Arrow Capacitive Touch Sensing

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Capacitive Touch Sensing

Capacitive sensing is a technology used for a human-device interface (HDI). It detects proximity, position, and selection by measuring the capacitance of the user's finger. There are two primary technologies for touch-sensitive devices. One technology detects changes in capacitance and the other technology is resistive-based, specifically designed for touch pads like personal digital assistant (PDA) screens. For example, the Apple® iPod® click wheel uses capacitive sensing. The Cypress Semiconductor marketing term for capacative sensing is CapSense™, which is a registered trademark of Cypress Semiconductor. It is often confused with the term capacitive sensing*.*

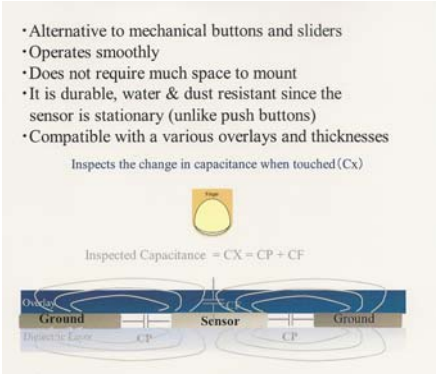
Cypress CapSense Express Family and CapSense Express Plus should not be confused with Cypress TrueTouch™, technology used on cell phone capacitive touch screens. Cypress TrueTouch technology supports multi-gestures or common gestures such as tap, press, flick, drag, dual-finger zoom, rotate, and more.

Cypress CapSense™

Cypress TrueTouch™

Capacitive Touch Sensing: What It Is and What It Is Used For

All capacitive sensors work by measuring the capacitance of the user's finger. The capacitance between the sensor and ground pads, shown in the diagram as *CP*, is intrinsic to the PCB layout. As the finger gets closer to the sensor pad we see a parallel circuit from the first pad, through the finger, to the second pad, increasing the total capacitance of the circuit. This increase of capacitance is what we measure. Laptop track pads, MP3 players, cell phones, computer monitors, and numerous other devices are using this technology as an alternative to mechanical buttons and sliders.



Capacitive touch switches replace mechanical buttons, membranes, and other moving parts with a proximity-sensitive interface. Two electrodes are covered by an insulating stratum—frequently plastic or glass—and, when a finger touches the surface, capacitance in the circuit is increased. This change in capacitance then triggers the execution of a pre-programmed function. The process relies on proximity-based sensing, where the maximum sensible proximity is set to the thickness of the stratum overlay and does not strictly require physical contact as seen in touch-sensing applications. It provides a control mechanism not subject

to dirt, dust, wear, moisture, or other factors that can affect the life of other control interface technologies.

Capacitive Controller ICs

Various manufacturers incorporate different technology approaches using two basic technologies, relaxation oscillation and successive approximation. With that said, there are two methods typically used to measure capacitance.

The first and most common method is to use the capacitance in a resistor capacitor (RC) oscillator. There are many variants of this method. One way is to use a 22K ohm resistor to charge the capacitor up to a reference voltage. At that point the capacitor discharges and the cycle repeats. An alternative to the same approach uses a current source to charge the capacitor, which is more flexible in that the current source can be programmed by a digital-to-analog (DAC) converter to handle temperature and humidity changes on the fly. Once we have a changing frequency based on changes of capacitance we can use a counter to decide the trip point. For example, if the oscillator counts up to 1,000 and then the counter resets, that would be the base count. If a finger is present, the capacitance will be higher and the RC oscillator will be a lower frequency, so the counter only goes up to 500. We can create an output so that if the count is 750 or less, we will know that a finger is present.

The second method begins with a capacitor with no charge and no finger nearby. We would turn on a current source so the voltage starts ramping up, then start a counter. When the voltage reaches 1V, we would turn off the counter. That count is the base value. We would then repeat with a finger present. Now the ramp will be slower because the capacitance is higher, so it will take more time to get to the reference voltage of 1V. In this case the count will be higher. Only Cypress (and only with their CY8C20x34-series parts) uses this method. The claim is that this new method has a higher signal-to-noise ratio (SNR) and in turn is more sensitive. In Cypress's nomenclature, the classic method is CapSense Relaxation Oscillator (CSR) and the new method is CapSense Successive Approximation (CSA).

The capacitance sensor can be applied for liquid sensing, proximity detection, and touch panels. Most applications are for touch panels.

CapSense is based on Cypress’s PSoC, a fully programmable system-on-chip that takes input from the capacitive sensor. It works with a variety of sensors and can interpret the inputs from multiple buttons, touchpads, and variable sliders simultaneously. Because of this flexibility, many consumer electronics manufacturers who make frequent changes late in the product design process have adopted capacitive sensors.

Atmel Quantum products, such as the QTouch™ Sensor ICs, work in the same manner as the Cypress products, taking the input from the capacitive sensor and interpreting which button, touchpad, or variable slider fuction was selected by the user, sending the result to the host for processing. The different Atmel Quantum products provide for a different number of keys, host interfaces, input voltages,

self calibration, auto-drift compensation, adjacent key suppression, IC packaging, and other features helpful to a design.

There are a number of other suppliers who offer capacative sensor controller ICs. It is best to contact your Arrow sales professionals to assist you in selecting the right components for your application.

