2019.8

# SC04B

## 4-button self-correcting capacitive touch sensor

# 1. Overview

## 1.1 Introduction

SC04B is a self-correcting capacitive touch sensor, which can detect whether 4 induction plates are touched. It can induce the changes in capacitance through any nonconductive medium (such as glass and plastics). Such capacitive sensing switches can be applied to many electronic products, increasing the added value of products.

## 1.2 Characteristics

- ◇ 4 completely-independent touch-sensitive buttons
- ◇ Maintain automatic correction without external intervention
- ◇ Complete joggling removal treatment of button output
- ◇ Parallel one-to-one output
- ◇ All buttons share a sensitivity capacitor
- ◇ Different length of induction line will not result in different sensitivities
- ◇ Operating voltage of 2.6V- 6.0V
- ◇ Environmental-friendly SOP16 encapsulation meeting the RoHS instructions

## 1.3 Application

- ◇ Replace mechanical switches
- ◇ Home applications (TV, display, keyboard)
- ◇ The human-machine interface for tools and interactive games
- ◇ Access control keys
- ◇ Lamp control switch
- ◇ The panel of sealed keyboards

## 1.4 Encapsulation

SOP16 encapsulation is adopted for SC04B

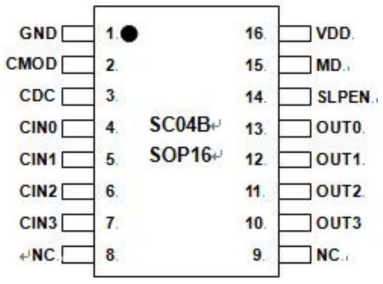



**Figure 1-1: The schematic diagram of encapsulation**

## 1.5 Pins

**Table 1-1: Summary of pins**

| Number of the pin | Name | Type | Function | Out-of-service |
|---|---|---|---|---|
| **1** | GND | **Pwr** | Power ground | - |
| **2** | CMOD | **I/O** | Connect to charge collecting capacitor | - |
| **3** | CDC | **I/O** | Connect to sensitivity capacitance | - |
| **4** | CIN0 | **I/O** | Induction button 0 – detection input | Hang in the air |
| **5** | CIN1 | **I/O** | Induction button 1 – detection input | Hang in the air |
| **6** | CIN2 | **I/O** | Induction button 2 – detection input | Hang in the air |
| **7** | CIN3 | **I/O** | Induction button 3 – detection input | Hang in the air |
| **8** | NC | | | |
| **9** | NC | | | |
| **10** | OUT3 | **OD** | Induction button 3 -output | Hang in the air |
| **11** | OUT2 | **OD** | Induction button 2-output | Hang in the air |
| **12** | OUT1 | **OD** | Induction button 1 -output | Hang in the air |
| **13** | OUT0 | **OD** | Induction button 0 -output | Hang in the air |
| **14** | SLPEN | **I** | Sleep enable terminal | - |
| **15** | MD | **I** | Mode selection terminal | - |
| **16** | VDD | **Pwr** | Positive electrode of power supply | - |

**Pin types**

| | |
|---|---|
| **I** | **CMOS input** |
| **I/O** | **CMOS input/output** |
| **OD** | **NMOS open-drain output** |
| **Pwr** | **Power supply/grounding** |

## 1.6 Description of pins

**VDD, GND**

Positive and negative input terminals of the power supply.

**CMOD**

The input end of the charge collecting capacitor which is connected to the fixed-value capacitor and is unrelated to the sensitivity.

**CDC**

It is connected to the sensitivity capacitor, with the range of capacitance of 5pf – 100pf. Appropriate capacitance value shall be selected according to the operating environment. The smaller the value is, the higher the sensitivity is.

**CIN0-CIN3**

It is connected to the induction plate and is the input inspection port of the induction

capacitance.

**OUT0-OUT3**

It is a parallel one-to-one output port, corresponding to CIN0-CIN3 respectively. The internal structure of the port is a NMOS open-drain output port with a pull-up resistor for outputting weak-high level or strong-low level, with the effective level of strong-low level.

**MD**

Output mode selection terminal. When MD connects with GND, OUT0-OUT3 is the direct output mode: When it detects that a finger touches it, its output will become low level from high resistance. After the finger leaves it, its output will become the original state. When MD connects with VDD, OUT0-OUT3 is the latch output mode: When it detects that a finger touches it each time, the output level will be switched and the status will be latched.

**SLPEN**

Sleep mode enable terminal. When SLPEN connects with GND, the chip is prohibited to enter into the sleep mode. When SLPEN connects with VDD, the chip can enter into the sleep mode.

