Chipsmall Limited consists of a professional team with an average of over 10 year of expertise in the distribution of electronic components. Based in Hongkong, we have already established firm and mutual-benefit business relationships with customers from,Europe,America and south Asia,supplying obsolete and hard-to-find components to meet their specific needs.

With the principle of “Quality Parts,Customers Priority,Honest Operation,and Considerate Service”,our business mainly focus on the distribution of electronic components. Line cards we deal with include Microchip,ALPS,ROHM,Xilinx,Pulse,ON,Everlight and Freescale. Main products comprise IC,Modules,Potentiometer,IC Socket,Relay,Connector.Our parts cover such applications as commercial,industrial, and automotives areas.

We are looking forward to setting up business relationship with you and hope to provide you with the best service and solution. Let us make a better world for our industry!

Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832
Email & Skype: info@chipsmall.com Web: www.chipsmall.com
Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China

zForce AIR™ Touch Sensor
User's Guide

2017-12-21

Legal Notice

Neonode may make changes to specifications and product descriptions at any time, without notice. Do not finalize a design with this information. Neonode assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using Neonode components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

Neonode components are neither designed nor intended for use in FDA Class III applications, or similar life-critical medical equipment. Customers acknowledge and agree that they will not use any Neonode components in FDA Class III applications, or similar life-critical medical equipment, and that Neonode will not be responsible for any failure to meet the requirements of such applications or equipment.

No part of the materials contained in any Neonode document may be copied, photocopied, reproduced, translated or reduced to any electronic medium or machine-readable form, in whole or in part, without specific written permission from Neonode Inc.

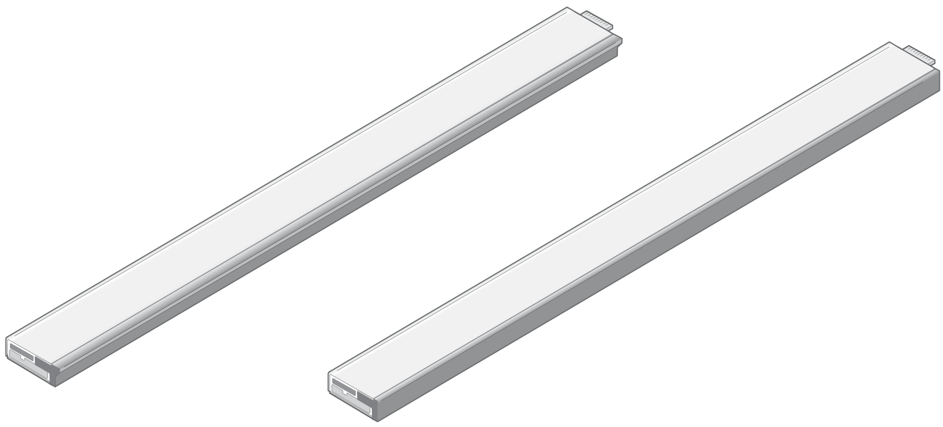
NEONODE, the NEONODE logo and ZFORCE are trademarks of Neonode Inc. registered in the United States and other countries. ZFORCE AIR is a trademark of Neonode Inc. All other trademarks are the property of their respective owners.

1 Table of Contents

2 Introduction

2.1 Product Overview

The zForce AIR Touch Sensor is a laser light based touch sensor that can be integrated and used in various applications. The sensor characteristics are high scanning frequency, low latency, good touch accuracy and the fact that it can be used on any surface or even in mid air. zForce AIR Touch Sensor can be connected to the host system through a standard connector and communicate through a standard I2C or USB interface.



2.1.1 Main Features

- Enables touch on any surface or in mid air
- Dual touch support
- High scanning frequency – up to 200Hz or more depending on sensor length
- Low touch latency
- High touch accuracy
- Idle mode for reduced current power consumption
- Configurable touch active area
- I2C and USB interface
- Standard 5V power supply

2.2 Product Variants

In order to fit in a wide range of applications, the zForce AIR Touch Sensor exists in two types and a number of different lengths.

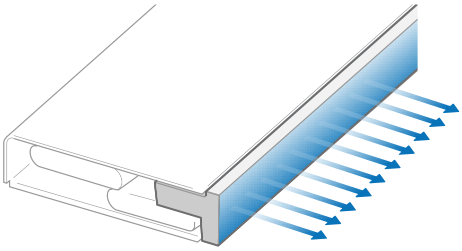
> ⚠ If the variant you are interested in is not available for purchase from your distributor, please contact the distributor or a Neonode sales representative (refer to www.neonode.com[1]) for more information.

1 http://www.neonode.com/

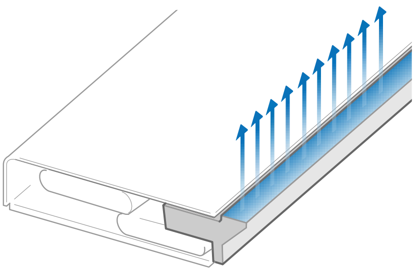
2.2.1 Sensor Orientation

The zForce AIR Touch Sensor is available in two types, one where the active area emerges straight out from the sensor (0° type) and one where it emerges out from the sensor at a 90° angle (90° type). This enables both vertical and horizontal integration.

