

Torque Sensors

Torque sensors manufactured by PCB® fall into two categories of measurement: reaction torque and rotational torque. Both styles utilize strain gages, which are configured into a Wheatstone bridge circuit, as their primary sensing element. Accuracies are typically within 0.1% and optional speed sensors permit additional measurement of rotational speed (RPM) and horsepower calculations.

Reaction torque sensors are rigid structures with no moving parts and are typically mounted in a fixed position. Their output signal varies proportionally to an applied torsional force. Applications for reaction torque sensors include torsional testing machines, brake testing, bearing friction studies, dynamometer testing, and viscosity and lubrication studies.

Rotary torque sensors employ a freely rotating shaft within a fixed housing. When installed, the rotating shaft becomes a coupling between a driving mechanism and an absorber or load. As the shaft is torsionally stressed, a proportional change in the output signal is observed. Changes in rotational speed and load affect the torque that is measured. Applications for rotary torque sensors include electric motor testing, automotive engine testing, dynamometer testing, drive train measurements, and gearbox testing.

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Reaction Torque Sensors

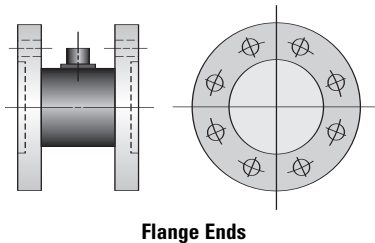
Reaction torque sensors are suitable for a wide array of torque measurement applications. They are typically used in torsional test machines, motor dynamometers, or in any application where rotation is limited to 360° or less. Due to the fact that these sensors do not utilize bearings, slip-rings, or other rotating elements, their installation and use can be very cost effective.

The rigid sensor mechanically resists rotation and will experience a torsional stress in response to an applied torsional force. This stress causes a proportional resistance change to occur in the strain gages, resulting in a voltage shift in the sensor's output signal. You might consider a reaction torque sensor to be similar to a pickle jar with a tight lid. As you try to twist the lid of the jar, the reaction torque experienced by the jar increases until the lid becomes loosened.

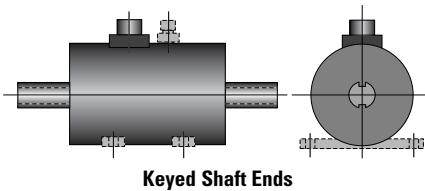
Reaction torque sensors are particularly useful in applications where the introduction of inertia due to a rotating mass between the driver motor and driven load is undesirable.

An example of this can be found in small motor testing, where introduction of a rotating mass between the motor and load device will result in an error during acceleration. For these applications, the reaction torque sensor can be used between the driver motor, or driven load, and ground. An added benefit is that such an installation is not limited in RPM by the torque sensor.

Shown below are some of the standard reaction torque sensor configurations offered by the PCB®. Capacities range from 5 to 500k in-lb (0.56 to 56.5k N-m).

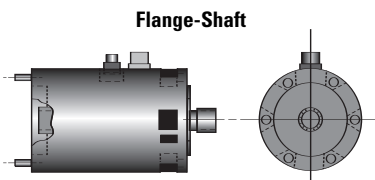


Flange Ends



Keyed Shaft Ends

AND



Flange-Shaft

Rotating Shaft Torque Sensors

Rotating shaft torque sensors are designed to mount in-line between a driving source, and an absorber, or load. They are used in engine dynamometers, electric motor testing, hydraulic pump testing, fan testing, and a multitude of other applications.

PCB® offers a choice of rotary transformer torque sensors. For most applications, a rotary transformer-type sensor will be recommended. The rotary transformer is a non-contacting type of sensor, providing very low maintenance, quiet operation (with an excellent signal-to-noise ratio), higher speed ratings, and better accuracy. This type of sensor should be used with an AC carrier excitation source, ideally operating at 3.28 k Hz.

The torque sensor's shaft is coupled between the rotating driving mechanism under test and a load. A variety of mounting styles are offered including keyed shaft, and flange-shaft. As the driving mechanism (such as an electric motor or automotive engine) turns the shaft, a torsional stress occurs, which causes a proportional resistance change in the strain gages, resulting in a voltage shift in the sensor's output signal. As the speed and the load on the rotating coupling changes, so too will the torque.

Rotary transformer torque sensors offer high accuracies and RPM ratings. They are designed with an advanced trans-former, shaft and housing to provide enhanced durability in rugged industrial applications.

Rotating shaft torque sensors are available in a wide range of configurations, with capacities from 50 in-oz to 100k in-lb (0.35 to 11.3k N-m).

TORKDISC®

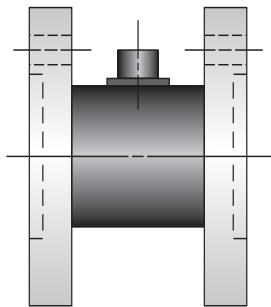
The TORKDISC® is a short-coupled, torsionally stiff structure that is ideal for a wide range of applications requiring high-accuracy, in-line rotary torque measurements. The sensor consists of a spring element which is torsionally loaded as torque is applied between an inner and outer mounting surface. Male and female pilots are provided to ensure good concentricity as the TORKDISC® is bolted into a driveline. Torque is transmitted by friction created between the mounting surfaces of the TORKDISC® and customer-provided mounting fixtures. Sixteen-bit digital telemetry signal transmission provides noise-free operation. The TORKDISC® is available in a wide range of capacities from 1k to 225k in-lb (113 to 25.4k N-m).



Typical measurement system for Series 2300 and 2500 reaction torque sensor

All PCB® reaction torque sensors utilize strain gages that are configured in a Wheatstone bridge as their primary sensing element. The resistance value of the strain gages changes when torsional load is applied to the sensing structure and consequently, any voltage through the bridge circuit will be varied. The Wheatstone bridge requires a regulated DC voltage excitation that is commonly provided by a strain gage signal conditioner. The resultant output signal from the torque sensor is typically expressed in units of millivolt per volt of excitation. This millivolt signal then varies proportionately to the applied torque. The strain gage signal conditioner provides zero and span adjustments to scale its 0 to 5 VDC analog output to be proportional to any desired input range. Additional features of the signal conditioner may include a digital display and alarm set point limits.

Reaction torque sensors are provided with an electrical connector, and cable assemblies are necessary to interface this connection to the strain gage signal conditioner. Two types of cable are commonly available, and their use is dependent upon signal transmission distance. Cable assemblies may be selected with a terminating connector, which makes it easier to connect to a PCB® strain gage signal conditioner, or with a pigtail termination that allows connection to screw terminal connections on other styles of strain gage signal conditioners.



Series 2300



Reaction Torque Sensor Cables
(see section 5)



Models 8159, 8160A, 8161A, and 8162
Reaction Torque Sensor Signal Conditioners
(see section 5)

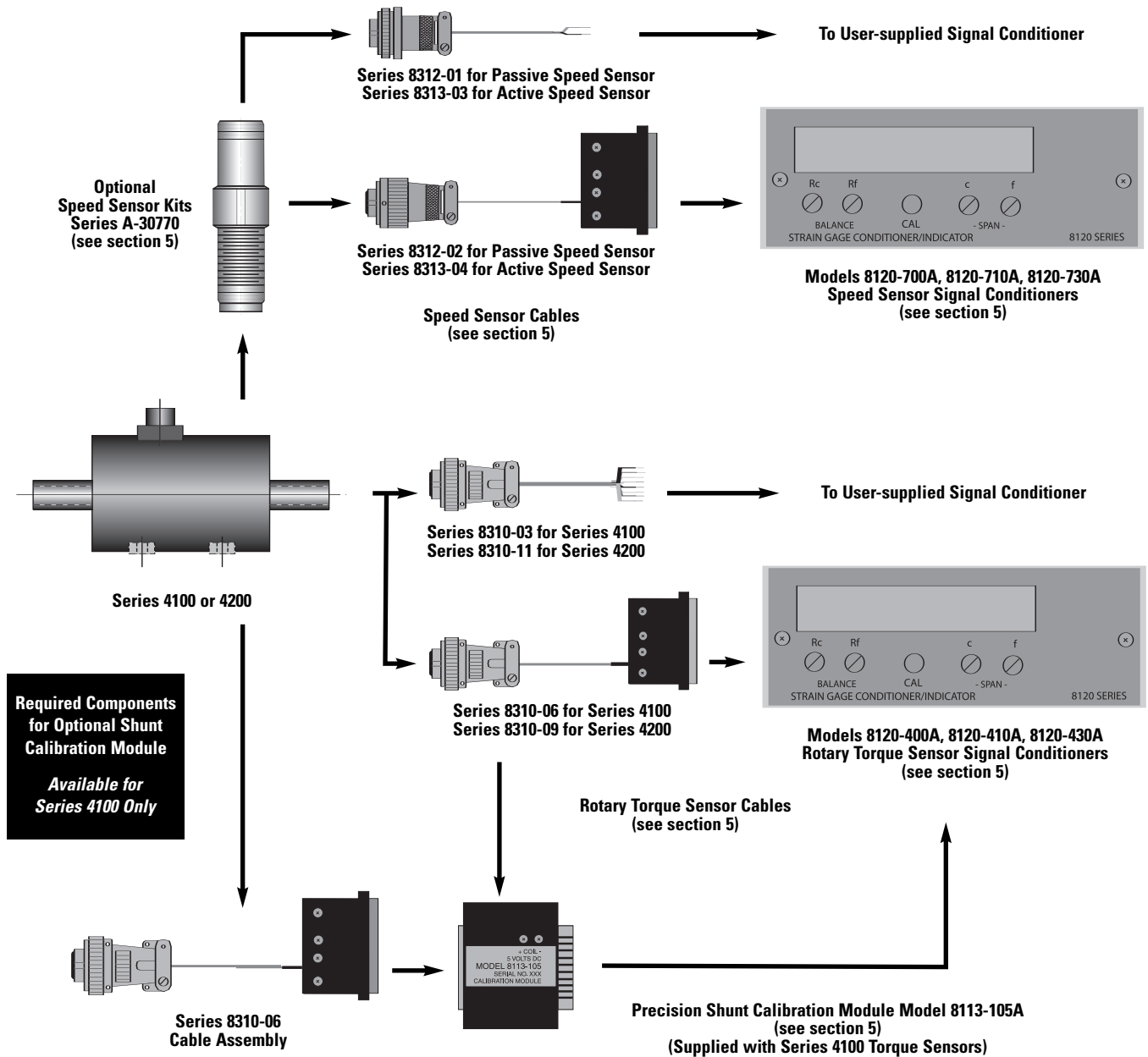
Typical measurement system for Series 4100 and 4200 rotary torque sensor

Rotary torque sensors utilize strain gages that are configured in a Wheatstone bridge as their primary sensing element. The resistance value of the strain gages changes when torsional load is applied to the sensing structure and consequently, any voltage through the bridge circuit will be varied. The Wheatstone bridge requires a regulated AC voltage excitation that is commonly provided by a strain gage signal conditioner. The resultant output signal from the torque sensor is typically expressed in units of millivolt per volt of excitation. This millivolt signal then varies proportionately to the applied torque. The strain gage signal conditioner provides zero and span adjustments to scale its 0 to 5 VDC analog output to be proportional to any desired input range. Additional features of the signal conditioner may include a digital display and alarm set point limits.

Most rotary torque sensors can accommodate an optional speed sensor to facilitate monitoring of the revolutions-per-minute of the system or for horsepower calculations. Speed sensors are Hall Effect devices whose output varies as a gear tooth passes its sensitive face. A typical speed gear within a rotary torque sensor will possess 60 teeth in order to provide 60 pulses per revolution of output from the speed sensor. Speed sensors require a DC excitation voltage that is commonly provided by a Hall Effect sensor signal conditioner.

Rotary torque sensors are provided with an electrical connector, and cable assemblies are necessary to interface this connection to the strain gage signal conditioner. Optional speed sensors incorporate their own electrical connector and will require a separate cable assembly and signal conditioner. Cable assemblies may be selected with a terminating connector, which makes it easier to connect to PCB®'s strain gage and Hall Effect signal conditioners, or with a pigtail termination that allows connection to screw terminal connections on other styles of strain gage and Hall Effect signal conditioners.

Required Components for Optional Speed Sensors



Torque Sensor Selection Guide

Typical Torque Applications

- Viscosity and Lubrication Studies
- Dynamometer
- Torsion Testing
- Brake Testing
- Bearing Friction
- Stepping Switch Torque
- Fractional HP Motor Testing
- Pump Testing
- Transmission Testing
- Efficiency Testing
- Electric Motor Testing
- Gear Box Efficiency Testing
- Fuel Pump Testing
- Hydraulic Pump
- Blower Testing
- Chassis Dynamometer
- Differential Testing
- Cantilevered Aerospace Hydraulic Pumps
- Cantilevered Aerospace Hydraulic Motors
- Drive Shaft Torque Measurement
- Torque Wrench Calibration
- Pulley Torque Testing
- Automotive Belt Testing
- Machine Feedback Testing
- Drive Shaft Torque
- Windmill Testing
- Assembly Production Machine Testing
- Torsion Bar Testing
- Reaction Torque

Reaction Torque

	Small Capacity Flange Mount			Flange Mount				
Size (dia x length) - in	2 x 2.25	3.5 x 2.75	2 x 3	4 x 3	5 x 3.5	8 x 7.38	9.75 x 8.5	14 x 10.5
Size (dia x length) - cm	5.08 x 5.72	8.89 x 6.99	5.08 x 7.62	10.16 x 7.62	12.7 x 8.89	20.32 x 18.75	24.77 x 21.59	35.56 x 26.67
Flange Dia B.C. - in	1.69	3	1.25	3.25	4.25	6.5	8	11
Flange Dia B.C. - cm	4.29	7.62	3.18	8.26	10.8	16.51	20.32	27.94
Connector	6-pin PT	6-pin PT	6-pin PT	6-pin PT	6-pin PT	6-pin PT	6-pin PT	6-pin PT
Page	2.12	2.12	2.12	2.10	2.10	2.10	2.10	2.10
Capacity	Model Number							
5 in-lb (0.56 N-m)	2308-01A*	2309-01A*						
10 in-lb (1.1 N-m)	2308-02A*	2309-02A*						
20 in-lb (2.3 N-m)	2308-03A*	2309-03A*						
50 in-lb (5.6 N-m)			2508-01A					
100 in-lb (11 N-m)			2508-02A					
200 in-lb (23 N-m)			2508-03A					
500 in-lb (55 N-m)			2508-04A					
1000 in-lb (115 N-m)			2508-05A					
2000 in-lb (225 N-m)				2301-01A				
5000 in-lb (565 N-m)				2301-02A				
10k in-lb (1130 N-m)					2302-01A			
20k in-lb (2250 N-m)					2302-02A			
50k in-lb (5650 N-m)						2303-01A		
100k in-lb (11.3k N-m)						2303-02A	2304-01A	
200k in-lb (22.6k N-m)							2304-02A	
300k in-lb (33.9k N-m)								2305-01A
500k in-lb (56.5k N-m)								2305-02A

* Aluminum load cells (low weight).
All other models are steel.