# 2. Functions of the chip

## 2.1 Initialization time

After the power on reset, the chip needs 200ms for initializing and calculating the environmental capacitance of induction pins before normal operation.

## 2.2 Setting of sensitivity

The sensitivity is determined by the capacitance value of the CDC port. The smaller the value is, the higher the sensitivity is.

## 2.3 Self-correcting

According to the drift of the external environment temperature and humidity, the benchmark reference value of the button capacitor will also drift. The chip will automatically adjust and correct the benchmark reference capacitance value of each button to adapt to the changes in the current environment.

When a button is detected, the chip will immediately stop correction for about 100s. Once the correction stop time is up, the chip will continue to conduct self-correction. If the button is still valid continuously, the button information will be updated immediately as the drift of the environment, that is, the effective detection time of the button will not exceed 100s.

## 2.4 Touch response time

Each channel will conduct sampling about per 4.5ms. After the joggling removal treatment of the button, the response time for detecting the button pressing is about 28 ms. The response time for detecting the button leaving is about 18 ms. Therefore, the maximum frequency for button detection is about 20 times per second.

## 2.5 Output logic

Touch output has two statuses: Weak high or strong low.

When MD connects with GND, if there is touch, the output is strong low; if there is no touch, the output is weak high.

When MD connects with VDD, each time of touch will cause output switching and the status will be latched.

**Table 2-1 MD connects with GND: Direct output mode**

| Time frame | Time frame 1 | Time frame 2 | Time frame 3 | Time frame 4 | Time frame 5 | Time frame 6 |
|---|---|---|---|---|---|---|
| Action | Reset of the chip | No finger | Finger touching | No finger | Finger touching | No finger |
| Touch output | Weak high | Weak high | Low level | Weak high | Low level | Weak high |

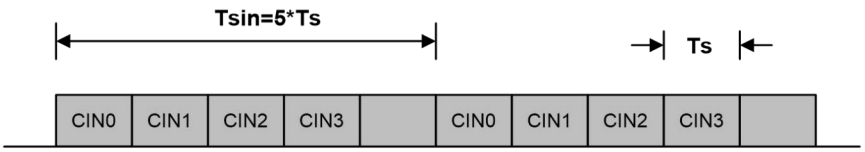
**Table 2-2 MD connects with VDD: Latch output mode**

| Time frame | Time frame 1 | Time frame 2 | Time frame 3 | Time frame 4 | Time frame 5 | Time frame 6 |
|---|---|---|---|---|---|---|
| Action | Reset of the chip | No finger | Finger touching | No finger | Finger touching | No finger |
| Touch output | Weak high | Weak high | Low level | Low level | Weak high | Weak high |

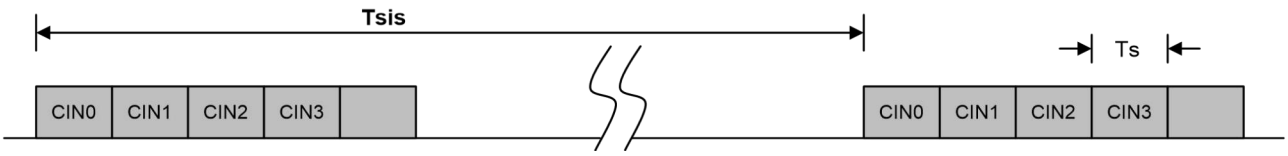
## 2.6 Sleep mode

When SLPEN connects with VDD, if the time under no finger touch exceeds 70s, the chip will enter into the sleep mode. In the sleep mode, the sampling interval of the key will become longer and the current consumption (Idd) will be reduced. If detecting the key, the chip will enter into the normal mode from the sleep mode immediately.

When SLPEN connects with GND, the chip is prohibited to enter into the sleep mode and will be always at a normal mode.




