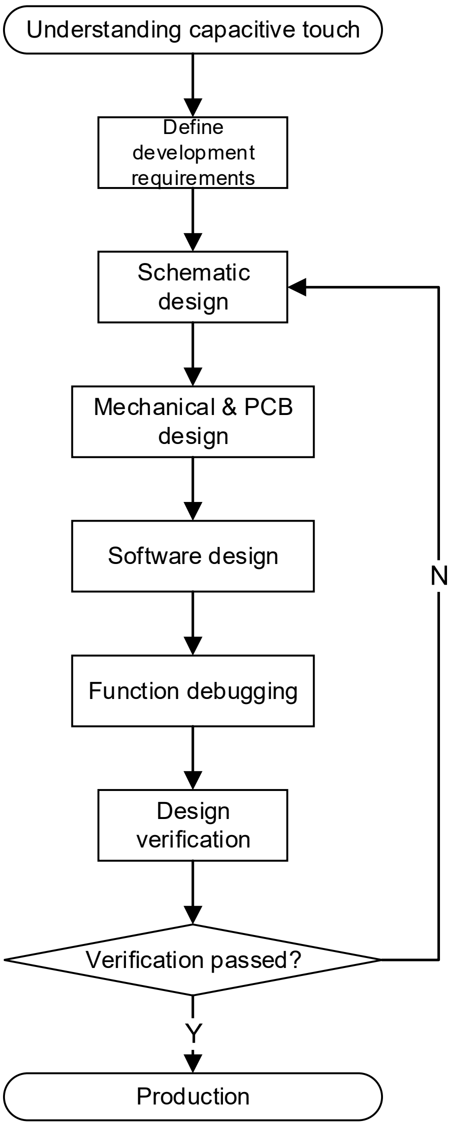
Chapter 1 Introduction

1.1 Overview

This guide describes how to design and apply capacitive touch detection in WCH QingKe RISC-V general-purpose series and Bluetooth Low Energy series MCUs. The main contents include: general PCB design for MCU touch detection, introduction of development tools and related development components. Reading this guide helps to improve the quality of touch applications.

1.2 Capacitive Touch Design Process

Figure 1-1 General flowchart for capacitive touchkey development

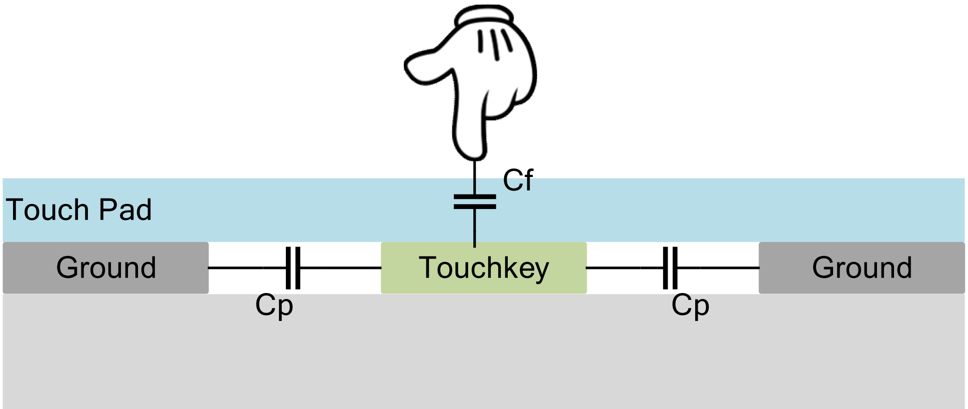


Chapter 2 Introduction to Touch Principle

2.1 Touchkey Capacitor Generation Principle

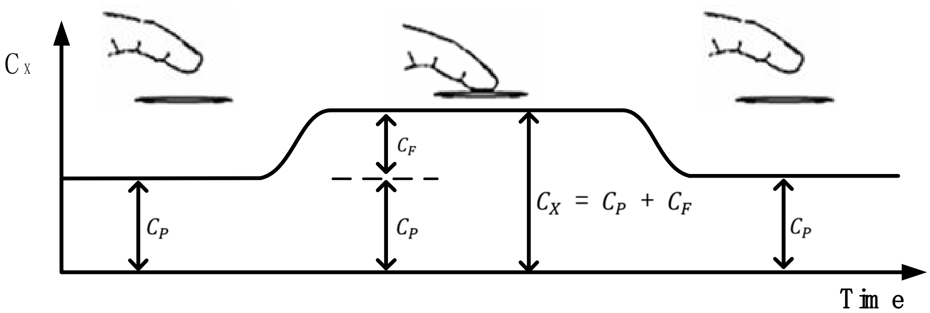
In general applications, the capacitance model of the finger and touch pad can be simplified instead of the capacitance model of the human body and touch pad, as shown in Figure 2-1.

