Implement capacitive proximity sensing in automotive applications

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Touch-free user interfaces are the new trend for automotive design engineers. There are multiple ways to implement this feature, and one of them is through proximity sensing. Proximity sensing is a technology through which objects such as the human body or metal can be detected at a distance without touch. Proximity sensing can be implemented using infrared (IR), optical, ultrasonic, and capacitive sensing. Each of these technologies has their advantages and disadvantages, making the right technology dependent upon your application.

Capacitive proximity sensing is becoming increasingly popular because of its inherent advantages like low power, low cost, and the ability to integrate additional user interface features such as touch buttons and sliders using the same sensors.

In this article, we will look at how capacitive proximity sensing is implemented, its benefits, and how the different characteristics of capacitive proximity sensing make it appropriate for automotive applications. This article will conclude with an example of how a capacitive proximity sensing solution can be implemented in a car infotainment system.

Human Machine Interface Proximity applications

Today, automotive OEMs are evaluating capacitive proximity sensing solutions for multiple applications. Some of the more common ones are:

- Infotainment systems: Wake-on-approach feature-based applications for audio panels, navigation systems and HVAC panels; for example, lighting-up the audio panel when the hand approaches the system
- 3-D gestures: Capacitive proximity sensing can also be used to support 3-D gestures like scrolling or a sideways swipe
- Keyless Entry systems: Detecting a hand approaching the door handle to initiate the car unlocking process
- Interior Lighting control: Switching interior car lights; for example: turning the light on/off in a glove box or a door

Capacitive Proximity Sensing

A capacitive proximity sensor is usually a copper trace on a PCB tuned to detect the presence of nearby objects without any physical contact. This method works on the same principle as capacitive button sensing; i.e., on the basis of the change in capacitance when the hand touches the
sensor/button. The difference between touch sensing and proximity sensing is that the sensor is tuned for higher sensitivity and the layout is designed to maximize E-field propagation. In addition, firmware filtering is implemented to ensure robustness and decision algorithms are implemented in firmware to reject false proximity events.

Figure 1. The figure depicts a typical capacitive proximity sensor system:

Capacitive proximity sensors can be implemented in multiple ways. Capacitive proximity sensor implementations include:

**Button** - A capacitive button with large parasitic capacitance can work as a proximity sensor. The sensitivity of a proximity sensor that is implemented as a button is much higher than a regular capacitive touch-sensing button.

**External wire as a proximity sensor** - A single length of wire works well as a proximity sensor. Since detecting a hand relies on the capacitance change from electric field changes, any stray capacitance or objects affecting the electrical field around the wire will affect the range of the proximity sensor. Using a wire sensor is not an optimal solution for mass production because of manufacturing cost and complexity.

**PCB trace as a proximity sensor** - A long PCB trace can form a proximity sensor. The trace can be a straight line, or it can surround the perimeter of a system’s use interface. This method is appropriate for mass production, but it is not as sensitive as a wire sensor.

**Ganged buttons as a proximity sensor** - Multiple sensor pads are combined in firmware to form a single proximity sensor thereby providing higher sensitivity.

**Flexible PCB** - Flexible printed circuit board trace can also be used as a proximity sensor.

**Proximity Sensing Benefits**
Not all these implementations can be implemented in every application. In general, layout requirements primarily determine the appropriate selection of the proximity sensor.

Another trend that has been popular in automotive design is the combination of proximity sensing along with a touch-screen interface. The proximity sensor here is an antenna that’s along the edges of the touchscreen. This can be controlled by the same capacitive touchscreen controller that is controlling the user interface.

**Benefits of capacitive proximity sensing**

One of the main reasons why capacitive proximity sensing is preferred over other technology is the level of integration that is possible. A capacitive proximity sensing solution can essentially integrate user interface features like touch buttons and sliders. These features are also easy to implement and sleek in nature, as opposed to more complicated system utilizing moving mechanical parts.

The other major advantage is the cost reduction that it offers against its competing technologies, as there is no need for having any LEDs or sensors, which add to the cost of a system.

Benefits of this technology include:

**Improved industrial design** - This technology offers sleek and clean aesthetics by replacing mechanical buttons, switches and sliders. It also enhances reliability by eliminating mechanical wear and tear, thereby reducing the overall system cost.

**Increased functionality** - It provides greater user interface design flexibility for product designers and supports advance features such as “Wake on Approach.”

**Increased usability** - Capacitive proximity sensing simplifies the design of most machine control interface, making systems more user-friendly.

**Application example**

Let’s take a look at a specific solution example that can be implemented using a Cypress’ CapSense proximity sensing solution. This example is based on the “Wake-on-approach” feature. The end-application is a typical touch panel in the infotainment system of the car.

The requirement is to light up the display when the finger or the hand of the driver approaches. The benefit of this feature is that the display and/or the user interface could be turned-off when not in use so as to not distract the driver while driving, and to light up when the hand approaches.

A detection distance of at least 4-5 cm is required for an optimal experience. There is also a need for additional decision algorithms in order to prevent false triggering. Due to the high sensitivity, noise interference could compromise normal operation of the proximity sensor. The electrical and mechanical design of the PCB should be carried out to avoid noise interference caused by adjacent cables or conductive surfaces. As mentioned earlier, the sensor implementation should strictly follow
Another requirement is to support 3-D gestures in the systems, which allow the driver to access basic functions without actually touching the screen. 3-D gestures include a horizontal/vertical swipe in the air or detection based on the distance of the hand from the interface. The simultaneous use of two or more capacitive proximity sensors enables simple spatial gestures such as hand waving in front of the device to be detected. Proximity sensing can be used to bring up menus on a car’s display with frequently used functions, which disappear when not in use. These menus would otherwise clutter the screen if displayed constantly, and the proximity sensors are used to reduce the graphical user interface complexity after users have made their selection.

Many of tomorrow’s car infotainment systems will use capacitive touchscreens along with capacitive proximity sensing. This architecture involves a touch controller for the touchscreen and a Capsense controller for proximity detection. There is also a need for these two controllers to be able to communicate with each other so as to be synchronized. It is also possible to have simultaneous proximity and touch scans depending on the end system.

Automotive environments provide a range of challenges for system designers like extreme temperatures, noise conditions with the higher expectation for quality and reliability. Automotive controllers offer proximity sensing of 5 cm and beyond. The controllers have robust capacitive sensing algorithm called CSD PLUS, which has high immunity to EMC noise and power supply voltage changes. It also offers other user interface features such as touch-buttons and sliders thereby integrating all features in a one-chip solution. The controller is also capable of providing audio/visual feedback through LEDs and buzzer.
Figure 3. System-level Block diagram of an HMI system in a car-infotainment panel