Oak CS

4 Channels Capacitive Proximity Switch and Sensor

Datasheet

Include Picture of Oak CS !

Contents

1. Introduction

The Oak CS is a USB attached capacitive proximity sensor with 4 channels. The device can be used as 4 channel touch sensor switches trough dielectric materials like glass or plastic. The Oak CS returns the states of the touch switches and the bare ADC values of the channels. With these bare values, the proximity of conductive materials can be identified in a range up to 20 cm from the sensor area.
For simple application, the Oak CS provides an 11x15mm sensor area on the back side. Due to the plane back side of the device, it is possible to stick the Oak CS directly to the dielectric material for an inexpensive capacitive touch switch. The other three sensor channels are available at an input socket and can be used for custom sensor areas. The Oak CS is shipped wit a suitable 30cm cable for easy connection of the 3 external sensor areas.
The sensitivity, resolution and thresholds of the Oak CS can be chosen by software in a wide range. Therefore, the sensor can be used for many different applications. For reliable touch sensor applications, the Oak CS features a self calibration of the base capacity.

The Oak CS can be integrated in a custom application very easily. The operating power as well as real time proximity data and uncritical device configuration data are all transferred through a simple USB cable. The very low power consumption, including automatic entering into sleep mode, allows using the device not only in fixed installation, but also in mobile applications.

1.1 Reference Documents

Application Note for Oak Capacitive Proximity Sensors
(This document is still under construction)

Programming Guide to the Oak Sensor Family

2. Hardware Specifications

2.1 Build-in Sensor Area

On the bottom side of the device, an 11x15mm sensor area is provided for the sensor channel 0 (S0). Due to the plane back side, the Oak CS can be stuck directly to the dielectric material by an adhesive tape or glue. This induces a simple capacitive touch sensor solution.

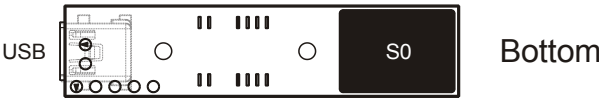

Figure 1: Bottom view of the Oak CS (original size)

2.2 External Sensors

For external sensor areas S1 to S3, the Oak CS provides a 3 pin input socket (S3B-PH-SM4-TB from JST). The Oak CS comes with a 30 cm cable with the mating connector. The external sensor areas can be constructed of a PCB copper area, copper tape or wire nets. Please refer the Application Note for Oak Capacitive Proximity Sensors for construction of the sensor area. For the best results, keep the wires to the sensors as short as possible and separate them from each other.

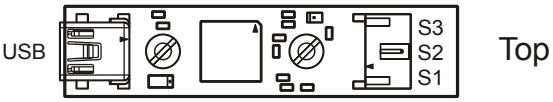

Figure 2: Top view of the Oak CS (original size)

2.3 Supported Sensor Features

Read switch states

Read bare capacity measuring data

Sensitivity, resolution and capacity baseline adjustable

Automatic baseline calibration can be disabled

Sample rate adjustable

2.4 USB Interface

Interface:	USB 2.0 Full Speed (12Mbits/s)
Connector:	Standard USB Mini-B
Device Class:	HID
Update Rate:	3ms to 65s, user adjustable
Report Rate:	1ms to 65s, user adjustable

3. Settings

Due to the flexible usage of the Oak CS, different settings can be adjusted for the best performance of the sensor. All the settings can be done by USB feature reports commands and can be stored permanent in the in the flash of the device. The feature report commands are described in the chapter 4.2. For a better understanding how the proximity sensor is working, please refer the Application Note for Oak Capacitive Proximity Sensors.

3.1 Sensitivity Range

The proximity of a conductive material (such as a finger) causes a change of the capacity of the sensor area to the environment. The Oak CS can measure this capacity. In principle, larger sensor areas induce higher changes of the capacity but have a higher base capacity when no conductive object is surrounded.

Because of the wide range of possible sensor areas, the measuring range of the capacity has to be adjusted. The Oak CS allows the adjustment of the range in 4 steps. For the best performance, the highest sensitivity range should be chosen that does not saturate the capacity measuring in the touched state.