0° Type



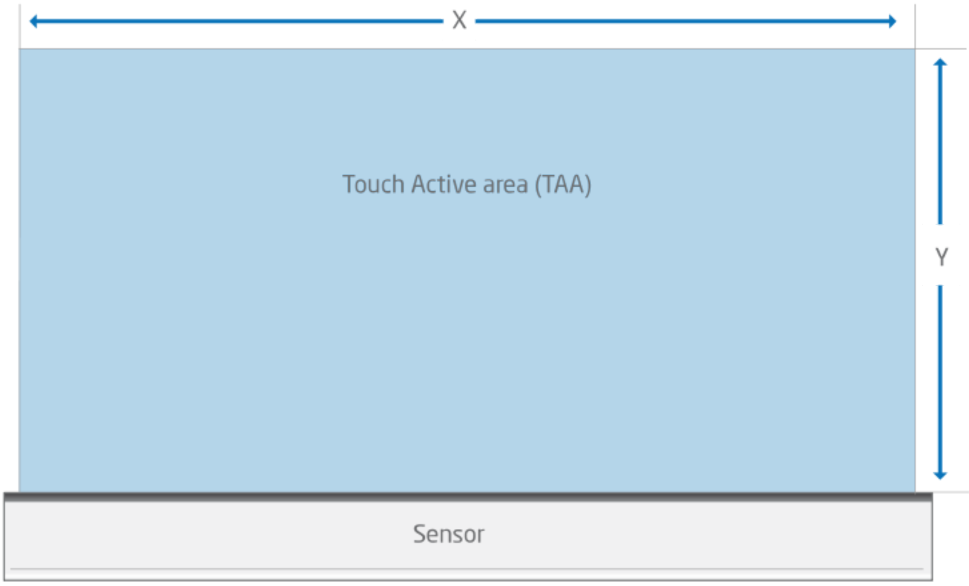
90° Type



2.2.2 Sensor Length

The Touch Sensor is available in 43 different lengths. The length affects the Touch Active Area (TAA) in both X and Y directions.

Touch Active Area



The table lists all product variants, the product number, and the TAA for each variant. See also Physical Dimensions and Position of Origin (see page 72).

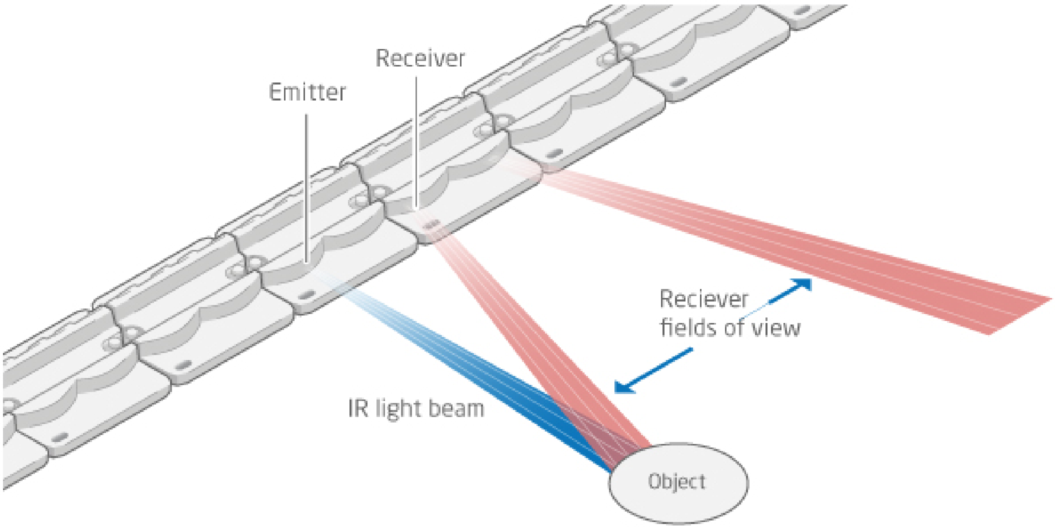
Product number		TAA (mm)	
0° Type	90° Type	X	Y
NNAMC0430PC01	NNAMC0431PC01	43.2	14.9
NNAMC0500PC01	NNAMC0501PC01	50.4	29.8
NNAMC0580PC01	NNAMC0581PC01	57.6	29.8
NNAMC0640PC01	NNAMC0641PC01	64.8	44.7
NNAMC0720PC01	NNAMC0721PC01	72	44.7
NNAMC0790PC01	NNAMC0791PC01	79.2	59.6
NNAMC0860PC01	NNAMC0861PC01	86.4	59.6
NNAMC0940PC01	NNAMC0941PC01	93.6	74.5
NNAMC1010PC01	NNAMC1011PC01	100.8	74.5
NNAMC1080PC01	NNAMC1081PC01	108	89.4
NNAMC1150PC01	NNAMC1151PC01	115.2	89.4

NNAMC1220PC01	NNAMC1221PC01	122.4	104.3
NNAMC1300PC01	NNAMC1301PC01	129.6	104.3
NNAMC1370PC01	NNAMC1371PC01	136.8	119.2
NNAMC1440PC01	NNAMC1441PC01	144	119.2
NNAMC1510PC01	NNAMC1511PC01	151.2	134.0
NNAMC1580PC01	NNAMC1581PC01	158.4	134.0
NNAMC1660PC01	NNAMC1661PC01	165.6	148.9
NNAMC1730PC01	NNAMC1731PC01	172.8	148.9
NNAMC1800PC01	NNAMC1801PC01	180	163.8
NNAMC1870PC01	NNAMC1871PC01	187.2	163.8
NNAMC1940PC01	NNAMC1941PC01	194.4	178.7
NNAMC2020PC01	NNAMC2021PC01	201.6	178.7
NNAMC2090PC01	NNAMC2091PC01	208.8	193.6
NNAMC2160PC01	NNAMC2161PC01	216	193.6
NNAMC2230PC01	NNAMC2231PC01	223.2	208.5
NNAMC2300PC01	NNAMC2301PC01	230.4	208.5
NNAMC2380PC01	NNAMC2381PC01	237.6	208.5
NNAMC2450PC01	NNAMC2451PC01	244.8	208.5
NNAMC2520PC01	NNAMC2521PC01	252	208.5
NNAMC2590PC01	NNAMC2591PC01	259.2	208.5
NNAMC2660PC01	NNAMC2661PC01	266.4	208.5
NNAMC2740PC01	NNAMC2741PC01	273.6	208.5
NNAMC2810PC01	NNAMC2811PC01	280.8	208.5
NNAMC2880PC01	NNAMC2881PC01	288	208.5
NNAMC2950PC01	NNAMC2951PC01	295.2	208.5
NNAMC3020PC01	NNAMC3021PC01	302.4	208.5
NNAMC3100PC01	NNAMC3101PC01	309.6	208.5

NNAMC3170PC01	NNAMC3171PC01	316.8	208.5
NNAMC3240PC01	NNAMC3241PC01	324	208.5
NNAMC3310PC01	NNAMC3311PC01	331.2	208.5
NNAMC3380PC01	NNAMC3381PC01	338.4	208.5
NNAMC3460PC01	NNAMC3461PC01	345.6	208.5

2.3 Basic Principles

zForce AIR Touch Sensors detect and trace objects by detecting diffusely reflected infrared light. The sensor comprises an optical system arranged to combine emitted IR beams and receiver fields of view within the same apertures. IR light beams are emitted perpendicular to the output window, while receivers field of view is centered at a certain angle left and right.



