Honeywell

Effectively Using Pressure, Load, and Torque Sensors with Today's Data Acquisition Systems

Utilizing high quality pressure, load, and torque sensors, and selecting the correct design and installation for the application are critical to ensuring data integrity for the measurement system. To be successful, the following information must be understood:
- **The basic operating parameters of pressure, load, and torque sensing technology**
- **The specific benefits of test validation and low test error by utilizing pressure, load, and torque sensors in demanding test and measurement applications**
- **The value to the customer utilizing quality outputs from sensors, combined with ease of connectivity and setup to modern data acquisition systems (DAS)**

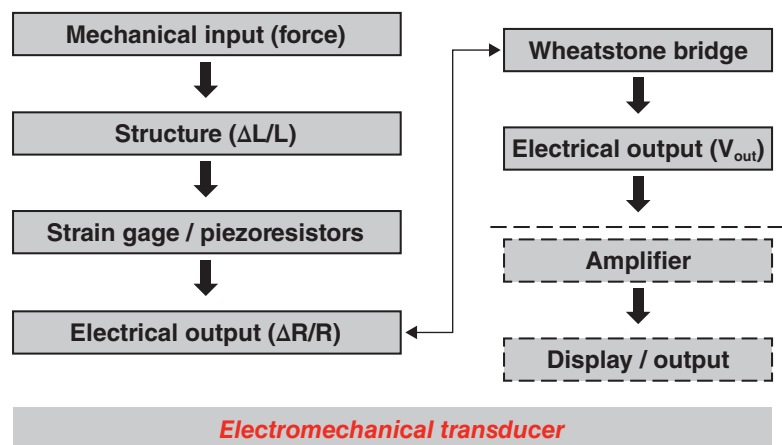## Basic Pressure, Load, and Torque Sensor Theory

Pressure, load and torque sensors consist of specially designed structures, that perform in a predictable and repeatable manner when force is applied (i.e., a very slight deflection). This force is translated into a signal voltage by the resistance change of the strain gages, organized in an electrical circuit and, applied to the load cell structure. A change in resistance indicates the degree of deflection and, in turn, the load on the structure.

The electrical circuit consists of strain gages or piezoresistors (silicon-based platform), typically connected in a four-arm (Wheatstone Bridge) configuration. This acts as an adding and subtracting electrical network and allows compensation for temperature effects as well as cancellation of signals caused by extraneous loading.

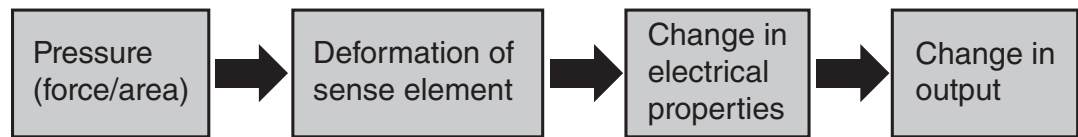The basic output is a low level voltage signal (i.e., mV), but through the use of signal conditioning and amplifiers, this signal can become a higher level voltage or current (i.e., 0 V to 5 V, 0 V to 10 V or 4 mA to 20 mA). These signals can be used to drive a digital/analog display, be part of a monitoring system, or form part of a closed loop feedback control system. The low level signal can also be converted into a digital output (i.e., RS-232, RS-485). However, USB is becoming increasingly popular.

Mechanical input (force) → Structure (ΔL/L) → Strain gage / piezoresistors → Electrical output (ΔR/R) → Wheatstone bridge → Electrical output (V$_{out}$) → Amplifier → Display / output

Electromechanical transducer

Understanding Pressure Sensors

Pressure is the force per unit area exerted by a fluid or gas. The recognized International System of Units (SI) for pressure measurement is the Pascal (Pa); however, pounds per square inch (psi), inches of water (in-H_2O), Newtons per millimeter squared (N/mm^2) and Bar are also common.

The most critical mechanical component in any pressure transducer is generally the pressure sensing structure (spring element). The pressure of the fluid or gas is a force on the pressure sensing structure. The function of the structure is to serve as the reaction for this applied force; and, in doing so, to focus the effect of the force into an isolated uniform strain field where strain gages can be placed for pressure measurement.

Pressure (force/area) ➡ Deformation of sense element ➡ Change in electrical properties ➡ Change in output

While there are various types of pressure sensing technologies, two will be discussed in this paper: Piezoresistive-Type Pressure and Foil-Based Pressure.
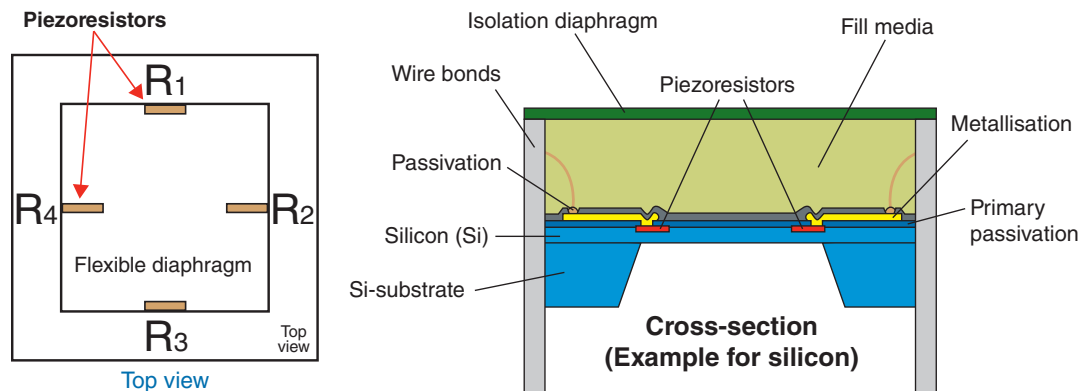
Piezoresistive-Type Pressure

In piezoresistive-type pressure sensors, the transduction elements which convert the stress from the diaphragm deflection into an electrical signal are called piezoresistors. Piezoresistance equals changing electrical resistance due to mechanical stress. The pressure sensing element is a diaphragm which is made from silicon. This silicon diaphragm is attached to a glass sub-structure (i.e., that acts as a constraint/mounting structure for the silicon). This silicon diaphragm structure performs in a predictable and repeatable manner as the pressure is applied (i.e., a very slight deflection in the structure). This pressure is translated into a signal voltage by the resistance change of the strain gages which are doped (i.e., implanted) onto the silicon diaphragm surface, then organized in an electrical circuit.

