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LDS6200 Family

PureTouch®* Low Channel Capacitive Touch Sensor IC Family

FEATURES

- o **Up to 8 touch sensor channels**
  - o **2ms update rate per active sensor input****
- o **Built-in Slider/Scroll Support**
- o **Configurable hysteresis and debounce**
- o **Touch Preference Modes**
- o **1.65-5.5v supply voltage**
- o **Low touch sensor operating power**
  - o **Full power mode (typ): <125uW*****
  - o **Optional low power mode**
- o **On-chip automatic calibration algorithm**
- o **I²C compatible serial I/F with VDDIO**
- o **Power on touch detection**
- o **Configurable for proximity sensing**
- o **GPIO and interrupt output**
- o **3mm x 3mm 16-pin and 20-pin TQFN packages**
  - o **SOIC packages also available**

APPLICATIONS

- o **Mobile handsets, personal media players**
- o **Portable navigation devices**
- o **Remote controls**
- o **Office equipment, multi-function printers**
- o **Set top boxes**
- o **Home appliances**
- o **Brown goods**
- o **Industrial controls**

DESCRIPTION

The LDS6200 Family of capacitive touch controllers enables streamlining of the human-machine interface through the implementation of touch-based user inputs such as touch buttons, sliders, and scroll wheels. Employing a finely tuned sigma-delta capacitance-to-digital converter and proprietary noise-filtering algorithms, each device is able to reliably sense small changes in capacitance, allowing touch-based inputs to replace a side variety of mechanical input types. On-chip automatic calibration accounts for environmental changes such as temperature, humidity, and dust and is executed automatically.

The LDS6200 Family consists of four products with up to 8 capacitive sensor input pins.

| Part #	Touch Sensors	Package
LDS6201	Up to 2	16ld TQFN
LDS6202	Up to 4	16ld SOIC
LDS6203	Up to 6	20ld TQFN
LDS6204	Up to 8	20ld SOIC

The LDS6200 Family supports touch sensor supply voltages from 1.65 to 5.5V. All parts support I²C compatible serial interfaces and offer both a General Purpose I/O (GPIO) and VDDIO support, enabling 1.65V to 5.5V voltage interface support. Typical touch sensor operating power for the device is less than 125uW***. Package offerings include thin form factor 3mm x 3mm 16-pin TQFN, 3mm x 3mm 20-pin TQFN, 3.9mm x 9.9mm 16-pin SOIC, 7.5mm x 12.8mm 20-pin SOIC.

* PureTouch is a registred trademark of IDT
** Nominal decimation rate (d=1024), per sensor input
*** 1.8V, excluding VDDIO current, which varies with VDDIO voltage, I/F type, and communication frequency

LDS6200 Family

TYPICAL APPLICATION CIRCUIT FOR DUAL SUPPLY VOLTAGES
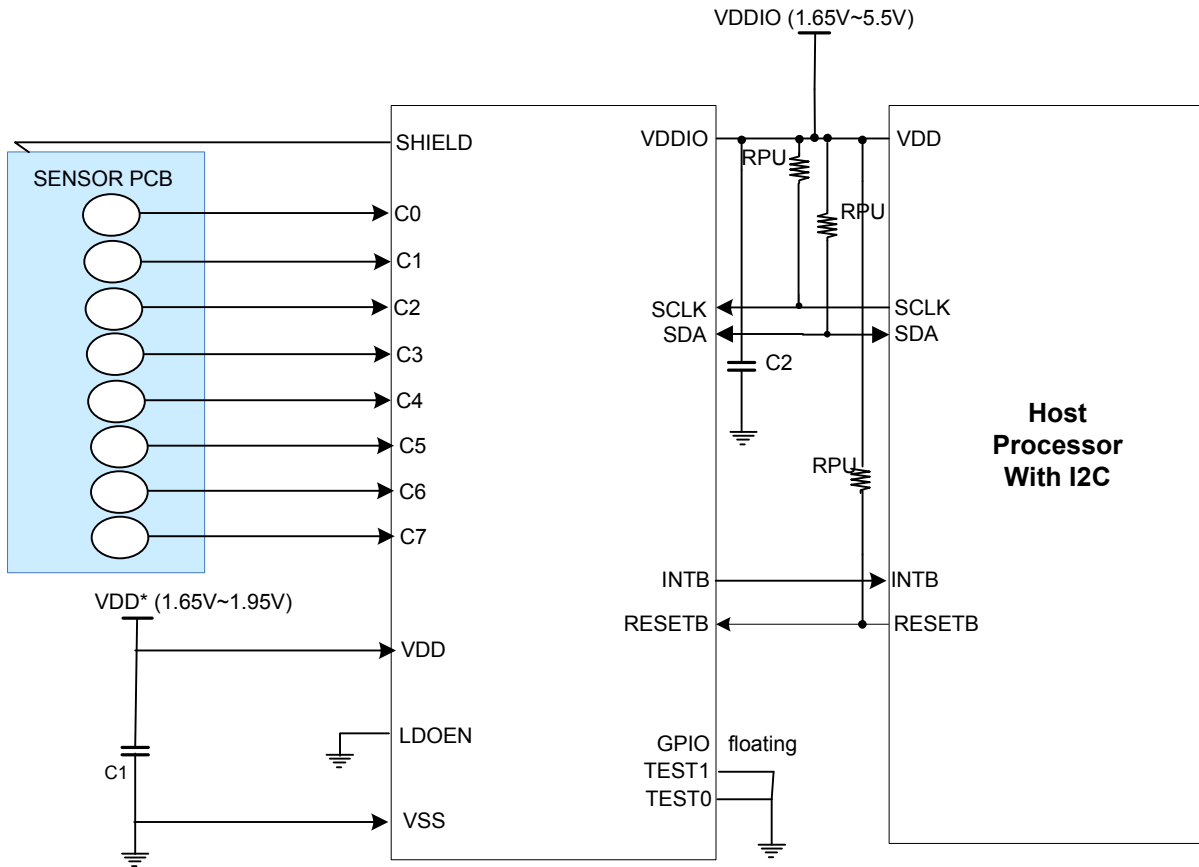
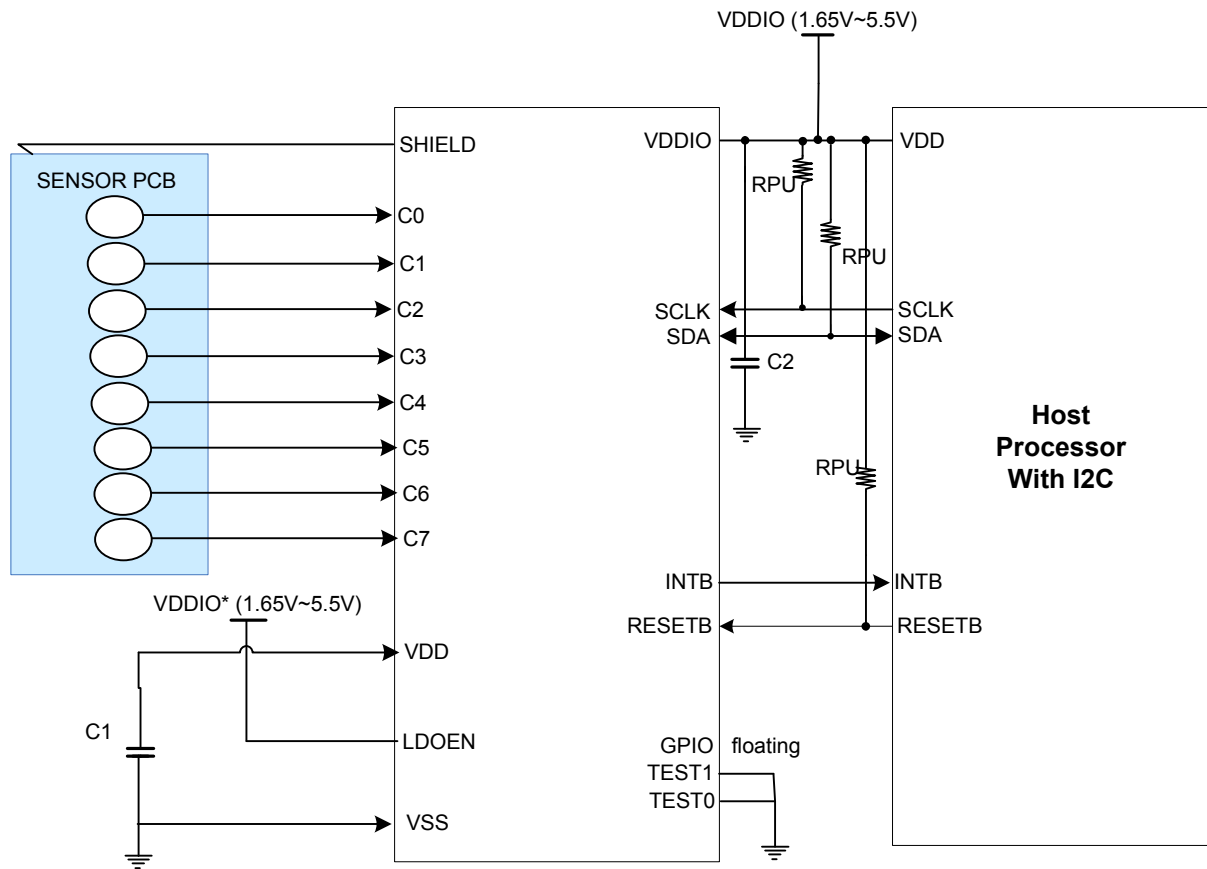C1, C2 > 1uF

