DYNAPAR™
INNOVATION - CUSTOMIZATION - DELIVERY

Proven rotary encoder and resolver solutions

Dynapar's vast product portfolio offers a wide selection of incremental and absolute rotary encoders engineered with cutting edge optical or magnetic technology, housed or frameless resolvers, and accessories.

There are three major categories of encoder which are differentiated by the demands of the operating environment. These run from heavy duty (the most demanding environment) to light duty (the most controlled environment).

Heavy, Servo, and Industrial Encoder Grades
Heavy industrial applications have three classes of encoder:

- Heavy
- Servo
- Industrial

As the name implies, heavy duty encoders can take the most abuse. They have excellent durability in high temperatures; with particulates, moisture, and contaminants; and under shock or vibration. They have superior speed performance, as well. Heavy duty encoders are the best choice for the most demanding environments – paper, steel, and ore mills where contamination is

constant and both shock and heat affect the motor, the stress of aerospace, and the fast factory environments of food and beverage processing. However, heavy duty encoders come at a cost of both size and expense. Unless the environment is truly brutal, a heavy duty encoder may be overkill.

The most common class of encoders is the industrial encoder. An industrial encoder can take punishing operating environments almost as well as heavy duty encoders – rough factories with contamination from dust, particulates,

and moisture, in addition to moderate shock and temperature. An industrial encoder offers excellent speed and positioning performance. The class of industrial encoders is versatile.

Servo encoders, unlike both heavy duty and industrial encoders, actually reside inside a motor housing. Because it is in a contained environment, it doesn't have strong sealing, but it has excellent temperature resistance and reliable shock/vibration resistance (which fits its operating environment). Because of its location, server encoders are smaller and are made for small to mid-sized motors, especially servo and stepper motors.

Light (or Commercial) Encoder Grade
Light duty encoders are used in more consumer-facing applications like office electronics (copiers, faxes, and computer accessories) and laboratory and medical equipment. These have "people-friendly" environments, meaning conditions are very controlled. Likewise, light duty encoders have good (but not demanding) performance for temperature, shock/vibration, and sealing, with better speed performance and high precision.

Details on Dynapar's Industrial Encoders

The industrial encoder selection covers all the typical options:

- Absolute and incremental encoders
- Optical or magnetic engines
- Hollow or solid shaft in a variety of standard sizes or to spec
- Resolutions up to 10,000 PPR

Additionally, the Dynapar **industrial encoder** line is engineered with a variety of options so that an industrial encoder can be designed for your specific application and environment:

- Barrierless housings
- Bearing-less movement
- Dual row bearings for ultimate vibration/shock resistance
- Optional shaft seals for even better protection against contaminants
- Unbreakable code disks on some optical versions

With absolute industrial encoders, there are even more options:

- Several different output options
- Multi-turn positioning for applications that require orientation greater than 360° – and all multi-positioning is battery-less because the absolute encoder keeps the orientation even when the unit is powered off

An Industrial Encoder Made to Your Specs

The design of an **industrial encoder** can be as unique as the application that uses it. And we can help. All Dynapar industrial encoders are made using a philosophy of just-in-time manufacturing. This manufacture-on-demand method means that we make every order to order with adaptable and lean manufacturing methods – no waste in either material or time.

This adaptability also makes it easier for us to do custom industrial encoder orders, not just standard sizes. If you have unique requirements, we can make an industrial encoder to your spec in the quantity you need – quickly.

Dynapar Magnetic Encoder Overview

The heart of an encoder is the way that it provides information – that's the *encoder engine*. An encoder engine takes the positional and speed information and then supplies the signal that is sent to the application.

The engine type is categorized by the method that the control information is determined. There are two major categories:

- Optical Encoder engines, both masked and phased array
- **Magnetic Encoder** engine

The differences in the way that a **magnetic encoder** and an optical encoder gather information lead to performance differences in different operating environments. Understanding how an optical and **magnetic encoder** work can help determine what kind of encoder is best suited to your application.

The Technology of Magnetic Encoder Engines

An optical encoder uses light (optics) to identify unique positions for the encoder. A **magnetic encoder** uses the same principle to determine a position as an optical encoder, but it does it using magnetic fields rather than light. With a **magnetic encoder**, a large magnetized wheel spins over a plate of magneto-resistive sensors. Just as the disk spins over the mask to let light through in predictable patterns, the wheel causes predictable responses in the sensor, based on the strength of the magnetic field. The magnetic response is fed through a signal conditioning electrical circuit.
The number of magnetized pole pairs on the wheel pole, the number of sensors, and the type of electrical circuit all work together to determine the resolution of the **magnetic encoder**.

The key to using magnetism as the element to produce a signal is that it is unaffected by very demanding environments – including dust, moisture, and extreme temperatures, and shock.

Magnetic Encoder Applications

A **magnetic encoder** is designed to output reliable digital feedback in the most demanding and harshest of application environments. Applications for this technology usually require broad temperature specs, high shock and vibration resistance, robust sealing, and contaminant protection all while focusing on output signal reliability, easy installation, and downtime reduction. Popular applications for magnetic encoders include position and velocity feedback in Steel, Pulp, Paper, & Lumber mills.

Dynapar's most-popular Magnetic Encoder products:
NorthStar RIM Tach NexGen line of digital tachometers

NorthStar SLIM Tach 56
HS60 Encoder

Dynapar Incremental Encoder Overview

An **incremental encoder** can be used in positioning and motor speed feedback applications which includes servo/light-, industrial- or heavy-duty applications. An **incremental encoder** provides excellent speed and distance feedback and, since there are few sensors involved, the systems are both simple and inexpensive. An **incremental encoder** is limited by only providing*change* information, so the encoder requires a reference device to calculate motion.

How an Incremental Encoder Works

An **incremental encoder** provides a specified amount of pulses in one rotation of the encoder. The output can be a single line of pulses (an “A” channel) or two lines of pulses (an “A” and “B” channel) that are offset in order to determine rotation. This phasing between the two signals is called quadrature. The typical assembly of an **incremental encoder** consists of a spindle assembly, PCB, and cover. The PCB contains a sensor array that creates just two primary signals for the purpose of position and speed.
Optionally, additional signals can be provided:
An index or ‘Z’ channel can be provided as one pulse per revolution signal for homing and pulse count verification on the A and/or B channels. This index can be gated to either A or B in their various states. It can also be un-gated and vary in width.
Commutation (U, V, W) channels can also be provided on some encoders. These signals are aligned to the commutation windings found on servo motors. They also ensure that the drive or amplifier for those motors apply current to each winding in the correct sequence and at the correct level.