Each emitter-receiver combination covers a narrow region on the active area. An object present in the active area will affect several emitter-receiver channels, and the reported coordinates is the outcome of a center of gravity calculation on these signals.

2.4 Applications

zForce AIR Touch Sensors can be integrated for a wide range of applications, such as:

- PCs/Tablets
- TVs/Monitors
- Printers
- Mechanical key replacement
- White goods
- Smart furniture
- Interactive mirrors
- Elevator panels
- eReaders

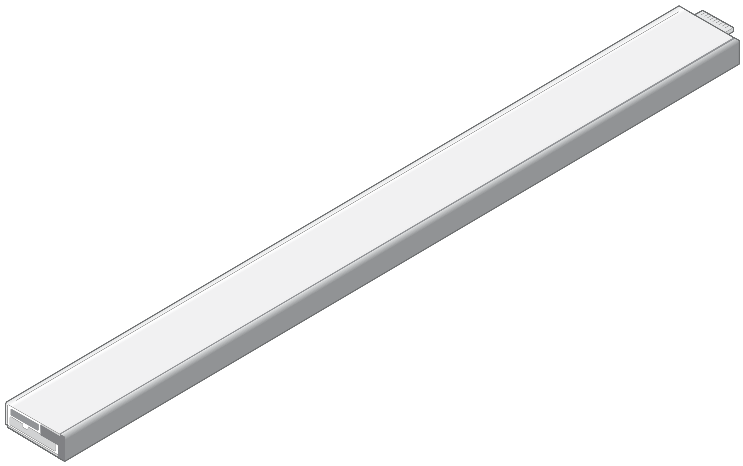
- Instruments
- Vending Machines
- ATM/POS terminals
- Robotics
- Range finders
- Collision detectors
- ... and much more

2.5 Product Design and Components

The zForce AIR Touch Sensor is a laser light based touch sensor that can be used for various touch and mid-air detection applications. The sensor is available in varying sizes, see Product Variants (see page 6).

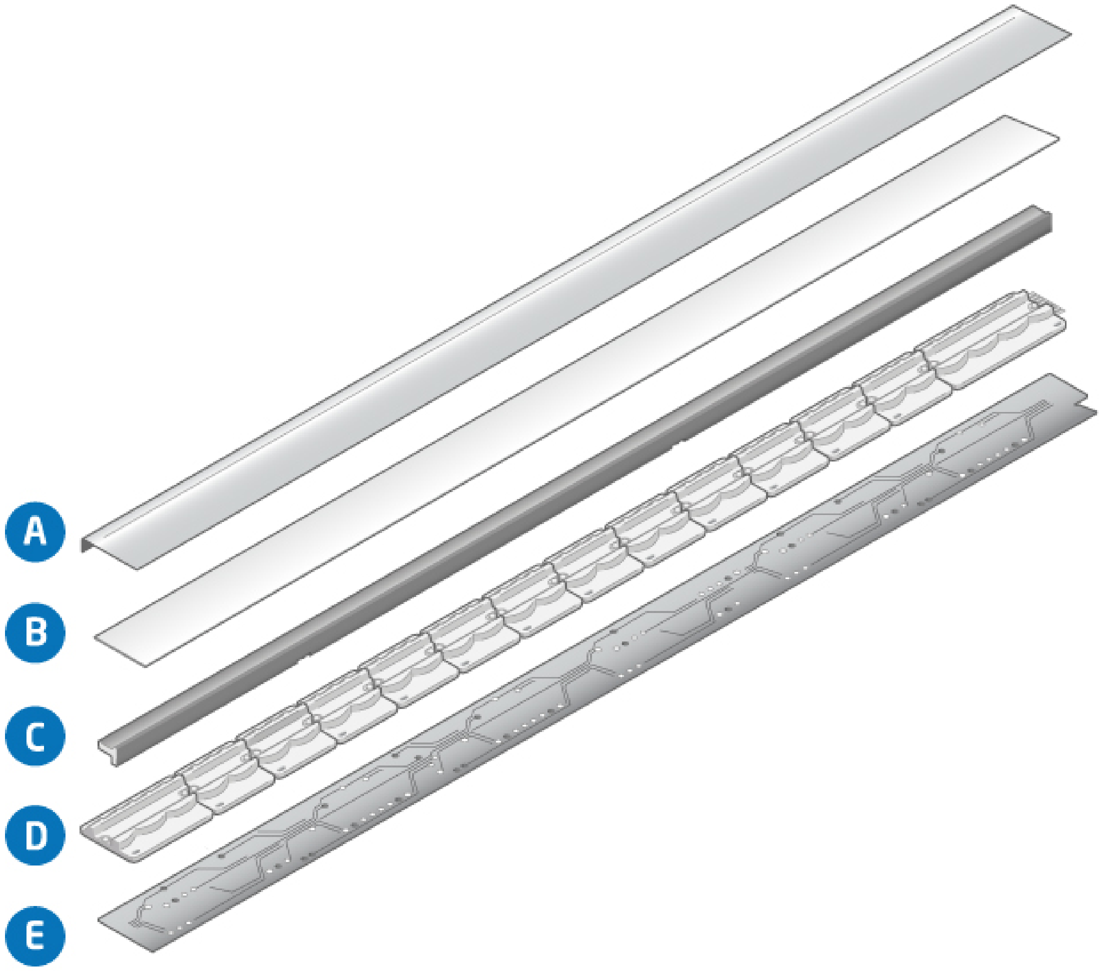
2.5.1 Sensor Design

The image below show the sensor design (0° type). The connector is shown to the far right.



Exploded view

The image below shows the sensor (0° type) in an exploded view.



