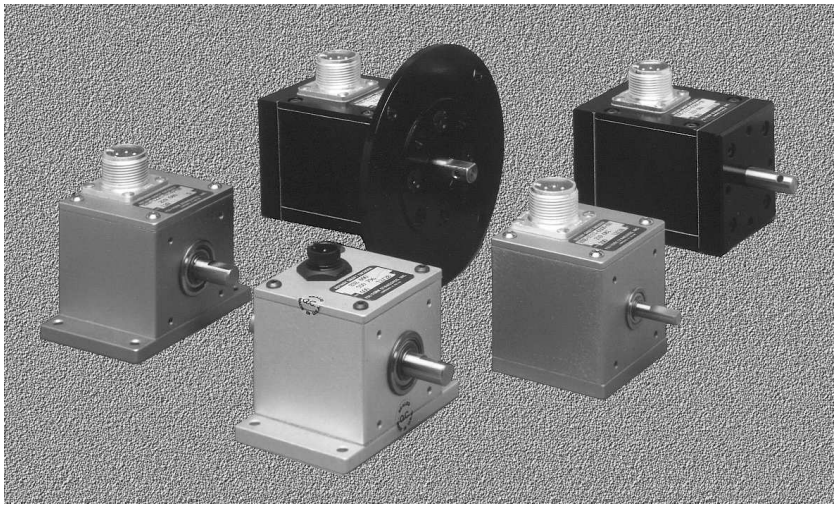
FSi™ Technologies

innovation

quality

performance



Optical Incremental Rotary Shaft Encoders

User's Manual

668 Western Ave. Lombard, IL. 60148-2097

Phone: (630) 932-9380 Fax: (630) 932-0016 or (800) 468-6009

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HISTORY

Founded in 1959, FSI Technologies Inc., formerly Fork Standards, Inc., had its beginnings in the design and manufacture of precision tuning fork time standards, primarily for use in military applications. In the mid 1960's FSI entered into the industrial market with a line of high performance logic compatible photoelectric sensors and controls for factory automation.

During the following years FSI continued development of its sensor line while branching into high speed IR sensors, optical rotary shaft encoders, capacitive sensors, fiber optics and other leading edge sensor technologies. Presently FSI manufactures state of the art sensors and electronic products for use in industrial, commercial, military, and medical applications.

IN HOUSE CAPABILITIES

- Standard sensors & encoders
- Custom sensors & encoders
- Application engineering & testing
- Electrical & Mechanical Engineering
- Prototype & production machining
- Darkroom & technical graphics
- Prototype PCB etching & fabrication
- PCB & mechanical assembly
- Machine vision engineering and manufacturing

The above capabilities and a creative, quality conscious staff make FSI the company of choice for both standard and custom products. FSI is committed to innovation, quality and customer satisfaction.

All of us at FSI and our capable network of Distributors look forward to assisting you.

Please call for the location of your nearest Distributor.

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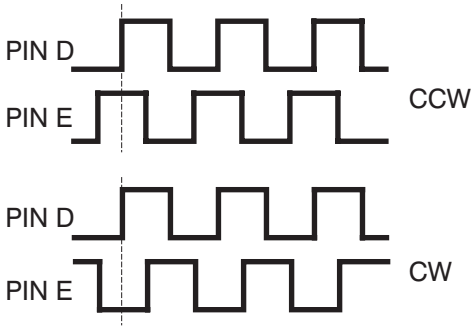
1.0 COMMON OUTPUT OPTIONS

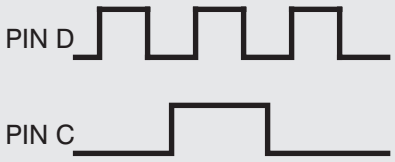
Option S Squarewave

A series of squarewaves corresponding to shaft rotation in either a clockwise (CW) or a counterclockwise (CCW) direction, will appear on Pin D.



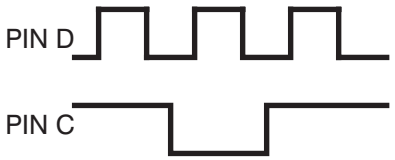
Option Q Quadrature

Quadrature Output on Pin E will lead the Pin D squarewave output for CCW shaft rotation and lag the Pin D squarewave output for CW shaft rotation.



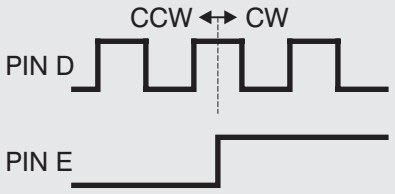
Option P Positive Index Pulse

In addition to the squarewave(s), one positive going index pulse per revolution will be on Pin C.



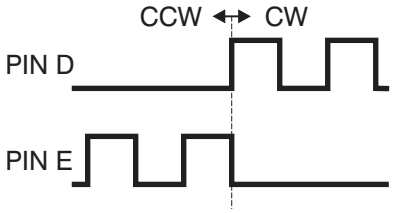
Option N Negative Index Pulse

In addition to the squarewave(s), one negative going index pulse per revolution will be on Pin C.



Option D Count / Direction

Squarewave will appear on Pin D regardless of direction of shaft rotation. Pin E will be "high" for CW (Up Count) and "low" for CCW (Down Count).



