TAC**HAMMER™**
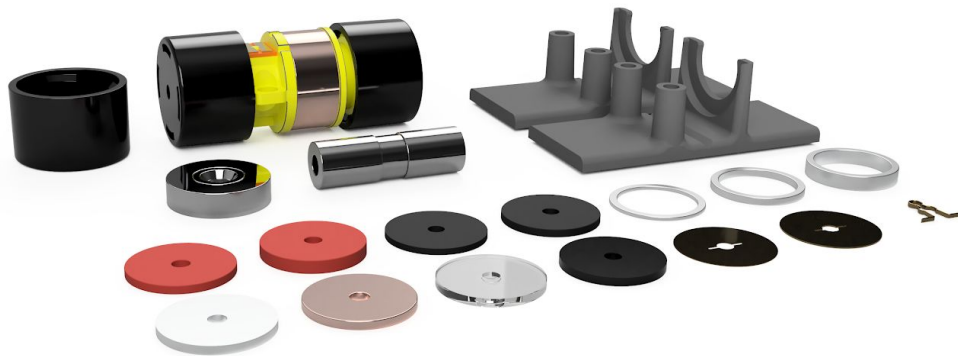
DEVELOPER KIT 1v1

The TacHammer™ Linear Magnetic Ram (LMR) Haptic Development Kit that provides customization of impact effects. Includes components for adjusting hammer travel distance and impact materials, and mounting clips and adhesive strips for prototyping.

INCLUDES:	REQUIRED TOOLS & (ADDITIONAL) MATERIALS*:
2x TacHammer - Carlton Variant	1x Arduino Micro
2x TacHammer caps	1x DRV2605 Haptic driver breakout
2x Adhesive mounts	1x 5v power supply
10x Impact discs	1x Breadboard
3x Spacers	1x Soldering iron
1x Spring Clip	3ft hookup wire
1x Set of magnets	*Required for use with sample code

TAC**HAMMER**

LMR CLASS HAPTIC ACTUATOR

3 HAPTIC MODES:

IMPACT | VIBRATION | PULSE

Product ID: D001
Revised February 11, 2019

TACHAMMER

TACHMMER DEVELOPMENT KIT

1   Getting Started

This Developer kit lets users experiment with customized impact haptics based on TacHammer's Linear Magnetic Ram (LMR) technology. It includes an assortment of tuning elements that lets you customize hammer travel distance (rings) and impact effects (discs).

This guide is written for the TI DRV2605 controlled by an Arduino Micro connected to a desktop computer. Other standard haptic drive unit like the TI DRV2605 may be used as well.

Developer Kit Additional Requirements:
- Arduino (Micro)
- TI DRV2605
- Desktop computer with an Internet connection
- USB cable (to connect Arduino unit to PC)
- Wiring + Soldering Kit - OR - Breadboard and Hookup wire Kit
- 5V power supply
- 150MB free hard drive space

1.1   Operating Principles

The TacHammer™ haptic actuator provides two different haptic sensations based on the actuation direction of the ram.

A "**hit**" is an impact haptic produced when striking the ram on a mechanical feature. This feature may be internal or external to the component (ie part a housing). Hits may produce audible effects which can be tuned through variations in the struck material.

A "**pulse**" is a non-impact haptic effect produced by driving the ram towards a magnetic brake within the component. Pulses are silent and do not produce audible effects. The haptics geerated in this mode are similar to ERM & LRA effects.

Direction of Impact Mode Operation
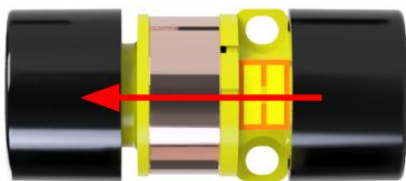
Direction of Traditional Mode Operation
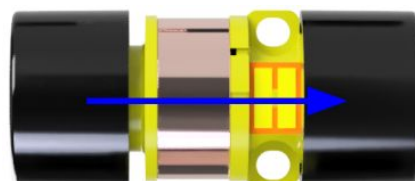
Both hits and pulses have variable intensities and actuation durations. Hits are used to generate sharp, momentary g-forces (like a click), and pulses are typically used to generate force sensations (like a bump).

