Selecting the Right Rotary Position Sensor for a Draw Wire Transducer in Industrial Applications

WHITE PAPER

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A major challenge for designers of industrial equipment is the accurate measurement of the displacement of an object over long ranges of linear motion. Industrial systems often require compact, precise, repeatable measurement solutions that can withstand harsh environmental conditions and provide feedback to the rest of the system. Additionally, the measurement solutions are often located away from the object in motion. In these types of applications, the draw wire method of measurement is seen as an optimal solution. The draw wire method combines a spring-loaded wire in a transducer with a rotary position sensor to enable simple displacement measurements. The transducer wire can also be configured with pulleys to measure movement in different orientations.

Draw wire transducers measure linear motion and provide an electrical signal that is proportional to the movement of an object in various applications. As the wire is drawn out from the transducer, the sensor shaft rotates. The rotation of the shaft results in an angular measurement corresponding to the distance of the object at the end of the wire that has moved. Designers have found that this method makes it possible to accurately measure, track and control the movement of components in large systems. This method can also be used to measure very fine movements of machinery.

The accuracy of the draw wire transducer and effectiveness of the design depends on selecting the appropriate type of rotary position sensor to meet or exceed the needs of a given application. This paper will explore important application characteristics to consider when selecting a rotary position sensor for a draw wire transducer. A variety of single-turn and multiturn rotary position feedback sensors will be discussed featuring analog and digital output, suitable for a diverse range of industrial draw wire applications.

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INTRODUCTION TO DRAW WIRE TRANSDUCERS

Draw wire displacement sensors and cable extension transducers, also known as string potentiometers, consist of electrical and mechanical components. As shown in figure 1, a typical draw wire transducer is made up of four main parts: a high torque, long-life power spring, a flexible high strength cable with hook or other attachment mechanism, a constant diameter spool and a rotary position feedback sensor.

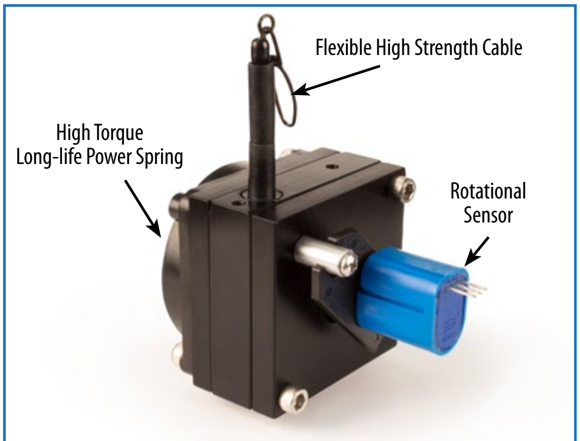

Figure 1. | Typical Draw Wire Transducer

The housing of the draw wire transducer is generally mounted to a stationary surface while the draw wire is attached to an object that is translating in either a linear or rotary motion. As the object moves, the rotary position feedback sensor in the transducer housing rotates proportional to the distance of movement, linear motion or angular displacement of the attached object. The output of the rotary position sensor is fed back as an electrical signal to the system for processing. Table 1 lists various industrial applications that typically use the draw wire method to measure angular or linear displacement of objects in a system.

Packaging and Handling	Mobile Off-Highway	Clean Energy
Pick and place, palletizing	Construction, road maintenance	Solar tracking of solar cell panels
Stretch-wrapping	Farm, forestry	Adjustment of windmill turbine houses
Filling	Recreational	Opening and closing of windmill hatches
Machine Tools	**Medical and Health**	**Aviation**
Loading and unloading of machined parts	Wheelchairs and mobility vehicles	Structural testing
Positioning of machining tools	Patient lifts	Landing gear
Operating doors, hatches, safety features	Dental chairs	Cockpit controls
		Payload displacement
Factory Automation	**Material Handling**	
Robots and manipulators	Overhead crane systems	Automatic/manual lift and transport aids
Printing and scanning	Conveyor systems	Feeding equipment
	Production line equipment	

Table 1. | Applications in numerous industries use draw wire transducers to obtain displacement and rotation measurements

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INDUSTRIAL EQUIPMENT TRENDS AND DEMANDS

Numerous factors have converged to increase the demand for draw wire transducers. Factory automation relies on repeatable and precise position feedback in order to monitor and control equipment. Low-voltage AC and DC drives are becoming widespread for retrofit and new designs due to the energy efficiency they provide. Along with this upgrade from hydraulics to electric drives, Programmable Logic Controllers (PLCs) and Input Output (I/O) ports have been added. Tying all of these factors together are the self-diagnostics, self-calibration and modern control processing optimization made possible by pervasive connectivity and the Internet.

As sensors become an integral part of the automated factory, the need for accuracy of measurement in this environment has introduced new demands on the sensor for consistent output, programmability, high reliability and reduced torque. Maintenance is also a major system consideration due to the cost of the technician, service call, sensor replacement and system downtime.