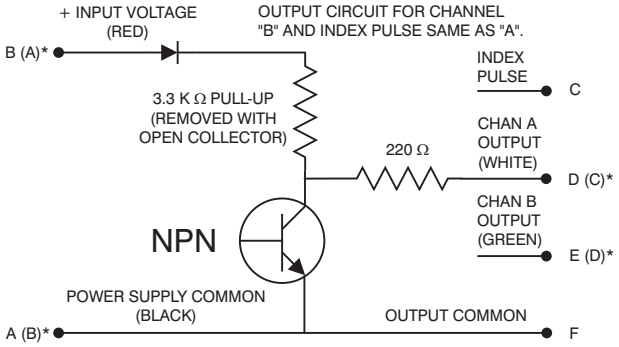
Option B Up / Down Count

A squarewave will appear on Pin D for CW shaft rotation and on Pin E for CCW shaft rotation.

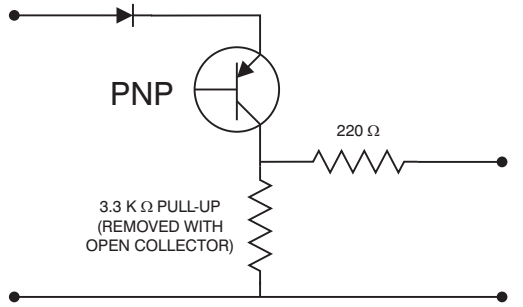
NOTE: Standard pin out shown - Additional output types are available - consult ordering guide.

2.0 WIRING INFORMATION

NOTE: Standard pin out shown - Additional output types are available.

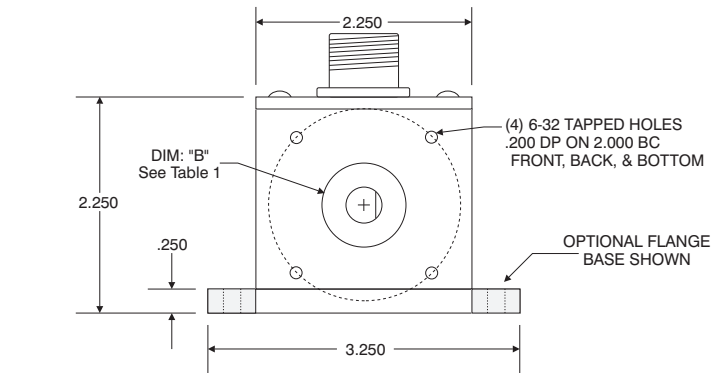


*** NOTES: (1) (X) INDICATES PIN OUT FOR OPTIONS 8 & 9.**
(2) CHANNEL "B" QUAD & INDEX PULSE ARE OPTIONS - SEE ORDERING GUIDE.



NOTE: "PNP" INPUT AND OUTPUT DESIGNATION SAME AS "NPN"

3.0 RSE SERIES MECHANICAL



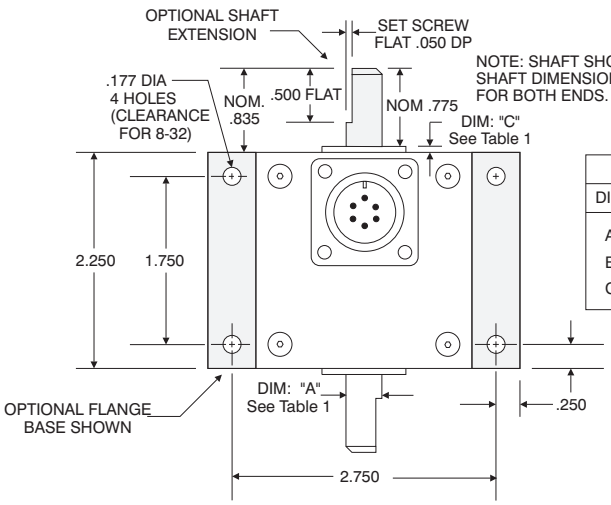
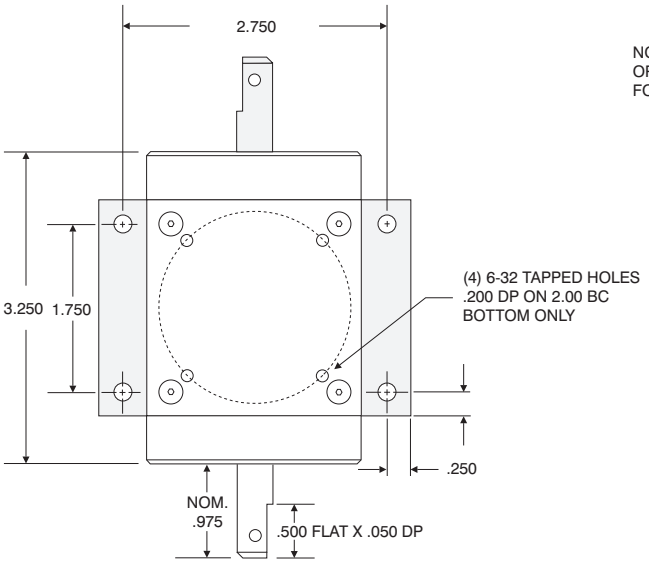


