The Classic of Touch Solution!

GREENCHIP

GreenTouch2™ GT216L Capacitive Touch Sensor

SPECIFICATION v1.0

GENERAL

The GT216L is one of the new GreenTouch2™ capacitive touch sensor series. Especially the GT216L can do capacitance sensing with 16 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.

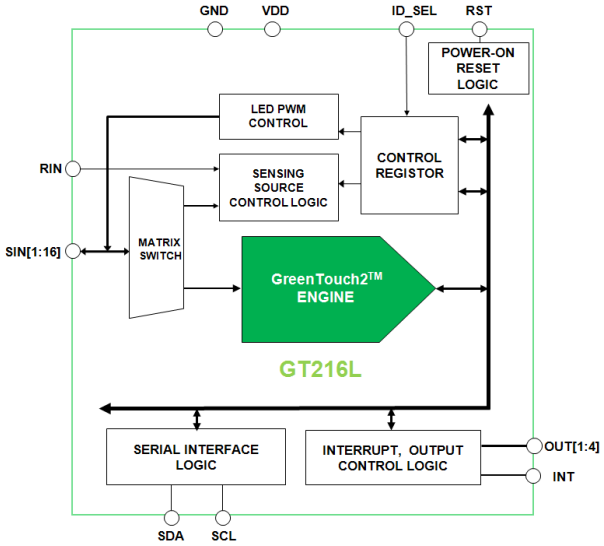
The GT216L offers 16 touch sense inputs which also can be used as dimming LED drive output ports. It's very economical solution when the LED feedbacks are required because there is no additional material cost for LED control. Almost every option that controls touch operation and dimming LED driving of the GT216L can be performed by internal control registers. These internal control registers are readable and writable using I²C. Touch output result are also readable using. The I²C interface might be useful when the MCU IO or connector resource is not enough in the application.

The GT216L can be applied under wide supply voltage range from 2.5 V to 5.0V. The ID_SEL pin of the GT216L provides switchable chip ID that make two chip parallel operation on the same I²C bus. And 4 exclusive output pins of the GT216L provide 25mA sinkable outputs.

FEATURES

- 16 channels touch sensing inputs
  - These ports can be used as LED driver ports
- **Embedded GreenTouch2™ Engine**
  - Analog compensation circuit
  - Embedded digital noise filter
  - Intelligent sensitivity calibration
  - Embedded CS, EFT enhancer core
- I²C interface supporting
- Provide interrupt function
- LED driver (32 steps dimming control)
- Four 25mA sinkable exclusive output ports
- Incredibly low power consumption
  - Normal mode: 250uA (@3.3V)
  - SLEEP mode: under 5uA(@3.3V)
  - Available various op-periods for current saving
- Wide supply voltage range: 2.5V to 5.0V
  - Single supply operation
- Package type
  - 28 QFN 4x4 package
- RoHS compliant

BLOCK DIAGRAM



APPLICATIONS

- Multi key application – Door lock, Remote controller and Etc.
- 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, Lighting controls, Toys, Gaming devices and Etc.

ORDERING INFORMATION

Part No.	Package
GT216L-QN4	28 QFN 4x4

REVISION HISTORY

Version	Date	Revision Contents
v1.0	March 2012	First release

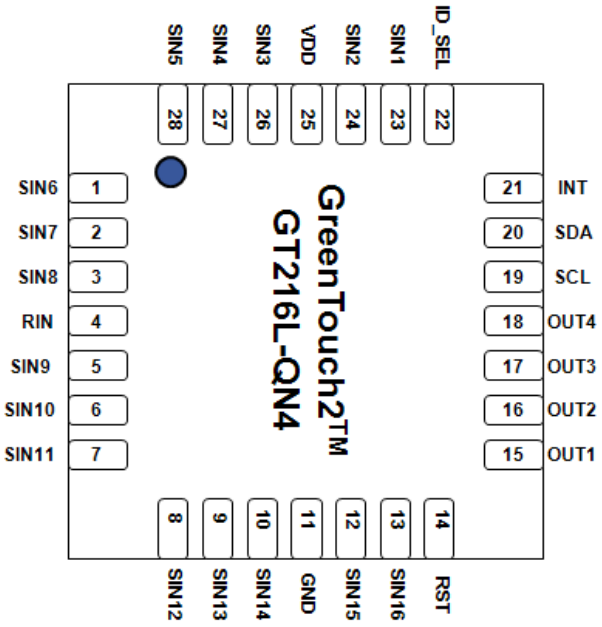
Chapter 1: Pinout Information

This section describes the lists and illustrates the GT216L of GreenTouch2™ family ports as well as pinout configuration. The GT216L device is available in the following package

1-1 28 QFN Pinout (GT216L-QN4)

Port No.	Type	Name	Description
1	AI/DO	SIN 6	Channel 6: Touch sensing input / LED PWM drive output
2	AI/DO	SIN 7	Channel 7: Touch sensing input / LED PWM drive output
3	AI/DO	SIN 8	Channel 8: Touch sensing input / LED PWM drive output
4	AI	RIN	Capacitance reference input
5	AI/DO	SIN 9	Channel 9: Touch sensing input / LED PWM drive output
6	AI/DO	SIN 10	Channel 10: Touch sensing input / LED PWM drive output
7	AI/DO	SIN 11	Channel 11: Touch sensing input / LED PWM drive output
8	AI/DO	SIN 12	Channel 12: Touch sensing input / LED PWM drive output
9	AI/DO	SIN 13	Channel 13: Touch sensing input / LED PWM drive output
10	AI/DO	SIN 14	Channel 14: Touch sensing input / LED PWM drive output
11	GND	GND	Ground connection
12	AI/DO	SIN 15	Channel 15: Touch sensing input / LED PWM drive output
13	AI/DO	SIN 16	Channel 16: Touch sensing input / LED PWM drive output
14	DI	RST	Reset control port (Low active)
15	DO	OUT 1	Exclusive output (User controllable) / LED PWM drive output
16	DO	OUT 2	Exclusive output (User controllable) / LED PWM drive output
17	DO	OUT 3	Exclusive output (User controllable) / LED PWM drive output
18	DO	OUT 4	Exclusive output (User controllable) / LED PWM drive output
19	DI	SCL	I^2C serial clock input
20	DIO	SDA	I^2C serial data communication port
21	DO	INT	Interrupt output port
22	DI	ID_SEL	Option chip ID selection (Connected to VDD or GND)
23	AI/DO	SIN 1	Channel 1: Touch sensing input / LED PWM drive output
24	AI/DO	SIN 2	Channel 2: Touch sensing input / LED PWM drive output
25	PWR	VDD	Supply Voltage
26	AI/DO	SIN 3	Channel 3: Touch sensing input / LED PWM drive output
27	AI/DO	SIN 4	Channel 4: Touch sensing input / LED PWM drive output
28	AI/DO	SIN 5	Channel 5: Touch sensing input / LED PWM drive output

