AN3236
Application note

Guidelines to increase the number of touch sensing touchkeys

Introduction

The touch sensing libraries allow management of the following number of channels depending on the targeted device series:

- up to 24 channels when using devices from the STM32F0, STM32F3, STM32L0 and STM32L4 Series.
- up to 34 channels when using devices from the STM32L1 Series.
- up to 6 channels when using devices from the STM8L101 lines.
- up to 20 channels when using devices from the STM8AL Series, STM8L151/152 and the STM8L162 lines.
- up to 24 channels when using devices from the STM8S and STM8AF Series.

The guidelines detailed into this document aim 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 targeted device.

Table 1. Applicable products

Type	Applicable products
Microcontrollers	STM32F0 Series, STM32F3 Series, STM32L0 Series, STM32L1 Series, STM32L4 Series, STM8L Series, STM8AL Series,STM8S Series, STM8AF Series.

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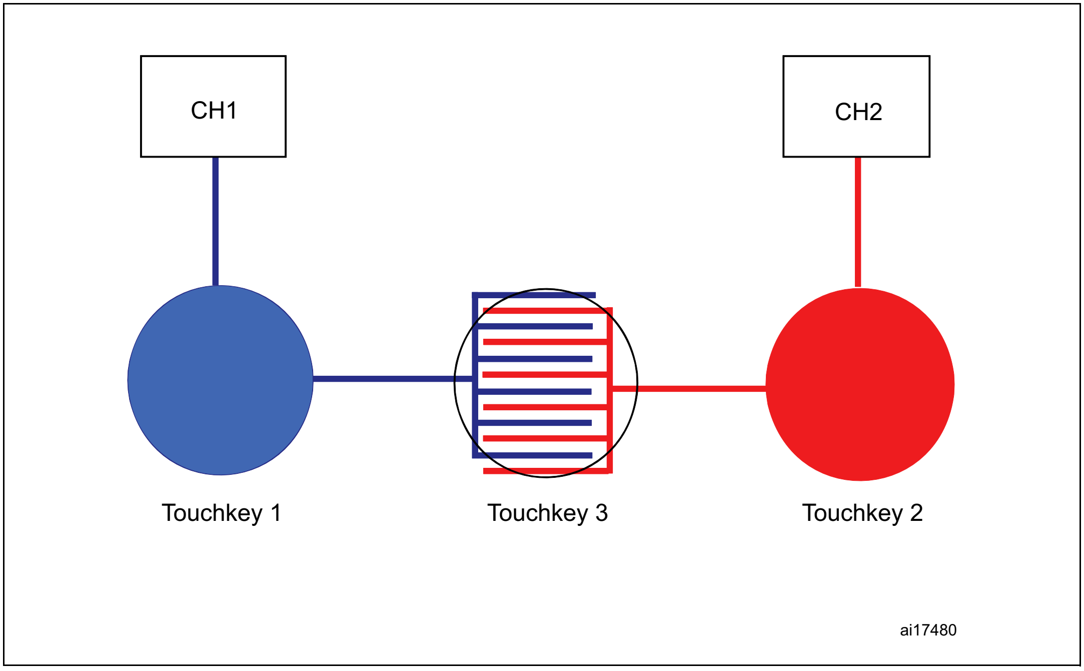
1 Adding an extra touchkey

This section explains how to add an extra touchkey to a pair of single electrodes for an application.

1.1 Basic hardware implementation

As shown in *Figure 1: Basic hardware implementation example*, a standard touchkey is made of a single ended electrode. Two single electrodes can generate a third touchkey by interlacing teeth coming from each electrode.

Figure 1. Basic hardware implementation example



1.2 Software implementation

The touch sensing library manages the channels acquisition as if there are only two single electrodes. The application must thus decode the result of the acquisition as shown in *Table 2: Decoding example*.