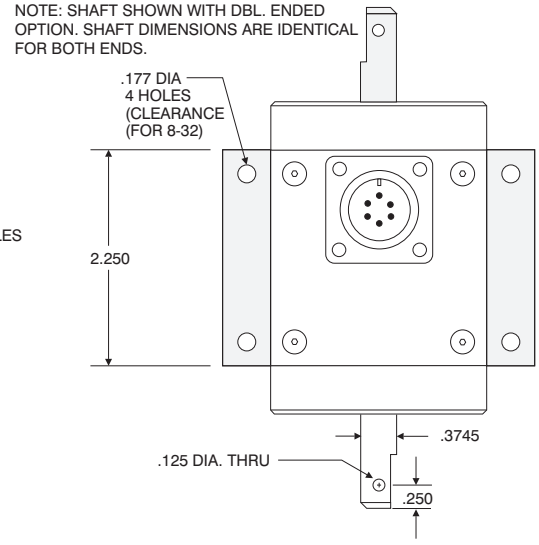
TABLE 1

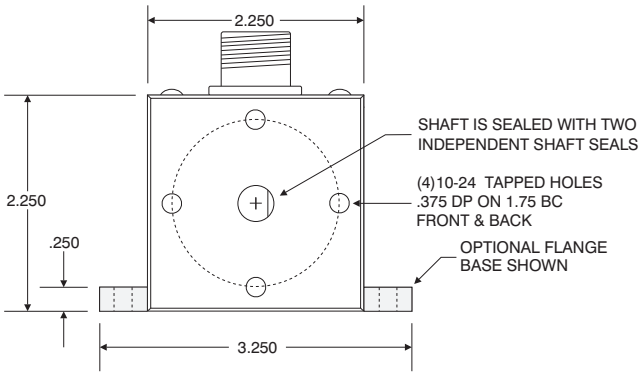
SHAFT & BEARING DIM.		
DIM.	1/4"	3/8"
A	.2495	.3745
B	0.690	0.969
C	0.042	0.062

