

Proximity Sensing White Paper



# New Possibilities for Freescale Proximity Touch Sensors

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## Overview

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### You can touch, but don't push

Pushbuttons are everywhere. Your laptop computer is covered with buttons. So are your phone and your car and your TV remote control. Many of us spend a great deal of our working lives pushing buttons. If you're not madly banging away on your computer keyboard, you're pushing buttons on your mouse to click simulated buttons on your screen. We've actually started using buttons that aren't really buttons (at least not pushbuttons), and therein lies one of the great advantages of creating buttons using proximity touch sensors.

### That's it ... no moving parts

With proximity touch sensors, there is literally nothing to push. They're touchbuttons, not pushbuttons. Proximity touch sensors have no moving parts ... anywhere. No springs, no clicks, no tops to pop off. What's more, they can fit in very tight spaces. Nothing sticks out, so developers can mount them flush to the contours of their designs.

Proximity touch control can be an especially attractive alternative for small or simple interfaces that require just one or two buttons. They can be easily integrated into the final product design with minimum fuss and can provide long-term advantages in power consumption and product life span. However, before we highlight a few such applications, let's discuss the technical merits of the kind of sensor that can enable these kinds of advantages—the very small Freescale MPR03x (MPR031 and MPR032) proximity capacitive touch sensor controllers.

### Touch control to Major Tom

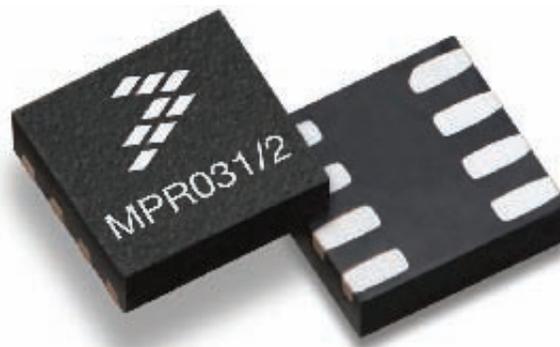
What was once commonly referred to as “space-age technology,” those products and applications considered to be “out of this world” now occupy every corner of our homes, our offices, our cars and even our coffee shops. What's more, a new generation of products are offering greater functionality while at the same time getting smaller and simpler. The MPR03x capacitive touch sensor controllers are designed to provide a human-machine interface for such products.

### A closer look at MPR03x sensors

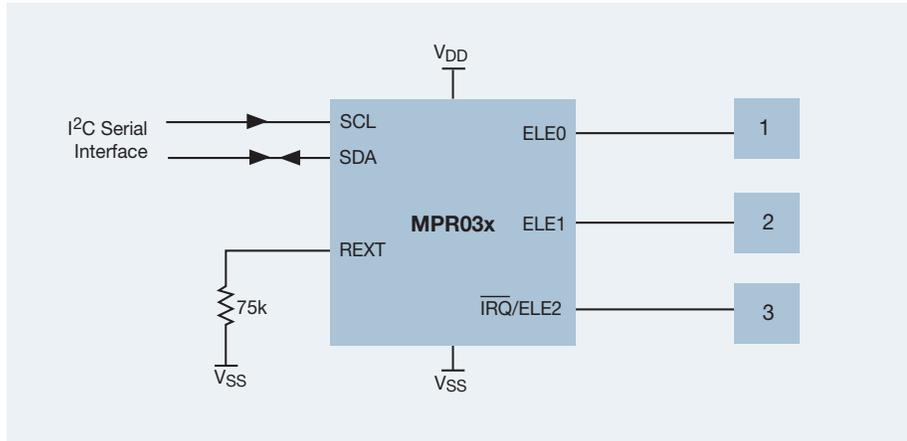
The MPR03x devices are optimized to manage two electrodes with interrupt (IRQ) functionality or three electrodes with IRQ disabled. This can accommodate a wide range of implementations due to increased sensitivity and a specialized feature set.