The graphical representation of the sampling period under the normal mode




The graphical representation of the sampling cycle under the sleep mode

Figure 2-1: The graphical representation of the sampling period under the normal and sleep modes

Note Ts: The sampling period of single button is about 860 us

Tsin: The sampling interval under the normal mode is about 4.5ms

Tsis: The sampling interval under the sleep mode is about 230ms

# 3. Application

## 3.1 The application circuit

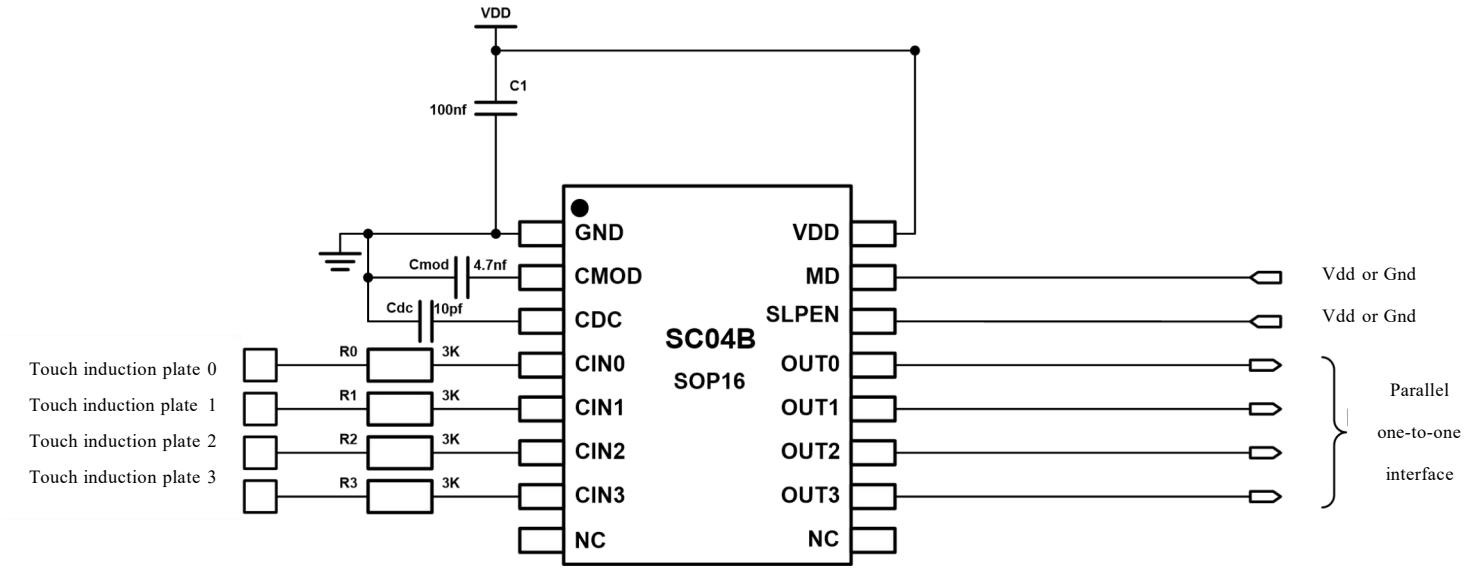



**Figure 3-1: The application circuit**

**Precautions:**

1. **Cmod is a charge collecting capacitor, with the normal value range of 1nf-10nf, with the**

typical value of 4.7nf.

2. Cdc is a sensitivity capacitor, the value range of 5pf - 100pf. The smaller the capacitance value is, the higher the sensitivity is.
3. OUT0-OUT3 output pin is integrated with a 10k pull-up resistor internally, which can be connected with the single chip microcomputer directly, without connecting with a pull-up resistor.

# 4. Detailed parameters

## 4.1 Rated value*

Working temperature ……-40 - +85ºC
Storage temperature ……-50 - +150ºC
Maximum Vdd voltage ……-0.3 - +6.0V
The maximum DC output current of the pin ……±10mA
The margin voltage of the pin ……-0.3V - (Vdd + 0.3) Volts

* Note: exceeding the above value may result in the permanent damage of the chip

## 4.2 Electrical characteristics

**Table 4-1: Electric parameter TA = 25℃**

| Characteristics | Symbol | Condition | | Minimum value | Typical value | Maximum value | Unit |
|---|---|---|---|---|---|---|---|
| Operating voltage | Vdd | | | 2.6 | | 6.0 | V |
| Current loss | Idd | VDD=5.0V | Normal mode | | 0.73 | | mA |
| | | VDD=3.3V | | | 0.51 | | mA |
| | | VDD=5.0V | Sleep mode | | 13 | | UA |
| | | VDD=3.3V | | | 10 | | UA |
| Power-on initialization time | Tini | | | | 200 | | ms |
| The capacitance range of the induction pin | Cin | | | | | 2.5*Cdc[1] | |

| | | | | | | |
|---|---|---|---|---|---|---|
| OUT0-OUT3 output resistance | Zo | delta Cin > 0.2pF | | 50 | | Ohm |
| | | delta Cin < 0.2pF | | 10K | | |
| OUT0-OUT3 output sink current | Isk | VDD=5V | | | 10.0 | mA |
| Minimum detection capacitance | delta_Cin | CDC=15pf | | 0.2 | | pF |

