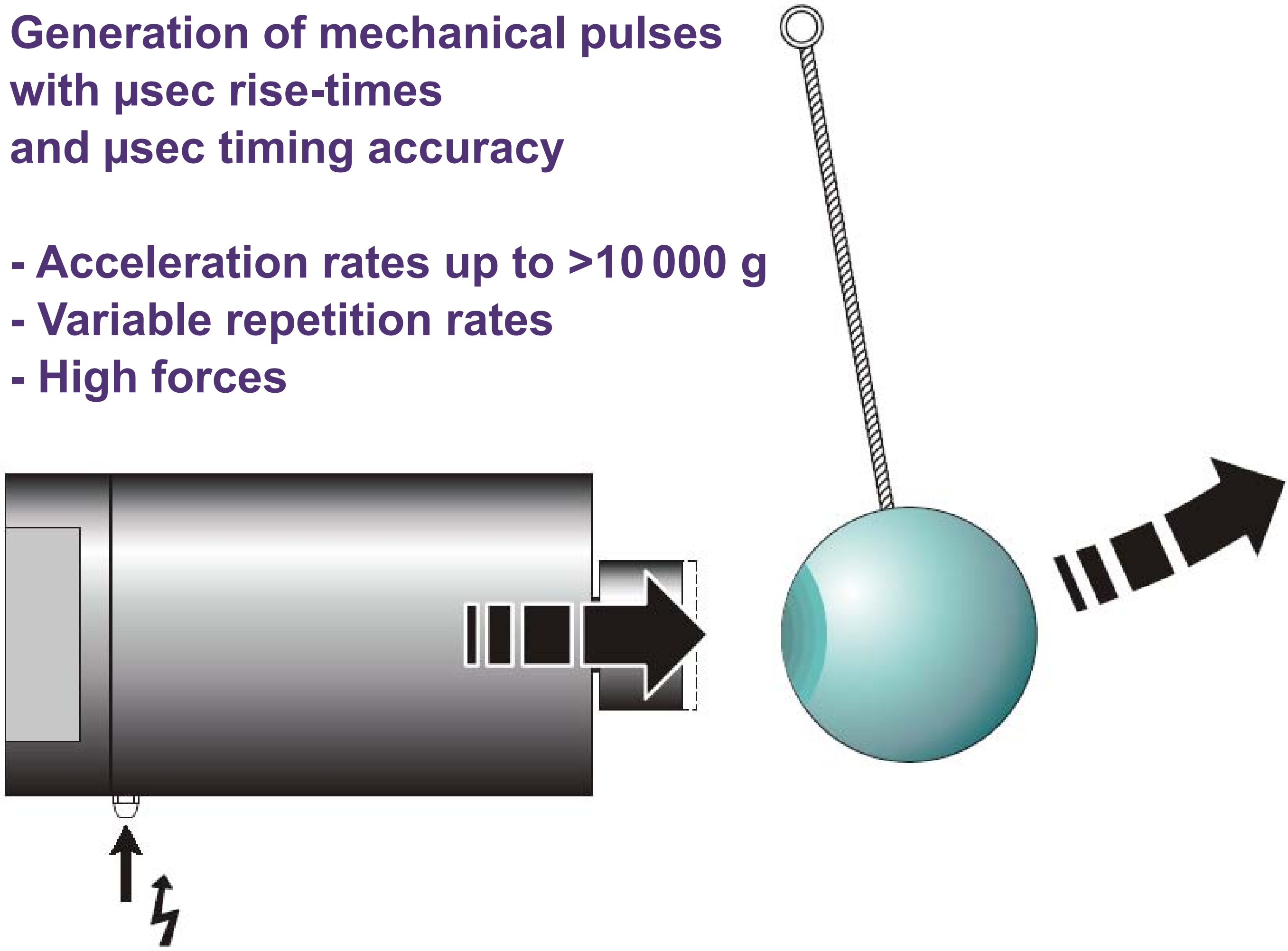
Piezomechanik GmbH

Piezo Impactors/Accelerators (PIA) for Shock and Impact Generation

Generation of mechanical pulses with µsec rise-times and µsec timing accuracy

- **Acceleration rates up to >10 000 g**
- **Variable repetition rates**
- **High forces**