Part	Decription
A	Cover
B	Adhesive
C	Front light pipe – straight shooting or 90 degree shooting depending on sensor type
D	Lenses - amount depends on size
E	PCBA

2.5.2 Sensor Components

The PCBA is equipped with both active and passive components, for example:

- MCU

- Co-processor, a Neonode proprietary scanning IC
- Optical lenses, made out of polycarbonate
- VCSELs
- Photo diodes
- Other passive components

2.6 Product Integration

The zForce AIR Touch Sensor can be integrated to any host system through a physical connector with 8 contact pads with support for both I2C and USB HID. The host system can communicate with the sensor through a communication protocol and an SDK developed by Neonode.

3 Getting started with zForce AIR Touch Sensor Evaluation

This section describes how to get started with the evaluation of a zForce AIR Touch Sensor.

3.1 Evaluation Kit Contents

The evaluation kit includes the following:

- 1 x zForce AIR Touch Sensor
- 1 x Interface board (with USB and I2C interface)
- 1 x FPC Cable with connector

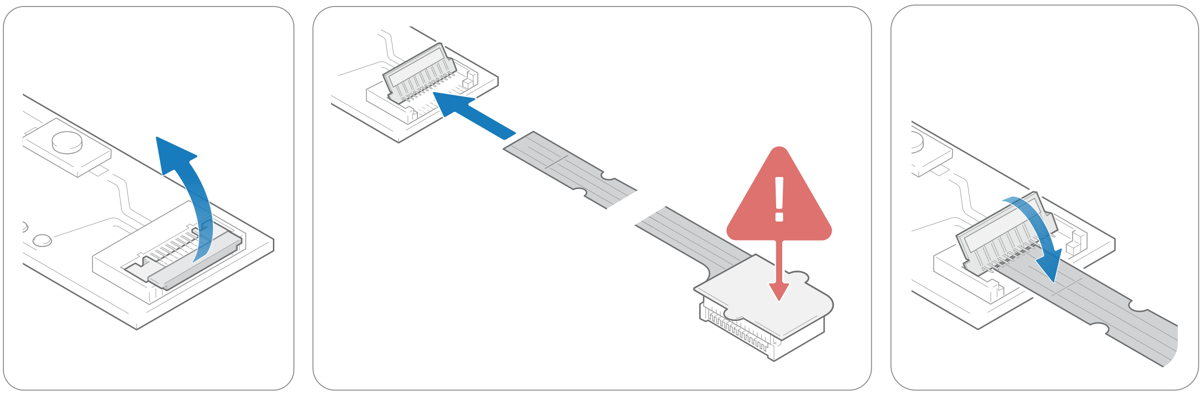
3.2 Getting Started

1. Connect the sensor according to Connecting Sensor (see page 14).
2. Start communicating using one of the means listed below:

- Neonode Workbench (see page 16). Use the Neonode Workbench software for Windows to configure a sensor and test and evaluate touch performance.
- USB HID Digitizer Mode (see page 17). This is the easiest and fastest way to try out the Touch Sensor. It only requires connecting the interface board to a Windows or Linux computer via USB, but is limited in functionality.
- USB HID Raw Mode (see page 17). This also uses a USB connection to a Windows or Linux computer, but requires communicating with the sensor using ASN.1 encoded messages.
- I2C Transport (see page 17). This involves sending and receiving ASN.1 encoded messages over I2C.
- SDK (see page 17). Using the zForce SDK function library facilitates communication with sensors without considering ASN.1 encoded messages.

3.3 Connecting Sensor

1. Connect the FPC cable to the interface board:

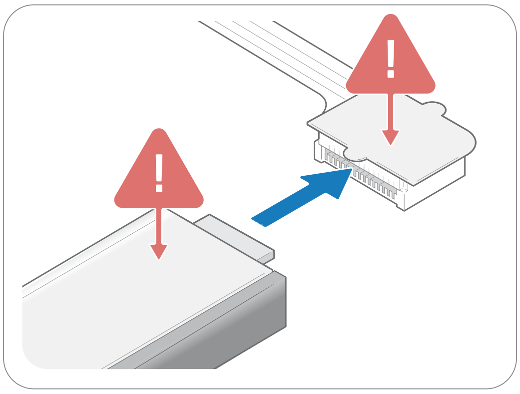


   a. Lift the flip lock on the interface board.
   b. Insert the FPC cable into the end of the connector, with the connector pads facing down, towards interface board. The yellow piece of PCB of the connector on the other side of the cable is facing upwards. Make sure the direction is straight into the connector and the pads have reached the end of the connector.

Make sure the connector pads of the FPC cable are facing downwards, towards interface board. The sensor risks damage if the FPC cable is connected in wrong direction.

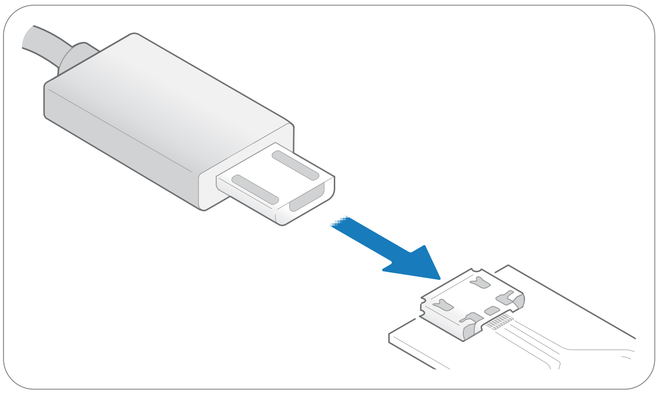
c. Press down the flip lock.

2. Connect the FPC cable to the sensor:



a. Place the sensor so that the sensor connector pads of the sensor are facing downwards (steel surface upwards).
b. Insert sensor into the connector on FPC cable (yellow piece of PCB of the FPC connector still facing upwards).
c. Make sure the direction of the pads is straight into the connector, and the pads have reached the end of the connector.

