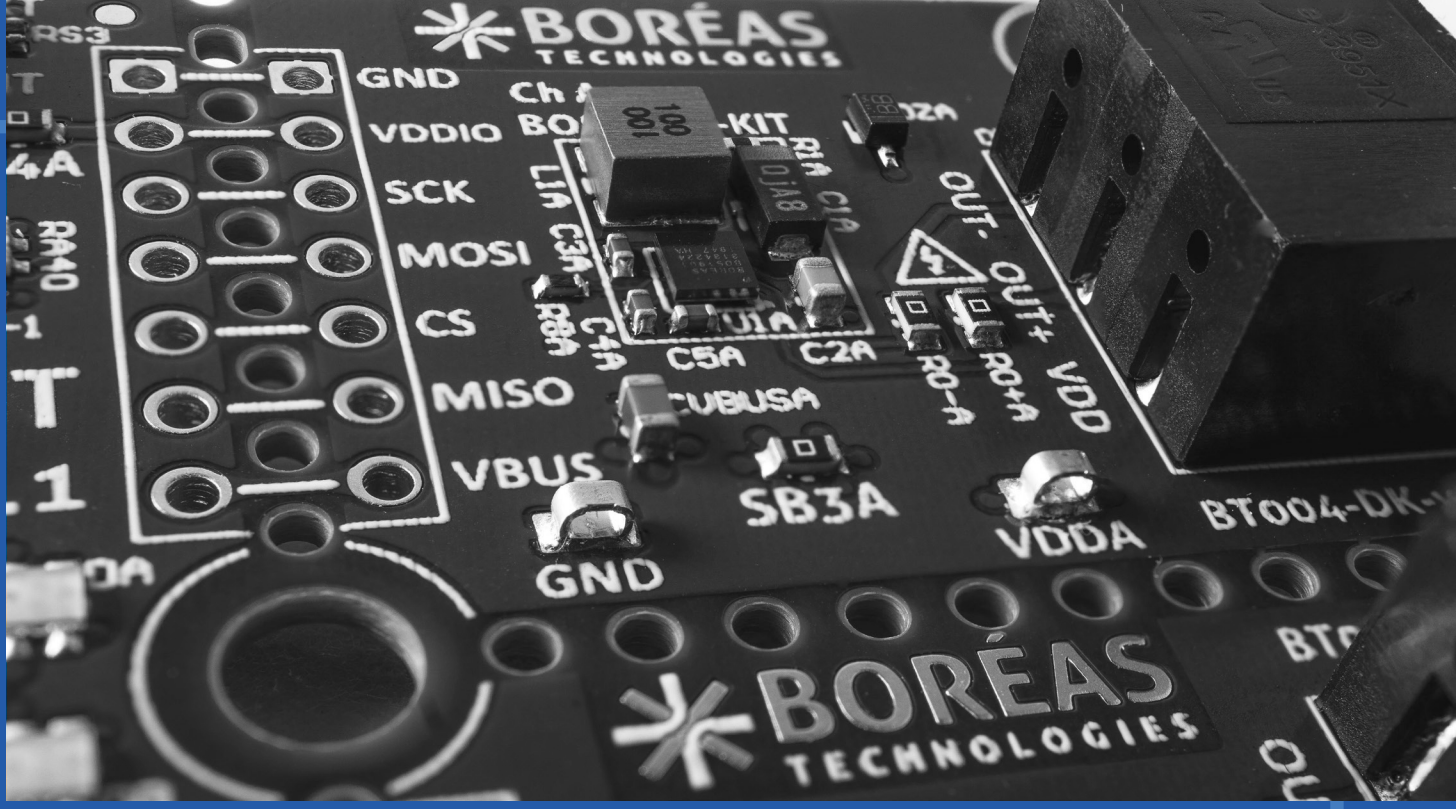

HOW TO

SELECT THE RIGHT PIEZO HAPTIC DRIVER AND ACTUATOR COMBINATION

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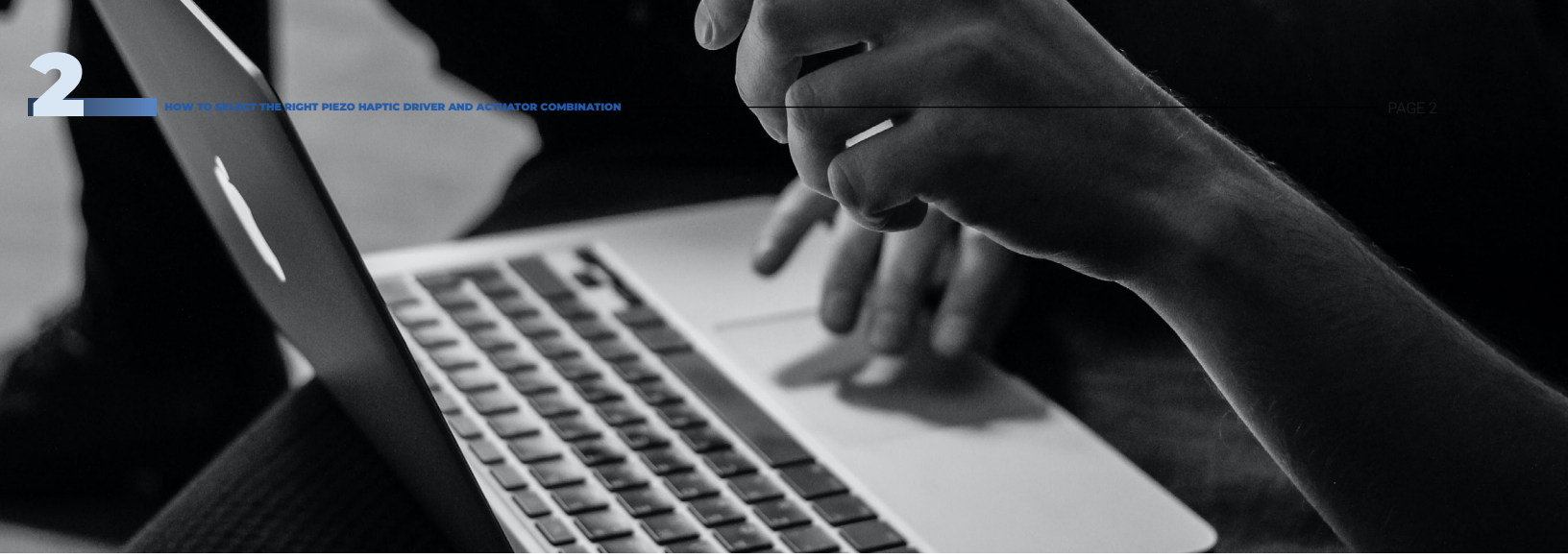


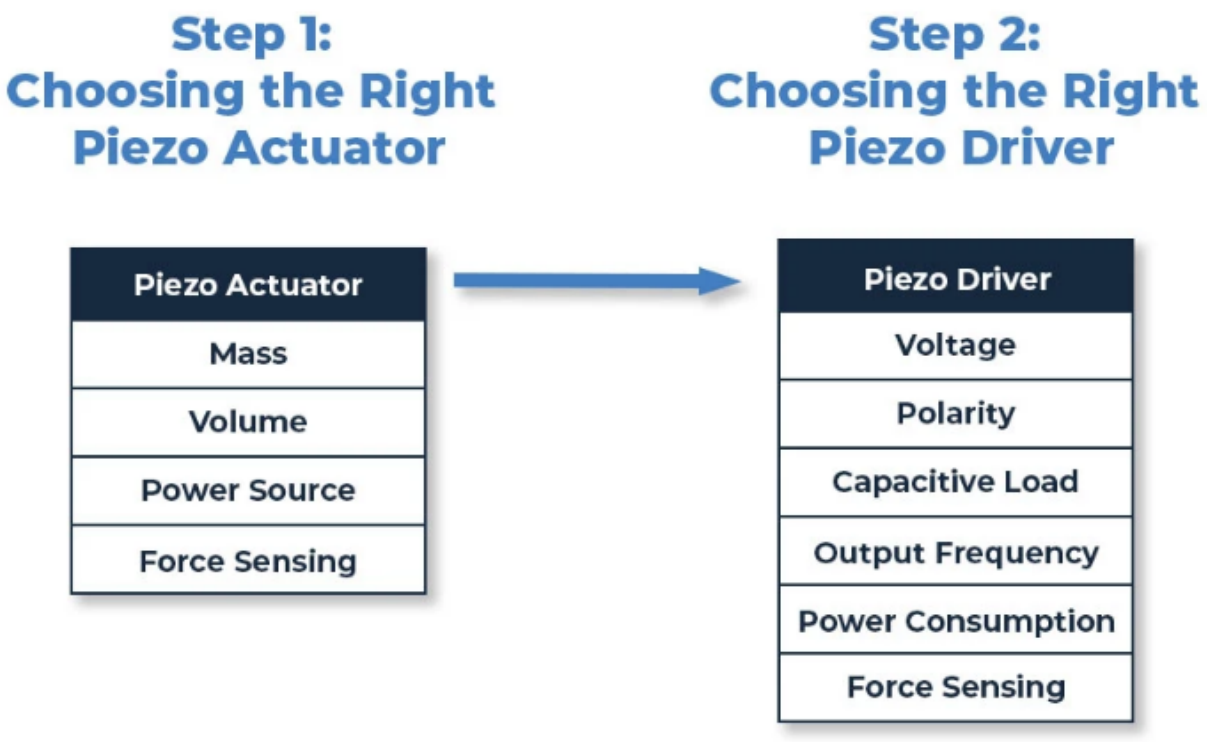
You've decided to provide the best haptic experience for the users of your next device by using piezo haptics -- the top of the line for haptics. But not all piezo haptics are equal. The driver and actuator combination that you select can make a dramatic difference not just in the user experience but in the amount of space required in your device, your power consumption, and other matters. Selecting the proper software and hardware combination is crucial to a successful piezo haptic implementation.