Incremental Encoder Alternatives

Resolvers
Resolvers are electro-mechanical precursors to encoders, based on technology

going back to World War II. An electrical current creates a magnetic field along a central winding. There are two windings that are perpendicular to each other. One winding is fixed in place, and the other moves as the object moves. The changes in the strength and location of the two interacting magnetic fields allow the resolver to determine the motion of the object.
The simplicity of the resolver design makes it reliable in even extreme conditions, from cold and hot temperature ranges to radiation exposure, and even mechanical interference from vibration and shock. However, the forgiving nature of resolvers for both origin and application assembly comes at the expense of their ability to work in complex application designs because it cannot produce data with enough accuracy. Unlike **incremental encoders**, resolvers only output analog data, which can require specialized electronics to connect with.

Absolute Encoder
Absolute encoders work in situations where accuracy for both speed and position, fail tolerance, and interoperability matters more than system simplicity. The absolute encoder has the ability to "know where it is" in reference to its position in case of system power-down and restart if the encoder were to move during a power-down.
The absolute encoder itself understands the positioning information – it doesn't need to rely on outside electronics to provide a baseline index for the encoder position. Especially when compared to resolvers and **incremental encoders**, the obvious strength of absolute encoders is how their positioning accuracy affects the overall application performance, so it is typically the encoder of choice for higher precision applications such as CNC, medical and robotics

Incremental Encoder Applications

An **Incremental Encoder** is designed to be versatile and customizable to fit a wide variety of applications. The three broad categories of applications based on environment are:

- Heavy Duty: demanding environment with a high probability of contaminants and moisture, higher temperature, shock, and vibration requirements as seen in pulp, paper, steel, and wood mills.
- Industrial Duty: general factory operating environment which requires standard IP ratings, moderate shock, vibration, and temperature specs as seen in food and beverage, textile, generally factory automation plants.

- *Light Duty/Servo: controlled environment with high accuracy and temperature requirements such as robotics, electronics, and semiconductors.*

Dynapar's most-popular Incremental Encoder options:
HS35R
Qube 22
NorthStar RIM Tach 8500 NexGen

Using Absolute Encoders with Your Application

Every **absolute rotary encoder** is used to determine the speed or position of something – the difference is in how that encoder determines that movement. The "how" defines what type of encoder works in your application. **Absolute encoders** work in situations where accuracy for both speed and position, fail tolerance, and interoperability matters more than system simplicity.

Accuracy Even in Complex Systems: Absolute Encoders

An **absolute rotary encoder** determines its position using a static reference point. The method is slightly different depending on whether the absolute rotary encoder is optical or magnetic, but the principle is the same either way. There are two discs, both with concentric rings with offset markers. One disc is fixed to the central shaft; the other moves freely. As the disc turns, the markers along the track of **absolute encoders** change position on the fixed disc. Each configuration along the disc of an absolute rotary encoder represents a unique binary code. Looking at the binary code within the absolute rotary encoder determines the absolute position of the object. For optical absolute encoders, the marker is an opening which lets through light. For magnetic absolute encoders, the markers are a magnetic sensor array that passes over a magnet and detects the position of the magnetic poles.

By having an integrated reference, an absolute rotary encoder is intrinsically able to deliver higher quality feedback:

- Better start up performance because of low homing (or initial position) time
- Higher overall resolution and orientation
- Accurate motion detection along multiple axes

- Multiple output protocols for better electronics integration
- Better recovery from system or power failures

Another key feature of **absolute encoders** is the different output options. Encoders can't just collect feedback data; they have to send it somewhere in a language that the larger system can understand. Absolute encoders use binary coding, which is translatable into many different protocols. If you have multiple components using the same communications bus (such as multiple electronics systems on a fire truck), then it is critical that the **absolute rotary encoder** can communicate with the bus.
The only cost of absolute encoders is increased system complexity.

Absolute Rotary Encoder Alternatives

If overall system simplicity matters more than performance, then there are alternatives to **absolute encoders**.

Resolvers

Resolvers are electro-mechanical precursors to encoders, based on technology going back to World War II. An electrical current creates a magnetic field along a central winding. There are two windings that are perpendicular to each other. One winding is fixed in place, and the other moves as the object moves. The changes in the strength and location of the two interacting magnetic fields allow the resolver to determine the motion of the object.
The simplicity of the resolver design makes it reliable in even extreme conditions, from cold and hot temperature ranges to radiation exposure, and even mechanical interference from vibration and shock. However, the forgiving nature of resolvers for both origin and application assembly comes at the expense of their ability to work in complex application designs because it cannot produce data with enough accuracy. Unlike absolute encoders, resolvers only output analog data, which can require specialized electronics to connect with.

Incremental Encoders

An incremental encoder determines relative position, looking only at the differences between measurements. The encoder engine sends out pulses in channels (called *quadratures*) and the offsets in these pulses indicate motion. Incremental encoders provide excellent speed and distance feedback and, since there are few sensors involved, the systems are both simple and inexpensive. However, incremental encoders are susceptible to environmental factors like vibration (something that is mitigated as sensor technology improves), and they can lose resolution at high speeds due to output frequency limitations. They are also limited by only providing

change information, so the encoder requires a reference device to calculate motion.

Absolute Situations: When You Need Absolute Encoders

The **absolute rotary encoder** itself understands the positioning information – it doesn't need to rely on outside electronics to provide a baseline index for the encoder position. Absolute encoders enable applications which rely on non-linear positioning to work without additional external components.

In real life, absolute encoders allow more precision work from applications:

- Determining multi-axis orientation for CNC machines used in parts manufacturing
- Automatically determining the height of scissor beds used in hospitals
- Accurately positioning multiple stabilizers for large vehicles like cranes or aerial lifts
- Moving automatic doors or bays without a limiting switch
- Continuing robotic movement cleanly even after a power failure

Especially when compared to resolvers and incremental encoders, the obvious strength of absolute encoders is how their positioning accuracy affects the overall application performance.

Building the Right Foundation with a Hollow Shaft Encoder

Every rotary encoder works by being mounted to a motor by a shaft. The encoder has a fixed housing with a rotor wheel (either a detached component or integrated within the housing with bearings) which revolves around the shaft. Those rotations are the basis for determining speed, positioning, and other motion information.

About the single most important thing that distinguishes between encoder designs is the mounting configuration. The inner workings of the encoder may all be the same – absolute or incremental, optical or magnetic – but the simple decision on how to attach the encoder can make a major difference in the physical design of your application.

A **hollow shaft encoder** mount is one of the lowest-overhead, lowest-stress options for an encoder. This design offers simplicity because a hollow shaft encoder is compact, adjustable, and versatile.

