The Classic of Touch Solution!

GREENCHIP

GreenTouch3™ GT316L Capacitive Touch Sensor

DATASHEET
VER2.80

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Table of Contents

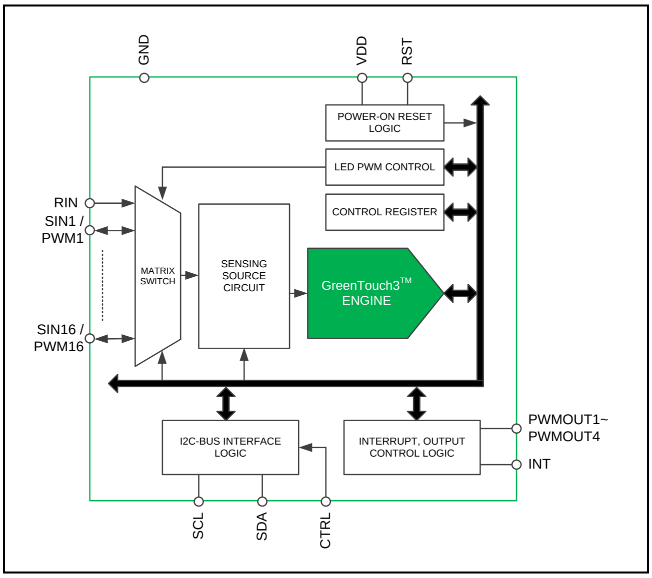
1. INTRODUCTION

The GT316L is one of the new GreenTouch3™ capacitive touch sensor series. Especially the GT316L can do capacitance sensing with 16 channels under above GreenTouch3™ engine operation. Thanks to this epochal GreenTouch3™ 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 GT316L offers 16 touch sense inputs which also can be used as dimming LED drive output pins. 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 GT316L can be performed by internal control registers. These internal control registers are readable and writable using I2C interface. 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 GT316L can be applied under wide supply voltage range from 1.8V to 5.5V. The CTRL pin of the GT316L provides switchable chip ID that make two chip parallel operation on the same I2C bus. And 4 exclusive output pins of the GT316L provide 25mA sinkable outputs.

2. FEATURES

- 16 channels touch sensing inputs
  - These pins can be used as LED driver pins
- Embedded GreenTouch3™ 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 pins
- Incredibly low power consumption
  - Standby mode : Min=9.6uA (@3.3V, RSP Time ≈ 800ms)
  - Available various op-periods for current saving
- Wide supply voltage range: 1.8V to 5.5V
  - Single supply operation
- Package type
  - QFN-28L, 4x4
  - TSSOP-30L
- RoHS compliant

3. BLOCK DIAGRAM



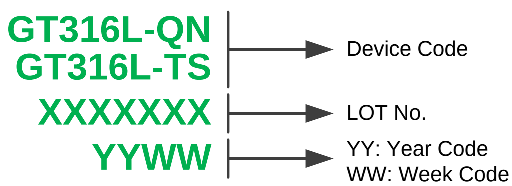
4. APPLICATIONS

- 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.

5. ORDERING INFORMATION

Part No.	Package
GT316L-QN	QFN-28L, 4x4
GT316L-TS	TSSOP-30L

6. MARKING INFORMATION

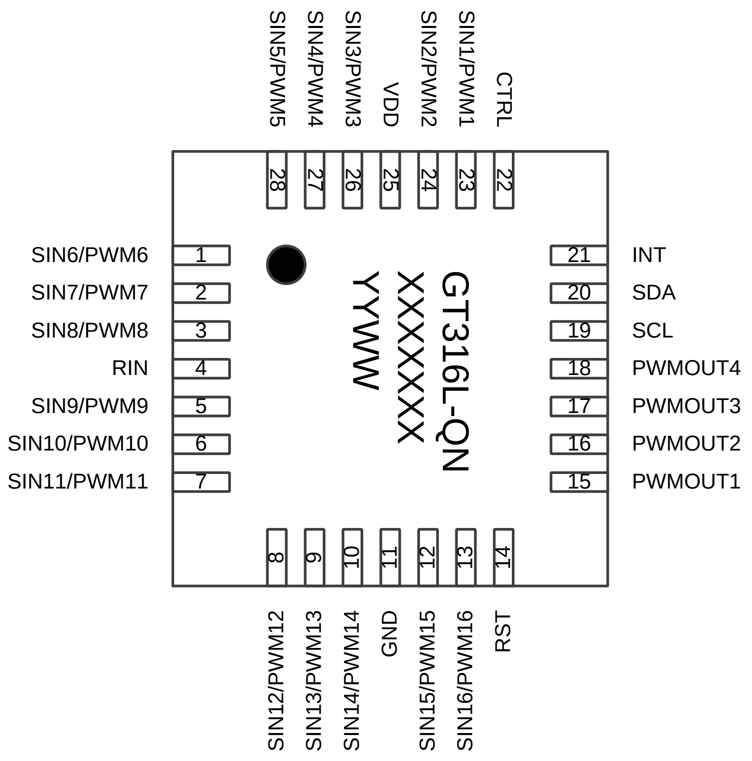


7. PIN DESCRIPTION

This section describes the pin names and pin functions of GT316L. Pinout configuration also illustrated as below. The GT316L device is available in the following packages.

7.1 QFN-28L PACKAGE

7.1.1 PACKAGE INFORMATION



(TOP view)

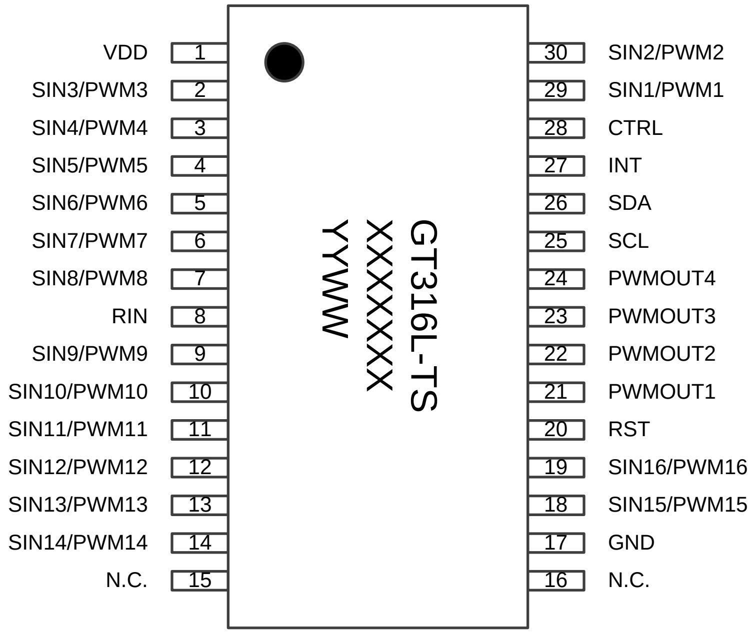
7.1.2 PIN CONFIGURATION

No.	Name	Type	Description
1	SIN6/PWM6	AI/DO	Channel 6: Touch sensing input / LED PWM drive output
2	SIN7/PWM7	AI/DO	Channel 7: Touch sensing input / LED PWM drive output
3	SIN8/PWM8	AI/DO	Channel 8: Touch sensing input / LED PWM drive output
4	RIN	AI	Capacitance reference input
5	SIN9/PWM9	AI/DO	Channel 9: Touch sensing input / LED PWM drive output
6	SIN10/PWM10	AI/DO	Channel 10: Touch sensing input / LED PWM drive output
7	SIN11/PWM11	AI/DO	Channel 11: Touch sensing input / LED PWM drive output
8	SIN12/PWM12	AI/DO	Channel 12: Touch sensing input / LED PWM drive output
9	SIN13/PWM13	AI/DO	Channel 13: Touch sensing input / LED PWM drive output
10	SIN14/PWM14	AI/DO	Channel 14: Touch sensing input / LED PWM drive output
11	GND	GND	Ground connection
12	SIN15/PWM15	AI/DO	Channel 15: Touch sensing input / LED PWM drive output
13	SIN16/PWM16	AI/DO	Channel 16: Touch sensing input / LED PWM drive output
14	RST	DI	Reset control pin (Active LOW)
15	PWMOUT1	DO	Exclusive output (User controllable) / LED PWM drive output
16	PWMOUT2	DO	Exclusive output (User controllable) / LED PWM drive output
17	PWMOUT3	DO	Exclusive output (User controllable) / LED PWM drive output
18	PWMOUT4	DO	Exclusive output (User controllable) / LED PWM drive output
19	SCL	DI	I2C serial clock input
20	SDA	DIO	I2C serial data communication pin
21	INT	DO	Interrupt output pin
22	CTRL	DI	chip ID selection (Connected to VDD or GND)
23	SIN1/PWM1	AI/DO	Channel 1: Touch sensing input / LED PWM drive output
24	SIN2/PWM2	AI/DO	Channel 2: Touch sensing input / LED PWM drive output
25	VDD	PWR	Supply Voltage
26	SIN3/PWM3	AI/DO	Channel 3: Touch sensing input / LED PWM drive output
27	SIN4/PWM4	AI/DO	Channel 4: Touch sensing input / LED PWM drive output
28	SIN5/PWM5	AI/DO	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