Table 2. Decoding example

Touchkeys	Channel 1 state	Channel 2 state
No touch	Idle	Idle
Touchkey 1 touched	Detect	Idle
Touchkey 2 touched	Idle	Detect
Touchkey 3 touched	Detect	Detect

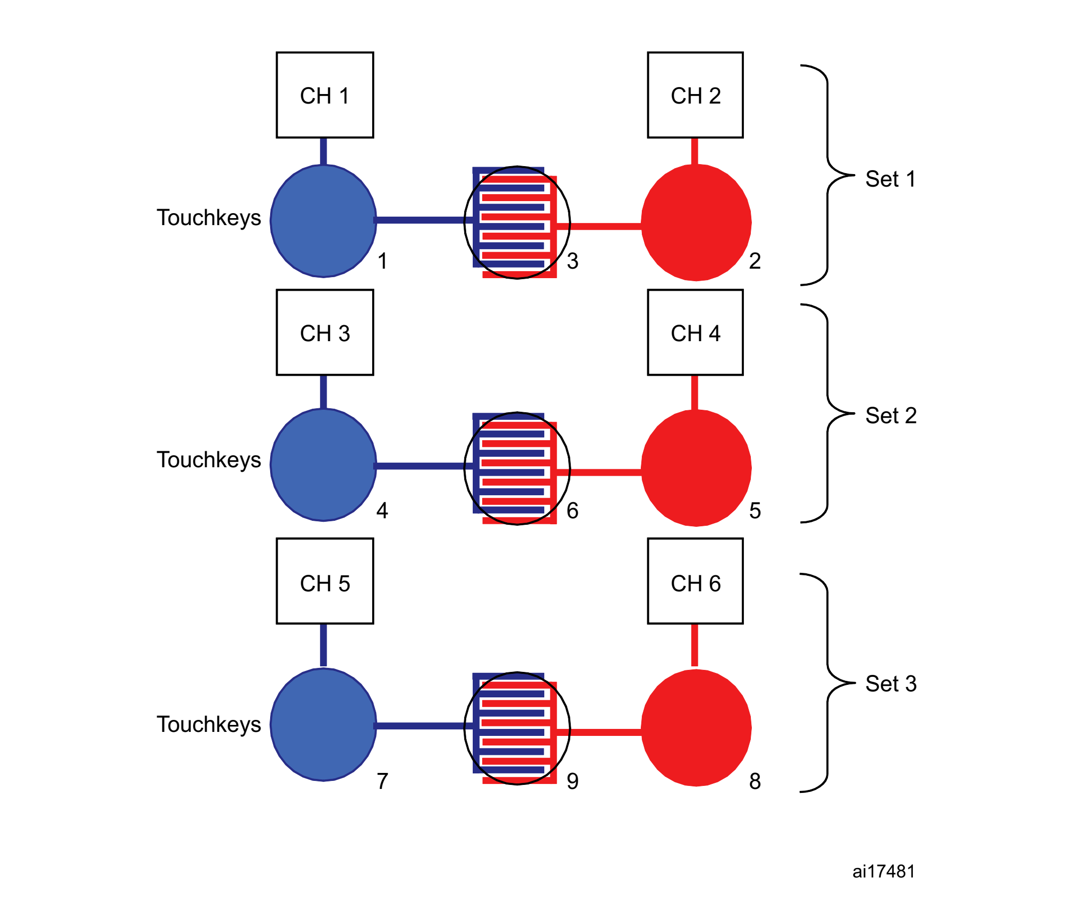
1.3 Limitation

The drawback of this hardware and software implementation is that there is no way to discriminate a touch on both touchkey 1 and touchkey 2 from a single touch on touchkey 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.