From Basic Solid Shafts to Hollow Shaft Encoder Mounts

The original encoder design used a *solid shaft*. As the name implies, a solid shaft encoder has a solid bar that attaches to the motor and is attached using a flexible coupling and an external flange. There are some limitations with this design, specifically with the fact that the shaft requires an exact width and length to the shaft to fit into the motor and that it requires two external pieces (the flex couple and flange), which add to the size of the encoder. Solid shaft encoders are also susceptible to misalignment, which can impair performance.

Since the original solid shaft design, more mounting options have come around, like direct mounts and a C-face or ring mount. These have benefits – like the easier installation of direct mounts or the bearingless C face-mounts which reduce wear. However, these designs also have drawbacks, particularly in how difficult these designs are to install or in the overall size of the encoder profile.

A **hollow shaft encoder** is one of the most common shaft designs because of its versatility. Instead of having a solid bar that has to match the motor, a hollow shaft encoder fits over the motor shaft and is then clamped in place. It's held in position by a flexible tether. This means that a hollow shaft encoder does not have to be perfectly sized to fit the motor and it does not require any external components which increase its size. A hollow shaft encoder also has a more forgiving installation; the clamp and the tether can be used to adjust the position and to absorb shocks and vibration that could cause misalignment.

Hollow Shaft Encoder in Summary

A hollow shaft encoder design offers simplicity to the application:

- More forgiving shaft sizing, especially in length

- Easier installation, positioning, and alignment
- Moderate resistance against shock and vibration
- Smaller installation profile, without extra coupling
- Good foundation for speed and RPM feedback

A hollow shaft encoder provides a strong, environment-tolerant style that is ideal for industrial duty applications. In fact, a hollow shaft encoder design is the most preferred style for speed feedback in industrial applications because of its reliable performance.

There are many options for mounting an encoder, and your environment should dictate what style to get. A **hollow shaft encoder** is the best choice for an environment where speed is a crucial information factor, size and simplicity are integral to the application design, and the environment can face contaminants like shocks, moisture, or particulates.

The Driving Force: Magnetic versus Optical Encoder Engines

The heart of an encoder is the way that it provides information – that's the *encoder engine*. An encoder engine takes the positional and speed information and then supplies the signal that is sent to the application.

The engine type is categorized by the method that the control information is determined. There are two major categories:

- Optical encoders, both masked and phased array
- Magnetic encoders

The differences in the way that magnetic and **optical encoders** gather information lead to performance differences in different operating environments. Understanding how magnetic and optical encoders work can help determine what kind of encoder is best suited to your application.

The Technology of Optical Encoder Engines

As the name implies, optical encoders use light (optics) to identify unique positions for the encoder. There are four components in an optical shaft encoder:

- A light source (an LED light)
- A sensor
- A moveable disk
- A fixed mask

The LED shines through one side of the **optical shaft encoder**. The disk has a series of tracks on it, similar to the concentric grooves in an LP. The mask has a corresponding track for every track on the disk of the optical encoder, and small perforations, called windows, are cut along the tracks in the mask. As the disk moves, different windows in the mask are covered or open, showing the movement and position of the optical encoder. Each arc in the rotation indicates a different position and has a different pattern of open/closed windows. The sensor behind the mask identifies the optical encoders' current pattern.

Each sensor represents one single signal for the **optical encoder**. A track can contain two sensors, which are offset to give two slightly different signals produced at the same time. These offset signals can be used by the optical encoder engine to determine more detailed motion information, like speed. A second track can be used to give an index pulse once per revolution, providing a method to orient the signals.

An even more reliable cousin to basic mask optical encoders is phased-array optical encoders. Phased-array **optical encoders** use multiple signal outputs to average together to create a single signal that is delivered by the engine. These multiple signals that are used by an **optical shaft encoder** are called the array. By using averages instead of a single reading, phased array-optical encoders have much more stable signals so they can be used in less stable environments, such as mining or heavy manufacturing, where vibrations or shock could affect a traditional mask optical shaft encoder. They require less precision during installation than traditional mask optical encoders.

The Technology of Magnetic Engines

A magnetic encoder uses the same principle to determine a position as an optical encoder, but it does it using magnetic fields rather than light.

With a magnetic encoder, a large magnetized wheel spins over a plate of magneto-resistive sensors. Just as the disk spins over the mask to let light through in predictable patterns, the wheel causes predictable responses in the sensor, based on the strength of the magnetic field. The magnetic response is fed through a signal conditioning electrical circuit.

The number of magnetized pole pairs on the wheel pole, the number of sensors, and the type of electrical circuit all work together to determine the resolution of the magnetic encoder.

The key to using magnetism as the element to produce a signal is that it is unaffected by very demanding environments – including dust, moisture, and extreme temperatures, and shock.

Applications for Optical Encoders

Optical encoder engines can be amazingly precise, with some designs hitting 4 million counts per revolution. This makes an optical encoder a desirable choice where resolution matters, from office equipment like computer mice and copiers to medical equipment. With phased-array technology, an optical encoder is increasingly able to perform in much tougher environments which require a combination of durability and resolution, like crane operations and automated vehicle guidance.

Still, the harshest operating environments may demand the physical durability of magnetic encoders.

The question to ask is what matters most to the performance your application: **optical encoders**' accuracy or magnetic encoders' ability to withstand the operating environment?

The Options of an Optical Rotary Encoder

An **optical rotary encoder** uses a reliable, defined pattern of light-and-dark to determine the position of the shaft and, therefore, the position of an object.

The most basic design for an optical rotary encoder is a mask encoder, but there are a multitude of other options that provide even more stability and more feedback information in an increasing variety of application environments.

The Basic Construction of a Optical Rotary Encoder

In a sense, the optical rotary encoder output is binary; it is either light or dark. An **optical rotary encoder** has a moving disk, with concentric tracks etched into the disk. Periodically, these tracks have an opening, called a window. The windows of every track are offset, so that each revolution of the optical rotary encoder has a different light/dark pattern.

On the other side of the optical rotary encoder is the mask, which is usually connected directly to a sensor, to increase the resolution. The mask, like the disk, is also grooved with corresponding tracks and windows. As the light source shines through the moving disk onto the mask of the optical rotary encoder, the different, unique light patterns illuminate the sensor.

Each optical rotary encoder track contains one or two sensors. Each sensor outputs its individual signal, and the sensors outputs are slightly offset from each other, creating slightly offset outputs. The two offset signals interact differently with the light source, creating a unique optical rotary encoder pattern. The pattern is the quadrature.

Since each arc revolution has a completely different pattern, an optical rotary encoder can be exceptionally accurate.