[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}	Normal operation	-	250	350	μA
		Sleep mode	-	-	5	
Internal reset voltage(2)	V_{DD_RST}	T_A = 25℃	-	1.6	2.0	V
Digital input/output						
Input high level voltage (Ports : SCL, RST, ID_SEL)	V_{IH}		V_{DD}*0.7	-	V_{DD}+0.3	V
Input low level voltage (Ports : SCL, RST, ID_SEL)	V_{IL}		-0.3	-	V_{DD}*0.3	V
Internal pull-up resistor (Ports : SCL, SDA, RST)	R_{PU}	Pull-up resistor enable	-	30	-	kΩ
Output (LED PWM) drive						
SIN[1:16] sink current	I_{S_SINK}	Active low output	-	-	10	mA
OUT[1:4] sink current	I_{O_SINK}	Active low output mode(3)		-	25	mA
OUT[1:4] source current	I_{O_SRC}	Active high output mode(3)		-	15	mA
Output PWM duty steps (LED brightness steps)	N_{DUTY}	Both SIN[1:16] and OUT[1:4]	-	32	-	step
Output impedance to GND (NMOS)	Z_{ON}	On mode	-	15	-	Ω
		Off mode	-	30	-	MΩ
Output impedance to VDD (PMOS)	Z_{OP}	Off mode	-	30	-	MΩ
		On mode	-	30	-	Ω
Maximum PWM low duty (Maximum brightness)	$D_{MAX(L)}$	LED output	-	100	-	%
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 under default control register value. (Unless otherwise noted)
(2) The GT216L has internal reset circuit, so external reset element or reset signal is not always necessary for power reset.
(3) OUT[1:4] ports 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}		-	30	-	sec
Minimum RST high pulse width for external reset	T_{P_ERST}	Active low reset	10	-	-	usec
Maximum I^2C communication speed	F_C	Maximum internal I^2C support CLK	-	400k	-	bps
Start time for I^2C communication after reset (ID_SEL = GND, VDD)	$T_{ID\_SEL\_I2C}$		1			msec
Touch Sensing (SIN, RIN)						
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		-	140	-	Ω
Max. sense external series resistor	R_{S_EX}		-	-	1	kΩ

2-3 ESD & Latch-Up Characteristics

2-3.1 ESD Characteristics

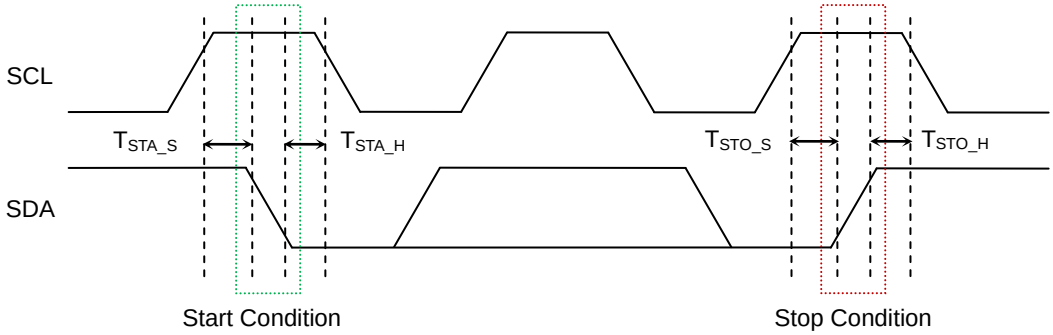
Mode	Polarity	Max	Reference
H.B.M	POSITIVE / NEGATIVE	Over 8000V (Class 3B)	VDD
			VSS
			P to P
M.M	POSITIVE / NEGATIVE	725V (Class C)	VDD
		600V (Class C)	VSS
		475V (Class C)	P to P

2-3.2 Latch-Up Characteristics

Mode	Polarity	Condition	Result
I Test	POSITIVE	100mA	Pass
	NEGATIVE	-100mA	
V supply	POSITIVE	8.25V	

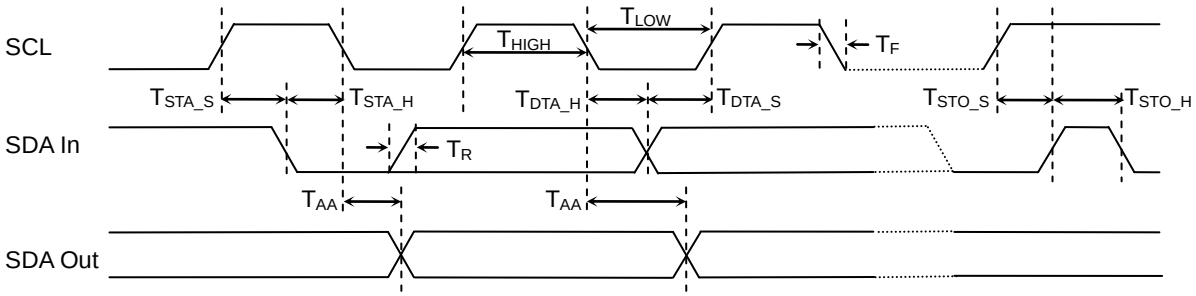
2-4 I²C Interface Timing Characteristics

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

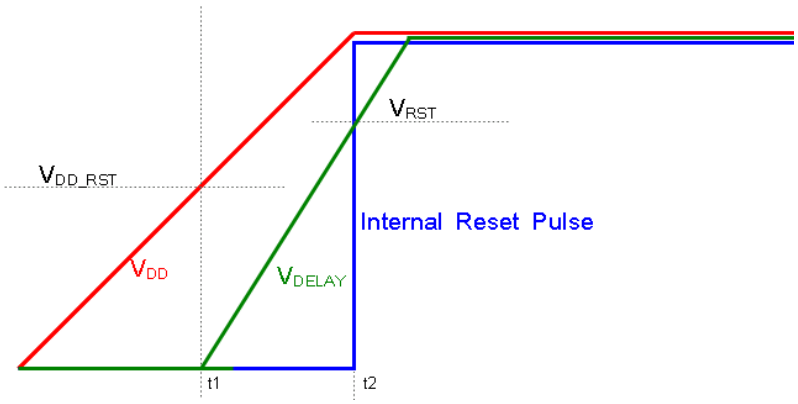


Symbol	Characteristic		Min	Max	Unit	Conditions
T_{HIGH}	Clock high time	100KHz mode	4000	-	ns	
		400KHz mode	1000	-	ns	
T_{LOW}	Clock low time	100KHz mode	4700	-	ns	
		400KHz mode	1300	-	ns	
T_{DAT_S}	Data Input setup time	100KHz mode	250	-	ns	-
		400KHz mode	100	-	ns	
T_{DAT_H}	Data input hold time	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 Internal and External Reset

The GT216L 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. Low 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.

