD	Digital Supply Voltage	3.3V/5V (VDDPAD)	Digital	Power
9	VSS	Digital GND	Digital ground	Digital ground	Ground
10	+ESL	ESL Data Output (+)	3.3V/5V (VDDPAD)	Digital	I/O
11	-ESL	ESL Data Output (-)	3.3V/5V (VDDPAD)	Digital	I/O
12		—			
13		—			
14		—			
15		—			
16	OSC_EXT	External Oscillator <sup>a</sup>	3.3V/5V (VDDPAD)	Digital	Input
17	ESL_SEL	Protocol Selection	Selection (VDD)	Digital	Power
18	EEPROM_SCL	EXT EEPROM Clock	3.3V/5V (VDDPAD)	Digital	I/O
19	EEPROM_SDA	EXT EEPROM Data	3.3V/5V (VDDPAD)	Digital	I/O
20	EEPROM_WP	EXT EEPROM Write Protect	3.3V/5V (VDDPAD)	Digital	Output
21	-A	Incremental -A Output	3.3V/5V (VDDPAD)	Digital	Output
22	+A/PROBE1	Incremental +A Output	3.3V/5V (VDDPAD)	Digital	Output
23	-B	Incremental -B Output	3.3V/5V (VDDPAD)	Digital	Output
24	+B/PROBE2	Incremental +B Output	3.3V/5V (VDDPAD)	Digital	Output
25	-I	Incremental -Index Output	3.3V/5V (VDDPAD)	Digital	Output
26	+I/PROBE3	Incremental +Index Output	3.3V/5V (VDDPAD)	Digital	Output
27	VSSA	Analog GND	Analog ground	Analog ground	Ground
28	VDDA	Analog Supply Voltage	3.3V/5V (VDDPAD)	Analog	Power
29		—			
30	PROBE4	Calibration Output <sup>b</sup>	3.3V/5V (VDDPAD)	Digital	Output
31		—			
32		—			
33		—			
34		—			
35	Common GND (VSSA)	Ground to VSSA	Analog ground	Analog ground	Ground

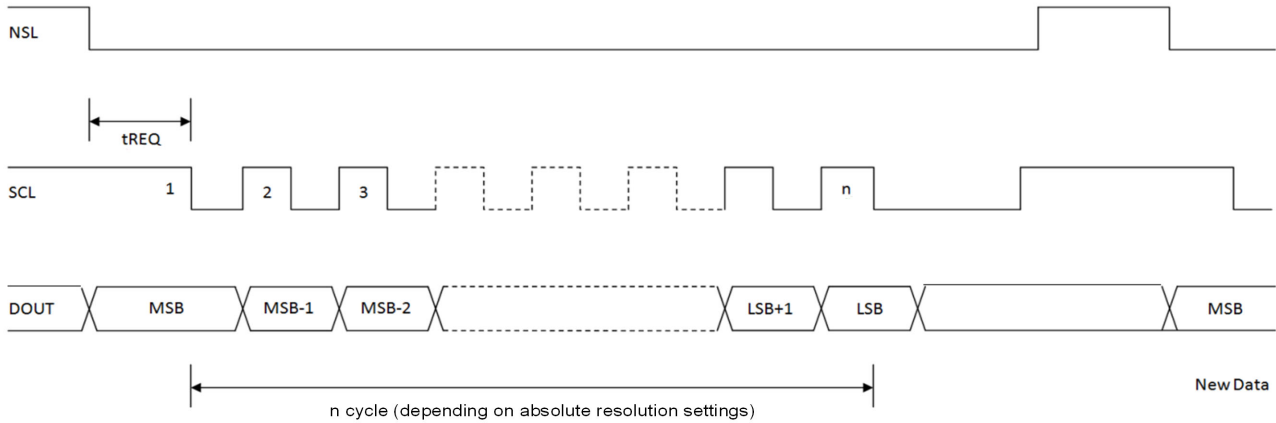
a. External Oscillator: 50Mhz (10ppm) oscillator input is required for ESL configuration

b. Calibration Output: Only required during initial calibration

# Communication Protocol

## SSI 3-Wire

Figure 10: SSI 3-Wire Timing Diagram



**NOTE:**

- NSL Toggle from high to low to start request position data.
- SCL maximum frequency is 10 MHz.
- $t_{REQ} = 10 \mu s$  is the time of data request processing.

