Attracting Tomorrow

Application Note for TDK's PiezoHapt™ Actuators

TDK Corporation
Electronic Components Business Company
Piezo & Protection Devices Business Group

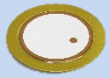
Ver.2.11 Revised in April 2022

Contents

Contents

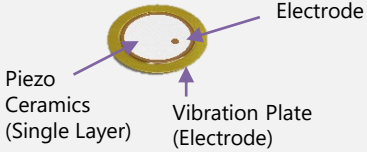
PiezoHapt™ Actuator Series

S Series



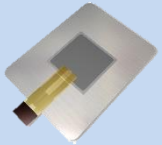
PHUA12-26A-9-000

PHUA15-26A-10-000



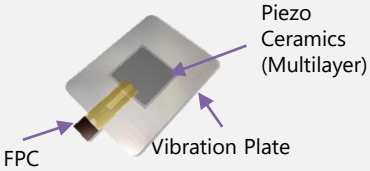
- Disc-shaped
- Single-layer element
- Mainly for button and switch

L Series



PHUA8060-35A-33-000

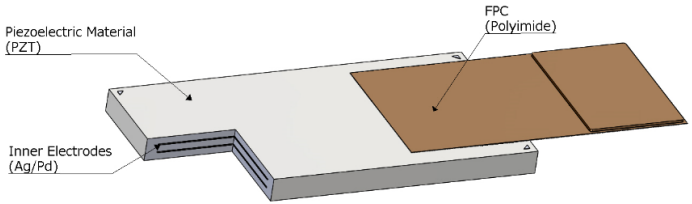
PHUA3015-30A-21-000



- Rectangle-shaped
- Multi-layer element
- Mainly for display

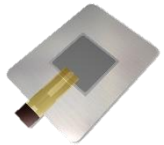
Part Number Construction

PHU	A	8060	-	35	A	-	33	-	000
Series name	Application	External vibration plate dimensions (LxW)		Total thickness	Type		External piezoelectric element dimensions (LxW)		Internal code
	A For general use B For automotive	8060 80x60mm 3015 30x15mm		35 0.35mm 30 0.30mm	A 42Ni-Fe + FPC		33 30x30mm 21 20x10mm		



PiezoHapt™ S and L series for automotive is currently under development.

Product Characteristics

		PiezoHapt™ S	PiezoHapt™ S	PiezoHapt™ L	PiezoHapt™ L
					
	P/N	**PHUA12-26A-9-000**	**PHUA15-26A-10-000**	**PHUA3015-30A-21-000**	**PHUA8060-35A-33-000**
Acceleration [G] 20g/100g		2.4 / 0.3	4 / 0.5	1.6 / 0.3	1.5 / 0.2
Thickness [mm]		0.26	0.26	0.30	0.35
Max. Input Voltage [V_{p-p}]		400	400	12 (±6)	24 (±12)
Capacitance [F] (1kHz, 1Vrms)		5.5n	6.5n	1.5u	0.6u
Max. Displacement [µm]		30	50	40	65
Operating Temperature [°C]		-40 to 85	-40 to 85	-10 to 60	-10 to 60

Contents

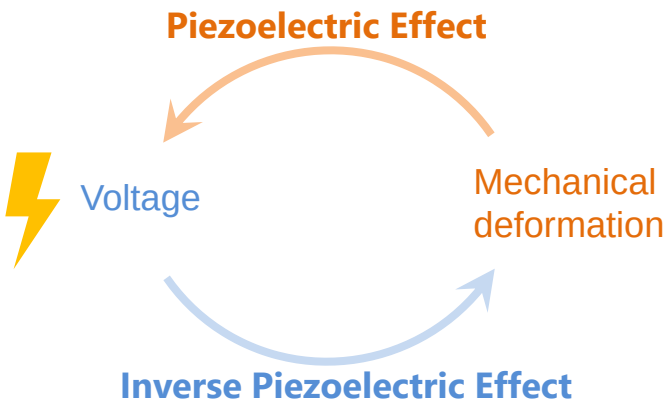
What's Piezoelecticity?

