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## Increase the number of touchkeys for touch sensing applications on MCUs

### Introduction

The guidelines detailed in this document help designers to overcome the channel number limitation. The number of touchkeys can be increased and/or a touchkey matrix can be created, keeping the same targeted device.

The touch sensing libraries allow the management of channels number, that depends on the targeted devices (refer to the product reference manuals for more details).

**Table 1. Applicable products**

Type	Product series
Microcontrollers	STM32F0 Series, STM32F3 Series, STM32L0 Series, STM32L1 Series, STM32L4 Series, STM32L4+ Series, STM32L5 Series, STM32U5 Series, STM32WB Series,

## 1 General information

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This document applies to Arm<sup>®</sup>-based STM32 microcontrollers.

*Note:* Arm is a registered trademark of Arm Limited (or its subsidiaries) in the US and/or elsewhere.

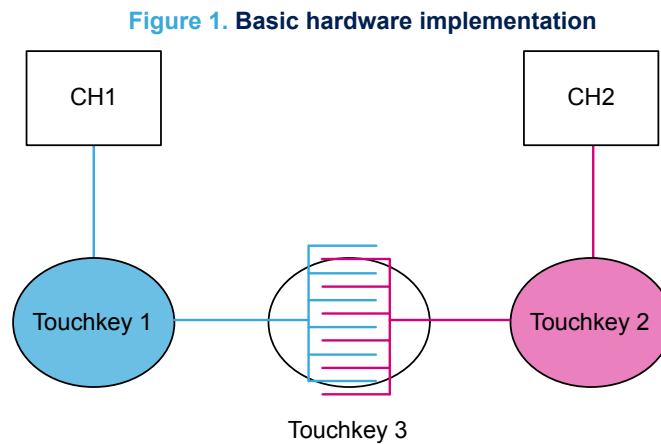


## 2 Adding an extra touchkey

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

### 2.1 Basic hardware implementation

As shown in the figure below, 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.



### 2.2 Software implementation

The touch sensing library manages the channels acquisition as if there were only two single electrodes. The application must decode the result of the acquisition as shown in the table below.

**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

### 2.3 Limitation

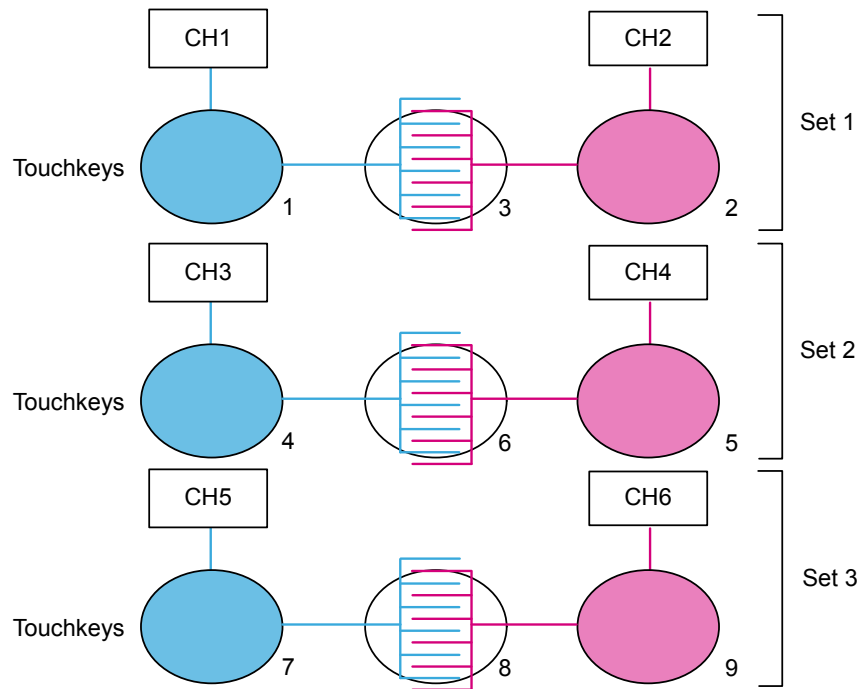
The drawback of this hardware and software implementation is that there is no way to discriminate a touch on both touchkey 1 and touchkey 2, from a single touch on touchkey 3 as implemented in Figure 1.