Hits and pulses may be used in combination. A typical alert vibration for example is created through a chain of pulses actuated at a specified frequency. Combinations of hits and pulses provide for a range of new effects, like the snap of a latch, or the creaking of a door.
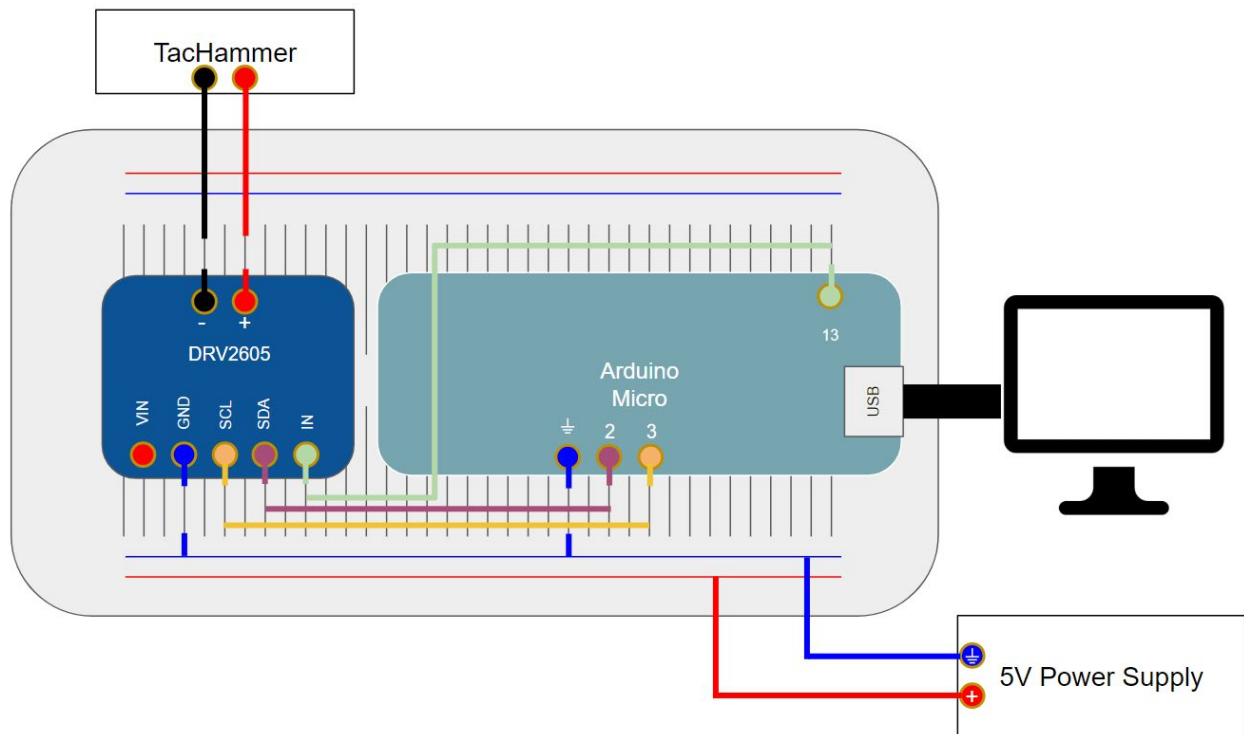
1.2   Kit Overview
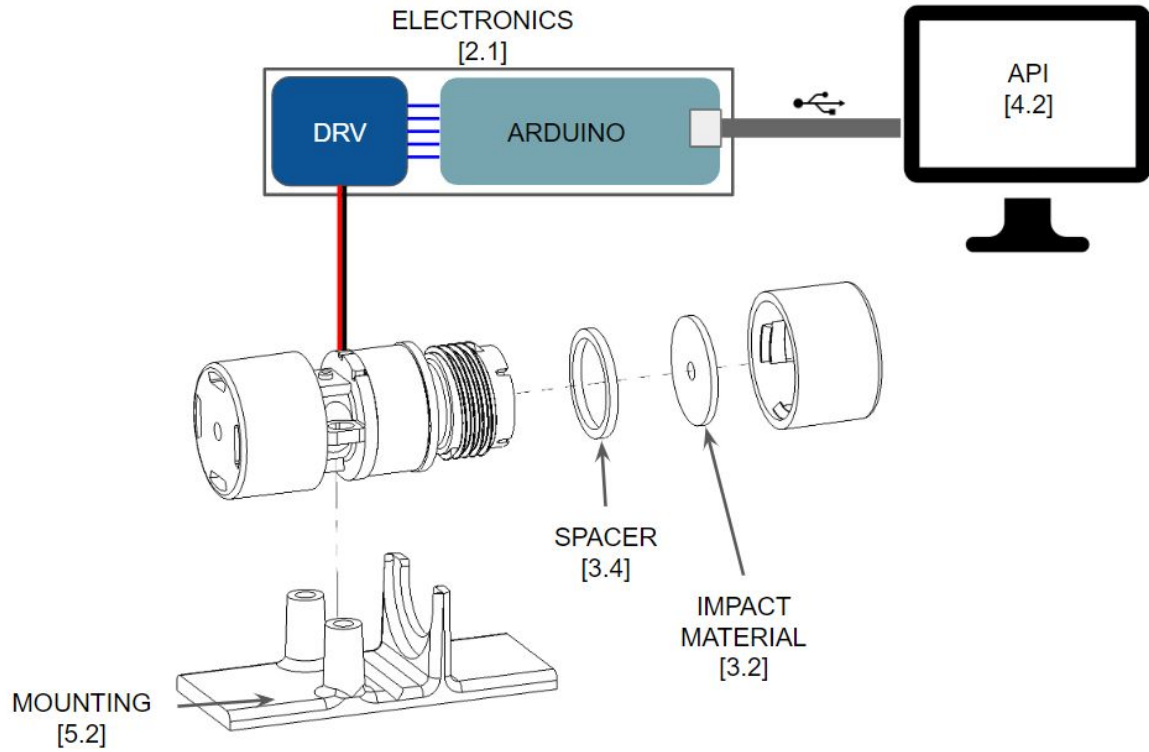
2   Setup

Required Tools & (Additional) Materials:

- Dev Kit Component
- DRV2605 breakout board
- Arduino Micro
- Breadboard
- 3ft Hookup Wire
- 5V Power supply, 800mA supply minimum
- Soldering Iron

2.1   Electronics

The wiring diagram below shows how the DRV2605, Arduino Micro, and TacHammer are to be wired together.