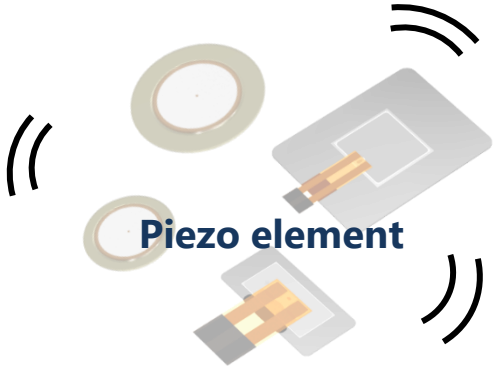
Piezoelectric Effect

An effect in which a voltage is generated in response to the stress caused by applying pressure to a crystal or a specific type of ceramic.

Inverse Piezoelectric Effect

When a voltage is applied to a crystal or ceramic that generates the piezoelectric effect, they are deformed.





Simple Structure of Piezo Element

Simple Structure
Slight movements and vibrations without any mechanical operations

Durable
Easily miniaturized
Excellent for precision

General Advantages of PiezoHapt™ Solution

01 Ultra-Thin Thickness between 0.26 to 0.35 mm

02 High-Definition Haptics Versatile waveforms and custom frequency, prompt response.

03 Low Voltage Drive* *PiezoHapt™L series only

How to use

- **As an Actuator (Single function)**
  Triggered and driven by an external signal (e.g. from IC), PiezoHapt™ vibrates as an actuator.

- **As Actuator and Sensor (Multi-functions)**
  When force is applied to PiezoHapt™, voltage is generated which can be used as a trigger signal for the actuation.

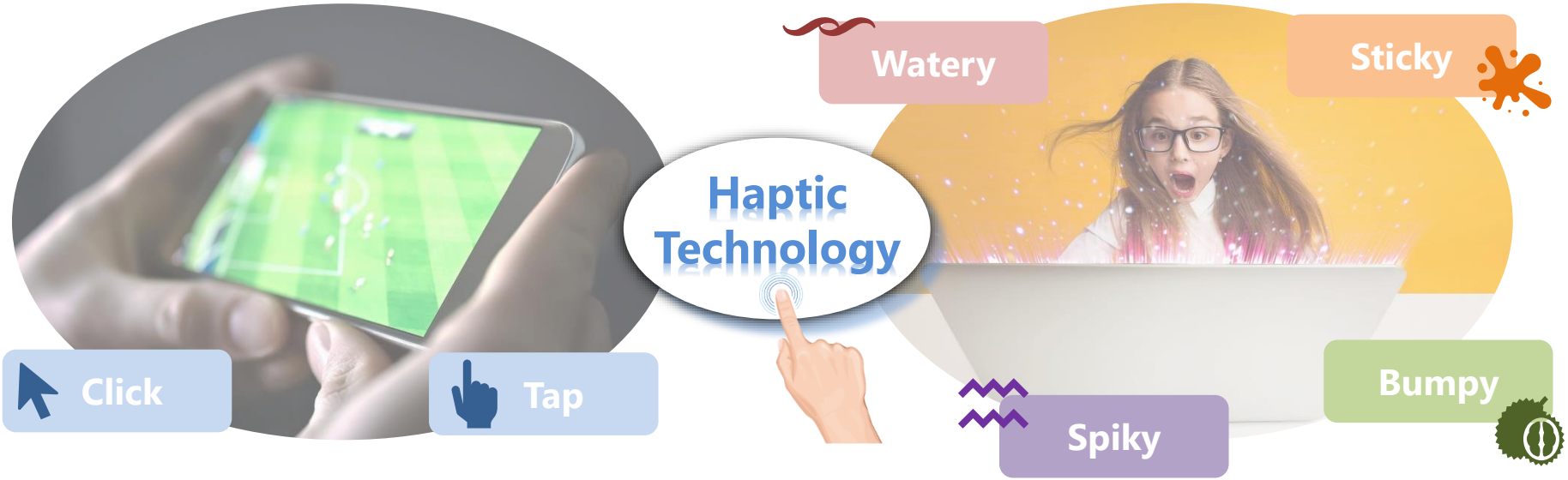
Installation Example

Mounted PiezoHapt™ into touchpad of laptop gives a sharp click feeling.