The silicon diaphragm, with the exposed doped Wheatstone Bridge, in test and measurement pressure sensors, is isolated from the pressure media being measured (i.e., media isolated pressure sensors). This is achieved by creating a cavity between the media being measured and the silicon diaphragm, then filling it with oil that does not attack the silicon or electrical circuit. On the opposite side of the cavity is a metal/steel diaphragm that is flexible to transmit the pressure being measured to the oil in the cavity, and the silicon diaphragm. This metal/steel diaphragm is called the isolating diaphragm.

This technology is used to measure pressures from inches of water (in-$H_2$0) to 10,000 psi (6.9 kPa to 69 MPa). *Note: 1kPa = 1 N/m^2.*

At a very top level, this technology can be described as a pressure sensor consisting of a micro-machined silicon diaphragm with piezoresistive strain gages diffused into it, fused to a silicon or glass back plate. Pressure induced strain increases or decreases the value of the resistors (i.e., strain gages). This resistance change can be as high as 30 %, that typically yields one of the higher outputs from a pressure sensing technology. The resistors are connected as a Wheatstone Bridge, and the output of which is directly proportional to the pressure.



Top view

Cross-section
(Example for silicon)

As shown above, typically four piezoresistors are used (connected in a Wheatstone Bridge circuit) to provide an output, that primarily changes with pressure.

Gaged diaphragm
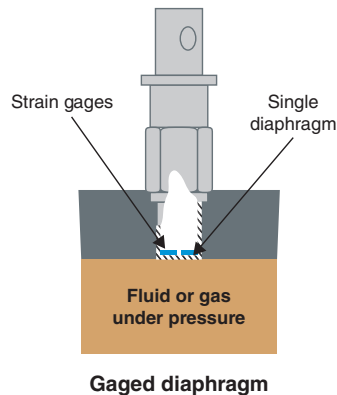
Foil-Based Pressure Sensors

Another common type of pressure sensor utilizes a bonded foil strain gage to measure an applied pressure in one of two ways. In some models, such as miniature pressure sensors, foil strain gages are bonded to the back of a steel diaphragm that is exposed to the media being measured. The diaphragm structure performs in a predictable and repeatable manner as the pressure is applied (i.e., a very slight deflection in the structure). This pressure is translated into a signal voltage by the resistance change of the strain gages, arranged strategically around the diaphragm surface, and is organized in an electrical circuit. (See image at left.)

**Gaged force sensor with
mechanical transmitter**
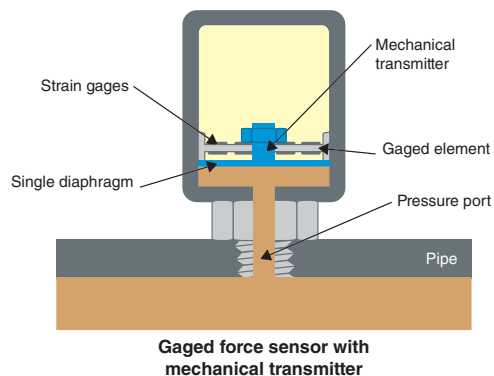
However, in many other models, the foil strain gages are bonded to an element that is mechanically connected to a diaphragm, then exposed to the media being measured. The strain gaged element is measuring the force transmitted from the diaphragm by the mechanical linkage. This element acts as a load cell (i.e., designed to measure force that is directly proportional to the load applied to the diaphragm). (See image at left.)

This technology is typically used to measure pressures from 10 psi 174,000 psi (69 kPa to 1,206 MPa). *Note: 1kPa = 1 N/m^2.*

Understanding Load Cells

The recognized SI unit of measure for force/load is the Newton (N). Load cells measure force directly and accurately. Strain gages are the measurement tools within the cell. The most critical mechanical component in any load cell or strain gage transducer is generally the structure (spring element). The function of the structure is to serve as the reaction for the applied load, and focus the effect of the load into an isolated uniform strain field where strain gages can be placed for load measurement.

There are three common load cell structure designs: multiple-bending beam, multiple-column, and shear-web, that form the basic building blocks for all possible load cell profiles and/or configurations. The load cell structure (spring element) materials are typically, but not limited to, carbon steel, stainless steel, or aluminum.
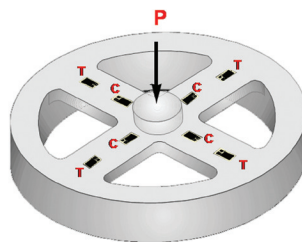