The solution is composed of a piezo actuator and a piezo haptic driver (amplifier). The two combine to deliver the tactile feedback. Therefore, selecting the right components is critical to achieving the best possible results.

And you need to select the best piezo haptic actuator and driver combination for the particular product that you are developing. Integrating piezo haptics in a smartphone will differ substantially from adding haptics to an automotive display or wearable, for example.

To help you select the perfect combination for your product, we will review the technical specifications that are relevant when choosing the components for your piezo haptic solution. You will want to involve others from your team in the decision; product designers, user experience engineers, mechanical engineers, and electrical engineers can help you analyze and select the best piezo haptic components for your product.

You start with choosing the best piezo actuator for your application, then go on to selecting the drive.



Selecting the Proper Piezo Haptic Actuator

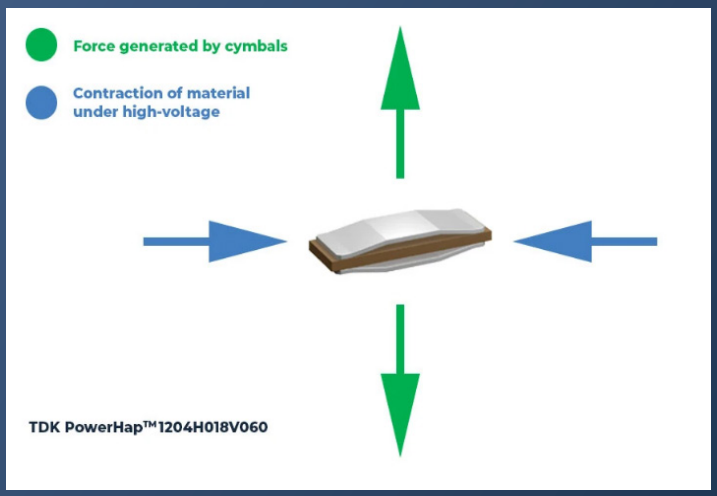
You need to answer four questions to select the best actuator:

- What's the mass you are trying to move?
- How much volume or space is available?
- What is the power source?
- Do you need force sensing in your product?

1. MASS

The first thing to consider before selecting your piezo components is the force requirement. The feedback strength is based on Isaac Newton's laws of motion. You can learn more about the mechanical fundamentals of piezo haptic actuators here.

Newton's second law of motion tells us that the force on an object F is equal to the mass m of that object multiplied by the acceleration a of the object: F = ma. (It is assumed here that the mass m is constant)



The piezo actuator is the hardware that generates the acceleration. It's the engine of your haptic solution. To choose an actuator, you will need to determine the mass you are trying to move. If your mass is small, like replacing a button on a smartphone, you can achieve high acceleration with a lower force (N) . On the contrary, if you need to move a large and heavy automotive infotainment system, you'll need a higher force actuator to achieve the same acceleration and tactile feedback. Moving a larger mass will limit the maximum achievable acceleration with a given actuator.

2. VOLUME

After determining the mass that you'll be moving, you then need to consider the volume you have available to fit the component into your product. Different piezo actuators have different shapes and sizes and can create force on different axes.

The actuator that you choose will depend on the available space and the axes on which you want to create the vibration. This will depend, of course, on your application and the type of tactile effect you are trying to achieve. You may have to update your design according to the piezo actuator to integrate it, so it's best to know early on which piezo actuator you will be using.

