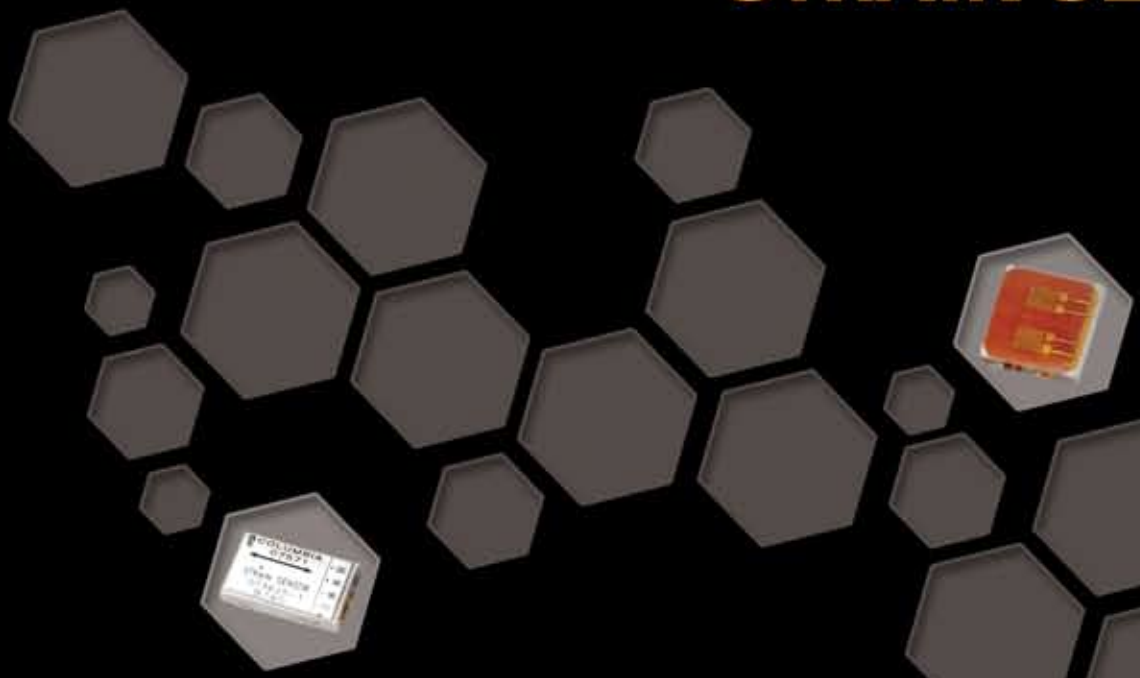
# Columbia Research Laboratories, Inc.

## STRAIN SENSORS



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# HISTORY OF COLUMBIA RESEARCH LABORATORIES, INC.
# WOOLDYN, PA

For over fifty years, Columbia Research Laboratories, Inc. has been committed to designing and manufacturing advanced technology, cost-effective products. Each product is designed to withstand hard use over long periods of time. Precision manufactured and tested to the most exacting quality standards, Columbia's products frequently exceed customer specifications.

Columbia offers a diversified product line with a wide selection of instruments. Columbia's continually growing product line includes, but is not limited to, Piezoelectric Accelerometers, Pressure Transducers, Force Balance Inertial Grade Accelerometers and Inclinometers, Standard Linear Variable Differential Transducers, Flight Qualified Fatigue Load monitoring Foil Strain Sensors, Charge Amplifiers for signal conditioning of Piezoelectric Accelerometers and Pressure Transducers, Force Balance Technology Inclinometer Systems, Hand Held Vibration Meters and Solid State Sensors. Columbia specializes in manufacturing to customers specifications.

Columbia's involvement in designing and manufacturing specialized products for the U.S. Government's Aerospace Programs and Commercial Aviation programs goes back many years as noted below:

Columbia provided the AS16-321 Vibration Measurement System for the LEM Spacecraft launched in 1974 and the Vibration Measurement Set model 123101 designed for the 1st M1T500 Flight Vehicle launched March 6, 1975. In more recent years, Columbia has designed and provided instrumentation for the Mark-12, GBU-15, AGM-130, AMRAM, HELLFIRE, ALCM, SLCM, Trident I & II, ASROC, Atlas II, Pershing II, MX, SICBM, P-3, DC-10, T-45 Trainer, Atlas-Titan, Atlas-Centaur, Shuttle Columbia, Cruise Missile, Lance Missile, ASAT Program, Killer Satellite, Captor Program, F-18 Fighter Aircraft, A-10 Fighter Aircraft, mark 21 HIT, AV-8, B-52, F-16 and JPATS.

Columbia was also involved in the recently retired venerable F117 Stealth Fighter Plane that served the U.S. so well for many years. However currently Columbia has participated in the Space X, F-22(test units), 787 Dream Liner (test units), C130 Hercules and MH-60 Black Hawk Helicopter.

This program history is typical of Columbia's performance. Columbia delivers quality products at competitive costs.


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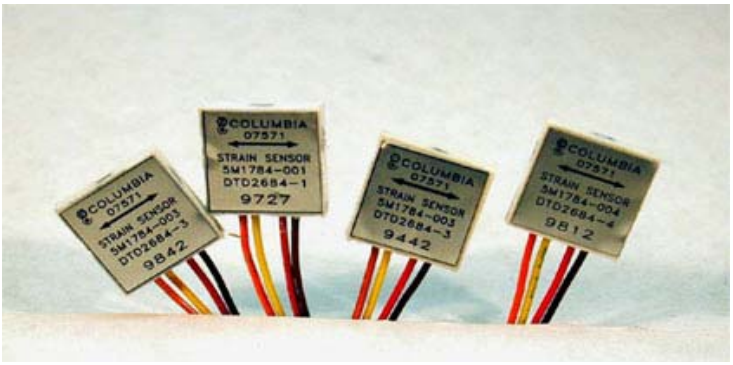
# APPLICATION




The COLUMBIA Fatigue-Monitor Strain Sensor may be bonded to critical airframe surfaces using conventional strain-gage bonding techniques. The unique construction and small size of the 2684 Series permits easy application with a new and higher level of accuracy and mechanical integrity. The four, #26 AWG, Teflon-insulated lead wires eliminate the tedious and difficult termination methods required with conventional strain gage installations. A final coating of flexible, waterproofing material provides additional environmental and mechanical protection.