#### Specifications:

- Typical operating supply voltage is 1.8V with average supply current in run mode influenced by the sample period. For instance, average supply current in run mode at 8 ms sample period is an ultra-low 8  $\mu$ A typical. At 64 ms sample period it's 4  $\mu$ A typical. These low current rates enable very long life for even the smallest coin cell batteries.
- Its super small size, 2 x 2 x .65 mm in a dual flat no-lead (DFN) 8-pin package, gives designers a great deal of flexibility in board strategies, enabling some very compact designs for applications that are particularly space constrained, such as key fobs and watches.
- The MPR03x proximity capacitive touch sensor controller requires only one external passive component, a 75 k $\Omega$  resistor from the REXT pin to ground.



## MPR03x Recommended System Connections



### Schematic connections:

- The MPR03x sensors manage up to three touch pad electrodes, with an optional interrupt output available to advise the host of electrode status changes. It's multiplexed with the third electrode output, so using the interrupt output reduces the number of electrode inputs to two. The MPR03x sensors also include three levels of input signal filtering to detect pad input condition changes due to touch without any processing by the application.
- Each MPR03x sensor operates as a slave that sends and receives data through an I<sup>2</sup>C 2-wire interface at data rates up to 400 kbps. The interface uses a serial data line (SDA) and a serial clock line (SCL) to achieve bidirectional communication between master(s) and slave(s). A master (typically a microcontroller) initiates all data transfers to and from the MPR03x sensor, and it generates the SCL clock that synchronizes the data transfer.

## Configuration

The MPR03x proximity capacitive touch sensor controllers have three levels of filtering. The first and second level filters allow the application to condition the signal for undesired input variation. The first filters high-frequency noise while the second filters low-frequency noise. The third level filter can be configured to reject touch stimulus and be used as a baseline for touch detection.

Furthermore, separate touch and release trip thresholds for each electrode result in a great deal of electrode independence. These thresholds also provide system hysteresis, meaning the state of the system does not rely on any particular system input. Specifically, the hysteresis provides a separate touch and release threshold. Thus, a user can configure that the touch and release occur at different values, preventing jitter across a threshold. The touch threshold is only active as the capacitance increases and the release threshold is activated as the capacitance decreases back to the baseline.

A unique feature of the MPR03x devices is that they have a settable capacitance range, which allows for a wide variety of applications to be covered by a single device. Since capacitance measurement is based on a sum of the charge supplied model, the only factor that affects the capacitance range is the total charge supplied. In this case, charge supplied is a combination of the charge rate (fixed current supply) and charge time. The current can be set from 1  $\mu$ A to 64  $\mu$ A, and the charge time can be set between 500 ns and 32  $\mu$ s. This results in a capacitance measurement range of 0.5 nF to 2000 nF, which is wide enough to cover door-sized electrodes to finger-tip buttons with the change of just two parameters.

The MPR03x family represents solutions that are essentially two devices in the same system. This means that two parts can be used on the same I<sup>2</sup>C bus, resulting in the ability to deploy more electrodes in the same system. Exploiting this flexibility, the MPR03x devices can be configured to gain the most functionality or energy efficiency, depending on the application's system priorities.

## MPR03x Family in Application

The MPR03x family of capacitive touch sensor controllers opens up a new range of opportunities for touch control where it may not have been possible in the past. Generally, these kinds of applications exhibit one or more of the following characteristics:

1. **Very small size, often hand-held**
2. **Exceptionally long battery life**
3. **Extremely simple electronics**

Below are several examples of these applications, with reference numbers (1, 2 and/or 3 as represented in the above list) that correspond with specific design priorities.