Figure 2-1 Capacitance model of finger and touchpad



The touch pad on the PCB and the nearby ground form a parasitic capacitance C_P. Due to the presence of human body capacitance, when the finger touches the key, the capacitance C_F is introduced and on the C_P, making the total capacitance increase, the total capacitance C_X can be expressed as follows: $C_X = C_P + C_F$. The capacitance change $\Delta C = C_F \approx 0.1{\sim}5pF$. The touch capacitance change is shown in Figure 2-2.

Figure 2-2 Touch capacitance change diagram



WCH touch detection module adopts a capacitive detection scheme:

The touch channel of the microcontroller is connected to the PCB touch pad, and the channel equivalent capacitor (induction capacitor (effective capacitor) + parasitic capacitor) is connected to the touch module inside the chip. After touch enabled, the module charges and discharges the equivalent capacitor. If there is no external factor (such as finger touching pad) causing the capacitance to change, the charging voltage will be relatively fixed; after finger touching pad (the equivalent capacitance increases as shown in Figure 2-2), the charging voltage will decrease. With the same charging time, the voltage value of the touch channel is collected through the internal

ADC of the microcontroller, and the value is different from the value when it is not pressed, and then the key presses and lifts are identified according to the defined threshold.

WCH provides 2 enhancement functions, active shielding and crowded mode, on the basis of the current source charging program. The enhancement function further improves the stability of the touch keys and makes the touch keys waterproof. Bluetooth Low Energy series CH58x/CH59x chips, RISC-V general-purpose series CH32L103 chips, CH32V006/CH32V007 chips support active shielding technology, and QingKe RISC-V general-purpose series, Cortex-M general-purpose series, and Bluetooth Low Energy series support crowded mode.

2.2 WCH Touch Function Description

Bluetooth Low Energy series chips and QingKe RISC-V general-purpose series chips, providing ready-to-use touch function library, customers can also follow the chip manual to develop their own touch function.

2.2.1 Touch Library

In the touch library, a variety of touch algorithms are provided in the form of filters, including filter mode 3 and filter mode CS10. Among them, filter mode 3 supports multiple keys and single keys. Filter mode CS10 can pass the IEC61000-4-6 standard 3-level immunity test, namely CS10V dynamic test, and currently only supports single key recognition. For details, please refer to the document "WCH Touch Library Instructions", which provides a detailed introduction to the use of the touch library.

2.2.2 Low-power Touch

In this mode, RTC wakes up the chip at a time and performs a single key scan. If the scan is suspected to be pressed, a quick scan will be performed to determine the key status. Confirm the key to exit the low-power mode after pressing, otherwise the chip will enter a sleep state again.

The following points should be paid attention to when touching low-power consumption:
(1) Need to enter low-power mode after a period of time without key trigger, the time can be configured by customer;
(2) The larger the timing wake-up interval, the lower the power consumption. In the official example, the timing time is 500ms; if the power consumption requirements are not high, you can shorten the wake-up interval by yourself.
(3) The number of keys and the number of scans have less influence on the power consumption, and only the wake-up interval has a significant influence on the average power consumption.

Chapter 3 Touch Application Development

3.1 Development Kit

3.1.1 Introduction to the development kit

The official touch development kit consists of a core board and a touch function expansion board.

The core boards are divided into 2 categories: general-purpose MCU series and Bluetooth Low Energy series, of which the compatible chip models of general-purpose MCU series core boards are: CH32V00X, CH32L103, CH32V20X, CH32V30X; the compatible chip models of Bluetooth Low Energy series core boards are: CH58X series, CH59X series.

