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8-Channel Self Calibration Capacitive Touch Sensor

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SPECIFICATION V1.7

## TS08P (8-CH Auto Sensitivity Calibration Capacitive Touch Sensor)

### 1 Specification

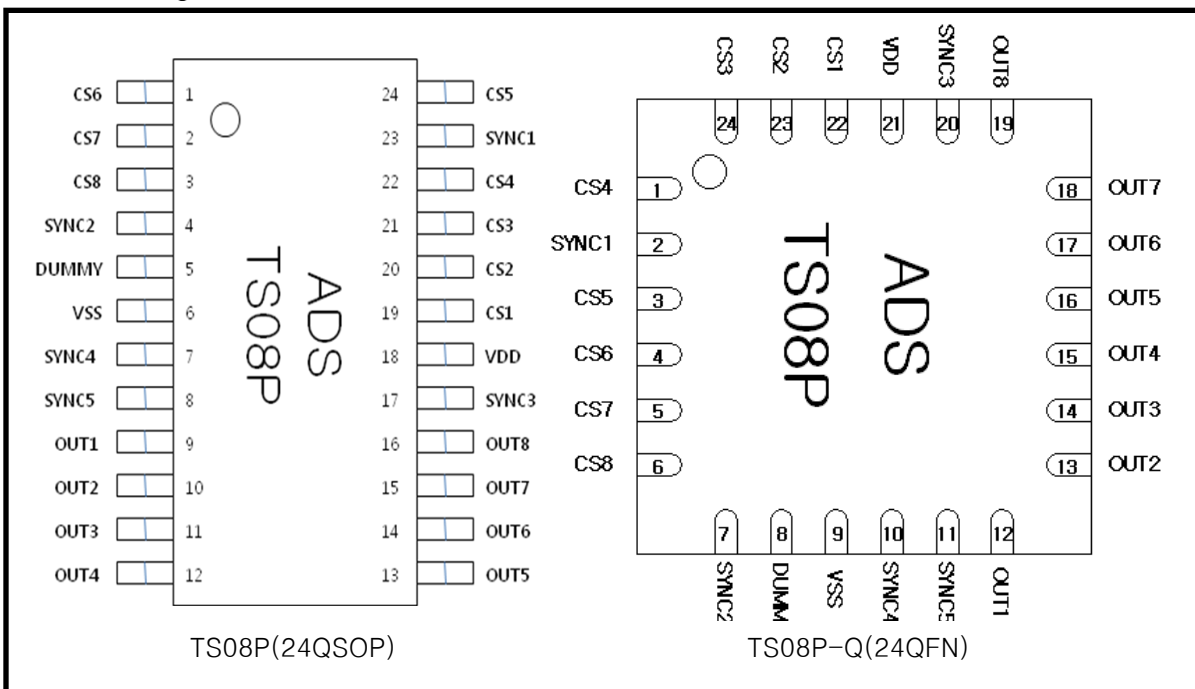
#### 1.1 General Feature

- 8-Channel capacitive sensor with auto sensitivity calibration
- Selectable output operation mode (single output / multi output / dual single output)
- Selectable output level (active high / active low / analog voltage output)
- Uniformly adjustable 9 step sensitivity
- 3 Step internal calibration speed selections
- Sync function for parallel operation
- 5 SYNC pins for various option selections
- Almost no external component needed
- Open-drain digital output
- Low current consumption
- Embedded common and normal noise elimination circuit
- RoHS compliant 24QSOP and 24QFN package

#### 1.2 Application

- Home application
- Membrane switch replacement
- Sealed control panels, keypads
- Door key-lock matrix application
- Touch screen replacement application

#### 1.3 Package (24QSOP/24QFN)



※ Drawings not to scale

## TS08P (8-CH Auto Sensitivity Calibration Capacitive Touch Sensor)

### 2 Pin Description

#### 2.1 TS08P-Q(24QFN package)

Pin Number	Name	I/O	Description	Protection
1	CS4	Analog Input	CH4 capacitive sensor input	VDD/GND
2	SYNC1	Digital Input /Output	Sensitivity selection input 1 (Note 1) Sync pulse input /output 1	VDD/GND
3	CS5	Analog Input	CH5 capacitive sensor input	VDD/GND
4	CS6	Analog Input	CH6 capacitive sensor input	VDD/GND
5	CS7	Analog Input	CH7 capacitive sensor input	VDD/GND
6	CS8	Analog Input	CH8 capacitive sensor input	VDD/GND
7	SYNC2	Digital Input /Output	Sensitivity selection input 2 (Note 1) Sync pulse input /output 2	VDD/GND
8	DUMMY	–	No Connection (Note 2)	VDD/GND
9	VSS	Ground	Supply ground	VDD
10	SYNC4	Digital Input /Output	Output level selection input (Note 3) Sync pulse input /output 4	VDD/GND
11	SYNC5	Digital Input /Output	Internal calibration speed selection input (Note 4) Sync pulse input /output 5	VDD/GND
12	OUT1	Digital Output /Analog Output	CH1 parallel output (Open drain) Ch1, 2, 3, 4 analog output	VDD/GND
13	OUT2	Digital Output	CH2 parallel output (Open drain)	VDD/GND
14	OUT3	Digital Output	CH3 parallel output (Open drain)	VDD/GND
15	OUT4	Digital Output	CH4 parallel output (Open drain)	VDD/GND
16	OUT5	Digital Output	CH5 parallel output (Open drain)	VDD/GND
17	OUT6	Digital Output	CH6 parallel output (Open drain)	VDD/GND
18	OUT7	Digital Output	CH7 parallel output (Open drain)	VDD/GND
19	OUT8	Digital Output /Analog Output	CH8 parallel output (Open drain) Ch5, 6, 7, 9 analog output	VDD/GND
20	SYNC3	Digital Input /Output	Output mode selection input (Note 5) Sync pulse input /output 3	VDD/GND
21	VDD	Power	Power (2.5V~5.5V)	GND
22	CS1	Analog Input	CH1 capacitive sensor input	VDD/GND
23	CS2	Analog Input	CH2 capacitive sensor input	VDD/GND
24	CS3	Analog Input	CH3 capacitive sensor input	VDD/GND