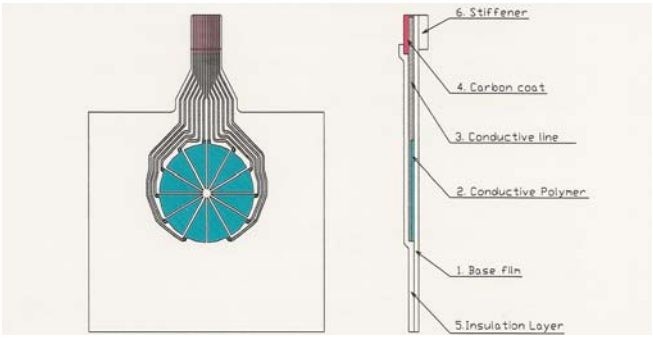
Interfaces based on capacitive sense have replaced more than 2.5 billion mechanical buttons and sliders, and according to IMS Research, hold 70% to 80% marketshare for cellular handset capacitive sensing functionality.

Resistive Controller ICs

A four-wire touch screen is typically constructed as two clear conductive layers with an insulating spacer in between. The conductive layers are of finite resistance (not zero). For a typical PDA, for example, the upper left would be the X+ terminal and the lower right would be the X- terminal. Accordingly, the other corners would be Y+ and Y-. When a stylus (or finger) is pressed into the screen, the two conductive layers meet, creating four voltages at each corner of the PDA display. From those voltages the IC can determine the X and Y coordinates of where the stylus was pressed.

This works well if you need to define a number of virtual buttons or have a display under the touch screen.

What are **Capacitive Sensors?**

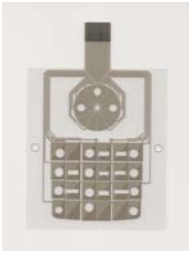


Capacitive sensors are typically custom designed for each application, since each device may have special shapes, locations, and sizes for the button/slider combinations. Construction of these sensors can contain different media such as copper, Indium tin Oxide (ITO), and printed ink. You can use single- and double-sided print technologies, so it is best to obtain as many details from your customer as possible so your sensor partner can assist in the best technology choices, such as:

- Low-cost, simple solutions that enable integration of up to 56 buttons
- Flexible technology that enables sensing through a wide range of protective overlay materials
- Buttons that can be individually calibrated with firmware parameters
- Capacitive sensing that offers a cost reduction of expensive modules and resistive-overlay technologies
- Configurable input/output (I/O) for some ICs that allows the support of a wide range of panel sizes
- Multisource-capabilities that allow multiple selections at the same time
- Proximity sensing that can wake up your application by sensing a conductive object

Different applications require differing sensor patterns, sizes, and spacing relative to the ground plane. Also, the type of sensing material used (FR4, Flex, ITO, and more) is matched to the device and full operating temperature range in which the sensor will operate. Notice the different styles of the capacitive touch sensors shown:

- Cell phones
- PDAs
- Cameras
- Wireless handsets
- PC peripherals (PC mice, touchpads, keyboards)
- Appliances
- LCD monitors
- TVs
- Notebook computers
- Automotive
- Toys
- Exercise equipment
- Kiosks
- Lighting sensors
- Industrial sensors
- Controls and more



Cell Phone Cap Sensor

Mouse Pad Cap Sensor

Control Cap Sensor

The application dictates the pattern used for the sensor. Notice on the mouse pad sensor a pattern is selected that is optimized for slider operation. A single slider requires a minimum of five buttons. The cell phone and control pad each use sensor patterns best suited for each touch application. Your partner will guide you in choosing the best solution for your customer's application.

Custom ITO/Capacitive Sensor Design

In most cases, controller IC suppliers such as Atmel, Cypress, Freescale Semiconductor, STMicroelectronics, Analog Devices, or Altera, will direct you to a supplier who has created sensor designs using their parts. Your Arrow sales professionals have a list of suppliers that have been identified to make custom sensors for your appliction.

Arrow Suppliers

Here is a quick summary of product offerings:

Manufacturer	Technology	Number of Sensors	Comments
Altera	Cap, CSR	up to 30	Uses the Arrow IP
Analog Devices	Cap, CSR	up to 14	Both SPI and I^2C interfaces available
Cypress Semiconductor	Cap, CSR, and CSA	up to 56	Part of PSoC mixed-signal portfolio
Freescale Semiconductor	Cap, CSR	up to 28	Three standalone products
STMicroelectronics		8	New part
Texas Instruments	Resistive	X-Y coord.	SPI interface
Texas Instruments	Capacitive		

Notes: CSR = Capacitive-sense using relaxation oscillator
CSA = Capacitive-sense using successive approximation
CapSense is a trademark of Cypress Semiconductor

For a complete list of capacitive touchpads, supplier choices, and technology differences, contact your Arrow sales professional.

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References:
Data from the following web sites have been used in the preparation of this document:
ADI, Atmel, Cypress, Freescale, NXP, STMicroelectronics, Texas Instruments, ShinEtsu Polymer Co., Ltd. And Wikipedia
http://en.wikipedia.org/wiki/Capacitive_sensing

Additional information evaluated in the preparation of this document was found in the following references:
Arrow IP-SOPC module

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