Touch Solutions

AT11805: Capacitive Touch Long Slider Design with PTC

APPLICATION NOTE

Introduction

Slider is a one-dimensional sensor that detects the linear movement of a finger during touch. Sliders are typically used in applications that require adjusting level of a specific user parameter or scrolling menus such as, display brightness or volume in an audio application. Typically, applications utilize sliders of length between 20 to 60mm, but for some applications, it can be more natural to have a longer slider to match the rest of the interface. Long sliders also make it easier to make subtle value adjustments.

This application note provides guidelines to design long slider sensors with PTC.

Features

This application note features the following contents:

- Challenges with a standard slider
- Design guidelines
- Layout recommendations

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1. Abbreviations and Definitions

- **Channel**: One of the capacitive points at which the controller can detect capacitive change.
- **Coplanar (Single Layer) design:** Both X and Y electrodes fabricated on the same layer of the PCB in mutual-capacitance sensor design.
- **Electrode**: A patch of conductive material on the substrate that forms the sensor. An electrode is usually made from copper, carbon, silver ink, or Indium Tin Oxide (ITO).
- **Flooded-X (Two-Layer) design:** Both X and Y electrodes are distributed in two layers of the PCB in mutual-capacitance sensor design.
- **Mutual-capacitance Sensor**: A sensor with connections to two parts of the sensor; an X (transmit) electrode, a Y (receive) electrode. The mutual capacitance from X to Y is measured by the controller.
- **One-dimensional Sensor:** A sensor that detects the linear movement of a finger during touch (along a single axis). Typical implementation of one-dimensional sensor is a slider.
- **Peripheral Touch Controller (PTC):** This is a microcontroller peripheral which acquires signals to detect touch on capacitive sensors.
- **Resistively Interpolated Sensor:** A type of sensor that uses physical resistors to electrically interpolate the electrodes.
- **Self-capacitance Sensor:** A sensor with only one direct connection to the sensor controller. A self-capacitance sensor tends to emit electric fields in all directions.
- **Sensor:** A component that detects the touch. Sensors consists of one or more electrodes. It can be key, slider, or wheel.
- **Spatially Interpolated Slider:** A type of sensor that uses the shape of the electrodes to spatially interpolate the electric fields above the sensor.

2. Standard Slider

PTC QTouch® library supports design of sliders using both self and mutual capacitance methods.

Self-capacitance acquisition method is suitable for designing small sliders (typically 20 – 60mm). PTC QTouch library supports only three channel slider for self-capacitance method. To design long slider sensor with self-capacitance method, the size of the sensor electrodes needs to be increased. Larger sensor electrodes will have higher self-capacitance. This may saturate the sensor exceeding the maximum limit of electrode capacitance measurable by PTC. Hence it is not suitable to design long sliders using self-capacitance method.

Mutual capacitance slider sensor is constructed from a series of electrodes located in close proximity to each other. All sensor electrodes are directly connected to X lines of the chip along with a common Y line. Using standard slider techniques, the number of series electrodes are used to determine the physical length of the sensor. PTC QTouch library can be used to create a mutual capacitance slider using between three to eight channels. A slider with approximately 68mm length can be achieved by using eight electrodes with 8mm width and a gap of 0.5mm between the electrodes. It is possible to design mutual-capacitance sliders much longer than 68mm when hardware interpolation techniques are used.

3. Design Guidelines

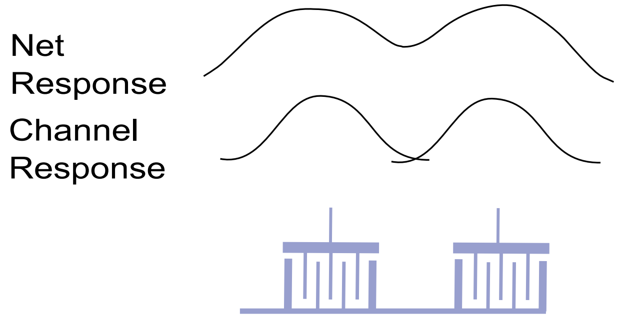
The below sections describes the guidelines to design mutual-capacitance sensor patterns for long slider. Both the One-layer (Coplanar) and Two-layer (Flooded X) patterns can be used to design long slider sensor.