7.2 TSSOP-30L PACKAGE

7.2.1 PACKAGE INFORMATION



(TOP view)

7.2.2 PIN CONFIGURATION

No.	Name	Type	Description
1	VDD	PWR	Supply Voltage
2	SIN3/PWM3	AI/DO	Channel 3: Touch sensing input / LED PWM drive output
3	SIN4/PWM4	AI/DO	Channel 4: Touch sensing input / LED PWM drive output
4	SIN5/PWM5	AI/DO	Channel 5: Touch sensing input / LED PWM drive output
5	SIN6/PWM6	AI/DO	Channel 6: Touch sensing input / LED PWM drive output
6	SIN7/PWM7	AI/DO	Channel 7: Touch sensing input / LED PWM drive output
7	SIN8/PWM8	AI/DO	Channel 8: Touch sensing input / LED PWM drive output
8	RIN	AI	Capacitance reference input
9	SIN9/PWM9	AI/DO	Channel 9: Touch sensing input / LED PWM drive output
10	SIN10/PWM10	AI/DO	Channel 10: Touch sensing input / LED PWM drive output
11	SIN11/PWM11	AI/DO	Channel 11: Touch sensing input / LED PWM drive output
12	SIN12/PWM12	AI/DO	Channel 12: Touch sensing input / LED PWM drive output
13	SIN13/PWM13	AI/DO	Channel 13: Touch sensing input / LED PWM drive output
14	SIN14/PWM14	AI/DO	Channel 14: Touch sensing input / LED PWM drive output
15	N.C.	-	Not connected
16	N.C.	-	Not connected
17	GND	GND	Ground connection
18	SIN15/PWM15	AI/DO	Channel 15: Touch sensing input / LED PWM drive output
19	SIN16/PWM16	AI/DO	Channel 16: Touch sensing input / LED PWM drive output
20	RST	DI	Reset control pin (Low active)
21	PWMOUT1	DO	Exclusive output (User controllable) / LED PWM drive output
22	PWMOUT2	DO	Exclusive output (User controllable) / LED PWM drive output
23	PWMOUT3	DO	Exclusive output (User controllable) / LED PWM drive output
24	PWMOUT4	DO	Exclusive output (User controllable) / LED PWM drive output
25	SCL	DI	I2C serial clock input
26	SDA	DIO	I2C serial data communication pin
27	INT	DO	Interrupt output pin
28	CTRL	DI	chip ID selection (Connected to VDD or GND)
29	SIN1/PWM1	AI/DO	Channel 1: Touch sensing input / LED PWM drive output
30	SIN2/PWM2	AI/DO	Channel 2: Touch sensing input / LED PWM drive output

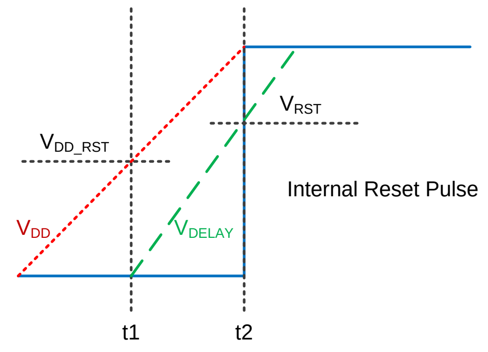
NOTE: DI: Digital Input, DO: Digital Output, DIO: Digital Input and Output, AI: Analog Input, AO: Analog Output, PWR: POWER

8. FUNCTION DESCRIPTION

8.1 INTERNAL AND EXTERNAL RESET (RST)

The GT316L has both internal power-on reset and external reset functions. The internal reset operation is used for initial power-on 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.



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 GT316L 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.

8.2 IMPLEMENTATION FOR SIN PINS (SIN1/PWM1 ~ SIN16/PWM16, RIN)

SIN pins (SIN1~SIN16) of GT316L 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 pins used as touch sensing input cannot be used as LED PWM drive pin and some or all of SIN pins used as LED PWM drive pin also cannot be used as touch sensing input. SIN using selection can be accomplished by internal register setting.

8.2.1 IMPLEMENTATION FOR TOUCH SENSING (SIN1~SIN16, RIN)

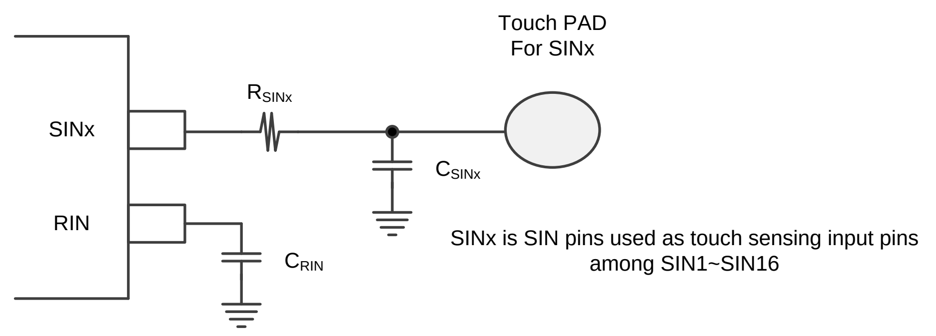
SIN pins can be used for touch sensing inputs for detection of capacitance variation sensing. The SIN input pins are connected to touch sensing pad and catches capacitance variation caused by direct touch or approaching. And RIN which is input pin for the reference capacitance is to be connected to a capacitor to compensate capacitance difference between SIN pins and RIN pin. The GT316L compares each capacitance of SIN pins and that of RIN pin and determines touch detection of each channel when that channels SIN pin capacitance increases. So, for correct capacitance comparison between SIN pins and RIN pin, the total RIN pin capacitance is to be compensated to be approximately equal to initial-steady state capacitance of SIN pins appeared by connection line between SIN pins 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 pins.

The GT316L 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 I2C interface, 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 GT316L 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 GT316L 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 ($R_{SIN1\sim16}$) of each SIN pin is required, then it should be less than 1kΩ and the location of resister is recommended as closer to the SIN pins of GT316L. The capacitors connected to touch pads are optional and it helps fine sensitivity control and capacitance compensation between each channels. For $C_{SIN1\sim16}$, C_{RIN} capacitor, less than 50pF capacitor can be used. Both $R_{SIN1\sim16}$ and $C_{SIN1\sim16}$ are not obligatory components.

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

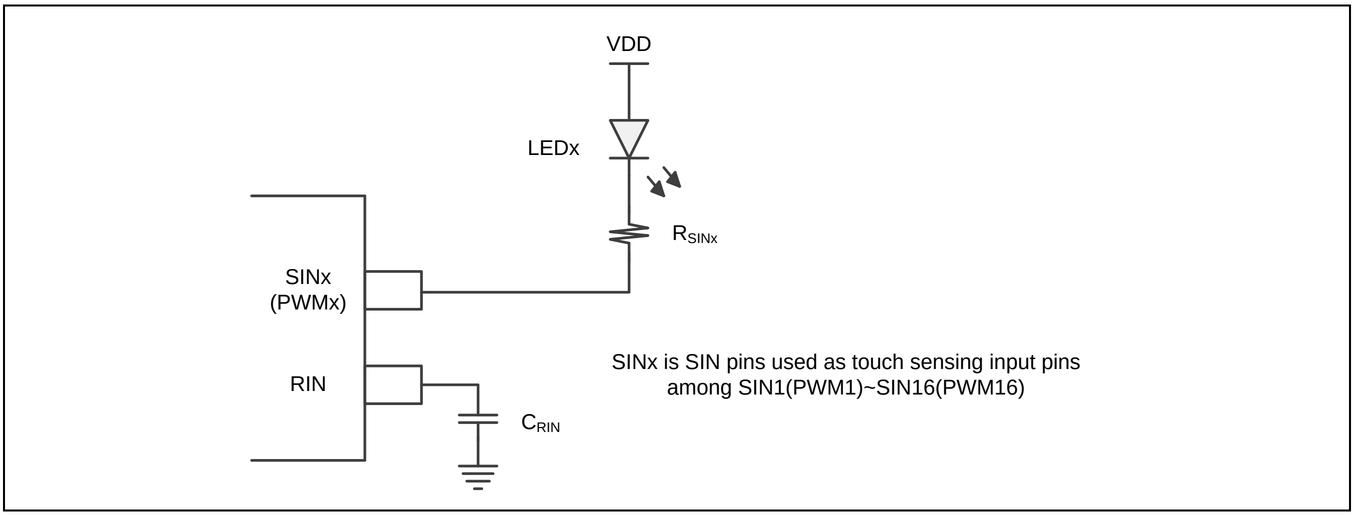


The connection line between SIN pins and touch pad routings are desirable to be routed as short as possible and the width of routing lines should be as narrow as possible and placed on opposite metal side. In other words, touch pad and touch pad connection lines should be placed on opposite metal side 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.