2 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



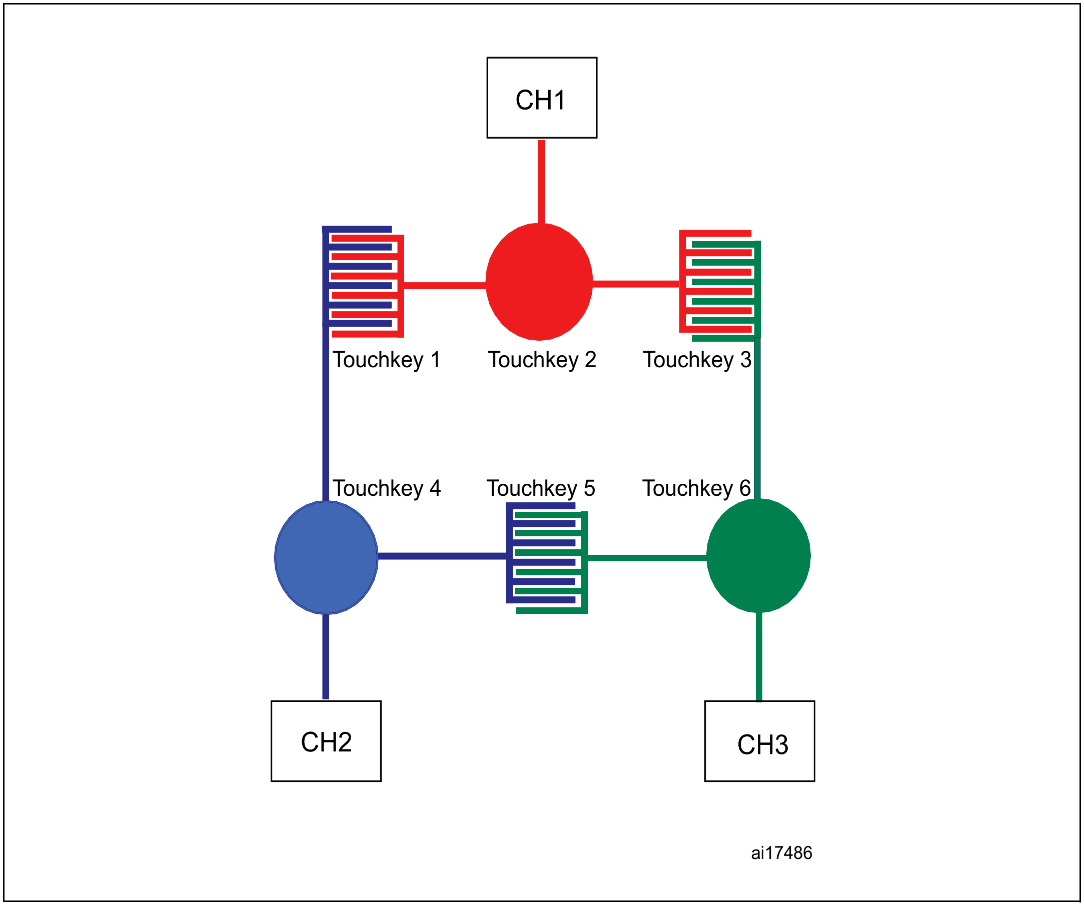
1. A set consists of three touchkeys acquired through two channels.

