The Classic of Touch Solution!

GREENCHIP

GreenTouch™ GT108M
Capacitive Touch Sensor

SPECIFICATION

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GENERAL

The GT108M is one of GreenTouch™ capacitive touch sensor series. Especially the GT108M can do capacitance sensing up to 8 channels under GreenTouch™ engine operation. GreenTouch™ engine is an environmental compensation circuit. Thanks to GreenTouch™ engine, the application will be more robust and problem free against EMC, EMI, H/W variation, voltage disturbance, temperature drift, humidity drift and so on.

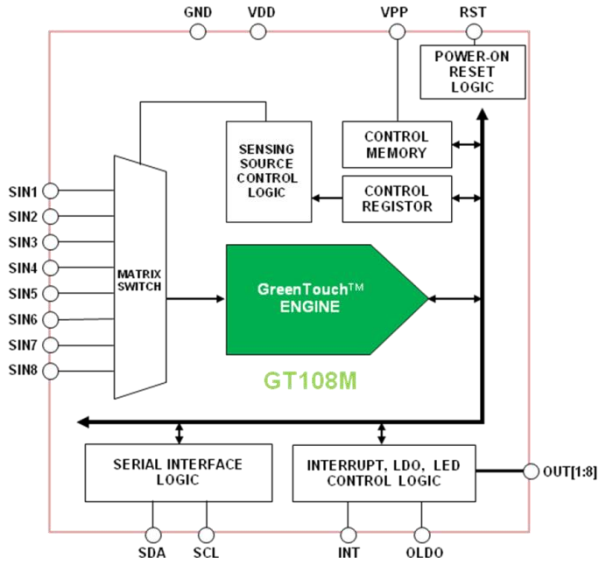
The GT108M offers 8 LED drivers with 16 steps dimming controller. The OUT[1:8] ports are using for PWM output for LED dimming control. It's very economical solution when the LED feedbacks are required because there is no additional material cost for LED control.

The input ports SIN[1:8] are using basically for capacitive touch sensing furthermore these ports can be also used for tact switch input without any external component. For getting the result, the I^2C or 1 to 1 direct output interface will be using same as getting touch sensor output. It might be one of the efficient features when the MCU IO or connector resource is not enough in the application.

FEATURES

- 8 channels cap. Sensing input
- **Embedded GreenTouch™ Engine**
  - Analog compensation circuit
  - Embedded digital noise filter
  - Intelligent sensitivity calibration
- Two type interface support
  - 1 to 1 direct interface mode
  - I^2C interface mode
- Provide interrupt function
- LED driver (16 steps dimming control)
- Available tact switch input interface without external pull-up
- Incredible low power consumption
  - Active mode: 160uA (@3.0V)
  - Normal mode: 130uA (@3.0V)
  - Sleep mode: 2.5uA (@3.0V)
- VDD range: 2.5V to 3.3V Single supply operation
- LDO enable port control for MCU power saving
- IR input protection
  - Available only in 32QFN 5x5 package
- Package type
  - 32QFN 5x5 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
GT108M-QN5	32QFN 5x5
GT108M-UQ4	24UQFN 4x4
GT108M-QSO	24QSOP

REVISION HISTORY

Version	Date	Revision Contents
PRELIMINARY	June 2009	Preliminary release
PRELIMINARY1	July 2009	Add 24UQFN package information
V1.0	August 2009	Release version
V2.1	September 2009	Update for revised register map Add 24QSOP package information
V2.2	October 2009	Update for revised factor default values

Contents

Chapter 1: Pinout Information

This section describes the lists and illustrates the GT108M of GreenTouch™ family ports as well as pinout configuration. The GT108M device is available in the following packages, all of which are shown on the following pages.

1.1 32 QFN Pinout

Port Number	Type	Name	Description
1	-	N.C.	No Connection
2	-	N.C.	No Connection
3	AI	SIN 5	Channel 5: Capacitance Sensing or Tact switch Input port
4	AI	SIN 6	Channel 6: Capacitance Sensing or Tact switch Input port
5	AI	SIN 7	Channel 7: Capacitance Sensing or Tact switch Input port
6	AI	SIN 8	Channel 8: Capacitance Sensing or Tact switch Input port
7	DI	I_IR	IR Noise Protection Input port
8	DO	OLDO	LDO Control Output port
9	-	N.C.	No Connection
10	DI	SCL	I^2C Serial Clock
11	-	N.C.	No Connection
12	DIO	SDA	I^2C Serial Data
13	GND	GND	Ground Connection
14	PWR	VPP	Supply Voltage for MTP Programming
15	-	N.C.	No Connection
16	DI	RST	Reset Control Port (High active)
17	DO	OUT 1	1 to 1 Direct Output for SIN 1 PWM Output for LED Dimming Control
18	DO	OUT 2	1 to 1 Direct Output for SIN 2 PWM Output for LED Dimming Control
19	DO	OUT 3	1 to 1 Direct Output for SIN 3 PWM Output for LED Dimming Control
20	DO	OUT 4	1 to 1 Direct Output for SIN 4 PWM Output for LED Dimming Control
21	-	N.C.	No Connection
22	DO	OUT 5	1 to 1 Direct Output for SIN 5 PWM Output for LED Dimming Control
23	DO	OUT 6	1 to 1 Direct Output for SIN 6 PWM Output for LED Dimming Control
24	DO	OUT 7	1 to 1 Direct Output for SIN 7 PWM Output for LED Dimming Control
25	DO	OUT 8	1 to 1 Direct Output for SIN 8 PWM Output for LED Dimming Control
26	-	N.C.	No Connection
27	DO	INT	Interrupt Output
28	PWR	VDD	Supply Voltage
29	AI	SIN 1	Channel 1: Capacitance Sensing or Tact switch Input port
30	AI	SIN 2	Channel 2: Capacitance Sensing or Tact switch Input port
31	AI	SIN 3	Channel 3: Capacitance Sensing or Tact switch Input port
32	AI	SIN 4	Channel 4: Capacitance Sensing or Tact switch Input port

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

1.2 24 UQFN Pinout

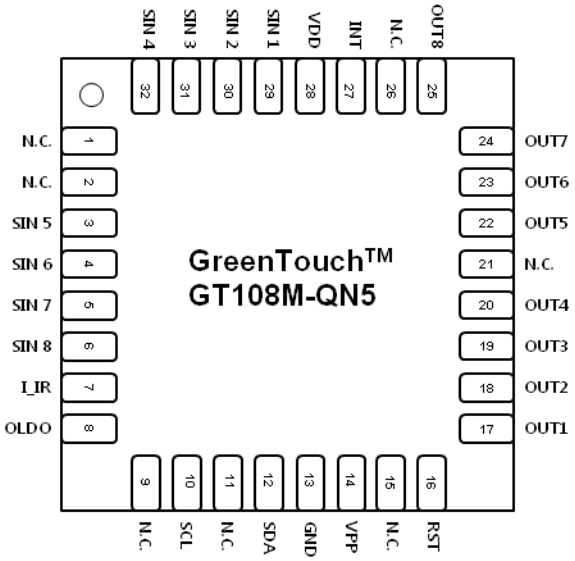
Port Number	Type	Name	Description
1	AI	SIN 4	Channel 4: Capacitance Sensing or Tact switch Input port
2	AI	SIN 5	Channel 5: Capacitance Sensing or Tact switch Input port
3	AI	SIN 6	Channel 6: Capacitance Sensing or Tact switch Input port
4	AI	SIN 7	Channel 7: Capacitance Sensing or Tact switch Input port
5	AI	SIN 8	Channel 8: Capacitance Sensing or Tact switch Input port
6	DO	OLDO	LDO Control Output port
7	DI	SCL	I^2C Serial Clock
8	DIO	SDA	I^2C Serial Data
9	GND	GND	Ground Connection
10	PWR	VPP	Supply Voltage for MTP Programming
11	DI	RESET	Reset Control Port (High active)
12	DO	OUT 1	1 to 1 Direct Output for SIN 1 PWM Output for LED Dimming Control
13	DO	OUT 2	1 to 1 Direct Output for SIN 2 PWM Output for LED Dimming Control
14	DO	OUT 3	1 to 1 Direct Output for SIN 3 PWM Output for LED Dimming Control
15	DO	OUT 4	1 to 1 Direct Output for SIN 4 PWM Output for LED Dimming Control
16	DO	OUT 5	1 to 1 Direct Output for SIN 5 PWM Output for LED Dimming Control
17	DO	OUT 6	1 to 1 Direct Output for SIN 6 PWM Output for LED Dimming Control
18	DO	OUT 7	1 to 1 Direct Output for SIN 7 PWM Output for LED Dimming Control
19	DO	OUT 8	1 to 1 Direct Output for SIN 8 PWM Output for LED Dimming Control
20	DO	INT	Interrupt Output
21	PWR	VDD	Supply Voltage
22	AI	SIN 1	Channel 1: Capacitance Sensing or Tact switch Input port
23	AI	SIN 2	Channel 2: Capacitance Sensing or Tact switch Input port
24	AI	SIN 3	Channel 3: Capacitance Sensing or Tact switch Input port

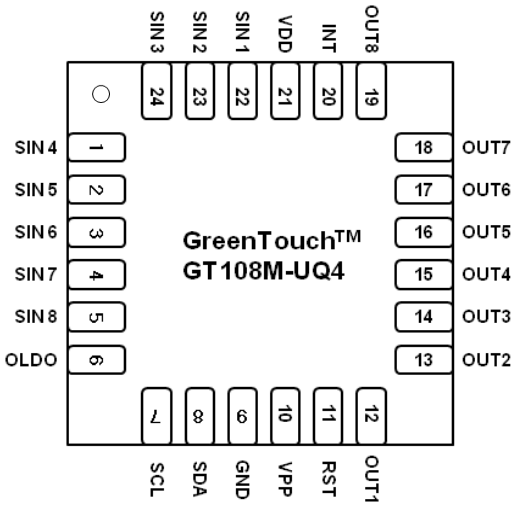
* DI: Digital Input, DO: Digital Output, DIO: Digital Input and Output, AI: Analog Input, PWR: POWER

