

# Feel the Real World

The final haptic feedback design solution

Need For Power Motor  
[www.nfpmotor.com](http://www.nfpmotor.com)

# Touch is....

...how we interact with...

...how we feel...

...how we experience...

...the **WORLD.**



# Touch Introduction

- Touch screens are replacing traditional user interfaces

|                         |                         |
|-------------------------|-------------------------|
| Cell Phones & Handhelds | Tablets                 |
| Laptops & Desktops      | Portable Gaming Devices |

- Touch screens have obvious advantages
  - Direct **interaction** with on-screen content
  - Flexibility provided by a **dynamic** display
  - Rich **input and gesture** vocabulary
  - Improved mechanical **durability**
- Touch screens have one major disadvantage
  - **No physical or mechanical feedback** when the screen is pressed or an event occurs
  - Loss of **tactile** or **haptic** feedback



# What is Haptics?

- 1** Haptics is the science and technology of touch



- 2** It simulates surfaces and movements by using vibrations



- 3** It's easy to implement and an inexpensive way to differentiate a product



- 4** A way to experience something new



# Haptics in Tablets & Handhelds

Applications come to life....

- The turning of a page
- A keyboard you can feel
- The vibrations of a game or movie



# Experience something new...

- A game console-like experience in a mobile device
- Feel the beat of a drum or the strum of a guitar
- Play a pin-ball game as if you were in an old-fashion arcade



# Add Haptics Even to Existing Applications

*Almost any application or game with sound effects.*



# What can Haptics do for you?



**Mobile**



**Medical**



**Education**



**Industrial**



**Commerce**



**Sports**



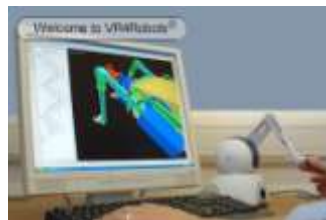
**White Goods**



**Consumer**



**Arts**



**Science**



**Gaming**



**Consumer**



# Touch Screens & Surfaces

- **Remotes** with static or dynamic controls
  - Audio/Video
- **Appliances**
  - Ovens
  - Washer/Dryer
- **Home Systems**
  - Alarm
  - HVAC
- **Computer Pads**
  - Mouse pad
  - Drawing Tablet



# How can Need For Power Motor help?

- NFP-Motor connects the digital world to your world using haptics technology
- We develop actuator drivers optimized for haptics applications
- Provide reference designs, schematics and hardware
- Work with customers and 3<sup>rd</sup> parties to provide complete hardware and software solutions
- A top choice for customers looking to enhance their products with haptics

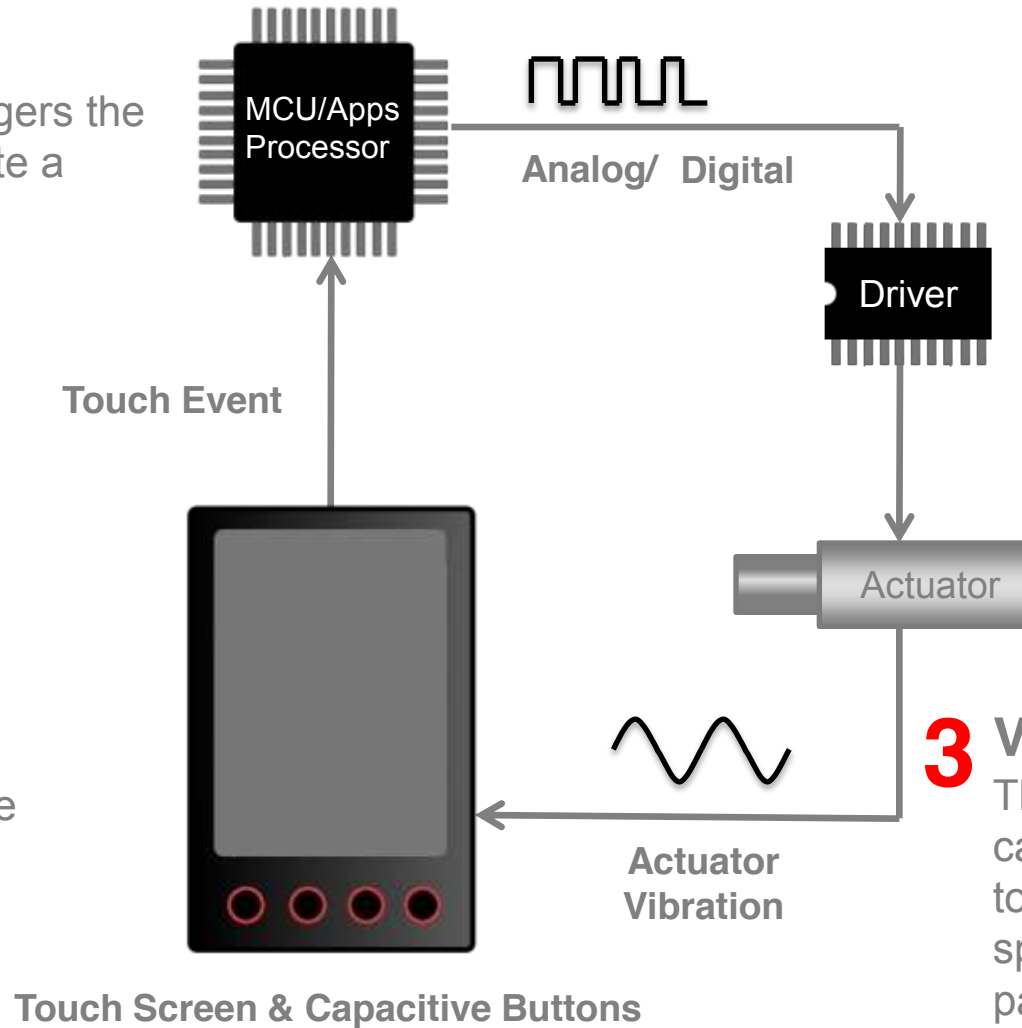
# Haptic ~~DELETED~~ Diagram

## 2 Generate

The touch event triggers the processor to generate a waveform.

