

Increasing Demand for Accurate Angular Positioning in Rotary Positioning Stages



White Paper

Abstract :

Accurate angular positioning is extremely important in many fields including photonics, life sciences, microelectronics and robotics. Although there are various types of digital encoders available, there is increasing demand for higher resolution optical encoder features with smaller form factor, reliable operating conditions and low-cost elements. These encoders are prominently gaining attention in the feedback devices market to serve the increasing demand of industrial applications such as X-Y and rotary positioning stages.

Avago Technologies' AEDA-3300 series optical encoder solution fulfills these industrial application demands. The encoder is a three-channel optical incremental encoder module with integrated bearing stage. It is rated for operation in the temperature range of -40°C to +125°C and comes in 17mm diameter form factor packaged for space constraint industrial applications. All this helps reduce manufacturing and R&D costs, also eliminating the need for purchasing additional supporting components.

The AEDA-3300 series optical encoders are now available in resolutions from 600 through 20,000 cpr, at speeds of up to 12,000 rpm (ranges from 10,000 rpm for 6,000 cpr to 1,950 rpm for 20,000 cpr resolution), and operating frequencies up to 1 MHz for resolutions less than 10,000 cpr, and 650 kHz for resolutions between 10,000 and 20,000 cpr. Using quadrature decoding, the encoder can provide a maximum of 80,000 pulses per revolution (ppr). Outputs are two-channel quadrature with a third gated index channel, and the encoder comes with an integrated RS-422 differential line driver.

Introduction to Rotary Positioning Stages

Rotary stages are required whenever there is a need for precision in angular positioning or controlled rotation. Rotary stages come in two forms: 1) Manually driven rotary position stages or 2) Motorized rotary position stages. Operating concepts behind both types are the same except the motorized stages employ servo control for speed and position control. Figure 1 below shows the components of the motorized rotary position stages.

The stage primarily consist of a stationary base, main bearing, drive mechanism, rotating top and a position feedback device. The main bearing is made up of high precision, low friction ball-bearing that supports the rotating top.

The rotating top is actuated by the drive mechanism which controls the rotational velocity and angular accuracy of the top. The drive mechanism consists of a worm wheel and worm gear drive, whereby the drive is directly coupled to the shaft of the electric motor. The electric motor is equipped with high resolution; high speed Optical Encoder feedback device.

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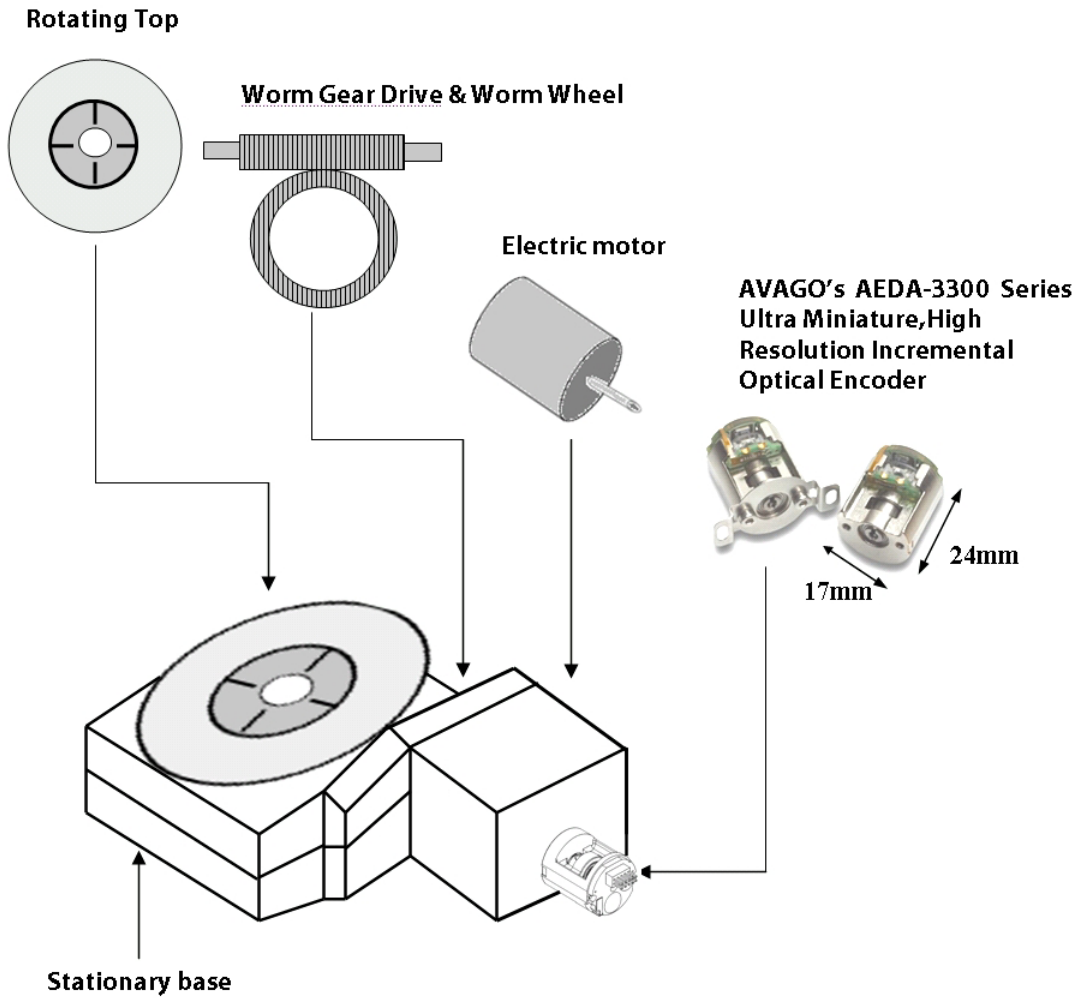


