Touch me – feel me!

Whether for smartphones, vehicles, industrial controls, domestic appliances or gaming consoles – the future belongs to piezo-based pushbutton solutions with haptic feedback. TDK offers a unique portfolio of products that are suitable for every imaginable haptic application.

As a result of the demand for greater convenience and safety, multifunctional human-machine interfaces (HMIs) such as touchscreens and other touch-sensitive surfaces can now be found almost everywhere. Existing solutions for haptic feedback such as eccentric rotary mass (ERM) or linear resonant actuators (LRA) have a number of drawbacks. These include their relatively large dimensions, the insertion height being particularly relevant for display controllers, and a high demand for power in battery-operated devices such as smartphones or tablets. Furthermore, neither the frequency nor the strength of the feedback are at best only variable within very narrow limits, and they do not have any sensory capabilities.

A considerably better alternative is offered by TDK PowerHap™ and PiezoHapt™ families of piezo-based actuators. These components are a combination of pressure-sensitive sensor and actuator in one. With the two product families, TDK offers the widest range of actuators for haptic feedback.

**PiezoHapt L – world's thinnest actuators for haptic feedback**

TDK has developed the L8060 and L3015 types specially for use in vehicle and smartphone displays. They have impressively low-profile insertion heights of just 0.35 mm and 0.3 mm with areas of 80 x 60 mm (L8060) or 30 x 15 mm (L3015). The unimorph design of the PiezoHapt is based on a flat multilayer piezo element that is connected to a vibration plate on one side and can be mounted directly underneath displays.

The actuators are designed for operating voltages of ≤24 V (L8060) or ≤12 V (L3015). Depending on the amplitude and frequency of the applied voltage, a wide range of vibration patterns can be generated with PiezoHapt. These types are especially well-suited for OLED displays.
PowerHap: Unrivalled acceleration, force and response time

The actuators of the PowerHap family are based on multilayer piezo plates with copper inner electrodes. Figure 2 illustrates the basic design.

If a voltage is applied to the piezo plate, it only expands minimally in the z axis, but due to the constant volume of the piezo effect it contracts simultaneously in both the x and y axes. Two titanium cymbals bonded to either side of the plate amplify this contraction by a factor of 15 in the z-axis, achieving a large displacement of up to 230 µm for the largest 2626H023V120 type. The high level of linearity between applied voltage and displacement is advantageous. For this type it is 1.8 µm/V, enabling precise and, at the same time, variable control of both amplitude and signal form.

Figure 2:
Design of square PowerHap actuators. This family of products includes four types with edge lengths of between 9.0 mm and 26.0 mm and insertion heights from 1.1 mm to 2.3 mm. Thanks to the multilayer technology, forces in excess of 25 N and displacements of 230 µm can be achieved.

Thanks to the multilayer piezo technology PowerHap offers unprecedented performance in terms of response time and acceleration. For example, with a rise time of just 1 ms the acceleration of the cymbals is already 15.0 g and attains a maximum value of 35 g when a mass of 100 grams is applied, generating a very large force of up to 25 N. Comparable values cannot be achieved using conventional solutions. Figure 3 illustrates the response time and acceleration for type 2626H023V120.
PowerHap actuators are suitable for a wide stimulation range from 1 Hz to 500 Hz with variable amplitudes, durations and signal shapes, such as sine, triangle or rectangle. Depending on the type, the drive voltage is between -20 V and 120 V or -10 V and 60 V. These actuators are therefore able to generate a customized haptic feedback to human mechanoreceptors. Correspondingly, these actuators enable designers to create specific, high-definition haptic feedback profiles that users expect from cutting-edge HMIs in automotive and industrial applications. The combination of low-profile designs no more than 2.3 mm thick and strong feedback allows these actuators not only to be integrated in displays, but also to be placed directly below flat surfaces. This enables solutions with a high degree of leak-tightness which is just as necessary in harsh industrial environments as in applications with stringent hygiene requirements, such as in the food industry or medical technology.

**Excellent sensory properties**

Apart from the excellent actuator performance, the PowerHap components also feature outstanding sensor functionality thanks to the multilayered piezo technology. In contrast to conventional switches or pushbuttons that, as is well known, can only provide the On and Off switching states, PowerHap delivers an output voltage that is proportional to the pressure applied. Figure 4 illustrates this behavior.

As a result, and unlike conventional mechanical pushbuttons, it is even possible to create solutions based on PowerHap that trigger different actions and haptic feedback, depending on the force applied.

Table 1 lists the currently available square types of the PowerHap series.