Schematic and PCB layout guidelines for QTouch PTC design can be referred in the application note PTC Robustness Design Guide in sections *'Schematic Design' and 'PCB Design'*.

3.1. Coplanar (One-layer) Design

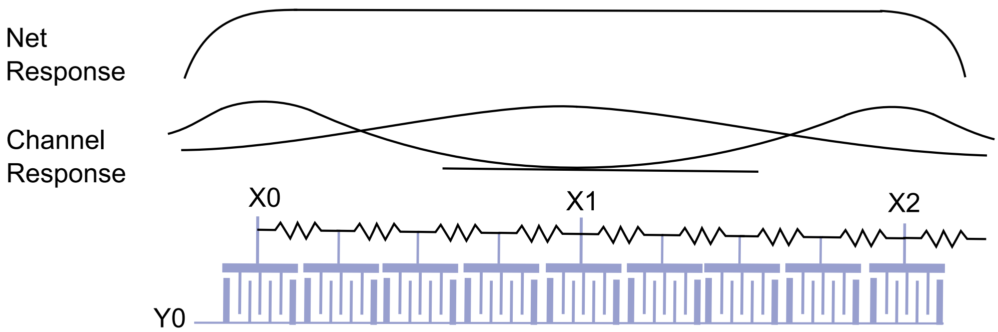
In coplanar design, both X and Y electrodes are fabricated on the same layer of the PCB. The length of a coplanar slider can be extended marginally by increasing the gap between each key, but the response will become increasingly non-linear with signal dropouts. The field strength decreases on a sensor electrode before it starts to rise on the next.

Figure 3-1 Capacitive Effect for Two Widely Seperated Sensor Keys



However, it is possible to extend the interpolation between each channel by introducing a series of sub-electrodes, each separated by a resistor. Instead of a single segment per channel, each channel in the slider is formed by one or more segments. The extra segments are created using resistive dividers on the X lines as shown in the following figure.

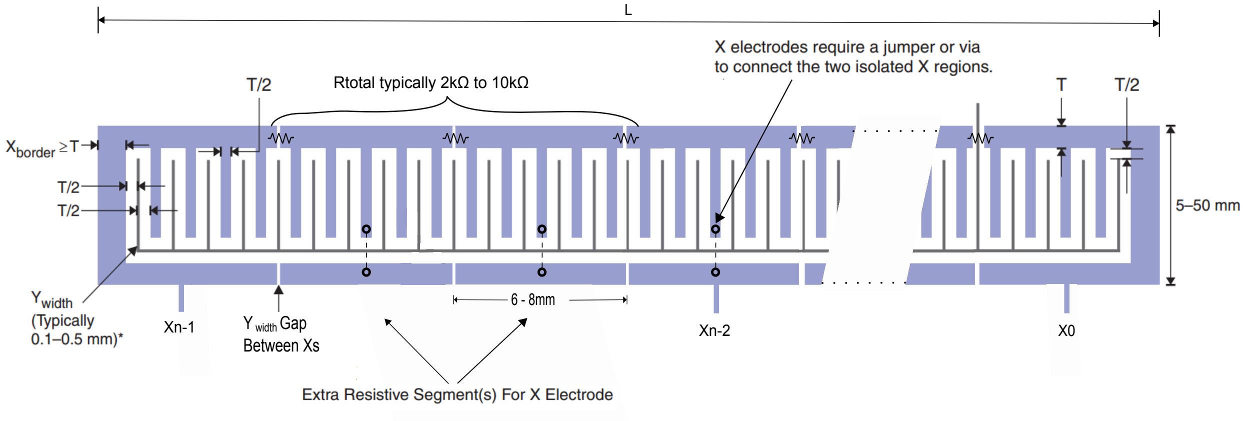
Figure 3-2 Use of Extra Segments to provide Interpolation on a Long Slider



This arrangement provides smooth transition between channels as the users move their finger along the sensor electrodes. Up to seven extra segments can be used between channels to achieve the required sensor length. It is possible to achieve 350mm slider length with this resistive interpolation method.

The following figure depicts the dimension of Resistively Interpolated sensor design.

