Application Note: GT-AN-090624

Managing Sensor Compensation with Cirque's Pinnacle ASIC

This is a companion document to
Interfacing to Cirque's Pinnacle ASIC through SPI or I^2C.

This document describes how to manage sensor compensation with Cirque's Pinnacle ASIC.

This document applies to Cirque's Pinnacle ASIC 2.4

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Revision History

Date	Previous Revision	Current Revision	Description

1.0 Managing Compensation

1.1 Overview

Cirque's Pinnacle ASIC self-calibrates at power-on, very efficiently ensuring that the touch device is calibrated to its operating temperature and environment. Compensation (or calibration) is an overall capacitance measurement of the sensor and its environment. The data is stored and used in the proper calculation of the finger position.

1.2 Forced Compensation

Though pinnacle automatically performs compensation when powered on and when triggered by specific events, compensation can also be forced by the Host at any time by asserting the Calibrate flag (Bit [0] Register 0x07, CalConfig1) (see Table 1). Refer to "*Interfacing to Cirque's Pinnacle ASIC through SPI or I^2C"* on how to write to a register.

Calibration takes approximately 100 ms. A compensation matrix of 92 values (each value is 16 bits signed) is stored sequentially in Pinnacle RAM, with the first value being stored at 0x01DF. Upon completion, the Calibrate bit is cleared by Pinnacle and both the Command Complete (SW_CC) and Hardware Data Ready (HW_DR) signals will be asserted. The host should then clear SW_CC.

Nothing should be on the sensor during calibration. A finger or object on the sensor during calibration will be compensated for, and when the object is removed, it will alter performance and cause incorrect tracking behavior.

The compensation matrix is stored in Pinnacle RAM, outside of the standard memory set and requires accessing the extended registers. The protocol for reading and writing to Pinnacle's extended memory is explained in "*GT-AN-090626: Extended Register Access for Cirque's Pinnacle ASIC*".

Table 1: CalConfig1 Register – 0x07

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Description		Calibration Matrix Disable[1]		Tap Comp Enable	Track Error Comp Enable	NERD Comp Enable	Background Comp Enable	Calibrate[2]
Read/Write		R/W		R/W	R/W	R/W	R/W	R/W
Values		1=disabled 0=enabled		1=enabled 0=disabled	1=enabled 0=disabled	1=enabled 0=disabled	1=enabled 0=disabled	1=calibrate 0=complete
Default		0		1	1	1	1	0

For typical applications, aside from the Calibrate flag (Bit[0]) leave this register at the default settings.

1. Calibration takes ~100ms. Upon completion, the Calibrate bit is cleared and SW_CC (Register 0x02, Status1) and HW_DReady are asserted. The host must clear SW_CC.

1.3 Calibration Comparison

To determine the best compensation strategy, and for evaluation during development, the Host will need to compare different sets of compensation data. Read and save one or both sets of calibration data. The evaluation conditions will vary for every product. The values of 20K and 500 are given as starting values for a general evaluation. Adjust those values as needed according to the performance of the overall product.

If any values are above 20K (absolute), it generally indicates a problem with the sensor. If no values exceed 20K, proceed with the data comparison. Compare each 16-bit value in one matrix to the corresponding 16-bit value in the other matrix. If the difference between the two values is greater than 500 (absolute), it indicates a change in the environment. Either an object was on the sensor during calibration, or the surrounding conditions (temperature, humidity, or noise level) have changed. One strategy is to force another calibration and compare again, if the values continue to differ by 500, determine whether to use the new data or a previous set of stored data. Another strategy is to average any two values that differ by more than 500 and write this new matrix, with the average values, back into Pinnacle.

During development, calibration data can be gathered and stored during different operating conditions to determine how the device performs. For Touch Panels, Cirque recommends this evaluation be performed with the LCD and housing in place. Plotting each matrix and the differences between the two can facilitate the evaluation (see Figure 1).