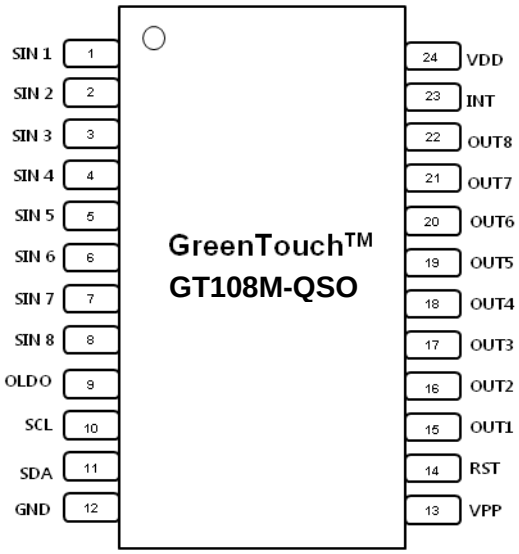
1.3 24 QSOP Pinout

Port Number	Type	Name	Description
1	AI	SIN 1	Channel 1: Capacitance Sensing or Tact switch Input port
2	AI	SIN 2	Channel 2: Capacitance Sensing or Tact switch Input port
3	AI	SIN 3	Channel 3: Capacitance Sensing or Tact switch Input port
4	AI	SIN 4	Channel 4: Capacitance Sensing or Tact switch Input port
5	AI	SIN 5	Channel 5: Capacitance Sensing or Tact switch Input port
6	AI	SIN 6	Channel 6: Capacitance Sensing or Tact switch Input port
7	AI	SIN 7	Channel 7: Capacitance Sensing or Tact switch Input port
8	AI	SIN 8	Channel 8: Capacitance Sensing or Tact switch Input port
9	DO	OLDO	LDO Control Output port
10	DI	SCL	I^2C Serial Clock
11	DIO	SDA	I^2C Serial Data
12	GND	GND	Ground Connection
13	PWR	VPP	Supply Voltage for MTP Programming
14	DI	RESET	Reset Control Port (High active)
15	DO	OUT 1	1 to 1 Direct Output for SIN 1 PWM Output for LED Dimming Control
16	DO	OUT 2	1 to 1 Direct Output for SIN 2 PWM Output for LED Dimming Control
17	DO	OUT 3	1 to 1 Direct Output for SIN 3 PWM Output for LED Dimming Control
18	DO	OUT 4	1 to 1 Direct Output for SIN 4 PWM Output for LED Dimming Control
19	DO	OUT 5	1 to 1 Direct Output for SIN 5 PWM Output for LED Dimming Control
20	DO	OUT 6	1 to 1 Direct Output for SIN 6 PWM Output for LED Dimming Control
21	DO	OUT 7	1 to 1 Direct Output for SIN 7 PWM Output for LED Dimming Control
22	DO	OUT 8	1 to 1 Direct Output for SIN 8 PWM Output for LED Dimming Control
23	DO	INT	Interrupt Output
24	PWR	VDD	Supply Voltage

* DI: Digital Input, DO: Digital Output, DIO: Digital Input and Output, AI: Analog Input, 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}	-	5.0	V	
Supply voltage range(1)	V_{DD_RNG}	2.0	4.0	V	
Voltage on any input port	V_{IN_MAX}	-	V_{DD}+0.3	V	
Maximum current into any port	I_{MIO}	-200	200	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) The real valid power supply voltage range consider supply ripple. Above range cannot be used as target supply voltage range.

2-2 DC & Operating Characteristics

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Power supply and current consumption						
Target supply voltage	V_{DD}		2.5	3.0	3.3	V
Supply voltage for MTP programming	V_{PP}	Max. 6.5seconds	6.2	6.5	6.75	V
Max VPP power maintain time	T_{VPP_MAX}	V_{PP} = 6.5V	-	6.5	-	sec
Current Consumption	I_{DD}	Slow clock operation(3)	-	90	150	μA
		Normal clock operation(3)	-	130	200	
		Fast clock operation(3)	-	180	220	
Sleep mode current consumption	I_{DD_SL}	Sleep mode	-	2.5	4	μA
Internal reset voltage(2)	V_{DD_RST}	T_A = 25℃	-	1.4	1.8	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 : I_IR, SCL, SDA)	R_{PU}	Pull-up resistor enable	-	40	-	kΩ
Internal pull-down resistor (Port : RST)	R_{PD}		-	40	-	kΩ
Output sink current (LED drivable)	I_{SINK}	Active low output(4)	-	15	-	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 source current	I_{SRC}	Active high output(4)	-	4	-	mA
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} = 3.0V, TA = 25℃ and normal operation mode (Unless otherwise noted)
(2) The GT108M 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 45msec sensing period 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}		-	15	-	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	-	600k	-	bps
Minimum detectable input capacitance variation	ΔC_{S_MIN}		0.1	-	-	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
Tact input pull-up current (SIN1~SIN8)	I_{T_PU}	Tact input mode	-	5	-	μA
Sense hold time for IR	T_{H_IR}		-	140	-	msec

2-3 ESD & Latch-Up Characteristics

2-3.1 ESD Characteristics

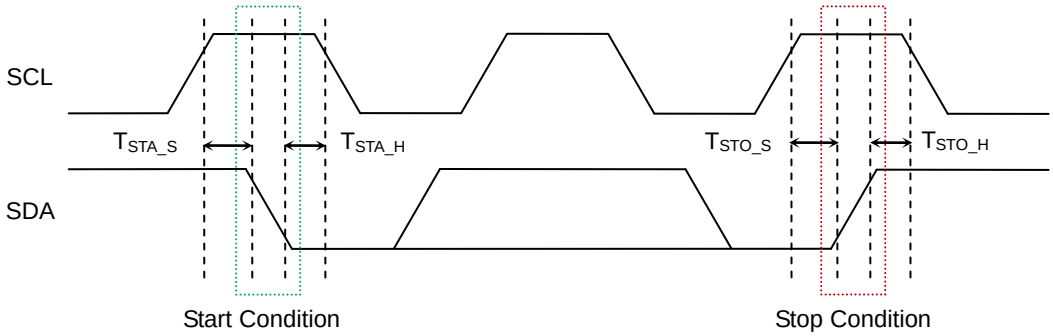
Mode	Polarity	Max	Reference
H.B.M	POSITIVE / NEGATIVE	Over 8000V	VDD
			VSS
			P to P
M.M	POSITIVE / NEGATIVE	1200V	VDD
		1000V	VSS
		700V	P to P
C.D.M	POSITIVE / NEGATIVE	800V	DIRECT

2-3.2 Latch-Up Characteristics

Mode	Polarity	Max	Test Step
I Test	POSITIVE	200mA	25mA
	NEGATIVE	-200mA	
V supply over 3.3V	POSITIVE	~ 5.0V	0.5V

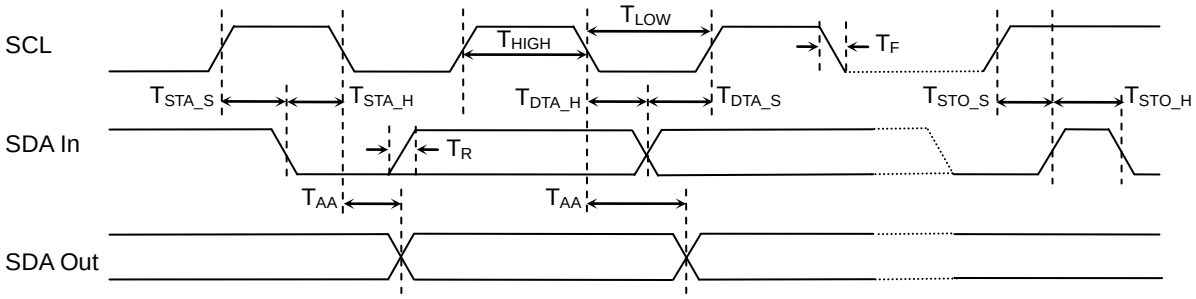
2-4 I²C Interface Timing Characteristics

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	

2-5 MTP Program/Read Conditions(1)

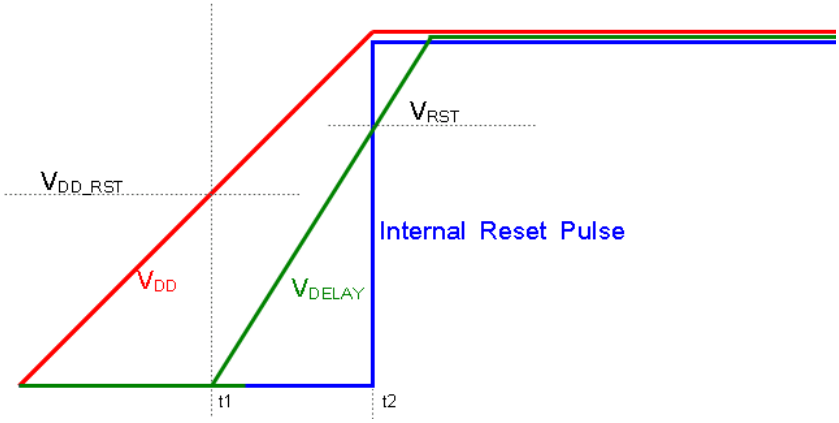
Operating Mode	Power Port	Min	Typical	Max	Unit
Read Mode	VDD	2.5	3.0	3.3	V
	VPP(2)	Open or VDD			
	VSS	0	0	0	V
PGM Mode	VDD	2.5	3.0	3.3	V
	VPP	6.25	6.5	6.75	V
	VSS	0	0	0	V

(1) Power supply voltage beyond above range is not guaranteed.
Power/Ground bouncing beyond DC operating range might cause invalid data output.
(2) In read mode, VPP port must be connected VDD or floating. Connection to GND may cause current problems.

