Driveability and Ride & Handling Sensors

Accelerometers, Force Sensors, Load Cells, Signal Conditioners, and Human Vibration Monitors

PCB PIEZOTRONICS INC.
MTS SYSTEMS CORPORATION

Automotive Sensors Division ☎ Toll-Free in USA 888-684-0014 ☎ 716-684-0001 www.pcb.com

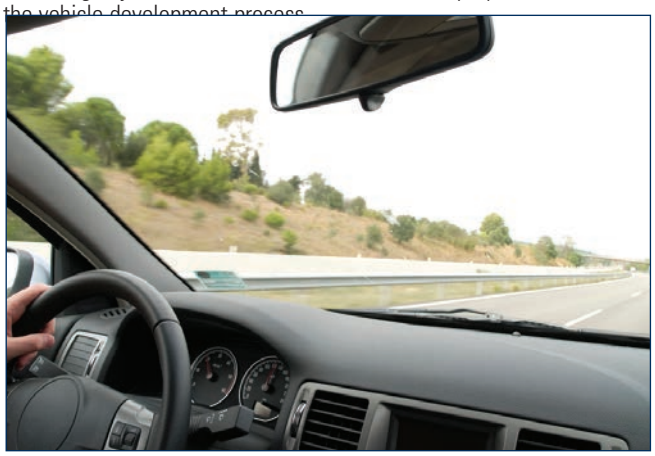
Driveability and Ride & Handling

Driveability is a vehicle's response to driver input through a series of drive cycles and is generally indicative of the degree of smoothness and steadiness of straight line acceleration and deceleration. Vehicle handling is also defined as a vehicle's response to driver input; however, the emphasis is on vehicle motion transverse to the primary direction of motion, particularly during cornering, lane change maneuvers and its ability to maintain the chosen path. The low frequency response of the vehicle to driver input defines the "character" of the vehicle and is the basis for the image and branding of particular vehicle types. Primary and secondary ride are important aspects of ride quality and development of their performance is often a compromise with vehicle handling attributes.

Although driveability and ride & handling are unique attributes, they share some commonality. Measurement for both attributes is conducted using low frequency measurement instrumentation. Primary ride is typically measured in the 0 to 3 Hz range, while secondary ride is higher, but typically less than 25 Hz. Driveability and vehicle handling require measurements down to DC, as changes in vehicle motion by driver input are the primary metrics. With advancements in engine and vehicle technologies, it is now common practice to collect not only vehicle motion data but also system information from the vehicle's CANBus, to monitor and adjust engine operating parameters, advanced combustion control (cylinder deactivation algorithms), stability control (brake and torque-based systems), and traction control, as these systems can play a significant role in driveability and ride & handling performance.

Driveability

Driveability can be a complex equation between driver expectation and how a vehicle actually performs over numerous maneuvers in a particular drive cycle. While parlaying objective measurements into subjective ratings is still very much under scrutiny, the process of collecting objective data is noncontroversial and plays a crucial role in the vehicle development process.



Typical test setups include measurement of driver input and low frequency vehicle response, including:

- Pedal force (brake, accelerator, and clutch)
- Longitudinal vehicle acceleration
- Vehicle pitch
- CANBus
  - Throttle position
  - Turbo boost pressure
  - Brake pressure
  - Transmission shift parameters

Calibration engineers routinely strike a balance between fuel economy, NVH, and driveability performance by optimizing engine combustion processes and transmission shift schedules.

Ride & Handling

Vehicle manufacturers strive to achieve optimal vehicle handling and to balance handling performance against other key attributes in chassis development, including ride comfort; road noise; and durability, in accordance with brand status. Vehicle handling is a complex interaction between driver and vehicle; actions and reactions of a driver, including acceleration/deceleration, brake or clutch operation, gear shift, and steering movements. Vehicle specifications and trim levels also play a role in handling, including vehicle weight distribution; suspension; tires and wheels; electronic stability control; and more. Numerous testing situations take into account different driving styles, from defensive to aggressive, as well as weather and road conditions. Track-based testing includes:

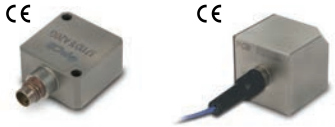
- Fishhook
- On-Center

While these tests are performed for benchmarking against baseline targets, they are also used for gap analysis during the development stage, and occasionally performed to satisfy safety regulations prior to market release.

Vehicle handling tests lend themselves to be somewhat subjective. PCB® accelerometers and accessories can help achieve specific objective measurements to aid in vehicle handling analysis. PCB® sensors are small, lightweight, and hermetically sealed, making them waterproof to accommodate typical track environments.

