Application Note:
Implementing a Capacitive Swipe-Switch

Introduction

Switches have been around since the start of electricity and to envision a world without switches seems almost senseless. Switching on and off is yet simple, but remains an integral component in all electronic circuitry.

The limitation of conventional tactile or electromechanical switches however, has increased the necessity and desirability of an electronic counterpart. The mechanical failure and relatively high cost of tactile switches are only two of the factors fuelling their abolition. With modern processing speeds that allow sampling periods in the nanosecond range, the switching transients or “bounce” of conventional switches do become an issue and a limiting factor.

Electronic switches such as capacitive touch sensors are becoming the technology of choice for modern applications. The requirement for invariable functioning of capacitive sensors is imperative. Sophisticated product specifications require better sensitivity, higher levels of safety, improved immunity against aqueous substances and ultra low power consumption, especially for portable and battery operated devices.

The capacitive touch sensor undoubtedly features as an ideal approach to the electronic switch, but minor limitations are unfortunately imposed on this technology:

i. All materials or objects possess a certain electrical permittivity or dielectric constant, thus the detection of foreign objects in the sense environment is inevitable and the unintended activation of a device may be produced by metallic objects and electrically conductive or ionic solutions. This may raise safety concerns for use in certain products like hot appliances (e.g. stove tops, hairdryers etc.)

ii. Further limitations of capacitive sensors include their uninterrupted power dissipation and the fact that portable devices are introduced to continuously changing environments, which may influence the sensor’s sensitivity due to a varying reference potential.

Accordingly, by implementing refined semiconductor technology together with innovative capacitive sense electrode designs and advanced processing algorithms, it is proposed that an intelligent capacitive “swipe-switch” may be implemented to circumvent the abovementioned limitations.

Design and Implementation

A capacitive swipe-switch is based on the concept of a 2 or 3 channel capacitive sense electrode, of which the input signals must satisfy specified control algorithms to register as valid swipe or gesture actions. This concept is illustrated in Fig. 1, which depicts a simple 3-channel self-capacitance sense electrode which can be implemented to perform the swipe detection.

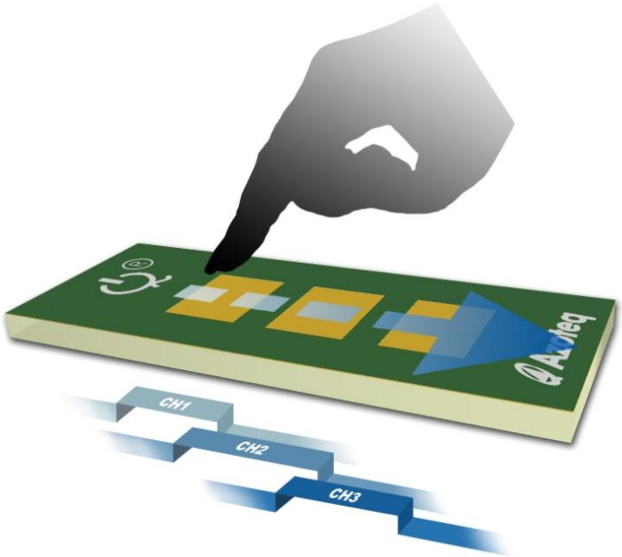

Figure 1: Example of a 3-channel sense electrode for a swipe-switch device.

The required user input is identified by sequences of a combination of input states, where a number (e.g. 1, 2 or 3) indicates a touch condition/state on the corresponding channel and a z-character indicates a zero condition/state.

For a 2-channel electrode, a simple swipe or gesture can be seen as a touch on the first electrode (1z), followed by a touch (12) on both electrodes and lastly followed by a touch on only the second electrode (z2). The required sequence of state combinations can be summarized as: **1z, 12, z2**. If a swipe event is to be recognized in the opposite/reverse direction, the required swipe sequence will be: **z2, 12, 1z**.
Any combination of states not seen in these orders will clear the current state machine, and will wait for the next valid start condition.
Depending on the design of the sensing electrodes, several small changes can be made to the state machine to improve the quality of the swipe sequence:

- **A minimum and maximum number of valid samples can be required per state combination.** This ensures that a finger should remain a certain amount of time on an electrode, reducing the probability of unintended swipe events. This may however limit the speed at which the swipe or gesture can be performed.
- **An overall sequence time can be imposed**.
- **Allowing zero state combinations**. Zero states or “no touch” conditions may be allowed for distant spaced electrodes.
- **Appending a zero state combination to the required sequence**. This requires the touch condition on the last electrode to be cleared before a valid swipe event is recorded – This reduces false activation by semi-stationary and foreign objects.

Implementing a 3-channel sense electrode will result in a more robust swipe sensor, due to a more strict sequence of state combinations being required. Examples of possible sequences of state combinations include:

- **1zz, z2z, zz3**

- **1zz, 12z, z2z, z23, zz3**
- **123, z23, zz3**

With modern day capacitive sensing solutions the designer has the choice of implementing either a self- or projected capacitive sense electrode. Figure 2 illustrates examples of simple 2 and 3-channel sense electrodes in both self- and projected configurations, which can be utilized for the detection of swipe or gesture events.

