CS FREE TOUCH SENSOR

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GREENCHIP

GreenTouch5C™ GTC08L Capacitive Touch Sensor

DATASHEET
VER4.10

GREENTOUCH™

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Table of Contents

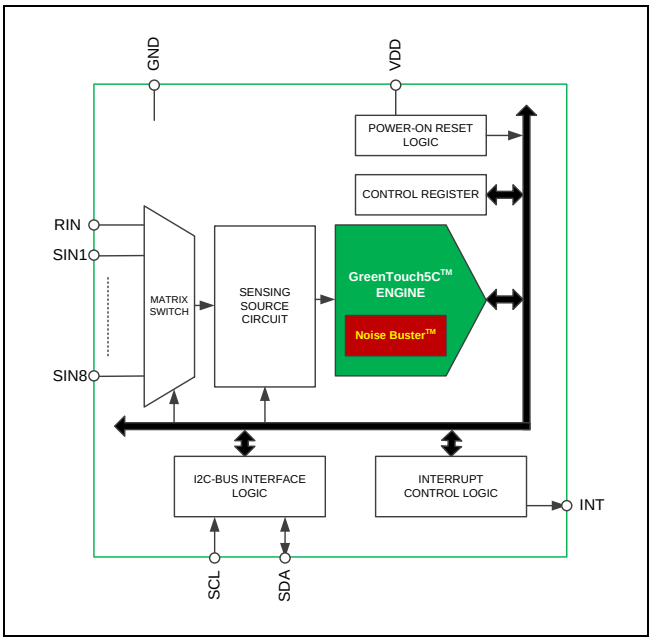
1. INTRODUCTION

The GTC08L is one of the new GreenTouch5C™ capacitive touch sensor series. Especially the GTC08L can do capacitance sensing with 8 channels under above GreenTouch5C™ engine operation. Thanks to this epochal GreenTouch5C™ engine, the applications will be more robust and problem free against EMC, EMI, H/W variations, voltage disturbance, temperature drift, humidity drift and so on. ***Especially, it doesn't make any issue against CS, RS, EFT, impulse and power ripple noise etc. environments occurred in any touch applications.***
The GTC08L can be applied under wide supply voltage range from 2.7V to 5.5V.

2. FEATURES

- 8 channels cap. Sensing input
- Simple & low cost solution
- Using minimum external component
- Embedded GreenTouch5C™ Engine
  - Analog compensation circuit
  - Embedded digital noise filter
  - Intelligent sensitivity calibration
  - Embedded Noise Buster™
    (CS, RS, EFT, impulse and power ripple noise)
- Provide interrupt function
- Provide slide function
- Provide “REGISTER WRITING LOCK” function
- Wide supply voltage range: 2.7V to 5.5V
  - Single supply operation
- Package type
  - SOP-16L (9.90x3.90x1.40,e=1.27)
- RoHS compliant

3. BLOCK DIAGRAM



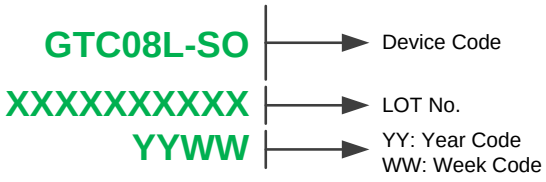
4. APPLICATIONS

- Multimedia Devices - TV, DVD player, Blue ray player, Home theater system, Set top box and Etc.
- Home Appliance - Refrigerator, Air cleaner, Air conditioner, Washing machine, Micro wave oven, Induction range, Cooker, Bidet, Water purifier, Humidifier, Wall switch and Etc.
- PC, OA and Others - PC, LCD monitor, Fax, Copy machine, Lighting controls, Toys, Gaming devices and Etc.

5. ORDERING INFORMATION

Part No.	Package
GTC08L-SO	SOP-16L (9.90x3.90x1.40,e=1.27)

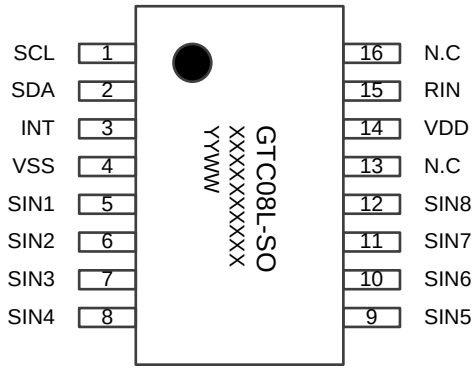
6. MARKING INFORMATION



7. PIN DESCRIPTION

This section describes the lists and illustrates the GTC08L of GreenTouch5C™ family pins as well as pin configuration. The GTC08L device is available in the following package.

7.1 PACKAGE INFORMATION (SOP-16L PACKAGE)



(TOP view)

7.2 PIN CONFIGURATION

No.	Name	Type	Description
1	SCL	DI	I2C serial clock input
2	SDA	DIO	I2C serial data communication pin
3	INT	DO	Interrupt output pin (Active LOW)
4	GND	GND	Ground connection
5	SIN1	AO	Channel 1: Touch sensing input
6	SIN2	AO	Channel 2: Touch sensing input
7	SIN3	AO	Channel 3: Touch sensing input
8	SIN4	AO	Channel 4: Touch sensing input
9	SIN5	AO	Channel 5: Touch sensing input
10	SIN6	AO	Channel 6: Touch sensing input
11	SIN7	AO	Channel 7: Touch sensing input
12	SIN8	AO	Channel 8: Touch sensing input
13	N.C		
14	VDD	PWR	Supply Voltage
15	RIN	AO	Capacitance reference input
16	N.C		

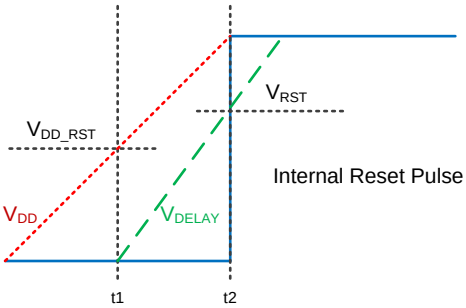
NOTE: DI: Digital Input, DO: Digital Output, DIO: Digital Input and Output, AI: Analog Input, AO: Analog Output, PWR: POWER

8. FUNCTION DESCRIPTION

8.1 INTERNAL RESET

The GTC08L has internal power reset function. The internal reset operation is used for initial power reset.

The internal power reset sequence is represented as below.



The internal V_{DELAY} voltage starts to rise when VDD come up to V_{DD_RST} level. The internal reset pulse is maintained as low between t1 and t2. During this low pulse period, the internal power reset operation is finished. Every time when VDD drops under V_{DD_RST} internal reset block makes V_{DELAY} signal low and then internal reset pulse drops to low. By above internal reset operation sequence GTC08L gets more certain and more correct power reset function than any others.