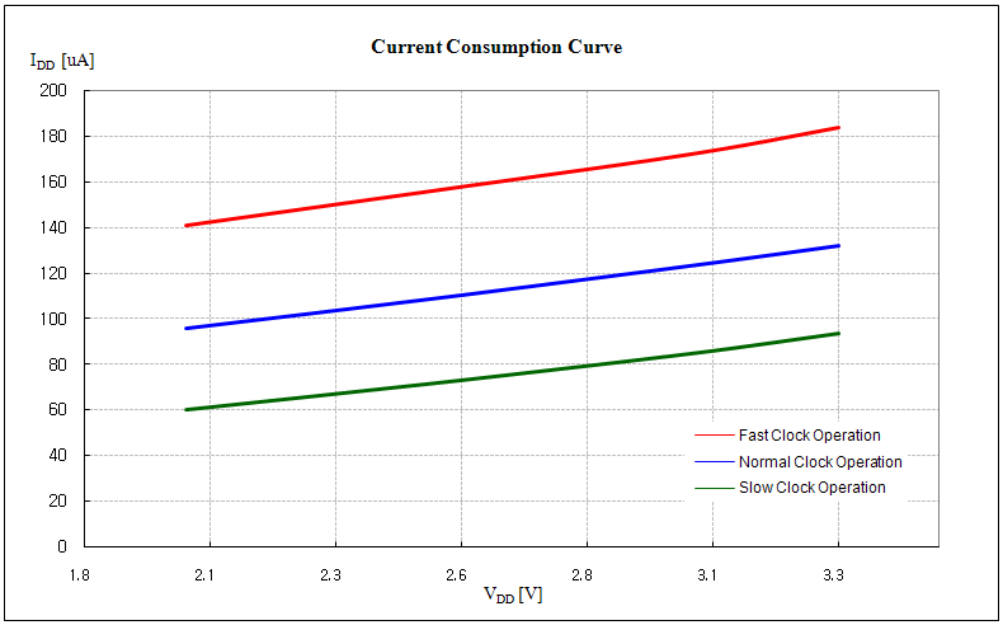
Chapter 3: Functional Description

3-1 Reset and Operation Modes

The GT108M has both internal and external reset operations. The internal reset operation is used for initial power reset and the external reset operation is done by RST. High pulse signal by RST is for an abrupt reset which is required for intensive system reset. The RST port might be floating and no more external reset components are required when the external reset is not in use. The internal power reset sequence is represented as below.



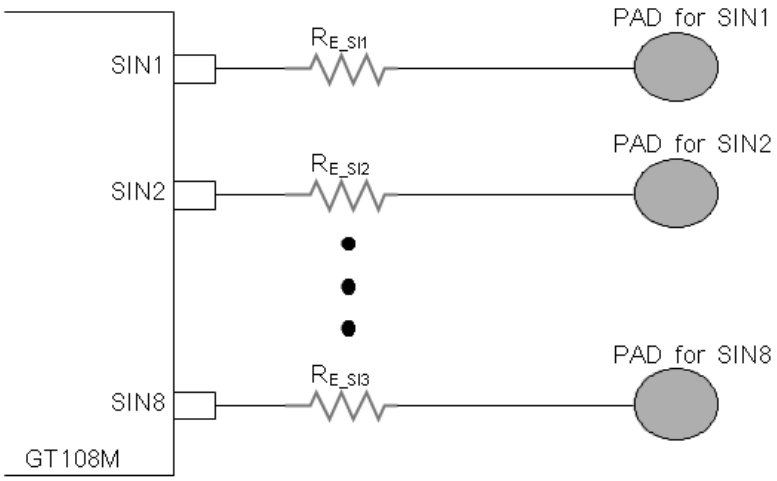
The internal V_{DELAY} voltage starts to rise when V_{DD} come up to V_{DD_RST} level. The internal reset pulse is maintained as low between t1 and t2. During this low pulse period, the internal power reset operation is finished. The external reset by RST port is activated in high input pulse period. The intensive system reset can be easily obtained by this high pulse input to the RST port. More than 10usec high pulse period is required for proper reset. The RST port has an internal pull-down resistor with 40kΩ. Therefore, the RST port might be floating during normal operation time.
The three clock operations could be selected by SYS_CLK_SEL register. 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 in normal clock operation. The typical current consumption curves on each operation mode of GT108M are represented in accordance with V_{DD} voltage as below.



Typical Current consumption curve of GT108M (At 40msec sensing period register setting condition)

3-2 Capacitance Variation Sensing (SIN1~SIN8)

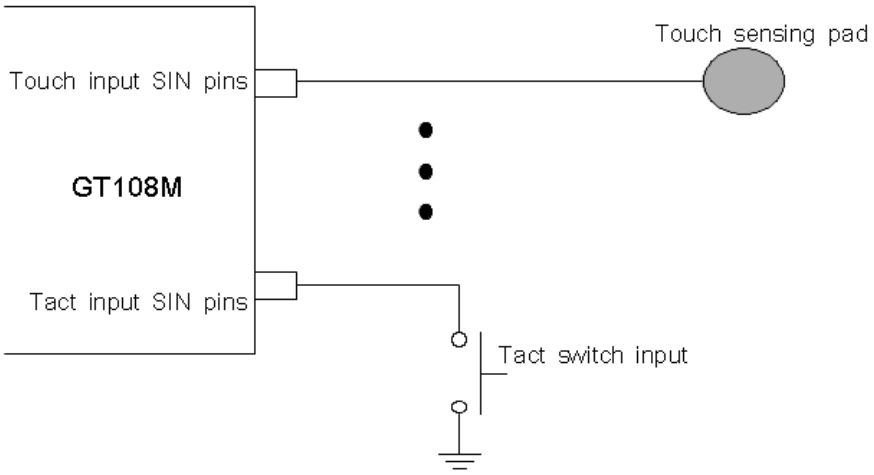
The SIN ports from SIN1 to SIN8 are typically used for detecting capacitance variation sensing. Moreover, the SIN ports could be used with tact switch without any external components. But the SIN ports can't be used for both capacitance variations sensing function and tact switch simultaneously. (*Refer to 3-3 in this chapter.*)
The GT108M has various intelligent sensing properties to detect correct touch free from error caused by various environmental effects. These advanced sensing methods will help faultless touch key systems under the worst conditions. The sensitivity selection is available within 64 steps and there will be no difficulty to satisfy systems require sensitivity. The internal intelligent sensitivity calibration removes sensitivity rolling caused by system noise, circuit deviation, and circumstantial drift. The sensitivity calibration is done independently on each channel. The GT108M 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 environment becomes very deteriorative. And another additional function which ignores a non-intention short touch is possible by changing sensing period. The longer sensing period will need longer touch input to get valid touch detection.
The sensitivity, calibration, noise filter gain control, and sensing period control are available with dedicated control registers. For more detail information, please refer to *Chapter 4: Register Description*.
The GT108M SIN ports have an internal series resistor for ESD protection. But in any case, if the additional external series resistors are required then it should be less than 1kΩ and the location of resister is recommended as closer to the SIN ports.



Implementation for SIN ports with external components and sensing pad.

3-3 Tact Switch Input (SIN1~SIN8)

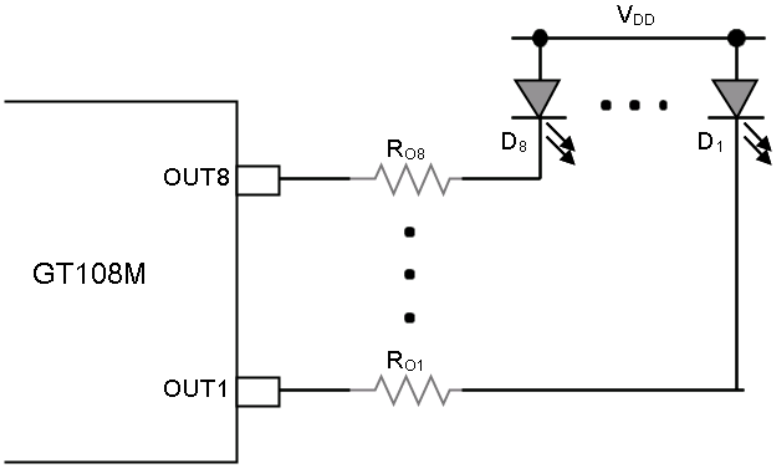
The SIN ports can also be used with tact switch. The mode for tact switch input is selected by TACT_CH_EN register (Address: 0x06). The SIN ports with tact switch input should be connected to GND through tact switch as below implementation figure. The internal pull-up current of tact switch input channel is self activated hence there is no need to use external pull-up resistor. The typical value of internal pull-up current is 5uA. The benefits of this function are that it does not require any additional pull-up resistors and connection port to MCU for tact switch implementation. The outputs can be obtained by 1 to 1 direct output ports or by reading output data register using I^2C interface.



