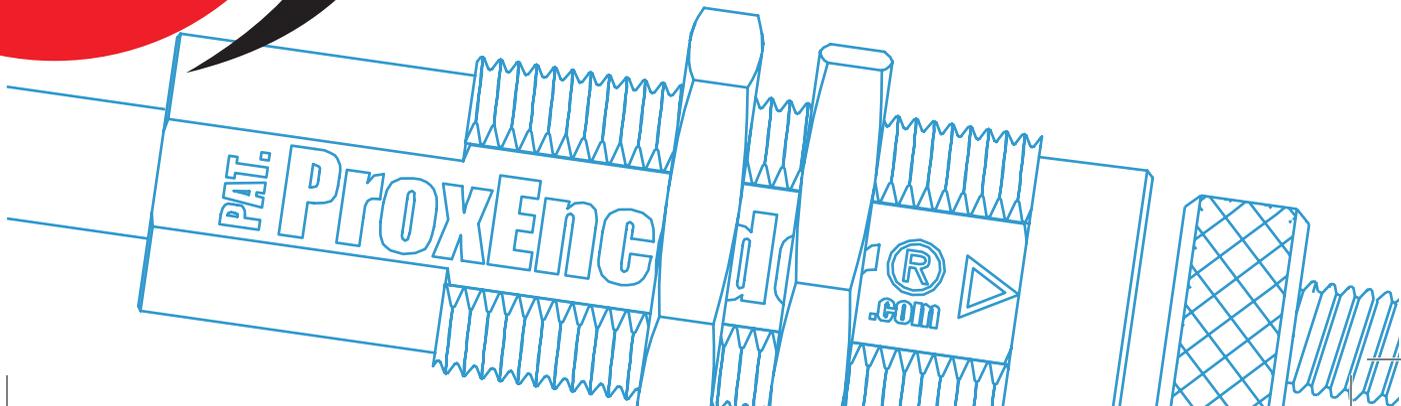


**JORAL**  
Capture **CREATIVITY**

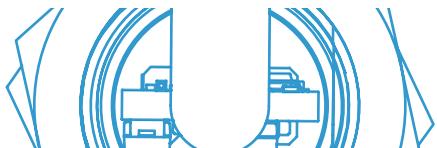
www.JORALLLC.com • (262) 378-5500  
640 PERKINS DRIVE MUKWONAGO, WI 53149

*ProxEncoder*<sup>®</sup>.com ▶

**Rotary Encoder Booklet**

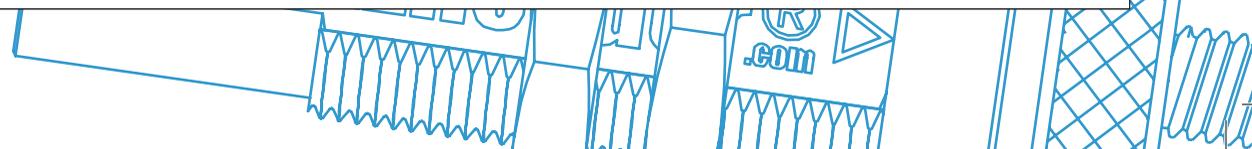


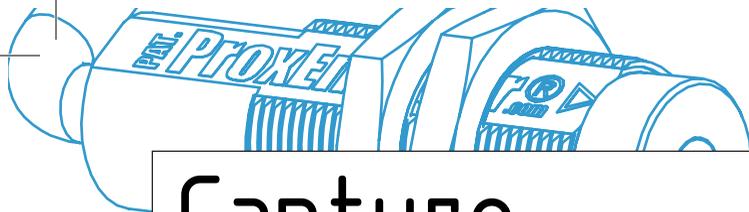




# Contents

introduction to joral	1
building a better encoder	3
encoder basics	7
applications	19
outputs	29
form factor & order guide	39
additional offerings	45





# Capture **CREATIVITY**

## the beginnings



Joral, LLC develops sensing solutions that cater to tough commercial environments. Established in 1995 producing controllers for timber harvesters, Joral manufactures rotary encoders, linear position sensors, inclinometers, and temperature modules.

## to build a better encoder

Joral's first encoder was developed in the field with equipment operators. Joral's new sensors were better encoders that replaced failing sensors originally supplied on timber harvesters.

Soon after release of the J1 Encoder, harvester operators called equipment dealers requesting to only be sent the "better encoder" Joral had developed.

## selling yourself out

Joral's shafted magnetic encoder worked well, too well for Joral to continue selling sensors only for timber harvesters. The J1 rotary encoders were not failing and operators no longer needed replacement encoders.

Joral expanded and quickly discovered the expansive world of mobile hydraulics. From custom non-contact gearbox solutions on cranes, high PSI housings on underwater submersibles, and explosion proof absolute multi-turn encoders on oil platforms, Joral has developed sensor solutions that survive all conditions.

## creating the family

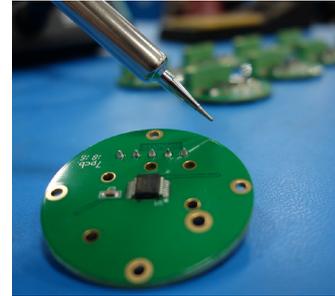
The family of Joral encoders are backed by a full offering of electrical outputs including J1939 absolute multi-turn. From shafted and non-contact rotary encoders Joral expanded into inclinometers and linear position sensing.

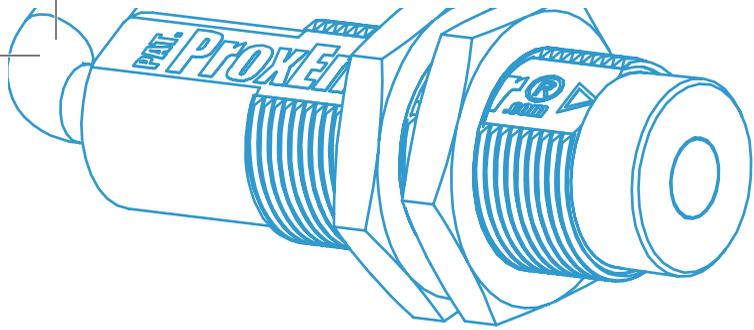
Three axis inclinometers are CAN J1939 capable and communicate their true angle to home regardless of orientation.

Linear position sensors are available in CAN J1939 incremental or absolute “zero power.” The absolute zero power linear sensor can record linear motion without source power.