**Note: [1] If the stray capacitance of the induction pin exceeds 2.5 times of the Cdc capacitance, the chip will not work normally (this limitation does not need to be considered mostly)**

## 4.3 The dimensional drawing of encapsulation (SOP-16)

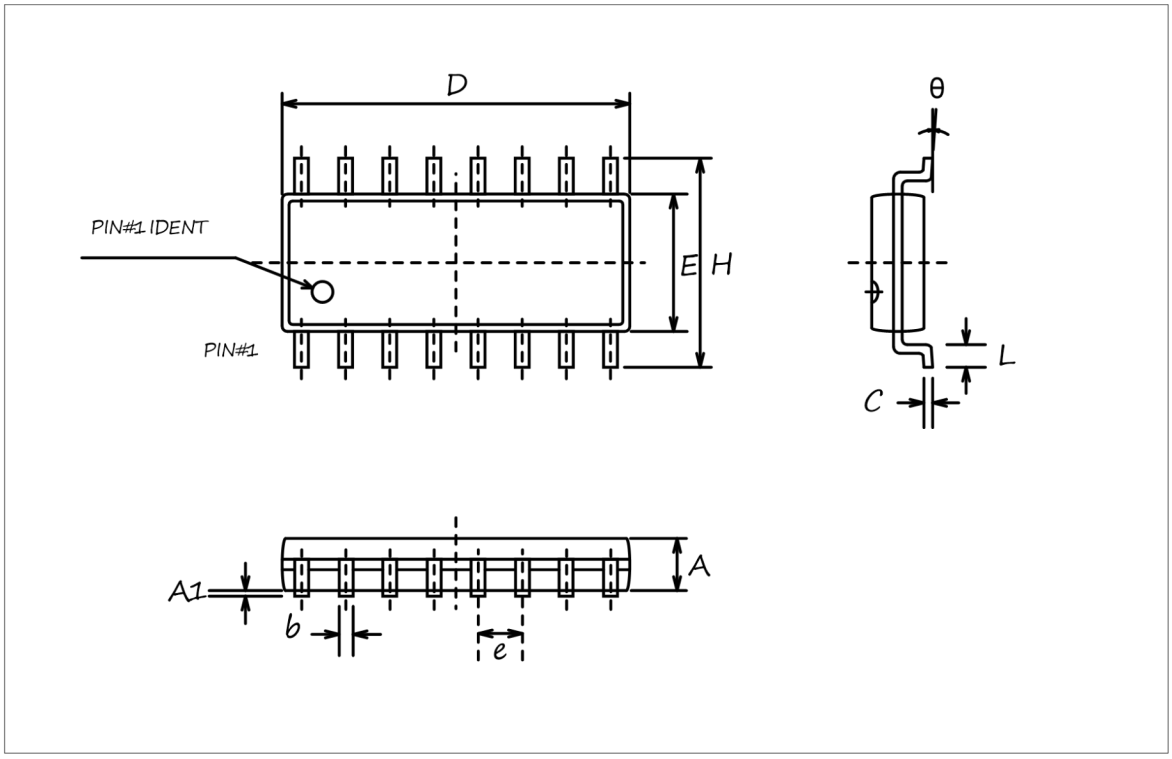



**Figure 4-1: The example of SOP16 encapsulation**

**Table 4-2: Dimension parameters of encapsulation**

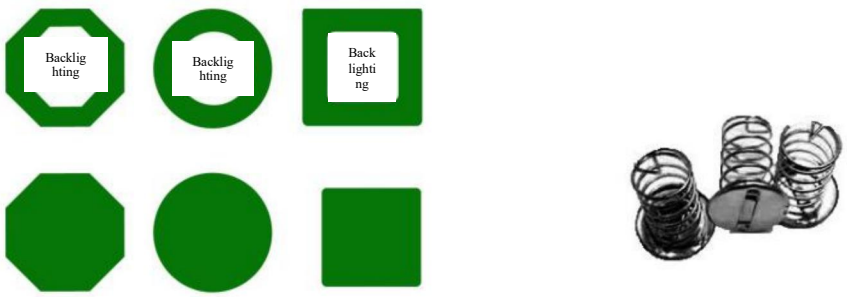
| Symbol | Dimensions In Millimeters | Dimensions In Inches |
|---|---|---|