**Note 1 :** Refer to 6.3.2 Sensitivity selections.

**Note 2 :** DUMMY pin should be no connection.

**Note 3 :** Refer to 6.3.4 Output level selections.

**Note 4 :** Refer to 6.3.5 Internal calibration speed selections.

**Note 5 :** Refer to 6.3.3 Output mode selections.

## TS08P (8-CH Auto Sensitivity Calibration Capacitive Touch Sensor)

### 2.2 TS08P(24QSOP package)

Pin Number	Name	I/O	Description	Protection
1	CS6	Analog Input	CH6 capacitive sensor input	VDD/GND
2	CS7	Analog Input	CH7 capacitive sensor input	VDD/GND
3	CS8	Analog Input	CH8 capacitive sensor input	VDD/GND
4	SYNC2	Digital Input /Output	Sensitivity selection input 2 (Note 1) Sync pulse input /output 2	VDD/GND
5	DUMMY	–	No Connection (Note 2)	VDD/GND
6	VSS	Ground	Supply ground	VDD
7	SYNC4	Digital Input /Output	Output level selection input (Note 3) Sync pulse input /output 4	VDD/GND
8	SYNC5	Digital Input /Output	Internal calibration speed selection input (Note 4) Sync pulse input /output 5	VDD/GND
9	OUT1	Digital Output /Analog Output	CH1 parallel output (Open drain) Ch1, 2, 3, 4 analog output	VDD/GND
10	OUT2	Digital Output	CH2 parallel output (Open drain)	VDD/GND
11	OUT3	Digital Output	CH3 parallel output (Open drain)	VDD/GND
12	OUT4	Digital Output	CH4 parallel output (Open drain)	VDD/GND
13	OUT5	Digital Output	CH5 parallel output (Open drain)	VDD/GND
14	OUT6	Digital Output	CH6 parallel output (Open drain)	VDD/GND
15	OUT7	Digital Output	CH7 parallel output (Open drain)	VDD/GND
16	OUT8	Digital Output /Analog Output	CH8 parallel output (Open drain) Ch5, 6, 7, 9 analog output	VDD/GND
17	SYNC3	Digital Input /Output	Output mode selection input (Note 5) Sync pulse input /output 3	VDD/GND
18	VDD	Power	Power (2.5V~5.5V)	GND
19	CS1	Analog Input	CH1 capacitive sensor input	VDD/GND
20	CS2	Analog Input	CH2 capacitive sensor input	VDD/GND
21	CS3	Analog Input	CH3 capacitive sensor input	VDD/GND
22	CS4	Analog Input	CH4 capacitive sensor input	VDD/GND
23	SYNC1	Digital Input /Output	Sensitivity selection input 1 (Note 1) Sync pulse input /output 1	VDD/GND
24	CS5	Analog Input	CH5 capacitive sensor input	VDD/GND

**Note 1 :** Refer to 6.3.2 Sensitivity selections.

**Note 2 :** DUMMY pin should be no connection.

**Note 3 :** Refer to 6.3.4 Output level selections.

**Note 4 :** Refer to 6.3.5 Internal calibration speed selections.

**Note 5 :** Refer to 6.3.3 Output mode selections.

## TS08P (8-CH Auto Sensitivity Calibration Capacitive Touch Sensor)

### 3 Absolute Maximum Rating

Battery supply voltage	6.0V
Maximum voltage on any pin	VDD+0.3
Maximum current on any PAD	100mA
Power Dissipation	800mW
Storage Temperature	-50 ~ 150°C
Operating Temperature	-20 ~ 75°C
Junction Temperature	150°C

**Note 6:** Unless any other command is noted, all above are operated in normal temperature.

### 4 ESD & Latch-up Characteristics

#### 4.1 ESD Characteristics

Mode	Polarity	Max	Reference
H.B.M	Pos / Neg	8000V	VDD
		8000V	VSS
		8000V	P to P
M.M	Pos / Neg	500V	VDD
		500V	VSS
		500V	P to P
C.D.M	Pos / Neg	500V	DIRECT
		800V	

#### 4.2 Latch-up Characteristics

Mode	Polarity	Max	Test Step
I Test	Positive	200mA	25mA
	Negative	-200mA	
V supply over 5.0V	Positive	8.0V	1.0V

## TS08P (8-CH Auto Sensitivity Calibration Capacitive Touch Sensor)

### 5 Electrical Characteristics

▪  $V_{DD}=3.3V$ , (Unless otherwise noted),  $T_A = 25^\circ C$

Characteristics	Symbol	Test Condition	Min	Typ	Max	Units	
Operating supply voltage	$V_{DD}$		2.5	3.3	5.5	V	
Current consumption	$I_{DD}$	$V_{DD}= 3.3V$	Slow calibration speed	–	60	100	$\mu A$
			Normal calibration speed	–	90	140	
			Fast calibration speed	–	130	210	
		$V_{DD}= 5.0V$	Slow calibration speed	–	80	130	
			Normal calibration speed	–	110	180	
			Fast calibration speed	–	170	250	
Internal reset criterion $V_{DD}$ voltage	$V_{DD\_RST}$	$T_A = 25^\circ C$	–	–	$0.3 \cdot V_{DD}$	V	
Output maximum sink current	$I_{OUT}$	$T_A = 25^\circ C$	–	–	4.0	mA	
Minimum detective capacitance difference	$\Delta C_{MIN}$		0.1	–	–	pF	
Output impedance (open drain)	$Z_O$	$\Delta C > \Delta C_{MIN}$	–	12	–	$\Omega$	
		$\Delta C < \Delta C_{MIN}$	–	30M	–		
Self calibration time after system reset	$T_{CAL}$	Slow calibration speed	–	100	–	ms	
		Normal calibration speed	–	80	–		
		Fast calibration speed	–	60	–		

**Note 7:** The sensitivity can be decreased with higher parallel capacitance of CS pin including parasitic capacitance made by neighbor GND or other pattern.