Figure 3-3 One-layer (Coplanar) Long Slider (Resistively Interpolated)



3.2. Flooded-X (Two-layer) Design

Flooded-X two-layer method distributes the X and Y electrodes across two layers of substrate. Two-layer (Flooded-X) long slider sensor can be designed using two methods:

1. Spatial Interpolation
2. Resistive Interpolation.

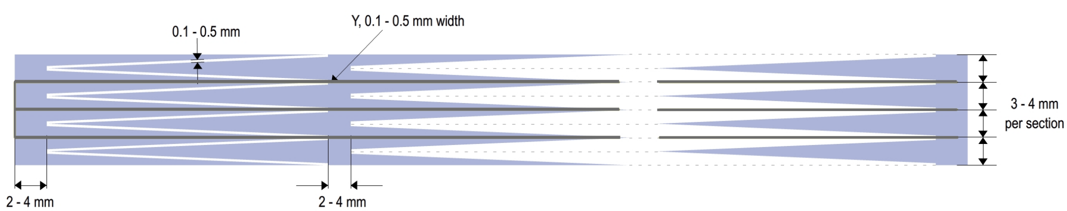
3.2.1. Spatial Interpolation

It uses toothed electrodes to interpolate the capacitive change spatially as a finger moves across the sensor. The length of the slider can be increased by stretching the interleaving teeth between segments. It is possible to achieve up to 200mm slider with spatial interpolation method.

The important point to consider while stretching the segments is that the touch surface area of two electrodes at each point along the slider. When moving left to right, there should be a linear decrease in touch area of the left electrode and a corresponding linear increase in area of the right electrode.

The following figure depicts the dimension of Spatially Interpolated sensor design.

Figure 3-4 Two-layer Long Slider (Spatially Interpolated)



To design a long slider, the number of interleaving teeth between segments can be increased to achieve a maximum width of 4mm between the two consecutive teeth.

Tip of the tooth should not be stretched extremely thin. Thinner the tip of the tooth, lesser will be the touch surface area towards the edge of each segment. This would cause a drop in signal while moving between segments. Minimum tooth width should be around 0.25mm to get the sufficient surface area at the edge of the teeth.

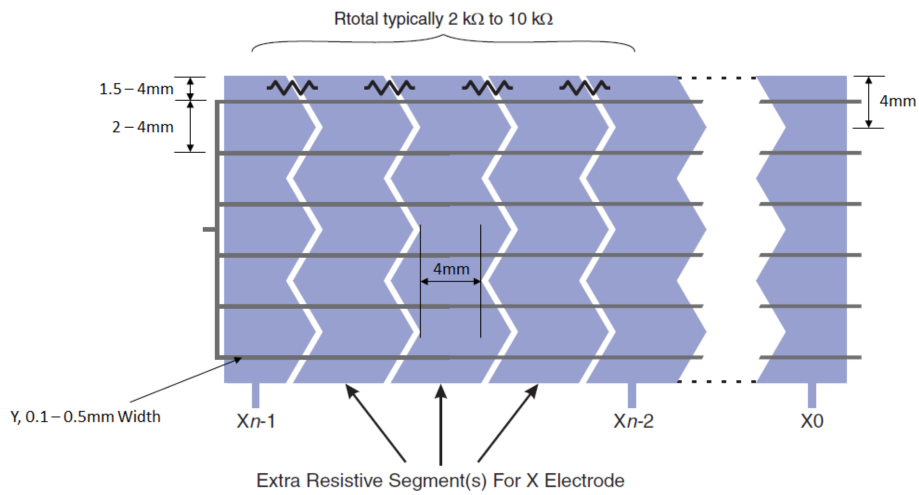
Using a two-layer spatially interpolating electrode array to make much longer slider (more than 200mm) is not advisable. Although it is possible to design longer sliders this way, the complexity involved in such sensor design favors the use of a resistively interpolated slider.

3.2.2. Resistive Interpolation

Similar to one layer long slider, resistive interpolation can be used to design two-layer long sliders. To increase the length of sensor, extra segments are created using resistive dividers on the X lines. The segments can be designed such that they are both spatially as well as resistively interpolated.

Up to six extra segments can be added between channels to achieve the required sensor length. Resistive interpolation method can achieve a slider length of up to 300mm.