8.2.2 IMPLEMENTATION FOR LED PWM DRIVE (PWM1~PWM16)

The LED PWM drive using SIN pins is available. There are 32 LED brightness control steps using PWM duty. These brightness steps can be controlled by internal control register via I2C interface. The maximum LED brightness has 100% on duty and the minimum has 0% on duty. Each SIN pin 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 PWMOUT1~4 pins rather than PWM1~16. The R_{SINx} are LED current limiting resistors.
(See register address 04h, 05h =IO_DIR1~16)
(See register address 06h = PWM_EN)
(See register address 20h~2Fh = PWM_DATA1~16)

The basic implementation for LED PWM drive is shown in the following figure.



8.2.3 PROGRAMMING THE RESPONSE TIME

The response time (RSP Time) is determined by programming the control register according to the following formula.

$$\text{RSP Time} \approx T_{IDLE\_TIME}^{(1)} + [\, T_{SENSING\_TIME}^{(2)} \times (N_{CH}^{(3)}+10) \times (\text{Touch Period}^{(4)}+1) \,]$$

NOTE:

(1) T_{IDLE_TIME} : Idle time (SEN_IDLE_TIME[3:0] + SEN_IDLE_TIME_SUFFIX[3:0])

(2) $T_{SENSING\_TIME}$: Sensing Time of the Slowest SBF Frequency (Refer to Sensing Time for SBF Frequency Table)

(3) N_{CH} : Enabled channel (IO_DIR1 ~ IODIR16)

(4) Touch Period : The continuous period for touch detection (TOUCH_PERIOD[2:0])

The Sensing Time for SBF Frequency is shown in the following table.

(TA = -25 to 85°C, V_{DD} = 3.3V)

SBFn(1) Frequency	SENSING_COUNT								Unit
	1000	1500	2000	2500	3000	3500	4000	4500	
1MHz	1.1	1.6	2.1	2.6	3.1	3.6	4.1	4.6	ms
2.4MHz	0.52	0.73	0.94	1.15	1.36	1.57	1.78	1.99	ms
4MHz	0.35	0.475	0.6	0.725	0.85	0.975	1.1	1.225	ms
5.6MHz	0.28	0.37	0.46	0.55	0.64	0.73	0.82	0.91	ms
8.8MHz	0.22	0.28	0.34	0.4	0.46	0.52	0.58	0.64	ms
10.4MHz	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	ms

NOTE: (1) n = SBF1~SBF4

The response time (RSP Time) is determined by changing the following control register. So, firstly, calculate the desired response time based on the RSP Time formula. Secondly, determine the control register value for calculated response time. Finally, set the calculated control register value for touch IC configuration in the MCU program.

- Address=04h, 05h (IO_DIR16 ~ IO_DIR1)
- Address=06h (SEN_IDLE_TIME)
- Address=08h (TOUCH_PERIOD)
- Address=0Ah (SENSING_COUNT)

Use the following procedure to make response time changes:

412.72ms ≈ 330ms + [0.94ms x (12+10) x (3+1)]

1. Write IDLE_TIME to control register 06h, 09h:
   a. Address 06h = 49h (330ms)
   b. Address 09h = 00h (0ms)
2. Write IO_DIR1~16 to control register 04h, 05h:
   a. Address 04h = FFh (SIN1~8 enable)
   b. Address 05h = 0Fh (SIN9~12 enable)
3. Write TOUCH_PERIOD to control register 08h:
   a. Address 08h = 27h (3 period)
4. Write SENSING_COUNT to control register 0Ah:
   a. Address 0Ah = 02h (2000 count)
5. Write SBF1~4 frequency to control register 0Ch~0Fh:
   a. Address 0Ch = 01h (SBF1=2.4MHz)
   b. Address 0Dh = 03h (SBF2=5.6MHz)
   c. Address 0Eh = 04h (SBF3=8.8MHz)
   d. Address 0Fh = 05h (SBF4=10.4MHz)

The current consumption to response time is shown in the following table.

(TA = -25 to 85°C, V_{DD} = 3.3V)

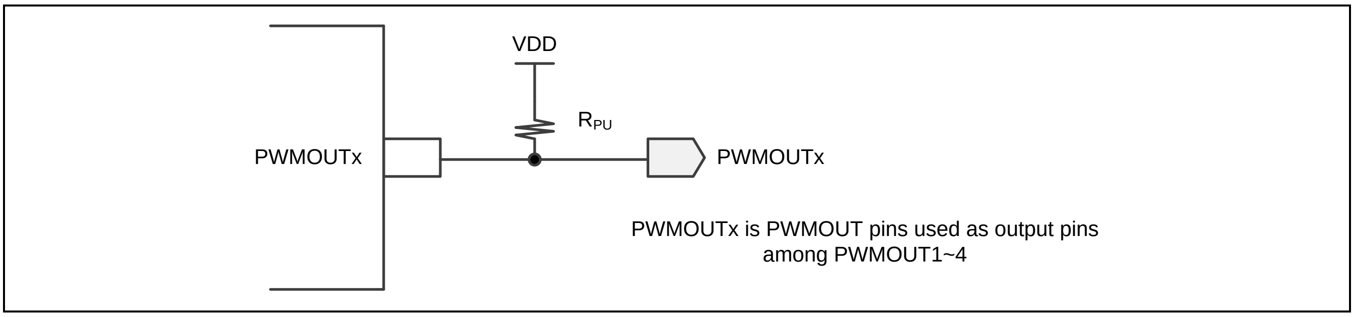
RSP Time(1)	Current Consumption (Typ.)
≈ 135ms (IDLE_TIME=55ms)	75uA
≈ 190ms (IDLE_TIME=110ms)	30uA
≈ 345ms (IDLE_TIME=165ms)	20uA
≈ 410ms (IDLE_TIME=330ms)	15uA
≈ 630ms (IDLE_TIME=550ms)	13uA

NOTE: (1) Test condition: Enabled Channel=12ch, SENSING_COUNT=2000 count, TOUCH_PERIOD=3 period

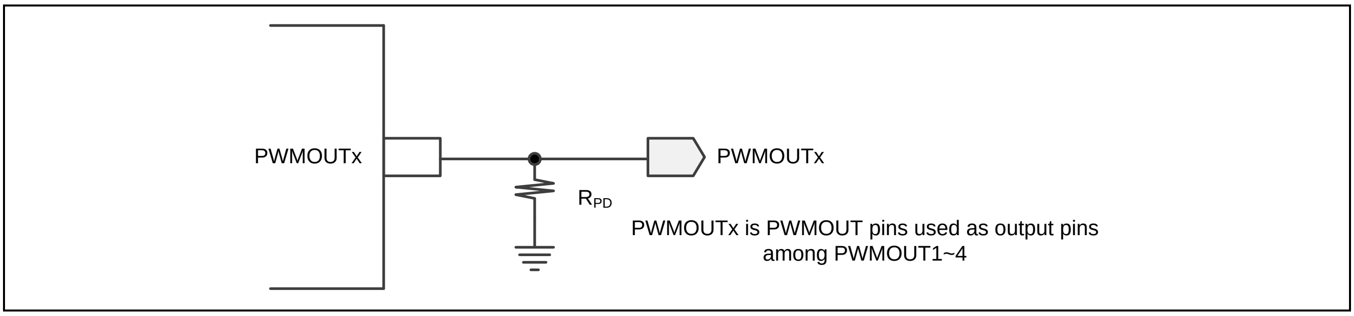
8.3 IMPLEMENTATION FOR PWMOUT PINS (PWMOUT1~PWMOUT4)

The GT316L has exclusive output pins PWMOUT1~4. Output pulse polarity of each OUT pins can be changed independent on other OUT pins by internal control register setting via I2C interface. 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 I2C interface PWMOUT1~4 pins are usefulness for high brightness LED drive. Each PWMOUT1~4 pins has sinking current ability typical 25mA and sourcing current ability typical 15mA.
(See register address 06h = PWM_EN)
(See register address 30h~33h =PWMOUT_DATA1~4)
(See register address 34h =PWMOUT_POL1~ 4)

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



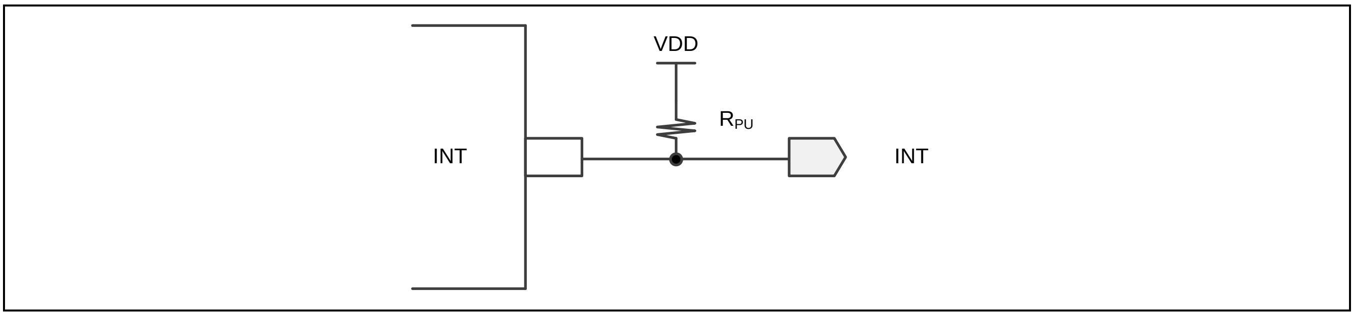
The basic implementations for active high modes are shown in the following figure.