*For direct application of 1.8V voltage.

Figure 1: Application Circuit with I²C I/F using dual voltage sources

LDS6200 Family

TYPICAL APPLICATION CIRCUIT FOR SINGLE SUPPLY VOLTAGE

C1, C2 > 1uF
*For voltages >1.95V, apply voltage to VDDIO and tie VDD to ground through C1

Figure 2: Application Circuit with I²C I/F using single voltage source

LDS6200 Family

ABSOLUTE MAXIMUM RATINGS

Item	Symbol	Rating	Unit
Touch Sensor Supply Voltage	VDD	-0.3 to +6.0	V
Serial Interface Operating Voltage	VDDIO	-0.3 to +6.0	V
Input voltage range (Digital)	VIN	-0.3 to VDDIO +0.3	V
Input voltage range (Analog)	AVIN	-0.3 to VDD +0.3	V
Output voltage range (Digital)	VOH	-0.3 to VDDIO +0.3	V
Output voltage range (Analog)	AVOH	-0.3 to VDD +0.3	V
Operating Temperature Range	T_{OPR}	-40 to +85	℃
Storage Temperature Range	T_{STG}	-55 to +125	℃

ESD PROTECTION LEVEL

Model	Test condition	Rating	Unit
Human Body Model	C = 100pF, R = 1.5kΩ	8000	V
Charge Device Model	Charging Resistor = 300MΩ	1500	V
Machine Model	C = 200pF, R = 0Ω	400	V

RECOMMENDED OPERATING CONDITIONS

Parameter	Condition	Unit
VDD*	1.65 to 1.95	V
VDDIO	1.65 to 5.5	V
Ambient Temperature Range	-40 to +85	℃

* For supply voltages >1.95V, apply to VDDIO pin and tie VDD pin to GND through C1
Typical application circuit shown on page 3

ELECTRICAL OPERATING CHARACTERISTICS

VDD = 1.8V, VDDIO = 1.8V T_{AMB} = -40℃ to +85℃ unless otherwise specified

Parameter	Symbol	Conditions	Related Pins	Min	Typ	Max	Unit
Power & Operating Voltage		-					
Operating Voltage(1) : Touch*	VDD	-	VDD	1.65	1.8	1.95	V
Operating Voltage(3) : Touch - I/O	VDDIO	-	VDDIO	1.65	-	5.5	V
Logic Inputs							
High Level Input Voltage	VIH	-	(*1)	0.7*VDDIO			V
Low Level Input Voltage	VIL	-	(*1)	VSS		0.3*VDDIO	V
Input Leakage Current	IIL	VIN= VDDIO or VSS	(*1)	-1			uA
Logic Outputs							
High Level Output Voltage	VOH	IOH= -1mA	(*2)	0.8*VDDIO			V
Low Level Output Voltage	VOL	IOL= +1mA	(*2)			0.2*VDDIO	V
Capacitance-to-Digital Converter							
CDC Update Rate per Active Sensor	Tcdc	(*3)		1.95	2.05	2.15	ms
CIN Input Leakage	IILcin	IOH= -1mA	C0~Cx				nA
Sensor Capacitance	Csensor					25 (*4)	pF

* For supply voltages >1.95V, apply to VDDIO pin, set LDOEN to logic high, and tie VDD1 pin to GND through C1
Typical application circuits shown on page 2 and 3

NOTE: (*1): SCLK, SDA, GPIO; (*2): SDA, INTB, GPIO; (*3) DECIMATION RATE = 1024, PER UTILIZED SENSOR; (*4): MAXIMUM SENSOR CAPACITANCE MAY BE ALLOWED TO EXCEED 25PF DEPENDING UPON SYSTEM CONDITIONS – CONTACT IDT FOR EXCEPTION CONDITIONS

ELECTRICAL OPERATING CHARACTERISTICS (CURRENT CONSUMPTION)

VDD = 1.8V, VDDIO = 1.8V, T_{AMB} = -40°C to 85°C unless otherwise specified

Parameter	Symbol	Conditions	Related Pins	Min	Typ	Max	Unit
Current Consumption							
Full Power Mode	Iddfp				55	100	uA
Sleep Mode	Iddsl				17		uA
Shutdown, T_{AMB} = 25°C	Iddsd	T_{AMB} = 25°C			0.5	5	uA
Shutdown	Iddsd	T_{AMB} = -40°C to +85°C				10	uA

LDS6200 Family

I²C-COMPATIBLE TIMING SPECIFICATIONS

For VDD = 1.65-1.95V, VDDIO = 1.65V to 5.5V, over ambient temperature range -40ºC to +85ºC.

