The Classic of Touch Solution!

GREENCHIP

GreenTouch2™ GT208L Capacitive Touch Sensor

v1.1
SPECIFICATION

www.greenchip.co.kr

GENERAL

The GT208L is one of the new GreenTouch2™ capacitive touch sensor series. Especially the GT208L can do capacitance sensing with 8 channels under above GreenTouch2™ engine operation.
Thanks to this epochal GreenTouch2™ 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 and EFT noise environments occurred in any touch applications.

The GT208L offers 8 LED drivers with 16 steps dimming controller. The OUT[1:8] ports can be used for PWM output for LED dimming control. It's very economical solution when the LED feedbacks are required because there is no additional material cost for LED control.

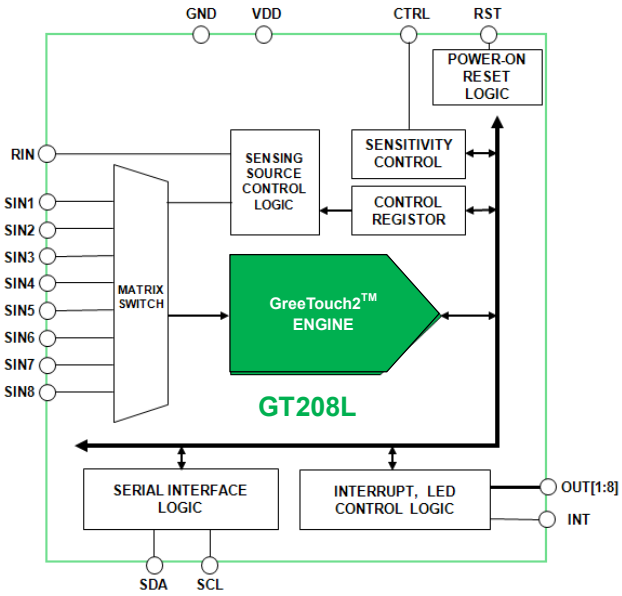
For the touch output result, the I^2C or 1 to 1 direct output interface can be used. I^2C interface might be useful when the MCU IO or connector resource is not enough in the application.

The GT208L can be applied under wide supply voltage range from 2.5 V to 5.0V. And it has CTRL pin to select sensitivity options by making CTRL pin connection to VDD, GND and OPEN. No other external components are required for selecting such options.

FEATURES

- 8 channels cap. Sensing input
- **Embedded GreenTouch2™ Engine**
  - Analog compensation circuit
  - Embedded digital noise filter
  - Intelligent sensitivity calibration
  - Embedded CS, EFT enhancer core
- Two types of interface support
  - 1 to 1 direct interface mode
  - I^2C interface mode
- Provide interrupt function
- LED driver (16 steps dimming control)
- Sensitivity control by CTRL pin connection
- Incredibly low power consumption
  - Normal mode: 120uA (@3.3V)
  - Normal mode: 150uA (@5.0V)
- Wide supply voltage range: 2.5V to 5.0V single supply operation
- Package type
  - 24QFN(4x4), 24QSOP package
- RoHS complaints

BLOCK DIAGRAM



APPLICATIONS

- Portable Electronics - Mobile phone, MP3, PMP, PDA, Navigation, Digital Camera, Video Camera and Etc.
- Multimedia Devices - TV, DVD player, Blue ray player, Digital photo frame, Home theater system and Etc.
- Home Appliance - Refrigerator, Air cleaner, Air conditioner, Washing machine, Micro wave oven and Etc.
- PC, OA and Others - PC, LCD monitor, Fax, Copy machine, Door lock, Lighting controls, Remote control, Toys, Gaming devices and Etc.

ORDERING INFORMATION

Part No.	Package
GT208L-QN4	24QFN 4x4
GT208L-QSO	24QSOP

REVISION HISTORY

Version	Date	Revision Contents
v1.0	May 2011	Release version
V1.1	June 2011	Edit 3-7 CTRL Pin selection (CHIP ID) Edit Description of SEN_IDLE_TIME in 4-3-8 General3 Control Registers

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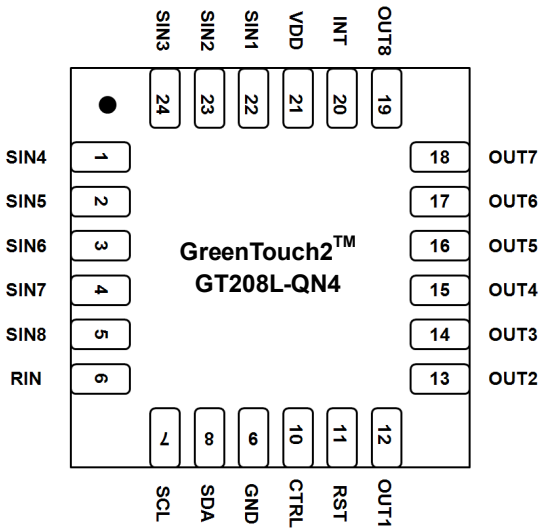
Chapter 1: Pinout Information

This section describes the lists and illustrates the GT208L of GreenTouch2™ family ports as well as pinout configuration. The GT208L device is available in the following package

1-1 24 QFN Pinout (GT208L-QN4)

Port No.	Type	Name	Description
1	AI	SIN 4	Channel 4: Capacitance sensing input
2	AI	SIN 5	Channel 5: Capacitance sensing input
3	AI	SIN 6	Channel 6: Capacitance sensing input
4	AI	SIN 7	Channel 7: Capacitance sensing input
5	AI	SIN 8	Channel 8: Capacitance sensing input
6	AI	RIN	Capacitance reference input
7	DI	SCL	I^2C serial clock input
8	DIO	SDA	I^2C serial data communication port
9	GND	GND	Ground connection
10	AO/DI	CTRL	Sensitivity control input
11	DI	RST	Reset control port (High active)
12	DO	OUT 1	1 to 1 Direct output port for SIN 1 / LED PWM drive output
13	DO	OUT 2	1 to 1 Direct output port for SIN 2 / LED PWM drive output
14	DO	OUT 3	1 to 1 Direct output port for SIN 3 / LED PWM drive output
15	DO	OUT 4	1 to 1 Direct output port for SIN 4 / LED PWM drive output
16	DO	OUT 5	1 to 1 Direct output port for SIN 5 / LED PWM drive output
17	DO	OUT 6	1 to 1 Direct output port for SIN 6 / LED PWM drive output
18	DO	OUT 7	1 to 1 Direct output port for SIN 7 / LED PWM drive output
19	DO	OUT 8	1 to 1 Direct output port for SIN 8 / LED PWM drive output
20	DO	INT	Interrupt output port
21	PWR	VDD	Supply Voltage
22	AI	SIN 1	Channel 1: Capacitance sensing input
23	AI	SIN 2	Channel 2: Capacitance sensing input
24	AI	SIN 3	Channel 3: Capacitance sensing input

[Note] DI: Digital Input, DO: Digital Output, DIO: Digital Input and Output, AI: Analog Input, AO: Analog Output, PWR: POWER

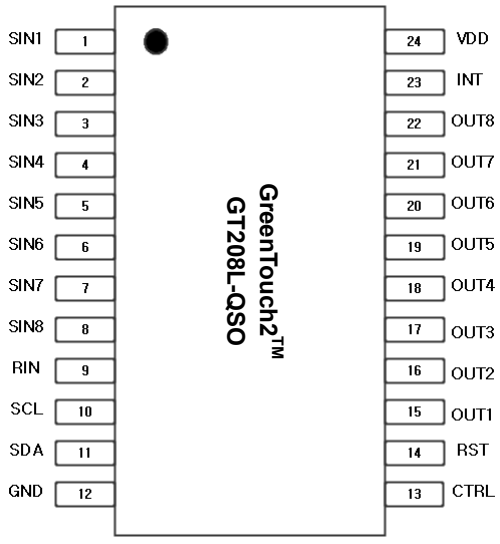


Refer to Chapter 6: Package Information for package outer scale

1-2 24 QSOP Pinout (GT208L-QSO)