Multiple-Bending Beam Load Cells
are low capacity (between 20 and 22K Newtons) and feature a wheel-shaped spring element, that is adaptable to low profile transducers, and four active gages or sets of gages per bridge arm, with pairs subjected to equal and opposite strains (beam in bending).
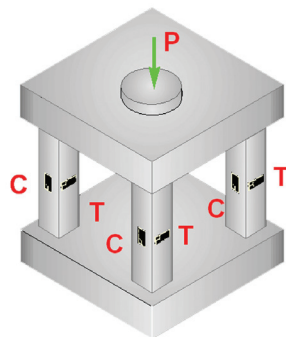
Multiple-Column Load Cells
are high capacity (between 110K and 9M Newtons) and consist of multiple columns for the increased capacity. In this design, there are four active gages or sets of gages per bridge arm, in a uni-axial stress field -- two aligned with maximum principal strain, and two "Poisson" gages (column).
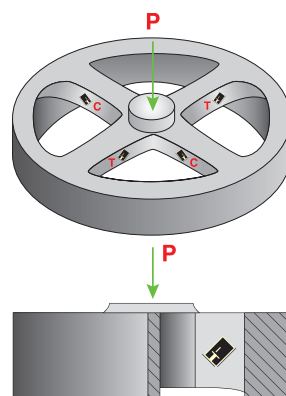
Shear-Web Load Cells
have a capacity between 2K and 1M Newtons and feature a structure in a wheel form with radial webs subject to direct shear. There are four active gages or sets of gages per bridge arm, with pairs subjected to equal and opposite strains (beam in bending).
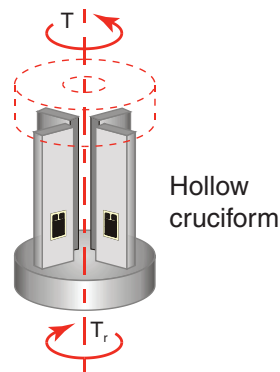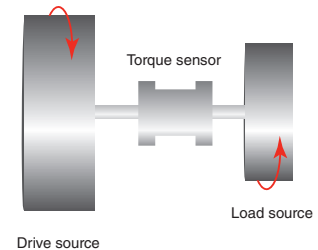

Load cells have "duty cycle" ratings. Fatigue-rated load cells are specially designed to withstand many millions of load cycles with no effect on the load cell performance. They are typically designed to achieve 50 to 100 million fully reversed load cycles, depending on the load level and amplitude. General-purpose load cells are designed to be used in static or low cycling frequency load applications. They typically survive up to 1 million cycles dependent on the load level and transducer material.
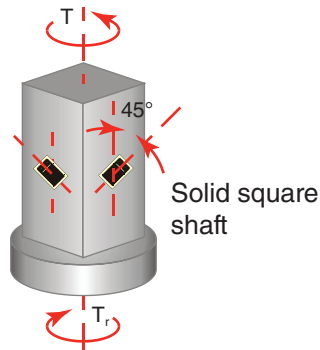
Understanding Torque

The recognized SI unit of measure for torque is Newton Meters (Nm). The simple definition for torque is: torque = force x distance, with a clockwise torque (twist) or a counter-clockwise torque (or twist). This provides either a positive or negative output from the Wheatstone Bridge.

A torque sensor measures the twist or windup between a rotating drive source and a load source. The four main types of torque sensors designs are:
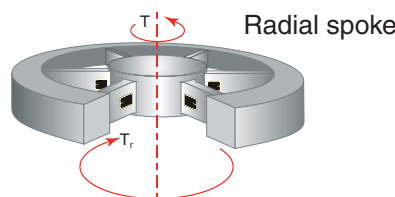
- hollow cruciform
- solid square shaft
- radial spoke
- hollow tubular

Torque sensor

Load source

Drive source

Hollow cruciform

A hollow cruciform design is basically a multiple-bending beam hollowed out in the middle. It is usually recommended for capacity ranges of 22 Nm (200 lb-in) and under. Advantages of the hollow cruciform design:

- Excellent for low capacity ranges
- Bending beam characteristic enhances predictability
- Less susceptible to bending moments, allowing for high signal output at low capacity ranges
- Allows adaptation to several mechanical configurations such as flange mount or circular keyed shaft
- Hollow center offers a through-hole access point for components such as wires, a tube or shaft

Solid square shaft

The solid square shaft design features gage positioning at a 45 degree angle and is usually recommended for torque capacities of 56 Nm (500 lb-in) and up. Advantages of the solid square shaft design over circular shaft:

- Easier for gaging
- Increased bending strength

The radial spoke design features strain gages that are placed on the radial spoked beams where torque is transitioned from the inner hub and outer hub connection points. This design can be used for a variety of torque ranges. Advantages of the radial spoke design:


Radial spoke

- Versatile, low-profile design allows it to adapt to many installations and configurations
- Radial spoke characteristics make it extremely predictable
- Greater insensitivity to bending loads
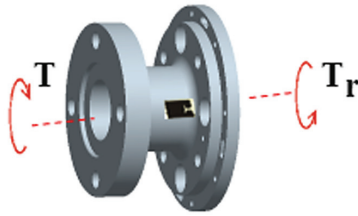
The hollow tubular design is a one-piece construction consisting of outer flanges and a center tube section. The gages are applied to the tube section, either on the inside or outside. This design is usually used for torque capacity ranges from 68 Nm (50 lb-ft) and up.

Advantages of the hollow tube design include:

- Simple, versatile design with:
  - Broad capacity ranges
  - Compact end-to-end length
  - Adaptability to many installations
- High resistance to bending moment and thrust loads
- Offers low mass and low rotating inertia
- High torsional stiffness
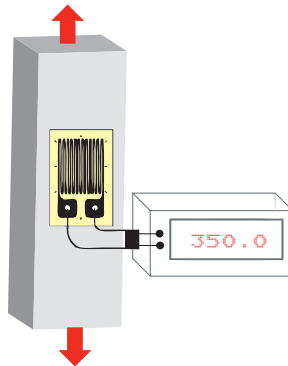
Wheatstone Bridge (Electrical Circuits)

The different designs for pressure, load and torque sensors become a transducer with the utilization of the Wheatstone Bridge. As can be seen on the figure on the left, when a force is applied (i.e., in this case a tensile force) to a structure with a single strain gage bonded to it (could also be a piezoresistive gage doped to a silicon substrate), the induced strain field will cause a resistance change (ΔR) in the gage (i.e., in this case, an increase in resistance). So we can see that strain ε is equal to the change in length of the structure (ΔL) divided by the original length (L) of the structure, which in turn is proportional to the change in resistance (ΔR) divided by the original resistance (R) when no force is applied.

