SigmaSense SDC300-128

Product Brief

High Precision Continuous Sensing Multi-Touch Controller

PB-10011 Rev. 1.1

Self-Referenced Sensing Technology

SigmaSense's high precision capacitive multi-touch controller is for use in the most demanding applications where performance and advanced features enable new customer experiences. Continuous, frequency domain DSP sensing fuels better data for advanced AI and ML applications. Information is captured directly to digital by using innovative self-referenced channels that can simultaneously drive and sense on the same pin. The closed-loop self-referenced system actively mitigates noise for improved sensitivity, faster response rate, and better efficiency while lowering system and sensor cost.

Features and Benefits

- High precision continuous, self-referenced channels using an advanced DSP architecture enables high performance even in high impedance sensor designs.
  - Frequency domain, current mode sensing extracts information from within environmental noise.
  - Low voltage sinusoidal signals minimize EMI and improve sensor metal migration concerns.
  - Low latency, gaming class 300Hz or faster reporting enables new touch and haptics experiences.
  - Multi-frequency support eliminates time domain multiplexing delays.
- 300 Hz concurrent multi-touch for 10 fingers or more plus multiple active pens.
- 300Hz low latency optimized passive stylus.
- SigmaInk low latency active pen with 600 Hz reporting.
- Up to 300Hz global-shutter capacitive imaging eliminates spatial distortion.
- All channels drive and sense simultaneously on a single pin; any channel can be TX or RX for design flexibility enabling support of almost any aspect ratio display.
- Four dedicated presence-specific channels provide low power alerts of an approaching hand.
- 1Mbit/sec I2C and two high speed QSPI interfaces for high bandwidth host data communication.
- Achieves a transmit Signal-to-Noise Ratio (SNR) of 90dB or more, depending upon the sensor.
- High precision pressure modeling using finger touch area may eliminate the need for additional transducers.
- Automatic touch sensing with thick gloves, running water, or passive pen requires no user-initiated mode switching.
- Up to 10mm thick cover glass or 5mm PMMA support with 300Hz reporting.
- Sensor fusion channel sharing allows sensing of additional surfaces, buttons, sliders, dials or remote transducers all controlled by the SDC300.
- Support for curved and 3D shaped sensors.
- Smooth, intuitive active pen support for either SigmaInk® V1.7 600Hz high performance or MPP 2.01 active pen.
- Concurrent sensing of all rows and columns allows Active Noise Cancelling delivering SNR improvements in noisy environments.
- High SNR provides thinner on-cell OLED stack up and foldable OLED display precision touch support.
- Proximity functions to enable touchless interaction and support gestures processing above the surface.
- Data transfer through touch innovation enables new applications and intuitive customer experiences.
- High resistance sensor support enables new novel sensor materials or use of non-uniform sensor impedance.
- NIST SP 800-193 Firmware Security platform
- Software Defined Sensing allows ease of design and features additions without new hardware.

A Better way to sense

Eliminating the need for external signal conditioning enables SigmaSense's high SNR continuous, self-referenced controller to provide higher precision data and higher performance even with high capacitive or resistance sensors. Extracting targeted signals within noisy environments markedly improves information integrity and system performance. Concurrent multi-channel operation and embedded noise management facilitate enhanced touch information extraction, unlocking innovations in human-machine interfaces and interactions.

SigmaSense's unique methodology delivers SNR sensitivity hundreds of times greater than alternatives when drive voltage and reporting time are considered. Minute touch signals such as those from gloves, water and proximity can be sensed accurately without the need for special user mode changes, or high voltage signals.

This novel implementation encompasses all four primary analog and digital functions (AFE, ADC, DAC, and DSP) integrated into each channel on a single pin. It enables accurate touch and overcomes the barriers of thinner stacks, noisier on-cell displays often with high capacitive loads.

By using a current mode, multi-frequency sensing methodology, without scanning, SigmaSense achieves much higher sensitivity, ultra-fast report rates, and superior SNRs at minimal drive voltages across various display types and form factors. The concurrency of each channel provides superior results and enables Advanced Noise Cancellation (ANC) to mitigate most environmental noise.