TORKDISC®				
Flange Mount				
Rotor Size (dia x thk) - in	7.00 x 1.10	8.49 x 1.10	9.49 x 1.64	17.98 x 2.09
Rotor Size (dia x thk) - cm	17.78 x 2.79	21.59 x 2.79	24.13 x 4.17	45.72 x 5.31
Receiver Size (l x w x h) - in	7.17 x 7.46 x 1.92	7.17 x 7.46 x 1.92	7.17 x 7.46 x 1.92	7.17 x 7.46 x 1.92
Receiver Size (l x w x h) - cm	18.21 x 18.95 x 4.88	18.21 x 18.95 x 4.88	18.21 x 18.95 x 4.88	18.21 x 18.95 x 4.88
Speed (RPM)	15k	10k	10k	4.5k
Page Number	2.22	2.22	2.22	2.22
Capacity		Model Number		
1000 in-lb (113 N-m)		5302C-03A*		
2000 in-lb (226 N-m)		5302C-01A*		
5000 in-lb (565 N-m)		5302C-02A		
6250 in-lb (706 N-m)		5302C-04A		
10k in-lb (1130 N-m)			5308C-01A	
20k in-lb (2250 N-m)			5308C-02A	
30k in-lb (3400 N-m)			5308C-03A	
50k in-lb (5650 N-m)				5309C-01A
100k in-lb (11.3k N-m)				5309C-02A
120k in-lb (13.5k N-m)				5310C-03A
180k in-lb (20.3k N-m)				5310C-01A
200k in-lb (22.5k N-m)				5310C-02A
225k in-lb (25.4k N-m)				5310C-04A

*Denotes aluminum models. All other models are steel.

Rotary Transformer											
Keyed Shaft Ends											
Size (dia x length) - in	4 x 6.5	4 x 10	4 x 10	4.8 x 12.75	5.5 x 15.75	6.5 x 19	4 x 10	4 x 10	4 x 12.75	5.5 x 15.75	6.5 x 19
Size (dia x length) - cm	10.16 x 16.51	10.16 x 25.4	10.16 x 25.4	12.19 x 32.39	13.97 x 40	16.51 x 48.26	10.16 x 25.4	10.16 x 25.4	10.16 x 32.39	13.97 x 40	16.51 x 48.26
Shaft Dia. - in	0.38	0.75	1	1.5	2.25	3	0.75	1	1.5	2.25	3
Shaft Dia. - cm	0.97	1.91	2.54	3.81	5.72	7.62	1.91	2.54	3.81	5.72	7.62
Connector	5-pin MS	5-pin MS	5-pin MS	5-pin MS	5-pin MS	5-pin MS	5-pin MS	5-pin MS	5-pin MS	5-pin MS	5-pin MS
Speed (RPM)	10k	15k	15k	12k	6700	6000	10k	10k	10k	6700	6000
Page	2.16	2.16	2.16	2.16	2.16	2.16	2.14	2.14	2.14	2.14	2.14
Capacity		Model Number									
50 in-oz (0.35 N-m)		4102-01A									
100 in-oz (0.71 N-m)		4102-02A									
200 in-oz (1.41 N-m)		4102-03A									
500 in-oz (3.53 N-m)		4102-04A									
1000 in-oz (7.06 N-m)		4102-05A									
100 in-lb (11 N-m)			4103-01A					4203-01A			
200 in-lb (23 N-m)			4103-02A					4203-02A			
500 in-lb (55 N-m)				4104-01A					4204-01A		
1000 in-lb (115 N-m)				4104-02A					4204-02A		
2000 in-lb (225 N-m)				4104-03A	4105-01A				4204-03A	4205-01A	
5000 in-lb (565 N-m)					4105-02A					4205-02A	
10k in-lb (1130 N-m)					4105-03A	4106-01A				4205-03A	4206-01A
20k in-lb (2250 N-m)						4106-02A					4206-02A
36k in-lb (4065 N-m)						4106-03A	4107-01A				4206-03A
50k in-lb (5650 N-m)							4107-02A				4207-01A
100k in-lb (11.3k N-m)							4107-03A				4207-02A
											4207-03A

* Low-noise cables are required to maintain **CE** conformance.

Rotary Transformer		
Flange Mount		
Size (dia x length) - in	6 x 9.35	6 x 9.94
Size (dia x length) - cm	15.24 x 23.75	15.24 x 25.25
Shaft Diameter - in	1.58	1.58
Shaft Diameter - mm	4	4
Number of teeth	16	24
Flange Dia B.C. - in	5	5
Flange Dia B.C. - cm	12.7	12.7
Connector	5-pin MS	5-pin MS
Speed (RPM)	15k	15k
Page	2.20	2.20
Capacity	Model Number	
50 in-lb (5.6 N-m)	4115A-01A	4115K-01A
100 in-lb (11 N-m)	4115A-02A	4115K-02A
200 in-lb (23 N-m)	4115A-03A	4115K-03A
500 in-lb (55 N-m)	4115A-04A	4115K-04A
600 in-lb (68 N-m)		4115K-05A
1000 in-lb (115 N-m)	4115A-05A	4115K-06A
1200 in-lb (135 N-m)		4115K-07A
2000 in-lb (225 N-m)		4115K-08A
2400 in-lb (270 N-m)		4115K-09A
3600 in-lb (405 N-m)		4115K-10A
5000 in-lb (565 N-m)		4115K-11A
6000 in-lb (675 N-m)		4115K-12A
10k in-lb (1130 N-m)		4115K-13A
All models are steel.		

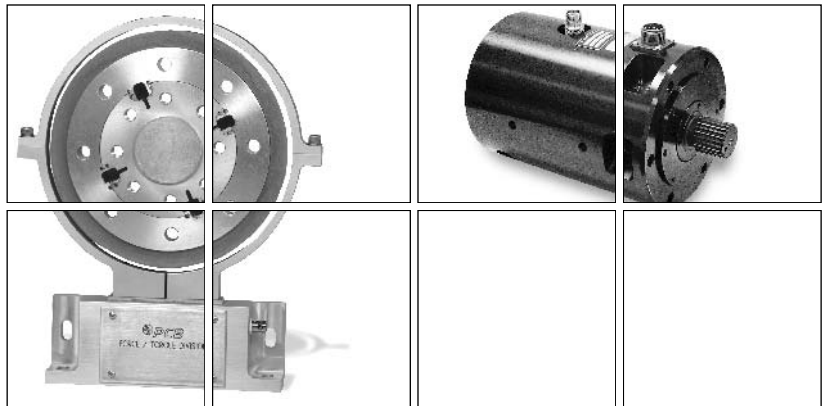
Shunt Resistor —

A fixed resistor which is placed in parallel or shunted across a strain gage bridge to provide a known test signal to permit the user with a means of easily performing an accurate system calibration of a torque sensor and signal conditioner.

Strain Gage Torque Sensors

Highlights

- Reaction torque measurements
- Low-maintenance rotary transformer type
- Noise-free digital telemetry type
- NIST traceable



Torque sensors manufactured by PCB® fall into two categories of measurement; reaction torque and rotational torque. Reaction torque sensors convert the torque applied to a fixed sensor into a useable measurement signal. Examples of reaction torque applications include automotive brake testing, dynamometer testing, and bearing friction and lubrication studies. Rotational, or rotary, torque sensors typically measure the torque generated by rotating devices such as electric motors, automotive engines, transmissions, pumps, and compressors.

Reaction torque sensors are machined from a single piece of rigid steel that is instrumented with strain gauges in a Wheatstone bridge circuit. They have no moving parts and are typically flange mounted into a fixed position.

Rotary torque sensors employ a freely rotating shaft within a fixed housing. The shaft is instrumented with strain gages in a Wheatstone bridge circuit. A non-contact rotary transformer facilitates electrical connection to the rotating strain gages. Advantages of the rotary transformer approach include less maintenance and less signal noise than older slip-ring designs.

The TORKDISC® represents a new approach to rotary torque measurements. Rather than slip-rings or rotary transformers, the TORKDISC® contains a miniature, 16-bit digital telemetry transmitter. Digitized measurement signals are picked up by a circumferential antenna and relayed to a receiver unit where they are conditioned to both a current and voltage output signal. Advantages include smaller sensor size and noise-free, digital signal transmission.

Custom torque sensors have been developed for unique or specialized applications. Please call to discuss any special needs.


Reaction Torque Sensors 2000 – 500k in-lb

Flange Mount Reaction Torque Sensors

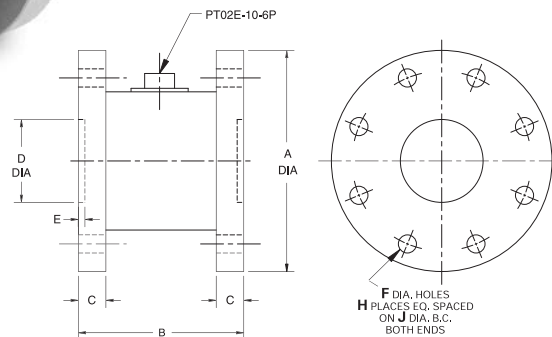
- Viscosity and Lubrication Studies
- Bearing Friction
- Braking Testing
- Torsion Testing
- Dynamometer
- Stepping Switch Torque

Series 2301, 2302, 2303, 2304, 2305 — flange mount reaction torque sensors

- Capacities from 2000 to 500k in-lb FS (225 to 56.5k N-m FS)
- 2 mV/V output sensitivity
- Flange mount both ends
- High torsional stiffness

Recommended cables and accessories  — see page 5.3 & 8.6

Select a signal conditioner from those featured beginning on page 5.2 & 8.2



Series 2301, 2302, 2303, 2304 and 2305

Dimensions — Inches (cm)

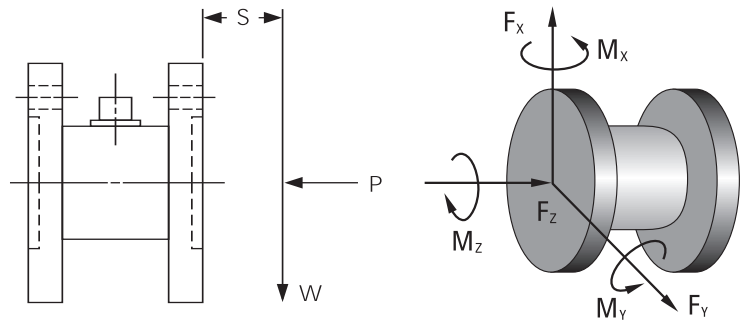
Series	A	B	C	D	E	F	H	Flange Dia. B.C.
2301-01A	4 (10.16)	3 (7.62)	0.5 (1.27)	1.5 (3.81)	0.12 (0.3)	0.33 (0.84)	8	3.25 (8.26)
2301-02A	4 (10.16)	3 (7.62)	0.5 (1.27)	1.5 (3.81)	0.12 (0.3)	0.33 (0.84)	8	3.25 (8.26)
2302-01A	5 (12.7)	3.5 (8.89)	0.75 (1.91)	2 (5.08)	0.25 (0.64)	0.39 (0.99)	8	4.25 (10.8)
2302-02A	5 (12.7)	3.5 (8.89)	0.75 (1.91)	2 (5.08)	0.25 (0.64)	0.39 (0.99)	8	4.25 (10.8)
2303-01A	8 (20.32)	7.38 (18.75)	1.5 (3.81)	3.5 (8.89)	0.31 (0.79)	0.64 (1.63)	8	6.5 (16.51)
2303-02A	8 (20.32)	7.38 (18.75)	1.5 (3.81)	3.5 (8.89)	0.31 (0.79)	0.64 (1.63)	8	6.5 (16.51)
2304-01A	9.75 (24.77)	8.5 (21.59)	1.5 (3.81)	4 (10.16)	0.31 (0.79)	0.77 (1.96)	8	8 (20.32)
2304-02A	9.75 (24.77)	8.5 (21.59)	1.5 (3.81)	4 (10.16)	0.31 (0.79)	0.77 (1.96)	8	8 (20.32)
2305-01A	14 (35.56)	10.5 (26.67)	2 (5.08)	6 (15.24)	0.31 (0.79)	1.02 (2.59)	8	11 (27.94)
2305-02A	14 (35.56)	10.5 (26.67)	2 (5.08)	6 (15.24)	0.31 (0.79)	1.02 (2.59)	8	11 (27.94)

Reaction Torque Sensors 2000 – 500k in-lb

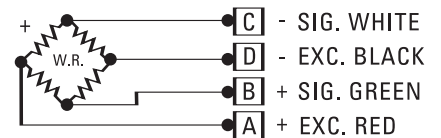
Specifications							Extraneous Load Limits		
Model Number	Capacity in-lb (N-m)	Safe Overload in-lb (N-m)	Torsional Stiffness in-lb/rad (N-m/rad)	Ringing Frequency Hz	Weight lb (kg)	Material	Overhung Moment $W \times S$ in-lb (N-m)	Shear W lb (N)	Thrust P lb (N)
Flange Mount Reaction Torque Sensors									
2301-01A	2000 (225)	3000 (340)	380k (42.9k)	1000	5 (2.27)	steel	1000 (115)	1000 (4450)	2000 (8900)
2301-02A	5000 (565)	7500 (850)	1.29M (145k)	1800	5 (2.27)	steel	2500 (280)	2500 (11.1k)	5000 (22.2k)
2302-01A	10k (1130)	15k (1700)	2.98M (337k)	1400	10 (4.54)	steel	5000 (565)	5000 (22.2k)	10k (44.5k)
2302-02A	20k (2250)	30k (3400)	7.5M (847k)	2200	10 (4.54)	steel	10k (1130)	10k (44.5k)	20k (89k)
2303-01A	50k (5650)	75k (8500)	10.2M (1.15M)	750	58 (26.3)	steel	25k (2825)	10k (44.5k)	50k (220k)
2303-02A	100k (11.3k)	150k (16.9k)	25.7M (2.9M)	1250	58 (26.3)	steel	50k (5650)	20k (89k)	100k (450k)
2304-01A	100k (11.3k)	150k (16.9k)	21.4M (2.4M)	690	106 (48.1)	steel	50k (5650)	15k (66.7k)	100k (450k)
2304-02A	200k (22.6k)	300k (33.9k)	53.9M (6.1M)	1100	106 (48.1)	steel	100k (11.3k)	30k (130k)	200k (900k)
2305-01A	300k (33.9k)	450k (50.8k)	75.8M (8.6M)	560	220 (99.8)	steel	150k (16.9k)	30k (130k)	300k (1.3M)
2305-02A	500k (56.5k)	750k (84.7k)	150M (16.9M)	780	220 (99.8)	steel	250k (28.2k)	50k (220k)	500k (2.2M)

Common Specifications

Output (nominal)2 mV/Volt	Excitation (max)20 Volts DC or AC rms
Non-linearity (max).....0.1% FS	Temp. Range (compensated)+70 °F to +170 °F (+21 °C to +77 °C)
Hysteresis (max).....0.1% FS	Temp. Range (usable)-65 °F to +200 °F (-54 °C to +93 °C)
Non-repeatability (max)0.02% FS	Temp. Effect on Zero (max)0.002% FS/°F (0.0036% FS/°C)
Bridge Resistance (nom)350 ohm	Temp. Effect on Output (max)0.002% reading/°F
Excitation (recommended)10 Volts	(0.0036% reading/°C)



Extraneous load limits are extraneous side force, thrust and bending moment that may be applied without electrical or mechanical damage to the torque sensor. Do not exceed moment ($W \times S$) or shear (W) whichever attained first.



