

GT911

5-Point Capacitive Touch Controller for Small-Sized MID

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1. Overview

GT911, a new-generation 5-point capacitive touch solution designed for 7" to 8" MID, consists of up to 26 Transmitter electrodes and 14 Receiver electrodes to provide higher touch accuracy.

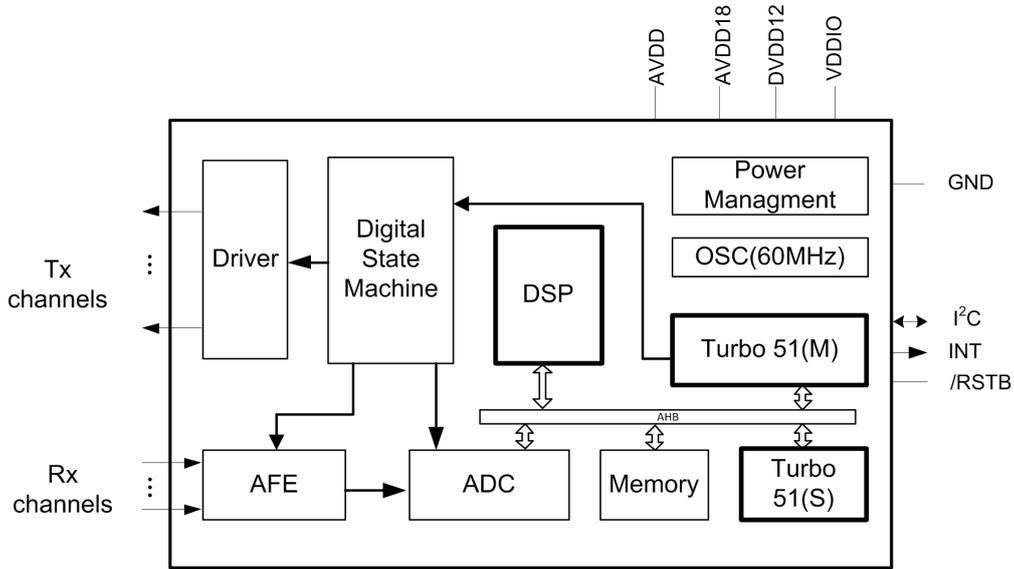
GT911 supports up to 5 concurrent touches with real-time tracking of accurate position and motion trajectory as well as touch area. Furthermore, it is able to report such information to the host as required.

2. Features

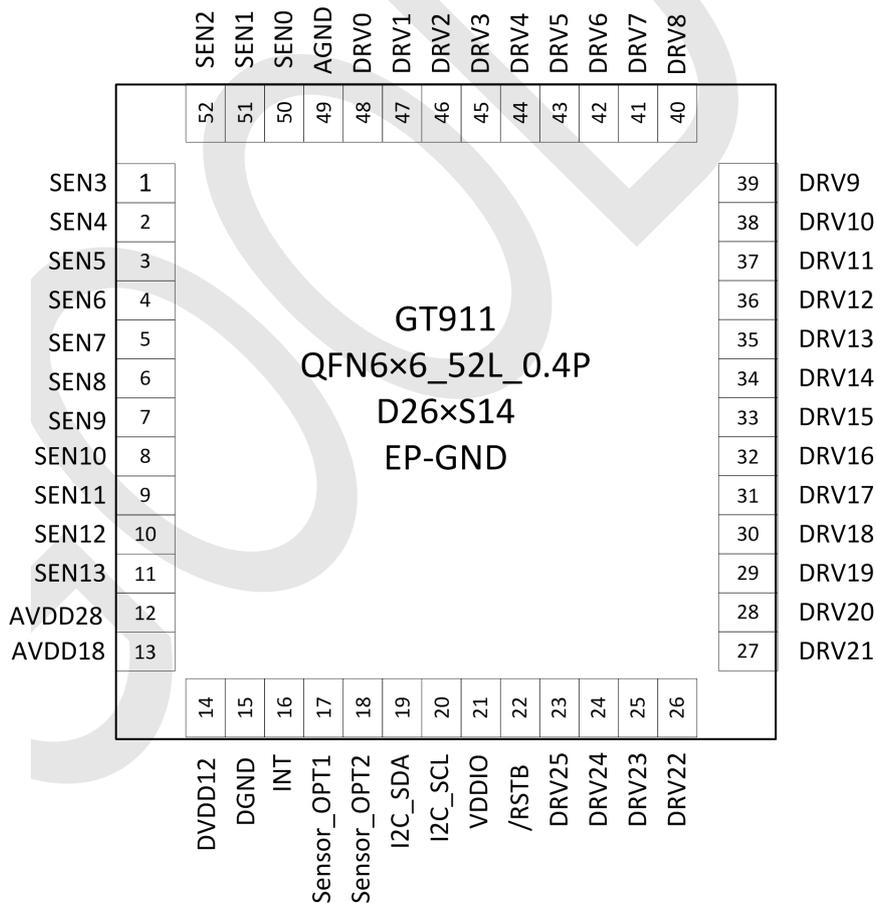
- ✧ Built-in capacitive sensing circuit and high-performance MPU
 - Report rate: 100Hz
 - Outputs touch coordinates in real time
 - Unified software applicable to capacitive touch screens of various sizes
 - Single power supply, internal 1.8V LDO
 - Flash embedded; In-system reprogrammable
 - HotKnot integrated
- ✧ Capacitive touch sensor
 - Channels: 26 (Tx channels)*14 (Rx channels)
 - Supports capacitive touch screen sizes: 7" to 8"
 - Supports touch key design on FPC
 - Supports ITO glass and ITO Film
 - Cover Lens thickness supported: 0.55mm ≅ Glass ≅ 2mm,
0.5mm ≅ PMMA ≅ 1.2mm,
(For details, please refer to *Sensor Design Guide*)
 - Adaptive frequency hopping
 - Supports OGS full lamination

