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CAP1214

Multiple Channel Capacitive Touch Sensor and LED Driver



PRODUCT FEATURES

Datasheet

General Description

The CAP1214 is a multiple channel Capacitive Touch sensor and LED Driver.¹

The CAP1214 contains up to fourteen (14) individual Capacitive Touch sensor inputs with programmable sensitivity for use in touch button and slider switch applications. Each sensor input contains automatic recalibration with programmable time delays.

The CAP1214 includes compensation circuitry that provides uniform touch sensitivity across a wide range of external sensing pad capacitance.

The CAP1214 also contains eleven (11) low side LED drivers that offer full-on / off, variable rate blinking, dimness controls, and breathing. LED outputs can be linked to capacitive sensor channels.

Applications

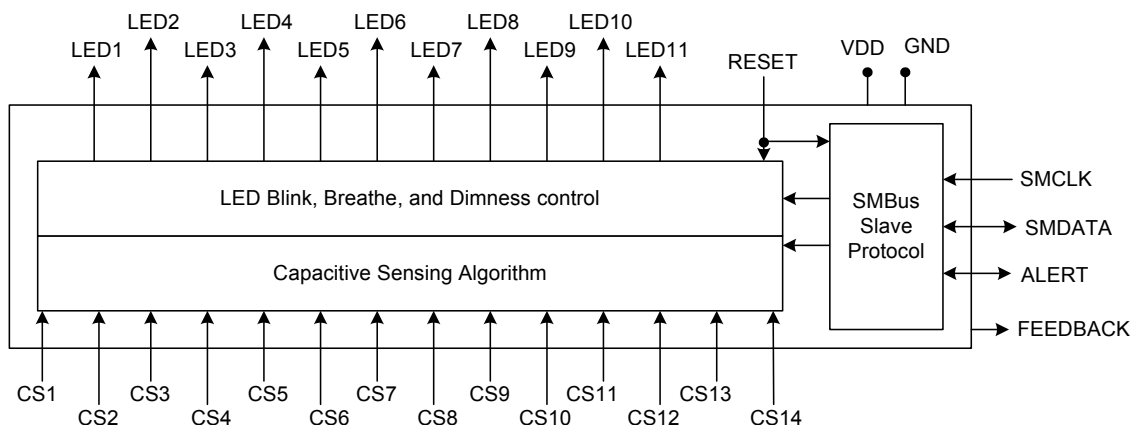
- Consumer Electronics
- Desktop and Notebook PCs
- LCD Monitors

Features

- Fourteen (14) capacitive touch sensor inputs
 - Compensates for variable sensing pads
 - Programmable sensitivity
 - High SNR allows for easy tuning
 - Automatic recalibration
 - Slider acceleration and position detection
 - Proximity detection
- Lid closure detection
- Low power operation
 - 4.5uA quiescent current in Deep Sleep
 - 250uA quiescent current in Sleep, monitoring 1 button
- FEEDBACK pin can drive a piezo transducer when a touch is detected
- User controlled reset
- Low external component count
- SMBus 2.0 compliant interface to change operating parameters to work in a wide variety of systems
 - Block Read and Write function for quick tasking
- Eleven (11) LED driver outputs
 - Programmable blink, breathe, and dimness controls
 - 8 configurable as GPIOs
 - LEDs can be linked to capacitive sensor channels
- Development boards and software available
- Available in 32-pin 5mm x 5mm QFN Lead-free RoHS Compliant package

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Block Diagram



Datasheet

Ordering Information:

| ORDERING NUMBER | PACKAGE | FEATURES |
|------------------------|----------------------------------------------------|------------------------------------------------------------------------------------|
| CAP1214-1-EZK-TR | 32-Pin QFN 5mm x 5mm (Lead Free RoHS compliant) | Fourteen Capacitive Touch Sensors. Eleven LED drivers. SMBus communications. |

REEL SIZE IS 4,000 PIECES

This product meets the halogen maximum concentration values per IEC61249-2-21

For RoHS compliance and environmental information, please visit www.smssc.com/rohs

Please contact your SMSC sales representative for additional documentation related to this product such as application notes, anomaly sheets, and design guidelines.