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.

### 3 Combined implementation

Combined implementation allows any touchkey from set 1, 2 or 3 to be touched simultaneously (see the figure below).

**Figure 2. Combined implementation for multi-touch capability**



Note: A set consists of three touchkeys acquired through two channels.

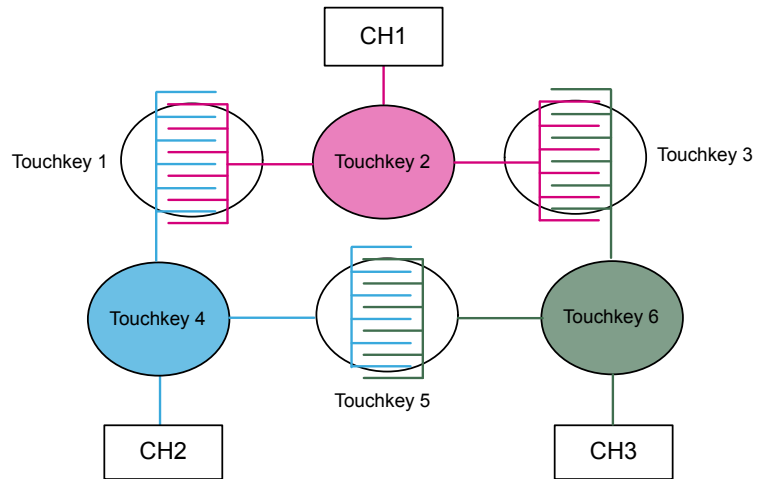
If two touchkeys from the same set are touched concurrently, an incorrect touchkey is detected. For example, touchkeys 1, 6 and 8 can be touched by the user at the same time and the application decodes them correctly. If touchkeys 2 and 3 are touched simultaneously, only touchkey 3 is reported. Likewise, if touchkeys 4 and 5 are touched concurrently, touchkey 6 is incorrectly reported.

A channel can be connected to several double-ended electrodes with the following results:

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

The figure below gives an example of an implementation where six touchkeys are generated with only three channels.

**Figure 3. Implementation for six touchkeys with only three channels**



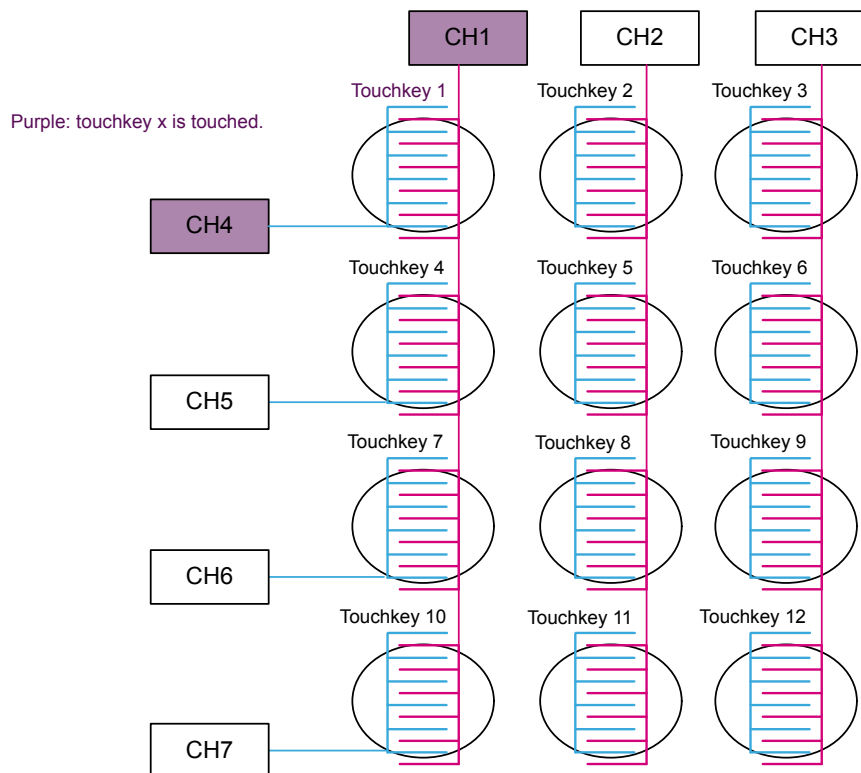
## 4 Touchkey matrix

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.