In aircraft applications, the use of direct strain measurement, in place of the counting accelerometer methods commonly in use for fatigue load monitoring, provide a more accurate representation of the fatigue loading experienced by tactical aircraft under various conditions of speed, weight, and mission configuration. Critical areas, such as under carriage structures and control surfaces may be more accurately monitored for potential fatigue damage induced by high-g maneuvers and high stress landings.

These rugged, easily installed sensors open up new areas of opportunity for monitoring critical structures in commercial aircraft as well as high-performance military tactical aircraft. By combining the strain sensors with level sensing and recording systems, a stress-related history can be maintained for structures or assemblies which may be subject to damage or abuse during maintenance and overhaul operations, as well as monitoring the stress loading encountered in normal flight operations. The use of stress histories in conjunction with established S-N (fatigue life) curves for commonly used materials will allow the development of safer, more cost-effective maintenance and overhaul programs thru the application of end of useful life predictions.

Although the COLUMBIA 2684 Series of Strain Sensors have been developed for the demanding requirements associated with tactical military aircraft, they are equally useful for performing many of the more common strain measurements encountered in the materials testing laboratory. It is, in fact, the out-standing simplicity, reliability, and ruggedness of these sensors that makes them suitable for routine laboratory use. The higher output levels associated with the two-active arm configuration provides a more sensitive device yielding higher installed accuracy. The built-in dummy gages provide optimum temperature compensation for zero shift stability. The complete, full bridge strain sensor needs only the most basic signal conditioning equipment to provide accurate, reliable data for any temperature-compensated strain measurement requirement.

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# Strain Sensors

## Model DTD2684 Series

- Flight Qualified
- Choice of Sensitive Axis Orientation
- Ease of Installation
- High Output - Two Active Arms

Columbia's Foil Strain Sensors measure the fatigue loading experienced by aircraft under various conditions of speed, weight and mission configuration more accurately than by older, less accurate counting accelerometer methods. These sensors allow critical undercarriage structures and surfaces to be more accurately monitored for potential fatigue damage induced by thousands of flight hours, high stress maneuvers and landings. The simplicity and reliability of these sensors also makes them suitable for routine use in the laboratory.

These sensors are available in a choice of sensitive axis orientations. Models DTD2684 -1, -2, -3, -4, -5 are flight-qualified sensors and have been the industry standard since introduced in the early 1980's. Models DTD2684-11, -12, -13, -14 provide all the accuracy, ruggedness and ease of installation but with an alternate sensitive axis direction. Models are available to compensate materials commonly used in aircraft structural fabrication. Columbia Model 5802 Strain Gage Amplifier is designed to amplify the sensor signals providing both strain and temperature outputs.

***Note: Exports from the United States are subject to the licensing requirements of the Export Administration Regulations (EAR) and/or the International Traffic in Arms Regulations (ITAR).***


### SPECIFICATIONS

| Operational [1] | Series DTD2684 |
|---|---|
| Input Resistance | 1000Ω, ±2% |
| Sensitivity | 1.025(±1%)mV/V/1000µЄ |
| Rated Excitation Voltage | 10.0VDC |
| Linearity | ±0.5% Max. |
| Zero Offset | ±0.5mV/V Typ. |
| Operating Range | -3500 to +5000µЄ |
| Output Resistance | 1000Ω, ±2% |
| Sensitivity Shift | ±0.013% / °F |
| Hysteresis, Repeatability | ±0.5% Max. |
| Zero Shift | ±0.00025mV/V/°F Typ. |
| Creep | <0.5%, 5 Min. @ 5000µЄ |

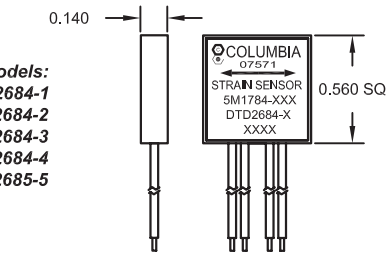
**Environmental** [2]

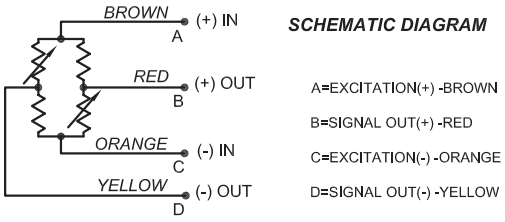
| | |
|---|---|
| Temperature Range | -54° to +125°C |
| Vibration | 30g, 10Hz to 2KHz |
| Humidity | MIL-STD-202 Method 103B |
| Salt Spray | MIL-STD-202 Method 101D (168 Hours) |
| Insulation Resistance | 100 Meg. min @ 500VDC |
| Dielectric Strength | 1050VRMS, 60Hz, 1 Min. |
| Altitude | Sea Level to 70,000 Ft. |
| Flammability | MIL-STD-202 Method 111A |
| Shock | 100g, 11mSec |
| Fluids | Resistance to short term exposure to fuel, lubricating oils and hydrolic fluids |

**Physical**

| | |
|---|---|
| Size | 0.560" x 0.560" x 0.150" Thick |
| Encapsulation | Silicone Rubber per MIL-S-23586A Type I, Class 2, Grade A |
| Weight | Approx. 13gms (Depending on length of leads) |
| Matrix | 0.001" Polyimide |
| Leads | #26AWG, Teflon Ins, SPC, 12" Min. |

[1] @25°C [2] Installed Gage




| Ordering Information (Note Sensitive Axis) | | |
|---|---|---|
| Model | Lead Length | Compensating Material |
| DTD2684-1 | 48" | Aluminum 7075-T6 or 7050-T73651, IVD |
| DTD2684-11 | 48" | |
| DTD2684-2 | 24" | Steel, AISI 4130 or HP9-4-.20 |
| DTD2684-12 | 48" | |
| DTD2684-3 | 48" | Titanium TI-6AL-4V Annealed |
| DTD2684-13 | 48" | |
| DTD2684-4 | 24" | Carbon/Epoxy MMS 549 Type 1 |
| DTD2684-5 | 48" | |
| DTD2684-14 | 48" | |

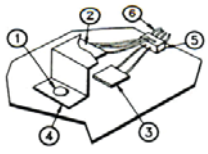



*Fig. 1 - Typical Installation of Old Style Strain Gages*

1. Bolt or rivet removed from assembly
2. Dummy gage(s) bonded to "Z Tab" of same material as structure.
3. Active gage bonded to structure under test.
4. "Z Tab" mounted to structure with bond or rivet.
5. Strain gage leads interwired and soldered to junction block.
6. Entire unit covered with protective material.