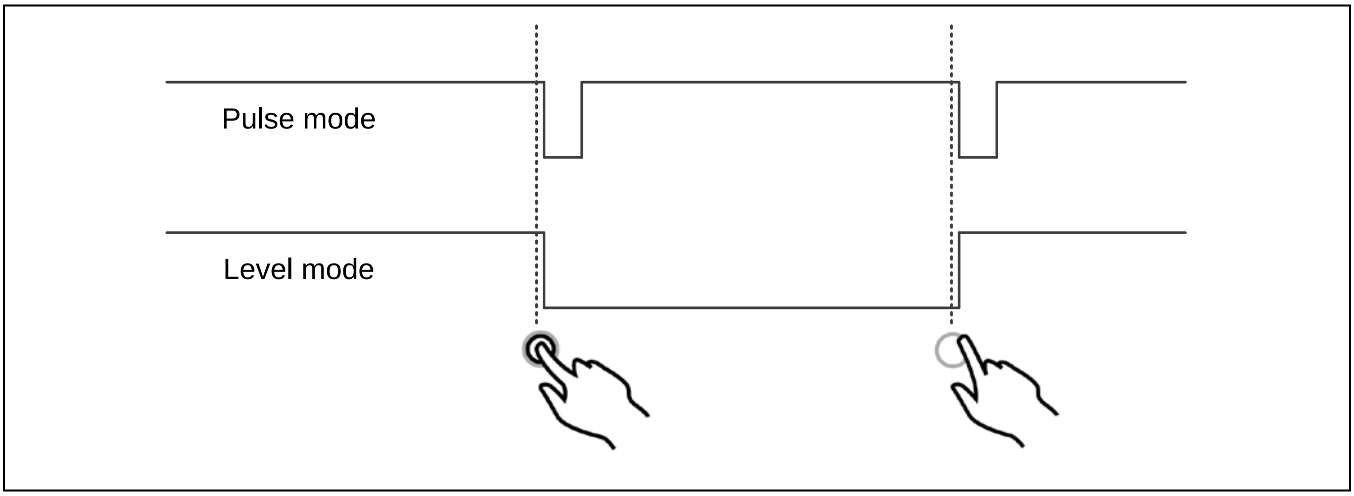
8.4 IMPLEMENTATION FOR INTERRUPT (INT)

The GT316L provides an interrupt (INT) function to reduce a communication load between MCU and GT316L. The INT will indicate a point of time that the touch detection data status registers at the address 02h and 03h 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. In the Pulse mode, a short interrupt pulse is generated every time the data at the touch detection data status register changes. In the level mode, an interrupt pulse maintains low during at least one of 16 channels touch is coming on the output status register.
(See register address 06h = INT_MODE)

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



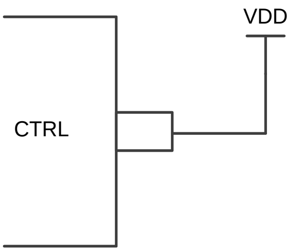
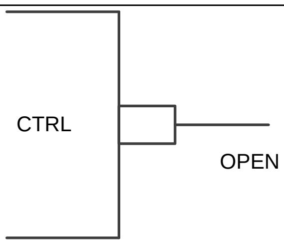
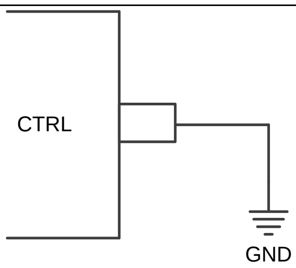
Two interrupt mode operations are shown in the following figure.



8.5 CTRL OPTION SELECTION (CTRL)

In the GT316L, three options are available by CTRL pin connection. Each option and its connections are shown in the table and figures below. 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.

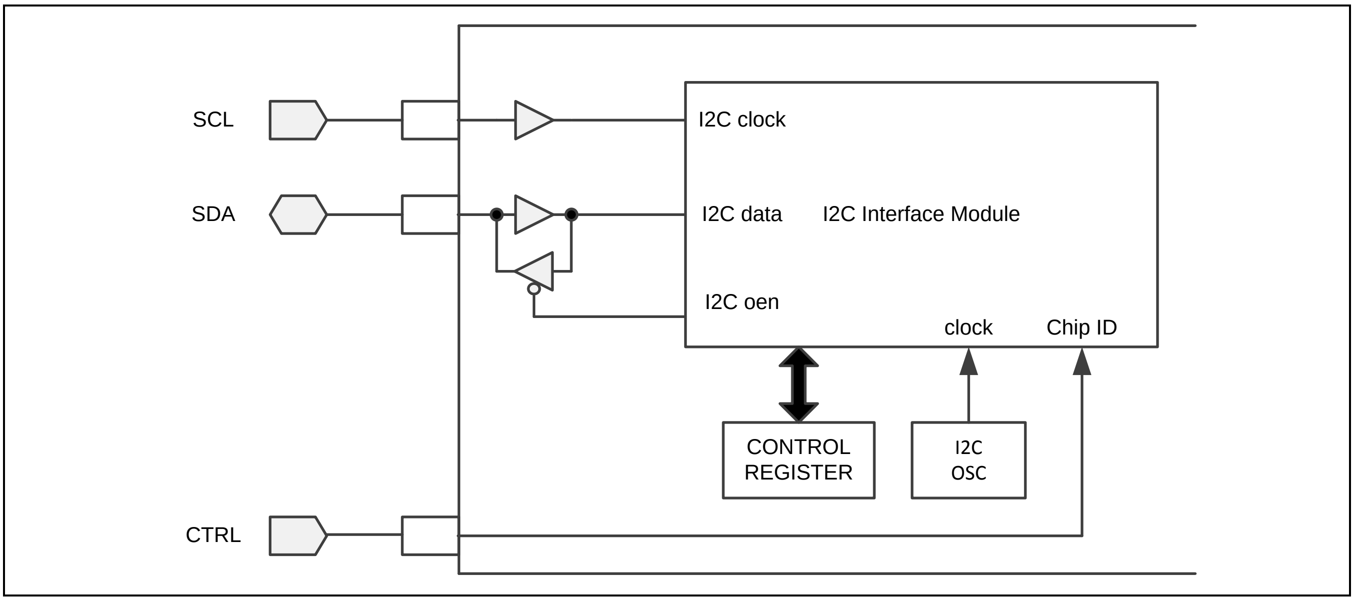
Each options and respective connection are shown in the following table.

CTRL Option	I2C Address	IO Direction	Touch Mode	Sensitivity
 Option 1 (Connect to VDD)	B2h	Analog Input Mode (FFh, FFh)	Multi Touch	Middle Sensitivity (0Fh)
 Option 2 (OPEN)	B2h	Digital Output Mode (00h, 00h)	Multi Touch	Middle Sensitivity (0Fh)
 Option 3 (Connect to GND)	B0h	Analog Input Mode (FFh, FFh)	Multi Touch	Middle Sensitivity (0Fh)

8.6 I2C INTERFACE (SCL, SDA, CTRL)

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 control register setting values of GT316L can be read and written. 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 VDD to reduce rising delay. The GT316L has an internal I2C clock oscillator. The internal oscillator is disabled when all of both the SDA and SCL lines are high for saving current consumption.

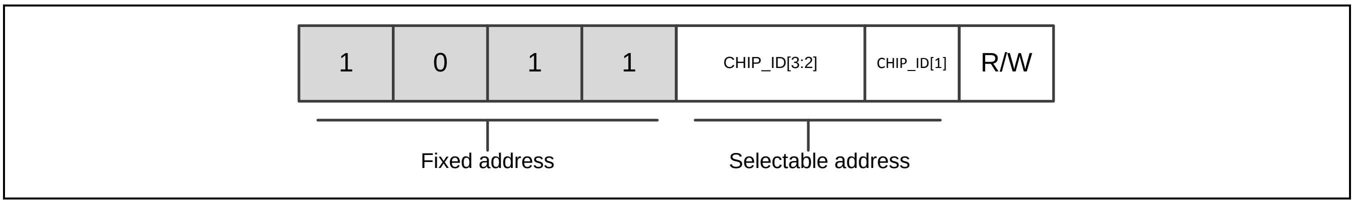
The simple internal block diagram for SCL and SDA is shown in the following figure.