### 4.1 Matrix hardware implementation

The double-ended electrode solution can be extended to create an electrode network as shown in the figure below.

**Figure 4. Matrix hardware implementation**



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 homogeneous 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.

### 4.2 Software implementation

The 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.

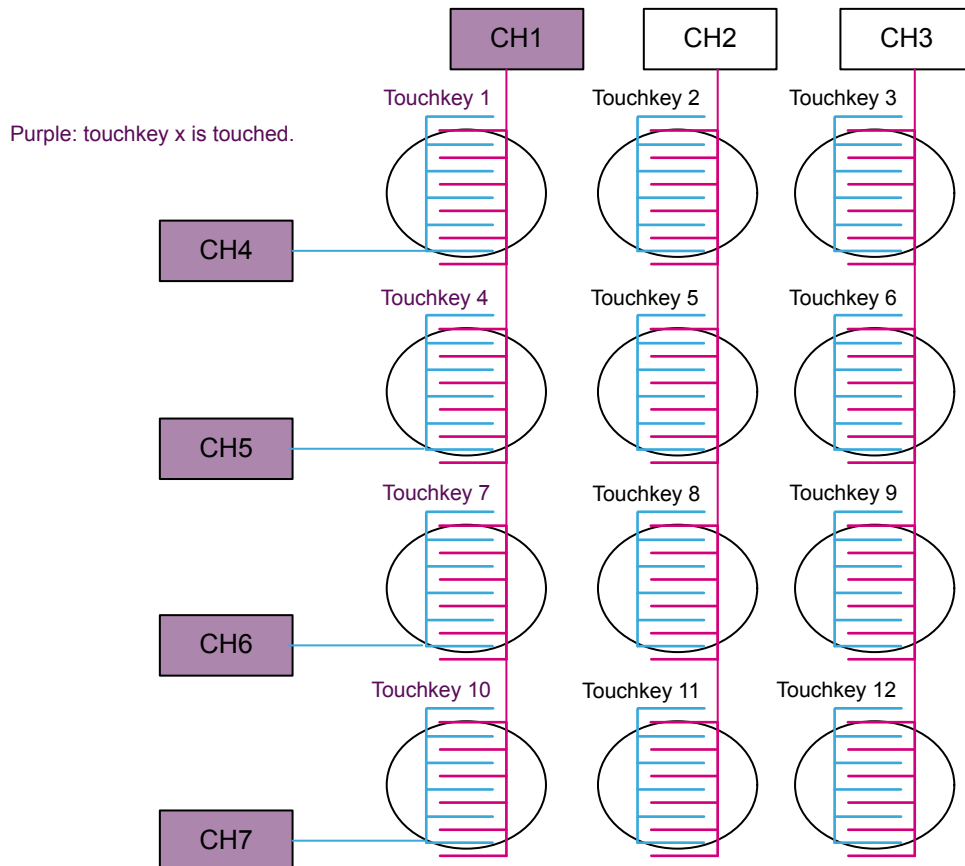
A touch on touchkey 1 triggers a detection on two channels, CH1 and CH4 (see [Figure 4](#)).

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.

### 4.3 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 the figure below, touchkey 1, 4, 7, and 10 are touched simultaneously and can be decoded without ambiguity.