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



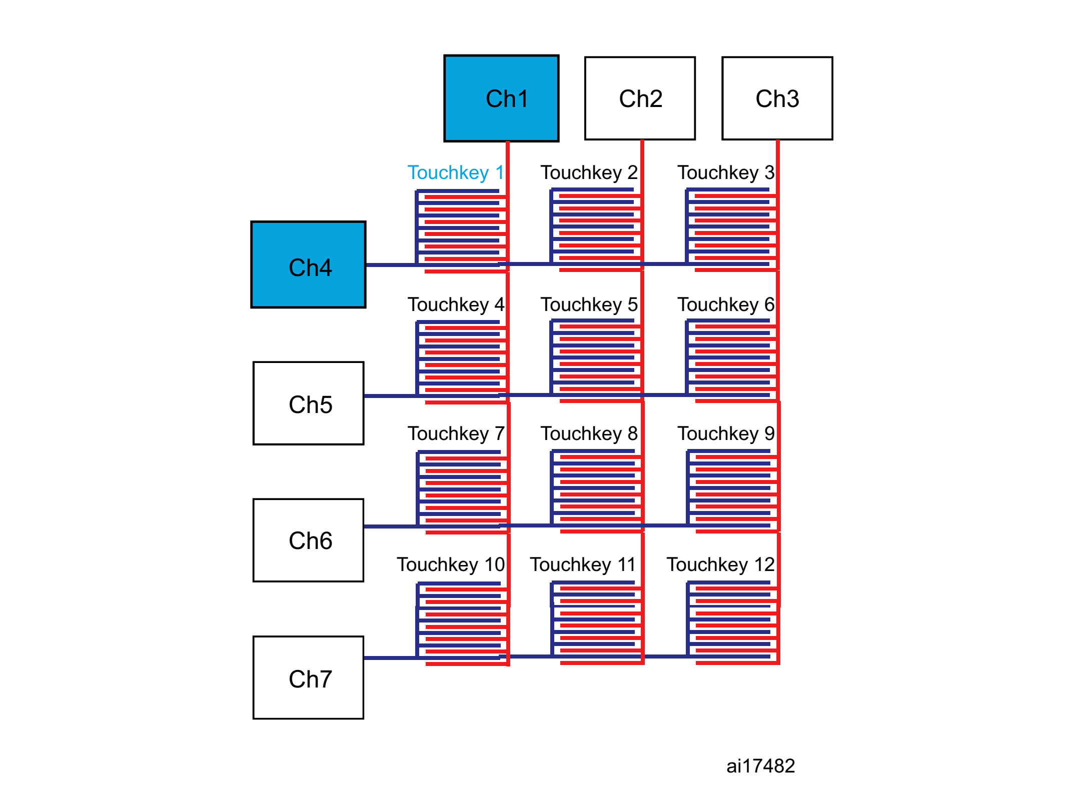
3 Touchkey matrix

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.

3.1 Matrix hardware implementation

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

Figure 4. Matrix hardware implementation example



In this implementation example, seven channels provide a touchkey matrix of12 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 touchkey has the same sensitivity. This simplifies the threshold setup and acquisition can be achieved using the same sampling capacitor value.

3.2 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 also performed at application level depending on the combination of detected channels.

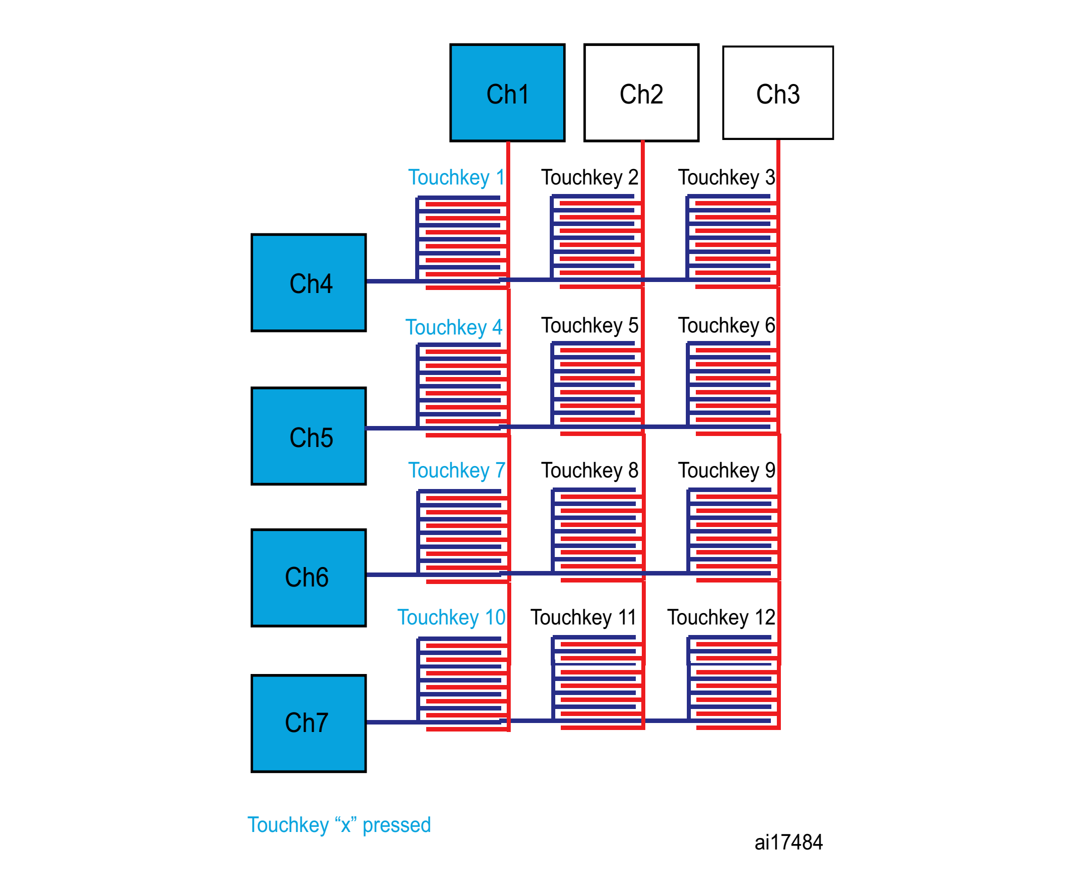
A touch on touchkey 1 triggers a detection on two channels, Ch1 and Ch4 (see *Figure 4: Matrix hardware implementation example*).

