QTAN0030 Implementing a Long Slide Control Using a QMatrix™ IC

QMatrix ICs such as the QT2160 can be used to produce very effective slider controls by merging the touch signals from a number of closely spaced keys. The basic technique will produce controls of up to 60 mm in length, but special interpolation techniques can be used to provide controls that extend 200 mm or more. Studying the techniques involved provides an interesting insight into how QMatrix ICs operate.

1. The Advantages of Touch Slide Controls

There are many advantages of introducing capacitive touch sense controls into a product. Touch controls:

- **can provide very low cost alternatives to relatively expensive mechanical components**
- **often require much less space to implement**
- **can provide a better user experience**
- **add design flexibility**
- **have the potential for much greater reliability**

Sliders implemented with Atmel chips are cost effective and require absolutely no maintenance. Since the sensing elements can be made from almost any conductive material, touch sliders can be integrated into the structure of a product in many different and innovative ways.

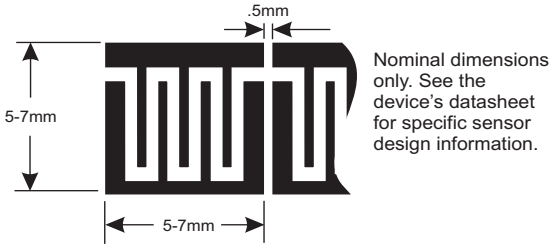
2. Standard Slider Limitations

QMatrix sliders are constructed from a series of touch keys located in close proximity to each other. Using standard slider techniques, the number of keys used determines the physical length of the control.

For instance, the QT2160 IC can be used to create a slide control using between 2 to 8 keys; assuming each key is 7 mm long with a gap of 0.5 mm between, using 8 keys will provide a slider approximately 60 mm long.

This compares favorably with the length of a traditional mechanical slide potentiometer but, as described later, QMatrix has the potential to produce sliders of even greater length when interpolation techniques are used.

Figure 2-1. Typical electrode array dimensions



Long Slide Controls with QMatrix ICs

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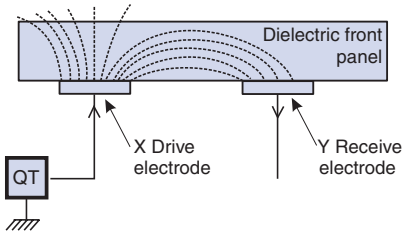
3. How QMatrix Sliders Work

To understand how to design a QMatrix slider it is important to understand how matrix based capacitive touch circuits work. QMatrix ICs employ what is known as transverse charge-transfer (QT™) sensing technology .

This is a technique that senses touch by looking for changes in an electrical charge which is forced across two electrode elements by a pulse edge (Figure 3-1). The electrode elements take the form of an array of X and Y elements.

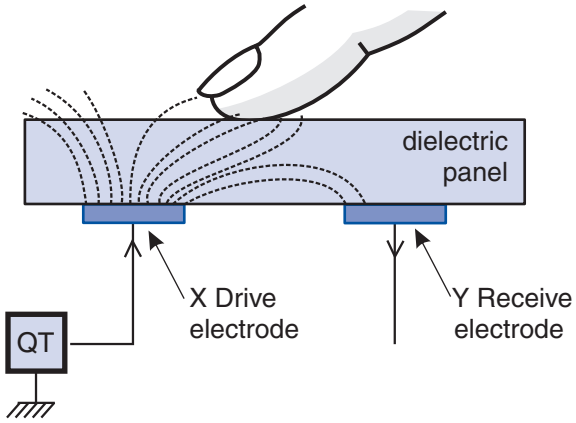
Figure 3-1. QT Touch sensing #1



In operation the touch sense controller generates a burst of drive pulses, which forces an electric charge from the X (drive) electrodes to the Y (receive) electrodes.

