

Lumissil's 3rd Generation of Automotive Touch Keys



Improved water and noise immunity makes it ideal for automotive applications

Capacitive sensing is a technology that allows touch-sensitive surfaces to detect the presence and location of a person's finger or other conductive object without the need for physical pressure. Capacitive sensing is used as buttons (referred to as touch key), proximity sensing, liquid or powder presence, level detection and chemical analysis such as a blood glucose monitor. In this article we will focus on automotive uses.

Capacitive sensing as a touch key is the most common use case. You see them everywhere in appliances and consumer electronics. They started showing up in cars more than 15 years ago to some mixed reviews. For example, in Oct of 2022 VW announced they will remove touch key buttons from their steering wheels due to poor reviews and complaints from customers. Mainly the complaints are that the buttons can accidentally be triggered when the driver's hand or forearm move across the buttons such as when turning the wheel or changing hand positions. On the other hand there are examples of well-liked implementation using touch keys. One example is starting with the 2013 Toyota Avalon using touch keys for the center console



Figure 1 Touch Keys

buttons for radio and environmental controls. Cars.com claims it's the best execution to date for capacitive touch buttons in a vehicle. They respond well, stable, repeatable and in an area that will not get an accidental touch like the steering wheel.

Capacitive sensing works by measuring changes in electrical capacitance of an electrode (metal pad). The change in capacitance is caused by a human body that naturally holds a charge and it will change the circuit's capacitance. When the finger touches the button, or even comes near, it disturbs the electrical field, which causes a reaction to the sensor's electronics. This disturbance is then converted into a signal that can be used to determine if a finger is touching the button.

There are many advantages and benefits to using touch keys:

- **Reliability:** Capacitive touch buttons are typically more reliable than mechanical buttons since they have no moving parts to wear out or break. This makes them ideal for applications where frequent use or exposure to harsh environments may cause mechanical buttons to fail.
- **Durability:** Capacitive touch buttons are often made from materials that are more durable than those used in mechanical buttons, such as glass or metal. This makes them resistant to scratches, abrasions, and other types of damage.
- **Sensitivity:** Capacitive touch buttons are highly sensitive and can detect even the slightest touch or change in capacitance.
- **Customization:** Capacitive touch buttons can be easily customized to suit a wide range of applications. They can be designed to include specific shapes, sizes, colors, and even lighting

effects, making them ideal for use in consumer electronics products, such as smartphones and tablets.

- Easy to clean: Capacitive touch buttons are easy to clean since they have no gaps or crevices where dirt and debris can accumulate. This makes them ideal for use in healthcare and other industries where hygiene is a top priority.

However, there are some disadvantages compared to mechanical switches that must be considered during design time.

- False triggers: Capacitive touch buttons can sometimes be triggered unintentionally by nearby objects, such as a user's hand or a metal object, which can lead to false inputs or errors. Therefore, consider the application environment before deciding to use touch keys.
- Power consumption: Capacitive touch buttons require a small amount of power to operate, which can be a concern for battery-powered devices where power consumption is critical. Lumissil has overcome this problem with the 3rd generation of touch keys that allow the MCU to sleep but still monitor the touch key. Sleep currents as low as 5µA
- Environmental factors: Capacitive touch buttons can be affected by environmental factors such as temperature, humidity, and electromagnetic interference (EMI), which can impact their accuracy and reliability. All of these can be overcome with design tricks. Please work with our application engineers to tailor the touch key to your application.

The future is bright for automotive capacitive touch keys. Ideal applications include front and rear reading light activation, mirror adjustment buttons, exterior work lights on tailgates, center console buttons, and seat adjustment buttons to name just a few.

There are other uses for capacitive sensing in automotive too, not just buttons. It can be used in the steering wheel to detect hands on wheels for driver attention. It is also used in door handles to activate the key fob system and unlock the door. Capacitive sensing can also be used for proximity detection up to about 10 mm. Proximity sensing can be used for basic gestures such as swiping up or down to control things like volume of the stereo or brightness of a lamp. It could be used to replace the light switch on reading lamps to solve the problem of feeling around for the switch in a very

dark environment. It can also be used for foot activation of rear cargo door. These other uses will be further explored in a future newsletter.

Lumissil is on its third generation of touch key technology. This latest technology is more robust than previous generations and allows for significantly lower power draw when just monitoring the keys. It is resilient to water droplets, less sensitive to EMC and faster to react.