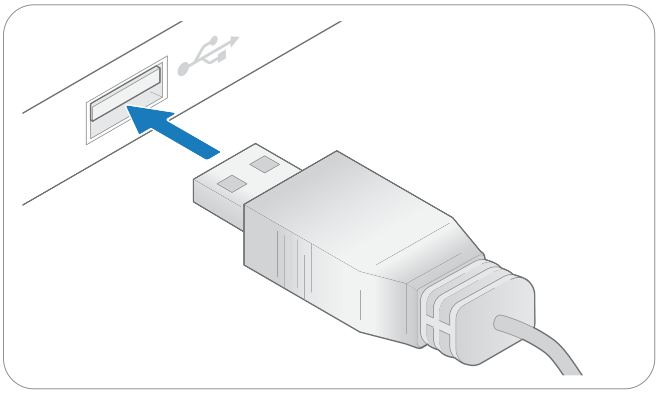
3. To use Neonode Workbench, USB HID Digitizer mode, USB HID Raw mode, or SDK: Connect a USB cable with a Micro USB type B connector to the interface board.



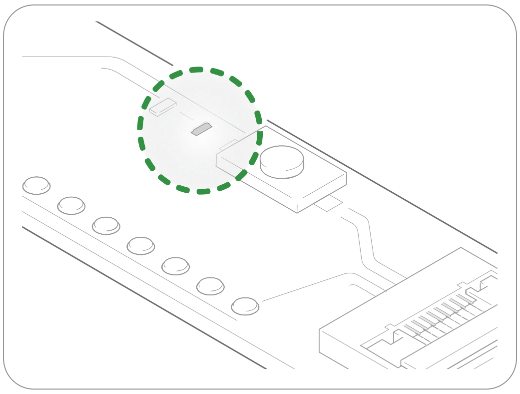
4. To use I2C Transport: Wire the pads of +5V, DR-B0, I2C-D, I2C-C, and GND on the interface board to the host system. For details, refer to Electrical Integration (see page 26). Do not connect power until the following steps have been performed.
5. Place the sensor on a table with the steel surface facing downwards and with the optical surface facing towards you.

Make sure no object is within the touch active area of the sensor before connecting power to the sensor through USB or I2C. The sensor calibrates itself when powered on and an object within the touch active area may interfere with the calibration.

6. To use Neonode Workbench, USB HID Digitizer mode, USB HID Raw mode, or SDK: Insert the USB cable into a computer meeting the requirements of USB HID or SDK, respectively.



7. To use I2C Transport: Connect the power to the sensor through the I2C.
8. The green LED on the interface board lights up when connected.



In case of strong side light, covering the short sides of the sensor with, for example, black tape might improve performace.

3.4 Communicating with Sensor

3.4.1 Neonode Workbench

Neonode Workbench is a software tool to use with zForce AIR™ sensors. With Neonode Workbench it is possible to:

- Visualize sensor touches.
- Temporarily configure sensor characteristics, such as active area and scanning frequency.
- View the sensor firmware version.
- Conduct Open/Short-circuit tests to identify any damaged photo or laser diodes.

Download Neonode Workbench from Downloads[2] and refer to separate Neonode Workbench documentation.

3.4.2 USB HID Digitizer Mode

The easiest way to see the Touch Sensor functionality is to use USB HID Digitizer mode:

1. When the sensor has enumerated, it will act as a touch screen USB HID device.
2. Put an object in the touch active area, touch HID reports will be send to host.

For more information on USB HID Digitizer mode, refer to USB HID Transport (see page 38).

3.4.3 USB HID Raw Mode

In USB HID Raw Mode, communication with a Touch Sensor is performed by sending and receiving messages as reports defined by the USB HID standard.

To start communicating, perform the following:

1. When the sensor has enumerated, start communicating as defined in USB HID Transport (see page 38). The messages are encoded with ASN.1.Refer to Presentation Layer (ASN.1) (see page 50).
2. The Touch Sensor starts sending touch notifications once it is initialized. For initialization procedures, refer to Initializing Sensors (see page 33).

3.4.4 I2C Transport

To start communicating, perform the following:

1. Send or read data over the I2C bus. Refer to I2C Transport (see page 35). The messages are encoded with ASN. 1. Refer to Presentation Layer (ASN.1) (see page 50).
2. The sensor starts sending touch notifications once it is initialized. For initialization procedures, refer to Initializing Sensors (see page 33).

3.4.5 SDK

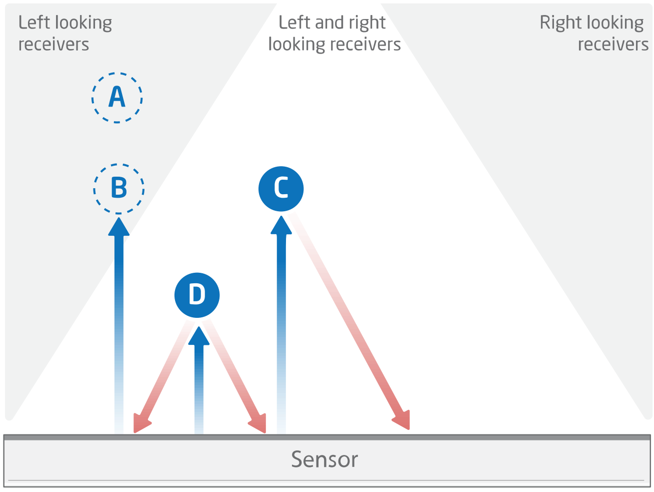
To start communicating, follow the Getting Started instructions in the separate SDK documentation.

2 https://support.neonode.com/docs/display/Downloads

4 Multi-Touch Functionality

zForce AIR Touch Sensor determine an object's position by signals derived from emitter-receiver pairs and have the capacity to detect and track several objects at the same time. Both the HW and the SW have been optimized in order to support standard touch gestures like, pinch-to-zoom, rotate, swipe and tap. However, some combinations of two or more objects might need special consideration.

4.1 Shadows



- An object directly behind another object cannot be illuminated. In the figure above, object A will not be detected since illumination is blocked by object B.
- The correct receiver must have a clear field of view. Object B is in a region covered only by left looking receivers. Object B will not be detected because its field of view is blocked by object D.
- Object C may be seen by both left and right looking receivers. Although the right looking field of view is blocked by object D, object C is detected by the left looking receiver.
- Object D is detected by both left and right looking receivers.