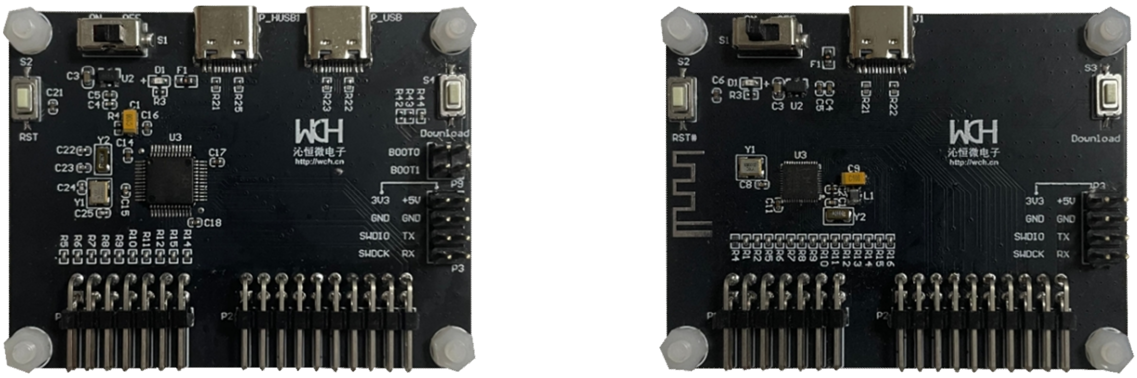
The expansion boards are currently available in 2 models, EX001 and EX002. Among them, EX001 is a comprehensive demo of touch applications, including four touch applications: touch slider, touch slider ring, touch keys and proximity sensing; EX002 is an 8-touchkey.

Note: The number of touch channels used in the expansion board only indicates the number of channels used in the design of the expansion board, please refer to the corresponding datasheet for the specific number of touch channels supported by the chip.

3.1.2 Core Board

Figure 3-1 Touch development kit core board

General MCU Series Bluetooth Low Energy Series



3.1.3 Touch Function Expansion Board

Figure 3-2 Touch development kit function expansion board

EX001

EX002

3.1.4 Sample Code

Examples of designing applications based on touch library are:

(1) 8-channel touchkeys

8-channel touchkeys, corresponding to the demonstration project: "Touch_EX002"; the touch development kit is composed of: core board + function board extended version "EX002", the demonstration function is 8 touchkeys, press the finger, the corresponding channel LED is on, and the LED is off.

(2) Comprehensive application of touchkeys

Comprehensive application of touchkeys, corresponding to the demonstration project: "Touch_EX001"; touch development kit is composed of: core board + function board expansion version "EX001", the demonstration function are: touch slider, touch slider ring, touch keys, Demonstration functions are: touch slide bar, touch slide ring, touch key, proximity sensing; show the effect:

- Proximity sensing: hand close to the expansion board, corresponding LED on, away from the LED off;
- Touchkey: finger presses down, corresponding LED lights up, release LED goes out;
- Touch Slider: LED follows the finger, which position the finger slides to, the corresponding position LED is on, and the rest of the position LED is off;
- Touch Wheel: the same as the touch slider, the LED follows the finger sliding position;

Note: Do not touch your hands or approach the expansion board when powering on;

Chapter 4 Touch Hardware Design

4.1 PCB Design

The state of the capacitive touchkey is related to the slight changes in the parasitic capacitance, so it will be more sensitive to interference. PCB Layout is very important in the design process of capacitive touch systems, which directly determines the stability and sensitivity of the touchkeys. Following the following PCB design rules during the development process can greatly simplify the difficulty of subsequent software development.

The state of the touchkey can be obtained by comparing the capacitance C_F introduced by the finger with the base capacitance C_P that was already present. In order to obtain a capacitive touch system with good sensitivity and high signal-to-noise ratio, we need to design the PCB with C_P as low as possible while ensuring that C_F is as large as possible.

The main components of C_P are the alignment capacitance and the Touch Pad capacitance, while C_F is determined by the contact area between the finger and the Touch Pad (the thickness of the touch panel is fixed).