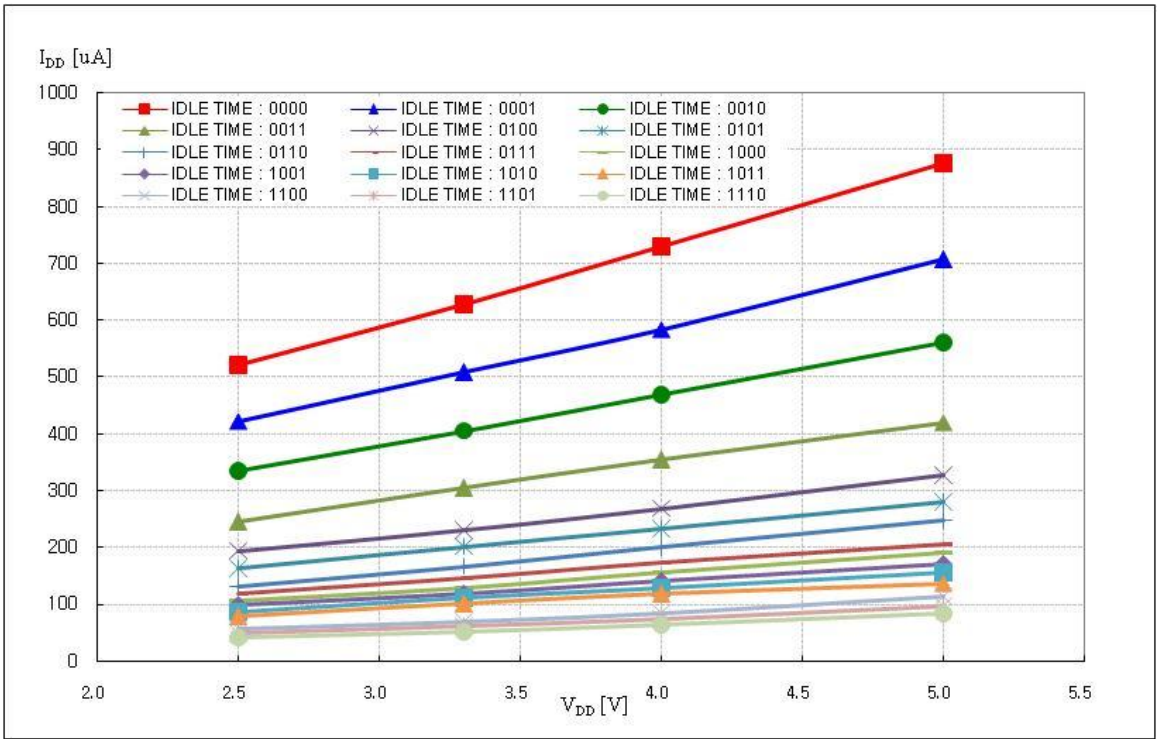


Internal reset sequence of GT216L

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. Every time when V_{DD} drops under $_{VDD\_RST}$ internal reset block makes V_{DELAY} signal low and then internal reset pulse drops to low. By above internal reset operation sequence GT216L gets more certain and more correct power reset function than any others.
The external reset using RST pin is activated during low input pulse. The intensive system reset can be easily obtained by this low pulse input to the RST pin. More than 10usec low pulse period is required for proper reset. Because RST pin has an internal pull-up resistor (typical value is 30kΩ), the RST pin might be floating.

3-2 SLEEP mode and Sensing Period Options (Current Consumption)

The GT216L has various consumption current saving operations. In the SLEEP mode, all of the internal system clock of GT216L are stopped and no current are consumed except basic biasing current of reset block (under 5uA)and no internal functions are available but I^2C blocks are still available for restoring. Therefore in mobile application that uses battery for system's power supply, this SLEEP mode is useful to prolong the using time of battery during no action and stand-by time term. The SLEEP mode setting or restoring can be controlled by control register setting via I^2C. (*For more detail information, please refer to chapter 4: Register Description.*)
Another current consumption saving strategy of GT216L is preparing various touch sensing period options. GT216L consumes lower current and touch detection needs somehow longer time at slow sensing period option than at fast sensing period option. That is the relation between current consumption and touch detection speed are complementary. These touch sensing period options can be selected according to application systems needs such as current consumption and touch detection speed by control register setting via I^2C. (*For more detail information, please refer to chapter 4: Register Description.*) Current consumption curves of each supply voltage condition and each sensing period option are such as below.



Typical current consumption curve of GT216L

3-3 Implementation for SIN Ports (SIN1~SIN16)

SIN ports (SIN1~SIN16) of GT216L have 2 main functions, the one is touch sensing input and the other is LED PWM drive output. Above two functions cannot be used simultaneously, that is some or all of SIN ports used as touch sensing input cannot be used as LED PWM drive port and some or all of SIN ports used as LED PWM drive port also cannot be used as touch sensing input. SIN using selection can be accomplished by internal register setting. (*For more detail information, please refer to chapter 4: Register Description.*)

■ Touch Sensing Input Implementation (SIN, RIN)

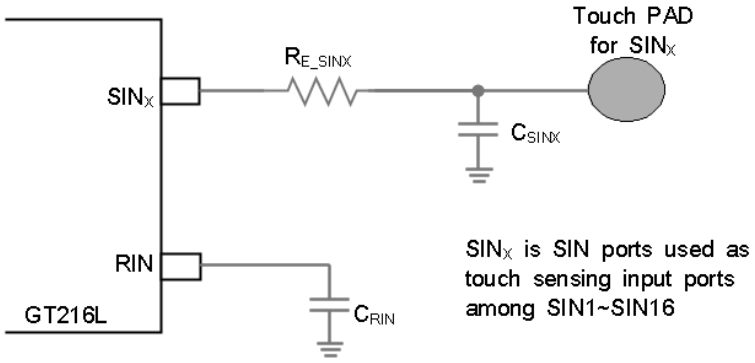
SIN ports can be used for touch sensing inputs for detection of capacitance variation sensing. The SIN input pins are connected to touch sensing pad and catches capacitance variation caused by direct touch or approaching. And RIN which is input port for the reference capacitance is to be connected to a capacitor to compensate capacitance difference between SIN ports and RIN port. The GT216L compares each capacitance of SIN ports and that of RIN port and determines touch detection of each channel when that channels' SIN port capacitance increases. So, for correct capacitance comparison between SIN ports and RIN port, the total RIN port capacitance is to be compensated to be approximately equal to initial-steady state capacitance of SIN ports appeared by connection line between SIN ports and touch pad and appeared by touch pad etc.. User can compensate initial-steady state capacitance difference between SIN inputs and RIN input by adding capacitor (C_{RIN}) to RIN pin. Experimentally, proper C_{RIN} capacitor value is about the average of total capacitance of each SIN ports.