- ◇ HotKnot
 - Transmission rate: 7.0Kbps(max)
 - Data frame maximum capacity: 128 bytes
 - Applicable sensor stackups: OGS/traditional GFF/GG/GF
- ◇ Environmental adaptability
 - Self-calibration during initialization
 - Automatic drift compensation
 - Operating temperature: -40°C to +85°C; humidity: ≅95%RH
 - Storage temperature: -60°C to +125°C; humidity: ≅95%RH
- ◇ Host interface
 - Standard I²C interface
 - Works in slave mode
 - Supports 1.8V to 3.3V host interface voltage
- ◇ Response time
 - Green mode: <48ms
 - Sleep mode: <200ms
 - Initialization: <200ms
- ◇ Power supply voltage:
 - Single supply: 2.8V to 3.3V
- ◇ Power supply ripple:
 - $V_{pp} \leq 50\text{mV}$
- ◇ Package: 52 pins, 6mm*6mm*0.8mm, QFN 0.4mm Pitch
- ◇ Tools that supports application development:
 - Touch panel parameter detector and generator
 - Touch panel performance tester
 - Mass production test kit
 - Reference driver code and documentary guide for host software development

3. Block Diagram



4. Pin Configurations



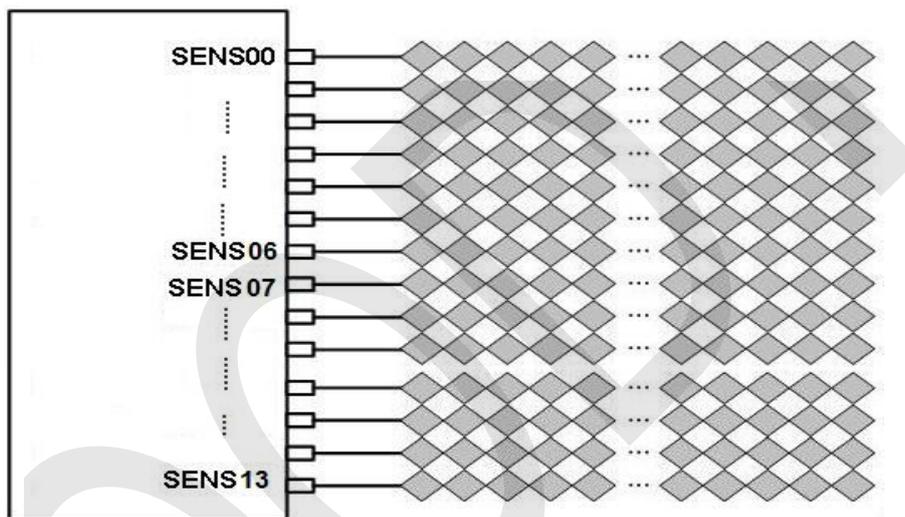
Pin No.	Name	Description	Remarks
1~11	SEN3 to SEN13	Receiver electrodes	Output drive signal while HotKnot function is on
12	AVDD28	Analog power	2.2uF filter capacitor to GND
13	AVDD18		2.2uF filter capacitor to GND
14	DVDD12		2.2uF filter capacitor to GND
15	DGND	Digital signal ground	
16	INT	Interrupt signal	Register configurable
17	Sensor_OPT1	Vendor ID pin 1	
18	Sensor_OPT2	Vendor ID pin 2	External pull-down resistor required
19	I2C_SDA	I ² C data signal	
20	I2C_SCL	I ² C clock signal	
21	VDDIO	Supply voltage of GPIO	2.2uF filter capacitor to GND Floating: 1.8V Connect to AVDD: AVDD
22	/RSTB	Reset pin	External 10K pull-up resistor required, active-low reset
23~48	DRV25 to DRV0	Transmitter electrodes	
49	AGND	Analog signal ground	
50~52	SEN0 to SEN2	Receiver electrodes	Output drive signal while HotKnot function is on

5. Sensor Design

5.1 Layout of Rx Channels

SENS0 to SENS13 are 14 Rx channels on the chip directly connected to 14 ITO Rx channels on the sensor either in sequence or reverse sequence. Please refer to the tool *Channel Selector* for channel selection when there are less ITO Rx channels on the sensor than Rx channels on the chip.

Sample Layout: the ITO Rx channels on the sensor are connected to the Rx channels on the chip in sequence from SENS0 to SENS13:



5.2 Layout of Tx Channels

DRV0 to DRV25 are 26 Tx channels on the chip directly connected to 26 ITO Tx channels on the sensor. Please refer to the tool *Channel Selector* for channel selection and assignment.

After the layout of the Tx channels is determined, relevant registers of GT911 shall be configured to ensure logic positions of Tx channels are consistent with their physical positions, so that the reported coordinates match the physical coordinates.

For details of sensor design, please refer to layout guidelines.

5.3 Sensor Design Specifications

	DITO Limit	SITO Limit
Tx Routing Trace Impedance	$\cong 3K\Omega$	$\cong 3K\Omega$
Tx Channel Impedance	$\cong 10K\Omega$	$\cong 10K\Omega$
Rx Routing Trace Impedance	$\cong 10K\Omega$	$\cong 10K\Omega$
Rx Channel Impedance	$\cong 40K\Omega$	$\cong 10K\Omega$
Node capacitance	$\cong 4pF$	$\cong 4pF$

Note:

- 1) For detailed sensor design specifications, please refer to *Sensor Design Guide* of Goodix.
- 2) When metal traces are employed for routing, some traces may be oxidized due to process control or other reasons and their impedance will become larger, making the impedance vary between traces. When ITO are employed for routing, though we've done our utmost to obtain impedance consistency by using matched length and width in design, there are still differences. To ensure data consistency and uniformity on the entire screen, it is necessary to ensure the sensor design complies with the above requirements.
- 3) In addition, when Tx trace and Rx trace are adjacent and parallel to each other, separate the traces with a ground trace. For ground trace width, please refer to *Sensor Design Guide*.