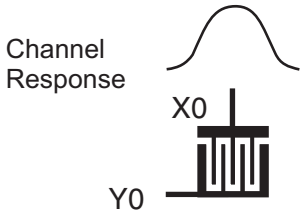
When a user places their finger near the electrode set the electric field is partially shunted into the human body. This causes a change in the received charge on the Y electrode (Figure 3-2).

Figure 3-2. QT Touch sensing #2



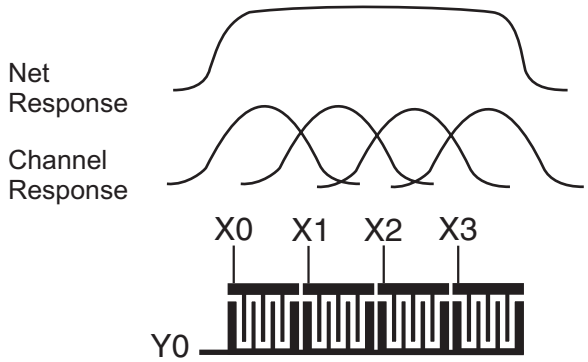
Although the field between the electrodes remains within the sensor area, the capacitive effect of the user's finger extends slightly beyond that area (Figure 3-3).

Figure 3-3. Range of capacitive effect for a single sensor key



With a key length of 7mm and a gap of around 0.5mm between the sensors there is a smooth transition of effect between the keys (Figure 3-4). For sliders in the 60 mm range this provides a natural interpolation between keys.

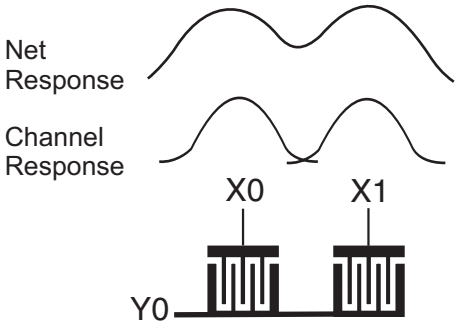
Figure 3-4. Range of capacitive effect for several adjacent sensor keys



4. Extending the Length of the Slide Control

As already mentioned, QMatrix ICs can be used to create sliders of 200 mm or more. However, this cannot be done simply by moving the sensor keys further apart. Figure 4-1 illustrates the reason for this.

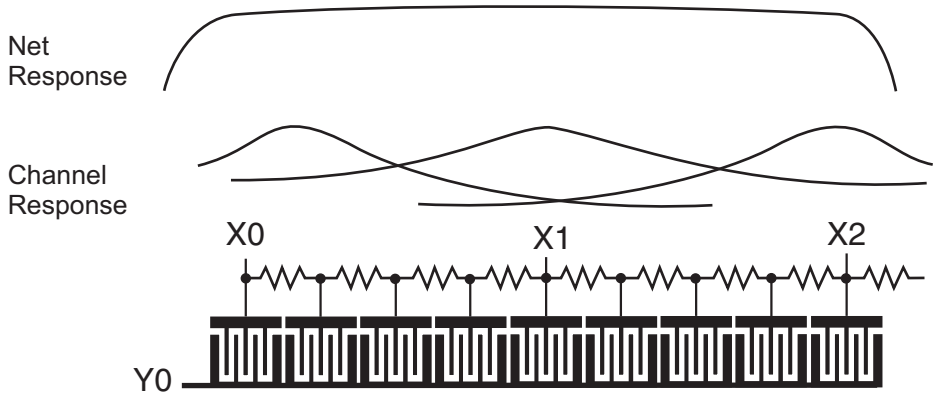
Figure 4-1. Range of capacitive effect for two widely separated sensor keys



The length of the slider can be extended a little by increasing the gap between the pads, but the response will become increasingly non-linear with signal drop-outs. The field strength will decrease on one sensor before it begins to rise on the next, and this imposes a natural limit to the length of the slider (Figure 4-1).

However, it is possible to extend the interpolation between each channel by introducing a series of sub-sensors, each separated by a resistor, between each channel (Figure 4-2).