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Chapter 1 Pin Description

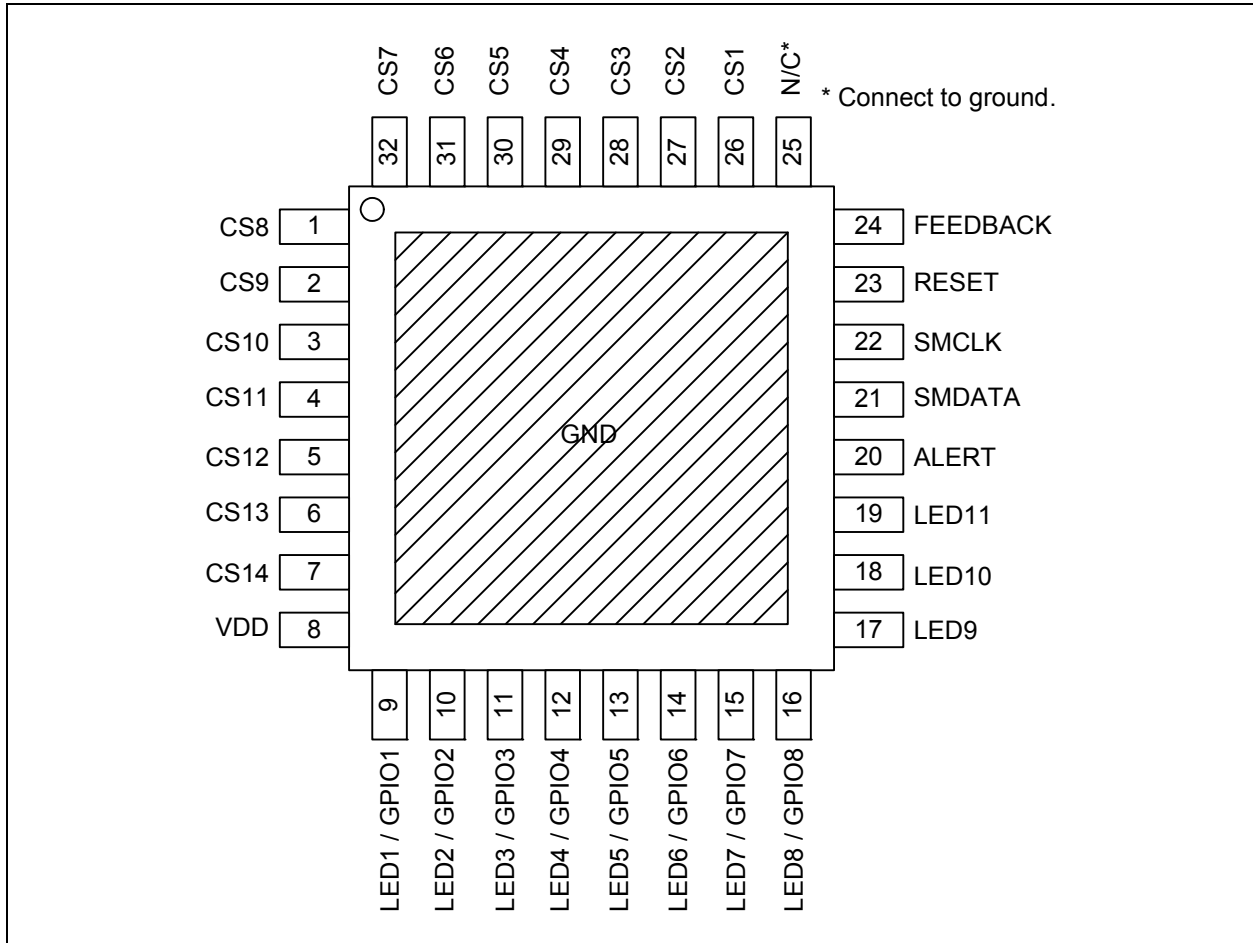


Figure 1.1 CAP1214 Pin Diagram (32-Pin QFN)

Table 1.1 Pin Description for CAP1214

| PIN # | PIN NAME | PIN FUNCTION | PIN TYPE | UNUSED CONNECTION |
|-------|----------|----------------------------|----------|-------------------|
| 1 | CS8 | Capacitive Touch Sensor 8 | AIO | Connect to Ground |
| 2 | CS9 | Capacitive Touch Sensor 9 | AIO | Connect to Ground |
| 3 | CS10 | Capacitive Touch Sensor 10 | AIO | Connect to Ground |
| 4 | CS11 | Capacitive Touch Sensor 11 | AIO | Connect to Ground |
| 5 | CS12 | Capacitive Touch Sensor 12 | AIO | Connect to Ground |
| 6 | CS13 | Capacitive Touch Sensor 13 | AIO | Connect to Ground |
| 7 | CS14 | Capacitive Touch Sensor 14 | AIO | Connect to Ground |

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Table 1.1 Pin Description for CAP1214 (continued)

| PIN # | PIN NAME | PIN FUNCTION | PIN TYPE | UNUSED CONNECTION |
|-------|---------------|-------------------------------------------------------|-----------|--------------------|
| 8 | VDD | Positive Power supply | Power | n/a |
| 9 | LED1 / GPIO1 | LED1 - Open drain LED driver | OD (5V) | Connect to Ground |
| | | GPI1 - GPIO 1 input (default) | DI (5V) | Connect to Ground |
| | | GPO1 - GPIO 1 push-pull output | DO | Leave open |
| 10 | LED2 / GPIO 2 | LED2 - Open drain LED driver | OD (5V) | Connect to Ground |
| | | GPI2 - GPIO 2 input (default) | DI (5V) | Connect to Ground |
| | | GPO2 - GPIO 2 push-pull output | DO | Leave open |
| 11 | LED3 / GPIO3 | LED3 - Open drain LED driver | OD (5V) | Connect to Ground |
| | | GPI3 - GPIO 3 input (default) | DI (5V) | Connect to Ground |
| | | GPO3 - GPIO 3 push-pull output | DO | Leave open |
| 12 | LED4 / GPIO4 | LED4 - Open drain LED driver | OD (5V) | Connect to Ground |
| | | GPI4 - GPIO 4 input (default) | DI (5V) | Connect to Ground |
| | | GPO4 - GPIO 4 push-pull output | DO | Leave open |
| 13 | LED5 / GPIO5 | LED5 - Open drain LED driver | OD (5V) | Connect to Ground |
| | | GPI5 - GPIO 5 input (default) | DI (5V) | Connect to Ground |
| | | GPO5 - GPIO 5 push-pull output | DO | Leave open |
| 14 | LED6 / GPIO6 | LED6 - Open drain LED driver | OD (5V) | Connect to Ground |
| | | GPI6 - GPIO 6 input (default) | DI (5V) | Connect to Ground |
| | | GPO6 - GPIO 6 push-pull output | DO | Leave open |
| 15 | LED7 / GPIO7 | LED7 - Open drain LED driver | OD (5V) | Connect to Ground |
| | | GPI7 - GPIO 7 input (default) | DI (5V) | Connect to Ground |
| | | GPO7 - GPIO 7 push-pull output | DO | Leave open |
| 16 | LED8 / GPIO8 | LED8 - Open drain LED driver | OD (5V) | Connect to Ground |
| | | GPI8 - GPIO 8 input (default) | DI (5V) | Connect to Ground |
| | | GPO8 - GPIO 8 push-pull output | DO | Leave open |
| 17 | LED9 | LED9 - Open drain LED driver | OD (5V) | Connect to Ground |
| 18 | LED10 | LED10 - Open drain LED driver | OD (5V) | Connect to Ground |
| 19 | LED11 | LED11 - Open drain LED driver | OD (5V) | Connect to Ground |
| 20 | ALERT | Active High Interrupt / Wake Up Input | DIO | Pull-down resistor |
| 21 | SMDATA | Bi-directional SMBus data - requires pull-up resistor | DIOD (5V) | n/a |
| 22 | SMCLK | SMBus clock input - requires pull-up resistor | DI (5V) | n/a |