8.2 IMPLEMENTATION FOR TOUCH SENSING (SIN1~SIN8, RIN)

SIN inputs (SIN1~SIN8) and RIN input are used for touch detection of capacitance variation sensing. The SIN input pins are connected to touch sensing pad and catches capacitance variation caused by direct touch or approach. And RIN input for the reference capacitance is connected to a capacitor and resistor to compensate capacitance difference between SIN inputs and RIN input. The GTC08L compares each capacitance of SIN input and that of RIN input and determines touch detection of each channel when capacitance of each SIN input increases. So, for correct capacitance comparison between SIN inputs and RIN input, approximately equal initial-steady state capacitance between SIN inputs and RIN input are recommended. User can compensate initial-steady state capacitance difference between SIN inputs and RIN input by adding capacitor to RIN pin.

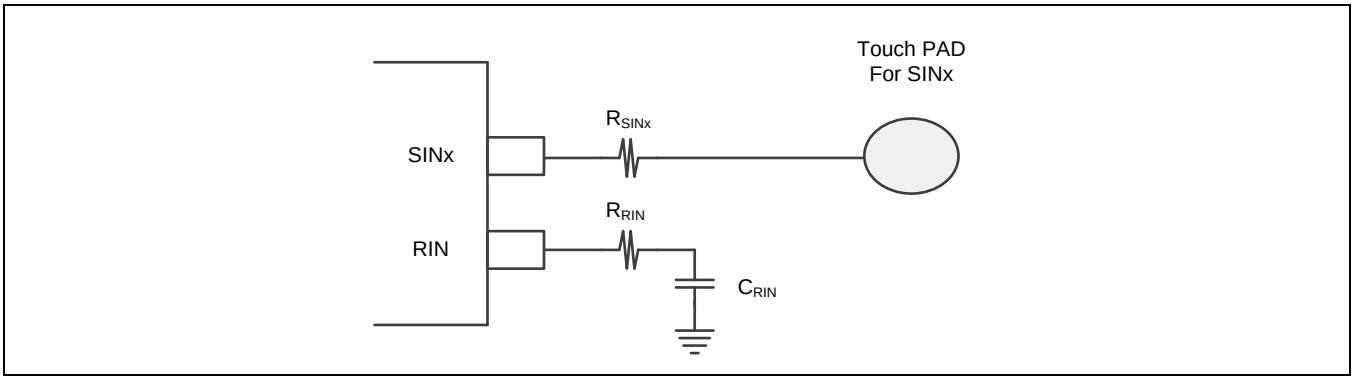
The GTC08L also has various intelligent sensing functions to determine valid touch from error or sensitivity problems caused by various environmental noise effects. These advanced sensing methods will help making faultless touch key systems under the worst conditions.

The internal intelligent sensitivity adjustment algorithm removes sensitivity rolling caused by system noise, circuit deviation, and circumstantial drift. The GTC08L has a special noise elimination filter for more powerful noise rejection and it will be very helpful for proper touch operation even if the system operates under deteriorative environment conditions.

The GTC08L SIN inputs have an internal series resistor for ESD protection. The additional external series resistors are profitable for prevention of abnormal actions caused by radiation noise or electrical surge pulse. In any case, if the additional external series resistor ($R_{SIN1\sim8}$, R_{RIN}) of each SIN and RIN input is required, then it should be less than 1.5KΩ to SIN and 10KΩ to RIN and the location of resister is recommended as closer to the SIN and RIN pins.

The SIN input routing lines are desirable to be routed as short as possible and the width of routing lines should be as narrow as possible and should be placed on bottom metal. In other words, a touch PAD and other parts should be placed on different metal each other. The additional extension line pattern of RIN input on application PCB can help prevention of abnormal actions caused by radiation noise, but excessive long RIN input line can be a reason for failure of touch detect. The SIN inputs and RIN input lines are desirable to be routed as far as possible from impedance varying path such as LED drive current path. All touch sensing pads are recommended to be surrounded by GND pattern in order to reduce noise influence.

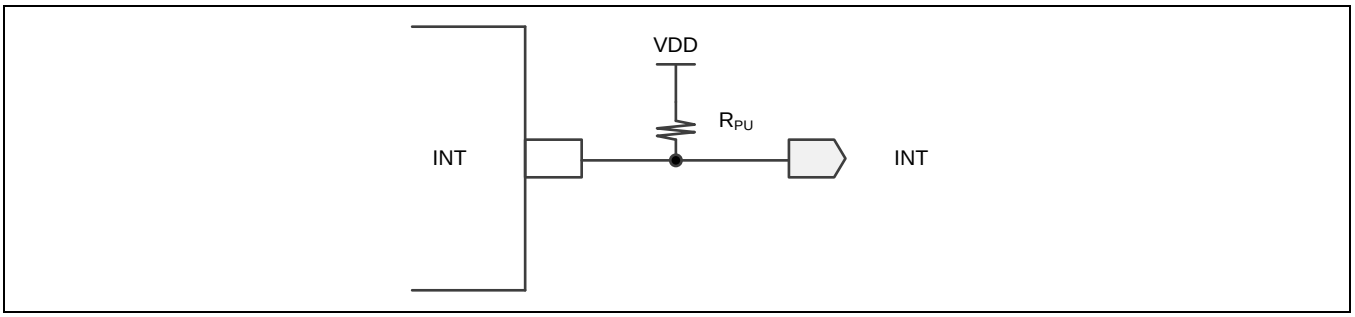
Implementation circuit for SIN pins and RIN pin is shown in the following figure.