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.

3.3 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.

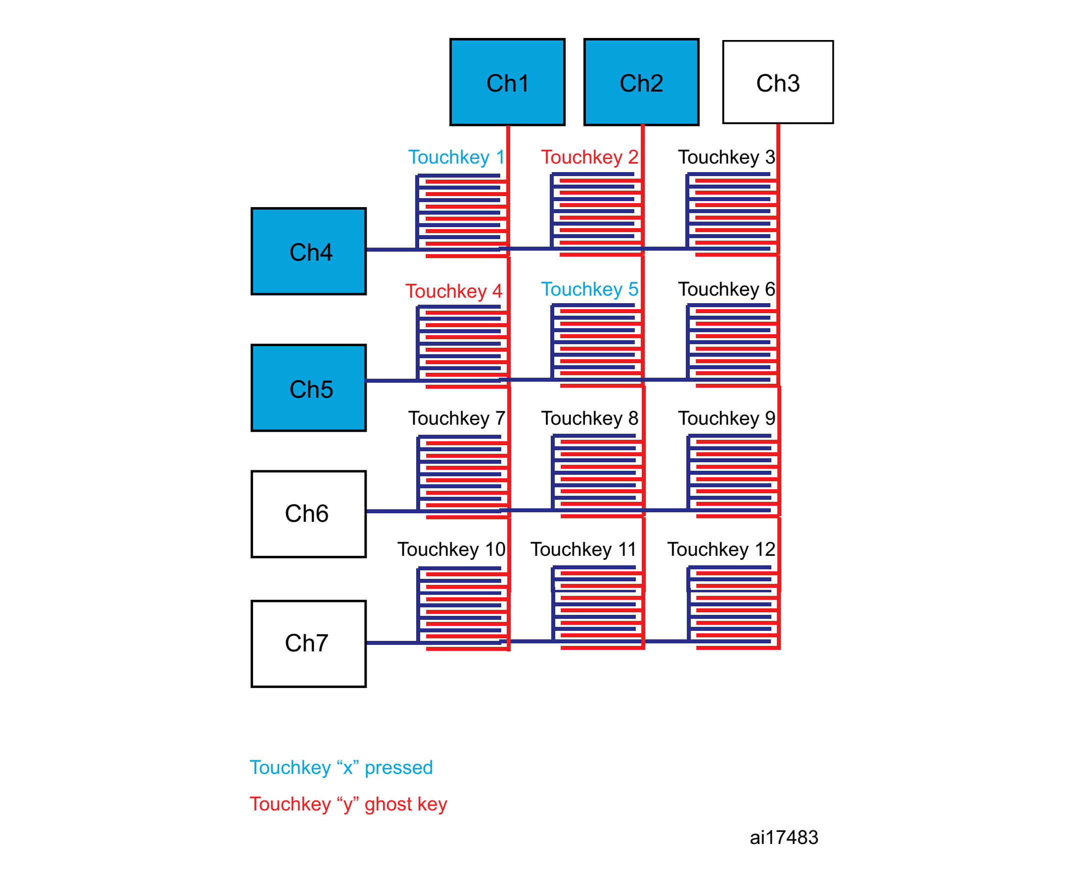
Figure 5. Decodable multi-touch example



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



4 Maximizing the number of touchkeys

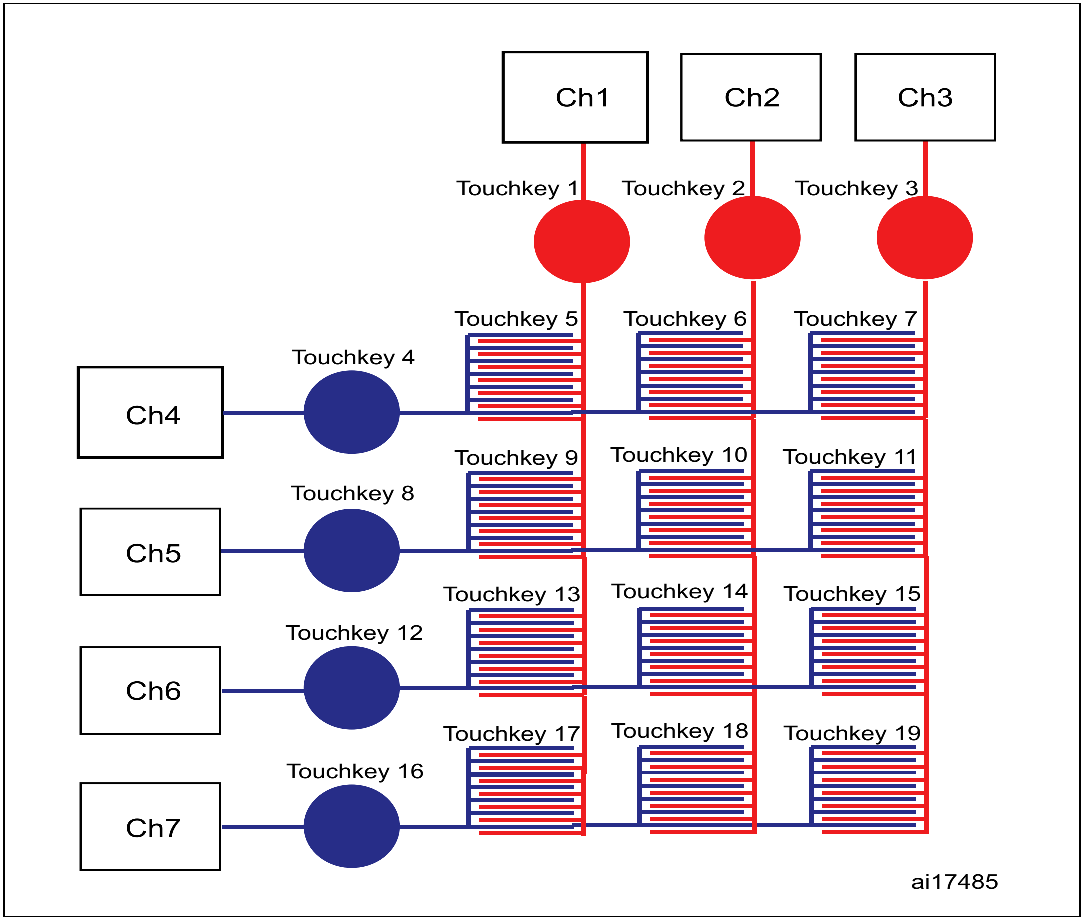
The user can combine the touchkey matrix with single electrode touchkeys to maximize the number of possible touchkeys. This gives a pure single touch interface.

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 touchkey 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



5 Working around the limitations

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

5.1 Touchkeys set definition

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

Sets can be catagorized as follows:

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

5.2 Detection exclusion system (DxS) usage

For a touchkey matrix (without single electrode touchkeys), DxS allows only the first detected touch inside a group to be reported. By defining a DxS 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.

6 Conclusion

The described guidelines allow the touchkey capabilities of STMicroelectronics microcontrollers 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 3. Document revision history

Date	Revision	Changes
18-Jun-2010	1	Initial release.
18-Nov-2013	2	Added support for STM32F0, STM32F3, STM32L1, STM8AF series and STM8L162 lines. Updated *Section 1: Adding an extra touchkey*. Updated*Section 3: Touchkey matrix*. Updated *Section 4: Maximizing the number of touchkeys*. Updated *Section 5: Working around the limitations*. Removed paragraph “Maximum touchkey matrix size by product”. Updated *Section 6: Conclusion*.
28-May-2014	3	Added support for STM32L0 series.
03-Nov-2015	4	Updated *Table 1*: STM32L4 series added (up to 24 channels) and STM8AL series added (up to 20 channels)

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