Immersion®

TouchSense® Programmable Rotary Modules

A Flexible, Intelligent Design Solution

User experience is a key to a product's market success. Give users the right features—and streamlined, intuitive operation—and you've created a significant competitive advantage.

The challenge is finding the balance between functional richness and ease of use. And if you want to satisfy a broad range of uses and preferences, your challenge is even greater.

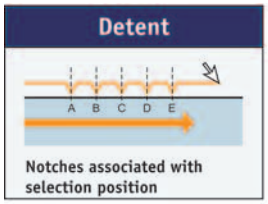
A winning user experience requires a design solution that supplies intuitive access to layers of functionality, or possibly even personalized features. The solution needs to consist of an elegant and ergonomic industrial design that meets space constraints.

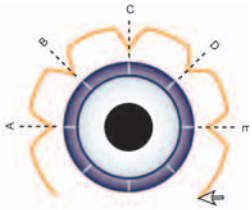
Immersion's TouchSense Programmable Rotary Modules enable a flexible, intelligent design solution for today's user interface—and an alternative to mechanical switches, encoders, and other types of electro-mechanical input devices.

TouchSense modules can be configured to supply users with touch feedback appropriate for the context of operation. With a wide selection of tactile or haptic effects—detents, barriers, vibrations, or other sensations—designers can leverage the under-used sense of touch. The multimodal combination of touch, sight, and sound in user controls can enhance productivity, ease of use, safety, ergonomics—and user satisfaction.

Programmable TouchSense rotary modules empower you to design the user interface with features not possible with traditional mechanical switches and encoders—context-sensitivity, precision control, and full-fidelity tactile feedback.

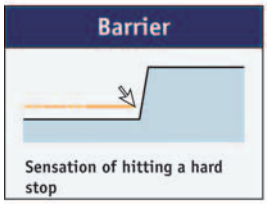
haptic effects library

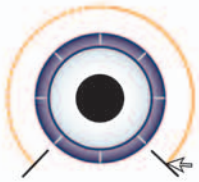




Detent – Notches associated with selection position

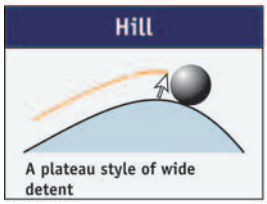
Used to mark fine or coarse increments or selections, detents can be customized in size, shape, and number to suit context-sensitive requirements.





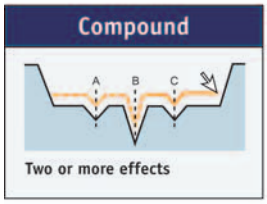
Barrier – Sensation of hitting a hard stop

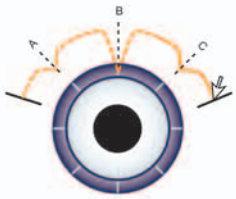
Barrier effects restrict the user's motion, and are useful for indicating first and last items, minimum and maximum, or the edge of an area. Range of rotation is programmable.



Hill – A plateau style of wide detent

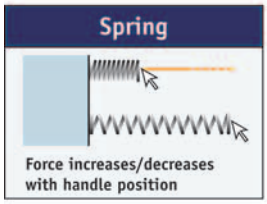
A hill effect could be used for menu wraparound, letting the user know they have moved from last to first menu item. A hill can also be used to indicate a return from a sub-menu back to the main menu or to signal the crossing of a boundary.

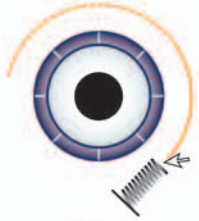




Compound – Two or more effects such as barriers and detents

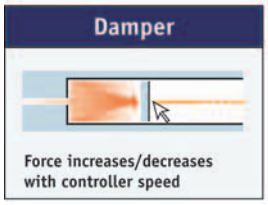
A compound effect, like small detents with a deeper center detent and barriers on both sides, would be appropriate for a balance control, for example. Compound effects help designers closely match tactile sensations to operational steps, which can enhance usability.





