Introduction

This application note concerns the STM8 Touch Sensing Library for STM8S and STM8L microcontrollers.

This firmware library allows management of the following number of channels:

- up to 6 channels when using devices from the STM8L101xx series
- up to 16 channels when using devices from the STM8L15xxx series
- up to 24 channels when using devices from the STM8Sxxxxx series.

The guidelines below are to help designers to overcome channel number limitation. They describe tips and tricks to increase the number of touchkeys and/or to create a touchkey matrix by keeping the same targetted device.

This document provides simple guidelines concerning three main aspects:

1. adding an extra touchkey
2. creating a touchkey matrix
3. working around the limitations.
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1 Adding an extra touchkey

The STM8 Touch Sensing Library for STM8S and STM8L devices allows the acquisition of a certain number of channels to be managed. This section explains how to add an extra touchkey to a pair of single electrodes for an application using the same device and the same firmware library.

1.1 Hardware implementation

As shown in Figure 1: Hardware implementation example, a touchkey is made by a double-ended electrode (i.e. one electrode with two connections). Two single electrodes can generate a third touchkey by interlacing teeth coming from one of each electrode.

Figure 1. Hardware implementation example
1.2 Software implementation

Channel acquisition is managed as if there are only two single electrodes in the touch sensing firmware library. The application must decode the result of the acquisition as shown in Table 1: Decoding example.

<table>
<thead>
<tr>
<th>Keys</th>
<th>Channel 1 state</th>
<th>Channel 2 state</th>
</tr>
</thead>
<tbody>
<tr>
<td>No key</td>
<td>Idle</td>
<td>Idle</td>
</tr>
<tr>
<td>Key 1</td>
<td>Detect</td>
<td>Idle</td>
</tr>
<tr>
<td>Key 2</td>
<td>Idle</td>
<td>Detect</td>
</tr>
<tr>
<td>Key 3</td>
<td>Detect</td>
<td>Detect</td>
</tr>
</tbody>
</table>

1.3 Limitation

The drawback of this hardware and software implementation is that there is no way to discriminate a touch on both electrode 1 and electrode 2 from a single touch on electrode 3 as implemented in Figure 1. So, this solution suits applications where only one touchkey can be detected at once or, if a few touchkeys are valid at the same time, where the touchkeys do not share an electrode.
1.4 Combined implementation

Combined implementation (see Figure 2) allows any touchkey from set 1, 2 or 3 to be touched simultaneously but, if two touchkeys from within the same set are touched concurrently, an incorrect touchkey is detected. For instance, touchkeys 1, 6 and 8 can be touched by the user at the same time and the application decodes them correctly but, if touchkeys 2 and 3 are touched simultaneously only touchkey 3 is reported. Likewise, if touchkeys 4 and 5 are touched concurrently, touchkey 6 is incorrectly reported.

Figure 2. Combined implementation example for multi-touch capability

1. A set consists of three touchkeys acquired through two channels.
A channel can be connected to several double-ended electrodes which allows the number of:

- touchkeys to be doubled (very suitable for products with few channels)
- GPIOs used for the touch sensing acquisition to be reduced.

*Figure 3* gives an example of an implementation where six touchkeys are generated with only three channels.

**Figure 3. Example of an implementation for six touchkeys with only three channels**
2 Touchkey matrix

In some applications, adding one touchkey by electrode pairs is not enough and building an electrode network to get a touchkey matrix is more efficient.

2.1 Hardware implementation

The double-ended electrode solution can be extended to create an electrode network as shown in Figure 4: Electrode network example

Figure 4. Electrode network example

In this implementation example, seven channels provide a touchkey matrix of 12 touchkeys. Each touchkey is generated by interlacing a channel row with a channel column. For example, touchkey 1 is generated by interlacing Ch1 with Ch4. It is recommended to have homogenous sized touchkeys so that each key has the same sensitivity. This simplifies the threshold setup and can be achieved by using the same sampling capacitor.
2.2 Software implementation

Channel acquisition is managed by the touch sensing firmware library in the same way as for single electrodes. A decoding step must be performed at application level depending on the combination of detected channels.

A touch on touchkey 1 triggers a detection on two channels, Ch1 and Ch4 (see Figure 4: Electrode network example).

The decoding table mirrors the matrix shown in Figure 4. A touchkey is activated when the two channels it is connected to are in detection state.

2.3 Limitation

For such a touchkey matrix, one or several touchkeys can be touched simultaneously on the same row or the same column. As shown in Figure 5, touchkey 1, 4, 7, and 10 are touched simultaneously and can be decoded without ambiguity.

Figure 5. Decodable multi-touch example
However, when two touchkeys are touched on different rows or columns, four channels are detected and it is difficult to discriminate a true touch from a false one. This phenomenon is known as the “ghost” effect.

In Figure 6, touchkey 1 and touchkey 5 are touched but, channels 1, 2, 4 and 5 are detected. From the application, it is impossible to determine which of the four touchkeys are touched.