> **NOTE:** A 5v supply able to provide 800mA is required for the DRV2605.The Arduino Micro is not able to supply this amount of power and the performance of the TacHammer will suffer if the DRV2605 is driven from the 5V line on the Arduino

2.2 Software Installation

Instal the Arduino IDE from https://www.arduino.cc/en/Main/Software. The latest version at the time of testing is v1.6.8.

2.2.1 Preparing Software for upload

1. Launch the Arduino IDE and open the [TacHammerDevKit.ino] file

> **NOTE:** The firmware code must be placed in a folder with the same name in order to compile and upload

2. Set the IDE's board selection to *Arduino/Genuine Micro* by navigating to Tools > Board and ensure that [Arduino/Genuine Micro] is selected.
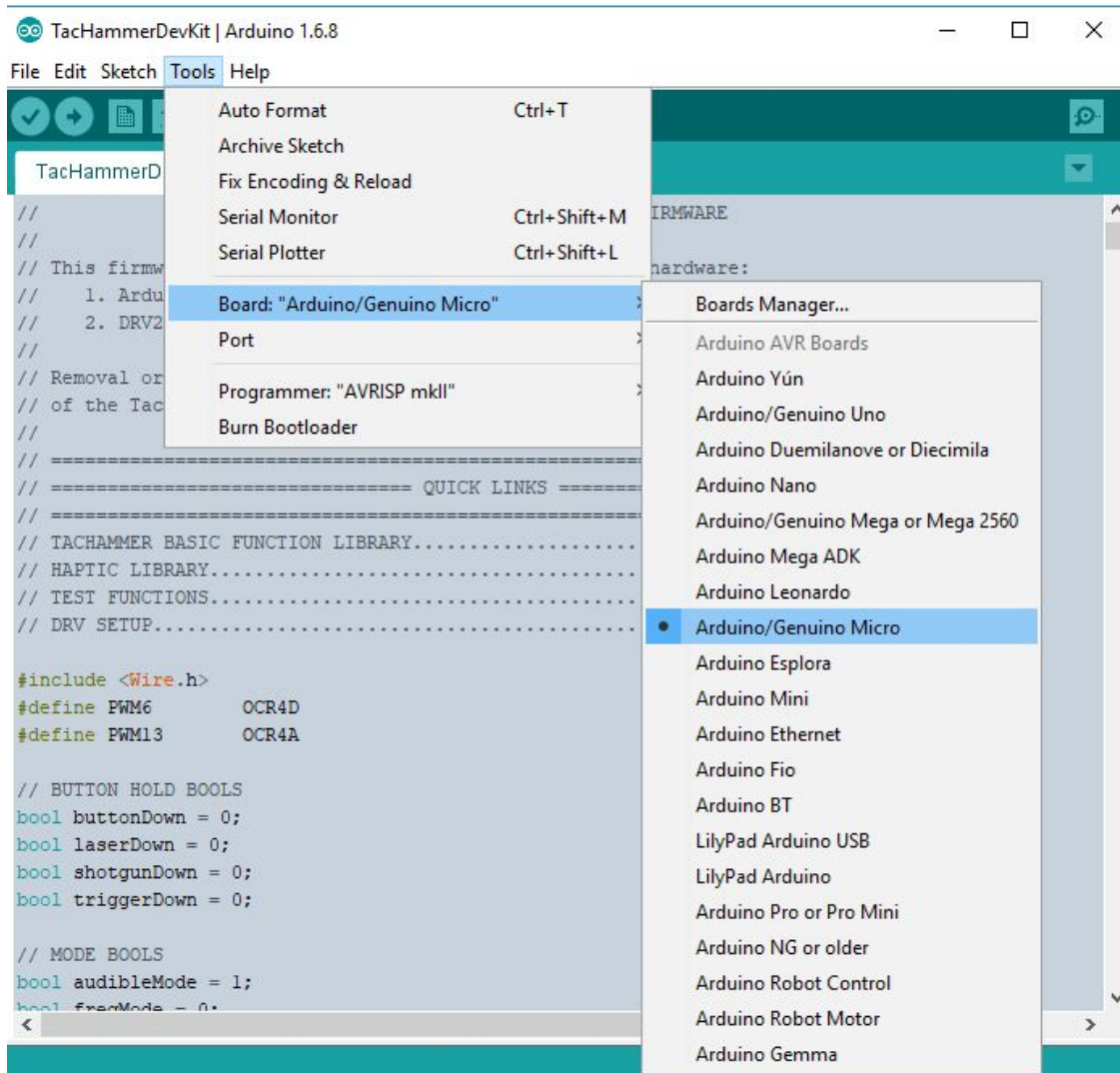
3. Set the IDE's port selection to *Arduino/Genuine Micro* by navigating to Tools > Port and ensure that [Arduino/Genuine Micro] is selected.
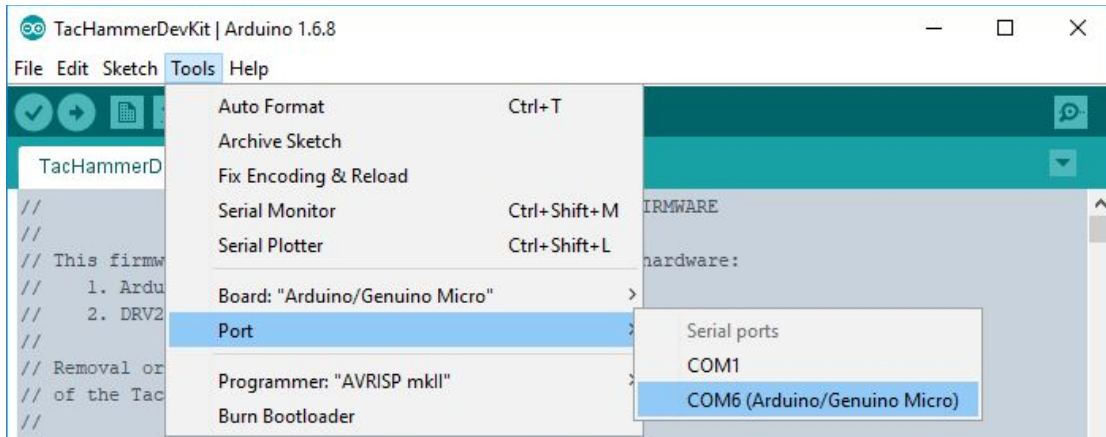
4. Click the Upload button to compile and upload firmware to the TacHammer Evaluation Unit.