## 1 Touch

The touch screen controller sends a trigger signal to the processor when a press is detected.

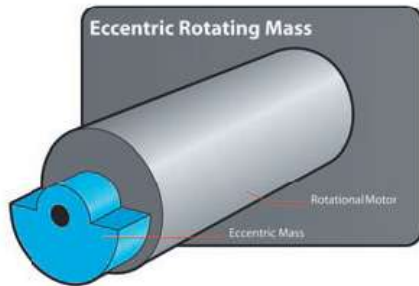


## 3 Vibrate

The waveform causes the actuator to move in a specific direction or pattern to create a vibration.

# Actuators

## Eccentric Rotating Mass (ERM)



**Voltage** 1 – 10 V<sub>DC</sub>

**Power** 10% of battery

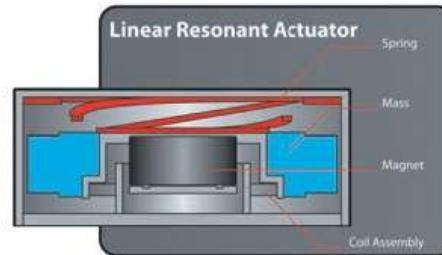
**Frequency** 1 – 300 Hz

**Response** 40 – 80 ms

**Waveform** DC Voltage

**Vendors** Sanyo, Jinlong  
Johnson Elec.

## Linear Resonant Actuator (LRA)



**Voltage** 2.5 – 10 V<sub>DC</sub>

**Power** 5% of battery

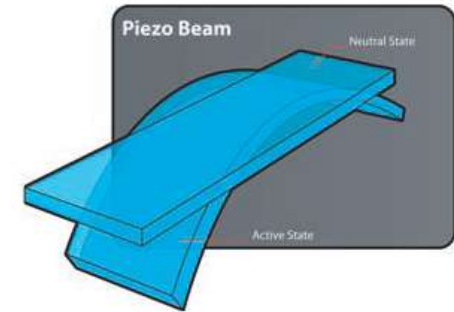
**Frequency** 175 Hz

**Response** 20 – 30 ms

**Waveform** Sine wave

**Vendors** SEMCO  
(Samsung)

## Piezo



**Voltage** 50 – 200 V<sub>pp</sub>

**Power** 7% of battery

**Frequency** 1-300Hz

**Response** < 1 ms

**Waveform** Sine wave

**Vendors** AAC, Murata  
Hokuriku, TDK

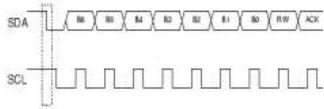
# Actuator Comparison

| Attribute               | ERM                | LRA                | SL Piezo                      | ML Piezo                      |
|-------------------------|--------------------|--------------------|-------------------------------|-------------------------------|
| Actuator Type           | Inertial           | Inertial           | Piezo                         | Piezo                         |
| Cost                    | \$                 | \$\$               | \$\$                          | \$\$\$                        |
| High Definition Haptics | No                 | No                 | Yes                           | Yes                           |
| Localized Haptics       | No                 | No                 | Yes                           | Yes                           |
| Whole-Device Haptics    | Yes                | Yes                | Yes                           | Yes                           |
| Size                    | Bulky              | Bulky              | Thin                          | Thin                          |
| Drive voltage (Vp-p)    | 10 V               | 10 V               | 150 V - 200 V                 | 30 V – 50 V                   |
| Control                 | DC                 | Amp. Mod.          | Large BW                      | Large BW                      |
| Response time           | 40-80 ms           | 20-30 ms           | <<1 ms                        | <<1 ms                        |
| Power Consumption       | Poor               | Best               | Good                          | Good                          |
| TI Products             | DRV8601<br>DRV**** | DRV8601<br>DRV**** | DRV****<br>DRV****<br>DRV**** | DRV****<br>DRV****<br>DRV**** |

SL – single layer, ML – multi-layer

\* Under development, \*\* Concept

# DRV2604/5 Features



## Digital & Analog Interfaces

Content the device to an available I<sup>2</sup>C, PWM, Audio, Analog, or GPIO



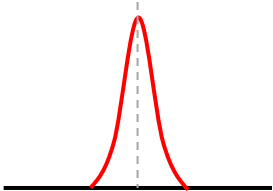
## Closed Loop Feedback

Automatically improve the response time of ERM and LRA actuators.



## Automatic Calibration

Automatically detect and configure the closed-loop feedback loop for every actuator



## Auto-resonance Detection

Automatically sense the resonance frequency of LRAs. Maximize vibration strength and improve consistency across devices.