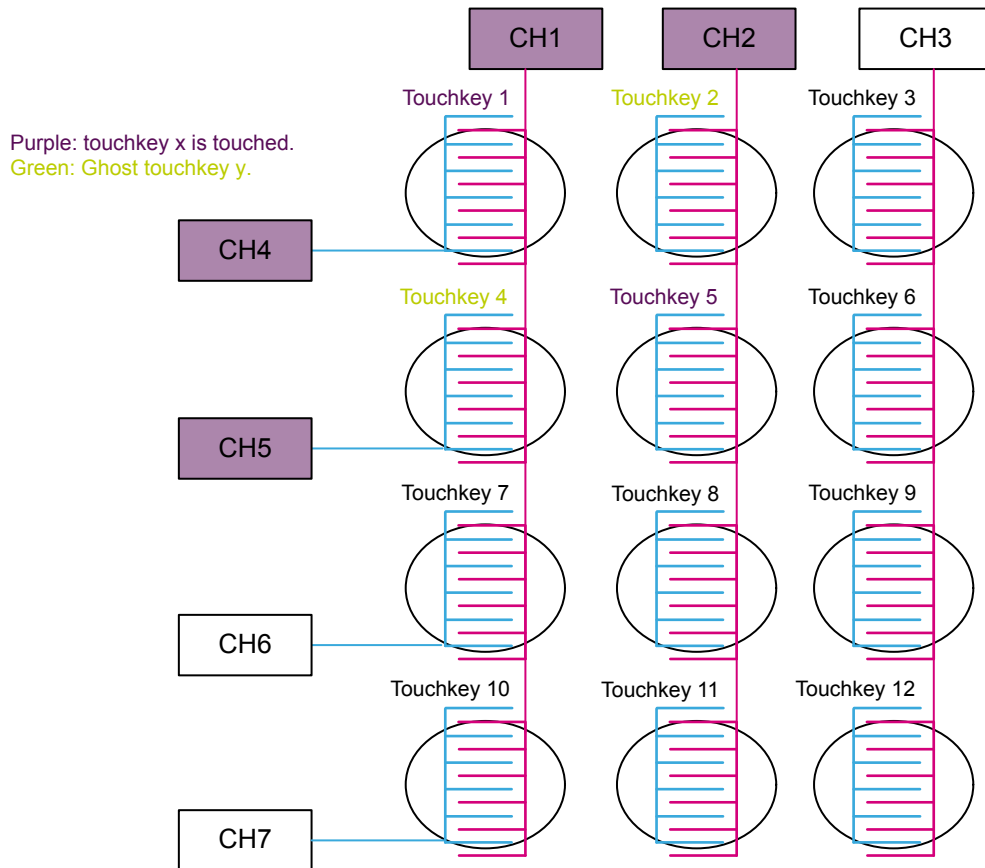
Figure 5. Decodable multi-touch



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 the figure below, 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