3 Impact Tuning

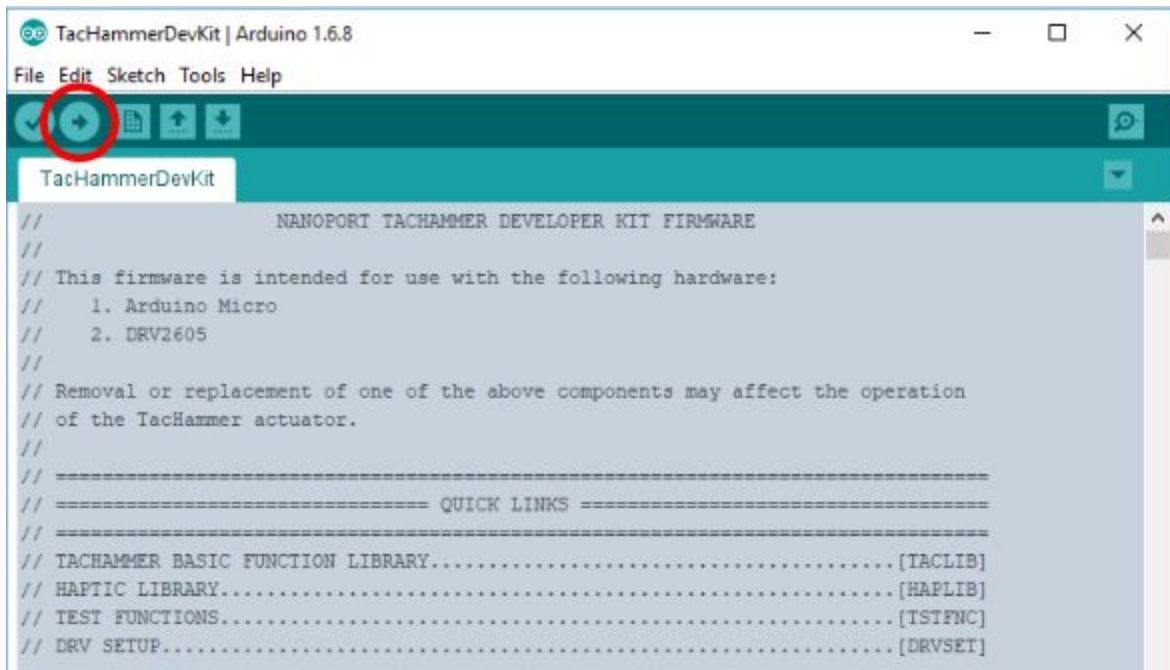Included in the development kit are several discs that can be installed in the TacHammer unit to modify and tune the haptic quality of the impact mode haptics. It should be noted that the included materials are a suggested starting point and not a comprehensive list of materials compatible with the TacHammer. The sections below will detail the materials included as well as offer suggestions on how to use them.

3.1 Operating Mode

In order to take advantage of the impact materials, operate the TacHammer component using the *hit* commands (see Section 1.1).