Figure 1. Components of the motorized rotary position stages

Precision Worm Gear Drive

Worm gears provide compact and efficient means to substantially decrease speed and increase torque. Small electric motors are generally high speed and low torque. Controlled rotation of the worm gear drive creates precise angular rotation of the worm wheel and rotating top. The worm gear drive and worm wheel are matching sets and are preloaded to remove backlash. This type of drive provides high resolution ranging from 45:1, 90:1, 100:1 or 180:1 ratios and continuous angular positioning over a full 360° range. Standard resolutions range from 0.2 arcs/second to 2 arcs/minute.

Encoder Counts vs Worm Gear Angular Position

The Incremental Encoder generates Quadrature feedback pulses. The host processor receives this feedback information in the form of “counts”; It is essential to establish a mathematical relationship with the encoder counts and worm wheel angular position to analyse the necessary pulses.

In this example, we will use a worm wheel ratio of 100:1 and AEDA-3300 Encoder resolution of 20,000 CPR for analysis.

The formulas are noted below:

$$\text{One Encoder Count} = \left(\frac{360}{\text{Worm Wheel Ratio} \times \text{Encoder CPR}^{**}} \right) \text{ Worm Wheel Mechanical Angular Position}$$

$$1 \text{ Encoder Count} = 0.00018 \text{ Mechanical Degree (0. 648 arc/sec)}$$

** Where Encoder CPR before quadrature decode = 20,000

$$\text{One Encoder Count} = \left(\frac{360}{\text{Worm Wheel Ration} \times (\text{Encoder CPR} \times 4)^{**}} \right) \text{ Worm Wheel Mechanical Angular Position}$$

$$1 \text{ Encoder Count} = 0.000045 \text{ Mechanical Degree (0. 162 arc/sec)}$$

** Where Encoder PPR after quadrature decode = 80,000

Rotary Stage Angular Positional Resolutions

Table 1. Possible Rotary Stage Angular Resolution using Avago’s AEDA-3300 Series Optical Incremental Encoder.

Encoder PPR after 4x Decode	Worm Wheel Ratio	Angular Resolution (arc/sec)
80,000	180:1	0.09
80,000	100:1	0.162
80,000	90:1	0.18
80,000	72:1	0.225
80,000	50:1	0.324
80,000	40:1	0.405
80,000	36:1	0.45
80,000	30:1	0.54

Summary

Motorized rotary positioning stages are gaining increasing demand in industrial market space for accurate angular positioning. Besides having precision worm gear drive, the Optical Encoder plays a critical role in enhancing the worm wheel angular resolution by refining it to the range of 0.09 to 0.81 arcs/sec as listed on Table 1.

Avago Technologies addresses the issue being faced by rotary position stage makers by introducing the AEDA-3300 Series ultra-miniature, high resolution Incremental Optical Encoder. The AEDA-3300 series encoder is a three-channel optical incremental encoder module with integrated bearing stage. It is rated for operation in the temperature range of -40°C to +125°C, and comes in 17mm diameter form factor packaged for space constraint industrial applications. Using quadrature decoding to achieve the highest resolution, it can provide a maximum of 80,000 pulses per revolution (ppr), and offer outputs in the form of two-channel quadrature with a third gated index channel. The encoder comes with an integrated RS-422 differential line driver.

References

AEDA-3300 Series
Ultra Miniature, High Resolution Incremental Kit Encoders
Datasheet

For product information and a complete list of distributors, please go to our web site: www.avagotech.com

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