AEAT-7000 Series

Ultra-precision 13-Bit Gray Code Absolute Encoder Module

Data Sheet

Description

Avago Technologies' AEAT-7000 Series is a high temperature rated optical encoder module that is capable of providing up to 13 bits of absolute positioning information. The photodetector ASIC and the light emitter are designed into a compact C-shape module. It's small, compact and modular form factor also makes it an ideal choice for space-constrained applications.

AEAT-7000 uses a sophisticated photodetector ASIC that consists of an array of photodiodes, precision amplifiers, and additional signal processing circuitry. This photodetector ASIC includes two pairs of analog photodiodes to generate 2 channels of true differential Sine and Cosine signals. For a closed loop emitter light monitoring, the ASIC will monitor internally and self regulate if the infrared (IR) LED degrades.

The Sin/Cosine photodiodes are used to drive a constant current source for the highly collimated IR illumination system.

Note: Avago Technologies encoders are not recommended for use in safety critical applications, e.g., ABS braking systems, power steering, life support systems and critical care medical equipment. Avago's products and software are not specifically designed, manufactured or authorized for sale as parts, components or assemblies for the planning, construction, maintenance or direct operation of a nuclear facility or for use in medical devices or applications. Customer is solely responsible, and waives all rights to make claims against Avago or its suppliers, for all loss, damage, expense or liability in connection with such use. Please contact sales representative if more clarification is needed.

Features

- 11 digital tracks plus 2 Sin/Cosine tracks generate precise 13-bit gray code
- Ultra fast, 1us cycle for serial data output word equals 16MHz
- Integrated highly collimated illumination system
- On-chip interpolation and code correction compensate for mounting tolerance
- 2 channels true differential Sine/Cosine outputs with 1024 cycles per revolution
- 1024CPR A/B channel incremental outputs
- MSB can be inverted for changing the counting direction
- Built-in monitor track for monitoring of LED light level
- Error output for LED degradation monitoring
- -40 to 85°C operating temperature

Applications

Typical applications include

- Rotary applications up to 13 bits/360° absolute position
- Industrial and maritime valve control
- High precision test and measurement machines
- Industrial and factory automation equipments
- Textile, woodworking & packaging machineries
- Nacelle & blades control in wind turbine

ESD WARNING: *Handling precautions should be taken to avoid static discharge.*

Absolute Maximum Ratings[1]

Parameter	Symbol	Min.	Max.	Units
Storage Temperature	T_S	-40	100	°C
Operating Temperature	T_A	-40	100	°C
Supply Voltage	V_{DD}	-0.3	6	V
Voltages at all input and output pins	Vin & Vout	-0.3	V_{DD}+0.3	V
DC supply voltage	VD	-0.3	6.0	V
Relative Air Humidity (non-condensing) [2]	T/RH		40 / 93	°C/%

Note:
1. Absolute Maximum Ratings are those values beyond which the safety of the device cannot be guaranteed. They are not meant to imply that the device should be operated at these limits. The tables "Recommended Operating Conditions and Characteristics" provide conditions for actual device operation.
2. Maximum combination of temperature on humidity

Recommended Operating Conditions

Description	Symbol	Min.	Typical	Max.	Units	Notes
Temperature	T_A	-40	25	85	°C	
Supply Voltage	V_{DD}	4.5	5	5.5	V	Ripple < 500 mVpp
Input-H-Level Threshold	V_{ih}	2.0		V_{DD}	V	Input-H-Level threshold
Input-L-Level Threshold	V_{il}	0		0.8	V	Input-L-Level threshold

Electrical Characteristics Table(V_{DD} = 4.5 to 5.5V, TA = -40 to +85°C)

Electrical characteristics over recommended operating conditions. Typical values at 25°C

Parameters	Symbol	Conditions	Min.	Typ.	Max.	units
Operating Currents						
Total Current	I_{Total}	LED current @10mA typ		52		mA
Digital Inputs						
Pull down Current	I_{pd}		-90	-60	-10	µA
Pull Up Current	I_{pu}		-90	-60	-10	µA
Digital Outputs						
Ouput-H-Level	V_{oh}	I_{oh} = 2 mA	V_{DD}- 0.5V		V_{DD}	V
Output-L-Level	V_{ol}	I_{ol} = -2mA	0		0.5	V
Serial Interface						
SCL Clock Frequency	f_{clock}				16	MHz
Duty Cycle fclock	T_{clock},LH	f_{clock} = 10MHz	0.4		0.6	
Accuracy within one revolution Notes 1, 2 ,3		f_{SCL} = 5MHz RPM = 100prm V_{ripple} = <50mVpp		+/-1		bits