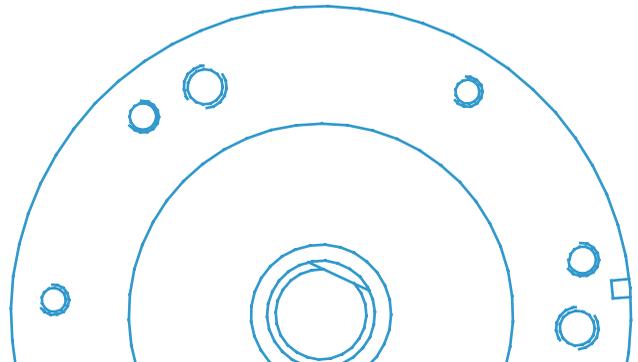
## joining forces

Today Joral works hand in hand with distribution and equipment manufacturers to provide sensors that capture motion so the world can create.

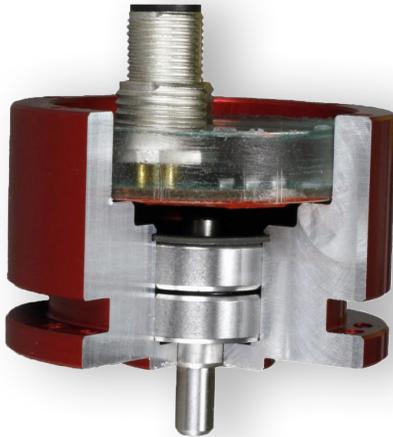




# building a better encoder



## MAKE IT SIMPLE



By nature magnetic encoders are mechanically less complex than their optical encoder counterparts. Reliability is achieved by providing a sensor that does not depend on fragile interconnected components for sensing.

When compared to optical encoders Joral's magnetic encoder has no sensitive optical eye or breakable internal encoder disk. Joral's sensor returns rotary position with a solid-state embedded microchip.

ENCODER #001



## MAKE IT STRONG

Solid-state embedded measuring allows the opportunity to seal the encoder with an automotive grade plastic epoxy. The shafted encoder body maintains a base protection class of IP67. All Joral electronics packages are rated to IP69k, with a properly sealed connector.

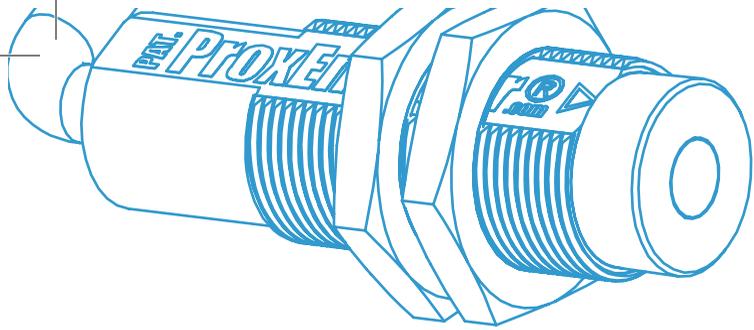
The Joral shafted encoder utilizes oversized bearings and a billet aluminum housing to prevent shaft push through. Rated MIL SPEC 202 for shock and vibration, the Joral magnetic rotary encoder is rated to handle extreme machine conditions.

# MAKE IT SUPERIOR

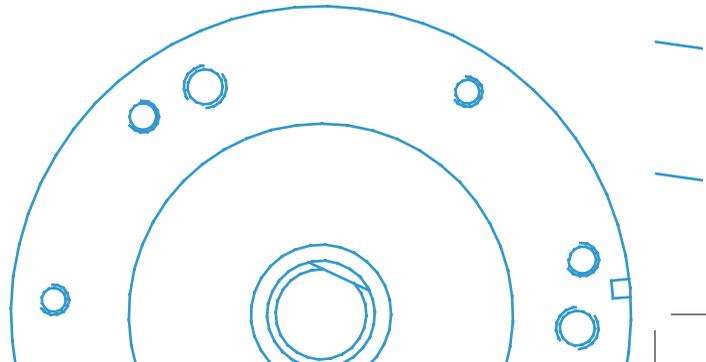


The development of the Joral magnetic rotary encoder reached a new level through a non-contact magnet package that eliminated the need for shaft and bearings. Shafted encoders, no matter how robust, still faulted from the requirement for physical coupling to the application itself.

The Joral non-contact magnetic encoder exceeds the limitation of a physical shaft by allowing up to 1/2 inch gap between the sensor and machine. A patented magnet package enables the Joral non-contact rotary encoder to detect rotation off axis and is able to handle 30° planar tilt.



# encoder basics

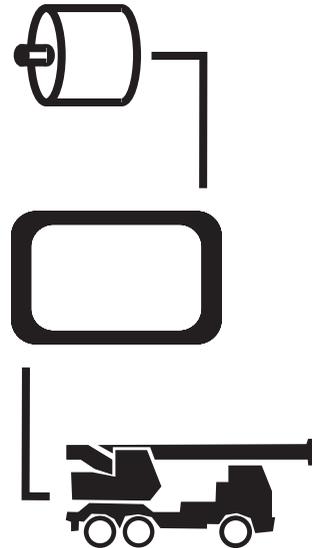


# Control Systems 101

Encoders output signals to a programmable logic controller (PLC), which runs the machine. The signals sent from the encoder are interpreted by the PLC which adjusts the machine according to programmed instructions.

For example, a rotary encoder used on a crane platform could provide the feedback for crane position. Knowing the position of the crane platform allows the controller to limit the movement of the crane to ensure safe operation.

The encoder installed on the crane's rotating platform communicates to the PLC, which regulates the machine's function.



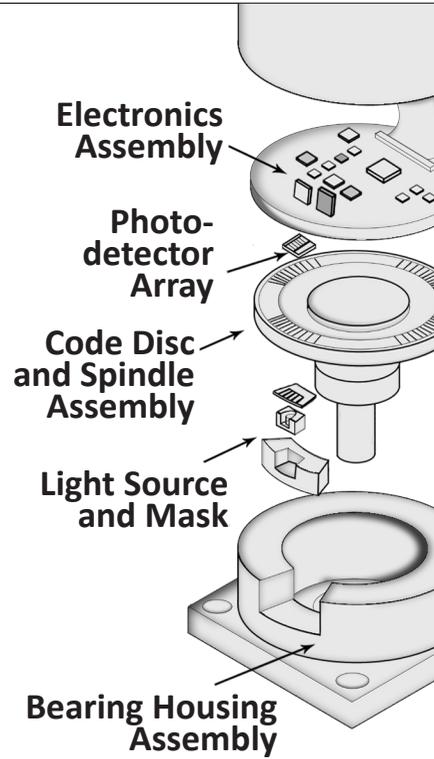
# Optical Shaft Encoder

Optical encoders use the interruption of light to detect rotary motion.