## Audio-to-Haptics

Provide haptics to applications that do not have haptics and enhance bass from music and movies



## Waveform Library

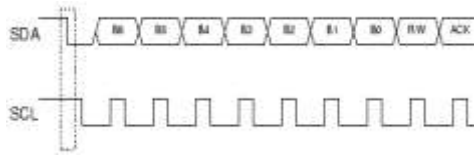
123 affects embedded, royalty free



## Automatic Diagnostics

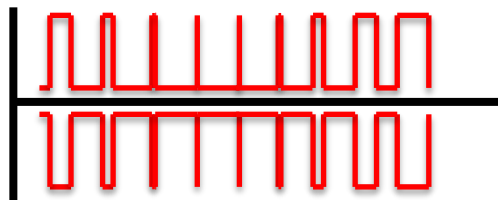
Automatically detect the status of the motor

# Interface Options



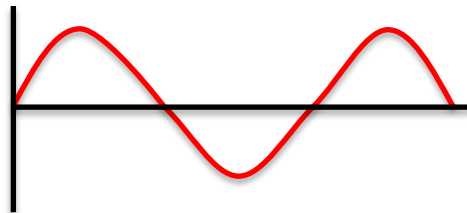
## I<sup>2</sup>C Interface

Can be used for control, waveform triggering, and real-time waveform playback.