5.4 Touch Key Design

GT911 supports a maximum of 4 touch keys in the following two ways:

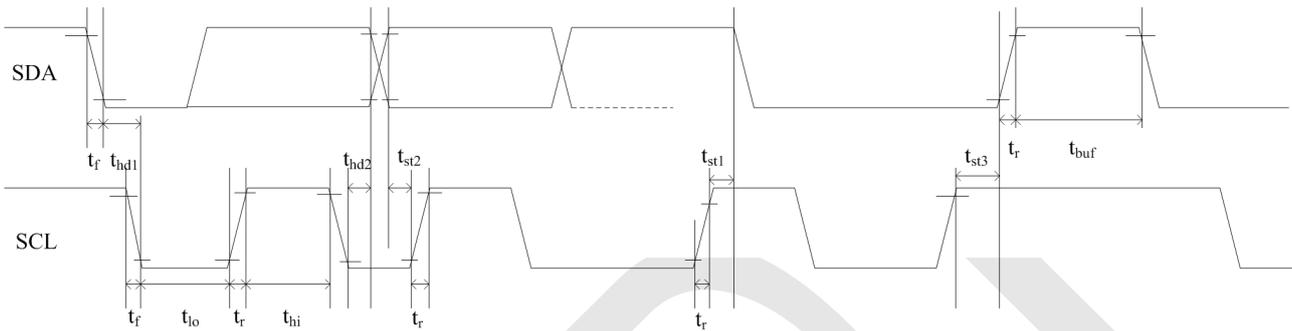
- 1) *Sensor extension*: Take one Tx channel as a common line for the touch keys and connect the Tx channel to four Rx channels to form four touch keys. The touch keys must not share their Tx channel with the touch screen. However, Rx channels have to be shared.
- 2) *Touch key design on FPC*: Connect one separate Tx channel to four Rx channels to form four touch keys. The touch keys have to share their Rx channels with the touch screen.

Touch key pattern on FPC should be designed independently.

6. I²C Communication

6.1 I²C Timing

GT911 provides a standard I²C interface for SCL and SDA to communicate with the host. GT911 always serves as slave device in the system with all communication being initialized by the host. It is strongly recommended that transmission rate be kept at or below 400Kbps. The I²C timing is shown below:



Test condition 1: 1.8V host interface voltage, 400Kbps transmission rate, 2KΩ pull-up resistor

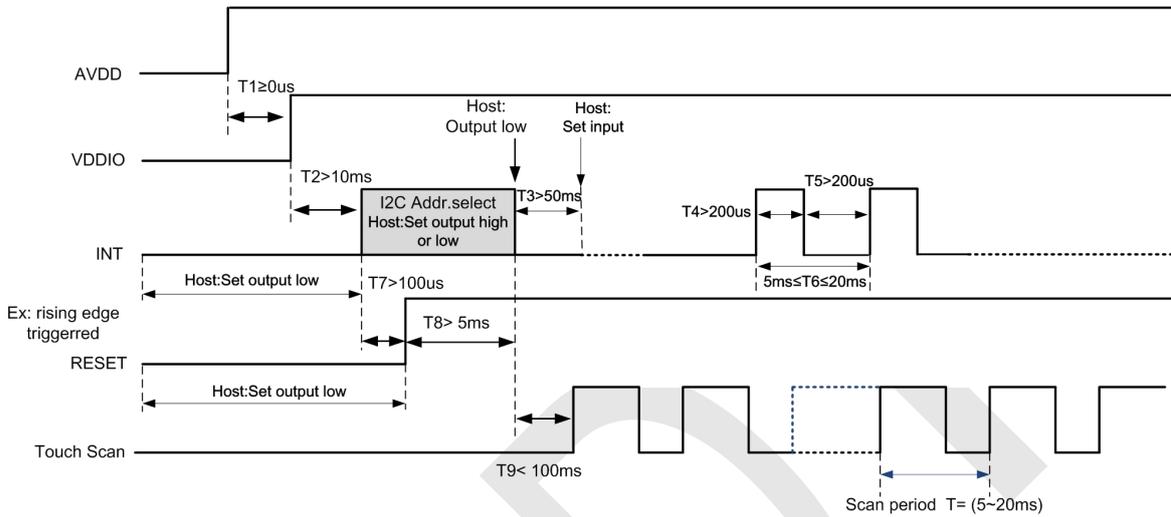
Parameter	Symbol	Min.	Max.	Unit
SCL low period	t _{lo}	1.3	-	us
SCL high period	t _{hi}	0.6	-	us
SCL setup time for Start condition	t _{st1}	0.6	-	us
SCL setup time for Stop condition	t _{st3}	0.6	-	us
SCL hold time for Start condition	t _{hd1}	0.6	-	us
SDA setup time	t _{st2}	0.1	-	us
SDA hold time	t _{hd2}	0	-	us

Test condition 2: 3.3V host interface voltage, 400Kbps transmission rate, 2KΩ pull-up resistor

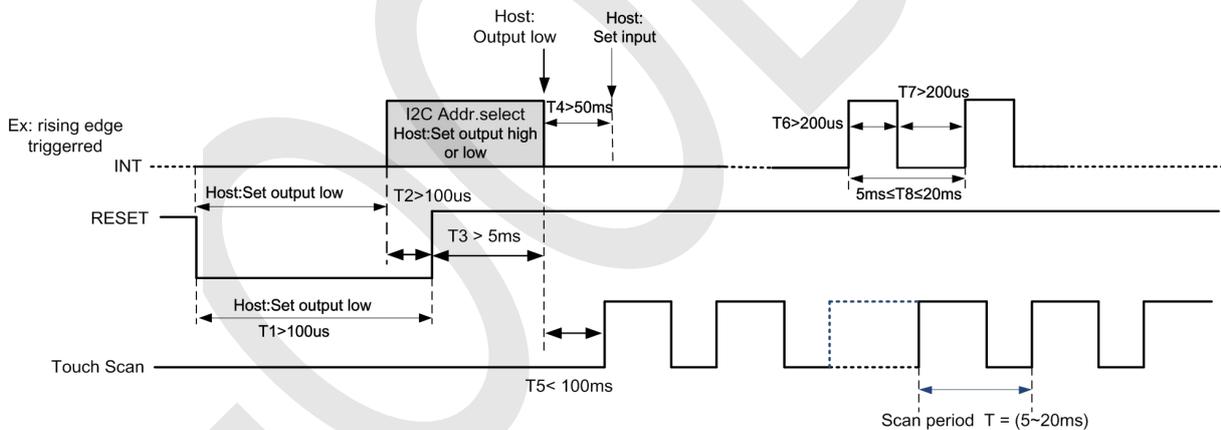
Parameter	Symbol	Min.	Max.	Unit
SCL low period	t _{lo}	1.3	-	us
SCL high period	t _{hi}	0.6	-	us
SCL setup time for Start condition	t _{st1}	0.6	-	us
SCL setup time for Stop condition	t _{st3}	0.6	-	us
SCL hold time for Start condition	t _{hd1}	0.6	-	us
SDA setup time	t _{st2}	0.1	-	us
SDA hold time	t _{hd2}	0	-	us