The GT216L also has additional intelligent touch detection algorithms to distinguish valid touch from error or sensitivity problems caused by various environmental noise effects. These advanced sensing algorithms will help making faultless touch key systems under the worst application conditions.

With sensitivity options by control register setting via I^2C, there is almost no difficulty to satisfy system's required sensitivity. The internal automatic sensitivity adjustment algorithm removes sensitivity rolling caused by system noise, circuit deviation, and circumstantial drift. The GT216L 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 ports and RIN port is shown in figure below. The GT216L 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_SINX}) of each SIN port is required, then it should be less than 1kΩ and the location of resister is recommended as closer to the SIN pins of GT216L. The capacitors connected to touch pads are optional and it helps fine sensitivity control and capacitance compensation between each channels. For C_{SINX}, C_{RIN} capacitor, less than 50pF capacitor can be used. Both R_{E_SIN} and $C_{SIN1\sim8}$ are not obligatory components.

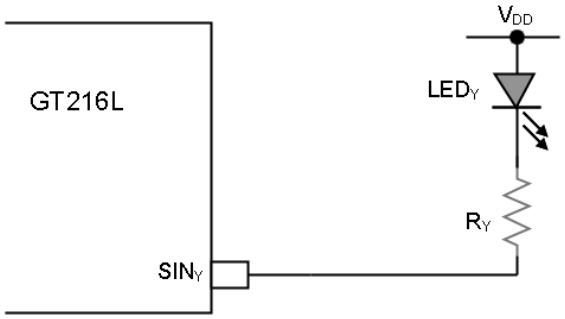


Implementations for SIN inputs and RIN input with external components and sensing pad.

The connection line between SIN ports and touch pad routings are desirable to be routed as short as possible and the width of routing lines should be as narrow as possible and placed on opposite metal side. In other words, touch pad and touch pad connection lines should be placed on opposite metal side of PCB. 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 lines. All touch sensing pads are recommended to be surrounded by GND pattern in order to reduce noise influence.

- LED PWM Drive Implementation (SIN)

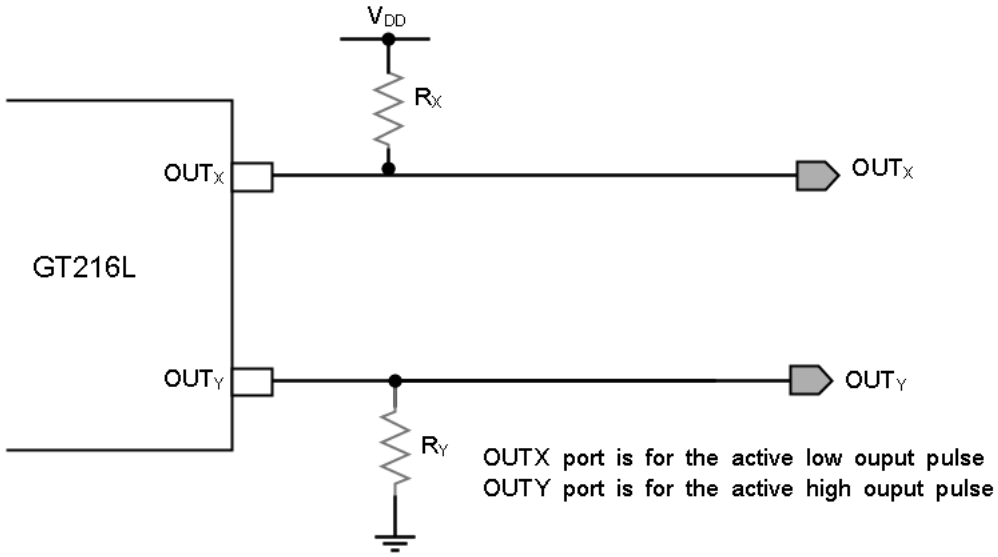
The LED PWM drive using SIN ports is available. There are 32 LED brightness control steps using PWM duty. These brightness steps can be controlled by internal control register via I^2C. (*For more detail information, please refer to chapter 4: Register Description.*) The maximum LED brightness has 100% on duty and the minimum has 0% on duty. Each SIN port has NMOS drive transistor and the maximum sink current is 10mA on under typical condition. Therefore if some more drive current needs it is necessary to use OUT[1:4] ports rather than SIN[1:16]. The basic implementation for LED PWM drive is shown in figure below. The R_{SINX} are LED current limiting resistors.



Implementations of output ports for LED PWM drive

3-4 Implementation for OUT[1:4]

The GT216L has exclusive output ports OUT [1:4]. Output pulse polarity of each OUT ports can be changed independent on other OUT ports by internal control register setting via I^2C. (*For more detail information, please refer to chapter 4: Register Description.*) When output pulse is set to have active low, NMOS output transistor makes output pulse and it needs external pull-up components. On the contrary, when output pulse is set to have active high, PMOS output transistor makes output pulse so external pull-down components are needed. For basic output pulse is fixed frequency PWM of which on duty can be easily changed from 0% to 100% by internal control register setting via I^2C (*For more detail information, please refer to chapter 4: Register Description.*) OUT [1:4] ports are usefulness for high brightness LED drive. Each OUT [1:4] ports has sinking current ability typical 25mA and sourcing current ability typical 15mA. The basic implementations for both two active modes are shown in figures following.



Implementations of OUT[1:4] ports

3-5 I^2C Interface (SCL, SDA, ID_SEL)

The SCL and SDA pins are used for I^2C interface. The SCL is I^2C clock input pin and the SDA is I^2C data input/output pin. By this I^2C interface, internal control register setting values of GT216L can be read and written. Output data also can be read from the address 0x02H and 0x03H 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 SCL and SDA pin needs additional external pull-up resistor which is connected to V_{DD} to reduce rising delay. The GT216L has an internal I^2C clock oscillator. The maximum data-rate is about 400Kbps. For a timing of I^2C interface, please refer to the section *2-4 I^2C Interface Timing Characteristics*.