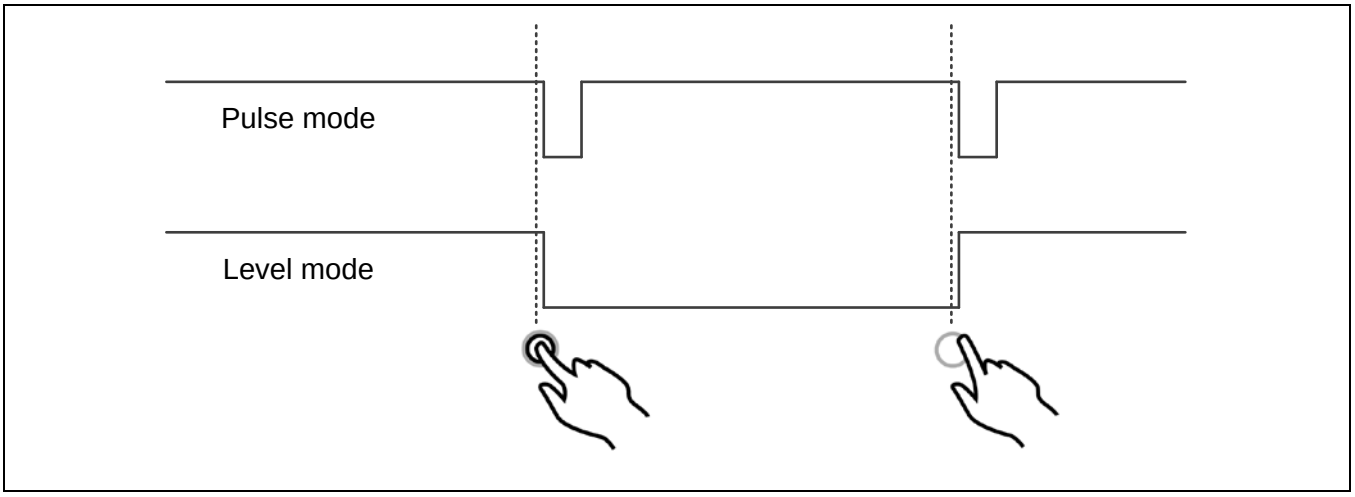
8.3 IMPLEMENTATION FOR INTERRUPT (INT)

The GTC08L provides an interrupt (INT) function to reduce a communication load between MCU and GTC08L. The INT will indicate a point of time that the output status registers at the address 2Ah changes and MCU needs to read it. The INT pin has an open drain NMOS structure hence a couple of kΩ pull-up resistor must be required.
(See register address 10h = INT_MODE)

The basic implementations for active low modes are shown in the following figure.



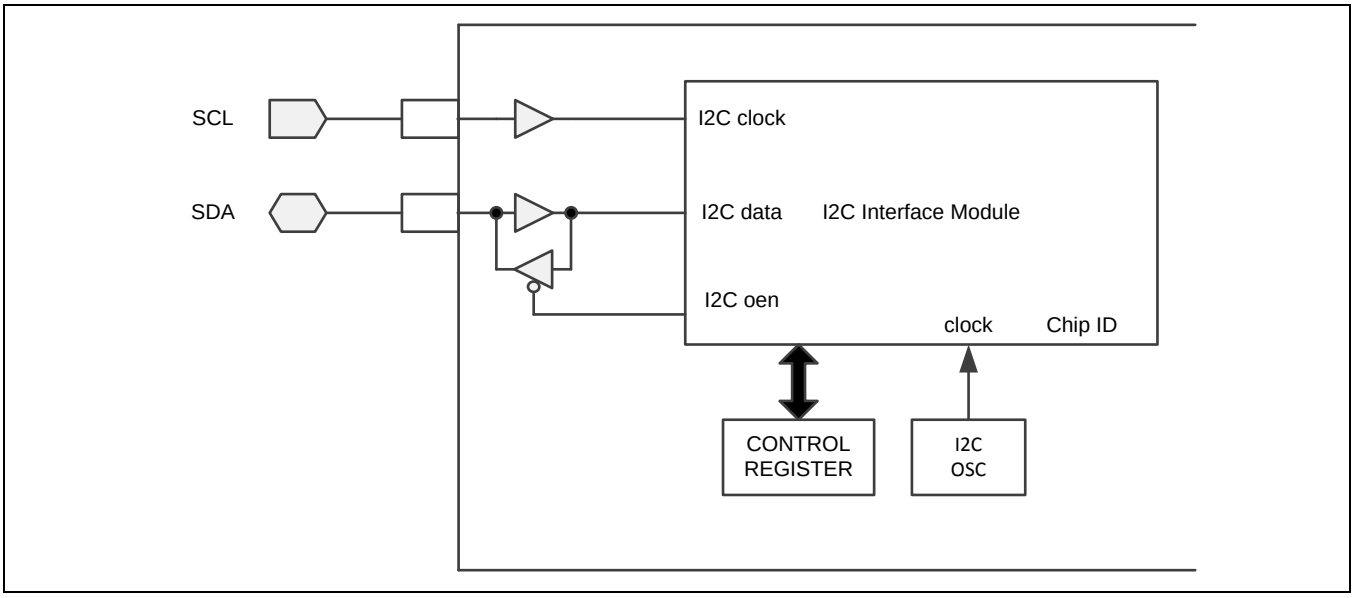
Two interrupt mode operations are shown in the following figure.



8.4 I2C INTERFACE (SCL, SDA)

The I2C-bus is for 2-way, 2-line communication between different ICs or modules. The serial bus consists of two bidirectional lines; one for data signals (SDA), and one for clock signals (SCL).
Both the SDA and SCL lines be connected to a positive supply voltage via a internal pull-up resistor (typical 10kΩ) to prevent open gate leakage current in input mode. But the lines must be connected to a positive supply voltage via a pull-up additional external resistor.
The internal oscillator is disabled when all of both the SDA and SCL lines are high for saving current consumption.

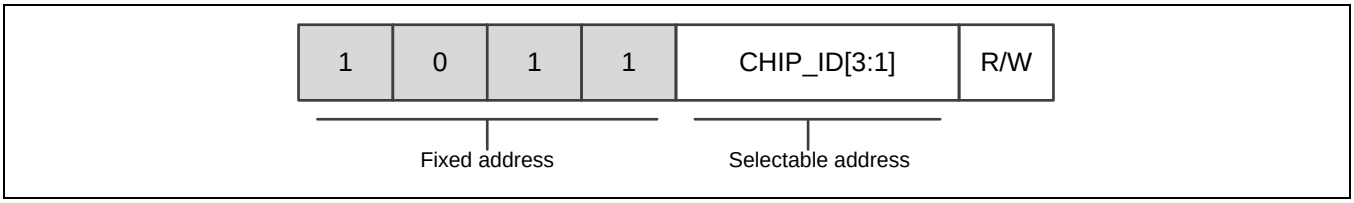
The simple internal block diagram for SCL and SDA is shown in the following figure.