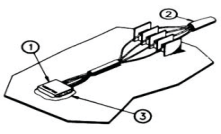



*Fig. 2 Installation of Columbia Strain Sensor*

1. Strain Sensor bonded to surface under test.
2. Leads connected to wire harness.
3. Coat sensor and wires with waterproofing material.

**ADVANTAGES**

- Higher level accuracy
- Twice the output
- Less installation time
- No loss of structural integrity
- Optimum temperature compensation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# Strain Sensors

## Model DT3625 Series

- Smallest Size
- Self Temperature Compensating
- Ease of Installation
- High Output - Two Active Arms

Columbia's Strain Sensors measure fatigue loading experienced by aircraft under various conditions of speed, weight and mission configuration more accurately than by older, less accurate counting accelerometer methods. These sensors allow critical undercarriage structures and surfaces to be more accurately monitored for potential fatigue damage induced by thousands of flight hours, high stress maneuvers and landings. The simplicity and reliability of these sensors also makes them suitable for routine use in the laboratory.

Series DT3625 sensors were developed in response to the need for fatigue measurements in tight spaces, and these sensors offer all the accuracy, ruggedness and ease of installation of the flight-qualified Series DTD2684 sensors. Models are available to compensate materials commonly used in aircraft structural fabrication. Columbia Model 5802 Strain Gage Amplifier is designed to amplify the sensor signals providing both strain and temperature outputs.

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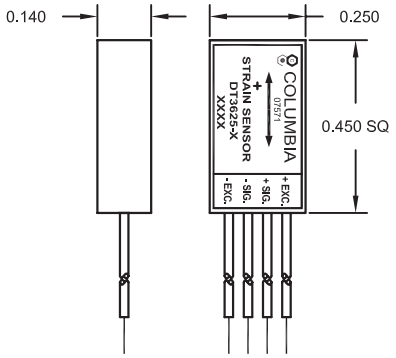



### SPECIFICATIONS

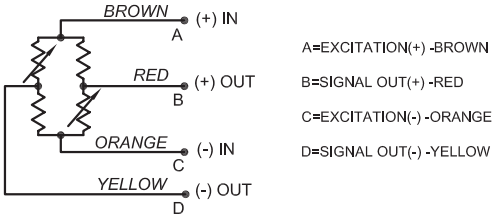
| Operational [1] | Series DT3625 |
|---|---|
| Input Resistance | 1000Ω, ±2% |
| Sensitivity | 1.025(±1%)mV/V/1000με |
| Rated Excitation Voltage | 10.0VDC |
| Linearity | ±0.5% Max. |
| Zero Offset | ±0.5mV/V Typ. |
| Operating Range | -3500 to +5000με |
| Output Resistance | 1000Ω, ±2% |
| Sensitivity Shift | ±0.005% / °F |
| Hysteresis, Repeatability | ±0.013% Max. |
| Zero Shift | ±0.00025mV/V/°F Typ. |
| Creep | <0.5%, 5 Min. @ 5000με |

| Environmental [2] | |
|---|---|
| Temperature Range | -54° to +125°C |
| Vibration | 30g, 10Hz to 2KHz |
| Humidity | MIL-STD-202 Method 103B |
| Salt Spray | MIL-STD-202 Method 101D (168 Hours) |
| Insulation Resistance | 100 Meg. min @ 500VDC |
| Dielectric Strength | 1050VRMS, 60Hz, 1 Min. |
| Altitude | Sea Level to 70,000 Ft. |
| Shock | 100g, 11mSec |
| Flammability | MIL-STD-202 Method 111A |
| Fluids | Resistance to short term exposure to fuel, lubricating oils and hydrolic fluids |

| Physical | |
|---|---|
| Size | 0.450" x 0.250" x 0.140" Thick |
| Encapsulation | Silicone Rubber per MIL-S-23586A Type I, Class 2, Grade A |
| Weight | Approx. 13gms (Depending on length of leads) |
| Matrix | 0.001" Polyimide |
| Leads | #26AWG, Teflon Ins, SPC, 12" Min. |

[1] @25°C [2] Installed Gage

***SCHEMATIC DIAGRAM***




**Ordering Information**

| Model | Lead Length | Compensating Material |
|---|---|---|
| DT3625-1 | 48" | Aluminum 7075-T6 or7050-T73651, IVD |
| DT3625-2 | 48" | Steel, AISI 4130 or HP9-4-.20 |
| DT3625-3 | 48" | Titanium TI-6AL-4V, B Annealed |
| DT3625-4 | 48" | Carbon/Epoxy MMS 549 Type 1 |
| DT3625-5 | 48" | Steel, Aermet 100 |
| DT3625-6 | 48" | Copper Alloy C110 |

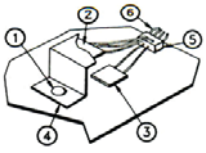



*Fig. 1 - Typical Installation of Old Style Strain Gages*

1. Bolt or rivet removed from assembly
2. Dummy gage(s) bonded to "Z Tab" of same material as structure.
3. Active gage bonded to structure under test.
4. "Z Tab" mounted to structure with bond or rivet.
5. Strain gage leads interwired and soldered to junction block.
6. Entire unit covered with protective material.

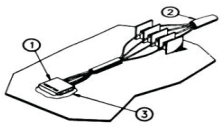



*Fig. 2 Installation of Columbia Strain Sensor*

1. Strain Sensor bonded to surface under test.
2. Leads connected to wire harness.
3. Coat sensor and wires with waterproofing material.