Table 1.1 Pin Description for CAP1214 (continued)

| PIN # | PIN NAME | PIN FUNCTION | PIN TYPE | UNUSED CONNECTION |
|--------------|----------|----------------------------------------------------------------|----------|-------------------|
| 23 | RESET | Soft reset for system - resets all registers to default values | DI (5V) | Connect to Ground |
| 24 | FEEDBACK | Sensor press feedback output. | DO | Leave open |
| 25 | N/C | Not Connected | N/A | Connect to Ground |
| 26 | CS1 | Capacitive Touch Sensor 1 | AIO | Connect to Ground |
| 27 | CS2 | Capacitive Touch Sensor 2 | AIO | Connect to Ground |
| 28 | CS3 | Capacitive Touch Sensor 3 | AIO | Connect to Ground |
| 29 | CS4 | Capacitive Touch Sensor 4 | AIO | Connect to Ground |
| 30 | CS5 | Capacitive Touch Sensor 5 | AIO | Connect to Ground |
| 31 | CS6 | Capacitive Touch Sensor 6 | AIO | Connect to Ground |
| 32 | CS7 | Capacitive Touch Sensor 7 | AIO | Connect to Ground |
| Bottom Plate | GND | Power Ground | Power | n/a |

The pin types are described in [Table 1.2, "Pin Types"](#). All pins labeled with (5V) are 5V tolerant.

Note: For all 5V tolerant pins that require a pull-up resistor, the voltage difference between VDD and the pull-up voltage must never exceed 3.6V.

Table 1.2 Pin Types

| PIN TYPE | DESCRIPTION |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| AIO | Analog Input / Output - this pin is used as an I/O for analog signals. |
| DI | Digital Input - this pin is used as a digital input. This pin is 5V tolerant. |
| DIOD | Digital Input / Open Drain Output - this pin is used as an digital I/O. When it is used as an output, It is open drain and requires a pull-up resistor. This pin is 5V tolerant. |
| DO | Push-pull Digital Output - this pin is used as a digital output and can sink and source current. |
| OD | Open Drain Digital Output - this pin is used as a digital output. It is open drain and requires a pull-up resistor. This pin is 5V tolerant. |
| Power | This pin is used to supply power or ground to the device. |

Chapter 2 Delta from CAP1114 to CAP1214

2.1 Summary

1. Updated Product ID to 5Ah.
2. Changed pin 24 from N/C to FEEDBACK.
3. Increased RESET Pin release to fully active operation from 400ms typical and 500ms max to 675ms typical and 775ms max (see [Table 3.2, "Electrical Specifications"](#)).
4. Reduced Time to First Conversion from 400ms typical and 500ms max to 100ms typical and 200ms max (see [Table 3.2, "Electrical Specifications"](#)).
5. Added Time to First Valid Detection 675ms typical and 775ms max (see [Table 3.2, "Electrical Specifications"](#)).
6. Added Power Supply Rejection ± 310 counts / V typical (see [Table 3.2, "Electrical Specifications"](#)).
7. Added bits 5 and 4 to the Queue Control register (1Eh - see [Section 6.12, "Queue Control Register"](#)). These bits control whether the accumulation of intermediate data and the consecutive negative delta counts counter are cleared when the noise status bit is set.
8. Added the following registers to implement the new Feedback feature, which enables the CAP1214 to activate an external transducer to send end user feedback in the form of sound or vibration when a touch is detected: Feedback Configuration (62h - see [Section 6.40, "Feedback Configuration Register"](#)), Feedback Channel Configuration (63h and 64h - see [Section 6.41, "Feedback Channel Configuration Registers"](#)), and Feedback One-Shot (65h - see [Section 6.42, "Feedback One-Shot Register"](#)).
9. Added LED11_CFG control as bit 5 of the Configuration 2 register (40h - see [Section 6.33, "Configuration 2 Register"](#)). This controls whether frequency of the LED11 driver is set at ~2000Hz or is configurable.
10. Added the LED11 Configuration register (8Ah) to determine base frequency and step settings for LED11.
11. Corrected anomaly where rise rate overrode any non-zero fall rate ([Section 6.58, "LED Direct Ramp Rates Register"](#)).
12. Corrected anomaly where Pulse 1 behavior failed on alternate presses when a sensor was linked to an LED and the Pulse 1 start trigger was set to "release".
13. Corrected anomaly where the delta counts were not cleared when the RF Detector circuit detected excessive RF signal on a capacitive sensor input.
14. Pulse 2 behavior modified. The number of pulses after release is the programmed number, not the programmed number minus one (see [Section 6.53, "LED Pulse 2 Period Register"](#)).
15. Breathe behavior modified. A breathe off delay control was added to the LED Off Delay Register (see [Section 6.59, "LED Off Delay Register"](#)) so the LED can be configured to remain inactive between breathes.
16. When the device enters the Deep Sleep state, the Slider Position / Volumetric Data Register (06h) is not cleared, if the register is set to represent volumetric data. If set to represent position information, the register is cleared.
17. Updated circuitry to improve power supply rejection.
18. Renamed BLK_DIG_NOISE bit to DIS_DIG_NOISE, and renamed BLK_ANA_NOISE bit to DIS_ANA_NOISE (see [Section 6.14, "Configuration Register"](#)). Renamed BLK_RF_NOISE bit to DIS_RF_NOISE (see [Section 6.33, "Configuration 2 Register"](#)).