8.6.1 DEVICE ADDRESSING

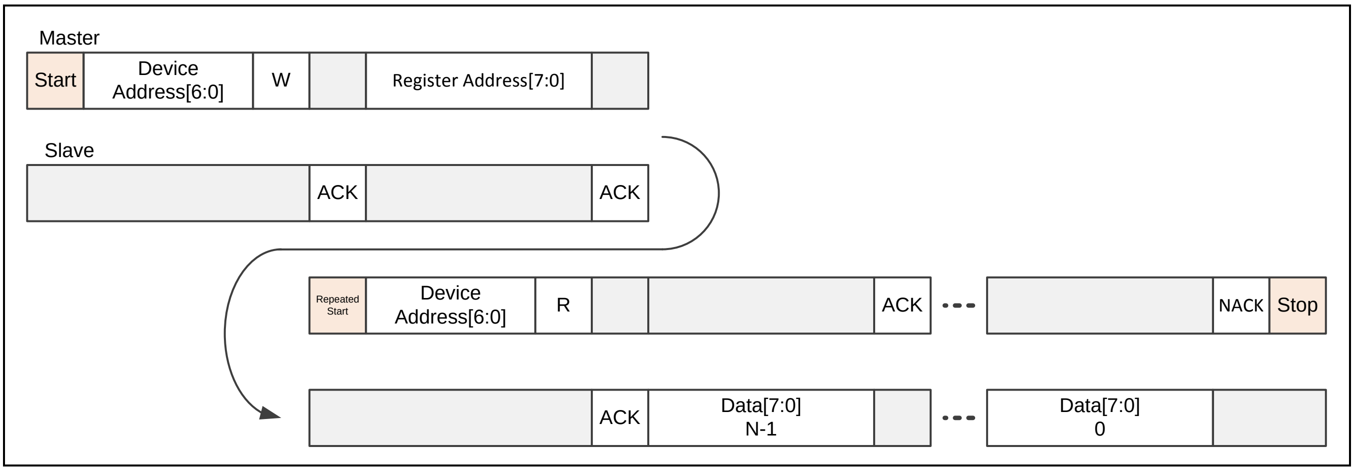
Following a START condition, the bus master must output the address of the slave it is accessing. To conserve power, no internal pull-up resistors are incorporated on the hardware selectable pins(CTRL) and it must be connected to VDD, GND or OPEN.
The last bit of the slave address defines the operation 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.



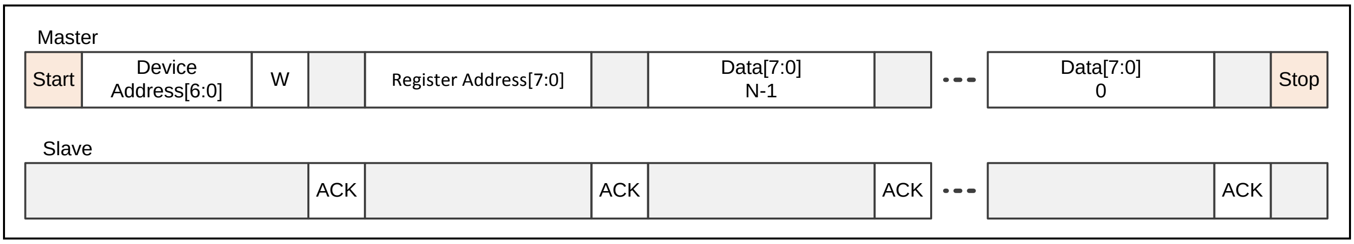
8.6.2 READ OPERATION

The following figure represents the I2C normal mode read operation.



8.6.3 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	R/W,	B0h B2h	1	0	1	1	CHIP_ID[3:2]		CHIP_ ID[1]	0
01h	R/W	02h	0	0	0	0	0	0	MON _RST	TOUCH
02h	R	-	TOUCH _OUT8	TOUCH _OUT7	TOUCH _OUT6	TOUCH _OUT5	TOUCH _OUT4	TOUCH _OUT3	TOUCH _OUT2	TOUCH _OUT1
03h	R	-	TOUCH _OUT16	TOUCH _OUT15	TOUCH _OUT14	TOUCH _OUT13	TOUCH _OUT12	TOUCH _OUT11	TOUCH _OUT10	TOUCH _OUT9
04h	R/W	FFh 00h	IO _DIR8	IO _DIR7	IO _DIR6	IO _DIR5	IO _DIR4	IO _DIR3	IO _DIR2	IO _DIR1
05h	R/W	FFh 00h	IO _DIR16	IO _DIR15	IO _DIR14	IO _DIR13	IO _DIR12	IO _DIR11	IO _DIR10	IO _DIR9
06h	R/W	42h	SOFT _RST	MULTI _MODE	PWM _EN	INT _MODE	SEN_IDLE_TIME			
07h	R/W	0Eh	0	0	0	EXP_TIME			EXP_EN	EXP_ MODE
08h	R/W	27h	0	TOUCH_PERIOD			CAL_TIME			
09h	R/W	00h	0	0	0	0	SEN_IDLE_TIME_SUFFIX			
0Ah	R/W	05h	0	0	0	0	0	SENSING_COUNT		
0Bh	R/W	02h	0	0	0	0	0	BUSY_TO_IDLE_TIME		
0Ch	R/W	01h	0	0	0	0	0	SBF1_SEL		
0Dh	R/W	03h	0	0	0	0	0	SBF2_SEL		
0Eh	R/W	04h	0	0	0	0	0	SBF3_SEL		
0Fh	R/W	05h	0	0	0	0	0	SBF4_SEL		

10h	R/W	0Fh	0	0	SENSITIVITY1					
11h	R/W	0Fh	0	0	SENSITIVITY2					
12h	R/W	0Fh	0	0	SENSITIVITY3					
13h	R/W	0Fh	0	0	SENSITIVITY4					
14h	R/W	0Fh	0	0	SENSITIVITY5					

15h	R/W	0Fh	0	0	SENSITIVITY6
16h	R/W	0Fh	0	0	SENSITIVITY7
17h	R/W	0Fh	0	0	SENSITIVITY8
18h	R/W	0Fh	0	0	SENSITIVITY9
19h	R/W	0Fh	0	0	SENSITIVITY10
1Ah	R/W	0Fh	0	0	SENSITIVITY11
1Bh	R/W	0Fh	0	0	SENSITIVITY12
1Ch	R/W	0Fh	0	0	SENSITIVITY13
1Dh	R/W	0Fh	0	0	SENSITIVITY14
1Eh	R/W	0Fh	0	0	SENSITIVITY15
1Fh	R/W	0Fh	0	0	SENSITIVITY16

20h	R/W	1Fh	0	0	0	PWM_DATA1
21h	R/W	1Fh	0	0	0	PWM_DATA2
22h	R/W	1Fh	0	0	0	PWM_DATA3
23h	R/W	1Fh	0	0	0	PWM_DATA4
24h	R/W	1Fh	0	0	0	PWM_DATA5
25h	R/W	1Fh	0	0	0	PWM_DATA6
26h	R/W	1Fh	0	0	0	PWM_DATA7
27h	R/W	1Fh	0	0	0	PWM_DATA8
28h	R/W	1Fh	0	0	0	PWM_DATA9
29h	R/W	1Fh	0	0	0	PWM_DATA10
2Ah	R/W	1Fh	0	0	0	PWM_DATA11
2Bh	R/W	1Fh	0	0	0	PWM_DATA12
2Ch	R/W	1Fh	0	0	0	PWM_DATA13
2Dh	R/W	1Fh	0	0	0	PWM_DATA14
2Eh	R/W	1Fh	0	0	0	PWM_DATA15
2Fh	R/W	1Fh	0	0	0	PWM_DATA16

30h	R/W	1Fh	0	0	0	PWMOUT_DATA1				
31h	R/W	1Fh	0	0	0	PWMOUT _DATA2				
32h	R/W	1Fh	0	0	0	PWMOUT _DATA3				
33h	R/W	1Fh	0	0	0	PWMOUT _DATA4				
34h	R/W	00h	0	0	0	0	PWMOUT _POL4	PWMOUT _POL3	PWMOUT _POL2	PWMOUT _POL1

9.2 REGISTER CONFIGURATION

9.2.1 00H REGISTER

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
00h	R/W,		1	0	1	1	CHIP_ID[3:2]		CHIP_ ID[1]	0
		B0h(1)	1	0	1	1	0	0	0	0
		B2h(2)	1	0	1	1	0	0	1	0

CHIP_ID[3:2]	Software selectable chip ID bit
CHIP_ID[1]	Hardware selectable chip ID bit
	CTRL pin = VDD, CHIP_ID[1] = 1 CTRL pin = OPEN, CHIP_ID[1] = 1 CTRL pin = GND, CHIP_ID[1] = 0
	NOTE: This bit might be controlled by CTRL pin.

NOTE: (1) CTRL pin = GND, (2) CTRL pin = VDD or OPEN

9.2.2 01H REGISTER

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
01h	R/W		0	0	0	0	0	0	MON _RST	TOUCH
		02h	0	0	0	0	0	0	1	0

MON_RST	Monitoring reset bit 0 = not active and clear bit by user 1 = active and set bit by GT316L
	NOTE: It's set '1' when GT316L is reset.
TOUCH	Touch detection status bit 0 = No touch detection 1 = Touch detection.
	NOTE: It's set '1' when touch detection occur.