Implementation of SIN ports for tact switch inputs and touch sensing inputs

3-4 LED PWM Drive (OUT1~OUT8)

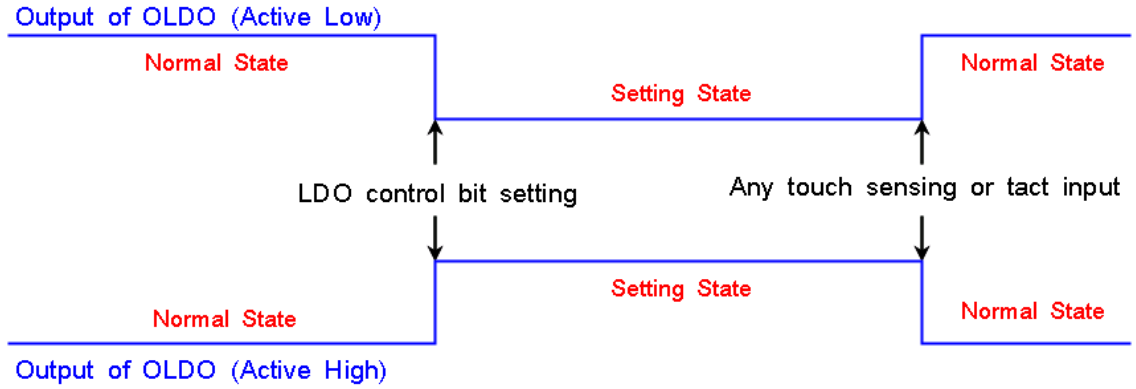
The LED PWM drive is available by using output ports from OUT1 to OUT8. The brightness of LED can be controlled by 16 steps PWM duty with PWM control register. (*For more detail information, please refer to chapter 4: Register Description.*) The maximum LED brightness is on 88% duty and the minimum is on 0% duty. The maximum sink current is 15mA on each port in typical condition. The OUT ports can't be used for touch sensing output when it is used for driving LED. The basic implementation for LED PWM drive is shown in below figure.



Implementation for LED PWM drive

3-5 LDO On-Off Control (OLDO)

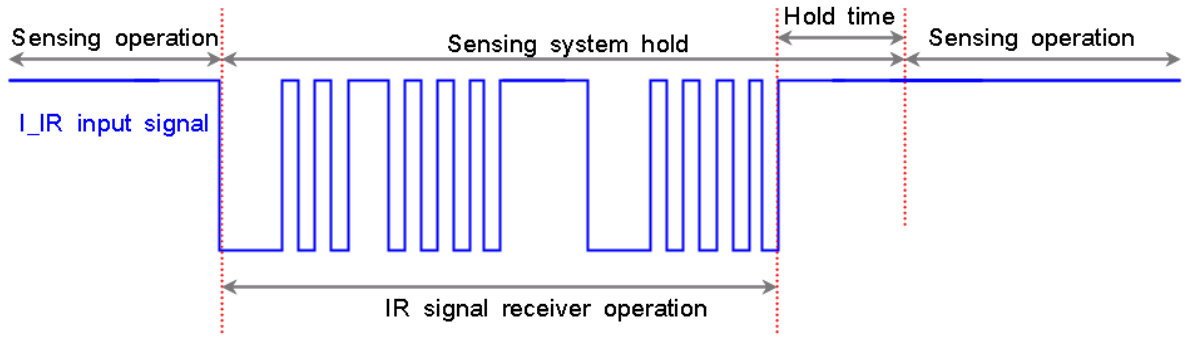
The OLDO output port is changed from LDO-off to LDO-on state by detecting a capacitive touch or tact switch when the LDO_CTL bit is set. And the polarity of LDO-on and LDO-off state is decided by LDO_POL bit. This function is useful for saving system power consumption through shutting-down LDO (Low Drop Output Regulator). The OLDO port has open drain NMOS or PMOS structure therefore the external pull-up resistor or pull-down resistor is required.



OLDO output signal setting/recover and signal polarity

3-6 IR Input Protection (I_IR)

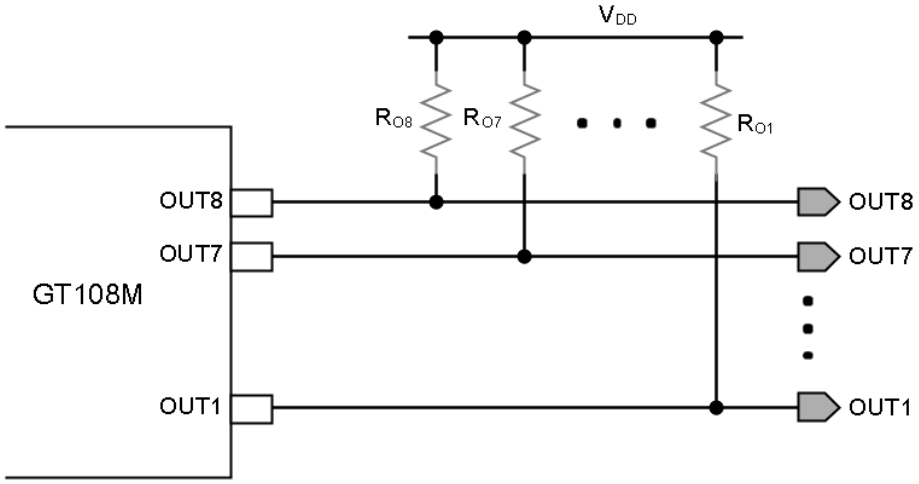
The GT108M can detect a falling edge on the input signal that is coming through I_IR port when IR_EN bit is set. All the operations of GT108M will enter into a holding status when the input signal on the I_IR port becomes a falling edge. This function prevents from IR interference caused by touch sensing clock or system clock noise. The GT108M will wait a rising edge of input signal during it is in holding status. The hold time is adopted from a rising edge and the GT108M will enter into a holding status again if the signal is coming again with a falling edge within hold time. The hold time can be selected by IR_HOLD_TIME bit. It'll be 70msec or 140msec. The GT108M will start again normal operation if the time is over than the hold time from a rising edge on I_IR input signal.



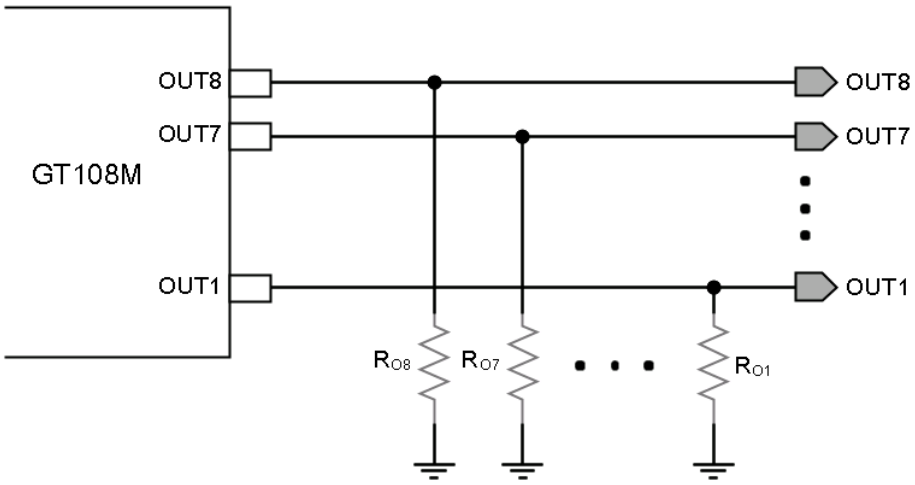
Sensing system hold interval and Hold time

3-7 Data Output Interfaces (OUT1~OUT8)

The GT108M has two different types of output interface methods. The one is a 1 to 1 direct output which is using the output ports from OUT1 to OUT8 and the other one is I^2C interface. This two interface methods are able to operate simultaneously. The 1 to 1 direct output ports OUTx corresponds to SINx respectively. These 1 to 1 output ports have an active low or high function. The output active polarity could be changed with DIR_OUT_POL bit and all OUTx ports will have same active polarity. The OUTx ports will have open drain NMOS structure and it needs pull-up resistors when the OUTx ports are set by active low mode. It will have open drain PMOS structure and it needs pull-down resistors in case of 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 below figures.



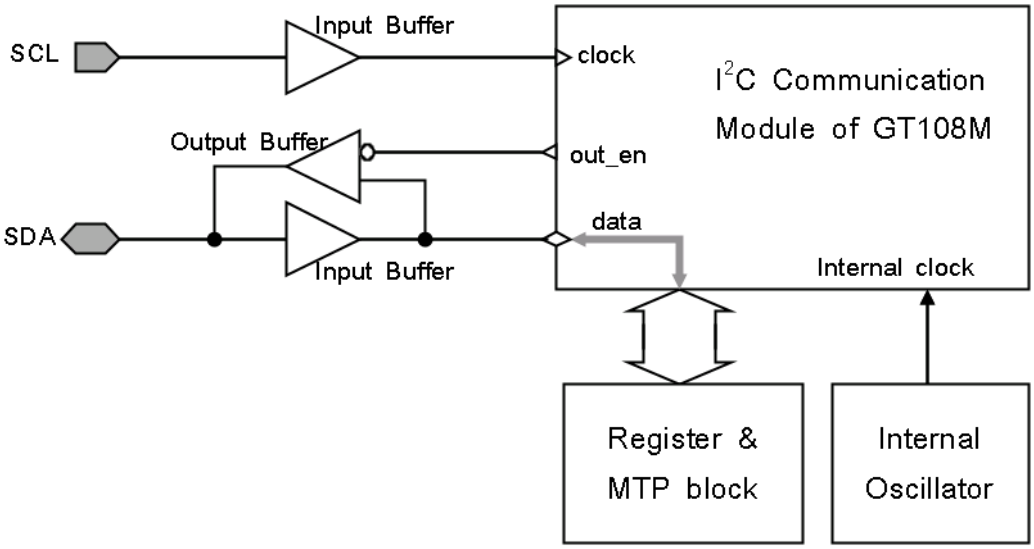
Implementation of OUTx ports used as active low mode