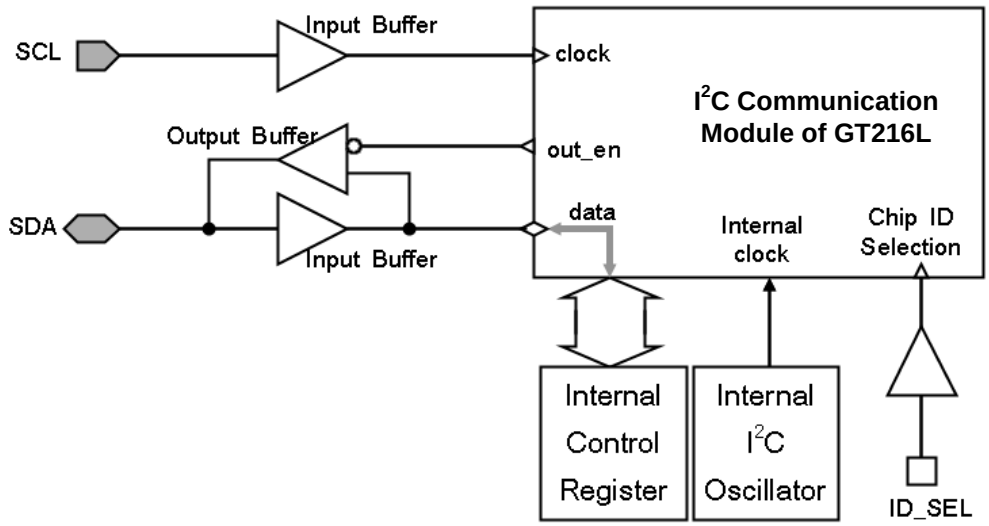
I^2C chip ID of GT216L can be selected by ID_SEL connection. Two connections are available, one is to be connected to GND and the other is to be connected to V_{DD}. This pin is not permitted to be opened to prevent open gate leakage current. ID_SEL pin makes it possible that two chip parallel I^2C interface free from communication error use same I^2C bus.

The simple internal block diagram for SCL and SDA is shown below.

- Device ID

1	0	1	1	0	0	ID_SEL	R/W

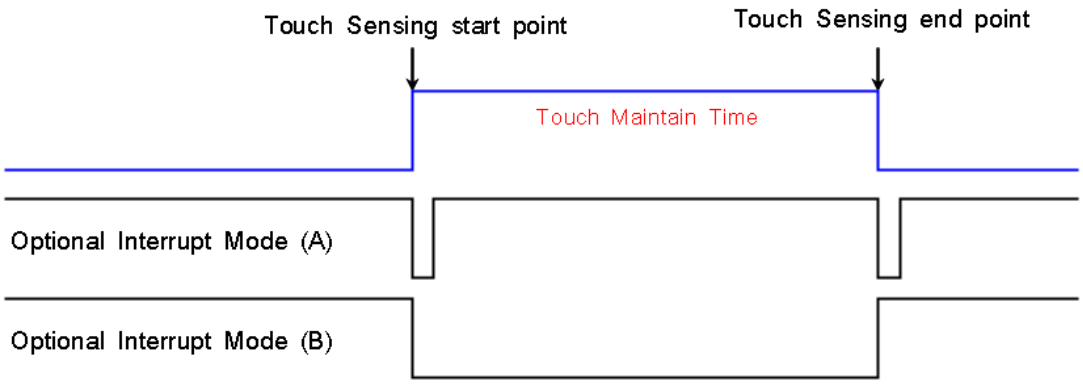
*** DEVICE ID : 0xB0 when ID_SEL is connected with GND.**
*** DEVICE ID : 0xB2 when ID_SEL is connected with VDD.**



Internal I^2C interface structure of GT216L

3-6 Interrupt Output (INT)

The GT216L provides an interrupt (INT) function to reduce a communication load between MCU and GT216L. The INT will indicate a point of time that the touch detection data status registers at the address 0x02H or 0x03H changes and MCU needs to read it. The interrupt function can be used in two modes according to internal control register setting. 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 touch detection data status register changes. In the other mode (B), an interrupt pulse maintains low during at least one of 16 channels' touch is coming on the output status register.



Optional interrupt modes of high interrupt pulse polarity selection case

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 0xB0	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 0xB0	ACK	Register Address 0x00	ACK	Stop

Start	Device Address 0xB1	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
00H	0xB0	Reserved				CHIP_ID[3:2]		Reserved	
01H	0x02	Reserved						RST	TOUCH
02H	--	TOUCH_OUT 8	TOUCH_OUT 7	TOUCH_OUT 6	TOUCH_OUT 5	TOUCH_OUT 4`	TOUCH_OUT 3	TOUCH_OUT 2	TOUCH_OUT 1
03H	--	TOUCH_OUT 16	TOUCH_OUT 15	TOUCH_OUT 14	TOUCH_OUT 13	TOUCH_OUT 12	TOUCH_OUT 11	TOUCH_OUT 10	TOUCH_OUT 9
04H	0xFF	IO_DIR 8	IO_DIR 7	IO_DIR 6	IO_DIR 5	IO_DIR 4	IO_DIR 3	IO_DIR 2	IO_DIR 1
05H	0xFF	IO_DIR 16	IO_DIR 15	IO_DIR 14	IO_DIR 13	IO_DIR 12	IO_DIR 11	IO_DIR 10	IO_DIR 9
06H	0x44	SLEEP	MULTI_MODE	PWM_EN	INT_MODE	SEN_IDLE_TIME			
07H	0x1A	Reserved			EXP_TIME			EXP_EN	EXP_MODE
10H	0x0F	Reserved		SENSITIVITY 1					
11H	0x0F	Reserved		SENSITIVITY 2					
12H	0x0F	Reserved		SENSITIVITY 3					
13H	0x0F	Reserved		SENSITIVITY 4					
14H	0x0F	Reserved		SENSITIVITY 5					
15H	0x0F	Reserved		SENSITIVITY 6					
16H	0x0F	Reserved		SENSITIVITY 7					
17H	0x0F	Reserved		SENSITIVITY 8					
18H	0x0F	Reserved		SENSITIVITY 9					
19H	0x0F	Reserved		SENSITIVITY 10					
1AH	0x0F	Reserved		SENSITIVITY 11					
1BH	0x0F	Reserved		SENSITIVITY 12					
1CH	0x0F	Reserved		SENSITIVITY 13					
1DH	0x0F	Reserved		SENSITIVITY 14					
1EH	0x0F	Reserved		SENSITIVITY 15					
1FH	0x0F	Reserved		SENSITIVITY 16					
20H	0x1F	Reserved			PWM_DATA 1				
21H	0x1F	Reserved			PWM_DATA 2				

Addr.	Def.	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
22H	0x1F	Reserved			PWM_DATA 3				
23H	0x1F	Reserved			PWM_DATA 4				
24H	0x1F	Reserved			PWM_DATA 5				
25H	0x1F	Reserved			PWM_DATA 6				
26H	0x1F	Reserved			PWM_DATA 7				
27H	0x1F	Reserved			PWM_DATA 8				
28H	0x1F	Reserved			PWM_DATA 9				
29H	0x1F	Reserved			PWM_DATA 10				
2AH	0x1F	Reserved			PWM_DATA 11				
2BH	0x1F	Reserved			PWM_DATA 12				
2CH	0x1F	Reserved			PWM_DATA 13				
2DH	0x1F	Reserved			PWM_DATA 14				
2EH	0x1F	Reserved			PWM_DATA 15				
2FH	0x1F	Reserved			PWM_DATA 16				
30H	0x1F	Reserved			PWM_DATA OUT 1				
31H	0x1F	Reserved			PWM_DATA OUT 2				
32H	0x1F	Reserved			PWM_DATA OUT 3				
33H	0x1F	Reserved			PWM_DATA OUT 4				
34H	0x00	Reserved				POL_OUT 4	POL_OUT 3	POL_OUT 2	POL_OUT 1

4-3-1 I²C CHIP ID Registers - R/W

☞ *Description:* The GT216L chip ID can be set bit[1] by ID_SEL pin and bit[3:2] by register.
(See 3-7 ID_SEL pin Selection)

00H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	Reserved				CHIP_ID[3:2]		Reserved	Reserved
Default	1	0	1	1	0	0	X	0

Addr.	Bits	Default	Name	Description
00H	7-4	BH	Reserved	Fixed “1011” = 0xBH
	3-2	00B	CHIP_ID[3:2]	GT216L chip ID
	1	XB	Reserved	This bit is set by ID_SEL pin.
	0	0B	Reserved	Don’t write

4-3-2 Interrupt status Registers - R/W

☞ *Description:* This register indicate the status of interrupt of GT216L. This register is needed to check after an interrupt signal occur.