8.4.1 DEVICE ADDRESSING

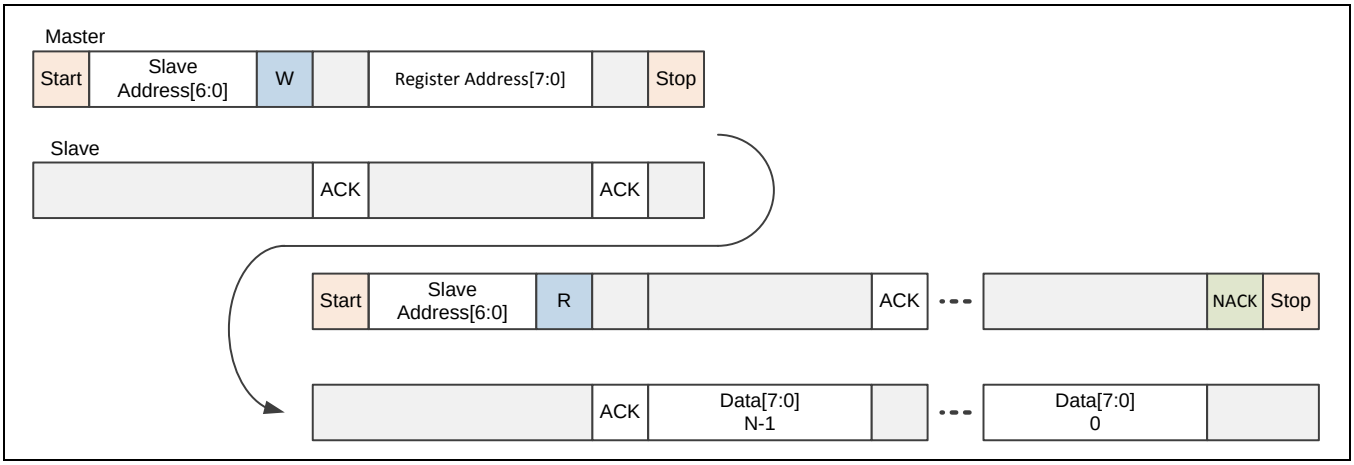
Following a START condition, the bus master must output the address of the slave it is accessing. The last bit of the slave address defines the operation to be performed. When set to logic 1, a read operation is selected, while a logic 0 selects a write operation.

The following figure represents the I2C slave address map.



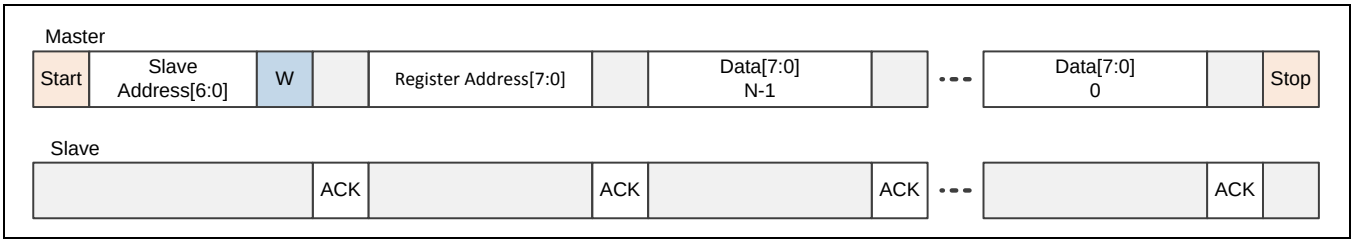
8.4.2 READ OPERATION

The following figure represents the I2C normal mode read operation.



8.4.3 WRITE OPERATION

The following figure represents the I2C normal mode write operation.



9. REGISTER DESCRIPTION

9.1 QUICK REGISTER MAP

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
00h										
01h	R/W	B8h	1	0	1	1	CHIP_ID[3:1]			0
02h										
03h										
04h	R/W	FFh	SIN8_ CH_EN	SIN7_ CH_EN	SIN6_ CH_EN	SIN5_ CH_EN	SIN4_ CH_EN	SIN3_ CH_EN	SIN2_ CH_EN	SIN1_ CH_EN
05h										
06h										
07h										
08h										
09h										
0Ah	R/W	31h	0	0	1	1	0	0	0	MON_ RST
0Bh	R/W	00h	0	0	0	0	0	0	0	SOFT_ RST
0Ch	R/W	00h	0	0	0	0	0	0	0	I2C_ PU_DIS
0Dh										
0Eh										
0Fh	R/W	5Ah	REGISTER_WRITE_LOCK							

NOTE: The blank register is assigned FFh data.

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
10h	R/W	11h	0	0	0	INT_ MODE	0	0	0	MULTI_ MODE
11h	R/W	32h	0	EXP_TIME			0	0	EXP_EN	EXP_ MODE
12h										
13h	R/W	0Ah	0	0	0	0	CAL_TIME			
14h	R/W	00h	0	0	0	0	SEN_IDLE_TIME			
15h	R/W	05h	0	0	0	0	SEN_IDLE_TIME_SUFFIX			
16h										
17h	R/W	04h	0	0	0	0	0	BUSY_TO_IDLE_TIME		
18h	R/W	00h	0	0	0	0	0	0	0	I2B_ MODE
19h	R/W	00h	0	0	0	0	0	0	0	SLIDE _FUNC
1Ah										
1Bh										
1Ch										
1Dh										
1Eh										
1Fh										

NOTE: The blank register is assigned FFh data.

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
20h	R/W	0Fh	0	0	SENSITIVITY1					
21h			0	0	SENSITIVITY2					
22h			0	0	SENSITIVITY3					
23h			0	0	SENSITIVITY4					
24h			0	0	SENSITIVITY5					
25h			0	0	SENSITIVITY6					
26h			0	0	SENSITIVITY7					
27h			0	0	SENSITIVITY8					
28h										
29h										
2Ah	R	-	TOUCH_ OUT8	TOUCH_ OUT7	TOUCH_ OUT6	TOUCH_ OUT5	TOUCH_ OUT4	TOUCH_ OUT3	TOUCH_ OUT2	TOUCH_ OUT1
2Bh	R	-	0	0	0	0	0	0	0	TOUCH_ OR
2Ch										
2Dh										
2Eh										
2Fh										

NOTE: The blank register is assigned FFh data.

9.2 REGISTER CONFIGURATION

9.2.1 01H REGISTER

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
01h	R/W		1	0	1	1	CHIP_ID[3:1]			0
		B8h	1	0	1	1	1	0	0	0

CHIP_ID[3:1]	Software selectable chip ID bit CHIP_ID[3:1] = changeable Chip ID bits

9.2.2 04H REGISTER

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
04h	R/W		SIN8_ CH_EN	SIN7_ CH_EN	SIN6_ CH_EN	SIN5_ CH_EN	SIN4_ CH_EN	SIN3_ CH_EN	SIN2_ CH_EN	SIN1_ CH_EN
		FFh	1	1	1	1	1	1	1	1

SINn(1)_CH_EN	Each of channel(SIN1~8) enable/disable bits 0 = disable 1 = enable
	NOTE: It's configured with the new offset when the SINn(1)_CH_EN bit is enabled.

NOTE: (1) n = SIN1 ~ SIN8 pin

9.2.3 0AH REGISTER

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0Ah	R/W		0	0	0	0	0	0	0	MON_RST
		31h	0	0	1	1	0	0	0	1

MON_RST	Internal and external reset monitoring bit 0 = not active and clear bit by user 1 = active and set bit by GTC08L
	NOTE: It's set '1' when GTC08L is reset.

