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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

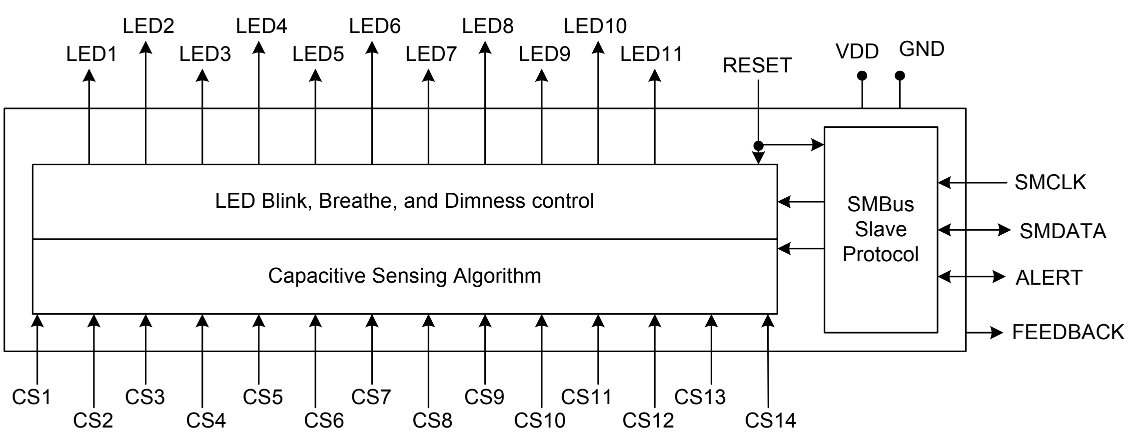
- Consumer Electronics
- Desktop and Notebook PCs
- LCD Monitors

1. SMSC and the SMSC logo are registered trademarks and SMSC RightTouch is a trademark of Standard Microsystems Corporation ("SMSC").

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

Block Diagram



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.smsc.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