Keywords

- Accelerometer testing
- Adaptive pulse mechanics
- Dynamic hardness test
- Impact tests
- Hopkinson test
- Incident bar
- Indentation
- Material testing
- Micro-indentor
- Micromechanical testing
- Shock propagation
- Split bar experiment
- Striker bar
- Structure mode analysis
- Structure borne acoustics
- Structure borne noise

PIA's piezo-impactor/accelerator philosophy

The PIA-devices are used for high g-accelerating an attached mass or to produce a compression impact into extended mass-loaded structures.

In principle a piezo stack is used as the mechanically active element similar as used for shaking.

The main difference to a shaker is, that PIA-devices produce a steep pulse action (square wave) instead of a cw-harmonic oscillation. Therefore maximum acceleration and highest pulse-powers are achievable independently of the repetition rate.

Shaker's acceleration etc. is coupled to the cycle rate of the system and can only be increased together with the average power-rating of the oscillator system. This strategy will be limited e.g. by strong self-heating.

For the PIA-system, acceleration can be maximized even for a single pulse.
So the average power requirement (repetition rate) can kept within acceptable limits even for maximum pulse powers.

Because of the higher pulse powers etc. a PIA piezo – impactor system needs a modified mechanical and electrical structure compared to a shaking system.

Fig.1: Set of various PIA-devices

Application of the PIA-Impactors / Accelerators

The PIA devices are used for

A. **Acceleration experiments**
B. **Impact experiments**

Maximum acceleration occurs, when the front piston of the PIA device can move freely.

Impacting (shock generation) occurs, when the expansion of the PIA piston is hindered by contact with a counter-part like a solid body of high mass. The pulse excitation results in a steep rise of the contact force, leading to a highly dynamic local compression of the impact partner. Both applications are covered by the PIA devices, differing only in the individual design of the front piston

Piezo- impactors / accelerators are available in a wide range of dimensions ranging from small-sized “mini-shockers” up to high power “piezo-hammers”

The specific highlights of the PIAs are

- Reproducible pulse profile
- Precision pulse timing
- Coherent multi-shocker arrangements
- Pulse shaping by electrical means
- Compact designs
- Pulse energies up to Joules
- Miniature design for micro-testing

A. Accelerator set-up

When actuator’s motion is free and unhindered, a steep shift of the front piston can be produced with

acceleration rates up to 100,000 m/sec² (> 10,000 g)

E. g. when a piezo-stack with **20 µm stroke** expands within **20 µsec rise-time.**
The acceleration rates can be varied by the electrical input pulse parameters. By this means acceleration tests can be carried out by attaching the test specimen to the moving top of the PIA device (fig.2).

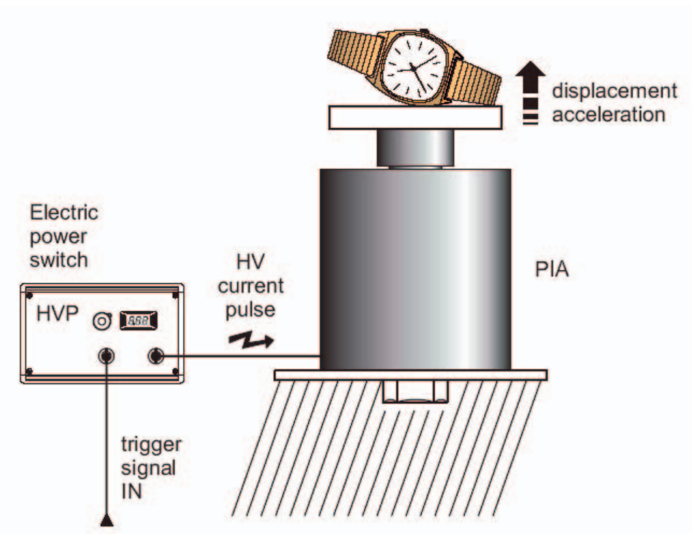


Fig 2: Schematic of a acceleration/shock-tester

B. Impactor: Generating elastic shocks into solid bodies

Notice:
with common pulse experiments, a moving striker (hammerhead) is used.
An impact shock is conventionally produced by the collision between the moving striker and the resting impact-partner(difference in velocity)

For the PIA-experiment ,both partners (PIA-generator and impact partner) are in rest and the PIA piston is already in contact with the impact partner.
The impact shock is generated by application of a high power electrical pulse to the PZT-piezo-ceramic.