9.2.4 0BH REGISTER

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0Bh	R/W		0	0	0	0	0	0	0	SOFT_RST
		00h	0	0	0	0	0	0	0	0

SOFT_RST	Soft reset bit 0 = Operation mode 1 = Sleep mode.
	NOTE: Current consumption can be saved and Touch engine is not work in sleep mode. **NOTE:** It's configured with the new offset when the SOFT_RST bit is changed from sleep mode to operation mode. **NOTE:** All the value of register are not changed by SOFT_RST bit.

9.2.5 0CH REGISTER

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0Ch	R/W		0	0	0	0	0	0	0	I2C_ PU_DIS
		00h	0	0	0	0	0	0	0	0

I2C_PU_DIS	I2C pull-up control bit 0 = I2C pull-up enable 1 = I2C pull-up disable

9.2.6 0FH REGISTER

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0Fh	R/W		REGISTER_WRITE_LOCK							
		5Ah	0	1	0	1	1	0	1	0

REGISTER_WRITE_LOCK	Register write lock bit 5Ah = All of registers can be read and write. Other = All of registers are locked. But it's possible to read registers.
	NOTE: When I2C is not used to write operation, it is recommended to prevent the write operation by using the "REGISTER_WRITE_LOCK" function.

9.2.7 10H REGISTER

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
10h	R/W		0	0	0	INT_ MODE	0	0	0	MULTI_ MODE
		11h	0	0	0	1	0	0	0	1

INT_MODE	Interrupt operation mode selection bit 0 = Pulse mode. 1 = Level mode.
MULTI_MODE	Touch engine mode selection bit 0 = Single touch mode 1 = Multi touch mode.

9.2.8 11H REGISTER

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
11h	R/W		0	EXP_TIME			0	0	EXP_EN	EXP_ MODE
		32h	0	0	1	1	0	0	1	0

EXP_TIME(1)	Touch expire time selection bit	
	000 = 4sec 001 = 9sec 010 = 13sec 011 = 17sec	100 = 21sec 101 = 26sec 110 = 30sec 111 = 34sec
EXP_EN	Touch expire enable bit 0 = disable 1 = enable	
	NOTE: It's configured with the new offset when the touch expire function is executed.	
EXP_MODE	Touch expire mode bit 0 = expire count is not restarted whenever a different touch occurs 1 = expire count is restarted if a different touch occur	

NOTE: (1) Test condition: VDD = 5.0V, TA = 25℃

9.2.9 13H REGISTER

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
13h	R/W		0	0	0	0	CAL_TIME			
		0Ah	0	0	0	0	1	0	1	0

CAL_TIME(1)	Calibration time selection bit	
	0000 = 0msec + 1 period	1000 = 800msec + 1 period
	0001 = 100msec + 1 period	1001 = 900msec + 1 period
	0010 = 200msec + 1 period	1010 = 1000msec + 1 period
	0011 = 300msec + 1 period	1011 = 1100msec + 1 period
	0100 = 400msec + 1 period	1100 = 1200msec + 1 period
	0101 = 500msec + 1 period	1101 = 1300msec + 1 period
	0110 = 600msec + 1 period	1110 = 1400msec + 1 period
	0111 = 700msec + 1 period	1111 = No Calibration
	NOTE: (1) The calibration time to protect from environmental change (2) Deviation : ±30% (@5.0V)	

NOTE: (1) Test condition: VDD = 5.0V, TA = 25℃

9.2.10 14H REGISTER

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
14h	R/W		0	0	0	0	SEN_IDLE_TIME			
		00h	0	0	0	0	0	0	0	0

SEN_IDLE_TIME(1)	Idle time section bit			
	0000= 1msec	0100= 400msec	1000= 800msec	1100= 1200msec
	0001= 100msec	0101= 500msec	1001= 900msec	1101= 1300msec
	0010= 200msec	0110= 600msec	1010= 1000msec	1110= 1400msec
	0011= 300msec	0111= 700msec	1011= 1100msec	1111= 1500msec
	NOTE: The idle time equation is as follows. IDLE_TIME = SEN_IDLE_TIME[3:0] + SEN_IDLE_TIME_SUFFIX[3:0] Ex> 110msec = 100msec + 10msec			

NOTE: (1) Test condition: VDD = 5.0V, TA = 25℃

9.2.11 15H REGISTER

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
15h	R/W		0	0	0	0	SEN_IDLE_TIME_SUFFIX			
		05h	0	0	0	0	0	1	0	1

SEN_IDLE_TIME_SUFFIX(1)	Idle time suffix section bit			
	0000= 0msec	0100= 40msec	1000= 80msec	1100= 120msec
	0001= 10msec	0101= 50msec	1001= 90msec	1101= 130msec
	0010= 20msec	0110= 60msec	1010= 100msec	1110= 140msec
	0011= 30msec	0111= 70msec	1011= 110msec	1111= 150msec
	NOTE: The idle time equation is as follows. IDLE_TIME = SEN_IDLE_TIME[3:0] + SEN_IDLE_TIME_SUFFIX[3:0] Ex> 110msec = 100msec + 10msec			

NOTE: (1) Test condition: VDD = 5.0V, TA = 25℃

9.2.12 17H REGISTER

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
17h	R/W		0	0	0	0	0	BUSY_TO_IDLE_TIME		
		04h	0	0	0	0	0	1	0	0

BUSY_TO_IDLE_TIME(1)	Busy to Idle time selection bit	
	000 = 0sec (disable) 001 = 1sec 010 = 2sec 011 = 3sec	100= 4sec 101= 5sec 110= 6sec 111= 7sec

NOTE: (1) Test condition: VDD = 5.0V, TA = 25℃

9.2.13 18H REGISTER

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
18h	R/W		0	0	0	0	0	0	0	I2B_ MODE
		00h	0	0	0	0	0	0	0	0

I2B_MODE	Idle to busy mode control bit 0 = auto mode 1 = manual mode

9.2.14 19H REGISTER

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
19h	R/W		0	0	0	0	0	0	0	SLIDE_FUNC
		00h	0	0	0	0	0	0	0	0

SLIDE_FUNC	Slide function enable bit 0 = disable 1 = enable
	NOTE: After touch output, the IC operates in slide function within the time set in "BUSY_TO_IDLE_TIME" register at the address 17h.