Implementation of OUTx ports used as active high mode

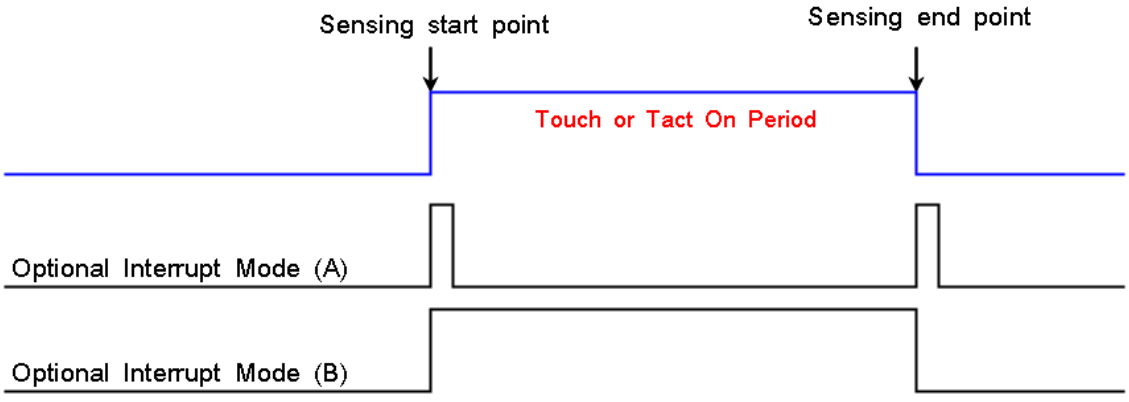
3-8 I²C Interface (SCL, SDA, INT)

The SCL and SDA ports are used for I²C interface. The SCL is I²C clock input port and the SDA is I²C data input/output port. These ports have an internal optional pull-up resistor which is about 40kΩ to prevent open gate leakage current in input mode. Therefore it can be floating when the I²C interface isn't in use. The internal optional pull-up resistor is enabled by default. For high speed communication, the SDA port needs lower value resistor which is connected to V_{DD} to reduce pulse rising delay. The internal simple block structure of SCL and SDA is shown below. The GT108M has an internal I²C clock oscillator and it is selectable by SCL_CLK_SEL register. The maximum data-rate is about 600Kbps. For a timing of I²C interface, please refer to the section 2-4. The program and read operations for MTP are also using the I²C interface.



Internal I²C interface structure of GT108M

The GT108M provides an interrupt (INT) function to reduce a communication load between MCU and GT108M. The INT will indicate a point of time that the data of output register changes and MCU needs to read it. The interrupt function can operate in two optional modes with INT_MODE bit and select the output polarity (High or Low) with INT_OUT_POL bit. The INT port can have an open drain NMOS or PMOS hence a pull-up or pull-down resistor must be required. Two optional interrupt mode operations are shown as below figure. In one mode (A), a short interrupt pulse is generated at every output register changing points. In the other mode (B), an interrupt pulse maintains high or low (depends on INT_OUT_POL) during at least one of eight channels' touch or tact switch input is coming on the output register.



Optional interrupt modes of high interrupt pulse polarity selection case

3-9 Initial Operation Values Changing (MTP ROM Programming)

In case of not using I^2C application, the default value of registers could be changed by using MTP ROM contents. The MTP ROM allows rewriting the contents up to six times. The GT108M loads all contents from MTP ROM to corresponding with registers during reset period. For more detail information about memory programming and read condition, please refer to 2-5 section. For programming to MTP, typical 6.5V power is required through VPP port. The maximum tolerable maintain time with VPP power for MTP programming is about 6.5 second. In the application, the VPP port must be connected to either VDD or floating. The connection to GND for VPP is forbidden in any 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 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.	Default	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
01H	0xFF	TOUCH_CH_EN							
02H	0xB8	CHIP_ID							RESERVE
04H	0x51	RESERVE					SINGLE_MODE	RESERVE	
05H	0x00	PWM_CH_EN							
06H	0x00	TACT_CH_EN							
2AH	0x--	TOUCH_OUTPUT							
38H	0x14	RESERVE	SINGLE_MODE	RESERVE					
39H	0xF1	SCL_PU_EN	SDA_PU_EN	IMP_SEL	SCL_CLK_SEL			SYS_CLK_SEL	
3AH	0x01	RESERVE	IR_HOLD_TIME	IR_EN	INT_MODE	INT_OUT_POL	INT_EN	DIR_OUT_POL	DIR_EN
3BH	0x00	LED_MODE	PWM_EN	LDO_POL	LDO_EN	SLEEP	RESERVE		SOFT_RESET
3CH	0x09	RESERVE			ACT_TIME_CTRL		SENSING_PERIOD		
3DH	0x16	RESERVE		EXPIRE_TIME				EXP_EN	EXP_MODE
3EH	0x35	RESERVE	NOISE_FILTER_GAIN			UP_SET		DOWN_SET	
3FH	0x13	LDO_SET	RESERVE						
42H	0x07	RESERVE		SENSITIVITY 1					
43H	0x07	RESERVE		SENSITIVITY 2					
44H	0x07	RESERVE		SENSITIVITY 3					
45H	0x07	RESERVE		SENSITIVITY 4					

Addr.	Default	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
46H	0x07	RESERVE		SENSITIVITY 5					
47H	0x07	RESERVE		SENSITIVITY 6					
48H	0x07	RESERVE		SENSITIVITY 7					
49H	0x07	RESERVE		SENSITIVITY 8					
4AH	0x00	PWM_DATA 2				PWM_DATA 1			
4BH	0x00	PWM_DATA 4				PWM_DATA 3			
4CH	0x00	PWM_DATA 6				PWM_DATA 5			
4DH	0x00	PWM_DATA 8				PWM_DATA 7			

4-3 Register Description

4-2-1 Touch Channel Enable Registers - R/W

☞ *Description:* The GT108M supports eight each touch channel enable register.

01H	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
01H	7-0	FFH	TOUCH_CH_EN	1~8 each touch channel enable

4-2-2 Chip ID Control Registers - R/W

☞ *Description:* The GT108M chip ID

02H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	CHIP_ID							RESERVE
Default	1	0	1	1	1	0	0	0

Addr.	Bits	Default	Name	Description
02H	7-1	5CH	CHIP_ID	GT108M chip ID
	0	0B	RESERVE	

4-2-3 Single and Multi-touch Control Registers - R/W

☞ *Description:* The GT108M single/multi-touch control

04H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	RESERVE					SINGLE_MODE	RESERVE	
Default	0	1	0	1	0	0	0	1

Addr.	Bits	Default	Name	Description
04H	7-3	01010B	RESERVE	
	2	0B	SINGLE_MODE	GT108M single/multi touch mode 0 : single 1 : multi
	1-0	01B	RESERVE	

4-2-4 PWM Channel Enable Registers - R/W

☞ *Description:* The GT108M 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

4-2-5 Tact Channel Enable Registers - R/W

☞ *Description:* The GT108M supports eight each T/S(Tact Switch) detection logic.

06H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	TACT_CH_EN							
Default	0	0	0	0	0	0	0	0

Addr.	Bits	Default	Name	Description
06H	7-0	00H	TACT_CH_EN	1~8 each TACT detection enable The opposite touch channel is disabled

4-2-6 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

4-2-7 Single and Multi-touch Control Registers - R/W

☞ *Description:* The GT108M single/multi-touch control

38H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	RESERVE	SINGLE_MODE	RESERVE					
Default	0	0	0	1	0	1	0	0

Addr.	Bits	Default	Name	Description
38H	7	0B	RESERVE	
	6	0B	SINGLE_MODE	GT108M single/multi touch mode 0 : single 1 : multi
	5-0	010100B	RESERVE	

4-2-8 General1 Control Registers - R/W

☞ *Description:* The GT108M supports control registers for meeting various user applications.

39H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	SCL_PU_EN	SDA_PU_EN	IMP_SEL	SCL_CLK_SEL			SYS_CLK_SEL	
Default	1	1	1	1	0	0	0	1

Addr.	Bits	Default	Name	Description
39H	7	1B	SCL_PU_EN	SCL pull-up enable
	6	1B	SDA_PU_EN	SDA pull-up enable
	5	1B	IMP_SEL	Impedance select
	4-2	100B	SCL_CLK_SEL	I^2C clock select 000: 4MHz 100: 2.3MHz 110: 1MHz 111: 0.5MHz
	1-0	01B	SYS_CLK_SEL	System clock select 00: 70KHz 01:100KHz 11: 140KHz

4-2-9 General2 Control Registers - R/W

☞ *Description:* The GT108M supports control registers for meeting various user applications.

3AH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	RESERVE	IR_HOLD_TIME	IR_EN	INT_MODE	INT_OUT_POL	INT_EN	DIR_OUT_POL	DIR_EN
Default	0	0	0	0	0	0	0	1

Addr.	Bits	Default	Name	Description
3AH	7	0B	RESERVE	
	6	0B	IR_HOLD_TIME	IR time select 0 : Touch operation restart after 160ms with IR finish 1 : Touch operation restart after 80ms with IR finish
	5	0B	IR_EN	IR detection enable 0: IR detection disable 1: IR detection enable
	4	0B	INT_MODE	Interrupt operation mode 0 : toggle mode (touch on/off) 1 : level mode
	3	0B	INT_OUT_POL	Interrupt polarity select 0: Low active 1: High active
	2	0B	INT_EN	Interrupt enable 0: Interrupt disable 1: Interrupt enable
	0	0B	DIR_OUT_POL	Direct output polarity 0: Low active 1: High active
	1	1B	DIR_EN	Direct output enable 0: Direct output disable 1: Direct output enable

4-2-10 General3 Control Registers - R/W

☞ *Description:* The GT108M supports control registers for meeting various user applications.

