

API Delevan® Resolvers

Understanding The Basics

With unlimited resolution, inherent noise protection, and no onboard processors, the resolver provides a robust, high-performance solution for a range of demanding applications.

A resolver is an analog electromagnetic transducer that can be used in a wide variety of position and velocity feedback applications ranging from semiconductor manufacturing to oil and gas drilling, from beverage packaging to radiation treatment. Because the resolver is an analog device and the electrical outputs are continuous through one complete mechanical revolution, the devices offer infinite theoretical resolution. With its simple transformer design and lack of any on board electronics, the resolver is much more rugged than almost any other type of feedback device, making it the natural choice for harsh environments involving temperature extremes, high shock and vibration, elevated radiation levels, and contaminants such as dirt, grease, and oil. Whether the application is in a steel mill, a jet engine, or a punch press, a resolver can do the job.

Basic Principles

Sometimes known as an analog trigonometric function generator or a control transmitter, a resolver is a special type of rotary transformer that couples voltage from an input (primary) winding into two output (secondary) windings with a magnitude that varies as a function of angular position.

The device consists of a rotor attached to a shaft that moves with the load, and a stator that remains stationary. The rotor typically carries the primary winding. The stator then carries two secondary windings that are angularly offset with respect to one another by 90°; they're designated as the sine winding and the cosine winding (see figure 1). In both sets of windings, the packing density of the individual turns of wire that make up the winding varies sinusoidally.

The function of a resolver is to resolve a vector into its sine and cosine components. An AC voltage applied to the reference winding inductively couples to the sine and cosine windings, generating an output voltage with a magnitude that varies as the sine or cosine, respectively, of the angular position



of the input shaft relative to some zero point. To understand how, we need a brief review of trigonometry and analytic geometry.

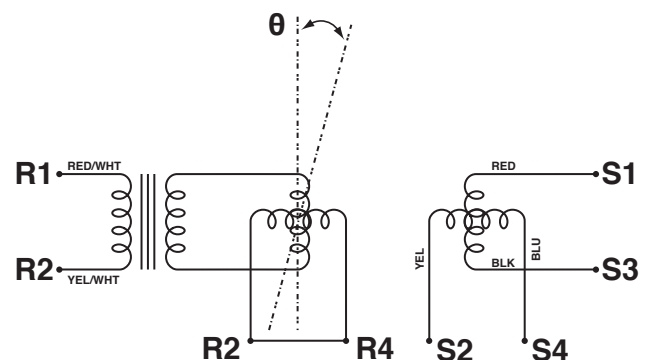


Figure 1

In a resolver, energy applied to the primary winding (the rotor coils, R1/R3) inductively couples to the secondary sine and cosine windings (the stator coils, S1/S3 and S2/S4) with a magnitude that varies as a function of the angular position θ of the rotor. Note that R2/R4 are shorted internally – this helps improve accuracy.

Consider a right triangle defined by the points (x_1, y_1) , (x_2, y_1) , and (x_2, y_2) ; see figure 2). For the angle θ , we define the side opposite θ as $y_2 - y_1$, the side adjacent to θ as $x_2 - x_1$, and the hypotenuse as R . We can then say:

$$\sin \theta = \frac{\text{opp}}{\text{hyp}} = \frac{(y_2 - y_1)}{R} \quad [1]$$

$$\cos \theta = \frac{\text{adj}}{\text{hyp}} = \frac{(x_2 - x_1)}{R} \quad [2]$$

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the accuracy. The Size 55 Frameless Resolver 55BRCX from API Delevan, for example, includes 32 poles with an accuracy of 4 arcmin spread. While accuracy is beneficial, there are trade-offs. Increasing the number of poles increases the complexity of the device and, hence, the cost. In addition, past a certain point, the ability to increase the number of speeds is limited by resolver diameter. Extremely demanding applications like MRI machines, for example, might use a resolver 4ft in diameter. Another approach is to combine a single-speed and a multi-speed resolver into a single package, which combines the absolute position of a single-speed resolver combined with the better accuracy of a multi-speed resolver to support fine and coarse positioning capabilities. The trade-off, again, is increased cost.

Using Resolvers

The simplicity of the resolver design makes it reliable in many extreme applications. Some require operation in temperatures as high as 200°C, in high-radiation environments, or in situations with very high shock and vibration loadings. Let's take a look at a sampling of interesting examples:

Aerospace

A missile launcher for high-velocity armor-protected, self-propelled missiles with multi-engagement capability leverages Size 21 Frameless Resolvers, R25 Housed Resolvers, and DC servo motors for precision motion control.

Factory Automation

A single-axis lamination and notching press for the electrical equipment industry takes position information from a crankshaft driven by a 1200 RPM flywheel. Due to the high shock and vibration, an encoder feedback system failed in short order. The R25 Housed Resolver solved the problem easily and economically.

Semiconductor Manufacturing

Rotary tables used in wafer production require high-accuracy position control, silent operation, and absolute minimum vibration in a clean room environment. The solution was to replace the gearbox with a large torque motor monitored by a large-diameter Size 55 Frameless Resolver.

Medical

Oncology machines use Size 10 Frameless Resolvers and Size 11 Housed, radiation-hardened resolvers for intensity-modulated radiation therapy (IMRT) that can "paint" the radiation dose onto a tumor with pinpoint precision. These machines need feedback devices that are radiation resistant to 10^8 rad. The ability to spare healthy surrounding tissue by using this technique is so impressive that clinicians around the world are using it to treat nearly every type of solid tumor.

Machine Tools

A high-velocity profiler manufactures large airplane wing spars from solid aluminum. Two 100-hp horizontal spindles running at 20,000 RPM carve out 1600 in³ of metal per minute. The three-story- high, 107 ft. x 48 ft. machine uses a Size 55 large bore Resolver for the ever-critical tool changes, controlling tool position in the tool holder. The resolver delivers precision performance while exposed to oil mists, cleaning agents, metal fragments, and leakage from hydraulic hoses and the coolant systems.

In Summary

Feedback systems need to perform, but they also need to last. The resolver is a simple, elegant, robust solution that's surprisingly versatile. With unlimited resolution, inherent noise protection, and no onboard processors, the resolver provides a high-reliability, high-performance solution for a range of demanding applications.

What to know before you call

1. What kind of accuracy do you need?
2. What are your operating conditions (temperature, contamination, vibration, etc.)?
3. What input voltage and frequency do your system present to the resolver?
4. What is your desired transformation ratio?
5. What is your system requirement for phase shift?

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