2.2 Register Delta

Table 2.1 Register Delta

| ADDRESS | REGISTER DELTA | DELTA | DEFAULT |
|---------|----------------|------------------------------------------------------------------------|---------|
| 1Dh | Added controls | Added bit 5 NO_CLR_INTD and bit 4 NO_CLR_NEG to Queue Control Register | 03h |
| 40h | Added control | Added bit 5 LED11_CFG to Configuration 2 Register | 00h |
| 62h | New | Feedback Configuration | 00h |
| 63h | New | Feedback Channel Configuration 1 | 00h |
| 64h | New | Feedback Channel Configuration 2 | 00h |
| 65h | New | Feedback One-Shot | 00h |
| 8Ah | New | LED11 Configuration | 00h |
| 95h | Added control | Added bits 6-4 BR_OFF_DLY[2:0] to LED Off Delay Register | 00h |
| FDh | Changed | Product ID changed. | 5Ah |

Chapter 3 Electrical Specifications

Table 3.1 Absolute Maximum Ratings

| | | |
|-------------------------------------------------------------------------------------------|------------------------|--------------------|
| Voltage on VDD pin | -0.3 to 4 | V |
| Voltage on 5V tolerant pins (V_{5VT_PIN}) | -0.3 to 5.5 | V |
| Voltage on 5V tolerant pins ($ V_{5VT_PIN} - V_{DD} $) (see Note 3.1) | 0 to 3.6 | V |
| Voltage on any other pin to GND | -0.3 to $V_{DD} + 0.3$ | V |
| Package Power Dissipation up to $T_A = 85^\circ\text{C}$ (see Note 3.2) | 1 | W |
| Junction to Ambient (θ_{JA}) (see Note 3.3) | 48 | $^\circ\text{C/W}$ |
| Operating Ambient Temperature Range | -40 to 125 | $^\circ\text{C}$ |
| Storage Temperature Range | -55 to 150 | $^\circ\text{C}$ |
| ESD Rating, All Pins, HBM | 8000 | V |

Note: Stresses above those listed could cause permanent damage to the device. This is a stress rating only and functional operation of the device at any other condition above those indicated in the operation sections of this specification is not implied.

Note 3.1 For the 5V tolerant pins that have a pull-up resistor, the pull-up voltage must not exceed 3.6V when the device is unpowered.

Note 3.2 The Package Power Dissipation specification assumes a thermal via design with the thermal landing be soldered to the PCB ground plane with 0.3mm (12mil) diameter vias in a 4x4 matrix at 0.9mm (35.4mil) pitch.

Note 3.3 Junction to Ambient (θ_{JA}) is dependent on the design of the thermal vias. Without thermal vias and a thermal landing, the θ_{JA} is approximately 60°C/W including localized PCB temperature increase.

Table 3.2 Electrical Specifications

| $V_{DD} = 3\text{V to } 3.6\text{V}$, $T_A = 0^\circ\text{C to } 85^\circ\text{C}$, all Typical values at $T_A = 27^\circ\text{C}$ unless otherwise noted. | | | | | | |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-----|------|-----|---------------|---------------------------------------------------------------------------------------|
| CHARACTERISTIC | SYMBOL | MIN | TYP | MAX | UNIT | CONDITIONS |
| DC Power | | | | | | |
| Supply Voltage | V_{DD} | 3.0 | 3.3 | 3.6 | V | |
| Supply Current | I_{DD} | | 0.55 | 1 | mA | Average current Capacitive Sensing Active, LEDs enabled |
| | I_{SLEEP} | | 250 | 400 | μA | Sleep state active, 1 sensor monitored; LED11 inactive $T_A < 85^\circ\text{C}$ |
| | I_{DSLEEP} | | 4.5 | 15 | μA | Deep Sleep, LED 11 inactive $T_A < 40^\circ\text{C}$ |

Table 3.2 Electrical Specifications (continued)

| V _{DD} = 3V to 3.6V, T _A = 0°C to 85°C, all Typical values at T _A = 27°C unless otherwise noted. | | | | | | |
|---------------------------------------------------------------------------------------------------------------------------------|---------------------|-----|------|-----|------------|-------------------------------------------------------------------|
| CHARACTERISTIC | SYMBOL | MIN | TYP | MAX | UNIT | CONDITIONS |
| Time to Communications | t _{COMM} | | 15 | 20 | ms | Time from power applied to communications active |
| Time to First Conversion | t _{CONV} | | 100 | 200 | ms | Time from power applied to first sensor sampled |
| Time to First Valid Detection | t _{CONV} | | 675 | 775 | ms | Time from power applied to first valid data |
| Capacitive Touch Sensor | | | | | | |
| Base Capacitance | C _{BASE} | 5 | | 50 | pF | Pad untouched |
| Detectable Capacitive Shift | ΔC _{TOUCH} | 0.1 | | 2 | pF | Pad touched |
| Sample Time | t _{TOUCH} | | 2.5 | | ms | |
| Update Time | Δt _{TOUCH} | | 35 | | ms | |
| Recalibration Interval | Δt _{CAL} | | 8 | | s | Automatic Recalibration active, no touch active, default settings |
| Power Supply Rejection | PSR | | ±310 | | counts / V | |
| LED / GPIO Drivers (LED / GPIO 1 - 8) | | | | | | |
| Duty Cycle | DUTY _{LED} | 0 | | 100 | % | Programmable |
| Drive Frequency | f _{LED} | | 2 | | kHz | |
| Sinking Current | I _{SINK} | | | 24 | mA | V _{OL} = 0.4 |
| Sourcing Current | I _{SOURCE} | | | 24 | mA | V _{OH} = V _{DD} - 0.4 |
| Input High Voltage | V _{IH} | 2.0 | | | V | LED / GPIO configured as input |
| Input Low Voltage | V _{IL} | | | 0.8 | V | LED / GPIO configured as input |
| LED Drivers (LED 9 - LED 10) | | | | | | |
| Duty Cycle | DUTY _{LED} | 0 | | 100 | % | Programmable |
| Drive Frequency | f _{LED} | | 2 | | kHz | |
| Sinking Current | I _{SINK} | | | 24 | mA | |
| Output Low Voltage | V _{OL} | | | 0.4 | V | I _{SINK} = 24mA |
| LED11 Driver | | | | | | |
| Duty Cycle | DUTY _{LED} | 0 | | 100 | % | Programmable |
| Drive Frequency | f _{LED} | | 2 | | kHz | Programmable |
| Sinking Current | I _{SINK} | | | 48 | mA | |
| Output Low Voltage | V _{OL} | | | 0.4 | V | I _{SINK} = 48mA |