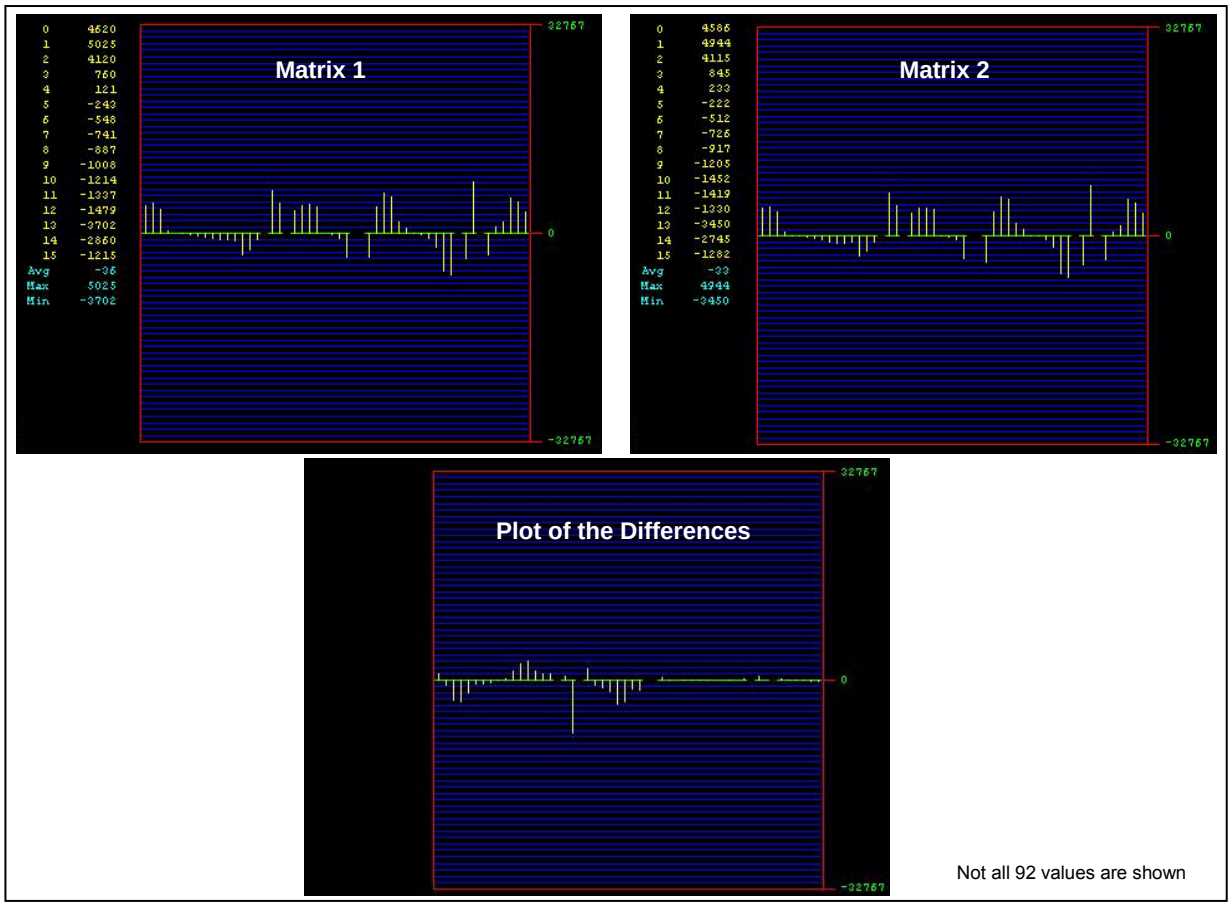

Figure 1: Compensation Matrix Comparisons

1.4 Compensation Methods

Pinnacle offers a variety of automatic compensation methods. For optimal performance, use a combination of the compensation strategies described. It is best to determine a compensation strategy during development that can then be programmed into the Host for the final product. At a minimum, Cirque recommends a Factory calibration on the final product. Each calibration method referred to in Table 2 is described in more detail below.