Innovative Optical Rotary Encoder Design: Z-Streams, Phased-Array

The most basic optical rotary encoder design has certain limits in signal stability and count methodology because it is limited to only a couple of signal outputs. The basic A/B signal is not the limit of **optical rotary encoder** design. Innovation for both incremental and absolute encoders allows optical engines to be highly accurate and to perform better in more extreme environments:

- For incremental encoders, a rotary optical engine requires some kind of external method to provide a baseline or index. This can be done by adding a track which only outputs a signal once every rotation, which provides the index marker.
- To limit susceptibility to shock or vibration, a phased-array optical rotary encoder averages multiple signals for a single output.

- For absolute encoders, multiple gears and sensors can be used in a single optical rotary encoder. Using multi-turn printed circuit boards and gear train keeps a perpetual count of the shaft rotation, and each gear keeps its own absolute position. This provides an exceptionally high level of accuracy for an absolute optical rotary encoder – up to 4 million counts per revolution.

Optical Rotary Encoder Applications

An **optical rotary encoder** engine can bring almost unparalleled accuracy for both incremental and absolute encoders. Look at the demands of your application – whether it is the delicate movement of a medical device or the precision of robotic assembly line units – to determine whether an optical rotary encoder can offer the required performance in the application environment:

- High precision
- Resistance to shock and vibration in industrial applications
- High operating RPMs on incremental encoders
- Multi-turn/multi-gear absolute encoders, which require a lifetime cumulative rotation count

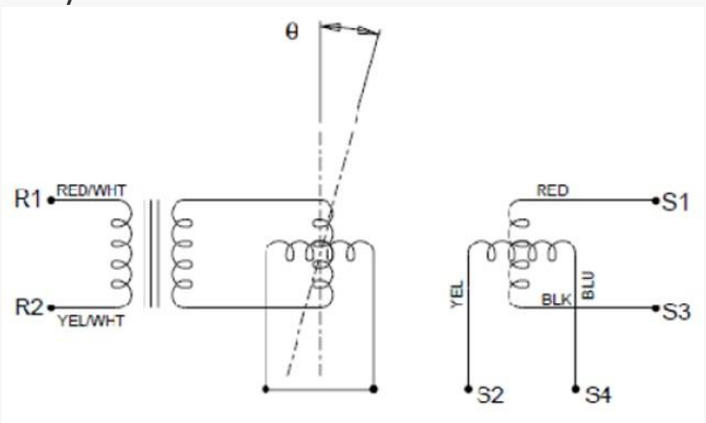
Resolver Overview

A **Resolver** is an electromagnetic transducer that can be used be used in a wide variety of position and velocity feedback applications which includes light duty/servo, light industrial or heavy duty applications. Because the **resolver** is an analog device and the electrical outputs are continuous through one complete mechanical revolution, the theoretical resolution of a single

speed **resolver** is infinite. Because of its simple transformer design and lack of any on board electronics, the **resolver** is a much more rugged device than most any other feedback device and is the best choice for those applications where reliable performance is required in those high temperature, high shock and vibration, radiation and contamination environments which makes the resolver the sensible design alternative for shaft angle encoding.

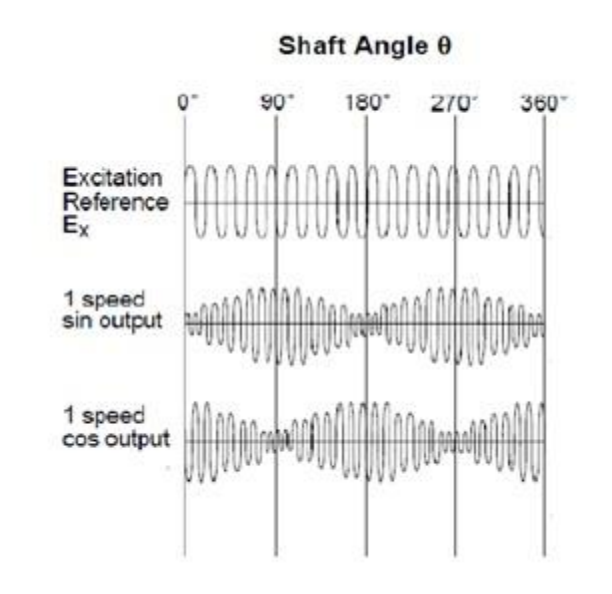
Resolver Design

The **resolver** is a special type of rotary transformer that consists of a cylindrical rotor and stator. Both the rotor and the stator are manufactured with multi-slot laminations and two sets of windings. The windings are normally designed and distributed in the slotted lamination with either a constant pitch-variable turn or variable pitch-variable turn pattern. In either case, the winding distribution is in a sinusoidal pattern. The windings for a single speed **resolver** create one complete Sine curve and Cosine curve in one mechanical revolution while the windings for a multi-speed **resolver** create multiple Sine and Cosine curves in one mechanical revolution. While a single speed provides absolute feedback and the multi-speed does not, the multi-speed does provide better accuracy. The number of speeds available is limited by the size of the **resolver**. The two sets of windings are positioned in the laminations at 90 degrees to each other. These are called the Sine and Cosine windings. One set of windings in the rotor are normally shorted internally to improve the accuracy.



How a Resolver Works

Energizing the input phase of the **resolver** with an AC voltage (VAC) induces a voltage into each of the output windings. The **resolver** amplitude modulates the VAC input in proportion to the Sine and the Cosine of the angle of mechanical rotation. The **resolver** is sometimes known as an Analog Trigonometric Function Generator or a Control Transmitter. The function of the **resolver** is to resolve a vector into its components (Sine and Cosine). Electrical Zero (EZ) is defined as the position of the rotor with respect to the stator at which there is minimum voltage amplitude across the Sine winding and the maximum voltage amplitude across the Cosine winding when the input winding is excited with the rated voltage. The rotor position or angle is simply the Arc tan of the voltage output of the Sine winding divided by the output of the Cosine winding. This ratio metric format provides an inherent noise reduction feature for any injected noise whose magnitude is approximately equivalent on both windings and also results in a large degree of temperature compensation.