Each self-contained channel stimulates and senses simultaneously, obtaining high resolution touch data while gathering additional embedded details within existing noise. This concurrent channel approach enables higher performance data rates and greater precision compared to legacy high voltage or time domain sequential channel sampling methods.

The flexible software defined architecture allows hardware reuse across designs, greatly reducing overall development effort. By providing high data rate global shutter capacitive imaging, spatial distortion is eliminated enabling more accurate AI/ML processing - becoming essential for advanced user experiences, especially for gaming interactions. Data through touch enables the ability to know who is touching the display and optionally provides data information used by HMI and AI applications during a touch.

SigmaSense aims to power the next generation of immersive, contextual human-technology interactions by overcoming limitations in scan-based capacitive touch.

Applications

With its superior sensitivity and robust performance, the SDC300 touch controller is ideal for a wide range of demanding applications including:

- Tablets, Laptops
- Displays & Kiosks
- Gaming Systems
- Digital Home Appliances
- Industrial, Rugged & Wet Environments
- Automotive Interfaces

The SDC300 delivers advanced touch interactivity through conditions such as thick glass, water droplets, debris, and gloves enabling seamless, smooth interactive solutions for indoor and outdoor kiosks, high-performance gaming controls, sleek home appliances, rugged mobile devices, industrial factory floors, and interactive automotive surfaces. The controller's leading configurability empower next-generation interface experiences across diverse environments.