Table 2: Pinnacle Compensation Methods

Method	Initiating Device	Initiating Event
Power-on	Pinnacle - Automatic	ASIC power-on reset (POR)
Factory	Host	Manufacturing/Test Requirement (Recommended)
Background	Pinnacle - Automatic if enabled	Scheduled event to compensate for environmental change
Periodic Environmental	Host	Scheduled event to compensate for environmental change
On-the-fly	Pinnacle - Automatic	Enabled by default at every POR, must be disabled for touch panel devices.

1.4.1 Power-On Compensation

Compensation is automatically performed every time the Pinnacle ASIC powers on. If an alternate set of calibration data is desired it must written into Pinnacle RAM, by the Host, after Power-on Reset (POR).

1.4.2 Factory Compensation

Due to the possibility of an object being on the sensor when Pinnacle performs the automatic compensation during POR, Cirque recommends performing a "Factory Compensation" on each unit as a routine step in the manufacturing test process. A Factory Compensation consists of the host device performing the following steps:

1. Force a calibration in a known environment (i.e., in the factory with nothing on the sensor, and in similar conditions to where the final product will be used).
2. Read the compensation data from Pinnacle memory.
3. Store the data permanently on the host device as 92 16-bit unsigned values of "known good" compensation values.
4. Compare subsequent compensation data with the stored Factory compensation data, and determine whether to use the most recent compensation or the stored Factory data.
    a. If using the Factory Compensation data, write the stored factory data back into Pinnacle RAM.

1.4.3 Background Compensation

Background Compensation is Pinnacle's default Periodic Environmental Compensation. It occurs on a regular interval, during periods of sensor inactivity, to compensate for temperature and humidity changes in the surrounding environment. To enable Pinnacle's Background Compensation feature the Background Comp Enable bit must be set (Bit [1] Register 0x07, CalConfig1) (see Table 1). Devices that auto-detect between stylus and finger, cannot use Pinnacle's Background Compensation feature and it should be disabled. A Periodic Environmental Compensation method will need to be established for such devices.

1.4.4 Periodic Environmental Compensation

A periodic compensation, forced by the Host, can help determine the effect of the surrounding environment on the device. A thorough environmental evaluation should be performed during the development/prototype phase. During development, program a forced calibration on a schedule during known environmental conditions (temperature, humidity, noise level, no objects on sensor). Track the data as the environmental conditions change. Ideally, any drift in environmental conditions will be compensated for and there will be no degradation to the sensor performance. However, a noticeable change in the compensation data indicates that the environment does affect the device and a calibration schedule or algorithm to compensate for the environment should be developed.

For example, force a calibration in ideal conditions and store the data. Increase the temperature in increments through the operating range specified by the final product. Force a calibration at each temperature increment and track the changes that occur in the compensation data. If a noticeable difference is observed over temperature, and the final product is likely to be in an environment that spans the temperature range, then it would be necessary to establish a strategy to calibrate the unit appropriately. A logical choice would be to simply program the Host to force a calibration on a periodic schedule. Another option would be to force a periodic calibration and compare it to the Factory Compensation and use the better or an average of the two matrices. When programming a periodic calibration, choose a time or event that is least likely to be influenced by an object on the sensor (i.e., between transactions, or after midnight).

1.4.5 Compensation on-the-fly (COTF)

Compensation on-the-fly (COTF) is a Pinnacle feature that is enabled by default at every POR. It accounts for invalid objects, invalid taps, and objects resting on the sensor. Though ideal for touchpads, COTF should be disabled for all touch panels. Disable COTF by Disabling Tap Comp, Track Error Comp, and NERD Comp (Bits [4], [3], and [2] in Register 0x07, CalConfig1) (see Table 1).