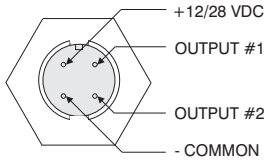
3/8" DIA. SHAFT SHOWN

4.0 HDE SERIES MECHANICAL

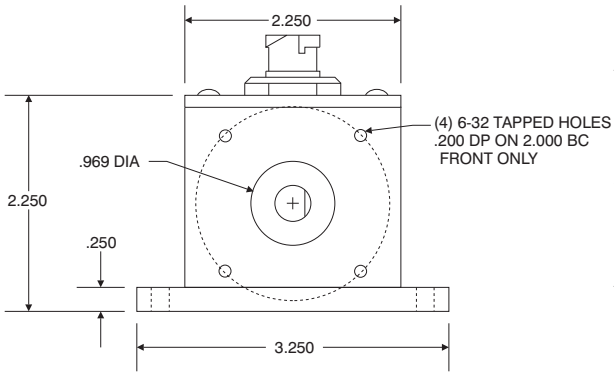


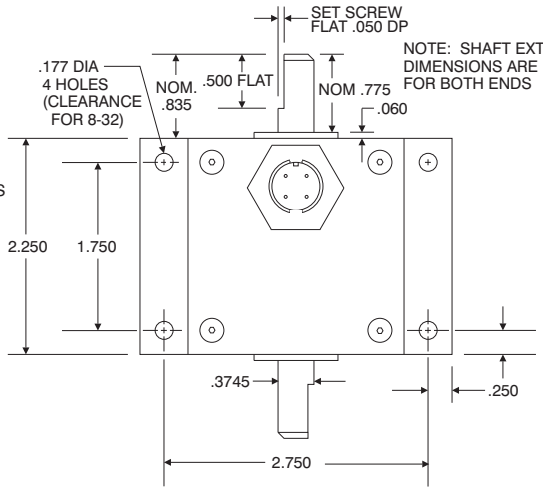




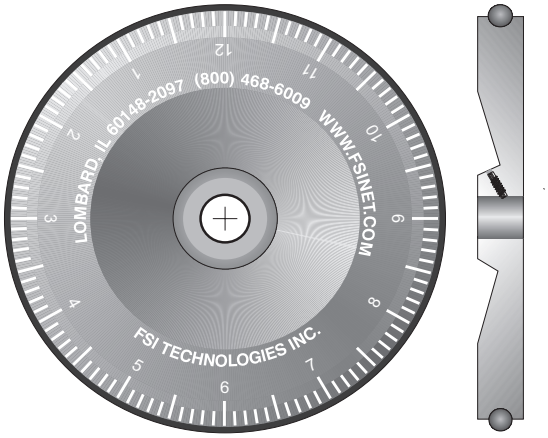


5.0 ESE SERIES MECHANICAL



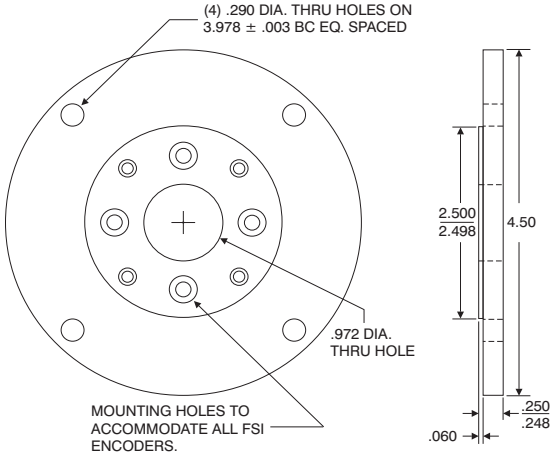


6.0 WH SERIES MEASURING WHEEL

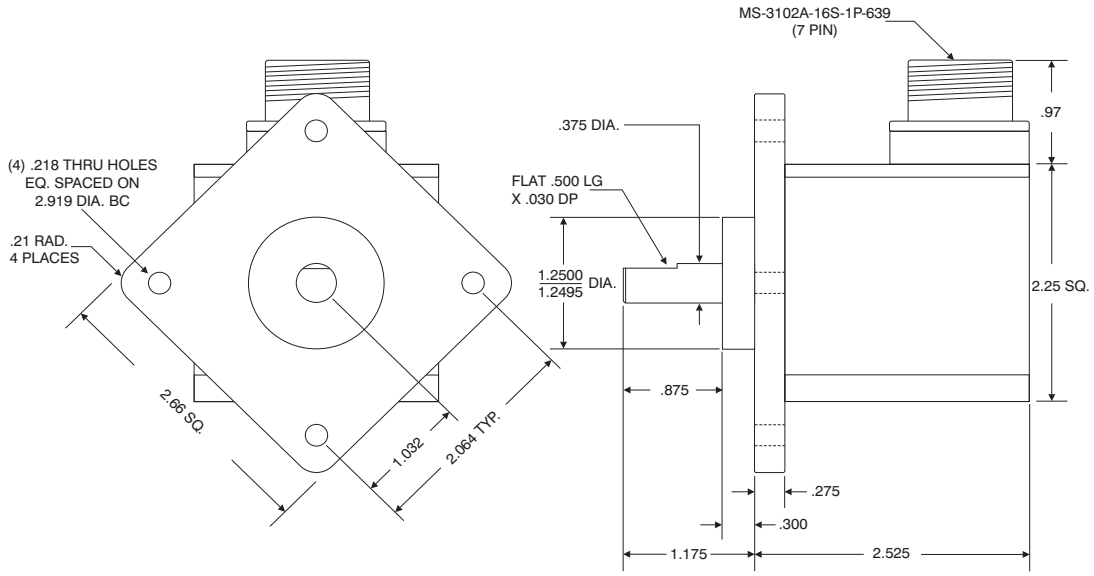


Note: See data sheet for additional information.

7.0 ADAPTER PLATE - 5PY



8.0 SERIES 25 ENCODER



9.0 COMMON ROTARY ENCODER FORMULAS

FIND LINE COUNT WHEN RESOLUTION IS KNOWN:

RES = Required resolution in degrees
PPR = Pulses per revolution or line count

PPR = 360 / RES

Example: To obtain a 5.0 degree resolution: 360 / 5 = 72 PPR

FIND MAX RPM, MAX LINE COUNT OR MAX OUTPUT FREQUENCY:

MRPM = Maximum revolutions per minute
MPPR = Maximum pulses per revolution or line count
MOF = Maximum output frequency in Hertz (Cycles per second)

MOF = (MRPM / 60) X MPPR MRPM = (MOF X 60) / MPPR MPPR = (MOF X 60) / MRPM

Example: A 600 RPM shaft with a 100 PPR disc would produce a 1000 Hz signal.
(See RPM Curves at end of section for additional information)

FIND THE LINE COUNT WHEN USED IN CONJUCTION WITH A LEAD SCREW:

First: Find the linear displacement of the screw.

(Linear displacement of one revolution) = 1 / PITCH

Second: Determine desired system resolution. (i.e. 0.0001")

Lastly: Apply formula:

PPR = (Linear Displacement) / (System Resolution)

Example: Screw pitch = 10
System resolution = 0.001"
Linear displacement = 0.1" per revolution

0.1 / 0.001 = 100 PPR

MAXIMUM OUTPUT FREQUENCY FOR FSI ENCODERS:

ESE Series = 10,000 CPS

HDE Series = 20,000 CPS

RSE Series = 20,000 CPS

10.0 ROTARY SHAFT ENCODER THEORY

10.1 OPERATION

The FSI optical rotary shaft encoder consists of a rugged extruded aluminum housing to support the precision bearings and enclose the electronics. Attached to the shaft is an optical disc with alternating clear and opaque segments photographically produced. Another photographic plate with a similar pattern called the aperture plate is placed parallel to the disc. A beam of infrared light produced by a LED is sent through both disc and plate causing the light beam to be pulsed by the rotating disc. The flashes of light correspond to the lines on the disc. This beam is received by a photo transistor receiver which compares this signal with a reference signal. This comparing of the two signals provides the encoder with its high noise immunity and wide operating temperature range. The output of the comparator is then sent to a logic board to provide many of the output options, after which the signal then goes to the output stage for interfacing to the outside world. In addition, the FSI encoder also utilizes an internal regulated power supply allowing a single model to operate on voltages ranging from 5 VDC to 28 VDC, while rejecting electrical noise that might otherwise be conducted in through the power supply. The FSI encoder also features reverse polarity protection and output short circuit protection. The output circuit is available in pulse output which contains an internal pull-up resistor or open collector output, which allows the encoder output to be interfaced with equipment of different supply voltages. Both output types are capable of driving 100 ma. loads. See output load charts for additional information.