Figure 3-5 Two-layer Long Slider (Resistively Interpolated)



3.2.3. Front Panel Thickness

Flooded-X sensor design can support front panel of 0.5 to 2mm in thickness. The front panel should have sufficiently high dielectric constant. The dielectric constants of some common materials are indicated in the following table.

Table 3-1 Dielectric Constants of Common Materials

Material	Dielectric Constant
Air	1
Common glass	7.8
Pyrex Glass	4.8
Lexan	2.9
Polyethylene	2.3
Polystyrene	2.6
FR-4	5.2
Plexiglas	2.8
PVC, rigid	2.9

Material	Dielectric Constant
Mylar	3
Nylon	3.2
Teflon	2.1

3.3. Dead Band

Dead band refers to the inactive area on both ends of the slider where no change in positions are reported on touch. If you have a touch contact only on an end channel and no capacitance change on adjacent channel, there is no second data to use for position interpolation calculation. The reported position will remain same.

For slider with a position resolution of 8 bits (position 0 – 255), touch in the dead band area shows position 0 on one end and position 255 on the other end of slider. Sliders may have dead band area of around 10% of the length of the slider on both sides. For example, a 100mm slider may have a dead band of around 10mm each on both sides.

For longer slider with standard sensor design techniques, the dead band area will be slightly larger.

If a 300mm slider is designed, ~30 mm (10% of the total length of the slider) may be inactive (dead band) on both ends. Thus for a 300mm slider, approximately 60mm would be unusable. Dead bands of such considerable length would be undesirable in case of applications with stringent space constraints.

Optimizing the length of end channel electrodes helps to reduce the dead bands. For a desired length of slider, length of the end channels and middle channels can be calculated as follows.

End Channel	Middle Channel	Middle Channel	….	Middle Channel	End Channel

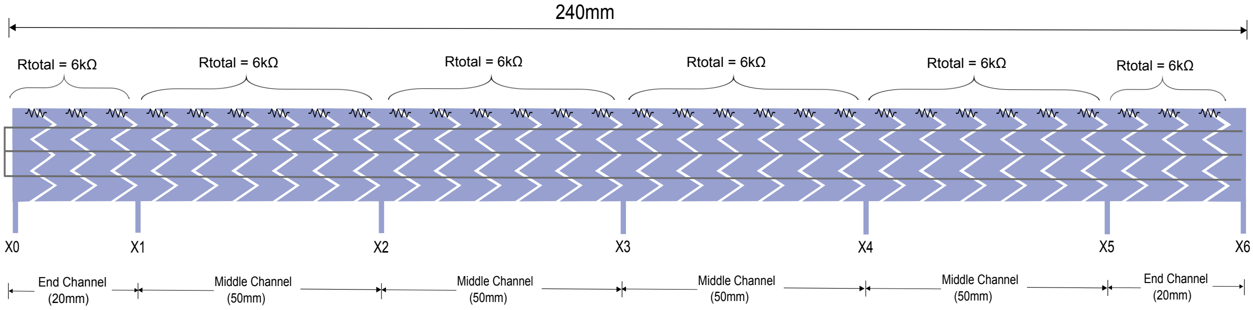
```
middle_channel_length = (slider_length*1.25)/(no_of_channels-1)
end_channel_length = [slider_length-(middle_channel_length*(no_of_channels-3))]/2
```

Note:

1. At least one extra segment should be present between End Channel and Middle Channel.
2. R_{total} (total resistance between channels) should be same for every channels (same R_{total} value should be used for both end channels and middle channels).

Sliders designed based on the above calculation can have size of dead bands reduced to 3% instead of 10% at both ends.

Figure 3-6 Channel Measurements for a 240mm Slider with Seven Channels



4. Noise Performance

Noise performance depends on the sensor design, ground shielding, power supply, and the end target environment. Better noise performance can be achieved by complying with the general rules and recommendations for sensor designs. For better noise performance with long sliders, Flooded-X resistive interpolated slider sensor is preferred compared to a coplanar sensor.

The noise robustness of the system can be improved by adjusting the software parameters in PTC QTouch library namely Filter Level, Auto Oversampling, Prescaler, Sense Resistor, and Acquisition Frequency Mode.

Refer QTouch Library Peripheral Touch Controller User Guide for more details about PTC QTouch library and its associated parameters.

Refer PTC Robustness Design Guide for additional information on Sensor Tuning for high noise immunity.