Table 4-1 Factors influencing touch parasitic capacitance

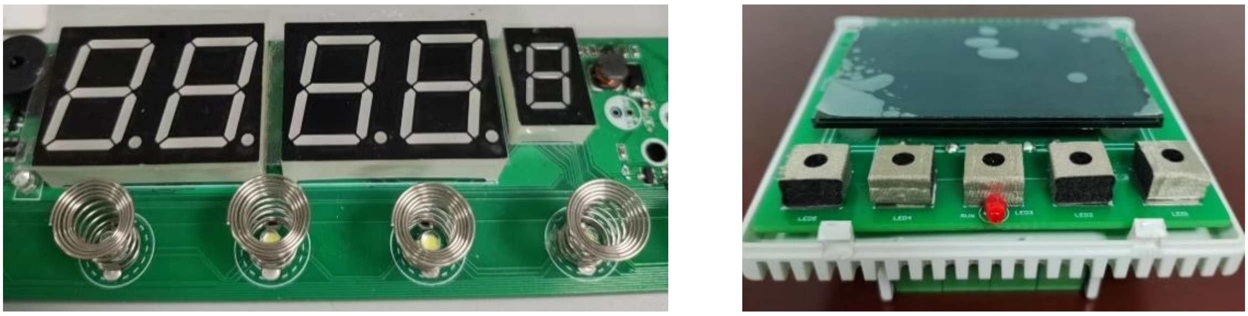
Influential factors	Condition	C_P	C_F
Touch Pad size	Increase	Increase	Increase
	Decrease	Decrease	Decrease
Touch alignment length	Increase	Increase	——
	Decrease	Decrease	——
The gap between touch Pad and the ground grid	Increase	Decrease	——
	Decrease	Increase	——
The gap between touch alignment and ground grid	Increase	Decrease	——
	Decrease	Increase	——

From the Table 4-1, the length of the alignment should be minimized in order to reduce the C_P value. Reducing the length of the alignment enhances noise immunity, reduces noise and improves the signal-to-noise ratio. When the touch pad is larger than the finger size, the C_F basically does not increase, but only increases the C_P, too large a pad in the touch application is not favorable.

Another way to reduce the C_P value is to increase the gap between the touch Pad, the alignment and the ground grid. Note that increasing the gap also reduces noise immunity. Reduce the size of the touch Pad, although it can reduce the C_P, but it will also reduce the C_F, weakening the signal strength. The above 2 measures need to be considered in the application of the actual situation according to a compromise.

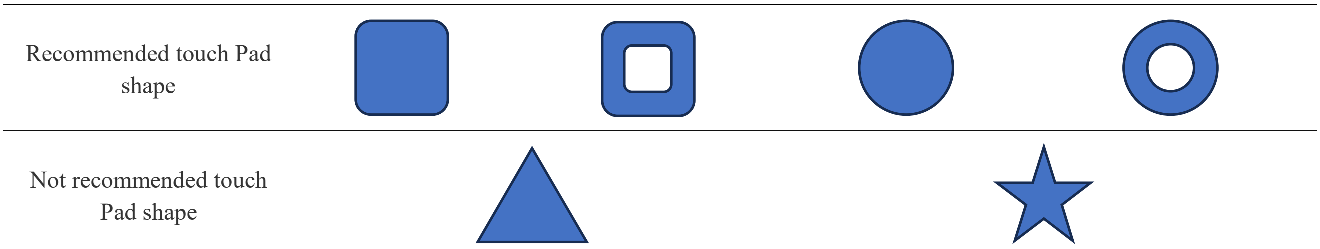
4.1.1 Design and Selection of Touch Pad

Figure 4-1 Flat top spring and conductive cotton used as touch keys



If the touch panel and PCB can be closely bonded by double-sided tape, the PCB copper foil induction key can be used. As a touch key, the copper foil should be coated with solder resist oil without copper exposure, and the shape of the key should be as regular and symmetrical as possible. Generally speaking, the shape of the touch Pad has no influence on the touch performance, as long as a certain effective contact area is ensured. However, attention should be paid to avoid sharp corners in the Pad pattern, and metal sharp corners are easily affected by radiation. Generally, a circular or rounded square pattern of 8mm-15mm is recommended, and the key spacing should be kept above 5 mm. Figure 4-2 lists some recommended and not recommended Pad shapes for reference.