9.2.15 20H~27H REGISTER

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
20h ~ 27h	R/W		0	0	SENSITIVITY1					
			0	0	SENSITIVITY2					
			0	0	SENSITIVITY3					
			0	0	SENSITIVITY4					
			0	0	SENSITIVITY5					
			0	0	SENSITIVITY6					
			0	0	SENSITIVITY7					
			0	0	SENSITIVITY8					
		0Fh	0	0	0	0	1	1	1	1

SENSITIVITYn(4)	Touch sensitivity control bit 05h = Very high sensitive 3Fh = Very high insensitive
	NOTE: It's recommended to use 0Ch~3Fh values at the sensitivity setting.

9.2.16 2AH, 2BH REGISTER

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
2Ah	R	-	TOUCH_OUT8	TOUCH_OUT7	TOUCH_OUT6	TOUCH_OUT5	TOUCH_OUT4	TOUCH_OUT3	TOUCH_OUT2	TOUCH_OUT1
2Bh	R	-	0	0	0	0	0	0	0	TOUCH_OR

TOUCH_OUTn(1)	Each of SIN touch detection status bit 0 = No touch detection 1 = Touch detection.
	NOTE: It's set '1' when touch detection occur.
TOUCH_OR	Touch detection status bit 0 = No touch detection 1 = Touch detection.
	NOTE: It's set '1' when touch detection occur.

NOTE: (1) n = SIN1~SIN8 pin

10. ELECTRICAL CHARACTERISTICS

10.1 ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Conditions	Min	Typ.	Max	Units
Maximum supply voltage	V_{DD_MAX}		-0.3		6.0	V
Supply voltage range(1)	V_{DD_RNG}		-0.3		6.0	V
Voltage on any input pin	V_{IN_MAX}		-0.3		VDD +0.3	V
Maximum current into any pin	I_{MIO}		-100		100	mA
Power dissipation	P_{MAX}		-		800	mW
Storage temperature	T_{STG}		-65		150	℃
Operating humidity	H_{OP}	8 hours	5		95	%
Operating temperature	T_{OPR}		-40		85	℃
Junction temperature	T_J		-40		125	℃

NOTE: (1) This is the real valid power supply voltage range considering allowable supply tolerance. It cannot be used as target supply voltage range which is separately presented at below I/O ELECTRICAL CHRACTERISTICS.

10.2 I/O ELECTRICAL CHARACTERISTICS

This section includes information about power supply requirements and I/O pin characteristics.

(TA = -25 to 85°C, V_{DD} = 2.7V to 5.5V)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Target supply voltage	V_{DD}		2.7	3.0 / 5.0	5.5	V
Current consumption	I_{DD}	Standby mode (VDD = 3.0V)	-	780	-	uA
		Standby mode (VDD = 5.0V)	-	1000	-	uA
Input high voltage	V_{IH}	All input pins	0.7VDD	-	VDD + 0.3	V
Input low voltage	V_{IL}	All input pins	-0.3	-	0.3VDD	V
Output high voltage	V_{OH}	All output pins (I_{OH}= -4mA, VDD = 5.0V)	VDD - 0.4	-	-	V
Output low voltage	V_{OL}	All output pins (I_{OL}= 10mA, VDD = 5.0V)	-	-	0.4	V
Output source current(1)	I_{SRC}	All output pins (Active high)	-	-	-4	mA
Output sink current(1)	I_{SINK}	All output pins (Active low)	-	-	10	mA
Output low leakage current	I_{LOL}		-	-	-1	uA
Output high leakage current	I_{LOH}		-	-	1	uA
SDA Internal Pull-up Resister(1)	R_{PU_SDA}		-	31	-	kΩ
SCL Internal Pull-up Resister(1)	R_{PU_SCL}		-	31	-	kΩ

NOTE:

(1) Test condition: VDD = 5.0V, TA = 25℃ and normal operation mode under default control register value. (Unless otherwise noted)

10.3 RESET CHARACTERISTICS

(TA = -25 to 85°C, V_{DD} = 2.7V to 5.5V)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
POR(1) Time	t_{POR}		-	-	600	usec
POR voltage	V_{POR}		-	2.4	-	V

NOTE: (1) POR = Internal Power-On Reset

10.4 INTERRUPT OUTPUT CHARACTERISTICS

(TA = -25 to 85°C, V_{DD} = 2.7V to 5.5V)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
INT low pulse width	t_{INT}		-	5	-	msec

10.5 SENSING INPUT CHARACTERISTICS

(TA = -25 to 85°C, V_{DD} = 2.7V to 5.5V)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Minimum detectable input capacitance variant	ΔC_{S_MIN}		0.1	-	-	pF
Maximum input external capacitance	C_{EXT_MAX}		-	-	100	pF
Sensitivity selection steps	N_{SEN}		-	60	-	step
Sense OSC internal series resistor	R_{INT}		-	140	-	Ω

10.6 SYSTEM CHARACTERISTICS

(TA = -25 to 85°C, V_{DD} = 2.7V to 5.5V)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Time for stable I2C communication after reset	t_{I2C}		1	-	-	msec
Time for stable Touch Operating after Reset	t_{OP}		300	-	-	msec
Touch On response time	t_{ON}	1 channel Touch at all of register default	-	80	-	msec

10.7 I2C INTERFACE TIMING CHARACTERISTICS

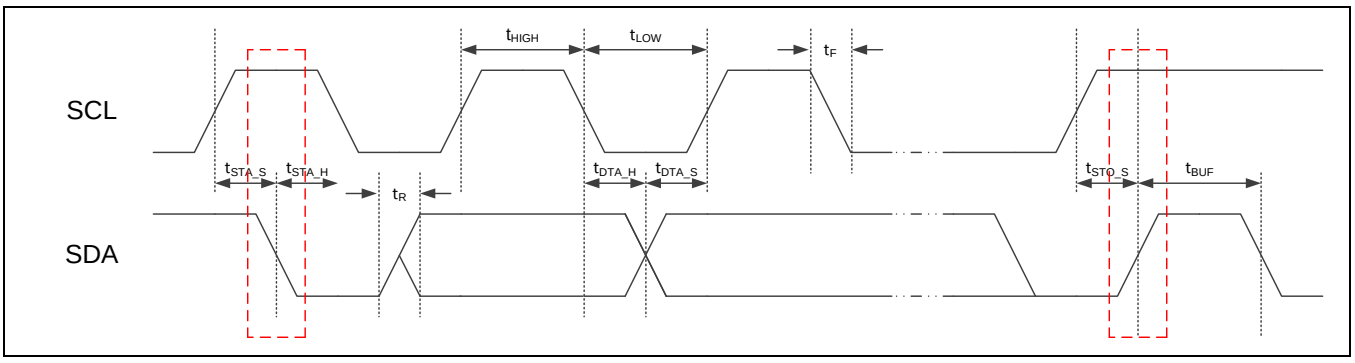
(TA = -25 to 85°C, V_{DD} = 2.7V to 5.5V)