$$\textbf{\textit{Strain}} = \varepsilon = \frac{\Delta L}{L} \propto \frac{\Delta R}{R}$$

A measure of this conversion from strain to resistance is called the Gage Factor (F), and it can be defined as the ratio of change in resistance, divided by the ratio of change in length of the structure, which is the strain induced in the element.

$$\textbf{\textit{Gage Factor}} = F = \frac{\dfrac{\Delta R}{R}}{\dfrac{\Delta L}{L}} = \frac{\dfrac{\Delta R}{R}}{\varepsilon} \longrightarrow \Delta R = RF\varepsilon$$

In a load cell (also applies to pressure and torque sensors), these strain gages are strategically placed on the force sensing element, and wired in such a fashion to make up the electrical circuit called a Wheatstone Bridge. The gages are placed to ensure that some of the resistance changes are increasing (+ resistance), and some are decreasing (- resistance). The end result is to unbalance the output of the bridge which will be proportional to the force applied to the load cell structure.

The Wheatstone Bridge is powered by a fixed input voltage (V in), which is typically, but not limited to, 0 Vdc to 10 Vdc applied across points A and C, and the output from the bridge is measured as a voltage between points B and D. In the unloaded condition, the output voltage (V out) measured between points B and D will be approximately 0, and when the full scale load is applied, the output voltage (V out) is measured in millivolts (mV).

Typically the sensitivity of a load cell is 2mV/V (i.e., if the input voltage was 10 V, then the output would be 20 mV in the fully loaded condition). However, load cells are designed with varying sensitivities, depending on such factors as the material of the load cell structure and the application.

+ increased resistance = increased output
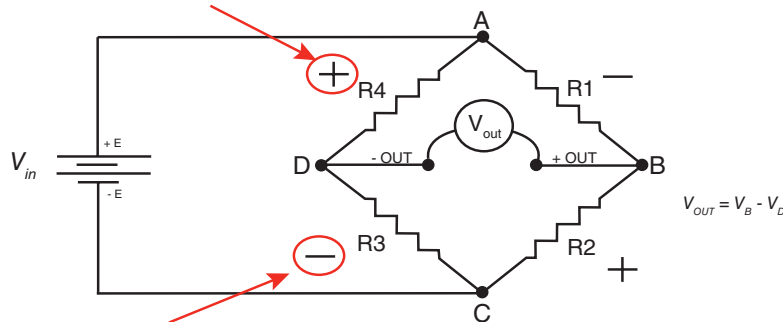
- decreased resistance = increased output

$$V_{OUT} = V_B - V_D$$

## Types of Pressure Sensors

In addition to the various sensor categories and designs available, there are a multitude of specific types within each sensor category. Pressure measurement applications can be divided as follows:

- **Absolute:** This is the pressure measured as referenced to an absolute vacuum. An example would be a barometer that measures the absolute pressure of the atmosphere.

- **Gage:** This is the pressure measured as referenced from an atmospheric pressure to a pressure being measured. An example would be a pressure gauge on a process pipeline.

- **Sealed Reference:** Very similar to gage pressure, except the back side of the sensing element is sealed during the fabrication of the sensor. The gage pressure is now a measure from this reference atmospheric pressure to the pressure being measured. This type of sensor will be susceptible to changes in atmospheric pressure and will give significant error measurements at lower pressures. More suited for higher pressure applications where the sensor has to be sealed from the environment (i.e., eliminating fluid or gas ingress).

- **Vacuum**: Similar to gage pressure, except the pressure in the system is below atmospheric pressure.

- **Differential:** This is the pressure difference measured between two different pressures. Typically wet/dry differential pressure is a measure of a liquid on the sealed side of the sensing element, and a dry gas on the back exposed side of the sensing element. Wet/wet differential pressure is typically a measure of two liquids, and both sides of the sensing element is isolated from the media.