| | Min | Nom | Max | Min | Nom | Max |
|---|---|---|---|---|---|---|
| A | 1.30 | 1.50 | 1.70 | 0.051 | 0.059 | 0.067 |
| A1 | 0.06 | 0.16 | 0.26 | 0.002 | 0.006 | 0.010 |
| b | 0.30 | 0.40 | 0.55 | 0.012 | 0.016 | 0.022 |
| C | 0.15 | 0.25 | 0.35 | 0.006 | 0.010 | 0.014 |
| D | 9.70 | 10.00 | 10.30 | 0.382 | 0.394 | 0.406 |
| E | 3.75 | 3.95 | 4.15 | .0148 | 0.156 | 0.163 |
| e | -- | 1.27 | -- | -- | 0.050 | -- |
| H | 5.70 | 6.00 | 6.30 | 0.224 | 0.236 | 0.248 |
| L | 0.45 | 0.65 | 0.85 | 0.018 | 0.026 | 0.033 |
| θ | 0° | -- | 8° | 0° | -- | 8° |

# 5. Button sensor of the capacitor

## 5.1 The material and shape of the touch button

The touch button can be a conductor in any shape, with a hole or hollow in the middle. However, a certain flat area shall be guaranteed. The round or square touch button with the diameter larger than 12mm is recommended. However, the point effect shall be avoided. The touch induction plate may be PCB copper foil, metal sheet, flat-top cylinder spring, conductive cotton, conductive ink, conductive rubber, conductive glass with ITO layer, etc.. As shown in Figure 5-1:




The button induction plate may be solid or hallow, in rectangle, circle or polygon

**Figure 5-1: Examples of button induction plates with different shapes**

## 5.2 The dimension of the touch induction plate

The size dimension of the touch induction plate: Minimum 4mmX4mm, Maximum 30mmX30mm. The actual area shall be determined according to the sensitivity. The area is proportional to the sensitivity. Generally, the diameter of the button induction plate shall be larger than 4 times of the

thickness of the plate. The increasing of the electrode dimension may improve the signal-to-noise ratio. The shape and area of each induction plate shall be the same, so as to ensure the consistent sensitivity. In general, the typical value for most applications is 12mmX12mm.

## 5.3 The connection way of the touch PAD and touch panel

(1) When PCB copper foil is used for manufacturing the touch PAD, the touch PAD shall be directly pasted on the touch panel with the double-side adhesive tape.

(2) When the paster with the spring is used for manufacturing the touch PAD, the touch PAD must be pressed against the panel.

(3) When the conductive rubber or conductive cotton is used, the bottom of the conductive rubber or conductive cotton shall be pasted in the copper foil of PCB. The top shall be closely attached to the panel as the induction plate.

(4) The flexible PCB made of conductive ink or ITO shall be inserted into the interface of the touch port.

## 5.4 The selection of the touch panel

The panel must be made of insulating materials, such as glass, polystyrene, polyvinyl chloride (PVC), nylon and resin glass. During the production, the material and thickness of the panel shall remain unchanged. Insulating paints must be used for the surface spraying of the panel. When the area of the touch induction plate is fixed, the sensitivity is based on the thickness and material of the plate.

The general plate thickness is 0-10 MM. The typical thickness of different materials is different. The surface of the button induction plate shall be flat and tightly attached to the panel, without air gap.

In the actual application, the customer shall find the ideal compromise value according to the actual needs. The following table shows the recommended values of PAD size and the thickness of different plates.

**Table 5-1: Recommended values for PAD size and the thickness of different plates**

| PAD diameter (MM) | Acrylic (Dielectric constant of 2.6-3.7) (MM) | Resin glass (Dielectric constant of 3.4) | ABS (Dielectric constant of 3.8-4.5) | Mica sheet (Dielectric constant of 4-8) | Common glass (Dielectric constant of 7.6-8.0) |
|---|---|---|---|---|---|
| 8 | 2.25 | 2.5 | 3 | 4.1 | 5 |
| 10 | 3.25 | 3.8 | 4.3 | 6.2 | 8 |
| 12 | 4.5 | 5.1 | 5.6 | 8 | 10 |
| 14 | 5.5 | 6 | 6.8 | 10 | 12.5 |

# 6. Power supply

## 6.1 Current voltage stabilizer

SC series touch chip can reflect the touch output by measuring the minor change of capacitance. Therefore, it is required that the ripple wave and noise of the power supply shall be small. Strong external interference due to the connection of the power supply shall be avoided. Especially for application in the induction cooker and the microwave oven, the external interference and voltage leap must be isolated effectively. Therefore, the power supply is required to have a higher stability. The 7805 voltage stabilizing circuit shown in the following figure is recommended to be adopted.