Wiring Diagram

Reaction Torque Sensors 5 – 1000 in-lb

Small Capacity Flange Mount Reaction Torque Sensors

- Bearing Friction
- Fractional HP Motor Testing
- Viscosity Measurements
- Small Motor Dynamometer

Series 2308, 2309, 2508 — small capacity flange mount reaction torque sensors

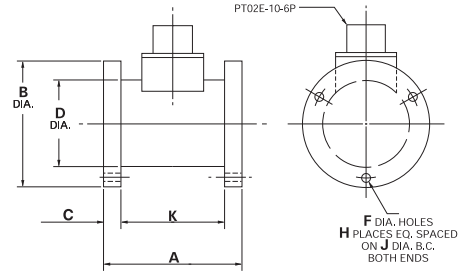
- Capacities from 5 to 1000 in-lb FS (0.56 to 115 N-m FS)
- 2 mV/V output sensitivity
- Flange mount both ends
- High torsional stiffness

Recommended cables and accessories ⑩
— see page 5.3 & 8.6

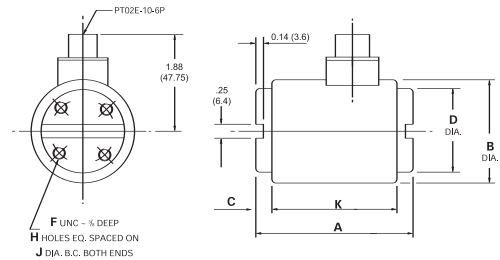
Select a signal conditioner from those featured
beginning on page 5.2 & 8.2



Series 2308 and 2309



Series 2508



Dimensions shown are in inches (millimeters).

Dimensions — Inches (mm)

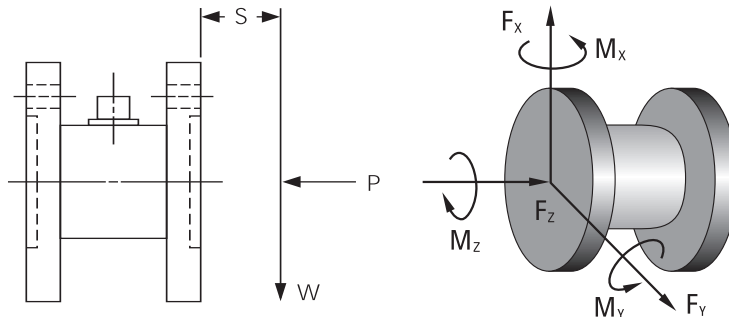
Series	A	B	C	D	F	H	J	K
2308	2.25 (57.2)	2 (50.8)	0.25 (6.4)	1.39 (35.3)	0.13 (3.3)	3	1.69 (42.9)	1.75 (44.5)
2309	2.75 (69.9)	3.5 (88.9)	0.25 (6.4)	2.5 (63.5)	0.28 (7.1)	4	3 (76.2)	2.25 (57.2)
2508	3 (76.2)	2 (50.8)	0.31 (7.9)	1.63 (41.4)	10-24	4	1.25 (31.8)	2.38 (60.5)

Specifications							Extraneous Load Limits		
Model Number	Capacity in-lb (N-m)	Safe Overload in-lb (N-m)	Torsional Stiffness in-lb/rad (N-m/rad)	Ringing Frequency Hz	Weight lb (kg)	Material	Overhung Moment $W \times S$ in-lb (N-m)	Shear W lb (N)	Thrust P lb (N)
Flange Mount Reaction Torque Sensors									
2308-01A	5 (0.56)	7.5 (0.85)	175 (20)	200	0.2 (0.09)	aluminum	2.5 (0.28)	2.5 (11)	5 (22)
2308-02A	10 (1.1)	15 (1.69)	500 (55)	350	0.2 (0.09)	aluminum	5 (0.56)	5 (22)	10 (45)
2308-03A	20 (2.3)	30 (3.4)	1400 (160)	580	0.2 (0.09)	aluminum	10 (1.1)	10 (45)	20 (90)
2309-01A	5 (0.56)	50 (5.6)	340 (38)	90	1.3 (0.59)	aluminum	2.5 (0.28)	2.5 (11)	5 (22)
2309-02A	10 (1.1)	50 (5.6)	960 (110)	150	1.3 (0.59)	aluminum	5 (0.56)	5 (22)	10 (45)
2309-03A	20 (2.3)	50 (5.6)	2700 (300)	250	1.3 (0.59)	aluminum	10 (1.1)	10 (45)	20 (90)
2508-01A	50 (5.6)	75 (8.5)	2350 (266)	380	1 (0.45)	steel	50 (5.6)	13 (57)	200 (900)
2508-02A	100 (11)	150 (17)	6700 (775)	620	1 (0.45)	steel	100 (11.3)	20 (90)	280 (1250)
2508-03A	200 (23)	300 (34)	18.8k (2100)	1040	1 (0.45)	steel	200 (22.6)	26 (116)	400 (1780)
2508-04A	500 (55)	750 (85)	73.6k (8200)	2050	1 (0.45)	steel	250 (28.2)	500 (2225)	500 (2225)
2508-05A	1000 (115)	1500 (170)	127k (14.3k)	2700	1 (0.45)	steel	500 (56.5)	800 (3560)	660 (2950)

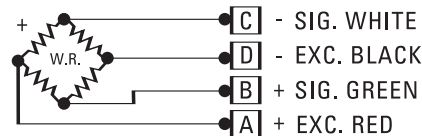
Common Specifications

Output (nominal).....2 mV/Volt	Excitation (max)20 Volts DC or AC rms
Non-linearity (max)0.1% FS	Temp. Range (compensated).....+70 °F to +170 °F (+21 °C to +77 °C)
Hysteresis (max)0.1% FS	Temp. Range (usable).....-65 °F to +200 °F (-54 °C to +93 °C)
Non-repeatability (max)0.05% FS	Temp. Effect on Zero (max)0.002% FS/°F (0.0036% FS/°C)
Bridge Resistance (nom)700 ohm ^[1]	Temp. Effect on Output (max)0.002% reading/°F (0.0036% reading/°C)
Excitation (recommended).....10 Volts	

Note: [1] 500 and 1000 in-lb capacities — 350 ohm



Extraneous load limits are extraneous side force, thrust and bending moment that may be applied without electrical or mechanical damage to the torque sensor. Do not exceed moment ($W \times S$) or shear (W) whichever attained first.



Wiring Diagram

Rotary Transformer Torque Sensors 100 – 100k in-lb

Shaft End Rotary Transformer Torque Sensors Non-contact rotary transformer

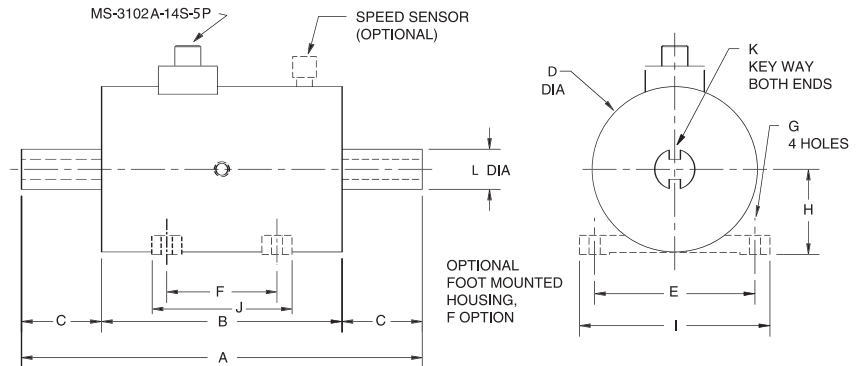
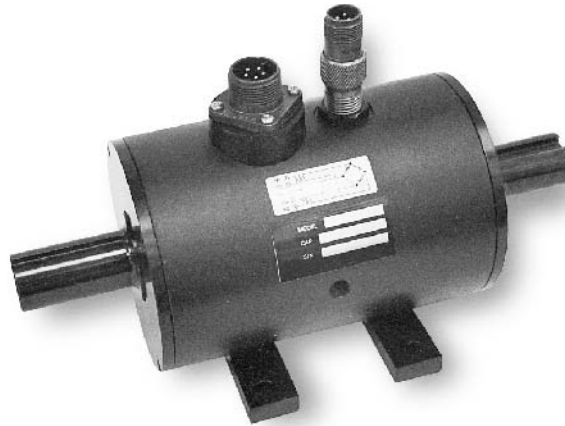
- Pump Testing
- Engine Dynamometer
- Electric Motor Testing
- Efficiency Testing
- Transmission Testing
- Gear Box Efficiency Testing

Series 4203, 4204, 4205, 4206, 4207

- Capacities from 100 to 100k in-lb FS (11 to 11.3k N-m FS)
- 2 mV/V output sensitivity
- Shaft ends
- Optional foot-mounted housing
- Integral shunt calibration network
- Temperature compensated

Recommended cables and accessories ④
– see page 5.3

Select a signal conditioner from those featured on page 5.2



Series 4203, 4204, 4205, 4206 and 4207

Dimensions — Inches (cm)

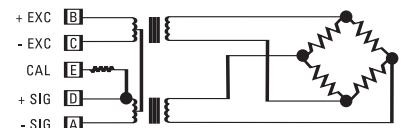
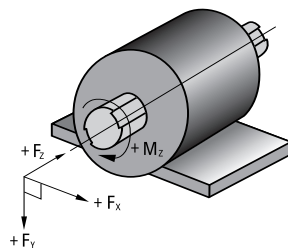
Series	A	B	C	D	E	F	G	H	I	J	K	L
4203	10 (25.4)	6 (15.24)	2 (5.08)	4 (10.16)	4 (10.16)	2.75 (6.99)	0.28 (0.71)	2.13 (5.4)	4.75 (12.07)	3.5 (8.89)	0.19 (0.48)	0.75 (1.91)
4204	10 (25.4)	6 (15.24)	2 (5.08)	4 (10.16)	4 (10.16)	2.75 (6.99)	0.28 (0.71)	2.13 (5.4)	4.75 (12.07)	3.5 (8.89)	0.25 (0.64)	1 (2.54)
4205	12.75 (32.39)	6 (15.24)	3.38 (8.59)	4 (10.16)	5.25 (13.34)	3 (7.62)	0.41 (1.03)	2.5 (6.35)	6.25 (15.88)	4 (10.16)	0.38 (0.97)	1.5 (3.81)
4206	15.75 (40.01)	8.25 (20.96)	3.75 (9.53)	5.5 (13.97)	6 (15.24)	4 (10.16)	0.53 (1.35)	3 (7.62)	7 (17.78)	5.25 (13.34)	0.5 (1.27)	2.25 (5.72)
4207	19 (48.26)	8.75 (22.23)	5.13 (13.13)	6.5 (16.51)	7 (17.78)	4 (10.16)	0.53 (1.35)	3.5 (8.89)	8.5 (21.59)	5 (12.7)	0.75 (1.91)	3 (7.62)

Rotary Transformer Torque Sensors 100 – 100k in-lb

Specifications

Model Number	Capacity in-lb (N-m)	Maximum Speed RPM	Overload in-lb (N-m)	Torsional Stiffness in-lb/rad (N-m/rad)	Rotating Inertia in-lb sec ² (N-m sec ²)	Weight lb (kg)	Housing Material
Rotating Transformer Torque Sensors with Shaft Ends							
4203-01A	100 (11)	10k	300 (34)	15k (1700)	0.004 (0.0005)	10 (4.5)	aluminum
4203-02A	200 (23)	10k	600 (68)	30k (3400)	0.004 (0.0005)	10 (4.5)	aluminum
4204-01A	500 (55)	10k	1500 (170)	85k (9600)	0.0026 (0.0003)	10 (4.5)	aluminum
4204-02A	1000 (115)	10k	3000 (340)	150k (16.9k)	0.0026 (0.0003)	10 (4.5)	aluminum
4204-03A	2000 (225)	10k	3000 (340)	150k (16.9k)	0.0026 (0.0003)	10 (4.5)	aluminum
4205-01A	2000 (225)	10k	6000 (675)	700k (79.1k)	0.008 (0.0009)	12 (5.4)	aluminum
4205-02A	5000 (565)	10k	15k (1700)	950k (107k)	0.008 (0.0009)	12 (5.4)	aluminum
4205-03A	10k (1130)	10k	15k (1700)	950k (107k)	0.008 (0.0009)	12 (5.4)	aluminum
4206-01A	10k (1130)	6700	30k (3400)	4.1M (460k)	0.036 (0.0004)	40 (18.2)	steel
4206-02A	20k (2250)	6700	60k (6775)	11.8M (1.33M)	0.036 (0.0004)	40 (18.2)	steel
4206-03A	36k (4065)	6700	60k (6775)	11.8M (1.33M)	0.036 (0.0004)	40 (18.2)	steel
4207-01A	36k (4065)	6000	100k (11.3k)	17.7M (2.0M)	0.15 (0.017)	80 (36.3)	steel
4207-02A	50k (5650)	6000	150k (16.9k)	20M (2.3M)	0.15 (0.017)	80 (36.3)	steel
4207-03A	100k (11.3k)	6000	150k (16.9k)	20M (2.3M)	0.15 (0.017)	80 (36.3)	steel
Rotating Transformer Torque Sensors with Shaft Ends and Foot Mount							
4203F-01A	100 (11)	10k	300 (34)	15k (1700)	0.004 (0.0005)	17 (7.7)	steel
4203F-02A	200 (23)	10k	600 (68)	30k (3400)	0.004 (0.0005)	17 (7.7)	steel
4204F-01A	500 (55)	10k	1500 (170)	85k (9600)	0.0026 (0.0003)	17 (7.7)	steel
4204F-02A	1000 (115)	10k	3000 (340)	150k (16.9k)	0.0026 (0.0003)	17 (7.7)	steel
4204F-03A	2000 (225)	10k	3000 (340)	150k (16.9k)	0.0026 (0.0003)	17 (7.7)	steel
4205F-01A	2000 (225)	10k	6000 (675)	700k (79.1k)	0.008 (0.0009)	22 (10)	steel
4205F-02A	5000 (565)	10k	15k (1700)	950k (107k)	0.008 (0.0009)	22 (10)	steel
4205F-03A	10k (1130)	10k	15k (1700)	950k (107k)	0.008 (0.0009)	22 (10)	steel
4206F-01A	10k (1130)	6700	30k (3400)	4.1M (460k)	0.0036 (0.0004)	44 (20)	steel
4206F-02A	20k (2250)	6700	60k (6775)	11.8M (1.33M)	0.0036 (0.0004)	44 (20)	steel
4206F-03A	36k (4065)	6700	60k (6775)	11.8M (1.33M)	0.0036 (0.0004)	44 (20)	steel
4207F-01A	36k (4065)	6000	100k (11.3k)	17.7M (2.0M)	0.15 (0.017)	85 (38.6)	steel
4207F-02A	50k (5650)	6000	150k (16.9k)	20M (2.3M)	0.15 (0.017)	85 (38.6)	steel
4207F-03A	100k (11.3k)	6000	150k (16.9k)	20M (2.3M)	0.15 (0.017)	85 (38.6)	steel
Common Specifications							
Output (nominal).....	2 mV/Volt			Excitation Voltage (AC/RMS).....	2 to 10 Volts		
Non-linearity (max)	0.05% FS			Bridge Current @ 5VAC (max)	50 mA		
Hysteresis (max)	0.05% FS			Temp. Range (compensated).....	+70 °F to +170 °F (+21 °C to +77 °C)		
Non-repeatability (max)	0.02% FS			Temp. Range (usable).....	-25 °F to +170 °F (-32 °C to +77 °C)		
Bridge Resistance (nominal).....	350 ohm			Temp. Effect on Zero (max)	0.001% FS/°F (0.0018% FS/°C) ^[2]		
Excitation Frequency (calibrated)	3.28k Hz ^[1]			Temp. Effect on Output (max)	0.001% reading/°F ^[2] (0.0018% reading/°C) ^[2]		

Note: [1] Consult factory for use with 3.0k to 5.0k Hz excitation frequencies [2] Series 4203 - temp. effect on output (max) 0.002% FS/°F (0.0036% FS/°C). Temp. effect on zero (max) 0.002% FS/°F (0.0036% FS/°C).