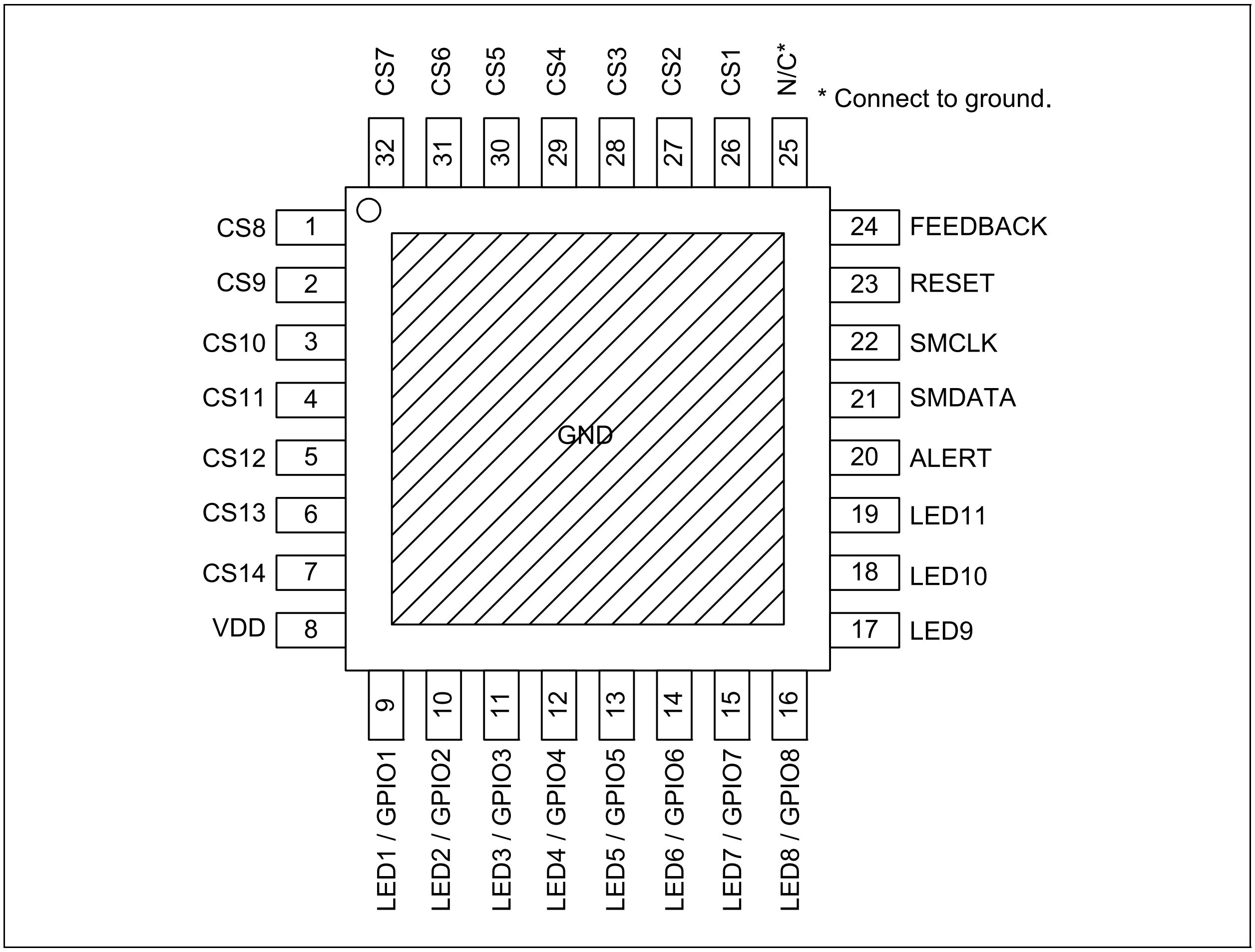

Figure 1.1 CAP1214 Pin Diagram (32-Pin QFN)

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

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 VDD + 0.3	V
Package Power Dissipation up to T_A = 85°C (see Note 3.2)	1	W
Junction to Ambient (θ_{JA}) (see Note 3.3)	48	°C/W
Operating Ambient Temperature Range	-40 to 125	°C
Storage Temperature Range	-55 to 150	°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} = 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**
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	uA	Sleep state active, 1 sensor monitored; LED11 inactive T_A < 85°C
	I_{DSLEEP}		4.5	15	uA	Deep Sleep, LED 11 inactive T_A < 40°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

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 TA < 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.

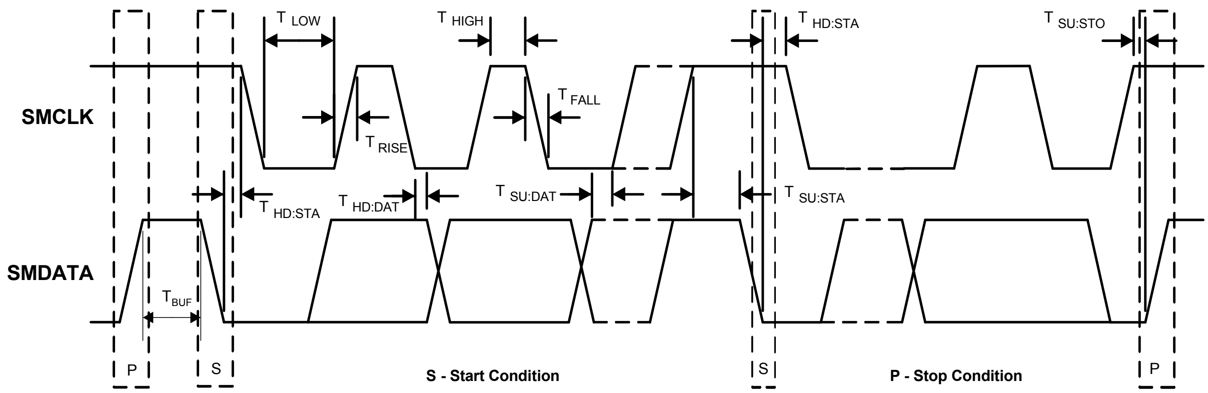

Figure 4.1 SMBus Timing Diagram

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 I^2C Compliance

The major differences between SMBus and I^2C 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 I^2C.
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. I^2C devices do not support the Alert Response Address functionality (which is optional for SMBus).
5. I^2C devices support block read and write differently. I^2C 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 I^2C 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 I^2C 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

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.