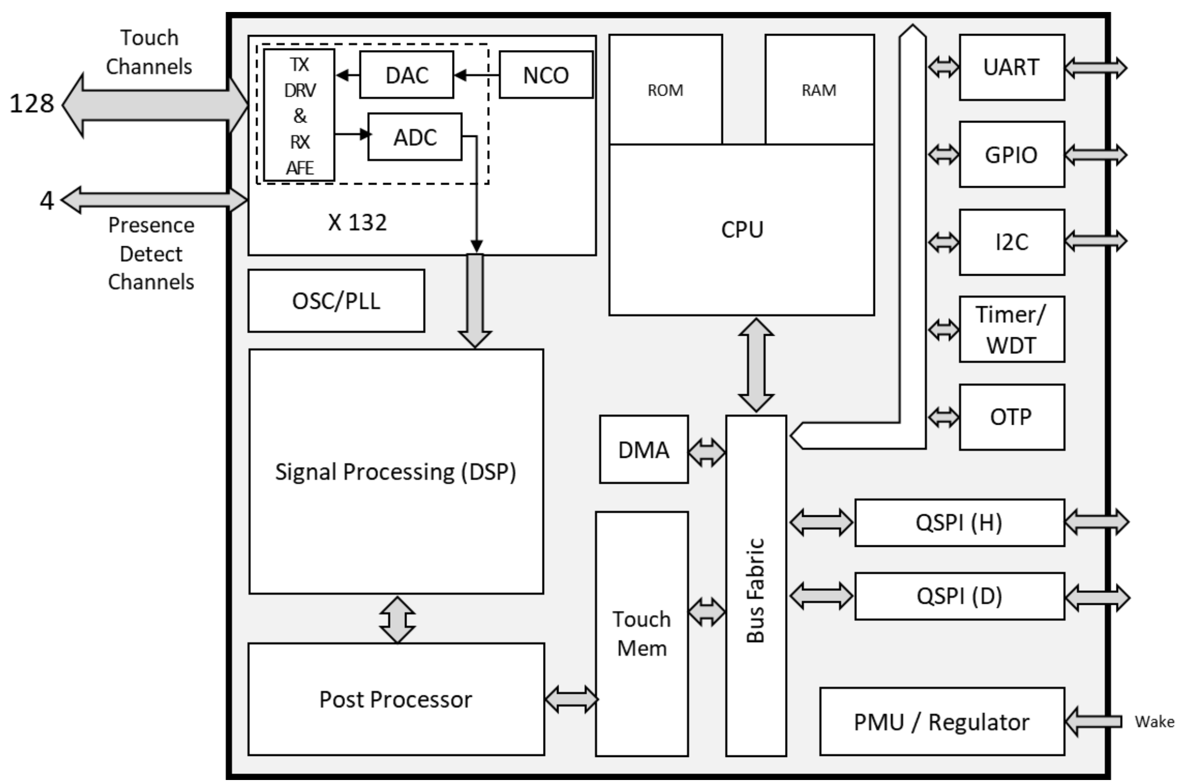
Description

The SDC300-128 controller uniquely uses a self-referenced drive and sense approach to concurrently capture multi-parameter data on all channels concurrently. This industry-leading architecture achieves a transmit SNR up to 90dB or more, depending upon the touch sensor, while achieving 300-600Hz reporting for high-performance human-machine interfaces (HMI).

Additionally, 300Hz high-fidelity capacitive imaging enables more precise AI/ML processing. It extracts desired signals, in parallel on each channel, from real-time environmental noise. Narrow band, multi-frequency operation per sensing channel provides noise resilience beyond current PCAP controllers.

The system delivers robust touch performance when operating in high impedance stacks, through thick glass greater than 10mm, or in challenging conditions like running water or when using gloves, without requiring the user to change operating modes. The SDC300 automatically optimizes its settings to maintain performance across various tough environmental situations. This ability to operate reliably through thick glass, water, and gloves makes the SDC300 ideal for rugged, industrial, and outdoor applications.

By directly digitizing small changes to the low voltage drive signal, using current mode and frequency signaling, the SDC300 overcomes limitations of traditional scanning, high voltage time domain techniques. This breakthrough approach opens possibilities for more responsive, adaptive, and context-aware user interaction.



SigmaSense SDC300-128 Block Diagram

Low leakage 40nm technology enables meeting critical requirements like ultra-low power consumption and fast responsiveness needed in today's power-constrained devices. This makes the SDC300-128 suitable for integration into a wide range of display form factors and applications.

- Low power sleep static leakage.
- Fast wake from sleep mode with programmable power management functions or dedicated presence detection channels.
- Support for very thin stack-up foldable OLED displays and high resistance or non-uniform resistance sensors.

Easy System Design

While general sensing technologies exist, manufacturers need new capabilities to solve difficult problems and improve outcomes. For system designers, heightened sensitivity, noise resilience, high SNRs and low power are crucial. SigmaDrive technology delivers these needs.

SigmaDrive architecture operates continuously on all channels, reducing the impact of system timing constraints. This not only boosts performance but also simplifies sensor design, eliminating the need for uniform impedance sensors and tight design tolerances on traces. Compatibility with a large variety of sensor materials, including low-cost high resistance sensors, regardless of aspect ratio is provided.

Software Defined Sensing

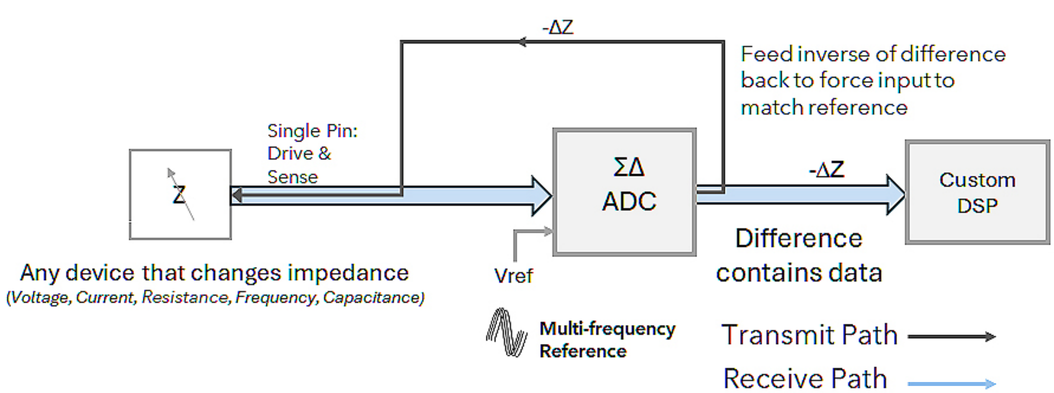
The SigmaSense approach enables narrow-band frequency detection and superior noise filtering, along with additional programmable functions defined by software rather than hardware-bound limitations.