How Does Haptic Technology Work?

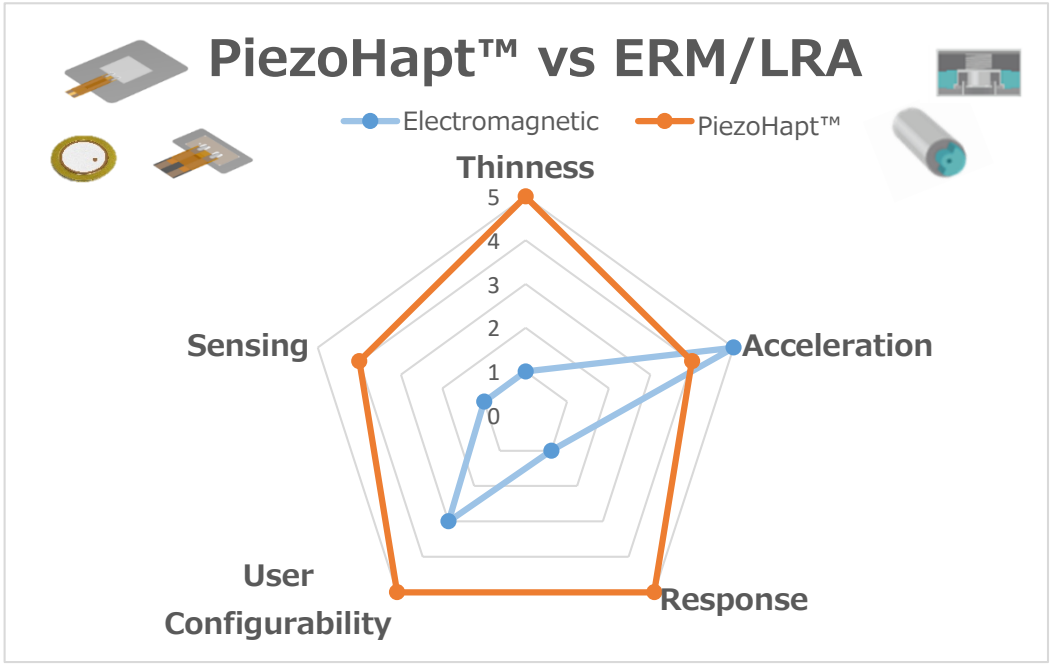
Virtual Button Function

Various Haptics Feedbacks



Advantages of PiezoHapt™ Compared to ERM/LRA

ERM: Eccentric Rotating Mass, LRA: Linear Resonant Actuator



ERM and LRA are commonly used as haptics solution in today's market.

TDK's PiezoHapt™ develops the performance of haptic technology for more real experience.

Key Advantages of PiezoHapt™

- **Lighter and Thinner**
  Easy to integrate to a flat panel.
- **Various Haptic Feedbacks**
  The force and operating frequency are adjustable.
- **User Configurable**
  Only piezo actuator can achieve customized waveforms.

Why Piezo Actuator Can Provide Realistic Feedback?

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ERM

LRA

Piezo actuator PiezoHapt™

Low — Haptic Sharpness — High

ERM and LRA take 20 to 50ms respectively to rise, which results in being perceived a vague sensation.

PiezoHapt™ reacts in 1ms, which is quite shorter than ERM and LRA, so that it provides more precise and crisp perception.

ERM: Eccentric Rotating Mass, LRA: Linear Resonant Actuator

Response Speed Comparison

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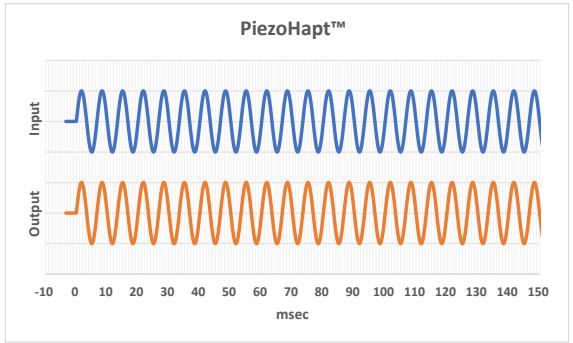
Measurement condition : 150Hz, sin wave

