hpower
high power actuators by piezosystem jena

ABOUT HPOWER

hpower actuators combine fastest response times in µs, superior kHz dynamics, high force generation in the range of tens of kN and nanometer precision in a way that is unmatched by any other linear driving system. The actuation can be obtained without any mechanical wear, making the actuators extremely durable. **hpower** products include ring and stack type actuators, as well as shakers and shock generators. **hpower** is the result of the collaboration between piezosystem jena and Piezomechanik GmbH and therefore combines centuries of piezo expertise with new innovations.

HPOWER SHOCK GENERATORS FOR IMPACTS THAT LAST

WORKING PRINCIPLE AND EXAMPLE SETUPS

Mechanical impacting is involved in many technical processes, e.g. demolition of concrete by chiselling, structure borne sound analysis, impact-echo analysis of extended strcutrues, characterization of material properties at high strain rates, and indentation hardness tests.

To generate an impact a hard mass body is accelerated during a starting phase (e.g. a hammer head) and collides with a hard counterpart (e.g. chisel) within µs.

The starting and contact phases of an impact scenario are difficult to be exactly reproduced. **Common setups of precision impact measurement do not allow high repetition rates. Another challenge is the precise timing of the impact. Meanwhile composite materials require more and more accurate testing methods.**

hpower shock generators follow a different approach. Our piezo technology uses an adaptive impact generation principle, where impact parameters and timing are controlled by electrical driving conditions. This gives **hpower** systems the following advantages over traditional solutions:

- adjustable impact parameters such as energy, acceleration and stroke E < 4 Joule, a > 20,000 g, Δ > 100 µm
- high repeatability of impact parameters, precise time behavior
- low rise time in the µs's
- pulse width at about 10 µs
- the complete system is at rest before igniting the impact process
- shocks can be generated with high repetition rates and high reproducibility (1 kHz within a burst)

Shock wave generation by piezo-stacks

A piezo-stack can be described as a solid bar of PZT-ceramics. When this PZT bar is electrically charged rapidly, the internal stress jumps instantaneously to a high level: The initial pressure is the blocking pressure, causing an accelerated expansion of the PZT-stack and a shock is created. By coupling the PZT rod to another solid body, the shock impulse can be transferred, and the shock wave is propagating. In this terminology a PZT-stack is an “active bar”, generating inherently mechanical shock pulses by electrical pulse excitation. Because the active bar is at rest, two pulses are generated propagating in opposite direction to balance the total impulse to zero. This kind of pulse generation is called “super elastic”, because the kinetic energy of the system after the shock generation is higher than before the shock event. The result can be compared with an explosive.

Figure 1: High load piezo-stack with 35 mm diameter, with shock proof wiring.

Symmetrical shock generator: PIA 2

The basic symmetry of the shock-generation within a resting active bar can be used for a single ram element with a nearly doubled energy and impulse output over identical impulse content. This allows sophisticated designs for calibration experiments.

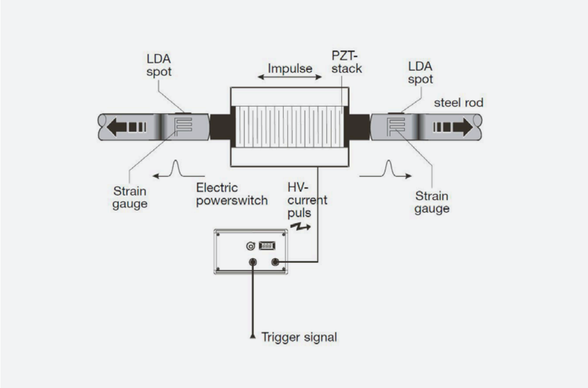

Figure 2: Symmetrical piezo-shock-generator with two-side shock propagation. The shock parameters are detected by strain gages & LDAs.

Design of a symmetrical piezo-shock-generator

The shockwave is generated with the piezo-bar and transferred to both ram elements (steel, titanium, brass etc.). Acoustical matching for maximum energy extraction is done by adoption of the cross sections of PZT-stack and the metal rams.

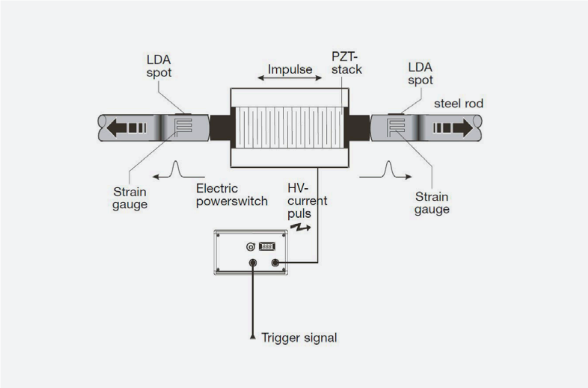

Figure 3: Schematic of a symmetrical piezo-shock generator.