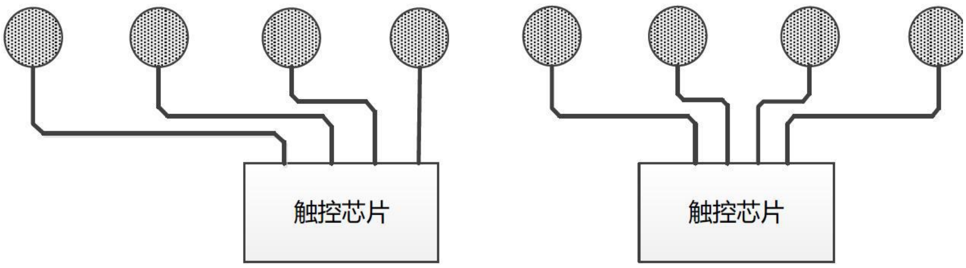
Figure 4-2 Suggestion on Touch Pad shape



4.1.2 Layout

Try to place the chip in the middle of the PCB, so that the distance difference between each channel pin and the touch Pad is small.

Figure 4-3 Schematic Diagram of Chip and pad layout



Poor layout Good layout

4.1.3 Touch Signal Line Layout

(1) The alignment should be as short as possible.

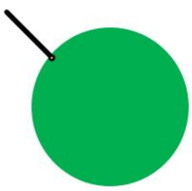
(2) Recommended PCB process allows the minimum line width, generally a minimum of 5mil, the maximum does not exceed 10mil.

(3) Neighboring keys of the alignment of each other as far as possible to ensure that the distance between the more than 20mil, otherwise the neighboring keys to increase interference, affecting the touch performance.

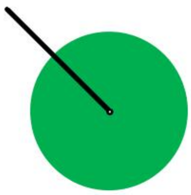
(4) The wiring should minimize the corners, such as cannot be avoided, the corners should be 45 degrees or rounded corners;

(5) Touch Pad can be perforated, the back of the touch signal line, in order to effectively reduce the probability of finger mis-touch. Control the number of holes, the location of the holes should be at the edge of the Touch Pad to reduce the length of alignment.

Figure 4-4 Placement of over hole position on Touch Pad



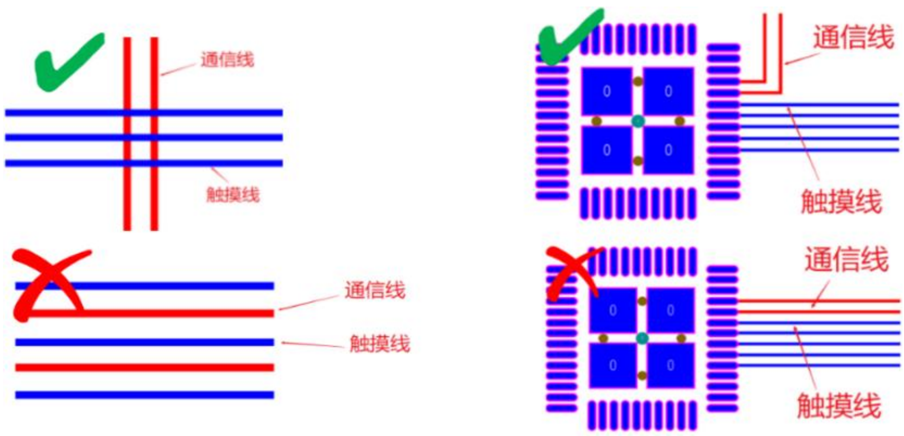
The via hole is at the edge of the Touch Pad, and the alignment is short.



The via hole is in the center of the Touch Pad, and the alignment is long.

(6) Alignment should be avoided close to the high-frequency signal line, such as cannot be avoided, the 2 vertical alignment, such as cannot be vertically aligned between the two need to add a ground (support active shielding of the chip can be used to isolate the shielding line). Add ground isolation should pay attention to the ground line and touch the key signal line spacing should be between 2 to 4 times the line width, as shown in Figure 4-5.

Figure 4-5 Layout Suggestions for the coexistence of touch signal lines and communication lines

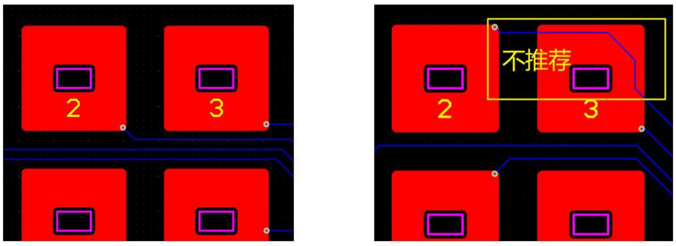


Red line - Communication line

Blue line – Touch line

(7) If the touch signal line and the touch Pad are layered, the signal lines of other keys cannot be taken under the touch Pad, as shown in Figure 46.