10.2 NOISE IMMUNITY

Encoders are fast switching devices and are often interfaced with counters and programmable controllers. Due to the type of environment that encoders are often used in, noise immunity is an important consideration. They are often found on heavy machinery located in areas with high levels of electrical noise. The FSI encoder has many features allowing it to operate in such environments. First, all inputs and outputs are protected by bypass capacitors. Second, the power supply is internally regulated and the noise bypassed. Third, the pulse shaping circuits utilize a differential comparator to cancel out any remaining noise. Even with all this internal protection, it is still important that the system designer adhere to proper interfacing and wiring techniques. This usually means using shielded cable and avoiding ground loops in the system wiring. If further information is required on proper installing techniques in a high noise environment, please contact our engineering department.

10.3 OUTPUT OPTIONS

FSI rotary encoders are available with many types of outputs to simplify your external electronic requirements. In its simplest form, the encoder has one output. This output is a square wave corresponding to the speed of the shaft and the number of lines on the disc. This type of encoder is often used to determine shaft RPM or to measure length. Since it has only one output, it is not able to tell in which direction the encoder shaft is rotating. The square wave output is referred to as Option 'S' when ordering. Another very popular output option is the quadrature option. The quadrature encoder provides two outputs, one 90 degrees out of phase with the other. When the encoder shaft is rotating clockwise, output 'A' leads output 'B' by 90 degrees. When the shaft is rotating counterclockwise, output 'B' leads output 'A' by 90 degrees. The quadrature output option therefore provides direction information as well as speed and position data. With the proper controller or counter it is possible to detect speed, direction, and relative position of the encoder shaft. The quadrature option is referred to an option 'Q' when ordering. If the device the encoder is interfacing with does not have the ability to interface with quadrature signals, the Option 'D' or 'B' can be specified. Both of these options specify encoders that have additional electronics to process the direction information. The 'D' Option provides one output that has a series of pulses corresponding to the speed of the shaft and the number of lines on the disc. The second output is either logic level high or low depending on the direction of rotation of the encoder shaft, i.e. Logic level high for CW and logic level low for CCW rotation. The 'B' Option is a variation on the 'D' Option and it also has two outputs. Output 'A' will have a pulse on it corresponding to the speed of the shaft and the number of lines on the disc, when the encoder shaft is rotated in a clockwise direction.

Conversely, output 'B' will have a signal on it, when the shaft is rotated in a counter- clockwise direction. One other option that is available with all the above options is the index pulse or 'P' Option. The index pulse option provides one additional output that has a signal or pulse on it every time the encoder shaft makes one complete revolution. This pulse is used as an index point or marking the zero point on the encoder shaft. Other types of outputs to increase the encoders resolution are available upon special request. These options include pulse doubling and pulse quadrupling. Please call FSI's engineering department if you have special requirements.

10.4 CONSTRUCTION

The FSI encoder is housed in an extruded, anodized aluminum package. The housing has aluminum top and bottom plates that are gasketted to keep out contamination. Shafts are stainless steel and available in 1/4", 3/8", 5/16" or special diameters. Chrome steel bearings, special seals and a choice of lubricants are available, often at no additional charge. Electrical connections are made by way of a MS series connector located on the housing cover plate. Mounting of the encoder is accomplished by using four of the twelve mounting holes located on either the front face, back face, or bottom plate. An optional flange mounting plate is available at no additional cost to allow for mounting with through holes on the flange plate. Internally, the FSI encoder consists of a disc held in place by hubs cemented to both sides. The hubs are held in place by set screws which are also cemented in place after adjustment. The encoder may have one or more printed circuit boards, depending on the options specified. These printed circuit boards utilize state of the art surface mount IC's and are assembled to give a high degree of reliability.

10.5 INTERFACING

The output circuits of FSI encoders are designed to simplify interfacing in the widest number of applications. The standard output consists of a NPN type transistor with a 3.3K pull-up resistor from the collector to the positive supply. In addition, there is a 220 ohm resistor in series with the output to provide output short circuit protection. A 470 pf capacitor is also tied across the output to reduce the possibility of noise entering through the output. This capacitor rounds off the output wave form slightly but in most cases this is not significant. The NPN output transistor is able to sink 100 ma. (See Output load curves). FSI encoders are also available with an optional open-collector output. In this output circuit the 3.3k resistor is eliminated so the output can be interfaced to a circuit operating on a voltage different than the encoder. Open-collector outputs must have an external pull-up resistor either at the encoder or in the device it is connected to. PNP, high voltage differential line driver and custom output options are also available.

10.6 POWER REQUIREMENTS

The supply voltage or voltage range is specified on the nameplate of the encoder. Most selections operate over a range of supply voltages such as 5-28 VDC. Because the encoder contains an internal voltage regulator, external regulation is not required in most cases. Ripple should be kept to less than 10% of supply voltage. FSI encoder current consumption varies based on the type of options selected and line count. Typical current for a lower resolution quadrature encoder is 45 ma. @ 15 VDC; single channel units draw less. FSI also manufactures encoders that operate on sp3ecial voltages. If you have specific supply requirements contact FSI's engineering department.

10.7 MECHANICAL LIMITS

Mechanical limits of the encoder are determined by the bearings (See Bearing load charts). Shaft RPM and loading directly affect the mechanical life of the bearings. *Typically, 6000 RPM and maximum loads of 15 lbs. radial and 7 lbs. axial for 1/4" bearings and 30 lbs. radial and 10 lbs. axial for 3/8" bearings should not be exceeded.* Often times unnecessary loads are placed on the encoder shaft by poor mounting technique. *Whenever possible use flexible shaft couplings, or properly adjusted timing belts when driving an encoder shaft.* This reduces the bearing load and increases encoder life substantially. The encoder housing must be securely mounted to eliminate vibration.