Notes:
1. LSB accuracy will also depend on mechanical precision of the shaft, bearing, hub etc, Final accuracy of the encoder module is dependent on the precision of the total assembly.
2. Accuracy would be influenced by installation control and the bearing and shaft type being used.
3. Other test conditions to determine accuracy are briefly listed as follows:
   (a) At nominal radial, tangential and gap position
   (b) On dual preloaded bearing with absolute assembly total runout of not exceeding 0.01mm TIR

Functional Description

Background

The 13 signal channels are set up as:

Two precision defining Signal (A0, A09), which are 90° electrical shifted sine, cosine signals. These are conditioned to be compensated for offset and gain errors. After conditioning they are on chip interpolated of 4bits.

11 analog (A1 – A11) channels which are directly digitized by precision comparators with hysteresis tracking. The digitized signals are called D1-D11. Internal correction and synchronization module allows the composition of a true 1bit Gray code by merging the data bits of A1-A11 and Sin/Cosine.

There is a Gray code correction feature for this encoder. This Gray code correction can be disabled/ enabled by the pin KORR.

The gain and offset conditioning value of the sine and cosine signals are preloaded on-chip by factory this will compensate for mechanical sensor misalignment error.

Signal channels A1-A11

The photocurrent of the photo diodes is fed into a trans-impedance amplifier. The analog output of the amplifier has a voltage swing of (dark/light) about 1.3V. Every output is transformed by precision comparators into digital signals (D1-D11). The threshold is at VDD/2 (=Analog-reference), regulated by the sin/cosine channel.

Monitor channel with LED control at Pin LEDR and LERR

The analog output signal of the monitor channel is regulated by the LED current. An internal bipolar transistor sets this level to VDD/2 (control voltage at pin (LEDR). Thus the signal swing of each output is symmetrical to VDD/2 (=Analog-reference)

The error bit at pin LERR is triggered if the Ve of the internal bipolar transistor is larger than VDD/2.

Signal channel A0, A09 with signal conditioning and calibration

These two channels give out a sine and cosine wave, which are 90 degree phase shifted. These signals have amplitudes which are almost constant due to the LED current monitoring. Due to amplifier mismatch and mechanical misalignment, the signals have gain and offset errors. These errors are eliminated by an adaptive signal conditioning circuitry. The conditioning value are on-chip preprogrammed by factory. The analog output signals of A0 and A09 are supplied as true-differential voltage with a peak-to-peak value of 1.0V at the pins A09P, A09N, A0P, A0N.

Interpolator for channels A0, A09

A0 channel will digitize to form D0 and the LSB bit (D-1) will generate from the interpolator. The D0 to D-1will be synchronize with the 11-bit data to D12…D0 to form a 13bit absolute position.

The channels A0, A09 and A1~A11 have very high dynamic bandwidth, which allows a real time monotone 12-bit Gray code at 12000RPM.

LSB gray code correction (Pin KORR)

This function block synchronizes the switching points for the 11-bit Gray code of the digital signals D1 to D11 with D0 and D09 (digitized signal of A0 and A09).

This Gray code correction only works for the 12-bit MSB(4096 step per revolution). The correction is not for the interpolated bits

Gray code correction can be switched on or off by putting the pin KORR = 1 (on) or = 0 (off).

MSBINV and DOUT Pins

The serial interface consists a shift register. The most significant bit, MSB (D11) will always be sent first to DOUT. The MSB can be inverted (change code direction) by using pin MSBINV. Setting MSBINV to high state, output data will be counting in another direction.

From top view, if code wheel turning clock wise output data will be increment up, if MSBINV set to high state, output data will be counting another direction.

If code wheel turning counter-clock wise the output data will be decrement, if the MSBINV set to high state, output data will be counting up.

DIN and NSL Pins

The serial input DIN allows the configuration as ring register for multiple transmissions or for cascading 2 or more encoders. DIN is the input of the shift register that shifts the data to DOUT.

The NSL pin controls the shift register, to switch it between load (1) or shift (0) mode. Under load mode, DOUT will give the logic of the MSB, i.e., D11.

Under shift mode (0), coupled with the SCL, the register will be clocked, and gives out the serial word output bit by bit. As the clock frequency can be up to 16MHz, the transmission of the full 13-bit word can be done within 1us.

Valid data of DOUT should be read when the SCL clock is low. Please refer to timing diagram (Figure 1).