GT911 supports two I²C slave addresses: 0xBA/0xBB and 0x28/0x29. The host can select the address by changing the status of Reset and INT pins during the power-on initialization phase. See the diagram below for configuration methods and timings:

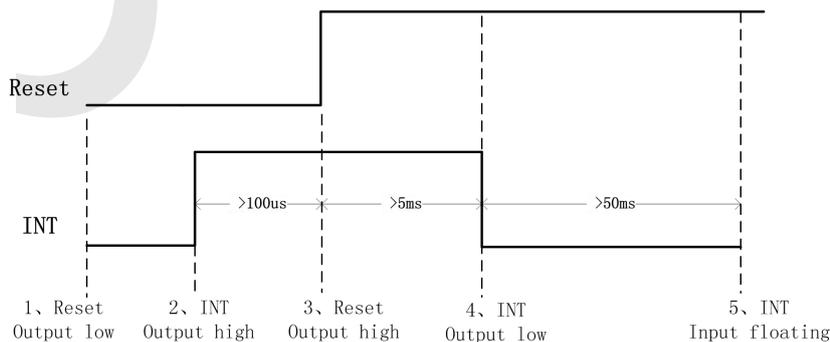
Power-on Timing:



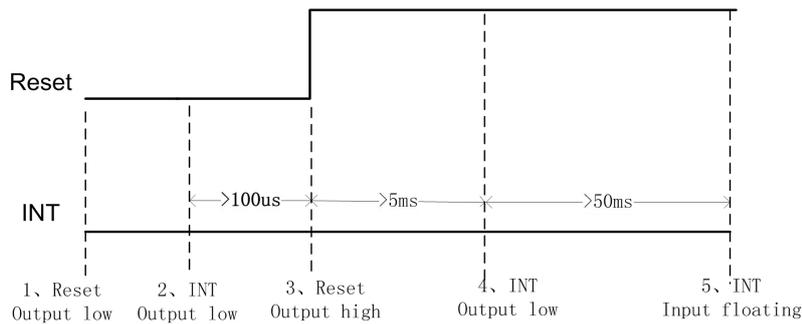
Timing for host resetting GT911:



Timing for setting slave address to 0x28/0x29:



Timing for setting slave address to 0xBA/0xBB:



a) Data Transmission

(For example: device address is 0xBA/0xBB)

Communication is always initiated by the host. Valid Start condition is signaled by pulling SDA line from “high” to “low” when SCL line is “high”. Data flow or address is transmitted after the Start condition.

All slave devices connected to I²C bus should detect the 8-bit address issued after Start condition and send the correct ACK. After receiving matching address, GT911 acknowledges by configuring SDA line as output port and pulling SDA line low during the ninth SCL cycle. When receiving unmatched address, namely, not 0XBA or 0XBB, GT911 will stay in an idle state.

For data bytes on SDA, each of 9 serial bits will be sent on nine SCL cycles. Each data byte consists of 8 valid data bits and one ACK or NACK bit sent by the recipient. The data transmission is valid when SCL line is “high”.

When communication is completed, the host will issue the STOP condition. Stop condition implies the transition of SDA line from “low” to “high” when SCL line is “high”.

b) Writing Data to GT911

(For example: device address is 0xBA/0xBB)



Timing for Write Operation

The diagram above displays the timing sequence of the host writing data onto GT911. First,

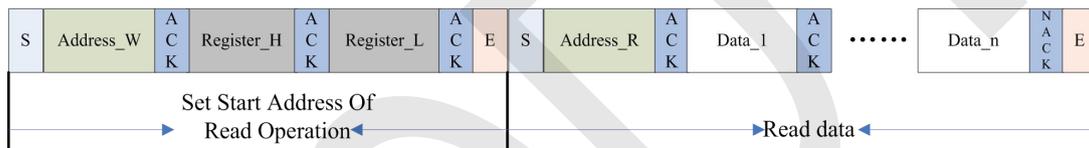
the host issues a Start condition. Then, the host sends 0xBA (address bits and R/W bit; R/W bit as 0 indicates Write operation) to the slave device.

After receiving ACK, the host sends the 16-bit register address (where writing starts) and the 8-bit data bytes (to be written onto the register).

The location of the register address pointer will automatically add 1 after every Write Operation. Therefore, when the host needs to perform Write Operations on a group of registers of continuous addresses, it is able to write continuously. The Write Operation is terminated when the host issues the Stop condition.

c) Reading Data from GT911

(For example: device address is 0xBA/0xBB)



Timing for Read Operation

The diagram above is the timing sequence of the host reading data from GT911. First, the host issues a Start condition and sends 0xBA (address bits and R/W bit; R/W bit as 0 indicates Write operation) to the slave device.

After receiving ACK, the host sends the 16-bit register address (where reading starts) to the slave device. Then the host sets register addresses which need to be read.

Also after receiving ACK, the host issues the Start condition once again and sends 0xBB (Read Operation). After receiving ACK, the host starts to read data.

GT911 also supports continuous Read Operation and, by default, reads data continuously. Whenever receiving a byte of data, the host sends an ACK signal indicating successful reception. After receiving the last byte of data, the host sends a NACK signal followed by a STOP condition which terminates communication.

7. HotKnot Mode

7.1 Start HotKnot

When data needs to be sent, the host sends command 0x21 to GT9, enabling GT911 to enter " Approach mode" and work as a transmitting terminal. GT911 will then be able to detect the receiving terminal communicating with it. When GT911 succeeds in detecting the receiving terminal, it will notify the the host to shut off LCD using an interrupt signal and then transmit data to the receiveing terminal.

7.2 Data Transmission between Touch Panels

After GT911 and another Hotknot terminal successfully detect one another, the host downloads HotKnot transmission firmware and sends the firmware to both terminals. While the transmission firmware runs, the two terminals are ready for data transmission, entering Receive mode by default. When the GT911 Transmit Buffer is refreshed correctly, GT911 works as the transmitting terminal and immediately transmits data to the other HotKnot terminal, which works as a receiving terminal detecting data sent by GT911.