PCB Piezotronics offers a complete line of sensors and instrumentation for vehicle driveability and ride & handling tests. Single axis and triaxial DC response accelerometers are designed to measure low-frequency vibration and motion. These units are inherently insensitive to base strain and transverse acceleration effects, and offer better thermal stability, higher overload protection, better signal-to-noise ratio, superior durability, and simpler test setups than strain gage-based DC sensors. Series 3711 and 3713 units are rugged by design; housed in titanium and hermetically sealed; and offer a single-ended output signal for each channel with power and ground leads. Series 3741 are precision units that offer a differential output signal for common-mode noise rejection. Model 356B41 triaxial, ICP® seat pad accelerometer measures whole body vibration influences associated with vehicle operation. The unit houses a triaxial accelerometer within a molded rubber pad that can be placed under a seated person or beneath a weighted test object. Model HVM100 human vibration meter utilizes accelerometer inputs to provide vibration severity measurements relative to human vibration exposure and is used with the seat pad accelerometer. Additional ICP®, triaxial accelerometers with high sensitivity, low frequency capability, and good resolution are available to aid in driveability and secondary ride measurement requirements. Series 1515-106 pedal effort force sensor is compact, lightweight, and designed to measure load applied to the brake, accelerator, and clutch pedals during acceleration, deceleration, and transmission shift events. Series 8161 and 8162 strain gage signal conditioners are used with the pedal effort force sensor. PCB® products are designed and manufactured in state-of-the-art facilities, and together with our global distribution network and Total Customer Satisfaction guarantee, you

DC Response Accelerometers for Driveability and Ride & Handling Applications

Series 3741	Sensitivity	Measurement Range (pk)	Frequency (± 10%)	Broadband Resolution (rms)
	10 mV/g	± 200 g	0 to 2000 Hz	5.1 mg
	20 mV/g	± 100 g	0 to 2000 Hz	4.5 mg
	40 mV/g	± 50 g	0 to 2000 Hz	2.5 mg
	66.7 mV/g	± 30 g	0 to 2000 Hz	2.5 mg
	200 mV/g	± 10 g	0 to 200 Hz	1.1 mg
	1000 mV/g	± 2 g	0 to 150 Hz	0.3 mg
Series 3711 and 3713				
	10 mV/g	± 200 g	0 to 1500 Hz	5.3 mg
	40 mV/g	± 50 g	0 to 1500 Hz	4.4 mg
	40 mV/g, 2.5 V offset	± 50 g	0 to 1500 Hz	4.4 mg
	100 mV/g	± 20 g	0 to 1500 Hz	3.6 mg
	100 mV/g, 2.5 V offset	± 20 g	0 to 1500 Hz	3.6 mg
	700 mV/g	± 3 g	0 to 150 Hz	1.1 mg

Model Number	3741 Single Axis	3711 Single Axis	3713 Triaxial
Overload Limit (Shock)	± 5,000 g pk	± 5000 g pk	± 5000 g pk
Temperature Range	-65 to +250 °F -54 to +121 °C	-65 to +250 °F -54.0 to +121 °C	-65 to +250 °F -54 to +121 °C
Excitation Voltage	6 to 30 VDC	5 to 30 VDC	5 to 30 VDC
Housing Material	Anodized Aluminum	Titanium	Titanium
Sealing	Epoxy	Hermetic	Hermetic
Size	0.30 x 1.00 x 0.85 in 7.62 x 25.4 x 21.6 mm	0.45 x 0.85 x 0.85 in 11.4 x 21.6 x 21.6 mm	1.1 in Cube 28 mm Cube
Weight Connector style Integral cable style	— 10 gm	14 gm 78 gm	78 gm 169 gm
Electrical Connector	10 ft. (3 m) Integral Cable	1/4-28 4-Pin or 10 ft. (3 m) Integral Cable	9-Pin or 10 ft. (3 m) Integral Cable
Output Configuration	Differential	Single-Ended	Single-Ended
Supplied Accessories			
Easy Mount Clip	—	080A152	—
Adhesive Base	—	—	080A208
Mounting Screws/Studs	081A103 M081A103	081A64 M081A64	081A05 M081A05
Additional Accessories			
Triaxial Mounting Block	080A208	080A153	—
Mounting Cable Connectors	—	AY	EN

Recommended Signal Conditioner for Series 3741

Model 482C27

Four-channel, line powered, bridge, incremental gain, digital control interface, RS-232 and ethernet

Recommended Signal Conditioners for Series 3711 & 3713

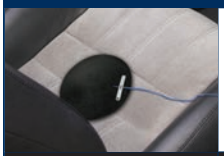
Model 478A01

Single-channel unity gain (internal battery powered)