Pressure Measurement Types
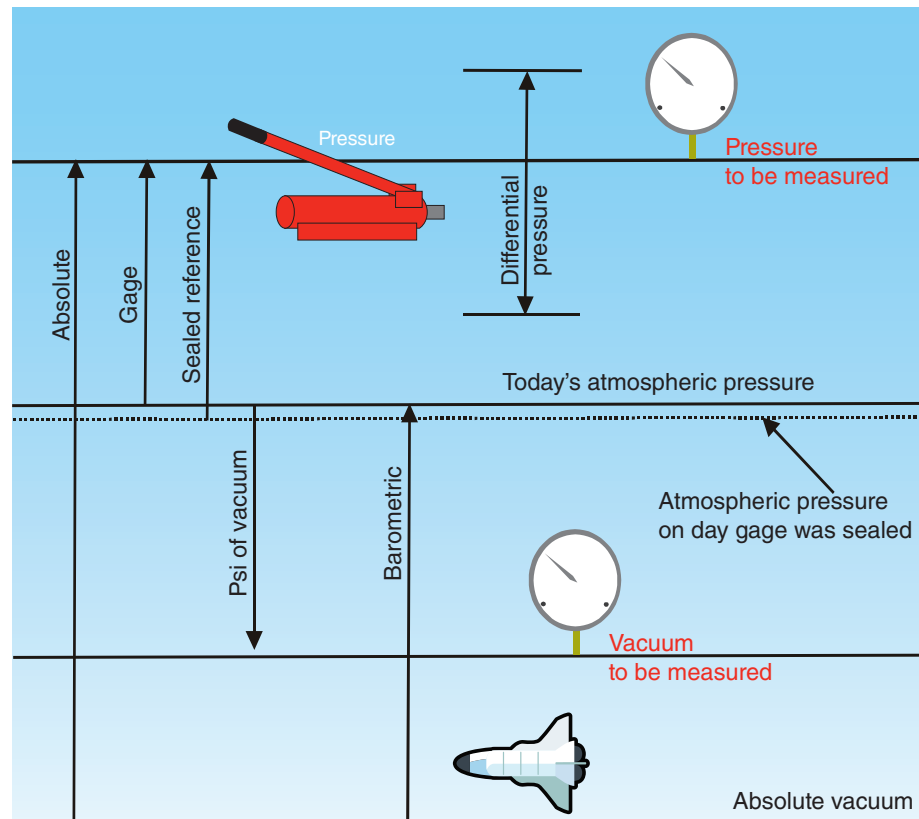
Diaphragm deflection for each of the different pressure reference types
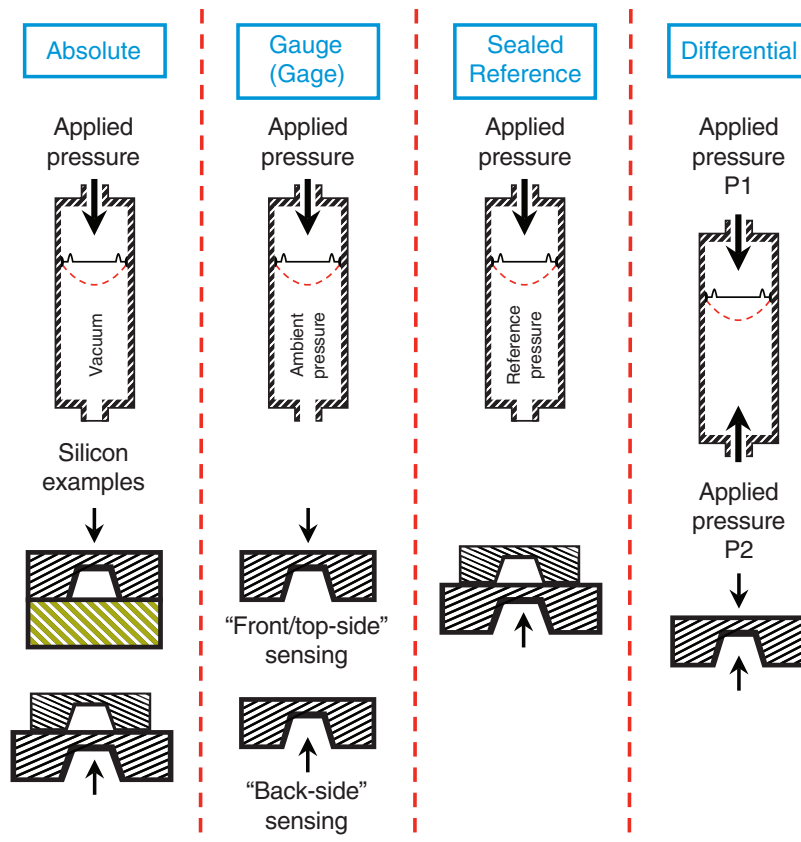
Types of Load Cells

Load cell types include various versions of bending beam, shear beam and column designs. Variations of form factors based off basic load cell designs may also be seen (as previously discussed in the Understanding Load Cells section of this paper).

Bending beam load designs include:
- Single-point weighbeam
- Bending beams with bellows
- Canister type
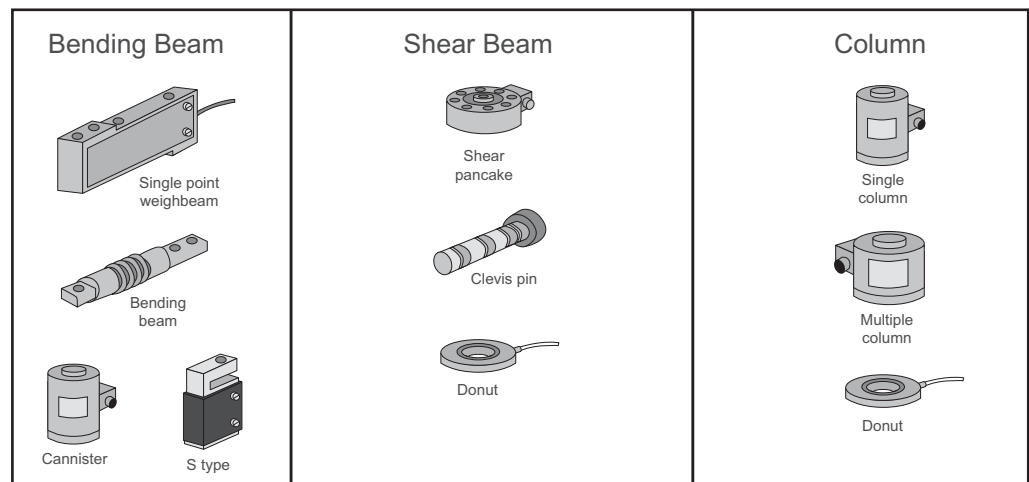- S-type
- Lower capacity low profile/pancake style

Shear web load designs include:
- Shear pancake/low profile - general purpose
- Shear pancake/low profile - fatigue-rated
- Clevis pins
- Donut cells (lower capacity)

Column load designs include
- Single-column canister
- Multi-column canister - fatigue rated
- Donut cells (higher capacity)

Load cells can be designed using any of these configurations for compression-only forces, or they can be designed to measure both a tension and compression (push / pull) force. The tension and compression load cells usually feature center female threads on top and bottom for fixturing, but could also have male to male threads or even a mixture of one female and one male thread. The type of load cell chosen for an application will relate to the type physical mounting requirements or constraints. Different form factors, depending on range and capacity, can have different design elements (i.e., a donut-style load cell can be made from both a shear beam and a column style design).

| Bending Beam	Shear Beam	Column
Single point weighbeam / Bending beam / Cannister / S type	Shear pancake / Clevis pin / Donut	Single column / Multiple column / Donut

Types of Torque Sensors

There are two main categories of torque sensors: reaction and rotary.