3.2 Impact Materials

3.2.1 Soft Materials Overview

These materials soften the blow of the impact, primarily reducing the sound created when generating haptics and changing the quality of the haptic to be heavier and less sharp. The table and charts below detail their qualities. See Section 6.4 for details on the effect soft materials have on acceleration and SPL.

3.2.2 Hard Materials Overview

These materials enhance and sharpen the quality of the haptic on impact.

3.2.3 Description of Included Materials

MATERIAL	COLOR	THICKNESS (MM)
Poron 1/32"	Black	0.8
Poron 1/16"	Black	1.6
Silicon 10A	Red	1.6
Silicon 20A	Red	0.8
Aluminum	Silver	1
Copper	Copper	1
Acrylic	Clear	1
Delrin	Black	1
Phosphor Bronze - 0.1mm	Bronze	0.1
Phosphor Bronze - 0.2mm	Bronze	0.2

3.3 Spacers

Spacers increase the distance the hammer must travel before impacting. They can be combined with the impact materials listed above to further modify the impact quality.

| LENGTH MODIFICATION	EFFECT
Increasing hammer travel distance	● Decreases the resonant frequency, the frequency that the highest acceleration can be generated ● Reduces the maximum acceleration generated
Reducing hammer travel distance	● Raises the resonant frequency, the frequency that the highest acceleration can be generated ● Reduces the maximum acceleration generated.

3.4 Installation of Impact Discs & Spacers

STEP	ACTION	
1	Insert disc between the tabs on the cap	
2	Push the disc past the remaining tab until the disc sits flat on the bottom of the cap	

3.5 Component Combinations

Combining multiple components together can significantly change the haptic quality beyond what a single impact disc can do. The examples listed below are suggested material combinations

COMPONENT A	COMPONENT B	EFFECT
0.5mm Spacer	Phosphor Bronze - 0.1mm	Hard impact with a heavy sprung effect
Spring Clip	Phosphor Bronze - 0.1mm	Metallic clinking noise accompanying impact

EXPLODED	ASSEMBLED
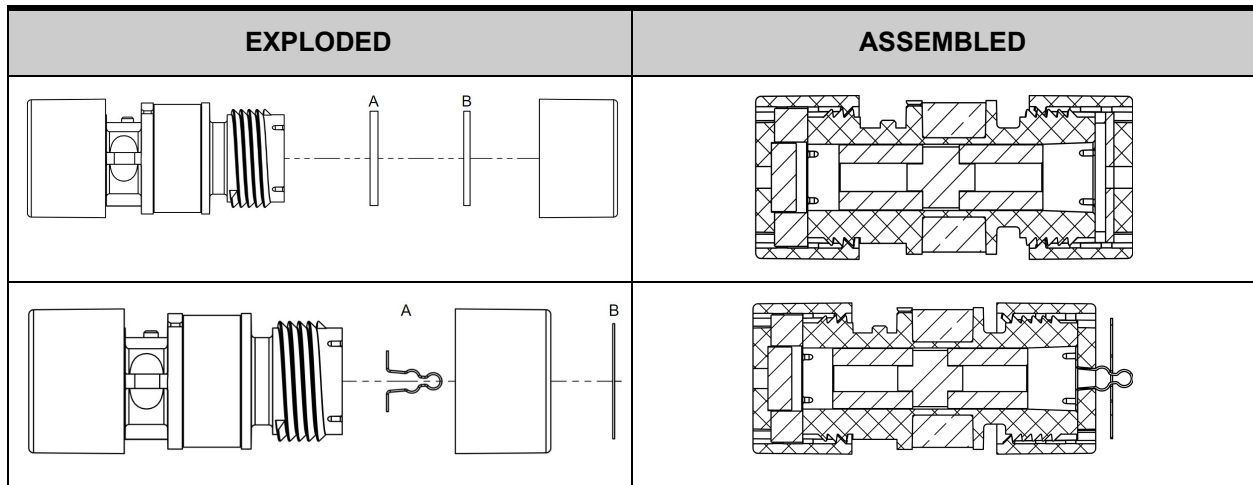
4 Software Programming

4.1 API

---

hit(intensity, duration);
Drives the ram into a mechanical stop to produce a sharp haptic sensation. May produce an audible effect.

PARAMETER	DESCRIPTION
Double intensity	Haptic intensity from 0-1. 1 provides maximum voltage from the electronic drive unit.
Double duration	Duration in milliseconds to charge the TacHammer from 0-50. Typically 30ms for maximum effect depending on unit dimensions and orientation.

---

pulse(intensity, duration);
Drives the ram into a damper to produce a soft haptic sensation. Does not produce audible effects.

PARAMETER	DESCRIPTION
Double intensity	Haptic intensity from 0-1. 1 provides maximum voltage from the electronic drive unit.
Double duration	Duration in milliseconds to charge the TacHammer from 0-50. Typically 30ms for maximum effect depending on unit dimensions and orientation.

---

pause(duration);
Powers off the TacHammer unit.

PARAMETER	DESCRIPTION
Double duration	Duration in milliseconds to charge the TacHammer from 0-50.