3. POWER SOURCE

Piezo haptics actuators require high voltages. (This is why you also need a piezo driver; it controls the actuator and amplifies the necessary voltage from the power source. More on that shortly.) Therefore, you need to be aware of your power source to ensure it will provide enough power to feed the piezo driver.

A mobile device battery doesn't offer the same power levels as an automotive alternator, for example. Piezo drivers are designed within particular parameters, and they won't all work on every power source. Select your components accordingly.

4. FORCE SENSING

Thanks to the reversible piezoelectric effect, piezo actuators can also be used as force sensors. Piezo material generates an electric charge when they are deformed. Applications where feedback is triggered by user input, like button replacement, can make great use of this feature.

With these four pieces of information, you can choose the best piezo actuator for your product.

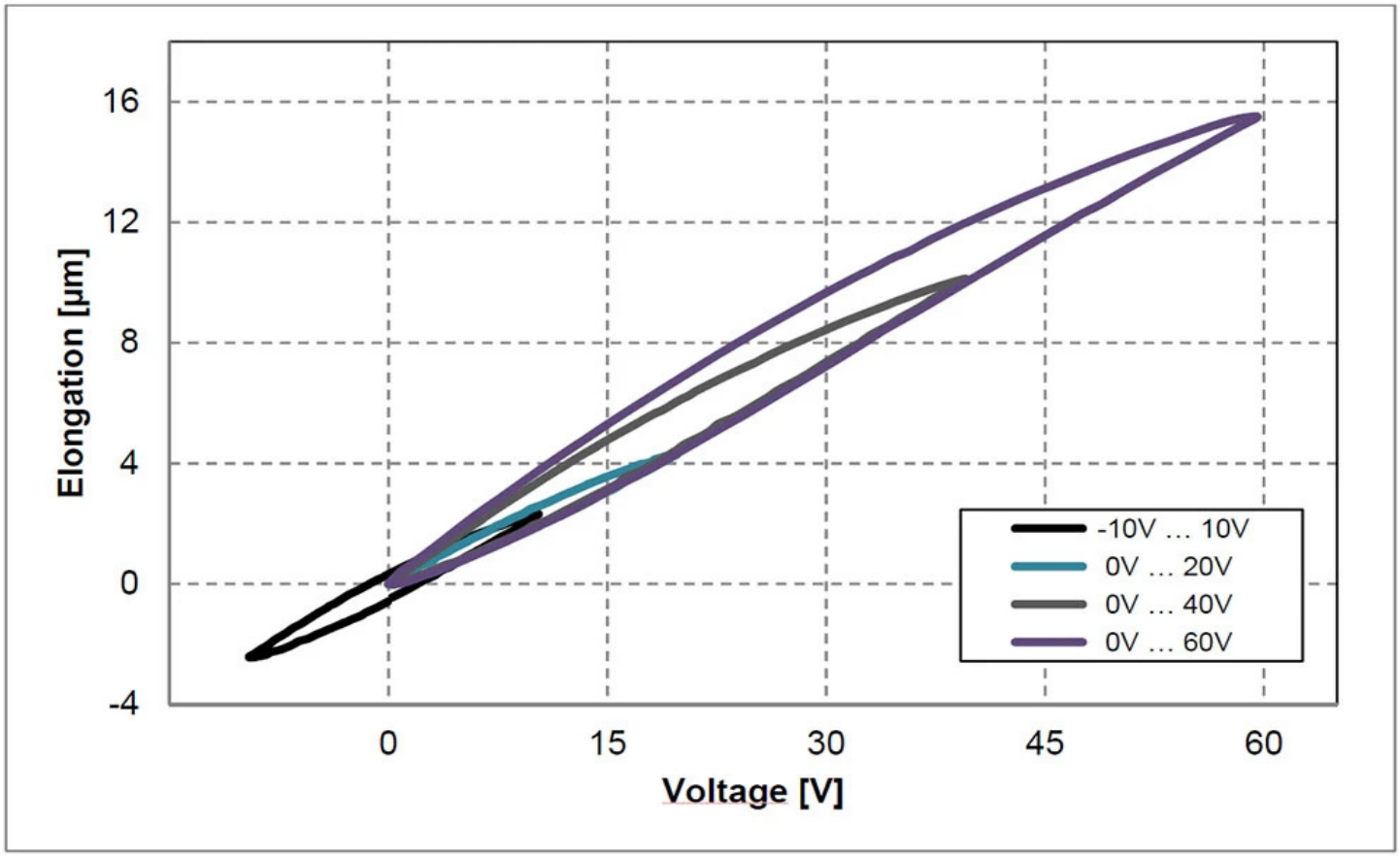
Selecting the Right Piezo Haptic Driver

Having chosen an actuator, now you need to select a suitable piezo driver to work with it. Please keep in mind that it is essential to have the actuator's technical requirements not too far along; they will help you select your driver.