5. PCB Layout

5.1. Flooded-X Spatial Interpolated Slider

Figure 5-1 Top Layer

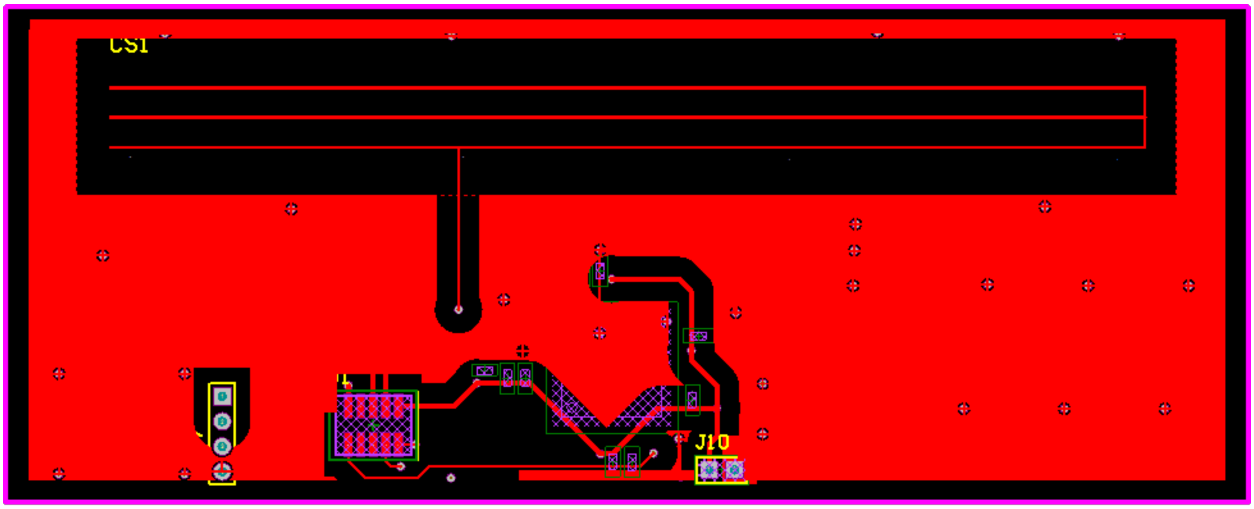
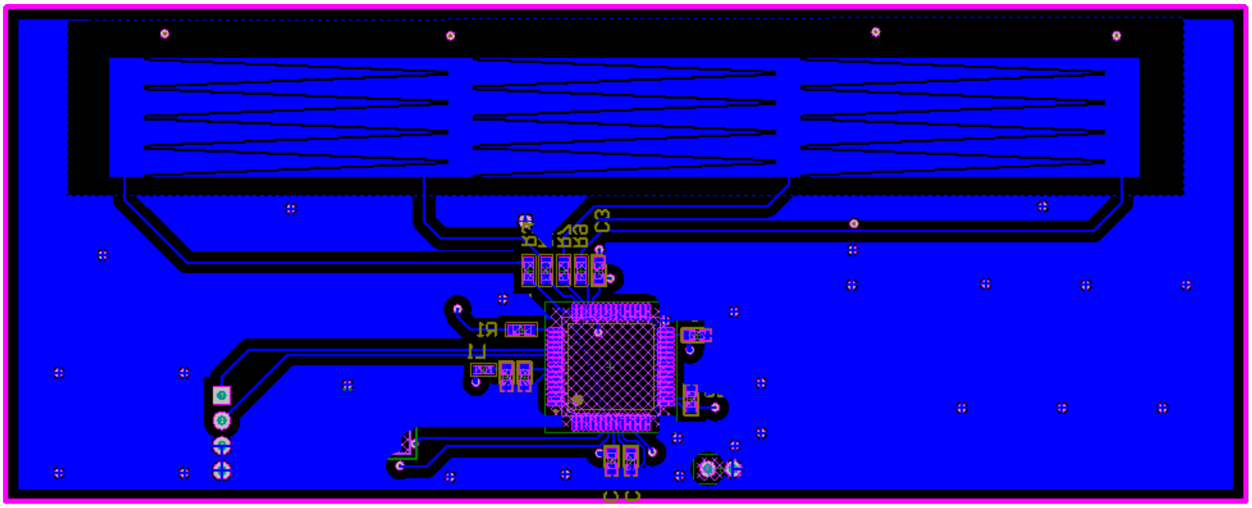