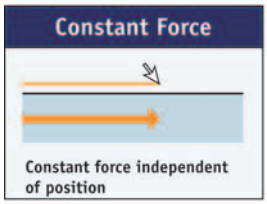
Spring – Force increases or decreases with handle position

A spring provides a good return-to-center or default position such as for a shuttle control used to regulate speed.



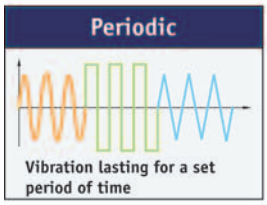
Damper – Force increases or decreases with controller speed

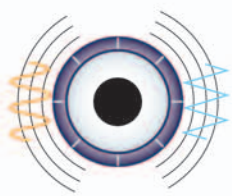
Damper effects create the sensation of drag or weight, and can be used to emulate the feel of high-quality controls such as those found on expensive audio equipment. A damper effect might also emulate a jog control used to move through video frames or data stacks.



Constant Force – Continuous force independent of position

Constant force can be used to simulate dynamics such as gravity, friction, or momentum.



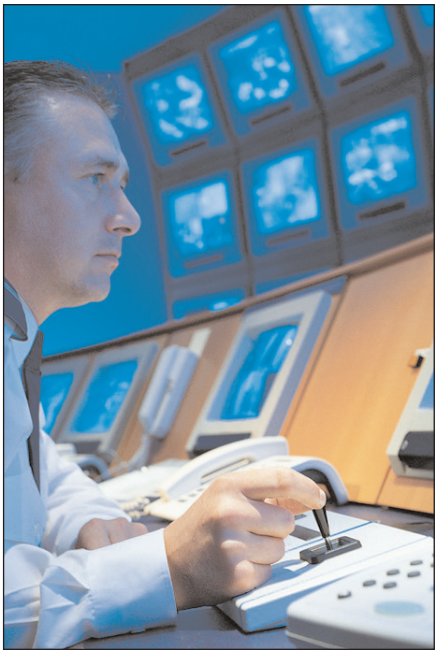


Periodic – Vibration lasting for a set period of time

A periodic of sine, square, or triangular waves can be triggered by an event to alert users to a specific situation or control position.

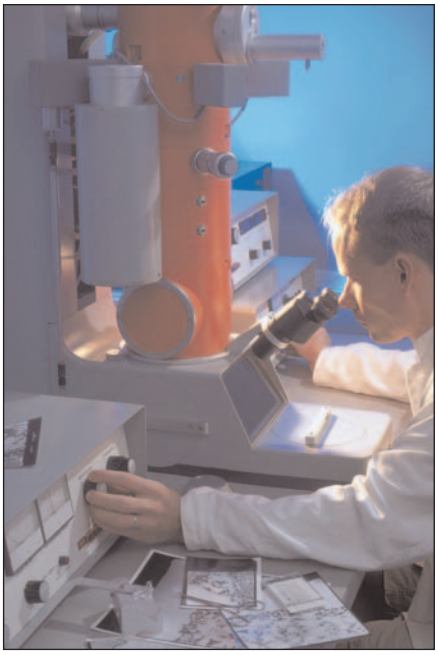
Note: Not all haptic effects are possible on all TouchSense modules.

real-world applications



Control Rooms
Noisy or distracting environments can limit user productivity or accuracy. Tactile feedback can offset distractions by providing unmistakable confirmation and warning signals.

Medical
TouchSense modules give users more control through their sense of touch, allowing visual attention to patients.



Test and Measurement
Where users need to be accurate, precise, or focused, touch feedback can help speed actions and facilitate user operations.

Automotive
Programmable rotary modules are used for driver primary controls as well as secondary controls such as climate, media, navigation, and other functions. Controls using programmable tactile feedback can reduce driver glance time. In addition to a potential safety improvement, touch contributes to the multimodal experience of higher perceived quality.

Audio/Video
TouchSense modules provide intuitive and precise control for more productive operation of complex controls. They can also help you reduce clutter and improve aesthetics by consolidating multiple controls into one.