Your piezo actuator will lead your driver selection. The two main tasks of your piezo driver are to amplify the voltage of your power source and control the actuator. Therefore, your actuator's technical specifications for required output voltage, polarity, capacitive load, and output bandwidth are essential for selecting the best piezo driver.

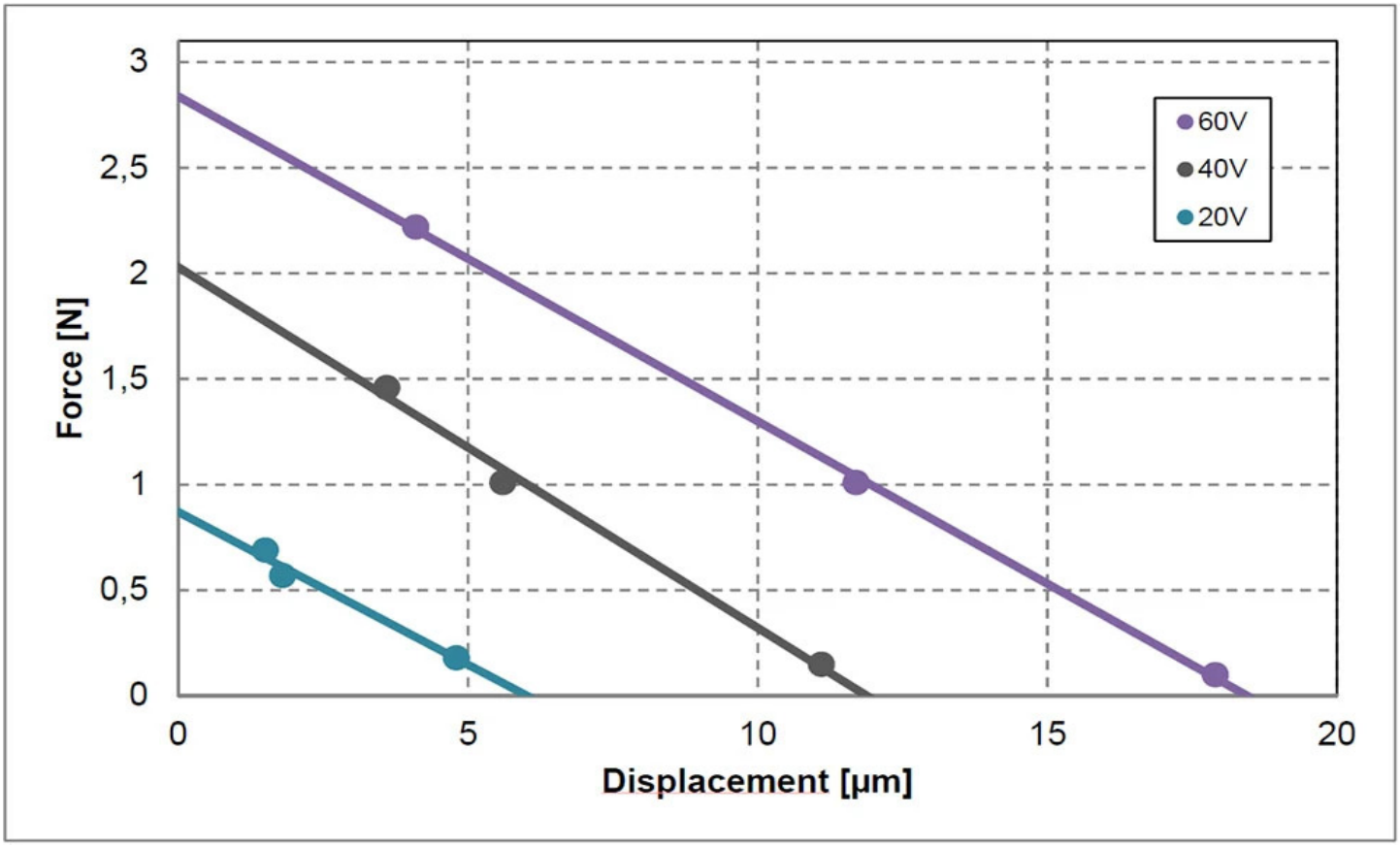
1. Voltage

The piezoelectric effect is the interaction between the mechanical and electrical potential in crystalline materials. Applying voltage through a piezoelectric material changes the crystals' electric polarization and creates mechanical deformations (the material can expand or shrink).