Model 478B05

Three-channel unity gain 36 VDC power adaptor (optional external battery pack)

Triaxial, ICP® Seat Pad Accelerometer



Model Number	356B41		
Sensitivity	100 mV/g	Supplied Accessory	010G05 Cable
Measurement Range	± 10 g pk	Electrical Connector	Integral Cable
Broadband Resolution	0.0002 g rms	Sealing	Hermetic
Frequency Range (± 5 %)	0.5 to 1000 Hz	Weight	272 gm
Temperature Range	+14 to +122 °F -10 to +50 °C	Size	7.87 x 0.472 in 200 x 12 mm

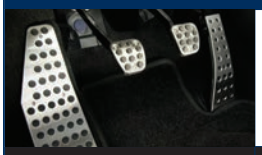
Recommended Human Vibration Monitor for Model 356B41 Seat Pad Accelerometer

Model HVM100 provides a portable, convenient way to collect and analyze data in accordance with ISO requirements for assessing steering wheel hand-arm and whole-body vibration exposure. This handheld instrument measures human exposure to vibration, performs relevant calculations, and provides overall metrics on its LCD display.

Triaxial ICP® Accelerometers

Model Number	356A16	356A17	356B18
Sensitivity	100 mV/g	500 mV/g	1000 mV/g
Measurement Range	± 50 g pk	± 10 g pk	± 5 g pk
Broadband Resolution	0.0001 g rms	0.00006 g rms	0.00005 g rms
Frequency Range (± 10 %)	0.3 to 6000 Hz	0.3 to 4000 Hz	0.3 to 5000 Hz
Temperature Range	- 65 to +176 °F - 54 to +80 °C	- 65 to +176 °F - 54 to +80 °C	- 20 to +170 °F - 29 to +77 °C
Electrical Connector	1/4-28 4-Pin Jack	1/4-28 4-Pin Jack	1/4-28 4-Pin Jack
Sealing	Epoxy	Epoxy	Epoxy
Housing Material	Anodized Aluminum	Anodized Aluminum	Anodized Aluminum
Weight	7.4 gm	9.3 gm	25 gm
Size	0.55 in Cube 14 mm Cube	0.55 in Cube 14 mm Cube	0.80 in Cube 20.3 mm Cube
Mounting	10-32 Thread	5-40 Thread	10-32 Thread
Supplied Accessories			
Wax/Adhesive	080A109	080A109	080A109
Mounting Base	080A12	080A145	080A68
Mounting Stud	081B05 M081B05	081A27 M081A27	081B05 M081B05
Additional Accessories			
Magnetic Mounting Base	080A27	—	080A27
Removal Tool	039A10	039A10	—
Mating Cable Connectors	AY	AY	AY
Recommended Stock Cables	034	034	034

Pedal Effort Force Sensor



Model Number	1515-106-01A	1515-106-02A	1515-106-03A
Measurement Range	100 lb 0.44 kN	200 lb 0.89 kN	300 lb 1.33 kN
Overload Limit	500 lb 2.20 kN	1000 lb 4.40 kN	1500 lb 6.67 kN
Temperature Range	-65 to +200 °F -54 to +93 °C		
Size	2.63 x 1.19 in 66.80 x 30.23 mm		
Weight	0.49 kg		
Housing Material	Plated Steel		
Electrical Connector	Pigtail Ends		

Recommended Signal Conditioners for Series 1515-106 Pedal Effort Force Sensor

Series 8161

DIN rail, 35 mm, strain gage signal conditioner, operates from 12 to 28 VDC, provides 5 or 10 VDC bridge excitation, and delivers ± 5 or ± 10 volts and 4 to 20 mA output signals. Adjustable zero and span with built-in shunt calibration.

Series 8162

Strain gage signal conditioner in IP66 (NEMA 4X) enclosure operates from 12 to 28 VDC and provides 5 or 10 VDC bridge excitation, and delivers ± 5 or ± 10 volts and 4-20 mA output via screw terminal connections. Adjustable zero and span with built-in shunt calibration.

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PCB® Automotive Sensors is a dedicated technical sales and support facility, located in Farmington Hills, Michigan, USA, devoted to the testing needs of the global transportation market. This team is focused on development and application of sensors and related instrumentation for specific vehicle development test programs, including modal analysis; driveability; ride & handling; component & system performance; durability; road load data acquisition; vehicle and powertrain NVH; legislative testing; quality control; powertrain development; and motorsport. PCB® offers exceptional customer service, 24-hour technical assistance, and a **Total Customer Satisfaction** guarantee.

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