Since wire length in a draw wire transducer can be any length from millimeters to tens of meters, designers have learned that having one rotary sensor that can be programmed for different wire lengths can be a major advantage. In addition, sensor programmability and reliability becomes more critical in remote locations where harsh environments are present and equipment is less accessible.

IMPORTANT DESIGN CONSIDERATIONS

Using draw wire transducers offers ease of installation, space reduction and cost advantages. This method offers straightforward measurement over relatively short distances, or when confined to a precise rotational angle. However, there are multiple ways to implement a draw wire transducer within a given system. The sensor may be mechanically connected to the moving object by wire, pulleys, levers, or other methods. Thus, the application characteristics, environment and performance requirements will vary greatly among systems. Once it is determined that a draw wire transducer is the right design approach, the specifications of the system will guide the designer in selecting the correct rotary sensor. Important considerations to evaluate include:

- Accuracy and resolution
- Output consistency over lifetime
- Programmability
- Rotational angle
- Rotational life
- Output interface (Communication protocol)
- Measurement type
- Constant power supply
- Torque
- Size and weight
- Mounting style
- Environmental capabilities

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IMPORTANT DESIGN CONSIDERATIONS *(Continued)*

The range of motion and type of application will determine the accuracy and resolution required. Since a transducer must provide precise measurements, it is important that the resolution of the sensor is high enough to differentiate position and produce a signal corresponding to the specifications. Programmability for zero position and slope can be especially useful for manufacturers producing a variety of draw wire transducers with multiple wire lengths.

The wire travel length will determine the necessary rotational angle, where 360 degrees is one rotation. Calculation of the sensor's required rotational life must take this and the lifetime of the assembly into account. It is important to balance the cost and life cycle by selecting a sensor that meets the assembly life cycle.

Available sensors feature digital or analog output signals to meet the needs of a broad range of system requirements. Potentiometers provide analog signals, and encoders produce digital output that can be incremental or absolute. An incremental signal is appropriate when relative displacement measurements are desired, while absolute may be necessary if repeatable positioning is desired. The availability of constant power will also have an impact on the type of sensor that is selected. Some sensors are affected by power interruption and require reprogramming or recalibration of the home position, which may not be acceptable in all systems.

Torque, size and weight, mounting style and environmental requirements are important factors for fitting a sensor into a transducer and the transducer into the system. Servo and bushing mounts are the most popular mounting styles for the sensors. To match environmental operational needs, many sensor manufacturers provide Ingress Protection (IP) ratings on dust and fluid tolerance. Another important consideration is the rotational torque of the sensor. A high rotational torque may interfere with the action of the return spring. Once the requirements of a given system are known, the importance of each factor must be weighed to narrow down the selection of the right sensor.

Communication protocol may also be a main consideration when selecting a sensor. Typically, potentiometric contacting sensors output a variable voltage, commonly known as an analog signal which requires conversion for use in a digital system, whereas encoders produce incremental quadrature or absolute output signals that can be directly integrated into digital systems. In today's highly computerized world, it is necessary to have flexibility with communication protocol in order to minimize circuitry and maintain maximum processing speed for a given system. Some of the more popular communication protocols are Synchronous Serial Interface (SSI), Serial Peripheral Interface (SPI), Controller Area Network (CAN), and Pulse-Width Modulation (PWM). These communication protocols are used in interrogation of the sensors to extract real-time data, to activate or deactivate the units and to perform diagnostics. Each type of communication protocol has its advantages and disadvantages, and is normally selected based on the system requirements.

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FOCUS ON SENSOR SPECIFICATIONS

The sensor selection process typically starts with contacting precision potentiometers, adding complexity until specifications are met. More stringent requirements and higher reliability can introduce the need for non-contacting technology and custom features.

Precision Potentiometers

Precision potentiometers use contacting technology to provide accurate and reliable measurements in many draw wire transducers. Most potentiometers offer the same device construction in terms of packaging and standard features, with the differences being the number of turns or the mounting style for which the device was designed. Single-turn potentiometers such as the Bourns® Model 6537, 6538, 6539 and 6639 provide accuracy over an extended temperature range. These potentiometers have an electrical angle of 340 degrees, essentially infinite resolution and offer 0.1 % standard output smoothness. The Bourns® Model 6537 and 6538 are servo mounted and can be customized with additional features. The extended life and ball bearings offering extremely low rotational torque in the Bourns® Model 6538 are the main differences between the two models. The Bourns® Model 6539 and 6639 are high quality single-gang potentiometers with rugged construction. Each delivers high rotational life and provides a compact, cost-effective option for applications with space constraints. The Model 6639 is mounted by bushing, and the Model 6539 is servo mounted with continuous and mechanical stop options.