Port No.	Type	Name	Description
1	AI	SIN 1	Channel 1: Capacitance sensing input
2	AI	SIN 2	Channel 2: Capacitance sensing input
3	AI	SIN 3	Channel 3: Capacitance sensing input
4	AI	SIN 4	Channel 4: Capacitance sensing input
5	AI	SIN 5	Channel 5: Capacitance sensing input
6	AI	SIN 6	Channel 6: Capacitance sensing input
7	AI	SIN 7	Channel 7: Capacitance sensing input
8	AI	SIN 8	Channel 8: Capacitance sensing input
9	AI	RIN	Capacitance reference input
10	DI	SCL	I^2C serial clock input
11	DIO	SDA	I^2C serial data communication port
12	GND	GND	Ground connection
13	AO/DI	CTRL	Sensitivity control input
14	DI	RST	Reset control port (High active)
15	DO	OUT 1	1 to 1 Direct output port for SIN 1 / LED PWM drive output
16	DO	OUT 2	1 to 1 Direct output port for SIN 2 / LED PWM drive output
17	DO	OUT 3	1 to 1 Direct output port for SIN 3 / LED PWM drive output
18	DO	OUT 4	1 to 1 Direct output port for SIN 4 / LED PWM drive output
19	DO	OUT 5	1 to 1 Direct output port for SIN 5 / LED PWM drive output
20	DO	OUT 6	1 to 1 Direct output port for SIN 6 / LED PWM drive output
21	DO	OUT 7	1 to 1 Direct output port for SIN 7 / LED PWM drive output
22	DO	OUT 8	1 to 1 Direct output port for SIN 8 / LED PWM drive output
23	DO	INT	Interrupt output port
24	PWR	VDD	Supply Voltage

[Note] DI: Digital Input, DO: Digital Output, DIO: Digital Input and Output, AI: Analog Input, AO: Analog Output, PWR: POWER



Refer to Chapter 6: Package Information for package outer scale

Chapter 2: Electrical Specification

2-1 Absolute Maximum Ratings

Parameter	Symbol	Min	Max	Units	Conditions
Maximum supply voltage	V_{DD_MAX}	-	8.0	V	
Supply voltage range(1)	V_{DD_RNG}	2.2	6.0	V	
Voltage on any input port	V_{IN_MAX}	-	V_{DD}+0.3	V	
Maximum current into any port	I_{MIO}	-100	100	mA	
Power dissipation	P_{MAX}	-	800	mW	
Storage temperature	T_{STG}	-65	150	℃	
Operating humidity	H_{OP}	5	95	%	8 hours
Operating temperature	T_{OPR}	-40	85	℃	
Junction temperature	T_J	-40	125	℃	

(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 DC & Operating Characteristics.

2-2 DC & Operating Characteristics

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Power supply and current consumption						
Target supply voltage	V_{DD}		2.5	3.3(5.0)	5.5	V
Current Consumption (Normal stand-by)	I_{DD}	Slow clock operation(3)	-	70	120	μA
		Normal clock operation(3)	-	120	170	
		Fast clock operation(3)	-	160	210	
Internal reset voltage(2)	V_{DD_RST}	T_A = 25℃	-	1.6	2.0	V
Digital input/output						
Input high level voltage	V_{IH}		V_{DD}*0.7	-	V_{DD}+0.3	V
Input low level voltage	V_{IL}		-0.3	-	V_{DD}*0.3	V
Internal pull-up resistor (Ports : SCL, SDA)	R_{PU}	Pull-up resistor enable	-	30	-	kΩ
Internal pull-down resistor (Port : RST)	R_{PD}		-	45	-	kΩ
Output (LED PWM) drive						
Output sink current (LED drivable)	I_{SINK}	Active low output(4)	-	-	10	mA
Output source current	I_{SRC}	Active high output(4)	-	-	4	mA
Output impedance to GND (NMOS)	Z_{ON}	Active low output (Low level)(4)	-	15	-	Ω
		Active low output (High level)(4)	-	30	-	MΩ
Output impedance to VDD (PMOS)	Z_{OP}	Active high output (Low level) (4)	-	30	-	MΩ
		Active high output (High level) (4)	-	30	-	Ω
Output PWM duty steps (LED brightness steps)	N_{DUTY}	LED output	-	16	-	step
Maximum PWM low duty (Maximum brightness)	$D_{MAX(L)}$	LED output	-	88	-	%
Minimum PWM low duty (LED off)	$D_{MIN(L)}$	LED output	-	0	-	%

(1) Test condition: V_{DD} = 3.3V, TA = 25℃ and normal operation mode (Unless otherwise noted)
(2) The GT208L has internal reset circuit, so external reset element or reset signal is not always necessary for power reset.
(3) The operation mode can be selected by option register setting. Refer to Chapter 4: Register Description.
These current consumption values are measured at normal sensing period (45msec) register setting condition.
(4) All the outputs can be selected as open-drain NMOS structure (Active Low) or as open drain PMOS structure (Active High).

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Timing and operations						
Time for stable power reset	T_{RST}		-	100	-	msec
Sense detection expire time	T_{EXP}		-	20	-	sec
Minimum RST high pulse width for external reset	T_{P_ERST}	Active high reset	10	-	-	usec
Maximum I^2C communication speed	F_C	Maximum internal I^2C support CLK	-	400k	-	bps
SIN (RIN) & CTRL						
Minimum detectable input capacitance variation	ΔC_{S_MIN}		0.1	-	-	pF
Max. SIN(RIN) input capacitance	C_{SIN_MAX} C_{RIN_MAX}		-	-	50	pF
Sensitivity selection steps	N_{SEN}		-	60	-	step
Sense internal series resistor	R_S		-	40	-	Ω
Max. sense external series resistor	R_{S_EX}		-	-	1	kΩ
Typical CTRL sink(source) current	I_{CTRL}	Normal clock operation, V_{DD} = 3.3V	-	20	-	μA

2-3 ESD & Latch-Up Characteristics

2-3.1 ESD Characteristics

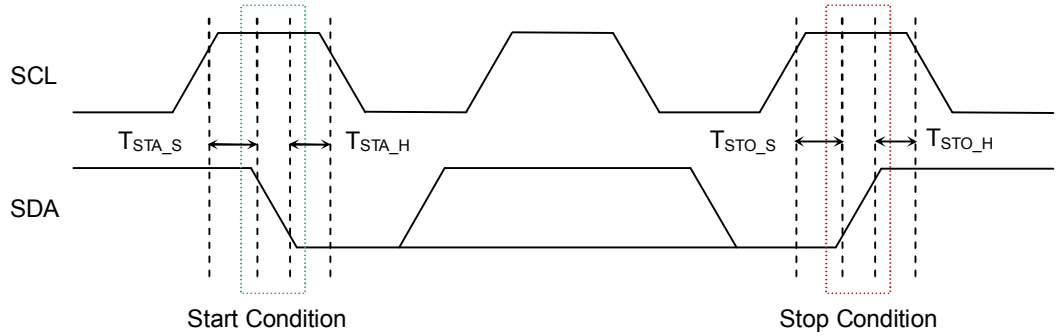
Mode	Polarity	Max	Reference
H.B.M	POSITIVE / NEGATIVE	Over 7500V	VDD
			VSS
			P to P
M.M	POSITIVE / NEGATIVE	500V	VDD
			VSS
			P to P

2-3.2 Latch-Up Characteristics

Mode	Polarity	Max	Test Step
I Test	POSITIVE	100mA	25mA
	NEGATIVE	-100mA	
V supply over 3.3V	POSITIVE	~ 8.5V	-