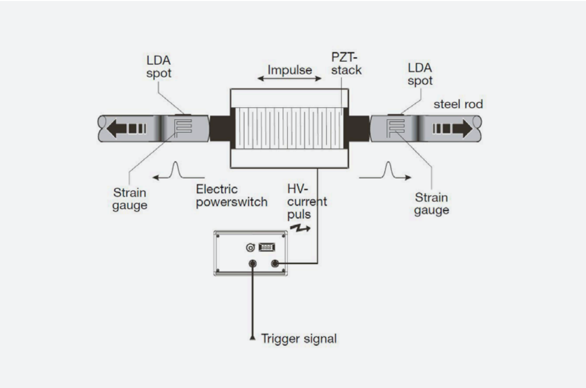

Figure 4: Symmetrical shock generator: shock output via the rams (PIA 2).

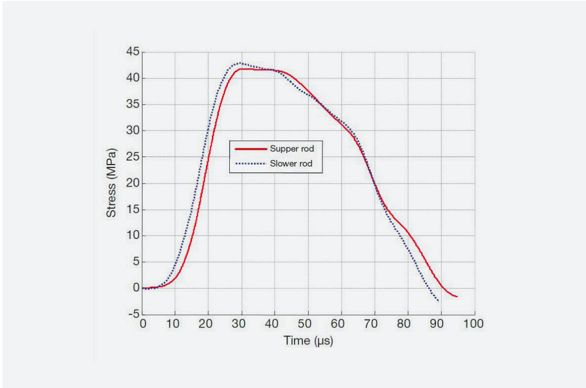

Figure 6: Shock profiles of a 50 mm active length SYMMETRICAL pulse generator, electrical pulse level 500V.

Figure 5: Symmetrical pulse generator vertical arrangement. Both sides are coupled to steel bars for two-sided impulse extraction. Notice the casing and mounting flanges steel for getting optical access for the LDA-measurements.

The **hpower** shock generator shown in Fig. 5 is used for R&D activites to shorten test periods for **HILTI**, the leading manufacturer of highest quality tools for demolition and chiselling. The shock pulses propagating within the steel abrs have aser-Doppler-Anemometry (LDA). Comparison of the shock profiles with the two steel bars derived from the above-mentioned symmetrical arrangement. The result is shown in Fig. 6. Timing is triggered by the transistor signal. The delay of the onset of the mechanical pulse is due to the distance from shock generator to the LDA-measuring spot on the steel bar. The peak stress was 42.5 MPa and the pluse was less than 100 microseconds.

Single end piezo-shock-generator: PIA

The above-mentioned symmetrical generator setup can be modified to a single ram element with nearly double the energy and impulse output. This is done by applying a bigger mass to support the PZT-stack on one side (seismic mass). The impulse will then be reflected and directed towards the other output. A double pulse is created by containing nearly double the pulse energy (by elongating the total pulse output duration). The compensating impulse is transferred to the seismic mass as recoil (similar to a rifle).

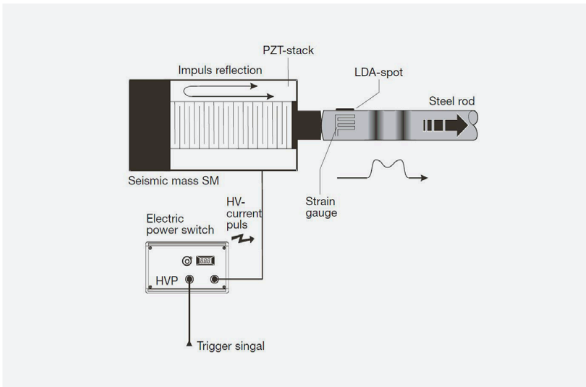

Figure 7: Schematic of a single end piezo-shock-generated system by application of a seismic mass. The interaction of travelling pulses results in an elongated double pulse output.

Design of a single end piezo-shock-generator

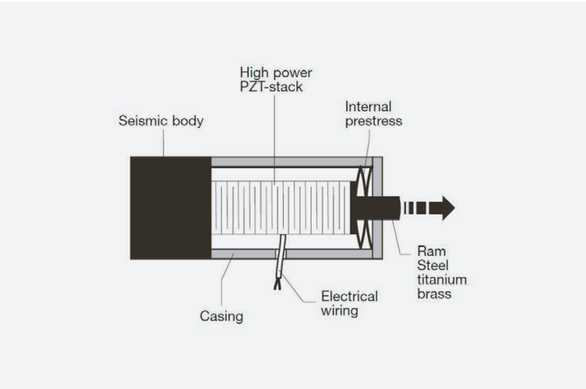

Figure 8: Schematic of a single end piezo-shock-generated system by application of a seismic mass.

Figure 9: Single output piezo-shock-generator: brass part: seismic counter mass (PIA).

Along with PIA 2 shock generator, single end piezo-shock-generator PIA was also used at **HILTI**. Fig. 10 shows a "head down" arrangement of the shock generator: the contact between the piezo-shock generator and the steel bar is thereby preloaded with the weight force of approx. 100 Newtons.

Figure 10: Test set up using a single output piezo-shock-generator with seismic mass for impulse reflection.

