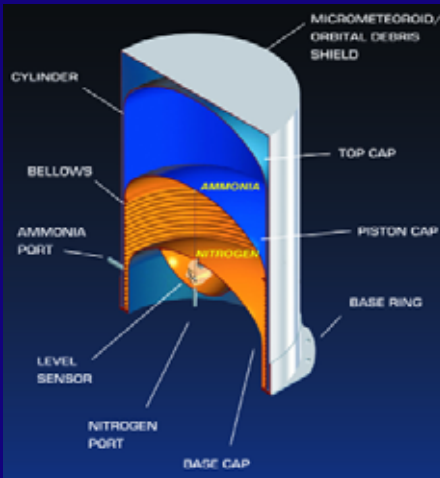


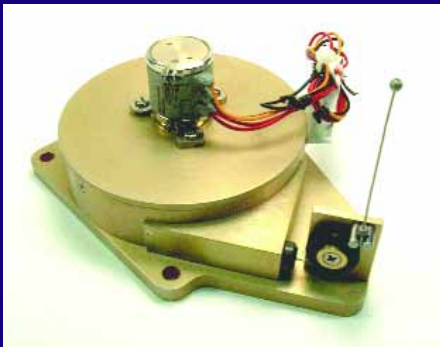
Rugged, Miniature Position Transducers Solution Guide



Environmental Controls



Inspection Systems



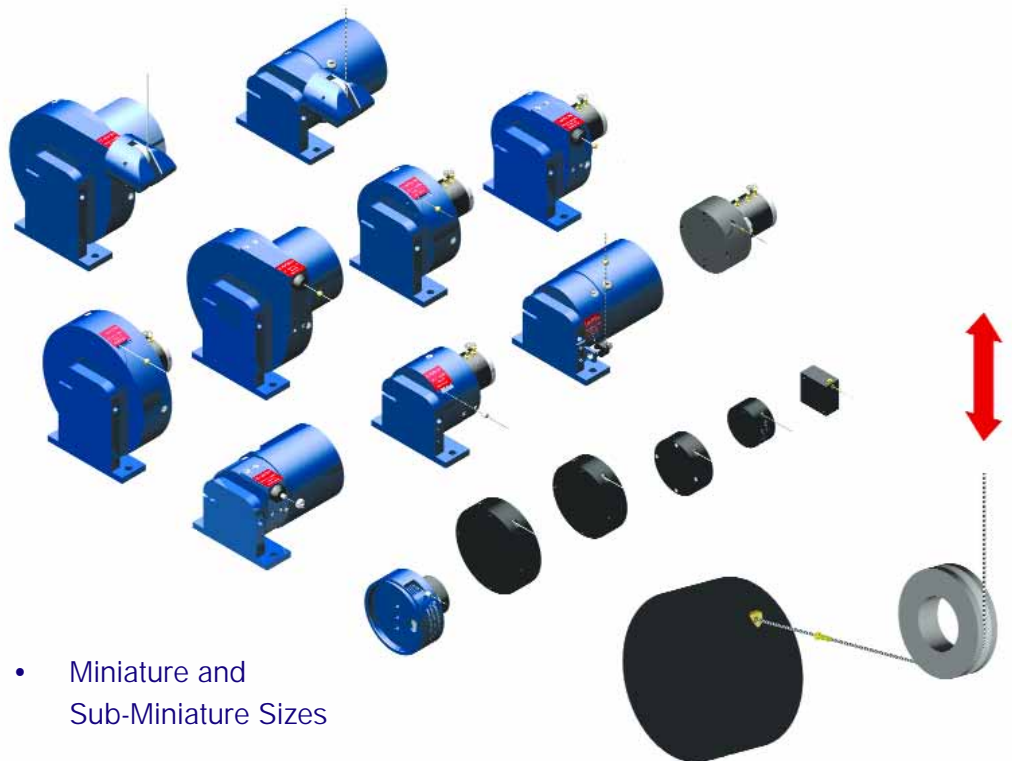
Quantity/Level Sensing



Vehicle and Crash Test



Flight Data Recorder



- Miniature and Sub-Miniature Sizes
- Off-the-Shelf and Custom Designs
- Operating Temperatures from -65° to $+125^{\circ}$ C
- Environmentally Tested to DO-160D, ED-14D, and MIL-STD-810E
- For Linear, Angular, Rotary, 2D, and 3D Motion
- Analog or Digital Electrical Outputs
- Qualified for Commercial/Military Aircraft and Manned Space Vehicle Use
- Vehicle, Aerospace, Industrial Control, OEM, Medical, and Test & Measurement Applications