PiezoHapt™

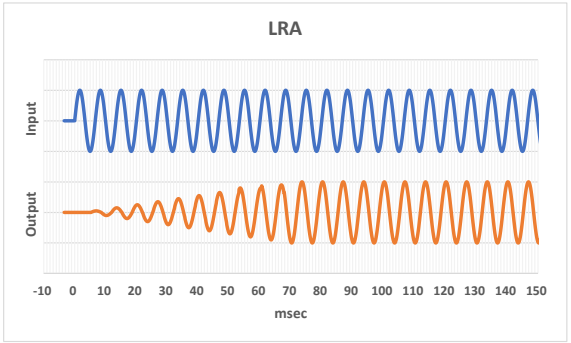


Response speed: <1ms

Response speed: **VERY GOOD**

Start up displacement: **VERY GOOD**

LRA

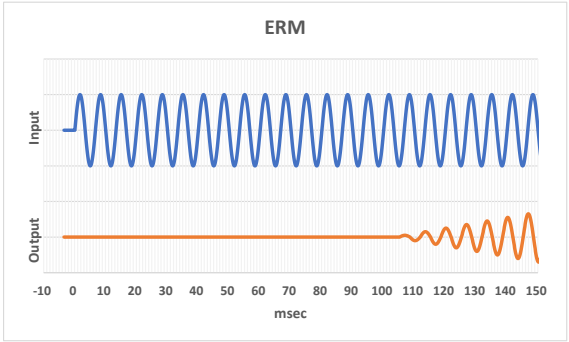


Response speed: approx. 10ms

Response speed: **FAIR**

Start up displacement: **POOR**

ERM



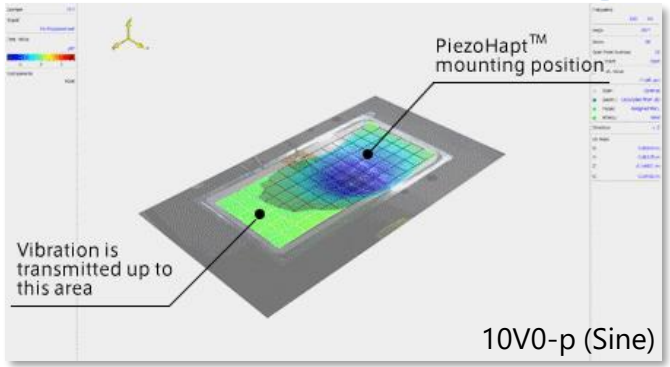
Response speed: approx. 100ms

Response speed: **POOR**

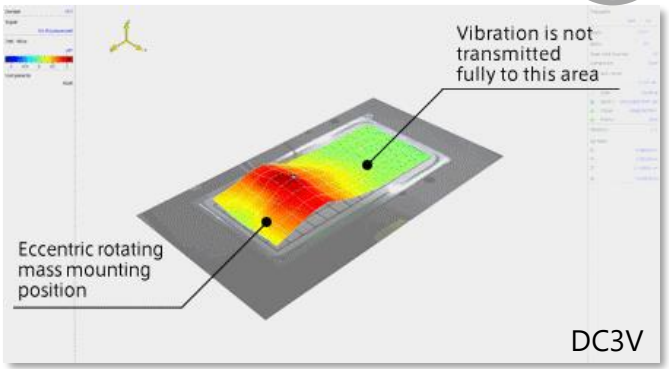
Start up displacement: **POOR**

Vibration Distribution

PiezoHapt™



ERM



PiezoHapt™ actuator transmits the uniform vibration to the whole surface.

Applications

Display
Touch Panel

Car Navigation System
Seamless Switch

PiezoHapt™ for automotive is currently under development.