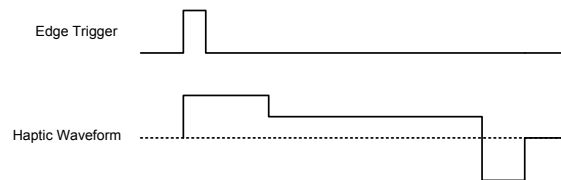
## PWM

Control both ERM and LRA using a PWM signal



## Analog Input

Drive hatpics through an available DAC

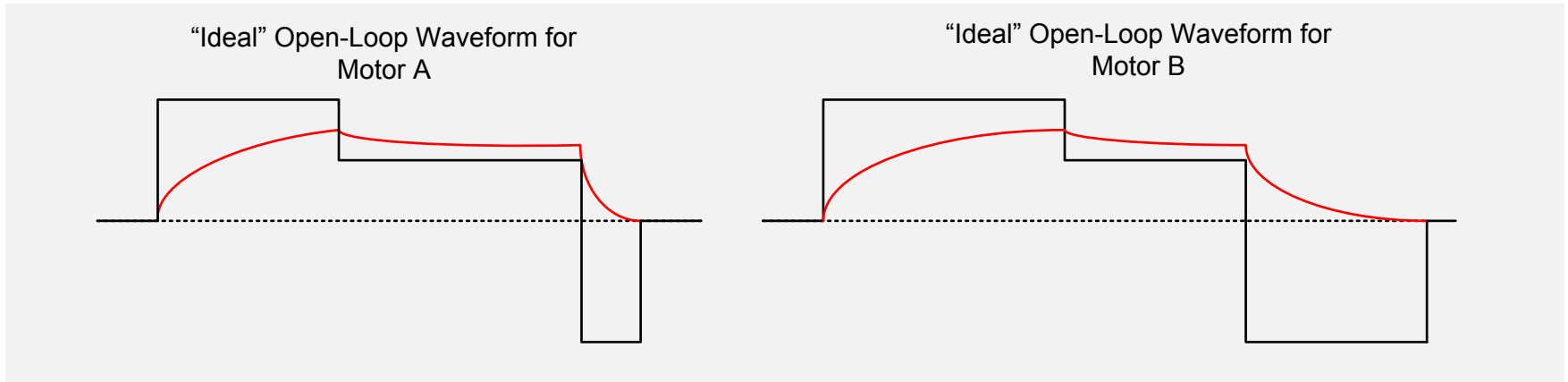


## Trigger Mode

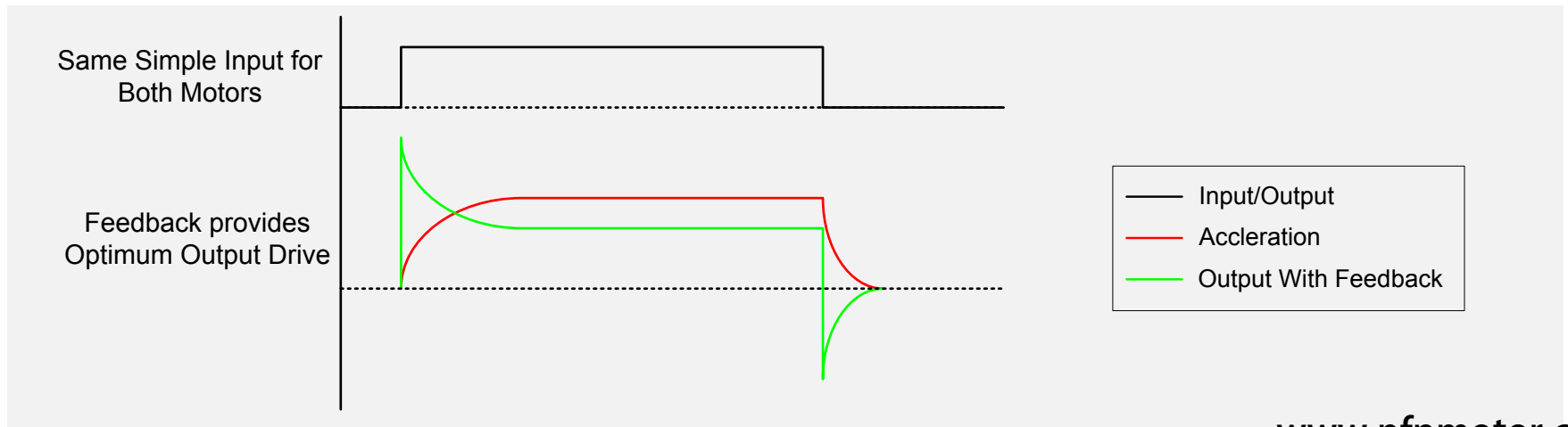
Trigger waveform output using a GPIO

# Driving with Closed-Loop Feedback

**Open-Loop:** Waveform startup and braking must be calculated and tested for each motor



**Closed-Loop:** Waveform startup and braking is automatic without testing and characterization





# Closed-Loop Feedback

## No Feedback



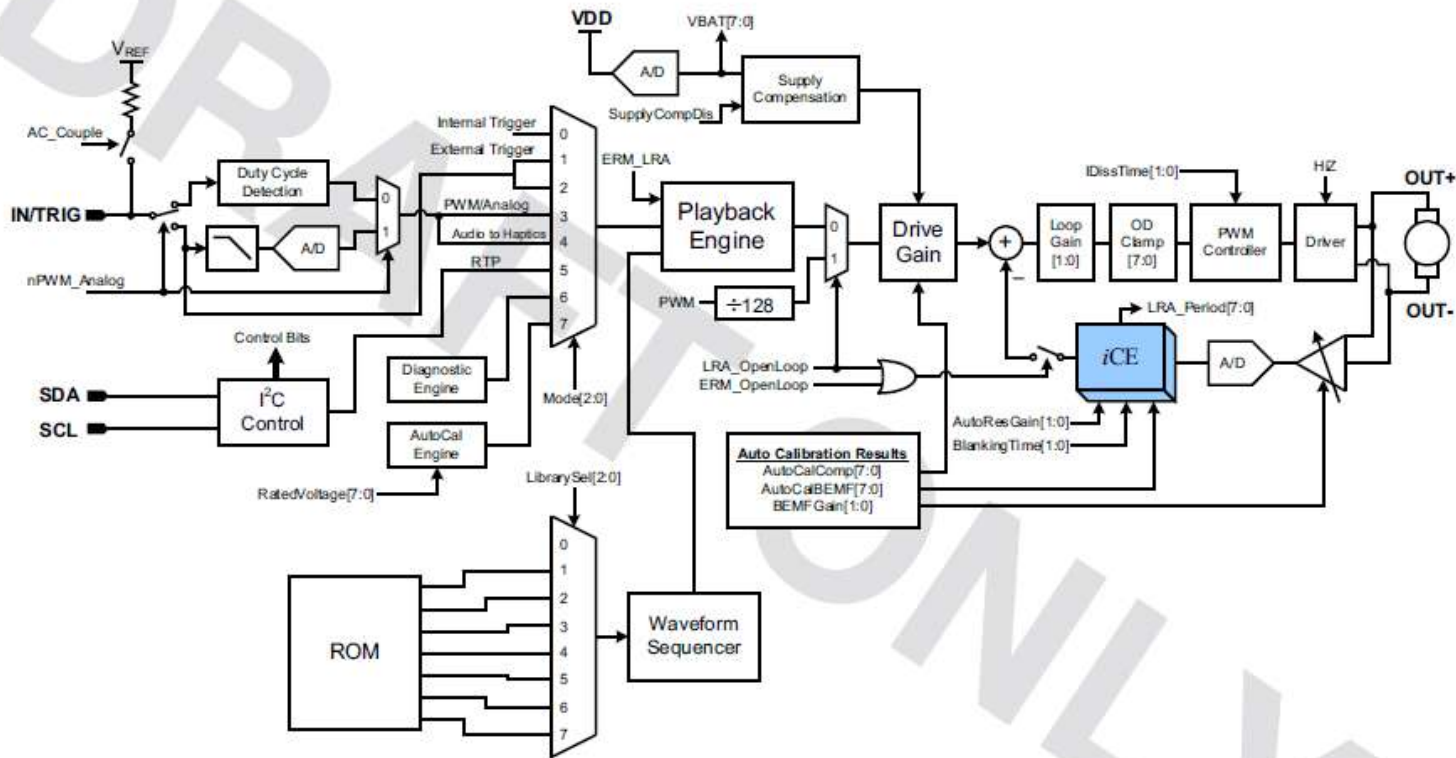
Faster Startup with  
**Automatic Overdrive**

## DRV2605 Feedback



Quicker and more controlled  
braking with **Automatic Braking**

# Auto Calibration



Our driver uses a patented algorithm based on our characterization and testing of numerous ERM and LRA. Auto-calibration ensure that no matter the actuator the DRV2605 is setup to accurately control it.

# Auto-Resonance Detection

## Auto-Resonance Detection

### Better Actuator Braking performance

Braking is important for creating “sharp” and “crisp” haptics effects as well as “event separation” for multiple-event waveforms like double-clicks.