<table>
<thead>
<tr>
<th>Type</th>
<th>Dimensions [mm] (l x w x h)</th>
<th>Operating voltage [V]</th>
<th>Acceleration [g] * (pk – pk)</th>
<th>Displacement [µm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0909H011V060</td>
<td>9 x 9 x 1.1</td>
<td>-10 to +60</td>
<td>2.5</td>
<td>35</td>
</tr>
<tr>
<td>1313H018V120</td>
<td>12.7 x 12.7 x 1.8</td>
<td>-20 to +120</td>
<td>7</td>
<td>65</td>
</tr>
<tr>
<td>1918H021V120</td>
<td>19.4 x 19.4 x 2.1</td>
<td>-20 to +120</td>
<td>25</td>
<td>130</td>
</tr>
<tr>
<td>2626H023V120</td>
<td>26 x 26 x 2.3</td>
<td>-20 to +120</td>
<td>35</td>
<td>230</td>
</tr>
</tbody>
</table>

* Under a load of 100 grams

**Slim design for lateral installation in slim devices**

In addition to the square PowerHap types that are particularly suitable for use under flat surfaces, TDK has also developed four slim, rectangular PowerHap types that are designed to provide lateral haptic feedback in addition to vertical haptic feedback. The two smallest versions with lengths of just 9 mm or 12 mm are particularly suitable for smartphones and tablets, home appliances, games consoles, VR/AR equipment, smart watches, digitizers or handheld medical devices. The two larger versions with side lengths of 60 mm are currently the most powerful PowerHap types, as they enable forces of up to 50 N to be generated, enabling masses of up to 1 kg to be moved. These powerful packages can, for example, be installed at the side of displays in order to achieve a horizontal haptic feedback, as shown in Figure 5.
Figure 5:
Rectangular PowerHap types are suitable for the lateral control of displays. Typical applications are vehicle displays.

Table 2 lists the key technical data of the rectangular PowerHap types.

<table>
<thead>
<tr>
<th>Typ</th>
<th>Dimensions [mm] (l x w x h)</th>
<th>Operating voltage [V]</th>
<th>Acceleration [g] (pk – pk)</th>
<th>Displacement [µm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0904H018V060</td>
<td>9 x 3.75 x 1.4</td>
<td>-10 to +10 / 0 to +60</td>
<td>4.5*</td>
<td>15</td>
</tr>
<tr>
<td>1204H024V060</td>
<td>12 x 4 x 1.8</td>
<td>9.2*</td>
<td></td>
<td>27</td>
</tr>
<tr>
<td>6005H070V120</td>
<td>60 x 5 x 7</td>
<td>-20 to +20 / 0 to +120</td>
<td>13**</td>
<td>280</td>
</tr>
<tr>
<td>6005H090V120</td>
<td>60 x 5 x 9</td>
<td>19**</td>
<td></td>
<td>150</td>
</tr>
</tbody>
</table>

* Under a load of 100 grams  
** Under a load of 500 grams

Figure 6:  
The evaluation kits provide an initial impression of haptic feedback with PowerHap actuators and allow users to evaluate design possibilities.
Competent design support through cooperation agreements

Systems with haptic feedback are relatively new technologies. Accordingly, no standard solutions yet exist which can be drawn upon. In order to enable customers from every industry to complete a fast and cost-efficient design-in of haptic solutions, TDK has entered into cooperation agreements with three leading touch response companies.

**Aito** offers controller solutions with its HapticTouch hardware and software, which convert piezo actuators into precise touch sensors with haptic feedback. These enable tactile switches or pushbuttons to be simulated on smooth surfaces. Using the combined haptic technologies of TDK and Aito, touch response solutions can be implemented on smartphone touchscreens, or conventional switches and pushbuttons in vehicles can be replaced. Aito specializes in solutions using the small TDK actuators of the PiezoHapt S series.

**Boréas Technologies** has developed the BOS1901 driver IC on the basis of its patented CapDrive™ technology. It is particularly energy efficient, also offering sensor functions, and is especially suitable for controlling TDK PowerHap actuators with an operating voltage of up to 60 V. In a further stage of development, Boréas will develop the first low-power piezo driver IC for the larger TDK PowerHap models with a maximum driver voltage of 120 V.

**Immersion** is a leading developer and licensor for touch-feedback technologies. A co-marketing agreement exists with this company for the TDK PowerHap and PiezoHapt actuators. Immersion certifies these actuators for the use with its software products and also includes the actuators in its reference designs. This enables customers to implement advanced haptic solutions with the world's thinnest and most powerful actuators.

In future, growing numbers of devices and systems will be equipped with haptic feedback to improve convenience, safety and operating reliability. With its unique product range and in collaboration with its joint-venture partners, TDK can offer solutions suitable for all haptic applications.