Button
Switch

Keyboard
Touch Pad

Contents

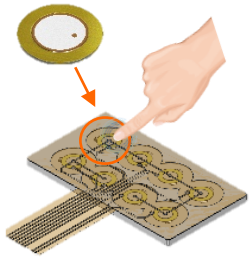
General Design Notes – Mounting

S Series

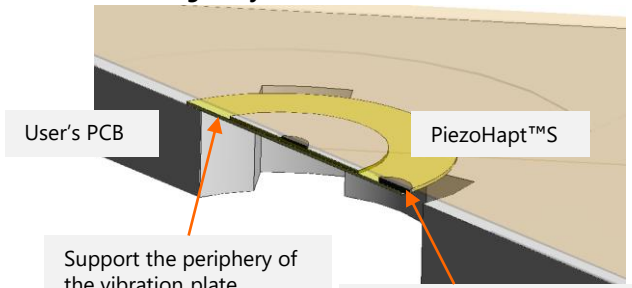
When mounting PiezoHapt™ S to the device, the vibration can be increased by supporting the periphery of the vibration plate.

Please use conductive paste or conductive double-sided tape to ensure connectivity with the PCB.

PiezoHapt™S



View from diagonally above

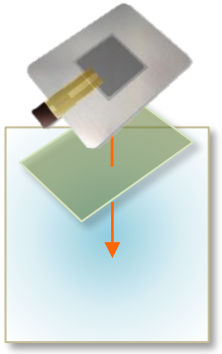


L Series

When mounting PiezoHapt™ L to the device, using a strong double-sided adhesive tape is recommended so that vibration is fully transmitted to the surface.
Adhesive tape should cover the entire back surface of the actuator's vibration plate.

PiezoHapt™L

Double-sided adhesive tape
(e.g. Nitto Denko 5000 or 510)



Your device
(Display module, housing etc.)

NOTE: For the both series, please carefully avoid exposure to corrosive gases (Cl2, NH3, H2S, SOx, NOx etc.), highly conductive substances (electrolytes, saltwater etc.) and Acid, alkali, or organic solvents

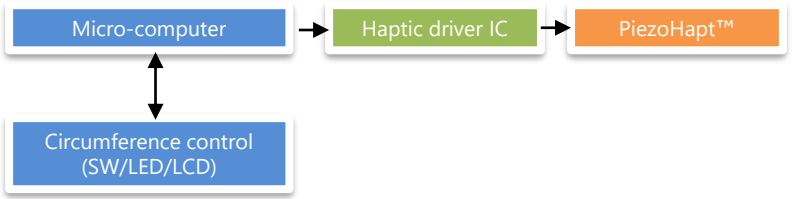
General Design Notes – Driver Circuit

We recommend the following driver ICs; **Aito solution**, **BOS1901**(Boréas Technologies) and **DRV2667**(Texas Instruments).

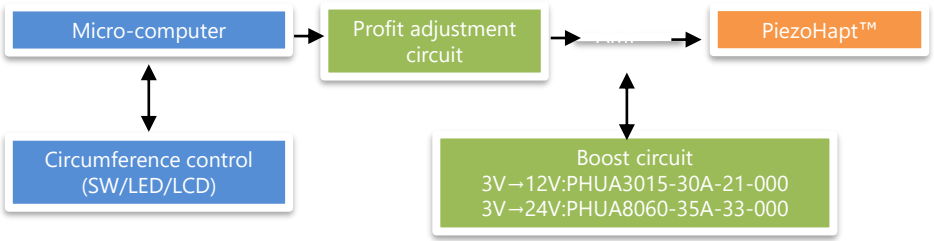
Driver IC Manufacturer (in alphabetical order)	Part No.	PiezoHapt™ S	PiezoHapt™ L	Sensing	Notes
Aito BV	*See the notes	✓		✓	*For details of specific driver ICs, please contact Aito directly.
Boréas Technologies Inc.	BOS1901		✓	✓	–
Texas Instruments Inc.	DRV2667		✓		–

PiezoHapt™ can be driven by a haptic driver IC or a discrete circuit.