The electrical pulse is instantaneously converted into potential mechanical energy:
the piezo-stack resembles now a compressed spring ,which starts its rapid expansion towards the elongated state.

In contrast to the conventional Hopkinson experiment, the impact is not created by the short-term interaction between the moving striker and the resting impact partner (e.g. Hopkinson incident bar).The PIA impact is created inside the ceramic by the piezo-mechanical dynamics of the electrical to mechanical pulse conversion.

To get this behaviour, the exciting electrical pulse width shall be remarkable shorter than the longitudinal resonance period time of the PIA device.

The special feature of the PIA devices are

- Highly reproducible impact profiles by mechanical pre-adjust of the contact point and electrical parameters
- Easy pulse profiling by electrical means
- Variable repetition rates of pulses

PIA generators are available in a wide range of sizes and operating parameters:

- Strokes up to 100 µm
- Forces up to 20,000 Newtons (static blocking)
- Velocity up to 2 - 3 m/sec
- Accelerations up to 10.000 g
- Repetition rates up to Hundreds of Hertz

Repetition rates:
The achievable repetition rates depend on the size of the PIA-device and the used electronic supply (average power).
Medium- sized PIAs allow repetition rates starting from single shot operation up to Hundreds of Hertz (depends on actuator configuration).
Higher ratings on request.

Electronic supplies:
Piezo-shock generation requires an electrical pulse-excitation of the PIA-generator.
The necessary pulse powers depend on the active size of the PIA-impactor and can easily reach a multi-kiloWatts range. (for 100 µsec duration).

PIEZOMECHANIK offers as standard the “HVP high voltage switches” for driving PIA-shockers.

Special solutions are offered on request.
Please check brochure ”Electronics for Piezomechanics: Technical data“

Using standard piezo-actuators as pulse generators?
Standard piezo stack actuators are mostly designed for positioning tasks with limited dynamics/ accelerations and powers (both peak and average). To certain extent, they can be used to generate mechanical shocks with very limited amplitudes / power levels.

Piezo-pulsing with high powers requires the adoption of the piezo-mechanical converter to the potentially very high dynamical force loading and high electrical current ratings. Piezomechanik is offering both: Normal piezo-actuators and piezo-impactors PIA. You can be sure to get the optimum solution for your problem.

► **Contact PIEZOMECHANIK**

Details of pulse-generation

Two basic PIA-configurations are available: W**ith and without a seismic mass.**

A PIA-device without seismic bottom mass

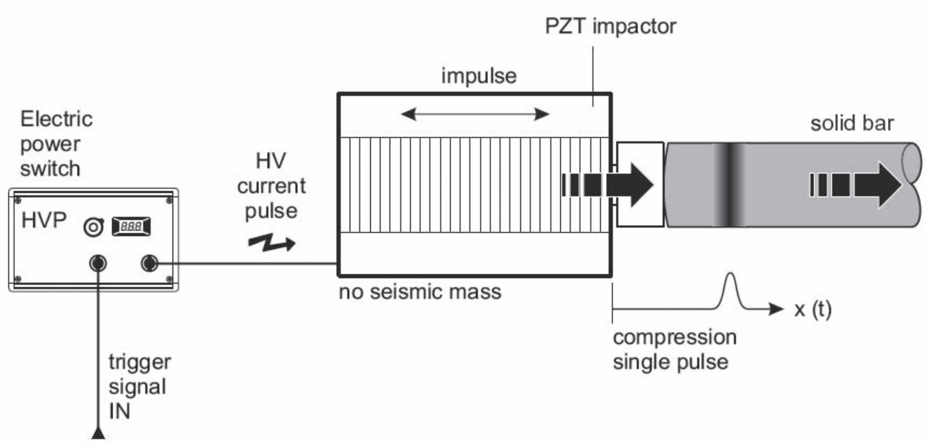


Fig. 3: Schematic of a piezoelectric pulse excitation without seismic mass: The piezo stack expands symmetrically to its centre of mass. Only the forward impulse is directed into the impact partner. The recoil impulse is not further used.