9.2.3 02H, 03H REGISTER

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
02h	R	-	TOUCH _OUT8	TOUCH _OUT7	TOUCH _OUT6	TOUCH _OUT5	TOUCH _OUT4	TOUCH _OUT3	TOUCH _OUT2	TOUCH _OUT1
03h	R	-	TOUCH _OUT16	TOUCH _OUT15	TOUCH _OUT14	TOUCH _OUT13	TOUCH _OUT12	TOUCH _OUT11	TOUCH _OUT10	TOUCH _OUT9

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.

NOTE: (1) n = SIN1~SIN16 pin

9.2.4 04H, 05H REGISTER

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
04h	R/W		IO _DIR8	IO _DIR7	IO _DIR6	IO _DIR5	IO _DIR4	IO _DIR3	IO _DIR2	IO _DIR1
		FFh(1)	1	1	1	1	1	1	1	1
		00h(2)	0	0	0	0	0	0	0	0
05h	R/W		IO _DIR16	IO _DIR15	IO _DIR14	IO _DIR13	IO _DIR12	IO _DIR11	IO _DIR10	IO _DIR9
		FFh(1)	1	1	1	1	1	1	1	1
		00h(2)	0	0	0	0	0	0	0	0

IO_DIRn(3)	IO direction selection bit 0 = digital output (touch input disable, PWM output enable) 1 = analog input (touch input enable, PWM output disable)
	NOTE: If CTRL pin is connected VDD or GND, the reset value is FFh. If CTRL pin is open, the reset value is 00h.

NOTE: (1) CTRL pin = VDD or GND, (2) CTRL pin = OPEN
(3) n = SIN1~SIN16 pin

9.2.5 06H REGISTER

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
06h	R/W		SOFT_RST	MULTI_MODE	PWM_EN	INT_MODE	SEN_IDLE_TIME			
		42h	0	1	0	0	0	0	1	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.			
MULTI_MODE	Touch engine mode selection bit 0 = Single touch mode 1 = Multi touch mode.			
PWM_EN	PWM output enable bit 0 = disable 1 = enable			
INT_MODE	Interrupt operation mode selection bit 0 = Pulse mode 1 = Level mode			
SEN_IDLE_TIME(1)	Idle time section bit			
	0000= 1ms 0001= 6ms 0010= 17ms 0011= 33ms	0100= 55ms 0101= 110ms 0110= 165ms 0111= 220ms	1000= 275ms 1001= 330ms 1010= 385ms 1011= 440ms	1100= 495ms 1101= 550ms 1110= 1100ms 1111= 1650ms
	NOTE: The idle time equation is as follows. IDLE_TIME = SEN_IDLE_TIME[3:0] + SEN_IDLE_TIME_SUFFIX[3:0] Ex> 127ms = 110ms + 17ms			

NOTE: (1) Test condition: VDD = 3.3V, TA = 25℃

9.2.6 07H REGISTER

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
07h	R/W		0	0	0	EXP_TIME			EXP_EN	EXP_MODE
		0Eh	0	0	0	0	1	1	1	0

EXP_TIME(1)	Touch expire time selection bit	
	000 = 9sec 001 = 18sec 010 = 27ec 011 = 36sec	100 = 45sec 101 = 54sec 110 = 63sec 111 = 72sec
EXP_EN	Touch expire enable bit 0 = disable 1 = enable	
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 = 3.3V, TA = 25℃

9.2.7 08H REGISTER

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
08h	R/W		0	TOUCH_PERIOD			CAL_TIME			
		27h	0	0	1	0	0	1	1	1

TOUCH_PERIOD	Touch period selection bit	
	000 = 1 period 001 = 2 period 010 = 3 period 011 = 4 period	100 = 5 period 101 = 6 period 110 = 7 period 111 = 8 period
	NOTE: The continuous period for touch detection. If the TOUCH_PEIROD is increased, it will be stronger to electrical noise. But, the response time is slower.	
CAL_TIME(1)	Calibration time selection bit	
	0000 = 0ms + 1 period 0001 = 90ms + 1 period 0010 = 180ms + 1 period 0011 = 270ms + 1 period 0100 = 360ms + 1 period 0101 = 450ms + 1 period 0110 = 540ms + 1 period 0111 = 630ms + 1 period	1000 = 720ms + 1 period 1001 = 810ms + 1 period 1010 = 900ms + 1 period 1011 = 990ms + 1 period 1100 = 1080ms + 1 period 1101 = 1170ms + 1 period 1110 = 1260ms + 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 = 3.3V, TA = 25℃

9.2.8 09H REGISTER

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
09h	R/W		0	0	0	0	SEN_IDLE_TIME_SUFFIX			
		00h	0	0	0	0	0	0	0	0

SEN_IDLE_TIME_SUFFIX[(1)]	Idle time suffix section bit			
	0000= 0ms 0001= 3ms 0010= 6ms 0011= 11ms	0100= 17ms 0101= 22ms 0110= 28ms 0111= 33ms	1000= 39ms 1001= 44ms 1010= 50ms 1011= 55ms	1100= 110ms 1101= 220ms 1110= 330ms 1111= 440ms
	NOTE: The idle time equation is as follows. IDLE_TIME = SEN_IDLE_TIME[3:0] + SEN_IDLE_TIME_SUFFIX[3:0] Ex> 127ms = 110ms + 17ms			

NOTE: (1) Test condition: VDD = 3.3V, TA = 25℃

9.2.9 0AH REGISTER

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

SENSING_COUNT	Sensing counter section bit	
	000= 1000 count 001= 1500 count 010= 2000 count 011= 2500 count	100= 3000 count 101= 3500 count 110= 4000 count 111= 4500 count
	NOTE: The sensing time equation is as follows. Sensing time = (SBFn[(1)] Frequency * 3500) + 0.1ms Ex> 3.6ms = (1MHz(0.001ms) *3500) + 0.1ms	

NOTE: (1) n = SBF1~SBF4

9.2.10 0BH REGISTER

Address	R/W	Reset Value	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0Bh	R/W		0	0	0	0	0	BUSY_TO_IDLE_TIME		
		02h	0	0	0	0	0	0	1	0

BUSY_TO_IDLE_TIME(1)	Busy to Idle time section bit	
	000 = 0.9sec 001 = 1.8sec 010 = 2.7sec 011 = 3.6sec	100= 4.5sec 101= 5.4sec 110= 6.3sec 111= 7.2sec

NOTE: (1) Test condition: VDD = 3.3V, TA = 25℃

9.2.11 0CH~0FH REGISTER

Address	R/W	Reset Value	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0Ch	R/W		0	0	0	0	0	SBF1_SEL		
		01h	0	0	0	0	0	0	0	1
0Dh	R/W		0	0	0	0	0	SBF2_SEL		
		03h	0	0	0	0	0	0	1	1
0Eh	R/W		0	0	0	0	0	SBF3_SEL		
		04h	0	0	0	0	0	1	0	0
0Fh	R/W		0	0	0	0	0	SBF4_SEL		
		05h	0	0	0	0	0	1	0	1

SBFn(1)_SEL	SBF frequency selection bit	
	000 = 1MHz 001 = 2.4MHz 010 = 4MHz 011 = 5.6MHz	100= 8.8MHz 101= 10.4MHz 11x= 10.4MHz

NOTE: (1) n = SBF1~SBF4

9.2.12 10H~1FH REGISTER

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
10h ~ 1Fh	R/W		0	0	SENSITIVITYn(1)					
		0Fh	0	0	0	0	1	1	1	1

SENSITIVITYn(1)	Touch sensitivity control bit 03h = Highest Sensitivity 3Fh = Lowest Sensitivity

NOTE: (1) n = SIN1~SIN16 pin

9.2.13 20H~2FH REGISTER

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
20h ~ 1Fh	R/W		0	0	0	PWM_DATAn(1)				
		1Fh	0	0	0	1	1	1	1	1

PWM_DATAn(1)	LED PWM brightness control bit 00h = 100% (LED on) 01h~1Eh = PWM duty rate control 1Fh = 0% (LED off)
	NOTE: When 06h[5]=PWM_EN is set '0', you can not be adjusted LED PWM Brightness. **NOTE:** LED PWM Brightness is controlled within 32 steps.