Each sensing channel is independently configurable, and functionality is software-defined for flexibility. This allows for design optimization based on desired application requirements from touch displays to sliders, buttons and presence detection. Hardware can be reused with software configuration defining new, desired features.

Continuous Drive Advantages

The SDC300-128 captures digital information directly into the frequency domain for processing. Noise mitigation and accurate reporting even with high and varying resistance is no longer a challenge. Implementing capacitive sensing is no longer as difficult for applications like thin stack-up on-cell OLED phones, EPD e-readers and foldable touch sensors where noise and resistance have been challenging.

SigmaDelta Modulator (SDM)



High Precision Continuous Current Mode Sensing

Traditional switched capacitive sensor arrays are limited in speed by the system's ability to switch, settle, and sample across channels. In contrast, the SigmaDrive architecture operates continuously on every channel, mitigating RC timing constraint effects for higher performance and easier sensor design.

There is no design requirement for uniform sensor impedance or equal length traces. Concurrent sensing of all nodes at once also enables advanced noise cancellation techniques that further improve signal-to-noise ratios.

Understanding the performance limitations of tau

By eliminating switch-settle-sample performance barriers and facilitating multi-node Advanced Noise Cancellation, SigmaSense's architecture provides performance and design flexibility advantages over traditional approaches. RC time constant tau (τ) dictates the exponential transient response and stabilization time of capacitive and inductive circuits subjected to high voltage stepped input changes traditionally used. Understanding the role of tau allows properly accounting for these non-instantaneous transitions between circuit steady states. These delays limit legacy touch controller performance.

SigmaSense uses low voltage sinusoidal drive reference signals eliminating the most detrimental tau effects inherent when using traditional high-voltage square wave sampling approaches. The SigmaDrive method provides improved noise resilience, timing flexibility, and eliminating many sensing performance limitations.

- 128 independently operated channels each with programmable ADC and DSP circuits for concurrent multi-parameter touch sensing.
- Optimized design focusing on performance and lower power and narrow band channel filters which enable improved noise mitigation techniques.

High Precision Continuous Sensing

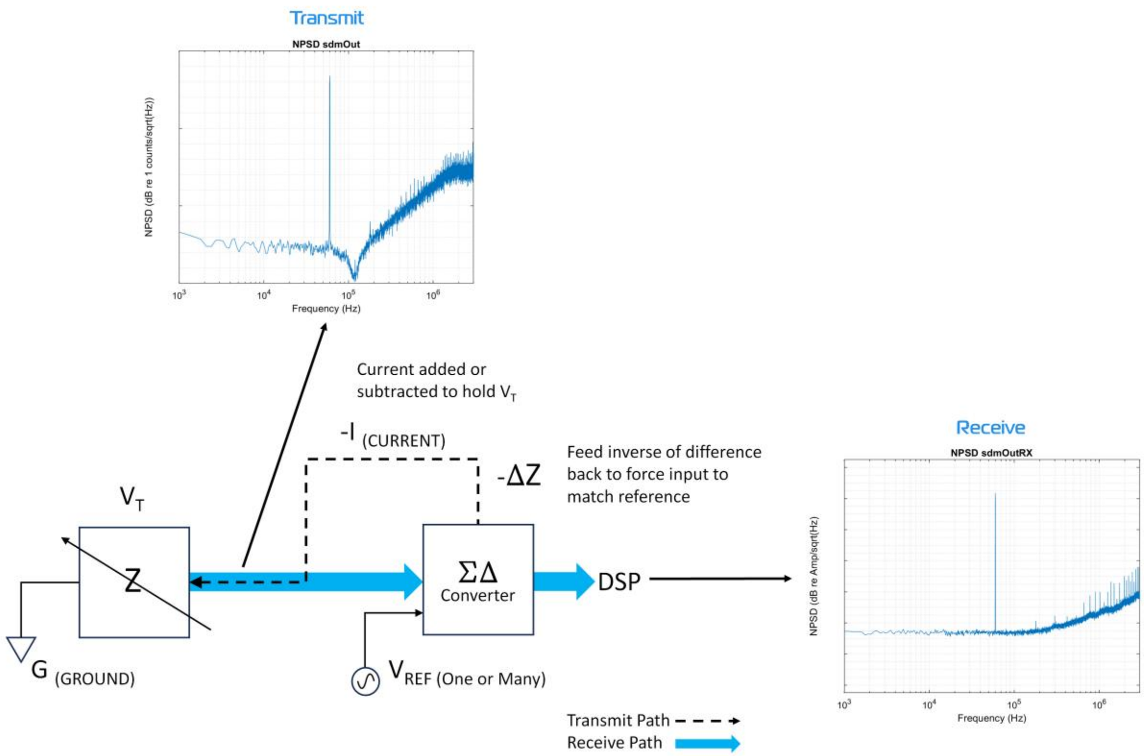
SigmaSense AFE's impedance sensing captures information directly into the digital domain by uniquely converting minute changes in current to digital data. Time based scanning is eliminated enabling higher performance and eliminating noise inducing multiplexing of the receive signal. All channels operate concurrently. This capability delivers unprecedented improvements in sensitivity and SNR. Sensor design constraints are also relaxed eliminating the typical requirement for equal length sensor traces and uniform sensor impedance. SigmaSense's proprietary Sigma-Delta drive and sense circuits offer continuous operation, ultra-low drive voltages, and self-excitation / self-referencing that moves digital sensing much closer to the analog event horizon.