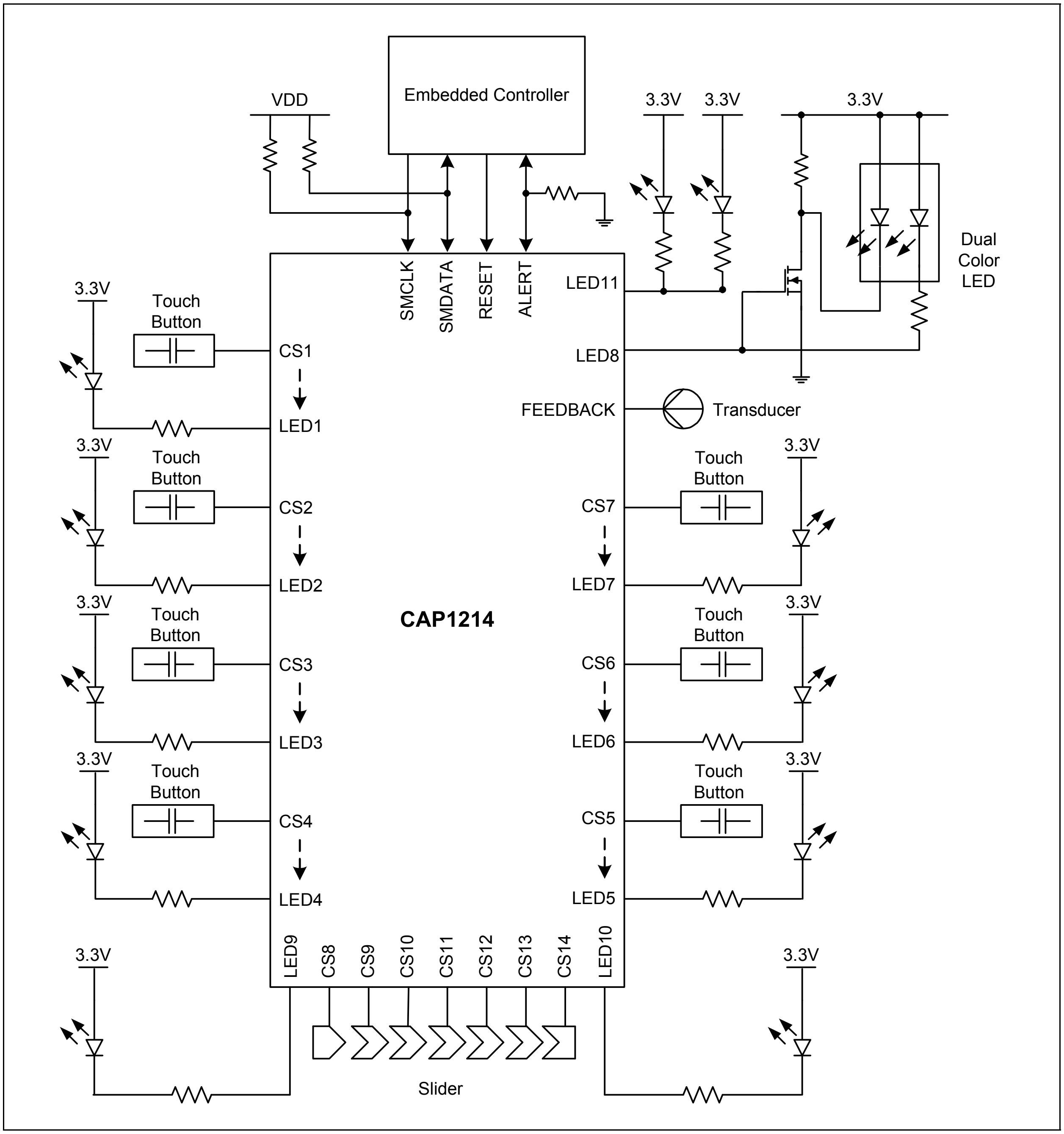

Figure 5.1 System Diagram for CAP1214

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.

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.