NOTE: (1) n = SIN1~SIN16 pin

9.2.14 30H~34H REGISTER

Address	R/W	Reset Value	Data							
			Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
30h	R/W		0	0	0	PWMOUT_DATA1				
		1Fh	0	0	0	1	1	1	1	1
31h	R/W		0	0	0	PWMOUT_DATA2				
		1Fh	0	0	0	1	1	1	1	1
32h	R/W		0	0	0	PWMOUT_DATA3				
		1Fh	0	0	0	1	1	1	1	1
33h	R/W		0	0	0	PWMOUT_DATA4				
		1Fh	0	0	0	1	1	1	1	1
34h	R/W		0	0	0	0	PWMOUT_POL4	PWMOUT_POL3	PWMOUT_POL2	PWMOUT_POL1
		00h	0	0	0	0	0	0	0	0

PWMOUT_DATAn(1)	LED PWM brightness control bit 00h = 100% (LED on) 01h~1Eh = PWM duty rate control 1Fh = 0% (LED off) **NOTE:** When 06h[5]=PWM_EN is set '0', you can not be adjusted LED PWM Brightness. **NOTE:** LED PWM Brightness is controlled within 32 steps.
PWMOUT_DATAn(1)	PWM output polarity selection bit 0 = active LOW 1 = active HIGH

NOTE: (1) n = PWMOUT1~4 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} = 1.8V to 5.5V)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Target supply voltage	V_{DD}		1.8	3.3 / 5.0	5.5	V
Current consumption	I_{DD}	Standby mode (VDD = 3.3V) (RSP Time ≈ 800ms)	-	11	-	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}= -15mA, VDD = 5.0V)	VDD - 0.4	-	-	V
Output low voltage	V_{S_VOL}	All output pins except PWMOUT1~4 (I_{OL}= 10mA, VDD = 5.0V)	-	-	0.4	V
	V_{O_VOL}	PWMOUT1~4 output pins (I_{OL}= 25mA, VDD = 5.0V)	-	-	0.4	V
Output sink current(1)	I_{S_SINK}	All output pins except PWMOUT1~4(2) (Active low)	-	-	10	mA
	I_{O_SINK}	PWMOUT1~4 output pins(3) (Active low)	-	-	25	mA
Output source current(1)	I_{O_SRC}	PWMOUT1~4 output pins(3) (Active high)	-	-	-15	mA

Output high leakage current	I_{LOH}		-	-	1	uA
Output low leakage current	I_{LOL}		-	-	-1	uA
RST internal pull-up resister(1)	R_{PU_RST}		-	30	-	kΩ
SDA Internal Pull-up Resister(1)	R_{PU_SDA}		-	30	-	kΩ
SCL Internal Pull-up Resister(1)	R_{PU_SCL}		-	30	-	kΩ

NOTE:

(1) Test condition: VDD = 5V, TA = 25℃ and normal operation mode under default control register value. (Unless otherwise noted)

(2) The SIN1(PWM1) ~ 16 pins can be selected as open-drain NMOS structure (Active Low).

(3) The PWMOUT1 ~ 4 pins can be selected as open-drain NMOS structure (Active Low) or as open drain PMOS structure (Active High).

10.3 RESET CHARACTERISTICS

(TA = -25 to 85°C, V_{DD} = 1.8V to 5.5V)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
RST input high width	t_{RST}		10	-	-	usec
POR(1) Time	t_{POR}		-	-	600	usec

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

10.4 PWM OUTPUT CHARACTERISTICS

(TA = -25 to 85°C, V_{DD} = 1.8V to 5.5V)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
PWM duty steps	N_{DUTY}		-	32	-	Step
PWM maximum duty	D_{MAX}		-	100	-	%
PWM minimum duty	D_{MIN}		-	0	-	%
PWM frequency	f_{PWM}		-	700	-	Hz

10.5 INTERRUPT OUTPUT CHARACTERISTICS

(TA = -25 to 85°C, V_{DD} = 1.8V to 5.5V)

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

10.6 SENSING INPUT CHARACTERISTICS

(TA = -25 to 85°C, V_{DD} = 1.8V 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
external series resistor	R_{EXT_SIN}		-	200	1,000	Ω

10.7 SYSTEM CHARACTERISTICS

(TA = -25 to 85°C, V_{DD} = 1.8V 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}		500	-	-	msec
Touch On response time	t_{ON}	1 channel Touch at all of register default	-	80	-	msec

10.8 I2C INTERFACE TIMING CHARACTERISTICS

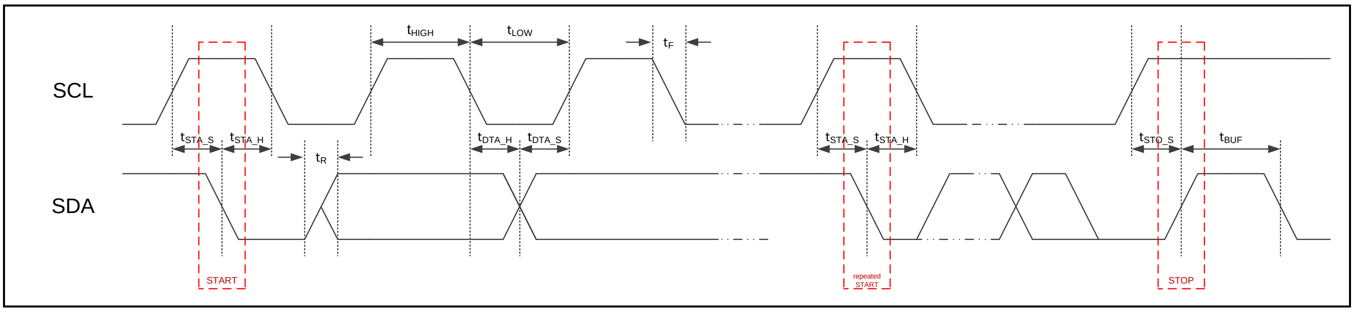
(TA = -25 to 85°C, V_{DD} = 1.8V to 5.5V)

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



10.9 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).

Rating	Symbol	Value	Unit
Human body model (HBM)	V_{HBM}	±8000	V
Machine model (MM)	V_{MM}	±500	V
Charge device model (CDM)	V_{CDM}	±2000	V

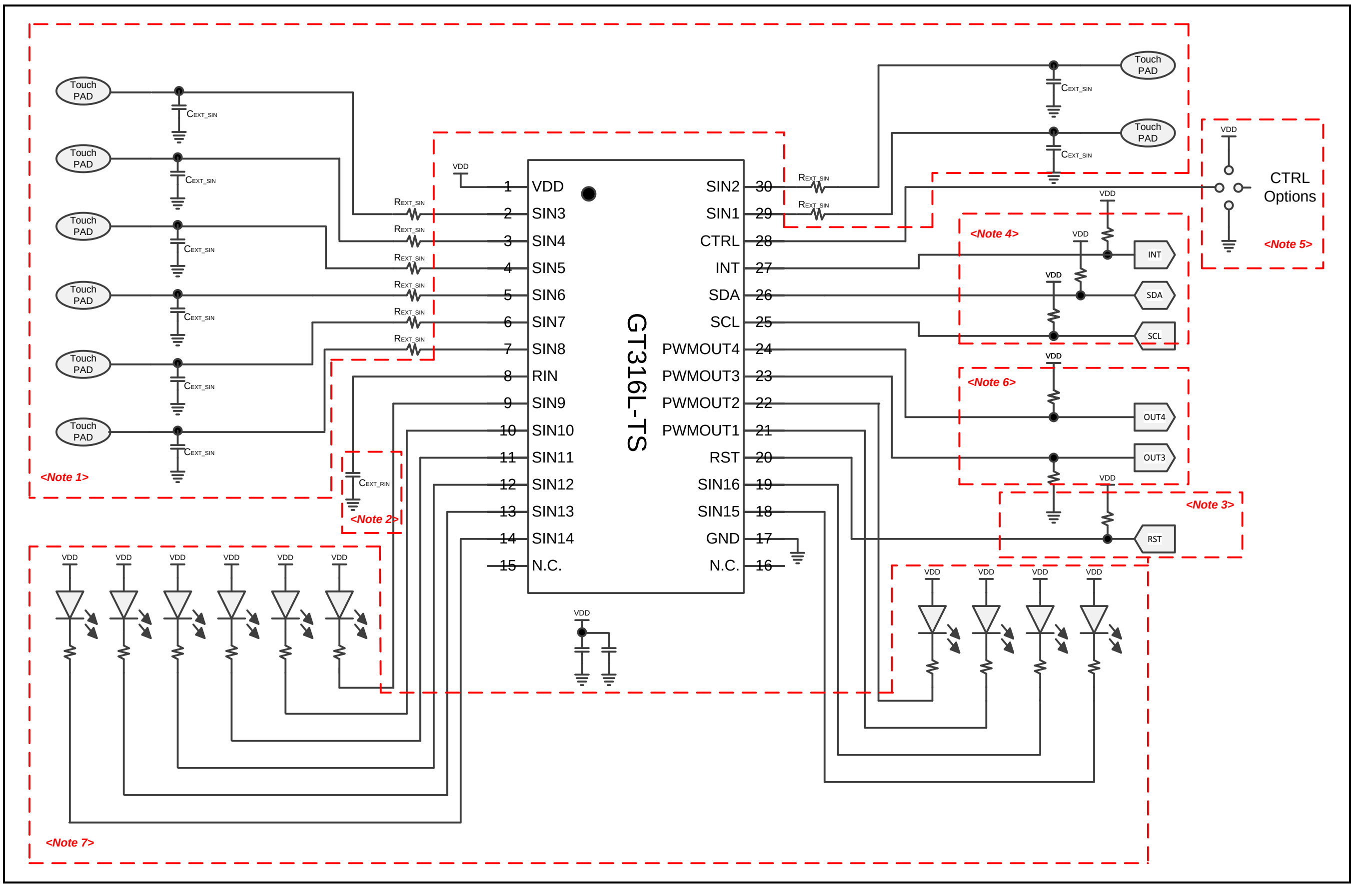
10.10 LATCH-UP CHARACTERISTICS

(TA = 85°C)

Rating	Symbol	Value	Unit
Latch-up current	I_{LATCH}	±200	mA

11. APPLICATION

11.1 EXAMPLE CIRCUIT (TSSOP-30L PACKAGE)



NOTE: R_{EXT_SIN} = 200 Ω, C_{EXT_SIN} = 1pF, C_{EXT_RIN} = 1pF (recommend)

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 GT316L 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.