If a rotation angle greater than 340 degrees is required, then the Bourns® Model 3547, 3548 and 3549 provide the same level of accuracy and reliability over 3-, 5- and 10-turns, respectively. Available with wirewound or Hybritron® technology, these precision potentiometers offer high rotational life and standard options including an anti-rotation lug, bushing or servo mount and side load capability. Once the number of turns has been decided, the element type can be selected, taking environment and current levels into consideration. Wirewound models offer greater moisture resistance, temperature coefficient, power dissipation, and wiper current capacity than Hybritron® and conductive polymer elements. Models with Hybritron® technology have enhanced performance benefits, but should only be used in designs with low to moderate input current as the technology is not suitable for use with high input current.

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FOCUS ON SENSOR SPECIFICATIONS (*Continued*)

Analog Non-Contacting Technology

If a draw wire system needs to operate in a more extreme environment and demands a sensor with higher reliability or programmability, analog non-contacting technology is an optimal solution. In addition to a longer consistent ouput, magnetic technology provides high resistance to vibration, shock and the ingress of dust or fluid, allowing the sensor to perform well in industrial applications. The Bourns® Model AMS22 Series of encoders are robust, magnetic, single-turn sensors with proven reliability and repeatability. This series is programmable at the factory for zero position. A servo mount is an option with the Bourns® Model AMS22U, and a bushing mount is offered with the Bourns® Model AMS22B. If a multiturn non-contacting sensor is required, designers can select the bushing mount Bourns® Model AMM20B, available with 3-, 5- and 10-turn options. The output signal slope is also programmable. Since there are a great variety of wire lengths in draw wire systems, having a single product that can be programmed for different wire lengths is a significant benefit delivered with these Bourns® sensors. These products can be factory programmed to provide the communication protocol required by the specific system, i.e., PWM, SPI, SSI or other protocol. Programming flexibility provides a single solution for multiple systems.

Digital Non-Contacting Technology

Draw wire designs comprising a microcontroller with a need for a microcontroller and need a digital signal from the sensor will find the Bourns® Model EN rotary encoder an ideal solution in numerous resolution options. The Bourns® Model EN encoder uses optical technology to provide both magnitude and direction information. Here, one sensor provides two components to a signal. This is a great choice for a system that moves back and forth or changes direction often. For example, the Bourns® EN devices can be used in new and retrofit elevators in observance of stringent safety guidelines. These encoders feature a two-channel quadrature output that is necessary for detecting both speed and direction of a hydraulic or traction elevator. The Bourns® Model EN has a square wave output pulse compatible with Transistor-Transistor Logic (TTL) and Complementary Metal-Oxide-Semiconductor (CMOS) interfaces. The compact size and digital accuracy of this component make it versatile, and its useful life of up to 200 million rotations means it can endure extended service applications.

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FOCUS ON SENSOR SPECIFICATIONS (*Continued*)

Non-Contacting Hall Effect Technology

The Bourns® Model EMS Series encoders are highly versatile non-contacting Hall Effect rotary position sensors with four available output signal types: pulse wave modulation (PWM), direction/step, quadrature, and absolute. A PWM signal provides excellent noise immunity in challenging settings. The direction/step option is used for incremental counting. Quadrature signals provide both direction and magnitude, similar to the Bourns® Model EN. An absolute output is not affected by power interruption since each position corresponds to a unique preset code, making it ideal for applications that do not have a constant, reliable power source and for systems that require exact position information. The absolute option is well-suited for high-speed rotation in fast-moving draw wire applications. The rotational lifetime of the Bourns® Model EMS Series is approximately 50 times greater than Bourns® models using contacting technology.

Additional advantages gained from selecting Bourns® sensors include customization and value-added options, and a best-in-class global supply chain. Bourns' contacting technology offers a cost-effective and highly precise solution. Non-contacting magnetic technology from Bourns is extremely resistant to vibration, shock, and the ingress of fluid and dust, making it a robust choice for use in industrial applications. This technology is repeatable and programmable at the factory for zero position. Bourns' rotary position sensors are designed to deliver reliability, repeatability and precision in even the most challenging conditions.

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WORKING WITH BOURNS

Bourns has an extensive history of providing reliable sensors proven in a variety of digital and analog applications. The company is committed to continual sensor enhancements in terms of durability, size, system compatibility and other features to fit the broad needs of systems using draw wire transducers. A prime example is Bourns' offering of innovative mounting options that eliminate the expense of special mounting fixtures, improve accessibility, and can help reduce maintenance time and costs. Additional advantages gained from selecting Bourns® sensors include customization and value-added options, and a best-in-class global supply chain.

Bourns delivers a complementary portfolio of customized magnetics, energy efficient shunts and low conductive, in-circuit current protection to assist in efficient power management of the system. In addition, Bourns' surge and circuit protection expertise enables sensitive circuits to operate reliably due to thorough testing performed to compliance standards. Integrated solutions are also available to assist in increasing reliability with the added benefit of reducing the physical footprint and Bill of Material (BOM) costs. Bourns has a history of providing reliable total application solutions to suit the most challenging operating environments.

ADDITIONAL RESOURCES

For more information about Bourns' complete line of sensors and controls, please visit:

www.bourns.com

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