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Table 3.2 Electrical Specifications (continued)

| V _{DD} = 3V to 3.6V, T _A = 0°C to 85°C, all Typical values at T _A = 27°C unless otherwise noted. | | | | | | |
|---------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------|-----|-----|------|------------------------------------------------------------------------------------|
| CHARACTERISTIC | SYMBOL | MIN | TYP | MAX | UNIT | CONDITIONS |
| I/O Pins - SMDATA, SMCLK, and ALERT Pins | | | | | | |
| Output Low Voltage | V _{OL} | | | 0.4 | V | I _{SINK_IO} = 8mA |
| Output High Voltage | V _{OH} | V _{DD} - 0.4 | | | V | ALERT pin active high and asserted I _{SOURCE_IO} = 8mA |
| Input High Voltage | V _{IH} | 2.0 | | | V | |
| Input Low Voltage | V _{IL} | | | 0.8 | V | |
| Leakage Current | I _{LEAK} | | | ±5 | uA | powered or unpowered T _A < 85°C pull-up voltage ≤ V _{DD} |
| FEEDBACK Pin | | | | | | |
| Output Low Voltage | V _{OL} | | | 0.4 | V | I _{SINK_IO} = 24mA |
| Output High Voltage | V _{OH} | V _{DD} - 0.4 | | | V | I _{SOURCE_IO} = 24mA |
| RESET Pin | | | | | | |
| Input High Voltage | V _{IH} | 2.0 | | | V | |
| Input Low Voltage | V _{IL} | | | 0.8 | V | |
| RESET Filter Time | t _{RST_FILT} | 10 | | | ms | |
| RESET Pin release to fully active operation | t _{RST_ON} | | 675 | 775 | ms | |
| SMBus Timing | | | | | | |
| Input Capacitance | C _{IN} | | 5 | | pF | |
| Clock Frequency | f _{SMB} | 10 | | 400 | kHz | |
| Spike Suppression | t _{SP} | | | 50 | ns | |
| Bus free time Start to Stop | t _{BUF} | 1.3 | | | us | |
| Hold Time: Start | t _{HD:STA} | 0.6 | | | us | |
| Setup Time: Start | t _{SU:STA} | 0.6 | | | us | |
| Setup Time: Stop | t _{SU:STO} | 0.6 | | | us | |
| Data Hold Time | t _{HD:DAT} | 0 | | | us | |
| Data Setup Time | t _{SU:DAT} | 0.6 | | | us | |
| Clock Low Period | t _{LOW} | 1.3 | | | us | |
| Clock High Period | t _{HIGH} | 0.6 | | | us | |
| Clock/Data Fall time | t _{FALL} | | | 300 | ns | Min = 20+0.1C _{LOAD} ns |

Table 3.2 Electrical Specifications (continued)

| V _{DD} = 3V to 3.6V, T _A = 0°C to 85°C, all Typical values at T _A = 27°C unless otherwise noted. | | | | | | |
|---------------------------------------------------------------------------------------------------------------------------------|-------------------|-----|-----|-----|------|----------------------------------|
| CHARACTERISTIC | SYMBOL | MIN | TYP | MAX | UNIT | CONDITIONS |
| Clock/Data Rise time | t _{RISE} | | | 300 | ns | Min = 20+0.1C _{LOAD} ns |
| Capacitive Load | C _{LOAD} | | | 400 | pF | per bus line |

Chapter 4 Communications

The CAP1214 communicates via the SMBus or I²C communications protocols.

APPLICATION NOTE: Upon power up, the CAP1214 will not respond to any SMBus communications until “time to communications” has elapsed (see Table 3.2, “Electrical Specifications”). After this time, full functionality is available.

4.1 System Management Bus Protocol

The CAP1214 communicates with a host controller, such as an SMSC SIO, through the SMBus. The SMBus is a two-wire serial communication protocol between a computer host and its peripheral devices. A detailed timing diagram is shown in Figure 4.1. Stretching of the SMCLK signal is supported; however, the CAP1214 will not stretch the clock signal.

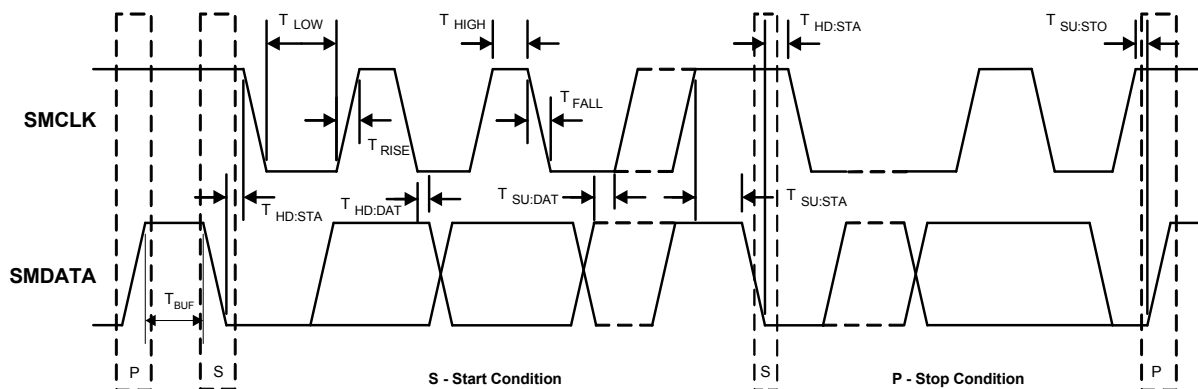


Figure 4.1 SMBus Timing Diagram

4.1.1 SMBus Start Bit

The SMBus Start bit is defined as a transition of the SMBus Data line from a logic ‘1’ state to a logic ‘0’ state while the SMBus Clock line is in a logic ‘1’ state.

4.1.2 SMBus Address and RD / $\overline{\text{WR}}$ Bit

The SMBus Address Byte consists of the 7-bit client address followed by the RD / $\overline{\text{WR}}$ indicator bit. If this RD / $\overline{\text{WR}}$ bit is a logic ‘0’, the SMBus Host is writing data to the client device. If this RD / $\overline{\text{WR}}$ bit is a logic ‘1’, the SMBus Host is reading data from the client device.