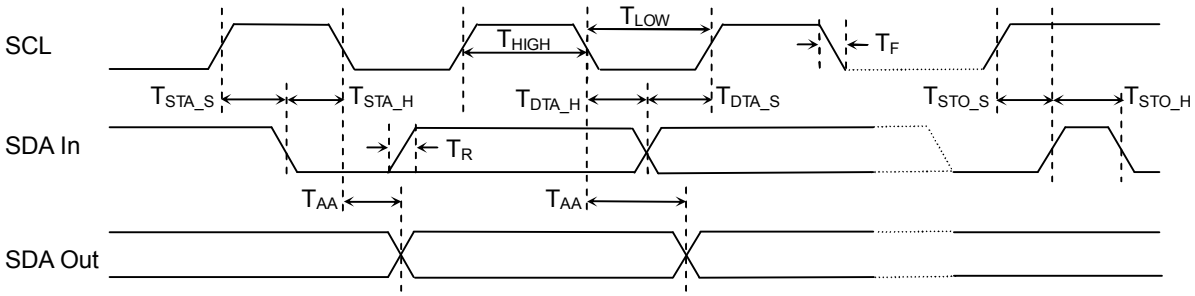
2-4 I²C Interface Timing Characteristics

2-4.1 Timing Diagram for SCL, SDA



Symbol	Characteristic		Min	Max	Units	Conditions
T_{STA_S}	Start condition setup time	100KHz mode	4.7	-	usec	Only relevant for repeated START condition
		400KHz mode	1.0	-	usec	
T_{STA_H}	Start condition hold time	100KHz mode	4.0	-	usec	After this period, the first clock pulse is generated
		400KHz mode	1.0	-	usec	
T_{STO_S}	Stop condition setup time	100KHz mode	4.7	-	usec	
		400KHz mode	1.0	-	usec	
T_{STO_H}	Stop condition hold time	100KHz mode	4.0	-	usec	
		400KHz mode	1.0	-	usec	

2-4.2 Timing Diagram for SCL, SDA In/Out

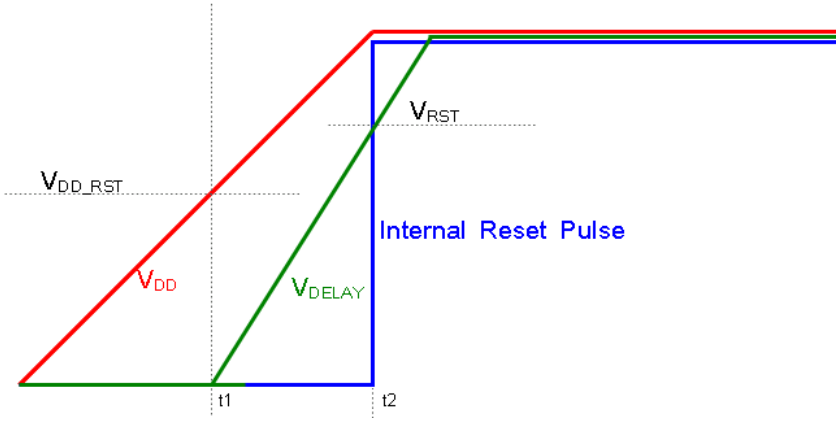


Symbol	Characteristic		Min	Max	Unit	Conditions
T_{HIGH}	Clock high time	100KHz mode	4000	-	ns	
		400KHz mode	1000	-	ns	
T_{LOW}	Clock low time	100KHz mode	4700	-	ns	
		400KHz mode	1300	-	ns	
T_{DAT_S}	Data Input setup time	100KHz mode	250	-	ns	-
		400KHz mode	100	-	ns	
T_{DAT_H}	Data input hold time	100KHz mode	0	3500	ns	-
		400KHz mode	0	900	ns	
T_{AA}	Output valid from clock	100KHz mode	-	2 clk	ns	System clock
		400KHz mode	-	2 clk	ns	
T_R	SDA and SCL rising time	100KHz mode	-	1000	ns	The range of Cb is from 10pF to 400pF.
		400KHz mode	20+0.1Cb	300	ns	
T_F	SDA and SCL falling time	100KHz mode	-	300	ns	The range of Cb is from 10pF to 400pF.
		400KHz mode	20+0.1Cb	300	ns	

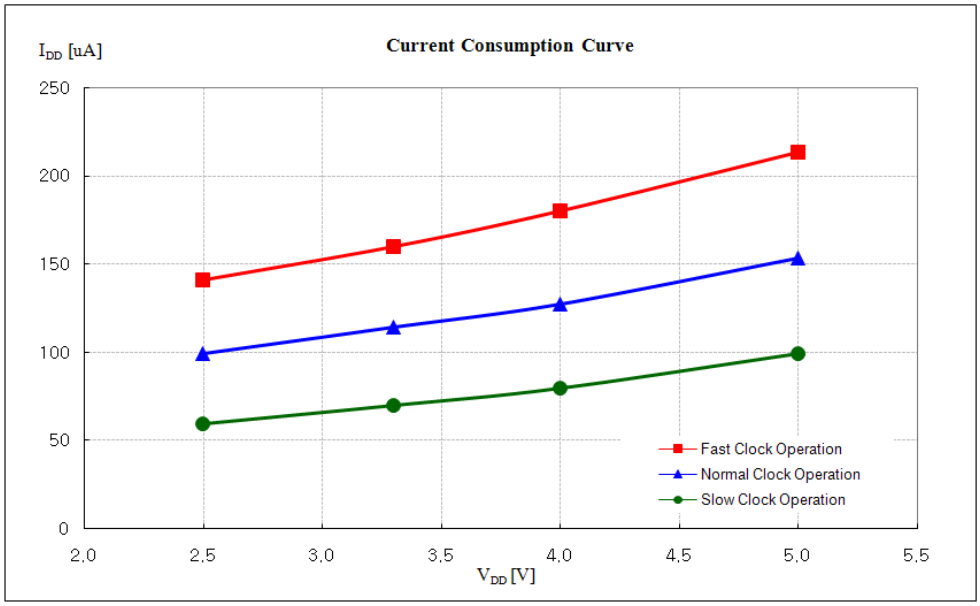
Chapter 3: Functional Description

3-1 Reset and Operation Modes

The GT208L has both internal power reset and external reset functions. The internal reset operation is used for initial power reset and the external reset operation is done by RST pin. High pulse signal by RST pin is for an abrupt reset which is required for intensive system reset. The RST pin might be floating and no external reset components are required when the external reset is not in use.
The internal power reset sequence is represented as below.



The internal V_{DELAY} voltage starts to rise when V_{DD} 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. The external reset by RST pin is activated during high input pulse period. The intensive system reset can be easily obtained by this high pulse input to the RST pin. More than 10usec high pulse period is required for proper reset. Because RST pin has an internal pull-down resistor (typical value is 45kΩ), the RST pin might be floating.
The three clock operations could be selected by 'SYS_CLK_SEL' register bit. The internal system clock and frequency bands of sense signal should change according to this selection. The current consumption will then increase as system and sense clock increases. The system and sense clock frequency are about 30% faster in fast clock operation and about 30% slower in slow clock operation than normal clock operation. The typical current consumption curves on each operation mode of GT208L are represented in accordance with V_{DD} voltage as below.



Typical Current consumption curve of GT208L (under 45msec sensing period register setting condition)

3-2 Implementation of Sensing & Reference Inputs (SIN1~SIN8, RIN)

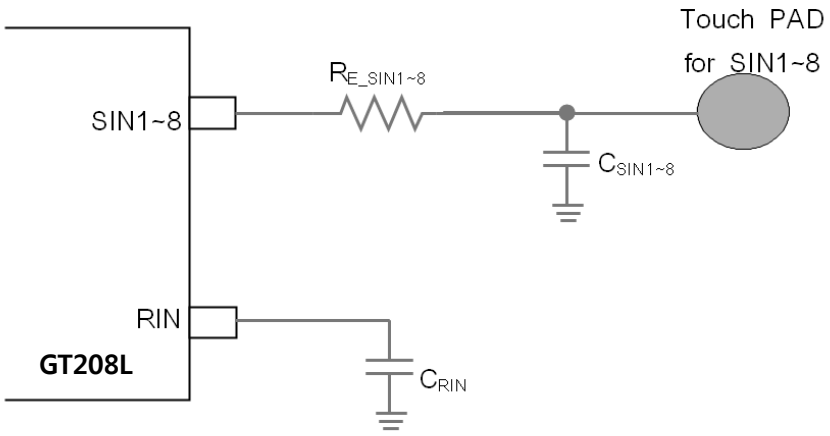
SIN inputs (SIN1~SIN8) and RIN input are used for touch detection of capacitance variation sensing. The SIN input pins are connected to touch sensing pad and catches capacitance variation caused by direct touch or approach. And RIN input for the reference capacitance is connected only to a capacitor to compensate capacitance difference between SIN inputs and RIN input. The GT208L 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. Experimentally, proper C_{RIN} capacitor value is about the average value of SIN inputs capacitors.