### Simplified Input Signaling

No specific input frequency required.  
Accepts PWM signals from 10kHz – 250kHz

**2x**

### More Force

when driving the linear resonant actuator at resonance

**50%**

### Less Power

when driving haptics events like clicks/alerts when compared to drivers with no automatic resonance detection

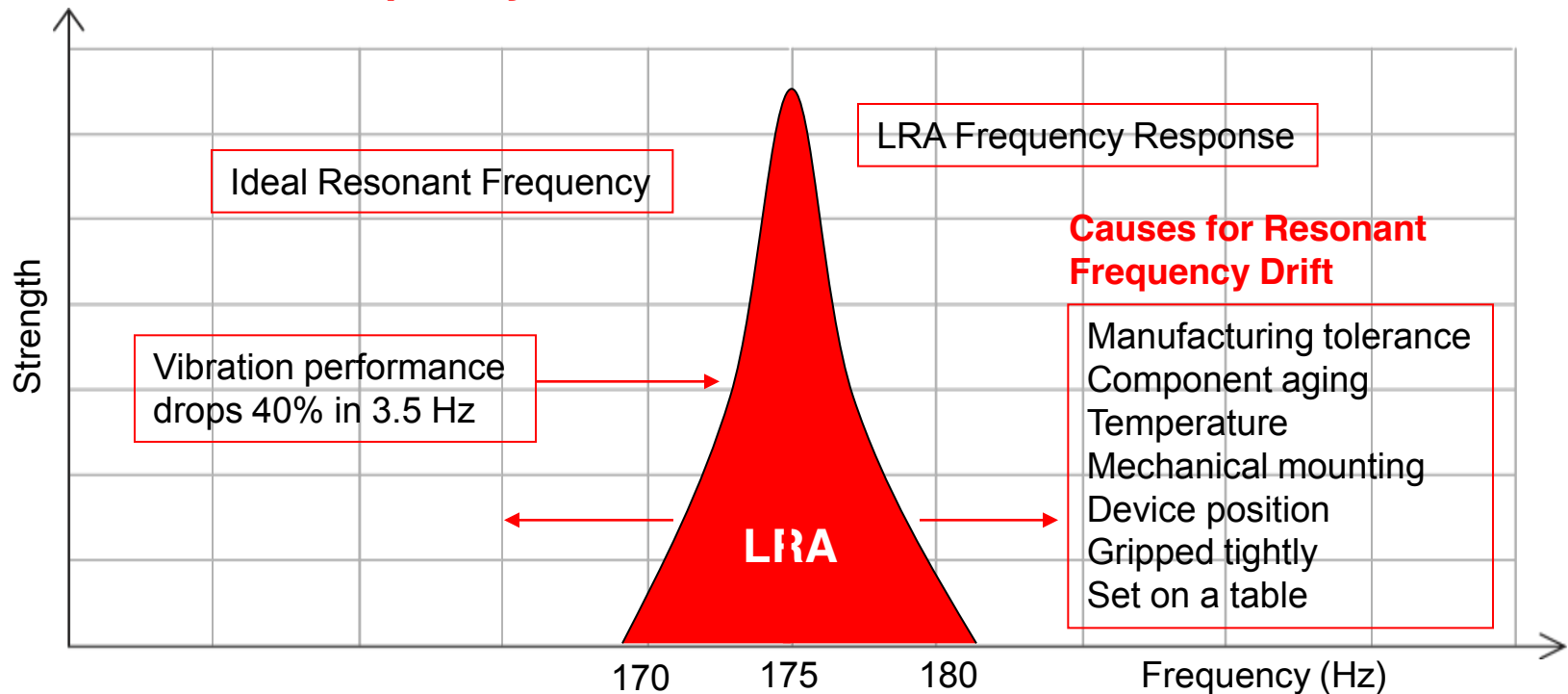
### Sensing Integrated

Resonance frequency detected through outputs

# Auto-Resonance – Why?

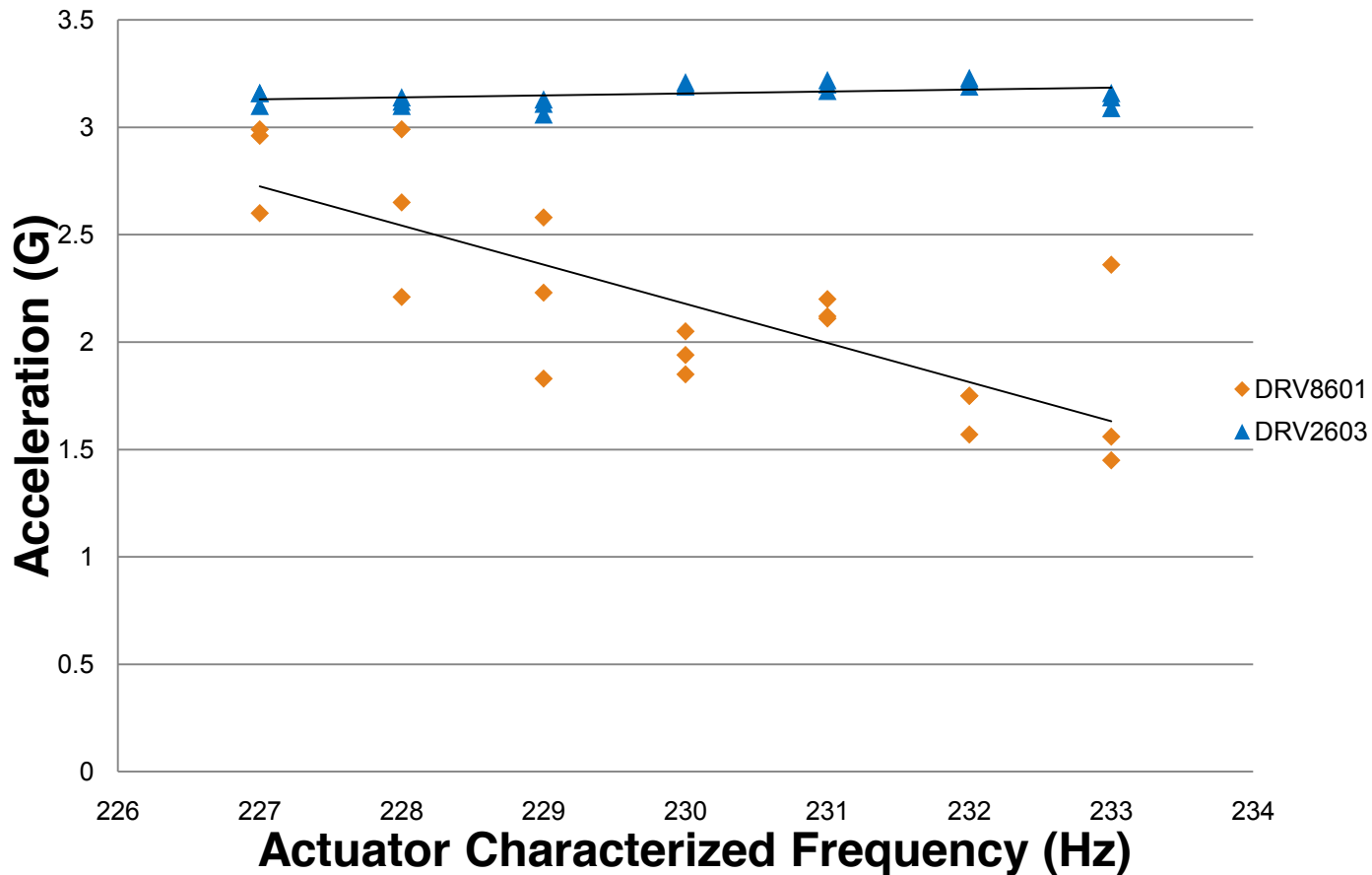
The LRA resonance frequency will change because of electrical, mechanical, and environmental factors. An LRA has a very narrow resonance so driving slightly off resonance can cause weak vibration strength.

## LRA Resonant Frequency Drift



# Auto-Resonance Provides Consistent Feel

The **orange dots** indicate the vibration strength when using a driver without auto-resonance, the **blue dots** show the vibration is more consistent when using auto-resonance.



# Audio-to-Haptics

Create haptics using audio for applications that do not natively support haptics

Use audio-to-haptics to enhance music and movies by adding bass vibrations

Audio Only



Audio + Haptic Vibrations



More realistic experience with haptic vibrations



# Embedded Waveform Library



The DRV2605 has 123 embedded waveforms (called TS2200C) that can be used without licensing fees. Simply send a trigger command to play waveform or use the included software API.