3BH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	LED_MODE	PWM_EN	LDO_ POL	LDO_EN	SLEEP	RESERVE		SOFT_RESET
Default	0	0	0	0	0	-	-	0

Addr.	Bits	Default	Name	Description
3BH	7	0B	LED_MODE	LED mode 0 : PWM operation enable if IR input 1 : PWM operation disable in IR input
	6	0B	PWM_EN	PWM enable 0: PWM disable 1: PWM enable
	5	0B	LDO_ POL	LDO polarity select 0: Low active 1: High active
	4	0B	LDO_EN	LDO enable 0: LDO disable 1: LDO enable
	3	0B	SLEEP_MODE	Sleep Mode 0 : Sleep disable 1 : Sleep enable
	2-1	--B	RESERVE	
	0	0B	SOFT_RESET	Software reset 0: Reset disable 1: Reset enable

4-2-11 General4 Control Registers - R/W

☞ *Description:* The GT108M supports control registers for meeting various user applications.

3CH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	RESERVE			ACT_TIME_CTRL		SENSING_PERIOD		
Default	0	0	0	0	1	0	0	1

Addr.	Bits	Default	Name	Description
3CH	7-5	---B	RESERVE	
	4-3	01B	ACT_TIME_CTRL	Active time select 00: 0.8 sec 01: 1.0 sec 10: 1.2 sec 01: 1.5 sec
	2-0	001B	SENSING_PERIOD	Sensing period select 000: 50ms(@Normal Clock Operation) 001: 40ms(@Normal Clock Operation) 010: 25ms(@Normal Clock Operation) 011: 22ms(@Normal Clock Operation) 100: 20ms(@Normal Clock Operation) 101: 18ms(@Normal Clock Operation) 110: 15ms(@Normal Clock Operation) 111: 10ms(@Normal Clock Operation)

4-2-12 General5 Control Registers - R/W

☞ *Description:* The GT108M supports control registers for meeting various user applications.

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

Addr.	Bits	Default	Name	Description
3DH	7-6	--B	RESERVE	
	5-2	0101B	EXP_TIME	Time = min (EXP_TIME * 4 + 2 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

4-2-13 General6 Control Registers - R/W

☞ *Description:* The GT108M supports control registers for meeting various user applications.

3EH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	RESERVE	NOISE_FILTER_GAIN			UP_SET		DOWN_SET	
Default	-	0	1	1	0	1	0	1

Addr.	Bits	Default	Name	Description
3EH	7	-B	RESERVE	
	6-4	011B	NOISE_FILTER_GAIN	Noise filer gain control [000] minimum gain ~ [101] maximum gain
	3-2	01B	UP_SET	Calibration up count 00: 1 01: 2 10: 3 11: 4
	1-0	01B	DOWN_SET	Calibration down count 00: 1 01: 2 10: 3 11: 4

4-2-14 General7 Control Registers - R/W

☞ *Description:* The GT108M supports control registers for meeting various user applications.

3FH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Name	LDO_SET	RESERVE						
Default	0	0	0	1	0	0	1	1

Addr.	Bits	Default	Name	Description
3FH	7	0B	LDO_SET	LDO user set Automatic clear with touch detection
	6-0	0B	RESERVE	

4-2-15 Sensitivity Control Registers - R/W

☞ *Description:* The GT108M can be controlled independently for getting the optimal sensitivity on each channel.

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

Addr.	Bits	Default	Name	Description
42H	7-6	00B	RESERVE	
	5-0	07H	SENSITIVITY 1	Channel 1 touch sensitivity
43H	7-6	00B	RESERVE	
	5-0	07H	SENSITIVITY 2	Channel 2 touch sensitivity
44H	7-6	00B	RESERVE	
	5-0	07H	SENSITIVITY 3	Channel 3 touch sensitivity
45H	7-6	00B	RESERVE	
	5-0	07H	SENSITIVITY 4	Channel 4 touch sensitivity
46H	7-6	00B	RESERVE	
	5-0	07H	SENSITIVITY 5	Channel 5 touch sensitivity
47H	7-6	00B	RESERVE	
	5-0	07H	SENSITIVITY 6	Channel 6 touch sensitivity
48H	7-6	00B	RESERVE	
	5-0	07H	SENSITIVITY 7	Channel 7 touch sensitivity
49H	7-6	00B	RESERVE	
	5-0	07H	SENSITIVITY 8	Channel 8 touch sensitivity

4-2-16 PWM Control Registers - R/W

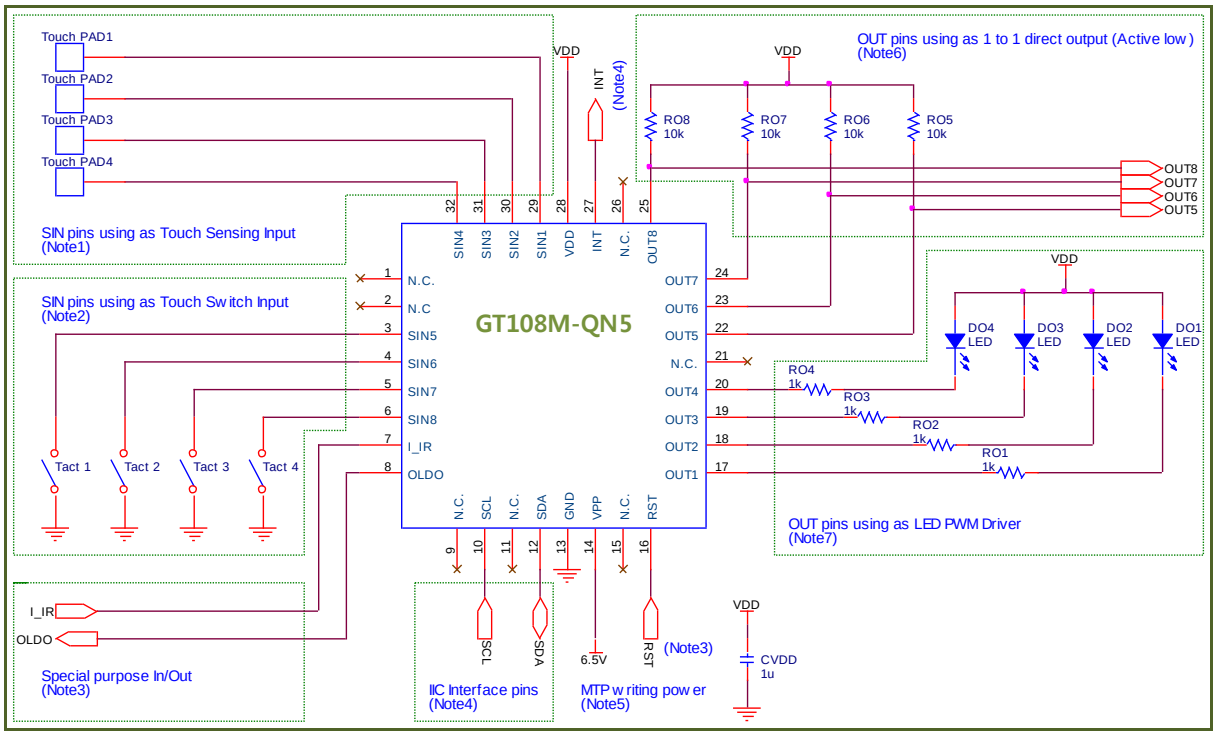
☞ *Description:* The GT108M supports each PWM period registers.

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

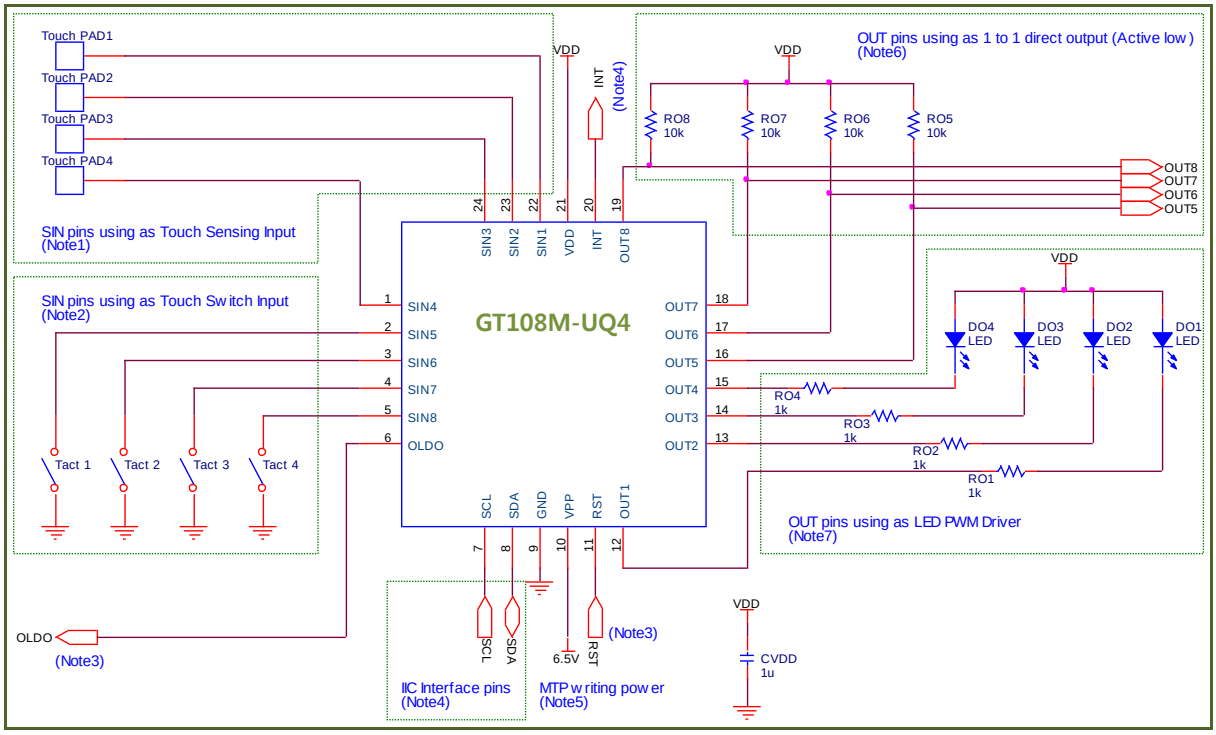
Addr.	Bits	Default	Name	Description
4AH	7-4	0000B	PWM 2	PWM 2 output period
	3-0	0000B	PWM 1	PWM 1 output period
4BH	7-4	0000B	PWM 4	PWM 4 output period
	3-0	0000B	PWM 3	PWM 3 output period
4CH	7-4	0000B	PWM 6	PWM 6 output period
	3-0	0000B	PWM 5	PWM 5 output period
4DH	7-4	0000B	PWM 8	PWM 8 output period
	3-0	0000B	PWM 7	PWM 7 output period