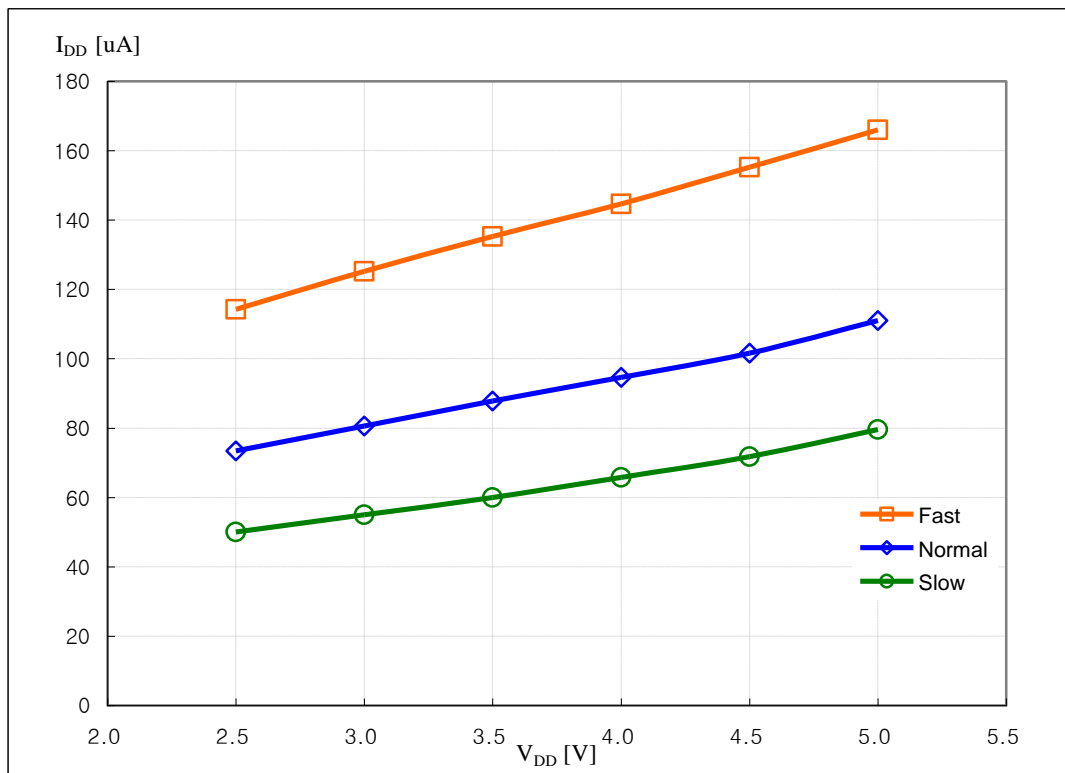
**Note 8:** The series resistor(under 1k $\Omega$ ) of CS can be used in noisy condition to avoid malfunction from external surge and ESD.

**Note 9 :** Slow calibration speed isn't recommended if it has not problem of current consumption.

### 6 TS08P Implementation

#### 6.1 Typical current consumption

TS08P uses internal bias circuit, so internal clock frequency and current consumption is fixed and no external bias circuit is needed. TS08P has three step optional calibrations speed. Faster calibration speed needs more current consumption than slower calibration speed. The typical current consumption curve of TS08P is represented in accordance with  $V_{DD}$  voltage as below. Internal bias circuit can make the circuit design simple and reduce external components.



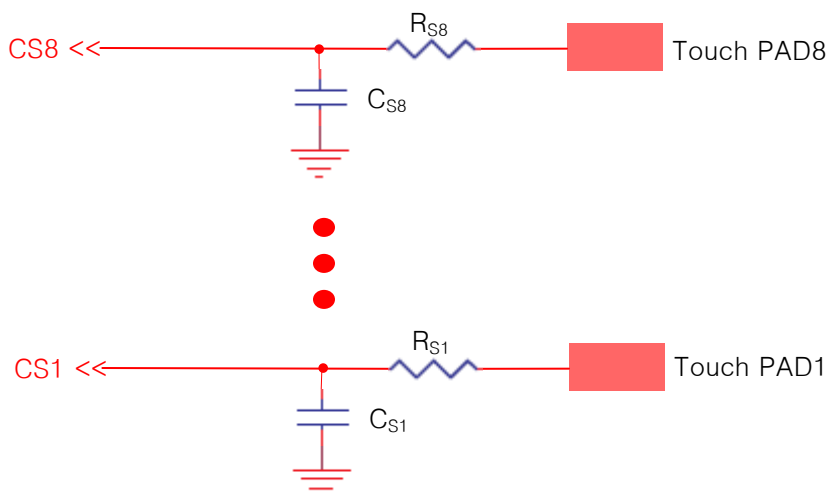
Typical current consumption curve of TS08P

## TS08P (8-CH Auto Sensitivity Calibration Capacitive Touch Sensor)

### 6.2 CS implementation

TS08P has 9 step selections of sensitivity and internal protection circuit so external components of CS pins such as series resistor or parallel capacitor isn't necessary. The parallel parasitic capacitance of CS pins caused by touch line, touch pad and neighbor GND or other pattern may affect sensitivity. The sensitivity will be decreased when bigger parallel parasitic capacitance of CS pin is added.

Parallel capacitor ( $C_{S1\sim S8}$ ) of CS pin is useful in case of detail sensitivity mediation is required such as for complementation sensitivity difference between channels. Same as above parallel parasitic capacitance, sensitivity will be decreased when a big value of parallel capacitor ( $C_{S1\sim S8}$ ) is used. Under 50pF capacitor can be used as sensitivity meditation capacitor and a few pF is usually used. The  $R_S$ , serial connection resistor of CS pins, may be used to avoid mal-function from external surge and ESD. (It might be optional.) From 200 $\Omega$  to 1k $\Omega$  is recommended for  $R_S$ . Refer to below CS pins application figure.



The TS08P has eight independent touch sensor input from CS1 to CS8. The internal touch decision process of each channel is separated from each other. Therefore eight channel touch key board application can be designed by using only one TS08P without coupling problem.

The size and shape of PAD might have influence on the sensitivity. The sensitivity will be optimal when the size of PAD is approximately an half of the first knuckle (it's about 10 mm x 7 mm). The connection line of CS to touch PAD is recommended to be routed as short as possible to prevent from abnormal touch detect caused by connection line.



## TS08P (8-CH Auto Sensitivity Calibration Capacitive Touch Sensor)

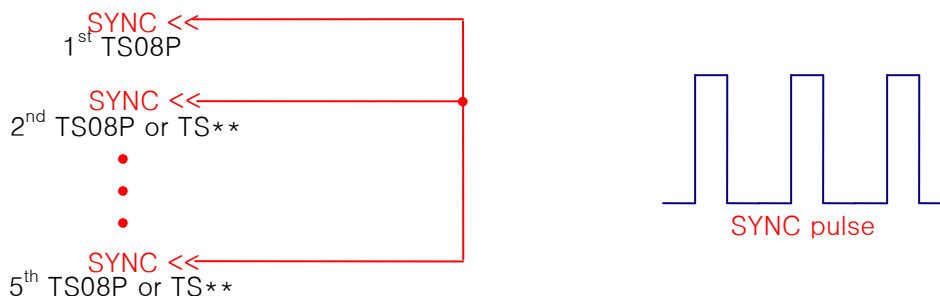
### 6.3 SYNC implementation

The TS08P has five SYNC pins to make it possible to operate with many optional functions such as SYNC™ function, sensitivity selections, output mode selection, output level selection, and calibration speed selection. No external component is used for above selections.

The determination of SYNC pins connection of TS08P is accomplished in initial operation periods. Therefore changing connection of SYNC pin after initial operation period cannot affect the optional function selection.

#### 6.3.1 SYNC™ function

For SYNC™ function, all SYNC pins (from SYNC1 to SYNC5) have same function. So, at least, one of five SYNC pins operates as SYNC™ function, TS08P can be operated with other TS08P or TSxx series without interfering with each other. Inside of TS08P, there is internal oscillator for SYNC pulse so no external component is used for SYNC™ function. Simply, it is needed to connect SYNC pin to other SYNC pin of TS08P or TSxx series for using SYNC™ function. For proper SYNC™ function, less five other TS08P or TSxx series can be connected with.