A rotating disc inside the encoder contains opaque lines or patterns, and as the disc is rotated through a light source, the patterns on the disc interrupt the projected light beam.

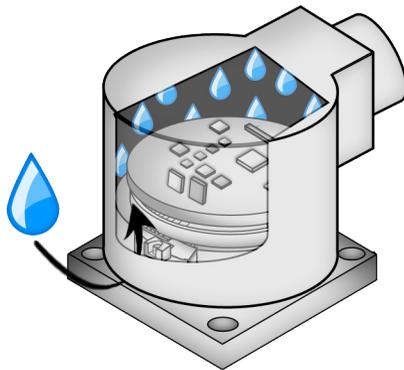
An internal photo-detector senses the pulsing light, which is translated and forwarded to an external control system via the encoder's electronics.

The need for a photo-detector and light source means the optical encoder requires a cap to maintain a dark environment for detection.



## Advantages

- High resolution with up to 16 bit position data
- Resistant to magnetic interference



## Disadvantages

- Complex / fragile mechanics
- Susceptible to dirt, oil, and dust contaminants
- Mechanical parts contact and require a shaft and bearing package
- Cap requirement prevents LED indicators

### optical encoders fail outdoors

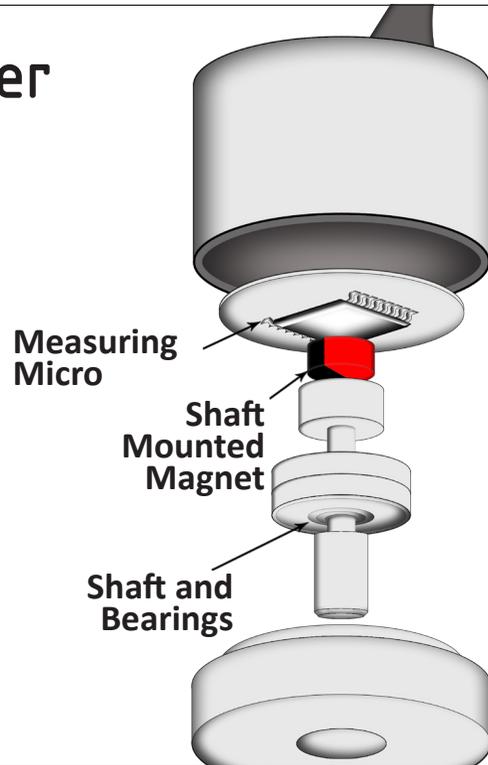
Equalizing air pressure destroys optical encoders because sensor seals cannot stop humid air from penetrating the electronics. Risk of encoders malfunctioning because of bad seals are amplified when water, dust, and chemicals are prevalent in the sensor's application.

# Magnetic Shaft Encoder

Magnetic encoders find rotation by sensing change in a local magnetic field. The typical magnetic rotary encoder relies on a silicon chip which contains a hall-effect sensor.

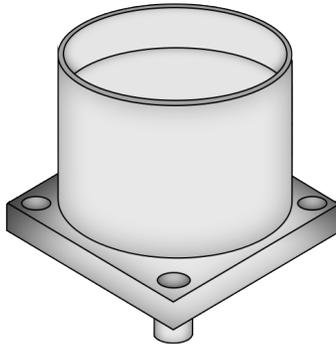
The hall-effect sensor, which is mounted within close proximity to a rotating magnet, finds the strength of the magnet's corresponding magnetic field and outputs a voltage relative to the change in magnetic polarity.

The varying voltage is translated by the encoder's electronics and sent out to an external control system.



## Advantages

- No complex internal mechanics
- Can be 100% sealed for environmental protection
- LED feedback indicators



## Disadvantages

- Susceptible to magnetic interference
- Lower resolution options (up to 14 bit)
- Mechanical parts contact and require a shaft and bearing package

### the joral advantage

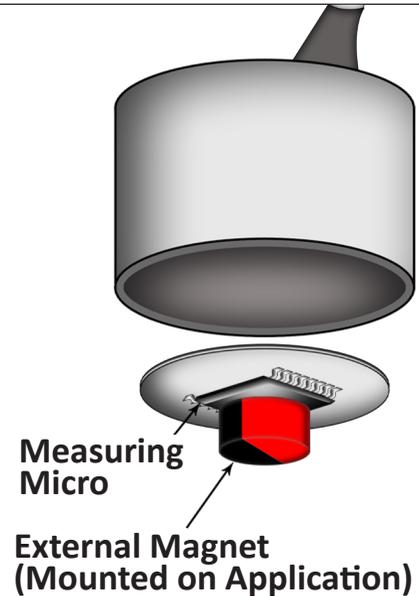
Joral magnetic shaft encoders are 100% sealed. Automotive epoxy is used to encapsulate the entire electronics package, preventing moisture from reaching sensitive components. Also, clear potting and an open design allows the use of LEDs, to help troubleshoot sensor power and communications.

# Hall Effect Encoder

Like the shafted magnetic encoder, the hall effect encoder uses a silicon chip with a hall-effect sensor array that can detect magnet rotation. The hall-effect sensor uses an external magnet held within tight tolerances to detect rotation.

The hall effect non-contact encoder doesn't require a shaft and bearing, however the detection tolerances are limited to 0.5mm (0.2") from the sensor face, and a restriction to only  $\pm 0.2\text{mm}$  (0.08") of travel.

Hall effect non-contact requires machine bearings to hold tight tolerances. Bearing wear or heavy machine vibration will cause output error.



## Advantages

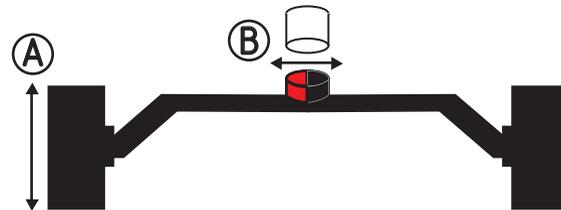
- No shaft and bearing requirement
- Can be 100% sealed for environmental protection

## Disadvantages

- Extreme tolerance limitations
- Machine bearing wear can create signal error
- Machine vibration can create signal error

### hall effect non-contact tolerance troubles

Where vibration and deflection are common hall effect non-contact struggles to maintain tolerance for detection. Shown right, a steering carriage demonstrates travel in the suspension (A) would result in misalignment of the sensor and external magnet (B).