There are 7 functional operating parameters which define the **resolver** operation. These are 1) Accuracy 2) Input Excitation Voltage 3) Input Excitation Frequency 4) Input Current Maximum 5) Transformation Ratio of Output Voltage to the Input Voltage 6) Phase shift of the Output Voltage from the Input Voltage and 7) Null Voltage

Resolver Applications

The simplicity of the **resolver** design makes it reliable in many standard and extreme applications such as servo motors, factory automation, steel and paper mills, oil and gas production, jet engine fuel systems, aircraft flight

surface actuators, communication position systems, missile fin actuators and land based military vehicles

Dynapar's most-popular Resolver products:

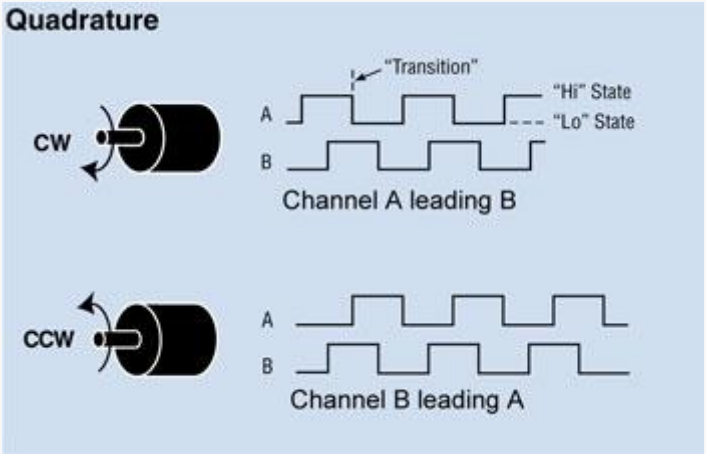
HaroMax Size 15
HaroMax Size 21
Frameless 10/15/21/31/55 Resolvers
Series 11 Heavy Duty

Quadrature Encoder Overview

Incremental encoders provide a specific number of equally spaced pulses per revolution (PPR) or per inch or millimeter of linear motion. A **quadrature encoder** is a type of incremental encoder used in many general automation applications where sensing the direction of movement is required.

How does a Quadrature Encoder work?

The code disk inside a **quadrature encoder** contains two tracks usually denoted Channel A and Channel B. These tracks or channels are coded ninety electrical degrees out of phase, as indicated in the image below, and this is the key design element that will provide the **quadrature encoder** its functionality. In applications where direction sensing is required, a controller can determine direction of movement based on the phase relationship between Channels A and B. As illustrated in the figure below, when the **quadrature encoder** is rotating in a clockwise direction its signal will show Channel A leading Channel B, and the reverse will happen when the **quadrature encoder** rotates counter clockwise.



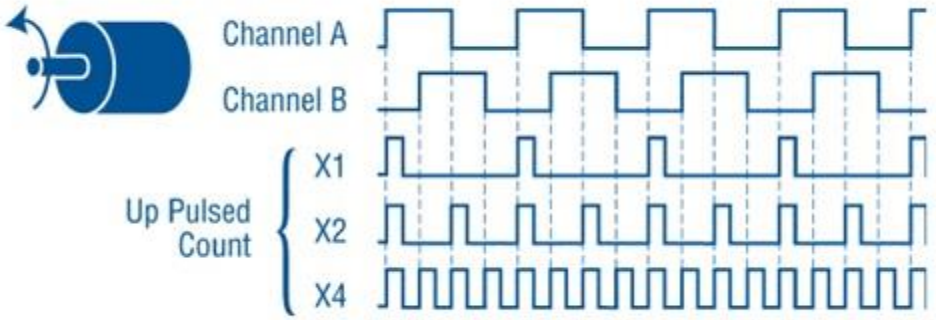
Apart from direction, position can also be monitored with a **quadrature encoder** by producing another signal known as the “marker”, “index” or “Z channel”. This Z signal, produced once per complete revolution of the **quadrature encoder**, is often used to locate a specific position during a 360° revolution.

When to use Quadrature Encoders?

Quadrature encoders are used in bidirectional position sensing and length measuring applications. However, in some unidirectional start-stop applications, it is important to have bidirectional information (Channel A & B) even if reverse rotation of the shaft is not anticipated. An error in count could occur with a single-channel encoder due to machine vibration inherent in the system. For example, an error in count may occur with a single-channel encoder in a start/stop application if it mechanically stops rotating when the output waveform is in transition. As subsequent mechanical shaft vibration forces the output back and forth across the edge the counter will up-count with each transition, even though the system is virtually stopped. By utilizing a **quadrature encoder**, the counter monitors the transition in its relationship to the state of the opposite channel, and can generate reliable position information.

Achieving higher resolution with Quadrature Encoders

When more resolution is needed, it is possible for the counter to count the leading and trailing edges of the **quadrature encoder’s** pulse train from one channel, which doubles (x2) the number of pulses per revolution. Counting both leading and trailing edges of both channels of a **quadrature encoder** will quadruple (x4) the number of pulses per revolution. As a result, 10,000 pulses per turn can be generated from a 2,500 PPR **quadrature encoder**. Typically with a Dynapar encoder, this 4x signal will be accurate to better than ±1 count.



Dynapar Motor Encoder Overview

An encoder is an electromechanical device that provides an electrical signal that is used for speed and/or position control. Encoders turn mechanical motion into an electrical signal that is used by the control system to monitor specific parameters of the application and make adjustments if necessary to maintain the machine operating as desired. The parameters monitored are determined by the type of application and can include speed, distance, RPM, position among others. Applications that utilize encoders or other sensors to control specific parameters are often referred to as closed-loop feedback or closed-loop control systems.

Understanding Motor Encoder

A **motor encoder** is a rotary encoder mounted to an electric motor that provides these closed loop feedback signals by tracking the speed and/or position of a motor shaft. There is a wide variety of **motor encoder** configurations available such as incremental or absolute, optical or magnetic, shafted or hub/hollow shaft, among others. The type of **motor encoder** used is dependent upon a number of factors, particularly motor type, the application requiring closed-loop feedback, and the mounting configuration required.

Key factors impacting motor encoder selection

Motor Type
When selecting components for a closed loop control system, the **motor**

encoder choice is first determined by the type of motor chosen in the application. The most common motor types are:

- **AC Induction Motors:** These motors are popular choices for general automation machine control systems as they are economical and rugged. **Motor encoders** are used for more precise speed control in applications using these motors, and often times need to have more robust IP, shock and vibration parameters.
- **Servo/Permanent Magnet Motors:** These motors offer closed loop feedback control systems to applications that require higher precision and accuracy, and are not as robust as AC Induction motors. The **motor encoder** used on these motors can be modular, incremental or absolute depending on the level of resolution and accuracy required.
- **Stepper Motor:** These motors are cost effective, precise, and are typically used in open-loop systems. In systems using stepper motors where speed control is required, an incremental **motor encoder** is often mounted to this motor.

Encoder Technology

The application in which the **motor encoder** is being utilized will determine the motor encoder technology that needs to be used. The two broad types of motor encoder technologies available are:

- **Incremental Encoders:** The output of an incremental **motor encoder** is used to control the speed of a motor shaft.

  Absolute Encoders: The output of an absolute **motor encoder** indicates both the motion and the position of the motor shaft. Absolute **motor encoders** are most often used on Servo Motors in applications where position accuracy is required.