The GT208L 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.

With sensitivity options by CTRL pin and $C_{SIN1\sim8}$ capacitors, there will be no difficulties to satisfy system's required sensitivity. The internal intelligent sensitivity adjustment algorithm removes sensitivity rolling caused by system noise, circuit deviation, and circumstantial drift. The GT208L 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.

Implementation circuit for SIN inputs and RIN input is shown in figure below. The GT208L 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_{E_SIN}) of each SIN input is required, then it should be less than 1kΩ and the location of resister is recommended as closer to the SIN pins. For $C_{SIN1\sim8}$, C_{RIN} capacitor, less than 50pF capacitor can be used. Both R_{E_SIN} and $C_{SIN1\sim8}$ are not obligatory components.

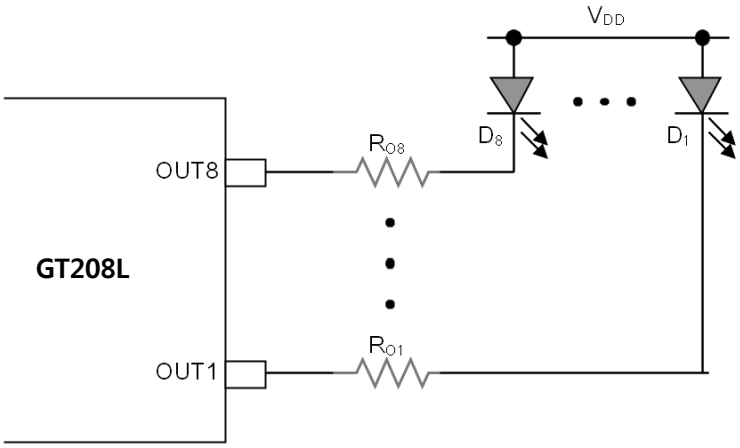
The SIN input routing lines are desirable to be routed as short as possible and the width of routing lines should be as narrow as possible and should be placed on bottom metal. In other words, a touch PAD and other parts should be placed on different metal each other. The additional extension line pattern 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.



Implementations for SIN inputs and RIN input with external components and sensing pad.

3-3 LED PWM Drive (OUT1~OUT8)

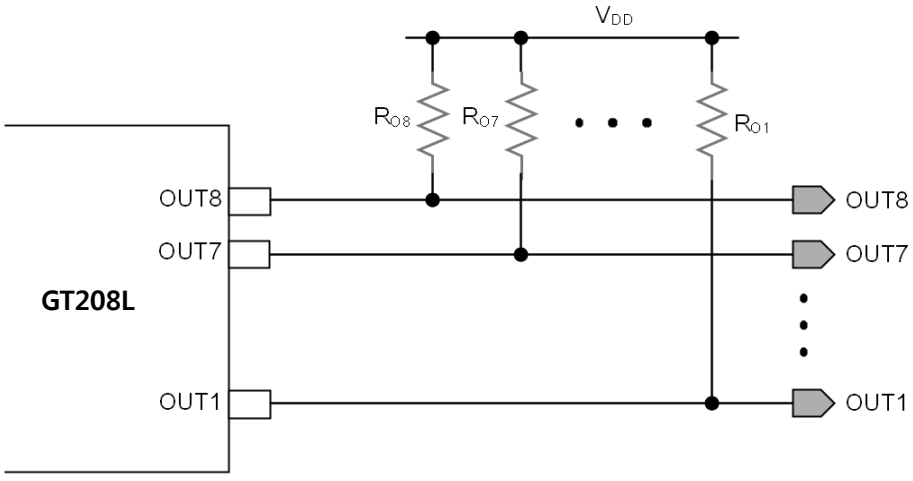
The LED PWM drive is available by using output pins from OUT1 to OUT8. There are 16 steps for the LED brightness and this can be controlled by PWM duty with PWM control register. (*For more detail information, please refer to chapter 4: Register Description.*) The maximum LED brightness is on 88% duty and the minimum is on 0% duty. The maximum sink current is 10mA on each pin under typical condition. OUT pins that are used for driving LED, can't be used for 1 to 1 direct touch sensing output simultaneously. The basic implementation for LED PWM drive is shown in figure below. The $R_{O1\sim8}$ are LED current limiting resistors.



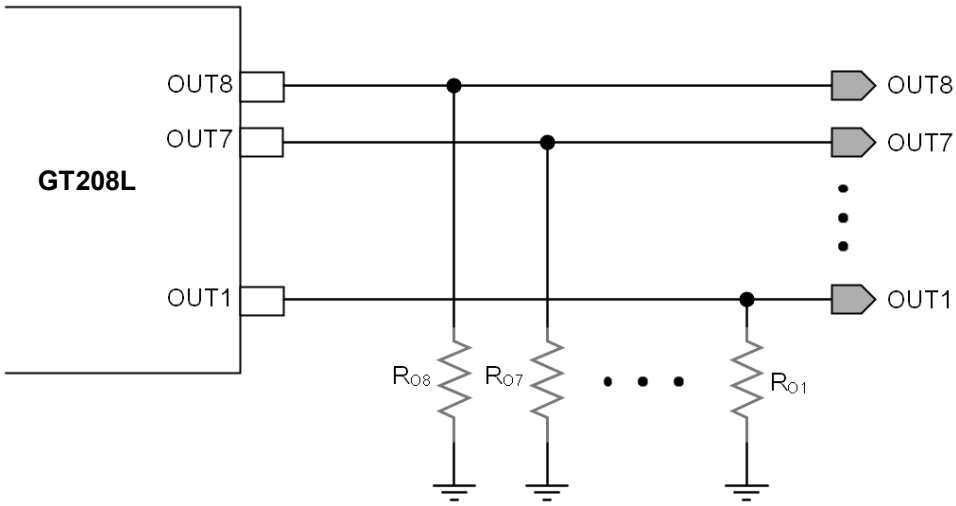
Implementations of output ports for LED PWM drive

3-4 1 to 1 Direct Output Interfaces (OUT1~OUT8)

The GT208L has two types of output data interface methods. The first method is 1 to 1 direct output using from the OUT1 to OUT8 pins which are corresponding to SIN1 to SIN8 respectively. (Output pins OUTx corresponds to sensing channel of SINx) The other one is I^2C interface using SCL and SDA pins. This two interface methods can be used simultaneously. These 1 to 1 direct output pins can operate in active low or active high mode. Its polarity of output can be changed with 'DIR_OUT_POL' register bit and all OUTx pins will have the same active polarity. The OUTx pins have open drain NMOS structure so therefore it needs pull-up resistors when the OUTx pins are used in active low mode. They also have open drain PMOS structure and they need pull-down resistors in active high mode. A couple of kΩ can be used for these pull-up or pull-down resistors. The implementations for both two active modes are shown in figures following.