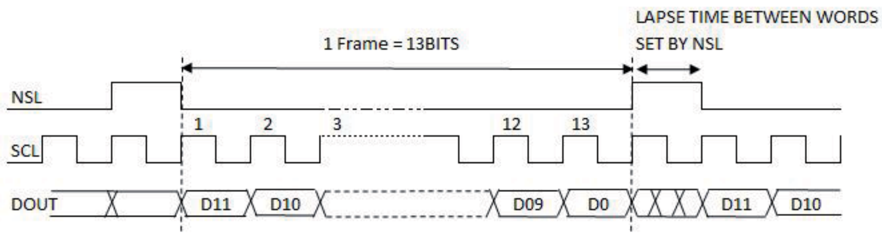


Figure 1. SSI Timing diagram

Pin out Descriptions

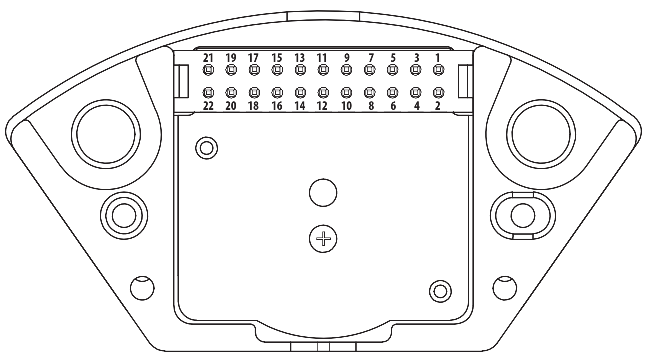
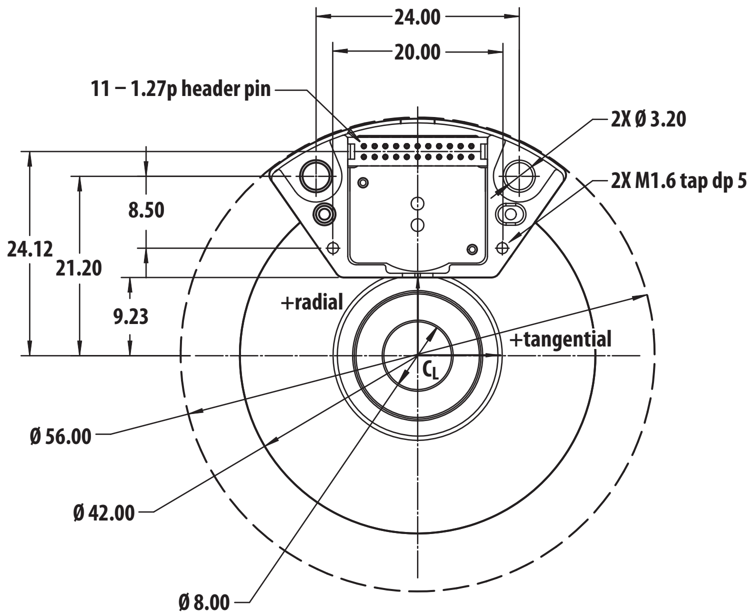
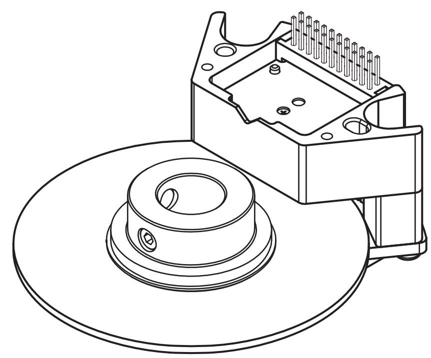


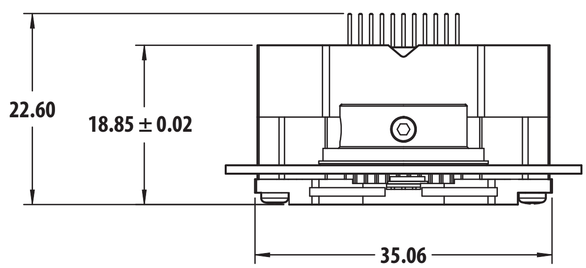
Figure 2. Top view of the encoder readhead