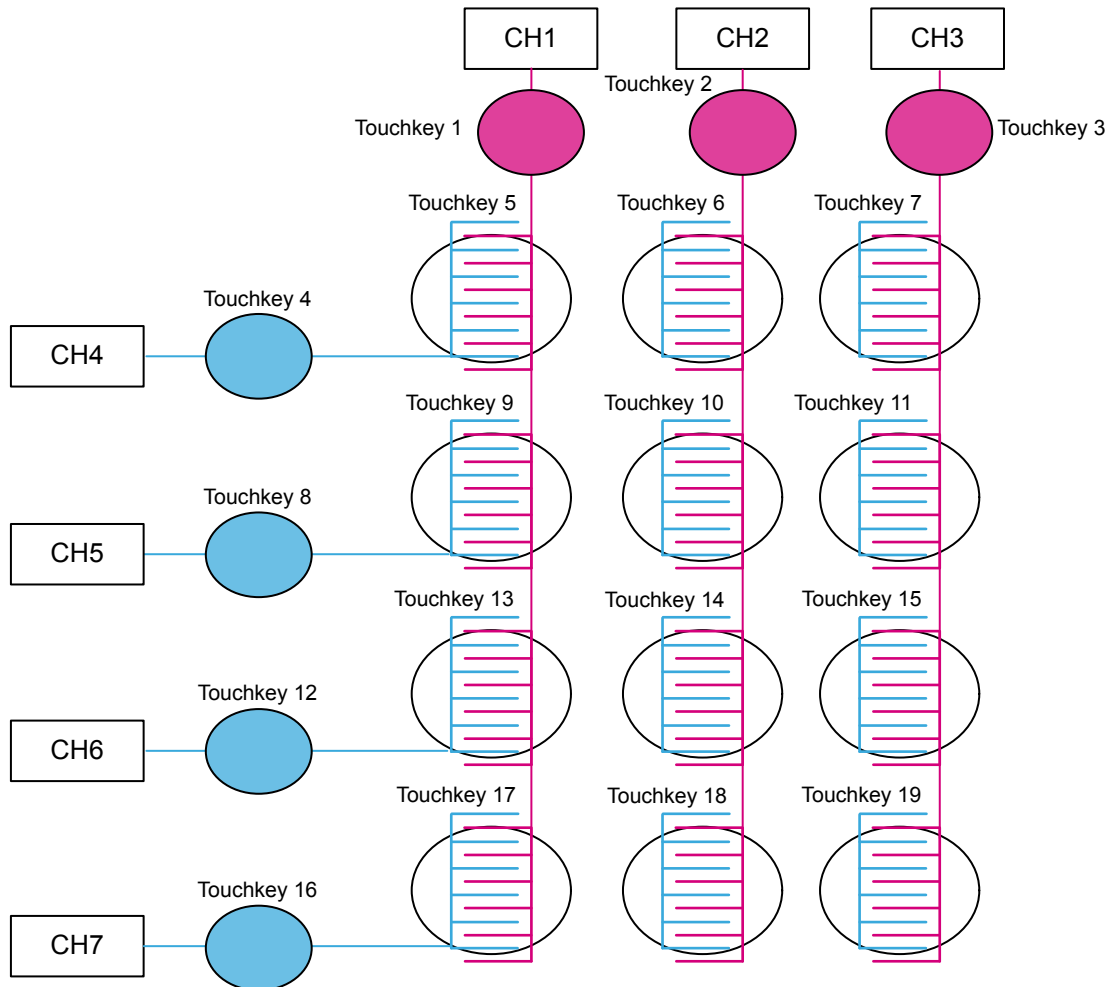


## 5 Maximizing the number of touchkeys

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 the figure below.

**Figure 7. Touchkey matrix with a single electrode on each channel**



There are two decoding cases detailed below:

- 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.

## 6 Working around the limitations

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

### 6.1 Touchkeys set definition

For extra touchkeys and touchkey matrices, it is important to define the sets of touchkeys in which the touchkeys 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 that allow simultaneous touches on any of the independent touchkeys plus one touch on the touchkey matrix
- two touchkey matrices that allow simultaneous touches on each touchkey matrix

### 6.2 Detection exclusion system (DxS)

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.

## **7 Conclusion**

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The guidelines described in this document 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.

## Revision history

**Table 3. Document revision history**

Date	Version	Changes
18-Jun-2010	1	Initial release.
18-Nov-2013	2	<p>Added support for STM32F0, STM32F3, STM32L1, STM8AF series and STM8L162 lines.</p> <p>Updated:</p> <ul style="list-style-type: none"> <li>• Section 1: Adding an extra touchkey</li> <li>• Section 3: Touchkey matrix</li> <li>• Section 4: Maximizing the number of touchkeys</li> <li>• Section 5: Working around the limitations</li> <li>• Section 6: Conclusion</li> </ul> <p>Removed paragraph "Maximum touchkey matrix size by product".</p>
28-May-2014	3	Added support for STM32L0 series.
3-Nov-2015	4	Updated Table 1: STM32L4 series added (up to 24 channels) and STM8AL series added (up to 20 channels).
17-Jan-2019	5	<p>Updated:</p> <ul style="list-style-type: none"> <li>• Title of the document</li> <li>• Introduction</li> </ul> <p>Added Section 1 General information.</p>
16-Mar-2020	6	Updated Table 1. Applicable products
10-Aug-2021	7	<p>Updated::</p> <ul style="list-style-type: none"> <li>• <a href="#">Table 1. Applicable products</a></li> <li>• <a href="#">Section 1 General information</a></li> </ul>

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