Motor Encoder Mounting Options

The third factor impacting **motor encoder** selection is the mounting option, and the most common options are:

- **Shafted:** Uses a coupling method to connect the **motor encoder** shaft to the motor shaft. The coupling provides mechanical and electrical isolation from the motor shaft but can add cost via the coupling and the longer shaft length required to mount the **motor encoder**.

- **Hub/Hollow shaft:** Direct mount to the motor shaft via a spring loaded tether. This method is easy to install and required no shaft alignment, but proper care must be taken to provide electrical isolation.
- **Bearningless:** Also known as Ring mount, this mounting option is comprised of a sensor assembly in the form of a ring that is mounted on the motor face, and a magnetic wheel which is mounted on the motor shaft. This type of **motor encoder** mounting configuration is mostly found in heavy duty applications like paper, steel and cranes.

Dynapar's most-popular Motor Encoder options:
HS35R
SL56
AD36

INDUSTRIES

Aerospace & Defense

When the military relies on a line of resolvers for proven performance, you know it's a top-of-the-line product. Precise feedback and speed control of their aircraft at all times is imperative to pilots. That's why they trust Harowe brand resolvers to deliver reliable and accurate feedback.

Thrust reversers, throttle valve indicators and starter/generator feedback are just some of the critical mechanical and jet operation applications that Harowe brand resolvers control. They are also used for flap position indicators, fuel control valve indicators, inertial guidance systems and auto-pilot controls.

Battling gravity and top speeds, pilots must be confident their resolvers will perform to specification.

Harowe products are designed to meet aerospace and defense requirements, including: high-speed applications (over 30,000RPM), high-temperature environments (up to 200C), high-shock and vibration environments, dual speeds, and tandems for redundancy applications. We can supply COTS, Modified COTS and ITAR solutions.

Recommended Solutions

HaroMax Resolver

Ideal for brushless motors, robots and direct-drive motors in precision rotary platforms and similar servo applications.

R25 Heavy Duty Brushless Resolvers

The better choice over encoders for applications that involve very high temperature, vibration and shock and/or dirty environments.

Size 31 & 55 Frameless Resolvers

Lightweight, compact and provide accurate, absolute position feedback and resistance to high shock, vibration, EMI noise, radiation

ELEVATORS

Ensuring a safe and dependable ride every time is the goal in the elevator industry. Precise vertical lift and speed measurement control are imperative to ensure passenger and mechanical safety within US and Canadian ASME A17.1, and CAN/CSA B44 manufacturing compliance standards.

Dynapar encoders provide reliability and accuracy in determining the position and speed of travel of the elevator while also communicating that feedback information to a computer that controls and adjusts the elevator's motor speed to consistently put the elevator car where it needs to be.

Dynapar's industrial duty encoder and counters and sensors provide critical feedback control to ensure elevators are working at optimum performance.

Recommended Solutions

HA725 Shafted Encoder

High direct read resolutions can be a requirement in an elevator application. The HA725 can read up to 10,000 PPR which make it an ideal fit for any elevator application.

HS35R Sealed Hollowshaft Encoder

Maximizing equipment uptime and increasing the reliability of your elevator are what the HS35R provides. The HS35R is has a high 400g shock rating, and larger bearings which enhances the life of your encoder

FACTORY AUTOMATION

Factory automation is a high-speed, high-volume industry. It requires precise speed and direction to ensure whatever the motor is driving runs safely and smoothly. Dynapar encoders can be found hard at work within the packaging industry and packaging OEM machinery and equipment for the food, beverage, pharmaceutical, personal care, and specialty chemical industries to name a few.

With the growing popularity of Form-Fill-Seal (FFS) machines along with the acceptance of flexible packages that are rapidly replacing bottles, cans, cartons, and bag-in-box packages- packaging companies are under pressure to save money by maximizing package functionality and by jettisoning expensive paper and board materials all while meeting market demand.

Dynapar's complete line of industrial encoders and counters are there providing critical unit counting, conveyor speed or cut to length (taper, batch or totalizing) feedback to packaging machinery operators. Our standardized and customized encoder products track how much material has been used as well as maintain fixed conveyor speed to ensure that packaging, manufacturing and sealing steps occur in proper sequence to prevent costly production scrap or waste.

Our encoders are used in a variety of applications from cartoning, multipacking and filling equipment to capping, sealing, and closing machinery.

Recommended Solutions

NEW 22 Qube Encoder

The New Qube has been enhanced with higher grade sealing for industrial applications like measuring and cut to length in environments where there can be dust and other contaminants. Click on the image above the learn more.

HD20 Harsh Duty Optical Encoder

Hollowshaft encoders eliminate the need for couplings and allow the encoder to be moved to the correct position for tethering without shaft modifications. The compact size of the HS20 provide flexibility for tight mounting constraints.

AI25 CAN Open Absolute Encoder

Precision and absolute positioning, required in some Factory Automation applications, allow for continuous feedback for pick and place, and other tight control applications. The AI25 is your solution if an application requires absolute positioning.

Medical Imaging

Thanks to advancements in medical imaging technology in recent decades, doctors are now able to capture in seconds what used to take hours for diagnosis.

MRI is a noninvasive diagnostic technique that uses nuclear magnetic resonance to produce cross-sectional images of organs and other internal body structures. Dynapar offers a range of industry duty encoders designed to

comply with FDA manufacturing guidelines for MRIs and X-Ray imaging. In x-Ray machines our encoders move water in and out of the machine, while in CT Scan and MRI machines they move patients in and out and measure the rotating speed.

Recommended Solutions

H20 Hubshaft

The H20, economical in size is the solution for your medical imaging application. It provides a wide range of resolutions along with a hubshaft with spring tether for easy installation.

AI25 Absolute Encoder

Precise positioning and onboard diagnostics make the AI25 absolute encoder an ideal fit for your medical imaging application. Single turn and multi turn capabilities allow for the critical feedback required in medical imaging devices.

Off Highway Vehicle

The off-highway vehicle market is expanding by the day and the demand for reliable speed & position sensing solutions is on the rise. Dynapar is leading the way as an innovator in encoder and resolver technology offering more accurate and rugged solutions than typical hall sensors, magnetic pickups, and potentiometers.

Used primarily in the agriculture, construction, and specialty vehicle industries, Dynapar encoders and resolvers provide greater accuracy and durability than traditional speed and position sensors. Crane booms & aerials, electric steering systems, speed & rate indicators, and HEV (Hybrid Electric Vehicle) motor systems are some of the more common places these innovative devices can be found. Dynapar products bring precision, efficiency, and reliability to these mission-critical applications.

With advanced technology, less maintenance, and competitive pricing, Dynapar products are leading the electro-hydraulic control trend in the off-highway market segment.

