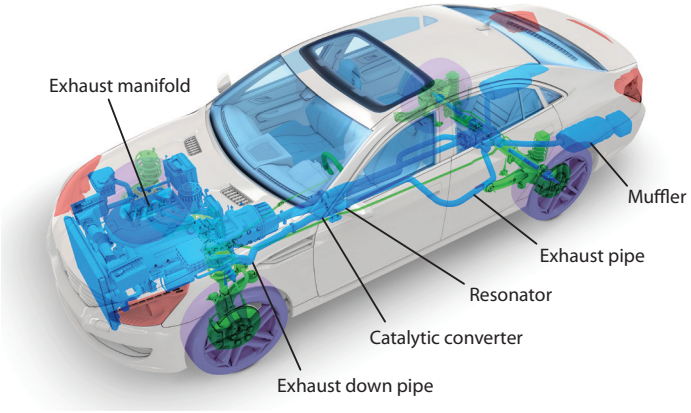
Signal Conditioning for Exhaust System Measurements

Get accurate measurements of strain, pressure, vibration under the harshest testing conditions.

Strain, pressure, and vibration sensors must be able to operate in temperatures exceeding 500°C during exhaust analysis. In such high temperatures, conventional sensors such as foil strain gages, IEPE pressure sensors, and accelerometers aren't an option. Instead special high-temperature strain gages are welded or bonded to the test article using ceramic cement. High-temperature piezoelectric accelerometers are used to measure vibration. Exhaust pressure measurement for diagnosing combustion instabilities may require recessed mounts and sensing tubes to protect pressure sensors from the heat. Interfacing to sensors used in this harsh environment requires sophisticated signal conditioners before the A/D converter.



Development of automotive exhaust systems require accurate testing in harsh conditions

Solutions Harsh Testing Conditions

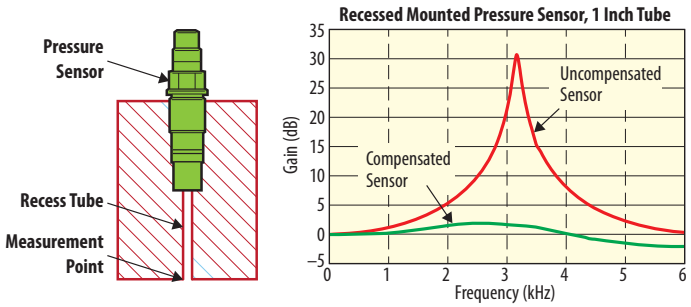
Strain Measurement

Strain gages measuring static or dynamic strain at very high temperatures require high-temperature alloys for leads. After engine startup, the temperature change causes sensor lead resistance changes of tens or even hundreds of ohms. In a high-temperature environment, a gage's substrate can break down, causing leakage. Electrostatic and magnetic fields can couple into the cables, degrading measurement signal-to-noise ratio.

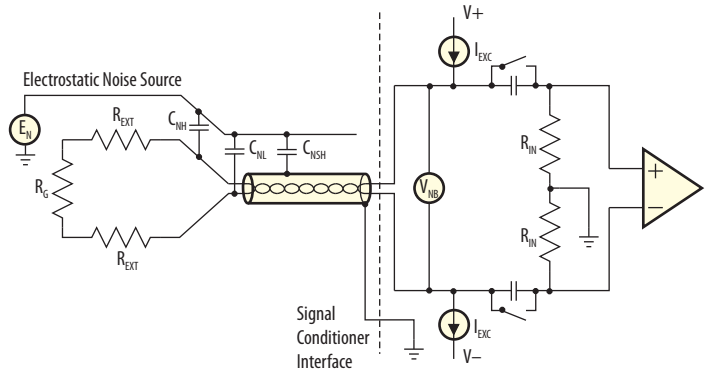
Precision Filters developed Balanced Constant Current™ technology to enable a wide dynamic range measurement of strain in harsh environments of automotive testing. The circuit is insensitive to temperature-induced changes in lead resistance. Because the circuit is balanced, the differential input amplifier rejects noise pickup in the leads. Also, the circuit continues to measure strain accurately—even if a gage terminal shorts to the test article.

Pressure Sensor Measurements

For applications where the sensor cannot be mounted flush with the exhaust system flow field due to temperature, the sensor is often recessed at the end of a tube. The tube produces an organ-pipe resonance that amplifies the pressure signal by 20 dB or more. This resonance limits the useful measurement bandwidth to about 20% of the first resonance—about 1 kHz for a 1 in. tube. Precision Filters and Kulite Semiconductor Products developed the patent-pending REZCOMP® technology to extend the frequency response of pressure sensors in real time with no need for post-processing.