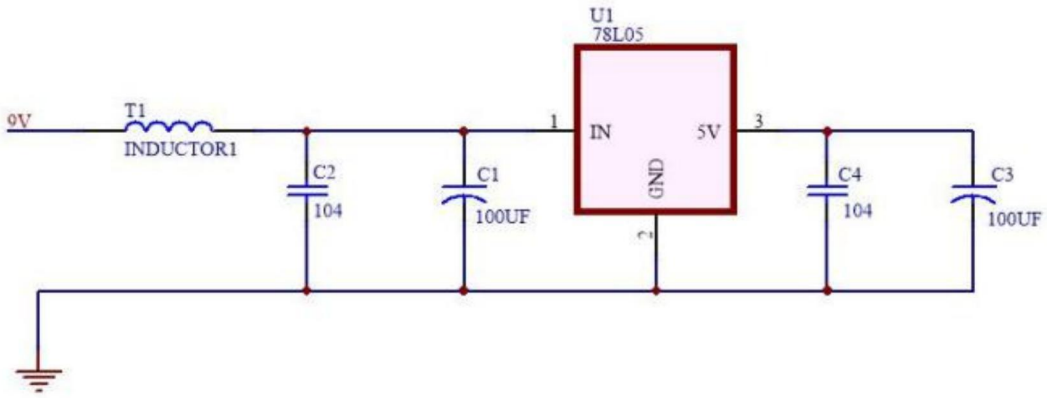



**Figure 6-1: 7805 voltage stabilizer**

During PCB layout, if the environment is harsh, the inductor T1 bonding pad in the above figure is recommended to be reserved to cope with the interference of high noise such as the induction cooker. During common applications, the inductor is not required.

## 6.2 The placement of the voltage stabilizer

During PCB LAYOUT, the devices of 7805 electrical power package shall be as close to the VDD and GND pins of the chip as possible. The devices of 7805 electrical power package shall be placed on the same circuit board as the touch chip to the greatest extent, and be placed centrally, so as to eliminate the noise caused by the excessively long power line.

## 6.3 Precautions under noise conditions

For application in the high noise environment, the overlapping of the mainboard with high voltage (220V), large current and high frequency and the touch circuit board shall be avoided. If it is

unavoidable, it shall be away from the area with high-voltage large-current devices as far as possible or a shielding shall be installed on the mainboard.

### 6.4 The 5V power supply of the host shall be used

If the user uses the 5V power supply of the host directly, it shall be connected to the filter circuit as shown in the following figure. The placement rules of C3 capacitor and C2 capacitor in the filter circuit are the same as that in 6.2.

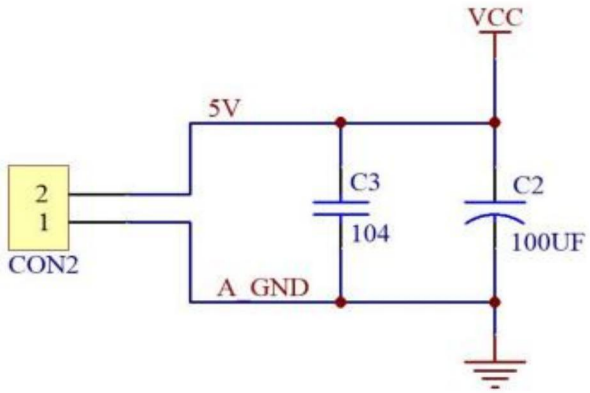



**Figure 6-2: The filter circuit with 5V power supply**

## 7. The design of the PCB for the touch induction circuit

### 7.1 Wiring design of the power line

The touch part is the analog sensitive device. The circuits of other sub-units in the same system shall avoid affecting the circuit of the touch part. Therefore, the VCC power line of the touch circuit shall be wired separately. The length shall be as short as possible. The wiring shall be thickened appropriately.

### 7.2 Wiring design of the grounding wire

The grounding wire of the touch chip shall not be shared with other circuits, and is better to be connected to the grounding point of the board power supply, i.e., usually referred to as the "star-earthed topology". The power grounding of the digital part and the analog part of the circuit shall be connected with star-connection respectively.

## 7.3 The wiring design of peripheral components and parts of the touch application circuit

The decoupling capacitors, CMOD capacitors, CDC capacitors and touchable current-limiting resistances of the touch-type chips shall be placed closely to the chips to the maximum extent and the routing distance shall be as short as possible.