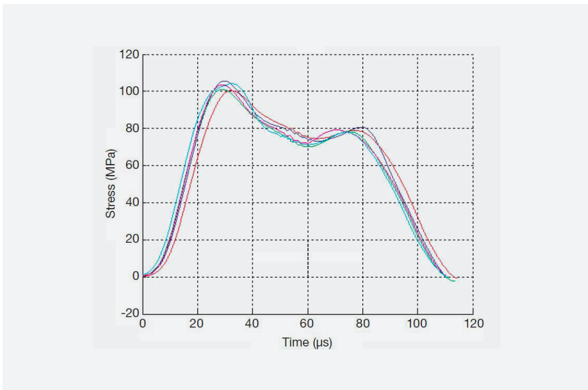

Figure 11: Mechanical stress/time profile time for a burst of shocks. Active stack length: 120 mm. Shockwave energy: 3.25J.

Fig. 11 shows the typical single output pulse profile exhibiting a double peak structure of the stress response. This is due to superposition of the primary impulse and the impulse reflected at the seismic mass. This elongates the total propagation time and leads to longer lasting output pulse. The energy content is increased nearly by a factor of two compared to a single pulse of a symmetric arrangement. The test was conducted five times and it showed that the repleatability of PIA was high.

Piezo-stacks with a length up to 200mm have been tested with a mechanical shock energy of more than 4 J. The physical impulse was measured with up to 2 kgm/s. For a "free end" bar experiment acceleration rates up to 200,000 m/s2 can be expected at the bar's tip.

Electrical pulse excitation: HVP 1000/200

Form an electrical perspective a piezo can be described as a capacitor and achieves its best performance with special electronics. The high voltage pulser **HVP 1000/200** has been designed to drive PIA shock generator with very high charging currents for “pulse” operation in a kind of “on-off” square-wave mode. During operation, the voltage at the PIA shock generator **increases in a few µs** to the pre-set value with a current of **200 A**.

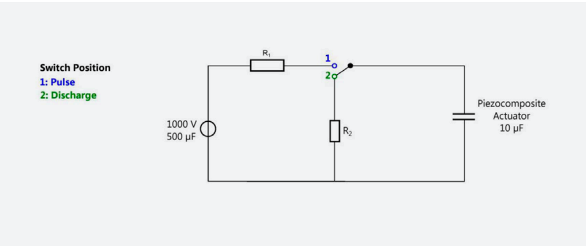

Figure 12: Schematic of piezo-actuator by a HighVoltagePulser (HVP).

Figure 13: HighVoltagePulser (HVP).

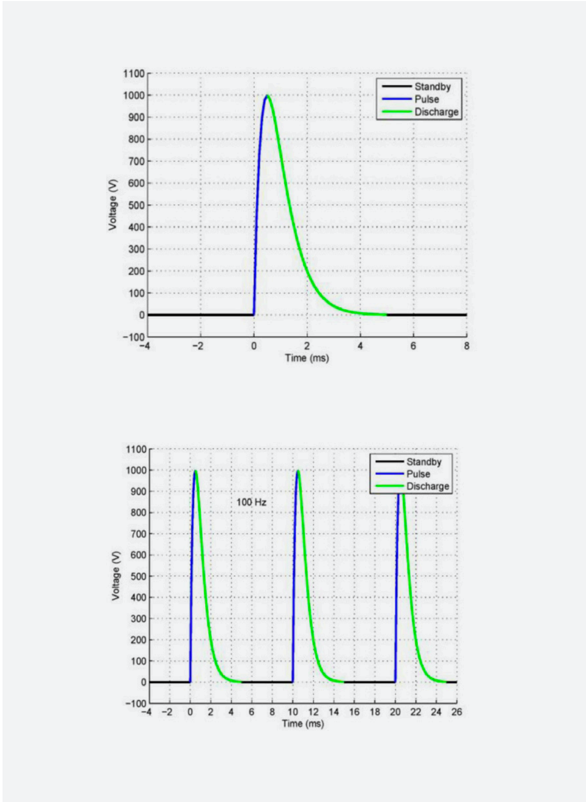

Figure 14: Performance of HighVoltagePulser (HVP) during operation.

As shown in Table 1, operating with HVP 1000/200, the PIA shock generator can achieve extremely high acceleration with very short rising time.

The team of **hpower** has experience with a wide variety of set ups for shock testing and is dedicated to find the fitting solution for your application. We are looking forward to to hearing from you.

Shock generator	Amplifier	Stroke, µm	Stiffness, N/ µm	rising time, µs	acceleration, g	Resonant Frequency, kHz
PIA 1000/35/60	HVP 1000/200	60	600	12	18,000	27
PIA 1000/16/150	HVP 1000/150	150	50	48	18,000	7

Table 1: Performance of the PIA shock generator

* source: L. Pickelmann, High power piezoelectric axial shockwave generation

Get in touch with us and we will help configuring the best solution.

phone: +1 508-634-6688 (USA) +49 3641 6688-38 (GERMANY)

e-mail: givememore@hpowermotion.com