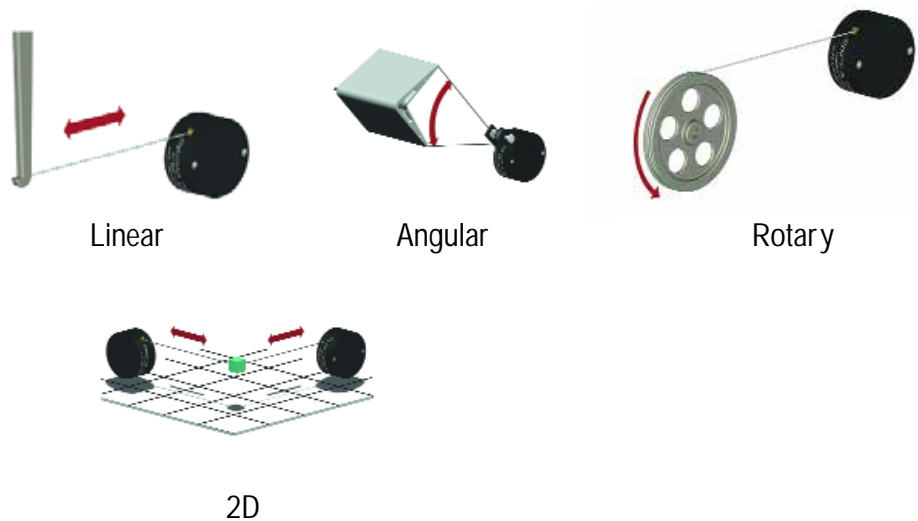
"The Flexible Alternative to LVDTs and Linear Potentiometers"

Unparalleled Flexibility

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These all-environment miniature displacement transducers are also referred to as draw wire transducers, string pots, string encoders, cable extension transducers, and yo yo pots. Firstmark Controls position transducers are noted for their small size, rugged performance, accuracy, flexible mounting, and easy installation. Their inherent high-strength flexible cable allows linear, angular, rotary, two-dimensional, and three-dimensional motion to be monitored.

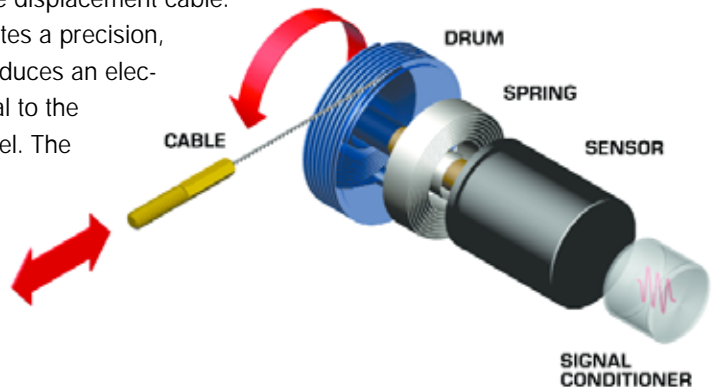


Technology Overview

How Position Transducers Work

Position transducers convert mechanical motion into an electrical signal that may be metered, recorded, or transmitted. Firstmark Controls position transducers consist of a stainless steel displacement cable wound on a threaded drum that is directly coupled to a precision, long-life sensor. Operationally, the position transducer is mounted in a fixed position and the extension cable is attached to a moving object. The axes of movement for the extension cable and moving object are aligned with each other. As movement occurs, the displacement cable extracts and retracts. An internal, engineered spring maintains tension on the displacement cable.

The threaded drum rotates a precision, long-life sensor that produces an electrical output proportional to the displacement cable travel. The output is measured to reflect the position, direction, or rate of motion of the moving object.