Parameter	Tmin	Tmax	Unit	Description
f_{SCLK}		400	kHz	SCLK clock frequency
t_R		300	ns	Clock/data rise time
t_F		300	ns	Clock/data fall time
$t_{HD:STA}$	0.6		µs	Start condition hold time
t_{SLW}	1.3		µs	Clock low period
t_{SHW}	0.6		µs	Clock high period
$t_{SU:DAT}$	100		ns	Data setup time
$t_{HD:DAT}$	0		ns	Data hold time
$t_{SU:STO}$	0.6		µs	Stop condition setup time
$t_{SU:STA}$	0.6		µs	Start condition setup time
t_{BUF}	1.3		µs	Bus free time between stop and start conditions
t_{SP}		50	ns	Max spike width suppressed by SCLK and SDA inputs
$t_{VD:DAT}$		0.9	µs	Data valid time
$t_{VD:ACK}$		0.9	µs	Data valid acknowledge time
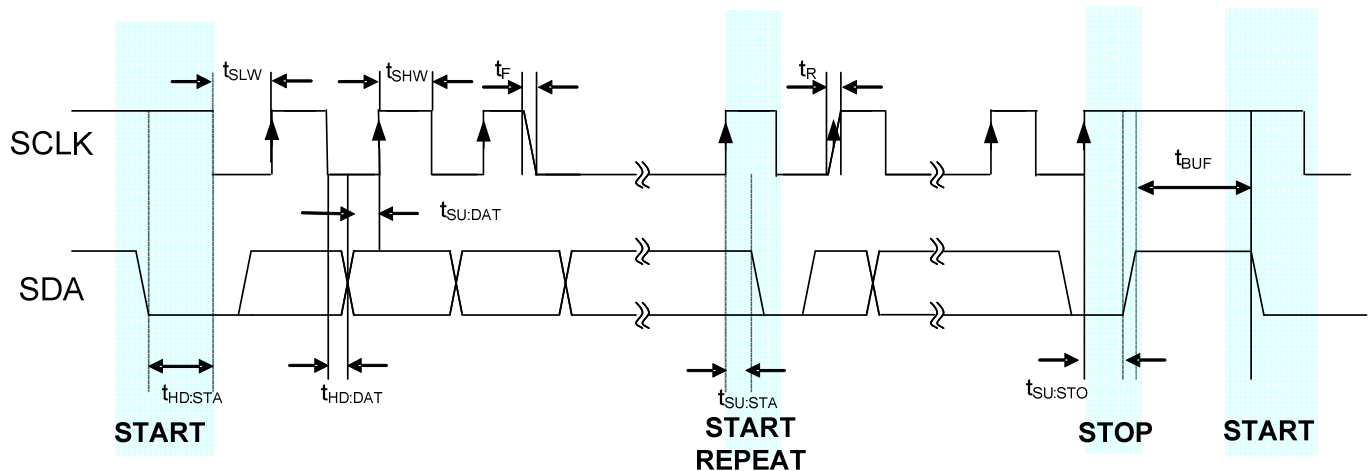
Figure 3: I²C-Compatible Detailed Timing Diagram

LDS6200 Family

WRITING AND READING OVER THE I^{2}C-COMPATIBLE INTERFACE

The LDS6200 Family is always a slave on the I^{2}C interface bus and uses the **7-bit device address of 0101 100**. Data transfer utilizes 8-bit bytes, with the master initiating a data transfer (START) by taking SDA from high-to-low while keeping SCLK high, followed by the 7-bit device address plus a read/write bit dictating the direction of data transfer **(read=1, write=0)**. Data is sent over a series of 9 clock pulses made up of 8 bits of data and an acknowledge bit from the LDS6200 Family. The STOP condition occurs when SDA is taken from low-to-high while keeping SCLK high, upon which the LDS6200 Family resets its address pointer to 0x000 and the serial interface pins enter the idle state. Data must be transitioned when the clock signal is low and remain stable when SCLK is high, as a low-to-high transition on SDA when SCLK is high would be interpreted as a STOP signal.

WRITING DATA OVER I^{2}C

The device address (0101 100) and read/write bit (0 for writing) are sent over the bus, followed by two data bytes containing the 10-bit register address to be written. The upper and lower register address bits are shown below:

MSB / **LSB**

7	6	5	4	3	2	1	0
X	X	X	X	X	X	Register Addr Bit 9	Register Addr Bit 8

MSB / **LSB**

7	6	5	4	3	2	1	0
Register Addr Bit 7	Register Addr Bit 6	Register Addr Bit 5	Register Addr Bit 4	Register Addr Bit 3	Register Addr Bit 2	Register Addr Bit 1	Register Addr Bit 0

The third and fourth data bytes contain the 8 MSBs and LSBs, respectively, to be written to the internal register pointed to by the 10-bit register address.
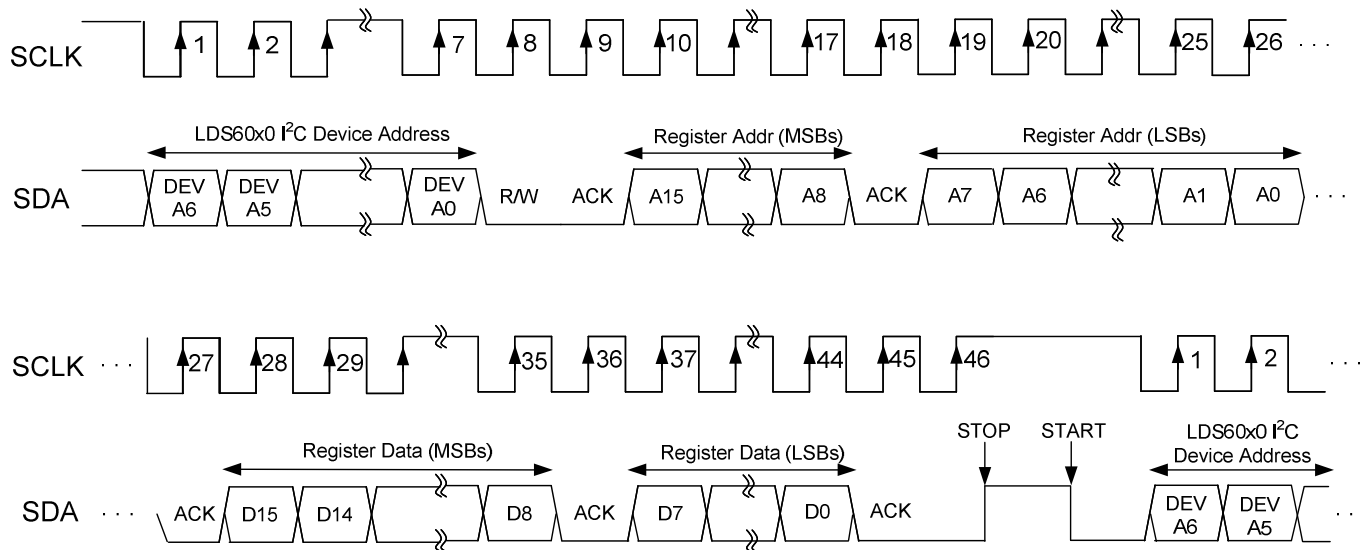

Figure 4: I^{2}C-Compatible Register Write

The LDS6200 Family automatically increments the address pointer enabling sequential writes to registers in the same write transaction. Finishing the transaction involves the master generating a stop condition on SDO or repeat start condition if the I^{2}C link is to remain active.

READING DATA OVER I2C

To initiate a read operation, the master must first write the read starting address to the LDS6200 Family. The device address (0101 100) and read/write bit (0 for initial write of starting address) is sent over the bus, followed by two data bytes that contain the 10-bit register address to be read. The address format is identical to that used during write operations, with only the 10 lower bits of the 16-bit address word containing address information.