Figure 11: AR35 SSI 3-Wire Format Output

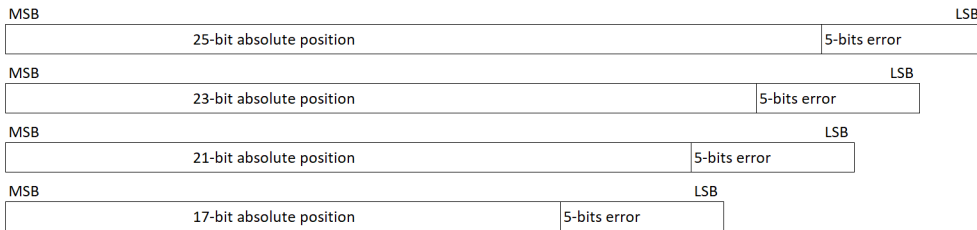


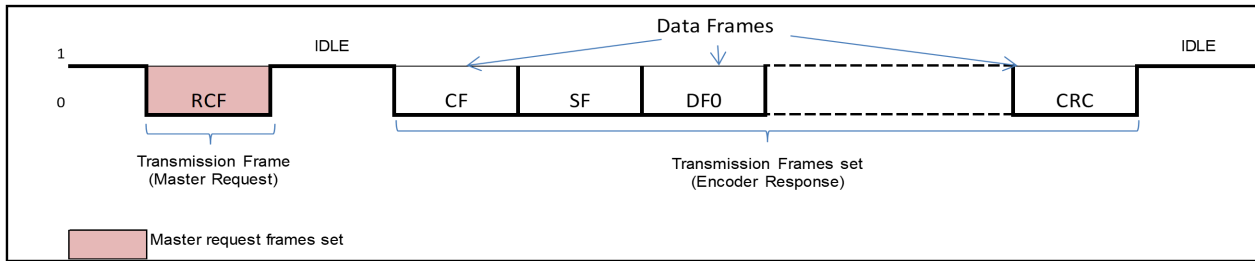
Figure 12: Alarm Bit Definition

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

Refer to the application notes for more detail.

## ESL

Figure 13: General Transmission Frames Format on Half-Duplex Line



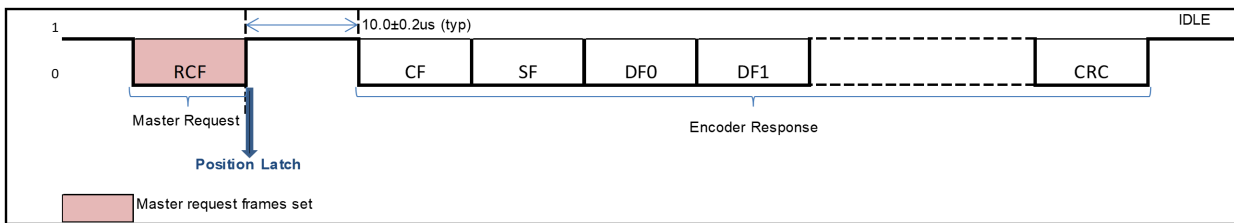
**Start of transmission frames set:** Upon detected the first logic of low state 0 on the transmission line after idling state, and if the following 3 bit conforms to command identifier, the encoder will acknowledge as a valid Request Command Frame (RCF), indicating the start of transmission frame set, else, it will continue to search for next available logic of low state 0.

**End of transmission frames set:** After the RCF 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.

## Encoder Data Read Out Frame Sets Format and Timing

Figure 14: Encoder Data Read Out Frames Set



Upon the master issue a RCF frame request, after  $10.0\ \mu\text{s}$  (typ.), the encoder will respond with encoder data frames set with the following content:

1. CF: Corresponds to the RCF issued from Master.
2. SF: Status frame.
3. DF0 through DF7: Data frames.
4. CRC: Cyclic Redundancy Check (CRC) frame.

Encoder position calculation is completed within  $10.0\ \mu\text{s}$  (typ.) after the end bit of Master RCF.

The Encoder response data frames set formats are dependent on the requested operation by the Master, see [Data Frames Content with Respective Command ID](#).