|  |   |  |
|--|---|--|
| 0 Strong Click                             | 42 Long Double Sharp Click Medium 3 - 60%           | 84 Transition Ramp Up Medium Smooth 2 - 0 to 100%  |
| 1 Med Strong Click 60%                     | 43 Long Double Sharp Tick 1 - 100%                  | 85 Transition Ramp Up Short Smooth 1 - 0 to 100%   |
| 2 Low Strong Click 30%                     | 44 Long Double Sharp Tick 2 - 80%                   | 86 Transition Ramp Up Short Smooth 2 - 0 to 100%   |
| 3 Sharp Click                              | 45 Long Double Sharp Tick 3 - 60%                   | 87 Transition Ramp Up Long Sharp 1 - 0 to 100%     |
| 4 Sharp Click 60%                          | 46 Buzz 1 - 100%                                    | 88 Transition Ramp Up Long Sharp 2 - 0 to 100%     |
| 5 Sharp Click 30%                          | 47 Buzz 2 - 80%                                     | 89 Transition Ramp Up Medium Sharp 1 - 0 to 100%   |
| 6 Soft Bump                                | 48 Buzz 3 - 60%                                     | 90 Transition Ramp Up Medium Sharp 2 - 0 to 100%   |
| 7 Med soft Bump 60%                        | 49 Buzz 4 - 40%                                     | 91 Transition Ramp Up Short Sharp 1 - 0 to 100%    |
| 8 Soft Bump 30%                            | 50 Buzz 5 - 20%                                     | 92 Transition Ramp Up Short Sharp 2 - 0 to 100%    |
| 9 Double-Click                             | 51 Pulsing Strong 1 - 100%                          | 93 Transition Ramp Down Long Smooth 1 - 50 to 0%   |
| 10 Double-click 60%                        | 52 Pulsing Strong 2 - 60%                           | 94 Transition Ramp Down Long Smooth 2 - 50 to 0%   |
| 11 Triple-Click                            | 53 Pulsing Medium 1 - 100%                          | 95 Transition Ramp Down Medium Smooth 1 - 50 to 0% |
| 12 Soft Fuzz                               | 54 Pulsing Medium 2 - 60%                           | 96 Transition Ramp Down Medium Smooth 2 - 50 to 0% |
| 13 Strong Buzz                             | 55 Pulsing Sharp 1 - 100%                           | 97 Transition Ramp Down Short Smooth 1 - 50 to 0%  |
| 14 [reserved]                              | 56 Pulsing Sharp 2 - 60%                            | 98 Transition Ramp Down Short Smooth 2 - 50 to 0%  |
| 15 [reserved]                              | 57 Transition Click 1 - 100%                        | 99 Transition Ramp Down Long Sharp 1 - 50 to 0%    |
| 16 Strong Click 1 - 100%                   | 58 Transition Click 2 - 80%                         | 100 Transition Ramp Down Long Sharp 2 - 50 to 0%   |
| 17 Strong Click 2 - 80%                    | 59 Transition Click 3 - 60%                         | 101 Transition Ramp Down Medium Sharp 1 - 50 to 0% |
| 18 Strong Click 3 - 60%                    | 60 Transition Click 4 - 40%                         | 102 Transition Ramp Down Medium Sharp 2 - 50 to 0% |
| 19 Strong Click 4 - 30%                    | 61 Transition Click 5 - 20%                         | 103 Transition Ramp Down Short Sharp 1 - 50 to 0%  |
| 20 Medium Click 1 - 100%                   | 62 Transition Click 6 - 10%                         | 104 Transition Ramp Down Short Sharp 2 - 50 to 0%  |
| 21 Medium Click 2 - 80%                    | 63 Transition Hum 1 - 100%                          | 105 Transition Ramp Up Long Smooth 1 - 0 to 50%    |
| 22 Medium Click 3 - 60%                    | 64 Transition Hum 2 - 80%                           | 106 Transition Ramp Up Long Smooth 2 - 0 to 50%    |
| 23 Sharp Tick 1 - 100%                     | 65 Transition Hum 3 - 60%                           | 107 Transition Ramp Up Medium Smooth 1 - 0 to 50%  |
| 24 Sharp Tick 2 - 80%                      | 66 Transition Hum 4 - 40%                           | 108 Transition Ramp Up Medium Smooth 2 - 0 to 50%  |
| 25 Sharp Tick 3 - 60%                      | 67 Transition Hum 5 - 20%                           | 109 Transition Ramp Up Short Smooth 1 - 0 to 50%   |
| 26 Short Double Click Strong 1 - 100%      | 68 Transition Hum 6 - 10%                           | 110 Transition Ramp Up Short Smooth 2 - 0 to 50%   |
| 27 Short Double Click Strong 2 - 80%       | 69 Transition Ramp Down Long Smooth 1 - 100 to 0%   | 111 Transition Ramp Up Long Sharp 1 - 0 to 50%     |
| 28 Short Double Click Strong 3 - 60%       | 70 Transition Ramp Down Long Smooth 2 - 100 to 0%   | 112 Transition Ramp Up Long Sharp 2 - 0 to 50%     |
| 29 Short Double Click Strong 4 - 30%       | 71 Transition Ramp Down Medium Smooth 1 - 100 to 0% | 113 Transition Ramp Up Medium Sharp 1 - 0 to 50%   |
| 30 Short Double Click Medium 1 - 100%      | 72 Transition Ramp Down Medium Smooth 2 - 100 to 0% | 114 Transition Ramp Up Medium Sharp 2 - 0 to 50%   |
| 31 Short Double Click Medium 2 - 80%       | 73 Transition Ramp Down Short Smooth 1 - 100 to 0%  | 115 Transition Ramp Up Short Sharp 1 - 0 to 50%    |
| 32 Short Double Click Medium 3 - 60%       | 74 Transition Ramp Down Short Smooth 2 - 100 to 0%  | 116 Transition Ramp Up Short Sharp 2 - 0 to 50%    |
| 33 Short Double Sharp Tick 1 - 100%        | 75 Transition Ramp Down Long Sharp 1 - 100 to 0%    |  |
| 34 Short Double Sharp Tick 2 - 80%         | 76 Transition Ramp Down Long Sharp 2 - 100 to 0%    |  |
| 35 Short Double Sharp Tick 3 - 60%         | 77 Transition Ramp Down Medium Sharp 1 - 100 to 0%  |  |
| 36 Long Double Sharp Click Strong 1 - 100% | 78 Transition Ramp Down Medium Sharp 2 - 100 to 0%  |  |
| 37 Long Double Sharp Click Strong 2 - 80%  | 79 Transition Ramp Down Short Sharp 1 - 100 to 0%   |  |
| 38 Long Double Sharp Click Strong 3 - 60%  | 80 Transition Ramp Down Short Sharp 2 - 100 to 0%   |  |
| 39 Long Double Sharp Click Strong 4 - 100% | 81 Transition Ramp Up Long Smooth 1 - 0 to 100%     |  |
| 40 Long Double Sharp Click Medium 1 - 100% | 82 Transition Ramp Up Long Smooth 2 - 0 to 100%     |  |
| 41 Long Double Sharp Click Medium 2 - 80%  | 83 Transition Ramp Up Medium Smooth 1 - 0 to 100%   |  |