Wiring Diagram

Typical systems located on page 2.5

Rotary Transformer Torque Sensors 50 in-oz – 100k in-lb

Shaft End Rotary Transformer Torque Sensors

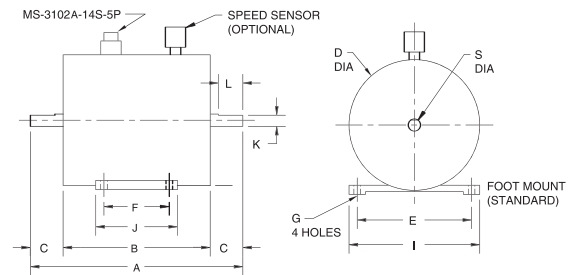
- Fuel Pump Testing
- Transmission Development
- Hydraulic Motor
- Dynamometer
- Hydraulic Pump
- Chassis Dynamometer
- Blower Testing
- Aerospace

Series 4102, 4103, 4104, 4105, 4106, 4107

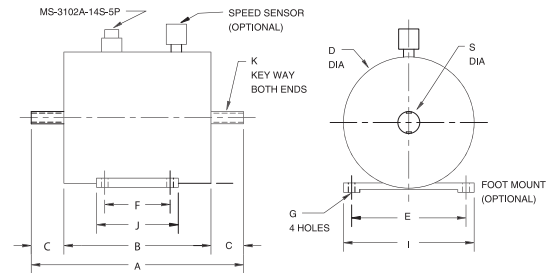
- Capacities from 50 in-oz to 100k in-lb FS (5.6 to 11.3k N-m FS)
- 2 mV/V or 2.5 mV/V output sensitivity
- Shaft ends
- High signal to noise ratio
- High accuracy
- High torsional stiffness

Recommended cables and accessories ⑩
— see page 5.3

Select a signal conditioner from those featured on page 5.2



Series 4102



Series 4103, 4104, 4105, 4106 and 4107

Dimensions — Inches (cm)

Series	A	B	C	D	E	F	G	H	I	J	K x L	S
4102	6.5 (16.51)	4.5 (11.43)	1 (2.54)	4 (10.16)	3.5 (8.89)	2 (5.08)	13/64	2.1 (5.33)	4 (10.16)	2.5 (6.35)	0.34 x 0.75 (0.86 x 1.91)	0.38 (0.97)

Dimensions — Inches (cm)

Series	A	B	C	D	E	F	G	H	I	J	K	S
4103	10 (25.4)	6 (15.24)	2 (5.08)	4 (10.16)	4 (10.16)	2.75 (6.99)	0.28 (0.71)	2.13 (5.41)	4.75 (12.07)	3.5 (8.89)	0.19 (0.48)	0.75 (1.91)
4104	10 (25.4)	6 (15.24)	2 (5.08)	4 (10.16)	4 (10.16)	2.75 (6.99)	0.28 (0.71)	2.13 (5.41)	4.75 (12.07)	3.5 (8.89)	0.25 (0.64)	1 (2.54)
4105	12.75 (32.39)	7.25 (18.42)	2.75 (6.99)	4.75 (12.07)	5.25 (13.34)	3 (7.62)	0.41 (1.03)	2.5 (6.35)	6.25 (15.88)	4 (10.16)	0.38 (0.97)	1.5 (3.81)
4106	15.75 (40.01)	8.25 (20.96)	3.75 (9.53)	5.5 (13.97)	6 (15.24)	4 (10.16)	0.53 (1.35)	3 (7.62)	7 (17.78)	5.25 (13.34)	0.5 (1.27)	2.25 (5.72)
4107	19 (48.26)	8.75 (22.23)	5 (12.7)	6.5 (16.51)	7 (17.78)	4 (10.16)	0.53 (1.35)	3.5 (8.89)	8.5 (21.59)	5 (12.7)	0.75 (1.91)	3 (7.62)

Reaction Torque Sensors 50 in-oz – 100k in-lb

Specifications

Model Number	Capacity in-oz (N-m)	Maximum Speed RPM	Overload in-oz (N-m)	Torsional Stiffness in-lb/rad (N-m/rad)	Rotating Inertia in-lb sec ² (N-m sec ²)	Weight without Foot Mount lb (kg)	Weight with Foot Mount lb (kg)	Housing Material
Shaft Ends with One Flat								
4102-01A	50 (0.35)	10k	150 (1.06)	400 (45)	0.0009 (0.0001)	N/A	15 (6.8)	aluminum
4102-02A	100 (0.71)	10k	300 (2.10)	1000 (113)	0.0009 (0.0001)	N/A	15 (6.8)	aluminum
4102-03A	200 (1.41)	10k	600 (4.25)	2500 (280)	0.0009 (0.0001)	N/A	15 (6.8)	aluminum
4102-04A	500 (3.53)	10k	1500 (10.6)	5500 (625)	0.0009 (0.0001)	N/A	15 (6.8)	aluminum
4102-05A	1000 (7.06)	10k	3000 (21.2)	8000 (904)	0.0009 (0.0001)	N/A	15 (6.8)	aluminum

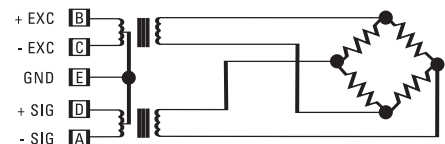
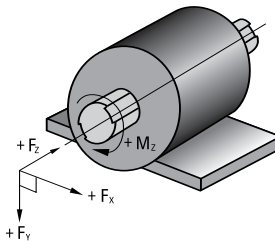
Specifications

Model Number	Capacity in-lb (N-m)	Maximum Speed RPM	Overload in-lb (N-m)	Torsional Stiffness in-lb/rad (N-m/rad)	Rotating Inertia in-lb sec ² (N-m sec ²)	Weight without Foot Mount lb (kg)	Weight with Foot Mount lb (kg)	Housing Material
Shaft Ends with Two Key Ways								
4103-01A	100 (11)	15k	300 (33)	13.5k (1500)	0.0026 (0.0003)	18 (8.2)	19.5 (8.8)	steel
4103-02A	200 (23)	15k	600 (66)	33k (3700)	0.0026 (0.0003)	18 (8.2)	19.5 (8.8)	steel
4104-01A	500 (55)	15k	1500 (170)	85k (9600)	0.0026 (0.0003)	18 (8.2)	19.5 (8.8)	steel
4104-02A	1000 (115)	15k	3000 (340)	150k (16.9k)	0.0026 (0.0003)	18 (8.2)	19.5 (8.8)	steel
4104-03A	2000 (225)	15k	3000 (340)	150k (16.9k)	0.0026 (0.0003)	18 (8.2)	19.5 (8.8)	steel
4105-01A	2000 (225)	15k	6000 (675)	700k (79.1k)	0.0084 (0.001)	28 (12.7)	30.5 (13.8)	steel
4105-02A	5000 (565)	15k	15k (1700)	950k (107k)	0.0084 (0.001)	28 (12.7)	30.5 (13.8)	steel
4105-03A	10k (1130)	15k	15k (1700)	950k (107k)	0.0084 (0.001)	28 (12.7)	30.5 (13.8)	steel
4106-01A	10k (1130)	6700	30k (3400)	4.1M (460k)	0.036 (0.004)	40 (18.2)	44 (20)	steel
4106-02A	20k (2260)	6700	60k (6775)	11.8M (1.3M)	0.036 (0.004)	40 (18.2)	44 (20)	steel
4106-03A	36k (4065)	6700	60k (6775)	11.8M (1.3M)	0.036 (0.004)	40 (18.2)	44 (20)	steel
4107-01A	36k (4065)	6000	100k (11.3k)	17.7M (2M)	0.152 (0.017)	80 (36.3)	85 (38.6)	steel
4107-02A	50k (5650)	6000	150k (16.9k)	20M (2.3M)	0.152 (0.017)	80 (36.3)	85 (38.6)	steel
4107-03A	100k (11.3k)	6000	150k (16.9k)	20M (2.3M)	0.152 (0.017)	80 (36.3)	85 (38.6)	steel

Common Specifications

Output (nominal)	2 mV/Volt ^[1]	Excitation Voltage (AC/RMS).....	2 to 10 Volts
Non-linearity (max)	0.05% FS	Bridge Current @ 5VAC (max)	50 mA
Hysteresis (max)	0.05% FS	Temp. Range (compensated).....	+70 °F to +170 °F (+21 °C to +77 °C)
Non-repeatability (max)	0.02% FS	Temp. Range (usable).....	-65 °F to +170 °F (-54 °C to +77 °C) ^[2]
Bridge Resistance (nominal).....	350 ohm	Temp. Effect on Zero (max)	0.001% FS/°F (0.0018% FS/°C) ^{[2][3]}
Excitation Frequency (calibrated)	3.28k Hz	Temp. Effect on Output (max)	0.001% reading/°F ^{[2][3]} (0.0018% reading/°C) ^[3]

Note: [1] Series 4104, 4105 - output (nominal) 2.5 mV/V [2] Series 4102 - temp. range (usable) -20 °F to +170 °F (-29 °C to +77 °C) temp. effect on zero (max) 0.002% FS/°F (0.0036% FS/°C) temp. effect on output (max) 0.002% FS/°F (0.0036% FS/°C) [3] Series 4103 - temp. effect on zero (max) 0.002% FS/°F (0.0036% FS/°C) temp. effect on output (max) 0.002% FS/°F (0.0036% FS/°C)



Wiring Diagram

Rotary Transformer Torque Sensors 50 – 10k in-lb

AND Flange-shaft Rotary Transformer Torque Sensors


Specifically designed for testing of

- Cantilevered Aerospace Hydraulic Pumps

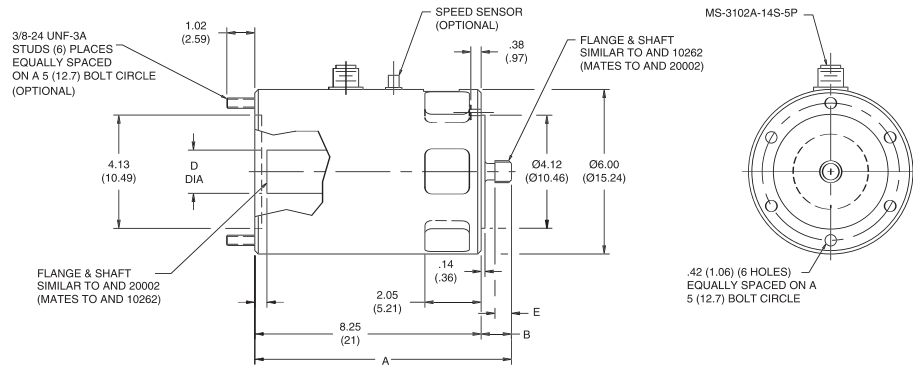
- Cantilevered Aerospace Hydraulic Motors

Series 4115A, 4115K

- Capacities from 50 to 10k in-lb FS (5.6 to 1130 N-m FS)
- 2.5 mV/V output sensitivity
- Splined shaft drive
- High signal-to-noise ratio
- High torsional stiffness

Recommended cables and accessories  — see page 5.3

Select a signal conditioner from those featured on page 5.2



Series 4115A, 4115K

Dimensions shown are in inches (centimeters).

Dimensions — Inches (cm)						Internal and External Spline Data			
Series	A	B	C	D	E	Pressure Angle	Pitch Dia — in (cm)	Pitch	Number of Teeth
4115A	9.35 (23.75)	1.10 (2.79)	0.25 (0.64)	1.58 (4)	0.6 (1.52)	30°	0.8 (2.03)	20/30	16
4115K	9.94 (25.25)	1.69 (4.29)	0.38 (0.97)	1.58 (4)	1 (2.54)	30°	1.2 (3.05)	20/30	24

Rotary Transformer Torque Sensors 50 – 10k in-lb

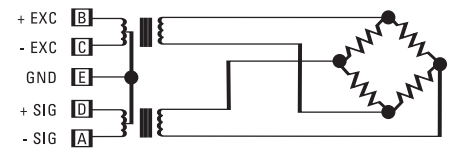
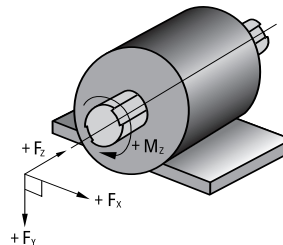
Specifications

Model Number	Capacity in-lb (N-m)	Maximum Speed RPM	Overload in-lb (N-m)	Torsional Stiffness in-lb/rad (N-m/rad)	Rotating Inertia in-lb sec ² (N-m sec ²)	Weight lb (kg)	Material
Flange-Shaft Rotating Transformer Torque Sensors							
4115A-01A	50 (5.6)	15k	150 (17)	4500 (500)	0.0047 (0.0005)	46 (20.9)	steel
4115A-02A	100 (11)	15k	300 (34)	13.5k (1500)	0.0048 (0.0005)	46 (20.9)	steel
4115A-03A	200 (23)	15k	600 (68)	33k (3700)	0.0049 (0.0005)	46 (20.9)	steel
4115A-04A	500 (55)	15k	1500 (170)	94k (10.6k)	0.005 (0.0006)	46 (20.9)	steel
4115A-05A	1000 (115)	15k	1500 (170)	94k (10.6k)	0.005 (0.0006)	46 (20.9)	steel
4115K-01A	50 (5.6)	15k	150 (17)	4500 (500)	0.0048 (0.0005)	47 (21.3)	steel
4115K-02A	100 (11)	15k	300 (34)	13.5k (1500)	0.0049 (0.0005)	47 (21.3)	steel
4115K-03A	200 (23)	15k	600 (68)	33k (3700)	0.005 (0.0006)	47 (21.3)	steel
4115K-04A	500 (55)	15k	1500 (170)	94k (10.6k)	0.0051 (0.0006)	47 (21.3)	steel
4115K-05A	600 (68)	15k	1800 (200)	120k (13.6k)	0.0051 (0.0006)	47 (21.3)	steel
4115K-06A	1000 (115)	15k	3000 (340)	204k (23k)	0.0052 (0.0006)	47 (21.3)	steel
4115K-07A	1200 (135)	15k	3600 (405)	204k (23k)	0.0052 (0.0006)	47 (21.3)	steel
4115K-08A	2000 (225)	15k	6000 (675)	204k (23k)	0.0052 (0.0006)	47 (21.3)	steel
4115K-09A	2400 (270)	15k	7200 (815)	380k (42.9k)	0.0055 (0.0006)	47 (21.3)	steel
4115K-10A	3600 (405)	15k	10.8k (1220)	420k (47.5k)	0.0058 (0.0007)	47 (21.3)	steel
4115K-11A	5000 (565)	15k	15k (1700)	500k (56.5k)	0.0062 (0.0007)	47 (21.3)	steel
4115K-12A	6000 (675)	15k	15k (1700)	500k (56.5k)	0.0062 (0.0007)	47 (21.3)	steel
4115K-13A	10k (1130)	15k	15k (1700)	500k (56.5k)	0.0062 (0.0007)	47 (21.3)	steel