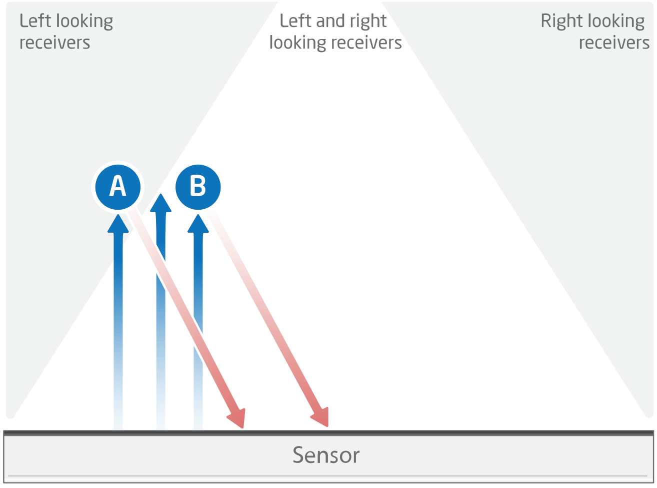
4.1.1 Shadow Trick

Note that in most cases, user experience is not affected by the shadow situations mentioned above. This is because of a functionality implemented in the Touch Sensor firmware called "shadow trick", which e.g. generates a smooth "rotate" feeling despite one touch object being shadowed during the rotate gesture . A previously detected object that can no longer be detected is still reported as present if:

- The object was last seen close to a location where it could be shadowed by another object.
- The potentially shadowing object is still detected and hasn't moved away from a shadowing location.

The shadow trick make multi-touch gestures such as "rotate" and "pinch-to-zoom" work better.

4.2 Adjacent Objects

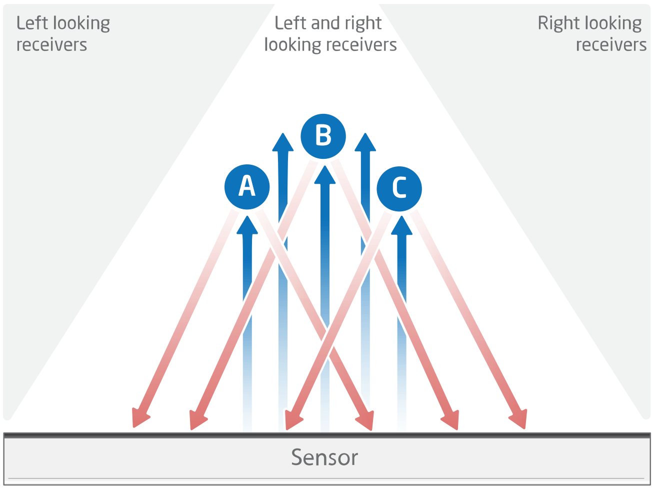


- In order to recognize two objects close to each other (A and B), a separation must allow at least one emitter-receiver channel (~10 mm) to pass freely between them. Otherwise, the two objects will be reported as one large object.

4.3 More Than Two Objects

When more than two objects are being tracked the likelihood that an object ends up being in the shadow of another object increases. Therefore, it is only recommended to enable more than two tracked objects if, for example:

- it is not vital to track all detected objects 100% in all possible combinations and locations at all time.
- When all objects are likely to be detected by the sensor, for example when it is expected that all objects will be placed along a line that is parallel to the sensor, as in the example below.

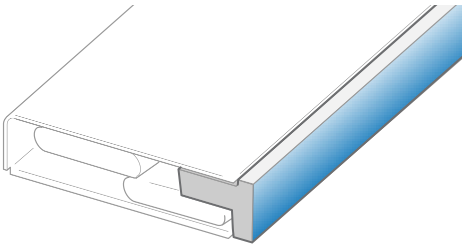


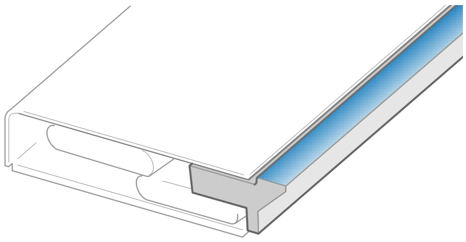
5 Mechanical Integration

zForce AIR Touch Sensor can be used for different purposes, such as touch on a surface or motion in mid-air. Assembly requirements differ depending on what purpose the Touch Sensor fulfills. In addition, different industries have different standards and demands to fulfill. Mid-air detection applications generally require lower mounting tolerances.

5.1 Means of Integration

zForce AIR Touch Sensor comes in two types: one is designed to be integrated horizontally and the other vertically. This allows different types of assembly possibilities and better adaptation of the available space in the host system. The two sensor designs are built on the same concept, but use two different front light pipes. One light path is unaffected; the other bent 90°.

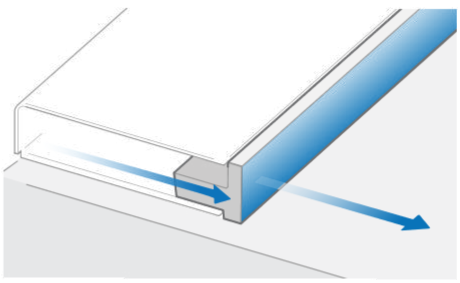


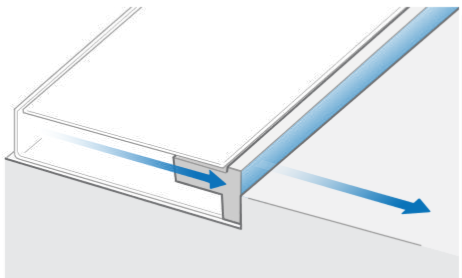


The front optical surface is not allowed to be blocked by the host system. In x direction the entire surface is used by the sensors optics.

5.1.1 Horizontal Integration

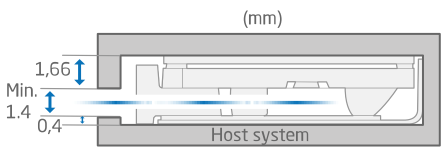
Light is sent straight out and enables an active area in front of the module (in the same plane).