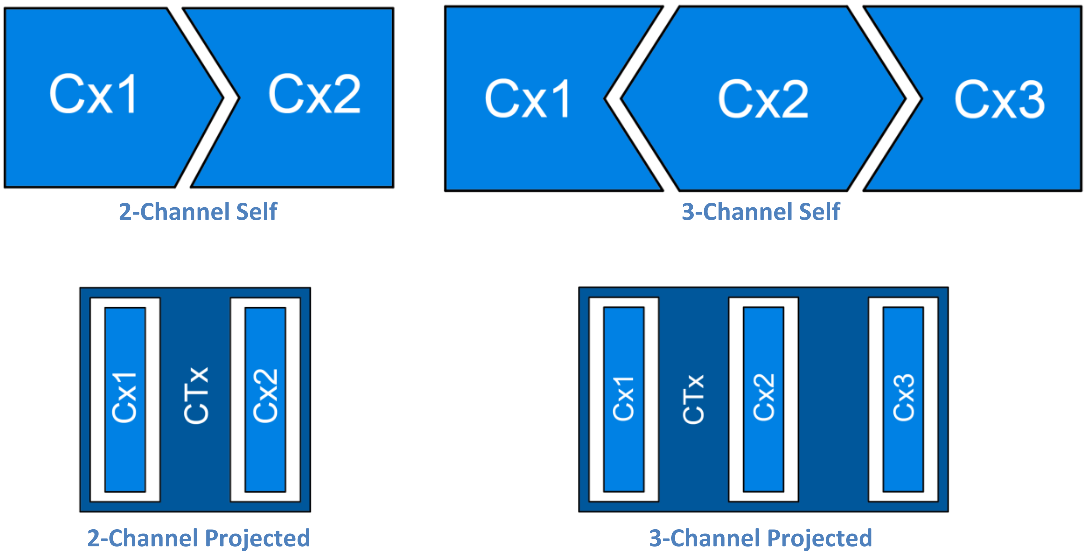

Figure 2: Example sense electrodes.

Typical user interfaces (UIs) that can be designed to complement a swipe-switch configuration include the following:

- **Single direction** - only one direction is allowed
- **Bi directional** - swipes in both directions toggles the same response. This is useful for applications where the first swipe can be in any direction.
- **Directional** - for specific applications where responses are dependent on the direction, for example volume control or a light switch.
- **Dual swipe** - A swipe in 1 direction followed by another in the opposite direction toggles the output. This can be used for applications where more switching reliability is required.
- Combined swipe and button actions to provide more UI options.

Endeavouring to mitigate the limiting criteria on capacitive sensors, Azoteq introduced their new ProxSense® SwipeSwitch™ IC – the IQS213. The SwipeSwitch™ device can provide an effective swipe or "gesture" activation of an electronic product. Together with the unsurpassed sensitivity and remarkable signal-to-noise ratios (SNR) of the latest ProxSense® capacitive sensors, the SwipeSwitch™ technology offers a unique sense of style to any application.

Compared to ordinary touch sensors, the new SwipeSwitch™ technology not only provides better safety features that prevent accidental activation, but it also features as a "**Zero-Power**" electronic switch. With current consumptions in the sub 2μA range with selected low power modes, the IQS213 offers extended battery life without sacrificing performance, whilst the average device current consumption is negligible compared to almost any realistic load.

Through patented market leading technology such as automatic ATI algorithms [1], the ProxSense® SwipeSwitch™ can easily be installed in a wide range of applications and designs with various non-conducting overlay materials, including wood, plastic and glass. Furthermore, the automatic drift compensation and advanced parasitic capacitance cancellation abilities of the innovative ProxSense® technology, makes the IQS213 SwipeSwitch™ ideal for portable and battery operated devices. These features, together with smart processing algorithms also results in better immunity against aqueous substances, without the implementation of sensor shield- and/or guard-electrodes (certain layout guidelines apply). In addition, the high sensitivity of the ProxSense® devices can allow the activation of a product or device by detecting successful swipe gestures through dry or even damp gloves and other protective gear.

Additional features of the new ProxSense® IQS213 device includes:

- Internal voltage regulation
- Internal reference capacitor (Cs)
- Small outline package (MSSOP10)

These result in a minimal component product, a cost effective design and easy integration into compact devices.

Furthermore, the various programmable user-input configurations, present a large degree of freedom to the design of the sense electrodes. This in fact can allow for reliable swipe detection over distances as short as 8mm and as long as 100mm, in straight or curved electrode arrangements and at swipe speeds varying from approx. 35-500 mm/s.

Follow the link to see SwipeSwitch™ in action: ProxSense® IQS213 SwipeSwitch™

The ProxSense® and SwipeSwitch™ technology is protected by numerous patents.

Conclusion

This article discussed the design of a fashionable swipe activated switch, using simple 2- or 3-channel capacitive sense electrodes. Since these capacitive switches are to be utilized as replacements for conventional electro-mechanical switches, the solution should be as cost effective as possible.

The advantages of a capacitive switch as opposed to conventional tactile switches include:

- Simplified manufacturing
- Waterproofing is easier since no holes have to be made for the switch.
- No mechanical wear and tear (no moving parts).
- More intelligence - better user interfaces can be designed, feature and security wise.

Ideally these electronic switches should also have the following properties to be viable replacements for normal switches:

- Low power - with sub 5µA current consumption considered as “no current”.
- Response rate - low power characteristics not influencing the response time of the switch.
- Robustness - false switching should not occur with accidental bumps and touches.
- Reliability - a swipe or gesture should be easily recognizable.
- Water immunity - since these switches can be implemented in a variety of products and environments, immunity against aqueous substances is highly required.

In general, capacitive swipe switches could be constructed using a microcontroller and a capacitive touch solution, which features at least 2 sense electrodes. However, such configurations are not always adequate due to cost and space requirements and because full control of the sampling rate of the required state combinations is not possible – this is at the heart of the ProxSense® IQS213 SwipeSwitch™.

References:

[1] J. Viljoen, Azoteq: Design capacitive touch systems for robustness and manufacturability. EETimes, 2011. [Online]. Available: http://www.eetimes.com/design/embedded/4230489/Design-capacitive-touch-systems-for-robustness-and-manufacturability.

[2] Azoteq Datasheets and Application Notes – www.azoteq.com

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