Reaction torque sensors are restrained so they are not able to rotate 360° without the cable wrapping up, as the housing or cover is fixed to the sensor element. Essentially it measures in-line torque but in a non-rotating state. In the diagram, if the load source is held rigid while the drive source is trying to rotate, the torque will be sensed (often called stalled torque). If the movement is a back and forth agitating type motion (±90°), a reaction sensor will often be used.

Rotary torque sensors are used when the shaft of a torque sensor is rotating 360° and a means must be provided to transfer the signal voltage from the rotational element to a stationary surface. This can be accomplished through the use of:

- Slip rings
- Rotary transformers
- Telemetry

The slip ring method will require contact between the slip rings and brushes, as well as the bearings. In this method, the strain gage bridge is connected to four silver slip rings mounted on the rotating shaft. Silver graphite brushes, stationary and connected to the housing, rub on these slip rings and provide an electrical path for the incoming bridge excitation and the outgoing signal. It has the advantage that either ac or dc can be used to excite the strain gage bridge.
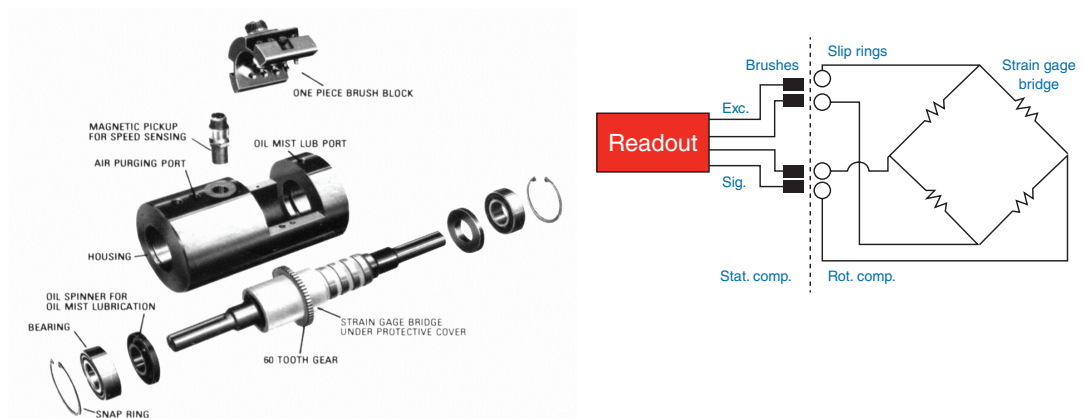
The rotary transformer method is non-contact other than the bearings that locate the rotating shaft in the stationary housing. Rotary transformers differ from conventional transformers only in that either the primary or secondary winding is rotating. One transformer is used to transmit the ac excitation voltage to the strain gage bridge, and a second transformer to transfer the signal output to the non-rotating part of the transducer. Thus, two transformers replace four slip rings and no direct contact is required between the rotating shaft and the stationary housing of the transducer.

The transformers themselves are 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 to one of these coils. A high permeability core is added to concentrate flux in a magnetic path and improve coupling between coils.
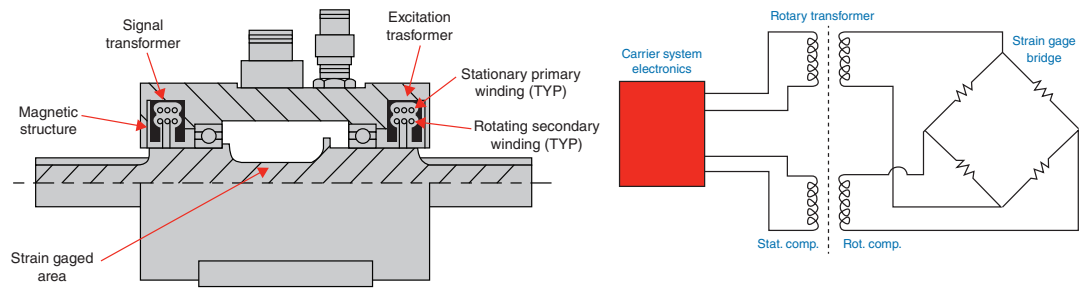
The "gap" in the magnetic structure is to allow the passage of a support member for the inner rotating coil. This particular geometry enables the transformer to exhibit high coefficient of coupling and, since there is no relative movement of any part of the magnetic path, to be free from "runout" effects.

Transmission of energy through any transformer requires that the current be alternating. A suitable carrier instrument providing excitation in the range of 3 kHz should be used.

The analog or digital telemetry method has no contact points. The signal transfer evolution has advanced from an analog telemetry to advanced digital-based telemetry. The digital telemetry system consists of a receiver-transmitter module, a caliper-style coupling module, and a signal processing module.
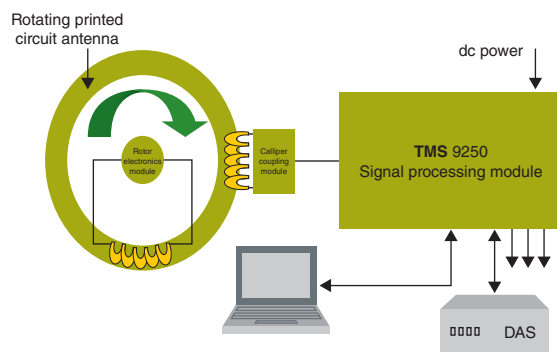
The receiver-transmitter module is an integral part of the torque sensor and is connected to the strain gages and to the epoxy glass annular printed circuit board that contains the antenna system. All of these components rotate as part of the system. Within the receiver-transmitter module, the sensor signals are amplified, digitized, and are then used to modulate the radio frequency carrier wave that is detected by the antenna after being transmitted across the air gap by the stationary caliper coupling module (receiver). That same frequency carrier wave is rectified to provide power to drive the strain gages and the electronic components in the module, which is managed by a miniature microprocessor.