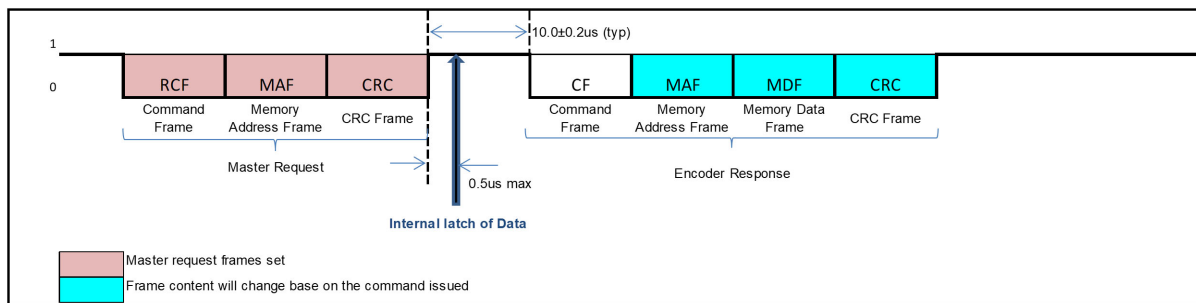
## Data Frames Content with Respective Command ID

Command ID	DF0	DF1	DF2	DF3	DF4	DF5	DF6	DF7
Command ID 4	ALMC <sup>a</sup>	ABS0 <sup>b</sup>	ABS1	ABS2	ABS3	—	—	—
Command ID 6	ABS0	ABS1	ABS2	ABS3	—	—	—	—
Command ID 8	ENID <sup>c</sup>	—	—	—	—	—	—	—
Command ID A	ALMC	—	—	—	—	—	—	—
Command ID B	ALMC	ABS0	ABS1	ABS2	ABS3	—	—	—
Command ID C	ALMC	ABS0	ABS1	ABS2	ABS3	—	—	—

- ALMC: Encoder alarm flags.
- ABS $n$ : Single-turn counts, LSB of the single-turn counts are located in ABS0 and MSB of the counts data are located in ABS3. Combining ABS0 through ABS3 will provide total to 32 bits of single-turn data. For single-turn 25 bits encoder option, the 7 MSB of ABS3 is fixed to 0, thus giving total 25 bits single turn-data.
- ENID: Encoder Single-turn bits identification. For the single-turn 25 bits encoder option, ENID fixed as 19h.

## Memory Data Read Out Frames Set Format and Timing

Figure 15: Memory Data Read Out Frames Set

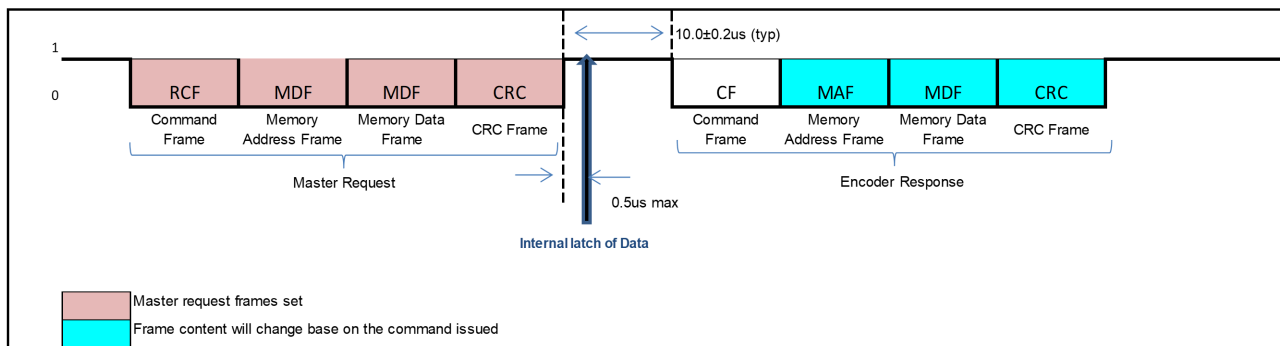


Content of transmission frames:

- RCF: Request Command Frame (RCF) from Master.
- CF: Corresponds to the RCF issued from Master.
- MAF: Memory Address Frame indicates the memory location to read.
- MDF: Memory Data Frame contains the data read from memory.
- CRC: Cyclic Redundancy Check (CRC) frame.

## Memory Data Write Frames Set Format and Timing

Figure 16: Memory Data Write Frames Set



Content of transmission frames:

1. RCF: Request Command Frame (RCF) from Master.
2. CF: Corresponds to the RCF issued from Master.
3. MAF: Memory Address Frame indicates the memory location to read.
4. MDF: Memory Data Frame contains the data read from memory.
5. CRC: Cyclic Redundancy Check (CRC) frame.