The master then either ends the write operation with a STOP signal followed by initiation (START) of a read operation, or more ideally, issues a "REPEAT START" command. In both cases, the read/write bit is set to "1" (see Figure 9 for details of both continuations methods). In either case, the LDS6200 Family provides the MSB eight bits of data first, followed by the LSB eight bits in the next byte.
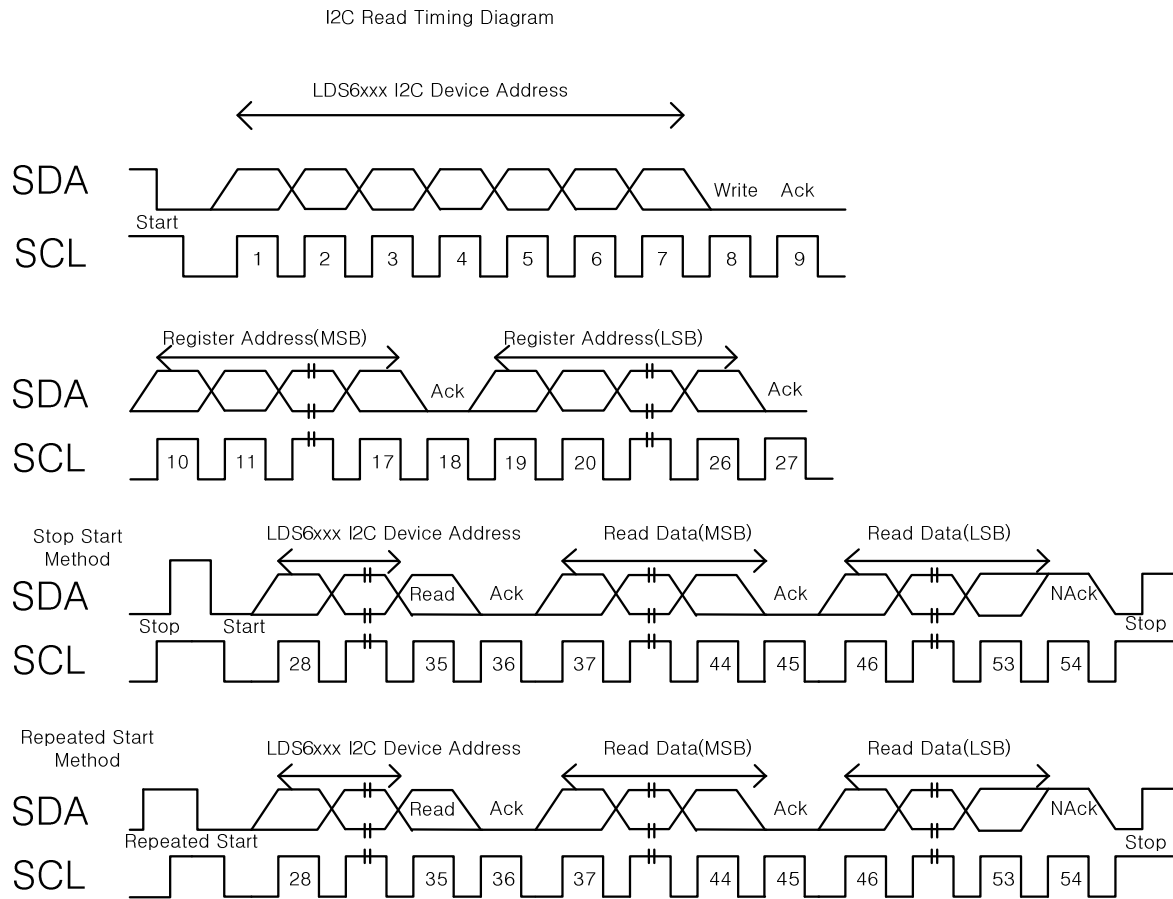
I2C Read Timing Diagram

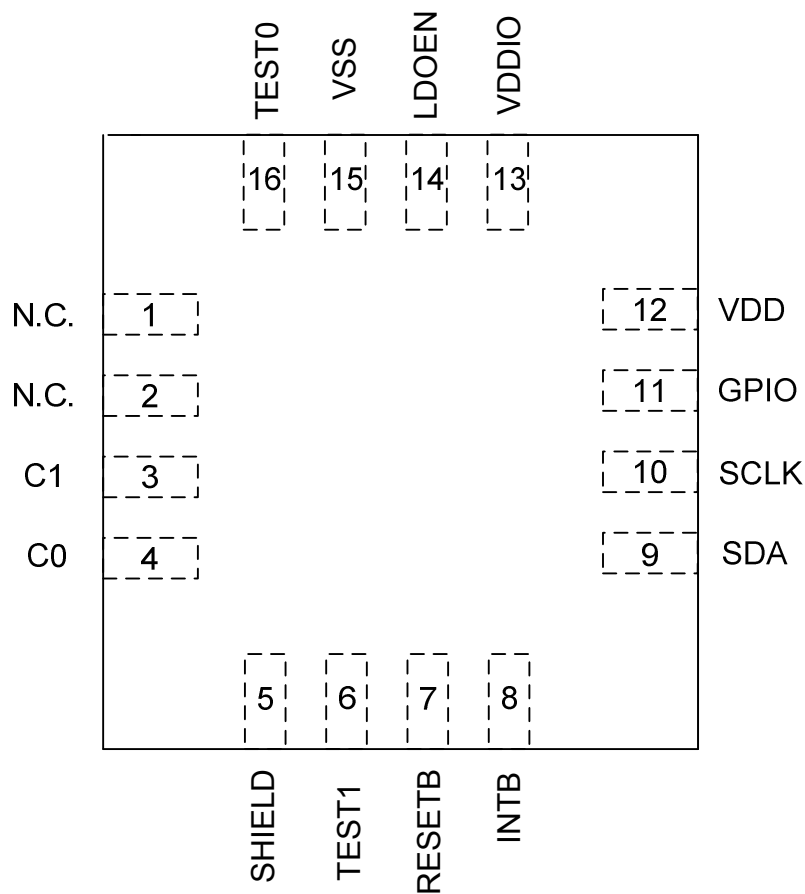*Figure 5: I^2C-Compatible Detailed Timing Diagram*

