There has been a steady rise in demand for proximity detection sensors in automotive applications which reliably detect the presence of objects near the sensor surface without physical contact and the number of possible proximity detection applications is countless:

- **Door entry control:** detecting a hand approaching the door handle to initiate the car unlocking process
- **Illuminating and waking up the touchscreen when a hand approaches the screen surface**
- **Switching interior car lights on/off when the hand is near the sensor**
- **Detection of simple spatial gestures to switch devices on/off**
- **Sensing the presence of large objects around the car during parking**

Many different proximity detection methods exist, for example, capacitive, infrared, ultrasonic, optical, etc. For the 5mm to 300mm proximity detection range, capacitive sensing has many advantages compared to other methods: excellent reliability, simple mechanical design, low-power consumption, and low cost base. This article describes capacitive proximity detection technology from Atmel®.

Atmel is a leading touch solutions manufacturer with many years of experience in this field. The company’s capacitive sensors are based on charge-transfer technology—a method pioneered by Atmel where voltage is generated on the sampling capacitor during the repetition of a specific control sequence applied over the I/O pins. Atmel currently holds multiple patents in the area of charge-transfer technology for self-capacitance sensors (Atmel QTouch®) and mutual-capacitance sensors (Atmel® QMatrix). The Atmel charge-transfer technology delivers key benefits to the user and offers advantages compared to other capacitive measuring methods: increased flexibility, very high sensitivity, excellent moisture resistance, and noise immunity.

QTouch and QMatrix technologies have been implemented in multiple touch controllers supporting touch buttons, sliders, wheels as well as touchscreens. Proximity detection support is also available with some of the standard products. Atmel is now developing and manufacturing new proximity algorithms.
Capacitive proximity sensors measure the capacitance change between the single electrode and ground (self-capacitance sensors) or between two electrodes (mutual capacitance sensors) as objects approach electrodes. While constant capacitance is between 10pF to 300pF, the capacitance changes are typically extremely small, ranging from a few fF to several pF. Since the electrical field lines around the self-capacitance sensors spread far away from the sensing electrode, self capacitance is the preferred proximity detection method over mutual capacitance where field lines are largely concentrated in the area between the transmitting and receiving electrodes.

Characteristics of Capacitive Proximity Sensors For Automotive Applications:

- **High sensitivity**: Detecting small changes in the measured capacitance requires increased and stable sensitivity. Special measures should be taken to reduce negative effects on sensitivity caused by capacitive loading, especially if the sensing electrode is placed on a conductive surface (metal plane, car body, etc.). An active shield layer is used to reduce the negative effect of capacitive loading between the electrode and the conductive surface as shown in Figure 1. Please refer to the Atmel application note about using active shields at http://www.atmel.com/dyn/resources/prod_documents/an-kd02_103-touch_secrets.pdf, page 7. A further advantage of active shields is their neutralizing effect on water films.

- **Moisture resistivity**: Moisture-induced changes in the measured signals can be more significant than changes from approaching objects. Water film on the surface is one of the biggest problems for capacitive solutions. Water films are more or less conductive and create a change of the measured signals that is similar to normal touch events. There are mainly two ways to handle effects caused by water films:
  1. Use of active shields (described above)
  2. Shorter charge transfer time – the water film could be utilized as a distributed RC circuit (as shown in Figure 2). Reduced charge transfer pulses will prevent full charging of the distributed capacitors C and hence reduce the impact of the water films. Best results can be obtained if the charge transfer time is in the range of 100ns to 250ns. A proper mechanical design of the sense area and the use of the appropriate materials prevent the emergence of thick water films on the sensing area.

- **Temperature stability**: In automotive applications extreme and rapid temperature changes may occur at any time. Special care should be taken with regards to a stable mechanical design – even the smallest gap changes near the conductive surfaces may cause false detection.

- **Noise immunity**: 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.

- **Fast response time**: The expected response time is usually between 10ms and 100ms
The following sections provide more detailed scenarios of automotive capacitive proximity detection.

**Door Entry System**

One example of capacitive proximity detection is in car door entry systems (see Figure 3). The proximity sensor that detects hand approaches is located within the car door handle (1). Once object proximity has been detected, the main unit (2) sends a wake-up signal via the LF antenna (3) which activates the car key transmitter (4). The car key transmitter then exchanges information with the RFID receiver (5) and – if the code matches the main control unit (2) – the door is unlocked. The entire process of proximity detection and ID recognition takes a fraction of a second. This means when the hand pulls the door handle, the door is already unlocked.

The advantage of using proximity detection rather than touch detection in door entry systems is the extended time to identify a person. As a result, the door lock state will always be resolved before the door handle is pulled.

**Spatial Gestures to Switch Devices On/Off**

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. Figure 4 shows a simple example of such a system to switch lights on/off inside the car – a wave of the hand in front of the light in one direction causes the light to switch on, a wave of the hand in the opposite direction switches it off. The system is able to analyze the signals from the proximity sensors and to decide whether to switch the lamp on or off.

There are many different options available for designing sensing electrodes inside a light – from using thin copper wires to conductive polymers that can be applied directly over the plastic.

**Conclusions**

- Implementation of capacitive proximity sensors in automotive applications paves the way to a broad range of comfort applications
- Moisture and rapid temperature changes are the main challenges for capacitive proximity sensors used in automotive systems. These challenges can be overcome by utilizing the most recent innovations in capacitive sensing technology from Atmel.