PowerHap – Piezo Haptic Actuators

PowerHap 0704

<table>
<thead>
<tr>
<th>Series/Type:</th>
<th>0704H013V060</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordering code:</td>
<td>Z63000Z2910Z001Z46 (Prototype)</td>
</tr>
<tr>
<td>Date:</td>
<td>2023-01-16</td>
</tr>
<tr>
<td>Version:</td>
<td>2</td>
</tr>
</tbody>
</table>
Features
- Compact design
- Fast response
- Force sensing capabilities
- Backstop to increase the maximum impact force resistance

Design
- Dimensions of actuator: 7 x 3.75 x 1.22 mm
- Steel bows for displacement amplification
- Contains RoHS-compatible PZT (lead zirconium titanate) ceramic (SVHC substance 12626-81-2)
- Contacting: Polarized piezo element, pay attention to the positive and negative terminal. Sample orders are supplied with a FPC connection (see page 10).

Application
- Stylus pen (tip vibration)
- Not intended for direct vibrotactile haptic feedback (limited force and displacement)

General technical data

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating voltage range</td>
<td>0 … 60 V</td>
</tr>
<tr>
<td></td>
<td>0 … 95 V extended voltage range for</td>
</tr>
<tr>
<td></td>
<td>overdrive mode for up to two</td>
</tr>
<tr>
<td></td>
<td>consecutive cycles. Overdriving</td>
</tr>
<tr>
<td></td>
<td>can be repeated with a minimum time</td>
</tr>
<tr>
<td></td>
<td>interval of 100 ms.</td>
</tr>
<tr>
<td>Operating temperature powered</td>
<td>−40 … +85 °C</td>
</tr>
<tr>
<td>Operating temperature unpowered</td>
<td>−40 … +125 °C</td>
</tr>
<tr>
<td>Maximum compressive force on the actuator</td>
<td>5 N</td>
</tr>
<tr>
<td>(during operation)</td>
<td></td>
</tr>
<tr>
<td>Maximum impact force on the actuator</td>
<td>50 N</td>
</tr>
<tr>
<td>(short-term)</td>
<td></td>
</tr>
<tr>
<td>Maximum operation frequency</td>
<td>The operation frequency is limited</td>
</tr>
<tr>
<td></td>
<td>by the self-heating of the component,</td>
</tr>
<tr>
<td></td>
<td>which should not exceed +30 °C. This</td>
</tr>
<tr>
<td></td>
<td>is reached after about 10 s of</td>
</tr>
<tr>
<td></td>
<td>continuous sine signal 0 … 60 V at</td>
</tr>
<tr>
<td></td>
<td>1.300 Hz.</td>
</tr>
<tr>
<td>Maximum voltage change rate</td>
<td>0.6 MV/s</td>
</tr>
</tbody>
</table>
Electromechanical characteristics at 25 °C

| Parameters     | Conditions                                                                 | Typical  
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacitance</td>
<td>C 1 kHz, 1 V_{RMS}</td>
<td>0.26 µF</td>
</tr>
<tr>
<td>Displacement</td>
<td>s 0 … 60 V, measured between the center part of the bows</td>
<td>15 µm</td>
</tr>
<tr>
<td></td>
<td>s 0 … 95 V, measured between the center part of the bows</td>
<td>23 µm</td>
</tr>
</tbody>
</table>

Further typical characteristics as a design reference for haptic applications at 25 °C

| Parameters     | Conditions                                                                 | Typical  
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1st resonance frequency</td>
<td>f_R 0.5 V_{RMS}</td>
<td>45 kHz</td>
</tr>
<tr>
<td>Stiffness</td>
<td>k 60 V various load stiffness</td>
<td>140 N/mm</td>
</tr>
<tr>
<td>Blocking force</td>
<td>F_b 60 V various load stiffness</td>
<td>3 N</td>
</tr>
<tr>
<td>Acceleration</td>
<td>a Load mass 20 g, single pulse sine wave, 200 Hz, 0 … 60 V</td>
<td>4 g (peak to peak) 1.9 g (peak)</td>
</tr>
<tr>
<td></td>
<td>a Load mass 20 g, single pulse sine wave, 200 Hz, 0 … 95 V</td>
<td>6.9 g (peak to peak) 3.3 g (peak)</td>
</tr>
<tr>
<td></td>
<td>a Load mass 100 g, single pulse sine wave, 200 Hz, 0 … 60 V</td>
<td>4.5 g (peak to peak) 2.3 g (peak)</td>
</tr>
<tr>
<td></td>
<td>a Load mass 100 g, single pulse sine wave, 200 Hz, 0 … 95 V</td>
<td>5.9 g (peak to peak) 3 g (peak)</td>
</tr>
</tbody>
</table>