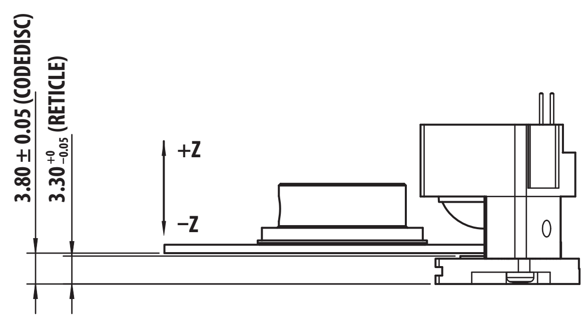
No.	Pin Name	Description	Function	Notes
1	LEDK		Internally connected to LED	Do not use
2	KORR	Digital input	1 = Gray Code Correction Active	CMOS,internal pu
3	SPI_CLK	Digital input	SPI clock input	CMOS, internal pd
4	SPI_SO	Digital output	SPI data output	CMOS
5	SPI_SI	Digital input	SPI data input	CMOS, internal pu
6	MSBINV	Digital Input	Inverted counting if set to high state	CMOS, internal pu
7	DIN	Digital Input	Shift register input (for cascading use)	CMOS, internal pu
8	NSL	Digital Input	Enable shift-register clock (for 3wire SSI)Note1	CMOS, internal pu
9	SCL	Digital Input Positive Edge	Shift-register Clock	CMOS, internal pu
10	DOUT	Digital Output	Shift-Register Data Out(MSB first)	CMOS
11	INCB	Digital Output	Incremental output B channel	CMOS
12	INCA	Digital output	Incremental output A channel	CMOS
13	VDD	Supply Voltage	+5V Supply	
14	GND	Ground for supply voltage	Ground	
15	COSINE+	Analog output	Diff Cosine+ analog output	CMOS, analog out
16	GND	Ground for supply voltage	Ground	
17	SINE+	Analog Output	Diff SINE+ analog output	CMOS, analog out
18	COSINE-	Analog Output	Diff Cosine- analog output	CMOS, analog out
19	VDD	Supply Voltage	+5V Supply	
20	SINE-	Analog Output	Diff SINE- analog output	CMOS, analog out
21	LERR	Digital Output	ERROR pin, error(=1)/no error(=0)	CMOS
22	SPI_EN	Digital input	SPI data input	CMOS

Mechanical Dimensions

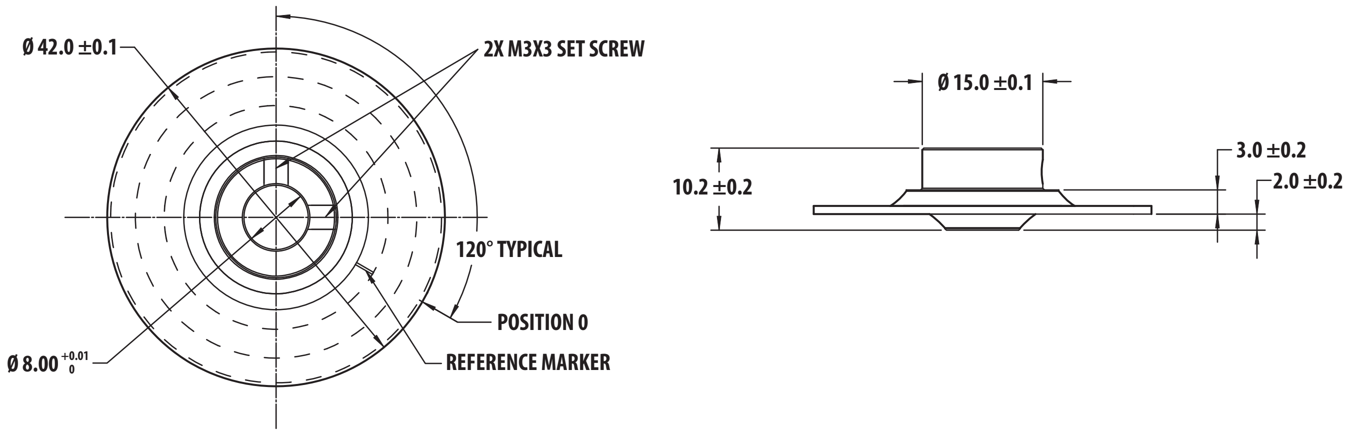






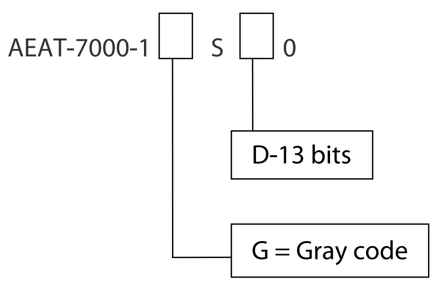


Code Wheel Dimensions



Notes:
1. All dimensions are in millimeter.
2. Tolerance: X.XX ± 0.10mm.
3. Shim thickness for Z height setting = 300µm +/- 10%
4. Code disk and readhead mounting tolerances for radial, tangential and gap are as below
   Radial : +/-50µm
   Tangential : +/-40µm

Ordering Information



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