◆ Haptic Driver IC



◆ Discrete



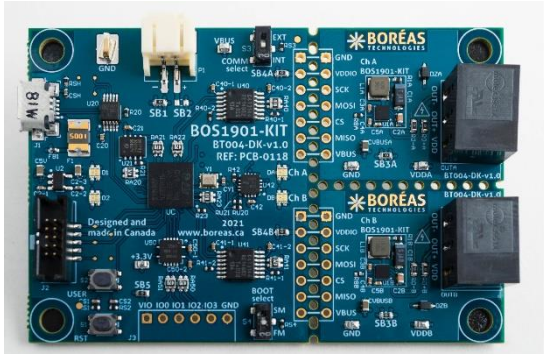
Contents

Evaluation Board Example (Boréas Technologies)

BOS1901 Development Kit

This EVM includes;
- Integrated Digital Front-End (SPI)

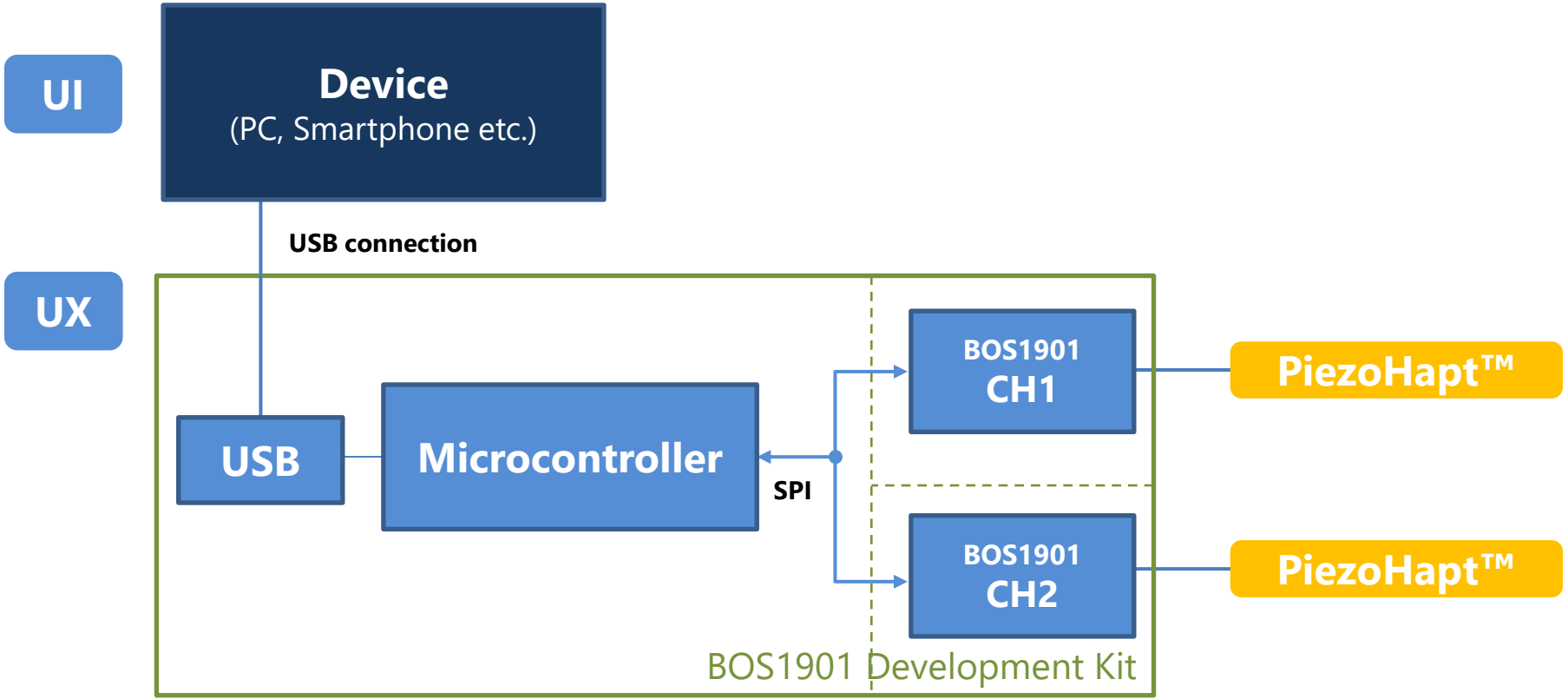
*Accessories
- TDK Piezo Actuator (PowerHap™ 2.5G)
- Power Connector



*The BOS1901 is a single-chip piezo actuator driver with energy recovery. It can drive actuators with up to 190 Vpk-pk waveforms while operating from a 3 to 5.5 V supply voltage. The BOS1901 uses a high-speed Serial Peripheral Interface (SPI) in its digital front end. It enables the user to query various data such as the actuator voltage for sensing applications (e.g. piezo buttons). In systems that cannot handle reverse current flow in the power delivery network, the BOS1901 features a Unidirectional Power Input (UPI).