Figure 4-6 Touch Pad alignment



Recommended Not recommended

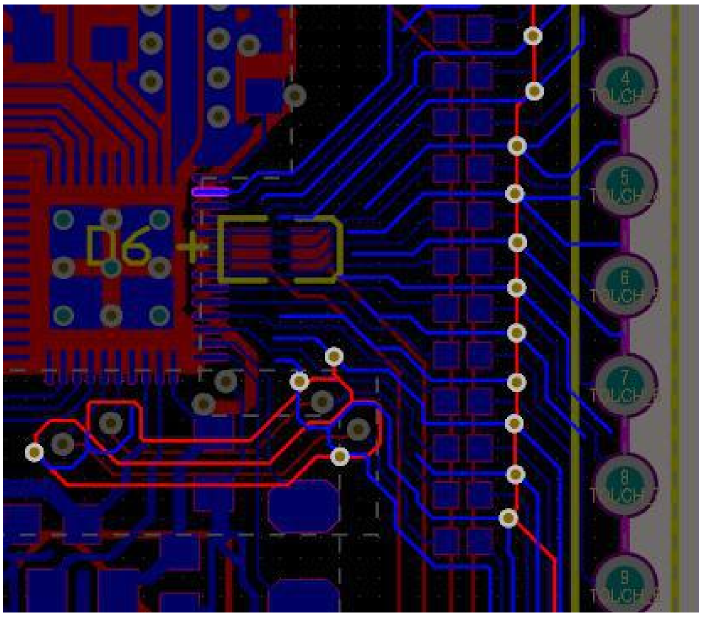
4.1.4 Active Shielding Mode and Crowded Mode Wiring

Active shielding mode and crowded mode are 2 enhanced auxiliary functions of WCH touch key scheme, which can significantly improve the touch effect under conventional layout. Currently, only CH58x and CH59x series chips are supported. RISC-V general series CH32L103 chip and CH32V006/CH32V007 chip. Using these 2 modes, while following the above PCB layout requirements, we should also pay attention to the following points respectively:

(1) Active shielding

On CH583 series and CH59x series chips supporting active shielding mode, the active shielding pin is fixed as PA4, which is turned on by enabling the corresponding register (see the chip manual for details). Active shielding pin alignment should wrap all touchkey alignment, as shown in Figure 4-7. In the highlighted part of the figure, the active shielding pin alignment reduces the basic capacitance by shielding the touchkey alignment, which can significantly improve the capacitance change of the touchkey. Among them, the CH32L103 chips, CH32V006/CH32V007 chips of the RISC-V general series and the CH585 of the Bluetooth Low Energy series are not limited to fixed shielding pins. Any touch pin can be used as shielding pins. Just turn on the active shielding enable and set the required channel shielding position, without actively shielding and wiring according to Figure 4-7.