3.2 Resolution

The Oak CS works with a sigma delta analog to digital converter. This type of converter allows a selection of the resolution. The drawback of a higher resolution is the longer measuring time and therefore the lower sensor update rate. The resolution can be chosen from 9 to 16bit but Toradex recommends using 12bit resolution for sensor switches and fast proximity sensor. For proximity sensor with a high resolution but a slower update rate, a resolution of 16bit is recommended.

The following table shows the fastest guaranteed update rates of the sensor values according to the selected resolution.

Resolution [bit]	Minimum update rate [ms]	Note
9	3	
10	4	
11	7	
12*	12	*Recommended for touch sensors
13	23	
14	45	
15	89	
16*	176	*Recommended for proximity sensors

3.3 Finger Threshold

The Oak CS provides for every sensor channel a digital switch output. This output can be used for touch sensor applications. The switch output goes on, if the measured capacity value is higher than the baseline + finger threshold + hysteresis. The output returns to off, if the measured value goes below the baseline + finger threshold – hysteresis. The hysteresis is set to a fix value of 10. This hysteresis is necessary for protect the switch against bouncing. There is a second debounce mechanism implemented. The output switches to the new state only after measuring the third sensor value on the same side of the according threshold.

The finger threshold can be adjusted by feature report commands. The suitable finger threshold for the application has to be searched experimentally. A low threshold allows a high sensitivity to sensing objects but maybe causes false detections. A high threshold means a high reliability to false detection but the objects must be closer to the sensor or must have larger areas.

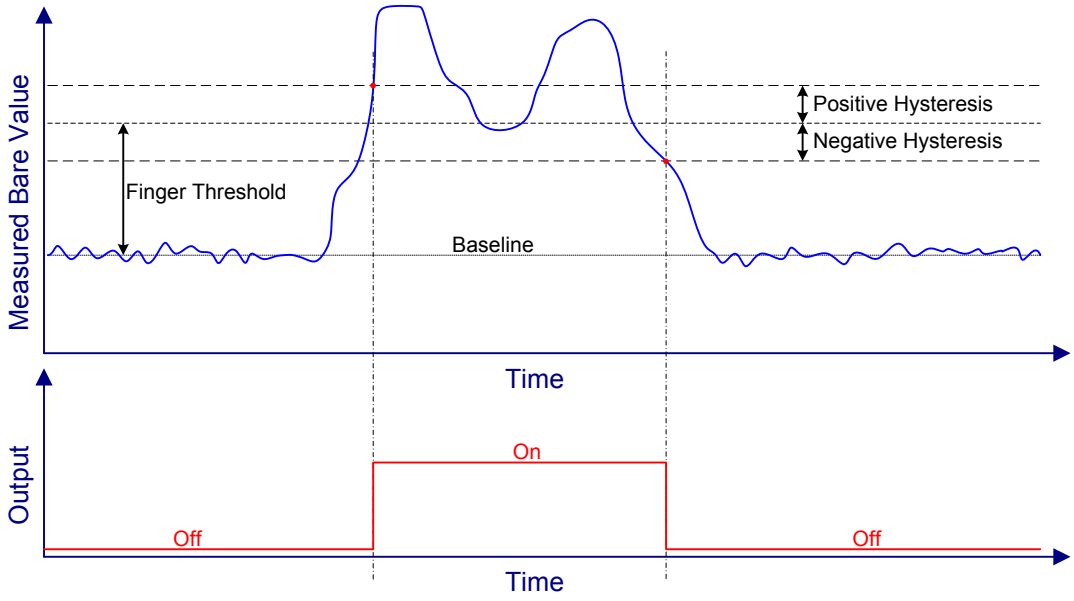

Figure 3: Switch output when a finger is detected (automatic baseline calibration off)

3.4 Baseline

Every sensor area has a certain capacity to ground, even if no conductive material is surrounded. This capacity is depending on the actual humidity among other things. The baseline represents the base capacity in the absent state of the touch sensor. The threshold for the present of a finger is calculated from this baseline

Every sensor channel has its own baseline. The baseline value can be set to the actual measured capacity of the channel during the plugging in of the Oak CS device. With a feature report command the baseline can be set to the actual measured capacity at runtime. In the same way it is possible to set the baselines to specific values.