#### 6.3.2 Sensitivity selections

SYNC1 and SYNC2 pin of TS08P can be used as sensitivity selection pin. Both of two SYNC pins have three methods of connection. Open connection (N.C., SYNC connection), connection to GND, and connection to VDD are these methods. As below table, TS08P has 9 step sensitivity selections. When SYNC1 pin or SYNC 2 pin has no connection to GND or VDD, that SYNC pin may be simultaneously used for SYNC™ function.

Sensitivity level (thickness [mm] of proper poly-carbonate insulator) of each sensitivity selection

SYNC2 \ SYNC1	Connect to VDD	Connect to GND	N.C. (SYNC connection)
Connect to GND	15.0	13.0	11.0
N.C. (SYNC connection)	9.0	7.5	6.0
Connect to VDD	5.0	4.0	3.0

**Note 10 :** The size of touch PAD is 10 mm x 7 mm used.

**Note 11 :** Above proper thickness is reliable but it can be changed by insulator material and application.

## TS08P (8-CH Auto Sensitivity Calibration Capacitive Touch Sensor)

### 6.3.3 Output mode selections

SYNC3 pin of TS08P is output mode selection input pin. SYNC3 also has three connections, such as open connection (N.C., SYNC connection), connection to GND, and connection to VDD. The output mode of each connection is such as below table. When SYNC3 pin has no connection to GND or VDD and TS08P operates as dual-single output mode, SYNC3 pin may be simultaneously used for SYNC™ function.

#### Output mode of each SYNC3 connections

SYNC3 connection	Connect to VDD	Connect to GND	N.C. (SYNC connection)
Output mode	Single output	Multi-output	Dual-single output

When SYNC3 is connected to VDD and TS08P operates as single output mode, the one output that is detected fastest is appeared. So application PCB composed very near touch pads is possible to operate without confusion of neighborhood touch. When SYNC3 is open and TS08P operates as dual-single output mode, the one output that is detected fastest among CS1~CS4 and the one output that is detected fastest among CS5~CS8 is appeared independently. At multi-output mode, all output of TS08P can be appeared.

### 6.3.4 Output level selections

SYNC4 pin of TS08P is output level selection input pin. SYNC4 also has three connections, such as open connection (N.C., SYNC connection), connection to GND, and connection to VDD. The output level of each connection is such as below table. When SYNC4 pin has no connection to GND or VDD and TS08P operates as active low output level, SYNC4 pin may be simultaneously used for SYNC™ function.

#### Output level of each SYNC4 connections

SYNC4 connection	Connect to VDD	Connect to GND	N.C. (SYNC connection)
Output level	Active high	Analog output	Active low

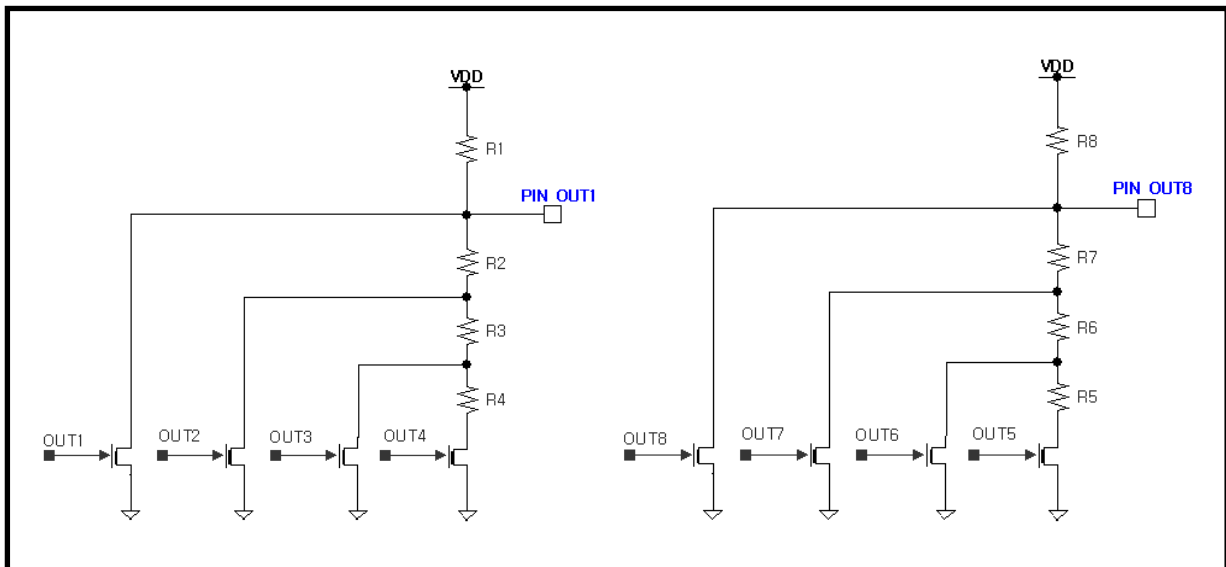
When active high is selected TS08P outputs are low in normal state and become high in touch detect state. When TS08P is used as active low output, the level of normal state is high and that of touch detect is low.

TS08P has internal analog output circuit and all the output of CS can be express as analog voltage value using only two output ports (OUT1, OUT8). Analog voltage output values for from OUT1 to OUT4 are expressed by OUT1 pin, and for from OUT5 to OUT8 are expressed by OUT8 pin. Analog voltage output values for each output in analog output mode are as below equations. In this analog output mode, other parallel outputs (OUT2~OUT7) have each states digital output (High or low) and output mode is selected by SYNC3 connection. But, even if output mode is multi-output, OUT1 (OUT8) has only one analog output value of lower voltage. No other external component is needed in this analog output mode.