B PIA shocker with seismic bottom mass

Case B, is derived from A, by simply adding a seismic mass to the bottom of the PIA impactor.
The recoil impulse is reflected at the seismic mass into the forward direction.
The PIA produces therefore a double-pulse:
The original pilot-pulse according A, and the reflected pulse.
Separation in time of the two pulses is defined by the propagation time of the reflected pulse through the PIA piezo-stack

The impact energy content is then nearly double that of case A.

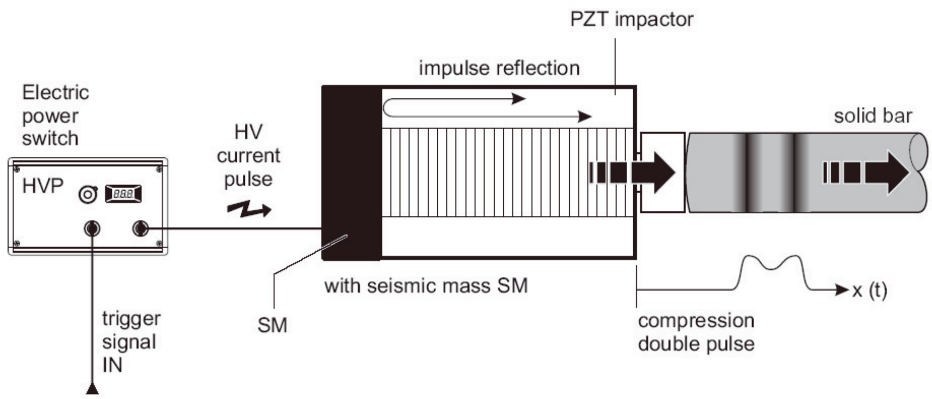


Fig.4: Schematic of a piezoelectric pulse excitation with seismic bottom mass

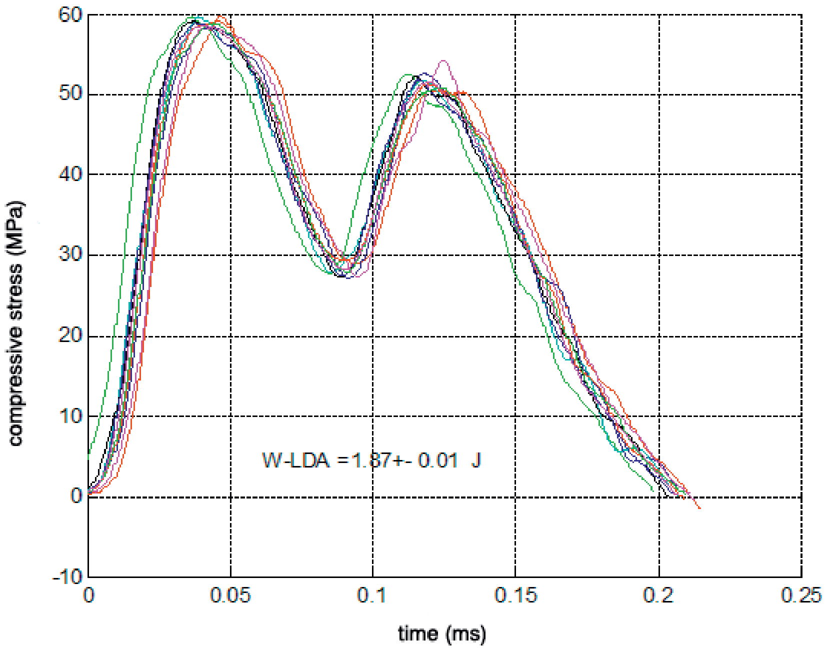


Fig 5: Double peaked shock front propagating through a 14 mm steel rod Excitation by a PIA striker with a 150 mm long piezo-element, high voltage type, Pulse current 500 Amperes Mechanical pulse detection via laser vibrometer (LaserDopplerAnemometer LDA). LDA monitors directly the sound particle velocity of steel rod's surface.