The caliper coupling module connects to the signal processing module via an RF cable. The detector circuitry in the signal processing module recovers the digital measurement data from the torque sensor and passes it to the second microprocessor for scaling and linearizing.

The third microprocessor provides the drive to the two analog outputs, as well as the standard digital interfaces and the optional digital interface modules. Extensive features are provided in software for setup and configuration of the complete system.

Potential Applications for Sensors

There are an endless number of potential applications for pressure, load, and torque sensors in various industries, such as:

Aerospace
- Flight control
- Pilot control
- Landing gears and doors
- Engine and fuel systems
- Environmental conditioning
- Airframe and engine testing
- Military and space

Automotive
- Component testing
- Powertrain
- Assembly and test
- Vehicle and proving ground
- Motorsports

Oil and Gas
- Exploration
- Production and development
- Offshore

Other Industries
- Industrial
- Off-road transportation
- Medical
- Semi-Conductor
- Pulp and paper
- Food and beverage
- Geological
- Manufacturing
- HVAC
- Water management
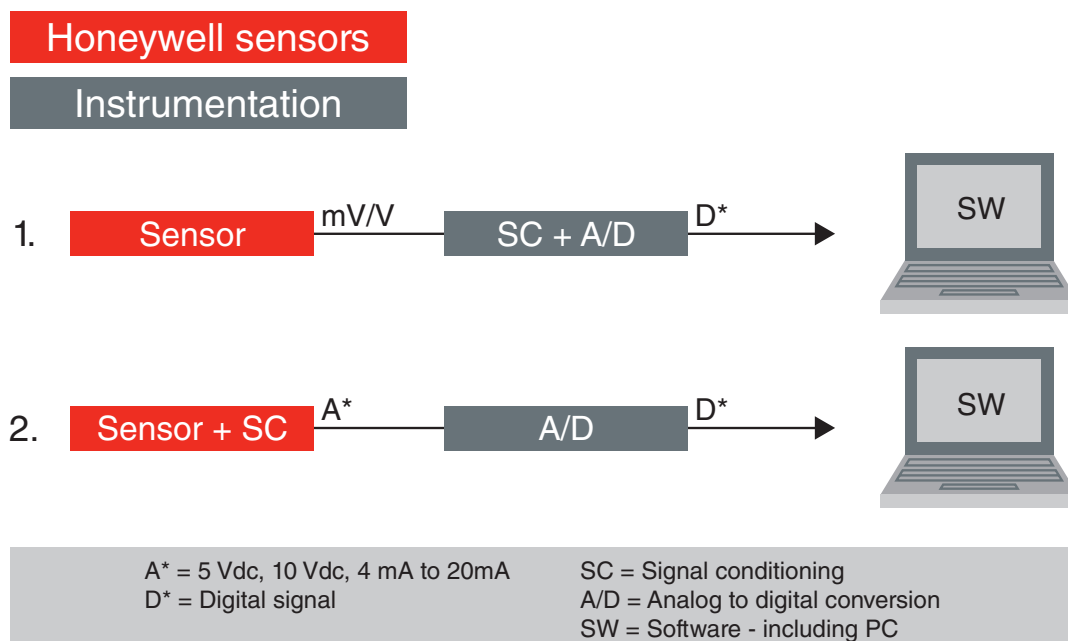- Universities
- And many more

Working with Instrumentation

Typically, the output from Wheatstone Bridge-based pressure, load and torque sensors is used to monitor and/or control an application or process. Since the full-scale output from a bridge-based sensor is typically low level voltage (i.e. 20 mV to 300 mV), additional signal conditioning (SC), and conversion to a digital signal (A/D) is typically required.

Two options are shown below, with both being very similar in that the mV signal from a Honeywell sensor is converted into the digital signal. The difference between the two revolve around combining the SC and A/D functions for Option 1, with separate instrumentation, and separating them in Option 2 (i.e., keeping the SC on the sensor and providing the A/D with separate instrumentation). The digital signal can then be supplied to a PC, where a variety of software programs can process the input, store the data, make decisions, etc.

Honeywell provides pressure, load and torque sensors that have an amplified output (i.e., signal conditioned signal), and this is shown in Option 2, where the signal can be converted into a digital signal.

Honeywell sensors

Instrumentation

1. Sensor — mV/V → SC + A/D — D* → SW

2. Sensor + SC — A* → A/D — D* → SW

A* = 5 Vdc, 10 Vdc, 4 mA to 20mA
D* = Digital signal

SC = Signal conditioning
A/D = Analog to digital conversion
SW = Software - including PC

Plug and Play

Connecting Honeywell sensors to data acquisition hardware and software can become even easier through the use of Transducer Electronic Data Sheet (TEDS). The IEEE 1451.4 standard covers the TEDS communication protocol, type and location of key sensor data that is stored in an EPROM, a small device which is physically located in the sensor or sensor cable. An example of the sensor information stored in the EPROM for a bridge base sensor is shown on the diagram below. On the right of this diagram, is how this data is viewed by software after successfully reading the EPROM attached to the sensor.