01H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	Reserved						RST	TOUCH
Default	0	0	0	0	0	0	1	0

Addr.	Bits	Default	Name	Description
01H	7-2	000000H	Reserved	
	1	1B	RST	It’s set ‘1’ when GT216L is reset.
	0	0B	TOUCH	It’s set ‘1’ when touch detection occur.

4-3-3 Touch Out Registers - R

☞ *Description:* This register indicate the status of interrupt of GT216L. This register is needed to check after an interrupt signal occurred.

XXH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	Touch Out n							
Default	0	0	0	0	0	0	0	0

Addr.	Bits	Default	Name	Description
02H	7-0	--H	Touch Out n	LSB Touch Out 0: No touch detection 1: Touch detection.
03H	7-0	--H	Touch Out n	MSB Touch Out 0: No touch detection 1: Touch detection.

4-3-4 IO Direction Registers – R/W

☞ *Description:* GT216L has 16 ports which can be selected analog input or digital output ports. The directions are set by this register.

XXH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	IO_DIR n							
Default	1	1	1	1	1	1	1	1

Addr.	Bits	Default	Name	Description
04H	7-0	FFH	IO_DIR n	LSB IO_DIR n 0: digital output (PWM) 1: analog input
05H	7-0	FFH	IO_DIR n	MSB IO_DIR n 0: digital output (PWM) 1: analog input

4-3-5 General1 Control Registers - R/W

☞ *Description:* The GT216L supports control registers for meeting various user applications.

06H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	SLEEP	MUTI_ MODE	Reserved	INT_MODE	SEN_IDLE_TIME			
Default	0	1	0	0	0	1	0	0

Addr.	Bits	Default	Name	Description
06H	7	0B	SLEEP	Current consumption can be saved in sleep mode. And GT216L is initialized when the bit change from 1 to 0 but the values of register are kept. 0: Normal operation mode 1: Sleep mode
	6	1B	MUTI_MODE	0: Only one channel can be touched at a time. (Single mode) 1: Multi channels are touched at a time. (Multi mode)
	5	0B	PWM_EN	PWM can be enabled. 0: PWM disable 1: PWM enable
	4	0B	INT_MODE	Interrupt operation mode 0 : toggle mode (touch on/off) 1 : level mode
	3-0	0100B	SEN_IDLE_TIME	Sensing idle time. 0000 : 0 ms 0001 : 5ms 0010 : 10ms 0011 : 20ms 0100 : 30ms 0101 : 40ms 0110 : 50ms 0111 : 60ms 1000 : 70ms 1001 : 80ms 1010 : 90ms 1011 : 100ms 1100 : 200ms 1101 : 300ms 1110 : 400ms 1111 : 400ms

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

☞ *Description:* The GT216L supports control registers for meeting various user applications.

3DH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	Reserved			EXP_TIME[5:3]			EXP_ EN	EXP_ MODE
Default	0	0	0	1	1	0	1	0

Addr.	Bits	Default	Name	Description
07H	7-5	000B	Reserved	
	4-2	110B	EXP_TIME[5:3]	Time ≒ (EXP_TIME[5:3],3'b111) x 16 x (SEN_IDLE_TIME(06H) + SENSING_TIME) (def. ≒ 35 sec)
	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

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

☞ *Description:* The GT216L 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
10H	7-6	00B	Reserved	
	5-0	0FH	SENSITIVITY 1	Channel 1 touch sensitivity 0x02 : Highest Sensitivity 0x3F : Lowest Sensitivity
11H	7-6	00B	Reserved	
	5-0	0FH	SENSITIVITY 2	Channel 2 touch sensitivity 0x02 : Highest Sensitivity 0x3F : Lowest Sensitivity
12H	7-6	00B	Reserved	
	5-0	0FH	SENSITIVITY 3	Channel 3 touch sensitivity 0x02 : Highest Sensitivity 0x3F : Lowest Sensitivity
13H	7-6	00B	Reserved	
	5-0	0FH	SENSITIVITY 4	Channel 4 touch sensitivity 0x02 : Highest Sensitivity 0x3F : Lowest Sensitivity
14H	7-6	00B	Reserved	
	5-0	0FH	SENSITIVITY 5	Channel 5 touch sensitivity 0x02 : Highest Sensitivity 0x3F : Lowest Sensitivity
15H	7-6	00B	Reserved	
	5-0	0FH	SENSITIVITY 6	Channel 6 touch sensitivity 0x02 : Highest Sensitivity 0x3F : Lowest Sensitivity
16H	7-6	00B	Reserved	
	5-0	0FH	SENSITIVITY 7	Channel 7 touch sensitivity 0x02 : Highest Sensitivity 0x3F : Lowest Sensitivity
17H	7-6	00B	Reserved	
	5-0	0FH	SENSITIVITY 8	Channel 8 touch sensitivity 0x02 : Highest Sensitivity 0x3F : Lowest Sensitivity
18H	7-6	00B	Reserved	
	5-0	0FH	SENSITIVITY 9	Channel 9 touch sensitivity 0x02 : Highest Sensitivity 0x3F : Lowest Sensitivity
19H	7-6	00B	Reserved	
	5-0	0FH	SENSITIVITY 10	Channel 10 touch sensitivity 0x02 : Highest Sensitivity 0x3F : Lowest Sensitivity
1AH	7-6	00B	Reserved	
	5-0	0FH	SENSITIVITY 11	Channel 11 touch sensitivity 0x02 : Highest Sensitivity 0x3F : Lowest Sensitivity
1BH	7-6	00B	Reserved	
	5-0	0FH	SENSITIVITY 12	Channel 12 touch sensitivity 0x02 : Highest Sensitivity 0x3F : Lowest Sensitivity
1CH	7-6	00B	Reserved	
	5-0	0FH	SENSITIVITY 13	Channel 13 touch sensitivity 0x02 : Highest Sensitivity 0x3F : Lowest Sensitivity

Addr.	Bits	Default	Name	Description
1DH	7-6	00B	Reserved	
	5-0	0FH	SENSITIVITY 14	Channel 14 touch sensitivity 0x02 : Highest Sensitivity 0x3F : Lowest Sensitivity
1EH	7-6	00B	Reserved	
	5-0	0FH	SENSITIVITY 15	Channel 15 touch sensitivity 0x02 : Highest Sensitivity 0x3F : Lowest Sensitivity
1FH	7-6	00B	Reserved	
	5-0	0FH	SENSITIVITY 16	Channel 16 touch sensitivity 0x02 : Highest Sensitivity 0x3F : Lowest Sensitivity

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

☞ *Description:* The GT216L supports each PWM period registers.