7.3 Host Receives Data from GT911

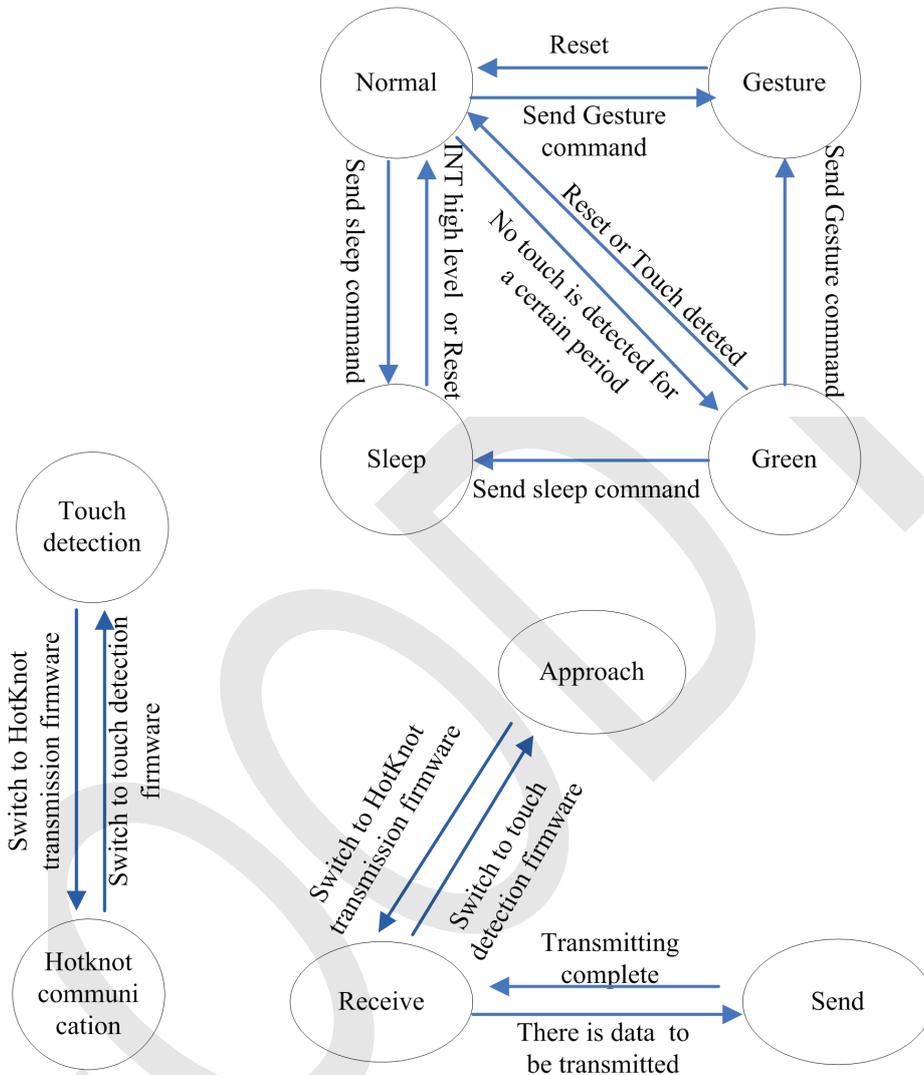
Following recieval or transmission of a data frame, GT911 inverts INT to notify the host to process data.

After receiving a data frame, the the host reads the value of the HotKnot-featured status register. If the value of the receive-status register indicates a successful reception, the host will read the data from the Receive Buffer via I²C. After reading the recieved data, the host writes 0xAA to the designated address and notifies GT911 that data reading is complete.

After GT911 transmits a data frame, the host reads the value of the HotKnot-featured status register. If the value of the transmit-status register indicates a successful transmission, the host will read the data from the Transmit Buffer via I²C. After reading this data, the host writes 0xAA to the designated address and notifies GT911 that data reading is complete. GT911 will automatically switch to Receive mode and will not start transmitting until Transmit Buffer is refreshed again.

8. Description on Functions

8.1 Operating Modes



a) Normal Mode

When GT911 is operating in Normal mode, its minimum coordinate refresh cycle is 7ms-10ms (subject to configuration; one step is 1ms).

When no touch occurs for a certain period (0s to 15s, subject to configuration; one step is 1s) in Normal mode, GT911 will automatically switch to Green mode to reduce power consumption.

b) Green Mode

In Green mode, the scanning cycle for GT911 is about 40ms. It automatically enters Normal mode if any touch is detected.

c) Gesture Mode

After the host enables GT911 to enter Gesture mode by sending I2C command 8 to 0x8046 and then to 0x8040, wake-up can be achieved by swipe, double-tap, or writing of specified letters on TP.

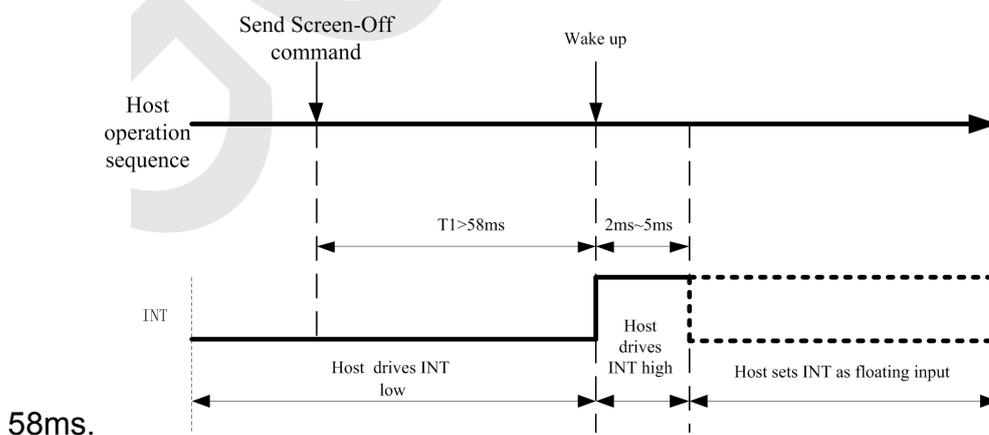
In Gesture mode, when GT911 detects any finger swipe on TP for a sufficiently long distance, INT will output a pulse for longer than 250us or a high level causing the host to wake up and turn on the screen.

In Gesture mode, when GT911 detects any double-tap on TP, INT will output a pulse for longer than 250us or a high level causing the host to wake up and turn on the screen.