Common Specifications

Output (nominal)	2.5 mV/Volt	Temp. Effect on Zero (from +70 °F to +225 °F)	0.002% FS/°F (0.0036% FS/°C)
Non-linearity (max)	0.05% FS	Temp. Effect on Span (from +70 °F to +225 °F)	0.002% reading/°F (0.0036% reading/°C)
Hysteresis (max)	0.05% FS	Temp. Effect on Zero (from -65 °F to +70 °F)	0.02% FS/°F (0.036% FS/°C)
Non-repeatability (max)	0.03% FS	Temp. Effect on Span (from -65 °F to +70 °F)	0.02% FS/°F (0.036% FS/°C)
Bridge Resistance (nominal)	350 ohm	Maximum Bending Moment	1200 in-lb (135 N-m) [1]
Excitation Frequency (calibrated)	3.28k Hz		
Excitation Voltage (AC/RMS)	2 to 10 Volts		
Bridge Current @ 5VAC (max)	50 mA		
Temp. Range (compensated)	+70 °F to +170 °F (+21 °C to +77 °C)		
Temp. Range (usable)	-65 °F to +225 °F (-54 °C to +107 °C)		

Note: [1] Bending moment induced by overhung pump weight



Wiring Diagram

Typical systems located on page 2.5

TORKDISC® — Rotary Torque Sensor System

For dynamometer and other applications requiring a robust rotary torque transducer where axial space is at a premium. On-board the transducer is a field-proven electronic module that converts the torque signals into a high-speed digital representation. Once in digital form, this data is transmitted to a non-contacting pick-up loop, with no risk of noise or data corruption. A remote receiver unit converts the digital data to a high-level analog output voltage, frequency output, and a serial digital output.

- chassis dynamometer
- 4-square dynamometer
- drive shaft torque measurement
- engine dynamometer
- efficiency testing

Series 5302C, 5308C, 5309C, 5310C

- Compact
- Low weight
- High torsional stiffness
- 16-bit digital telemetry
- Immune to RF interference
- Low sensitivity to axial and thrust bending moments
- Robust construction



Series 5302C

TORKDISC® Rotary Torque Sensor System 1000 – 225k in-lb

TORKDISC® Rotary Torque Sensor System								
Model Number	Unit	5302C-01A	5302C-02A	5302C-03A	5302C-04A	5308C-01A	5308C-02A	5308C-03A
Continuous Rated Capacity	in-lb (N-m)	2000 (226)	5000 (565)	1000 (113)	6250 (706)	10k (1130)	20k (2260)	30k (3400)
Bolt Joint Slip Torque ^[1]	in-lb (N-m)	3300 (373)	10k (1130)	3300 (373)	10k (1130)	35k (4000)	35k (4000)	35k (4000)
Safe Overload	in-lb (N-m)	6000 (678)	15k (1695)	3000 (339)	15k (1695)	30k (3400)	60k (6775)	75k (8475)
Failure Overload	in-lb (N-m)	8000 (904)	20k (2260)	4000 (452)	20k (2260)	40k (4500)	80k (9040)	100k (11.3k)
Torsional Stiffness	in-lb/rad (N-m/rad)	5.8M (655k)	14.5M (1.6M)	2.9M (328k)	14.5M (1.6M)	33.5M (3.8M)	67M (7.6M)	100M (11.3M)
Torsional Angle @ Capacity	degrees	0.02	0.02	0.02	0.02	0.017	0.017	0.017
Rotating Inertia	in-lb sec ² (N-m sec ²)	0.056 (0.006)	0.117 (0.013)	0.056 (0.006)	0.117 (0.013)	0.24 (0.027)	0.24 (0.027)	0.24 (0.027)
Axial Load Limit ^[2]	lb (N)	500 (2224)	1000 (4448)	250 (1112)	1000 (4448)	1350 (6000)	2700 (12k)	4000 (17.8k)
Lateral Load Limit ^[2]	lb (N)	500 (2224)	1000 (4448)	250 (1112)	1000 (4448)	1650 (7300)	3375 (15k)	5000 (22.2k)
Bending Moment Limit ^[2]	in-lb (N-m)	1500 (169)	3000 (339)	750 (85)	3000 (339)	5000 (565)	7500 (850)	10k (1130)
Maximum Speed	RPM	15k	15k	15k	15k	10k	10k	10k
Rotor Weight	lb (kg)	3.5 (1.59)	9 (4.08)	3.5 (1.59)	9 (4.08)	10 (4.5)	10 (4.5)	10 (4.5)
Rotor Material		aluminum	steel	aluminum	steel	steel	steel	steel

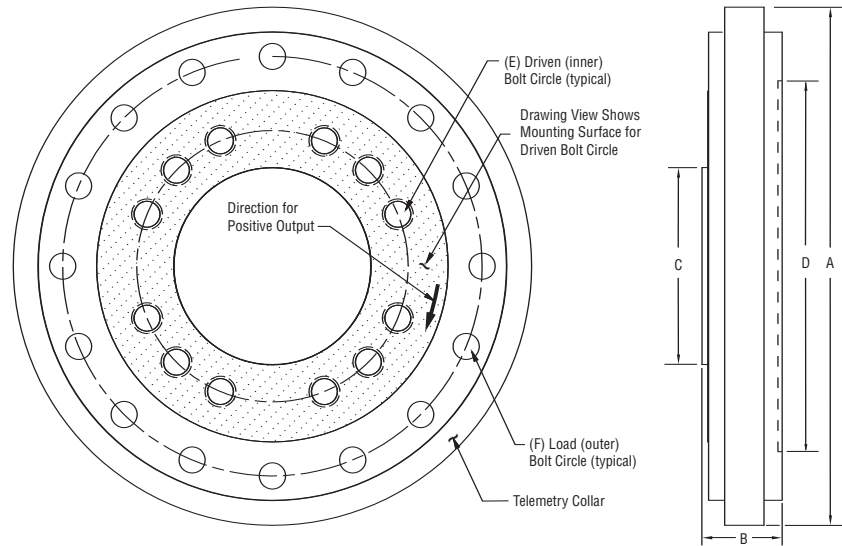
TORKDISC® Rotary Torque Sensor System (Con't)							
Model Number	Unit	5309C-01A	5309C-02A	5310C-01A	5310C-02A	5310C-03A	5310C-04A
Continuous Rated Capacity	in-lb (N-m)	50k (5650)	100k (11.3k)	180k (20.3k)	200k (22.5k)	120k (13.5k)	225k (25.4k)
Bolt Joint Slip Torque ^[1]	in-lb (N-m)	85k (9600)	110k (12.4k)	268k (30.3k)	268k (30.3k)	268k (30.3k)	268k (30.3k)
Safe Overload	in-lb (N-m)	100k (11.3k)	200k (22.6k)	540k (61.0k)	600k (67.8k)	360k (40.7k)	675k (76.3k)
Failure Overload	in-lb (N-m)	125k (14k)	250k (28.2k)	720k (81.3k)	800k (90.4k)	480k (54.2k)	900k (101.7k)
Torsional Stiffness	in-lb/rad (N-m/rad)	115M (13M)	230M (26M)	1.1B (124M)	1.2B (138M)	730M (82.5M)	1.35B (152.5M)
Torsional Angle @ Capacity	degrees	0.017	0.017	0.01	0.01	0.01	0.01
Rotating Inertia	in-lb sec ² (N-m sec ²)	0.874 (0.099)	0.874 (0.099)	7.514 (0.849)	7.514 (0.849)	7.514 (0.849)	7.514 (0.849)
Axial Load Limit ^[2]	lb (N)	5000 (22.2k)	10k (44.5k)	13.5k (60k)	14k (62k)	12k (53k)	15k (66.7k)
Lateral Load Limit ^[2]	lb (N)	5000 (22.2k)	10k (44.5k)	13.5k (60k)	14k (62k)	12k (53k)	15k (66.7k)
Bending Moment Limit ^[2]	in-lb (N-m)	25k (2825)	50k (5650)	90k (10.2k)	95k (10.7k)	80k (9040k)	100k (11.3k)
Maximum Speed	RPM	10k	10k	4500	4500	4500	4500
Rotor Weight	lb (kg)	30 (13.6)	30 (13.6)	100 (45)	100 (45)	100 (45)	100 (45)
Material		steel	steel	steel	steel	steel	steel

Common Specifications

Output at rated capacity (analog/voltage)0 ± 10 Volts	Temperature effect on zero within the compensated range
(Frequency)10k Hz ± 5k Hz± 0.003% FS/°F
(Digital) ^[3]QSPI	Temperature range, usable+32 °F to +185 °F
Combined effect of non-linearity, hysteresis, and non-repeatability	Electronics measuring bandwidth ^[4]2000 Hz
.....± 0.1% FS	Digital resolution16-Bit
Temperature range, compensated+70 °F to +170 °F	Digital sample rate26,000 samples/second
Temperature effect on output within the compensated range	Permissible radial float, rotor to stator± 0.25 in.
.....± 0.003% FS/°F	Permissible axial float, rotor to stator± 0.25 in.
	Power requirements90-240 VAC, 50-60 Hz

Note: The acceptable cable lengths between the electronics box and the stator portion of the TORKDISC® is 24, 80, or 112 ft (7.3, 24.4, or 34.1 m), as supplied from factory. Do not shorten cable; coil any excess. [1] Bolt joint slip torque is calculated assuming a coefficient of friction (μ) of 0.1 and that grade 8 socket head cap screws are used and tightened to 75% of yield for steel sensors and 30% of yield for aluminum sensors. Model 5309C-02A requires the use of Supertanium bolts on the inner bolt circle diameter to maintain proper clamping frictional forces, tightened to 70% of yield. [2] Extraneous load limits reflect the maximum axial load, lateral load, and bending moment that may be applied singularly without electrical or mechanical damage to the sensor. Where combined extraneous loads are applied, decrease loads proportionally. Request Application Note AP-1015 regarding the effects of extraneous loads on the torque sensor output. [3] Request Technical Note FTQ-STN5 regarding digital output signal. [4] Output can be filtered via internal DIP switch (33, 55, 125, 250, 450 Hz), 2-pole low pass Butterworth.

TORKDISC® Rotary Torque Sensor System 1000 – 225k in-lb

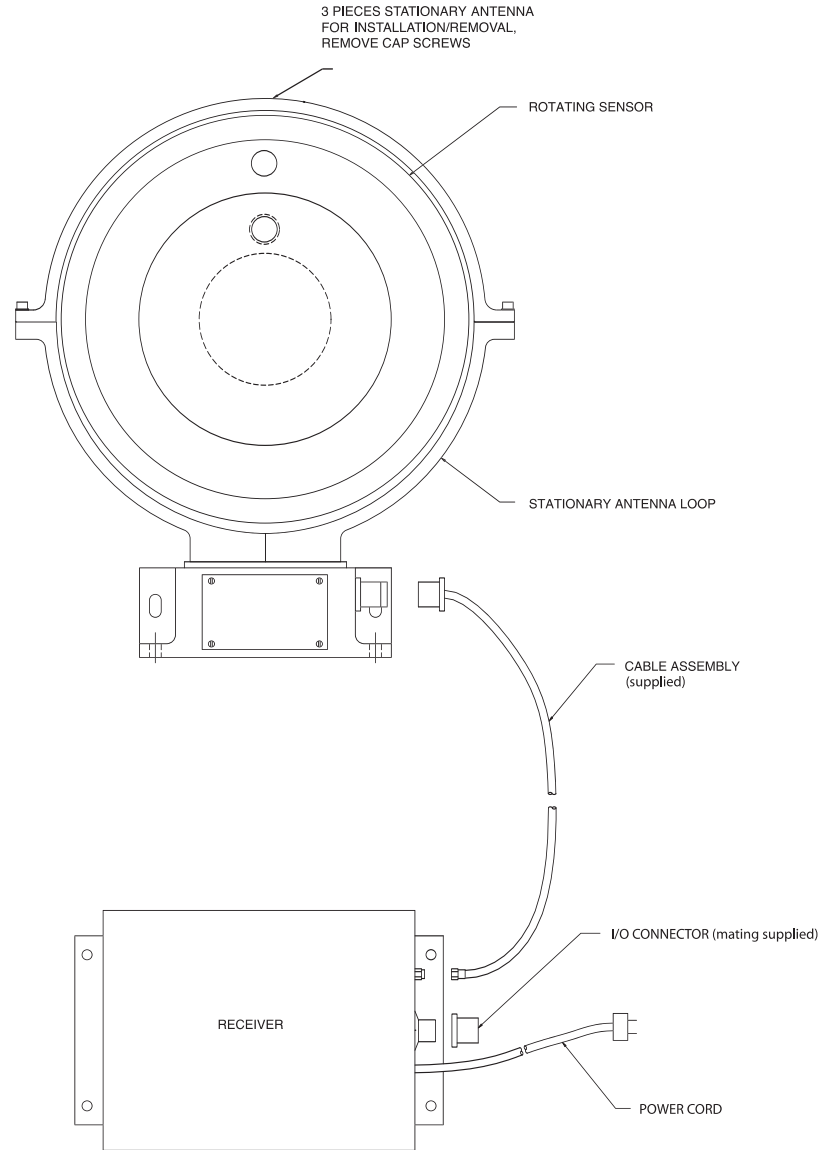


Request Detailed Drawing for Installation

TORKDISC® Sensor Dimensions

	A	B	C	D	E	F
Series	O.D. - Outside Diameter (including telemetry collar)	Overall Thickness	Male Pilot Diameter	Female Pilot Diameter	Driven (inner) Bolt Circle	Load (outer) Bolt Circle
5302C	7.00 in (177.8 mm)	1.10 in (27.9 mm)	1.999 in (50.8 mm)	4.375 in (111.1 mm)	(8) 3/8-24 threaded holes, equally spaced on a 3.00 in (76.20 mm) B.C.	(8) 0.406 in (10.31 mm) dia through holes equally spaced on a 5.00 in (127.0 mm) B.C.
5308C	8.49 in (215.5 mm)	1.10 in (27.9 mm)	2.748 in (69.9 mm)	5.513 in (140.0 mm)	(8) 5/8-11 threaded holes, spaced on a 3.75 in (95.25 mm) B.C.	(8) 0.531 in (13.49 mm) dia through holes equally spaced on a 6.5 in (165.0 mm) B.C.
5309C	10.49 in (241.0 mm)	1.64 in (41.7 mm)	3.998 in (101.5 mm)	7.500 in (190.5 mm)	(12) 5/8-11 threaded holes, spaced on a 6.0 in (152.4 mm) B.C.	(16) 0.531 in (13.49 mm) dia through holes equally spaced on a 8.5 in (215.9 mm) B.C.
5310C	17.98 in (456.7 mm)	2.09 in (53.0 mm)	5.499 in (139.7 mm)	11.001 in (279.4 mm)	(12) 7/8-14 threaded holes, spaced on a 9.0 in (288.6 mm) B.C.	(16) 0.780 in (19.8 mm) dia through holes equally spaced on a 13.0 in (330.2 mm) B.C.