The LDS6200 Family address pointer automatically increments after each read, resulting in a continuous output of read data until the master returns a no acknowledge (ACK signal high) and stop condition to the bus. If the address pointer reaches its maximum value and the master continues to attempt to read from the part, the LDS6200 Family continues to send data from the last register that was addressed.
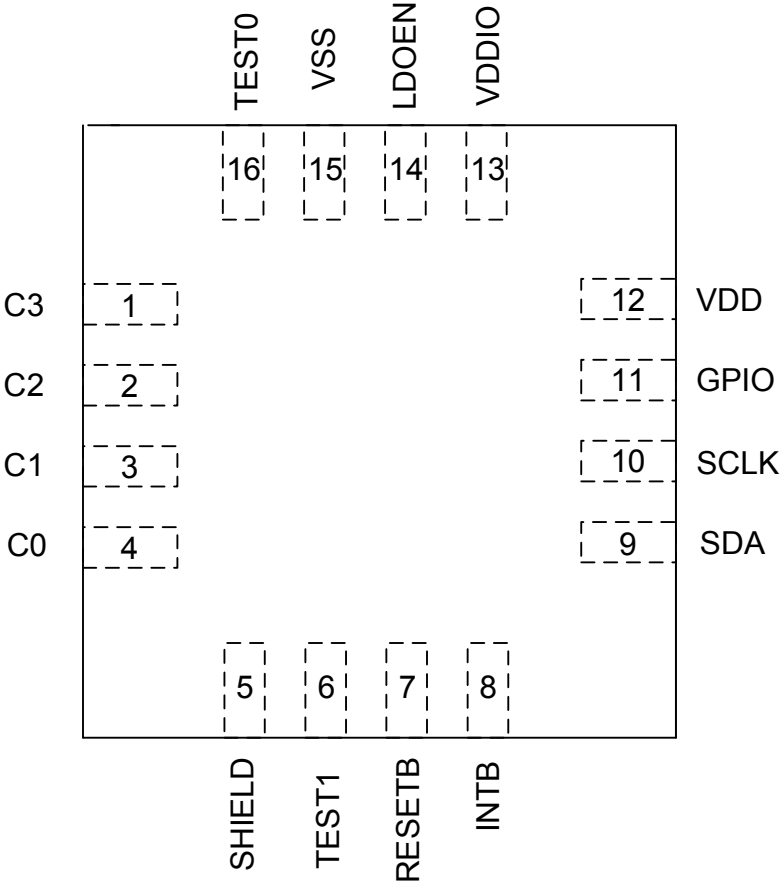
DEVICE PINOUTS (QFN)
LDS6201NTGI
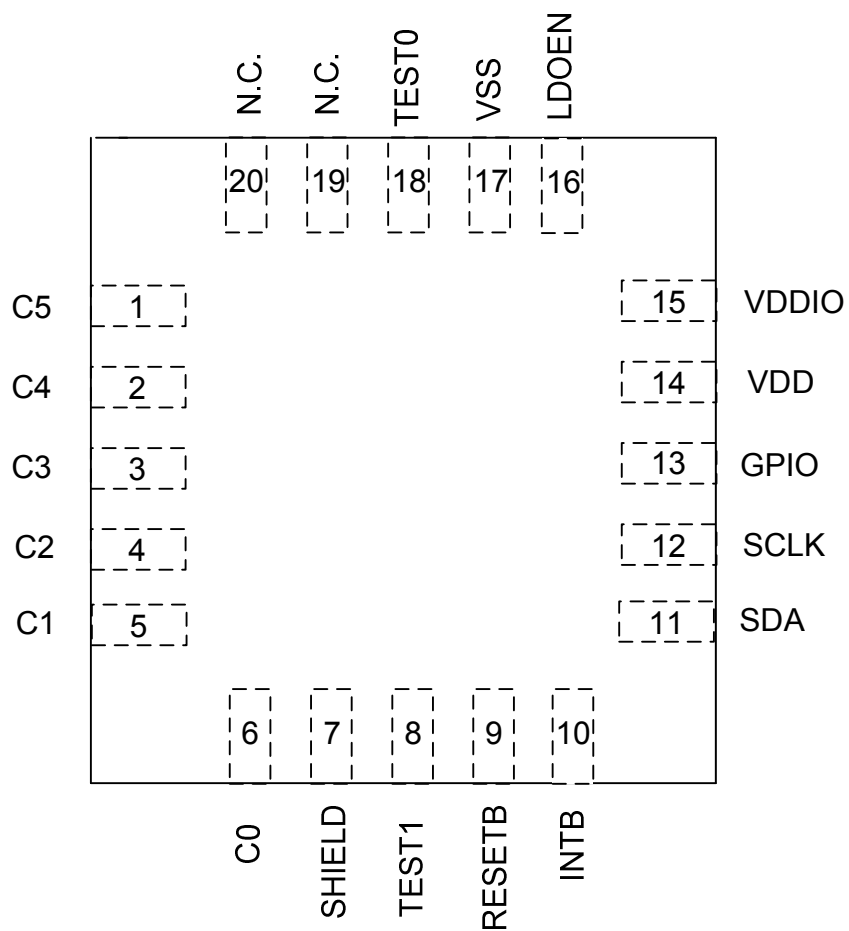
LDS6202NTGI

```
                    TEST0  VSS  LDOEN  VDDIO

                    ┌─16─┐ ┌─15─┐ ┌─14─┐ ┌─13─┐

        C3  ┌─ 1 ─┐                         ┌─ 12 ─┐  VDD

        C2  ┌─ 2 ─┐                         ┌─ 11 ─┐  GPIO

        C1  ┌─ 3 ─┐                         ┌─ 10 ─┐  SCLK

        C0  ┌─ 4 ─┐                         ┌─ 9 ─┐   SDA

                    ┌─ 5 ─┐ ┌─ 6 ─┐ ┌─ 7 ─┐ ┌─ 8 ─┐

                    SHIELD TEST1 RESETB INTB
```

LDS6203NTGI

N.C. 20
N.C. 19
TEST0 18
VSS 17
LDOEN 16

C5 1
C4 2
C3 3
C2 4
C1 5

C0 6
SHIELD 7
TEST1 8
RESETB 9
INTB 10

VDDIO 15
VDD 14
GPIO 13
SCLK 12
SDA 11

LDS6200 Family

LDS6204NTGI
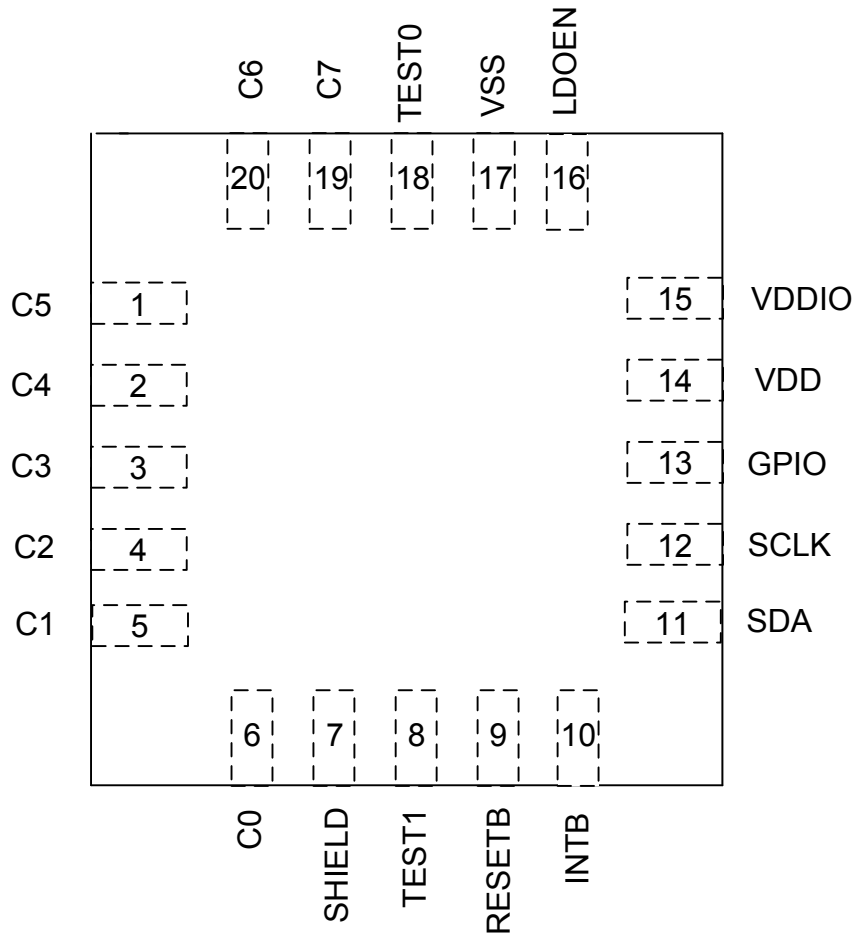
DEVICE PINOUTS (SOIC)

LDS6201DCGI

Pin #1
ID MARK

Left	Pin		Pin	Right
VSS	1		16	LDOEN
TEST0	2		15	VDDIO
N.C.	3		14	VDD
N.C.	4		13	GPIO
C1	5		12	SCLK
C0	6		11	SDA
SHIELD	7		10	INTB
TEST1	8		9	RESETB