TDK PowerHapTM 0904H014V060 elongation measured between cymbal end-caps as a function of voltage.
Source: 0904H014V060 Datasheet

The piezo actuator's mechanical movement is the result of the applied electric field through the material. Therefore, it is essential to respect the minimum voltage requirements for your piezo driver. Using less than the required voltage will result in less material movement and less feedback from the actuator.



TDK PowerHapTM 0904H014V060 force-stroke diagram with different load springs. Typical stiffness 150 N/mm. Source: 0904H014V060 Datasheet

2. Polarity

Some actuators are bipolar: they can sustain waveforms with both positive and negative amplitudes. A unipolar actuator can only work with positive voltage waveforms. Also, a bipolar driver can drive a unipolar piezo actuator, but the opposite is not true. You will need to consider this when you select your piezo driver.

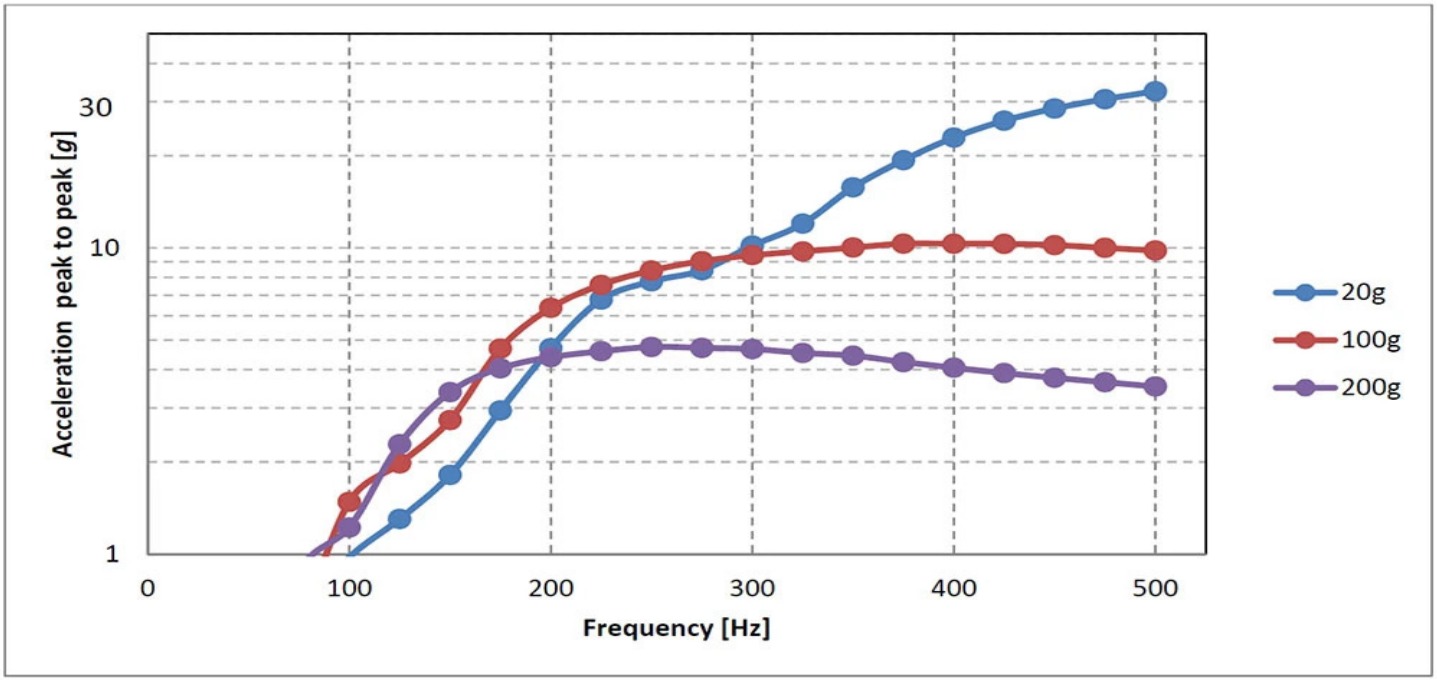
The Boréas BOS1901 piezo driver is bipolar; it can drive 190 volts peak-to-peak (+ 95 and – 95 V).