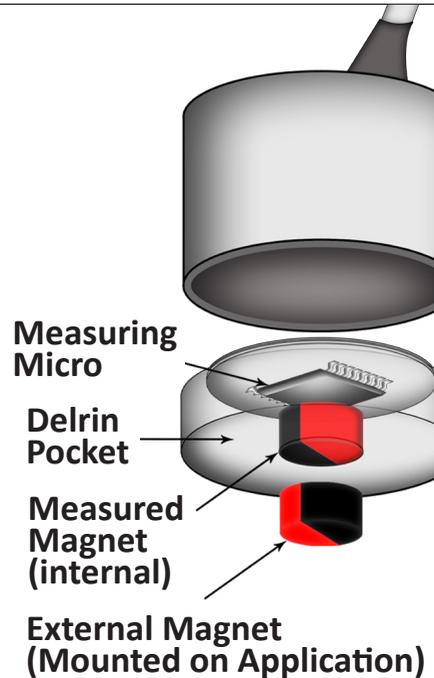
# Joral ProxEncoder®

## NON-CONTACT ROTARY ENCODER

The Joral non-contact rotary encoders use a hall sensor assembly with an internal magnet and an external application magnet to detect rotation.

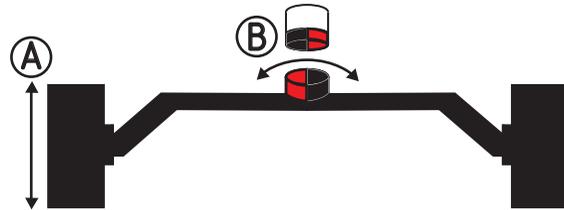
The ProxEncoder® non-contact rotary encoder senses rotation up to 13mm (0.5") from the sensor with patented technology developed in house by Joral.

With no shaft to seal and potted electronic package, Joral non-contact rotary encoders operate in high pressure environments, detect through non-ferrous barriers, and handle daily wash down without skipping a count.



# Advantages

- True non-contact, rated 13mm (0.5") air gap between sensor and application
- Tolerates 30° planar tilt and 2.5mm (0.1") axial misalignment
- 100% sealed, IP69K
- LED feedback indicators
- Detects through non-ferrous barriers
- Accepts custom application magnet assemblies
- Resistant to bearing slop and machine vibration
- Magnetic coupling makes for flexible installation



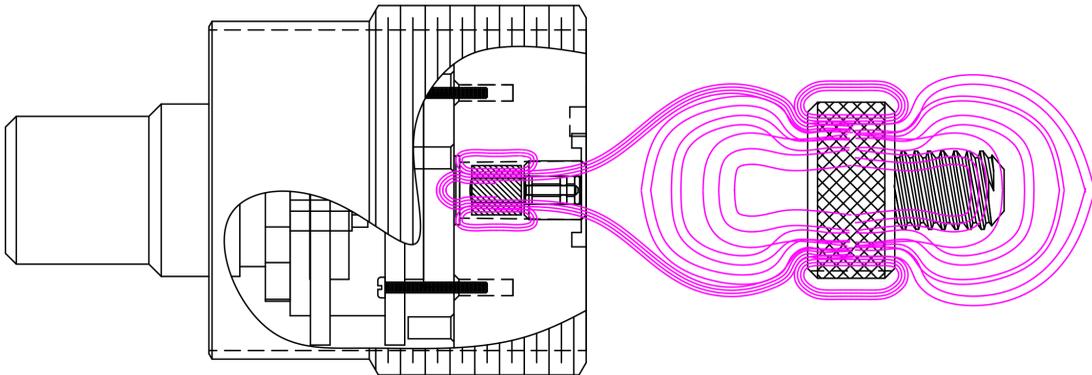
## the joral advantage

ProxEncoder® non-contact rotary encoder can tolerate vibration, misalignment, and bearing slop. The magnet used for detection is built into the sensor and the application magnet drives the internal magnet measured by the micro.

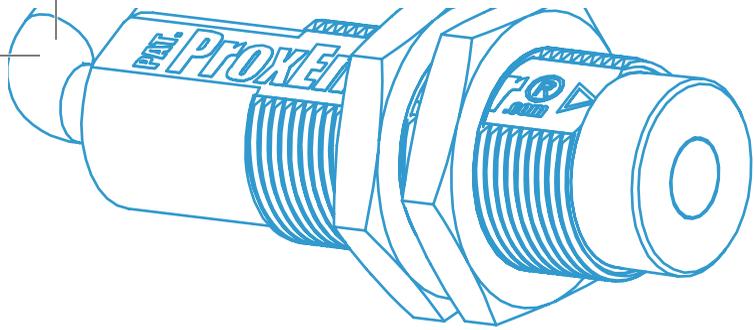
Shown above, travel in suspension (A) is tolerated by the operating tolerance of the magnetic coupling (B).

# Magnetic Coupling

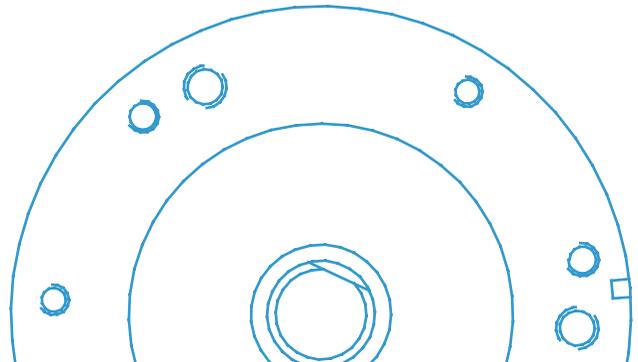
Below is a drawing demonstrating the magnetic flux lines coupling to the internal magnet of the ProxEncoder® non-contact rotary encoder to the external magnet mounted on the rotating application.







# applications

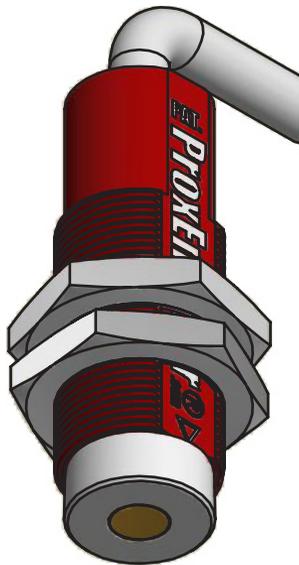


# Choosing the right encoder for you

In a perfect world Joral would recommend encoders for all applications, we even believe nothing makes a better stocking stuffer than an encoder!

But Joral understands not everybody would enjoy an encoder for a gift, we also understand some encoders are not suited for particular conditions.

The following section outlines common applications, the faults of applying a traditional encoder, and how the Joral ProxEncoder® non-contact rotary encoder is better suited for the measuring application.