Figure 4-2. The use of sub keys to provide interpolation on a long slider



This arrangement provides smooth transition between the channels as the user moves their finger along the sensor array.

5. Where to Use Long Slider Controls

The technique described in this application note has resulted in the construction of effective slide controls up to 200 mm in length with a resolution of 8 bits (255 discrete levels). Longer sliders are possible, but up to 220 mm is the practical limit imposed by usability.

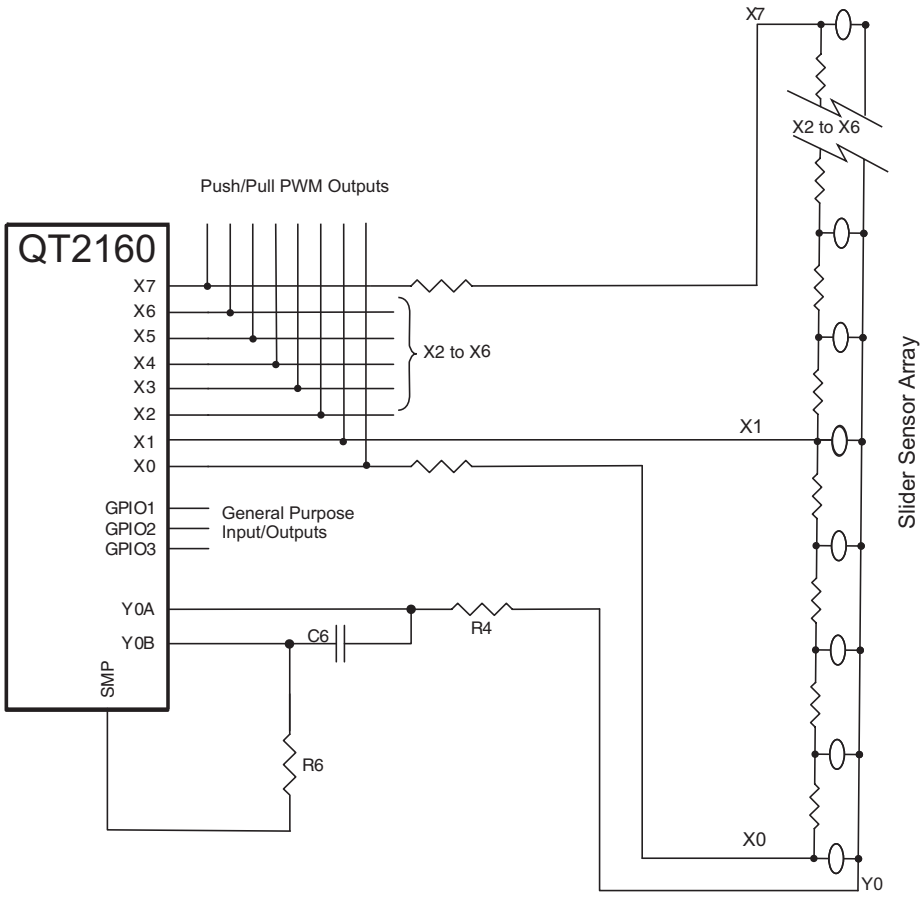
This is an important point to consider when making your early design decisions. In many circumstances long slider controls have only limited usability. An audio volume control, for instance, does not need the fine control that a long slider provides. The human ear is relatively insensitive to small changes in audio level, and the responsiveness provided by a short slide control with less resolution would probably be more appropriate.

However, there are some applications where the fine control provided by a long slider is essential. One very good example of this is the next generation digital photo frames that are now being provided with touch interfaces to allow users to interact with their photo collections. A long slider, used to provide an accelerated slideshow preview, has sufficient precision to allow a single image to be selected from a collection of two hundred or more.