---

vibrate(frequency, intensity, duration, duty cycle);
Uses a sequence of pulses to produce a vibration haptic.
See App Note in Section 6.1.2 for additional details on the relationship between frequency and duty cycle

PARAMETER	DESCRIPTION
Double frequency	Frequency of the vibration in Hz from 1-2000.
Double intensity	Intensity of the vibration from 0-1.
Double duration	Duration of the vibration in milliseconds from 1-2000
Integer duty cycle	Optional duty cycle parameter of the vibration from 0-1. Default value: 0.4.

4.2   Chained Effects

Cocking the hammer (hit)
Increases the travel distance of the ram by driving the ram away from the stop with a short duration pulse before calling a high intensity hit, resulting in a high strength hit.

SAMPLE CODE

```
pulse(0.3,20);
hit(1,27);
```

Braking the hammer (see: singlePulse)
Two of the same commands (pulse or hit) are called with a short pause between them in order to catch the magnetic hammer as it rebounds after impact.

SAMPLE CODE

```
pulse(1,20);
pause(3);
pulse(0.17,22);
```

5   Mounting Guide

The development kit includes an adhesive backed mount to mount the TacHammer to your device of choice. Whether it's a controller or a head-mounted display, the following images will guide the placement and orientation of the TacHammer to maximise your experience
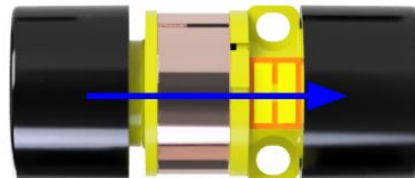
5.1   Haptics Direction

The TacHammer generates haptics primarily in the direction of travel. It is recommended that the TacHammer is mounted so that it is oriented towards the user.
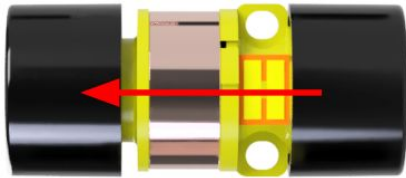
| Direction of Impact Mode Operation	Direction of Traditional Mode Operation

5.2   Using the Mount

| STEP	ACTION	
1	Place the TacHammer inside the mount (it will click into place	
2	Use 2mm nominal plastic thread cutting screws to tightly mount the TacHammer into the Mount	

5.3   Mounting Boss Specification

SCREW DIMENSIONS			

DIMENSION	SYMBOL	VALUE (mm)	
Recess Width	A	1.75	
Nominal Screw Diameter	d1	2	WN 5452
Screw Head Diameter	d2	3.5	
Screw Height Height	k	1.6	
Thread Length	L	6	
Recess Depth	t	7	
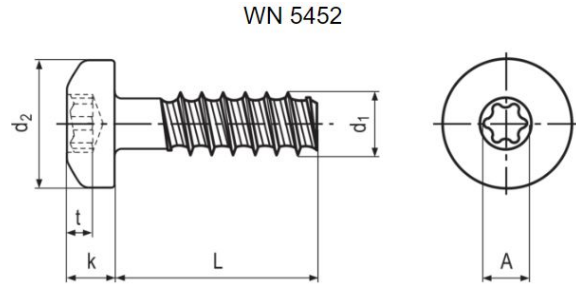
BOSS DIMENSIONS			

DIMENSION	SYMBOL	VALUE (mm)	
Nominal Screw Diameter	d1	2	
Boss Diameter	D	4	
Edge Relief	de	2.2	
Edge Relief Height	he	0.6-0.8	
Thread Engagement	te	4	
Pilot Hole	d	1.6	
Recommended minimum 1° draft			
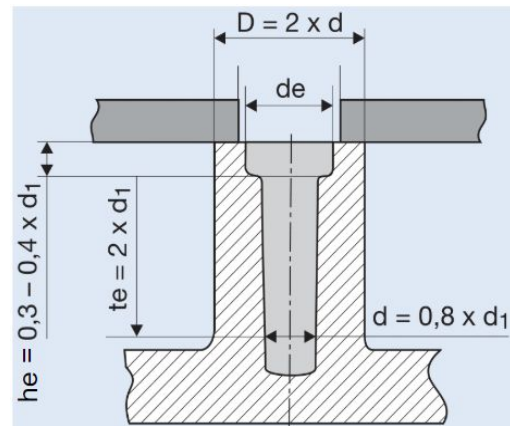
SCREW MOUNT DIMENSIONS
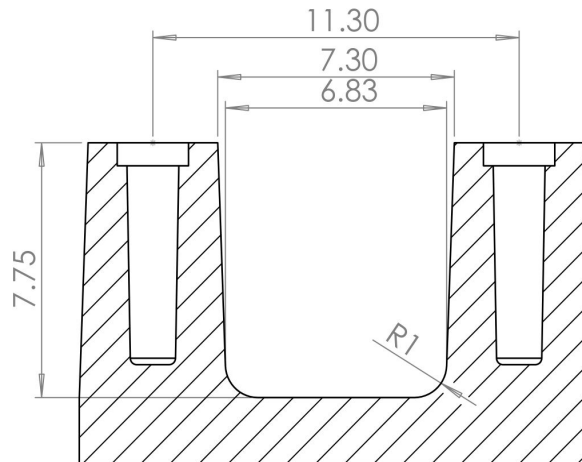
5.4 Product Dimension Specification