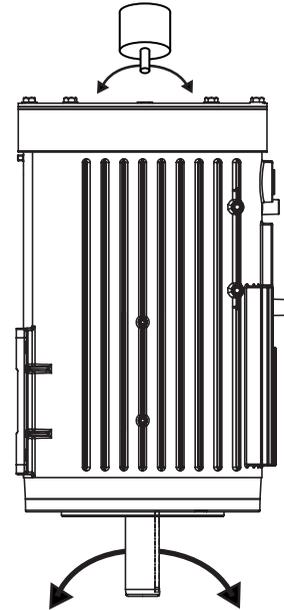
# Motor Feedback

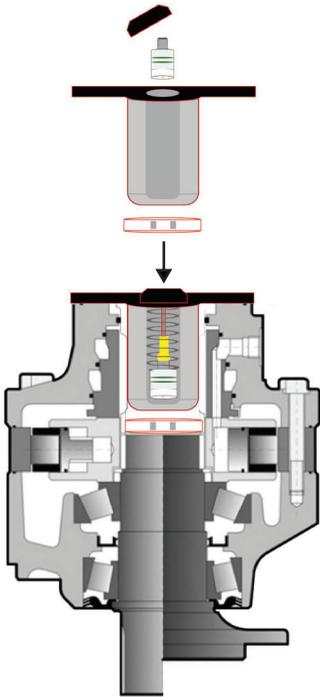
Encoders can be used to monitor motor position and speed, as well as track cycles for scheduled maintenance.

Rotary encoders are typically mounted through a direct mechanical coupling to the bell housing of the motor. In some cases, an encoder can be installed off motor through the use of a chain and sprocket or belt and pulley.

One drawback of mechanically coupling the motor to the encoder is shaft load and machine vibration. Any physical coupling to the encoder causes physical forces to transfer through the shaft into the sensor.

Removing the mechanical coupling between encoder and motor eliminates wear and tear caused by daily use.





The ProxEncoder® non-contact rotary encoder can be integrated directly into motor assemblies (figure left).

Whether built directly into the motor or coupled with a mount, removing physical shaft contact eliminates the transfer of vibration and shock into the sensor.

Last, in the event of bearing failure, the non-contact encoder will be isolated from shaft damage.

## Advantages

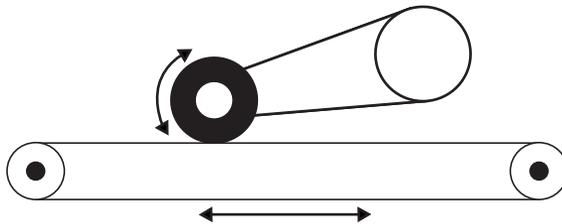
- Reduce motor vibration transferred to encoder
- Detect through motor barriers for feedback on motor speed, direction, and RPM
- Able to integrate into motor assembly

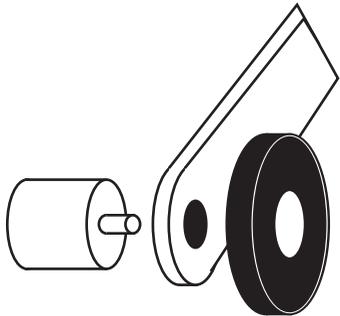
## Conveyor Monitoring (LINEAR MOTION)

Linear measurement is a common application for encoders. Rotary encoders are used to measure linear travel in conveyors, autonomous vehicles, and cable reels.

Typically a measure wheel is applied to couple the rotary encoder to the traveling conveyor. Sometimes the encoder shaft is used to load the encoder wheel on the conveyor, leading to bearing wear and the encoder's destruction.

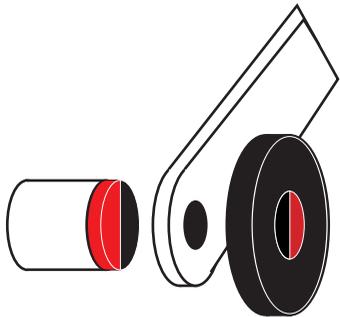
For vehicles and cable reels an encoder is mechanically coupled to a rotating item that extends and retracts (a reel wire), or travels on a linear surface (the road). Complicated assemblies require access to the application's shaft coupling for service.





It is possible to remove shaft load and complicated couplings by eliminating the need for a shaft entirely with the ProxEncoder® non-contact rotary encoder.

Magnet assemblies can be designed directly into wheels and bearings to allow easy changing of the sensor, or to change a worn assembly without having to realign the physical shaft.



## Advantages

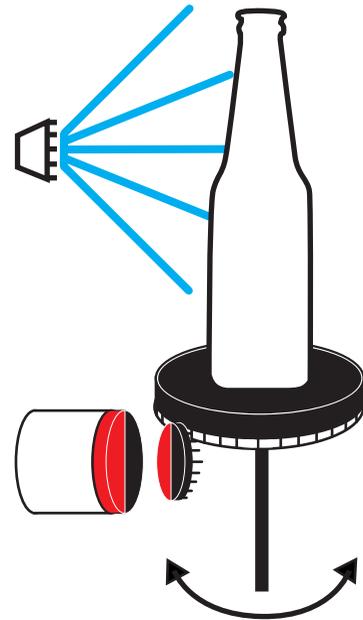
- Designers are able to integrate the sensor's application magnet into linear monitoring devices, a for example rotating wheel or cable reel
- Easy assembly and maintenance with no complex shaft components

# Platform Rotation

Common in industrial filling and mobile hydraulic boom control, platform monitoring via rotary encoder provides precise feedback. However, restricted access and limited installation tolerances create a headache for systems that utilize sensitive electronics in extreme environments.

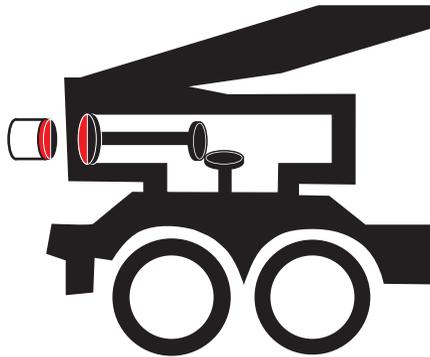
Moisture, vibration, and machine wear lead to machine down time. Creating an installation that limits physically coupled parts, increases time between maintenance, and reduces labor requirements during scheduled service.

Figure right demonstrates a non-contact encoder coupled to a turning platform for bottle wash-down.



Food and beverage processing often requires regular caustic wash-down that destroy encoders. Utilizing the ProxEncoder® non-contact rotary encoder removes bearing seals and provides a 100% sealed sensing solution

Figure below shows a gearbox inside a crane's large moving platform. The platform utilizes the internal mechanics of the gearbox that drives the crane. A magnetic coupling through the gearbox housing provides a totally sealed IP69k solution to measure platform rotation.