Recommended Solutions

HS35R

Maximizing heavy equipment uptime and increased sensor reliability is what the HS35R provides. The HS35R's high 400g shock rating and large hollow shaft capability makes it well-suited for winch or hoist drum speed & position control. Its IP67 seal rating and powder coated finish resist the outdoor elements, making it a perfect solution for agricultural rate indicator applications as well.

HDN58

The innovative non-contact "shaftless" technology of the HDN58 eliminates seals, bearings, and couplings that contribute to equipment downtime in the

field. A wide sensing envelope and encapsulated electronics make this sensor ideal for harsh-environment rate indication & coarse angular position sensing. Choices of pulse output, analog voltage, or J1939 protocol make integration into existing control systems easy.

AR62/63

Some Off Highway Vehicle applications require precise feedback of critical movements. The AR62/63 is a magnetic absolute encoder that can withstand extreme conditions and is available in stainless steel with IP69k sealing.

Oil & Gas

As one of the most potentially volatile industries, the oil & gas industry requires reliable encoders that meet industry standards.

With ATEX Zone 0 and Zone 1, NEC Class I Div II, CE and CSA certifications, Dynapar's NorthStar encoders offer advanced sensing technology and reliable solutions for Oil & Gas. Certifed for use at -50• to 100• C, they are independently tested at up to 400G shock and 20G vibration. These unique encoders provide reliable output signal up to 1000 feet with high current driver and offer the industry's toughest optical engine with unbreakable disc.

For the corrosive oil and gas environment, our encoders offer to oilfield equipment manufacturers and end users enhanced sealing, industry certifications and an overall improved solution. They are used in drill motors, top drives, rotary tables, mud pumps, pipe handling, production equipment and more.

Recommended Solutions

DWD38 – Drawworks Applications

The DWD38 encoder is designed exclusively for drawworks applications on an oil rig. The NorthStar DWD38 is certified as an ATEX Zone 0 Intrinsically Safe encoder. The DWD38 has a temperature range of -40 to 100°C with a 400g shock rating making it ideal for the tough environment of the oil rig.

EN42 – Drilling Motor Applications

The EN42 is ATEX certified for use in Zone 1 on the oil rig. A barrier is normally required for a Zone 1 application which can add additional cost to the solution. The EN42 encapsulated electronics eliminate the need for a barrier and with an industry leading -50 to 100°C temperature range, it is ideal for Zone 1 applications.

EN44 – Drilling Motor Applications

The EN44 is ATEX certified for use in Zone 1 on the oil rig. A barrier is normally required for a Zone 1 application which can add additional cost to the solution. The EN44 isolated coupling compensates for motor shaft run out and endplay and the encapsulated electronics remove the need for a barrier.

Pulp & Paper

Speed, precision and control are critical in the fast-paced pulp and paper industry. Northstar offers a wide range of heavy-duty encoders and mill-duty magneto-resistive encoders designed to meet the performance and environmental extremes of the pulp and paper mills industry including Northstar brand RIM Tach® Series encoders.

Our comprehensive line of digital control systems provides reliable speed and web tensioning control for reliable plant operation. These rugged, standardized and customized digital encoders are engineered with magneto-resistive technology to track machine speed for precise control in the harshest of environments.

Our Mill-Duty (RIM Tach®) encoders provide reliability and precision even under the most challenging conditions and provide solid signals to precisely track machine speed for better control and for trouble-free and trustworthy performance. Our Heavy-Duty (Slim Tach®) encoders incorporate a bearingless and ultra-thin design for longer encoder life and a variety of motor mounting possibilities.

Recommended Solutions

HSD37 Harsh Duty Optical Encoder

Paper mills require equipment that is robust enough to handle dust and moisture while performing time critical applications. The HSD37 harsh duty optical encoder is built with an unbreakable plastic or stainless steel code disc, and is environmentally sealed at both ends preventing the penetration of dirt and moisture.

RIM Tach®8500 NexGen

The NEW RIM Tach®8500 NexGen was designed with the customer in mind. Now with the largest air gap (70 thousandths) in the industry the NexGen RIM Tach provides more generous axial play allowing for easier installation. To learn more about this revolutionary encoder click on the image above.

HS60

With an industry leading 2-7/8” hollowshaft capability, the HS60 fits large motor shafts in pulp and paper mills. Oversized bearings, multi stage sealing and stainless steel construction all add up to an encoder that is resistant to moisture and contamination.

Servo Motor

The use of servo motor has been growing rapidly thanks to their affordable price tag. As a viable alternative to pneumatic, hydraulic, and some

electromechanical forms of motion and positioning control, servo units have been used in a variety of applications, including robotics, XYZ tables, factory automation, and related precision control operations in production facilities worldwide.

In the fiercely competitive servo motor market, OEMs are driven by cost efficiency and prefer electronic motion control and feedback solutions for their integration ease that provide high efficiency, small size, and high torque technology at an attractive price.

Dynapar standardized and customized brand motor mount encoders and Harowe brand resolvers are reliable, affordable and extremely compact in size to enable production personnel to monitor critical motor speed and position parameters within their motion control and production applications. Accurate motor speed tracking ensures optimum machine performance and operation designed to prevent motor burnout, or worst case, costly machine shutdown.

Recommended Solutions

AD34 Single Turn Absolute Encoder

The AD34 absolute encoder has a special notched shaft allowing for easy one step installation and eliminates coupling issues. The wide temperature range of -15 to +120°C make it the perfect fit for your servo motor application

AD35 Single Turn Absolute Encoder

The AD35 absolute encoder's short mounting depth allows for installation in tight motor endbells. With up to 10,000 RPMs, this encoder is suited for high speed servo motor applications.

AD25 Absolute Encoder

A special conical shaft for concentric motor mounting are one of the key features that differentiate this product from other servo motor encoders on the market today. With up to 22 bits of singleturn absolute positioning it is the perfect fit for low speed motor performance.

Steel Mills

Steel mills have some of the harshest conditions of any industry, so they need feedback products that can handle tough environments.

NorthStar heavy-duty encoders as well as Dynapar absolute encoders can be found operating in length positioning and speed tensioning applications within the casting and finishing process modes of steel manufacture, specifically controlling and monitoring swing bucket position. The swing bucket pours molten steel into casting forms before returning to home position to refill

again, whereby machine operators need to be able to locate the bucket at all times to reduce incidence of scrap, waste or injury.

NorthStar offers a wide range of heavy duty encoders equipped with magneto-resistive technology that are not affected by the harsh conditions of steel production, e.g. water and airborne contaminants to mechanical shock and vibration. Their advanced encapsulated electronics ensure that they are unaffected by natural contaminants and extreme temperatures.