FRONT	BACK
⌀ 15.08	⌀ 15.08

SIDE

34.28
23.03
12.20
11.30
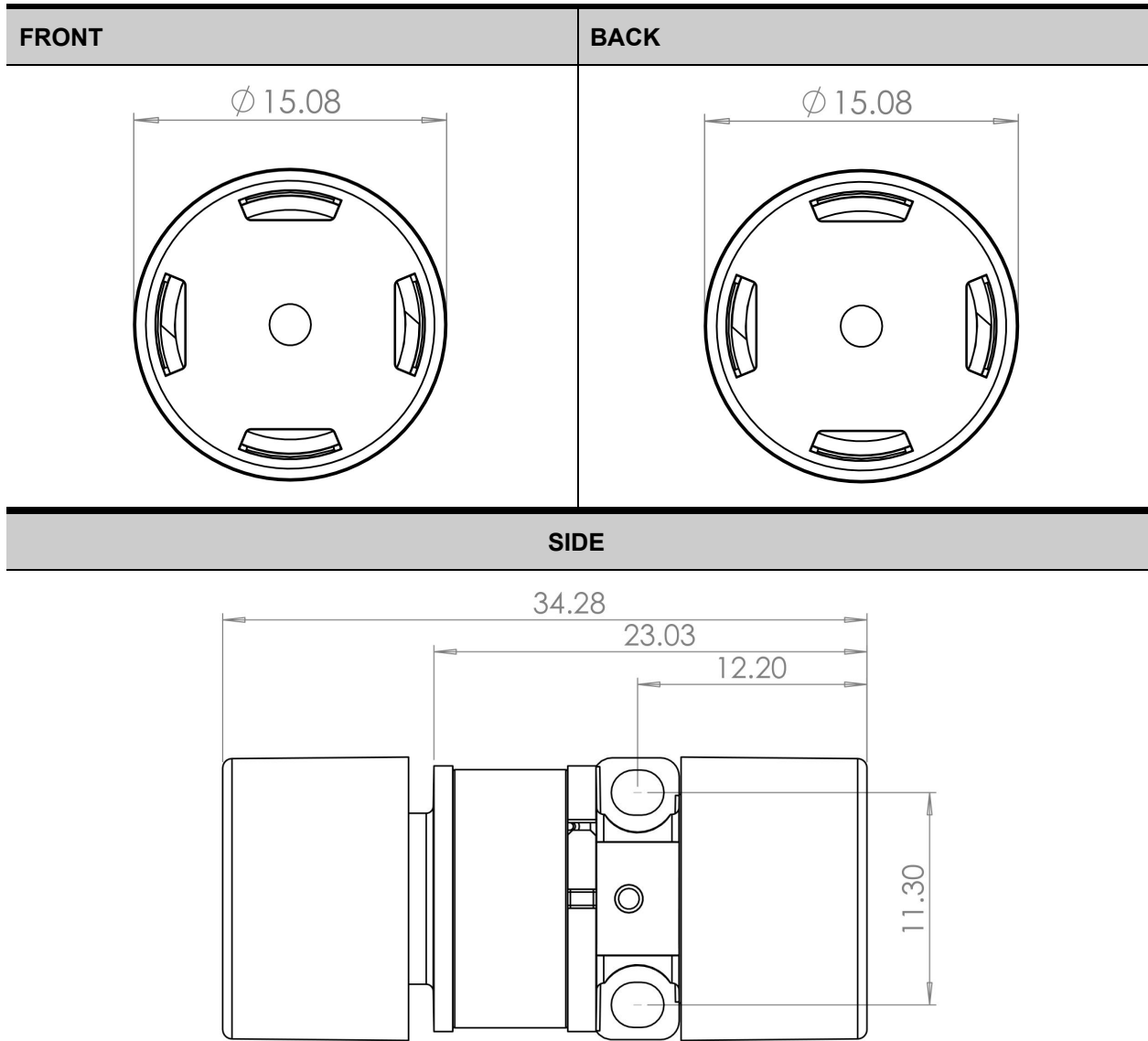
6 Application Notes
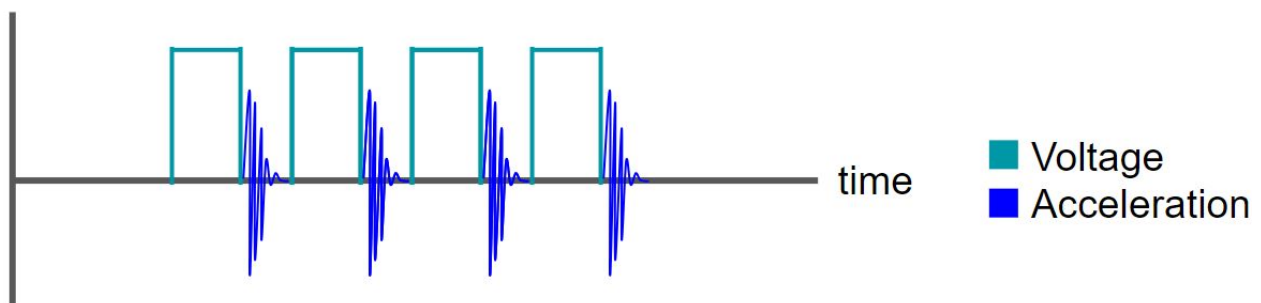
6.1 Driving Signal