TORKDISC® Rotary Torque Sensor System 1000 – 225k in-lb



The TORKDISC® and receiver make up a complete system. No additional signal conditioning is required. The receiver box provides voltage, frequency, and digital output via a 25-pin (F) D-sub connector.



Photo Courtesy of Mustang Dynamometer.

The robust construction, high stiffness, and low rotating inertia of the TORKDISC® make it ideal for applications such as chassis and engine dynamometers. The TORKDISC® system consists of a rotating sensor flange, a fixed receiving antenna, and a signal conditioning module. Torque is measured using a unique strain gage structure within the rotating flange. The measurement signal is then digitized, and is transmitted without wires to the receiving antenna. The signal is conditioned to a voltage, frequency, and digital output.



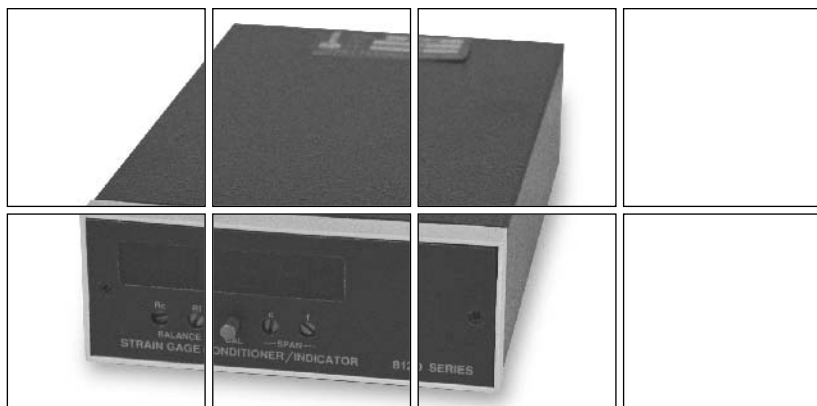
Photo Courtesy of Mustang Dynamometer.

Model 5308 Shown installed in chassis dynamometer.

Torque Sensor Accessories and Services

Highlights

- Strain gage signal conditioners
- Cable assemblies
- Speed sensors
- Shunt calibration modules and thermocouples
- Calibration services



Signal Conditioners For use with Torque or Speed Sensors

The Series 8120 family of signal conditioners are designed for use with either strain gage reaction torque sensors, strain gage rotary torque sensors, or Hall Effect speed (RPM) sensors. Within each category, the series offers a choice of either a basic signal

conditioner, signal conditioner with digital display, or signal conditioner with digital display and Hi-Lo set points. Each unit delivers a 0 to ± 5 Volts analog output signal.



Models: 8120-110A, 8120-130A, 8120-410A, 8120-430A, 8120-710A, and 8120-730A



Models: 8120-100A, 8120-400A, and 8120-700A

Available Signal Conditioner Options (Consult Factory)		Can be Combined with One of the Options Listed
B	12 Volt DC Power	P, C, G, R
P	Peak Capture	F, B
C	4 to 20 mA Current Output	F, B
F	230 VAC Power	P, C, G, R, S
G	± 10 Volt Output (0.1% FS Non-linearity)	F, B
R*	Dual Limits - Mechanical Relays	F, B
S*	Dual Limits - Solid State Relays	F
* Model 8120-X30A Only		
Supplied Accessories		
Star Bridge Sensor Simulator* (if precision shunt calibration module is not supplied)		
Mating Connector (if cable is not purchased)		
Power Cord		
* Hall Effect signal conditioners are not supplied with a star bridge, as they contain built-in crystal oscillators		

Sensor/Excitation	*Strain Gage DC Excitation (Reaction)	Strain Gage AC Excitation (Rotary)	Hall Effect (Speed)
Basic Signal Conditioner	8120-100A	8120-400A	8120-700A
Signal Conditioner with 4 1/2 digit LED display 3 Hz refresh rate	8120-110A	8120-410A	8120-710A
Signal Conditioner with LED display and Hi-Lo set points (TTL compatible)	8120-130A	8120-430A	8120-730A
Input transducers	90-2000 ohm	90-1000 ohm	0.1-200V
Excitation	5 or 10 VDC	2 VAC (RMS) @ 3.28 kHz	9 VDC
Accuracy	$\pm 0.05\%$ FS	$\pm 0.05\%$ FS	$\pm 0.05\%$ FS
Balance range	10 turn coarse and fine pots, ± 1.5 mV/V imbalance	10 turn coarse and fine pots, ± 1.5 mV/V imbalance	—
Span range	10 turn coarse and fine pots, 1 to 8 mV/V	10 turn coarse and fine pots, 0.5 to 5 mV/V	Selectable ranges of 0, 100, 200, 500, 1000, 2000, 5000, 10k, 20k, 50k
Active filter	Selectable 2, 200, 2000 Hz	Selectable 2, 400 Hz	2 Hz on input ranges of 0-500 Hz, 10 Hz on all other
Output ripple and noise	0.02% FS (RMS) with 2 Hz filter 0.15% all other filter ranges	0.02% FS (RMS) with 2 Hz filter 0.15% all other filter ranges	0.1% FS (RMS) from 20%-100% of input range
Input power	110/120 VAC @ 50-400 Hz, 9 watts max	110/120 VAC @ 50-400 Hz, 9 watts max	110/120 VAC @ 50-400 Hz, 9 watts max
Operating temp. range	0 to +130 °F (0 to +54 °C)	0 to +130 °F (0 to +54 °C)	0 to +130 °F (0 to +54 °C)
Weight (approx.)	2 lb (0.9 Kg)	2 lb (0.9 Kg)	2 lb (0.9 Kg)

* For additional signal conditioners for use with reaction torque sensors, see section 8

Recommended Cables and Accessories

Code	Model #	Description
12	8311-01-10A	Cable assembly for sensors with PT conn., 10-ft, PT conn. to pigtails, 4-cond. cable
13	8315-01-10A	Cable assembly for sensors with PC conn., 10-ft, PC conn. to pigtails, 4-cond. cable
14	8310-06-10A	Cable assembly for Series 4100 w/Series 8120, 10-ft, MS conn. to to card edge conn., 6-cond. cable
15	8310-09-10A	Cable assembly for Series 4200 w/Series 8120, 10-ft, MS conn. to to card edge conn., 8-cond. cable

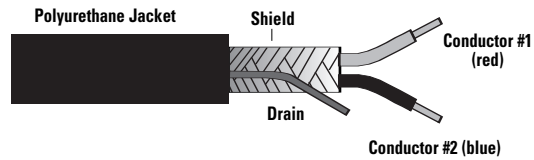
Speed Sensor Cables

Speed Sensor Cable Specifications and Standard Models

The following tables provide specifications and configuration diagrams for the variety of cable types available. Where applicable, standard cable assembly model numbers are provided. Standard models can be less costly than custom cables and available for immediate shipment. For alternate cable lengths or custom models, contact the factory.

General Purpose Twisted, Shielded Pair Cables

Usage		Construction	
General purpose, 2-conductor, twisted, shielded, pair cable with a black polyurethane jacket. Use with speed sensors.			
Outer Jacket	Polyurethane, black		
Diameter	0.25 in	6.35 mm	
Capacitance	36 pF/ft	118 pF/m	
Temperature Range	-58 to +250 °F	-50 to +121 °C	



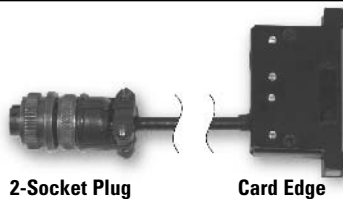
Standard Cable Assemblies for Passive Speed Sensors

Model #	Length (feet)	Length (meters)
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8312-01-05A	5 ft	1.5 m
8312-01-10A	10 ft	3.0 m
8312-01-20A	20 ft	6.1 m
8312-01-50A	50 ft	15.2 m

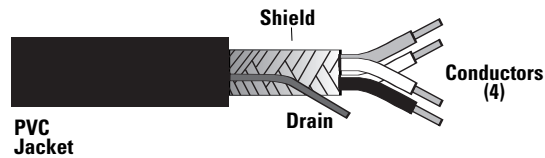


8312-02-05A	5 ft	1.5 m
8312-02-10A	10 ft	3.0 m
8312-02-20A	20 ft	6.1 m
8312-02-50A	50 ft	15.2 m



Twisted, Shielded, Four-Conductor Cables

Usage		Construction	
General purpose, use with speed sensors. 24AWG common stranded tinned copper drain wire, polypropylene insulated, twisted pair in a chrome PVC jacket.			
Outer Jacket	PVC, grey		
Diameter	0.168 in	4.27 mm	
Capacitance	35 pF/ft	44.3 pF/m	
Temperature Range	-4 to +140 °F	-20 to +60 °C	
Impedance	45 ohm		



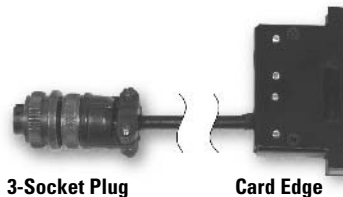
Standard Cable Assemblies For Active Speed Sensors

Model #	Length (feet)	Length (meters)
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8313-03-05A	5 ft	1.5 m
8313-03-10A	10 ft	3.0 m
8313-03-20A	20 ft	6.1 m
8313-03-50A	50 ft	15.2 m



8313-04-05A	5 ft	1.5 m
8313-04-10A	10 ft	3.0 m
8313-04-20A	20 ft	6.1 m
8313-04-50A	50 ft	15.2 m



Reaction Torque Sensor Cable Assemblies

Model #	Length (feet)	Length (meters)		
8314-20-05A	5 ft	1.5 m	 9-socket (F) D-sub	 Pigtails
8314-20-10A	10 ft	3.0 m		
8314-21-05A	5 ft	1.5 m	 15-pin (M) D-sub	 Pigtails
8314-21-10A	10 ft	3.0 m		

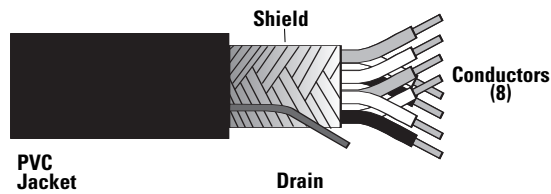
Eight-Conductor Cables

Usage







General purpose, use with reaction torque sensors. 24AWG common stranded tinned copper drain wire, polypropylene insulated, twisted pair in a chrome PVC jacket. Use when desired cable is ≥ 20 feet (6.1 m).

Outer Jacket	PVC, grey	
Diameter	0.363 in	9.22 mm
Capacitance	13.5 pF/ft	44.3 pF/m
Temperature Range	-4 to +140 °F	-20 to +60 °C
Impedance	100 ohm	

Construction



Standard Cable Assemblies

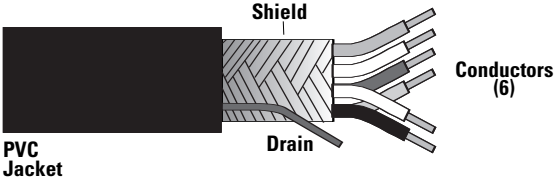
Model #	Length (feet)	Length (meters)		
8311-02-20A	20 ft	6.1 m	 PT	 Pigtails
8311-02-50A	50 ft	15.2 m		
8311-05-20A	20 ft	6.1 m	 PT	 Card Edge
8311-05-50A	50 ft	15.2 m		
8311-18-20A	20 ft	6.1 m	 PT	 9-pin (M) D-sub
8311-18-50A	50 ft	15.2 m		


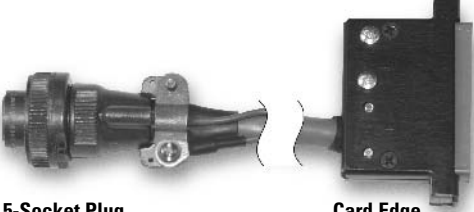
Rotary Torque Sensor Cable Assemblies

Recommended Rotary Torque Sensor Signal Conditioners and Cables		
	Signal Conditioners	
	8120 Series	Pigtails (other)
Rotary Torque Sensor Type	Recommended Cables	
Series 4100 Rotary Transformer Torque	8310-06-xxA	8310-03-xxA
Series 4200 Rotary Transformer Torque	8310-09-xxA	8310-11-xxA
"xx" indicates length in feet. Standard lengths include 5 ft (1.5 m), 10 ft (3 m), 20 ft (6.1 m), & 50 ft (15.2 m).		

Rotary Torque Sensor Cable Specifications and Standard Models

The following tables provide specifications and configuration diagrams for the variety of cable types available. Where applicable, standard cable assembly model numbers are provided. Standard models can be less costly than custom cables and available for immediate shipment. For alternate cable lengths or custom models, contact the factory.

Six-Conductor Cables				
Usage	Construction			
General purpose, use with rotary torque sensors. Aluminum polyester shielded 24AWG common stranded tinned copper drain wire, twisted pair in a PVC jacket.	 <p style="text-align: center;">PVC Jacket Shield Drain Conductors (6)</p>			
Outer Jacket			PVC, grey	
Diameter			0.359 in	9.12 mm
Capacitance			12.5 pF/ft	41.0 pF/m
Temperature Range			-4 to +140 °F	-20 to +60 °C
Impedance			100 ohm	

Standard Cable Assemblies			
Model #	Length (feet)	Length (meters)	
8310-03-20A	20 ft	6.1 m	 <p style="text-align: center;">5-Socket Plug Pigtails</p>
8310-03-50A	50 ft	15.2 m	
8310-06-05A	5 ft	1.5 m	 <p style="text-align: center;">5-Socket Plug Card Edge</p>
8310-06-10A	10 ft	3.0 m	
8310-06-20A	20 ft	6.1 m	
8310-06-50A	50 ft	15.2 m	

Rotary Torque Sensor Cable Assemblies

Eight-Conductor Cables

Usage

General purpose, use with rotary torque sensors. Aluminum polyester shielded 24AWG common stranded tinned copper drain wire, twisted pair in a PVC jacket.