**ADVANTAGES**

- Higher level accuracy
- Twice the output
- Less installation time
- No loss of structural integrity
- Optimum temperature compensation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# Curved Strain Sensors

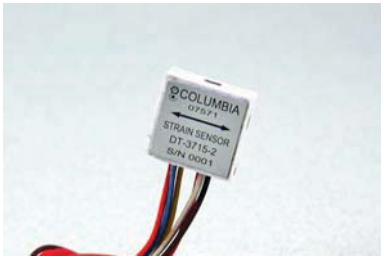
## Model DT3747 Series

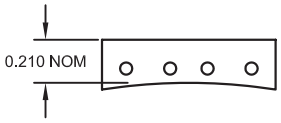
- **Strain Outputs**
- **Choice of Cylindrical Mounting Radius**
- **Self Temperature Compensating**

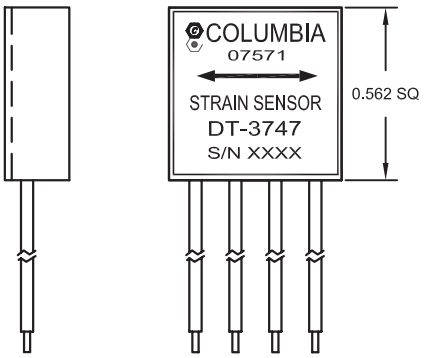
Columbia Series DT3747 sensors were designed to accurately measure strain on curved mounting surfaces. These sensors offer all the accuracy, ruggedness and ease of installation of the flight-qualified Series DTD2684. Similar devices have been utilized to monitor rocket motor expansion. They can also be used in many industrial and military applications involving pipe expansion measurements, explosive body applications, aircraft surface load, and engine monitoring of all types.

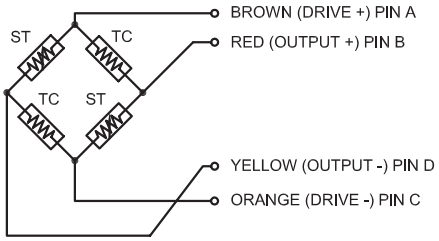
Series DT3747 sensors are customized to measure circumferential strain around the diameter of the surface to which it is mounted. The specified mounting radius is custom molded into the body of the sensor providing a method of controlling operator alignment during sensor mounting. Models are available to compensate materials commonly used in aircraft structural fabrication as well as other materials as specified. Columbia Model 5802 Strain Gage Amplifier is also available to power and signal condition the strain output of the sensor.

***Note: Exports from the United States are subject to the licensing requirements of the Export Administration Regulations (EAR) and/or the International Traffic in Arms Regulations (ITAR).***




***SCHEMATIC DIAGRAM***

### SPECIFICATIONS

| Operational [1] | Series DT3747 |
|---|---|
| DC Input Resistance | 1000Ω, ±2% |
| DC Output Resistance | 1000Ω, ±2% |
| Sensitivity | 1.025(±1%)mV/V/1000με |
| Rated Excitation Voltage | 10.0VDC |
| Linearity | ±0.5% Max. |
| Zero Strain Offset | ±0.5mV/V Max. |
| Operating Range | -3500 to +5000με |
| Sensitivity Shift | ±0.005% / °F |
| Hysteresis, Repeatability | ±0.013% Max. |
| Zero Shift | ±0.00025mV/V/°F Typ. |
| Creep | <0.5%, 5 Min. @ 5000με |

| Environmental [2] | |
|---|---|
| Temperature Range | -54° to +125°C |
| Vibration | 30g, 10Hz to 2KHz |
| Humidity | MIL-STD-202 Method 103B |
| Salt Spray | MIL-STD-202 Method 101D (168 Hours) |
| Insulation Resistance | 100 Meg. min @ 500VDC |
| Dielectric Strength | 1050VRMS, 60Hz, 1 Min. |
| Altitude | Sea Level to 70,000 Ft. |
| Shock | 100g, 11mSec |
| Flammibility | MIL-STD-202 Method 111A |
| Fluids | Resistance to short term exposure to fuel, lubricating oils and hydrolic fluids |

| Physical | |
|---|---|
| Size | 0.562"Sq (Thickness Varies w/ Specified Mounting Radius) |
| Encapsulation | Silicone Rubber per MIL-S-23586A Type I, Class 2, Grade A |
| Weight | Approx. 15gms (Depending on radius selected) |
| Matrix | 0.001" Polyimide |
| Leads | #26AWG, Teflon Ins, SPC, 24" Nom. |

[1] @25°C [2] Installed Gage

**Ordering Information***

| Model | Lead Length | Compensating Material |
|---|---|---|
| DT3747-1 | 24" | Aluminum 7075-T6 or 7050-T73651, IVD |
| DT3747-2 | 24" | Steel, AISI 4130 or HP9-4-.20 |
| DT3747-3 | 24" | Titanium TI-6AL-4V Annealed |
| DT3747-4 | 24" | Carbon/Epoxy MMS 549 Type 1 |

****Mounting Radius Required upon Ordering***

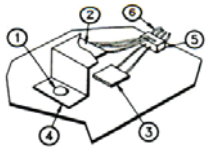



*Fig. 1 - Typical Installation of Old Style Strain Gages*

1. Bolt or rivet removed from assembly
2. Dummy gage(s) bonded to "Z Tab" of same material as structure.
3. Active gage bonded to structure under test.
4. "Z Tab" mounted to structure with bond or rivet.
5. Strain gage leads interwired and soldered to junction block.
6. Entire unit covered with protective material.

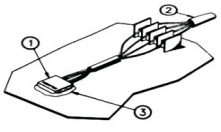



*Fig. 2 Installation of Columbia Strain Sensor*

1. Strain Sensor bonded to surface under test.
2. Leads connected to wire harness.
3. Coat sensor and wires with waterproofing material.

**ADVANTAGES**

- **Higher level accuracy**
- **Twice the output**
- **Less installation time**
- **No loss of structural integrity**
- **Optimum temperature compensation**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# Foil Strain Sensors

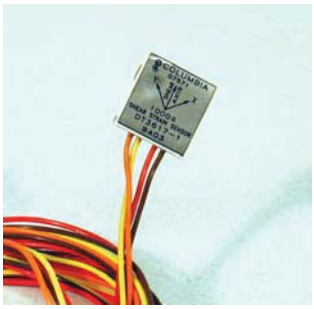
## Model DT3617 Series

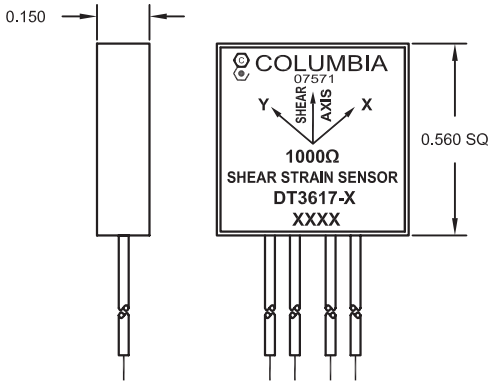
- 90° Rosette Gage
- Self Temperature Compensating
- Two 1000Ω Precision Strain Gage Grids
- Rugged Construction

Columbia Series DT 3617 Strain Sensors are designed for the measurements of planar shear strain forces when the axis of principal strain is identified. Each sensor is a complete, compact, easily installed device utilizing the proven technology of the Columbia DTD 2684 Series Fatigue Monitoring Sensors. The DT 3617 Shear Strain Sensor consists of two 1000Ω precision strain gage grids arranged orthogonally on a one mil polyimide substrate and a matching pair of 1000Ω bridge completion elements. The entire gage configuration is assembled in a rugged, molded silicone rubber package with four, M22759, 26-gage TFE insulated aircraft lead wires. The bottom surface of the sensor is polymide substrate of active strain gage elements and is supplied pre-processed for bonding to the test structure. The top surface of the sensor contains the axis identification marking to assist in aligning the gage with the principal strain axis.