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## TS08P (8-CH Auto Sensitivity Calibration Capacitive Touch Sensor)



Analog output circuit of TS08P

$$\text{Analog } OUT1 : V_{OUT1\_CS1} = \frac{0}{R1} \cdot V_{DD} = 0[V]$$

$$\text{Analog } OUT2 : V_{OUT1\_CS2} = \frac{R2}{R1 + R2} \cdot V_{DD} = 0.306 \cdot V_{DD} [V]$$

$$\text{Analog } OUT3 : V_{OUT1\_CS3} = \frac{R2 + R3}{R1 + R2 + R3} \cdot V_{DD} = 0.5 \cdot V_{DD} [V]$$

$$\text{Analog } OUT4 : V_{OUT1\_CS4} = \frac{R2 + R3 + R4}{R1 + R2 + R3 + R4} \cdot V_{DD} = 0.706 \cdot V_{DD} [V]$$

$$\text{Analog } OUT5 : V_{OUT8\_CS5} = \frac{R7 + R6 + R5}{R8 + R7 + R6 + R5} \cdot V_{DD} = 0.706 \cdot V_{DD} [V]$$

$$\text{Analog } OUT6 : V_{OUT8\_CS6} = \frac{R7 + R6}{R8 + R7 + R6} \cdot V_{DD} = 0.5 \cdot V_{DD} [V]$$

$$\text{Analog } OUT7 : V_{OUT8\_CS7} = \frac{R7}{R8 + R7} \cdot V_{DD} = 0.306 \cdot V_{DD} [V]$$

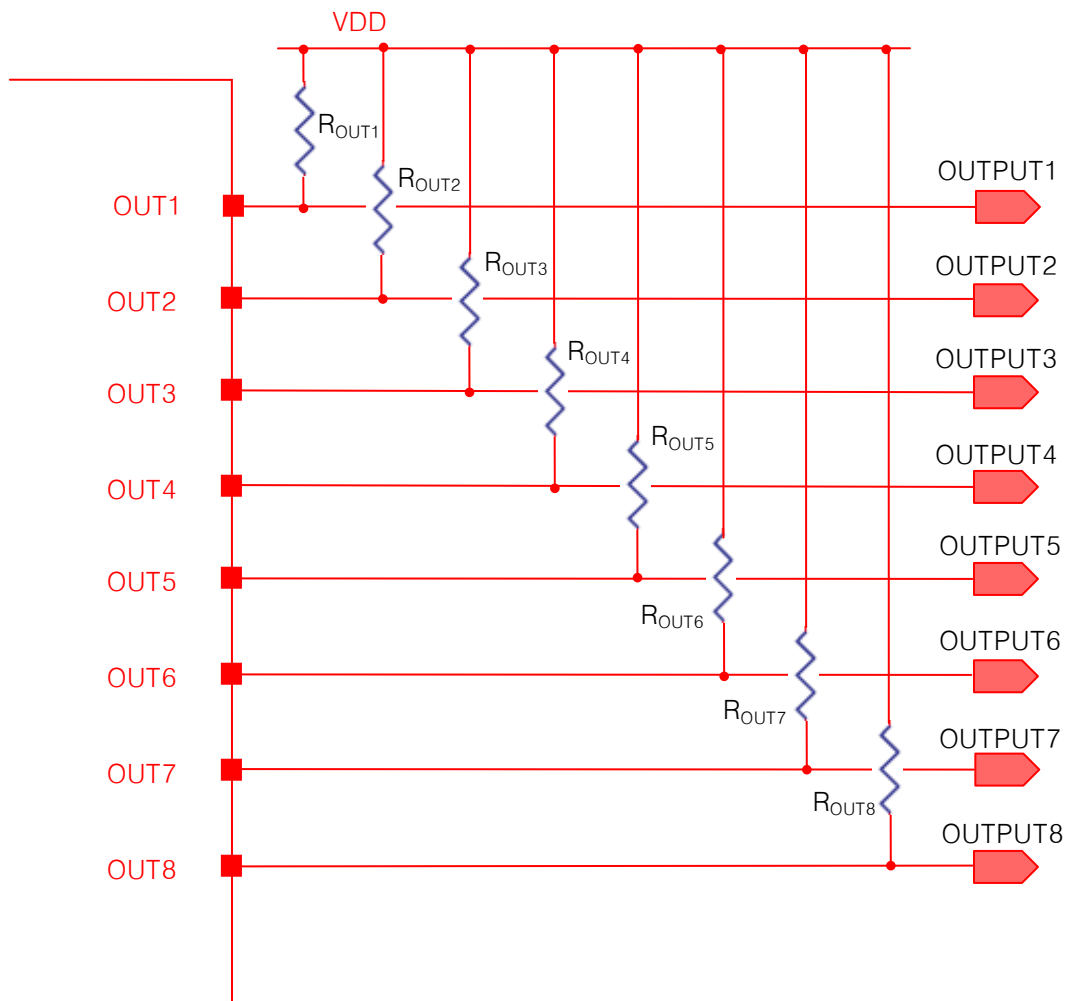
$$\text{Analog } OUT8 : V_{OUT8\_CS8} = \frac{0}{R8} \cdot V_{DD} = 0[V]$$

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## TS08P (8-CH Auto Sensitivity Calibration Capacitive Touch Sensor)

The OUTPUT pins have an open drain structure. For this reason, in the case of using TS08P as active high or active low the connection of pull-up resistor  $R_{OUT}$  is required between OUTPUT and VDD. The maximum output sink current is 4mA, so over a few  $k\Omega$  must be used as  $R_{OUT}$ . Normally 10k $\Omega$  is used as  $R_{OUT}$ .



## TS08P (8-CH Auto Sensitivity Calibration Capacitive Touch Sensor)

### 6.3.5 Internal calibration speed selections

SYNC5 pin of TS08P is calibration selection input pin. SYNC5 also has three connections, such as open connection (N.C., SYNC connection), connection to GND, and connection to VDD. The calibration speed of each connection is such as below table. When SYNC5 pin has no connection to GND or VDD and TS08P operates as normal calibration speed, SYNC5 pin may be simultaneously used for SYNC™ function.

#### Calibration speed of each SYNC5 connections

SYNC5 connection	Connect to VDD	Connect to GND	N.C. (SYNC connection)
Calibration speed	Fast	Slow	Normal

It is recommendable to use fast calibration speed at various environmental conditions. But slow calibration speed isn't recommended if it has not problem of current consumption. Current consumption is increased when faster calibration speed is used.(refer 6.1 Current consumption)