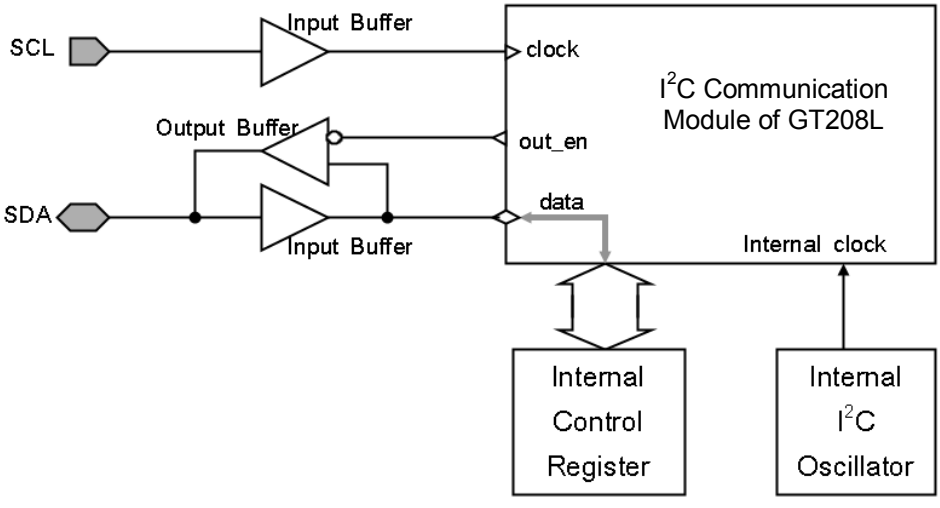
Implementations of OUTx ports used as active low mode



Implementations of OUTx ports used as active high mode

3-5 I²C Interface (SCL, SDA)

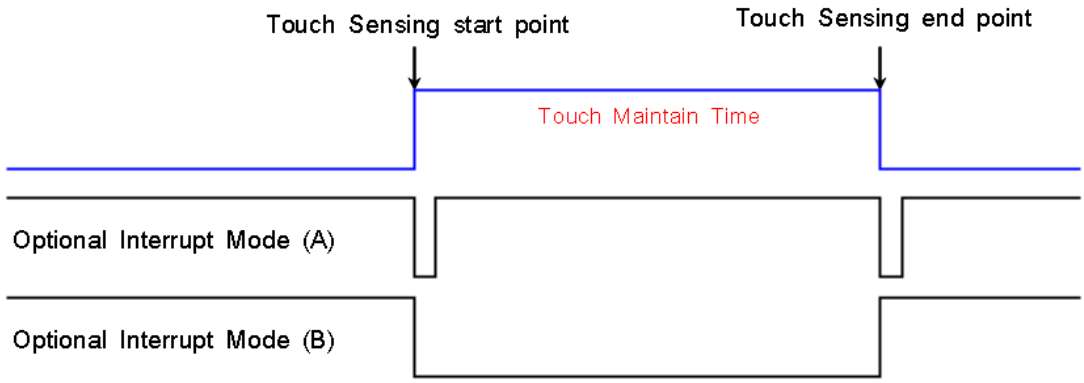
The SCL and SDA pins are used for I²C interface. The SCL is I²C clock input pin and the SDA is I²C data input/output pin. By this I²C interface, internal register values of GT208L can be read and written. Output data also can be read from the address 0x2A of internal register. These pins have an internal pull-up resistor (typical 30kΩ) to prevent open gate leakage current in input mode. For high speed communication, the SDA pin needs additional external pull-up resistor which is connected to V_{DD} to reduce rising delay. The simple internal block diagram for SCL and SDA is shown below. The GT208L has an internal I²C clock oscillator. The maximum data-rate is about 400Kbps. For a timing of I²C interface, please refer to the section 2-4.



Internal I²C interface structure of GT208L

3-6 Interrupt Output (INT)

The GT208L provides an interrupt (INT) function to reduce a communication load between MCU and GT208L. The INT will indicate a point of time that the output status registers at the address 0x2A changes and MCU needs to read it. The interrupt function can be used in two modes by setting 'INT_MODE' register bit. The INT pin has an open drain NMOS structure hence a couple of kΩ pull-up resistor must be required. Two interrupt mode operations are shown in the figure below. In the mode (A), a short interrupt pulse is generated every time the data at the output status register changes. In the other mode (B), an interrupt pulse maintains low during at least one of eight channels' touch is coming on the output status register.



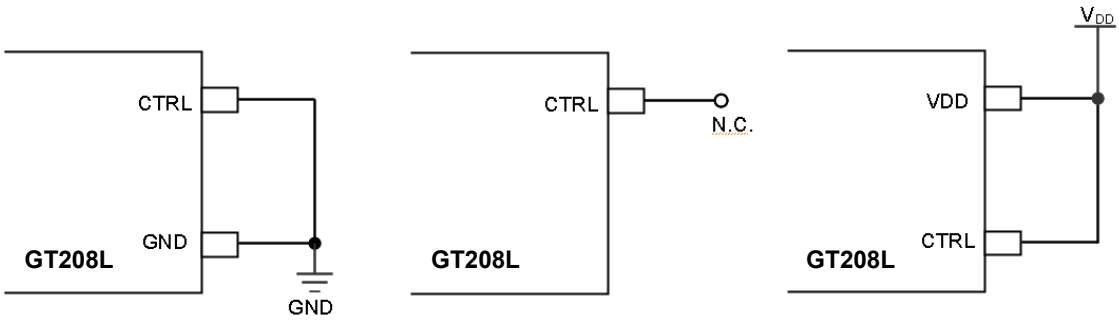
Optional interrupt modes of high interrupt pulse polarity selection case

3-7 CTRL Pin Selection (Sensitivity, Single/Multi mode, CHIP_ID)

In the GT208L, three options are available by CTRL pin connection. Each option and its connections are shown in the table and figures below. A pulse generator is implemented for connection indication signal. This CTRL pulse signal starts at internal power reset time and finishes after a few operation period and options setting. For more detail sensitivity adjustment, C_{SIN} capacitors should be used. (please refer to chapter 3.2)

CTRL pin connection		
[case 1] GND Connection ▶ High sensitivity ▶ Single touch mode ▶ CHIP ID: 0xB4	[case 2] Open Connection ▶ Middle sensitivity ▶ Multi touch mode ▶ CHIP ID: 0xB8	[case 3] VDD Connection ▶ Low sensitivity ▶ Multi touch mode ▶ CHIP ID: 0xB8

CTRL pin connection table



[Case1] GND Connection [Case2] Open Connection [Case3] VDD Connection

Chapter 4: Register Description

4-1 I²C Write/Read Operations in Normal Mode

The following figure represents the I²C normal mode write and read registers.

☞ Write operation (Write the data AA and BB to register 0x00 and 0x01)

Start	Device Address 0xB8	ACK	Register Address 0x00	ACK	Data AA	ACK	Data BB	ACK	Stop

☞ Read operation (Read a data from register 0x00 and 0x01)

Start	Device Address 0xB8	ACK	Register Address 0x00	ACK	Stop

Start	Device Address 0xB9	ACK	Data Read AA	ACK	Data Read BB	ACKB	Stop

From Master to Slave

From Slave to Master

4-2 Register Map

Addr.	Def.	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
02H	0xB8	Reserved				CHIP_ID[3:1]			Reserved
03H	0xFF	TOUCH_CH_EN							
04H	0x55	Reserved					MULTI_ MODE	Reserved	
05H	0x00	PWM_CH_EN							
2AH	0x--	TOUCH_OUTPUT							
39H	0x01	Reserved						SYS_CLK_SEL	
3AH	0x05	Reserved		UCTRL_EN	INT_MODE	Reserved		DIR_OUT_ POL	Reserved
3BH	0x20	Reserved	SEN_IDLE_TIME		PWM_EN	Reserved			SOFT_RST
3DH	0x1A	Reserved			EXP_TIME			EXP_EN	EXP_ MODE
40H	0x0F	Reserved		SENSITIVITY 1					
41H	0x0F	Reserved		SENSITIVITY 2					
42H	0x0F	Reserved		SENSITIVITY 3					
43H	0x0F	Reserved		SENSITIVITY 4					
44H	0x0F	Reserved		SENSITIVITY 5					
45H	0x0F	Reserved		SENSITIVITY 6					
46H	0x0F	Reserved		SENSITIVITY 7					
47H	0x0F	Reserved		SENSITIVITY 8					
48H	0x00	PWM_DATA2				PWM_DATA1			
49H	0x00	PWM_DATA4				PWM_DATA3			
4AH	0x00	PWM_DATA6				PWM_DATA5			
4BH	0x00	PWM_DATA8				PWM_DATA7			
4FH	0x20	Reserved		MON_RST	Reserved				

4-3 Register Description

4-3-1 Chip ID Control Registers - R/W

☞ *Description:* The GT208L chip ID. It can be set 0xB0 ~ 0xBF. This register control should be available when the CTRL pin is connected to open or VDD. Chip ID be set at 0xB4 when CTRL pin is connected to GND. (See 3-7 CTRL Pin Selection)

02H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	Reserved				CHIP_ID[3:1]			Reserved
Default	1	0	1	1	1	0	0	0

Addr.	Bits	Default	Name	Description
02H	7-4	1011B	Reserved	Fixed '1011' = 0xBH
	3-1	100B	CHIP_ID[3:1]	GT208L chip ID.
	0	0B	Reserved	

4-3-2 Touch Channel Enable Registers - R/W

☞ *Description:* The GT208L supports eight each touch channel enable register.