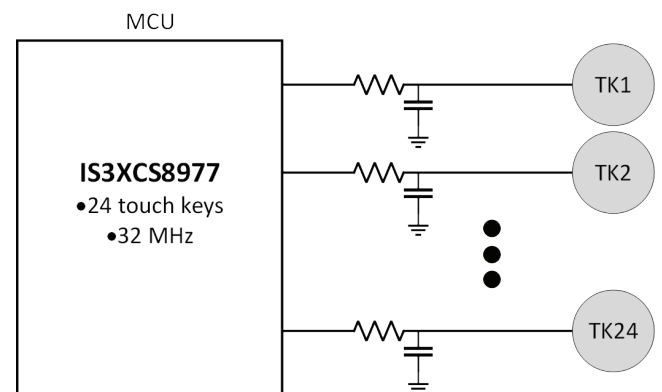


Figure 2 Typical touch key circuit using Lumissil's 3rd generation technology.

Figure 2 shows a typical circuit of the 3rd generation touch key. It is shown connected to the IS3XCS8977 [consumer or automotive grade] MCU.

Lumissil's newest touch key technology is based on differential dual slope operations. A dual-slope capacitance-to-digital converter (CDC) is a type of analog-to-digital converter (ADC) that uses a capacitor to convert an analog voltage into a digital signal. The CDC works by charging and discharging a capacitor for a fixed period of time, and then measuring the amount of time it takes for the capacitor to discharge through a known resistance.

To implement a dual-slope CDC, a capacitor is first charged with a known reference voltage. The charged capacitor is connected to the touch key and allowed to discharge through a fixed resistance. The amount of time it takes for the capacitor to discharge through the resistance is proportional to the capacitance value. This discharge time is measured using a digital counter, which is clocked by a precision oscillator.

The CDC works in two phases: the integration phase and the measurement phase. In the integration phase, the capacitor is charged to a known voltage. The integration time is fixed and is determined by an external clock. At the end of the integration phase, the input voltage is

disconnected, and the capacitor is allowed to discharge through a known resistor, R. The discharge time, t, is measured using a digital counter that counts the number of clock cycles during the discharge time. The count value is then proportional to the touch key capacitance.

The dual-slope technique offers several advantages over other ADC techniques, including good linearity, low sensitivity to noise and interference, and low power consumption.

Improved water immunity of the 3rd generation touch key is achieved by placing an active shield around the touch key that will offset the added capacitance caused

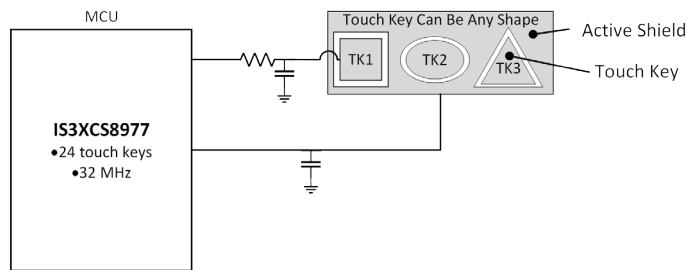


Figure 3 Touch key with active shield for water and noise immunity

LUMISSIL TOUCH CONTROLLERS

Part	Touch Keys	Proximity Sensing	Melody Generator	Package	Size, mm
IS3XSE5117	16	Yes	Yes	QFN-24	4 x 4
IS3XSE5118	8	Yes	Yes	TSSOP-16	6.4 x 5
IS3XSE5120	24	No	No	QFN-32	5 x 5

by the presence of water. When water droplets are present, the capacitance change seen on the key is the same as on the shield, so the net difference is still 0. See Figure 3.

The IS3XCS8977 is a general purpose MCU that comes in both automotive and consumer grade. It is based on 32MHz, 1-T 8051 processor with an enhanced multiplication and division accelerator. It is loaded with features such as temperature sensors, 12 bit ADC, PWM and timers. Also, I/O rich with up to 28 GPIOs, I2C, SPI and UART. It is capable of monitoring up to 27 of our 3rd generation touch keys.

Lumissil also offers this newest technology in 3 different capacitive touch controllers. These devices will take the burden of monitoring touch keys off a host MCU and communicate through a 400 kHz I2C to a host MCU. All three controllers are available as full automotive AECQ100 grade 2 or consumer grade components.

Lumissil engineers are available to help you design the best touch key circuit and pad for your application. Please reach out to us at Lumissil.com

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