You can edit waveforms by:
MATLAB®, Python®, Audacity® and many other softwares.

Demo Structure Example Using BOS1901 Development Kit

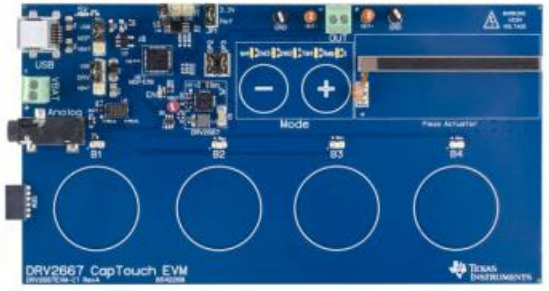


Evaluation Board Example (Texas Instruments)

DRV2667EVM-CT

This EVM includes;

- Integrated Digital Front-End (I2C)
- Integrated Boost Converter (105V) with up to 200Vpp Output
- Piezo Actuator (Non-TDK product)
- Capacitive Touch Buttons
- Microcontroller
- Sample pre-set waveforms

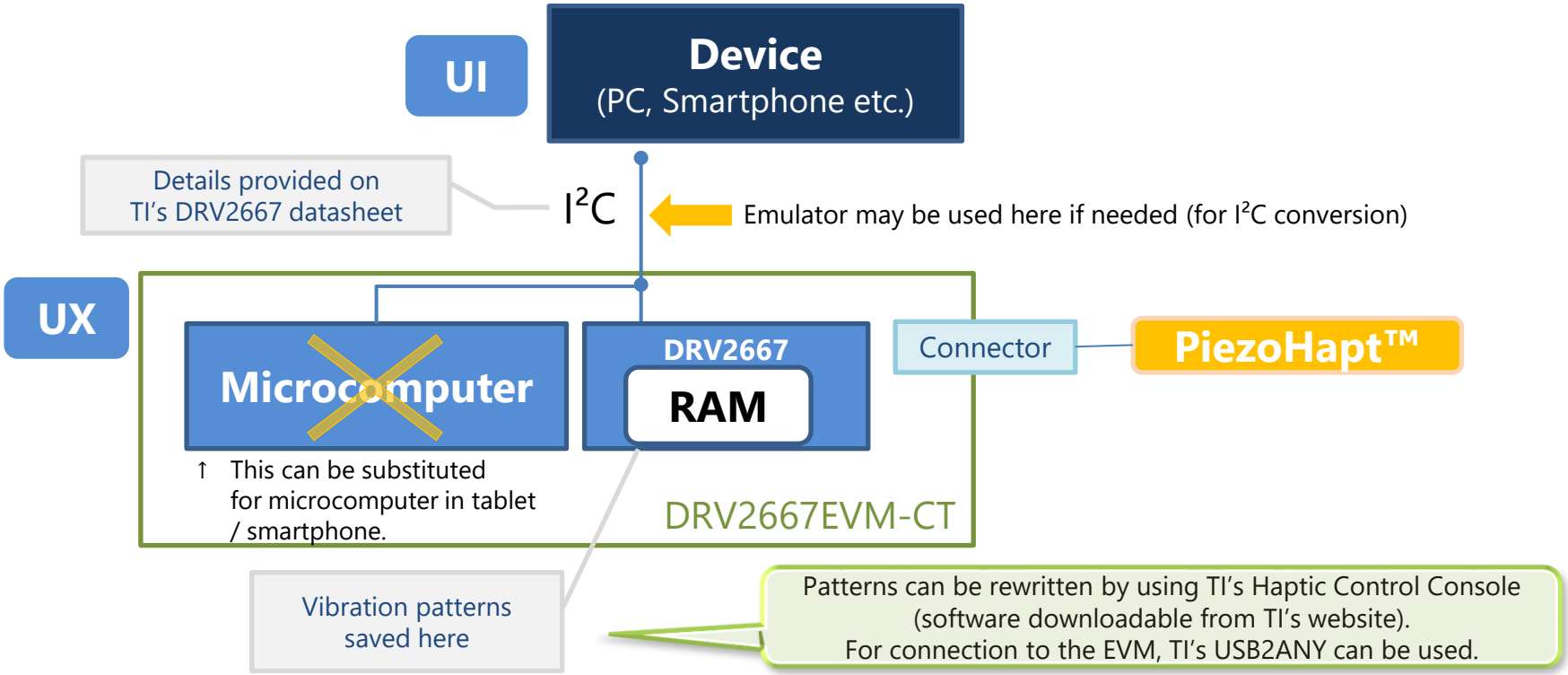


*The DRV2667 is a digitally controlled, high-voltage driver designed to control piezo actuators. The DRV2667 eliminates many design complexities of driving piezo by including an integrated 105V boost converter and 200-Vpp differential output amplifier. In addition, the digital control interface (I2C™) includes real-time waveform playback, a waveform generator, and embedded RAM for waveform storage.

You can edit waveforms by:

1) Using USB2ANY and Haptic Control Console (TI) and save on RAM embedded in the IC.
