Specifying Haptics in an Automotive RFQ

The user interface in an automobile is evolving away from mechanical buttons to digital input technologies such as touch screens, touch pads and button pads. As part of this evolution, manufacturers are realizing the need to incorporate haptics, or touch feedback, into their designs to create a more intuitive UI, lower visual demands, and increase the user’s confidence in the automotive system.

As a leading expert in the field of haptics, Immersion has identified achievable haptics feedback performance characteristics that auto manufacturers can include in request for quote (RFQ) documents that specify use of haptic technologies.

The key areas that auto manufacturers should pay close attention to when specifying an automotive system with haptics include the following:

- **Haptic surface definition**
- **System latency**
- **Steady state response**
- **Transient response**
- **Displacement, life & other considerations**

While there are many subjective qualities that are critical to the overall success of implementing haptics in an automotive user experience, the recommendations presented here focus on system specifications.

### Haptic Surface Definition

It is important to specify which elements in a particular application will be physically coupled to the haptic surface. This will ensure that the moving mass of the system is understood as part of the actuation selection. Below are some common configurations:

- **Touch Screen only**: Only the touch screen moves. The display, bezel and mechanical buttons are rigidly fixed to the vehicle.

- **Touch Screen and Buttons or Bezel**: The touch screen and some surrounding elements, such as flush bezel or capacitive buttons, are connected to the haptic touch screen. Other elements of the system, such as the display, are fixed.

- **Bonded Touch Screen**: In these cases the display is attached to the touch screen (including optical bonding) and the elements move together.
Steady-State Response

Steady-state haptic effects are commonly used in systems using ERM or piezo motors and can be employed to create longer effects or series of strong pulses. The steady-state response provides general information about the system. To specify the steady-state performance of a haptic system, the following three characteristics must be scoped:

Frequency Response Curve

The frequency response (strength vs. output frequency) curve defines the range of effects that the system must be able to create. Frequencies that generate at least 1G are useful for generating steady-state effects. A minimum of five data points should be specified to establish the curve. Frequencies should be selected to include the full range of desired effects.

- **Recommended Values**: Immersion recommends that the peak of the curve should measure at least 3 Gs. Specifying more than 6 Gs will generally add more cost to the system with little gain in haptic experience. The recommended full range of useful effects for automotive applications is 70 Hz to 250 Hz.

Rise Time

Rise time indicates how quickly the system responds to input. Rise time is measured from the start of the input signal until the first acceleration peak, positive or negative, which exceeds the desired percentage of peak performance. Immersion specifies rise time measurements for two levels relative to peak performance: 90% and 50%.

- **Recommended Values**: Immersion recommends that a 90% rise time should be achieved in 70 ms or less. A 50% rise time should be achieved in 20 ms or less.

Decay Ratio

The decay ratio specifies how quickly an actuator returns to its non-energized state. A high decay ratio will ensure that “clean” and “crisp” effects are possible; low decay ratios will lead to effects that feel “buzzy.” Note that it is preferable for a high decay ratio to be achieved actively, through braking, rather than passively through friction or dampening.

- **Recommended Values**: The decay ratio is expressed as a maximum or “not to exceed” value. For automotive applications, Immersion recommends a decay ratio of 0.40. A specified value that is higher than 0.65 will yield “buzzy” effects. Specifying a decay ratio lower than 0.30 is not recommended as it will add cost and decrease peak performance without offering any increase in perceived quality.
Transient Effect Response

Transient effects can be used to provide more dynamic and differentiated haptic feedback for large actuators, such as short, sharp “clicks” or rapid ramp effects indicating progress along a slider or radial dial. To specify the performance of a haptic system utilizing transient effects, manufacturers should specify the following three characteristics:

Magnitude of Dominant Acceleration Peak-to-Peak
The peak-to-peak (pp) magnitude of the dominant acceleration curve gives the maximum acceleration that can be generated on a vibrating surface. It is measured for the two largest consecutive peaks, one positive and one negative.

- **Recommended Values:** Immersion recommends 5 Gs for this parameter. Effects created by accelerations below 1G may not be distinguishable from other background vibrations. More than 5G may add unnecessary costs.

Frequency of Dominant Acceleration Peak
The frequency of the dominant acceleration peak will have significant impact on the user experience and the types of haptics technologies that can be used in a system.

- **Recommended Values:** Immersion recommends that manufacturers specify dominant peak frequency between 70 and 200 Hz, with a tolerance of ±15%. In touch applications, frequencies below 60 Hz and above 200 Hz are not effectively perceived as dominate frequencies.

**Transient Rise Time**
When used to characterize transient effects, rise time quantifies how quickly an actuator responds to an electrical signal.

- **Recommended Values:** Immersion recommends a rise time to the first dominant peak of no more than 40 ms.

**System Latency**

**Touch Confirmation**
Managing latency is critical to the overall success of an automotive haptic interface. High latency means users do not get confirmation as fast as they need it or they miss the haptics experience all together. On the other hand, requiring an exceptionally quick response can unnecessarily drive up costs without adding any value to the user experience.

- **Recommended Values:** For systems that use primarily confirmation interactions, 50 ms to 80 ms is acceptable. For systems with many sliders and list interactions, keeping the latency as close as possible to 50 ms is recommended. Immersion also recommends requesting a mapping of the expected communication loop from surface interaction to haptic response.

**Multi Modal Confirmation**
If the user will experience haptics in conjunction with simultaneous audio and visual cues, it is important to trigger haptics first to overcome inherent differences that influence human response to stimuli.

- **Recommended Values:** Audio feedback should follow haptic feedback.
Displacement, Life and other considerations

Displacement

Displacement of the touch surface is required to create vibration effects, but the movement should be minimized to avoid user distraction.

- **Recommended Values:** Immersion recommends a displacement specification of no more than 400 um.

Life

An actuator's useful life should be specified based on the number of touch events expected.

- **Recommended Values:** For a reasonable high-use case, Immersion recommends specifying a lifetime of 400,000 touch events, which allows for more than 100 touches per day every day for 10 years.

Audio

Haptic actuators are not perfectly quiet and generate some noise when excited.

- **Recommended Values:** Immersion recommends a noise limit of 60 dBA @ 40 cm measured when the haptics system is installed in the car.

Performance Variations

Several factors can cause variation in performance. The factors include temperature, voltage as well as possible variations in uniformity across the surface.

- **Recommended Values:** Immersion recommends that temperature and voltage each create no more than ±10% variation. The uniformity across a surface should vary no more than ±25%.

About Immersion

Founded in 1993, Immersion is the leading innovator in haptic technology; the company's touch feedback solutions deliver a more compelling sense of the digital world. Using Immersion's high-fidelity haptic systems, partners can transform user experiences with unique and customizable touch feedback effects; excite the senses in games, videos and music; restore "mechanical" feel by providing intuitive and unmistakable confirmation; improve safety by overcoming distractions while driving or performing a medical procedure; and expand usability when audio and visual feedback are ineffective.

Immersion's TouchSense technology provides haptics in mobile phone, automotive, gaming, medical and consumer electronics products from world-class companies. With over 1,300 issued or pending patents in the U.S. and other countries, Immersion helps bring the digital universe to life. Hear what we have to say at blog.immersion.com.

For additional information about tactile feedback, haptics, and the human response to specific haptic effects and performance parameters, contact Immersion at focus@immersion.com.

Many consumer studies and whitepapers are also available on Immersion web site. To access and download these documents, please visit http://www.immersion.com/whitepapers