- **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.
  - 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 pins for better stable operation.
  (Refer to IMPLEMENTATION FOR SIN PINS)
– All touch sensing pads are recommended to be surrounded by GND pattern to reduce noise influence.

- **External Reset <Note3>**
  – The RST pin is for the abrupt reset input signal. The low signal pulse can make system reset. This pin has also an internal pull-up resistor hence the RST pin can be floating.
    (Refer to INTERNAL AND EXTERNAL RESET)

- **I2C Interface Applications <Note4>**
  – 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)

- **CTRL Option Selection <Note5>**
  – Three optional sensitivities are available by CTRL pin connection. Open connection (e.g. N.C.) comes to digital output mode, VDD and GND connection comes to analog input mode.
    (Refer to CTRL OPTION SELECTION)

- **PWMOUT pins for Pulse Output <Note6>**
  - The PWMOUT1~4 pins 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 pins can be controlled by internal control register via I2C.
  - Each PWMOUT1~4 pins has sinking current ability typical 25mA and sourcing current ability typical 15mA on typical temperature condition.

    (Refer to IMPLEMENTATION FOR PWMOUT PINS)

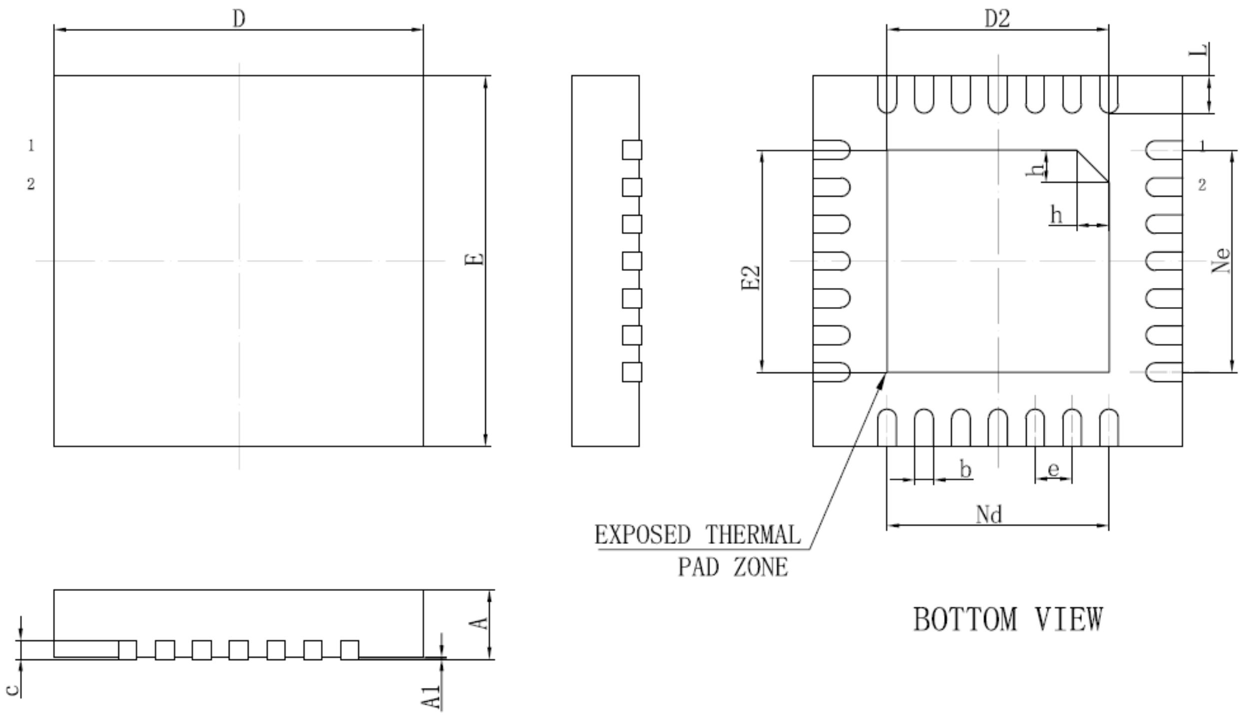
- **LED PWM Drive Applications <Note7>**
  - The maximum 10mA LED drive current can be sunk by a single SIN pin on typical temperature condition. The SIN pins which are used as LED PWM drive pins cannot carry out the role of touch sensing input simultaneously. The 32 steps brightness control is possible.

    (Refer to IMPLEMENTATION FOR LED PWM DRIVE)
  - More high current LED drive is possible by using PWMOUT1~4 pins which sinking current ability typical 25mA on typical temperature condition.

    (Refer to IMPLEMENTATION FOR PWMOUT PINS)
  - To prevent V_{DD} line from being fluctuated by LED drive current a additional capacitor is recommended.

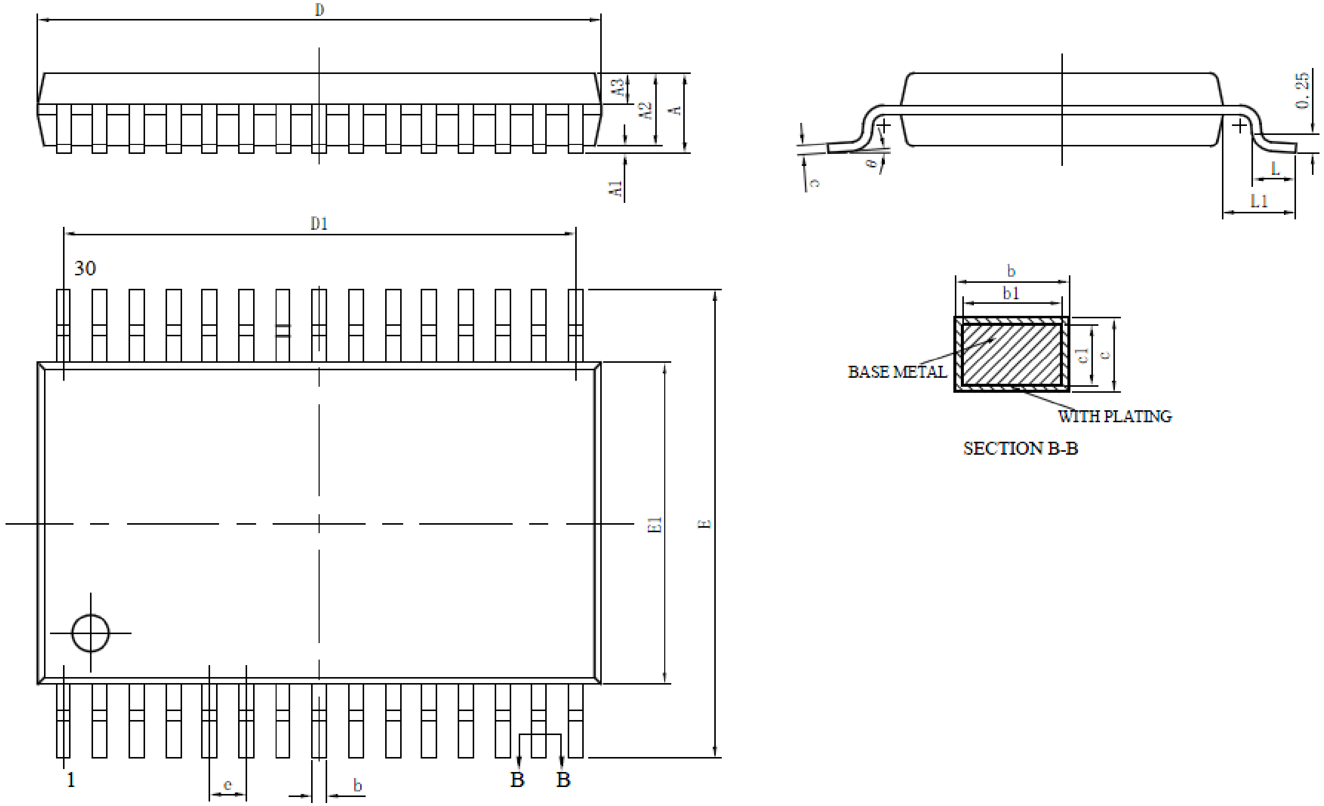
12. PACKAGE DIMENSION

12.1 QFN-28L PACKAGE



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
L/F载体尺寸 (Mil)	110*110		

12.2 TSSOP-30L PACKAGE



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	1.20
A1	0.05	—	0.15
A2	0.80	1.00	1.05
A3	0.39	0.44	0.49
b	0.18	—	0.27
b1	0.17	0.20	0.23
c	0.13	—	0.18
c1	0.12	0.13	0.14
D	7.70	7.80	7.90
D1	6.90	7.00	7.10
E	6.20	6.40	6.60
E1	4.30	4.40	4.50
e	0.50BSC		
L	0.45	0.60	0.75
L1	1.00BSC		
θ	0	—	8°