03H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	TOUCH_CH_EN							
Default	1	1	1	1	1	1	1	1

Addr.	Bits	Default	Name	Description
03H	7-0	FFH	TOUCH_CH_EN	1~8 each touch channel enable

4-3-3 Single and Multi-touch Control Registers - R/W

☞ *Description:* The GT208L is supported single and multi touch mode. This register is available when UCTRL_EN(3AH[5]) is set or the CTRL pin is connected to VDD or Open.

04H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	Reserved					MULTI_ MODE	Reserved	
Default	0	1	0	1	0	1	0	1

Addr.	Bits	Default	Name	Description
04H	7-3	01010B	Reserved	
	2	1B	MULTI_MODE	GT208L single/multi touch mode 0 : single 1 : multi
	1-0	01B	Reserved	

4-3-4 PWM Channel Enable Registers - R/W

☞ *Description:* The GT208L supports eight each PWM output generation.

05H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	PWM_CH_EN							
Default	0	0	0	0	0	0	0	0

Addr.	Bits	Default	Name	Description
05H	7-0	00H	PWM_CH_EN	1~8 each PWM channel enable 0: disable 1: enable

4-3-5 Touch Output Registers - R

☞ *Description:* An each touch channel status can be monitored.

2AH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	TOUCH_OUTPUT							
Default	-	-	-	-	-	-	-	-

Addr.	Bits	Default	Name	Description
2AH	7-0	--H	TOUCH_OUTPUT	Touch channel detection monitoring

4-3-6 General1 Control Registers - R/W

☞ *Description:* The GT208L supports control registers for meeting various user applications.

39H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	Reserved						SYS_CLK_SEL	
Default	0	0	0	0	0	0	0	1

Addr.	Bits	Default	Name	Description
39H	7-2	000000B		
	1-0	01B	SYS_CLK_SEL	System clock select 00: 70KHz 01:100KHz 11: 140KHz

4-3-7 General2 Control Registers - R/W

☞ *Description:* The GT208L supports control registers for meeting various user applications.

3AH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	Reserved		UCTRL_EN	INT_MODE	Reserved		DIR_OUT_POL	Reserved
Default	0	0	0	0	0	1	0	1

Addr.	Bits	Default	Name	Description
3AH	7-6	00B	Reserved	
	5	0B	UCTRL_EN	The value of sensitivity control registers (40H ~ 47H) could be adopted when UCTRL_EN is set to 1. 0 : Disabled 1 : Enabled
	4	0B	INT_MODE	Interrupt operation mode 0 : toggle mode (touch on/off) 1 : level mode
	3-2	01B	Reserved	
	0	0B	DIR_OUT_POL	Direct output polarity 0: Low active 1: High active
	1	1B	Reserved	

4-3-8 General3 Control Registers - R/W

☞ *Description:* The GT208L supports control registers for meeting various user applications.

3BH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	Reserved	SENSING_PERIOD		PWM_EN	Reserved			SOFT_RESET
Default	0	0	1	0	0	0	0	0

Addr.	Bits	Default	Name	Description
3BH	7	0B	Reserved	
	6-5	01B	SEN_IDLE_TIME	Sensing idle time. 00: 20ms (@Normal Clock Operation) 01: 45ms (@Normal Clock Operation) 10: 50ms (@Normal Clock Operation) 11: 60ms (@Normal Clock Operation)
	4	0B	PWM_EN	PWM enable 0: PWM disable 1: PWM enable
	3-1	000B	Reserved	
	0	0B	SOFT_RESET	GT208L will be initialized but the values of register are not changed. Edge operation therefore the bit should be set 1 to 0. 0: Reset disable 1: Reset enable

4-3-9 Expiration Control Registers - R/W

☞ *Description:* The GT208L supports control registers for meeting various user applications.

3DH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	Reserved			EXP_TIME			EXP_ EN	EXP_ MODE
Default	0	0	0	1	1	0	1	0

Addr.	Bits	Default	Name	Description
3DH	7-5	000B	Reserved	
	4-2	110B	EXP_TIME	Time = (EXP_TIME) x 16 period (approximate)
	1	1B	EXP_ EN	Touch expire enable 0: Disable 1: Enable
	0	0B	EXP_ MODE	Touch expire mode 0 : Expire count is not restarted in a touch state 1 : Expire count is restarted if a different touch occur

4-3-10 Sensitivity Control Registers - R/W

☞ *Description:* The GT208L can be controlled independently for getting the optimal sensitivity on each channel.

XXH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	Reserved		SENSITIVITY n					
Default	0	0	0	0	1	1	1	1

Addr.	Bits	Default	Name	Description
40H	7-6	00B	Reserved	
	5-0	0FH	SENSITIVITY 1	Channel 1 touch sensitivity UCTRL_EN(3AH[5]) must be set '1'. Otherwise, Sensitivity follows CTRL pin connection. 0x02 : Highest Sensitivity 0x3F : Lowest Sensitivity
41H	7-6	00B	Reserved	
	5-0	0FH	SENSITIVITY 2	Channel 2 touch sensitivity UCTRL_EN(3AH[5]) must be set '1'. Otherwise, Sensitivity follows CTRL pin connection. 0x02 : Highest Sensitivity 0x3F : Lowest Sensitivity
42H	7-6	00B	Reserved	
	5-0	0FH	SENSITIVITY 3	Channel 3 touch sensitivity UCTRL_EN(3AH[5]) must be set '1'. Otherwise, Sensitivity follows CTRL pin connection. 0x02 : Highest Sensitivity 0x3F : Lowest Sensitivity
43H	7-6	00B	Reserved	
	5-0	0FH	SENSITIVITY 4	Channel 4 touch sensitivity UCTRL_EN(3AH[5]) must be set '1'. Otherwise, Sensitivity follows CTRL pin connection. 0x02 : Highest Sensitivity 0x3F : Lowest Sensitivity
44H	7-6	00B	Reserved	
	5-0	0FH	SENSITIVITY 5	Channel 5 touch sensitivity UCTRL_EN(3AH[5]) must be set '1'. Otherwise, Sensitivity follows CTRL pin connection. 0x02 : Highest Sensitivity 0x3F : Lowest Sensitivity
45H	7-6	00B	Reserved	
	5-0	0FH	SENSITIVITY 6	Channel 6 touch sensitivity UCTRL_EN(3AH[5]) must be set '1'. Otherwise, Sensitivity follows CTRL pin connection. 0x02 : Highest Sensitivity 0x3F : Lowest Sensitivity
46H	7-6	00B	Reserved	
	5-0	0FH	SENSITIVITY 7	Channel 7 touch sensitivity UCTRL_EN(3AH[5]) must be set '1'. Otherwise, Sensitivity follows

				CTRL pin connection. 0x02 : Highest Sensitivity 0x3F : Lowest Sensitivity
47H	7-6	00B	Reserved	
	5-0	0FH	SENSITIVITY 8	Channel 8 touch sensitivity UCTRL_EN(3AH[5]) must be set '1'. Otherwise, Sensitivity follows CTRL pin connection. 0x02 : Highest Sensitivity 0x3F : Lowest Sensitivity

4-3-11 PWM Control Registers - R/W

☞ *Description:* The GT208L supports each PWM period registers.