Under no circumstances should the encoder housing be machined, opened, or modified in any way. The encoder is a precision mechanical and opto-electronic device and may be damaged or its life reduced by improper mounting technique. FSI is able to modify or provide special mounting configurations. Please consult factory with your requirements.

10.8 ELECTRICAL SPEED LIMITS

The FSI Model "RSE" and "HDE" encoders are capable of output frequencies (speed) of up to 20,000 pulses per second. Though this is a very fast response rate, it can be reached at fairly low RPM with a high resolution disc. Model "ESE" has a maximum frequency (speed) of 10,000 pulses per second. Consult the Max. Speed vs. Line Count Chart to help determine the limits.

10.9 ENVIRONMENTAL LIMITS

The FSI encoder is designed to operate over a temperature range of 0 to 65 degrees centigrade with humidity ranging up to 90% non-condensing. Wider temperature ranges are available, please consult factory.

10.10 MAXIMUM LINE RESOLUTION

Standard line counts are available up to 2500 lines per revolution, but in some cases pulse doubling and quadrupling can be specified to provide outputs up to 10,000 lines. Discuss special requirements with FSI engineering.

CONSULT THE FSI ENCODERS, CONTROLS & SENSORS ORDERING GUIDE FOR THE LATEST INFORMATION.

11.0 GLOSSARY OF TERMS

ACCURACY: Independent of resolution - the precision of a device.

BI-DIRECTIONAL: See Quadrature.

CMOS: Complimentary Metal Oxide Semiconductor. An Integrated circuit (IC) that has low power drain, high speed operation, and high noise immunity.

CHIP: The semiconductor die inside an I.C.. Also slang for an I.C.

CURRENT: The rate of electron flow in amperes. One amp flows through a one ohm resistor when one volt is applied.

CURRENT SINK OUTPUT: An NPN output that provides a current path to ground when it is on. Current flow is from the load to the encoder, hence a current "sink".

CURRENT SOURCE OUTPUT: A PNP output that provides a current path from +Vcc when it is on. Current flow is from the encoder to the load, hence a current "source."

DIODE: A semiconductor device that only allows current to flow in one direction. An electronic check valve.

DIRECT CURRENT: (DC) A current or voltage that does not alternate.

GROUND: An electrical common point. A return path for signals.

HERTZ: (HZ) A unit of frequency. Also cycles per second (CPS)

INDEX PULSE: An encoder output that gives one pulse per revolution. The pulse width is the width of one main channel pulse. Index pulses are often used for homing or zeroing a positioning system. Index pulses are sometimes called a "marker pulse" or "zero channel".

INFRARED: (IR) A wave length of light below that of visible light. An IRED emits infrared light.

INTEGRATED CIRCUIT: (IC) A semiconductor device containing many circuits.

KILO: (K) 1000 i.e.. 1 Khz=1000 Hz.

LIGHT EMITTING DIODE: (LED) A semiconductor diode that emits light. May be infrared, green, yellow, red, blue, or orange.

MILLISECOND: (ms) .001 second. (one thousandth of a second).

NOISE, ELECTRICAL: Unwanted electrical signals produced by equipment, may cause erratic operation of electronic devices.

NOISE IMMUNITY: The ability to reject electrical noise.

OHM: Ω The unit of electrical resistance.

OPEN COLLECTOR: A type of encoder output used with some equipment. Allows the output to switch at a different supply voltage than the encoder uses.

11.0 GLOSSARY OF TERMS (CONTINUED)

PULSE: An abrupt change in voltage.

QUADRATURE: An encoder output of 2 channels, one of which is 90° out of phase with the other. The phase relationship changes depending on direction of rotation. This allows a counter, controller or other device with suitable inputs to sense direction of rotation.

RATE: Anything per unit of time. Ex RPM, inches/sec., etc.

RESISTANCE: The opposition which a device or material offers to the flow of current. Measured in ohms.

RESISTOR: A discrete device made to offer a specific unit of resistance.

RESOLUTION: The number of segments in one revolution of an encoder. A 360 pulse encoder has a resolution of 1 degree.

SCHMITT TRIGGER: Converts a slow rising or falling signal into a sharp squarewave.

SEMICONDUCTOR: A class of elements that various solid state devices are made of, hence the name semiconductor devices.

TACHOMETER: A single channel output encoder. Also called an Incremental Encoder. Cannot be used to sense direction.

TRANSDUCER: A device that converts from one type of energy to another. An encoder converts from a rotary motion to an electrical signal, with the frequency proportional to the speed of rotation.

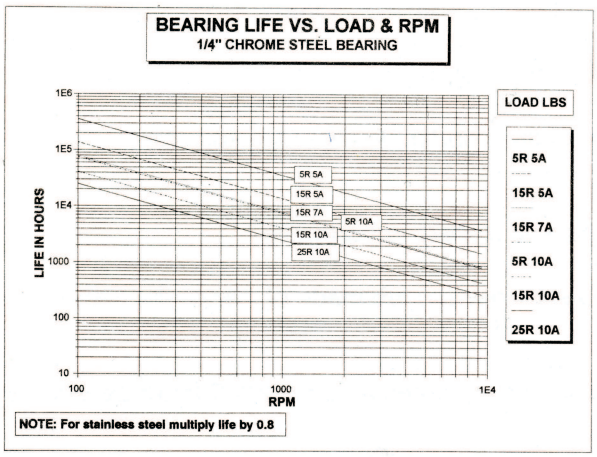
VOLT: (V) A unit of electrical potential.

