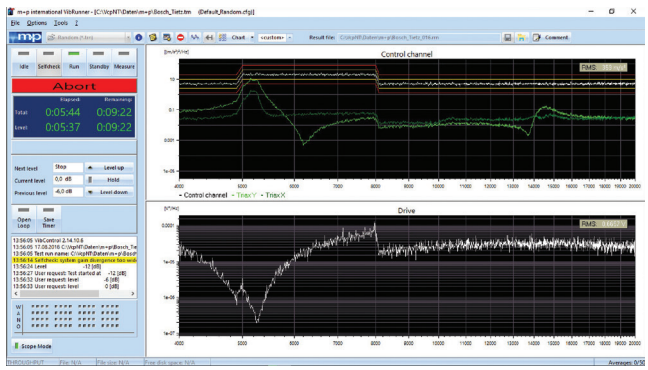
High-frequency vibration

A new vibration testing technique based on piezo-actuators goes beyond the limitations of traditional analysis methods

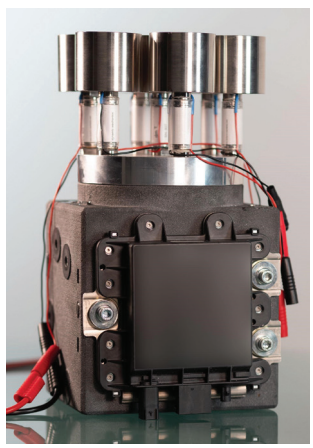
A novel method for high-frequency (HF) mechanical excitation (>2-40kHz) of large (>100mm) and heavy (>100g) test specimens has been developed. The objective of this method is to excite the DUT or the test fixture onto which the DUT is directly mounted, using piezoelectric actuators. This new technique offers a considerable increase in performance with regard to the achievable frequency limit and vibration amplitude, as well as a reduction in the transverse vibration, at a lower cost than conventional methods. In addition to the calibration of vibration sensors in the HF range, environmental simulation of higher vibration frequencies (such as >5kHz) will become more critical in the future.

There are several typical fields of application. This includes investigation of the HF vibration immunity of MEMS gyroscopes and related assemblies (e.g. ECUs). Currently the gyroscopes serve as control sensors in driving stability systems (ESP), but in the future the sensors may also be used in automated driving technologies. Malfunction due to high vibration must be avoided in these safety-critical applications.

Another application of the newly developed method is acoustic characterization of vehicle components at higher frequencies. Modern, low-noise electric propulsion systems are steadily gaining market share. High-frequency acoustic noises that were previously unperceivable by the human ear due to the masking of the sound by the internal combustion engine can now be heard. This noise must be examined and reduced or refined.



LEFT: m+p VibControl display: single actuator 20kHz, lateral acceleration (green)



LEFT: Seven piezo-actuators with ceramic block. Images: Dynamic Mechanics, Dresden, Germany

Another application is durability testing of automotive components such as contacts and sensors. Vibration time histories measured in the field can be reproduced in the laboratory. For greater realism, tests can also be combined with climatic conditioning (temperature and humidity), which can be achieved up to a maximum of 2-3kHz.

Currently the most common way to perform a vibration test is by using an electrodynamic shaker. This device typically excites the test specimen (of sizes and masses as aforementioned) within a frequency range of <5-10kHz. When operating above the mechanical frequency limits, problems (armature resonances) can often occur with the control and signal quality (control deviations, transverse vibrations).

This new concept uses a piezoelectric inertial exciter, mounted onto a seismic base with a reactionary mass, onto which a sample can be mounted. The piezo-actuator is capable of achieving the following performance:

- Force: 100N;
- Frequency range: 1-40kHz (depending on DUT/test fixture);
- Temperature range: -40°C/F to 120°C (248°F).

The piezo-actuator has a modular design, which offers greater versatility across a wide range of applications, e.g. as a single actuator for smaller test samples or in parallel operation for larger test samples.

As an example, plane excitation of an ESP ECU could be carried out under the following specifications:

- Force: 700N;
- DUT test fixture: 150 x 150 x 150mm, 7kg, 3D-printed ceramics;
- Acceleration: 100m/s² RMS;
- Frequency range: 1-30kHz.

With the m+p VibControl vibration control system from m+p international, traditional vibration tests (sine, random) can be carried out similarly to an electrodynamic shaker, but with greater flexibility in terms of the frequency and amplitudes possible. m+p believes that this sets a new standard in control accuracy and signal quality when testing larger components. By operating in an extended temperature range, this method increases the boundaries of traditional test methods and improves the reliability of results. ❮

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