Figure 4-7 Active shielding pin alignment

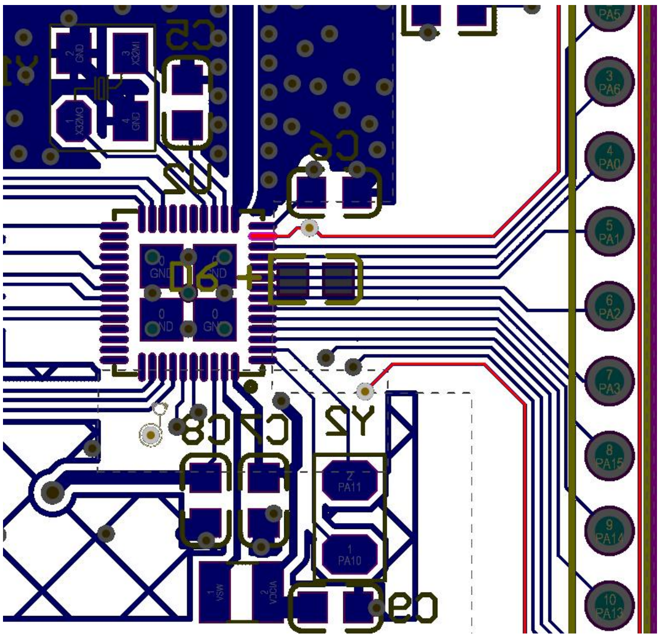


(2) Crowded mode

The crowded mode is used in the case that the PCB space is insufficient and the distance between touchkey alignment is very close, and it supports all chips including touch peripherals in our company. In this mode, the requirement of alignment length can be relaxed appropriately. As shown in Figure 4-8, the crowded mode needs to occupy an additional touch channel, which is used to wrap the touch alignment as a whole, and the key that initializes the touch library for this channel is located at the end of the touch queue and does not participate in the trigger.

Crowded mode can solve the problem of insufficient PCB layout space, and has a certain waterproof effect, and its anti-interference ability is not as good as that of conventional mode, so it needs to be considered in practical use. Please consult our technical support for specific usage.

Figure 4-8 Crowded mode alignment



4.1.5 Grounding

When designing grounding, you can refer to the following suggestions:

(1) The grounding layer around the Touch Pad shall be a grid pattern. If a grounding layer is used on both the top and bottom layers of the PCB, the top layer should occupy 25% of the grid and the bottom layer should occupy 17% of the grid. If an active shield is used instead of a grounding layer, both the top and bottom layers shall use the same grounding grid.

(2) Firmly ground other parts of the PCB not related to capacitive touchkeys as much as possible.

(3) Try to splice the grounding layers on different layers to each other. A large number of layers can be spliced together to reduce the grounding inductance and bring the chip grounding layer closer to the power supply grounding layer. This is especially important when there is a large sink current through the ground layer (e.g., during RF processes).

(4) The bottom layer of the Touch Pad is not grounded directly underneath, and the top layer is generally networked if ground isolation is required. The distance between the Touch Pad and its leads and ground should be guaranteed to be greater than 3mm.

4.1.6 Power Circuit

If the power supply of the touch MCU has strong interference, or the power supply ripple is large, it is recommended to use LDO, ferrite beads and other processing before supplying to the MCU, so as to avoid abnormal operation of the touchkeys.

The VDD and GND of the power supply should be filtered by capacitors and then connected to the VDD and VSS pins of the MCU. The more capacitance on the power supply circuit, the stronger the anti-interference ability.

The decoupling capacitors of MCU should be placed as close as possible to the VDD and VSS pins.

The power supply of the power load is separated from the power supply of the MCU, and the power load should be powered before the decoupling capacitor.

4.2 Touch Pad Selection

Touch pad for insulating or non-conductive materials, its dielectric constant is generally between 1.5 ~ 4. The dielectric constant is too small will lead to poor sensitivity, the dielectric constant is too large will increase the crosstalk between the keys, is not conducive to the accurate recognition of the keys.

Table 4-2 Relative dielectric constants of common materials

Material	Relative dielectric constant
Air	1
Wooden	1.2~2.5
PMMA	2.8
Polycarbonate (PC)	2.7~2.9

Glass	7.6~8
Water	48~80

The greater the thickness of the touch panel, the smaller the touch sensitivity and the lower the signal-to-noise ratio. When using acrylic material, the recommended thickness is 1.5 ~ 3 mm.

It is generally recommended to use double-sided adhesive between the touch panel and the touch pad PCB. The thickness of double-sided adhesive is 0.1~0.15mm, and it is recommended to use 3M 468MP with a thickness of 0.13 mm. Ensure that there is no air gap between the touch PCB and the touch panel, and the air dielectric constant is 1, which greatly affects the sensitivity of touch keys.

4.3 ESD Protection

The non-conductive cover material used in capacitive touch provides a fixed protection function to prevent ESD. The following table lists the thickness of various coating materials to prevent the touch sensor from being affected by 12kV discharge.

Table 4-3 Relationship between common material thickness and breakdown voltage

Material	Breakdown voltage (V/mm)	Minimum thickness to avoid influence (mm)
Air	1200-2800	10
Wooden	3900	3
Common glass	7900	1.5
Glass-borosilicate	13000	0.9
PMMA	13000	0.9
ABS	16000	0.8
Polycarbonate (PC)	16000	0.8

Chapter 5 Modify Records

Version	Date	Description
V1.0	2025.02.12	First edition release