## Customer Configurations and Signal Output

### Absolute Encoder Configuration Settings for LPI 248, CS INC Pitch 102.4 $\mu\text{m}$

Page (Hex)	Address	Bit(s)	Name	Settings	Output	Default (Hex)
0x08	0x00	0–7	Register Unlock	Unlock (Write 0xAB)	Unlock register	8'h00
0x0E	0x09	7	EEPROM Disable	0	Enable EEPROM	8'h80
				1	Disable EEPROM	
		5	Code Strip Direction (Right To Left)	0	Count UP	
				1	Count DOWN	
	0–2	ESL Encoder ID	000	Default		
	0x0B	0–1	Abs Resolution (nm)	00	400	8'h3F
				01	25	
10				6.25		
11				1.56		

### Incremental Encoder Configuration Settings for LPI 318, CS INC Pitch 80 $\mu\text{m}$

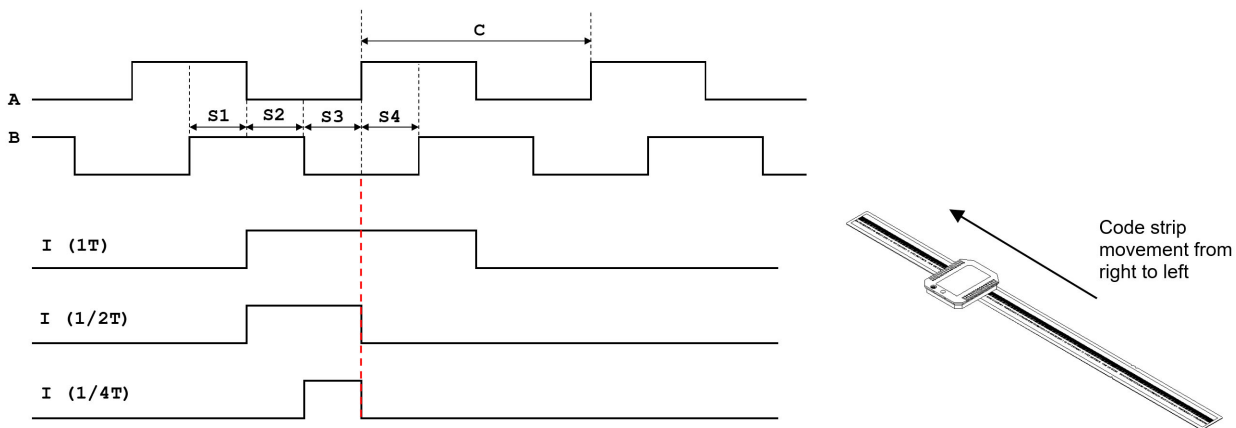
Page (Hex)	Address	Bit (s)	Name	Settings	Output	Default (Hex)
0x08	0x00	0–7	Register Unlock	Unlock (Write 0xAB)	Unlock register	8'h00
0x0E	0x09	7	EEPROM Disable	0	Enable EEPROM	8'h80
				1	Disable EEPROM	
		5	Code Strip Direction (Right To Left)	0	A lead B	
				1	B lead A	
	0–2	ESL Encoder ID	000	Default		
	0x0A	4–3	I-width Setting	00	90 edeg	8'h00
				01	180 edeg	
				10	360 edeg	
				11	90 edeg	
		0–2	Resolution ( $\mu\text{m}$ ) in Quadrature	000	1.25	
001				2.5		
010				5		
			011	10		

## Customer Reserved Zero Offset and Calibration Registers

Page	Address	Bit (s)	Name	Description
0x0Eh	0x09	0–5	Customer Configuration 1	User Programmable
	0x0A	0–7	Customer Configuration 2	User Programmable
	0x0C	0–7	Zero Reset 0	Zero Reset Position [8:1]
	0x0D	0–7	Zero Reset 1	Zero Reset Position [16:9]
	0x0E	0–7	Zero Reset 2	Zero Reset Position [24:17]
	0x14	7	Alarm Reset	Alarm Clear