As shown in the following diagram, it is possible that increases of the base capacity can cause false detections of present fingers at the sensor area. For example changes of the air humidity can cause such changes of the base capacity.

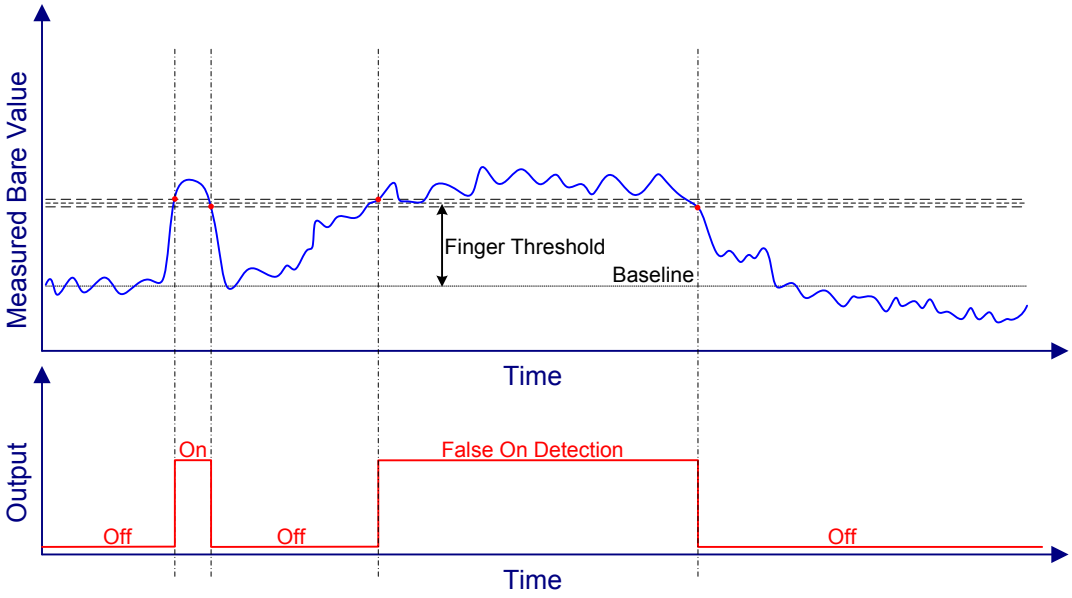

Figure 4: False detection when the automatic baseline calibration is disabled

For avoiding false proximity detection due to environmental influences, the Oak CS sensor has an automatically baseline calibration. If this function is enabled, the base line increases or decreases slowly, if the measured capacity is higher or lower than the baseline. The automatically base line calibration function can be enabled or disabled by feature report commands.

