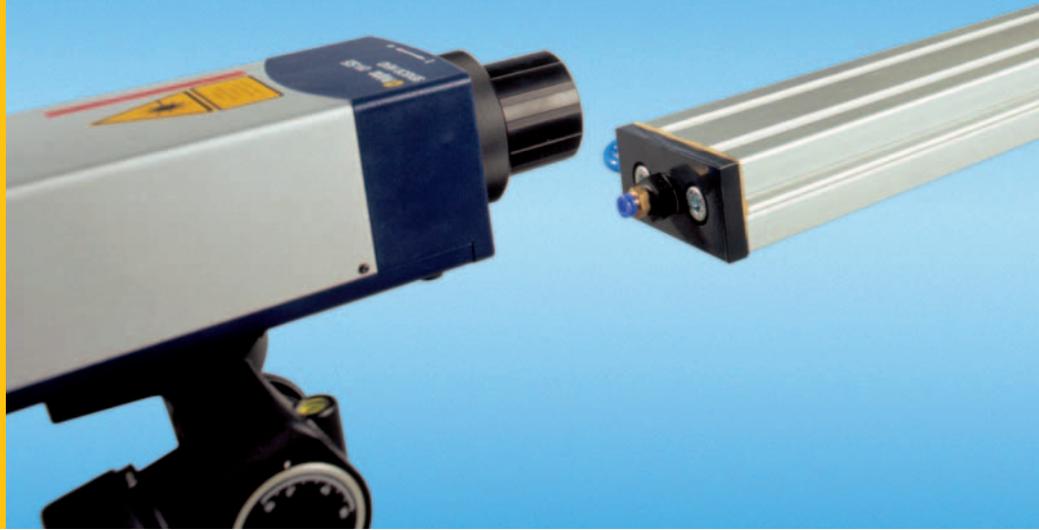


Shock sensors that measure high accelerations from about 3000 m/s<sup>2</sup> upwards are used in crash tests and in the aerospace and aviation industries. To calibrate these sensors properly, impulse accelerations are necessary that cannot be generated with conventional electro-dynamic shock exciters. Alternative shock exciters such as the Hopkinson bar are used with laser vibrometer monitoring for accuracy.

# Certified Crash Sensor Calibration

Precise, Laser Vibrometer-enabled Primary Calibration of Shock Sensors up to 750,000 m/s<sup>2</sup>



## Shooting for a Good Cause

With the classic Hopkinson bar (Fig. 1), a projectile hits a long, movably bedded slim metal rod and generates a high short power surge, which the bar converts into a sinusoidal like acceleration impulse at the other end (Fig. 2). This acceleration

impulse is used to calibrate the attached sensor (Unit Under Test or UUT). For calibration purposes, a reference signal is required which can be measured in the following ways:

- A reference sensor attached to the end of the rod, on which the test sample

is mounted back-to-back, supplies the reference signal. This version is the least expensive but reliable; however, the additional mass of the reference sensor can lead to mechanical problems, meaning that higher tolerances must be accepted.



Fig. 1: Measurement setup with Hopkinson bar.



Fig. 4: OFV-5000 Vibrometer Controller and OFV-505 Sensor Head.



### Combination of Proven and New Technologies

To produce the highest accelerations from 10,000 m/s<sup>2</sup> to 750,000 m/s<sup>2</sup>, a projectile driven by compressed air is used. The strength of the impulse is controlled by the length of the acceleration path which can be set using an electric motor. For medium accelerations of 20 m/s<sup>2</sup> up to 50,000 m/s<sup>2</sup>, a completely new kind of electromechanical impulse generator is used. This new method allows, for the first time, accurate, independent setting of shape, amplitude and duration of the impulse over a wide range. By controlling the shape and duration of the input impulse, the spectrum of the shock can be selectively influenced. This process can prevent excitation of the test sample close to its resonant frequency, avoiding excessive values of sensor sensitivity during calibration or even a destruction of the sensor.

The new electromechanical shaker has the great advantage that it can easily be linked into automated shock calibration and measurement systems, and that the shock parameters are precisely reproducible as a result of the precise mechanics and the high-precision reference measurement. Automation is of great interest when determining the linearity of the sensor's response by subjecting the sensor to a series of shocks with increasing shock amplitude. Using the SPEKTRA CS18's software, the number of shocks, the shock

width and the required amplitudes can be set. After the start of the measurement, the results of the measurement series are available within a few seconds without any further intervention by the operator.

### Primary Calibration through Laser-accurate Measurement

As a reference, the primary shock calibration systems used by SPEKTRA incorporate an OFV-5000 laser vibrometer from Polytec. The vibrometer is capable of measuring speeds in a range from 1 mm/s up to 10 m/s with great precision and covers the required acceleration range. The direct traceability of the measurement to a standard physical quantity, in this case the wavelength of the laser light, allows a primary calibration according to ISO 16063-13. For this purpose, the vibrometer provides a continuous measurement signal in both analog and digital form to the SPEKTRA CS18 measurement system. A close and productive relationship between SPEKTRA and Polytec has made it possible to find an optimal solution for this measurement task.

- Strain gauges, which are attached along the rod, measure the transitory shock wave and supply the reference signal. Due to the properties of the strain gauges also higher tolerances must be accepted.
- A laser beam is aligned towards the contact surface between the end of the rod and the UUT and measures the acceleration there during the impulse (Fig. 3). Although this process is the most complex, it offers the highest accuracy, since there is no corruption of the impulse by a contact measurement.

The new family of shock exciters for the calibration at high acceleration amplitudes, which has been developed at SPEKTRA Schwingungstechnik und Akustik GmbH in Dresden, is based on the Hopkinson bar principle and additionally allows programmable calibration tasks to be processed efficiently.

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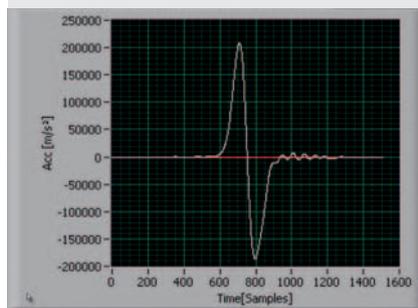


Fig. 2: Acceleration impulse from a Hopkinson bar, calculated from the velocity measured using a laser vibrometer.

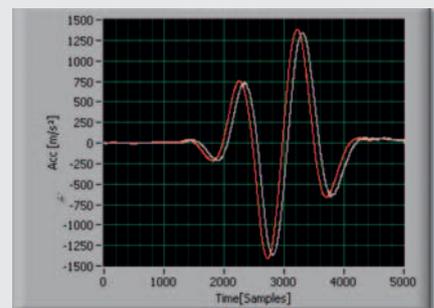


Fig. 3: Shape of the acceleration produced with electromechanical shock exciter (white = laser vibrometer, red = conventional acceleration sensor).