Parameter	Symbol	Standard-mode		Fast-mode		Unit
		Min.	Max.	Min.	Max.	
SCL clock frequency	f_{SCL}	-	100	-	400	kHz
Hold time for START condition	t_{STA_H}	4.0	-	0.6	-	usec
LOW period of the SCL clock	t_{LOW}	4.7	-	1.3	-	usec
HIGH period of the SCL clock	t_{HIGH}	4.0	-	0.7	-	usec
Set-up time for START condition	t_{STA_S}	4.7	-	0.6	-	usec
Data hold time	t_{DAT_H}	5	-	40	-	nsec
Data set-up time	t_{DAT_S}	250	-	100	-	nsec
Rise time of both SDA and SCL signals	t_R	-	1000	20 + 0.1 C_b (2)	300	nsec
Fall time of both SDA and SCL signals	t_F	-	300	20 + 0.1 C_b (2)	300	nsec
Set-up time for STOP condition	t_{STO_S}	4.0	-	0.6	-	usec
Bus free time between a STOP and START condition	t_{BUF}	4.7	-	1.3	-	usec
Capacitive load for each bus line	Cb	-	400		400	pF

NOTE:

(1) All values referred to VIH and VIL levels (please refer to I/O ELECTRICAL CHRACTERISTICS).

(2) C_b = total capacitance of one bus line in pF.



10.8 ESD CHARACTERISTICS

Qualification tests are performed to ensure that these devices can withstand exposure to reasonable levels of static without suffering any permanent damage. During the device qualification, ESD stresses were performed for the Human Body Model (HBM), the Machine Model (MM) and the Charge Device Model (CDM).

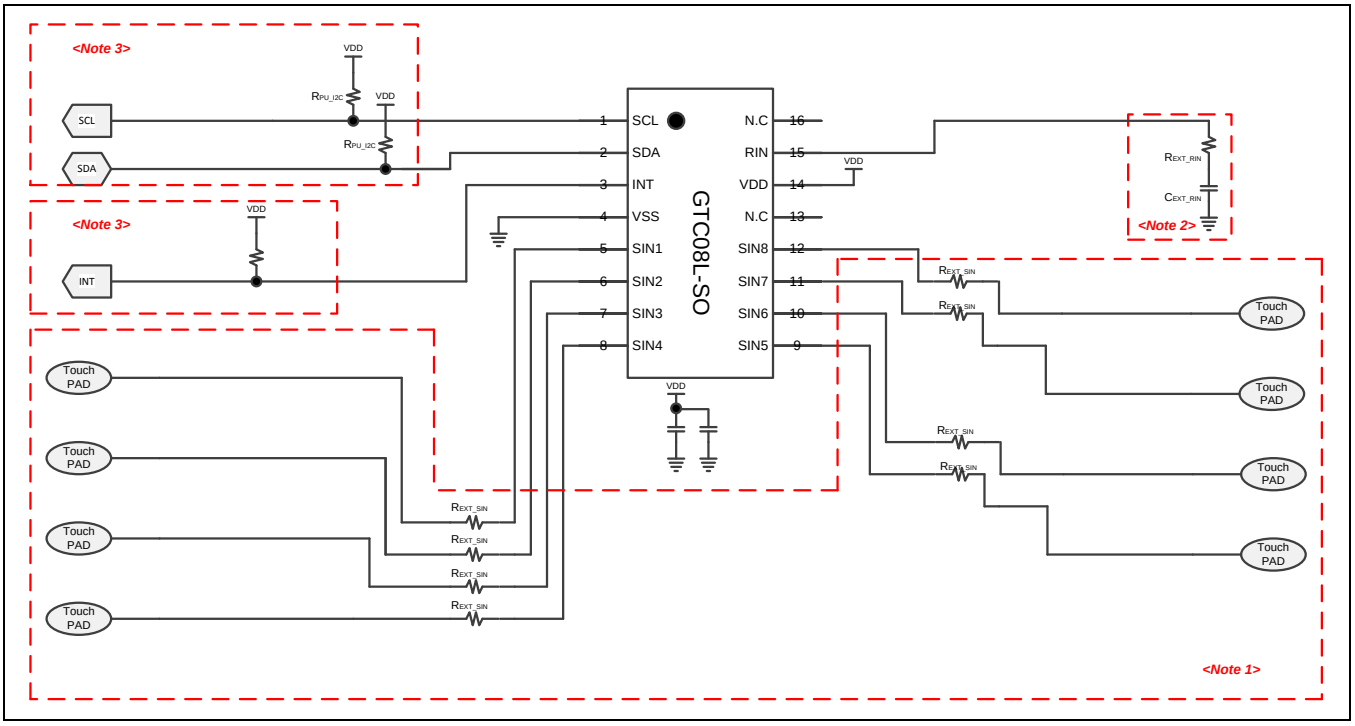
Test Mode	Symbol	Test Pin (Reference)	Max	Unit	Reference Document
Human body model (HBM)	V_{HBM}	VSS, I/O (VDD)	±8000	V	JS-001-2014
		VDD, I/O (VSS)	±8000	V	
		Every I/O (All I/O)	±8000	V	
Machine model (MM)	V_{MM}	VSS, I/O (VDD)	±500	V	JESD22-A115C :2010
		VDD, I/O (VSS)	±500	V	
		Every I/O (All I/O)	±500	V	
Charge device model (CDM)	V_{CDM}	Every Pin	±2000	V	JESD22-C101F :2013

10.9 LATCH-UP CHARACTERISTICS

Test Type	Symbol	Polarity	Max	Unit	Reference Document
I test	I_{LAT_POS}	Positive	200	mA	JESD78E :2016
	I_{LAT_NEG}	Negative	200	mA	
V_{supply} over V_{DD_MAX}	V_{LAT_POS}	Positive	8.25	V	

11. APPLICATION

11.1 EXAMPLE CIRCUIT (SOP-16L PACKAGE)



NOTE: R_{EXT_RIN} = 560Ω (recommend), R_{EXT_SIN} = 560Ω (recommend), R_{PU_I2C} = 10KΩ (recommend)
C_{EXT_RIN} = 3pF (recommend)

NOTE: The values of resistance and capacitance can be changed depending on the application set.

11.2 APPLICATION NOTES

Normally a touch sensing operation is ultimately impedance variation sensing. Hence a touch sensing system is recommended to be taken care of prevention of the external sensing disturbance. Although the GTC08L has enough noise rejection algorithms and various protection circuits to prevent error touch detection caused by noise and incapable sensing, it is better to take care in noisy applications such as home appliances. There are many measurable or invisible noises in system that can affect the impedance sensing signal or distort that signal. The main principal design issues and required attentions are such as below.