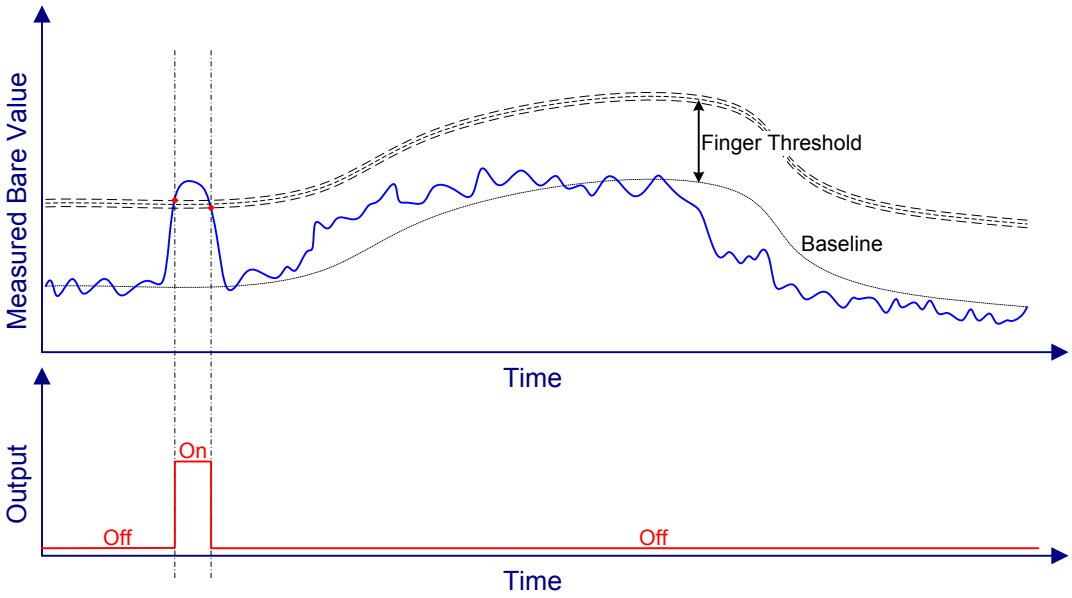

Figure 5: Automatic baseline calibration avoids false detections

Normally, environmental influences change the base capacity slow compared to the fast changes of the capacity in touch sensor applications. Therefore in normal touch sensor

applications, the automatic baseline calibration function works fine. If the Oak CS is used to detect the long term proximity of conductive objects, the automatic calibration can cause problems. If an object is present at the sensor area, the calibration function increases slowly. After a certain time, the baseline is increased to a value that induces the false detection of the absent of the object.

The time until a present object is misleadingly as absent detected depends on the difference signal strength. If the measured capacity during the present of the object is much higher than the base capacity, the maximum detection time is long. Even if the signal of the present object is only a little higher than the base capacity, the maximum detection time is normally several seconds. However for long term proximity detection applications, the automatic baseline calibration function should be disabled.

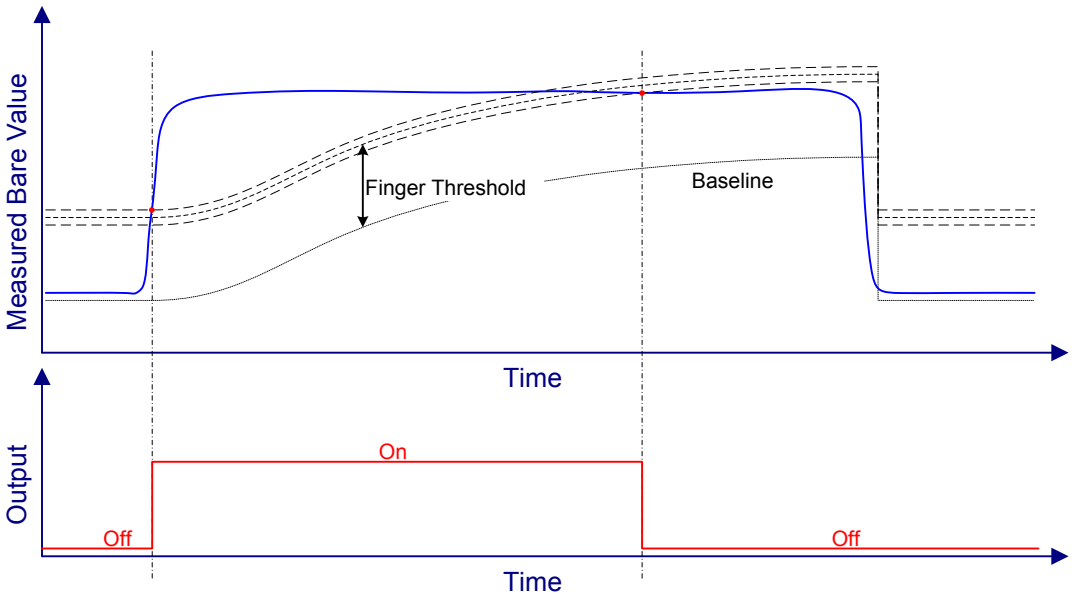

Figure 6: Long time proximity sensing with enabled automatic baseline calibration

4. Software Specifications

All Oak Devices are implemented as HID devices. Thus driver support is built into all major operating systems.

The sensor data is transmitted through an INTERRUPT IN report. Therefore real time processing can be guaranteed. The data can be received by the host using regular file read operation. Chapter 4.1 describes the contents of this report.