Haptics and Your Sense of Touch

Haptics—the science of integrating touch into the human/machine interface—taps into a powerful sense not being fully utilized in the user interface today. In addition to sight and sound, touch provides several higher-order advantages for the user.

The sense of touch provides reflex-rate responses in milliseconds and allows precise control and discrimination. In addition, through haptics, users can innately verify engagement or completion and intuitively understand continuous monitoring and progress.

Touch feedback can be used to reduce visual strain, especially for exacting or prolonged tasks. A gentle resistance provided by a TouchSense module can make it easier to control motion and to identify discrete elements or boundaries.

Because understanding is instinctive, using touch can reduce cognitive loading and the need for focused attention. Because joining touch with sight and sound enlarges the multimodal experience, using touch can enhance even very simple tasks.

Programmability Gives You a Competitive Edge

Because they're programmable, TouchSense modules provide advantages in usability, design, and cost:

- **Context sensitivity** – relevant tactile cues help users instinctively navigate menus or operate equipment for improved safety, productivity, or enjoyment
- **Precise control** – coarse to fine scaling can be performed by one module and intuitively communicated to the user through unique tactile feedback cues
- **Expanded control options** – non-linear or dynamic haptic effects not possible with mechanical devices are easy to program
- **Design flexibility** – haptic effects can be quickly created and edited so final decisions can be made later in the design process
- **Upgradeability** – haptic effects for controls can be modified in the field
- **Brand reinforcement** – the unique feel of your controls can be consistently recreated
- **Personalization** – manufacturers may provide user options for feel or action of the control
- **Space saving** – controls can be consolidated to save space, minimize clutter, and improve aesthetics
- **Inventory simplification** – one TouchSense module can be implemented as many different controls including dials, scroll wheels, and levers
- **Fast and easy configuration** – an easy to use developer tool generates source code for embedding in your application

Context-sensitive Touch Feedback Enhances Usability

The same TouchSense module can be configured to act like a high-quality tuner knob, then a five-position selector switch, and later, a control that automatically returns to a center position. Tactile sensations such as detents, barriers, and pulses give users cues that make selecting, adjusting, and controlling a more intuitive process.

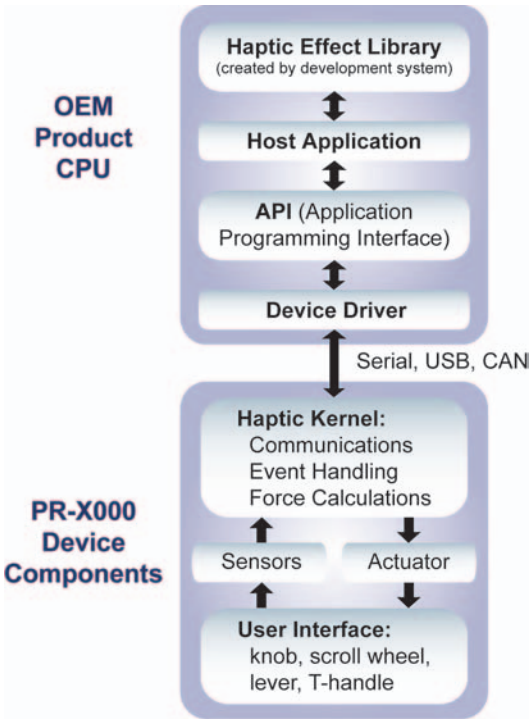
In combination with sight and sound, tactile feedback provides confirming response for a satisfying, congruent, multimodal experience. When users can also rely on their sense of touch, they perform tasks faster, more precisely, and with greater confidence. Moreover, tactile cues may reduce dependence on sight for some applications.