LDS6202DCGI

```
                Pin #1
               ID MARK

          VSS ┌───┐ │ 1  +     16 │ ┌───┐ LDOEN
        TEST0 ┌───┐ │ 2        15 │ ┌───┐ VDDIO
           C3 ┌───┐ │ 3        14 │ ┌───┐ VDD
           C2 ┌───┐ │ 4        13 │ ┌───┐ GPIO
           C1 ┌───┐ │ 5        12 │ ┌───┐ SCLK
           C0 ┌───┐ │ 6        11 │ ┌───┐ SDA
       SHIELD ┌───┐ │ 7        10 │ ┌───┐ INTB
        TEST1 ┌───┐ │ 8         9 │ ┌───┐ RESETB
```

LDS6203SOGI

```
                  Pin #1
                  ID MARK

           TEST0  ┌───┐  1  ⊕         20  ┌───┐  VSS
            N.C.  ┌───┐  2             19  ┌───┐  LDOEN
            N.C.  ┌───┐  3             18  ┌───┐  VDDIO
              C5  ┌───┐  4             17  ┌───┐  VDD
              C4  ┌───┐  5             16  ┌───┐  GPIO
              C3  ┌───┐  6             15  ┌───┐  SCLK
              C2  ┌───┐  7             14  ┌───┐  SDA
              C1  ┌───┐  8             13  ┌───┐  INTB
              C0  ┌───┐  9             12  ┌───┐  RESETB
           SHIELD ┌───┐ 10             11  ┌───┐  TEST1
```

LDS6204SOGI

Pin #1
ID MARK

Left	Pin		Pin	Right
TEST0	1		20	VSS
C7	2		19	LDOEN
C6	3		18	VDDIO
C5	4		17	VDD
C4	5		16	GPIO
C3	6		15	SCLK
C2	7		14	SDA
C1	8		13	INTB
C0	9		12	RESETB
SHIELD	10		11	TEST1

LDS6200 Family

PIN LIST and FUNCTIONAL DESCRIPTIONS

| Pin Name	Functional Description
Cx	Dedicated Capacitance Sensor Input
VDD	Touch Sensor Supply Voltage (1.8V nominal, LDO Disabled)
VSS	Touch Sensor Ground
LDOEN	LDO Enable ("0" = LDO Disable, 1.8V applied directly to VDD pin) ("1" = LDO Enable, Supply Voltage Applied to VDDIO)
VDDIO	Touch Sensor Supply Voltage (>1.95V, LDO Enabled) and/or Serial I/F Operating Voltage
SDA	I²C Data I/O
SCLK	I²C Clock Input
GPIO	General Purpose Input Output
INTB	Interrupt Output (CMOS Output)
RESETB	Hardware Reset pin for device (Active low)
SHIELD	CDC Shield. Connect to external shield/plane to reduce stray capacitance.
TEST0	Test pin must be connected to ground
TEST1	Test pin must be connected to ground
N.C.	No Connect **(must be left floating)**

FUNCTIONAL BLOCK DIAGRAM
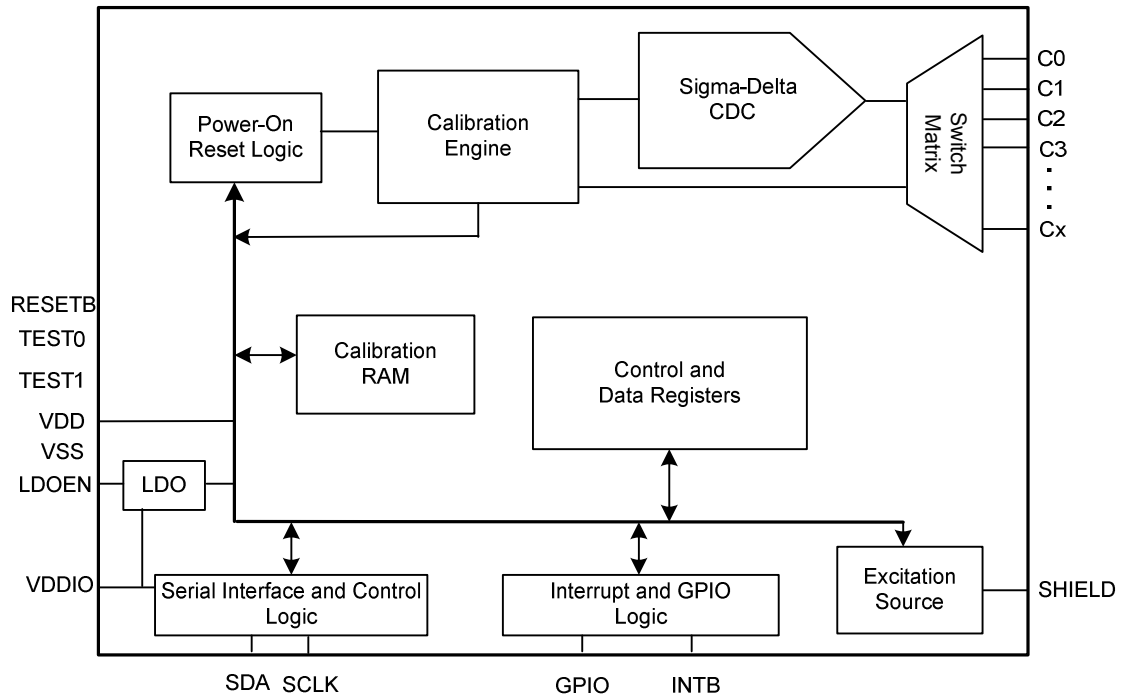
Figure 6: LDS6200 Family Functional Block Diagram

THEORY OF OPERATION

The LDS6200 PureTouch® Family of capacitive touch controllers feature a highly-accurate capacitance-to-digital converter (CDC) for touch button, slider, and scroll applications. Capacitive sensing is accomplished using a sigma-delta converter capable of converting a sensor input signal into a digital output that is compared against a touch/no-touch threshold value to determine if a touch has occurred. The button status and digitized capacitance values are stored in on-chip registers available to a host processor via the I^{2}C or SMBus-compatible serial interface options.

On-chip self-calibration continously takes environmental effects such as temperature, humidity, and dust into consideration to establish an accurate baseline capacitance for each sensor to ensure maximum responsiveness to true touch events.

The LDS6200 Family includes up to 8 sensor input pins, with a programmable switch matrix determining which sensor inputs are connected to the CDC at any given time. The sensor inputs may be connected to external capacitance sensors arranged as buttons, sliders, scroll wheels or other creatively arranged user inputs. Button, slider, and scroll inputs are natively supported using built in logic, with location and direction automatically calculated for slider and scroll inputs.

On-chip registers allow adjustment of the sampling (decimation) rate, threshold/sensitivity for each individual sensor, and hysteresis and debounce characteristics, enabling a very high degree of configurability in scan rate, button sensitivity and overall touch characteristics.

An interrupt output, INTB, is available to notify the host when a touch event has occurred. A GPIO is also available to act as an input to control the INTB output. The GPIO pin may also be configured as an output low or output high pin to turn on and off an external LED.

Due to its ultra-low touch sensor power consumption of <125uW*** (typ), the LDS6200 Family may be operated continuously at full power to achieve the most responsive touch charactersitics and best possible user experience. In this mode, touch sensor detection occurs continuously at very low power levels, eliminating the need for sleep periods between detection cycles that result in touch latency and an inconsistent user experience.

The LDS6200 Family operates with supply voltages ranging from 1.8V to 5.5V. Available package options vary by device and include two thin form factor 3mm x 3mm 16-pin and 3mm x 3mm 20-pin TQFN packages, and 3.9mm x 9.9mm 16-pin or 7.5mm x 12.8mm 20-pin SOIC packages.

*** 1.8V, excluding VDDIO current, which varies with VDDIO voltage, I/F type, and communication frequency

LDS6200 Family

OPERATING MODES

The LDS6200 Family may be programmed to operate in three different modes.