On an independent communication channel, device configuration is done using FEATURE reports that are 32 Bytes in length. Special operating system calls exist to transmit / receive feature reports. Chapter 4.2 shows the structure of a feature report for each supported command.

Please refer also to the document “Programming Guide to the Oak Sensor Family“ for more details.

4.1 INTERRUPT IN Report Contents (Real time data)

The INTERRUPT IN report contains the following items:

16 Bit	Frame Number	10^{-3} s
8 Bit	Touch Sensor State	
16 Bit	Bare ADC Value Sensor Channel 0	
16 Bit	Bare ADC Value Sensor Channel 1	
16 Bit	Bare ADC Value Sensor Channel 2	
16 Bit	Bare ADC Value Sensor Channel 3	

The touch sensor state contains all switching states of the 4 touch sensor channels. Bit 0 represents the state of channel 0, bit 1 the channel 1 and so on. The bare ADC value items contain the measured capacity to ground of the according channel. The values have no units, because the representing capacity is depended on the resolution and sensitivity settings.

4.2 FEATURE Report Commands

4.2.1 Report Mode

Byte#	0	1	2	3	4	5
Content	GnS	Tgt	0x01	0x00	0x00	RPTMODE

GnS: 0 = Set
1 = Get

Tgt: 0 = RAM
1 = Flash

RPTMODE: 0 = After Sampling (Factory Default)
1 = After Change
2 = Fixed Rate

4.2.2 LED Mode

Byte#	0	1	2	3	4	5
Content	GnS	Tgt	0x01	0x01	0x00	LEDMODE

GnS: 0 = Set
1 = Get

Tgt: 0 = RAM
1 = Flash

LEDMODE: 0 = Off
1 = On
2 = Blink Slowly
3 = Blink Fast
4 = Blink 4 pulses
5 = On if Touch Sensor 0 is Touched
6 = On if Touch Sensor 1 is Touched
7 = On if Touch Sensor 2 is Touched
8 = On if Touch Sensor 3 is Touched
9 = On if any Touch Sensor is Touched (Factory Default)

4.2.3 Report Rate

Number of milliseconds between two IN reports. This parameter will only be regarded if Report Mode = 2 (fixed rate)

Byte#	0	1	2	3	4	5	6
Content	GnS	Tgt	0x02	0x00	0x00	RptRate LSB	RptRate MSB

GnS: 0 = Set
1 = Get

Tgt: 0 = RAM
1 = Flash

RptRate: Report Rate [ms]

4.2.4 Sample Rate

This is the actual sample rate the sensor is working on. If Report Mode = 0 (After Sampling) this is also the rate at which the device reports values to the host PC. Please refer chapter 3.2 for the possible minimum sample rate in the chosen settings.

Byte#	0	1	2	3	4	5	6
Content	GnS	Tgt	0x02	0x01	0x00	SampRate LSB	SampRate MSB

GnS: 0 = Set
1 = Get

Tgt: 0 = RAM
1 = Flash

SampRate: Sample Rate [ms]

4.2.5 User Device Name

Byte#	0	1	2	3	4	5-25
Content	GnS	Tgt	0x15	0x00	0x00	UsrDevName

GnS: 0 = Set
1 = Get

Tgt: 0 = RAM
1 = Flash

UsrDevName: User defined name for the whole device
Null-terminated string, max. 20+1 characters

4.2.6 User Channel Name

Byte#	0	1	2	3	4	5-25
Content	GnS	Tgt	0x15	ChP1	0x00	UsrChName

GnS: 0 = Set
1 = Get

Tgt: 0 = RAM
1 = Flash

ChP1: 1 = Channel 0 (Frame Number)
2 = Channel 1 (Touch Sensor State)
3 = Channel 2 (Bare Value Sensor Channel 0)
4 = Channel 2 (Bare Value Sensor Channel 1)
5 = Channel 2 (Bare Value Sensor Channel 2)
6 = Channel 2 (Bare Value Sensor Channel 3)

UsrChName: User defined name for the channel
Null-terminated string, max. 20+1 characters

4.2.7 Sensitivity Range

Please refer to chapter 3.1 for a description of the sensitivity range setting.