Outer Jacket PVC, grey

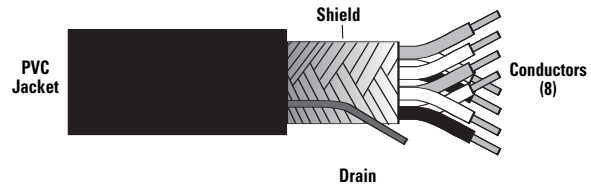
Diameter 0.359 in 9.12 mm

Capacitance 12.5 pF/ft 41.0 pF/m

Temperature Range -4 to +140 °F -20 to +60 °C

Impedance 100 ohm

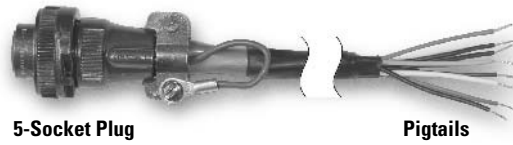
Construction



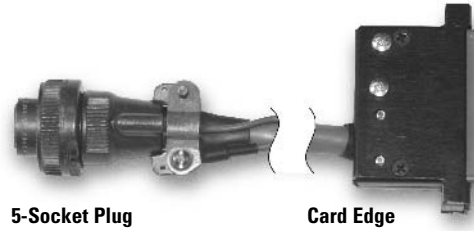
Standard Cable Assemblies

Model # Length (feet) Length (meters)

8310-11-05A	5 ft	1.5 m
8310-11-10A	10 ft	3.0 m
8310-11-20A	20 ft	6.1 m
8310-11-50A	50 ft	15.2 m



8310-09-05A	5 ft	1.5 m
8310-09-10A	10 ft	3.0 m
8310-09-20A	20 ft	6.1 m
8310-09-50A	50 ft	15.2 m



Speed Sensors

Speed sensors may be used with rotary torque sensors to provide a measurement of rotational speed. Horsepower can then be calculated using the speed and torque measurements by the following relationship:

$$HP = \frac{\text{Torque (in-lbs)} \times \text{RPM}}{63025}$$

These devices install into ports provided on Series 4100 and Series 4200 torque sensors. The output of a speed sensor switches in the presence of ferromagnetic material such as steel gear teeth.

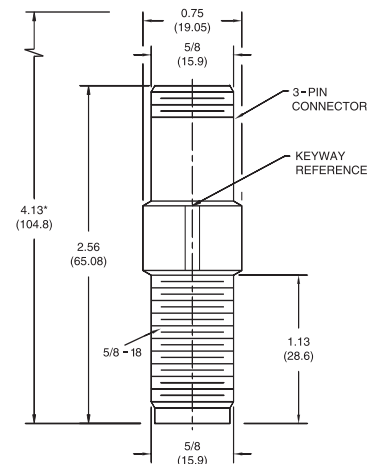
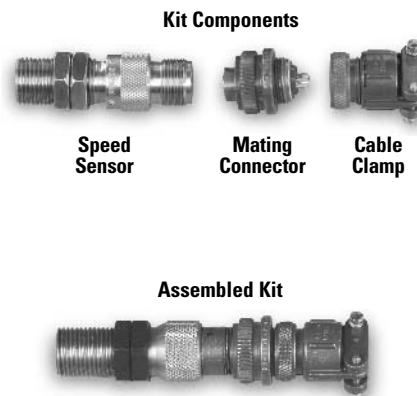
Output amplitude and wave-form are affected by gear speed and tooth shape.

Speed sensor gears are usually made with 60 teeth. A speed sensor used with a 60 tooth gear will have an output of 100 Hz for a shaft speed of 100 RPM.

Proper orientation of the sensor tip, relative to gear movement, is required. See drawing below for orientation information.

Model A-30775-1A — active speed sensor kit

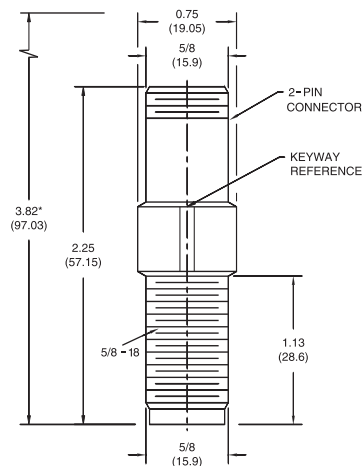
- Requires supply voltage
- 0 to 20,000 RPM max
- 3-pin connector



Active Speed Sensor
* Length with mating connector

Model A-30774A — passive speed sensor kit

- Self-generating
- 200 RPM to rated speed of torque sensor
- 2-pin connector



Passive Speed Sensor
* Length with mating connector

Speed Sensors Kits

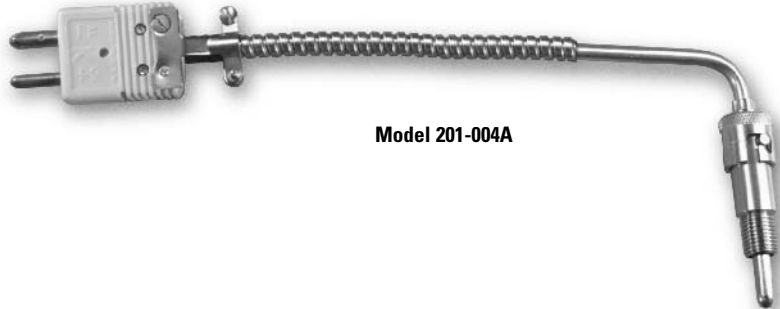
Model Number	Unit	A-30775-1A	A-30774A
Specifications			
Type		Active	Passive
Supply Voltage	VDC	5 to 15	Self-generating
Supply Current - typical	mA	15	—
Frequency Range	Hz	0 to 20k	200 to 20k
Output Voltage - logic 0	VDC	0.6 max	—
- logic 1	VDC	2.4 min	—
Output Voltage	V P-P	—	10 to 170
Supplied Accessories			
Mating Connector		180-021A (MS3106A-10SL-3S)	180-017A (MS3106A-10SL-4S)
Cable Clamp		180-018A (MS3057-4A)	180-018A (MS3057-4A)
Pin Out			
A		5 to 15 VDC	Signal Output
B		Signal	Signal Common
C		Common	—

Torque Sensor Accessories

Thermocouples — K-type

Thermocouples are offered as an option on our rotating torque sensors to monitor bearing temperatures.

A pre-drilled hole (3/8-24) is provided on each torque sensor for easy installation. Available Type "K" thermocouples are housed in 304 stainless steel and are supplied with a 5 feet long, 0.275 inch diameter (1.5 m, 7 mm) flexible steel armored cable.



Model 201-004A

Description	Model Number	Cold End Termination
Thermocouple with 90° bend	201-004A	2-pin male connector
Bayonet Adaptor (supplied with thermocouple for all other models)	201-002A	N/A
Bayonet Adaptor (supplied with thermocouple for Models 4115K and 4115A)	201-008A	N/A

Model 8113-105A — relay activated precision shunt calibration modules with built-in star bridge

- Supplied with all Series 4100 Rotary Transformer Torque Sensors
- Card edge connectors



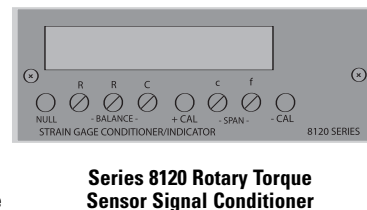
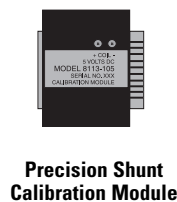
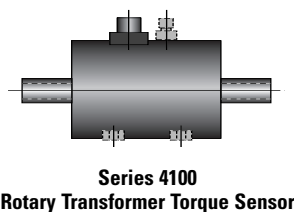
Card Edge Receptacle

Model 8113-105A

Precision Shunt Calibration Module (use with Series 4100 Rotary Transformers)

Shunt calibration modules provide a known resistance which produces a known signal that simulates an output from the strain gages in the torque sensor.

Typical Installation Including Shunt Calibration Module



PCB® maintains a completely equipped calibration laboratory for calibration and re-certification of strain gage based torque sensors, single axis load cells, and multi-axis transducers. These services are available for sensors manufactured by PCB® as well as other companies.

Calibrations and recertifications performed by PCB® are traceable to the National Institute of Standards and Technology (NIST) and conform to ISO/IEC 17025-1999 and ANSI/NCCL Z540-1-1994. PCB®'s calibration laboratory is accredited by The American Association for Laboratory Accreditation (A2LA) to ISO 17025 standards, as documented on the company's A2LA "Scope of Calibration".

The scope of our accreditation for torque sensors is:

Range	Best Uncertainty [1] (±)
10 to 25k in-lb (1.1 to 2.8k N-m)	0.04% FS
25k to 100k in-lb (2.8k to 11.3k N-m)	0.14% FS
100k to 300k in-lb (11.3k to 33.8k N-m)	0.09% FS

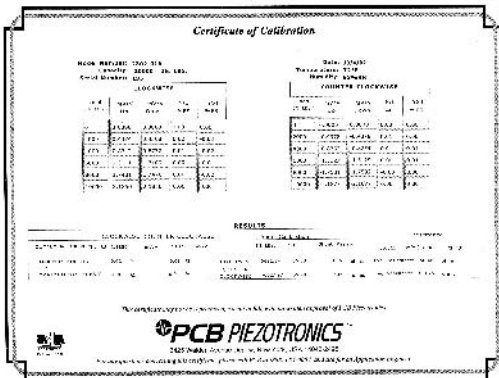
[1] Best uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor $k = 2$.



Cutaway view of a rotary transformer torque sensor with optional speed sensor installed.

Basic Calibration

Standard calibration services include five (5) ascending and descending points in the clockwise and counterclockwise directions for torque sensors. Charted calibration data is provided in a theoretical vs. actual format with mV/V, non-linearity, and hysteresis provided at each increment. Shunt calibration data is also provided along with a precision shunt calibration resistor. The standard calibration service includes a basic certificate of NIST traceability.



Torque Sensor Calibration Services

PCB Sensor	Competitor Sensor	
Calibration Code	Calibration Code	
TCS-1A	TCS-0	Calibration of torque sensor, 5-point, single bridge, up to 5000 in-lb (565 N-m)
TCS-1B	TCS-0	Calibration of torque sensor, 5-point, single bridge, above 5000 in-lb (565 N-m) and up to 30k in-lb (3400 N-m)
TCS-1C	TCS-0	Calibration of torque sensor, 5-point, single bridge, above 30k in-lb (3400 N-m) and up to 250k in-lb (28.2k N-m)
TCS-1D	TCS-0	Calibration of torque sensor, 5-point, single bridge, above 250k in-lb (28.2k N-m) and up to 500k in-lb (56.5k N-m)
TCS-2A	TCS-0	System calibration (torque sensor, signal conditioner, cable), 5-point, single bridge, up to 5000 in-lb (565 N-m)
TCS-2B	TCS-0	System calibration (torque sensor, signal conditioner, cable), 5-point, single bridge, above 5000 in-lb (565 N-m) and up to 30k in-lb (3400 N-m)
TCS-2C	TCS-0	System calibration (torque sensor, signal conditioner, cable), 5-point, single bridge, above 30k in-lb (3400 N-m) and up to 250k in-lb (28.2k N-m)
TCS-2D	TCS-0	System calibration (torque sensor, signal conditioner, cable), 5-point, single bridge, above 250k in-lb (28.2k N-m) and up to 500k in-lb (56.5k N-m)

Other calibration services available; contact factory for more information.



Photo Courtesy of Mustang Dynamometer.

Torque sensors are used for many non-automotive applications, such as motorcycles, agricultural vehicles, hydraulic pumps, motors, and lawn and garden equipment.

Torque Sensor Technical Information

Highlights

- Introduction to torque sensors
- Glossary of terms

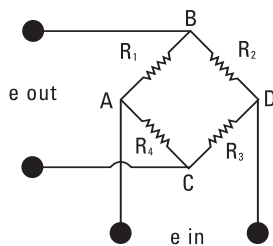


Figure 1.
Wheatstone Bridge

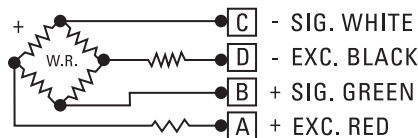


Figure 2.
Series 2300 Reaction Torque Sensor Wiring Code

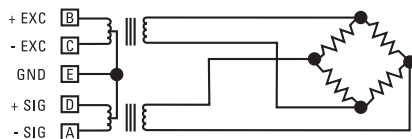


Figure 3.
Series 4100
Rotary Transformer Torque Sensor Wiring Code

Principle of Operation

All torque sensors manufactured by PCB® are strain gage based measuring instruments whose output voltage is proportional to applied torque. The output voltage produced by a resistance change in strain gages that are bonded to the torque sensor structure. The magnitude of the resistance change is proportional to the deformation of the torque sensor and therefore the applied torque.

The four-arm Wheatstone Bridge configuration shown in **Figure 1** depicts the strain gage geometry used in the torque sensor structures. This configuration allows for temperature compensation and cancellation of signals caused by forces not directly applied about the axis of the applied torque.

A regulated 5 to 20 volt excitation is required and is applied between points A and D of the Wheatstone bridge. When torque is applied to the transducer structure the Wheatstone bridge becomes unbalanced, thereby causing an output voltage between points B and C. This voltage is proportional to the applied torque.

Series 2300 reaction torque sensors have the wiring code illustrated in **Figure 2**. Series 4100 rotary transformer torque sensors have the wiring code illustrated in **Figure 3**. Series 4200 rotary transformer torque sensors have the wiring code illustrated in **Figure 4**.

Axis Definition

PCB® torque sensors comply with the Axis and Sense Definitions of NAS-938 (National Aerospace Standard-Machine Axis and Motion) nomenclature and recommendations of the Western Regional Strain Gage committee.

Axes are defined in terms of a “right-handed” orthogonal coordinate system, as shown in **Figure 5**.

The principal axis of a transducer is normally the z-axis. The z-axis will also be the axis of radial symmetry or axis of rotation. In the event there is no clearly defined axis, the following preference system will be used: z, x, y.

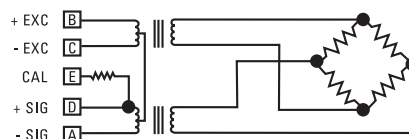


Figure 4.
Series 4200
Rotary Transformer Torque Sensor Wiring Code

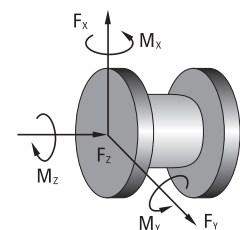


Figure 5.
Right-handed Orthogonal
Coordinate System

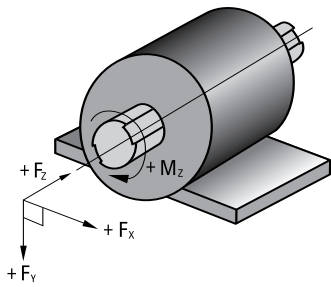


Figure 6.
Axis and Sense Nomenclature for Torque Sensors

The principal axis of a transducer is normally the z-axis. The z-axis will also be the axis of radial symmetry or axis of rotation. In the event there is no clearly defined axis, the following preference system will be used: z, x, y.

Figure 6 shows the axis and sense nomenclature for our torque sensors. A (+) sign indicates torque in a direction which produces a (+) signal voltage and generally defines a clockwise torque.

Torque Sensor Structure Design

Torque sensor structures are symmetrical and are typically manufactured from steel (SAE 4140 or 4340) that has been heat-treated Rc 36 to 38. Common configurations are solid circular shaft, hollow circular shaft, cruciform, hollow cruciform, solid square, and hollow tube with flats.

The solid square offers advantages over the solid circular design, especially in capacities greater than or equal to 500 in-lb (55 N-m). The solid square offers high bending strength and ease of application of strain gages. Torque sensors with capacities less than 500 in-lb (55 N-m) are usually of the hollow cruciform type. The hollow cruciform structure produces high stress at low levels of torque, yet has good bending strength. Common configurations are shown in **Figure 7**.

A variety of end configurations are available, including: keyed shaft, flange, and spline. (See below).