In full power mode, touch detection occurs continuously, without delays between detection cycles. This mode is utilized when the touch inputs need to be fully active and always responsive to touch inputs. Due to its ultra-low touch sensor power consumption of <125uW***, the LDS6200 Family may be operated continuously in full power mode even when battery life is of premium importance.

The device may also be put into a configurable low power mode for situations where a small inserted delay (typically less than 0.3s) between the first touch and touch reporting is acceptable. This optional low power mode can cut power by more than half.

Lastly, the device can be put into Shutdown mode, which disables touch sensing and lowers power consumption to ~1uW (typical). Only the serial interface bus is active during Shutdown mode to receive any commands (such as exit from Shutdown mode).

Two methods of device reset are provided. Software Reset (writing any value to register 0x001) executes a soft reset of the device by initiating a new calibration cycle and resetting the state machine, including the Interrupt Status Register. Previously configured control registers, however, are not affected by a Software Reset, so no reconfiguration or re-initialization need occur.

Hardware Reset (setting RESETB low or writing any value to register 0x000) resets the state machine and all previously configured registers, requiring a re-initialization by the host to set configuration registers to their proper state.

Both Software and Hardware Reset take ~0.5-1s in the typical case to return the device to its fully functioning state. The actual time depends upon the number of active sensors requiring calibration and the relative sensor values. Where start-up time is especially important, fine-tuning of certain configuration registers is possible to expedite initial calibration. Please contact your IDT representative if start-up time optimization is required.

POWER-UP/INITIALIZATION SEQUENCE

The power up and initialization sequence involves the following flow:

Power-Up → Cold Reset Command → Initialize Configuration Registers → Software Reset Command

Initialization of the configuration registers is required to define the functionality of each channel, set touch sensitivity levels, and generally specify the desired configuration of the highly flexible LDS6200 Family touch controller. The Cold Reset and Software Reset Commands are required to ensure consistency of operation before and after the initialization process occurs.

AUTOMATIC CALIBRATION MODE

The LDS6200 Family integrates on-chip sensor calibration to compensate for uncontrollable environmental factors such as moisture and temperature changes. Without such compensation, the baseline "no-touch" value may drift over time, affecting the ability of the device to measure valid touch events. The calibration algorithm is executed after every conversion cycle, ensuring that even rapidly changing ambient conditions are well compensated.

*** 1.8V, excluding VDDIO current, which varies with VDDIO voltage, I/F type, and communication frequency

LOW POWER MODE CONFIGURATION

Low power mode may be utilized when extremely low power consumption is desired and a small amount of added delay/latency is acceptable. By setting Bit 1 of the Power Configuration Register (0x002) to "1", low power mode is activated and the touch controller will alternate between full power sensing and a lower power sleep mode where power is conserved but touches are not sensed.

The amount of power saved is a function of the sleep period time inserted between full power scan cycles. The full power scan cycle time is equal to ~2ms x the number of active sensors. For example, 10 active sensors would result in a full power scan cycle time of ~20ms.

The amount of sleep time inserted occurs in 1ms increments by setting the Sleep Configuration Register (0x056) to the # of milliseconds desired for the sleep cycle. For example, a setting of 50 (decimal) will insert 50ms of sleep time, lowering the average power consumption compared to a continuous full power state. The longer the sleep period added, the lower the average power consumption will be, with the trade-off of longer potential latency between touch and touch recognition

The following tables show that low power mode current consumption is a function of not only the inserted sleep period, but also the number of active sensors. It should also be noted that the greatest power savings benefit is realized when adding the first ~250ms of sleep period (less when fewer sensors are active). When adding sleep periods longer than ~250ms, the resulting reduction in current is relatively minor. Accordingly, the system designer should take into consideration the # of active sensors and incremental power savings when deciding upon the sleep period, as it may not be materially beneficial to insert longer sleep periods.

In an example scenario of 8 active sensors, current consumption may be lowered to ~24uA*** (>60% current reduction) when introducing a relatively brief 100ms of sleep. Adding an additional 150ms of sleep (for 250ms total) only saves an additional 4uA.

Once a touch is detected, the touch controller will remain in full power mode, maximizing touch responsiveness, until a certain amount of time passes without a touch event. The Sleep Wait Register (0x003) specifies the time the controller will remain in full power mode (waiting for a new touch) before going back to low power mode.

Current vs Sleep Period & Active Sensors (50/100/250ms)

# Active Sensors	Sleep Period (ms)	Current Consumption (uA)	Sleep Period (ms)	Current Consumption (uA)	Sleep Period (ms)	Current Consumption (uA)
1	50	20	100	18	250	18
2	50	22	100	19	250	18
3	50	23	100	20	250	18
4	50	25	100	21	250	19
5	50	26	100	22	250	19
6	50	27	100	23	250	20
7	50	29	100	24	250	20
8	50	30	100	24	250	20

Current vs Sleep Period & Active Sensors (500/1000ms)

# Active Sensors	Sleep Period (ms)	Current Consumption (uA)	Sleep Period (ms)	Current Consumption (uA)
1	500	17	1000	17
2	500	18	1000	17
3	500	18	1000	17
4	500	18	1000	17
5	500	18	1000	18
6	500	18	1000	18
7	500	18	1000	18
8	500	19	1000	18
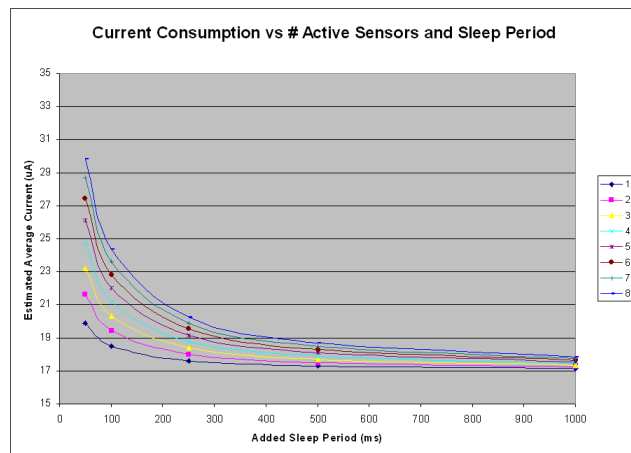
Current Consumption vs # Active Sensors and Sleep Period

*** 1.8V, excluding VDDIO current, which varies with VDDIO voltage, I/F type, and communication frequency

SELECTIVE TOUCH MODES

The LDS6200 Family touch controller is capable of detecting up to 8 simultaneous touches (on LDS6204). However, in certain situations, the application may want to only allow one or two valid touch events at any given time.

To accommodate such application requirements and avoid inadvertent touches, the LDS6200 Family has four selective touch modes: **Strongest Absolute Touch** and **Two Strongest Absolute Touches**. As the names indicate, Strongest Absolute Touch mode only registers the single strongest touch event at any given time, as judged by the absolute capacitance value, as long as it is above the touch threshold value. Similarly, Two Strongest Absolute Touches mode only registers the two strongest touch events at any given time, as judged by absolute capacitance values.

New to the LDS6200 Family are **Strongest Relative Touch** and **Strongest Two Relative Touches**. Instead of judging strongest touch by absolute capacitance value, the judgments are made looking at the delta between measured capacitance value and touch threshold value. The largest **delta** (defined as "capacitance value minus threshold level" for each sensor) is considered the strongest relative touch (and largest two deltas considered the two strongest relative touches). Where sensor sizes (and therefore the resulting capacitance values resulting from a touch) are significantly different, these two new modes can help achieve the desired effect of registering the most definitive/intended touch or touches.