In Gesture mode, when GT911 detects any writing of specified letters on the TP, INT will output a pulse for longer than 250us or a high level causing the host to wake up and turn on the screen.

d) Sleep Mode

GT911 enters Sleep mode if it receives corresponding I²C command from the host (requires INT output low before the command). GT911 exits Sleep mode and enters Normal mode when host outputs a high level to INT pin for 2ms to 5ms. The interval between sending screen-off command and wake-up should be longer than



e) Approach Mode

When HotKnot proximity detection is enabled, GT911 operates in Approach mode by default. If GT911 exits Approach mode, the host can enable it to enter Approach mode again by sending command 0x20 or 0x21. In Approach mode, touch detection and near-field proximity detection alternate.

If the host sends 0x21, GT911 will work as a transmitting terminal and transmit signals with a specified pattern and frequency via Tx and Rx channels. Then, GT911 detects whether there are feedback signals with the same specified pattern and frequency from the receiving terminal. This helps to determine whether any receiving terminal exists. If the host sends 0x20, GT911 will work as a Receiving terminal and detect signals with a specified pattern and frequency from the transmitting terminal. If such a signal is detected, GT911 responds using signals with the specified pattern and frequency to the transmitting terminal.

In Approach mode, when detecting any HotKnot-compatible terminal within the near-field range, GT911 will notify the host via INT to capture status. To ensure reliable detection between the transmitting terminal and the receiving terminal, it is required to keep detecting for a minimum of 150ms after the two terminals have detected each other. Then the host downloads and sends HotKnot transmission firmware to enable GT911 to enter Receive mode.

f) Receive Mode

In Approach mode, after notified that GT911 has successfully detected another HotKnot terminal, the host downloads and sends HotKnot transmission firmware to enable GT911 to enter Receive mode. In Receive mode, GT911 continues to detect frame start signal, once the signal is detected, GT911 begins to detect and receive data. When the receiving process is completed, GT911 verifies the data. If GT911 finds erroneous data, the receiving process begins again. If the data is found to be correct, GT911 notifies the host via INT to read data in the Receive Buffer.

g) Send Mode

When GT911 works in Receive mode, the host sends outgoing data to the Transmit Buffer. When detecting that the Transmit Buffer is refreshed and there is data to be sent, GT911 automatically switches from Receive mode to Send mode. In Send mode, GT911 sends a frame start signal. If it detects ACK fed back from the receiving terminal, it continues to send the data signal. After sending a data chunk, GT911 begins to detect ACK. If it does not detect any ACK or if it detects an erroneous ACK, GT911 will resend the data chunk. If this resending fails over 5 times, it will resend the current data frame another time to the receiving terminal until the host enables GT911 to exit Send mode due to timeout. If GT911 detects ACK and sends the data successfully, it will automatically switch to Receive mode after the host completes the data processing or due to timeout.

8.2 Interrupt Triggering Mechanism

When touched, GT911 sends a pulse via INT pin in every scanning cycle to notify the host to read coordinates. Host will then set a triggering mechanism via relevant register "INT" bit. INT as "0" indicates rising edge-triggered, which means GT911 will notify the host by driving INT output from low to high when operated by user; INT as "1" indicates falling edge-triggered, which means GT911 will notify the host by pulling INT output from high to low when operated by user .

8.3 Sleep Mode

When the touch screen is off or there are no running operations on the TP, the host sends I²C command to enable GT911 to enter Sleep mode, which reduces power consumption. When GT911 needs to operate, the host outputs a high level to INT pin for a certain period to awake it. For detailed timings of host enabling GT911 to enter and exit Sleep mode, please refer to section 8.1.

8.4 Stationary Configuration

GT911 supports Stationary Configuration. After receiving configuration parameters from the host, GT911 will fix parameters to the latest version. Once these parameters are fixed,

GT911 will communicate with the host solely via I2C bus and will not receive any parameters of previous versions from the host.

8.5 Adaptive Frequency Hopping

GT911 is equipped with reliable anti-interference hardware. When the drive spectrum of GT911 overlaps with the peak spectrum of noise signal, GT911 will switch to another frequency using a self-adaptive frequency hopping mechanism to avoid interference.

8.6 Self-calibration

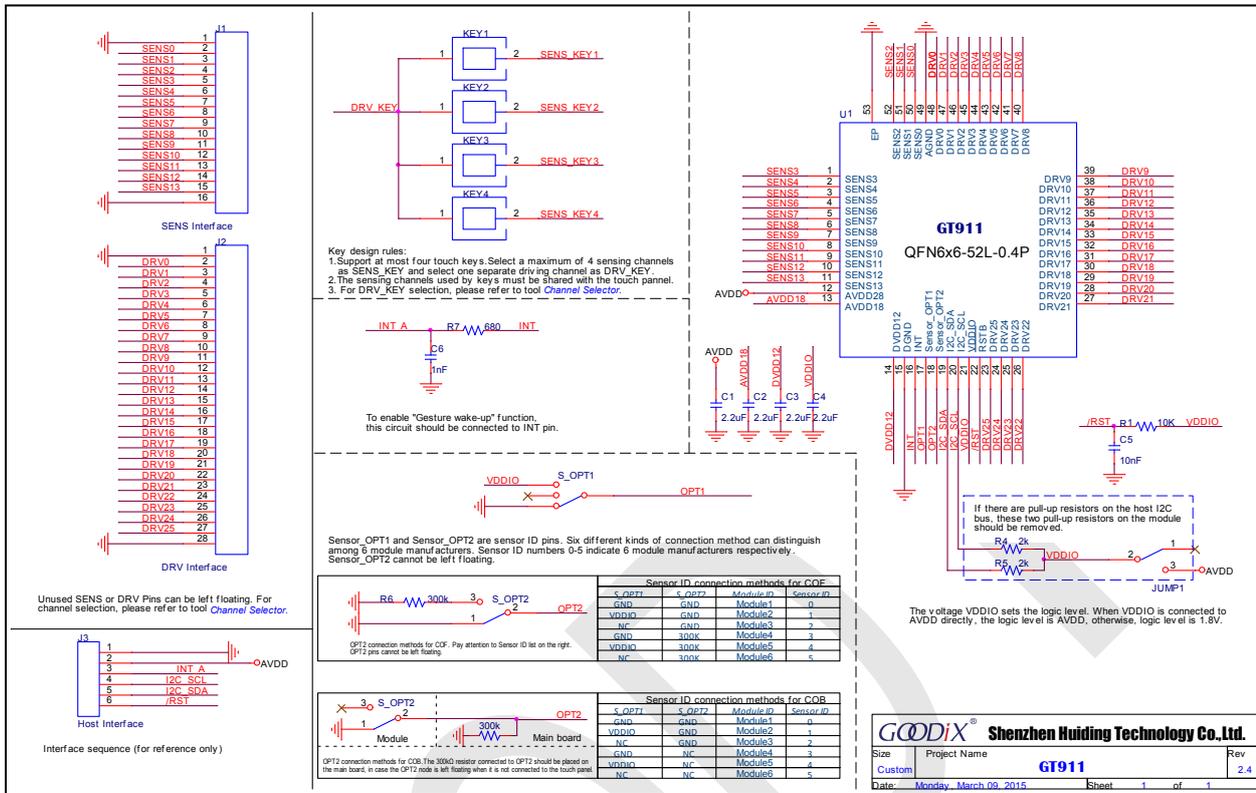
a) Self-calibration during Initialization