Recessed mounted pressure sensor resonance



Balanced Constant Current excitation circuit

Vibration Measurements

The high temperature of engine exhaust system components also make vibration measurement a challenging task. Charge amplifiers condition piezoelectric accelerometers; at temperatures above 500°C, accelerometers often have extremely low insulation resistance across the piezoelectric sensing element. Using a general-purpose charge amplifier could result in low-frequency gain peaking as high as 20 to 30 dB—causing excessive low-frequency noise, gain errors, or even total saturation of the charge amplifier. Precision's vibration amplifiers are compatible with the highest-temperature accelerometers available and exhibit minimal peaking—even with accelerometer shunt resistance as low as 10 kOhm.

Verifying Cable and Sensor Health

Even the best signal conditioner is of little value if the measurement system fails during a test. Discovering a faulty sensor or a defective cable after the test is too late. Lost data sometimes cannot be recovered and repeating the test may be expensive. A simple, fail-safe protocol for verifying the health of all sensors, lead wires, and cabling is essential to any successful measurement system.

Precision Filters' signal conditioning systems have built-in hardware and software that allow the measurement team to quickly and easily run a series of automated sensor, circuit, and cable checks. Precision Filters' signal conditioning cards facilitate real-time monitoring of sensor and cable health, measure and report cable roll-off, and detect insulation leakage.

System Testing, Calibration, and Lifetime Costs

For defendable test data, yearly calibration is a must. Most research facilities require additional validation and documentation of performance specifications. Continual setup and teardown take a toll on sensitive circuitry and demand a rigorous approach to system verification. Yet verification protocols are seldom followed if inconvenience and cost outweigh the perceived benefits. The Precision 28000 self-test subsystem conducts comprehensive yearly calibrations and on-site pretest go/ no-go diagnostics at the push of a button – without removing the system from the equipment rack.

The lifetime cost of a test measurement system is the total cost of ownership. This includes the purchase price of the components; installation; time required for setup, teardown and reconfiguration; acceptance testing; maintenance; and calibration. Operation and maintenance costs, notably staff time, generally exceed acquisition costs, particularly with poor-quality equipment. Often overlooked is the cost of bad data, or no data – a high price to pay for failing to conduct adequate pretest verifications. The cost of a failed test can be immense.

The Precision Filters 28000 system significantly reduces lifetime costs and provides automated self-diagnostic and calibration capabilities that can reduce or eliminate component or system failures.

A systems approach to designing a signal conditioning system helps to ensure accurate measurements in the challenging environment of gas turbine engine testing. The Precision Filters 28000 system's innovative signal conditioning techniques, combined with automated go/no-go testing and simple annual calibration, give you confidence in your data – while reducing lifecycle and ownership costs.

Conclusion

Precision Filters' 28000 highly configurable test cell signal conditioning system and C-Series (CompactDAQ and CompactRIO) signal conditioning modules for in-vehicle test environments are designed to address the challenging automotive test environment. Testing is expensive and time consuming; every feature of Precision's signal conditioners offers the highest level of confidence in test data and reduces set-up and troubleshooting time.

Precision Filters' Systems for Automotive Testing

Precision Filters' range of products support any installation, large or small. Companies have relied on Precision Filters products for testing engines and powertrains, aerodynamics in wind tunnels, NVH, wheel balance, and more.

28000 Signal Conditioning System

Ideal for test cell applications, our versatile 28000 system features built-in NIST traceable self-test for performing annual calibrations and automated pre-test go/no-go tests for run-time system verification. The 28000 includes a complete line of signal conditioners suitable for dynamic or static measurements and able to accommodate any transducer: voltage, charge, static or dynamic strain, as well as bridge-type transducers such as pressure sensors, piezoresistive accelerometers, load cells, and more.

28000 Signal Conditioning System

Filter/Amplifier Systems

For low channel count labs, choose the economical two-channel PFA-2 filter/amplifier or the eight- or sixteen-channel PF-1U-FA filter/amplifier. Both are compact, highly programmable, and offer flat/pulse low-pass filter technology for time- or frequency-domain measurements.

PFA-2 Two-Channel Compact Filter/Amplifier

PF-1U-FA Multi-Channel Programmable Filter/ Amplifier System

C Series Signal Conditioning Modules

When you need a rugged, portable system, our high-performance C Series signal conditioning modules integrate seamlessly with National Instruments' CompactRIO and CompactDAQ chassis, making them ideal for in-vehicle installations or installations close to the DUT.

Precision C Series Signal Conditioning Modules

PRECISION FILTERS, INC.
ISO 9001 CERTIFIED QUALITY

Precision Filters, Inc.
240 Cherry Street
Ithaca, New York 14850

Telephone: **607-277-3550**
E-mail: **pfinfo@pfinc.com**
Web Site: **www.pfinc.com**

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