The CAP1214 responds to the slave address 0101_000xb. Multiple addressing options are available. For more information contact SMSC.

4.1.3 SMBus Data Bytes

All SMBus Data bytes are sent most significant bit first and composed of 8-bits of information.

4.1.4 SMBus ACK and NACK Bits

The SMBus client will acknowledge all data bytes that it receives. This is done by the client device pulling the SMBus Data line low after the 8th bit of each byte that is transmitted. This applies to both the Write Byte and Block Write protocols.

The Host will NACK (not acknowledge) the last data byte to be received from the client by holding the SMBus data line high after the 8th data bit has been sent. For the Block Read protocol, the Host will ACK each data byte that it receives except the last data byte.

4.1.5 SMBus Stop Bit

The SMBus Stop bit is defined as a transition of the SMBus Data line from a logic '0' state to a logic '1' state while the SMBus clock line is in a logic '1' state. When the CAP1214 detects an SMBus Stop bit, and it has been communicating with the SMBus protocol, it will reset its client interface and prepare to receive further communications.

4.1.6 SMBus Time-out

The CAP1214 includes an SMBus time-out feature. Following a 30ms period of inactivity on the SMBus where the SMCLK pin is held low, the device will time-out and reset the SMBus interface.

The time-out function defaults to disabled. It can be enabled by setting the TIMEOUT bit in the Configuration register (see [Section 6.14](#)).

4.1.7 SMBus and I²C Compliance

The major differences between SMBus and I²C devices are highlighted here. For complete compliance information, refer to the SMBus 2.0 specification.

1. Minimum frequency for SMBus communications is 10kHz. There is no minimum frequency for I²C.
2. For SMBus communications, the client protocol will reset if the clock is held low longer than 30ms.
3. For SMBus communications, the client protocol will reset if both the clock and the data line are high for longer than 400us (idle condition).
4. I²C devices do not support the Alert Response Address functionality (which is optional for SMBus).
5. I²C devices support block read and write differently. I²C protocol allows for unlimited number of bytes to be sent in either direction. The SMBus protocol requires that an additional data byte indicating number of bytes to read / write is transmitted.

Note: The CAP1214 supports the I²C block read and write only.

4.2 SMBus Protocols

The CAP1214 is SMBus 2.0 compatible and supports Send Byte, Read Byte, Block Read, Receive Byte as valid protocols as shown below. The CAP1214 also supports the I²C block read and block write protocols.

All of the below protocols use the convention in [Table 4.1](#).

Table 4.1 Protocol Format

| DATA SENT TO DEVICE | DATA SENT TO THE HOST |
|---------------------|-----------------------|
| Data sent | Data sent |

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4.2.1 SMBus Write Byte

The Write Byte is used to write one byte of data to a specific register as shown in [Table 4.2](#).

Table 4.2 Write Byte Protocol

| START | CLIENT ADDRESS | WR | ACK | REGISTER ADDRESS | ACK | REGISTER DATA | ACK | STOP |
|-------|----------------|----|-----|------------------|-----|---------------|-----|--------|
| 1 ->0 | 0101_000 | 0 | 0 | XXh | 0 | XXh | 0 | 0 -> 1 |

4.2.2 Block Write

The Block Write is used to write multiple data bytes to a group of contiguous registers as shown in [Table 4.3](#). It is an extension of the Write Byte Protocol.

APPLICATION NOTE: When using the Block Write protocol, the internal address pointer will be automatically incremented after every data byte is received. It will wrap from FFh to 00h.

Table 4.3 Block Write Protocol

| START | CLIENT ADDRESS | WR | ACK | REGISTER ADDRESS | ACK | REGISTER DATA | ACK |
|---------------|----------------|---------------|-----|------------------|---------------|---------------|--------|
| 1 ->0 | 0101_000 | 0 | 0 | XXh | 0 | XXh | 0 |
| REGISTER DATA | ACK | REGISTER DATA | ACK | ... | REGISTER DATA | ACK | STOP |
| XXh | 0 | XXh | 0 | ... | XXh | 0 | 0 -> 1 |

4.2.3 SMBus Read Byte

The Read Byte protocol is used to read one byte of data from the registers as shown in [Table 4.4](#).

Table 4.4 Read Byte Protocol

| START | CLIENT ADDRESS | WR | ACK | REGISTER ADDRESS | ACK | START | CLIENT ADDRESS | RD | ACK | REGISTER DATA | NACK | STOP |
|-------|----------------|----|-----|------------------|-----|-------|----------------|----|-----|---------------|------|--------|
| 1->0 | 0101_000 | 0 | 0 | XXh | 0 | 1 ->0 | 0101_000 | 1 | 0 | XXh | 1 | 0 -> 1 |

4.2.4 Block Read

The Block Read is used to read multiple data bytes from a group of contiguous registers as shown in [Table 4.5](#). It is an extension of the Read Byte Protocol.

APPLICATION NOTE: When using the Block Read protocol, the internal address pointer will be automatically incremented after every data byte is received. It will wrap from FFh to 00h.

Table 4.5 Block Read Protocol

| START | CLIENT ADDRESS | WR | ACK | REGISTER ADDRESS | ACK | START | CLIENT ADDRESS | RD | ACK | REGISTER DATA |
|-------|----------------|-----|---------------|------------------|---------------|-------|----------------|---------------|------|---------------|
| 1->0 | 0101_000 | 0 | 0 | XXh | 0 | 1->0 | 0101_000 | 1 | 0 | XXh |
| ACK | REGISTER DATA | ACK | REGISTER DATA | ACK | REGISTER DATA | ACK | ... | REGISTER DATA | NACK | STOP |
| 0 | XXh | 0 | XXh | 0 | XXh | 0 | ... | XXh | 1 | 0->1 |

4.2.5 SMBus Send Byte

The Send Byte protocol is used to set the internal address register pointer to the correct address location. No data is transferred during the Send Byte protocol as shown in [Table 4.6](#).