### 6.4 Internal reset operation

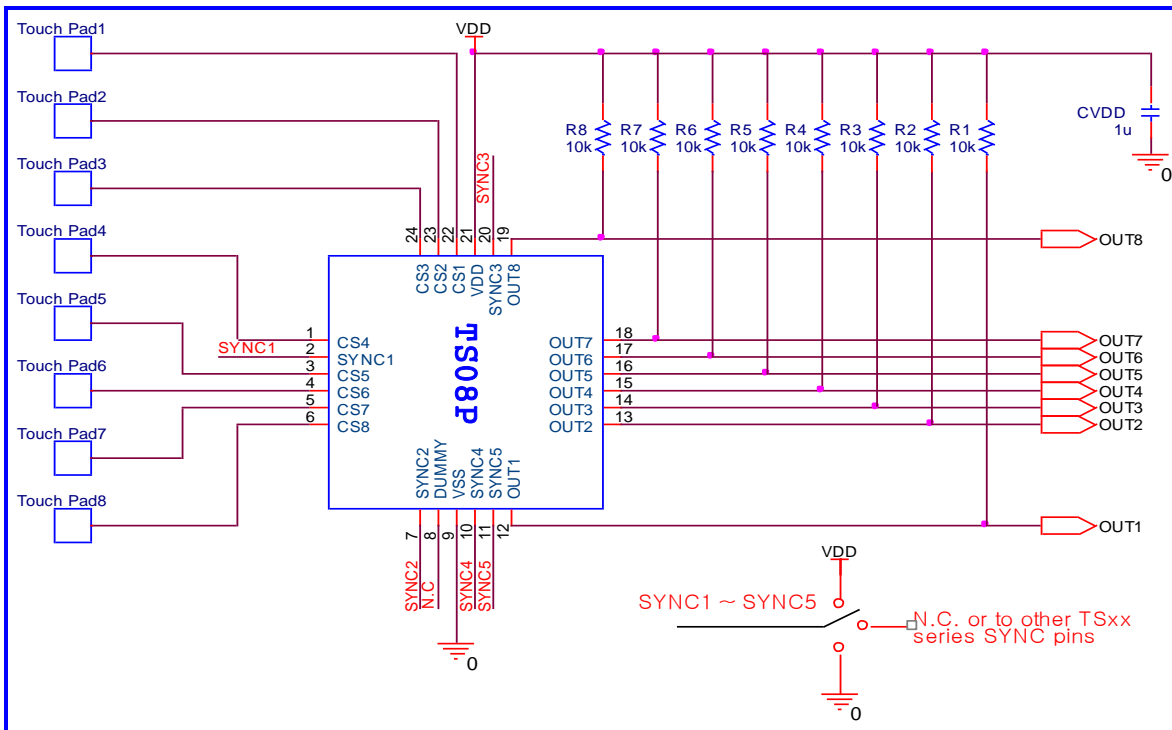
The TS08P has stable internal reset circuit to offer reset pulse to digital block. The supply voltage for a system start or restart should be under 0.3·VDD of normal operation VDD. No external components required for TS08P power reset, that helps simple circuit design and to realize the low cost application.

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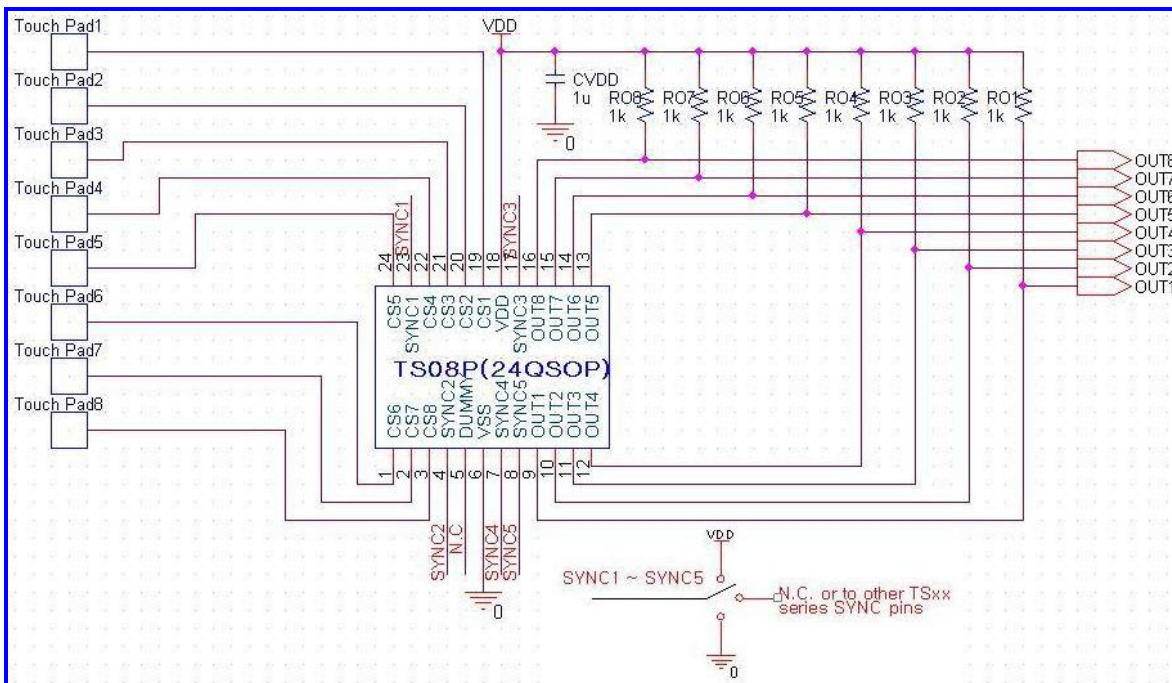
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## TS08P (8-CH Auto Sensitivity Calibration Capacitive Touch Sensor)

### 7 Recommended Circuit Diagram



TS08P-Q(24QFN) Application Example Circuit



TS08P(24QSOP) Application Example Circuit

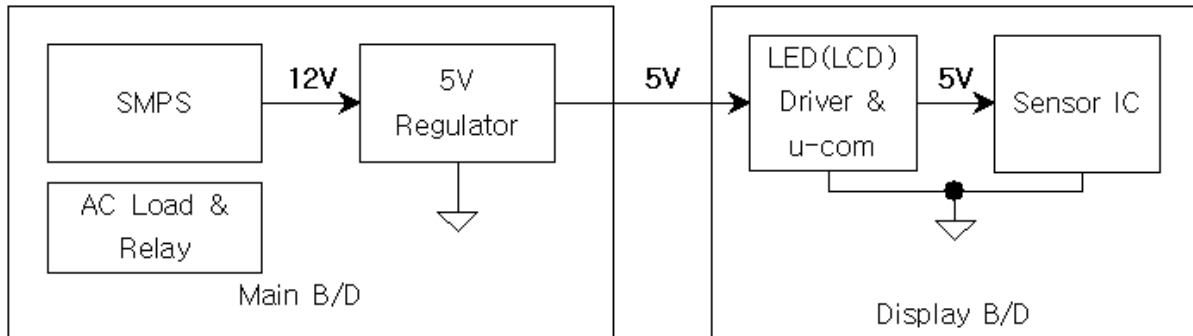
## TS08P (8-CH Auto Sensitivity Calibration Capacitive Touch Sensor)