Chapter 5: Application Notes

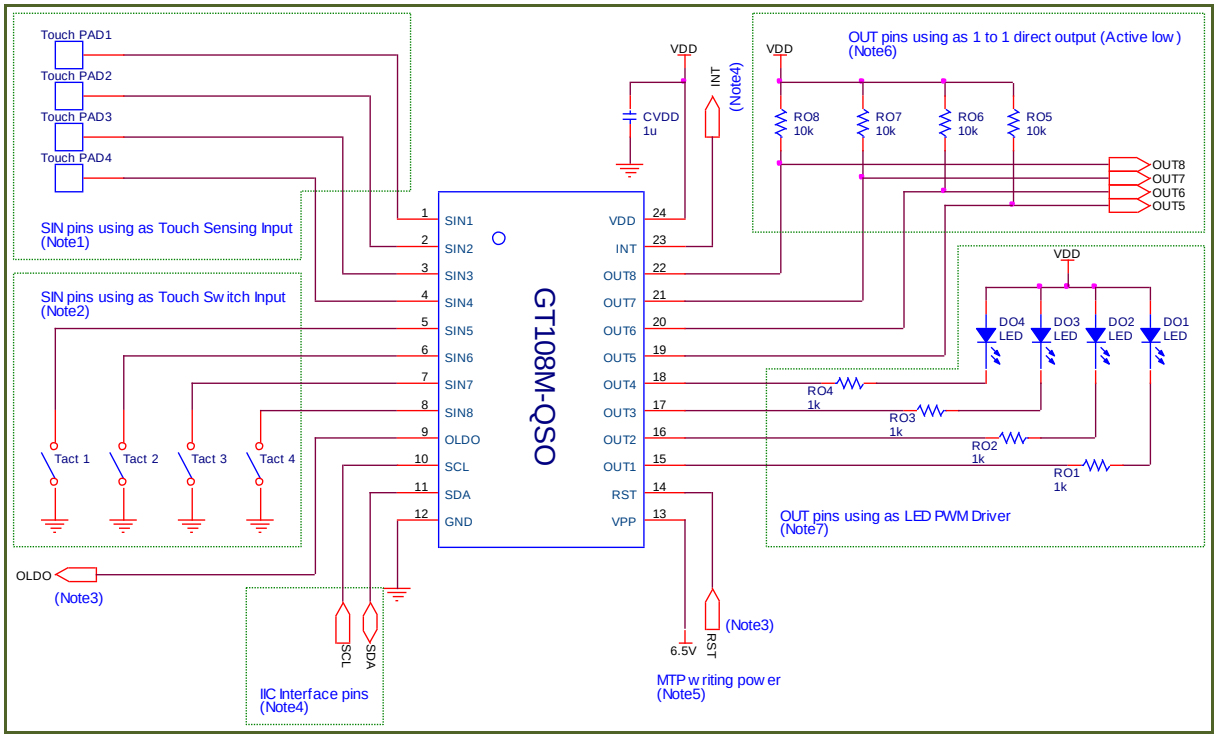
5-1 Circuit Examples for Various Applications



Application example circuit for 32QFN package



Application example circuit for 24UQFN package



Application example circuit for 24QSOP package

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 GT108M has enough noise rejection algorithms and various protection circuits to prevent noise causing error touch detection or incapable sensing, it is better to take care in noisy applications such as home appliances. There are many measurable or invisible noisy in system that can affect the impedance sensing signal and 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 can cause system reset.
- The capacitor connected between V_{DD} and GND is somehow obligation element for buffering above power line noises.

5-2-2 Sensing Input Line for Touch Detect <Note1>

- The sensing line for touch detection is 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 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 or the MTP ROM memory writing. (Recommendation)
- The series resistor value should be less than 1kΩ and the location of resister is better if it is closer to the SIN ports for better stable operation. (Refer to 3-2)

5-2-3 Sensing Input Line for Tact Input <Note2>

- No external pull-up resistor is needed, because the internal pull-up current can be substituted the external pull-up resistor.
- The tact switch must be connected to GND not to VDD. (refer to 3-3)

5-2-4 Special Purpose IN/OUT Ports <Note3>

- The I_IR has an optional pull-up resistor inside of the chip. It can be controlled by resistor setting (or MTP ROM writing). When this port is not used, it can be floating by using this internal pull-up resistor.
- The I_IR port is for the signal input that makes system to hold all sensing operation. (Refer to 3-6)
- The OLDO is an output only port. It also can have an active low or an active high output mode. Both output modes are all open drain type. So, the pull-up or the pull-down resistor is required for valid output.(Refer to 3-5)
- The OLDO is for the output signal that can control other external components to move into sleep or stand-by mode for saving current until occurring sensing detection.
- 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 resistor connected to V_{DD} to reduce pulse rising delay. (Refer to 3-8)
- INT is for the output signal that indicates changing of sensing output data. This port is output only port and also can have active low output mode and active high output mode. Both output modes are all open drain type. So, pull-up or pull-down resistor is required for valid output.(Refer to 3-8)

5-2-6 VPP Power Port <Note5>

- The typical voltage of VPP is 6.5 V that is provided through VPP port. The maximum tolerable maintain time with VPP power for writing MTP is 6.5 second. In the application, the VPP port must be connected to either VDD or floating. The connection to GND for VPP is forbidden in any case. (refer to 3-9)

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

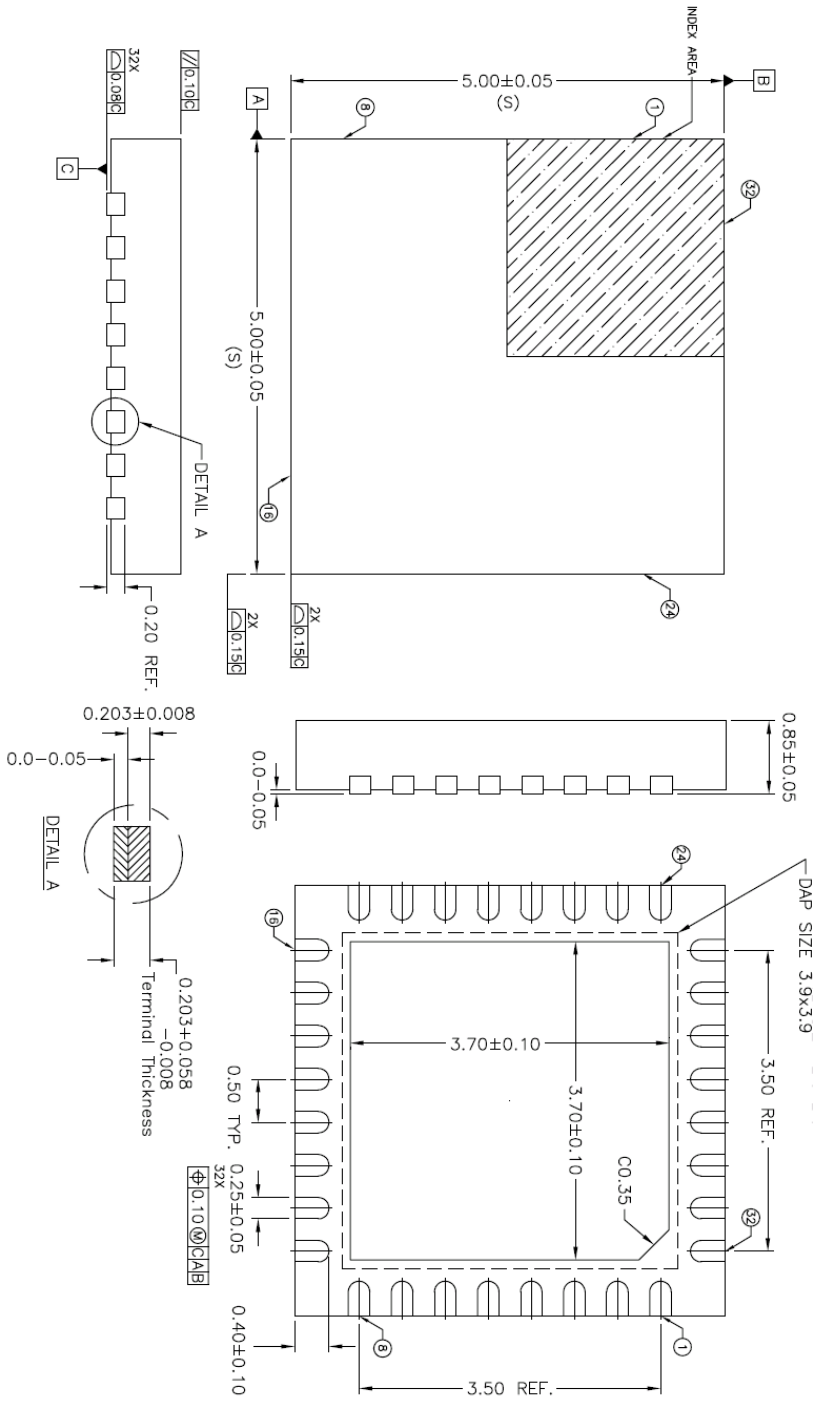
- The ports that are used for 1 to 1 direct output have an active low and high output mode. Both output modes are all open drain type. Therefore a pull-up or a pull-down resistor is required for a valid output. The OUTx port corresponds to SINx sense input respectively. (Refer to 3-7)