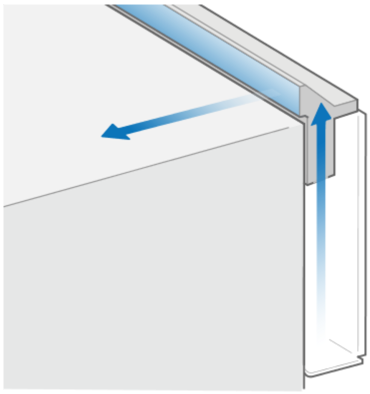
When integrating zForce AIR Touch Sensor into a host system make sure not to interfere with the light path. For horizontal integration, the opening for the sensors light path must be ***minimum 1.4 mm.***

If the host system have large tolerances, opening must be adjusted to always be minimum 1.4 mm.

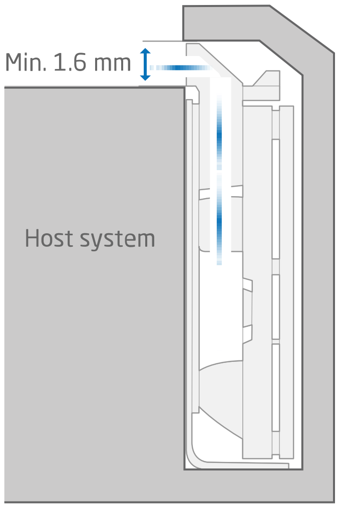


5.1.2 Vertical Integration

Light is bent 90 degrees within the Touch Sensor. This allows the sensor to be assembled vertically but still have an active area in the horizontal plane.



To make sure not to interfere with the sensor light path, opening must be ***minimum 1.6 mm.*** If host system have large tolerances, opening must be adjusted to always be minimum 1.6 mm. Also note that it is not allowed to mount, glue or in any other way affect the sensors optical surfaces since it will affect the performance. This applies to both the sensors visible optical surface and also the built-in optical surface A (mirror surface).



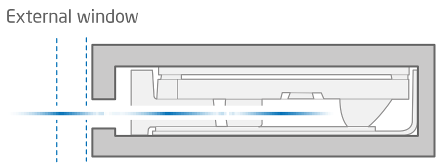
5.1.3 Options for Guiding and Fastening

- **Double adhesive tape** – for smaller sizes this can be used alone to hold the zForce AIR Touch Sensor. The host system geometry needs to provide a flat supporting surface.
- **Snaps** – Host system geometry provides some sort of snap features holding the zForce AIR Touch Sensor in place. These must be developed for each case to fit the host System cover and the surrounding.
- **Sandwiched** – the zForce AIR Touch Sensor is mounted by pressing the Touch Sensor between host system exterior cover and display. A structure (ribs, foam gasket or adhesive) is needed to make sure the Touch Sensor cannot move.

The zForce AIR Touch Sensor needs to be protected from outer pressure and forces that can bend the sensor and by that change the direction of the sensor light. The most common cause of bending is when a Touch Sensor is mounted on a non-flat surface, so the host system supporting structure needs to be flat.

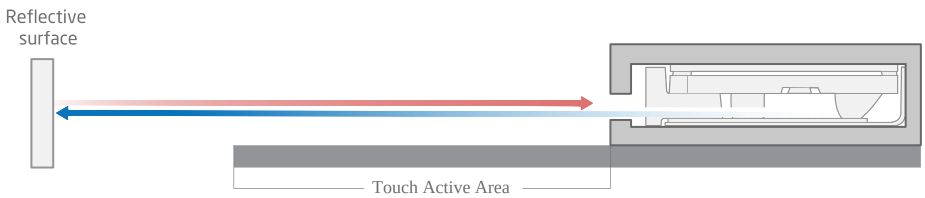
5.1.4 External Window

An external window is something placed between the sensor and the desired touch active area, usually in form of a plastic or glass “window”. It is of high importance for the function that these surfaces fulfill the optical demands stated in Optical Requirements on External Window (see page 71). It is important to know that each window the light passes through will reduce the sensors received signal levels, even though the requirements are fulfilled, which in some applications might reduce the maximum detection range.



5.1.5 External Reflective Surface

An external reflective surface is a surface located outside the active area, but close enough to be reached by the IR light emitted by the sensor. Depending on the angle and the reflectance of the surface, reflected light might enter the sensor and interfere with touch object detection. If the external reflective surface is close to the touch active area, it is recommended to make sure it has a low reflectance in the direction back towards the sensor.



5.2 Touch Applications

The sections below describe integration aspects specific for touch applications and do not concern mid-air applications.

5.2.1 Touch Accuracy

Mechanical integration of zForce AIR Touch Sensor and assembly tolerances has a direct impact on touch accuracy. For this reason relaxed assembly tolerances might in some applications have an impact on the perceived touch performance. The best user experience is achieved when the projected touch Active Area from the zForce AIR Touch Sensor perfectly overlaps the intended touch sensitive area on the host device, for example, the active area on a display.

Touch active area of host system and zForce AIR Touch Sensor needs to be well aligned. Translational tolerances in x and y directions and rotational tolerances will affect accuracy. See Translational Tolerances (see page 23) (x and y direction) and Rotational Tolerances (see page 23) (angle "b").

5.2.2 Hovering Touches

Hovering touch means that the Touch Sensor reports a touch event before the object reaches the surface. The basic principle of the Touch Sensor is that light is sent above the surface. To provide a good user experience the Touch Sensor software adjusts the signal and reports a touch first when the object reaches the surface.

Hovering touches is also direct linked to how the zForce AIR Touch Sensor is integrated in the host system. It's important that the mounting surface has the correct angle compared to the intended touch surface. Twisting and tilting of zForce AIR Touch Sensor should always be avoided. Relaxed tolerances can lead to missed touches and increased hovering. See Translational Tolerances (see page 23) (z direction) and Rotational Tolerances (see page 23) (angle "a").

Furthermore, host system active area surface need to be flat or slightly concave. A convex surface can give false touches.