1) g is the unit of acceleration. g = 9.81 m/s²

Ordering code
Z63000Z2910Z001Z46
Dimensional drawings

Fig. 1: Dimensional drawings of PowerHap 0704H013V060
Typical characteristics of 0704H013V060 as a design reference for haptic applications

Fig. 2: Typical measurement of quasi-static displacement without preload measured between center parts of the bows as a function of voltage

Fig. 3: Typical force-displacement diagram with different load springs for preload 5 N
In the force-displacement measurements, the PowerHap actuator is put under a dedicated pre-force of 5 N, and then the displacement and load under various voltages are measured.
Acceleration characteristics

Fig. 5: Measurement setup for acceleration

Fig. 6: Typical acceleration as a function of the input voltage with 100 g load. Input voltage with a half wave sinus signal form of amplitude 0 … 60 V and pulse length 5 ms which is equivalent to 200 Hz.
Sensor characteristics

By applying a compressive force to the center parts of the bows, an electric signal is generated.

Fig. 7: Principle of measurement of the sensor signal

For a measurement circuit with very high impedance, i.e. near the open circuit limit, this can be measured as voltage. The typical voltage per force is 0.60 V/N.

Fig. 8: Sensor characteristics open circuit voltage as a function of applied force
Integration guidelines

1. Design guide and reference example
   General information on the mechanical system integration of PowerHap components can be found in the document “PowerHap Starter Kit Design Guide” (see QR-code). The document describes the integration of different PowerHap components contained in the PowerHap Starter Kit.

2. Mechanical integration
   The actuator is to be mounted in a way so that the flat central parts of the two bows upon device operation exert forces perpendicular to the load side and the backing side interfaces, respectively. The acting interfaces with the opposing surfaces should encompass the whole flat central parts.

   Adhesive mounting of the actuator to the contact surfaces on both sides is recommended. Double-sided pressure-sensitive adhesive tapes are suitable in many cases. The thickness variation of adhesive tapes may be used for adjustment of tolerances in height direction.

   In case that the actuator is mounted without adhesion only by clamping, care must be taken to avoid lateral dislocation of the actuator during operation.

   To avoid damage on the actuator, forces and deformations must be kept within the following limits:
   Tensile load (pulling force on bow central parts):
   - Max. force: 10 N
   - Max. displacement: 100 µm
   Max. impact force on actuator (short term):
   - Max. force: 50 N
   - Max. compression: 160 µm

   The stiffness of the load side, seen from the actuator, should be low relative to the stiffness of the actuator (160 N/mm) to achieve high energy transfer and acceleration. This can be achieved by thinning to a membrane-like shape, or by mounting the load with flexible elements such as springs, grommets, or foam gaskets.

3. Explicit warning
   If under storage conditions temperature variations occur, the electrical contacts must be shortened.

   Operation of the PowerHap component outside of the defined specifications will lead to component failure and/or change of component parameters (e.g. displacement). If the component is exposed to temperatures exceeding the aforementioned temperature limit (see General technical data on page 2 of this document) and no component failure occurs, the displacement of the component may increase when operated again at standard operation conditions. The increase in displacement is only temporary and it will relax to the previous displacement after a few voltage cycles.
Contacting: FPC module dimensions for sample orders

Electric connection
Sample orders according to this datasheet are delivered soldered to a flexible printed circuit board (see fig. 9). The height of the FPC at the contact pads is lower than the actuator height to ensure normal operations without any interferences by the FPC itself.

Dimensional drawing

Fig. 9: Dimensional drawing of PowerHap 0704H013V060 including an FPC

FPC details:
- Material: Polyimide flex
- Thickness: 0.1 mm
- Cu finish: Immersion gold 1U"
- Layers: 2
- Stiffener: Resulting in 0.3 mm thickness within the connector area
- Connector PN: FH34D-4S-0.5SH50 from Hirose
- Connector details: The 4-pin Hirose connector, having a pitch of 0.5 mm, is the smallest ZIF connector found, which the supplier has validated for up to +120 V. The required creepage and clearance distances, according to IPC-2221, can be fulfilled by contacting only pin 1 and pin 4. Pay attention to the polarity, connect the positive pin to the high voltage boost of the piezo driver.
- FPC gerber files are available on request
General Notes

Some parts of this publication contain statements about the suitability of our ceramic piezo components for certain areas of application, including recommendations about incorporation/design-in of these products into customer applications. The statements are based on our knowledge of typical requirements made of our components in the particular areas. We nevertheless expressly point out that such statements cannot be regarded as binding statements about the suitability of our piezo components for a particular customer application. As a rule, TDK is either unfamiliar with individual customer applications or less familiar with them than the customers themselves. For these reasons, it is always incumbent on the customer to check and decide whether the piezo component components with the properties described in the product specification are suitable for use in a particular customer application.