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

Addr.	Bits	Default	Name	Description
20H	7-5	000B	Reserved	
	4-0	1FH	PWM_DATA 1	PWM1 duty rate output 0x00 : GND 0x1F : VDD
21H	7-5	000B	Reserved	
	4-0	1FH	PWM_DATA 2	PWM2 duty rate output 0x00 : GND 0x1F : VDD
22H	7-5	000B	Reserved	
	4-0	1FH	PWM_DATA 3	PWM3 duty rate output 0x00 : GND 0x1F : VDD
23H	7-5	000B	Reserved	
	4-0	1FH	PWM_DATA 4	PWM4 duty rate output 0x00 : GND 0x1F : VDD
24H	7-5	000B	Reserved	
	4-0	1FH	PWM_DATA 5	PWM5 duty rate output 0x00 : GND 0x1F : VDD
25H	7-5	000B	Reserved	
	4-0	1FH	PWM_DATA 6	PWM6 duty rate output 0x00 : GND 0x1F : VDD
26H	7-5	000B	Reserved	
	4-0	1FH	PWM_DATA 7	PWM7 duty rate output 0x00 : GND 0x1F : VDD
27H	7-5	000B	Reserved	
	4-0	1FH	PWM_DATA 8	PWM8 duty rate output 0x00 : GND 0x1F : VDD
28H	7-5	000B	Reserved	
	4-0	1FH	PWM_DATA 9	PWM9 duty rate output 0x00 : GND 0x1F : VDD
29H	7-5	000B	Reserved	
	4-0	1FH	PWM_DATA 10	PWM10 duty rate output 0x00 : GND 0x1F : VDD

Addr.	Bits	Default	Name	Description
2AH	7-5	000B	Reserved	
	4-0	1FH	PWM_DATA 11	PWM11 duty rate output 0x00 : GND 0x1F : VDD
2BH	7-5	000B	Reserved	
	4-0	1FH	PWM_DATA 12	PWM12 duty rate output 0x00 : GND 0x1F : VDD
2CH	7-5	000B	Reserved	
	4-0	1FH	PWM_DATA 13	PWM13 duty rate output 0x00 : GND 0x1F : VDD
2DH	7-5	000B	Reserved	
	4-0	1FH	PWM_DATA 14	PWM14 duty rate output 0x00 : GND 0x1F : VDD
2EH	7-5	000B	Reserved	
	4-0	1FH	PWM_DATA 15	PWM15 duty rate output 0x00 : GND 0x1F : VDD
2FH	7-5	000B	Reserved	
	4-0	1FH	PWM_DATA 16	PWM 16 duty rate output 0x00 : GND 0x1F : VDD

4-3-9 PWM Control Registers for exclusive output - R/W

☞ *Description:* The GT216L supports each PWM period registers.

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

Addr.	Bits	Default	Name	Description
30H	7-5	000B	Reserved	
	4-0	1FH	PWM_DATA OUT 1	PWM OUT 1 duty rate output 0x00 : GND 0x1F : VDD When 0x06H[5] 'PWM_EN' is set '0'. 0x00: GND Otherwise : VDD
31H	7-5	000B	Reserved	
	4-0	1FH	PWM_DATA OUT 2	PWM OUT 2 duty rate output 0x00 : GND 0x1F : VDD When 0x06H[5] 'PWM_EN' is set '0'. 0x00: GND Otherwise : VDD
32H	7-5	000B	Reserved	
	4-0	1FH	PWM_DATA OUT 3	PWM OUT 3 duty rate output 0x00 : GND 0x1F : VDD When 0x06H[5] 'PWM_EN' is set '0'. 0x00: GND Otherwise : VDD
33H	7-5	000B	Reserved	
	4-0	1FH	PWM_DATA OUT 4	PWM OUT 4 duty rate output 0x00 : GND 0x1F : VDD When 0x06H[5] 'PWM_EN' is set '0'. 0x00: GND Otherwise : VDD

4-3-10 Output polarity for exclusive output - R/W

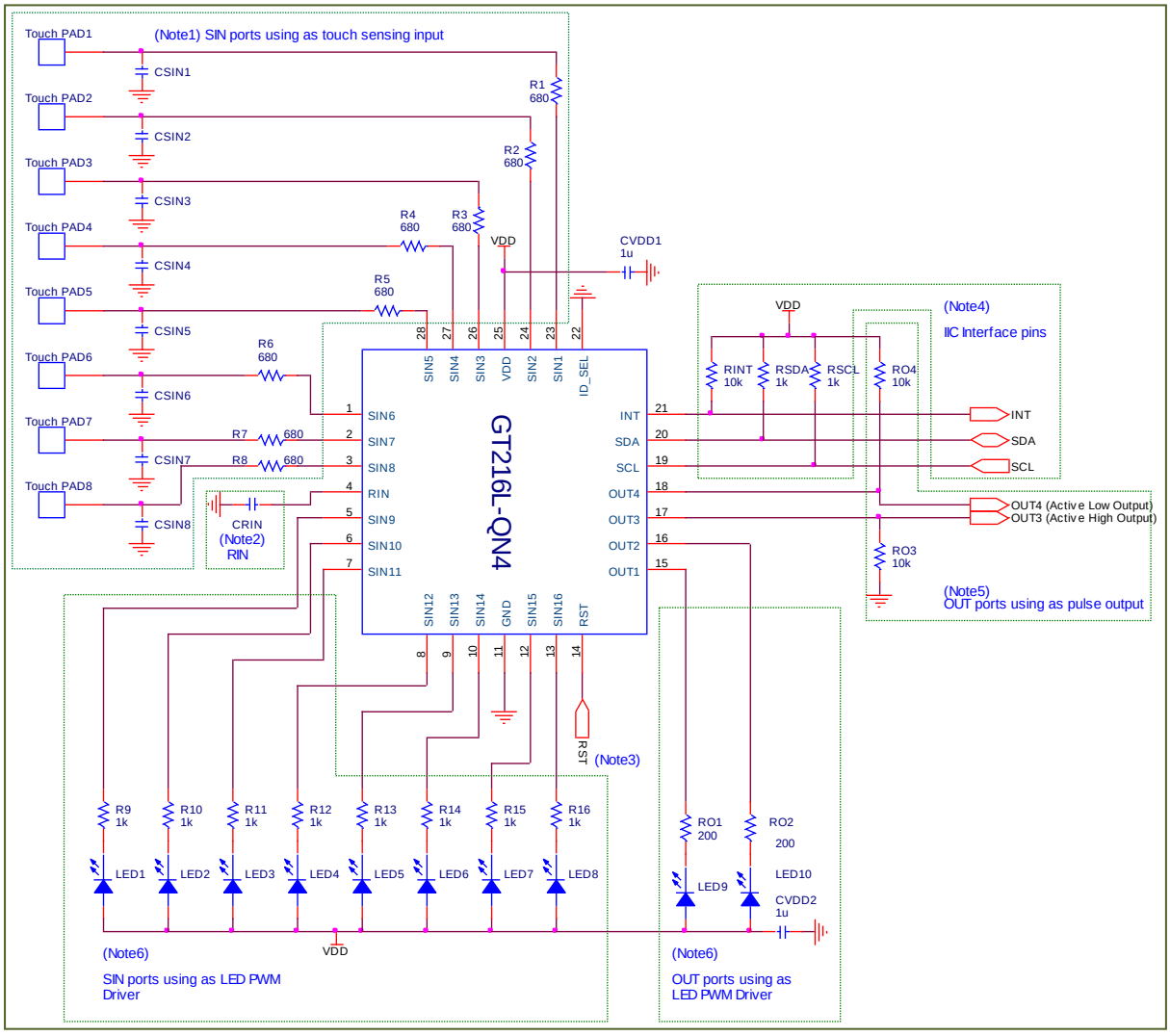
☞ *Description:* The GT216L has 4 exclusive output ports. These ports can be selected polarity.