Figure 6. Ghost effect example
3 Maximizing the number of touchkeys

The user can combine the touchkey matrix with single electrode touchkeys to maximize the number of possible touchkeys. This gives a pure single touch interface.

In this configuration, single electrodes are added on each row and column of the touchkey matrix as shown in Figure 7. There are two decoding cases:

- if one channel is detected, the connected single electrode is touched
- if two channels are detected, the touchkey corresponding to the intersection of the two channels is touched.

In the case of multi-touches, it is impossible to discriminate which touchkeys are touched. This solution is only adapted for applications where the user touches one key at a time.

Figure 7. Touchkey matrix with a single electrode on each channel
4 Working around the limitations

The limitations can be reduced through careful management of the touchkeys and touch key matrices.

4.1 Defining sets of touchkeys

For extra touchkeys and touchkey matrices, it is important to define sets of touchkeys in which the keys cannot be touched at the same time. This allows multi-touching capability across sets.

Sets can be categorized as follows:

- a touchkey matrix and a few independent touchkeys which allow simultaneous touches on any of the independent keys plus one touch on the touchkey matrix.
- two touchkey matrices which allow simultaneous touches on each touchkey matrix.

4.2 Using detection exclusion system (DES) functionality

For a touchkey matrix (without single electrode touchkeys), DES allows only the first detected touch inside a group to be reported. By defining a DES group with channel rows and another group with channel columns, only one touchkey can be activated at a time. For application managing only single touch, this simplifies the processing at application level.
5  Maximum touchkey matrix size by product

5.1  Products supporting the charge transfer principle

Table 2: Maximum touchkey number with CT principle summarizes the maximum touchkey matrix size which can be implemented with products supporting the charge transfer technique.

<table>
<thead>
<tr>
<th></th>
<th>STM8L10xxx</th>
<th></th>
<th>STM8L15xxx</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>28-pin</td>
<td>32-pin and 48-pin</td>
<td>28-pin</td>
</tr>
<tr>
<td></td>
<td>package</td>
<td>package without LCD</td>
<td>package</td>
</tr>
<tr>
<td></td>
<td></td>
<td>with LCD</td>
<td>with LCD</td>
</tr>
<tr>
<td>Maximum channel</td>
<td>3</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>number</td>
<td></td>
<td></td>
<td>13</td>
</tr>
<tr>
<td>Maximum matrix</td>
<td>N/A(1)</td>
<td>3x3</td>
<td>5x5</td>
</tr>
<tr>
<td>size</td>
<td></td>
<td></td>
<td>7x6</td>
</tr>
<tr>
<td>Maximum touchkey</td>
<td>6</td>
<td>15</td>
<td>35</td>
</tr>
<tr>
<td>number(2)</td>
<td></td>
<td></td>
<td>55</td>
</tr>
</tbody>
</table>

1. If only three channels are available, there is no advantage in designing a touchkey matrix. However, by creating an extra touchkey between each of the three single electrodes, the user can provide the application with six touchkeys (see Figure 3: Example of an implementation for six touchkeys with only three channels).

2. The maximum number of touchkeys is obtained by combining the biggest matrix with a single electrode on each channel as shown in Figure 7.

5.2  Products supporting the RC principle

With products using the RC acquisition technique, a maximum of 24 channels dispatched on a maximum of three GPIO ports is supported. Consequently, a touchkey matrix up to 12 x 12 can be implemented. The pinout diagram of the device must provide a “load” pin in addition to the channel pins.

Table 3. Maximum touchkey number with RC principle

<table>
<thead>
<tr>
<th></th>
<th>STM8Sx03xx (20-pin package)</th>
<th>STM8S105xx (32-pin package)</th>
<th>STM8Sx03xx (32-pin package)</th>
<th>STM8Sx03xx &amp; STM8S20xxx (44-pin &amp; 48-pin packages)</th>
<th>STM8S20xxx (64 and 80-pin packages)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Max. channel no.</td>
<td>Max. matrix size</td>
<td>Max. touchkey number</td>
<td>Max. channel no.</td>
<td>Max. matrix size</td>
</tr>
<tr>
<td></td>
<td>23 (PD[8] +PC[7] + PB[8])</td>
<td>12x11</td>
<td>155</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Note:

1. For all packages listed in Table 3, maximum matrix size is the theoretical maximum which does not take the communication channels or output driving pins into account.

2. \((P_i[n]+P_j[m]+P_k[p])\) stands for using the full GPIO port “i” containing “n” GPIOs plus the full GPIO port “j” containing “m” GPIOs plus the full GPIO port “k” containing “p” GPIOs.

6 Conclusion

Using the guidelines described above allows the touchkey capabilities of STM8L and STM8S products to be improved without modifying the touch sensing firmware library. In application software, the processing must provide a simple decoding step to determine which touchkey is touched when a pair of channels is activated.
7 Revision history

Table 4. Document revision history

<table>
<thead>
<tr>
<th>Date</th>
<th>Revision</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-Jun-2010</td>
<td>1</td>
<td>Initial release</td>
</tr>
</tbody>
</table>
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