XXH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	PWM m				PWM n			
Default	0	0	0	0	0	0	0	0

Addr.	Bits	Default	Name	Description
48H	7-4	0H	PWM 2	PWM2 duty rate output 0x0 : 0% Duty Cycle 0xF : 88% Duty Cycle
	3-0	0H	PWM 1	PWM2 duty rate output 0x0 : 0% Duty Cycle 0xF : 88% Duty Cycle
49H	7-4	0H	PWM 4	PWM2 duty rate output 0x0 : 0% Duty Cycle 0xF : 88% Duty Cycle
	3-0	0H	PWM 3	PWM2 duty rate output 0x0 : 0% Duty Cycle 0xF : 88% Duty Cycle
4AH	7-4	0H	PWM 6	PWM2 duty rate output 0x0 : 0% Duty Cycle 0xF : 88% Duty Cycle
	3-0	0H	PWM 5	PWM2 duty rate output 0x0 : 0% Duty Cycle 0xF : 88% Duty Cycle
4BH	7-4	0H	PWM 8	PWM2 duty rate output 0x0 : 0% Duty Cycle 0xF : 88% Duty Cycle
	3-0	0H	PWM 7	PWM2 duty rate output 0x0 : 0% Duty Cycle 0xF : 88% Duty Cycle

4-3-12 General4 Control Registers - R/W

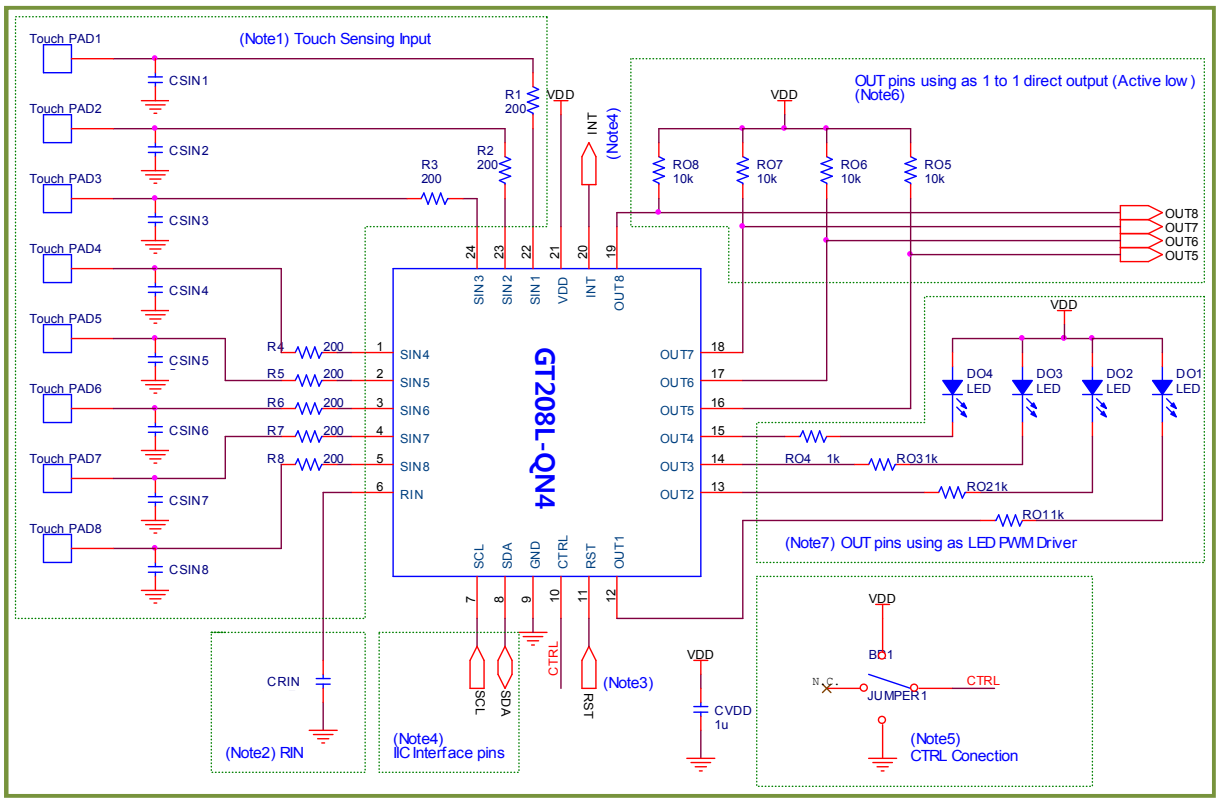
☞ *Description:* The GT208L supports control registers for meeting various user applications.

4FH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name			MON_RST					
Default	0	0	1	0	0	0	0	0

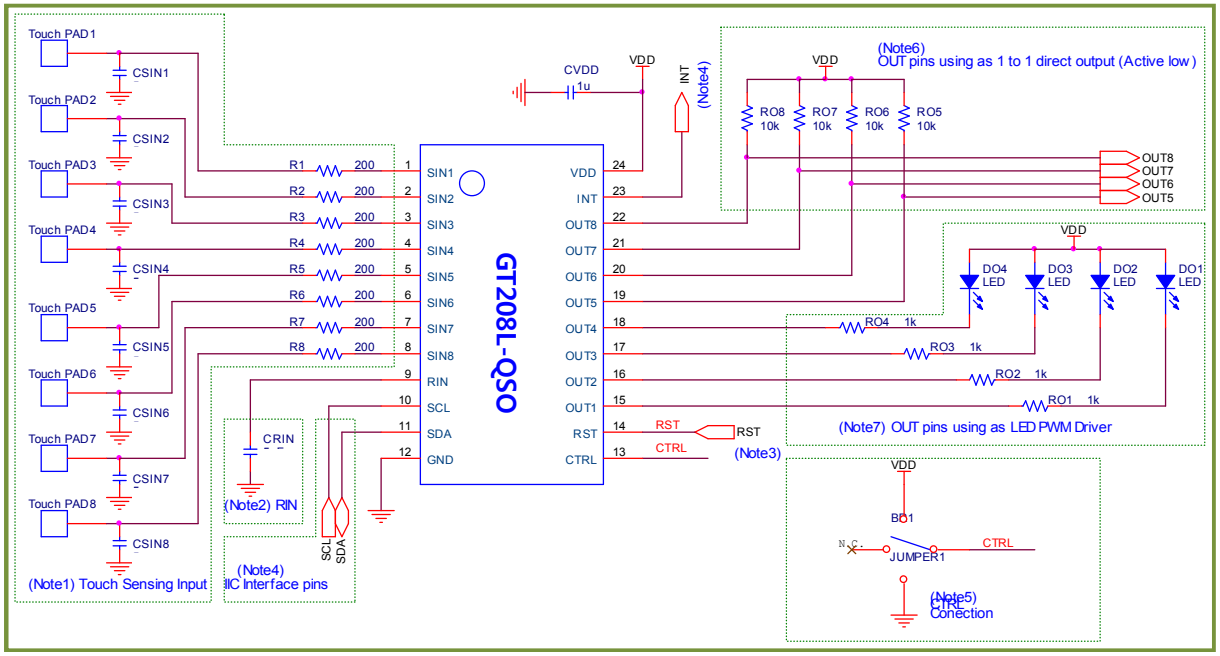
Addr.	Bits	Default	Name	Description
4FH	7-6	00B	Reserved	
	5	1B	MON_RST	This bit is set 1 immediately after GT208L is reset. Clear by software.
	4-0	00000B	Reserved	

Chapter 5: Application Notes

5-1 Application Circuit Example



Application example circuit for 24QFN package



Application example circuit for 24QSOP package

5-2 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 GT208L 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.

5-2-1 Power Line

- The touch sensor power line is recommended to be split from the other power lines such as relay circuits or LED that can make pulsation noise on their 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.

5-2-2 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.
- SIN capacitor is useful for sensitivity reduction adjust. A bigger capacitor of SIN makes sensitivity of corresponding channel to be lower.
- RIN capacitor value is about average value of SIN inputs capacitors.
- 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 series resistor value should be less than 1kΩ and the location of resister is better as near as possible to the SIN ports for better stable operation. (Refer to 3-2)
- All touch sensing pads are recommended to be surrounded by GND pattern to reduce noise influence.