Table 4.6 Send Byte Protocol

| START | CLIENT ADDRESS | WR | ACK | REGISTER ADDRESS | ACK | STOP |
|-------|----------------|----|-----|------------------|-----|------|
| 1->0 | 0101_000 | 0 | 0 | XXh | 0 | 0->1 |

4.2.6 SMBus Receive Byte

The Receive Byte protocol is used to read data from a register when the internal register address pointer is known to be at the right location (e.g. set via Send Byte). This is used for consecutive reads of the same register as shown in [Table 4.7](#).

Table 4.7 Receive Byte Protocol

| START | CLIENT ADDRESS | RD | ACK | REGISTER DATA | NACK | STOP |
|-------|----------------|----|-----|---------------|------|------|
| 1->0 | 0101_000 | 1 | 0 | XXh | 1 | 0->1 |

Chapter 5 Product Description

The CAP1214 is a multiple channel Capacitive Touch sensor and LED Driver.

The CAP1214 has up to 14 individual Capacitive Touch sensor inputs with programmable sensitivity for use in touch button and slider switch applications. Each sensor input includes automatic recalibration.

The CAP1214 also has eleven (11) open drain LED drivers that offer full-on / off, variable rate breathing, and dimness controls. Eight (8) of these LEDs can double as GPIOs and support open-drain or push-pull operation. Additionally, LEDs 1-7 may be optionally linked to Buttons 1-7 so that when a touch is detected, the LED is actuated.

The device communicates with a host controller using SMBus. The host controller may poll the device for updated information at any time or it may configure the device to flag an interrupt whenever a press is detected on any sensor.

Each sensor input is polled by the device approximately every 35 ms. The host may also initiate a recalibration routine for one or more sensor inputs or set up times and conditions so that the device automatically invokes the re-calibration routine.

The CAP1214 contains multiple power states including several low power operating states. In addition, it contains a user driven RESET pin.

A typical system diagram is shown in [Figure 5.1](#).

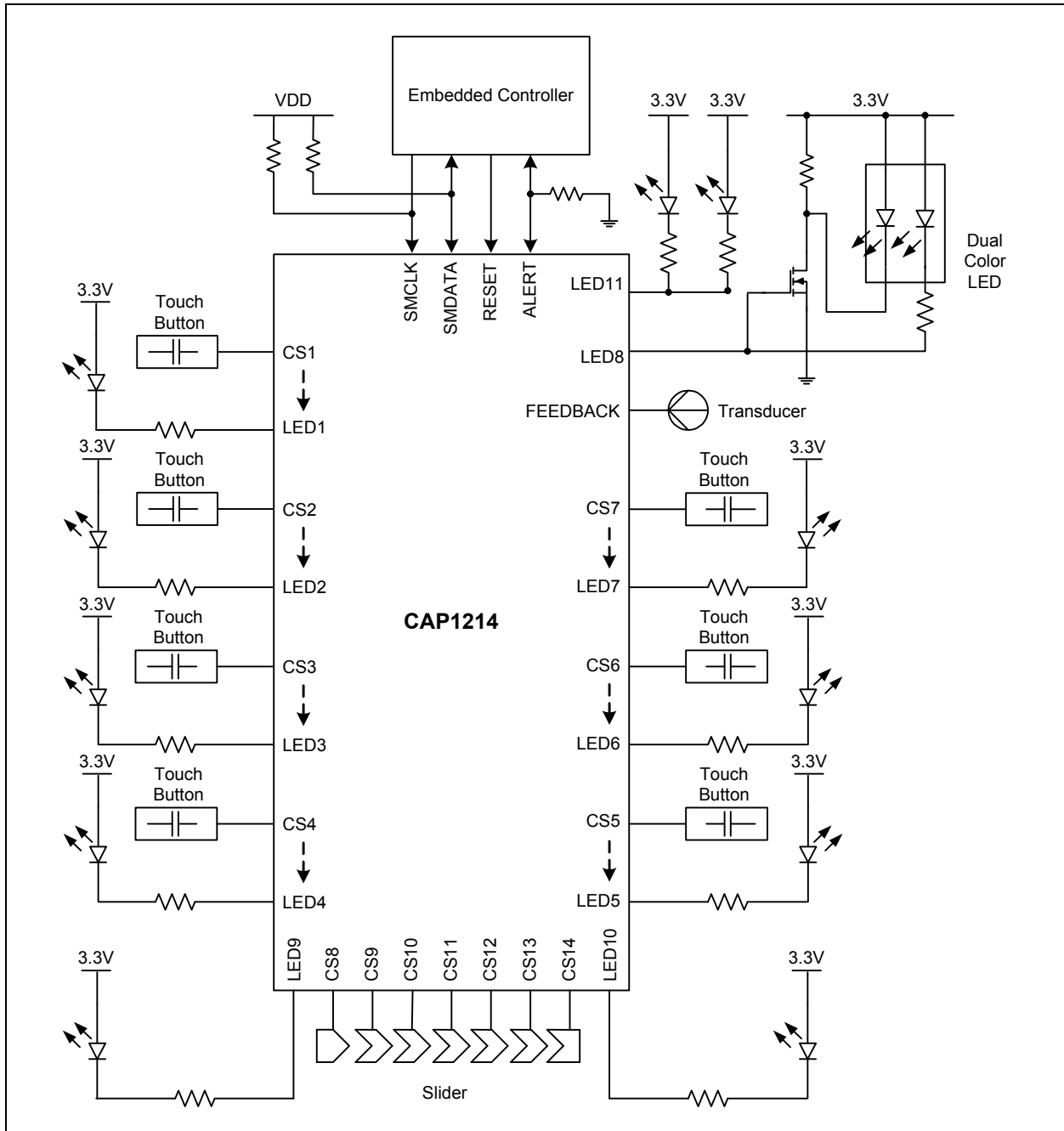


Figure 5.1 System Diagram for CAP1214

5.1 Power States

The CAP1214 has four operating states depending on the status of the SLEEP, DEACT, and DSLEEP bits (see Section 6.1). They are described below and summarized in Table 5.1. When the device transitions between power states, previously detected touches (for deactivated channels) are cleared and the status bits reset.