### Advantages

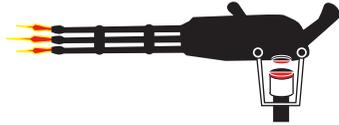
- No shaft for 100% environmental protection in wash-down environments
- Couples non-contact through barriers for integration into gearbox assemblies
- Reduce assembly costs by limiting mounting hardware and expensive shaft couplers

# Operator Positioning

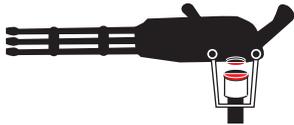
A growing application for the rotary encoder is the need to translate operator input into feedback for a control system. Autonomous vehicles require a feedback device to verify steering position. Load management systems for cranes and lifting trucks require boom position to limit the operator from tipping the machine.

Whether it be an arm position on a destructive mine sweeper, a grabbing claw on a timber harvester, or auto positioning for an autonomous truck (below), operator position feedback enables safety and efficiency by removing the mechanical complexity of a shafted coupling.

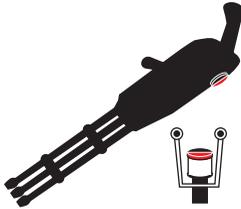




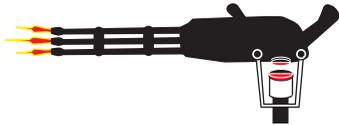
Shown left, a machine gun turret. The ProxEncoder® non-contact rotary encoder is mounted on the turret base and magnet package mounted on the firearm to assist the gunner to aim and fire with precision.



If there is a jam the operator can remove the assembly from the turret, clear the jam, and slam the gun together without having to assemble an encoder coupling.

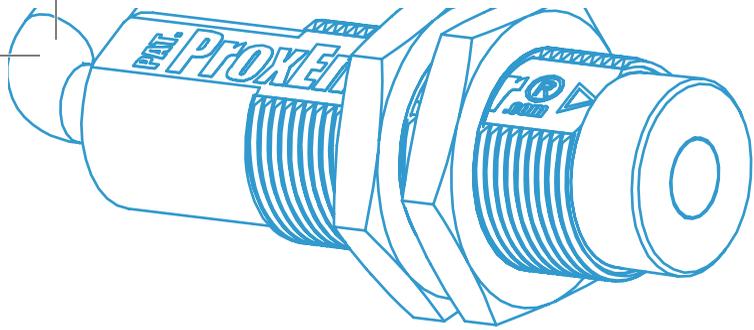


When seconds matter the Joral ProxEncoder® non-contact rotary encoder is ready for duty.

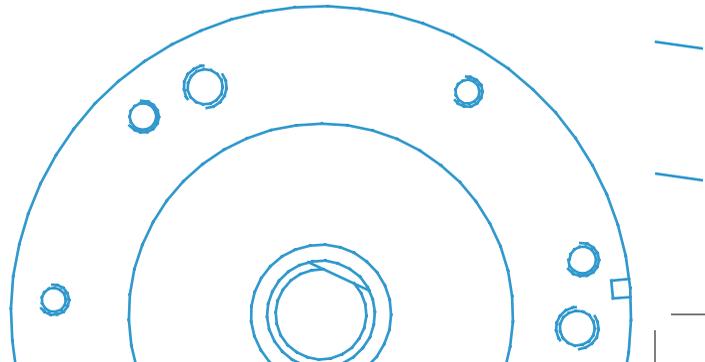


## Advantages

- Repeatabile assembly and disassembly without shaft coupling
- Tolerance accepts axial misalignment and planar tilt of application magnet for quick swap service



# outputs

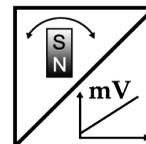
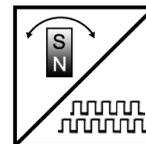


# What's on the Inside Counts

Selecting the best encoder for your application has two important stages, the physical package and the electrical output. The electrical output is the term for the signal the rotary encoder sends to the programmable logic controller (PLC).

Rotary encoder outputs include common signals such as analog (voltage or current), quadrature, SSI, Step and Direction, and more complex digital communications including CAN bus, CAN J1939, USB, Ethernet and more.

The following pages dive into understanding the qualities of outputs and provide some information on the most common encoder outputs, including best use and basic signal/messaging information.





# Absolute vs Incremental

Absolute or incremental refers to the type of position data the rotary encoder outputs. An absolute encoder provides a unique position value for each point of rotation, which represents the 'absolute' position of the encoder.

The incremental encoder works by generating pulses an external PLC interprets as length, direction, and speed. The pulses generated by the encoder must be tracked by an external PLC.

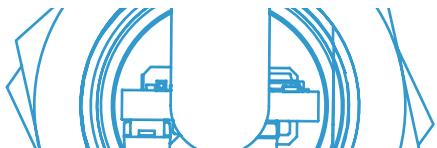
Selecting an absolute or incremental sensor will influence the quality of output data and the equipment required to interface with the rotary encoder.

## Incremental

- Cost effective/less complex than absolute
- Good for simple pulse counting and frequency monitoring

## Absolute

- Can recall position after power down
- Multiple output interfaces: Analog, CAN, Ethernet, SSI
- Single-turn and Multi-turn options



# Single-turn vs Multi-turn

Absolute encoders relate their exact position across one full rotation and are capable of measuring multiple application turns. Single-turn and Multi-turn refer to the absolute encoder's capacity to measure and record turn information.

Single-turn encoders output a signal for each position across the sensor's rotation and are suited for short rotation applications. Multi-turn encoders operate the same as as single-turn, but also report multiple application turns.

Absolute multi-turn encoders are better for safety or longer positioning applications. Joral manufactures a zero-power multi-turn absolute encoder that will record its position and turns in the event of power loss.

Determining turn requirements requires knowing application and design goals. Single-turn, multi-turn, and zero power provide increasing levels of data which helps ensure safety, performance, and reliability.



# Analog

Joral analog position sensors are available with custom angles and voltage ranges. Compared to the traditional potentiometer, Joral analog position sensors do not contain any contacting parts, and do not wear out like a potentiometer's wiper blade. The fully customizable voltage or current output is available in both clockwise or counter-clockwise outputs.