Unlike purely mechanical switches, encoders, and other control devices, TouchSense modules provide a two-way channel of communication. The modules supply a position input to the system and function as touch feedback output devices, (see Runtime System Architecture, at right). You can configure the modules to perform within the context of operation as the user would naturally expect for tasks such as:

- Adjusting parameters – low to high, magnitude, volume, brightness, speed, etc.
- Varying ratio settings – balance, fade, treble/bass
- Selecting discrete items – on/off, an item in a list of options
- Choosing nonlinear settings – arbitrary and changing parameters irregularly spaced along a scale
- Navigating a layered hierarchy – a menu tree
- Scrolling selections – long and short lists
- Making precision adjustments – fine or coarse gain

design flexibility

Runtime System Architecture



TouchSense modules use a position sensor, actuator, amplifier, microprocessor with firmware controls, and push-to-select (PTS) switch to provide precise and reliable response that won't degrade over time.

Haptic effect files created with Immersion Studio for Rotary software form the system's haptic effect library, which is embedded in the host ***Application*** or called by the ***Application*** from a separate file. Given position or selection information from the Rotary API, the Application updates the user interface, display screen, or device state, determines the need for control action, and requests those actions be communicated to the module by the Rotary API.

The ***Rotary API***, software that manages haptic effects, runs under the host system's application, typically on the same CPU. The ***API*** receives event notifications from the rotary module's kernel through device drivers, notifies the host application of these events, and receives instructions from the application to send back to the kernel.

The ***Kernel*** initiates haptic effects and scenes and executes them by sending control signals to the module's ***Actuator***. The ***Sensor***, such as an optical encoder, determines the module's rotary position and sends the information back through the kernel to the API, which sends them on to the host ***Application***.

Actuators Make The Difference

With the family of TouchSense modules, you can satisfy applications needing small size, low cost, and low power, as well as applications with the most demanding performance requirements, including strong forces and wide ranges of motion.

Three TouchSense models—PR-1000, PR-3000, and PR-5000—provide a range of design choices. All modules can be configured for dial, scroll wheel, thumb wheel, lever, or T-handle devices, and all can include a push-to-select function. In addition, common standard communications protocols—RS-232, USB, CAN, and TTL serial—can be supported.

Each model contains different actuator technology and varies in torque, size, power consumption, cost, in the haptic effects it produces, and in the characteristics of those effects, (see also Specifications, back page).

TouchSense Rotary Module Comparison

	PR-1000	PR-3000	PR-5000
Detent	•	•	•
Barrier	•	•	•
Hill	•	•	•
Constant force	•	•	•
Spring		•	•
Damper		•	•
Periodics		•	•
Pulses		•	•

Haptic effects and their specific characteristics vary according to actuator technology.

Standard and Custom Models Provide Design Flexibility

A comparison of module performance can best be understood by considering how their actuators are applied to create different events:

Braking Actuator – PR-1000

PR-1000 modules use braking actuators that dissipate energy and resist user motion. A braking-based system would play a steeply sided detent with a sharp peak (a saw-tooth or triangular shape) by applying the brake with increasing force. As the user turns the module's shaft into the downward portion of the effect, the braking actuator lets go, applying zero force, which gives the sensation of falling into the detent.

The PR-1000 plays a barrier by applying the brake, which sharply stops any further rotation in that direction.

A standard component that comes ready to install, the PR-1000 has the lowest power requirement and the smallest size of any in the family, yet it's still powerful enough to render stiff width-adjustable barriers and satisfying detents. In fact, its higher torque enables stiffer barriers than the PR-3000.

haptic effect design

The PR-1000 can be easily integrated into a wide variety of control panels and systems (see PR-1000 Overall Dimensions, back page), and connects to system electronics through a four-pin connector (power, ground, and two signal wires). The shaft uses industry-standard dimensions to accept most commercial dials, knobs, and levers.

Motor Actuator – PR-3000

PR-3000 modules use motor actuators to apply a force to either oppose or reinforce user motions. A motor-based actuator system plays a triangular shaped detent by pushing against the direction of the user's motion until the top of the triangle is reached. If the user continues to exert force to enter the detent, just after the peak position, the PR-3000 begins to push in the same direction as the user's motion, which supplies a very smooth action.