## 7.4 Wiring between input pins of the sense element of PAD and IC

The touch-type IC shall be placed in a central position to the greatest extent and the distance between such chip and PAD is balanced basically.

The routing of PAD input end and routing of a single sided board are suggested to be 8MIL-13MIL in distance and the routing of a double-sided board is suggested to be 5-8mil in distance. Where the process permits, it is suggested that the thinner the better is.

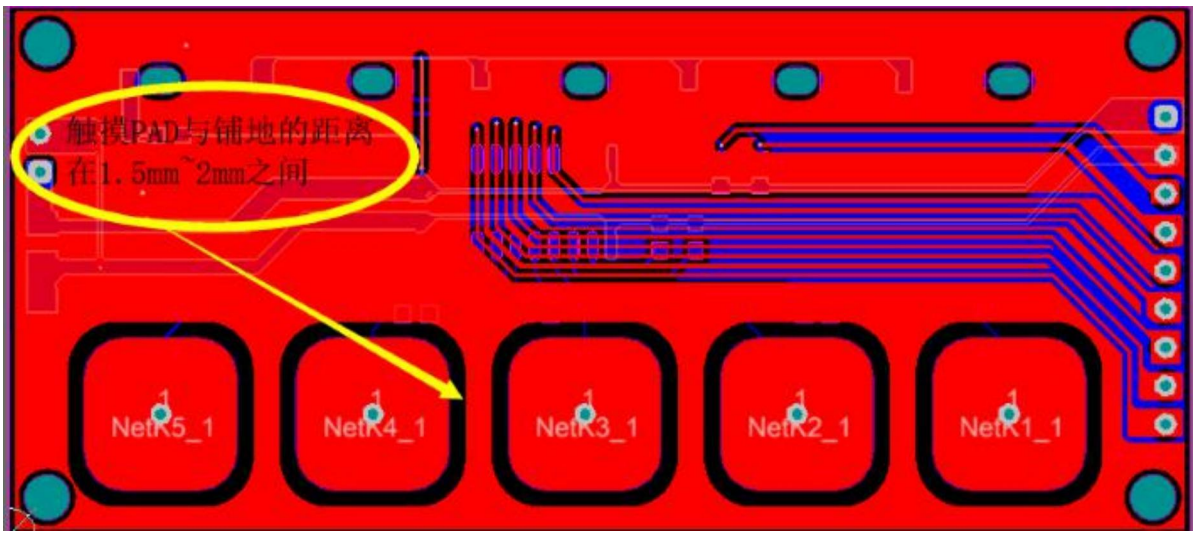
The wire between PAD input end and the touch-type IC cannot be across other signal lines. Especially, it cannot be across high-frequency signal lines with strong interference.

Other signal lines shall not be routed within 0.5MM scope around the wire between PAD input end and the touch-type IC.

## 7.4 Circuit routing rules in the ground

Circuits of the touch-type IC and other related peripheral circuits shall be routed in the ground, which can effectively enhance the capacity of resisting disturbance of products. The attention shall be paid on key points below about circuit routing in the ground:

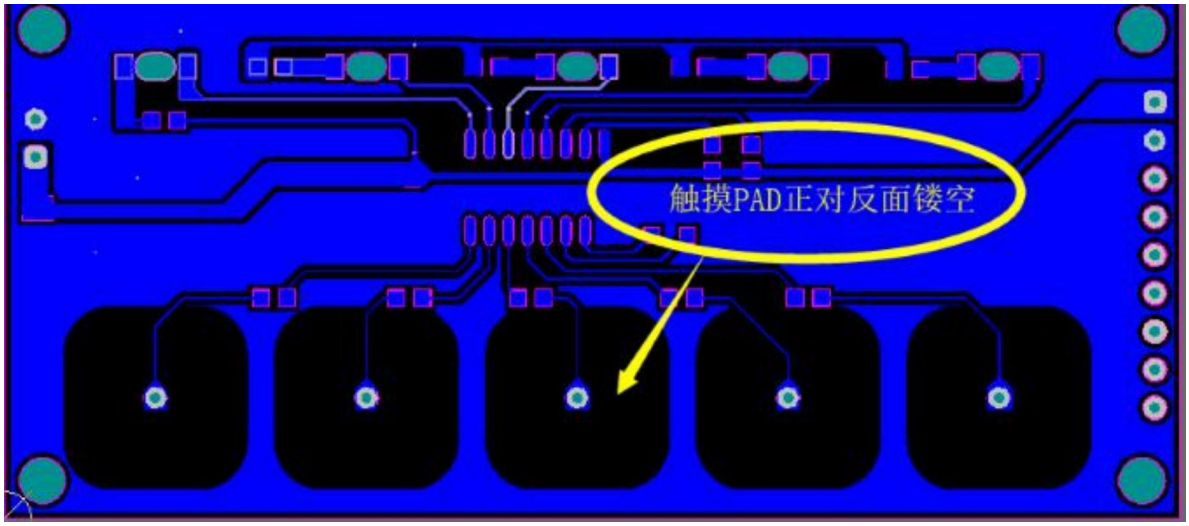
(1) It is recommended that the distance between the touch-type PAD and the ground where it is routed should be 1.5MM-2.0MM, where the interference rejection of the system and the sensitivity to touch can be balanced effectively.