3. Capacitive Load

Piezo actuators have inherent capacitance so they behave like a capacitor. Typically ranging from a few nF to a few µF for haptic piezo actuators, the capacitance determines the amount of energy required to create a voltage that will induce enough strain in the piezoelectric material to create a vibration.

A higher capacitive load will require higher power to charge it quickly; make sure your piezo driver supports the actuator capacitance.

4. Output Frequency Bandwidth



TDK PowerHapTM 0904H014V060 acceleration peak-peak as a function of frequency for different loads. Source: 0904H014V060 Datasheet

Frequency plays a significant role in haptics quality for three reasons:

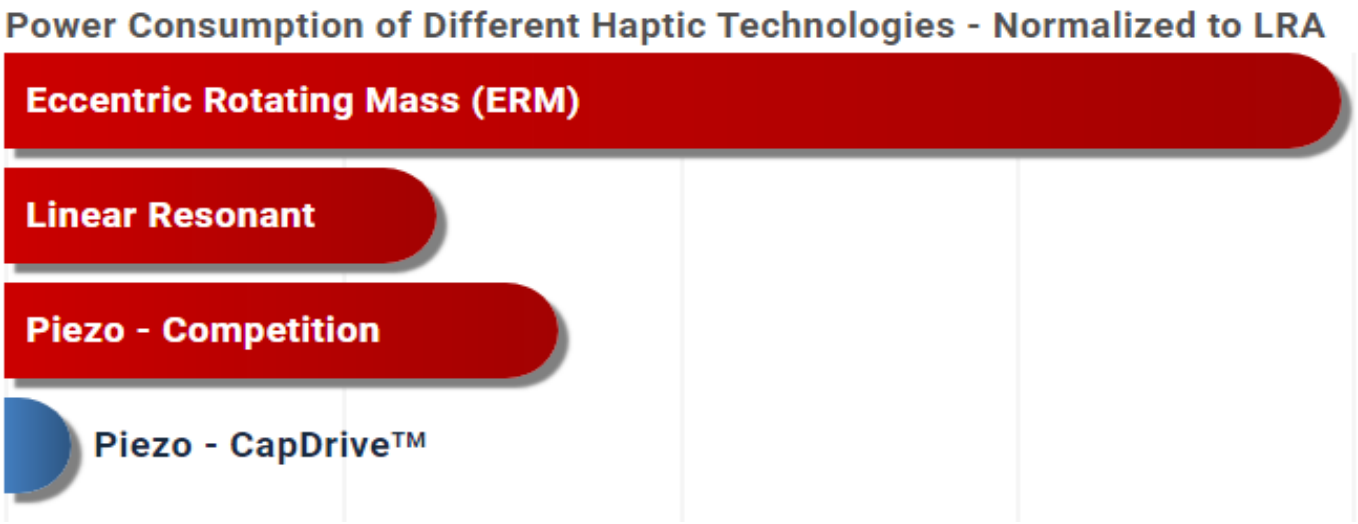
1. A higher frequency generally results in a higher acceleration and a stronger perceived effect for a given sense receptor.

2. Our somatosensory system (touch sense) uses different receptors depending on the vibration's frequency. Depending on the type of tactile effect you are trying to achieve, you need to use the appropriate frequency range for the relevant touch receptors.

3. The natural resonance is the frequency at which the mass you are trying to move resonates when it is vibrating and the mass displacement is amplified to its maximum. Typically, a lower mass increases the natural frequency, while a higher mass reduces it. This concept is essential for applications desiring to maximize the effect of continuous vibrations.

Piezo actuators have a wide frequency bandwidth so they can vibrate over a continuous frequency range. You need a piezo driver that can provide the maximum required frequency for the actuator capacitance and maximum voltage to achieve its highest acceleration performance.