## Advantages

- Absolute single-turn output
- Voltage or current signal options
- Fully customizable angle range, output range, and signal direction
- Simple three wire setup: V+, GND, and Signal
- Easy system troubleshooting permits technicians to measure sensor output on signal line
- Interfaces with PLC analog input for easy system design

# Output Breakdown

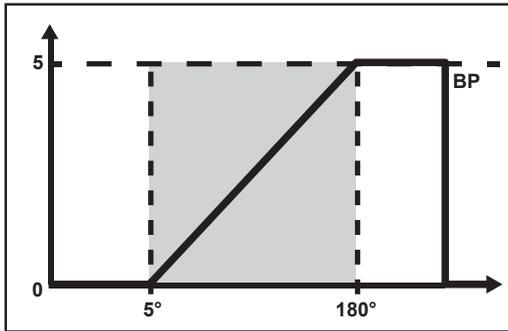
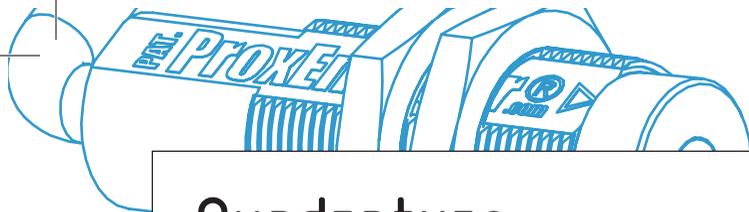


Figure left shows an example analog output with angle range from 0-180° and a voltage range from 0-5v. As the sensor spans the range of 180° the output voltage will indicate the angle of the sensor shaft.

After the sensor spans 0-180° the output will remain steady until it hits the breakpoint (BP). The breakpoint (BP) is a customizable feature of the Joral analog, and is used to reset the output to allow measurement of the next rotation.



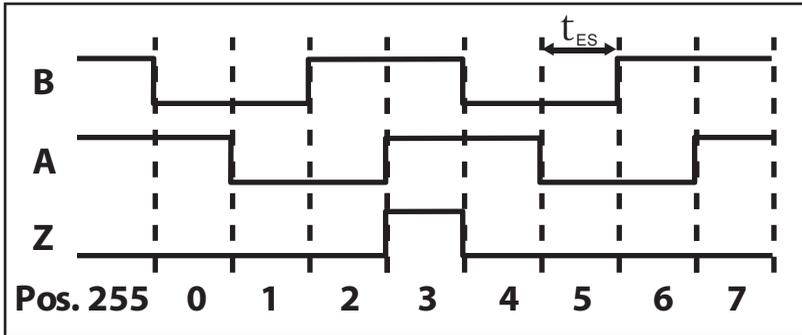
# Quadrature

Joral quadrature encoders are designed with the operator in mind. LED lights sync to the sensor output to provide immediate feedback that shows the operation. Electronic spike protection reduces harm to the sensor caused by voltage spikes that may destroy sensitive components.

## Advantages

- Incremental output
- Signal provides directional information
- Available with prime output to prevent channel interference
- Marker pulse for turn counting

# Output Breakdown



Channel B leads A when the magnet rotation is CW.

The counting direction can be changed by swapping the A and B channels.

Joral quadrature encoders contain three signals for incremental output: Channel A, B and Z. The first two channels are quadrature shifted by  $90^\circ$  and the Z channel is a reference. With a 64 PPR, the number of counts per revolution post quadrature evaluation is 256 ( $64 \times 4 = 256$ ).

The Z channel signal is once per revolution. The width of the Z pulse is  $1/4$  of the quadrature signal period. Above is the timing structure of all three channels with CW rotation. Channel B leads A when the magnet rotation is CW.



# J1939

The Joral J1939 encoder is available in both absolute single turn or multi-turn. The J1939 encoder only requires two signal lines to communicate and is able to save position on stop, recall position on power up, save turns, and more.

## Advantages

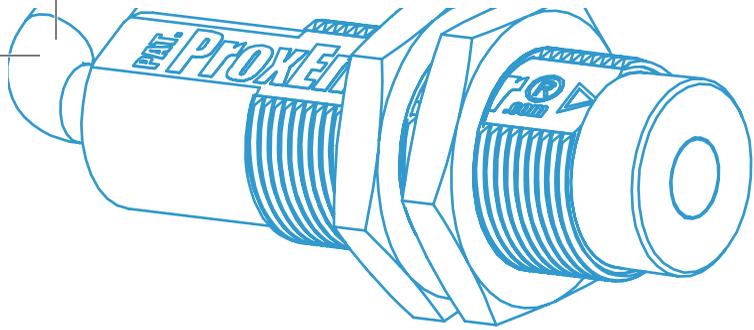
- Absolute single-turn or multi-turn output
- Two wire communication for daisy chain control systems
- Address tags allow multiple sensors on one network
- Capable of commands on power up and motion stop

# Messaging Structure

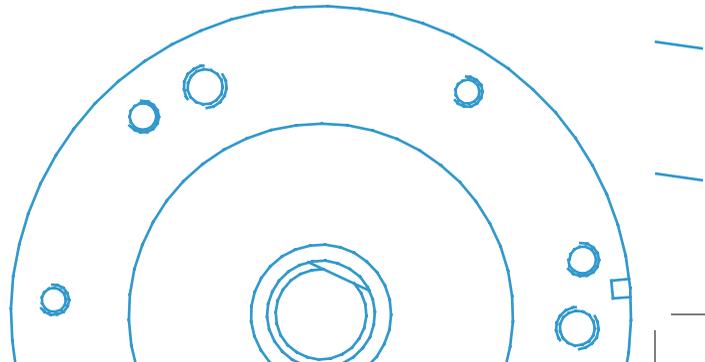
Below is an example of the ProxEncoder® non-contact rotary encoder J1939 message structure. For detailed program instructions, data sheets, and message structures consult Joral.

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Data Field	CW/CCW		RPM		Home		Reset	
	1	1	On RPM		Clear POS		Save POS	
	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1

	bit7	bit6	bit5	bit4	bit3		bit2	bit1	bit0	
Data Field	Position									
	CW		CCW							LSB
	RPM									LSB
	NEG		POS		x			x	MSB	
	Count									LSB
	MSB									



# form factor & order guide



# The PE Form Factor

The ProxEncoder® non-contact rotary encoder is available in two 'proximity sensor' style housings with a threaded barrel. All housings are available with multiple connector options and stainless steel options for 100% environmental protection.

To assist with product application dimensioned drawings and 3D design files are available upon request.

From left to right, the PE30, the PE18, and the PEBX non-contact rotary encoders



# The HP Form Factor

The HP non-contact rotary encoder is available in two puck style housings. A more versatile offering the HP housings are available in 58mm or 38mm diameters.

Available in aluminum, stainless steel, or medical grade delrin the housings offer alternate mounting and a shorter option than the barrel threaded PE style housings.



## no fear of the fishes

The Joral HP and PE ProxEncoder® non-contact rotary encoders carry an IP69k protection class and function fully submerged.