| | |
|---|---|
| 触摸PAD与铺地的距离在1.5mm-2mm之间 | The distance between the touch-type PAD and the ground where it is routed is 1.5mm-2.0mm |

**Figure 7-1: The touch-type PAD is 1.5MM above the ground where it is routed**

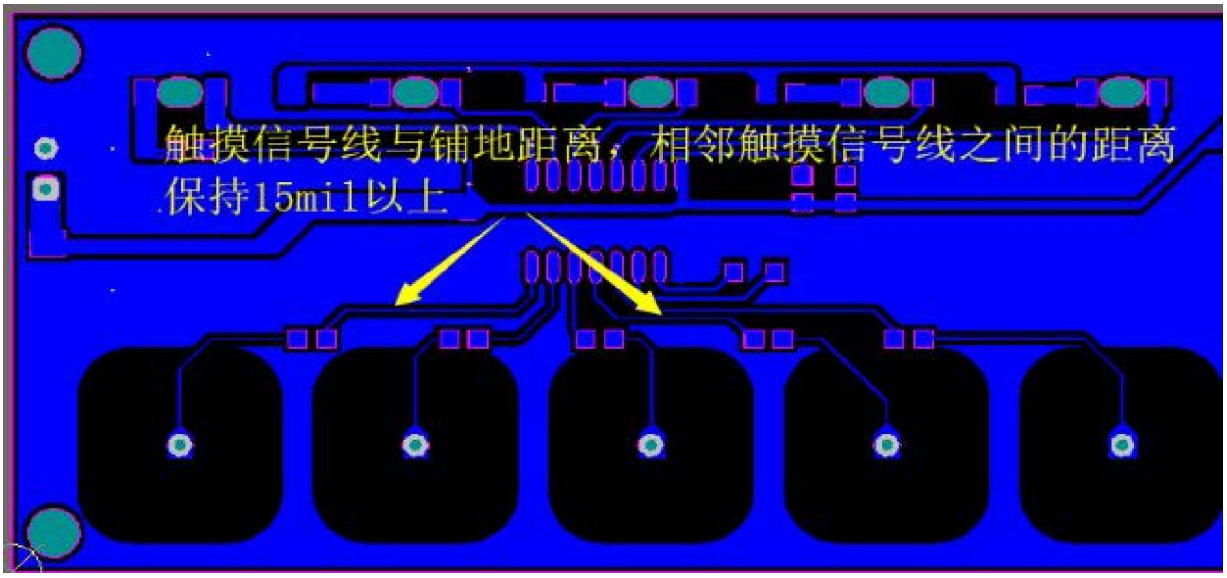
(2) The periphery parts of the touch-type PAD need to be routed in the ground. And the obverse and reverse sides of the touch-type PAD need to be subject to hollow-out processing for routing in the ground, so as to reduce the stray capacitance, improve the sensitivity. And there shall be no other devices or large-area copper foils and no other high-frequency signal lines.




| | |
|---|---|
| 触摸PAD正对反面镂空 | The obverse and reverse sides of the touch-type PAD are hollowed out |

**Figure 7-2: The obverse and back sides of the touch-type PAD are hollowed out**

(3) The touch-type signal line keeps 15mil above the ground where it is routed and 15mil above needs to be kept between adjacent touch-type signal lines, so as to avoid crosstalk. As shown in the figure below:




| | |
|---|---|
| 触摸信号线与铺地距离，相邻触摸信号线之间的距离保持15mil以上 | 15mil above needs to be kept between the touch-type signal line and the ground where it is routed as well as between adjacent touch-type signal lines |

**Figure 7-3: 15mil above needs to be kept between the touch-type signal line and the ground where it is routed and adjacent touch-type signal line**

(4) It is suggested that the touch-type IC and its related peripheral circuits should be routed with the solid copper, so as to enhance the capacity of resisting disturbance of the chip.