How They Are Used

Position transducers are used in a broad range of position, displacement, and velocity measurement applications to:

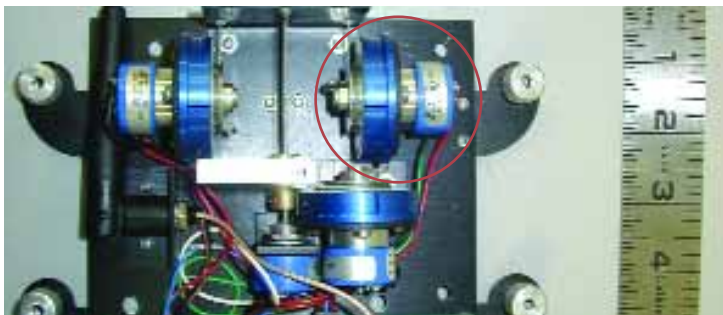
- ensure distance traveled
- continually sense location or relative position
- indicate levels
- act as limit sensors
- control actuators through position sensing
- act as a signal generator for recording position versus time, cycle rate, and magnitude of random cycle events
- monitor relative motion
- indicate events



Train Suspension Monitoring



Vehicle Side Impact Testing



Medical Diagnostic Equipment

Typical Applications

Auto/Truck/Bus/ Off-Highway

Suspension
Vehicle Dynamics
Powertrain
NV&H
Ride and Handling
Driver Behavior
Safety Systems
Crash Testing
Motorsports
Driver Controls
Durability
Passenger Comfort
Linkages
Braking Systems

Aircraft

Control Systems
Flight Dynamics
Linkages
Engine
Landing Gear
Braking Systems
Flight Data Recorder
Flight Simulators

Aerospace

Launch Systems
Solar Panel Deployment
Environmental Controls
Docking and Capture
Bellows Level

Experiments

Actuator Position
Rail
Suspension
Material Handling
Vehicle Stability
Earthquake Monitoring

Nautical/Offshore

Controls
Actuators
Engines

Industrial Machinery

Material Handling
Robotics
Packaging
Assembly Equipment
Control Systems











Biomechanics

Man-Machine Interface
Entry and Egress
Prosthetics
Orthotics
Ergonomics

Entertainment and Sports

Bicycles/Motorcycles
Amusement Park Rides
Animation
Sports Equipment
Firearms
Simulators
Virtual Reality
Stage Positioning