5-2-4 External Reset <Note3>

- The RST port is for the abrupt reset input signal. The high pulse signal can make system reset. This port has also an internal pull-down resistor hence the RST port can be floating. (Refer to 3-1)

5-2-5 I^2C Interface Applications <Note4>

- The SCL is I^2C clock input port and SDA is I^2C data input/output port. SCL and SDA have internal optional pull-up resistor. So, when I^2C interface is not required, SCL and SDA ports can be floating. For high speed communication, SDA port needs small pull-up resistor connected to V_{DD} to reduce pulse rising delay. (Refer to 3-5)
- INT is for the output signal that indicates changing of sensing output data. This port is output only port and has active low function. Because INT pin has open drain structure, pull-up resistor is required for valid output.(Refer to 3-6)

5-2-6 Sensitivity Selection <Note5>

- Three optional sensitivities are available by CTRL pin connection. Open connection (e.g. N.C.) comes to normal sensitivity, VDD connection comes to low sensitivity, and GND connection comes to high sensitivity. This sensitivity selection is valid for all sensing channels. (Refer to 3-7)

5-2-7 1 to 1 Direct Output Applications <Note6>

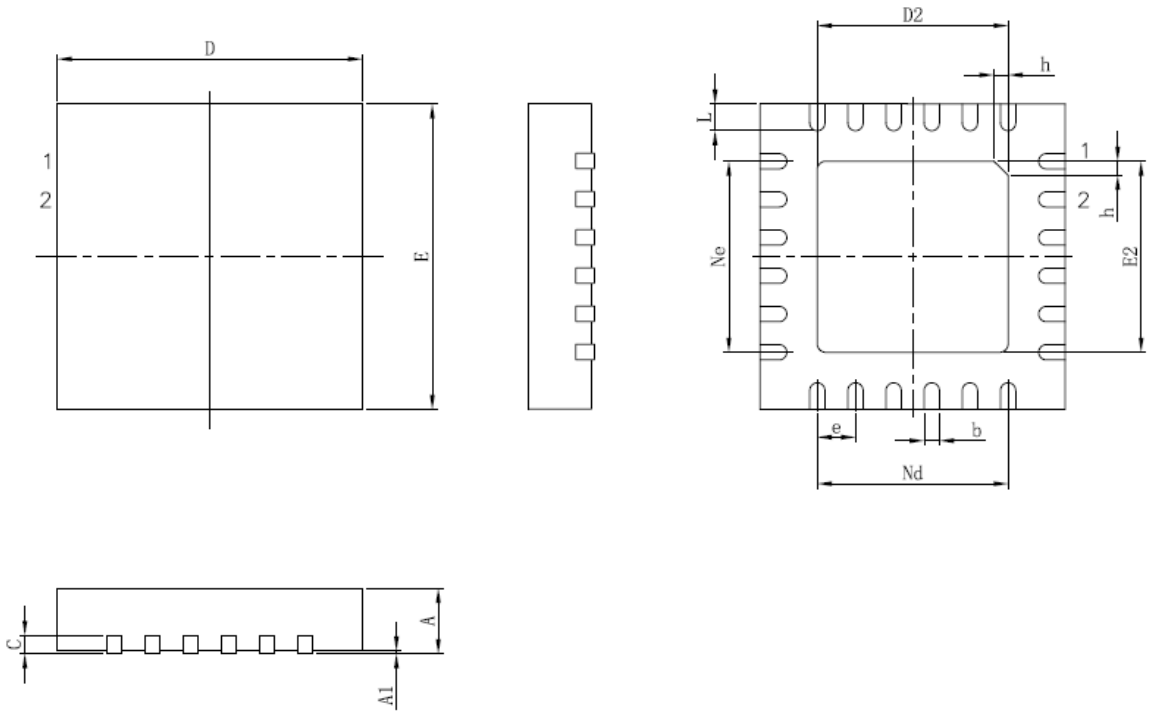
- The ports that are used for 1 to 1 direct output have an active low and high output mode. Both output modes are all open drain type. Therefore a pull-up or a pull-down resistor is required for a valid output. The OUTx port corresponds to SINx sense input respectively. (Refer to 3-4)

5-2-8 LED PWM Drive applications <Note7>

- The maximum 10mA LED drive current can be sunk by a single OUT port on typical temperature condition. The OUT ports which are used as LED PWM drive ports cannot carry out the role of 1 to 1 direct out simultaneously. The 16 steps brightness control is possible. (Refer to 3-3)

Chapter 6: Package information

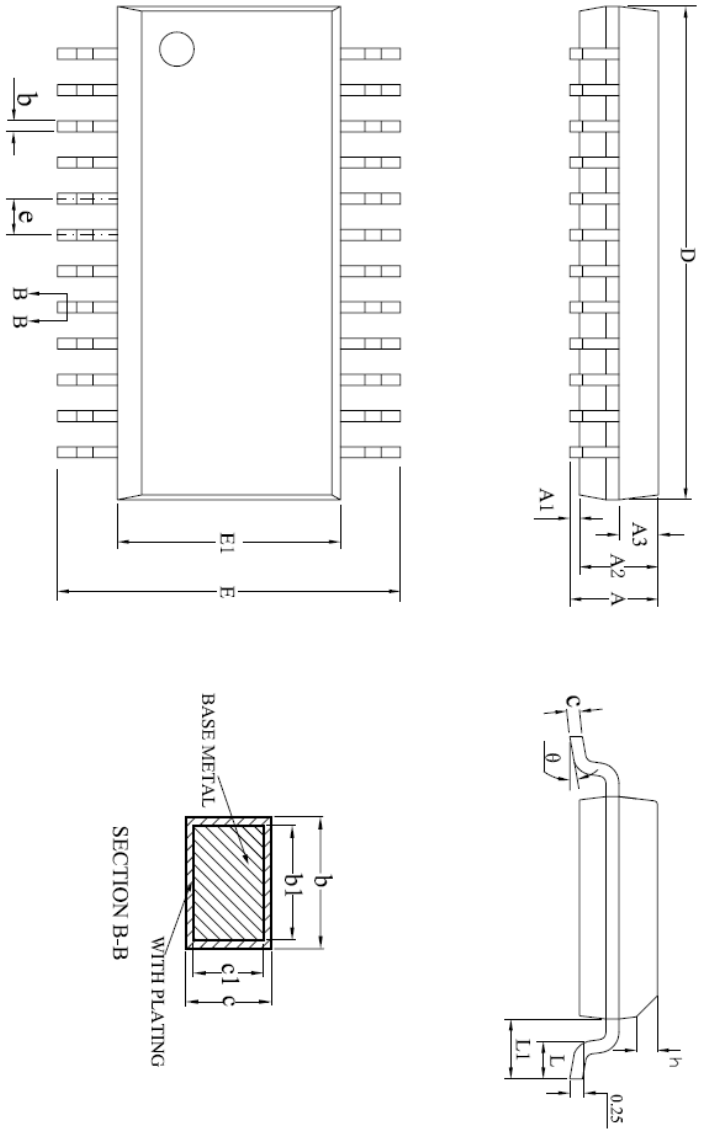
6-1 Package Outside Drawings for GT208L-QN4



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	—	0.01	0.05
b	0.18	0.25	0.30
c	0.18	0.20	0.25
D	3.90	4.00	4.10
D2		2.50REF	
e		0.50BSC	
Ne		2.50BSC	
Nd		2.50BSC	
E	3.90	4.00	4.10
E2		2.50REF	
L	0.35	0.40	0.45
h	0.30	0.35	0.40

Note : All dimensions are in mm. Angles in degree.

6-2 Package Outside Drawings for GT208L-QSO



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	--	--	1.75
A1	0.10	--	0.25
A2	1.30	1.40	1.50
A3	0.60	0.65	0.70
b	0.23	--	0.33
b1	0.22	0.25	0.28
c	0.21	--	0.25
c1	0.19	0.20	0.21
D	8.45	8.65	8.85
E	5.80	6.00	6.20
E1	3.70	3.90	4.10
e	0.635BSC		
h	0.25	--	0.50
L	0.50	--	0.80
L1	1.05BSC		
θ	0	--	8°

Note : All dimensions are in mm. Angles in degree.