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

- The maximum 15mA 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 port cannot carry out the role of 1 to 1 direct out simultaneously. The 16 steps brightness control is possible. (Refer to 3-4)

Chapter 6: Package information

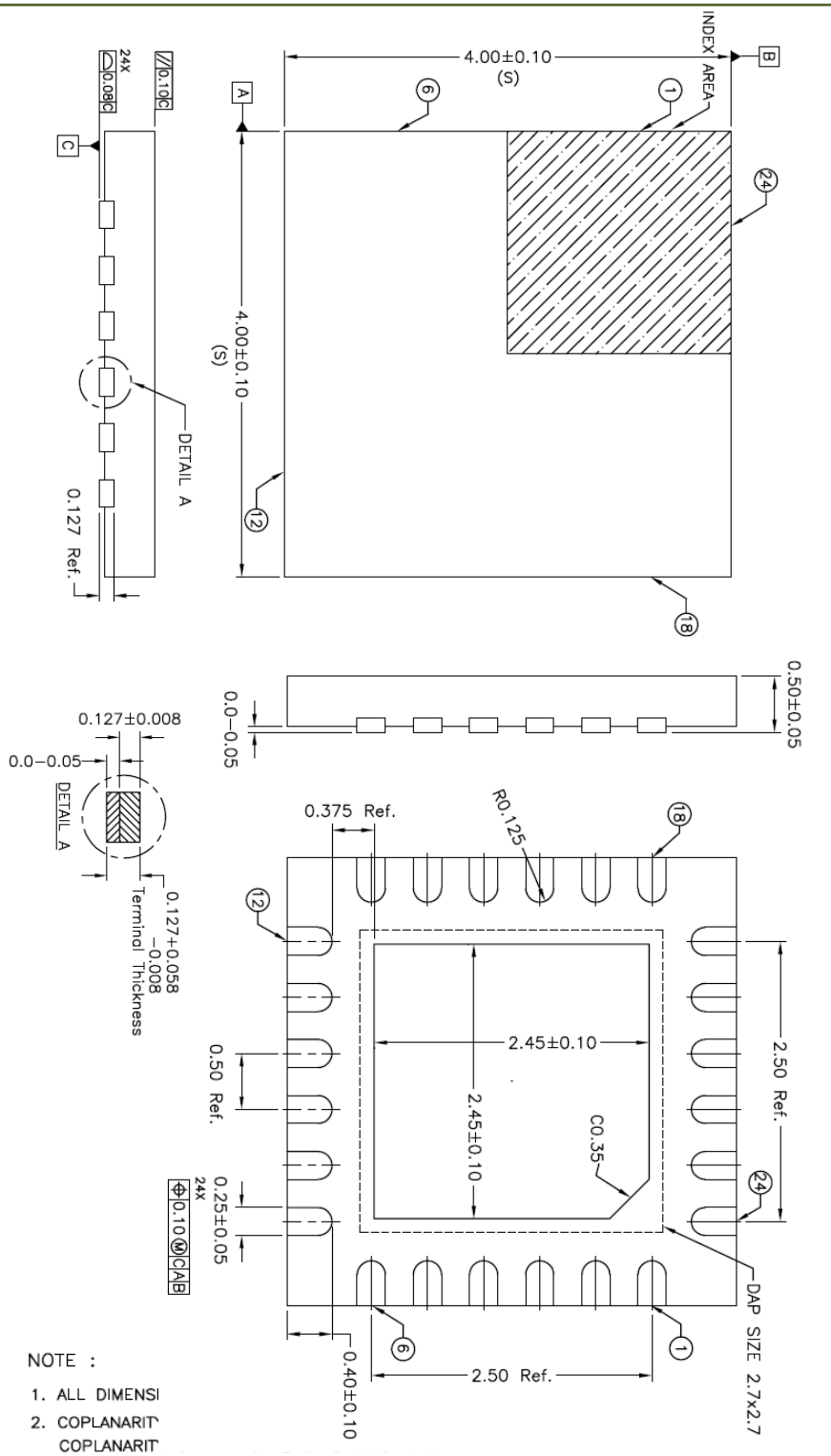
6-1 Package Outside Drawings for GT108M-QN5



NOTE :

1. ALL DIMENSION ARE IN mm. ANGLES IN DEGREES.
2. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS. COPLANARITY SHALL NOT EXCEED 0.08 mm.
3. WARPAGE SHALL NOT EXCEED 0.10 mm.
4. PACKAGE LENGTH / PACKAGE WIDTH ARE CONSIDERED AS SPECIAL CHARACTERISTIC. (S)
5. REFER JEDEC MO−220.
6. L/F STOCK# FR0113 (Ag Ring), NSE PKG CODE NQ55B032A OR NQ−500E500B032A.

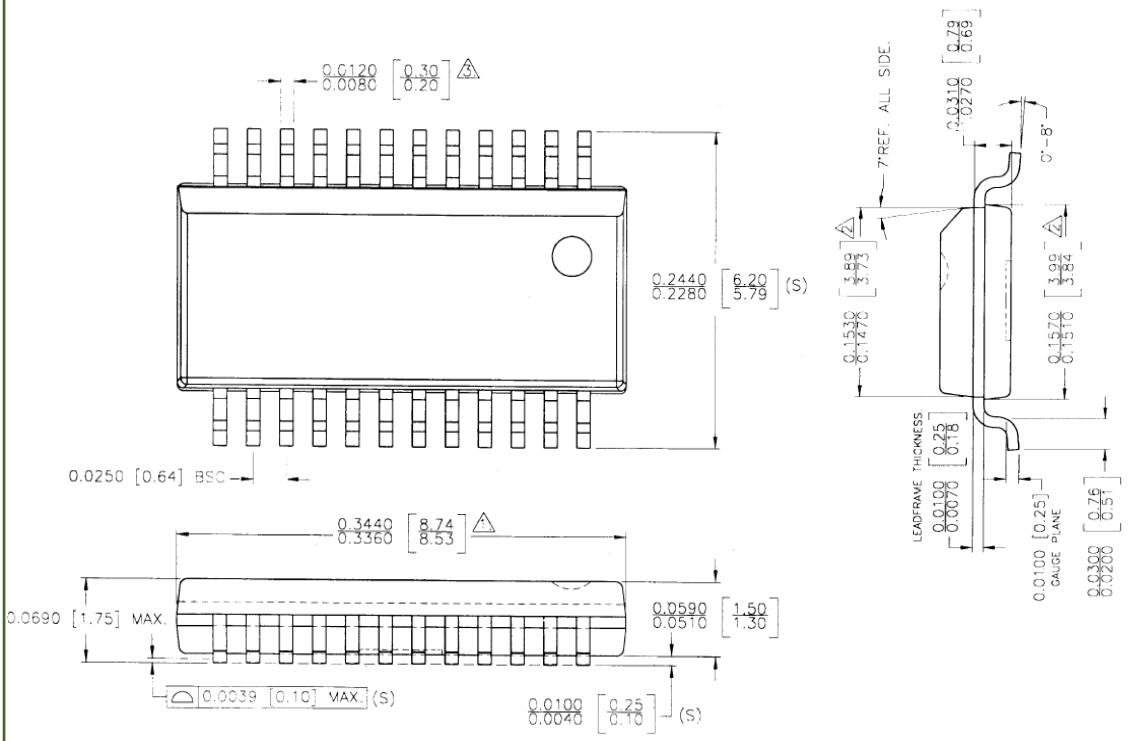
6-2 Package Outside Drawings for GT108M-UQ4



NOTE :

1. ALL DIMENSI
2. COPLANARIT
   COPLANARIT
3. WARPAGE SHALL NOT EXCEED 0.10 mm.
4. PACKAGE LENGTH / PACKAGE WIDTH ARE CONSIDERED AS SPECIAL CHARACTERISTIC. (S)
5. REFER JEDEC MO-236/MO-248
6. L/F STOCK# FN0076 (Ag Ring), UTL PKG CODE UQ44B024A OR UQ-400X400B024A

6-3 Package Outside Drawings for GT108M-QSO



Notes:

1 DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.
MOLD FLASH, PROTRUSIONS GATE BURRS SHALL NOT EXCEED .006 IN PER SIDE.
2 DOES NOT INCLUDE INTER-LEAD FLASH OR PROTRUCSIONS.
INTER-LEAD FLASH AND PROTRUSIONS SHALL NOT EXCEED .010 IN PER SIDE.
3 DOES NOT INCLUDE DAMBAR PROTRUSIONS.
ALLOWABLE DAMBAR PROTRUCSION SHALL BE 0.004 IN.
4 THIS PART IS COMPLANT WITH JEDEC SPECIFICATION MO-137 AE.
5 LEAD SPAN/STAND OFF HEIGHT/COPLANARITY ARE CONSIDERED AS SPECIAL CHARACTERISITIC.(S)
6 CONTROL DIMENSIONS IN INCHES.[mm^2]