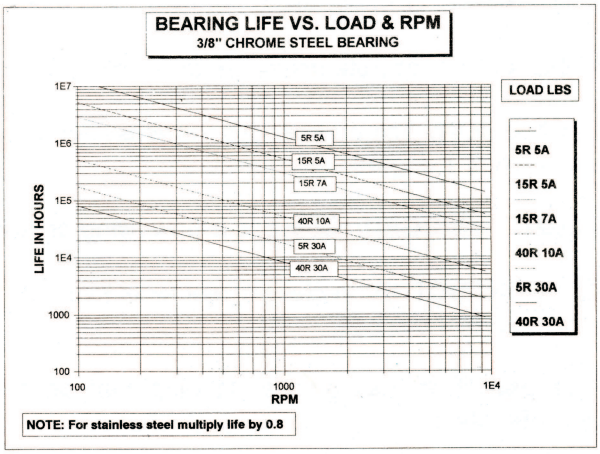
VOLTAGE: The difference of potential between two conductors measured in volts.

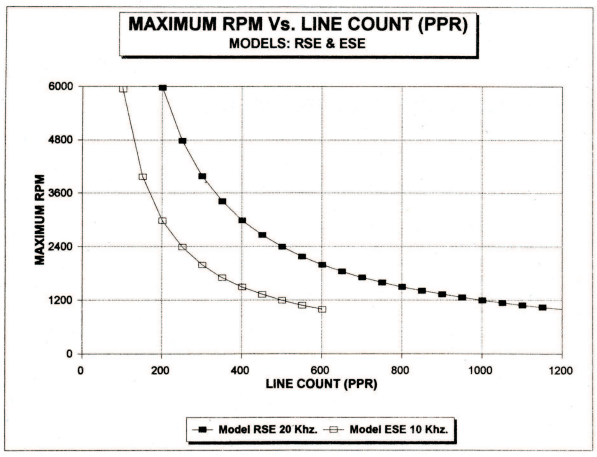
VOLTAGE TRANSIENT: A short duration voltage spike that is caused by equipment (motors starting, etc.) or natural causes (lighting). A form of electrical noise.

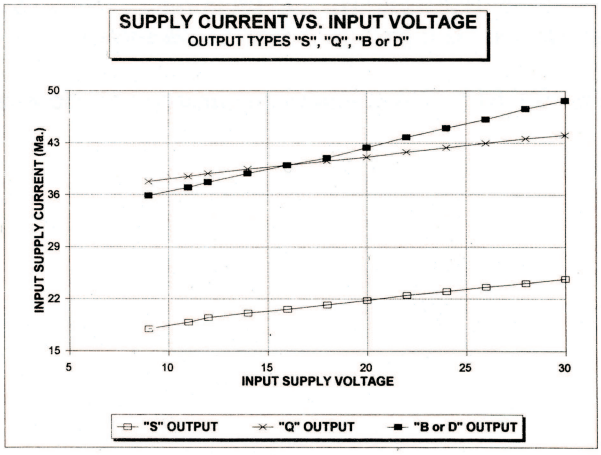
WAVEFORM: The shape of an electromagnetic wave. Our encoders output square waves.

12.0 LIFE & OUTPUT CURVES









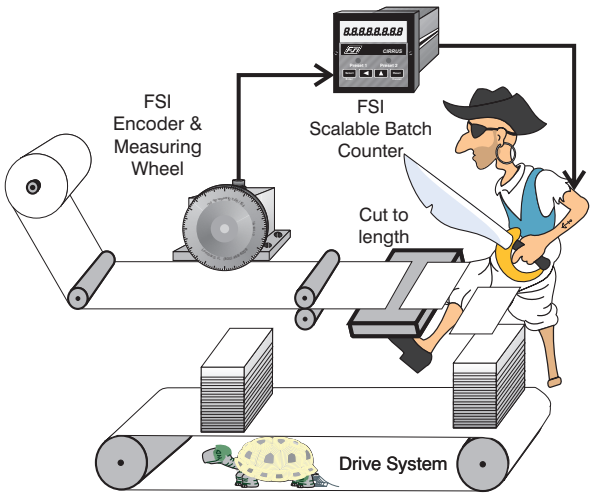
13.0 TYPICAL APPLICATIONS FOR ROTARY SHAFT ENCODERS

CNC Equipment
Metal Working Machines
Stamping Machines
Automatic Back Gauges
Cold Saws
Medical Equipment
Packaging Equipment
Bag Making and Filling
Tray Forming
Printing Presses - Web & Offset
Ink Jet Printing
Robotics
Motor Drives
Rotary Index Tables
Spray Nozzle Positioning
Blister Packing
Mixing Systems
Conveyor Systems
Transfer Systems
Feedback for Speed Control
Cranes
Instrumentation
Injection Molding
Pick and Place Systems
Semiconductor Fabrication
Automated Storage Systems
Weighing Systems
Bulk Processing Industries
Paper Manufacturing
X-Y Tables