5.2.3 Assembly Tolerances

Translational Tolerances

Direction	Recommended Tolerances for Touch Applications
x-direction	±0.5 mm
y-direction	±0.5 mm
z-direction	0 mm to +0.5 mm

Translational tolerances affects the overlap between the display active area and the touch active area. For example, if the Touch Sensor is translated 0.5 mm in x-direction there will be a systematic touch offset of 0.5 mm for the complete sensor in x-direction.

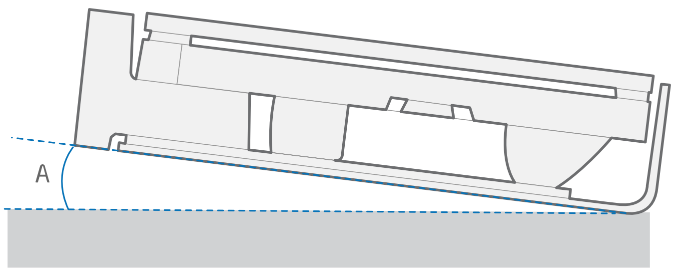
A 0 mm translation in z-direction means that the host system active area surface is positioned exactly at the edge of the light path. A positive translation means that zForce AIR Touch Sensor, and therefore the light path, is translated up from the host system active area surface. This will not affect the touch accuracy in the sensor, but it can affect the perceived touch performance, since it leads to increased hovering. A negative translation in z-direction should be avoided since parts of the light will be blocked which leads to no or reduced touch performance.

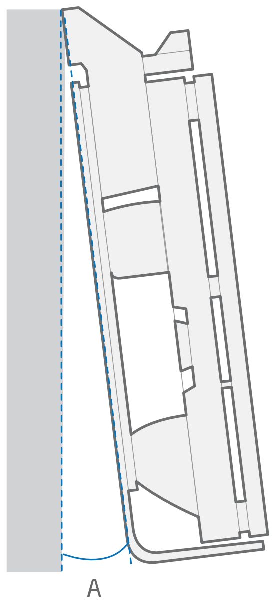
Rotational Tolerances

There are two types of rotations that can affect the performance; defined as the angles "a" and "b". Angle "a" affects the floating and angle "b" affects the overlap between the intended active area and the Touch Sensor active area. Both these issues will grow with larger display sizes. The angles are exaggerated in the pictures to better illustrate the problem.

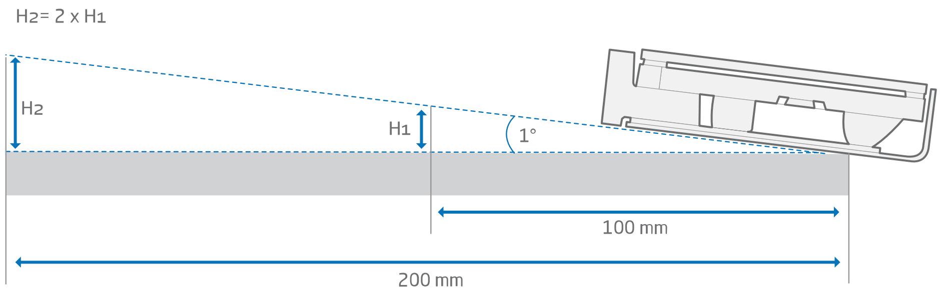
Angle "a"

The angle "a" is defined as shown in the images below.



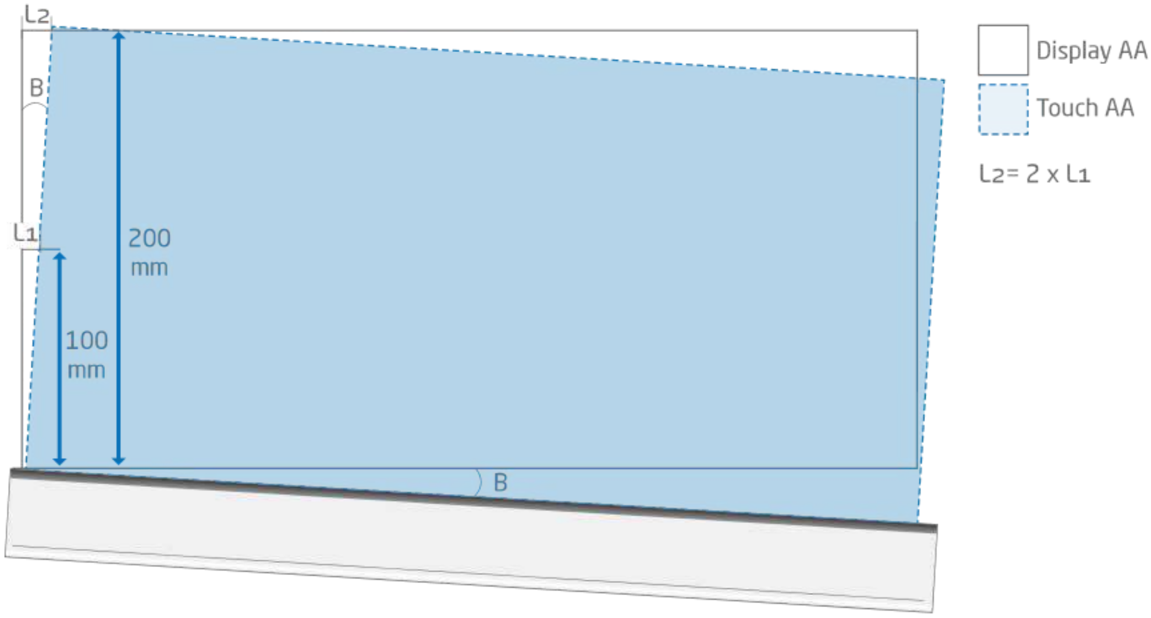


The example below illstrates the problem increasing with larger active areas.



Angle "b"

The angle "b" is defined as shown in the image below. How sensitive zForce AIR Touch Sensor is for assembly rotations is directly linked to the size. At any given angle b, the touch AA will be tilted twice as much at 200 mm compared to at 100 mm.


L2
B
L1
200
mm
100
mm
B
Display AA
Touch AA
L2= 2 x L1