- ✦ TS08P is reset by internal reset circuit. VDD voltage rising time should be shorter than 100msec for proper operation.
- ✦ The VDD periodic voltage ripple over 50mV and the ripple frequency is lower than 10 kHz can cause wrong sensitivity calibration. To prevent above problem, power (VDD, GND) line of touch circuit should be separated from other circuit. Especially LED driver power line or digital switching circuit power line certainly should be treated to be separated from touch circuit.
- ✦ The CS patterns also should be routed as short as possible and the width of line might be about 0.25mm.
- ✦ Parallel capacitor of CS pin could be useful in case detail sensitivity mediation is required such as for complementation sensitivity difference between channels.
- ✦ Serial connection resistor of CS pins may be used to avoid mal-function from external surge and ESD.
- ✦ The capacitor that is between VDD and GND is an obligation. It should be located as close as possible from TS08P.
- ✦ The CS pattern routing should be formed by bottom metal (opposite metal of touch PAD).
- ✦ The empty space of PCB must be filled with GND pattern to strengthen GND pattern and to prevent external noise from interfere with sensing frequency.
- ✦ The sensitivity can be changed by connection of SYNC1 and SYNC2.  
(See 6.3.2 Sensitivity selections)
- ✦ Output modes (single / multi / dual single) can be changed by connection of SYNC3.  
(See 6.3.3 Sensitivity selections)
- ✦ Output level in each state is selectable by connection of SYNC4.  
(See 6.3.4 Output level selections)
- ✦ The OUT1 ~ OUT8 are open drain output ports. Therefore, in the case of active high output or active low output, the pull-up resistor should be needed as above figure. But it is not necessary to use any pull-up resistor in analog output mode. (See 6.3.4 Output level selections)
- ✦ Internal sensitivity calibration speed can be changed by connection of SYNC5. It is recommendable to use fast calibration speed at various environmental conditions.  
(See 6.3.5 internal calibration speed selections)
- ✦ At least, one of five SYNC pins has SYNC connection, TS08P can be operated with other TS08P or TSxx series without interfering with each other. (See 6.3.1 SYNC™ function)
- ✦ Unused CS pins may be connected to GND for stable operation.

## TS08P (8-CH Auto Sensitivity Calibration Capacitive Touch Sensor)

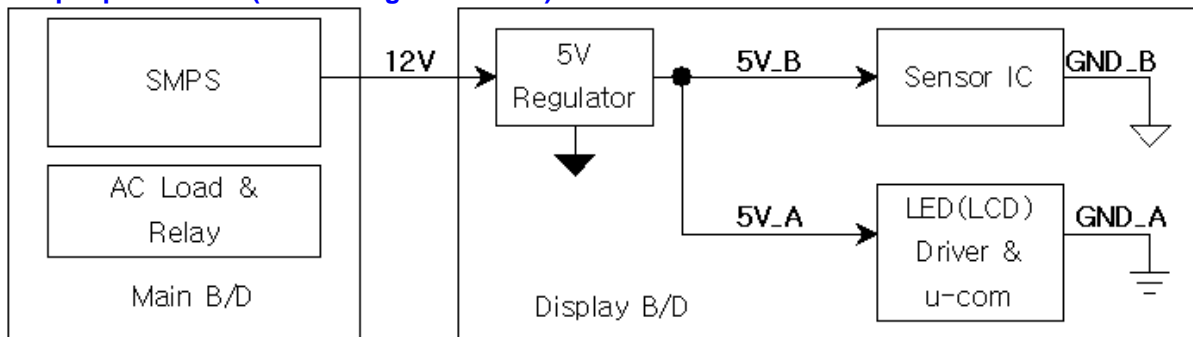
### 7.1 Example – Power Line Split Strategy PCB Layout

#### A. Not split power Line (Bad power line design)

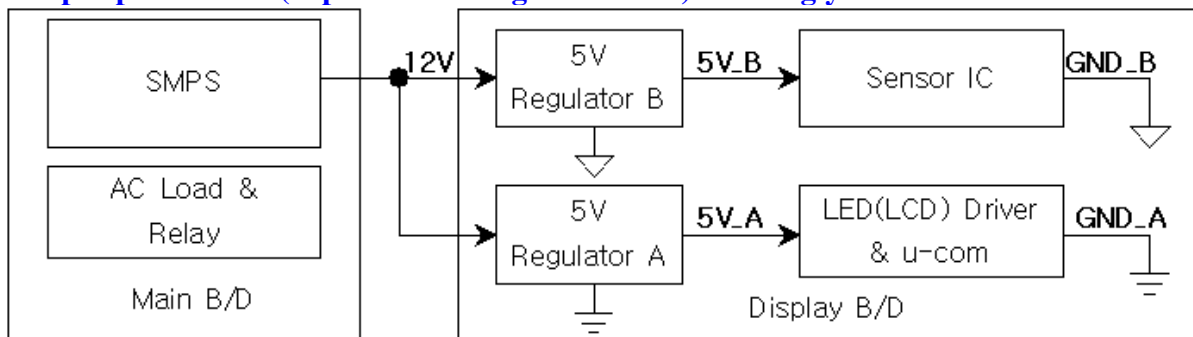


- ✦ The noise that is generated by AC load or relay can be loaded at 5V power line.
- ✦ A big inductance might be appeared in case of the connection line between main board and display board is too long, moreover the voltage ripple could be generated by LED (LCD) display driver at VDD (5V).