Product Matrix

Relative Size	Series	Data Sheet	Electrical Output (In (mm))	Maximum Measurement Range (inches (mm))	Nominal Mass (oz (g))	Outline Dimensions (inches(mm))	Best Operating Temperature Range (°F (°C))	Best Frequency Response (g's)	Best Water/Dust Protection
	150	www.firstmarkcontrols.com/s021f.htm	analog (voltage divider)	1.5 (38.1)	0.5 (15)	0.75 x 0.75 x 0.38 (19 x 19 x 10)	-85 to +257 (-65 to +125)	49	NEMA 3S / IP54
	170 173 174 175 176	www.firstmarkcontrols.com/s021g.htm www.firstmarkcontrols.com/s021g1.htm	analog (voltage divider)	6.5 (165)	1 (28) (Series 170)	.96 dia. x 0.45 (24 dia. x 11) (Series 170)	-85 to +257 (-65 to +125)	6 to 40	NEMA 3S / IP54
	160 161 162	www.firstmarkcontrols.com/s021h.htm	analog (voltage divider)	42.5 (1080)	4 (113) (Series 160)	1.8 x 2.2 x 2.5 (46 x 56 x 64) (Series 160)	-67 to +257 (-55 to +125)	less than 50	NEMA 4X / IP66
	D60 D61 D62	www.firstmarkcontrols.com/s021i.htm	digital (quadrature)	43.13 (1095)	6 (170) (Series D60)	1.8 x 2.2 x 2.5 (46 x 56 x 64) (Series D60)	-4 to +212 (-20 to +100)	less than 50	NEMA 4X / IP66
	6	www.firstmarkcontrols.com/s021k.htm	voltage divider, bridge, voltage conditioner, 4-20mA, velocity, or digital (quadrature)	85.0 (2159)	6 (170) (Series 60)	1.8 x 2.2 x 3.7 (46 x 56 x 94) (Series 60)	-40 to +185 (-40 to +80)	less than 50	NEMA 4X / IP66
	161H 162H	www.firstmarkcontrols.com/s021j.htm	analog (voltage divider)	42.5 (1080)	7 (198) (Series 161H)	2.4 x 3.0 x 2.87 (62 x 76 x 73) (Series 161H)	-67 to +257 (-55 to +125)	greater than 50	NEMA 4X / IP66
	180-0803	www.firstmarkcontrols.com/s021l.htm	analog (voltage divider)	10.0 (254)	2 (57)	1.5 dia. x 1.7 (38 x 43)	-67 to +257 (-55 to +125)	9	NEMA 3S / IP54
	8	www.firstmarkcontrols.com/s021t.htm	voltage divider, bridge, voltage conditioner, 4-20mA, velocity, or digital (quadrature)	2000.0 (50800)	64 (1814)	9.0 x 9.0 x 5.0 (229 x 229 x 127)	-40 to +185 (-40 to +85)	10	NEMA 4 / IP65
	L	www.firstmarkcontrols.com/s021o.htm	analog (voltage divider) or digital (quadrature)	21.25 (540)	3 (85)	1.7 dia. x 1.87 (43 dia. x 47)	-40 to +185 (-40 to +85)	20	NEMA 12 / IP53 (NEMA 4 / IP66 optional)
	M	www.firstmarkcontrols.com/s021u.htm	voltage divider, voltage conditioner, 4-20mA, velocity, or digital (quadrature)	85.0 (2159)	6 (170)	3.91 dia. x 1.78 (99.3 dia. x 45.2)	-4 to +185 (-20 to +85)	10	NEMA 12 / IP53 (NEMA 4 / IP66 optional)

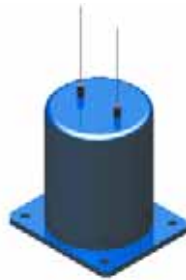
All specifications are subject to change without prior notice.

Key Innovations

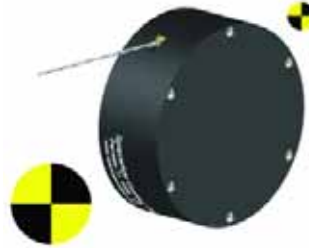
Firstmark Controls has pioneered a broad range of techniques and designs to improve displacement sensing ease of use, accuracy, and miniaturization. A few of these innovations are shown below.



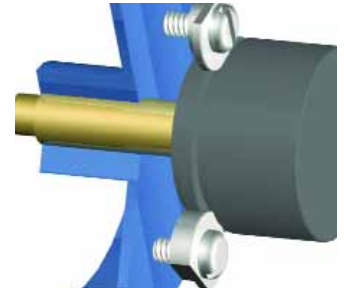
Patented (1974) universal mounting base provides 2-axis rotational capability in a compact form factor.



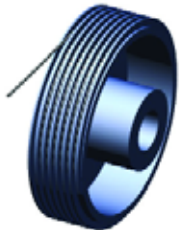
Compact, proven, dual-redundant designs provide high-reliability in cylinders and accumulators. Applications include space vehicles, aircraft, and environmental control systems.



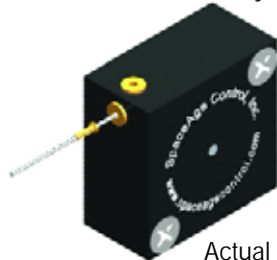
High cable-tension, ultra-low-inertia Model 174-0321T position transducer has the highest frequency response for all sub-miniature position transducers.



Direct Connect™ sensor-to-drum technology eliminates the use of backlash-causing torsion springs, clutches, gears, and other devices.



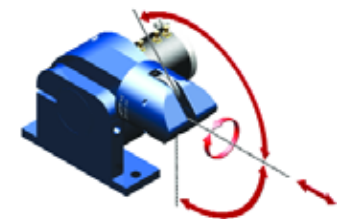
AccuTrak™ threaded drums are offered only by Firstmark Controls and enhance repeatability performance by not allowing cable overlap nor cable spread.