- **Power Line**
  - The touch sensor power line is recommended to be split from the other power lines such as relay circuits or LED power that can make pulsation noise on power lines.
  - The big inductance that might exist in long power connection line can cause power fluctuation by other noise sources.
  - The lower frequency periodic power noise such as a few Hz ~ kHz has more baneful influence on sensitivity calibration.
  - An extra regulator for touch sensor is desirable for prevention above power line noises.
  - The V_{DD} under shooting pulse less than internal reset voltage (V_{DD_RST}) can cause system reset.
  - The capacitor connected between V_{DD} and GND is somehow obligation element for buffering above power line noises. This capacitor must be placed as near to IC as possible.

- **Sensing (Reference) Input Line for Touch Detect <Note1><Note2>**
  - The sensing lines for touch detection are desirable to be routed as short as possible and the width of routing path should be as narrow as possible.
  - The sensing line for touch detection should be formed by bottom metal, in other words, an opposite metal of a touch PAD.
  - The additional extension line pattern of RIN input on application PCB can help prevention of abnormal actions caused by radiation noise, but excessive long RIN input line can be a reason for failure of touch detect.
  - The sensing line for touch detection is desirable to be routed as far as possible from impedance varying path such as LED drive current path.
  - An unused sensing channel is desirable to be turned off by control register. (Recommendation)
  - Additional external series resistors are profitable for prevention of abnormal actions caused by radiation noise or electrical surge pulse. The location of resister is better as near as possible to the

SIN and RIN pins for better stable operation.

(Refer to IMPLEMENTATION FOR TOUCH SENSING)

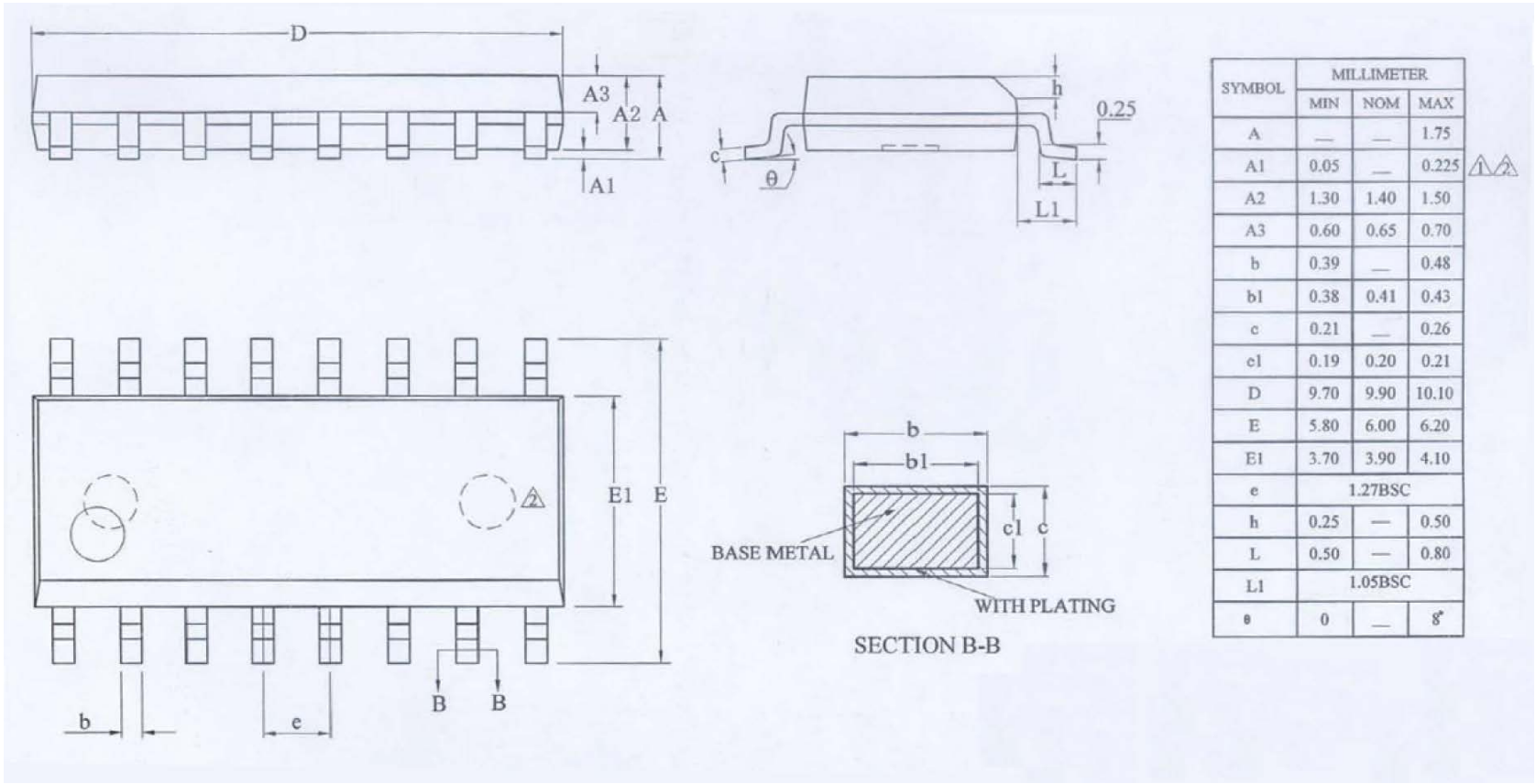
- All touch sensing pads are recommended to be surrounded by GND pattern to reduce noise influence.

- **I2C Interface and Interrupt Applications <Note3>**
  - The SCL is I2C clock input pin and SDA is I2C data input/output pin. SCL and SDA have internal optional pull-up resistor. So, when I2C interface is not required, SCL and SDA pins can be floating. For high speed communication, SDA pin needs small pull-up resistor connected to V_{DD} to reduce pulse rising delay.

    (Refer to I2C INTERFACE)
  - INT is for the output signal that indicates changing of sensing output data. This pin is output only pin and has active low function. Because INT pin has open drain structure, pull-up resistor is required for valid output.

    (Refer to IMPLEMENTATION FOR INTERRUPT)

12. PACKAGE DIMENSION (SOP-16L PACKAGE)



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	1.75
A1	0.05	—	0.225
A2	1.30	1.40	1.50
A3	0.60	0.65	0.70
b	0.39	—	0.48
b1	0.38	0.41	0.43
c	0.21	—	0.26
c1	0.19	0.20	0.21
D	9.70	9.90	10.10
E	5.80	6.00	6.20
E1	3.70	3.90	4.10
e	1.27BSC		
h	0.25	—	0.50
L	0.50	—	0.80
L1	1.05BSC		
θ	0	—	8°