#### B. Split power Line (One 5V regulator used) – Recommended



#### C. Split power Line (Separated 5V regulator used) – Strongly recommended

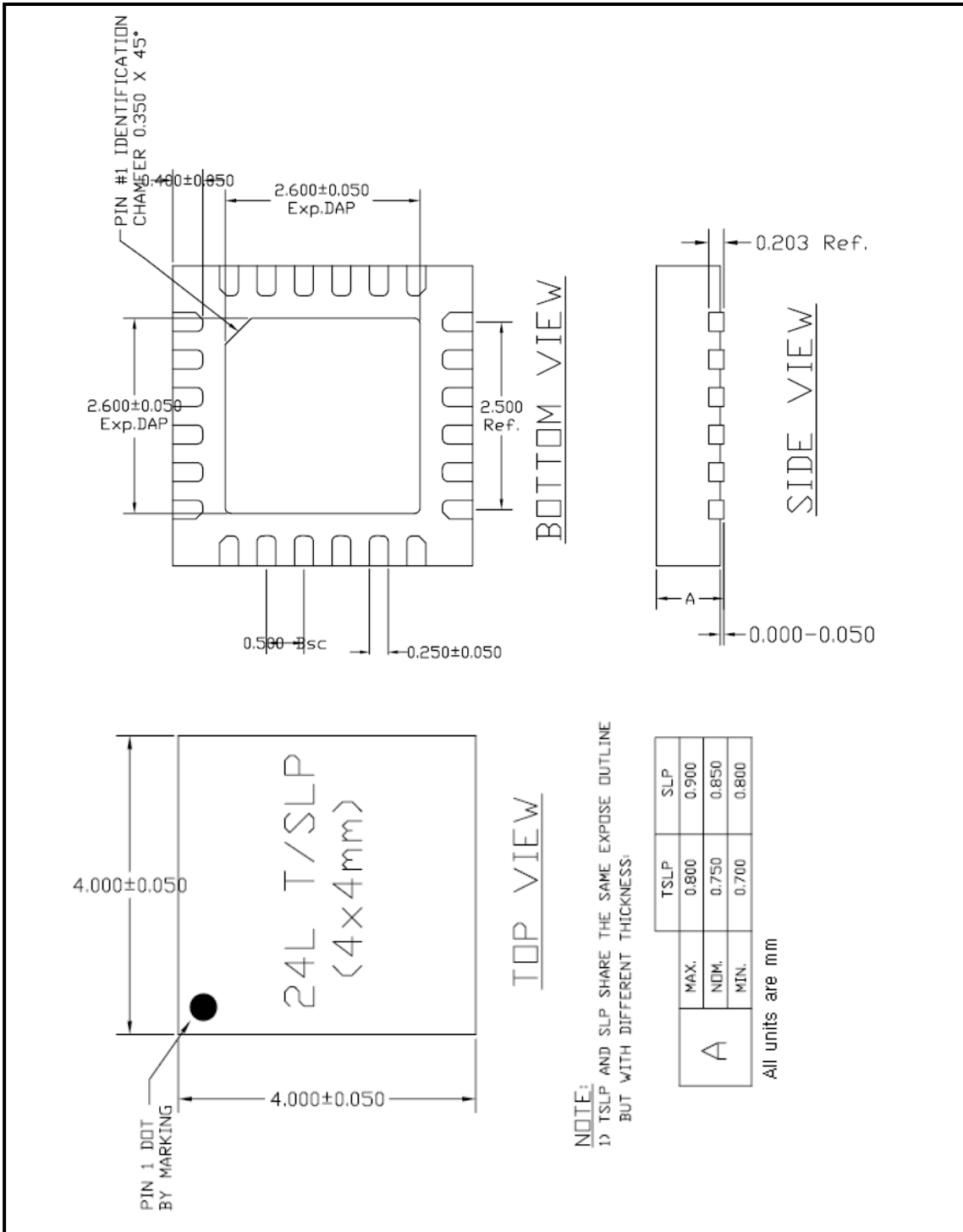




## TS08P (8-CH Auto Sensitivity Calibration Capacitive Touch Sensor)

### 8 MECHANICAL DRAWING

#### 8.1 Mechanical Drawing of TS08P-Q (24 QFN)

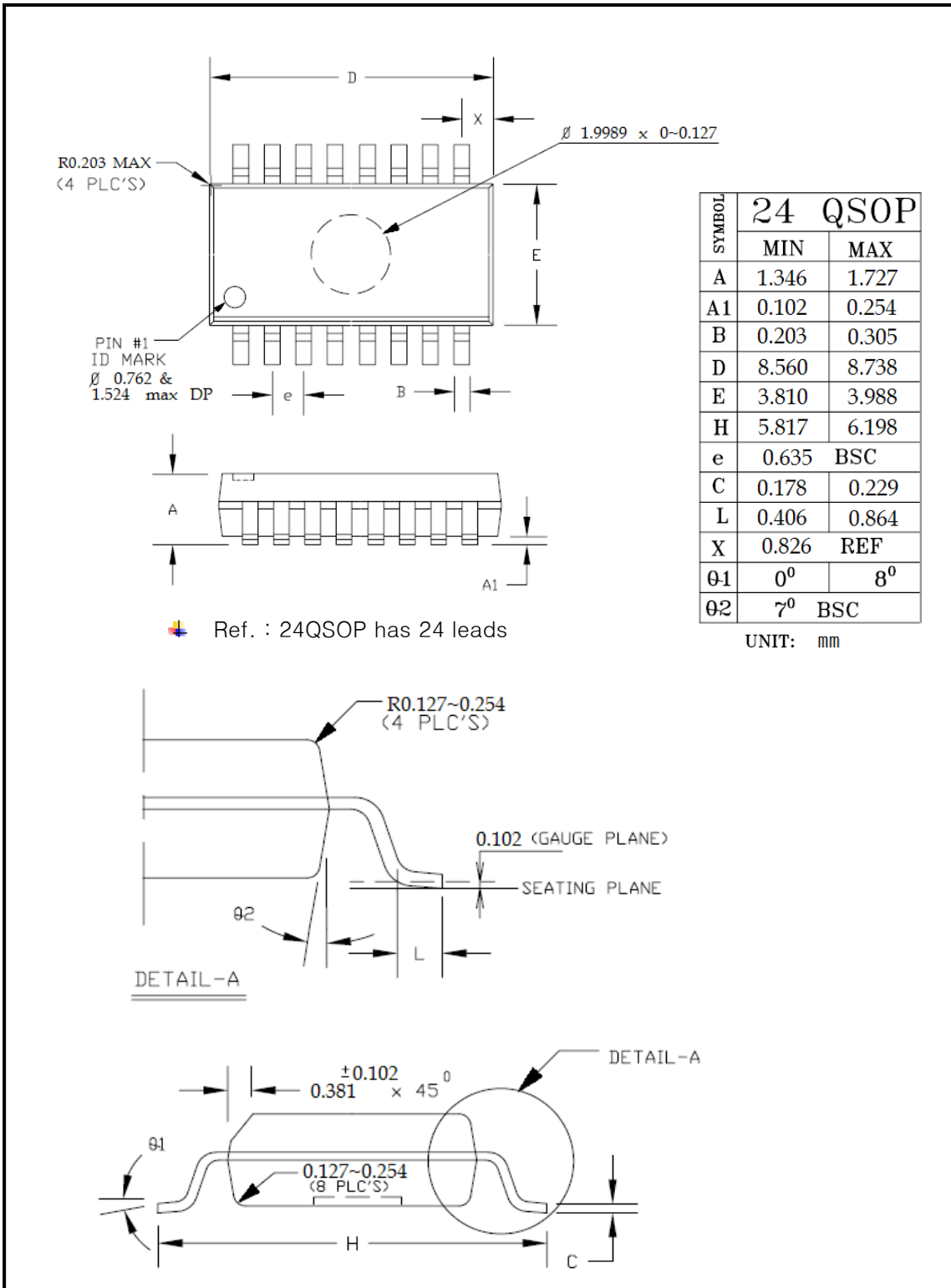


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### 8.2 Mechanical Drawing of TS08P (24 QSOP)



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## TS08P (8-CH Auto Sensitivity Calibration Capacitive Touch Sensor)

### 9 MARKING DESCRIPTION

Device Code : **T S 0 8 P**

Type of version  
Channel Number  
Touch Switch Group

Weekly Code : **YY WW**

Manufacturing Week  
Manufacturing Year

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## TS08P (8-CH Auto Sensitivity Calibration Capacitive Touch Sensor)

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NOTES:

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