Figure 5-2 Bottom Layer



5.2. Coplanar and Flooded-X Resistive Interpolated Sliders

Figure 5-3 Top Layer

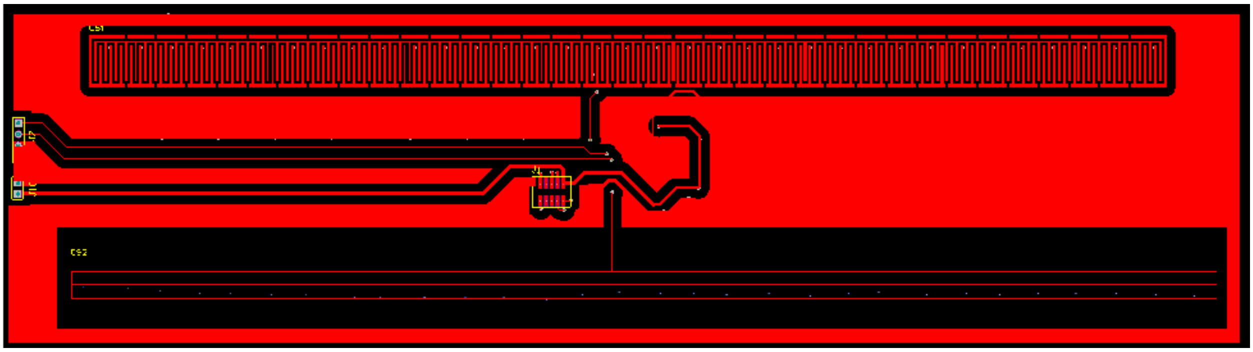
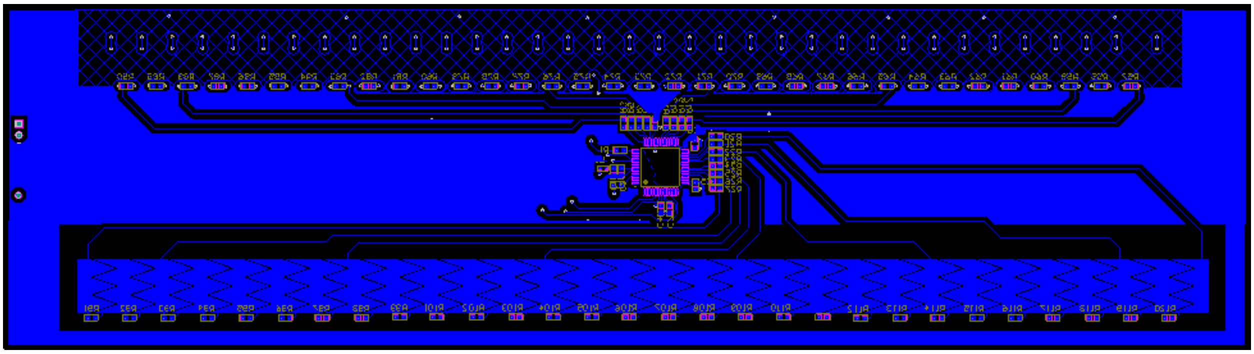


Figure 5-4 Bottom Layer



6. References

[1]. BSW Touch Sensor Design Guide - http://www.atmel.com/Images/doc10752.pdf
[2]. SAM D Peripheral Touch Controller User Guide - http://www.atmel.com/Images/Atmel-42195-QTouch-General-Library-Peripheral-Touch-Controller_User-Guide.pdf
[3]. PTC Robustness Design Guide - http://www.atmel.com/Images/Atmel-42360-PTC-Robustness-Design-Guide_ApplicationNote_AT09363.pdf

7. Revision History

Doc Rev.	Date	Comments
42479B	07/2015	Updated document title to Capacitive Touch Long Slider Design using PTC.
42479A	06/2015	Initial document release.

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Atmel Corporation 1600 Technology Drive, San Jose, CA 95110 USA **T:** (+1)(408) 441.0311 **F:** (+1)(408) 436.4200 | **www.atmel.com**