Byte#	0	1	2	3	4	5
Content	GnS	Tgt	0x01	0x02	0x00	Sensitivity

GnS: 0 = Set
1 = Get

Tgt: 0 = RAM
1 = Flash

Sensitivity: 0 = Very Low Sensitivity
1 = Low Sensitivity
2 = Medium Sensitivity (Factory Default)
3 = High Sensitivity

4.2.8 Finger Threshold

Please refer to chapter 3.3 for a description of the finger threshold setting.

Byte#	0	1	2	3	4	5
Content	GnS	Tgt	0x01	0x04	0x00	Threshold

GnS: 0 = Set
1 = Get

Tgt: 0 = RAM
1 = Flash

Threshold: Threshold value in the range 10 to 255 (Factory Default 40)

4.2.9 Resolution

Please refer to chapter 3.2 for a description of the resolution setting.

Byte#	0	1	2	3	4	5
Content	GnS	Tgt	0x01	0x05	0x00	Resolution

GnS: 0 = Set
1 = Get

Tgt: 0 = RAM
1 = Flash

Resolution: possible resolution setting: 9 to 16
12 = Recommended for touch sensor or fast proximity sensors (Factury Default)
16 = Recommended for high resolution proximity sensors

4.2.10 Automatic Baseline Calibration

Please refer to chapter 3.4 for a description of the baseline.

Byte#	0	1	2	3	4	5
Content	GnS	Tgt	0x01	0x07	0x00	Auto Baseline

GnS: 0 = Set
1 = Get

Tgt 0 = RAM
1 = Flash

Auto Baseline: 0 = Automatic Baseline Calibration disabled
1 = Automatic Baseline Calibration enabled (Factory Default)

4.2.11 Set Baseline Manual

This feature sets the baseline of the according channel to a specific value. Only useful if automatic baseline calibration is disabled. Otherwise, the baseline is calibrated to a different value after a while. If Baseline is set to 65535, the baseline is set to the actual measured value after the starting of the device. Please refer to chapter 3.4 for a description of the baseline

Byte#	0	1	2	3	4	5	6
Content	GnS	Tgt	0x02	ChP3	0x00	Baseline LSB	Baseline MSB

GnS: 0 = Set
1 = Get

Tgt 0 = RAM
1 = Flash

ChP1 3 = Sensor Channel 0
4 = Sensor Channel 1
5 = Sensor Channel 2
6 = Sensor Channel 3

Baseline: Baseline Value in the range 0 to 65534
65535 (0xFFFF) = Baseline is set to the actual measured value after the staring of the sensor (Factory Default)

4.2.12 Initialize Baseline

This command initiates a setting of the baselines to the actual measured capacity value. Please refer to chapter 3.4 for a description of the baseline

Byte#	0	1	2	3	4
Content	0x00	0x80	0x00	0x01	0x00

5. Technical Specifications

5.1 Current Consumption

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
I_q	Operating current				30	mA
I_{Stby}	Standby current	No USB activity			500	µA

5.2 Mechanical Dimensions

The PCB is designed to be mounted using two standard M2 screws or to stick the back side to the dielectric material. There are no components on the back side of the PCB, the back side is plane.

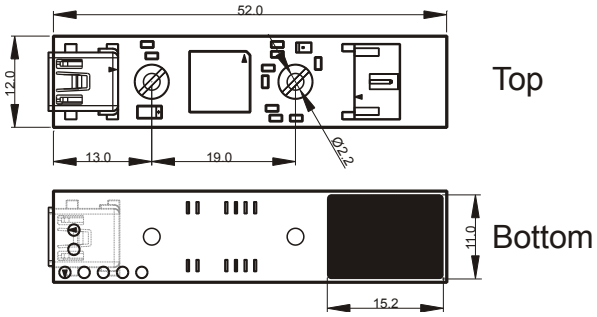

Figure 7: Mechanical dimensions of the Oak CS device

5.3 RoHS Compliance

Unless otherwise stated, all Toradex products comply with the European Union's Directive 2002/95/EC: "Restrictions of Hazardous Substances".

Revision history

Date	Doc. Rev.	Changes
03-Jan-2008	Rev. 0.9	Preliminary Release