Fluctuations in temperature, humidity and environment may affect the reference capacitance of the capacitive sensor in idle state. GT911 will update detection reference capacitance according to environmental conditions within the first 200ms of initialization. Then, GT911 will complete the initialization of the TP test.

b) Automatic Drift Compensation

Gradual changes in environmental factors such as temperature, humidity, or dust may also affect the reference capacitance of the capacitive sensor in idle state. GT911 will detect real-time changes in data and perform statistic analysis of historic data to revise reference capacitance and thus reduce the impact that environmental changes have on the TP test.

9. Sample Schematic



GT911 Sample schematic

Note:

- This schematic only represents basic application. Adjustments may be required to fit in with actual situations and application environments.
- It is recommended that the capacitor be ceramic X7R.

10. Electrical Characteristics

10.1 Absolute Maximum Ratings

(Ambient temperature: 25°C)

Parameter	Min.	Max.	Unit
Analog power AVDD28 (please refer to AGND)	2.66	3.47	V
VDDIO (please refer to DGND)	1.7	3.47	V
Voltage on digital I/O	-0.3	3.47	V
Voltage on analog I/O	-0.3	3.47	V
Range of operating temperature	-40	85	°C
Range of storage temperature	-60	125	°C
ESD susceptibility (HBM)	—	±2	KV

10.2 Recommended Operating Conditions

Parameter	Min.	Typ.	Max.	Unit
AVDD28	2.8	-	3.3	V
VDDIO	1.8	-	3.3	V
Operating temperature	-20	25	85	°C

10.3 AC Electrical Characteristics

(Ambient temperature: 25°C, AVDD=2.8V, VDDIO=1.8V)

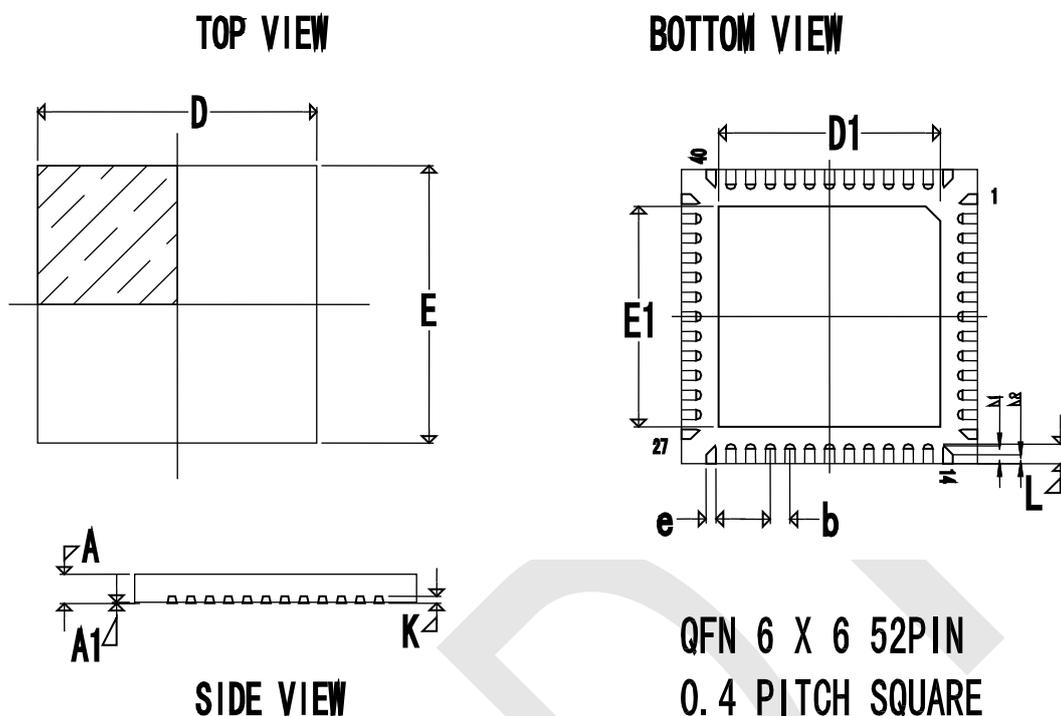
Parameter	Min.	Typ.	Max.	Unit
OSC oscillation frequency	59	60	61	MHz
I/O output rise time, low to high	-	14	-	ns
I/O output fall time, high to low	-	14	-	ns

10.4 DC Electrical Characteristics

(Ambient temperature:25°C, AVDD=2.8V, VDDIO=1.8V or VDDIO=AVDD)

Parameter	Min.	Typ.	Max.	Unit
Normal mode operating current	-	8	14.5	mA
Green mode operating current	-	3.3	-	mA
Sleep mode operating current	70	-	120	uA
Doze mode operating current	-	0.78	-	mA
Digital input low voltage/VIL	-0.3	-	0.25*VDDIO	V
Digital input high voltage/VIH	0.75*VDDIO	-	VDDIO+0.3	V
Digital output low voltage/VOL	-	-	0.15*VDDIO	V
Digital output high voltage/VOH	0.85*VDDIO	-	-	V