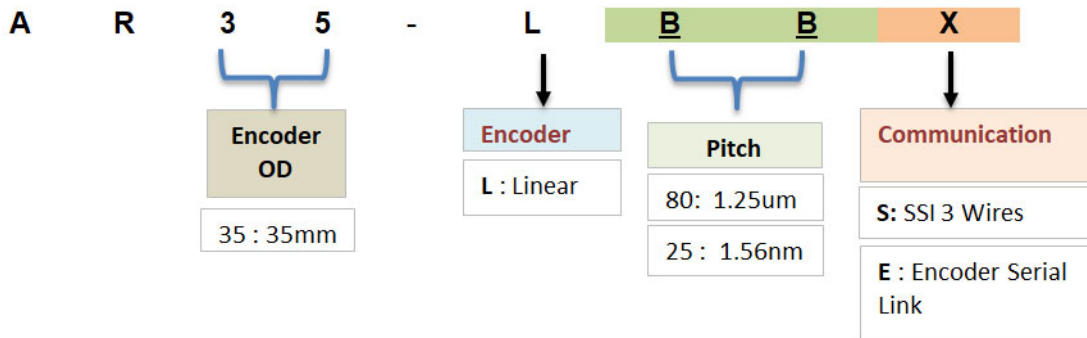
## Incremental Output Format

Figure 17: ABI signals Output Based on Code Strip Direction Setting 0



## Ordering Information

Figure 18: Encoder Ordering Information

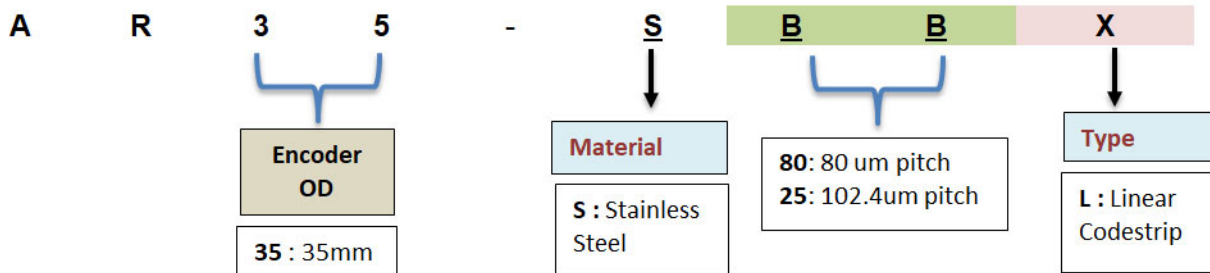


## Calibration Kit

- Ordering Part Number: A25E-0030
- Description: Linear and Through Hole, AR35 Calibration Kit

Figure 19: Code Strip Ordering Information

### Linear Code Strip

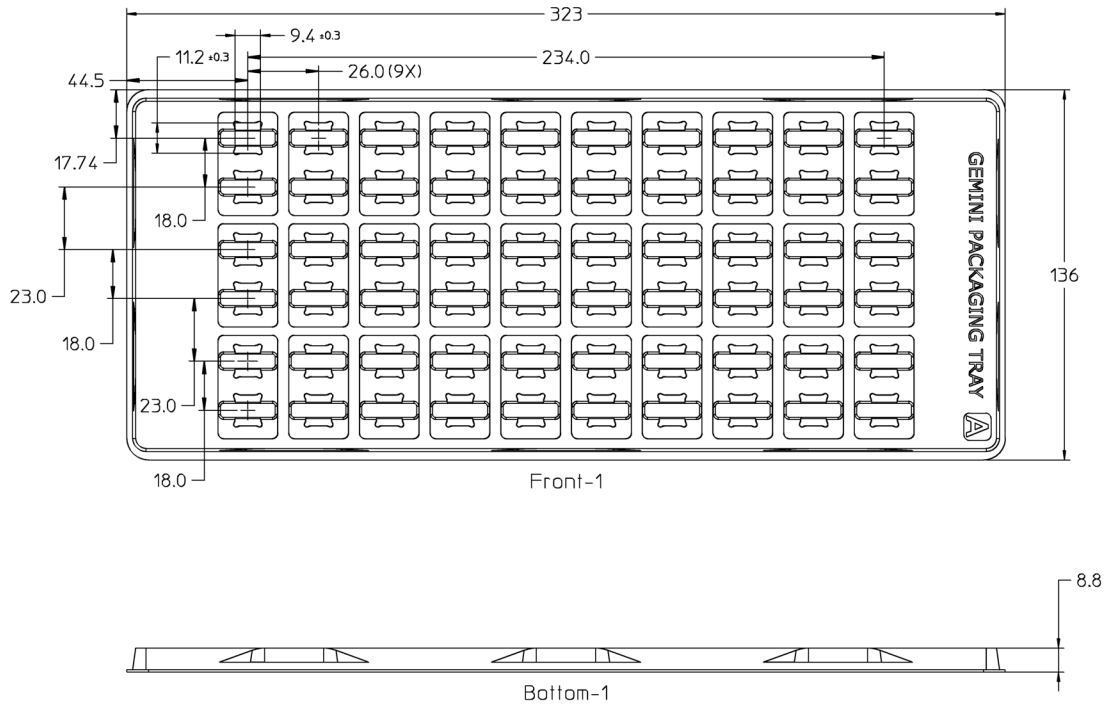




## Packaging

- Encoder Packaging Information (Tray): 60 units per tray
- Code Strip Packaging Information: 30 units per bundle

Figure 20: Encoder Tray Packaging Information



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