   OR
2) Using an emulator and Code Composer Studio (TI) to re-write the CPU on the board.

Demo Structure Example Using DRV2667EVM-CT

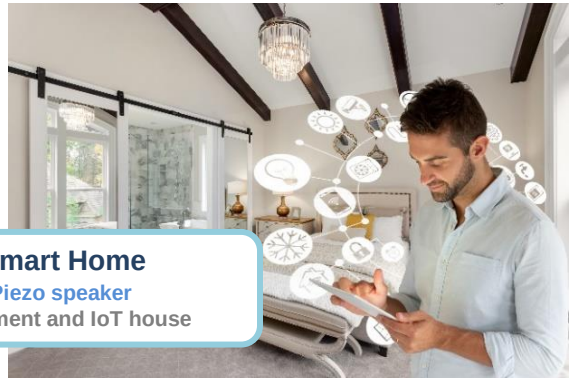


Desirable Piezo Product for Our Future

A Comfortable Space Not Just a Transportation

Piezo speaker, Haptics

Contribute to immersive sound and seamless design



More Comfortable Smart Home

Smart meter, Haptics, Piezo speaker

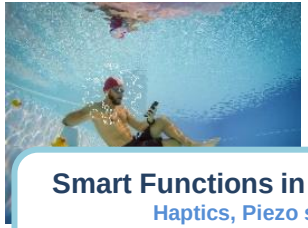
More efficient energy management and IoT house

Drone with Multiple Applications

(AI smart drone, smart agriculture)

Piezo actuator

Drone's higher image quality contributes to various situations



Smart Functions in Any Scenes

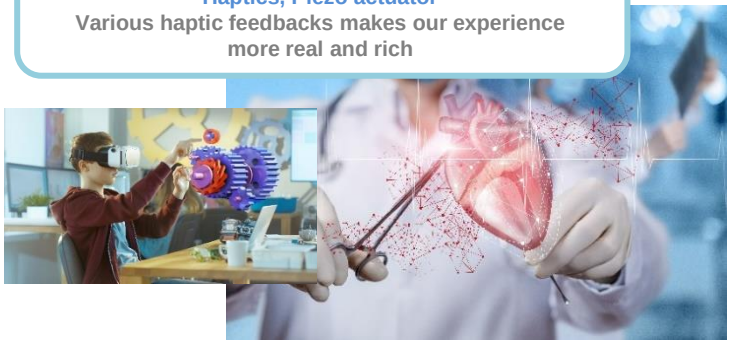
Haptics, Piezo switch

Various functions work in any environments even under the water

Realistic Feedback even at a Distance

Haptics, Piezo actuator

Various haptic feedbacks makes our experience more real and rich

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