11. Package



Symbol	Dimensions In Millimeters		
	Min.	Normal	Max.
A	0.70	0.75	0.80
A1	0.00	0.035	0.05
b	0.40BSC		
D	6.00BSC		
D1	4.40	4.50	4.60
E	6.00BSC		
E1	4.40	4.50	4.60
e	0.15	0.20	0.25
L	0.30	0.40	0.50
L1	0.31	0.36	0.41
L2	0.13	0.18	0.23
K	0.203BSC		

12. Requirements on SMT Reflow Solder

12.1 Moisture Sensitivity Level (MSL)

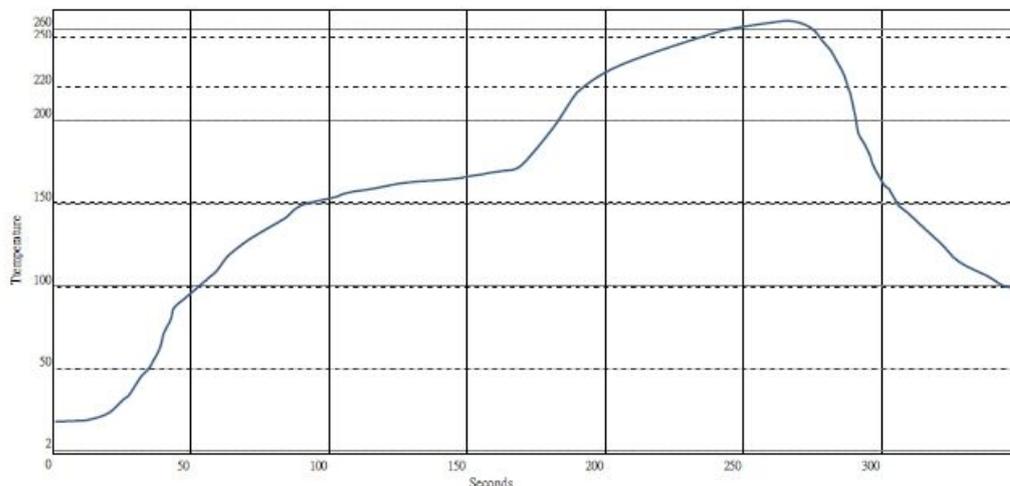
GT911 is classified as **MSL3**. The detailed requirements are listed below:

- 1) Calculated shelf life in sealed Moisture-Barrier Bag: 12 months at $<40^{\circ}\text{C}$ and $< 90\%$ relative humidity (RH)
- 2) After bag is opened, devices that will be subjected to IR reflow solder or other high temperature process ($<260^{\circ}\text{C}$) must be
 - a) Mounted within: 168 hours of factory conditions $\leq 30^{\circ}\text{C}/60\%$ RH, OR
 - b) Stored at $< 10\%$ RH (such as a dry cabinet)
- 3) Devices require bake, before mounting, if:
 - a) Humidity indicator card is $>20\%$ when read at $23\pm 5^{\circ}\text{C}$
 - b) 2a or 2b not met
- 4) If baking is required:
 - a) Devices shipped in low temperature carriers (such as Tape and Reel) can be baked in carriers for 192 hours at $40^{\circ}\text{C}+5^{\circ}\text{C}/-0^{\circ}\text{C}$ and $<5\%$ R.H.
 - b) Devices shipped in high temperature carriers (such as Tray) can be baked in carriers for 24 hours at $125^{\circ}\text{C} +5/-0^{\circ}\text{C}$
 - c) After baking, device should be put into the Moisture-Barrier Bag right after it cools down. Device shipped in low temperature carriers (such as Tape and Reel) should be packed inside the bag along with at least 5g desiccant and a six-spot humidity indicator card; Device shipped in high temperature carriers (such as Tray) should be packed inside the bag along with at least 10g desiccant and a six-spot humidity indicator card. Each bag should be vacuumized and sealed.

12.2 Reflow Passes

Number of reflow passes: ≤ 3 .

12.3 Pb-Free Reflow Temperature Profile



GT911 follows the standard J-STD-020D-01 and more particularly these parameters:

Profile Feature			Pb-Free Assembly (For reference)		
Room Temperature to Peak Temperature	A . Pre-heating zone (25°C—150°C)		Duration	80s—120s	
			Ramp Up Rate	<3°C/s	
	B. Soak zone (150°C—200°C)		Duration	60s—120s (100s is recommended by Goodix)	
			Ramp Up Rate	<1°C/s	
	Time Above 217°C	C. 217°C—260°C	Duration	60s—85s	Time above 217°C: 60s—150s
			Ramp Up Rate	<3°C/s	
	D. Peak Temp. (255°C—260°C)	Duration	20s—30s		
	E .260°C—217°C	Ramp Down Rate	<6°C/s		
--	F. Time Below 217°C(Cooling zone)		Ramp Down Rate	1 °C/s—3°C/s	

The time spent on ramping up from room temperature to peak temperature should be less than 8 minutes.

Note: Please follow the standard “J-STD-020D-01”.

13. Revision History

Revision	Date	Description
Rev. 00	2012-11-02	Preliminary version
Rev. 01	2012-11-22	Modified configurations Updated sample schematic
Rev. 02	2012-12-26	Modified storage temperature, supply currents in various modes and some descriptions
Rev.03	2013-03-19	Added descriptions on filter
Rev.04	2013-05-14	Added reflow conditions
Rev.05	2013-06-19	Updated product features Added sensor design specifications of SITO Updated register map Modified operating modes switch diagram Modified description on sleep mode and wakeup timing Deleted reflow conditions Updated sample schematic Modified the typ. value of Normal mode operating current
Rev.06	2013-08-27	Added layout of Rx channels Updated I2C timing Updated power-on timing Updated register map Updated absolute maximum ratings
Rev.07	2014-07-09	Modified product features Modified pin definition Added touch key design specifications Updated power-on timing Added reset timing Updated I2C addressing timing Deleted register map Modified operating modes diagram Modified sample schematic Updated DC electrical characteristics
Rev.08	2014-08-22	Updated power-on and reset timings
Rev.09	2015-03-11	Modified I2C addressing timing Modified sample schematic Updated AC and DC electrical characteristics Modified package parameters
Rev.10	2015-06-25	Added section 12 "Requirements on SMT Reflow Solder" (including MSL); Deleted description on "soldering temperature" in Absolute Maximum Ratings; Modified description on ground trace width in sensor design.

14. Contact Information



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