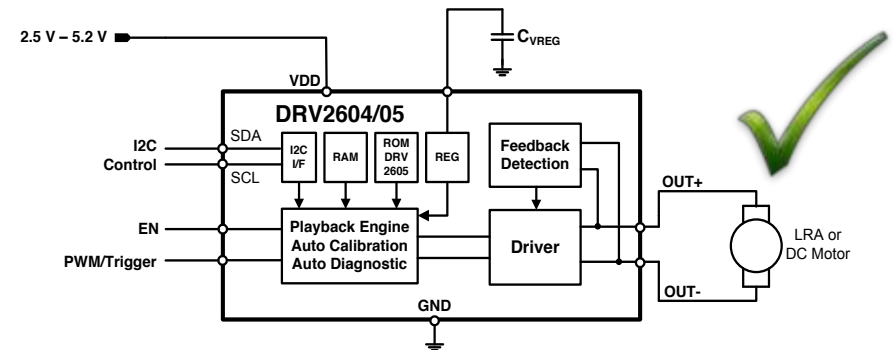
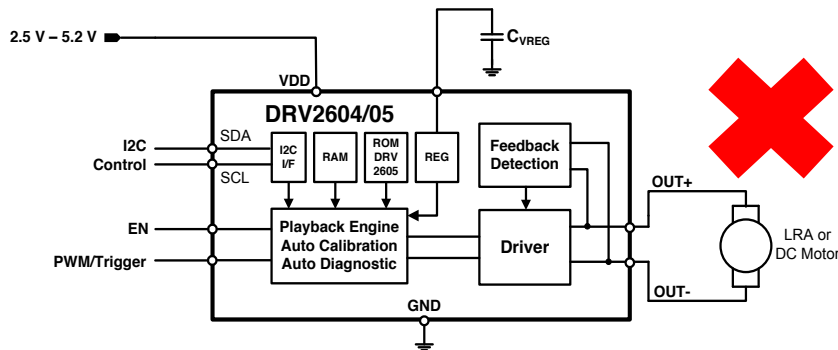
# Automatic Actuator Diagnostics



**Automatic Diagnostics** allow you to test the actuator through the DRV2605 in production.

## Detect if the actuator is:

- Not Connected
- Shorted or Over-Current is detected
- Generating poor back-EMF (this identifies a bad actuator)





# DRV8601

## Haptics Motor / Linear Vibrator Driver with Ultra-Fast Turn-On

### Features

- High Current Output of **400 mA** from 3V Supply
- 2.5 V - 5.5 V Operation
- Support for Loads as Low as 7W
- Input Frequency Range: 20 Hz - 30 kHz
- Only 3 External Components Needed
- Fast Turn-On Time of **100 us**
- Low Quiescent Current of **1.7 mA**
- Low Shutdown Current of **10 nA**
- Output Short Circuit Protection
- Thermal Overload Protection
- 2 mm x 2 mm MicroStar BGA package
- 3 mm x 3 mm QFN (DRB)

### Applications

- Mobile Phones
- Tablets
- Portable Navigation Devices
- Portable Gaming Consoles

### Availability



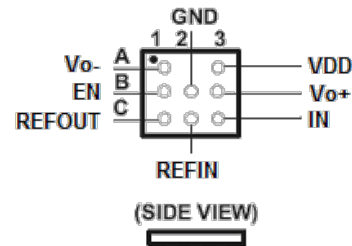
**Samples: Now**  
**EVM: Now**  
**Production: Now**

### Benefits

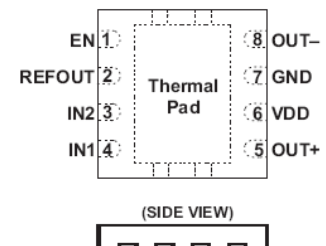
- Drives ERM and LRA Actuator types
- Direct Connection to Battery
- Drives both Motors (ERM) and Linear Vibrator (LRA)
- Wide Range of Input Frequencies
- Very Small Solution Size
- ~60x faster Haptic Feedback Response
- ~10x lower quiescent current for low power
- Low Shutdown Power Consumption
- Protection from Accidental Short Circuit
- Protection from Overheating
- Small Size, Saves Board Space

### Pin-out information

MicroStar Junior™ (ZQV) PACKAGE  
(TOP VIEW)

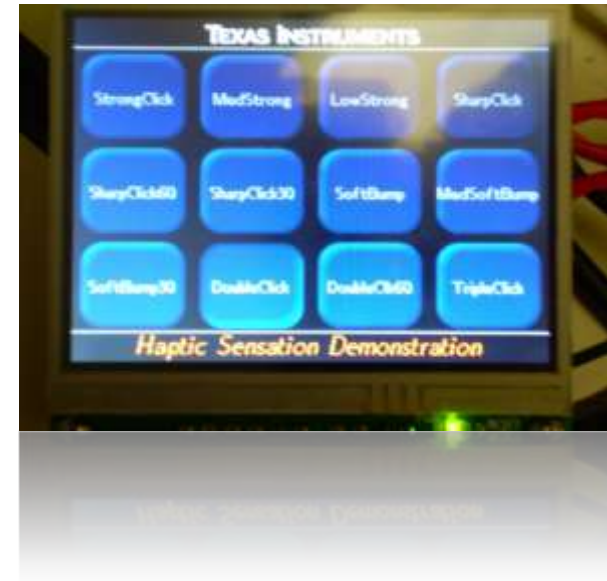


DRB Package  
(Top View)

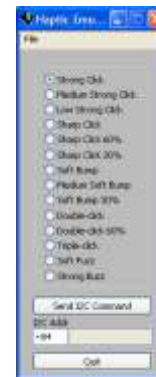


# DRV8601 Demo Boards

- ERM Haptics Demo using a Stellaris Touch Screen
- Uses MSP430 + DRV8601 to generate effects through I<sup>2</sup>C



- ERM Haptics Demo using a GUI
- Uses MSP430 + DRV8601 to generate effects from GUI



**Thanks**