Bits 8 and 9 of the "Touch Configuration Register" (0x040) control whether selective touch is active (Bit 8/9 = 1/0 for Strongest Touch, 0/1 for Two Strongest Touches). The device defaults to the unrestricted or "all touch" mode (Bits 8 and 9 = 0) upon power up.

To select between Absolute and Relative touch preference modes, a single bit RELATIVE_EN (bit 15 of Register 0x075) is utilized, with bit status "0" used for the Absolute modes and bit status "1" used for the Relative Modes.

To avoid frequent toggling of the strongest touch with two touches of comparable strength, an additional (optional) time criteria may be added that requires a new and stronger touch to remain stronger for a certain period of time before replacing the current strongest touch. The REPLACEMENT_TIME bits (0-15 of Strongest Touch Replacement Time Configuration Register 0x028) are used for this purpose. This option is available in Strongest Touch mode (Absolute or Relative) only and is not applicable to Two Strongest Touch modes.

RECALIBRATION FOR "STUCK" TOUCHES

The LDS6200 Family of products enables an automatic forced recalibration when a touch persists beyond a certain length of time. This optional feature enables recalibration in the case that some material remains on the sensor resulting in a continuous, but unintended, touch signal.

The Stuck Touch Recalibration Register (0x053) sets the time limit for a continous touch before a recalibration is forced. When a recalibration occurs, all active sensors are recalibrated. **To ensure that a lengthy, but real, touch does not result in recalibration, it is generally advisable to set the timer limit for stuck touch recalibration to be well above the expected duration for a valid touch.** The actual time limit is a function of the # of configured active sensors. For more detail on how to set a specific stuck touch time limit, please refer to the Detailed Register Document for the particular device being used.

PROXIMITY SENSOR

The LDS6200 Family has built in proximity sesnsor cabability. Each touch sensor can be enabled to act as a proximity sensor by using register 0x039 bits 0-7, but only one touch sensor can be used as a proximity sensor. Register 0x046 bits 0-7 are used to check the status of the proximity sensor. Increasing bits 10 – 15 of register 0x039 will increase the sensitivity of the proximity channel. Sensitivity should be adjusted for each application to achieve solid reliability. **For more information please see Application Note 62xxAN1.**

## TOUCH EVENT DURING POWER ON

When the device is first powered on the device will automatically calibrate to adjust to external conditions such as ambient temperature, humidity and smudges. To indicate a touch event during power on, bit 0 of register 0x038 will need to be enabled by setting to '1'. In order to be able to identify a touch event upon power up SELC values must be predefined for each active touch sensor using registers 0x030 – 0x037. By setting a predefined SELC value a touch event can still be recognized on power up without concern of not having the touch event aknowledged since it has been calibrated into the signal. **For more information please see Application Note 62xxAN1.**

LDS6200 Family

TOUCH OPTIMIZATION

DEBOUNCE

The debounce feature enables a time criteria to be set as an "acceptance" criteria for a touch being recognized as valid. Because capactive touch inputs frequently involve rigid overlays, there is no compression or "give" associated with a touch. As a result, a finger may very lightly "bounce" for a period of time, resulting in a fluctuating capacitive effect on the capacitive sensor. If the fluctuation results in capacitance values varying above and below the touch threshold level, multiple touches may be erroneously reported to the host processor.

By setting a time criteria required for the capacitive signal to remain above the threshold value, this type of inadvertant multiple touch event may be eliminated. The Debounce Registers (0x020 to 0x027) are used for this purpose. Bits 0-8 set the # of **consecutive** scan cycles that the capacitive signal must remain above the touch threshold value before a touch is reported to the host. The LDS62xx family allows each channel to set its debouce criteria independently of the other channels.
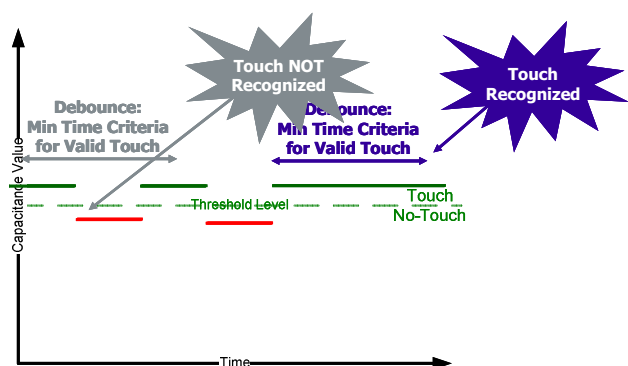
The diagram above shows an example of fluctuating capacitive signal and the debounce time that eliminates multiple touch reporting.

HYSTERESIS

Hysteresis is another method of ensuring touch stability. The hysteresis feature enables a "buffer region" to be established within which the capacitive value of an established touch may vary and still be recognized as a continous touch. Hysteresis Configuration Register 0x075 (bits 0-5) sets the amount of capacitance variation (referenced from the Touch Threshold level depicted in the diagram below) that may be tolerated before the current touch is reported as being removed from the sensor.
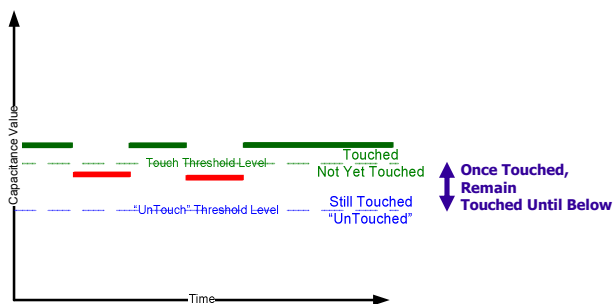
The diagram above shows a typical example of hysteresis, which allows a certain amount of capacitance variation to occur without multiple touch events being reported to the host. In the above diagram, the buffer region is defined by the area below the Touch Threshold Level and above the "UnTouch" Threshold level. This size of this region is effectively specified by programming the amount of capacitance variation allowed via the Hysteresis Configuration Register value.

With hysteresis, the weaker capacitive signal depicted by the two intermittent lines falling below the original touch threshold are now considered a continuation of the original touch since they remain above the UnTouch threshold level.

CAPACITANCE-TO-DIGITAL CONVERSION

The LDS6200 Family capacitance-to-digital converter (CDC) utilizes a sigma-delta design for capacitive sensing. Up to 8 sensor inputs are available to be connected through a switch matrix to the CDC.

The nominal decimation (oversampling) rate is 1024, which designates the number of samples acquired per sensor input for each scan cycle. The decimation process averages multiple samples from the CDC to arrive at one optimized result. The process of averaging multiple samples reduces the effect of spurious noise that can adversely affect touch detection.

The decimation rate may be programmed from the nominal value of 1024 to alternate rates of 128, 256, 512, or 2048. Since the update time per sensor is directly affected by the selected decimation rate, care should be taken to assure that the proper balance is achieved between system performance and touch update rates. In the majority of cases, the default decimation rate is optimal.

The conversion time per sensor input depends upon the programmed decimation rate and the possible options are shown in the table below:

Conversion Time/Input vs Decimation Rate (ms)

	Decimation Rate (d)			
	128	256	512	**1024**
Conversion Time	0.256	0.512	1.024	**2.048**

Table 1: Conversion Time (in ms) per Input vs Decimation Rate

The update rate (time between sequential scan cycles) is the product of the single output CDC conversion rate above multiplied by the number of active sensors. For the highest channel LDS6200 offering, if all 8 sensor inputs are utilized, the maximum possible update rate would be ~16ms.