Rated for 600 PSI Joral's non-contact encoders have been utilized from deep sea salt-water submersibles to corrosive wash down conveyors.





# Order Guide

Below is an order guide for the PE and HP 10 bit non-contact rotary encoder. 13 bit resolution, housing options, and greater output offerings are available. The listed selection is trimmed to assist assembling basic part numbers for sample selection.

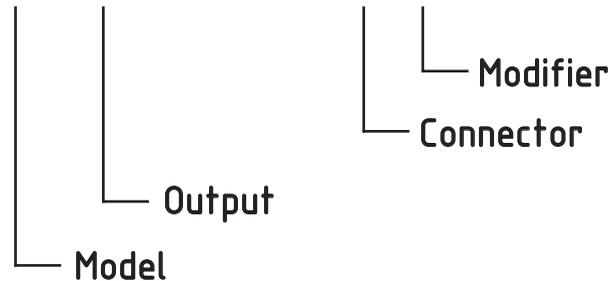
HOUSING		OUTPUT (10 bit)		CONNECTION	
PE18	18mm Cylinder Housing	B-0064-SEPP	64 pulse single ended quadrature output	M8	6 pin M8 male
PEBX	2" x 1" x 1" box Square Mount Housing	V1	0-5VDC across 0-360 absolute position analog output	M12	5 pin M12 male
PE30	30mm Cylinder Housing	I1	4-20mA across 0-360 absolute position analog output	DE6	6 pin male Deutsch
HP38	38mm Puck Style Housing	B-1939	256 count absolute single-turn J1939 output	C72	72" flying lead cable
HP58	58mm Puck Style Housing				

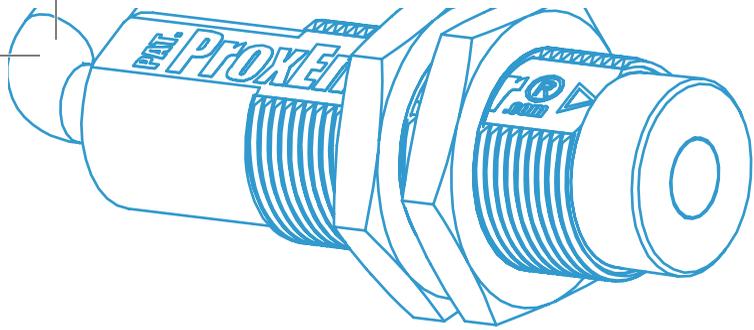
# Sample Part Numbers & Modifiers

Joral part numbers are assembled all with the same logic, first the sensor's housing code followed by the desired output code and connection code. Modifiers, or custom options are added to the end of the part number, and do not need to be added in any order.

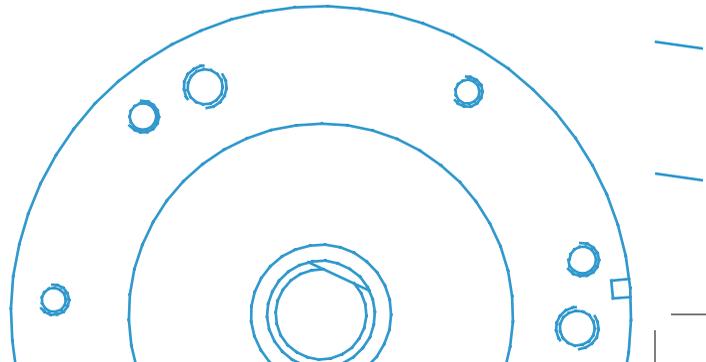
MODIFIERS	
51	Housing material Red aluminum
53	Housing material Black aluminum
54	Housing material Stainless Steel
101	Sense element orientation Side sense orientation

PE18-B-0064-SEPP-M8-53





# additional offerings



# J1 Shafted Encoders

Joral J1 series shafted magnetic encoders are a solid-state alternative to optical encoders. The fully encapsulated electronics defend the sensor from moisture, ensuring a base protection rating of IP67.

The family of encoders now feature the JZ series absolute multi-turn variant that detects motion during power down. The zero power technology enables users to capture machine motion even during application power interruption.

Available in standard and custom form factors, Joral shafted encoders are fully adaptable to application demands.



# Linear Position Sensors

The Joral LP and LZ non-contact linear position sensors are designed to detect linear motion up to 1/4" increments. Made to replace the typical wire-reel found on booms and outriggers, the CAN J1939 linear sensors are IP69k and perform in the harshest environments.

The LP30 is the compact incremental solution, while the LZBM and LZXS provide an absolute J1939 solution. The absolute LZ sensors are able to detect motion while powered down and upon restart reports absolute change from defined homed position.



# Zero Power Encoders

The Joral Z series zero power position sensors have been developed in multiple form factors for absolute sensing. Available in rotary, linear and turn counter variants the Z series absolute position sensors are able to track motion while powered down.

While disconnected from machine power the Z series sensor wakes up from sleep, writes position to memory and returns to a no power state. The absolute zero power function is accomplished with an internally sealed battery that can be supplemented with an in line serviceable backup.

The internal battery used by the Z series is a 10 year extreme temperature cell that enables the sensors to detect machine motion during total power loss or drift during power down.

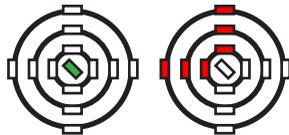


# Incline Sensors

The three axis incline sensors are available as a stand alone unit, the SINC, or two units tethered together that communicate as one, the DINC.

Solid-state accelerometer technology allows true position sensing regardless of orientation to programmed zero. J1939 standard message contains angular position for X, Y, and Z.

The Joral 3-axis inclinometer can be mounted to fit the requirements of the application, installed orientation does not influence output.



LED display for installation and at a glance level check. Red LEDs display level condition and green LED shows sensor is level.



# Temp Control Units

The Joral TCM1 temperature sensor/controller is built in a single package that threads directly into cooling systems to provide a total control solution.

The Joral temperature controllers are rated to handle up to 25 amps at 12 VDC or 12.5 amps at 24 VDC. The sensors have been engineered to regulate the electrical stresses generated from operating powerful cooling fans.

Totally sealed and rated IP69k the T series temperature control sensors utilize a magnet wand to engage a fail safe programming interface. Using the magnet wand operators are able to use a switch encapsulated in the sensor to select operating modes.



The background of the slide is a technical drawing in blue lines. It features various mechanical components: a large cylindrical part at the top left with the word 'PROXETA' on it, a circular flange with four holes on the left, and several other circular and cylindrical parts at the bottom. A large white rectangular box is centered on the page, containing the word 'notes' in a bold, black, sans-serif font.

**notes**