Individual models are available to compensate materials commonly used in aircraft structural fabrication. Columbia Model 5802 Strain Gage Amplifier is designed to amplify the sensor signals providing both strain and temperature outputs.

***Note: Exports from the United States are subject to the licensing requirements of the Export Administration Regulations (EAR) and/or the International Traffic in Arms Regulations (ITAR).***






### SPECIFICATIONS

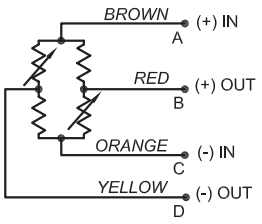
| Operational [1] | Series DT3617 |
|---|---|
| DC Resistance | 1000Ω ±2% |
| Gage Factor (GF) | 2.05±1.5% |
| Rated Excitation | 10.0VDC |
| Strain Limits | 1% |
| Working Range | ±2000με |
| Fatigue Life | $10^6$ Cycles |
| Null Offset [2] ($E_z$) | 2.5mV |
| Linearity | 0.5% BFSL |
| Hysteresis, Repeatability | ±0.5% |
| GF Temp. Coeff. | ±0.02%/°C |
| $E_z$ Temp. Coeff. | 0.0005mV/V/°C |

| Environmental [3] | |
|---|---|
| Temperature Range | -55° to +125°C |
| Vibration | 30g, 10Hz to 2KHz |
| Humidity | MIL-STD-202 Method 110A |
| Salt Spray | MIL-STD-202 Method 101D (168 Hours) |
| Insulation Resistance | 100 Meg. min @ 500VDC |
| Dielectric Strength | 500VRMS, 60Hz, 1 Min. |
| Altitude | Sea Level to 70,000 Ft. |
| Shock | 100g, 11mSec |
| Flammability | MIL-STD-202 Method 111A |
| Fluids | Resistance to short term exposure to fuel, lubricating oils and hydrolic fluids |

| Physical | |
|---|---|
| Size | 0.560" x 0.560" x 0.150" Thick |
| Encapsulation | Silicone Rubber per MIL-S-23586A Type I, Class 2, Grade A |
| Weight | Approx. 13gms (Depending on length of leads) |
| Matrix | 0.001" Polyimide |
| Leads | #26AWG, Teflon Ins, SPC, 12" Min. |

[1] @25°C [2] As supplied (un-mounted) [3] Installed Gage

***SCHEMATIC DIAGRAM***




A=EXCITATION(+) -BROWN
B=SIGNAL OUT(+) -RED
C=EXCITATION(-) -ORANGE
D=SIGNAL OUT(-) -YELLOW

| Ordering Information | | |
|---|---|---|
| Model | Lead Length | Compensating Material |
| DT3617-1 | 24" | Aluminum 7075-T6 or 7050-T73651, IVD |
| DT3617-2 | 24" | Steel, AISI 4130 or HP9-4-.20 |
| DT3617-3 | 24" | Titanium TI-6AL-4V, Annealed |
| DT3617-4 | 24" | Carbon/Epoxy MMS 549 Type 1 |

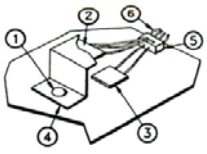


*Fig. 1 - Typical Installation of Old Style Strain Gages*

1. Bolt or rivet removed from assembly
2. Dummy gage(s) bonded to "Z Tab" of same material as structure.
3. Active gage bonded to structure under test.
4. "Z Tab" mounted to structure with bond or rivet.
5. Strain gage leads interwired and soldered to junction block.
6. Entire unit covered with protective material.

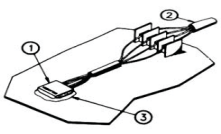


*Fig. 2 Installation of Columbia Strain Sensor*

1. Strain Sensor bonded to surface under test.
2. Leads connected to wire harness.
3. Coat sensor and wires with waterproofing material.

**ADVANTAGES**

- Higher level accuracy
- Twice the output
- Less installation time
- No loss of structural integrity
- Optimum temperature compensation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# Strain / Temperature Sensors

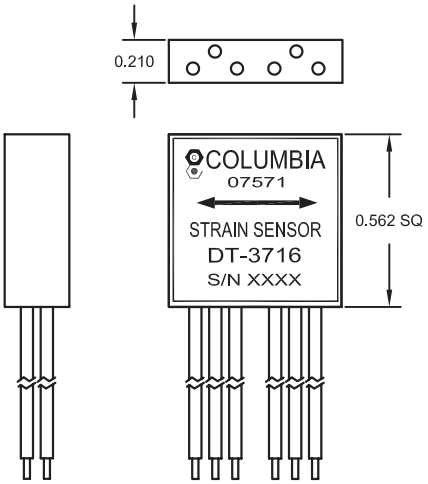
## Model DT3716 Series

- **Strain & Temperature Outputs**
- **Straight Surface Mounting**
- **Self Temperature Compensating**

Columbia Series DT3716 sensors were designed to accurately measure both strain and temperature on straight mounting surfaces. These sensors offer all the accuracy, ruggedness and ease of installation of the flight-qualified Series DTD2684 sensors and also incorporate a DIN standard 1000Ω platinum RTD which provides accurate temperature measurements at the exact point of sensor mounting. Similar devices have been utilized to monitor potential fatigue damage on aircraft subject to thousands of flight hours, high stress maneuvers and landings. The simplicity and reliability of these sensors also makes them suitable for routine use in the laboratory.