PR-3000 modules play barriers by exerting increasing opposing force as the user continues to rotate the control into the barrier. Motor actuators alone can't produce barriers as stiff as a braking actuator.

The PR-3000 module is a custom product configured to customer specifications. In addition to detents, barriers, hills, and dampers, it can produce more sophisticated dynamic effects such as springs and time-based periodics.

Hybrid Actuator – PR-5000

PR-5000 modules include both braking and motor actuators to produce a very wide range of effects. The PR-5000 plays detent effects in the same way as the PR-3000 and barrier events in the same way as the PR-1000.

Like the PR-3000, the PR-5000 is also a custom product designed to customer specifications. It produces dynamic effects such as springs, periodics, and detents—and its barriers are extremely stiff, more so than the PR-3000.

Immersion Studio® For Rotary Designs Haptic Effects

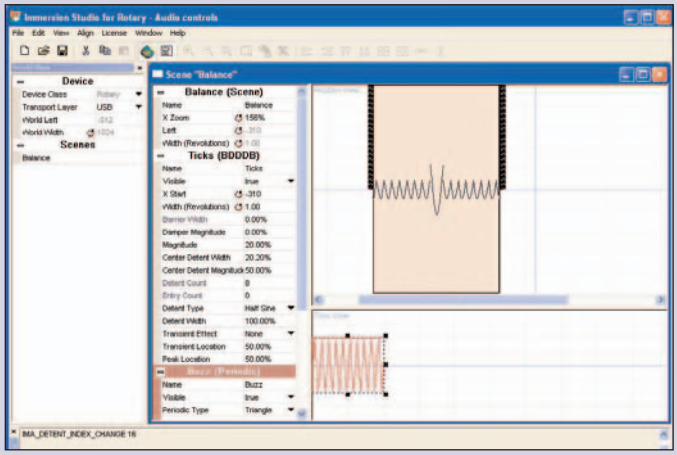
The Windows (2000/XP) compatible Immersion Studio for Rotary application provides a graphic drag-and-drop environment for designing and testing haptic effects for all TouchSense modules. With good haptic design principles built-in, the software makes creating haptic effects fast and easy.

Immersion Studio for Rotary software lets designers focus on the haptic experience and how it should fit into the user interface—not on low-level programming. Even non-technical designers can use the software to precisely design appropriate, engaging effects.

The system uses a what-you-see-is-what-you-feel approach where users view and edit a graphic representation of the haptic effect. Detent parameters such as magnitude, width, and shape are modified with drag-and-drop ease or pull-down menus. Effects can be combined just by placing their graphics side-by-side. A haptics library of simple and compound effects can be built from the application's pre-programmed effects.

Haptic scenes, which are a collection of effects that play together (corresponding to the functions on a single display screen, for example), can be assembled, experienced, and saved. As users play the effect on the developer kit's demonstration unit, a cursor moves across the graphic; Designers immediately feel the haptic sensations and can identify areas for possible improvement.

Immersion Studio for Rotary software creates both position-based and time-based effects. Position-based effects play within a scene as the module's shaft moves to a particular rotational position or as a function of velocity. If, for example, the scene requires that five detents play, the user can feel those position-based detents repeatedly by rotating the control until a selection is made.