6. Sensor Circuit Design

The QT2160 QMatrix IC (Figure 6-1) is ideal for use in a long slider application of this sort. It provides the slider control and (using the Y1 matrix input) up to 8 additional keys that can be used for configuration and transport controls. In addition, it provides 8 outputs that can be used to control LEDs for feedback. If required, the 3 general purpose I/O ports can be configured as floating inputs for use with switches and logic signals, or as outputs for additional LEDs. All of the outputs can provide Pulse Width Modulated signals which will allow the LED's overall brightness to be controlled by software.

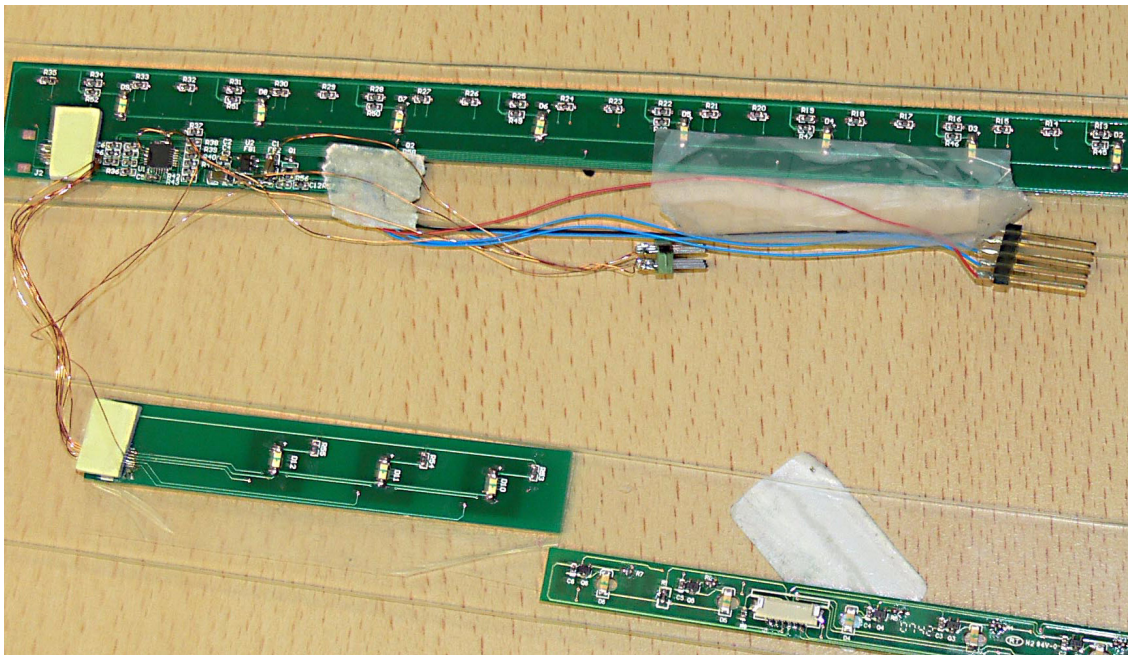
Figure 6-1. Example slider control circuit using the QT2160 IC



7. Circuit Construction

The circuit could be configured in many different ways, but always produce a prototype so its response can be fully tested before finalising the design (Figure 7-1). QMatrix technology is sensitive to small changes in the materials and dimensions of the sensor substrate and the overlying panel. It is important to evaluate the design to make sure it has an effective configuration before moving on to other details.

Figure 7-1. Always produce a prototype array for evaluation before moving to the final design



The sensor circuit can be constructed from a variety of materials, including FR-4, Flexible Printed Circuit Board (FPCB), silver silkscreened on to plastic film, and punched single sided CEM-1 or FR-2. It is also possible to construct a sensor array from patterns printed in conductive materials on the inside of the product's front panel.

8. Associated Publications

The following documents published by Quantum Research Group (QRG) are also of interest:

ANKD01 - QMatrix Panel Design Guidelines

QAN0015 - Power supply considerations for Quantum capacitive-touch ICs

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