Series DT3716 sensors provide automatic temperature compensation of strain outputs when mounted to a variety of surface materials. Models are available to compensate materials commonly used in aircraft structural fabrication as well as other materials as specified. The sensors incorporate 26 AWG Teflon insulated lead wires that simplify electrical connection. Columbia Model 5802 Strain Gage Amplifier is also available to power and signal condition both the strain and temperature outputs of the sensors.

***Note: Exports from the United States are subject to the licensing requirements of the Export Administration Regulations (EAR) and/or the International Traffic in Arms Regulations (ITAR).***

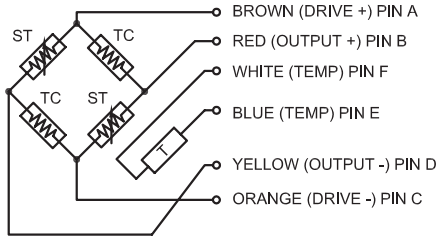

### SPECIFICATIONS

| Operational [1] | Series DT3716 |
|---|---|
| Input Resistance | 1000Ω, ±2% |
| Output Resistance | 1000Ω, ±2% |
| Sensitivity | 1.025(±1%)mV/V/1000με |
| Rated Excitation Voltage | 10.0VDC |
| Linearity | ±0.5% Max. |
| Zero Strain Offset | ±0.5mV/V Typ. |
| Operating Range | -3500 to +5000με |
| Sensitivity Shift | ±0.005% / °F |
| Hysteresis, Repeatability | ±0.013% Max. |
| Zero Shift | ±0.00025mV/V/°F Typ. |
| Creep | <0.5%, 5 Min. @ 5000με |
| Temperature Sensor | Platinum RTD, 1000Ω @ 0°C DIN EN 60751, Class 2B (0.3mA Max. Current) |

| Environmental [2] | |
|---|---|
| Temperature Range | -54° to +125°C |
| Vibration | 30g, 10Hz to 2KHz |
| Humidity | MIL-STD-202 Method 103B |
| Salt Spray | MIL-STD-202 Method 101D (168 Hours) |
| Insulation Resistance | 100 Meg. min @ 500VDC |
| Dielectric Strength | 1050VRMS, 60Hz, 1 Min. |
| Altitude | Sea Level to 70,000 Ft. |
| Shock | 100g, 11mSec |
| Flammibility | MIL-STD-202 Method 111A |
| Fluids | Resistance to short term exposure to fuel, lubricating oils and hydrolic fluids |

| Physical | |
|---|---|
| Size | 0.562" x 0.562" x 0.210" Thk |
| Encapsulation | Silicone Rubber per MIL-S-23586A Type I, Class 2, Grade A |
| Weight | Approx. 15gms (Depending on radius selected) |
| Matrix | 0.001" Polyimide |
| Leads | #26AWG, Teflon Ins, SPC, 24" Nom. |

[1] @25°C [2] Installed Gage




***SCHEMATIC DIAGRAM***

| Ordering Information | | |
|---|---|---|
| Model | Lead Length | Compensating Material |
| DT3716-1 | 24" | Aluminum 7075-T6 or 7050-T73651, IVD |
| DT3716-2 | 24" | Steel, AISI 4130 or HP9-4-.20 |
| DT3716-3 | 24" | Titanium TI-6AL-4V Annealed |
| DT3716-4 | 24" | Carbon/Epoxy MMS 549 Type 1 |

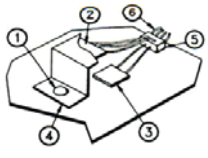



*Fig. 1 - Typical Installation of Old Style Strain Gages*

1. Bolt or rivet removed from assembly
2. Dummy gage(s) bonded to "Z Tab" of same material as structure.
3. Active gage bonded to structure under test.
4. "Z Tab" mounted to structure with bond or rivet.
5. Strain gage leads interwired and soldered to junction block.
6. Entire unit covered with protective material.

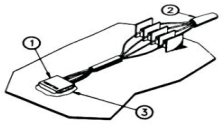



*Fig. 2 Installation of Columbia Strain Sensor*

1. Strain Sensor bonded to surface under test.
2. Leads connected to wire harness.
3. Coat sensor and wires with waterproofing material.

**ADVANTAGES**

- **Higher level accuracy**
- **Twice the output**
- **Less installation time**
- **No loss of structural integrity**
- **Optimum temperature compensation**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# Strain / Temperature Sensors

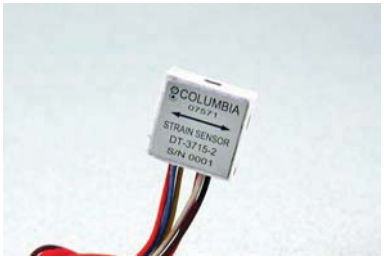
## Model DT3715 Series

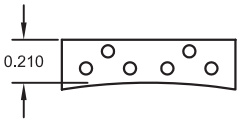
- **Strain & Temperature Outputs**
- **Choice of Cylindrical Mounting Radius**
- **Self Temperature Compensating**

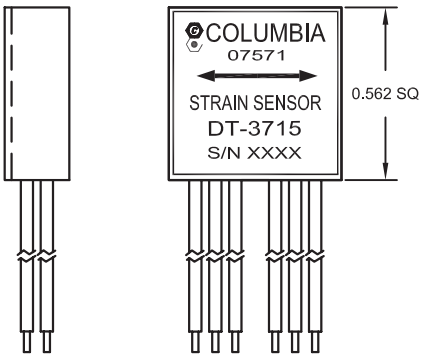
Columbia Series DT3715 sensors were designed to accurately measure both strain and temperature on curved mounting surfaces. These sensors offer all the accuracy, ruggedness and ease of installation of the flight-qualified Series DTD2684 sensors and also incorporate a DIN standard 1000Ω platinum RTD which provides accurate temperature measurements at the exact point of sensor mounting. Similar devices have been utilized to monitor rocket body expansion. They can also be used in many industrial and military applications involving pipe expansion measurements, explosive body applications, aircraft surface load, and engine monitoring of all types

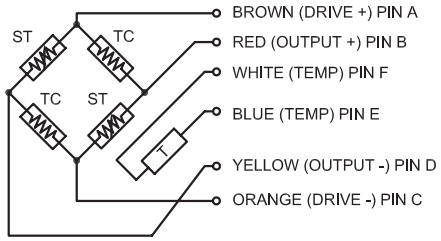
Series DT3715 sensors are customized to measure circumferential strain around the diameter of the surface to which it is mounted. The specified mounting radius is custom molded into the body of the sensor providing a method of controlling operator alignment during sensor mounting. Models are available to compensate materials commonly used in aircraft structural fabrication as well as other materials as specified. Columbia Model 5802 Strain Gage Amplifier is also available to power and signal condition both the strain and temperature outputs of the sensors.