XXH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	Reserved				POL_OUT4	POL_OUT3	POL_OUT2	POL_OUT1
Default	0	0	0	0	0	0	0	0

Addr.	Bits	Default	Name	Description
34H	7-4	0000B	Reserved	
	3	0B	POL_OUT4	Output 4 polarity 0: active low 1: active high
	2	0B	POL_OUT3	Output 3 polarity 0: active low 1: active high
	1	0B	POL_OUT2	Output 2 polarity 0: active low 1: active high
	0	0B	POL_OUT1	Output 1 polarity 0: active low 1: active high

Chapter 5: Application Notes

5-1 Application Circuit Example



Application example circuit for GT216L

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 GT216L has enough noise rejection algorithms and various internal 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 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.

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 total capacitance of each SIN touch sensing inputs.
- 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 3-3)
- 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 low signal pulse can make system reset. This port has also an internal pull-up 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)

5-2-7 OUT ports for Pulse Output <Note5>

- The OUT [1:4] ports that are used pulse 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. These output signals of OUT ports can be controlled by internal control register via I^2C. (Refer to 3-4)
- Each OUT [1:4] ports has sinking current ability typical 25mA and sourcing current ability typical 15mA on typical temperature condition.. (Refer to 3-4)

5-2-8 LED PWM Drive Applications <Note6>

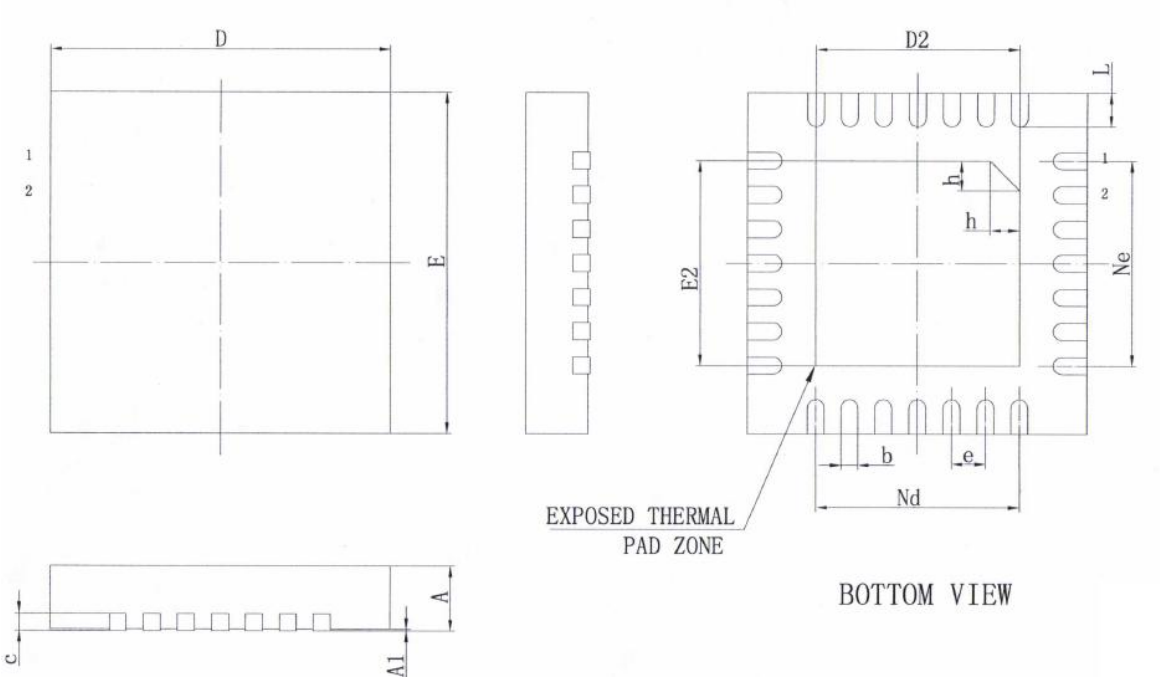
- The maximum 10mA LED drive current can be sunk by a single SIN port on typical temperature condition. The SIN ports which are used as LED PWM drive ports cannot carry out the role of touch sensing input simultaneously. The 32 steps brightness control is possible. (Refer to 3-3)
- More high current LED drive is possible by using OUT [1:4] port which sinking current ability typical 25mA on typical temperature condition.
- To prevent V_{DD} line from being fluctuated by LED drive current a additional capacitor (CVDD2) is recommended.

5-2-9 ID_SEL and Exposed Pad

- ID_SEL port must be connected to V_{DD} or GND. Open connection is not permitted.
- Exposed pad of package must be connected to GND.

Chapter 6: Package information

6-1 Package Outside Drawings for GT216L-QN4



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0	0.02	0.05
b	0.15	0.20	0.25
c	0.18	0.20	0.25
D	3.90	4.00	4.10
D2	2.30	2.40	2.50
e		0.40BSC	
Nd		2.40BSC	
E	3.90	4.00	4.10
E2	2.30	2.40	2.50
Ne		2.40BSC	
L	0.35	0.40	0.45
h	0.30	0.35	0.40

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