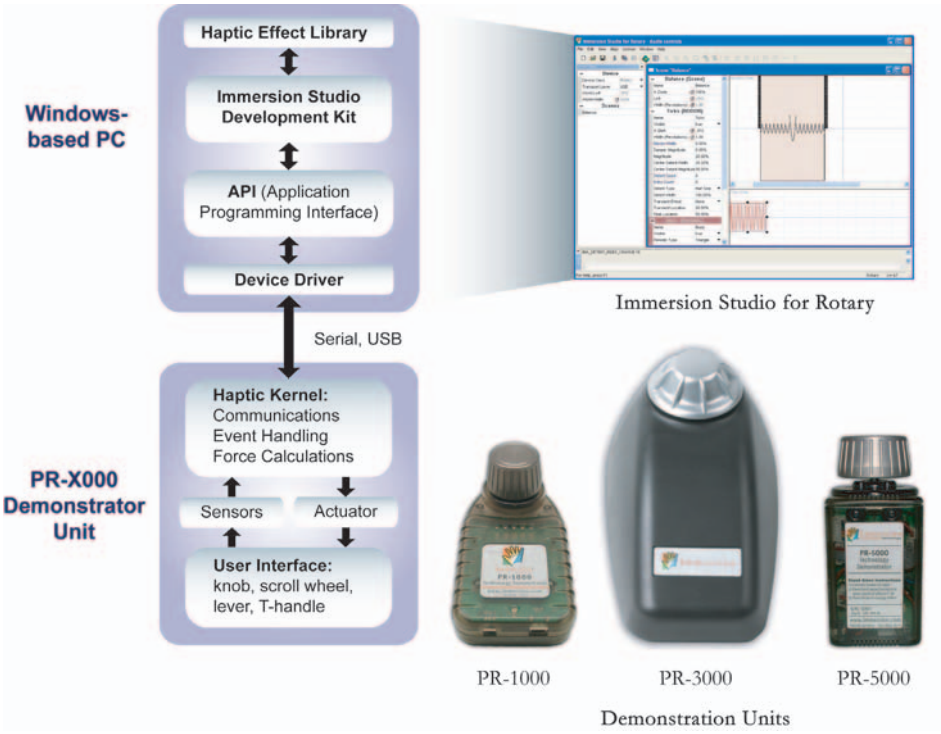
Immersion Studio for Rotary software provides an easy-to-use graphical user interface for creating haptic effects. When triggered, a time-based effect (periodic) shown in the bottom frame will play for a set period of time. A position-based event, such as the one shown in the top frame, will play as the user rotates the rotary module. The scene property window on the left allows designers to change all haptic parameters including amplitude, start position, width, duration, and shape.

Time-based effects—a periodic (vibration), pulse, or a constant force—start and stop at a set period of time within a scene. A time-based scene might play a two-second vibration when the user turns past a preset limit.

When effect or scene design is complete, Immersion Studio for Rotary software can automatically generate C++ code for embedding in host system software. This code interfaces with the Immersion Rotary API within the host system, which takes requested control action from the host software and sends signals to the module through a device driver.

easy integration

Development System Architecture



Similar to the Runtime System Architecture, haptic effects created by Immersion Studio for Rotary software are sent by the Rotary API through the device driver to the demonstration unit so designers can immediately experience their haptic creations.

Developer Kits Supply Everything You Need

Developer kits support easy design and integration of TouchSense modules into your system. There's a developer kit specific to each module, and all developer kits contain:

- A license to use Immersion Studio for Rotary, the Rotary API, and device drivers
- A serial or USB hardware demonstration unit to experience haptic effects
- A demo program with source code
- Complete documentation

The PR-1000 developer kit also contains TouchSense programmable rotary modules, an RS-232 and USB interface board, and cables necessary for prototyping purposes.

In addition, Immersion can provide customized training and support for product design, integration, and application development.

A Long History with Haptics

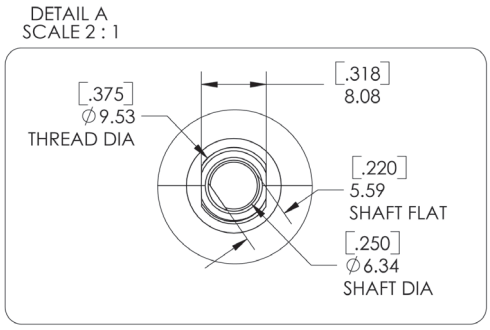
Since 1993, Immersion has been the world's leading provider of touch feedback products and technology. We sell 3D simulation and interaction products to research facilities, and medical training simulators to schools and healthcare organizations. These products provide an immersive virtual reality experience, complete with realistic tactile feedback.