***Note: Exports from the United States are subject to the licensing requirements of the Export Administration Regulations (EAR) and/or the International Traffic in Arms Regulations (ITAR).***




***SCHEMATIC DIAGRAM***

### SPECIFICATIONS

| Operational [1] | Series DT3715 |
|---|---|
| DC Input Resistance | 1000Ω, ±2% |
| DC Output Resistance | 1000Ω, ±2% |
| Sensitivity | 1.025(±1%)mV/V/1000µЄ |
| Rated Excitation Voltage | 10.0VDC |
| Linearity | ±0.5% Max. |
| Zero Strain Offset | ±0.5mV/V Max. |
| Operating Range | -3500 to +5000µЄ |
| Sensitivity Shift | ±0.005% / °F |
| Hysteresis, Repeatability | ±0.013% Max. |
| Zero Shift | ±0.00025mV/V/°F Typ. |
| Creep | <0.5%, 5 Min. @ 5000µЄ |
| Temperature Sensor | Platinum RTD, 1000Ω @ 0°C DIN EN 60751, Class 2B (0.3mA Max. Current) |

| Environmental [2] | |
|---|---|
| Temperature Range | -54° to +125°C |
| Vibration | 30g, 10Hz to 2KHz |
| Humidity | MIL-STD-202 Method 103B |
| Salt Spray | MIL-STD-202 Method 101D (168 Hours) |
| Insulation Resistance | 100 Meg. min @ 500VDC |
| Dielectric Strength | 1050VRMS, 60Hz, 1 Min. |
| Altitude | Sea Level to 70,000 Ft. |
| Shock | 100g, 11mSec |
| Flammibility | MIL-STD-202 Method 111A |
| Fluids | Resistance to short term exposure to fuel, lubricating oils and hydrolic fluids |

| Physical | |
|---|---|
| Size | 0.562"Sq (Thickness Varies w/ Specified Mounting Radius) |
| Encapsulation | Silicone Rubber per MIL-S-23586A Type I, Class 2, Grade A |
| Weight | Approx. 15gms (Depending on radius selected) |
| Matrix | 0.001" Polyimide |
| Leads | #26AWG, Teflon Ins, SPC, 24" Nom. |

[1] @25°C [2] Installed Gage

**Ordering Information***

| Model | Lead Length | Compensating Material |
|---|---|---|
| DT3715-1 | 24" | Aluminum 7075-T6 or 7050-T73651, IVD |
| DT3715-2 | 24" | Steel, AISI 4130 or HP9-4-.20 |
| DT3715-3 | 24" | Titanium TI-6AL-4V Annealed |
| DT3715-4 | 24" | Carbon/Epoxy MMS 549 Type 1 |

****Mounting Radius Required upon Ordering***

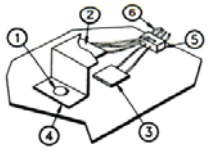



*Fig. 1 - Typical Installation of Old Style Strain Gages*

1. Bolt or rivet removed from assembly
2. Dummy gage(s) bonded to "Z Tab" of same material as structure.
3. Active gage bonded to structure under test.
4. "Z Tab" mounted to structure with bond or rivet.
5. Strain gage leads interwired and soldered to junction block.
6. Entire unit covered with protective material.

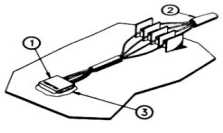



*Fig. 2 Installation of Columbia Strain Sensor*

1. Strain Sensor bonded to surface under test.
2. Leads connected to wire harness.
3. Coat sensor and wires with waterproofing material.

**ADVANTAGES**

- **Higher level accuracy**
- **Twice the output**
- **Less installation time**
- **No loss of structural integrity**
- **Optimum temperature compensation**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# Strain Gage Amplifier

## Model 5804

- Connects to any Columbia Full Bridge Strain Sensor
- Strain & Temperature Outputs
- Wide Input Power Range
- Auto Zeroing Capability

The Columbia Model 5804 Military-Grade Strain Gage Amplifier is designed to amplify signals from Columbia's DT and DTD Series Full-Bridge Strain Sensors. The system will provide both strain and temperature outputs.

The strain output incorporates a microprocessor-driven auto zeroing circuit capable of compensating for input offsets of up to ±3000 μЄ equivalent and will automatically drive the output to 0.00 VDC in the presence of input offset equivalent strains within that range. This feature allows the operator to correct for any strain offsets resulting from gage mounting, material fatigue or material deformation. Auto zeroing may be performed automatically on power-up, or on command manually with the use of the auto zero function pin on the power connector.

The temperature output is derived from a 1000Ω platinum RTD and provides a linearized output of 40 mV / Deg C from -40°C (0.00 V) to +85°C (5.00 V). The temperature output will remain within ±3° or ±120mV of the straight line passing thru these two points over its rated operating range.

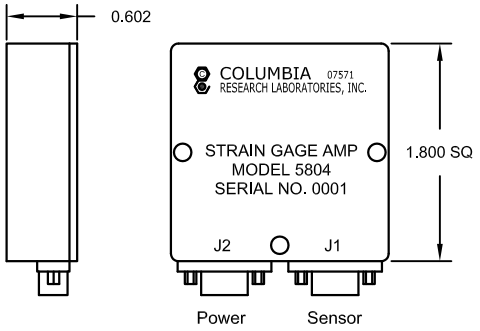
### SPECIFICATIONS

| Operational | 5804 |
|---|---|
| Power Required | +15 to +35VDC (+28VDC Nom.) |
| DC Current Drain | 25mA Max. |
| Strain Signal Output [1] | ±5.000VDC 0.00VDC= 0 Micro Strains<br>***Standard:*** Output corresponding to ±5000 μЄ<br>***Optional:*** Output corresponding to Specified Range |
| Temperature Output | 0.0VDC @-40°C and 5.00VDC @+85°C ±3° or ±120mV of straight line passing thru |
| Temperature Scale Factor | 40Mv/°C Nominal |
| Output Protection | Over-Voltage and Over-Current Protection on both Strain and Temperature Outputs |
| Measurement Accuracy (Strain) | ±5% |
| Electronic Filtering [2] | 2-Pole Butterworth Filter with response set to -3dB @2000Hz |
| Fault Detection | The amplifier will provide fault detection on all four strain sensor lead wires with positive indication of any combonation of broken or unconnected strain sensor lead wires. Faults will be indicated by an out-of-range output from the amplifier at the end of the auto-zeroing period. Open fault detection of the temperature probe is intrinsic. |
| Operating Temperature | -40 to +85°C |