6.1.1 Single Haptics

Single haptics such as a single Hit or Pulse is optimally driven with a single pulse. The following table lists the recommended duration for the respective haptic.

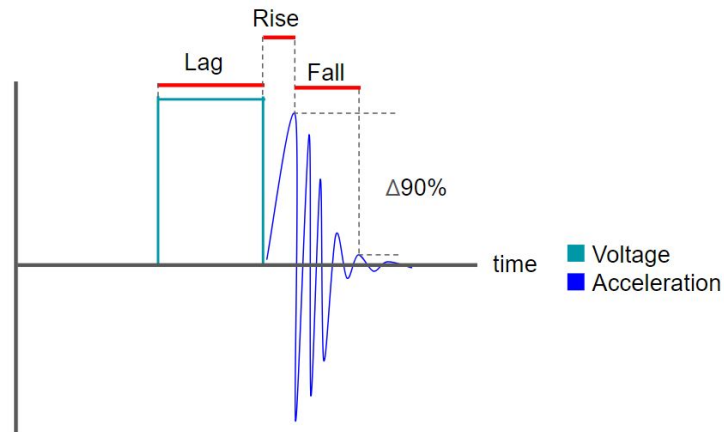| HAPTIC	DURATION	UNIT
Hit	8.6	ms
Pulse	10	ms

6.1.2 Repeated Haptics

For repeated haptics such as vibrations, the TacHammer™ haptic actuator is optimally driven with a square wave input. The following tables list recommended frequencies and duty cycles.

6.2   Response Time Note

Note: Above image is a representation of the driving signal and corresponding acceleration waveform for a single impact haptic.
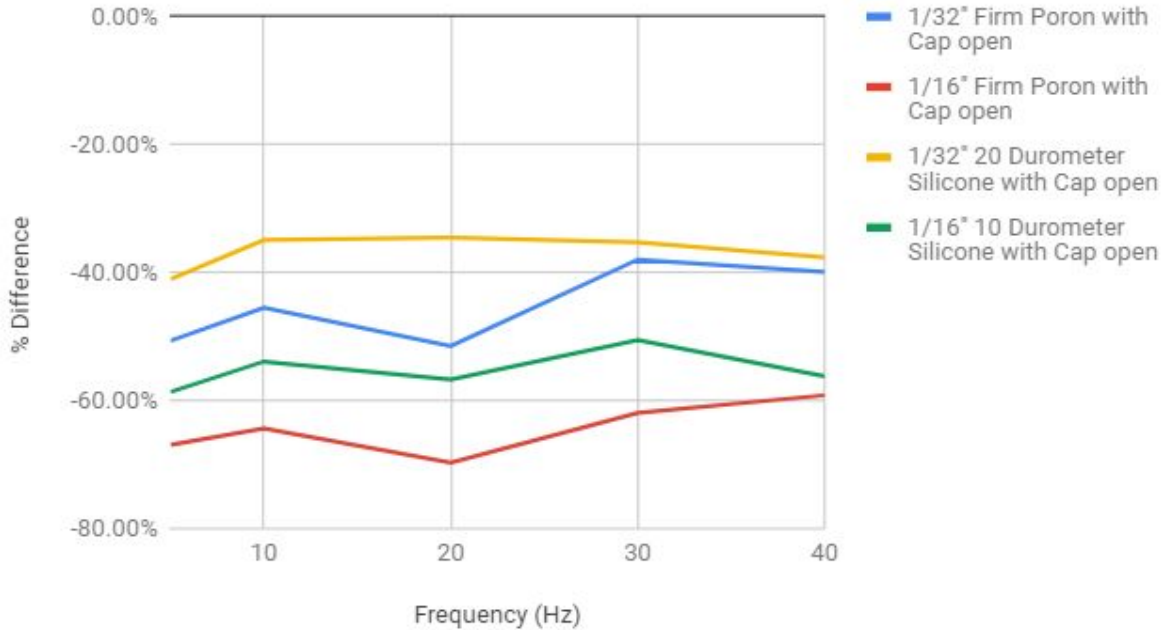
6.3   Driving Note

This device may be driven using off the shelf haptic driver ICs such as the TI DRV2605 in PWM mode or by a simple H-Bridge.

Additionally, the device is fully back compatible and is capable of taking advantage of LRA waveforms and libraries, such as that found on the TI DRV2605.

6.4 Acceleration and SPL Effect of Soft Impact Materials

Acceleration % Difference

SPL (dbA) % Difference