Some NorthStar models are even equipped with dual sensors as a built in sensor backup to prevent costly mill downtime scenarios.

Recommended Solutions

RIM Tach® 8500 NexGen

The NEW RIM Tach®8500 NexGen was designed with the customer in mind. Now with the largest air gap (70 thousandths) in the industry the NexGen RIM Tach provides more generous axial play allowing for easier installation. To learn more about this revolutionary encoder click the image above.

RIM Tach® 6200 Severe Duty Encoder

The RIM6200 can either be foot mounted or mounted to a 56 C Face and is ideal for belt drive applications in a steel mill. Heavy duty bearings and cast iron construction provide long life to an encoder built for tough environments.

HS60 Hollowshaft Encoder

With an industry leading 2-7/8” hollowshaft capability, the HS60 fits large motor shafts in steel mills. Oversized bearings, multi stage sealing and stainless steel construction all add up to an encoder that is resistant to harsh conditions and contamination.

Vector Motor

Modern Industry is driven by various electric motor types including AC, DC and permanent magnet (PM) motors. Many motors are used in general purpose applications where precise control is not critical and do not require encoders. However, many motor applications do require precise speed, torque or position regulation which requires an encoder for feedback.

Demanding “systems” applications like process industries (paper, steel, textile, film etc), material handling (cranes, hoists, conveyors etc), precise positioning (medical tables, metal cutting, and elevator) and other industries like Oil & Gas and Energy require the use of closed loop Vector Motors.

By incorporating encoders, Vector Motors provide precise speed, torque and position control over a much wider speed range thereby maximizing the performance of the motor. Typically mounted on the non-drive end of the motor on either a simple stub shaft, NEMA C-face flange or coupled to the shaft, the encoders come in a wide variety of styles, materials and resolutions to accommodate any motor design and customer application.

Originally founded as Lakeshore, NorthStar brand encoders earned recognition as a “pioneer” in delivering innovative and extremely reliable encoder

feedback solutions to the AC, DC and PM Vector Motor market. Pre-engineered designs to fit standard NEMA flanges of 4.5”, 8.5” and 12.5” bring precision, efficiency, and reliability to these mission-critical applications.

Recommended Solutions

HS35R Sealed Hollowshaft Encoder

Unique and different are two words to describe the HS35R and what makes it different from any other vector motor encoder. Larger mechanically held bearings, and dual v seals all add up to a longer life in any vector motor application.

HSD35 Heavy Duty Optical Encoder

The HSD35 incorporates the same design as the HS35R, but with a couple of key differences for specific vector motor applications in mill environments. The HSD35 design includes a latching field serviceable connector, stainless steel shaft hub and dual split clamp make this encoder stand up to tough vector motor environments.

RIM Tach® 8500 NexGen Encoder

RIM Tach 8500® NexGen Encoder featuring a new sensor providing up to 0.075" of Air Gap, Over 50% More Than Competitive Models. Expanded Resolution up to 2048 (4096 Coming Soon)

Wind Energy

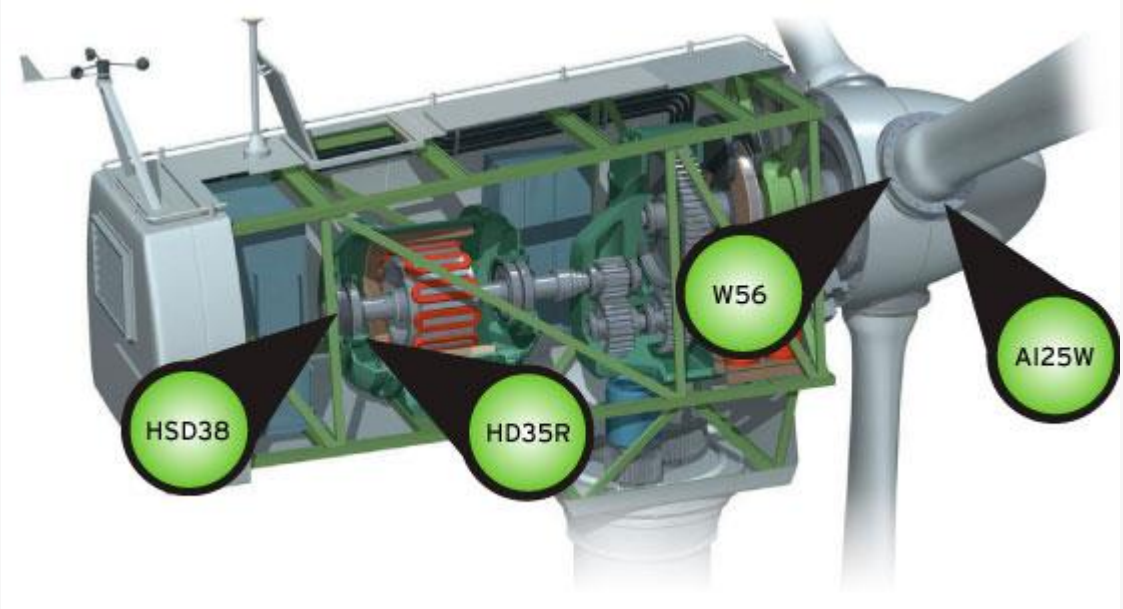
While the world looks for new forms of energy, the wind power industry is a market that is on the rise. Wind power is a renewable source that is

anticipated to generate more electricity in 15 years than all of Saudi Arabia's oil, without being depleted. New wind is created every day by the heating and cooling of the earth and is not affected by fuel price increases or supply disruptions.

From wind power plants to large commercial wind turbines to small residential wind generators, wind has become a popular alternative energy commodity and industry to harness, control and measure.

Designed to meet the manufacturing and maintenance requirements of the wind energy industry, Dynapar encoders are a trusted component in wind generators and commercial wind turbines. They measure air movement or speed, as well as the rate at which a generator's fan blades are spinning to ensure optimum machine performance and energy output and usage.

Dynapar industrial and heavy-duty encoders are perfect for this industry can be customized for specific projects.



Recommended Solutions

HSD38 - Generator Applications

Wind turbines are often operating in extreme environments. The HSD38 encoder can withstand temperature ranges of -40 to 100°C and the special double labyrinth sealing makes this encoder virtually impenetrable.

W56 - Pitch Control Applications

The W56 encoder is designed specifically for pitch control unit feedback and can currently be found operating in MW class towers. This robust bearingless encoder is unaffected by environmental contaminants making it a perfect solution for Wind Energy

HD35R - Wind Generator Applications

HD35R Generator Encoder featuring a phased array sensor for reliable signal output and a rugged design with oversized bearings.