5. Power Consumption



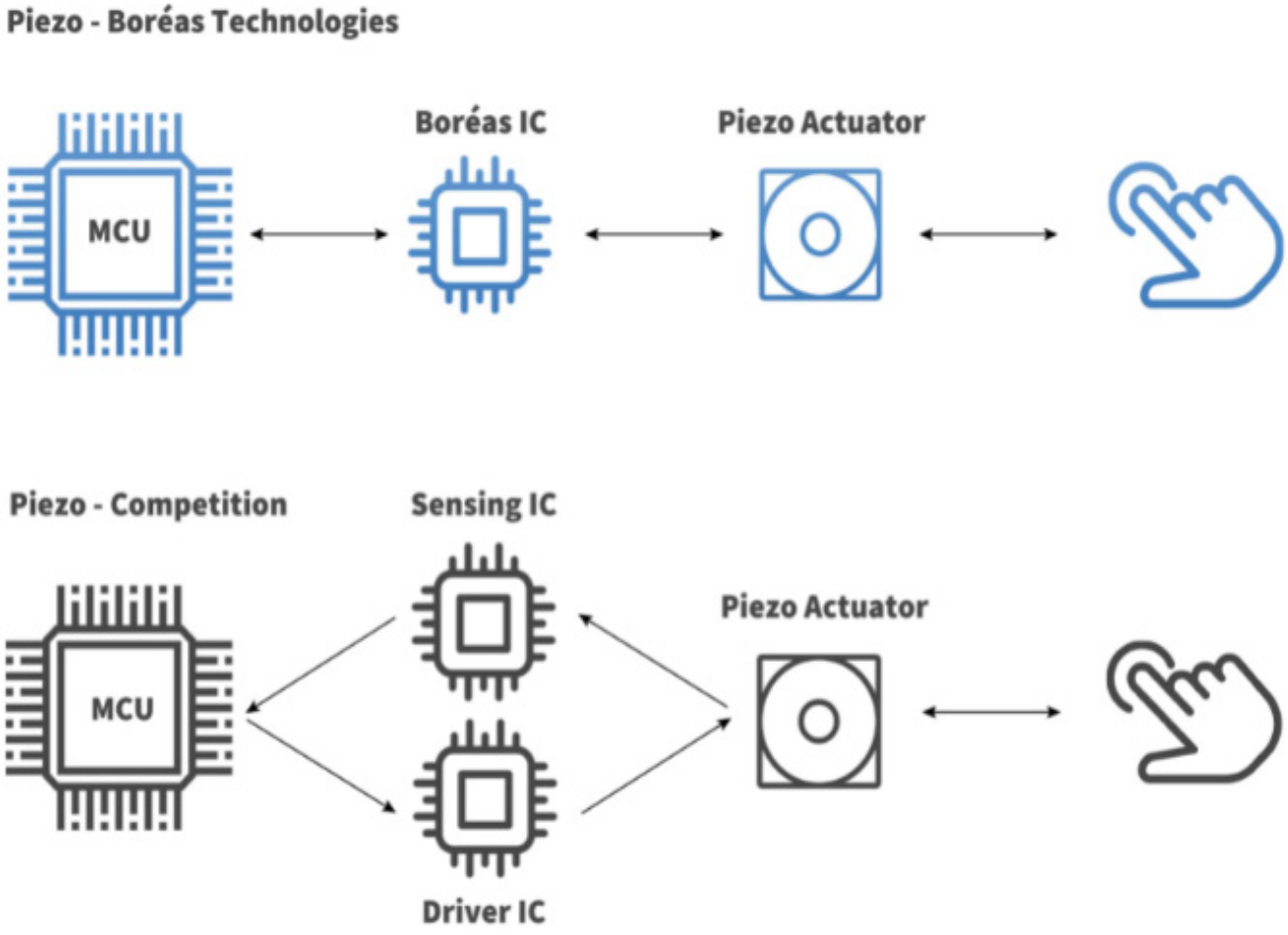
Source: Data extracted from Haptic Energy Consumption, Application Report SLOA194, Texas Instruments (TI), May 2014. Data point for Boréas was extrapolated from comparative measurements between the TI DRV8662 chip and Boréas' driver.

While power consumption isn't related to the actuator's feedback quality, it is still a significant factor when choosing a piezo driver. High power consumption will drain your device battery and generate excessive heat that may limit the functionality or even be a hazard for the system.

Not all piezo drivers are power-efficient. Previous piezo driver technologies used inefficient architectures to amplify voltage and generate high-voltage waveforms. In technical terms, they were power hogs. Boréas Technologies' CapDriveTM technology

architecture is different. It recovers the energy from the actuator's internal capacitance and reuses it instead of draining all the battery power. It allows Boréas drivers to use less than one-tenth of the power of other piezo drivers on the market and avoid overheating issues.

Bonus: CapDrive Exclusive Force Sensing Feature



Another advantage of the Boréas CapDrive technology is the driver's ability to sense the pressure applied to the piezo actuator. Since the piezo effect is reversible, the actuator generates an electric voltage when mechanical stress is applied to it. CapDrive drivers can detect this voltage change and allow a single IC to be used for sensing and haptic feedback functions. Depending on your application and actuator integration you may be able to replace the complete sensing hardware with the Boréas haptic solution.

Contact Us For More Information About Piezo Haptic

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