**Physical**

| | |
|---|---|
| Size | 1.800±0.010" Square x 0.602±0.015" High |
| Mounting | (3) #6 Clearance Holes |
| Weight | 55gm Nominal |
| Case Seal | Epoxy |
| Grounding | Case Isolated from Signal / Power Ground |
| Power Interface | Cannon MSN-9PSB Connector |
| Sensor Interface | Cannon MDM-9SSP Connector |

[1] Specify optional Strain Output Range as model number suffix (e.g. Model 5804 - Range ± XXXX μ Є)
[2] Optional cutoff Frequencies Available




| SENSOR PIN FUNCTIONS | |
|---|---|
| 1 | Bridge Drive (+) |
| 2 | Bridge Output (+) |
| 3 | Bridge Output (-) |
| 4 | Bridge Drive (-) |
| 5 | Shield/Case Ground |
| 8 | Temperature Sensor |
| 9 | Temperature Sensor |

| AMPLIFIER PIN FUNCTIONS | |
|---|---|
| 1 | +DC Power Input |
| 9 | DC Power Ground |
| 7 | Strain Output |
| 3 | Temperature Output |
| 5 | Signal Ground |
| 4 | Auto Zero Select |
| 8 | Shield/Case Ground |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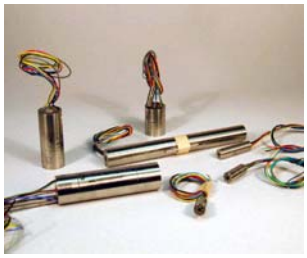
# OTHER PRODUCT LINES OFFERED BY COLUMBIA RESEARCH LABORATORIES, INC.

The Columbia product line of piezoelectric accelerometers is widely known for reliable performance, quality and ruggedness and is always expanding to meet the unique challenging and ever changing requirements of our customers. The selection of specifications, sizes and configurations is large and diverse and suitable for use on many applications requiring features such as, high performance, high accuracy, high temperature, seismic event, 4-20mA output, airborne, miniature size and general purpose use.

Columbia's product line of piezoelectric pressure sensors is extensive, with a variety of features for many pressure applications including very high and low pressure, wide frequency response, vibration compensated, general purpose, high temperature, choice of sensitivities, choice of electrical interface, electrical isolated, choice of pipe thread, or straight thread mounting, hermetically sealed, low output impedance, corrosion-resistant and fast pressure variations, surges and dynamic blasts.



Columbia's series of linear variable differential transformers are designed for applications demanding the highest level of performance and reliability under the rugged conditions and harsh environments characteristic of military and industrial environments and construction equipment and where maximum life under adverse conditions is required. Columbia's line of LVDT's includes many displacement ranges and core sizes, high stroke/length ratio, frequency ranges, and units with sensitivity and extended temperature range for high temperature environments.

Columbia offers a wide selection of force balance servo accelerometers and inclinometers specifically designed to give the user a diversified choice of sizes, configurations and performance levels for industrial, OEM and military requirements. Many of Columbia's transducers have been in-flight qualified in accordance with MIL standards and are currently being used on a variety of technically demanding in-flight weapons systems. High reliability product performance has been a significant feature of Columbia's force balance servo accelerometer and inclinometer product line. The selection of accelerometers in this product line is wide and includes models with features such as high performance, ultra rugged, high sensitivity, high accuracy, 4-20mA output, seismic event, high temperature, miniature general purpose and airborne.

Bulletin - 106

Other product bulletins available from:

Columbia Research Laboratories, Inc.

**Bulletin 100:** "Piezoelectric Products Division"
**Bulletin 103:** "Inertial Products"
**Bulletin 104:** "Pressure Transducers and Acoustic Sensors"
**Bulletin 106:** "Foil Strain Sensors"
**Bulletin 107:** "L.V.D.T.'s"

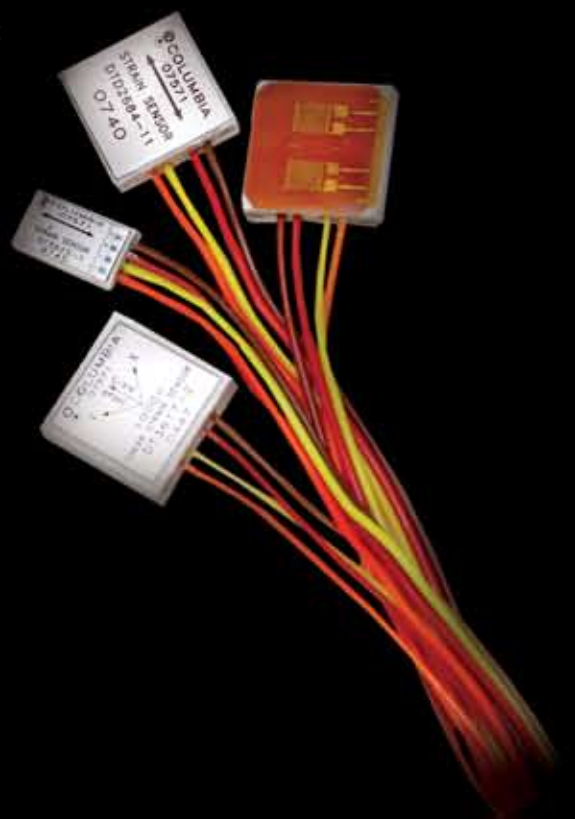
Request these informational bulletins from your local Representative or directly for Columbia.
Visit Columbia on the web: **www.crlsensors.com**

# STRAIN SENSORS

Specifications definitions are consistent with accepted industry standards.

All Columbia Accelerometers are supplied with standard Columbia Test and Calibration Data. Other test data can be supplied at additional cost.

Continued product improvements necessitate that specifications are subject to change without notice. Please consult our website for the latest specifications.



ISO 9001:2008 with Design & AS 9100

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