The unique SigmaSense approach uses multiple sinusoidal low voltage, typically about 1V, to stimulate the capacitive touch sensor and measure any impedance change in the sensor which is proportional to the change in current needed to maintain the sinusoidal voltage constant. This current-mode approach achieves SNR far greater than legacy PCAP controllers and minimizes radiated energy reducing EMC and EMI challenges.

A high accuracy narrow band sinusoidal drive (carrier) signal eliminates the harmonic problems associated with high voltage square waves further improving emissions and can improve sensor reliability by dramatically slowing down the effects of electro-migration and e-field induced damage to the sensor materials.

Overcoming Environmental Challenges

By overcoming noise and optimization for power and flexible, thin stack up displays, the SDC300 makes capacitive sensing viable for industrial and rugged applications. Regardless of environment, normal touches, touch through running water, or wearing thick gloves, all are accurately processed automatically. This is a boon to all customers, but especially customers for ruggedized systems relieving the user from the tedious task of setting different modes of operation depending upon the use of gloves or water on the display.



SigmaDrive Single Pin Block Diagram

SigmaSense has redefined analog touch sensing through innovative Sigma-Delta architecture improvements that radically boost sensitivity and SNRs. These major performance gains result from four key innovations:

- Current mode ADC, Sigma-Delta architecture
- Eliminating quantization noise inherent in Sigma-Delta techniques
- Employing aggressive narrowband DSP filtering
- Enabling dynamic noise avoidance via spectral analysis

Additionally, the frequency domain direct-to-digital approach removes the extra analog pre-processing circuitry typically found in analog front ends (AFEs). This leads to a 90% digital chip that is smaller, lower cost and lower power.

By enabling robust high-fidelity touch sensing, SigmaSense's extensive future proofing make possible innovative interfaces and experiences for AI enabled devices. The rearchitected Sigma-Delta foundation unlocks sensing advances necessary for next-generation AI data demands, and flexible human-machine experiences.