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1. Fully Active - The device is monitoring all active Capacitive Sensor channels and driving all LED channels as defined.
2. Sleep - The device is monitoring a limited number of Capacitive Sensor channels (default 0). Interrupts will still be generated based on the active channels. The device will still respond to SMBus commands normally and can be returned to the Fully Active state by clearing the SLEEP bit. The LED11 channel is controlled via the PWR_LED control (see [Section 6.1](#)). All other LEDs will not be affected.
3. Deep Sleep - The device is not monitoring any Capacitive Sensor channels. The LED11 channel is controlled via the PWR_LED control (see [Section 6.1](#)). All other LEDs will be driven to their programmed non-actuated state and no PWM operations will be done.

When the device enters the Deep Sleep state, it will release control to the ALERT pin and will change the direction of the ALERT pin (i.e. the device will monitor the ALERT pin instead of driving it).

APPLICATION NOTE: When the device enters the Deep Sleep state, the Slider Position / Volumetric Data Register (06h) is cleared, if the register is set to represent position data.

The device has two methods to exit the Deep Sleep state. They are:

- a. The ALERT pin is driven to its active state.
- b. Any SMBus communications are directed at the device.

When the device leaves the Deep Sleep state, it automatically returns to its previously defined state and clears the DSLEEP bit.

4. Inactive - The device is not monitoring any Capacitive Sensor channels. The device will still respond to SMBus commands normally and can be returned to Fully Active state by clearing the DEACT bit. All LEDs will have PWM controls suspended so they should be disabled prior to entering this state. If these LEDs are not disabled, the system will show excess current draw from these LEDs.

Table 5.1 Power States

| POWER STATE | INACTIVE | SLEEP | DSLEEP |
|-----------------------------------|----------|-------|--------|
| Fully Active | 0 | 0 | 0 |
| Deep Sleep waking to Fully Active | 0 | 0 | 1 |
| Sleep | 0 | 1 | 0 |
| Deep Sleep waking to Sleep | 0 | 1 | 1 |
| Inactive | 1 | 0 | 0 |
| Deep Sleep waking to Inactive | 1 | 0 | 1 |
| Inactive | 1 | 1 | 0 |
| Deep Sleep waking to Inactive | 1 | 1 | 1 |

The priority of power control signals is:

1. DSLEEP - when set, will override DEACT and disable all LEDs except LED11.
2. DEACT - when set, will override the SLEEP controls. It will disable sensor measurement and all LEDs.
3. SLEEP - when set, will enable Sleep state.

5.2 RESET Pin

The RESET pin is an active high reset that is driven from an external source. The pin contains an internal delay timer (t_{RST_FILT}) that will block errant glitches on the RESET pin. The RESET pin must be driven high or low longer than this time before the CAP1214 will react to the pin state.

While the RESET pin is held high, all the internal blocks will be held in reset including the SMBus. All configuration settings will be reset to default states and all readings will be cleared. Furthermore, the device will be held in Deep Sleep that can only be removed by driving the RESET pin low.

Once the RESET pin is pulled low, the CAP1214 will begin operation as if a power-on-reset had occurred. When this happens, the RESET bit will be set and an interrupt will be generated.

5.3 LED Drivers

The CAP1214 contains eleven (11) LED Drivers. Each LED Driver is controlled independently of the others. LED drivers 1 - 8 can be configured to operate with either push-pull or open-drain drive (see [Section 6.44, "LED / GPIO Output Type Register"](#)) and may also be configured to operate as GPIOs (see [Section 6.43, "LED / GPIO Direction Register"](#)). LED drivers 9 - 11 will only operate as open-drain drivers.

LEDs 1 - 7 and 9 and 10 may be linked to the corresponding Capacitive Touch Sensor input (see [Section 6.50, "Sensor LED Linking Register"](#)) so they can be actuated by a touch. When not linked to sensor inputs, LEDs can be actuated by the host (see [Section 6.46, "LED Output Control Registers"](#)).

When actuated, the LED drivers operate using one of the following behaviors (see [Section 6.51, "LED Behavior Registers"](#)):

1. Direct - The LED is configured to be on or off when the corresponding input stimulus is on or off (or inverted). The brightness of the LED can be programmed from full off to full on (default). Additionally, the LED contains controls to individually configure ramping on, off, and turn-off delay.
2. Pulse 1 - The LED is configured to "Pulse" (transition ON-OFF-ON) a programmable number of times with programmable rate and min / max brightness. The LED can be configured to be actuated upon a touch detection (or when hosts sets drive bit) or release detection (or when host clears drive bit) (see [Section 6.52, "LED Pulse 1 Period Register"](#)).
3. Pulse 2 - The LED is configured to "Pulse" while actuated and then "Pulse" a programmable number of times with programmable rate and min / max brightness when the sensor is released.
4. Breathe - The LED is configured to transition ON-OFF-ON (i.e. to "Breathe") continuously (or with a programmed off delay) with a programmable rate and min / max brightness.

When an LED is not linked to a sensor and is actuated by the host, there's an option to assert the ALERT pin when the LED has completed its behavior (see [Section 6.55, "LED Configuration Register"](#)).

LED11 operates differently than the other LED outputs in several ways. It is configured to drive up to two external LED channels simultaneously. It is not automatically disabled during the Sleep or Deep Sleep states of operation (see [Section 6.1, "Main Status Control Register"](#)). It allows for different behaviors when the device is in Fully Active state versus when the device is in Sleep or Deep Sleep state. It can drive at a different PWM frequency.

5.3.1 Linking LEDs to Capacitive Touch Sensors

LEDs 1 - 7 can be optionally linked to Capacitive Touch Sensors 1-7 so that when the sensor detects a button press, the corresponding LED will be actuated at one of the programmed responses.

LEDs 9 and 10 may be optionally linked to the Grouped Sensors to indicate a slide / tap / press and hold in the "Up" or "Down" directions.