Ultra-small designs fit where other technologies are too large. Series 150 products are the world's smallest.

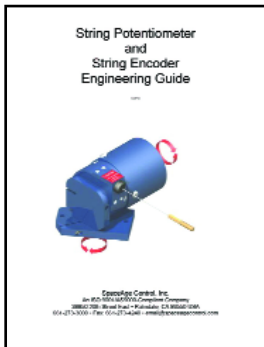


Coming soon: the Series 8 long-range position transducer offers an environmentally-protected displacement cable exit, enhanced repeatability, and increased lifecycle capability.



Patented RoundAbout™ cable guide allows cable extraction direction to change "on the fly" without re-orienting the position transducer.

String Potentiometer and String Encoder Engineering Guide



Would you like to receive a 12-page, full-color copy of the "String Potentiometer and String Encoder Engineering Guide"?

If so, complete a web form at www.firstmarkcontrols.com/req054b.htm and you will be qualified for a FREE downloadable (electronic) copy. This publication will get you up and running on cable-actuated displacement-sensing technology, uses, designs, benefits, and limitations.

More Information

For complete information including data sheets, fully-dimensioned installation drawings, and CAD solid models, visit www.firstmarkcontrols.com/ptmain.htm. Or, contact us by phone (919-956-4203), fax (919-682-3786), or e-mail (info@firstmarkcontrols.com).

Additional Resources

For more information on displacement measurement and sensors, review these publications:

<u>Publication</u>	<u>http://www.firstmarkcontrols.com/</u>
• Selecting Position Transducers	selpt.htm
• Sensor Total Cost of Ownership	s054a.htm
• Application Note for Aircraft/Aerospace	s004a.pdf
• Application Note for Ground Vehicles/Transportation	s005a.pdf
• Application Note for Industrial Control/OEM Uses	s054f.htm
• Thermal Effect Calculator	calctemp.htm
• Catenary Curve (Cable Sag) Calculator	calccabl.htm
• Sinusoidal Motion Calculator	calcsinm.htm
• Linearity Calculator	calclin.htm
• Cable Stretch Calculator	calcstre.htm
• Cost of Ownership Calculator	calctco.htm
• Zero-Span Calculator	calczs.htm
• Voltage Divider and Power Calculator	calcvd.htm
• Installation Guide	s023a.pdf
• Position Measurement & Control Newsletter	reqsub.htm
• Evaluation Position Transducer Request Form	requevalpt.htm

Company Background

Leading The Way In Position Measurement

Firstmark Controls was founded and launched with the acquisition of SpaceAge Control's position transducer product line. Today Firstmark Controls' continues a proud tradition in the development and production of innovative, small-size position transducers.

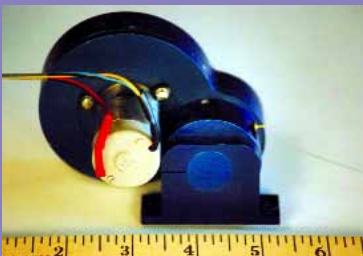
Since the 1970's virtually all U.S., Canadian, and European aerospace companies use our position transducers in their research, development, and test activities. Often these products are designed and manufactured to custom specifications. In the late 1980's an auto racing team began using our position transducers to monitor throttle movement and suspension travel. This use

resulted in the adoption of the products in a broad range of vehicle test and measurement projects including anthropomorphic dummy instrumentation, impact testing, and control verification.

Firstmark Controls' products benefit customers in over 20 industries and in over 40 countries, including the largest auto manufacturing companies and the largest aerospace companies. Our products are used on diverse applications such as off-road heavy equipment, manned space vehicles, and Formula 1/Indy/NASCAR race cars. Environmentally tested to commercial aircraft and military standards, Firstmark Controls' position transducers are the products of choice for demanding measurement applications.



Early position transducer use: YF-12 aircraft dynamic testing in 1970.



Initial designs set the standard for small size, ruggedness, and accuracy.

Displacement Sensors for a Demanding World

Represented by:



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