Item	Property	Description	Data type	Units
1	-	Manufacturer ID	Enter value [Values from 17 to 16381]	None
2	-	Model number	Enter value [Values from 0 to 32767]	None
3	-	Version letter	Enter value [Values from A to Z]	None
4	-	Version number	Enter value [Values from 0 to 63]	None
5	-	Serial number	Enter value [Values from 0 to 16777215]	None
6	Template	Template TypeID	Enter "39" (bridge sensors)	None
7	%ElecSigType	Electrical signal type	Enter "3" (bridge sensors)	None
8	%MinPhysVal	Min. physical value	Enter value for load, pressure, torque and some vibration units	Load: N, lb, kgf, g Pressure: Pa, psi Torque: Nm, oz-in
9	%MaxPhysVal	Max. physical value	Enter value for load, pressure, torque and some vibration units	Load: N, lb, kgf, g Pressure: Pa, psi Torque: Nm, oz-in
14	%MinElecVal	Case 2: Min. electrical value	Enter sensor sensitivity value (typically stated as mV/V)	V/V
15	%MaxElecVal	Case 2: Max. electrical value	Enter sensor sensitivity value (typically stated as mV/V)	V/V
16	%MapMeth	Mapping method	Enter "0" (asign linear mode)	None
17	%BridgeType	Bridge type	Enter "quarter", "half", "full"	None
18	%SensorImped	Bridge element impedance	Enter value	Ohms
19	%RespTime	Response time	Enter value	seconds
20	%ExciteAmpNorm	Excitation level, nominal	Enter value	V
21	%ExciteAmpMin	Excitation level, min	Enter value	V
22	%ExciteAmpMax	Excitation level, max	Enter value	V
23	%CalDate	Calibration date	Enter value	None
24	%CalInitials	Calibration initials	Enter value	None

TEDS Properties	Value
Manufacturer ID	Sensotec (IS# 40)
Model number	41
Version number	0
Version letter	R
Serial number	1185518
Transducer electrical signal type	Bridge sensor
Minimum force/weight	-1.000000E+2 lb
Maximum force/weight	1.000000E+2 lb
Minimum electrical value	-1.008900E-3 V/V
Maximum electrical value	1.008900E-3 V/V
Mapping method	Linear
Bridge type	Full
Impedance of each bridge element	3.520000E+2 Ohm
Response time	1.009457E-3 sec
Excitation level (normal)	1.000000E+1 V
Excitation level (minimum)	1.000000E+0 V
Excitation level (maximum)	2.000000E+1 V
Calibration date	1/24/2008
Calibration initials	MK
Calibration period (days)	1797 days
Measurement location ID	0
Calibration date	1/1/1998
Sensitivity @ Fref	1.000000E-4 V/(m/s^2)
Fref	1.017502E+1 Hz
F hp electrical	1.000000E-2 Hz

All the relevant information about the sensor (i.e., manufacturer, model, version, and serial number) is stored on the EPROM. In addition, the sensitivity of the sensor (as displayed on the calibration certificate) is also stored, along with its full scale range and units of measure. This information can be used by TEDS-compatible hardware and software to automatically setup scaling factors, software front ends, and more, so that sensors can be exchanged without having to reprogram or re-setup the sensor.

The benefits of this "Plug and Play" capability include reduced setup time, eliminating the time required to review both the various manufacturers' data sheets/calibration certificates. In addition, it eliminates the possibility of error by the end user (i.e., maintaining data integrity from the sensor to the monitoring/control system), who would otherwise have to manually set up the data acquisition hardware and software. There is also the benefit of not requiring a skilled technician/engineer to set up the system. Anyone can interrogate the system for needed information.

For increased accuracy of measurement, TEDS has the capability of using a sensor calibration look-up table, or a curve-fitting table to provide better characterization of the sensor. With prior agreement from the manufacturer, up to 128 calibration points, or the coefficient for a segmented multi-order polynomial can be stored.

Choosing a Supplier and Product

With all the different types and formats of sensing technology, it can be overwhelming to choose the right one to meet specific application and data acquisition software needs. More importantly, how does one go about choosing the right supplier for the job?

- Make sure you understand the application needs and the parameters. Consider temperature ranges, operating conditions and environmental factors that must be endured. All of this is critical in determining the correct sensor and design (i.e., if it's a load cell you need, will it be a multiple-bending, multiple-column or shear-web design? What size and configuration would be needed?).

- Insist on an accurate, reliable and robust product, and look for a standard product first -- there are hundreds available. If none seem to fit the bill, you'll want to look for a supplier that can customize designs to fit your needs. Easy customization is another benefit of certain technologies like load cell technology – it can be adapted as required.

- Choose a supplier with a proven track record and solid brand reputation. Honeywell's roots date back to 1885 and span many industries.

- Look for experience and quality, dedicated engineers who understand customer applications and needs. Fundamental product design knowledge, evaluation/simulation capabilities, a focus on quality and reliability, and dependable customer service are all musts.

- Inquire about the company's custom engineering experience. Look for mature, proven technology within all custom packages offered. Honeywell offers the most sophisticated and extensive custom engineering capabilities in the test and measurement industry, which allows "outside the catalog" product range expansion.

- Ask the company about its evaluation and simulation capabilities, as well as its quality and reliability testing. Request customer testimonials or case studies. Honeywell Sensing and Control has fully integrated design, manufacturing and testing capabilities. The company's centrally located Columbus, Ohio facility is the center of expertise for Sensing and Control's Test and Measurement product group, and it is supported by a Juarez, Mexico facility. Both are certified to ISO 9001; 2000, and the Juarez facility is also AS9100. The Honeywell quality team has a significant experience base to achieve and maintain these standards.

- Ensure the company has the capabilities to deliver quickly to meet the timeframe. For example, Honeywell's load cells are manufactured as 'quick ship,' 'fast track,' and 'build to order' to provide the fastest delivery possible.

- Consider the company's customer service reputation and process. Honeywell Sensing and Control takes a consultative partnership approach with customers and strives to be accessible and responsive to customer needs. Customer service is an on-going effort, continuing far beyond an initial product sale. When you choose Honeywell, you choose a business partner who is committed to providing solutions.

- Essentially, do your homework … on your needs and your supplier!

Honeywell

Find out more
Honeywell serves its customers through
a worldwide network of sales offices,
representatives and distributors.
For application assistance, current
specifications, pricing or name of the
nearest Authorized Distributor, contact
your local sales office.
To learn more about Honeywell's test and
measurement products, call
+1-614-850-5000, visit
measurementsensors.honeywell.com,
or e-mail inquiries to
info.tm@honeywell.com

Sensing and Control
Honeywell
1985 Douglas Drive North
Golden Valley, MN 55422
honeywell.com

Honeywell