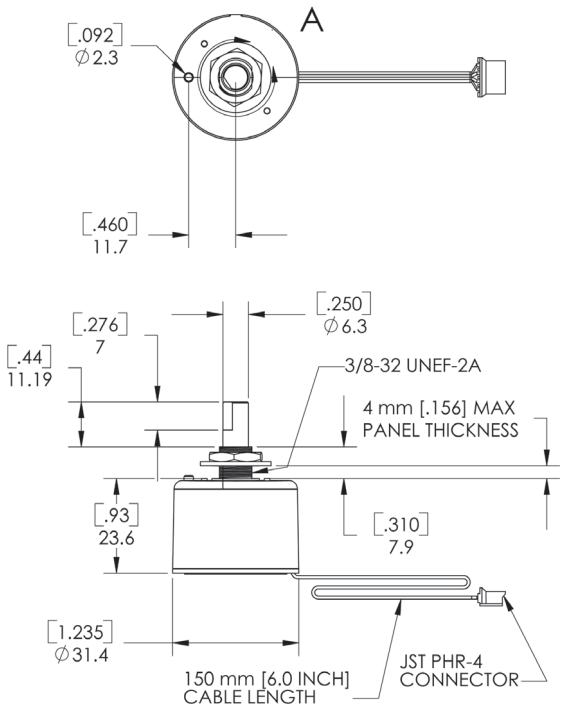
Through partner relationships, our haptic technology has been widely installed in computer and console gaming products and in automotive controls. We have a long history of supporting developers and OEMs in producing successful haptics-enabled products for a wide range of industries. TouchSense Programmable Rotary Modules signify another way haptic solutions can enhance products for broad market appeal.

Our innovative product solutions are based on an extensive intellectual property portfolio that includes over 240 U.S. and international patents and an additional 280 patents pending. Our technology portfolio covers a full range of innovations for enabling haptic feedback across a variety of applications. Today, Immersion is truly the technology leader in haptics—and the expert in the design and control of haptic effects for user interfaces.

PR-1000 Overall Dimensions

mm [inches]





Specifications

The configurable nature of the PR-3000 and PR-5000 mean that the specifications below represent one suggested scenario which could be optimized for your application; PR-3000 and PR-5000 module capabilities are specified by the customer.

Parameter	Unit of Measure Metric (English)	PR-1000	PR-3000	PR-5000
Type of Actuator				
Type of Actuator		brake	motor	brake + motor
Torque				
Maximum Peak Torque (room temperature)	mNm (oz-in)	100 (14.16)	65 (9.20)	120 (17.00)
Maximum Frictional Torque	mNm (oz-in)	7 (1.0)	3–7 (0.42–1.0)	7 (1.0)
Electrical and Communications				
DC Supply Voltage	V	5	12 – 16	12 – 16
Max System Current	A	0.5	2.25 (at 12V)	1.50 (at 12V)
Max Power Consumption	W	2.5	27	18
Standby Current	mA	50	50	50
Bus Interface		5V UART[1]	USB[2] RS-232 CAN	USB[2] RS-232 CAN
Dimensions				
Module Diameter (behind panel)	mm (in)	32 (1.260)	60 max (2.362 max)	60 (2.362)
Module Length (behind panel)	mm (in)	24 (.945)	70 (2.756)	80 (3.359)
Shaft Diameter	mm (in)	6.35 (.250)	as required	as required
Shaft Length	mm (in)	11 (.433)	as required	as required
Mounting Information				
Package Style	—	panel mount (refer to drawing)	custom face mount	custom face mount
Push-To-Select (PTS) Switch				
Push-To-Select (PTS) Switch	—	yes	yes	yes
PTS Switch Force	gf (oz)	500 – 750 (17.6 – 26.5)	900 (31.7)	900 (31.7)
PTS Switch Displacement	mm (in)	0.25 – 0.50 (.010 – .020)	1.2 (.047)	1.2 (.047)

[1]Native TTL serial support in the PR-1000; other bus architectures (CAN, USB, RS-232, etc.) support through interface adapter hardware.

[2]External power required.

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