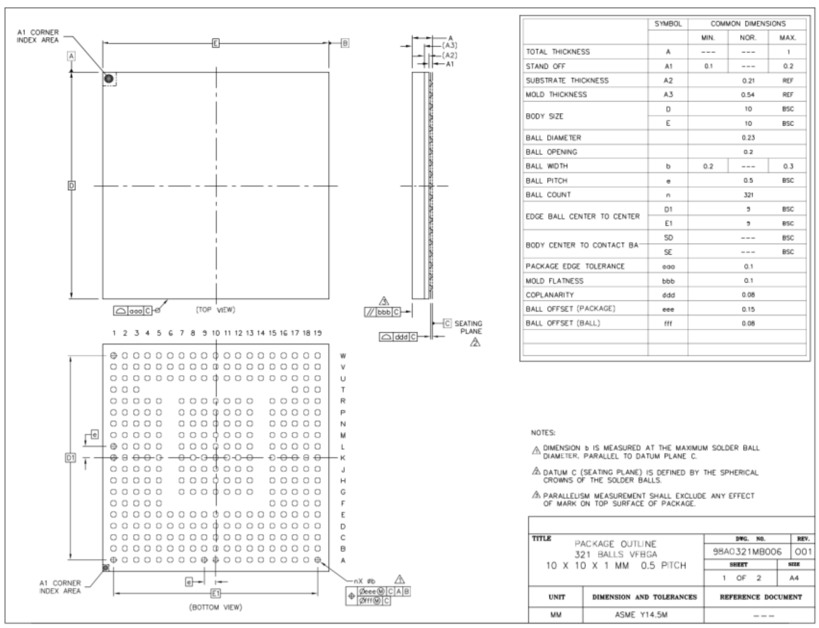
In summary, SigmaSense's sensing advances through both Sigma-Delta enhancements and digitization streamlining to provide the high signal purity and low power vital for a new generation of advanced touch interfaces and capabilities.

Active Pen up to 600Hz Performance

The SDC300 supports multiple active pen protocols and high performance, low latency passive stylus.

- Traditional Microsoft MPP 2.0 Active pen protocol for legacy compatibility.
- SigmaInk high performance active pen protocol.
    - 1024-4096 pressure levels, barrel buttons, tilt, up to four pens in simultaneous use on the display.
    - Simultaneous Pen and Touch (SPT) with 300Hz touch and up to 600Hz pen reporting without time-domain multiplexing.
    - 300 – 600 Hz active pen reporting.
- High performance 300Hz reporting, low latency passive stylus, which surpasses the reporting performance of many active pen protocols.

Packaging



SigmaSense SDC300-128 Device Package Outline

Device P/N	Package	Total Balls	Ball Diameter	Ball Pitch	Sense Channels
SDC300-128 B0-1.1.1	BGA	321	0.3 mm	0.5 mm	128

T_A	Ambient operating temperature	-40 to +85	°C
T_{sa}	Storage temperature	-40 to +125	°C
RH_A	Ambient relative humidity (non-condensing)	10 to 90	% RH

Traditional Touch Sensing Methodology

Traditional PCAP touch controllers operate using a charge transfer methodology. The mutual capacitors between the row and column are driven by a high voltage square wave. The pulses are integrated on the capacitor and the number of pulses is effectively scanned and counted. A touch will change the quantity of pulses necessary to charge the capacitor. Environmental noise can affect the total charge making the signal to noise ratio (SNR) a fundamental challenge for all charge transfer PCAP architectures. Current approaches require more time, or an increase to the voltage of the square waveto improve precision. While this improves the SNR, it may slow response and also creates more challenging EMI issues and reliability concerns in some sensors. This has a negative impact on reliability, performance and the user experience. Improving SNR without increased voltage or slowing the report rate is crucial for robust, high performance PCAP systems in order to improve user experiences.

Touch Sensing Background

A touch screen panel consists of row terminals and column terminals with a mutual capacitance C_m coupling each row to each column, and self-capacitances C_{pTx} from each column to ground and C_{pRx} from each row to ground. When a touch occurs, the electric fields couple to C_m, C_{pTx}, and C_{pRx}, changing the effective value of C_m, C_{pTx} and C_{pRx}. For mutual capacitance sensing, this change in capacitance is detected in order to identify the occurrence of a touch. The diagram below illustrates the touch screen sensor model of a unit cell.

An SDC300 touch controller drives the mutual signals on rows (typically) and receives them on the columns (typically) to calculate the locations of the touch. At each row and column interface, a current is injected onto the terminal and measured via a Sigma-Delta Modulator (SDM).

The measured current has two components:

- SELF current (from the row r_i or column c_i to ground)
- MUTUAL current (from the row r_j capacitively coupled through the mutual capacitance Cm to the column c_i)

(a) Unit Cell Sensor Model (b) Row and Column Location Triangulation