Synchronised multi-source impact generation

The very precise timing accuracy of piezo-electric PIA-generators allows the exact synchronization of several devices to produce coherent shock propagation within extended structures. Arranging PIA-generators in a phased array, different impact patterns with varying propagating directions of the shock front can be achieved without changing the hardware, simply by individual timing of the shock-generators (fig. 6)

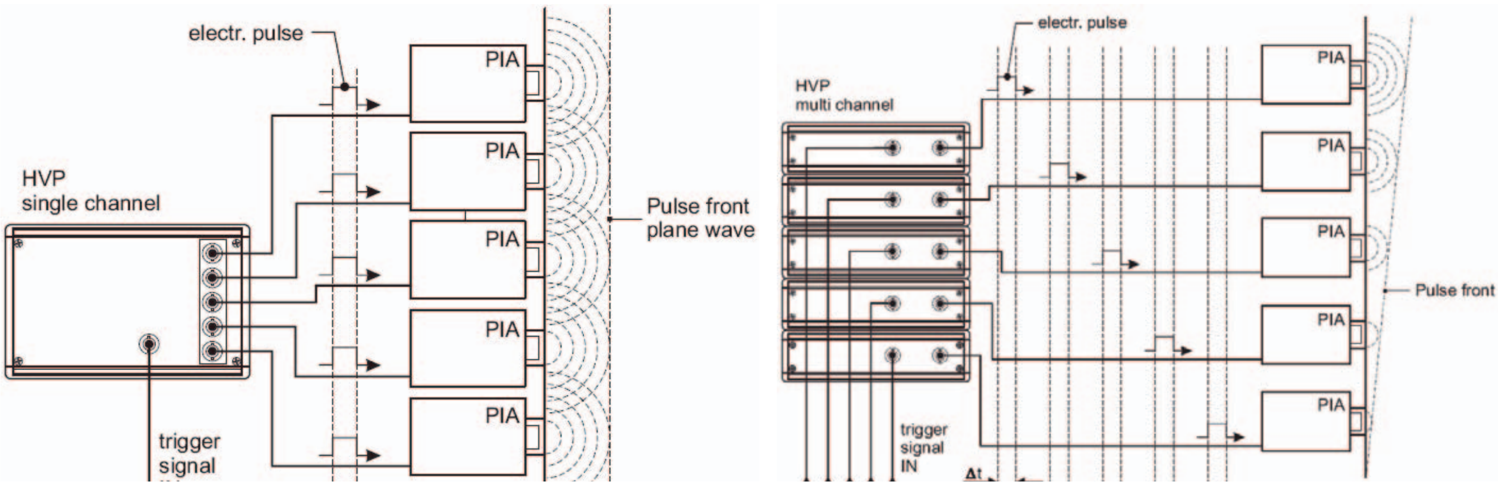


Fig 6: Schematics of multi source impact arrangement with variation of direction of shock front propagation by pulse timing.

PIEZOMECHANIK's offer:

Contact PIEZOMECHANIK for analysing your application to provide the best-matched piezo solution.

PIEZOMECHANIK's know how of piezo impactor/accelerators covers a wide range of mechanical parameters with regard to stroke and forces together with well-adapted mechanical designs and driving electronics.

Piezomechanik · *Dr. Lutz Pickelmann GmbH*
Berg-am-Laim-Str. 64 · D-81673 Munich · Phone ++ 49/89/4315583 · Fax ++ 49/89/4316412
e-mail: info@piezomechanik.com · http://www.piezomechanik.com

Stand: Mai 2006