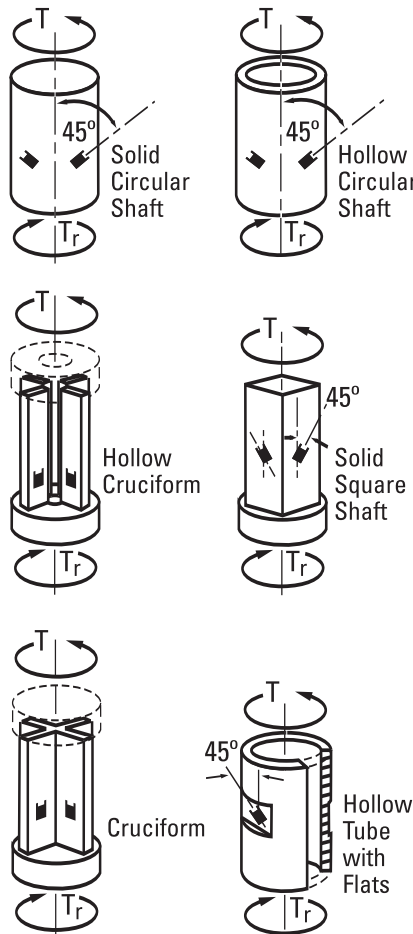


Figure 7.
Common Torque Sensor Configurations



Keyed Shaft



Spline Drive

Reaction Torque Sensors

Typical reaction torque sensor applications include:

- Bearing friction
- Starter testing
- Stepping switch torque
- Automotive brake testing
- Axle torsion test

Reaction torque is the turning force or moment, imposed upon the stationary portion of a device by the rotating portion, as power is delivered or absorbed. The power may be transmitted from rotating member to stationary member by various means, such as the magnetic field of a motor or generator, brake shoes or pads on drums or rotors, or the lubricant between a bearing and a shaft. Thus, reaction torque sensors become useful tools for measuring properties such as motor power, braking effectiveness, lubrication, and viscosity.

Reaction torque sensors are suitable for a wide range of torque measurement applications, including motor and pump testing. Due to the fact that these sensors do not utilize bearings, slip-rings, or any other rotating elements, their installation and use can be very cost effective. Reaction torque sensors are particularly useful in applications where the introduction of a rotating inertia due to a rotating mass between the driver motor and driven load is undesirable. An example of this can be found in small motor testing, where introduction of a rotating mass between the motor and load device will result in an error during acceleration. For these applications, the reaction torque sensor can be used between the driver motor, or driven load, and ground. An added benefit is that such an installation is not limited in RPM by the torque sensor. PCB® manufactures reaction torque sensors with capacities ranging from a few inch ounces to 500k in-lb (56.5k N-m), in configurations including keyed shaft and flange.

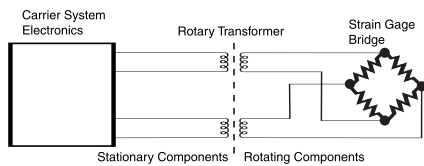


Figure 8.

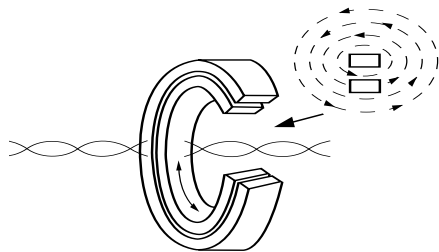


Figure 9.

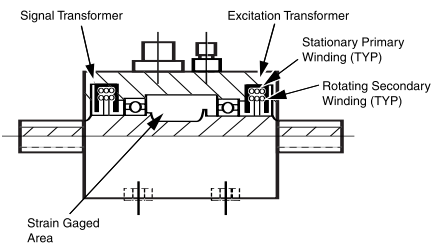


Figure 10.
Rotary Transformer Torque Sensor Diagram

Rotary Torque Sensors

Typical rotary torque sensor applications include:

- Chassis dynamometer
- Engine dynamometer
- Efficiency testing
- Clutch testing
- Blower or fan testing
- Small motor / pump testing

Rotating torque sensors are similar in design and in application to reaction torque sensors, with the exception that the torque sensor is installed in-line with the device under test. Consequently, the torque sensor shaft rotates with the device under test. In PCB® Series 4100 and 4200 models, the rotating torque sensor shaft is supported in a stationary housing by two bearings. Signal transfer between the rotating torque sensor shaft and the stationary housing is accomplished by means of rotary transformers.

Rotary Transformers

Rotary Transformers provide a non-contact means of transferring signals to and from the rotating torque sensor structure. Rotary transformers are similar to conventional transformers, except that either the primary and secondary winding is rotating. For rotating torque sensors, two rotary transformers are used. One serves to transmit the excitation voltage to the strain gage bridge, while the second transfers the signal output to the non-rotating part of the transducer. Thus no direct contact is required between the stationary and rotating elements of the transducer (see **Figure 8**).

Rotary transformers are made up of a pair of concentrically wound coils, with one coil rotating within or beside the stationary coil. The magnetic flux lines are produced by applying a time varying voltage (carrier excitation) to one of the coils (see **Figure 9**).

Figure 10 depicts a typical rotary transformer torque sensor:

Transmission of energy through any transformer requires that the current be alternating. A suitable signal conditioner with carrier excitation in the range of 3 to 5000 Hz is required to achieve this.

Mechanical Installation of Keyed Shaft Torque Sensors

Proper installation must be observed when assembling a torque sensor into a driveline. Careful selection of components must be made so that problems are not created which could lead to part failure or danger to personnel.

Shaft misalignment

Provision must be made to eliminate the effects of bending and end loading on the torque sensors shaft due to parallel offset of shafts, angular misalignment, and shaft end float. The proper use of couplings can reduce these problems to a negligible level.

All shafts must first be aligned mechanically, as accurately as possible, to lessen the work the couplings must do. Alignment within 0.001 inch per inch of shaft diameter is normally satisfactory, however, for some critical applications such as high speed, this level of alignment is not acceptable, and a tighter tolerance must be achieved. Please contact our factory, or your coupling vendor, for information regarding your application.

Torque sensor with foot-mounted housing installation

A foot-mounted torque sensor has a plate on its housing, which can be securely attached to a machine base or bedplate. This installation reduces the mass in suspension on the couplings and can increase the shaft's critical speed, if the torque sensor is within its speed rating. Normally, if both the driving and load sources are fully bearing-supported in foot-mounted housings, and the torque sensor housing is foot-mounted, double-flex couplings should be used on each shaft end. Double-flex couplings provide for two degrees of freedom, meaning they can simultaneously allow for angular and parallel misalignment, and reduce the effects of bending on the torque sensor shaft. Half of each coupling weight is supported on the torque sensor's shaft, and the other half is carried by the driving and load shafts.

Torque sensor with floating shaft installation

A floating shaft torque sensor does not have a foot-mount plate on the housing, nor is the housing affixed to a bedplate in any other fashion. It depends on being carried by the driver and load shafts for its support. The housing, which is meant to remain stationary and not rotate with the shaft, must be restrained from rotating with a conductive flexible strap. Tapped threaded holes are provided on the side of the housing for this purpose. The other end of the strap is bolted to a bedplate or other stationary-grounded member, which will electrically ground the torque sensor housing to the electrical system ground.

Therefore, with the floating shaft, there is just one degree of freedom between each shaft end of the torque sensor and the adjacent mating shaft, which is bearing-supported (driver and load shafts) on the bedplate. Consequently, a single flex coupling is required at each end of the torque sensor.

Error Analysis

PCB® typically supplies accuracy information on its products in the form individual errors. They are non-linearity, hysteresis, non-repeatability, effect of temperature on zero unbalance, and effect of temperature on output.

The customer can combine these individual errors to establish the maximum possible error for the measurement, or just examine the applicable individual error. If the temperature remains stable during the test, the temperature related errors can be ignored. If the sensor is used for increasing load measurement only, ignore the hysteresis error. If the load measurement is near the full capacity, the linearity error can be ignored. If the capability exists to correct the data through linearization-fit or a look-up-table, the error in the measurement can be minimized. A sophisticated user can get rid of all the errors except for the non-repeatability error in the measurement.

Often overlooked by the customer is error due to the presence of non-measured forces and bending moments. Even though the single axis of measurement sensors are designed and built to withstand these non-measured forces and bending moments (extraneous loads), the errors due to them are present. The user can design the set-up to eliminate or minimize these extraneous loads. However, if these extraneous loads are present, the errors due to them should be considered.

Application Questionnaire

Determine the capacity required

- A. What is the maximum expected torque, including transients?
- B. What is the minimum expected torque?
- C. What is the typical expected torque?
- D. What are the dynamics of the system, (i.e. frequency response)?
- E. What are the maximum extraneous loads to which the torque sensor will be subjected?

How will the torque sensor be integrated into the system?

- A. What are the physical constraints, (e.g. length, diameter)?
- B. Will the torque sensor be foot-mounted or floated?
- C. Couplings, torsionally stiff, or torsionally soft?

What type of environment will the torque sensor be operating in?

- A. Maximum temperature?
- B. Minimum temperature?
- C. Humidity?
- D. Contaminants, (e.g. water, oil, dirt, dust)?

What speed will the torque sensor be required to rotate?

- A. What length of time will the torque sensor be rotating, and at what speed?

Accuracy —

Stated as a limit tolerance, which defines the average deviation between the actual output versus theoretical output.

In practical transducer applications, the potential errors of non-linearity, hysteresis, non-repeatability and temperature effects do not normally occur simultaneously, nor are they necessarily additive.

Therefore, accuracy is calculated based upon RMS value of potential errors, assuming a temperature variation of ± 10 °F (± 5.5 °C), full rated load applied, and proper set-up and calibration. Potential errors of the readout, cross-talk, or creep effects are not included.

Ambient Conditions —

The conditions (humidity, pressure, temperature, etc.) of the medium surrounding the transducer.

Ambient Temperature —

The temperature of the medium surrounding of transducers.

Calibration —

The comparison of transducer output against standard test loads.

Calibration Curve —

a record (graph) of the comparison of transducer output against standard test loads.

Combined Error (Non-linearity & Hysteresis) —

the maximum deviation from a straight line drawn between the original no-load and rated load outputs expressed as a percentage of the rated output and measured on both increasing and decreasing loads.

Compensation —

The utilization of supplementary devices, materials, or processes to minimize known sources of error.

Creep —

The change of transducer output occurring with time, while under load, and with all environmental conditions and other variables remaining constant.

Note: Usually measured with rated load applied and expressed as a percent of rated output over a specific period of time.

Creep Recovery —

The change in no-load output occurring with time, after removal of a load, which has been applied for a specific period of time.

Cross-talk —

With one component loaded to capacity, and the other unloaded, the output of the unloaded component will not exceed the percentage specified of its full-scale capacity.

Deflection —

The change in length along the primary axis of the load cell between no-load and rated load conditions.

Drift —

A random change in output under constant load conditions.

Error —

The algebraic difference between the indicated and true value of the load being measured.

Excitation, Electrical —

The voltage or current applied to the input terminals of the transducer.

Fatigue Capacity —

Capacity as percentage of the nominal load limit capacity, and based on 100 X 10⁶ cycles (minimum) from zero to full fatigue capacity and 50 X 10⁶ cycles (minimum) from full fatigue capacity tension to full fatigue capacity compression load.

Hysteresis —

The maximum difference between the transducer output readings for the same applied load, one reading obtained by increasing the load from zero and the other by decreasing the load from rated load.

Note: Usually measured at half rated output and expressed in percent of rated output. Measurements should be taken as rapidly as possible to minimize creep.

Insulation Resistance —

The DC resistance measured between the transducer circuit and the transducer structure.

Note: Normally measured at fifty volts DC and under standard test conditions.

Natural Frequency —

The frequency of free oscillations under no-load conditions.

Nominal Load Limit Capacity —

It is the designed normal maximum capacity of a transducer. Output sensitivity of the transducer is based on this capacity unless specified.

Non-linearity —

The maximum deviation of the calibration curve from a straight line drawn between the no load and rated load output, expressed as a percentage of the rated output and measured on increasing load only.

Output —

This signal (voltage, current, etc.) produced by the transducer.

Note: Where the output is directly proportional to excitation, the signal must be expressed in terms of volts per volt, volts per ampere, etc. of excitation.

Output, Rated —

The algebraic difference between the outputs at no-load and at rated load.

Overload Rating —

The maximum load in percent of rated capacity, which can be applied without producing a permanent shift in performance characteristics beyond those specified.

Primary Axis —

The axis along which the transducer is designed to be loaded; normally its geometric centerline.

Rated Capacity (Rated Load) —

The maximum axial load that the transducer is designed to measure within its specifications.

Repeatability —

The maximum difference between transducer output readings for repeated loading under identical loading and environmental conditions.

Resolution —

The smallest change in mechanical input, which produces a detectable change in the output signal.

Sensitivity —

The ratio of the change in output to the change in mechanical input.

Shunt Calibration —

Electrical simulation of transducer output by insertion of known shunt resistors between appropriate points within the circuitry.

Shunt-to-load Correlation —

The difference in output readings obtained through electrically simulated and actual applied loads.

Standard Test Conditions —

The environmental conditions under which measurements should be made, when measurements under any other conditions may result in disagreement between various observers at different times and places. These conditions are as follows:

Temperature 72 °F ± 3.6 °F (23 °C ± 2 °C)

Relative Humidity: 90% or less

Barometric Pressure: 28 to 32 inch Hg

Static Extraneous Load Limits —

Static Extraneous Load Limits are calculated such that only one extraneous load (Fx or Fy or Mx or My or Mz) can be applied simultaneously with 50% of the nominal load limit applied.

Temperature Effect on Output —

The change in output due to a change in transducer temperature.

Note: Usually expressed as a percentage of load reading per degree Fahrenheit change in temperature.

Temperature Effect on Zero Balance —

The change in zero balance due to a change in transducer temperature.

Note: Usually expressed as the change in zero balance in percent of rated output per degrees Fahrenheit (change in temperature).

Temperature Range, Compensated —

The range of temperature over which the transducer is compensated to maintain rated output and zero balance within specified limits.

Temperature Range, Usable —

The extremes of temperature within which the transducer will operate without permanent adverse change to any of its performance characteristics.

Terminal Resistance —

The resistance of the transducer circuit measured at specific adjacent bridge terminals at standard temperature, with no-load applied, and with the excitation and output terminals open-circuited.

Terminal Resistance, Excitation —

The resistance of the transducer circuit measured at the excitation terminals, at standard temperature, with no-load applied, and with the output terminals open-circuited.

Terminal Resistance, Signal —

The resistance of the transducer circuit measured at the output signal terminals, at standard temperature, with no-load applied, and with the excitation terminals open-circuited.

Traceability —

The step-by-step transducer process by which the transducer calibration can be related to primary standards.

Zero Balance —

The output signal of the transducer with rated excitation and with no-load applied, usually expressed in percent of rated output.

Zero Return —

The difference in zero balance measured immediately before rated load application of specified duration and measured after removal of the load, and when the output has stabilized.

Zero Shift, Permanent —

A permanent change in the no-load output.

Zero Stability —

The degree to which the transducer maintains its zero balance with all environmental conditions and other variables remaining constant.

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Technical Articles

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