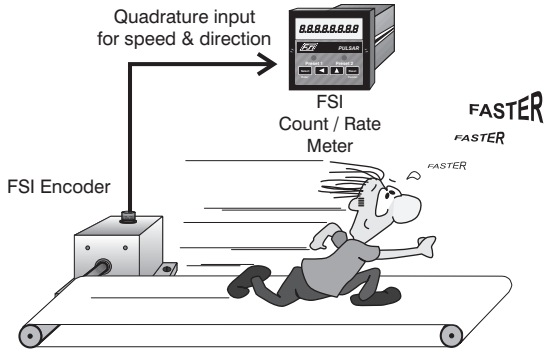
Punch Presses
Bending Machines
Coil Feeders
Assembly Machines
Valve Controls
Wood Working Machines
Bottling Machines
Canning Machines
Paper Converting
Label Equipment
Book and Magazine Publishing
Indexers
Elevators
Automatic Cutting
Wire and Rope Manufacturing
Coating Machines
Laminators
Screw Jacks
Material Handling
Telescopes
Rate Metering
Steel Rolling Mills
Plastics Extrusion
Aluminum Extrusion
Automobile Plants
Antennas
Cut to Length Systems
Copy Machines
Automated Welding
Textile Mills

14.0 TYPICAL APPLICATIONS

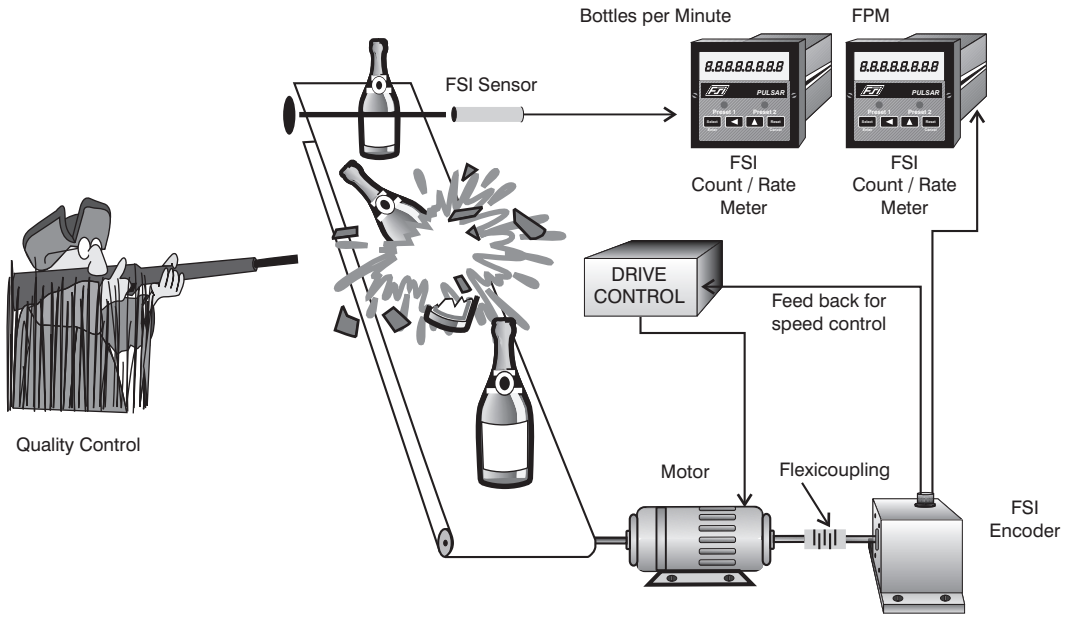
Automatic sheet cutter



Speed Alarm or Over - Under Rate Detection



Packaging / Bottling



15.0 A WORD ABOUT SAFETY

Most of FSI's products are designed for general and not for specific applications. Because of this, we usually are not aware of how they eventually will be used. However, they are frequently employed in controlling automatic machinery or processes.

Although FSI makes products of high reliability, every product, given enough time, can be expected to fail. Statistically, devices can fail after a short period of time or a long period of time or anything in between. In essentially all cases, failure means (1) failure to provide a logic signal or power to an electrical load when it should or (2) the providing of such a signal or power when it should be absent. Less often, failure means failure to meet some other specification. But, in all cases, it means to do something unwanted or unexpected.

Since the failure of automatic machinery or processes can create hazardous conditions for personnel or property, whatever the definition of failure might be, it is necessary to consider the consequences of failure and design the application in which the FSI product is used so that failure will not create a hazard to personnel or property. The design must insure that any failure will result in a fail-safe condition and there will be no danger to personnel and/or property involved in the use of the product. *FSI products are not intended for use as final safety devices.*

Designs incorporating controls of any kind should be carefully considered to provide for their eventual failure.

IMPORTANT NOTICE

The use of this product is beyond the control of the manufacturer, no guarantee or warranty, expressed or implied, is made as to such effects incidental to such use, handling or possession or the results to be obtained, whether in accordance with the directions of the claimed so to be. The manufacturer expressly disclaims responsibility therefore. Furthermore, nothing contained herein shall be construed as a recommendation to use any product in conflict with existing laws and/or patents covering any material or use. Stenographic and clerical errors are subject to correction.

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All of us at FSI wish to thank you for considering FSI as your source for encoders, sensors and controls.

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