- **Bluetooth headset** – Bluetooth headsets are getting smaller, with restrictions on button size and location. Using touch buttons can make design easier and allow for one or two simple multifunction buttons to control power, device pairing and volume control. For devices with more space this can be done with two buttons for additional ease of use. The size restriction and small battery make this an ideal application for a 2 x 2 mm low power sensor controller. **(1, 2)**
- **Table lamp** – Table lamps using simple metal contact switches with touch enabled functionality have been available for years. However, by switching to capacitance sensing much more precise control can be enabled, including dimming, off/on control or even home automation intelligence. Using a smarter sensor will create simple and intuitive interfaces for many devices in the modern home. **(3)**
- **Bottled water server** – Instead of fiddling with the plastic faucet handles on a standard bottled water dispenser, a capacitive touch sensor can enable a one-touch design to deliver water with less fuss. For instance, the MPR03x family can control a touch button each for cold and hot water. **(3)**
- **Key fob** – Remote keyless entry (RKE) has three important design considerations: extreme low-power consumption, small size and ease of use. A small, 2 x 2 mm capacitive touch sensor addresses all three issues and also enables the designer to better integrated lock, unlock, trunk latch release and emergency alarm functionality into the final key fob design. **(1, 2)**
- **Pen with laser pointer and LED** – The MPR03x family is small enough to be integrated into a pen-sized application to add multifunction capabilities on a low-energy battery-powered budget. A single on/off touch button can be used to activate an LED for low light environments or a laser pointer for presentations and such, without compromising the pen's slim design. **(1, 2, 3)**
- **Watch or alarm clock** – A small 2 x 2 mm capacitive sensor is ideal for supporting multi-functional touch buttons on a wristwatch's extremely limited surface area. The sensor's low-power characteristics also extend the application's battery life. The same sensor can also facilitate multi-functional touch buttons on an alarm clock, where space is not as critical, but low cost and power consumption remain high-priority issues. **(1, 2)**
- **Multimedia keys on a computer** – Laptop computers have many extra buttons to enable functions from wireless cards and presentation modes to volume controls and hardware-based DVD players. Simple touch buttons can be used to simplify the mechanical design and give computers a slick modern look. **(3)**
- **Thermostat** – Smart thermostats are increasingly used for more efficient climate control. Capacitive touch sensors facilitate a more energy-efficient and easy-to-use thermostat design, replacing mechanical pushbuttons with touch pads for time, temperature and menu select in a more elegant compact design. **(1, 3)**
- **Light dimmer** – Capacitive touch sensing can replace the “push to turn on” and “push again to turn off” dimmer switches that have the maddening tendency to break. A single 2 x 2 mm capacitive sensor can support two touch pads, one can be used to dim down, one to dim up and both to toggle the light ... with no moving parts. **(3)**
- **DVD drive** – This is a very simple application where the small size and low-power characteristics of the capacitive touch sensor can allow designers to incorporate a single, robust touch button to open or close the disk tray. **(2, 3)**
- **Webcam** – Most webcams are simple, compact and inexpensive, whether used for frame capture or video streaming. A small, low-power capacitive touch sensor can be integrated with the webcam as a single start/stop button to reduce complexity, improve reliability and keep development costs and sales prices down. **(2)**

- **Airplane seats** – Touch buttons are particularly effective in such high traffic, high abuse environments as commercial airplane seats. Economical and reliable, capacitive sensors and drive buttons for audio and video channel and volume control. Since there are no moving parts, the maintenance normally required for extended periods of use can be minimized. **(1, 2, 3)**
- **Coffee maker** – For an application that is used every day, non-mechanical touch buttons provide reliable service for the life of the appliance. A single 2 x 2 mm sensor can simplify design and improve ease-of-use by controlling just two buttons, one on/off and the other to switch modes. **(3)**

## Conclusion

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Using touch sensor controllers with the small size and flexible capabilities of the MPR03x family, product designers can integrate touch buttons almost anywhere they please. The results will be more efficient, more robust designs with multi-functional capabilities—even for very small or very simple applications.

For more information on Freescale’s MPR03x family of ultra-small proximity capacitive touch sensor controllers, please visit [www.freescale.com/proximity](http://www.freescale.com/proximity).



The KITMPR03xEVM helps you design touch sense technology into a variety of applications.

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