- Do not use TDK piezo components for purposes not identified in our specifications, application notes and data sheets.
- Ensure the suitability of a piezo component in particular by testing it for reliability during design-in. Always evaluate a piezo component under worst-case conditions.
- Pay special attention to the reliability of piezo components intended for use in safety-critical applications (e.g. medical equipment, automotive, spacecraft, nuclear power plant).
- Do not drive the piezo actuator under resonance conditions.

Design notes

- Consider de-rating at higher operating temperatures and loads.
- In some cases, the malfunctioning of passive electronic components or failure before the end of their service life cannot be completely ruled out in the current state of the art, even if they are operated as specified. In applications requiring a very high level of operational safety and especially when the malfunction or failure of a passive electronic component could endanger human life or health (e.g. in accident prevention, life-saving systems, or automotive battery line applications such as clamp 30), ensure by suitable design of the application or other measures (e.g. installation of protective circuitry or redundancy) that no injury or damage is sustained by third parties in the event of such a malfunction or failure. Do not use piezo components in safety-relevant applications.
- Specified values only apply to piezo components that have not been subject to prior electrical, mechanical or thermal damage.

Operation

- Use piezo actuator components only within the specified operating temperature range.
- Use piezo actuator components only within specified voltage and current ranges.
- Piezo actuator components have to be operated in a dry, non-reducing atmosphere which must not contain any additional chemical vapours or substances. We recommend appropriate drying of all components prior to hermetically sealing.
- Prevent a piezo actuator component from contacting liquids and solvents. Make sure that no water enters a piezo actuator component (e.g. through plug terminals).
- Avoid dewing and condensation.
TDK piezo actuator components are mainly designed for encased applications. Under all circumstances avoid exposure to:
- direct sunlight
- rain or condensation
- steam, saline spray
- corrosive gases
- atmosphere with reduced oxygen content.

We expressly point out that in case of non-observance of the aforesaid notes, in particular due to reasons attributable to chemical vapours, a malfunction or failure of the piezo actuator components before the end of their usual service life cannot be completely ruled out, even if they are operated as specified.

Storage, handling, and mounting instructions

Storage
- Store the piezo actuator component with terminals short-circuited.
- Avoid contamination of the piezo actuator component surface during storage.
- Avoid storage of the piezo actuator components in harmful environments where they are exposed to corrosive gases (e.g. SOx, Cl).
- Storage conditions:
  - Storage temperature: -25 °C to +45 °C
  - Relative humidity (RH): ≤ 75% annual average, ≤ 95% on 30 days a year
  - Dew precipitation is inadmissible.
- Process piezo actuator components within 12 months after shipment from TDK.

Handling
- Do not drop piezo actuator components or allow them to be chipped.
- During handling exert minimum force to the component.
- Do not touch piezo actuator components with bare hands, powderless nitrile gloves are recommended.
- Avoid contamination of the piezo actuator component surface during handling.

Mounting
- Make sure the surface of the leads is not scratched before, during or after the mounting process.
- Make sure contacts and housings used for assembly with piezo actuator components are clean and dry before mounting.
- Avoid contamination of the surface of the piezo actuator component during processing.
- Make sure ceramic end surfaces are clean before mounting process. We recommend short-circuiting the piezo actuator component during the whole mounting process.
Cautions and warnings

The piezo component must be operated in a dry, non-reducing, open environment and atmosphere which must not contain any chemical vapors or substances. To prevent damages on the piezo component, tensile stresses must be avoided under all driving conditions.

We expressly point out that in case of non-observance of the aforesaid notes, due to reasons attributable to chemical vapors, a malfunction of the piezo sample or failure before the end of their usual service life cannot be completely ruled out, even if they are operated as specified.

Depending on the individual application, piezo samples are electrically connected to voltages and currents, which are potentially dangerous for life and health of the operator. Installation and operation of piezo sample must be done by authorized personnel only. Ensure proper and safe connections, couplers, and drivers.

**Caution:** Piezo components are highly efficient charge storing capacitors. Even when they are disconnected from a supply, the electrical energy content of a loaded actuator can be high and is held for a long time. Always ensure a complete discharging of an actuator (e.g. via a 10 kΩ resistor) before handling. (Do not discharge by simple short-circuiting, because of the risk of damaging the ceramic.)

Electrical charges can be generated on disconnected actuators by varying load or temperature. **Caution:** Discharge an actuator before connecting it to a measuring component/electronics, when this component is not sufficiently voltage proofed.

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2. We also point out that **in individual cases, a malfunction of electronic components or failure before the end of their usual service life cannot be completely ruled out in the current state of the art, even if they are operated as specified**. In customer applications requiring a very high level of operational safety and especially in customer applications in which the malfunction or failure of an electronic component could endanger human life or health (e.g. in accident prevention or life-saving systems), it must therefore be ensured by means of suitable design of the customer application or other action taken by the customer (e.g. installation of protective circuitry or redundancy) that no injury or damage is sustained by third parties in the event of malfunction or failure of an electronic component.

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